Water Quality: What We Collect and Why

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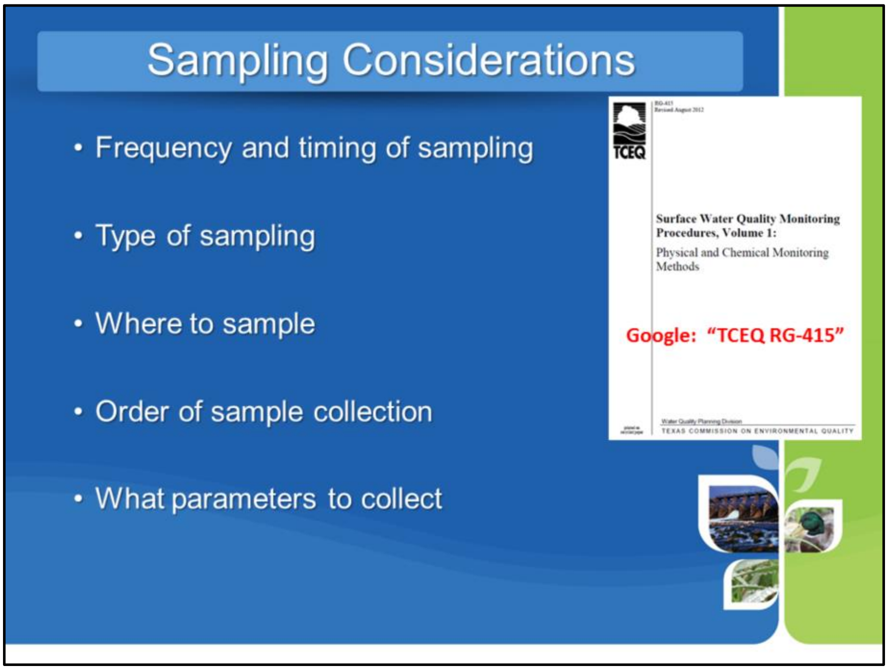
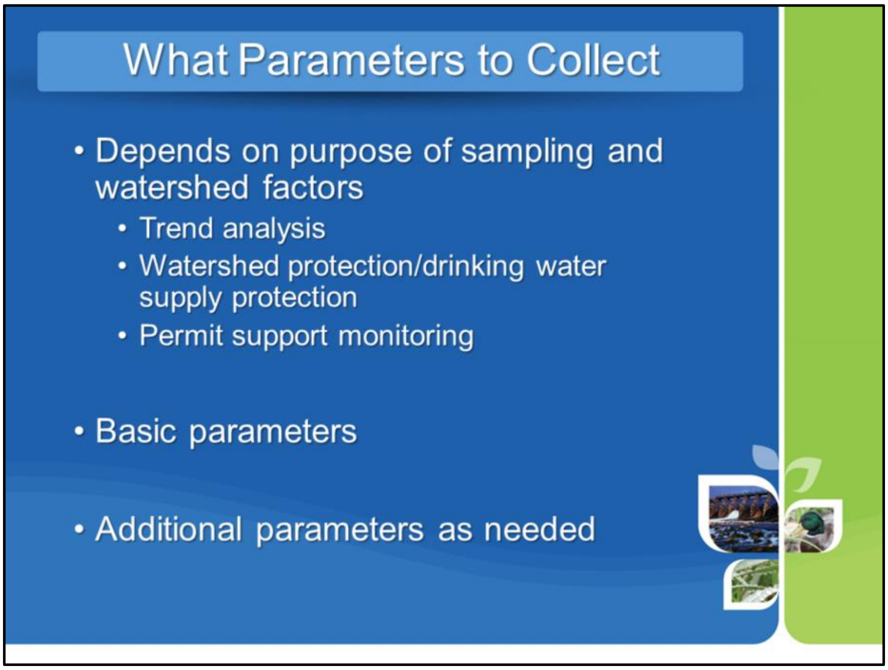
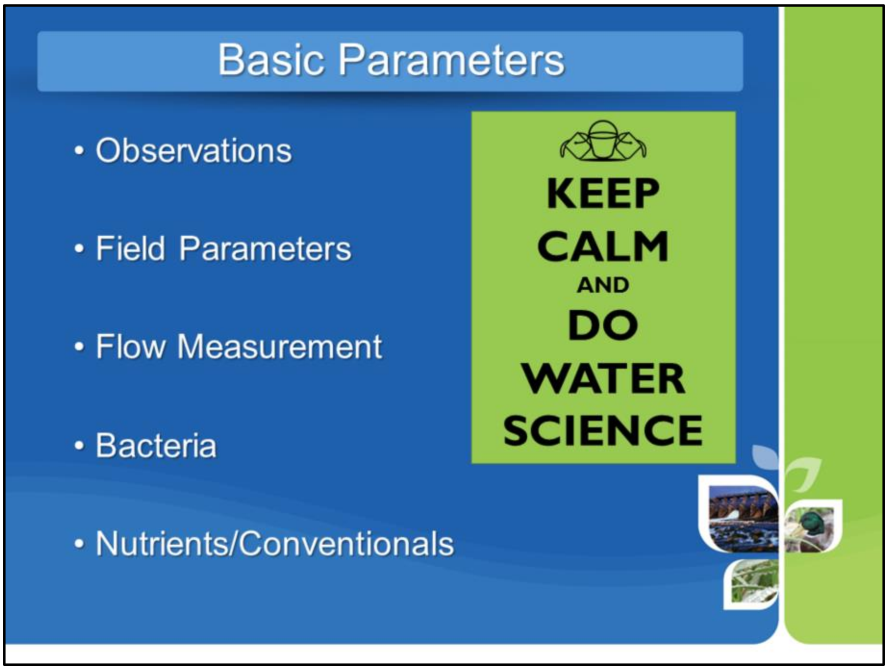
Trinity River Authority of Texas
Enriching the Trinity basin as a resource for Texans



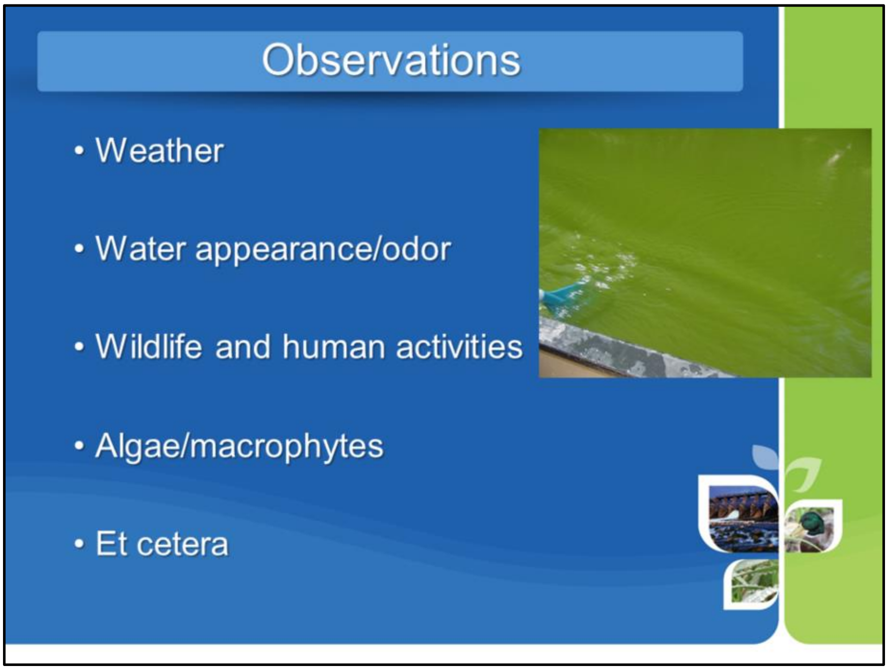
- Frequency and timing of sampling, the sample locations, and the type of sampling being conducted are generally already established in an existing monitoring program.
- Where to sample in the waterbody and the order in which samples are collected can be found in the SWQM Procedures manual volume 1.
  - Since this is a living document and there are occasional updates, it is best access this document online rather than keeping a hardcopy.
  - Google: TCEQ RG-415
- Focus of this presentation is on the aspects of routine monitoring and why certain parameters are collected.



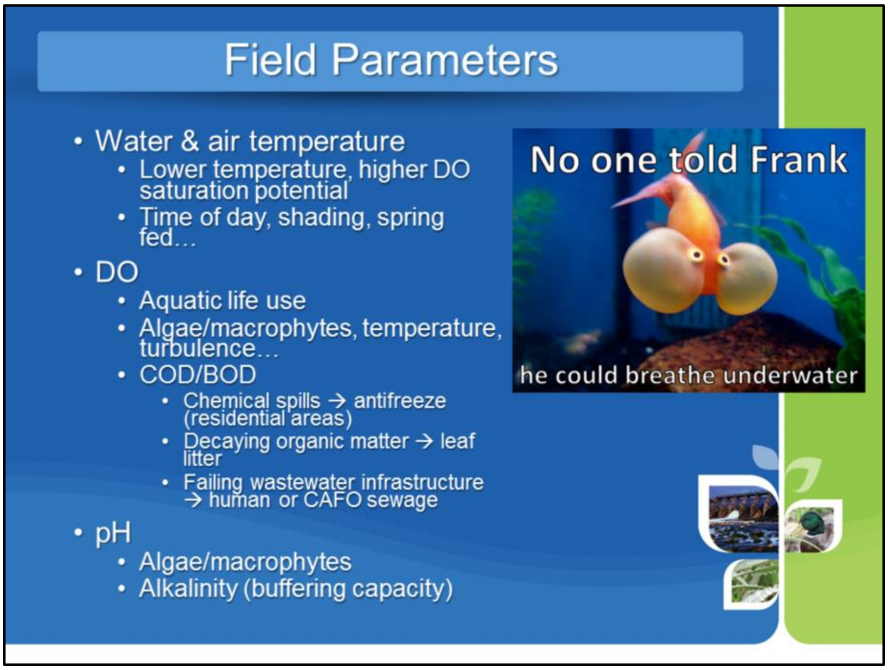
- What parameters should be collected?
- It depends on the purpose of the sampling and watershed factors.
- Are you sampling for long term trend analysis of certain parameters?
- Are you sampling for watershed protection or drinking water supply protection?
- Permit support monitoring?
- Regardless of the purpose, there are some basic parameters that are usually collected and some additional parameters that can be added on an as needed basis depending on what's going on in the watershed.



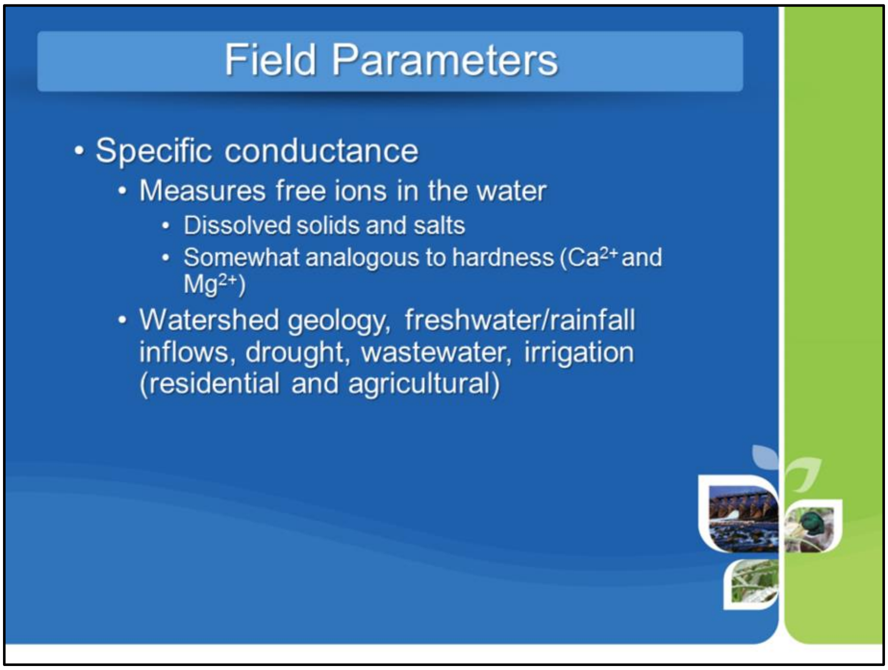
- The basic parameters include observations, field parameters, flow measurements, bacteria, and nutrients and conventionals.



- Observations can be very helpful during data QA and analysis.
- Everything is interconnected and every piece of information can be meaningful.
- Weather may help explain low dissolved oxygen levels in the middle of the day if it's cloudy.
- If the water is green, it could confirm chlorophyll-a values.
- If the water smells like rotten eggs or is milky, there could be a sewage leak and high E. coli levels.
- If there are a lot of birds or animal tracks, that could explain high E. coli levels that are not related to human sewage.
- Any comments made about the conditions at the time of sampling can be meaningful especially for people using this data in the future.

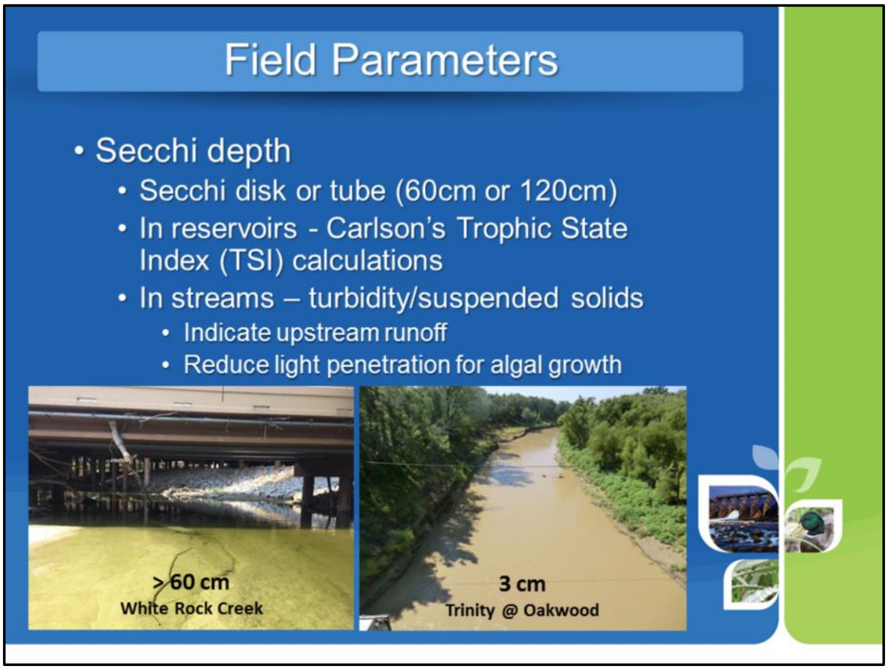


- Water and air temperature can give a clue of how much dissolved oxygen could be in the water.
  - In the absence of all other things, the colder the water, the more oxygen it can hold.
  - If there are higher air temperatures but lower water temperatures, it may be because the sample was taken in the morning, the waterbody is heavily shaded, or it's spring fed.
- Dissolved oxygen is a huge component of the ability of the waterbody to support aquatic life.
  - It can be affected by algae and macrophytes, water temperature, and stream turbulence among other things.
  - Chemical Oxygen Demand and the related sub-parameter Biochemical Oxygen Demand from things like chemical spills, decaying organic matter, and sewage leaks can also affect DO.
- Like DO, pH can be affected by algae or macrophytes.
  - Discussed later in presentation.
- The alkalinity (or buffering capacity) of the water can also affect pH - higher alkalinity waters tend to have more stable pH values.

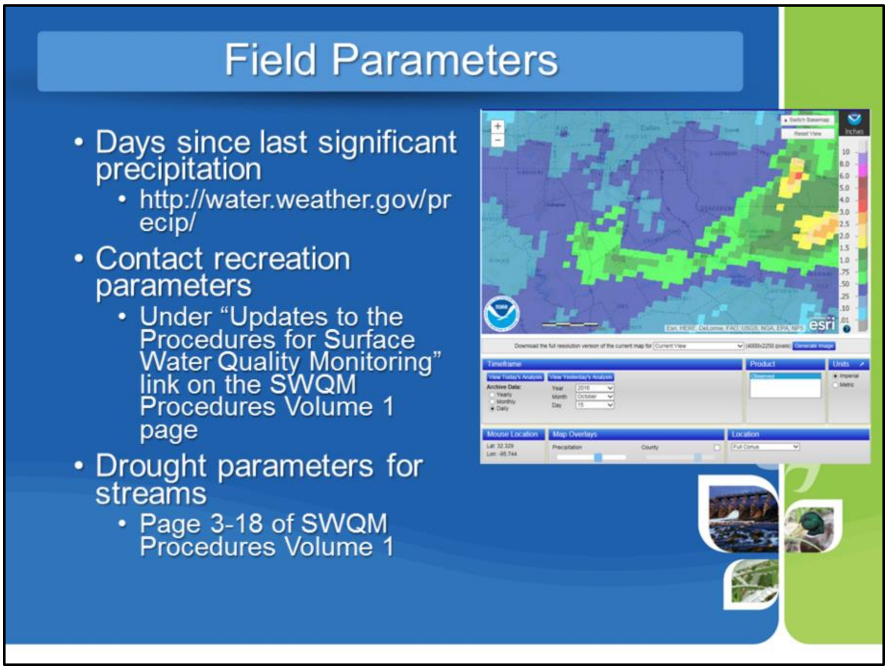


- The specific conductance of the water is a measure of how easily electricity can pass through the water.
- This is a measure of the ion concentration in the water which indirectly measures dissolved solids and salts.
    - Somewhat analogous to the hardness except specific conductance measures all the ions in the water and hardness is a measure of only Ca2+ and Mg2+.
- Generally, the specific conductance of the water is tied to the geology of the watershed.
- Other things also affect specific conductance.
    - Rainfall can introduce fresh water into the system and decrease conductance.
    - Drought and resultant evaporation can increase conductance.
    - Some industries discharging into wastewater collection systems can have high conductance effluent.
        - In smaller treatment facilities or collection systems with a large number of these industries, this may cause the effluent to waterbodies to have higher conductance.
    - Irrigation can also affect specific conductance.
        - As water evaporates, it leaves behind it’s dissolved solids and during the next irrigation or rainfall, these salts can get washed into the

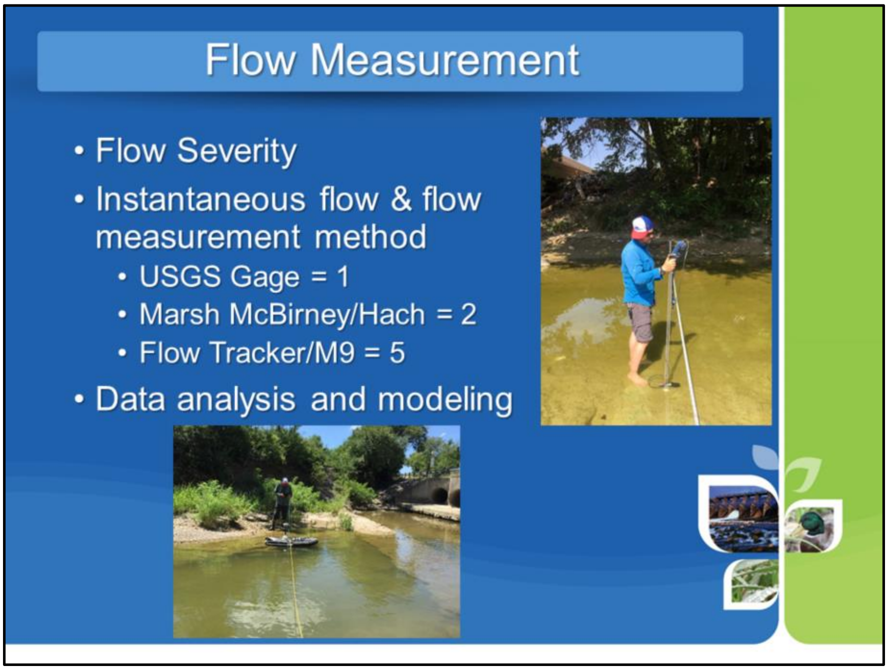
waterbody.



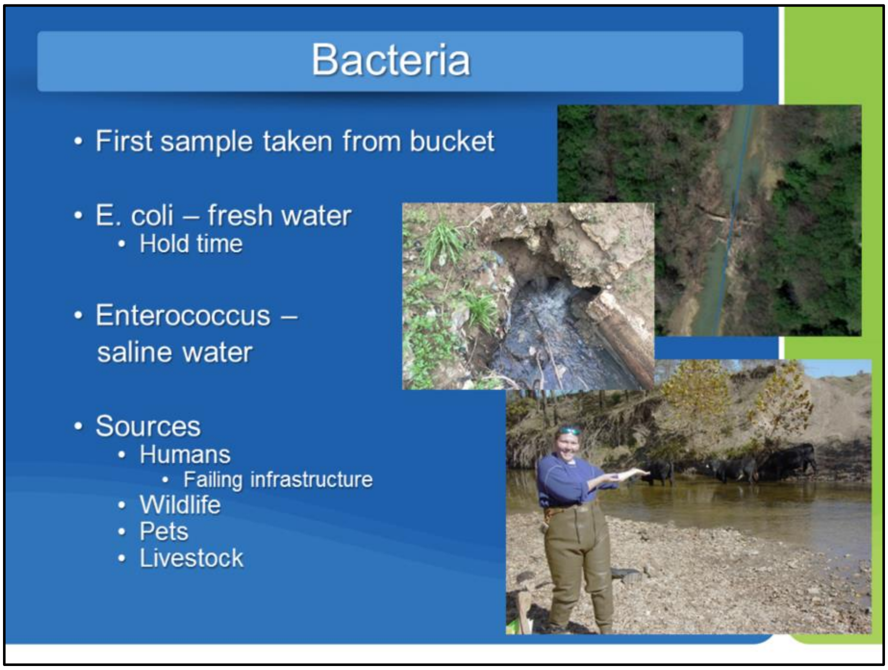
- Secchi depth is measured with either the standard disk or with a tube which is much easier to use in flowing systems.
- It is a component of Carlson TSI calculations for reservoirs along with Total Phosphorus and chlorophyll-a.
  - These calculations are used to classify the level of eutrophication in a reservoir (oligotrophic to hypereutrophic).
- In streams it can be used as a rough estimator for turbidity or suspended solids.
  - In the Trinity basin there is a huge range of Secchi depth in the streams and rivers from > 60 cm down to 3 cm.
  - In many cases, this is due to the geology of the watershed.
    - White Rock Creek flows through a bedrock system.
    - The Trinity at Oakwood has picked up sediment from the blackland prairies which is highly erodible.
  - Decreased Secchi depths could also indicate runoff has taken place upstream and may indicate other parameters might be expected to be elevated due to runoff – bacteria, nutrients from fertilizers, etc.
  - Lower Secchi depths may also be associated with decreased chlorophyll-a values since the sediment load limits light penetration for algal growth.



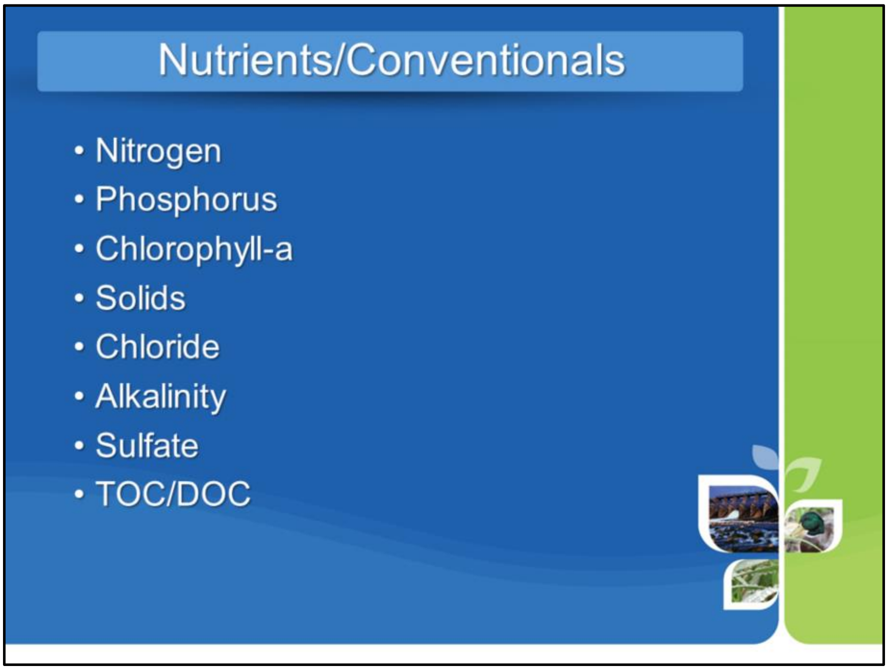
- Like Secchi depth, the days since the last significant precipitation can help explain anomalous data due to runoff.
  - Significant precipitation would be any amount that would produce runoff and influence water quality.
    - A 0.01 inch rainfall with antecedent dry conditions may not produce runoff.
    - But during wet conditions this may result in runoff.
    - This will be subject to sampler's knowledge of the watershed.
- The NOAA precipitation analysis page is useful for determining when the last precipitation occurred and how much fell.
  - Zoom in to any area, select daily analysis, and step back through the days to see the last precipitation amounts.
- Collect information on evidence of primary contact recreation and pool measurements in streams.
  - Information about these parameters can be found in SWQM Procedures Volume 1 and the addendums which links from the Volume 1 webpage.



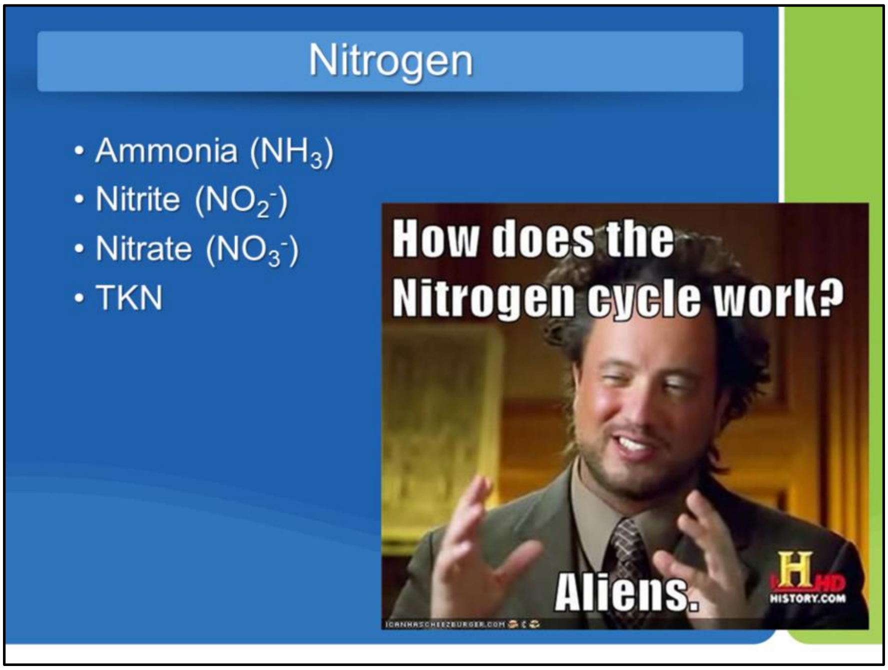
- Collecting flow data is an extremely important factor of water quality sampling.
  - Typically flow is obtained from USGS gages, electronic flow meters (like the Marsh McBirney and its direct replacement by Hach), or using acoustic Doppler (like the Flow Tracker and the M9).
- Without knowing the instantaneous flow, it cannot be determined if low flow samples were collected above the 7Q2 or not.
  - Flow severity is categorical and it's impossible to know if the sample is above or below the 7Q2 just from a low flow value reported under flow severity.
  - A large range of flows could be represented by a flow severity of 2.
- Data analysis is very difficult without an actual cfs flow value.
  - There can be relatively strong correlations between flow and other parameters like solids, nutrients, and bacteria.
    - You can't sufficiently determine these correlations with categorical flow severity values.
- Most modeling is not possible without flow values.
  - If there isn't a USGS gage to go back to, the opportunity to obtain flow for historical data is lost.



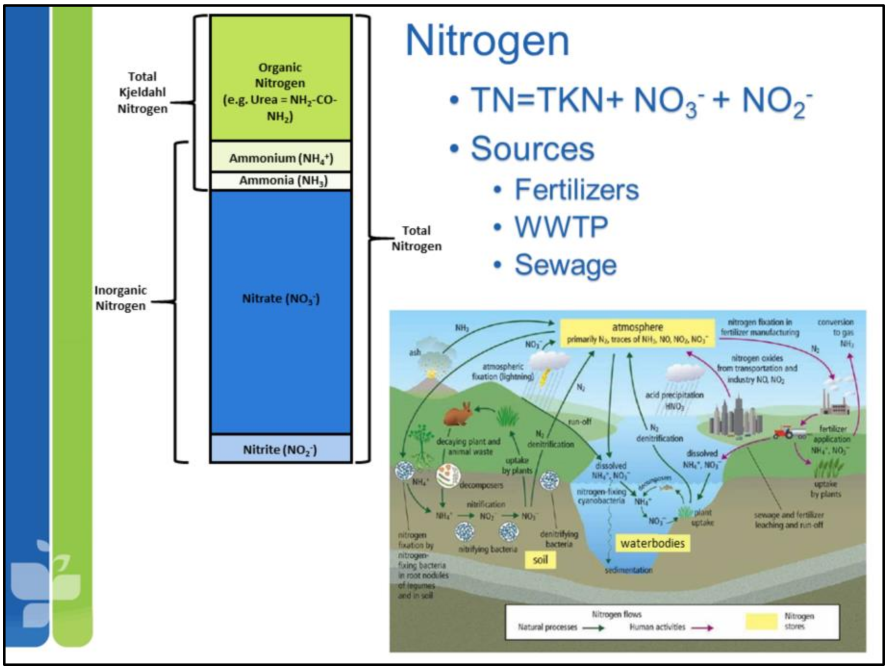
- If samples are being collecting from a bucket, bacteria is the first sample to be poured off before pouring the other samples or putting a sonde in for the field parameters.
- E. coli is the indicator bacteria for freshwater and Enterococcus for saline waters.
    - Some entities may also report a holding time if going over the standard 8 hour hold time.
- Sources for bacteria can be from humans via failing infrastructure like broken pipelines or failing septic systems.
    - Input from wildlife and pets generally comes from runoff that gets washed in during rain events.
    - Livestock input can come from runoff as well or by livestock visiting the waterbody and defecating directly in the waterbody.



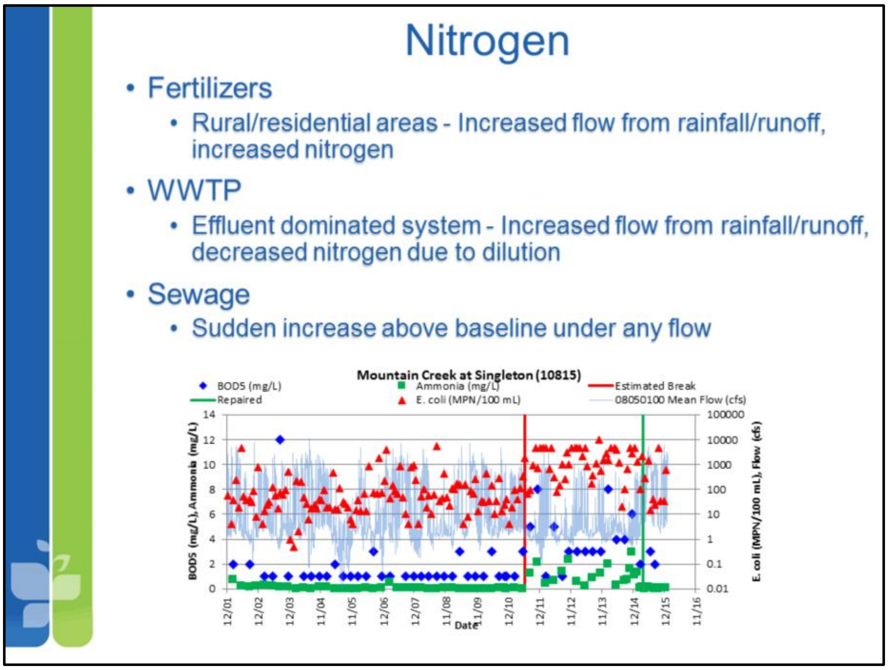
- The remainder of the basic parameters include lab analyzed parameters such as the nitrogen and phosphorus series, alkalinity, solids, chloride, sulfate, chlorophyll-a, and dissolved or total organic carbon.



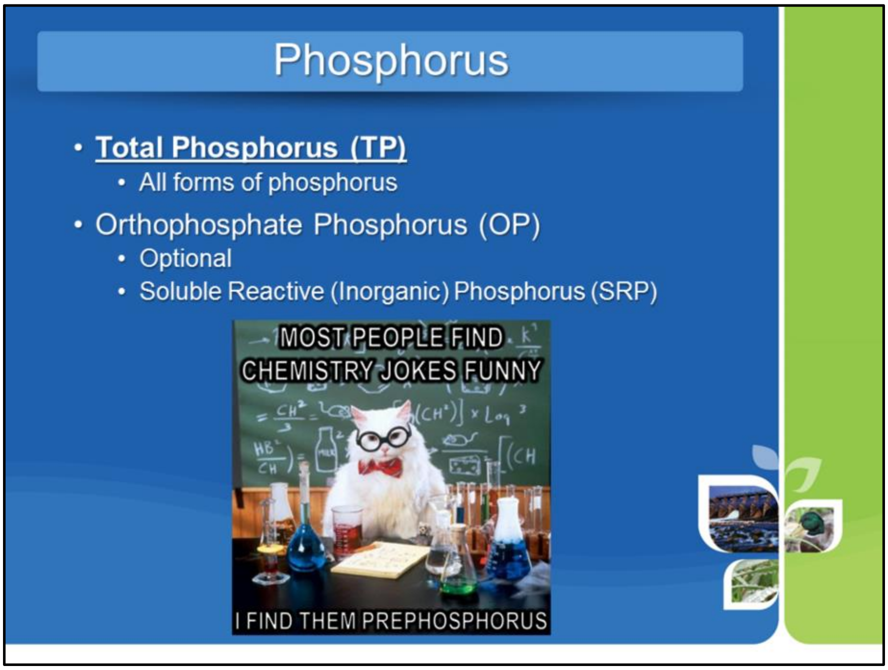
- The recommended nitrogen species are ammonia, nitrite, nitrate, and TKN.



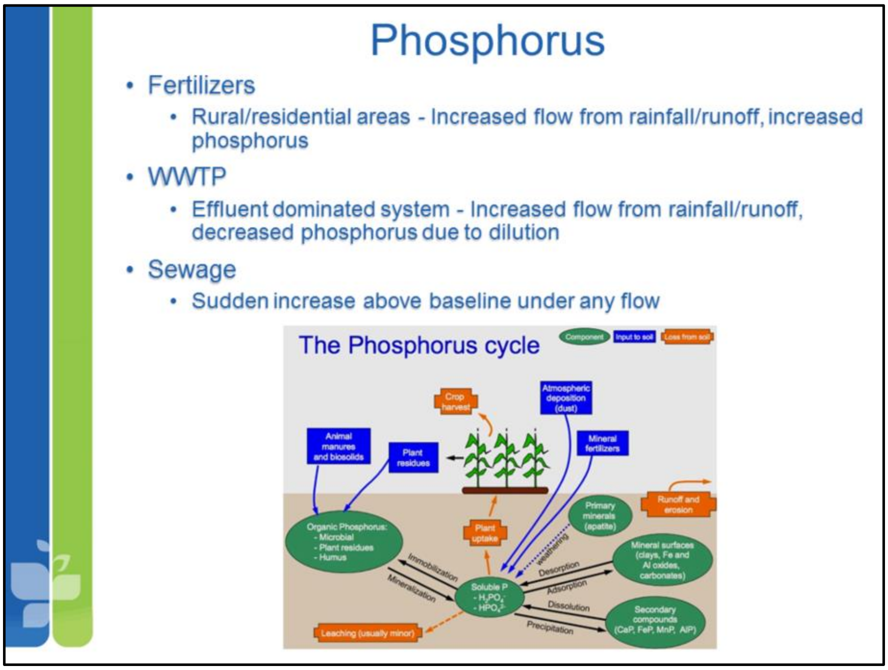
- This graphic provides a good visual of the nitrogen series and their relative concentrations.
  - With TKN, nitrate, and nitrite, we can calculate total nitrogen which is what the standards are moving toward.
- This nitrogen cycle image shows some common sources and pathways.
  - Common sources are fertilizers, WWTPs, and sewage.
- Some of the more common fertilizers contain ammonia (which is an injected liquid), urea, or ammonium nitrate (both of which are granular).
- WWTP effluent can also contribute nitrogen to waterbodies.
  - Most treatment plants do not yet have advanced nutrient removal.
- Raw sewage from failing infrastructure and septic systems can introduce nutrients to waterbodies.



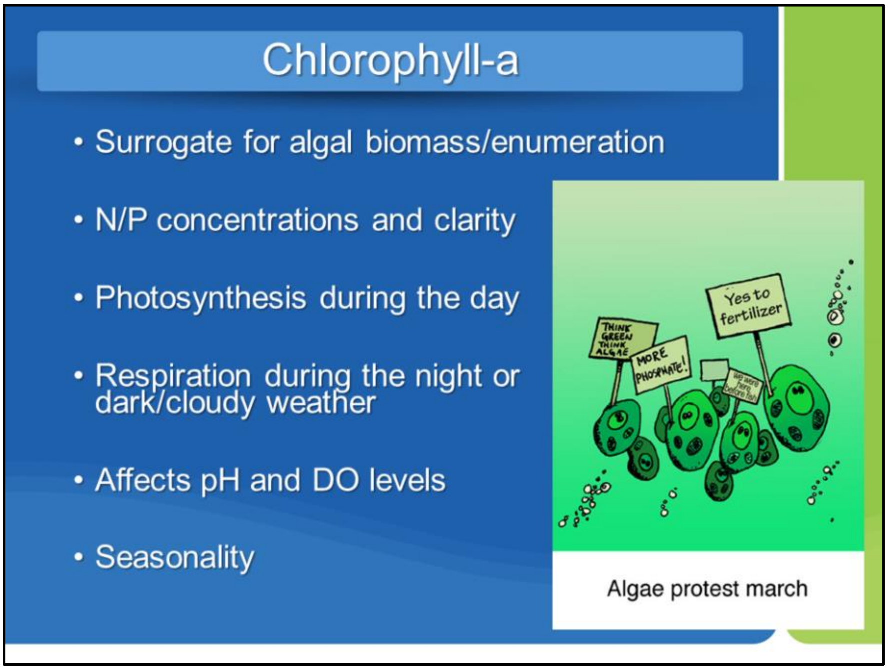
- Some commonly seen nitrogen patterns:
  - In rural or residential areas - nitrogen increases as flows increase from rainfall/runoff due to fertilizer use.
  - In effluent dominated systems (like the Trinity River though DFW) - decreasing nitrogen with increasing flow due to rainfall dilution of the WWTP effluent.
  - In an area where there has been a sewer line break - the values suddenly increase (as seen in graph).
    - Rainfall would tend to dilute nitrogen in this case as well.



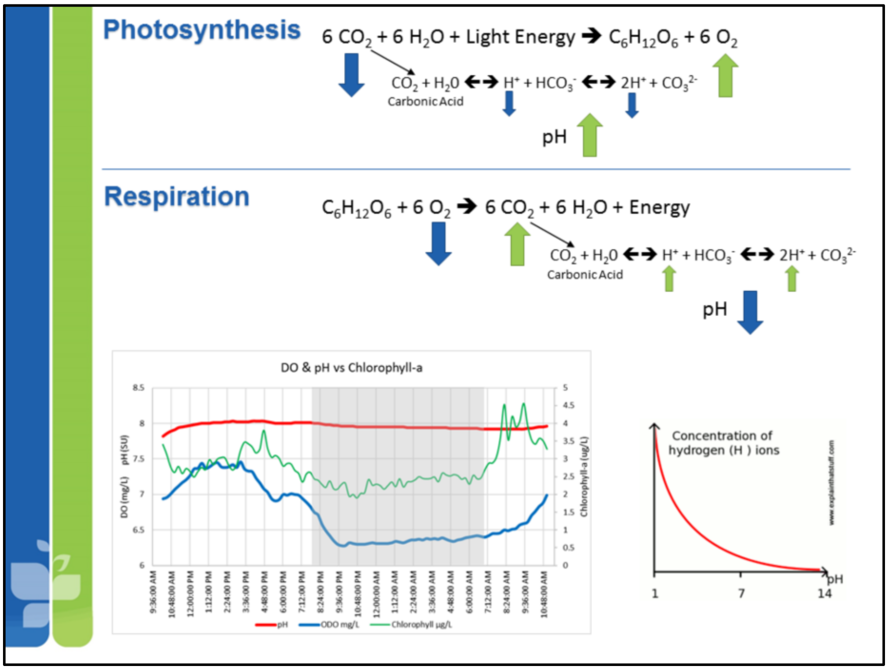
- The phosphorus series includes Total Phosphorus and Orthophosphate Phosphorus.
- Standards and screening levels are based on Total Phosphorus so that is the preferred parameter.
- Orthophosphate phosphorus is optional.
    - This is also known as soluble reactive phosphorus or inorganic phosphorus and is the form of phosphorus most readily used by plants.



- Similar to Nitrogen, sources of phosphorus typically include fertilizers (which are generally in some form of water soluble phosphate [$X_N(PO_4)_n$]), WWTP effluent, and sewage.
- The relationships between flow and phosphorus would the same as for nitrogen.

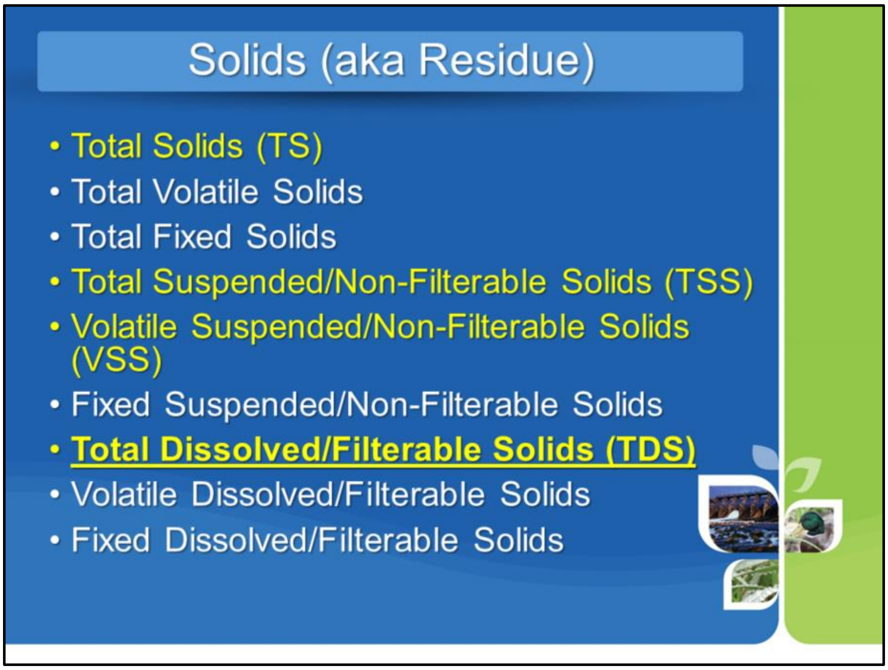


- Chlorophyll-a is a photosynthetic pigment in plants and is used as a surrogate for algal biomass and enumeration.
  - Higher chlorophyll-a indicates higher algal counts.
  - Any visible plant matter like leaves or grass in the sample would skew the results.
- Nitrogen and phosphorus concentrations and light typically have a direct influence on the amount of algae.
  - Waters with higher nutrient levels and clarity will tend to have higher algal counts and chlorophyll-a than waters with lower nutrient levels or lower clarity.
- Like any other plant, algae photosynthesizes during the day and respires at night or during dark/cloudy weather.
- Photosynthesis and respiration affect pH and DO levels in the water.
- There can also be some seasonality to chlorophyll-a levels.
  - May see high values in the summer and low values in the winter.

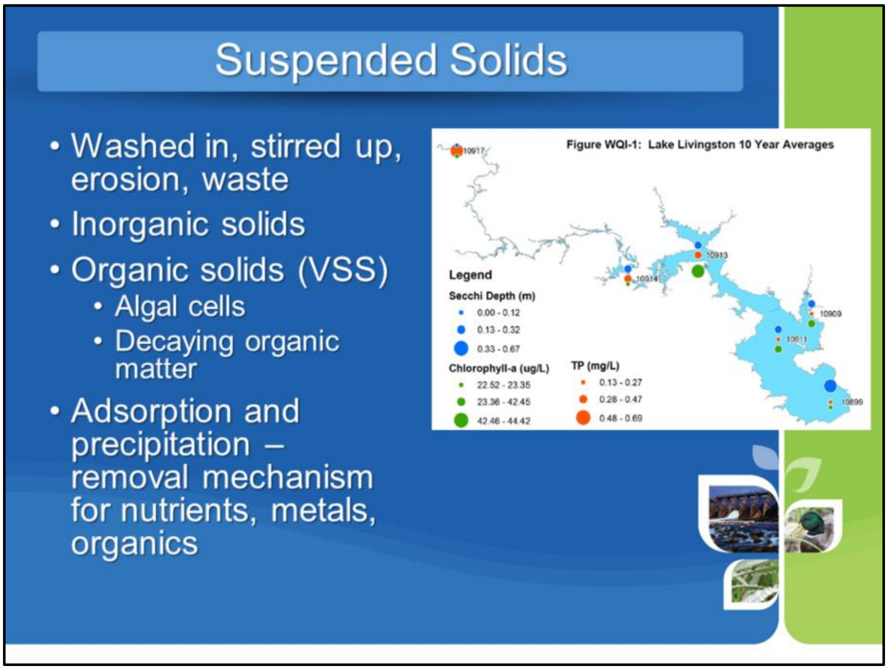


- During photosynthesis, algae will take up carbon dioxide which reduces the carbonic acid levels in the water.
    - As the availability of free hydrogen ions in the water decreases, the pH of the water increases.
    - The products of photosynthesis are glucose which is stored in the algal cells and oxygen which is given off and becomes dissolved in the water.
- When the algal cells switch over to respiration at night or during cloudy weather, the stored glucose is used to create energy for the cell.
    - This process consumes oxygen in the water and creates carbon dioxide which in the presence of water forms carbonic acid and increases the hydrogen ion concentration in the water which decreases the pH.
- In a diurnal deployment, DO, pH, and chlorophyll-a diurnal swings are observed (see graph).
    - Chlorophyll-a was measured with an EXO sensor calibrated with a single point zero - only provides a relative chlorophyll-a.
        - Needs a 2-point calibration with rhodamine to get a more accurate reading.
        - Chlorophyll absorbs high energy low wavelength light (470 nm) and fluoresces at low energy higher wavelengths (650-700 nm).

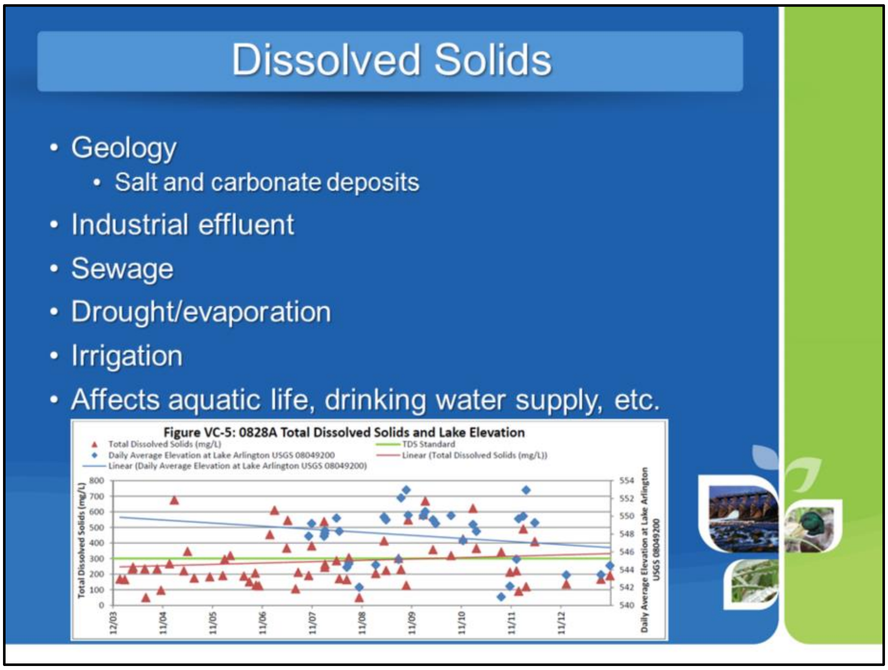
- Diurnal swing in chlorophyll-a is due to the fact that algal reproduction is greater during daylight hours while phytoplankton consumption is pretty constant over the 24-hour period.



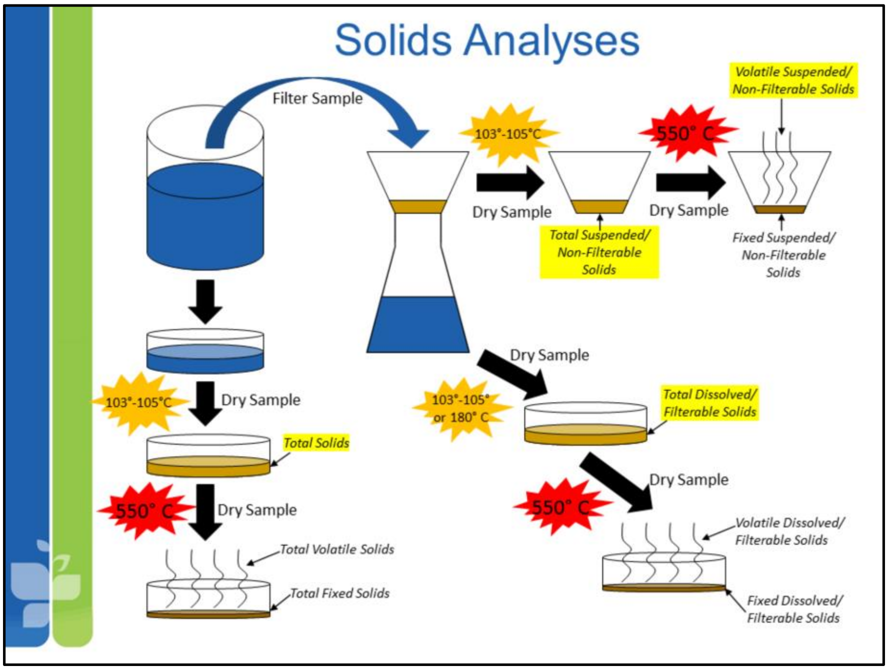
- Solids are referred to as residues in the STORET CODE list.
- These are the types of solids with the most commonly measured highlighted in yellow.
- Standards are based on Total Dissolved Solids.



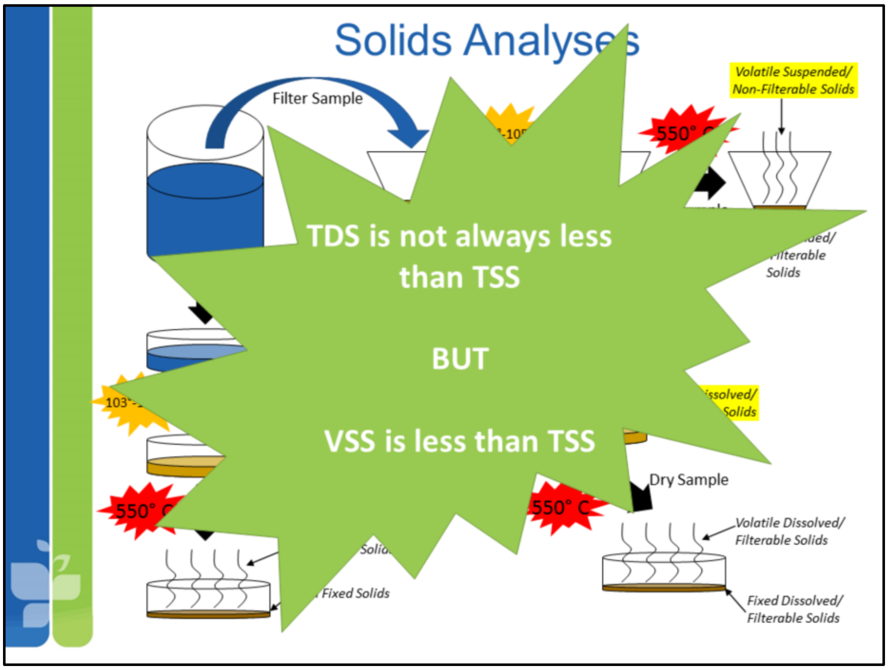
- Suspended solids are usually washed in to a stream or stirred up from the sediments during storm events.
  - Erosion and waste from industry or sewage can add suspended solids to a system.
- These solids can be inorganic like sand and silt.
- Organic solids such as algal cells and decaying organic matter can contribute to the suspended solids.
- Adsorption to suspended sediments and precipitation of those particles to the bottom of the lake can be a removal mechanism for nutrients in reservoirs.
  - Moving toward the dam, increasing clarity and decreasing suspended solids and decreasing nutrient concentrations (see TP and Secchi Depth on map).
  - This same pathway can also be a removal mechanism for metals and organic contaminants such as PCBs.



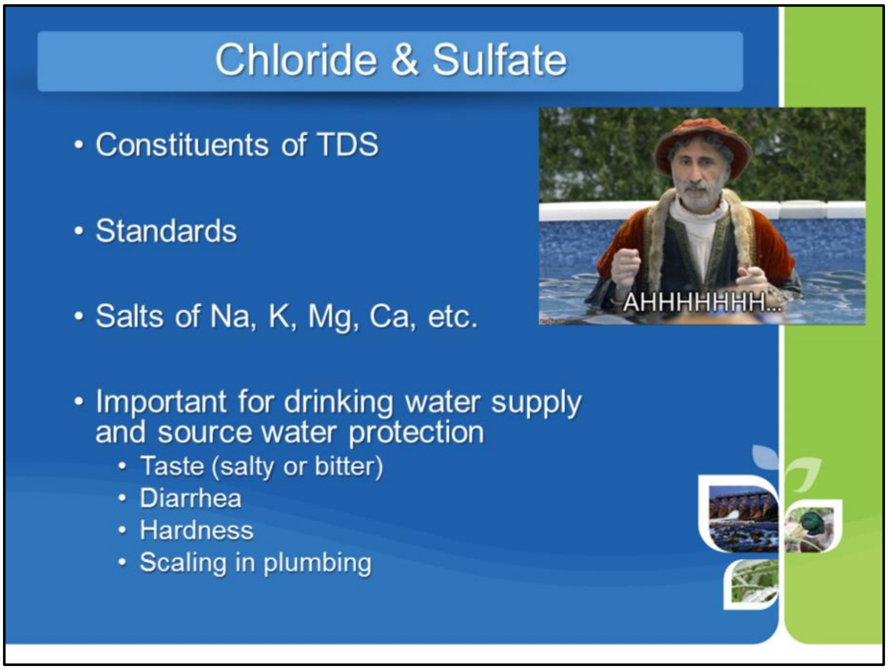
- Like specific conductance, dissolved solids are generally related to the geology of the watershed.
    - Salt and carbonate deposits are an example of systems that would contribute TDS to a waterbody.
- Industrial effluents and sewage can have high TDS concentrations.
- Drought and high evaporation can concentrate the dissolved solids already in the water (see graph).
- Irrigation can wash dissolved solids into waterbodies (from solids left behind as irrigation water evaporates).
- Elevated TDS can have major effects on aquatic life and drinking water supplies.
    - Increased TDS can affect species already present in a water body or affect the assemblage of species that are able to live in that waterbody.
    - High TDS source water can also affect the treatment processes for drinking water.



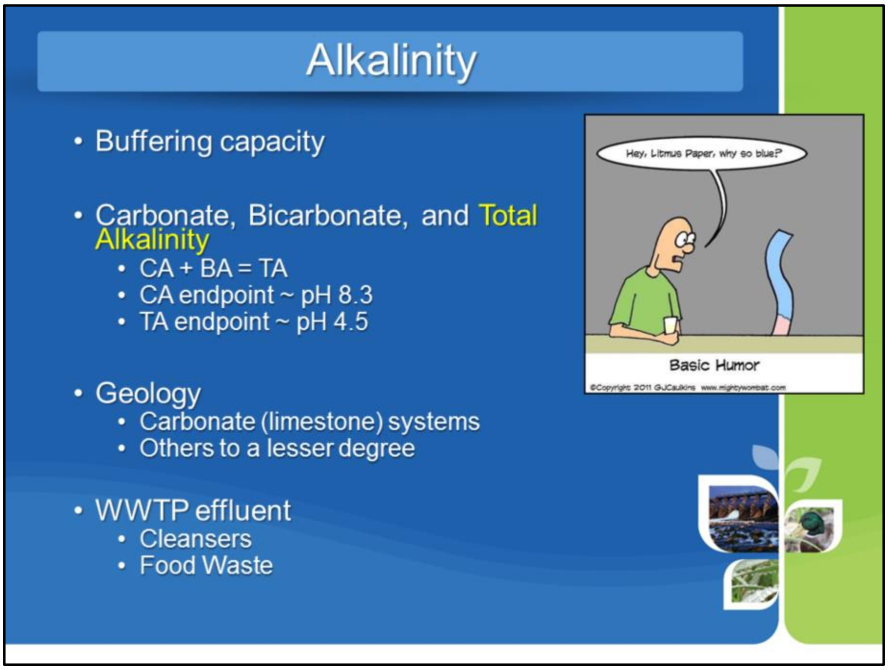
- Overview of the different solids and how they are analyzed.
- A water sample is collected and the whole water is put in an evaporating dish.
    - It's dried and the residue is the total solids.
    - It's dried at a higher temperature and the residues remaining in the dish are the total fixed solids while the weight that was lost on ignition is the total volatile solids.
- Another series of analyses are done with a filtered sample.
    - The solids remaining in the filter are the suspended or non-filterable solids.
    - The solids in the filtrate are the dissolved or filterable solids.



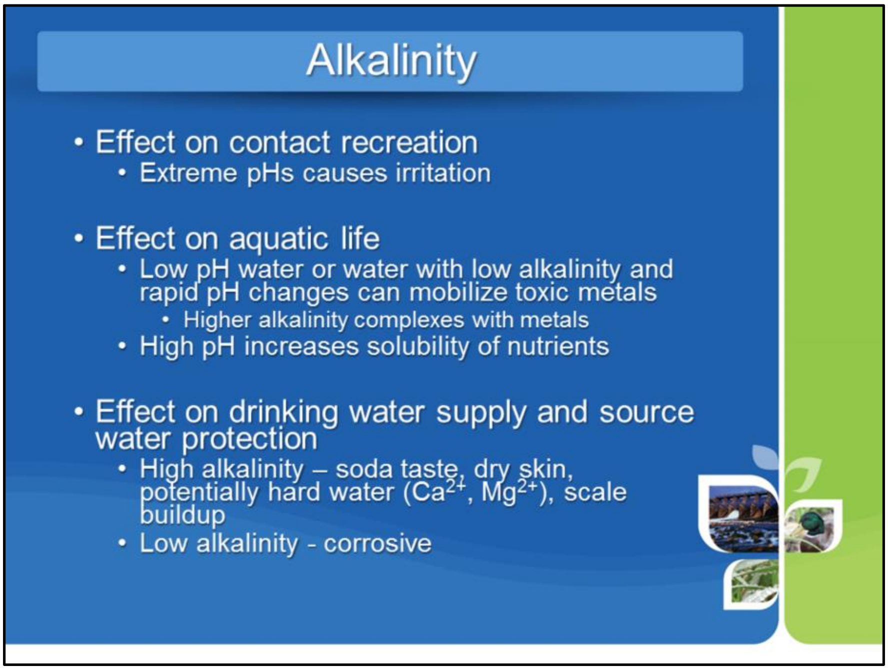
- It's important to note that TDS is not always less than TSS but VSS should always be less than TSS.



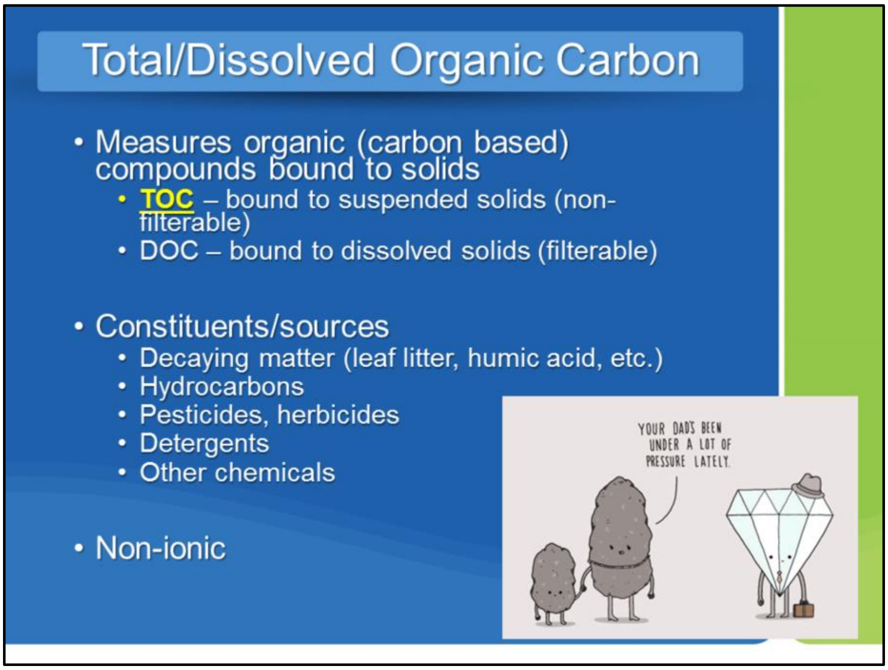
- Chloride and sulfate are components of TDS and will have the same general sources and influences as TDS – geology, effluents, drought, irrigation, etc.
- Chloride and sulfate are also part of the standards.
- These are found as salts of cations like Na, K, Mg, and Ca.
- These parameters are important for source water protection for drinking water supplies.
    - High levels of chloride or sulfates can cause taste issues and high sulfate levels can cause diarrhea.
    - If the cations are Ca or Mg, then high levels of the parameters could indicate hard water issues.
    - High levels can cause scaling issues in plumbing.



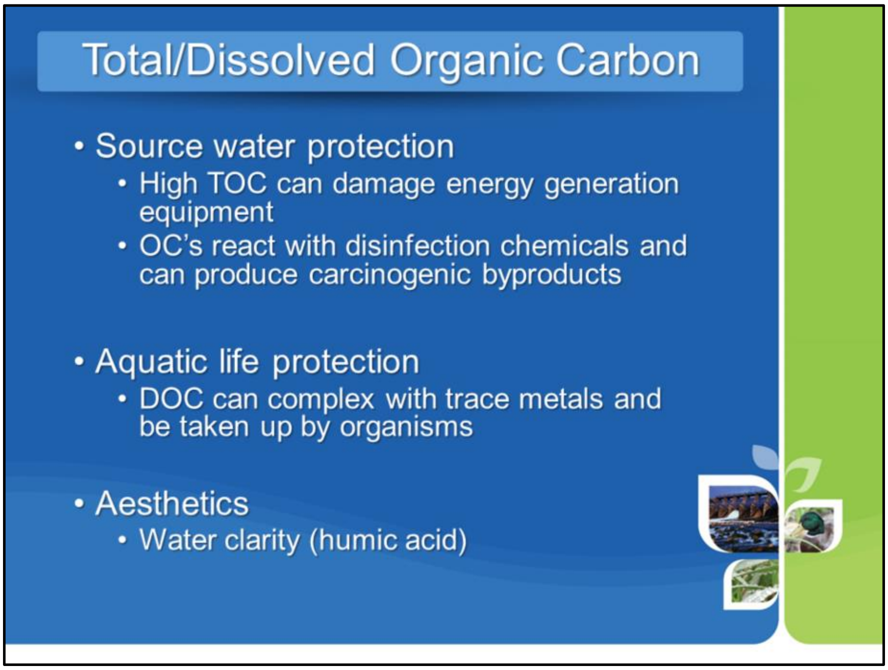
- Alkalinity is also known as the buffering capacity which is the ability of the water to resist rapid pH changes by absorbing the hydrogen ions.
- The most commonly measured forms are carbonate, bicarbonate, and total alkalinity but Total Alkalinity is predominant.
    - Carbonate alkalinity is determined by titration to approximately pH 8.3 (phenolphthalein indicator endpoint).
    - Total alkalinity is determined by titration to approximately pH 4.5 (methyl orange indicator endpoint).
    - Difference between the two is bicarbonate alkalinity.
    - The approximate endpoint pH is because the exact endpoint depends on the alkalinity – higher alkalinities will have lower endpoint pH values.
- Alkalinity is affected by the geology of the watershed.
    - Carbonate, bicarbonate, and hydroxide based systems provide most of the alkalinity but borate, silicate, and phosphate based rocks can also contribute some alkalinity to the system.
    - Alkalinity is related to hardness if the system is rich in magnesium carbonate or calcium carbonate (limestone).
- WWTP effluents can also increase the alkalinity - cleansers, food waste.



- Alkalinity can affect the contact recreation in a waterbody because extreme pH values can cause irritation.
- Aquatic life issues:
  - Low pH water or water with low alkalinity and rapid pH changes can mobilize toxic metals out of the sediments.
  - Higher alkalinity can complex the carbonate with metals and make them less bioavailable.
  - Higher pH can increase solubility of nutrients for uptake by plants and algae which can cause DO problems.
- For source water protection of drinking water supplies, high alkalinity waters can have a soda taste, cause dry skin, be related to hard water, and can cause excessive scale buildup.
  - However, low alkalinity water can be corrosive to plumbing which can cause metals to leach out of the pipes.



- Total organic carbon is a measure of all organic compounds in the water.
    - Organic in this sense means carbon based and can be natural or synthetic.
    - DOC is included here but it is not regularly collected.
- This can include decaying matter, hydrocarbons, pesticides, herbicides, detergents and other synthetic chemicals.
    - Sources can be anything from the plants in and around the stream to runoff to chemical spills.
- These are generally non-ionic - won't get a measure of these compounds from specific conductance.

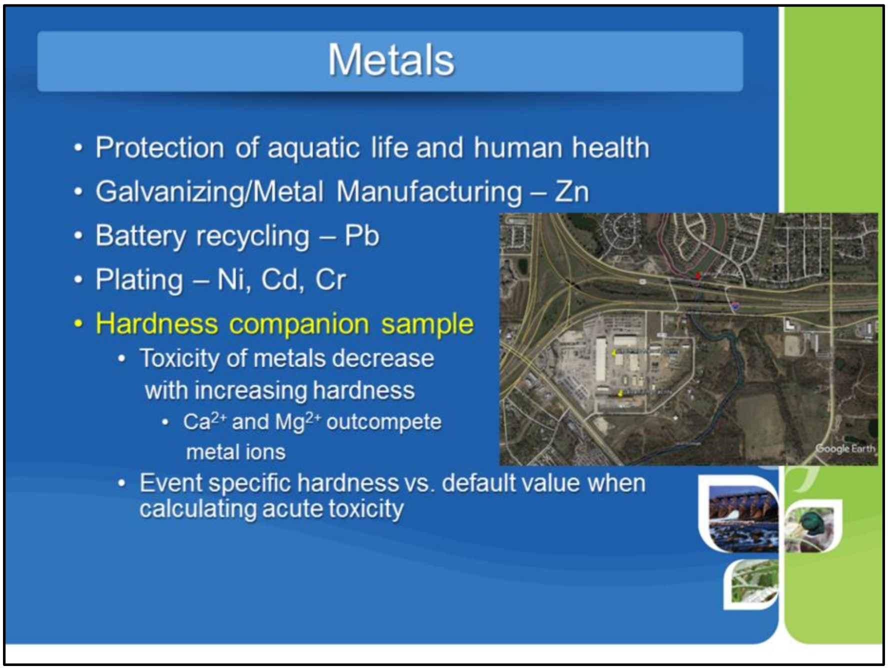


- High levels of TOC in source water can damage energy generation equipment.
- Organic carbons can react with disinfection chemicals in drinking water plants and create carcinogenic byproducts.
- DOC can complex with trace metals and become a pathway for the metals to be taken up by organisms.
- And it can affect the clarity of the water.

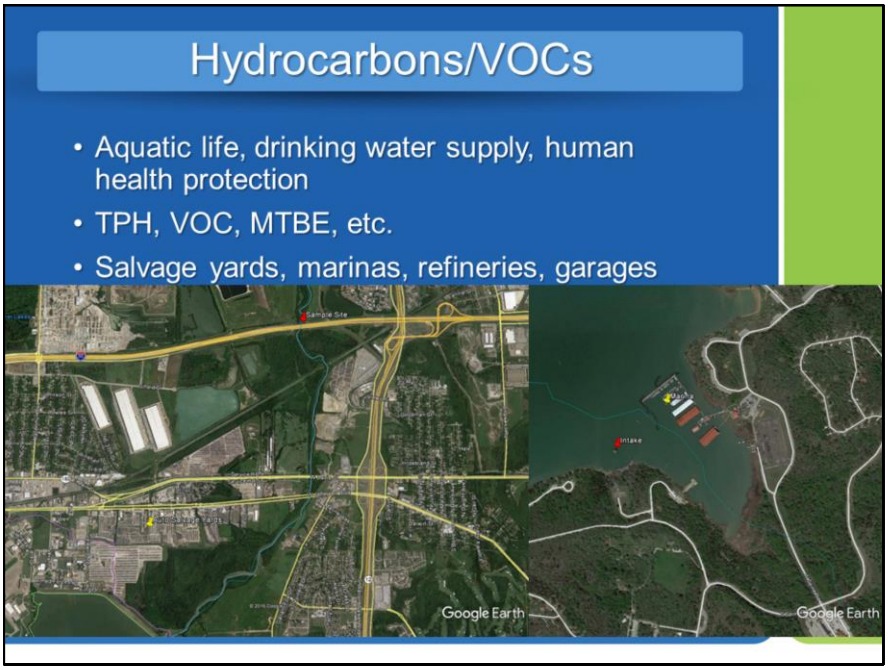
Additional Sampling Parameters

- Metals
- Hydrocarbons/VOCs
- Organics
- Sediments
- Tissue

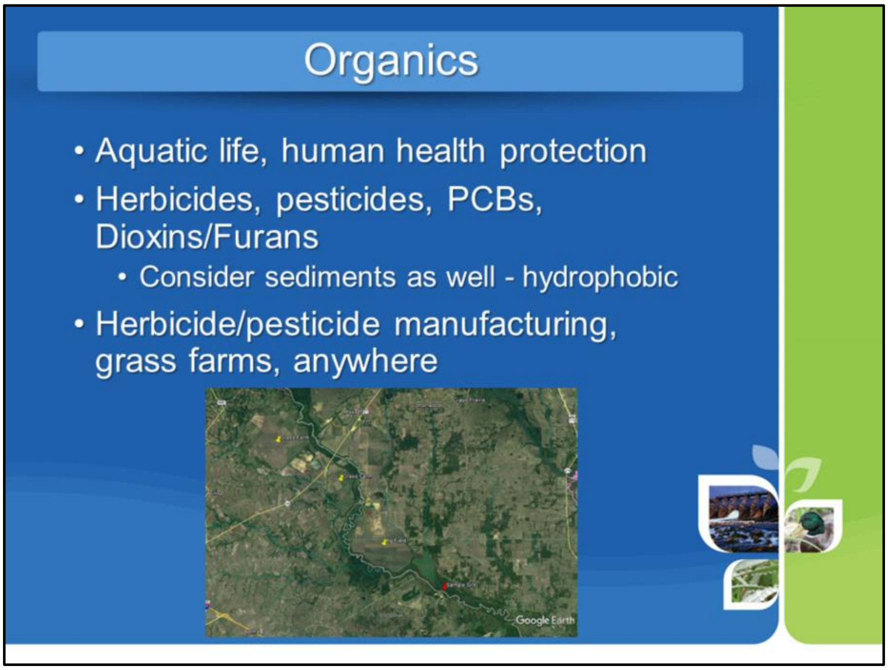
- There are some additional parameters that may be collected based on what’s going on in the watershed.
- For example metals, hydrocarbons and VOC, organics, sediments, and tissue.



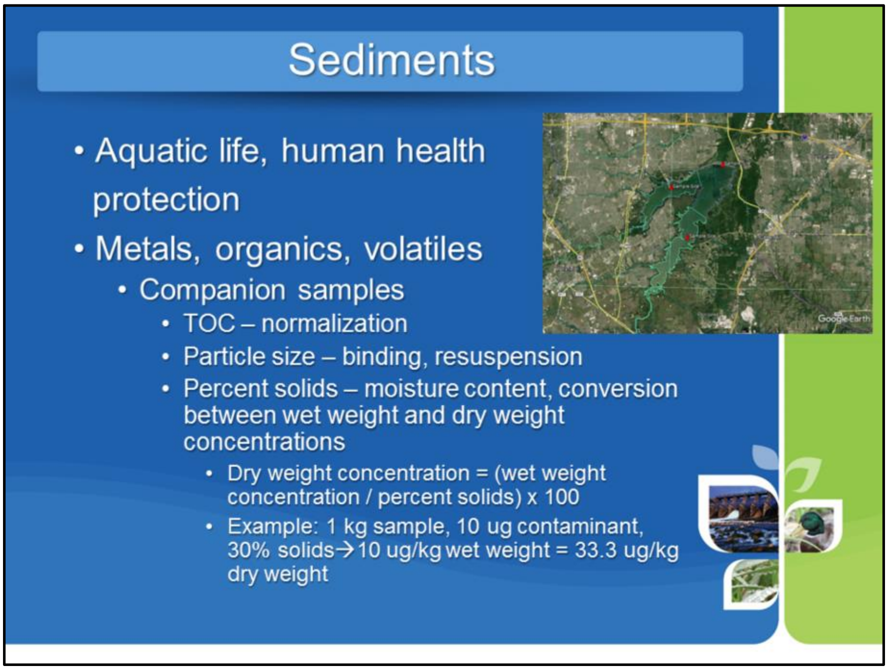
- Metals are collected for protection of aquatic life and, by extension, human health.
- There are several industries that might release metals into the watershed.
  - Generally, a suite of metals is collected however specific metals might be expected downstream of certain industries if they are not properly containing their materials/waste/runoff.
    - Galvanizing and metal product manufacturing may release Zn.
    - Battery recycling facilities might release Pb.
    - Metal plating and finishing facilities frequently use Ni, Cd, Cr.
- Any time metals are collected, a hardness sample should also be collected because the toxicity of metals decreases with increasing hardness.
  - The Ca and Mg ions compete with the metals ions for the uptake sites on the cell walls of organisms basically blocking the metals from entering the cells.
  - The reason hardness should always be collected is because a default value is used in calculations if there is not a hardness sample collected at the same time - might make the metals appear more toxic than they are if the water is actually harder than the default value.



- Sample for TPH, VOC, MTBE, and other similar parameters might be collected near locations where there are vehicles or other sources of fuel or related products.
    - For example, an area with several auto salvage yards upstream from a sample site.
    - Or a marina adjacent to a drinking water intake.
    - May also sample these kinds of parameters near fuel refining facilities and vehicle repair facilities.



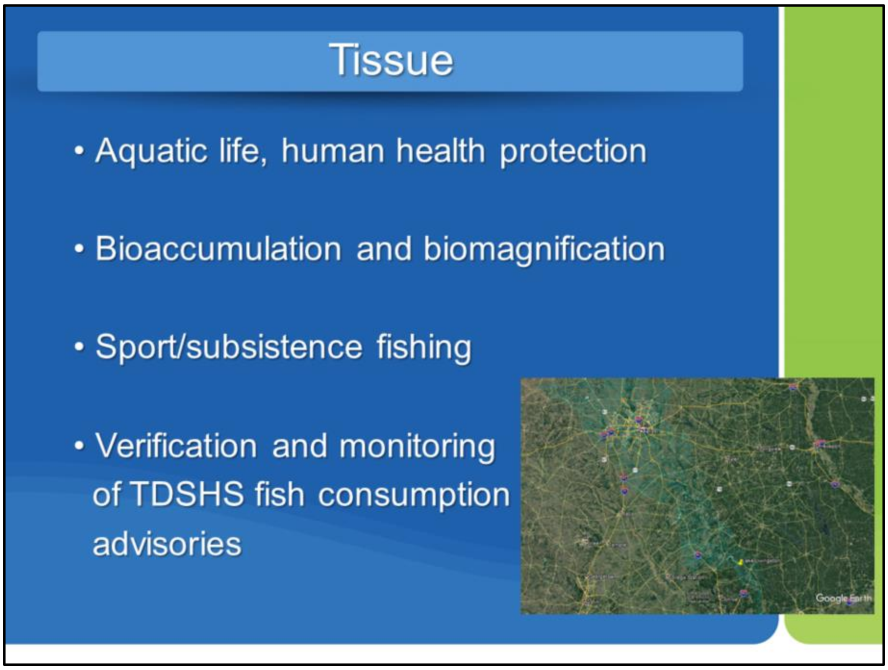
- Referring to organics as carbon based chemicals like herbicides, pesticides, PCBs, Dioxins and Furans.
- Many of these chemicals are hydrophobic and bind to sediment particles so sediment sampling for these parameters might also be considered.
- Might expect to find these chemicals downstream of facilities manufacturing these chemicals, grass farms (as shown in this map), and anywhere where herbicides and pesticides are applied.
- Dioxins/Furans might be seen downstream of industrial or municipal incineration activities.
- These chemicals, like metals and other compounds, can bioaccumulate and biomagnify up the food chain so human health is affected if contaminated fish are consumed.



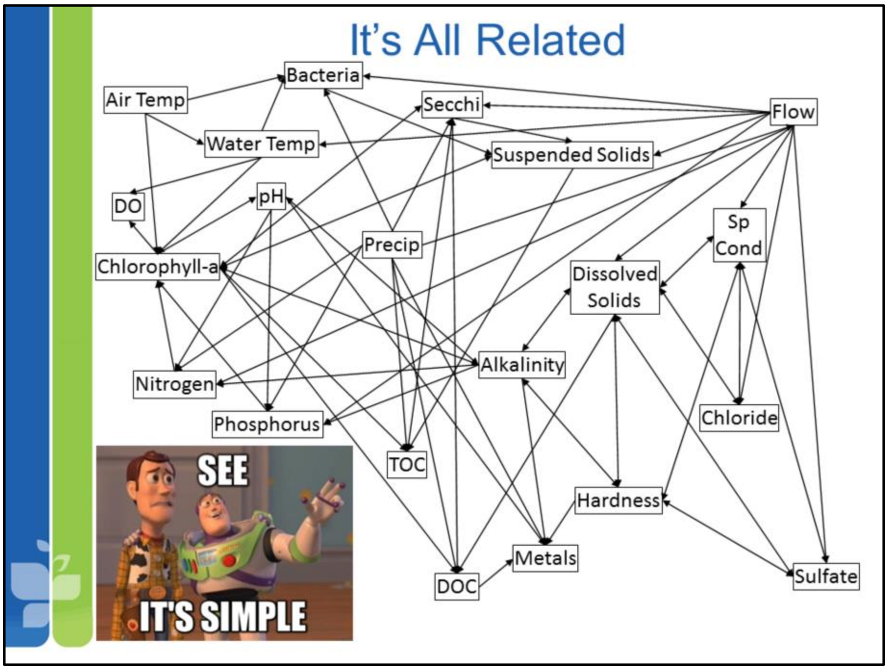
- Sediment samples might be considered in reservoirs or anywhere sediments deposit or fishing occurs.
- As noted earlier, metals can be mobilized out of the sediment and be made bioavailable under low pH/low alkalinity conditions.
- Organics bioaccumulate and biomagnify, so benthics, bottom feeders, and predator species are all affected by these compounds in the sediment.
    - Any time sediments are collected, TOC, particle size, and percent solids samples must also be collected.
    - These parameters are used to help determine how bioavailable these contaminants are in the sediment.
        - TOC can be used to normalize the data to amount of contaminant per gram of organic carbon.
        - Particle size is important for at least two reasons.
            - One is that some compounds preferentially bind to specific sizes of particles.
            - The other is that sediments with smaller particles are easier to disturb and re-suspend through flow changes, bioturbation, or other disturbances.
        - Standards for toxic substances in sediment are based on units dry

weight.

- If results are reported based on units wet weight, the percent solids (or moisture content) is needed in order to calculate the value in units dry weight for assessment purposes.
- Usually, results are reported in dry weight by calculation using the percent solids.
- Wet weight reporting will bias the results down because analysis is performed on a separated and dried sample and the water taken off the sediments prior to GC/MS analysis is not represented.



- Tissue samples can be collected when there is a concern for the health of aquatic and human life.
- Previously noted some metals and organics can bioaccumulate and biomagnify so high contaminant concentrations can impact not only the fish and other aquatic organisms but also other animals and humans that eat those aquatic organisms.
- For example, Lake Livingston is a large on-channel reservoir downstream from the DFW Metroplex and is a huge draw for sport fishing.
    - It was recently listed for a consumption advisory due to PCBs and Dioxins.
    - This or any other reservoir may also have a large amount of subsistence fishing.
- Sampling could consist of verification and monitoring of TDSHS fish consumption advisories because they have limited resources to conduct additional rounds of sampling.
    - However, you will not lift an advisory with the data you collect – any advisory must be lifted using data collected by TDSHS.


It's All Related
Bacteria
Air Temp
Secchi
Flow
Water Temp
Suspended Solids
DO
pH
Sp
Cond
Precip
Chlorophyll-a
Dissolved
Solids
Alkalinity
Nitrogen
Chloride
Phosphorus
TOC
SEE
Hardness
Metals
DOC
Sulfate
IT'S SIMPLE


ENVIRONMENTAL SCIENTIST
WHAT MY PARENTS THINK I DO
WHAT MY FRIENDS THINK I DO
WHAT MY COWORKERS THINK I DO
WHAT MY BOSS THINKS I DO
WHAT SOCIETY THINKS I DO
WHAT I THINK I DO
STAND BACK! I'M DOING SCIENCE!
WHAT I ACTUALLY DO
QUESTIONS?

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