Water Quality Parameters

What they are

&

Why they are important

Water Quality Parameters

Water quality parameters are collected to determine when to collect a "representative" sample, but they also provide a lot more valuable insight into what's going on at your site.

- temperature
- pH
- conductivity,
- REDOX
- dissolved oxygen (DO)
- turbidity.

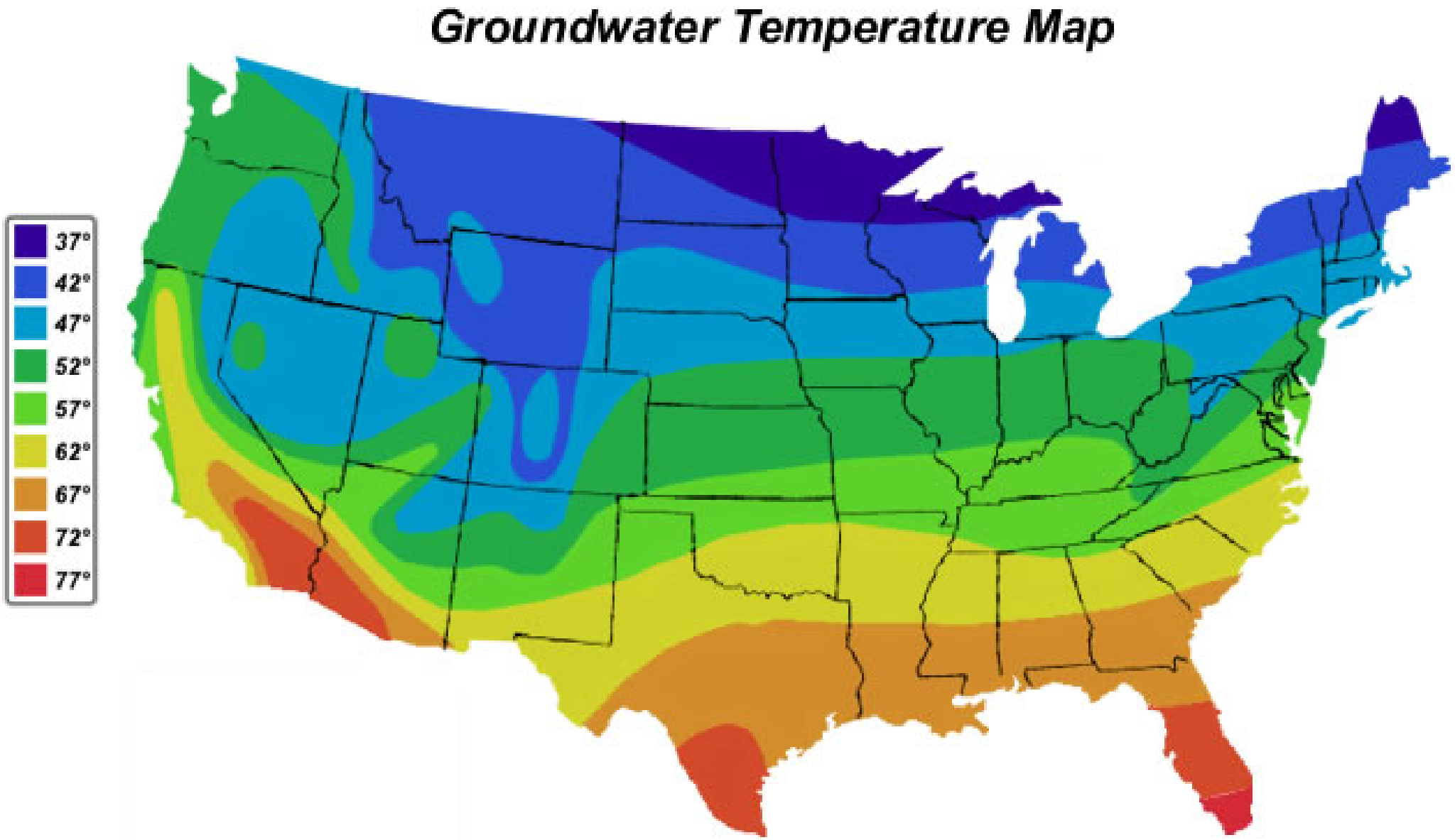
Stabilization of Water Quality Parameters

Water quality parameters are considered stable when three successive readings, collected 3-5 minutes apart, are within:

- ± 3% for temperature (minimum of ± 0.2C),
- ± 0.1 for pH,
- ± 3% for conductivity,
- ± 10 mv for redox potential,
- ± 10% for dissolved oxygen (DO), and
- ± 10% for turbidity.

Temperature

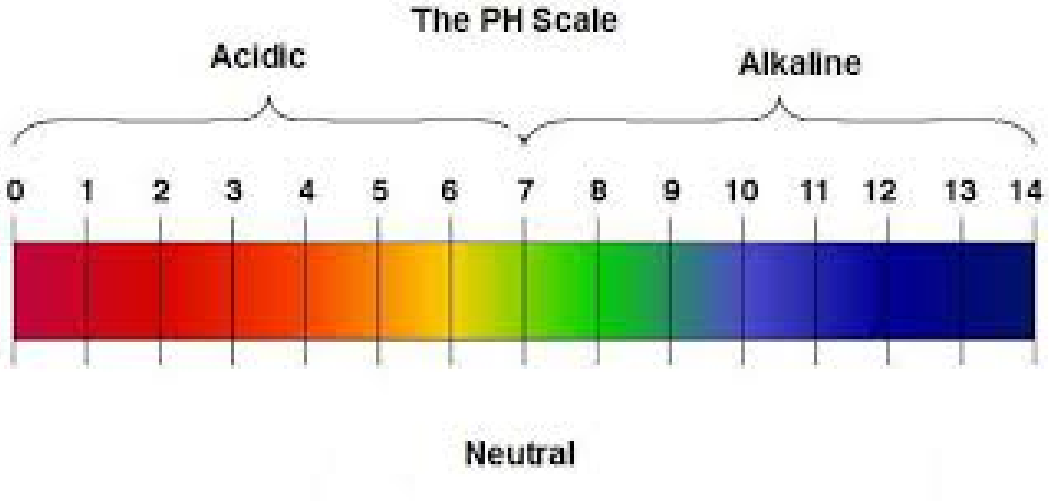
- Generally relates to air temperature, but decreases with depth (decreases 1° F for each ~60ft of depth)
- Remarkably stable parameter
- Impacts on biological life
- Impacts water chemistry
  - Rate of chemical reactions increases at higher temperatures
  - Increased solubility with higher temperatures
  - Increased temperature results in higher electrical conductivity because of more dissolved constituents
  - Some compounds are more toxic at higher temperatures



Groundwater temperatures range from 32-40°F in Alaska

pH

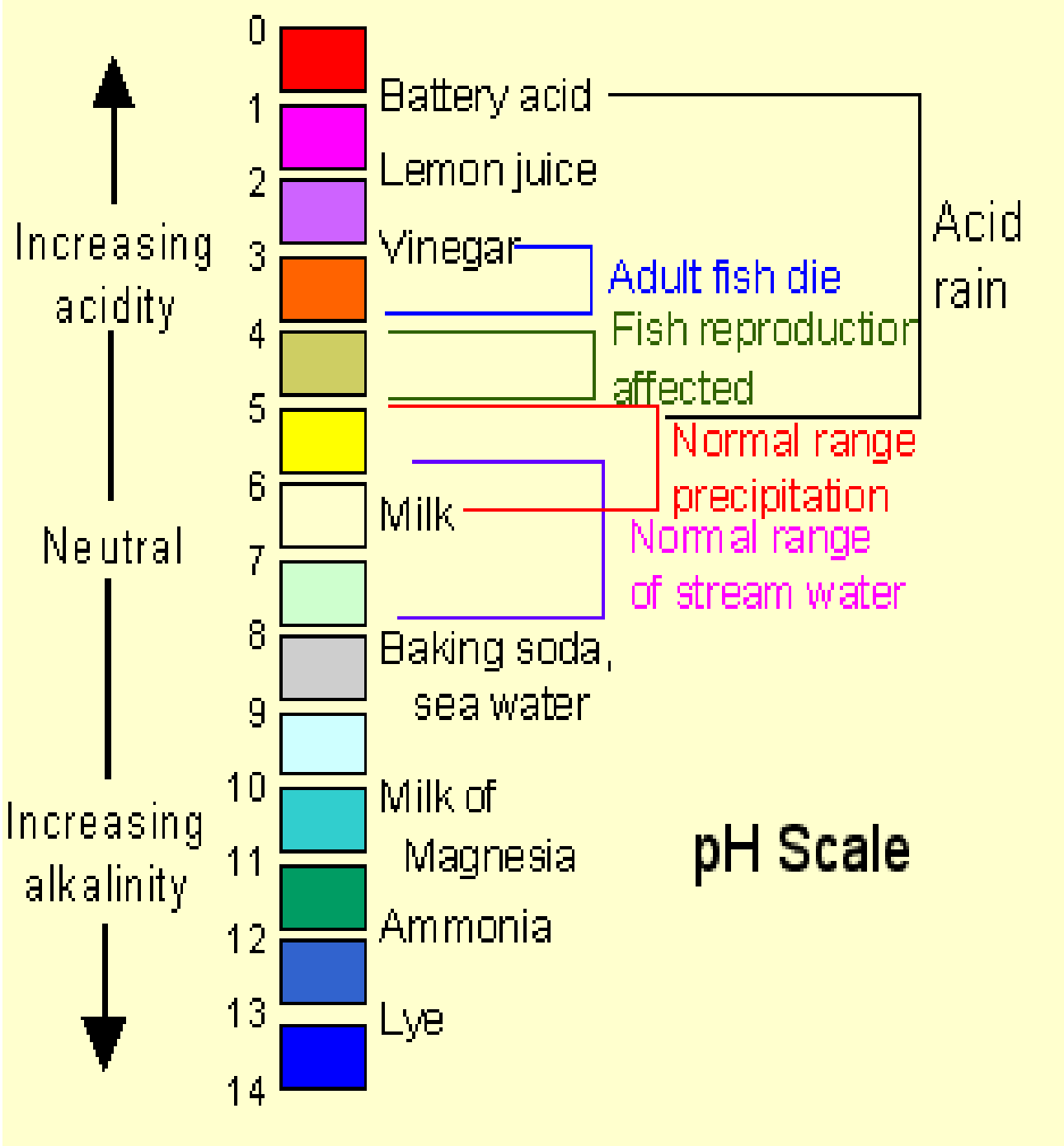
- pH – “power of hydrogen”
- Logarithmic scale from 1 to 14
  - pH = 7 is neutral
  - pH < 7 is acidic; soft water; unhealthy to drink
  - pH > 7 is basic; hard water



- Each whole pH value is an order of magnitude (10X) the next pH value
  - Example: pH of 3 is 10X more acidic than pH of 4 and 100X more acidic than pH of 5
- pH determines solubility & biological availability of chemicals in water
- Increased metals solubility at lower pH

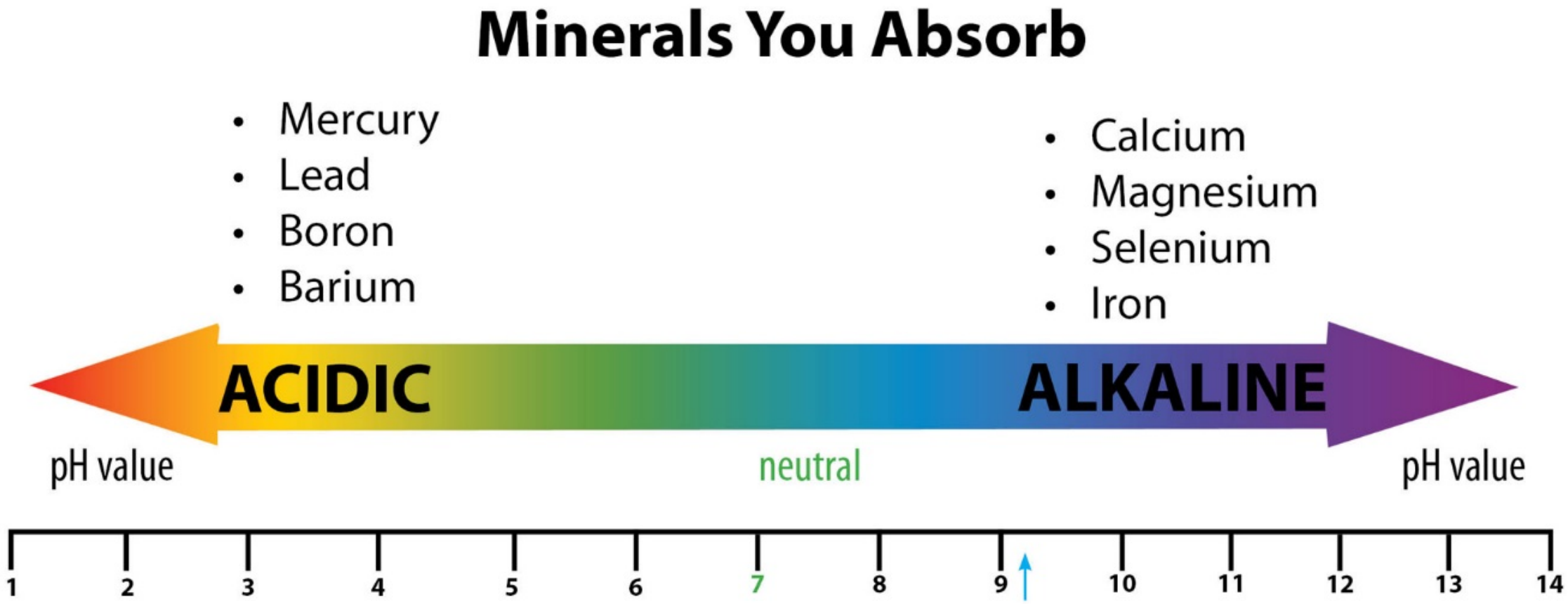
Groundwater typically has a neutral pH, but different things can impact water's pH.

- Soil & bedrock type waters move through
  - Limestone tends to neutralize acid while granite has no effect on pH
- Organic matter
  - Decomposing organic matter releases carbon dioxide which combines with water to form carbonic acid lowering pH
- Chemical contaminants in water
- Precipitation



Courtesy of Environment Canada (http://www.ns.ec.gc.ca/)

pH & Bioavailability

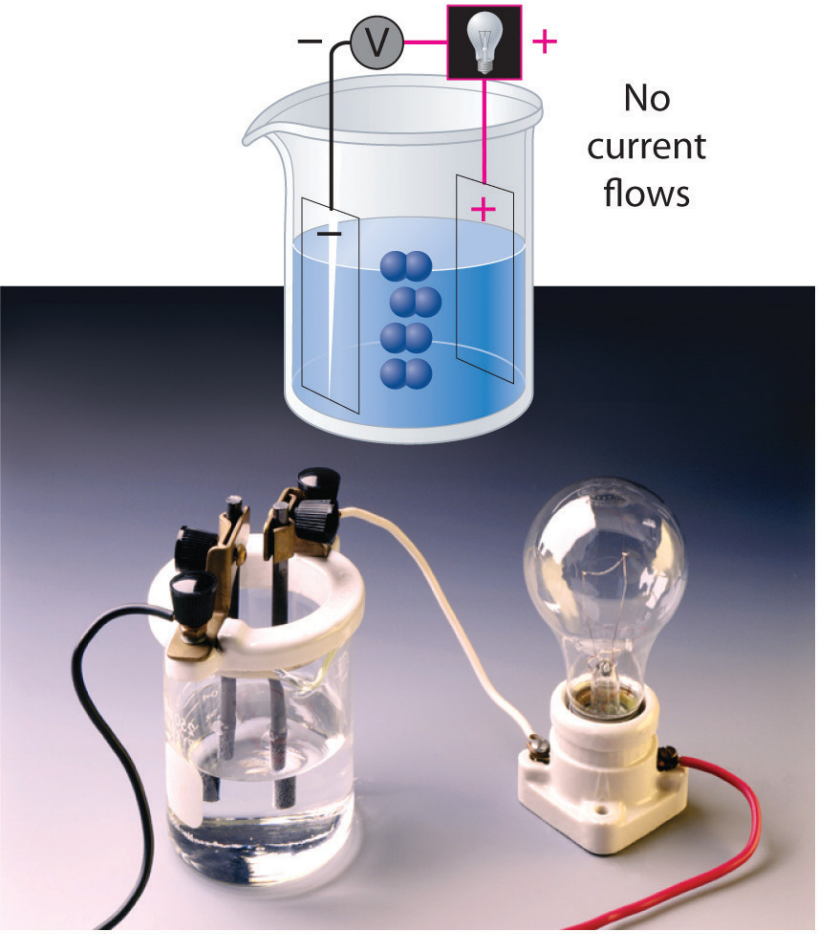


Conductivity

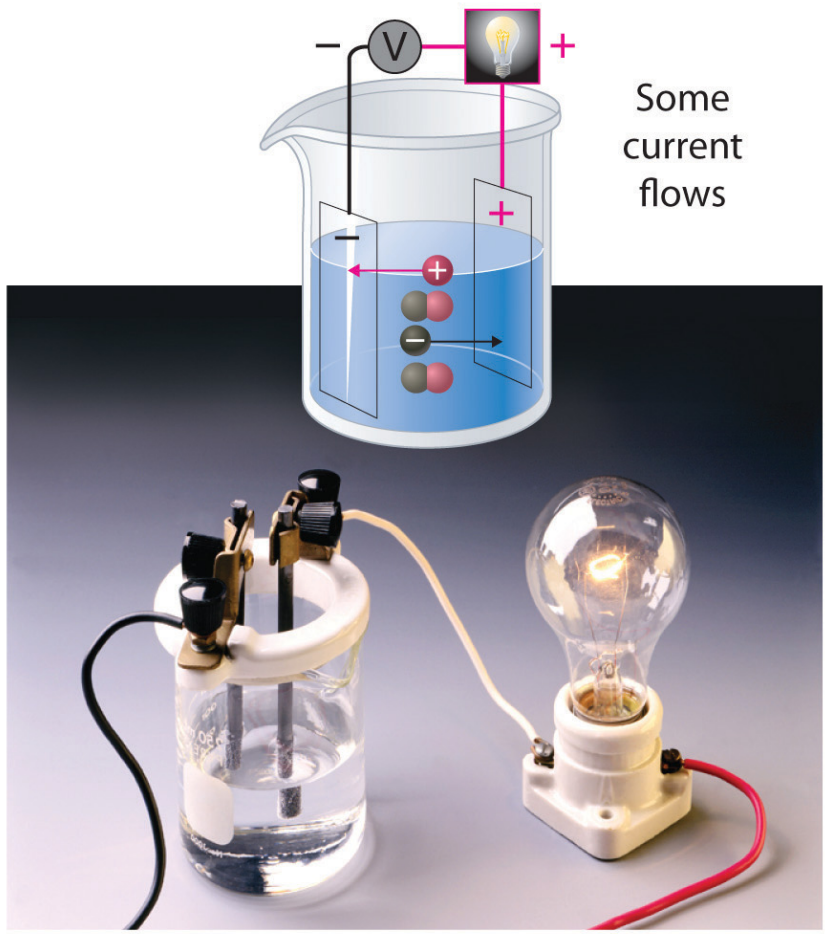
- Measure of the ability of water to pass an electrical current
- Measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µs/cm)
- Water is an excellent insulator & does not readily conduct electricity, but water is also an excellent solvent.
- When water has dissolved substances in it, it becomes more conductive.
  - Conductivity increased by inorganic dissolved solids
    - chloride, nitrate, sulfate,-phosphate anions (negative ions)
    - sodium , magnesium, calcium, iron, aluminum cations (positive ions)
  - Conductivity lowered by organic compounds (oil, alcohols, phenols)

Conductivity

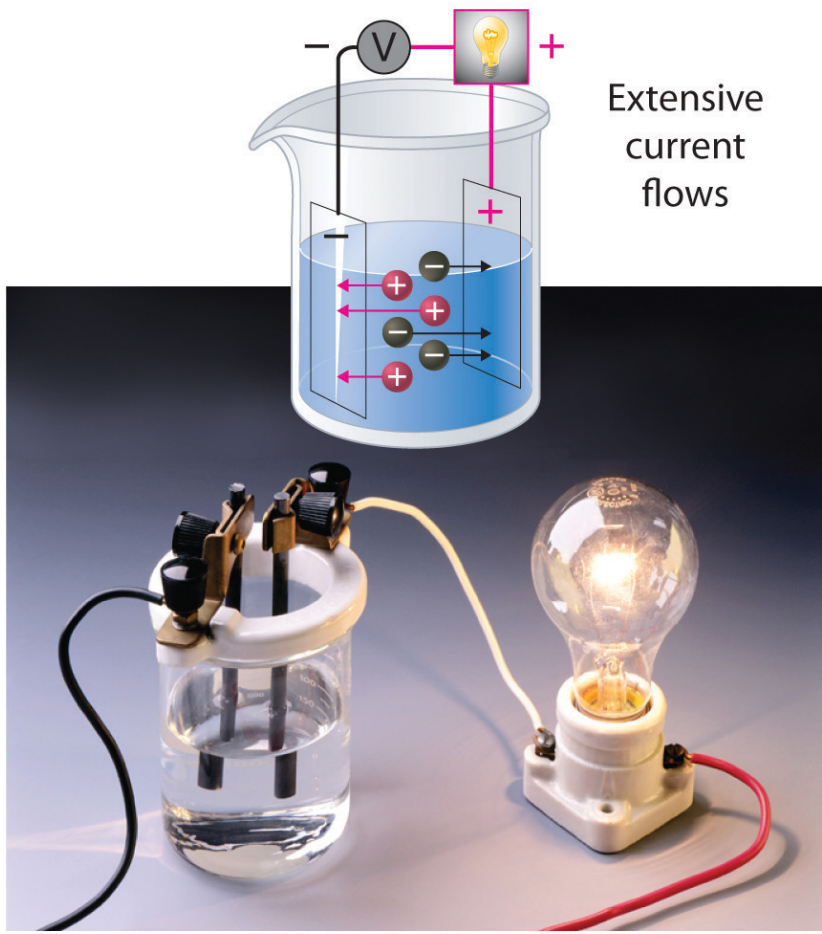
- Conductivity typically pretty constant so a change in conductivity may indicate an impact to groundwater
  - Distilled water conductivity of 0.5-3 µmhos/cm
  - Industrial wastewaters conductivity of 10,000µmhos/cm
- Warmer the water the higher the conductivity
- Affected by geology water flows through
  - Lower conductivity if water flowing through granite
  - Higher conductivity if water flowing through clay



(a) Nonelectrolyte

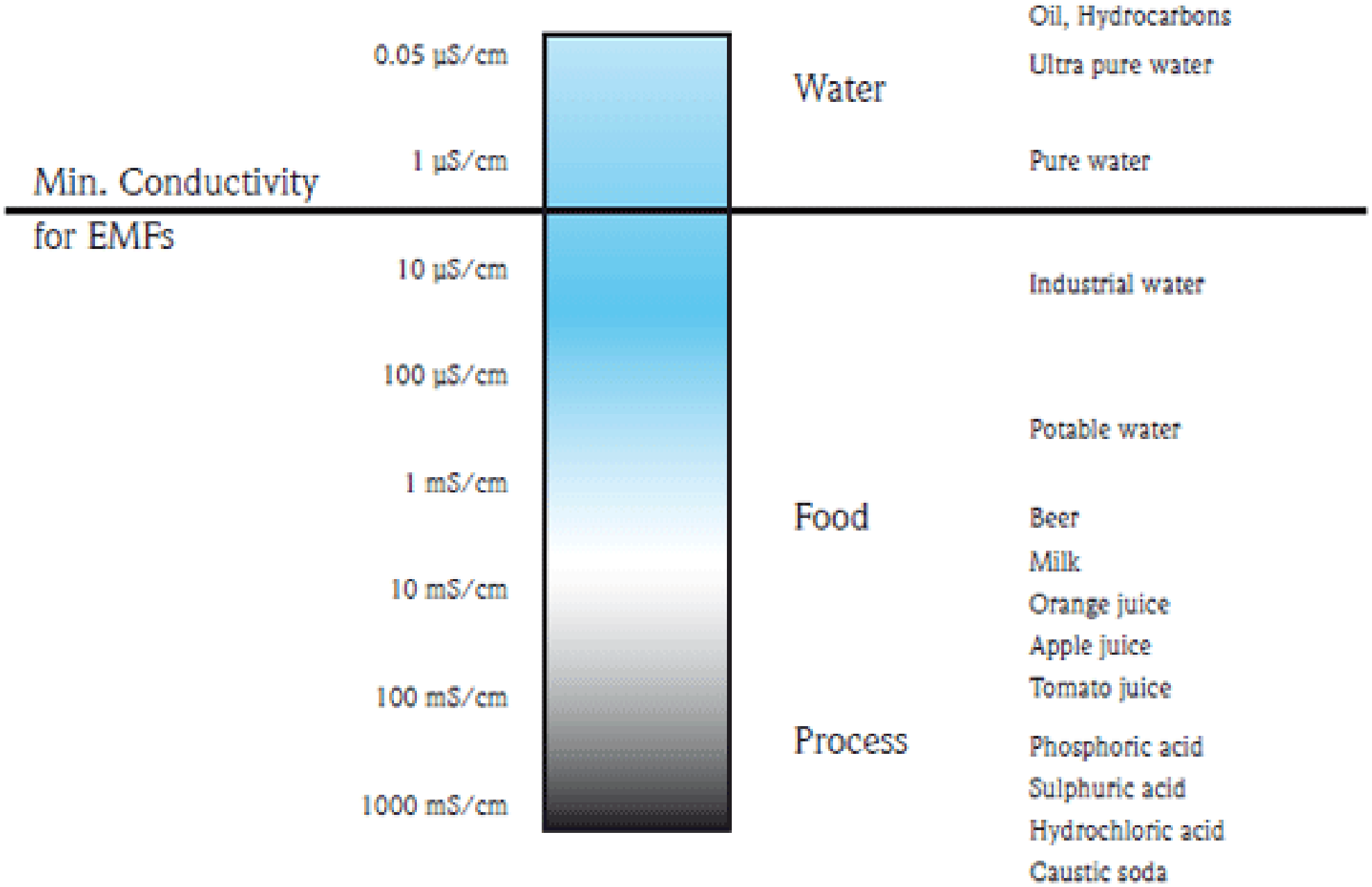


(b) Weak electrolyte



(c) Strong electrolyte

Conductivity



Oxidation-Reduction Potential (ORP or REDOX)

- REDOX - reactions in which electrons are transferred.,

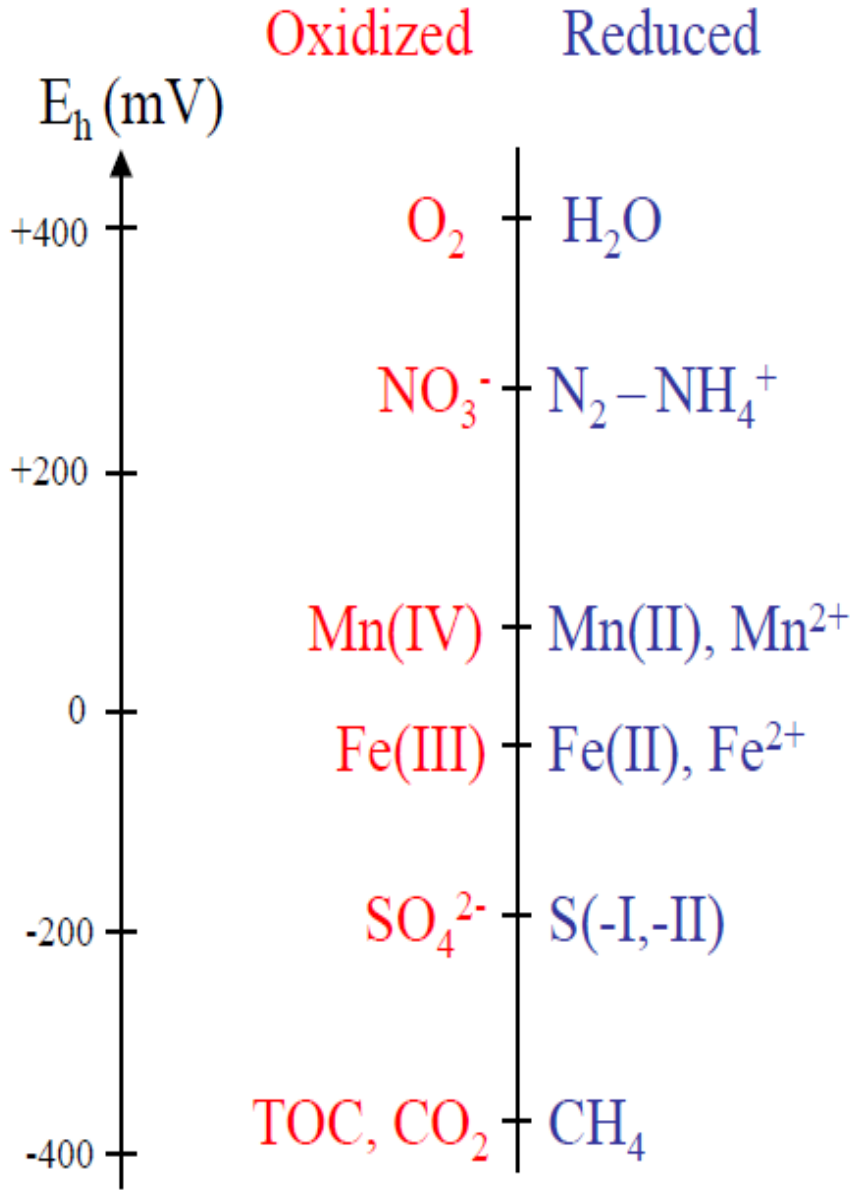
  - **Oxidation** - *loss* of electrons or an *increase* in oxidation state by a molecule, atom, or ion. Species donating electrons is oxidized.
  - **Reduction** - *gain* of electrons or a *decrease* in oxidation state by a molecule, atom, or ion. Species receiving electrons is reduced.

- Eh – measurement of electrical potential or REDOX state expressed in volts (V) or millivolts (mV)

REDOX

- Water tends to become more reducing as it moves along a flow path.
- Almost all redox reactions in groundwater are biogeochemically mediated.
- REDOX related to Dissolved Oxygen (DO)
  - Water in contact with air has Eh of +350mV to +500mV.
  - Aerobic when DO ≥ 1mg/L (use of oxygen as electron acceptor)
  - Anaerobic when DO <1mg/L (nitrate, manganese, iron, sulfate, carbon dioxide reducing)
- Microbial mediated REDOX processes may result in values as low as -300mv.
- REDOX processes can mobilize or immobilize contaminants

REDOX Ladder of Electron Acceptors & Donors



Aerobic Degradation $CH_2O + O_2 = CO_2 + H_2O$ $3CH_2O + 4NO^{3-} = 2N_2 +$

Denitrification $3HCO^{3-} + H^+ + 2H_2O$

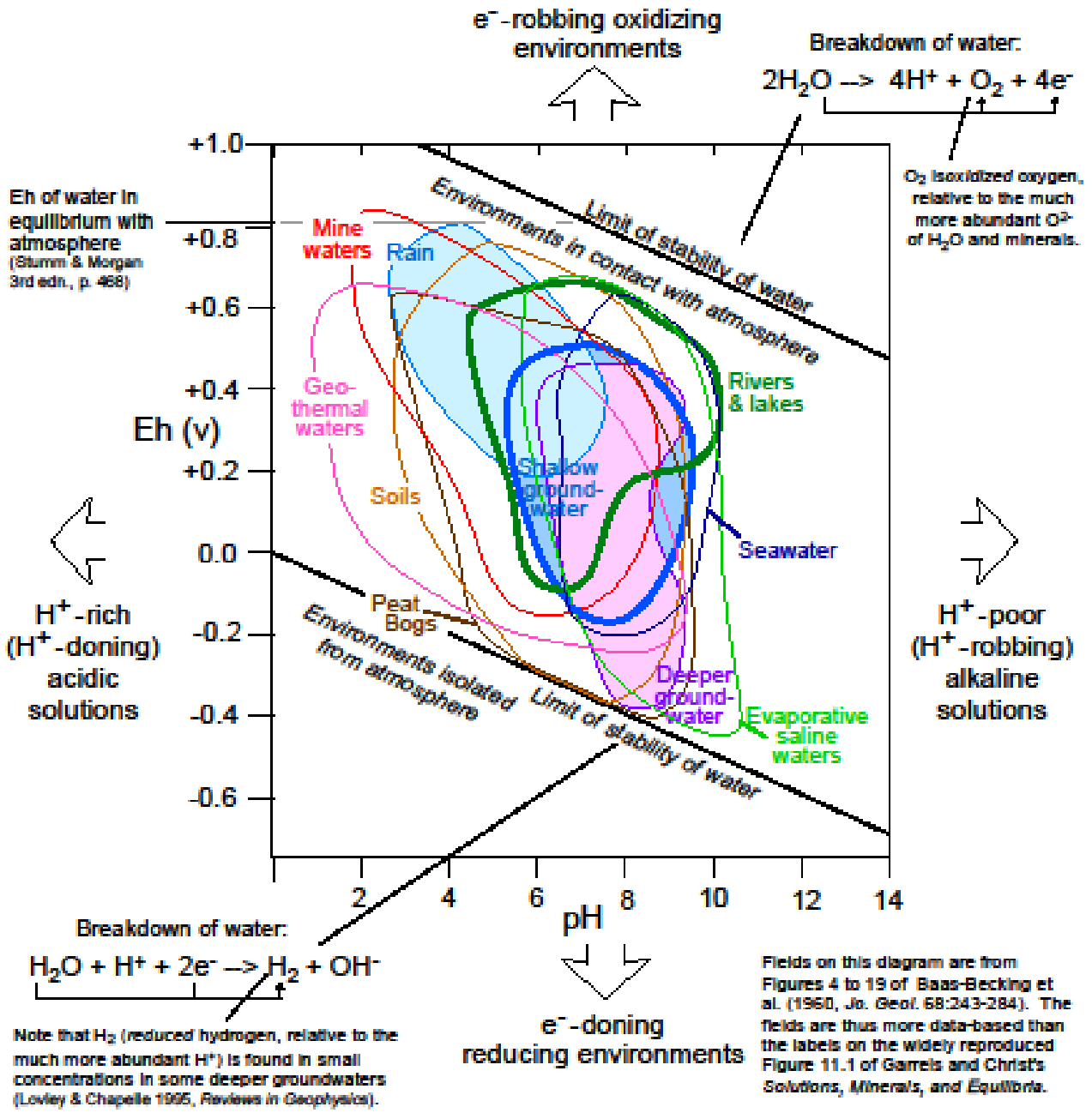
Manganese (IV) Reduction $CH_2O + 2MnO_2 + 3H^+ = 2Mn2+ + HCO^{3-} + 2H_2O$

Ferric Iron Reduction $CH_2O + 4Fe(OH)_3 + 7H^+ = 4Fe^{2+} + HCO^{3-} + 10H_2O$

Sulfate Reduction $2CH_2O + SO_4^{2-} = HS^- + HCO^{3-} + H^+$ $2CH_2O + H_2O = CH_4 +$

Fermentation & Methanogenesis $HCO^{3-} + H^+$

Characterization of solutions by pH and Eh



Comparative Oxidation Reduction Potential

Tap Water ORP
+400mV to +500mV

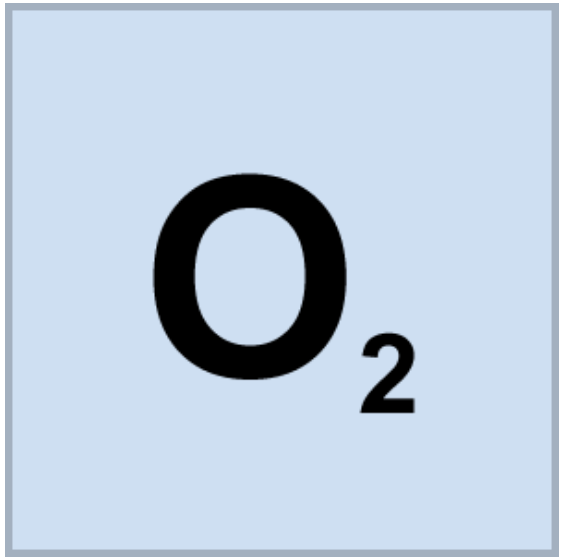
Reduced Alkaline Water ORP
-250mV to -350mV

Dissolved Oxygen (DO)

- Measured in either milligrams per liter (mg/L) or percent saturation
  - mg/L – amount of oxygen in liter of water
  - Percent saturation – amount of oxygen in a liter of water relative to total amount of oxygen water could potentially hold at that temperature

- Used to determine if aerobic or anaerobic conditions present
  - DO ≥ 1mg/L - aerobic
  - DO < 1mg/L – anaerobic

- DO fluctuates seasonally & even within 24hr period



Dissolved Oxygen (DO)

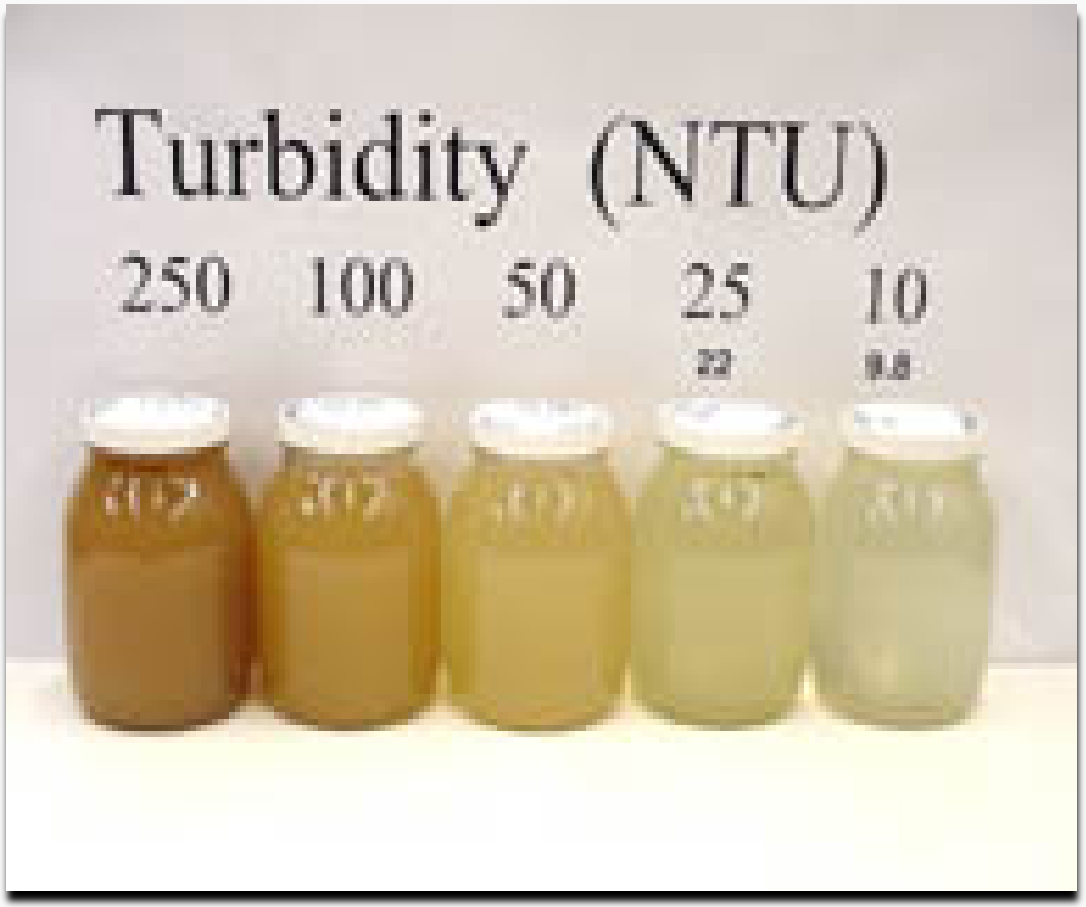
- Temperature dependent
  - Cold water can hold more DO than warm water
- Altitude dependent
  - Altitude affects flow & rate of water movement impacts DO
- Faster moving water has more DO than slower moving water
- Low DO & things die off; indicator of organic pollution
- High DO water tastes better (5mg/L standard)

Maximum DO vary with temperature

Temperature (°C)	DO (mg/l)	Temperature (°C)	DO (mg/l)
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.16
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.41
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

Turbidity

- Measurement of suspended & dissolved matter in water; measure of clarity of water
- Measurements dependent upon color of dissolved constituents, particulate matter, particle size, and density.
- More particulate matter in water, the higher the turbidity.
- Nephelometry preferred method of measurement; nephelometric units (NTU)



Turbidity

- High turbidity usually means high metals concentrations

- High turbidity may be result of poor sampling techniques (bailing wells), but also may be representative of actual site conditions
  - Higher groundwater flow rate, the higher the turbidity
  - Lower flow rate, the lower the turbidity
  - Shallow groundwater typically more turbid than deep groundwater
  - Precipitation event may result in higher turbidity
  - Construction/digging near wells may result in higher turbidity

Summary

- Water quality parameters provide a lot more information than just signaling when to collect an analytical sample.
- Water quality parameters play an important role in contaminant fate & transport.
- Water quality parameters may indicate an potential landfill impact before the actual chemical constituents we monitor for do.
- Look for changes in parameters over time and between up gradient & down gradient wells