

# WETLAND RESTORATION MANUAL

*for High School Students*



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# Preface

Wetland Restoration can range from a major creek corridor renovation to removing old concrete dams and other barriers so water can move naturally. Restorations can be the endeavors of a few concerned citizens or the collaboration of many city governments and federal agencies. Depending on the scale that you would like to restore, anything is possible with enough money and volunteer support.

The focus of this book is small scale restoration a project that can be facilitated by students and their peers and also maintained by future generations for the all the inhabitants to enjoy.

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We would also like to thank, Clipart.com, U.S. Department of Agriculture for use of their photos.

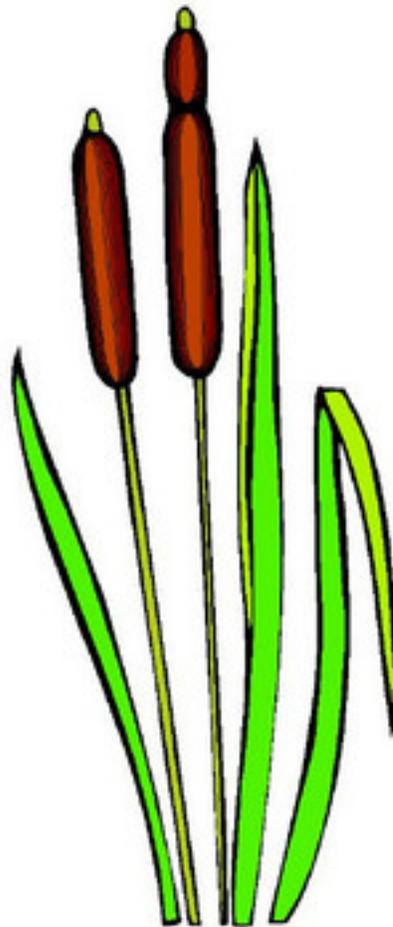
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# Restoration in the San Francisco Bay



## WHAT IS WETLAND RESTORATION?

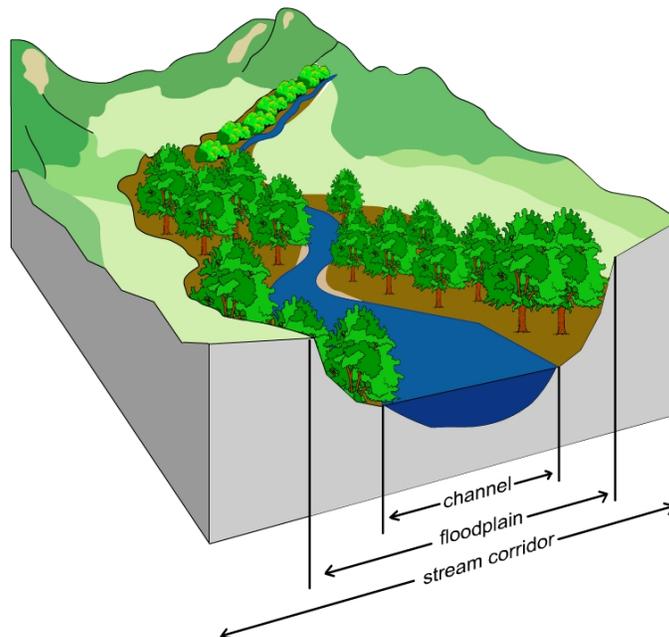
**Restoration** is a process that helps to transform an area that has been impacted by human or natural activity to an area that can sustain native habitats. Restoring an area is a long process that requires an understanding of an area. Learning about the history of an area and its **succession** through time, will help determine how to restore an area. Success can be determined if the **ecosystem** can recapture its **natural dynamics**. It is not possible to recreate ecosystems exactly, as change is a part of nature.

There are different types of wetlands that require different strategies. In this course we will consider **stream corridor**, **open aquatic**, and **bay coastal** restoration. Stream corridor and open aquatic are **fresh water** environments while the bay coastal can range from fresh, **brackish**, normal **marine** (35 parts per million) to **hypersaline**.

There are different ways to approach restoring wetlands depending on the degradation of that wetland. Wetland restoration can be expensive. Streams are dependant on nature to heal past practices, but nature is not always predictable. Monitoring during and after the restoration is a way to help detect problems before they become unmanageable. Monitoring usually involves looking at the biological, geological, hydrological, chemical and physical components of the creek.

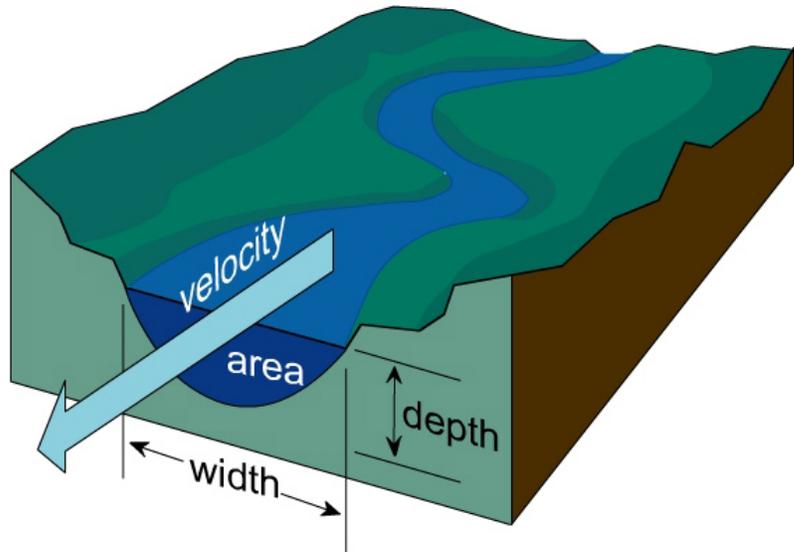
### STREAM CORRIDOR

A stream corridor refers to rivers and creeks and the adjacent areas that the water has influence. Water can be derived from surface (rain) or through aquifers. Some streams run all year (**perennial**) or can dry up during portions of the year (**ephemeral**).

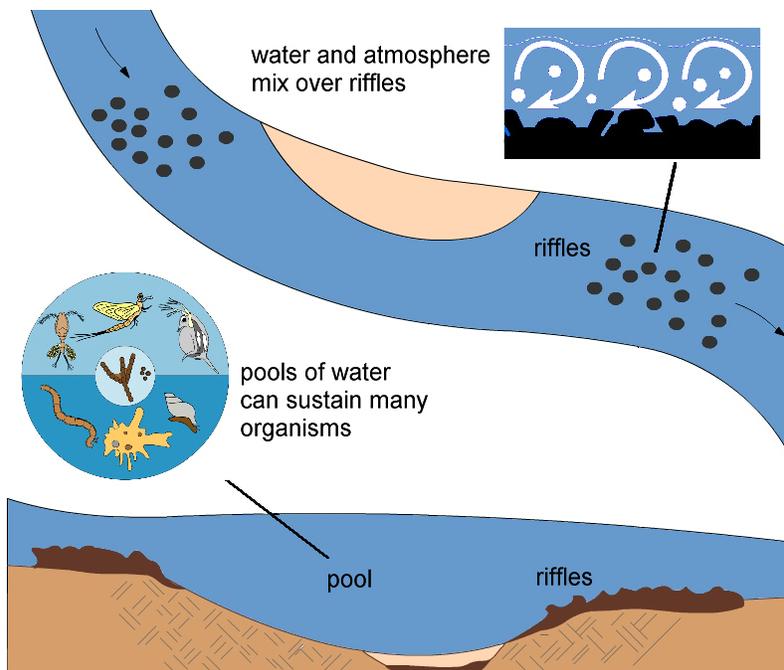


The shape and lateral extent of the stream is dependant on the type of rock, soil composition, biological growth, and tectonic forces. Creekside vegetation is referred to as the "riparian zone." It helps protect the stream channel while providing habitat for organisms who use the creek.

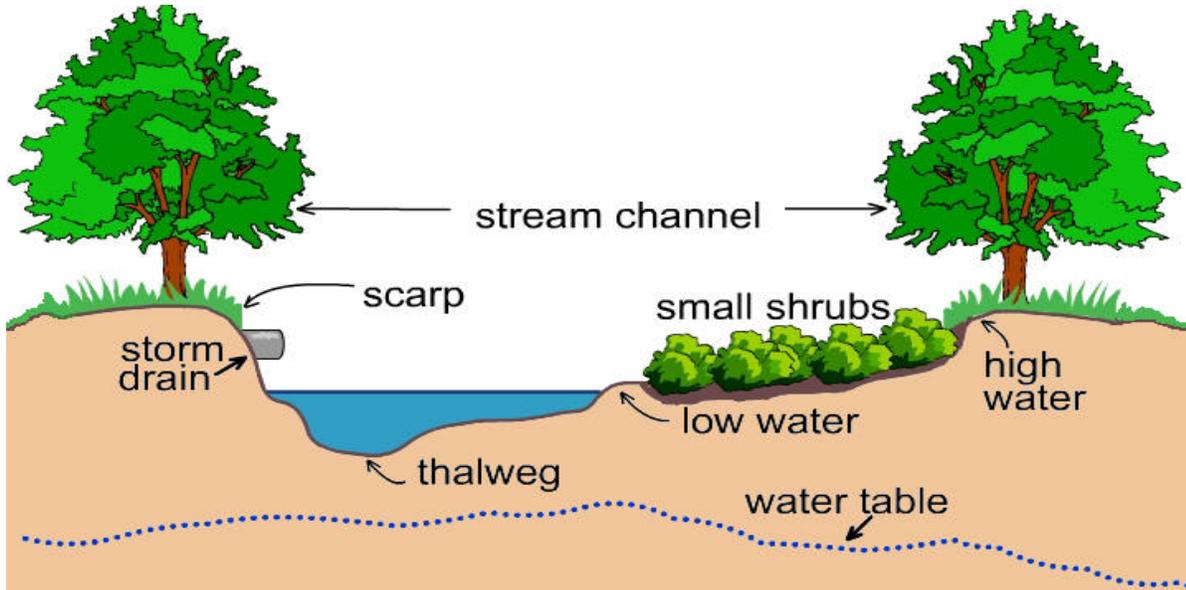
A stream channel is created and maintained by its energy flow. The erosion in streams are the result of topography, rock type, soil cover, climate, ground water, and vegetation. Erosion of the streambed increases when velocity of the flow increases. Soil and rock particles are detached when energy is highest. In low energy areas particles will be deposited. A stream is always changing



A stream can be a challenge for organisms that live in water. Flowing water can move mud, sand, and gravel. The faster the water flows the larger the particles it can move. As the water slows, particles will settle out and be deposited. High velocity can scour areas that create pools, which support plankton (floating organisms), and larger animals like frogs and fish. Riffles, or areas of gravel help provide dissolved oxygen as the water mixes with the atmosphere. Organisms require dissolved oxygen to live.

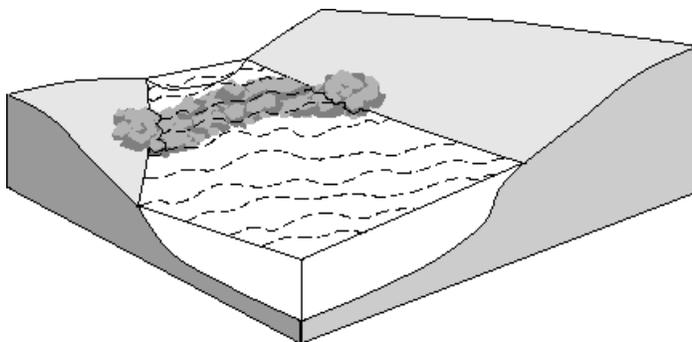


Trees throughout the stream corridor create many habitats for different organisms. Shade protects aquatic organisms by helping to lower the water temperature during the summer; in the winter the canopy provides protection from the effect of storms. Tree roots assist in reducing erosion within the floodplain.



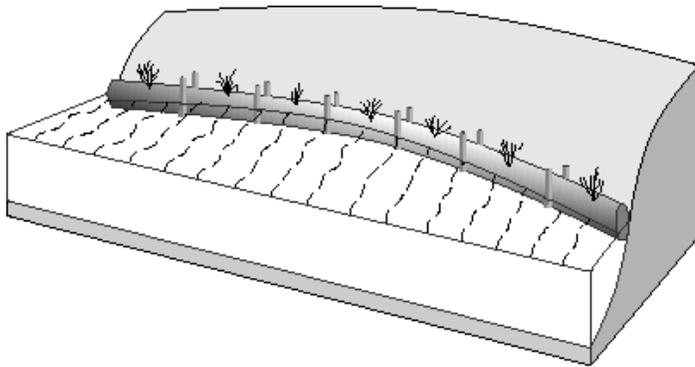
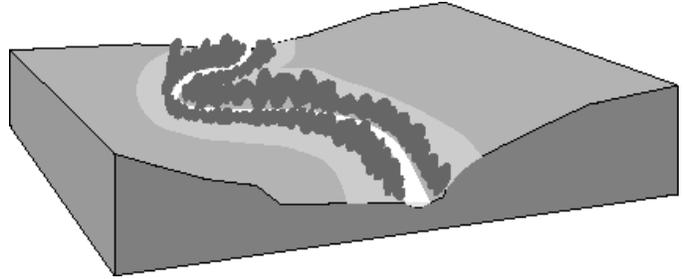
*A lateral view (cross section) of a stream and its area of influence.*

When a stream corridor needs to be restored there are many different techniques. There are engineering solutions as well as biological solutions. Below are just a few examples to help you get an understanding of the complexities.



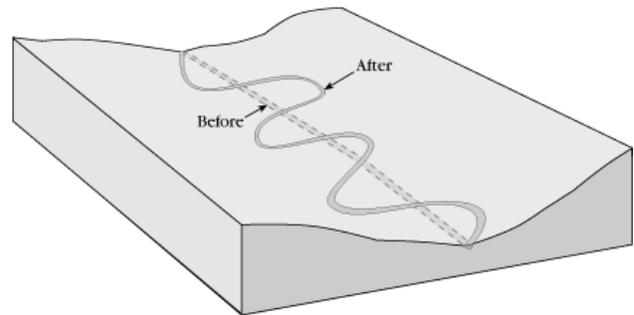
**Weirs or Sills** - A weir or sill can be composed of logs, boulders, or any large structure placed across a channel to help anchor the stream bank to create a pool habitat, control bed erosion or collect and retain gravel.

**Riparian Forest buffers** - A buffer helps to preserve a “core” habitat area. It usually consists of vegetation that helps to lower water temperature, provides a source of detritus, nutrients, and can shelter the area from urban pollution.



**Coconut Fiber Rolls** - These are cylindrical structures composed of coconut husk fibers bound together with twine to protect slopes from erosion while trapping sediment to encourage plant growth.

**Stream Meander Restoration** - Streams that are straight do not allow a stable environment for habitat. A channel can be engineered into a meander.



## OPEN AQUATIC

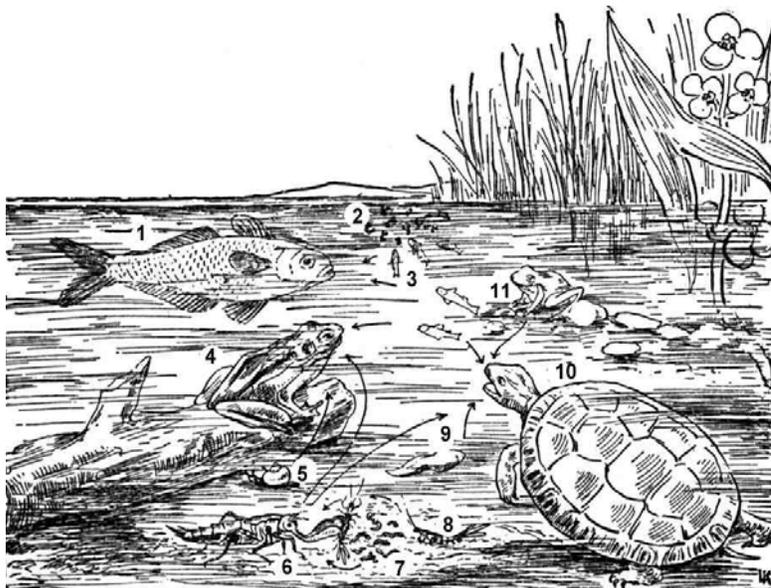
A lake or pond has some different characteristics than a flowing stream. The restoration of a fresh water aquatic environment must understand how nature is keeping the environment in equilibrium in a sometimes-enclosed basin. In the San Francisco Bay area we have many ponds that are created by faults. Geologically they are called sag ponds. The water is from underwater aquifers that a fault breaches. It also is supplied with storm water during the rainy season. There are also lakes in the region, many which have been converted into reservoirs, so can maintain its level throughout the year through human engineering.

**Limnology** is a sub discipline of hydrology, concentrating on the study of fresh waters, specifically lakes and ponds (both natural and manmade). This includes the biological, physical and chemical make up of the environment.

Organisms in small ponds are sometimes stressed during the summer because the demand on the oxygen and nutrients is great as the water begins to evaporate. When the pond or lake is out of equilibrium eutrophication may occur. Eutrophication is a condition in an aquatic ecosystem where high nutrient concentrations stimulate blooms of algae (e.g., phytoplankton).

Eutrophication is a natural process in the aging of lakes and some estuaries, but human activities can greatly accelerate eutrophication by increasing the rate at which nutrients and organic substances enter aquatic ecosystems from their surrounding watersheds. Agricultural runoff, urban runoff, leaking septic systems, sewage discharges, eroded stream banks, and similar sources can increase the flow of nutrients and organic substances into aquatic systems. These substances can over stimulate the growth of algae, creating conditions that interfere with the recreational use of lakes and estuaries, and the health and diversity of indigenous fish, plant, and animal populations.

When restoring the ecosystem of a pond, a full understanding of the organisms that use the pond from small to large must be understood. For example, in the diagram to the right the larger animal an ideal food web is determined. If one of the



1. adult fish, 2. crustaceans, 3. young fish, 4. frog, 5. snail, 6. dragonfly nymph, 7. midge larvae, 8. mayfly nymph, 9. tadpole, 10. turtle, 11. young frog

species is threatened it can upset the balance. If another species is introduced to the area it can also upset the system.

## **BAY COASTAL**

Restoring areas that are within a coastal bay environment must take into consideration the varying amount of salt content in the different habitats. The amount of different habitats varies from area to area, with many microenvironments. In the next section on San Francisco Estuarine System it goes through several of those environments.

## San Francisco Estuarine Wetlands

The San Francisco Estuarine system is a complex of interconnected embayments, sloughs, marshes, channels, and rivers. The system is comprised of the Delta Area (north), receiving the waters of the Sacramento and San Joaquin river systems and the San Francisco Bay proper (south), into which the Delta waters flow. Geographically and hydrodynamically the estuary can be divided into the northern bay, which passes south, and westward from the Delta through Suisun and San Pablo bays, and the south bay, which extends southeastward toward San Jose. They join in the central bay near the Golden Gate, the connection with the Pacific Ocean.

The waters of the San Francisco Bay are a mixture of the salt water flowing in from the Pacific Ocean and the fresh water flowing from rivers that feed into the bay. The water in the bay is neither salty nor fresh, but brackish. This entire system is known as an estuary. The San Francisco estuarine system is made up of three bays: San Francisco in the south and the San Pablo and Suisun Bays in the north. There is only one outlet to the Pacific Ocean for all 3 bays, a small opening underneath the Golden Gate Bridge (connecting San Francisco and Marin). The force of tides (caused by gravitational attraction of the Moon and Sun) causes water to move into and out of the bay. The influence of this mass movement caused by the tides flushes the estuarine system.

The San Francisco estuarine system is a very productive area. It is important to the entire ecosystem of the western United States. Many organisms depend on the bay for food, safety and shelter. Migrating birds need to rest here on their trips to warmer climates and nest during breeding seasons. The animals in the estuarine system are varied. Mammals, birds, reptiles, amphibians, invertebrates, protozoa, and fish are all components of this system. The system has many parts to it because of the need of the larger animals to feed on the smaller animals. This process is called the food chain and it gives us clues to why animals eat and live where they do.

The bays today are very shallow, 85% of the water is less than 30 feet deep. There are deep, narrow channels that cut the bottom of the bay, the Golden Gate (about 400 feet deep) and the Carquinez Strait (about 100 feet deep). Circulation of the bays is dependent mainly on the strong tidal action, especially in the south bay and river inflow, especially in the north bays. Winds, storms and bottom topography change these patterns locally.

Salt marshes of the San Francisco Bay area are highly productive and extremely valuable to the bay's ecology. Salt marshes contain a variety of plants, but there are only a few common to all California salt marshes. The plant groups occur in four distinct zones due mainly to the amount of salt in the soil, texture of soil, rates of sediment deposition, and the length of submergence. The specific location of each zone changes in response to time of the year and environmental conditions, but their relative positions remain the same.

San Francisco Bay Area is rich in human history that used our wetlands. The Native Americans needed wetlands for food source, building materials, and transportation. The Spaniards also used the wetlands especially for food and transportation. Unlike the Native Americans they used wood and adobe as their preferred building material. The Mexican Rancheros who owned much of the land prior to the California Gold Rush in the 1850's used the wetlands for their farming and ranching lifestyle. Farmers on the 1900's learned how to control the wetlands for their agricultural and ranching lifestyles. They also learned how to use wells to draw water from the wetlands for their everyday life. Today we use water for every facet of our lives from manufacturing to drinking. Without water the San Francisco Bay Area would not be what it is today.

### **Habitats of the San Francisco Estuarine area**

The San Francisco Bay Area has many diverse habitats ranging from open water to grassland to high saline environments. This is a brief look at the characteristics of the different habitats.

The **Tidal Flat** is an area that is affected by daily tidal action. During high tide many fish species use the area to forage for food. Once the tide has gone out the water birds begin to feast on those unfortunate enough to get stuck on the flat. Most of the vegetation consists of algae, sea lettuce and eel grass. Invertebrates include worms, diatoms and shellfish. This is considered one of the most important areas for shorebirds such as the American Avocet.

The **Tidal Marsh** is also effected by tidal action but it contains some amount of water all day (usually around 6-12" at low tide) and vascular vegetation suitable for the brackish to saline environment. The vegetation can vary widely depending on the area of the bay you are working in due to the interaction of fresh water and bay water, the amount of sediment, erosion and the type of soil available for the vegetation to grow.

A **brackish** tidal marsh would contain cattails, tules, and alkali bulrush in the lower tidal portions. Around mid marsh species such as spike rush, Baltic rush, silverweed and salt grass begin to emerge. Towards the more upland areas common pickleweed, salt grass, gumplant,



*Tidal marsh at Mud Slough and Coyote Creek.*

and alkali-heath are found.

A **tidal salt marsh** contains plants such as Pacific cordgrass and pickleweed. The higher salt content than the brackish marsh and therefore the plants must be able to remove the salt from the water in order to produce any form of food.

**Diked Wetland** are historic tidal marsh areas that have been blocked from the tides in an effort to “reclaim” the land usually for agriculture. The water found in this type of wetland can vary drastically due to the local influences of other waters and how long it goes before receiving any new water. These areas are usually full of more upland plants along with many non-native species. Some native species found in this area includes common pickleweed, saltgrass, alkali bulrush tules and cattail.

**Managed Marsh** is a diked wetland that is maintained for wildlife habitat. Depending on the wildlife you wish to encourage the type of plants and animals along with water salinity will vary.

Other examples of diked Baylands include **salt ponds** and **storage/treatment ponds**. The salt ponds are usually maintained for the production of salt for manufacture. As times are more stringent on the process of solar salt crystallizing more of these ponds are being restored and need to be watched carefully so that many of the species that utilize these ponds do not disappear. The storage/treatment ponds are areas where local city governments and or industry store or treat runoff so that it does not flow into the natural waterways. This way many of the contaminants do not flow directly into the bay, after they all settle out the area is dredged and recycled elsewhere.

A **Riparian Forest** is the area that separates a creek or river from the surrounding vegetation. These areas can be steep or gradual, wide or narrow depending on the body of water they are surrounding. The amount of light and moisture available also plays a part in the type of habitat that surrounds the area. Common trees include the California bay laurel, western sycamore, cottonwood, box elder, willows and oaks. Some of the understory can consist of elderberry, wild rose, and California blackberry. This is thought to be the most densely populated area for wildlife because it can be the habitat for animals such as the California newt, Pacific treefrog, ring necked snake, ornate shrew, broad-footed mole, deer mouse, opossum, striped skunk, raccoon, black-tailed deer, a variety of birds which include: scrub jay, song sparrows, woodpeckers, great horned owl, and tree swallows. This is creekside vegetation that usually is the majority of restoration projects.

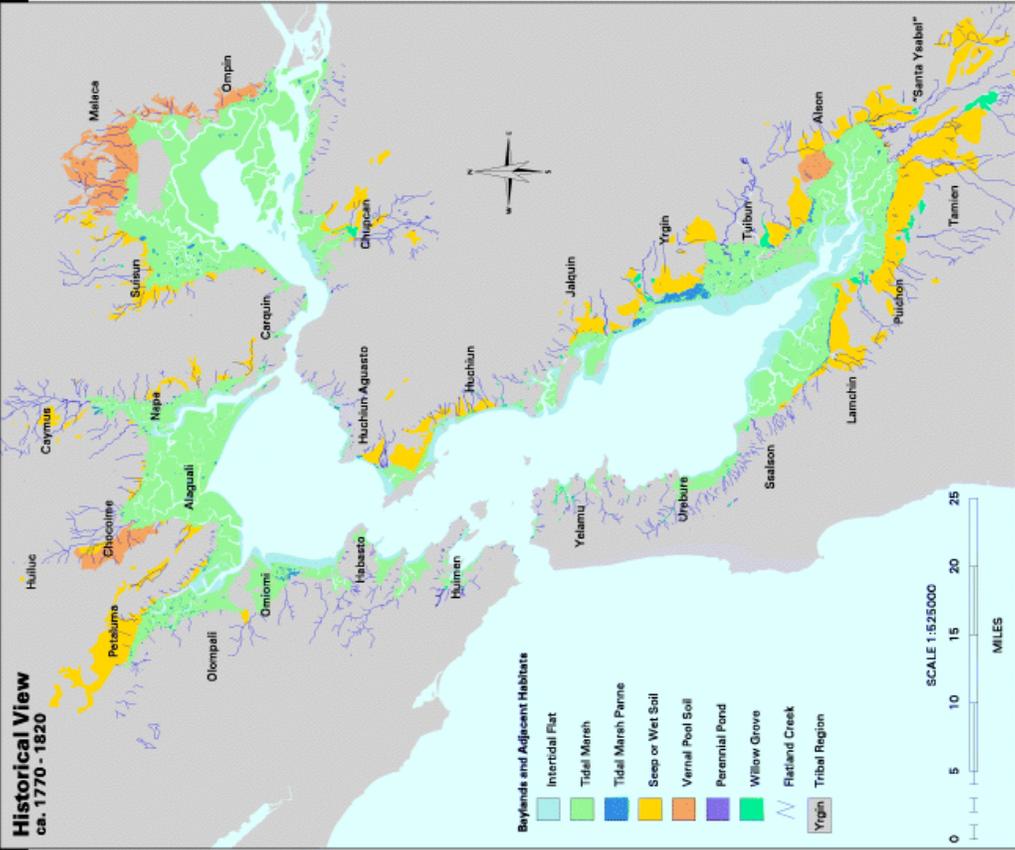
The **Willow Grove** is an area of willows that seem to come out of nowhere. These willows tend to grow where there is groundwater surfacing in intermittent ponds, springs, or where creeks go back into the ground. They act as a riparian habitat usually much smaller than the forest and provide the necessary shelter for a variety of amphibians and other birds that prey on the amphibians.

**Grasslands** are areas that are usually flat and were once used for cattle grazing or farming purposes. Historically they were covered with native grasses and sages, but

with the increase in agriculture around the bay these habitats were filled with more appropriate grasses for cattle from other parts of the world. This is the area for many of the small mammals that inhabit the area along with the burrowing owl, kestrels, hawks, various reptiles and some amphibians.

**Oak woodland** is usually found on the hillsides surrounding the bay. The habitat includes oak trees and provides the necessary shelter and nesting habitat for wildlife. This is the area where plants such as madrone, manzanita, coffeeberry, pink flowering current, poison oak, creeping snowberry, California blackberry, and cream bush make their residence. Wildlife can include southern alligator lizard, gopher snake, red-tailed hawk, California quail, woodpeckers, scrub jays, California ground squirrel, black tailed deer and others.

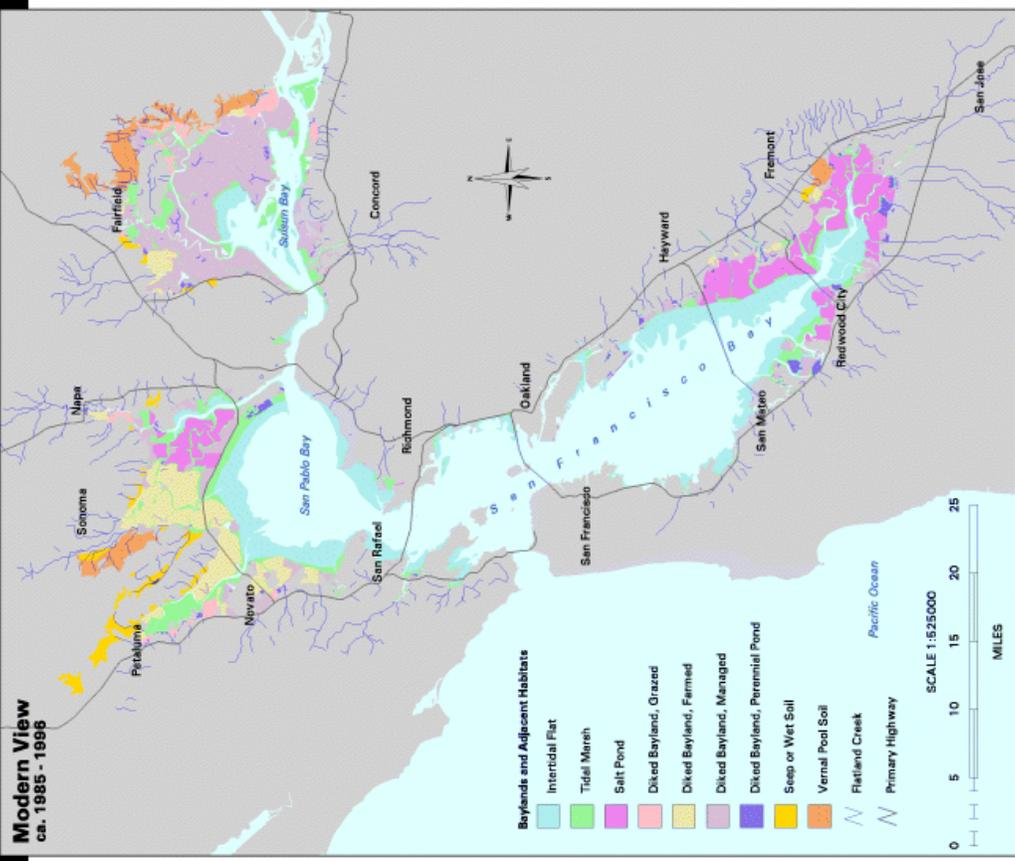
# Bay Area EcoAtlas



**Historical View Primary Sources:**  
US Coast Survey, US Geological Survey, US Department of Agriculture, Spanish diaries, explorers' journals, and local archives.  
Tribal Regions courtesy of Randall Milliken.

**Projection:**  
1927 North American Datum  
Universal Transverse Mercator Projection  
UTM Zone 10

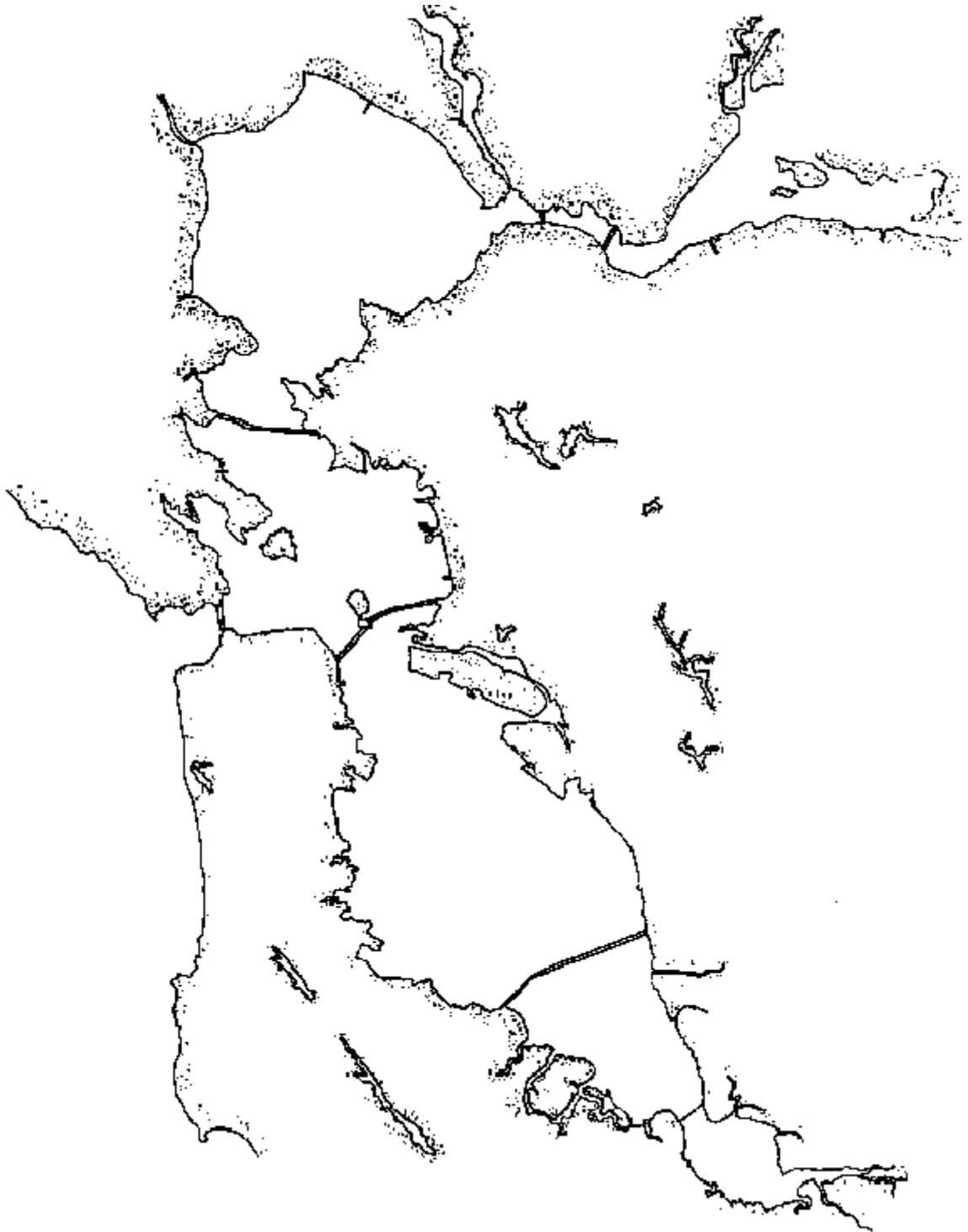
# Past and Present



**Modern View Primary Sources:**  
CA State Lands Commission, US Geological Survey, US Fish and Wildlife Service, US National Aeronautical and Space Administration, and local experts.

**Production:**  
Science coordination, GIS and Map Design by the San Francisco Estuary Institute, Richmond, California <http://www.sfei.org>  
EcoAtlas 1.0 ©1997 SFEI

Label the 3 bays, key cities, bridges, Pacific Ocean. Color in dark blue marsh areas affected by salt water; light blue marsh areas affected by brackish water; green marsh areas affected by fresh water; and red areas affected by total marine conditions.



## NOTES

# BACKGROUND INFORMATION

**Importance of Water**

**Movement of Water**

**Watersheds**



## IMPORTANCE OF WATER



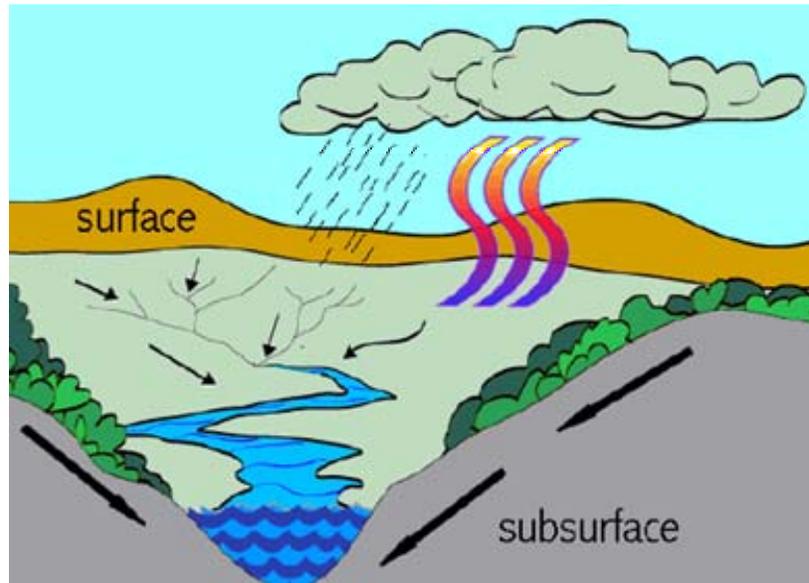
Water is our lifeline that bathes us and feeds us. In ancient cultures water represented the very essence of life. The Romans were the first to pipe water into their growing cities, especially with their **aqueducts**. They also realized that **sewage** water could cause damage to their people, and needed to be removed from large areas of people.

Water has played a role not only in the history of countries, but in religion, mythology, and art. Water in many religions cleanses the soul through holy water. For example, the water at Lourdes, France is thought by many religions to be sacred water with healing powers. In Egyptian mythology, the Nu was the beginning of everything and represented water. It brought life to their people, but in drought, produced chaos.

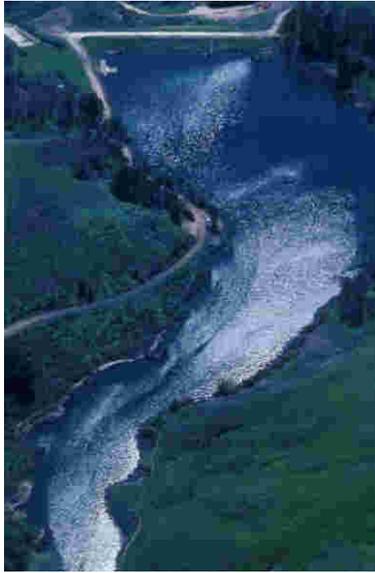
Water has always been perceived as a gift from the gods as it rained from the heavens.

### Water Cycle

The water or **Hydrologic** cycle explains interactions between the atmosphere, **hydrosphere**, and **lithosphere**. The water or hydrologic cycle is a major driving force on our planet. Water is in constant motion, evaporating into the atmosphere from oceans, lakes, rivers and streams. When the atmosphere can no longer support the moisture within the clouds, we experience rain, snow, hail, or sleet. Some water is locked in the form of ice at the polar caps and in glaciers. Water melts in the spring, producing runoff that percolates through the Earth as groundwater (subsurface) or makes its way back to the sea (surface). The oceans contain most of the water, but it is salt water, which is unusable by most organisms. Only pure H<sub>2</sub>O (water) can interact with organisms.



The movement of the oceans also has a direct effect on the atmosphere. The atmosphere is that envelope of gas that keeps organisms living on this planet. Oceans and atmosphere interact to give us weather.



A dam in California

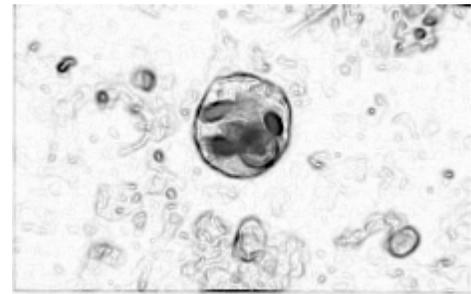
Water provides the Earth with the capacity of supporting life. An organism doesn't have to be told how important water is to their existence. An amphibian knows to lay their eggs in water or else there will be no new born. Even flies know to lay their eggs in fresh water.

The only organism that doesn't understand the importance of water is humans, especially in industrialized countries. Children in those societies turn on the water in a sink and never think about the trouble someone has gone for that "miracle" to occur.

In the United States it is mandated by law that its citizens should be given clean and abundant water. Dams, reservoirs, filtering plants, and pipes all bring clean water when the facet is turned on. Sewage water is only mixed with recycled water supplies after the water goes through rigorous cleaning methods.

Water borne diseases do not effect the U.S. population like in other countries that do not treat their water supply.

Water borne diseases are any illnesses caused by drinking contaminated water. Diseases can include infection from bacteria (*Salmonella*), viruses, or by small parasites (*Cryptosporida*, *Giardia*, and *Toxoplasma*). These organisms and viruses cause diseases like cholera, typhoid fever, malaria, botulism, polio, dysentery, giardia, and hepatitis A. One of the first symptoms of these diseases is diarrhea, which cause about three million deaths throughout the world, mainly in India, Africa, and South America.



*Entamoeba histolytica*, an amoeba that causes dysentery

Sewage is sometimes discharged into rivers, where children downstream might be taking a bath or using the water to drink. The simplest treatment method is boiling. Just bring the water to a boil for at least one minute, and then allow it to cool. But this is not always effective in heavily chemical polluted water supplies.



Schistosomiasis worms, parasite in water.

Without water, organisms could not exist. Water is a resource that should not be taken for granted. It needs to be conserved, just as we save other valuable resources.

Water is one of the weirdest compounds known to humans. The difference between the boiling point and freezing point of water is one of the largest ranges of any compound. It is this span of temperature that mirrors the range of where life can exist, from bacteria to humans. Water also has a very high specific heat, which means that it can absorb or lose much heat before its temperature changes. This is important in maintaining body heat in mammals. It also takes a lot of energy before vaporization can occur. For this reason, water evaporates slowly from ponds and lakes, where many life forms are dependent on a stable, warm environment.



Water creates a stable environment.



Life is abundant under ice sheets

Water is less dense in its solid state than in its liquid state, so that ice floats instead of sinking. This property permits life to develop in polar and subpolar regions where ice floats and allows life to continue living below the surface. If ice were heavier than water, it would sink, and more ice would form on top of it. As a result, all life in the waters would be trapped in the ice in the many areas of the world where it gets cold enough to freeze water.

Water is a remarkable solvent, where most elements and compounds can dissolve in its powerful molecular structure. Gases such as oxygen and carbon dioxide can also dissolve, making it readily available for photosynthetic and nonphotosynthetic organisms to use.



Resistance of water to a disturbance.  
organisms.

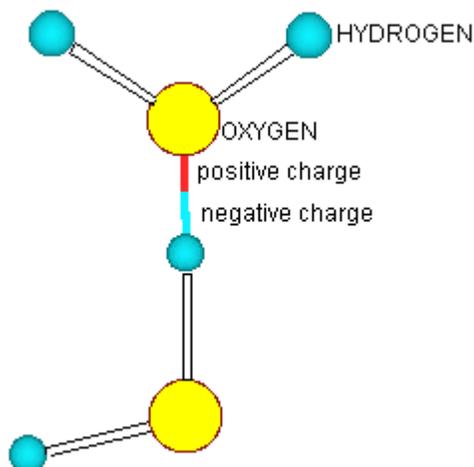
Water also exhibits viscosity. One can observe the effects of viscosity alongside a stream or river with uniform banks. The water along the banks is nearly still, while the current in the center may be swift. This resistance between the layers is called viscosity. This property allows smaller fish to live near the shore, while larger fish are able to swim efficiently in strong currents. Viscosity is also responsible for the formation of eddies, creating turbulence that leads to good mixing of air in the water and more uniform distribution of microscopic

How water provides all these properties are complex, but only emphasizes the importance of water to every organism on Earth.

## WATER CHEMISTRY

Water is a transparent, odorless, tasteless liquid composed of the elements hydrogen and oxygen. Water is a universal solvent, meaning that many elements can be dissolved by water. Fresh water has relatively few elements dissolved in the water, while the oceans contain many dissolved salts.

Water is important to our lives, and without it we could not live. In fact, there are no living creatures that can live without water. Water most probably originated on this planet as gases were emitted from volcanoes. The Earth's atmosphere captured this water and has continuously recycled it throughout time, in what is called the water cycle. Water evaporates and forms clouds – the clouds provide rain and snow – which is collected in rivers, lakes, underground reservoirs, and oceans – that are the source for further evaporation. Water is the perfect substance for the water cycle, because it has a high boiling point and a low freezing point.



The molecular structure of water resembles that of a teddy bear's head. The hydrogen and the oxygen atoms have a very tight covalent bond formed where the hydrogen and the oxygen share electrons. Bonding between molecules of water is called a hydrogen bond, which has a weaker attraction. The hydrogen atoms of one water molecule stick to the oxygen atoms of nearby water molecules. These weak bonds are very important for the chemistry of life. Molecules that stick to water, such as alcohol and sugar, are called hydrophilic, meaning "water loving."

How water molecules "stick" together.

Not all molecules are sticky. The scientific name is hydrophobic which means "water fearing." Examples of slippery molecules are fats and oils.

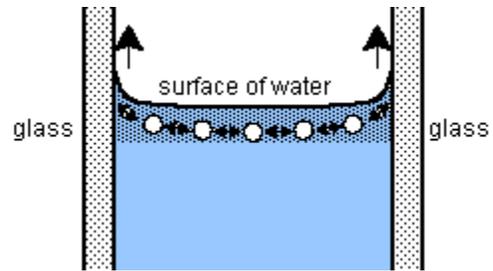


Droplets are caused by surface tension

Water exhibits **surface tension**. Surface tension of water or the ability of a substance to stick to itself makes water an excellent substance to float heavy objects on its surface. The molecules of water on the surface of a calm and quiet pond tend to be drawn into the liquid, so that the liquid surface is taut, like a sheet of rubber drawn over the open mouth of a jar. This tautness is caused by surface tension.

Surface tension is responsible for the shape of liquid droplets. Although easily deformed, droplets of water tend to be pulled into a spherical shape by the cohesive forces of the surface layer. The surface of water can support small objects like a sewing needle until the surface tension is broken. This "skin" on the water aids the growth of mayflies and caddisflies that are attached to the water's surface. However, surface tension can also trap flying insects that accidentally fall into the water and are unable to fly out.

Soaps and detergents help the cleaning of clothes by lowering the surface tension of the water. This allows the water to soak into pores and dirty areas more effectively. Small insects such as the water strider can walk on water because their weight is not enough to penetrate the power of surface tension.



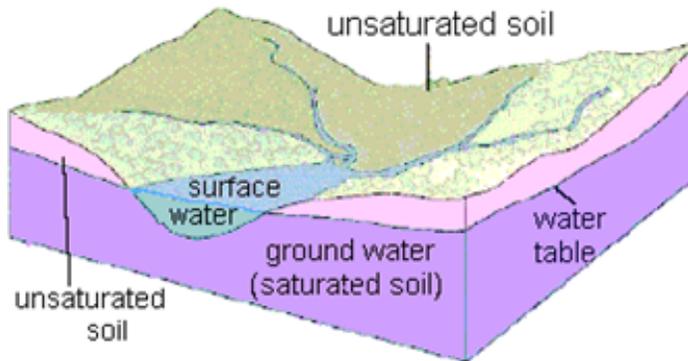
Capillary action on a wide tube

Common tent materials are somewhat rainproof because surface tension of water will bridge the pores in the finely woven material. But if you touch the tent material with your finger, you will break the surface tension and the rain will drip through.

Water can defy gravity as it can "walk" up the sides of a thin tube. The molecule is actually attracted to the side and pulls itself up. It might take a long time to get up a thin capillary tube, but it is working against gravity.

## MOVEMENT OF WATER

Surface movement includes rivers, streams, creeks, lakes, ponds, and human-made "flood" control. All surface water is trying to reach sea level due to gravity. As water flows in **channels**, the **streambed** and banks of the channel will resist the flow of water. The velocity of the water is dependant on steepness of the slope, type of rock or soil, amount of vegetation, shape of streambed, and obstructions. Surface water provides the liquid where most evaporation takes place.

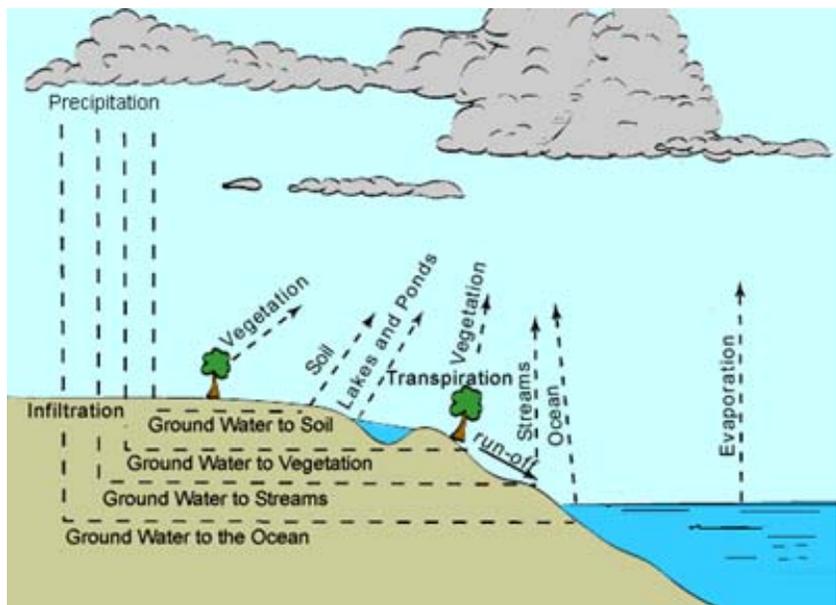


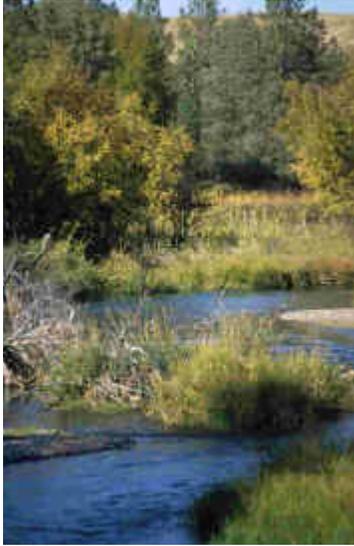
**Groundwater** refers to water that has penetrated the soil or bedrock and moves through rocks that have a high pore space. The water comes from **infiltration** of surface waters including lakes, rivers, recharge ponds, and even wastewater treatment systems. Groundwater is also affected by the force of gravity. However, because of some of the

properties of water, it can pool in higher area and actually defy gravity in some cases. The water stable is the upper level of the saturated zone of groundwater.

Rivers, streams and creeks are a surface water system with a network of channels that collect and move runoff.

**Runoff** is excess water that is not adsorbed by the surrounding area. Runoff can be created by rainfall, melting snow, or groundwater discharge. The shape of the river system will depend on the topography, the type of rock or soil it is traveling through, and the style of its biological diversity. For instance, pine trees require a lot of water to grow. Runoff in a pine tree forest would be less than if the area was populated by oak trees. Oak trees require less water than pine, so more water would be available as runoff.





Perennial stream

Rivers and streams change depending on the amount of water that flows throughout the year. This relies on a continuous source of water is from the surface or subsurface. A **perennial** flow is a channel that has water all year round. An example would be the great rivers of the world including the Ganges River (India), Amazon River (South America), or the Nile River (Africa). An **intermittent stream** would be a flow that is more than 50% during the year. An **ephemeral** flow generally refers to a stream or creek that only has water part of the year. This is usually in

areas, like deserts, that are dry most of the year, but do have maybe 2 months of rain.

Surface flows will wiggle and wind through the surface landforms. There are many flow types depending on the velocity of the river. If the velocity is high, it tends to cut into bedrock in a "straight" line. Velocities will be high if there is sufficient relief. When the velocity is low, the stream will tend to **meander** if the rock type and topography permit it.



Dry or ephemeral creek



Braided streams

Water velocity helps to create three basic types of channel patterns, including **braided**, meandering, and straight. There are many patterns that grade into each other. Rivers in a straight pattern do not stay ruler straight for long! The physical properties of water and the area the river is eroding tend to have the deepest part of the river (called the **thalweg**) alternating from side to side on the channel. Erosion of the land starts a physical separation of the pieces. Larger pieces don't move very far and drop out of the system. However,

finer grained sediment settles out in quieter area. So water will be attacking one side of the river and the other side will be depositing sediment. Over the years this will create meandering.

In many areas where you find braided channels, surface water is just "dumped" into a lower topographic area. The sediment load is large and the river gets confused and breaks up into smaller channels with a branching, but braided look.