
THE URBANIZATION OF THE WATER LANDSCAPE

ETH Studio Basel
Contemporary City Institute
Myriam Perret, Katrin Zumbrunnen
Prof. Roger Diener, Prof. Marcel Meili
Mathias Gunz, Rolf Jenni, Milica Topalovic
Christian Mueller Inderbitzin

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THE CHANGING WATER LANDSCAPE

Natural conditions of florida's water
Water consumers in a subdivided territory

HOUSE -

IMPERVIOUS SURFACE VS INFILTRATION

Pressure on the waterl andscape
Housing development leading to sealed surfaces and excessive water use
Consequences of transformed land surface
Step towards controlled water practices

AGRICULTURE -

WITHDRAWAL VS RECHARGE

Enabling agricultural landuse
Cultivating the water landscape
Excessive irrigation due to cold snap leads to sinkholes
Wells to recharge and stabilize the underground reservoir

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STRAIN OF URBANIZED SURFACEWATER

Affected surfacewater due to human impact
Water flowing through the phosphate mining industry
The water supply industry
The water treatment industry

URBANIZATION OF WATER LANDSCAPE -

DEMAND FOR HYPER-CONTROL

Large spatially defining effect due to rapid transformations
Wish of total control through complex artificial water network



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THE CHANGING WATER LANDSCAPE

In between the anciently pristine water landscape and today's urbanized waterbodies, a fast and intense urbanization of the water landscape took place. To be able to dive into those changing processes, this introducing chapter gives an insight into the former and contemporary appearance of the Floridian water landscape. A focus is given on the one hand to climatic conditions and the basic water bodies that can be found in this state. On the other hand, to understand today's water landscape, the different major water consumers and the statewide organisations dealing with water issues are presented.



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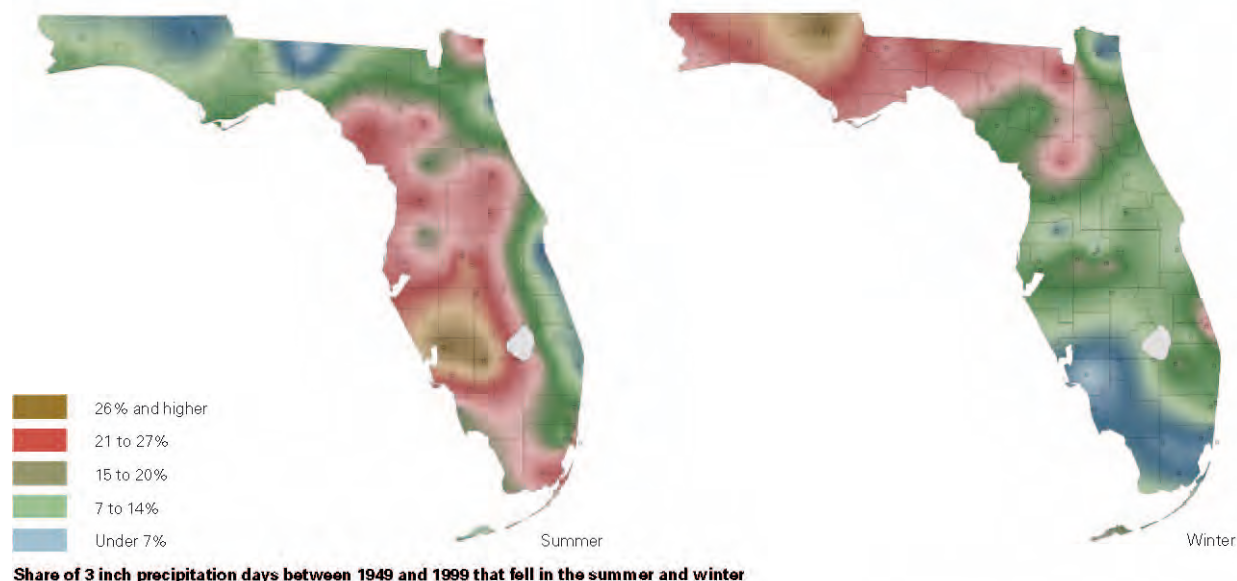
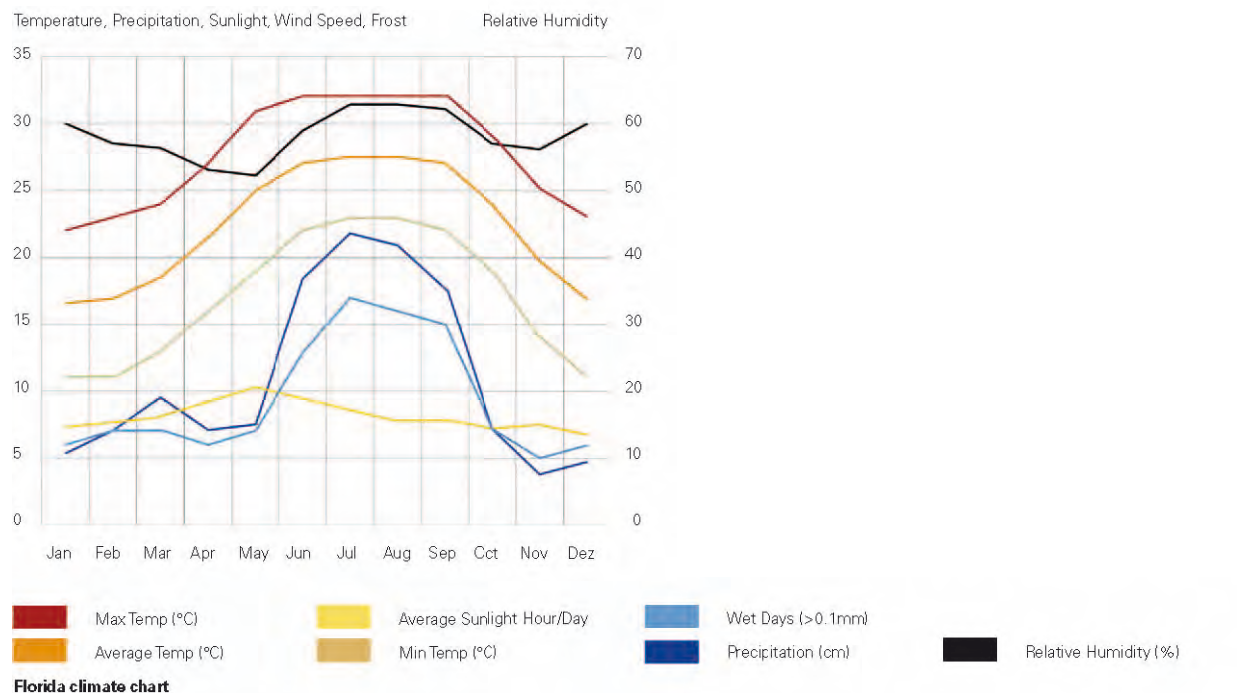
Map of 1764 drawn by Bellin

Natural conditions of Florida's water

Florida's ancient history as a submerged plateau is rather apparent in this 1764 made map of cartographer Jacques-Nicolas Bellin. This drawing of the peninsula gives the impression of Florida as a series of islands with interjacent waterways. It shows the complete dominance of water over the landscape. Over half of the ancient landscape used to be covered with swamps and marshland. A various ecological habitat was inherent to those wetlands. A watercycle including precipitations and the balance act between surface- and groundwater took place in a self-adjusting way.



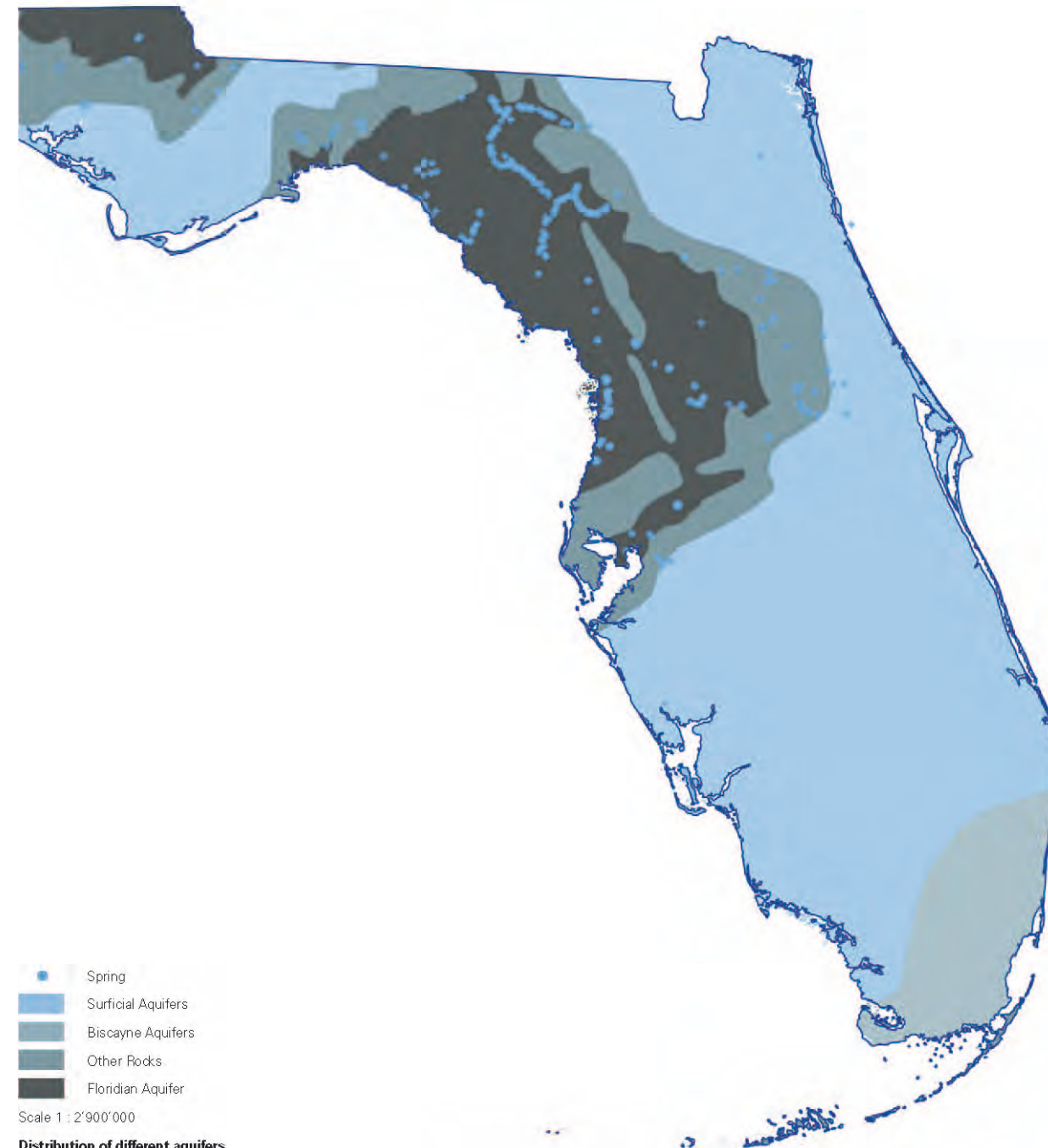
Oil painting by Albert Ernest Backus "Egrets' Roost" (1965) showing Florida's ancient wetlands



Seasonal climatic change

In Florida, precipitation varies regionally and especially seasonally. While in the north-west of the state, there is considerable rainfall all year long, in the Tampa Bay area for example, precipitations vary a lot during the year and aren't that even-tempered. In Tampa Bay, during the winter months, there can be droughts, while in summer there's heavy rainfall. Also in the Tampa Bay region, the chance of

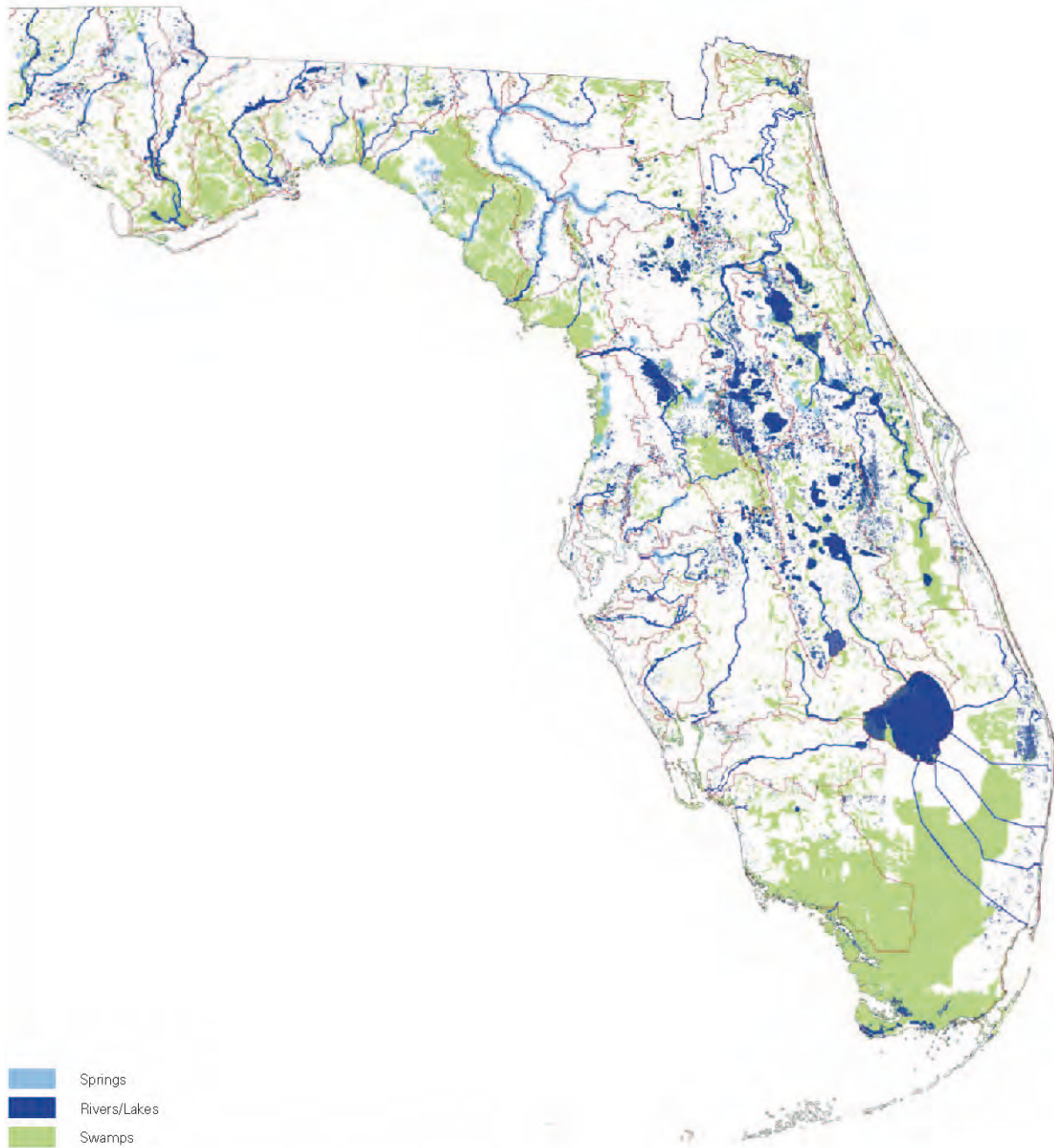
heavy thunderstorms is much higher than in the north. This uneven a seasonal concentration of rainfall can lead to an immense accumulation of water. One can encounter those seasonally or even daily varying waterbodies typically in some floridian areas.



Florida's aquifers

An aquifer is a wet underground layer of permeable rock or sand that stores groundwater. Florida has several aquifers, generally divided into surficial, intermediate and floridian aquifer. Surficial aquifers such as the Biscayne Aquifer (only in the south) are highly vulnerable to pollution as they lie close underneath the surface. The Floridian Aquifer is the

deepest, largest and oldest in the southeastern U.S. and is one of the most productive in the world. It contains water under pressure and in case the pressure is high enough, groundwater is pushed towards the surface and a spring flows.



- Springs
- Rivers/Lakes
- Swamps
- Watersheds

Scale 1 : 2'900'000

Distribution of the different surfacewater and the watersheds in Florida

Surfacewater / Watersheds

The state has 29 major watersheds. A watershed is a drainage basin where surfacewater from rainfall flows to a single point. It is therefore not a political border but a natural. The floridian peninsula is covered with different

types of surfacewater and has more than 11'000 miles of rivers, streams and waterways. Beside freshwater bodies like springs, lakes, streams, rivers or wetlands, Florida has salinewater bays as it is surrounded by the ocean.

Springs primarily in the north

As water flows into the aquifer, groundwater increases its pressure. When the water pressure is great enough, groundwater then breaks through the surface and a spring forms. The state has more than 600 natural springs, bringing groundwater from the different aquifers to the surface. The water temperature in floridian springs is relatively constant at about 21°C (70°F).



Dense network of rivers

A river is a natural freshwatercourse mostly flowing from a spring towards another river, a lake or the ocean. In Florida, water from the river is often used for drinking water supplies. Beside rivers as natural watercourses, Florida has a so-called "River of Grass" representing the Everglades, a world-renowned wetland where the water flows through.



A state full of lakes

There are several thousand lakes in Florida which clearly dominate the natural scenery. Some of them were naturally formed, mostly through erosion, some of them were artificially made whether for aesthetic pleasure, flood control, stormwater treatment, irrigation, fishing or recreation.



The surrounding ocean

With a coastline of over 1'100 miles, the ocean is a major attractor for floridian tourism but also for urbanization. Tampa Bay is Florida's largest open-water estuary with about 400 square miles. An estuary is a water body where freshwater mixes with saltwater.



Wetland as most dominant natural element

Wetlands consist of areas which are permanently or seasonally moistured. The soil of those areas is saturated either by ground- or surfacewater. Wetlands fulfill different tasks concerning the natural ecobalance. They are responsible to equalize the waterbalance and represent a biologically diverse ecosystem with a wide range of wildlife and vegetation. Further, they recharge the underlying aquifer. Therefore, wetlands take a key role in Florida's landscape. Also nowadays, wetland areas still dominate the natural environment in Florida,



Wetland

Wetlands consist of areas with continuous flooding. They can be subdivided into marshes which are shallow, and swamps which may be larger and deeper.



Agriculture

Florida's agriculture is one of the leading on the north american continent. Therefore, this consumer is a major water user

Water consumers in a subdivided territory

The occupation and organisation of the Floridian water landscape is explained. During the past 150 years only, Florida has undergone a major transformation. Through the fast growing population of the peninsula, an intense urbanisation process occurred. Land and water were reallocated and are nowadays shared amongst different water consumers and some single remainders of the ancient water landscape. Towards the end of last century, the territory was subdivided into a system of organisations which influenced the steady growth of water consumption. Those organisations will be presented in this chapter.



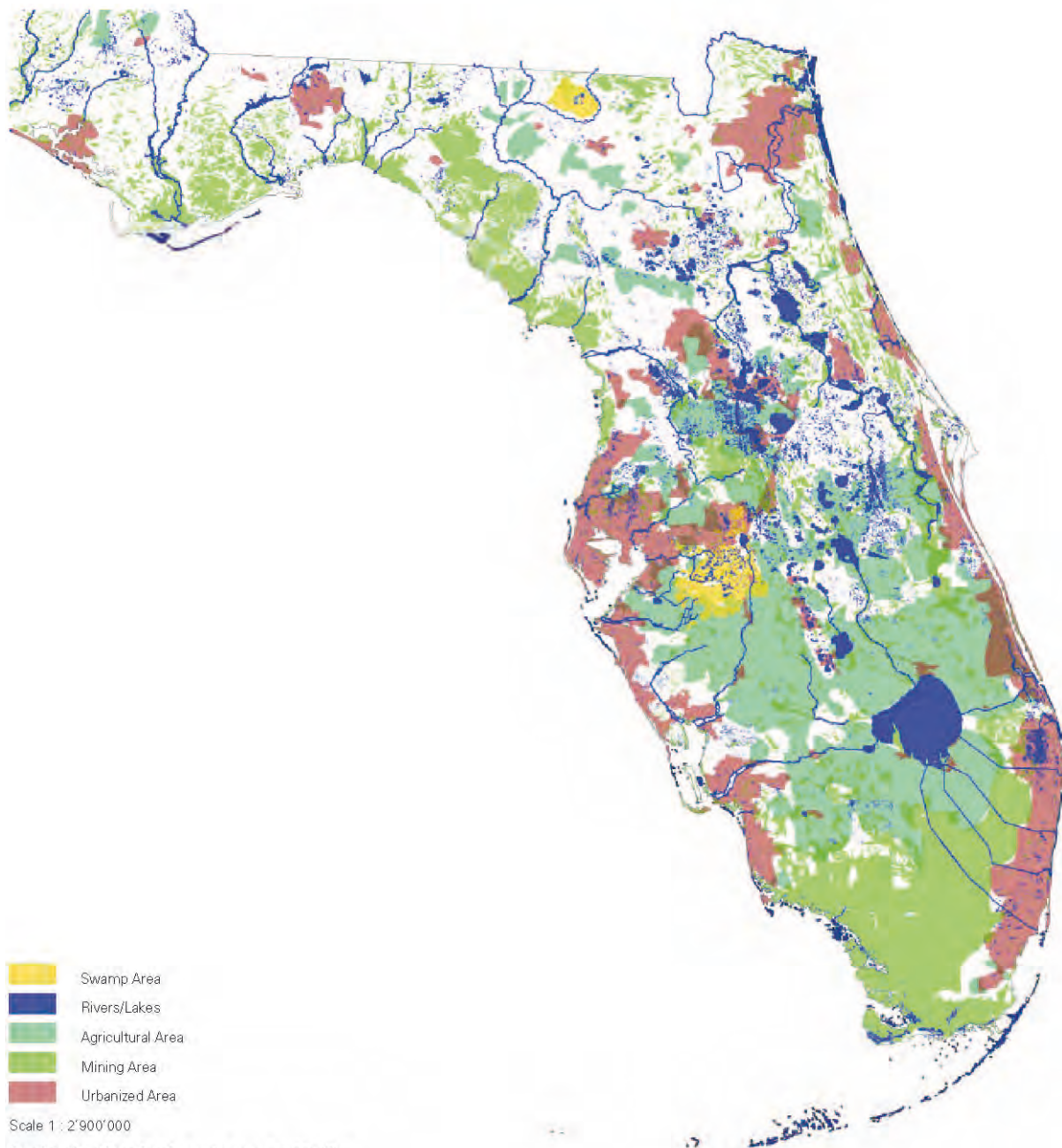
Industry

Beside widespread industry, the Floridian industry sector knows an important contributor in phosphate mining, which also uses high amounts of water.



Housing And Urban Areas

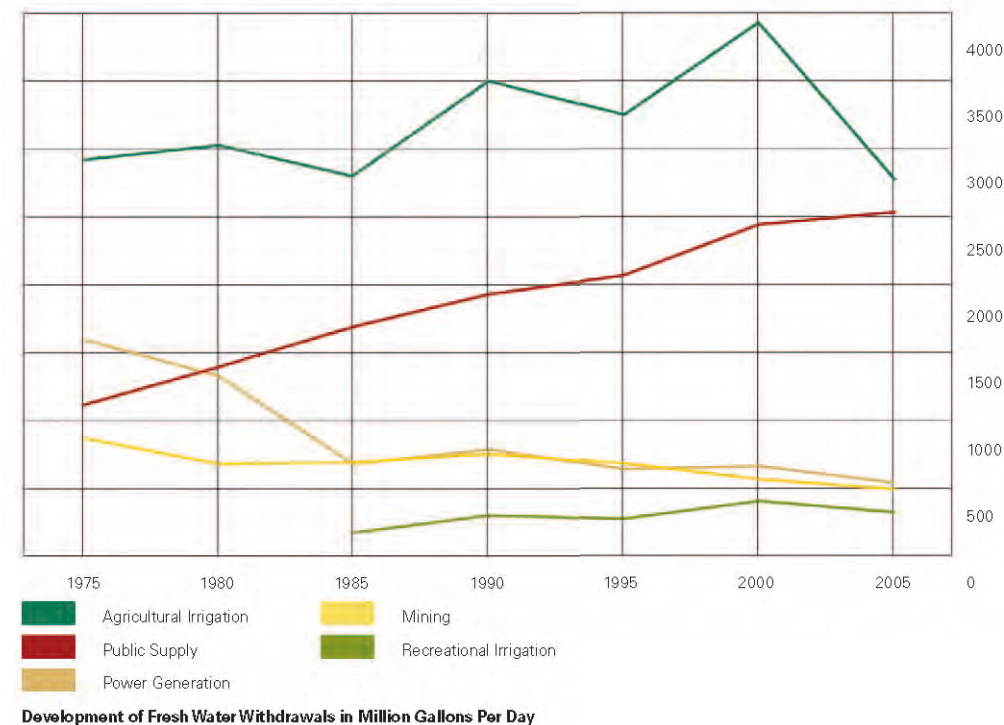
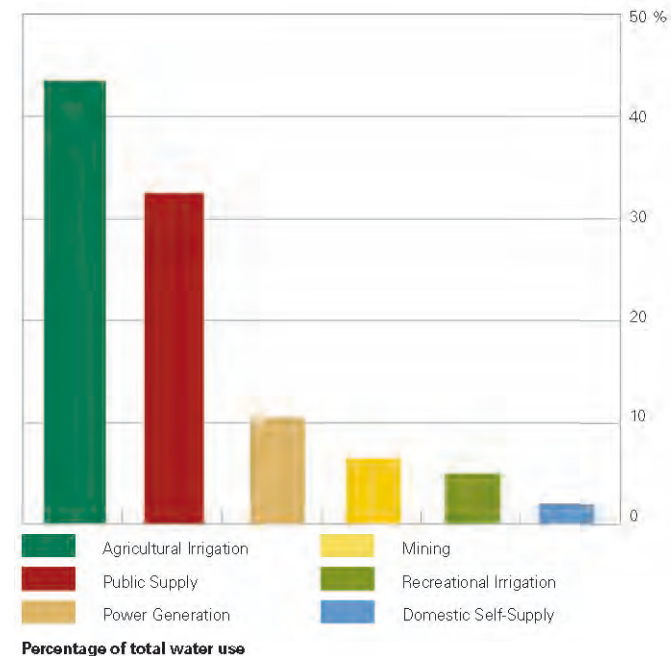
Private or public housing represents a large water consumer of the Floridian peninsula.



Distribution of the water use in time and space

The map above shows the spatial allocation of major water users parallel with the main Floridian waterbodies. It shows that the main water consumer, agriculture, has huge spreads especially in South Florida. Urban areas tend to concentrate along the coast and the phosphate mining

industry concentrates around central Florida. The north of the state knows less land occupation through the different users and therefore consumes less water. Agriculture is the main water consumer in the state, needing its water to irrigate the crops. The public supply of



mostly urbanized areas represents the second largest user. The mining industry, only covering a rather low percentage of the state's land, accounts together with commercial industries for 6.5% of the total water use in Florida. Already during the last 40 years, agriculture had the highest

consumption followed by the public supply. In both cases, an increase of water use can be noticed. Between 2000 and 2005, agricultural water withdrawals decreased due to losses in irrigated acreage attributed to diseases, weather, urbanization and long-term water restrictions.



Department of Environmental Protection



Tampa Bay Regional Planning Council



South West Florida Water Management District



County and City

Organisation Of The Water Management

Florida gives the impression of having enough water as the whole landscape is laced with lakes, rivers, wetlands etc. But still, seasonal changing precipitations and the growth of population need a well organized concept to be able to guarantee watersupply not only in high quantity but also in

high quality. Also the protection of the water resources and the environment is a major issue that needs to be considered. Therefore, different organisations have been set into place which coordinate the water management in the floridian peninsula.



Tampa Bay Regional Planning Council

1962, the oldest of Florida's eleven Regional Planning Councils, the Tampa Bay Regional Planning Council, was established. The TBRPC coordinates planning among local governments and other appointees. Concerning the water, they are especially concerned about water quality, the protection and restoration of the Tampa Bay estuary but also flood protection through emergency preparedness planning.



County

Florida has 67 counties. Hillsborough County declares its mission towards the water as to treat and deliver drinking water to its inhabitants and to collect and treat wastewater and distribute reclaimed water. It follows the water use restrictions set by the SWFWMD.



City

The City of Tampa is subdivided in several departments. Among others, there is a water, a stormwater and a wastewater department. The water department is in charge of water conservation and treating and delivering drinking water. The stormwater department is responsible for the planning and maintenance of the stormwater system. This system has over 600 miles of stormwater pipes and over 100 treatment ponds. Also they clean the roads so the water entering the drainage system is less polluted. Further, the wastewater department maintains the sanitary sewer system and informs about reclaimed water. They push the idea of using reclaimed water for irrigation to conserve drinking water.



Department of Environmental Protection

The Department of Environmental Protection DEP is the mother agency of the 5 existing floridian water management districts. It protects, conserves and manages the water resources and enforces the environmental regulations of the state. So it not only considers water related issues, but the whole environment. Concerning the water, its main goal is to protect and restore the water quality.



South West Florida Water Management District

The SWFWMD declares their main mission as to ensure a sustainable water supply to meet public demand, while protecting the environment and the water resources. They try to improve water quality and are further assigned to flood control in their district. It is further divided into 8 watershed basins, where the basin board members identify water resource problems in their basin and suggest plans and budgets to improve it. The SWFWMD has an important role in the management of the water supply.

HOUSING

IMPERVIOUS SURFACE VS INFILTRATION

Land reclamation in Florida happened out of a need for different human activities, a major one being housing. By conducting the water through drainage canals, housing areas could spread over the peninsula. The construction of houses and streets caused a large growth in sealed surface which led to unforeseen catastrophic consequences. Also, the rise of aesthetic standards caused excessive water use.

Water As Decoration

Irrigation

Housing

Precipitation

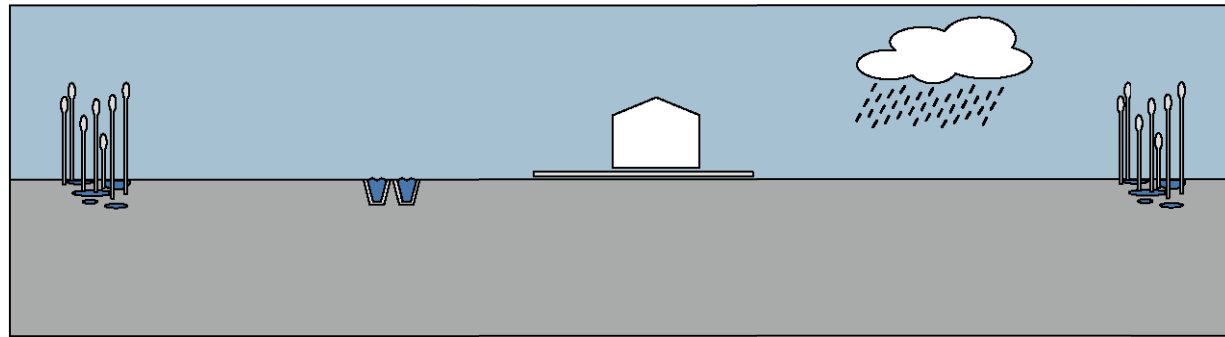
Drainage

Stormwater Lake

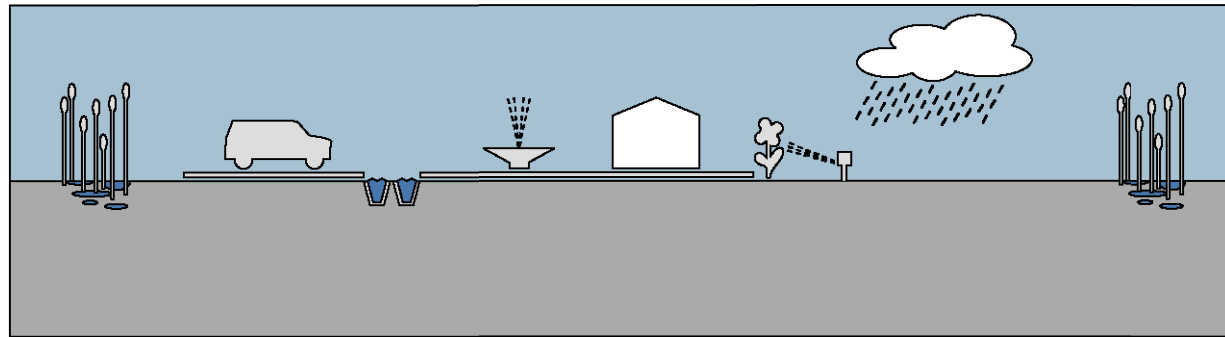


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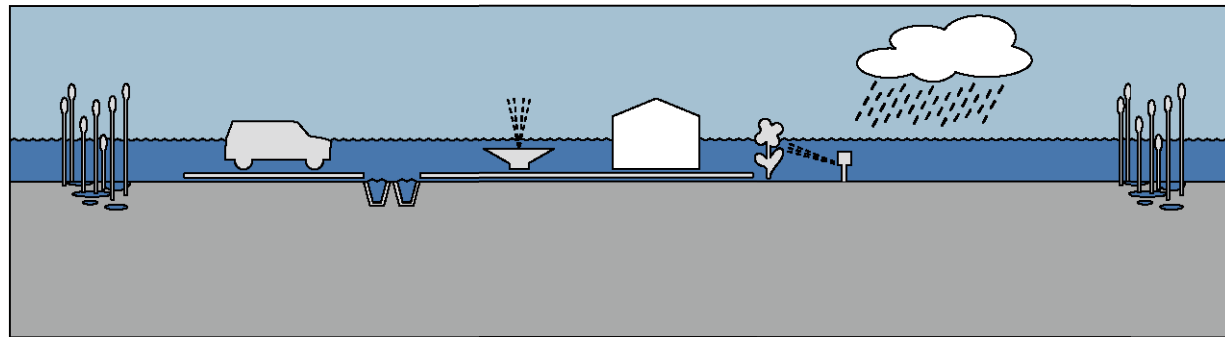
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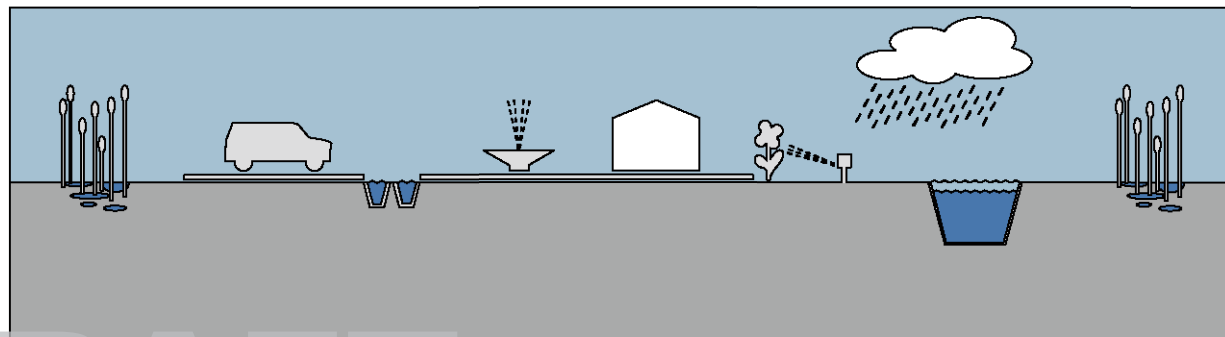
Drainage and occupation of the water landscape



Housing development with excessive water use



Flooding due to impervious surfaces



Step towards controlled water practices

Story about the housing and the water; from wetland to stormwaterlake

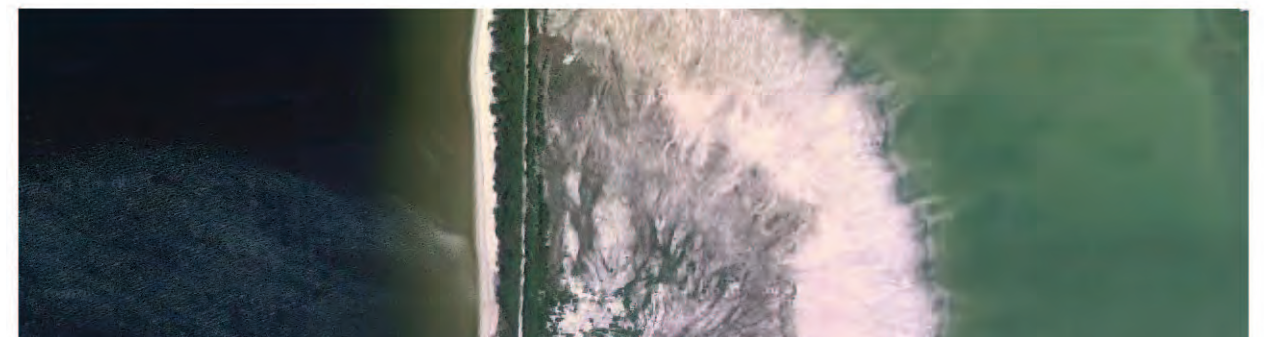
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First steps from a natural towards an occupied landscape



Floridian settlement in drained landscape

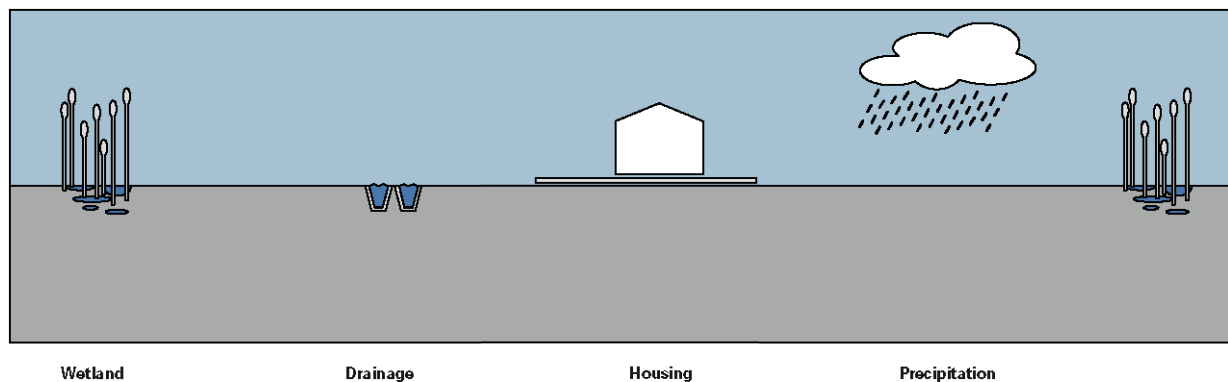


Omnipresence of water hazards



Stormwater ponds in a typical Floridian settlement





Pressure on the water landscape

Before the floridian urbanization process of the past 150 years began, the Floridian landscape was still covered over 50% by wetlands. Those specific areas containing diverse habitats of flora and fauna were major attractors for nature lovers and other visitors. Over the years, a demographic growth took place. But to give room to this growth, the water landscape had to be controlled and therefore underwent a huge transformation. By draining the wetlands, the water landscape got usable for human activities so urban and agricultural areas could develop throughout Florida.



"Florida sunrise" by George Herbert McCord ca. 1880



Brochure advertising the "emerald kingdom" in 1926

Early tourism and settlements

In the first half of the nineteenth century, people started to be interested in recreation-hunting or fishing and bird-watching. Later, artists and photographers were attracted to the peninsula. The springs and wetlands with their diverse habitat were an eyecatcher for many people. In 1926, the above-pictured brochure was sent to domestic

homes throughout the U.S. to advertise Florida as the "emerald kingdom". The commercial image-making was very important and helped to reach the big success of the floridian tourism where the water counts as a central force of attraction.



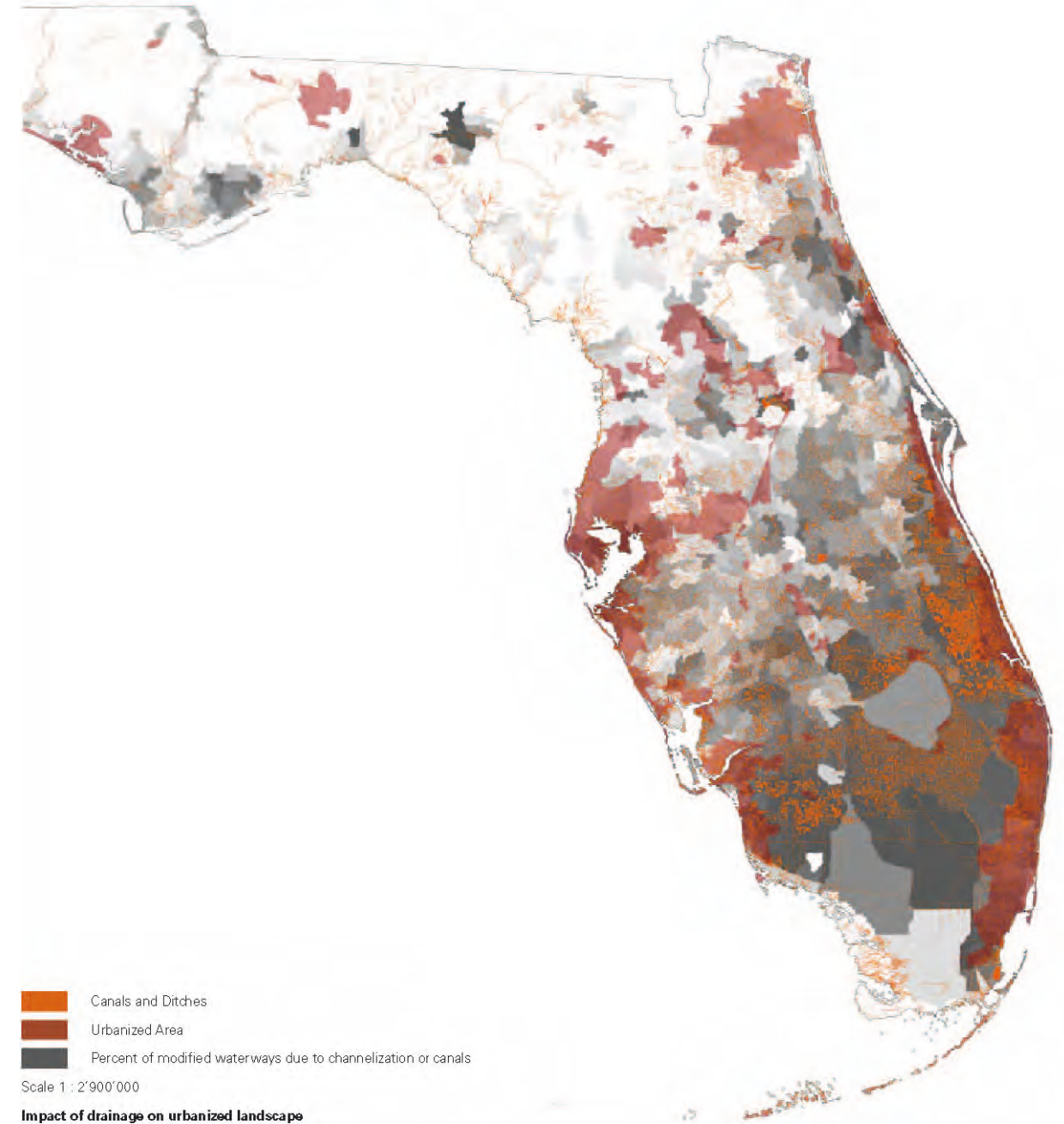
Shell canals of the Caluso Indians

The Caluso Indians are native americans who used to live in the southern part of Florida in the 16th century and later. Their culture based especially on estuary fishery. Therefore, they used to make the water usable and dug canals. As so-called "Shell Indians," they used to clad the canals with shells. Nowadays, some of those canals can still be visited. Caluso Indians were somehow the first people to make the floridian water landscape usable for supply purposes



Development of drainage

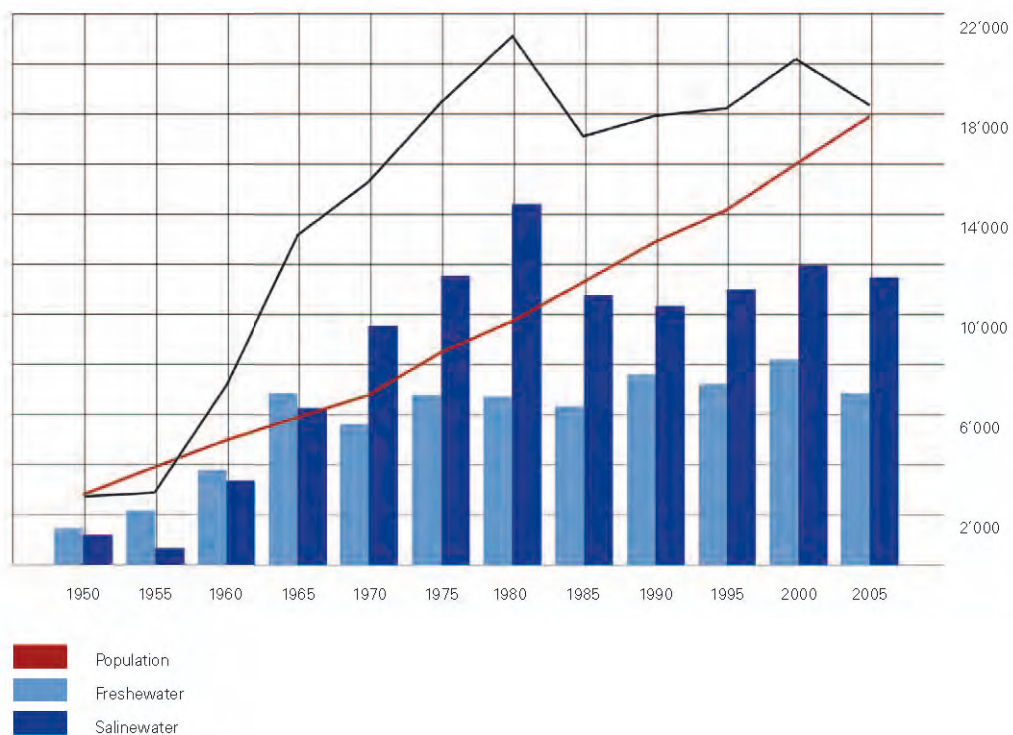
With Hamilton Disston, the modern history of the water drainage of Florida began. In 1881, he wanted to drain the Everglades in South Florida and bought 4 mio acres of wetlands. The goal in draining wetlands was to make the floridian landscape usable by either having the possibility of building houses or creating new agricultural land. Also the newly built drainage canals became navigable and connected inland towns such as Kissimmee with the Gulf of Mexico.



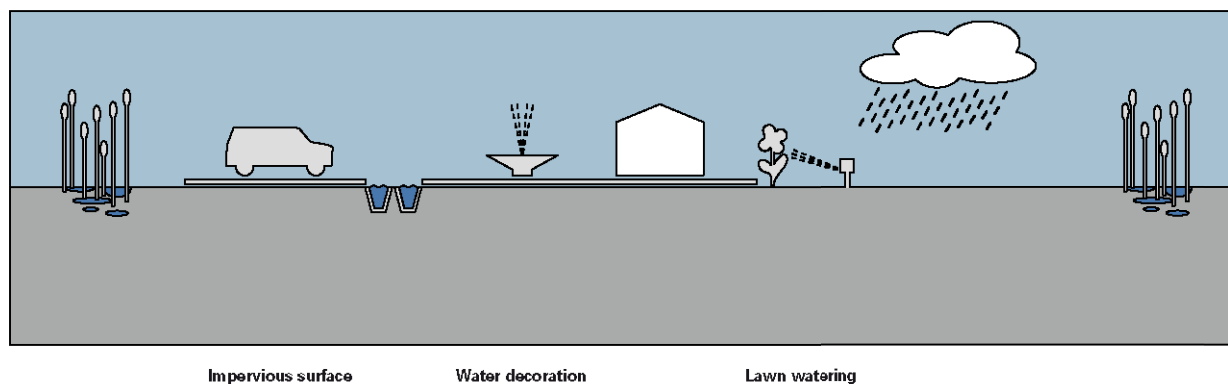
Intensity of transformation through drainage

The use of the landscape in Florida is heavily influenced by the process of drainage. Darkgrey regions have undergone large changes in their landscape, also due to drainage. The large urbanization and cultivation of the floridian landscape was only possible due to the water drainage projects in

the early 20th century. Through this transformation, more than 50% of the original wetlands were drained. In general, Florida can nowadays be divided into urban areas, agricultural land and natural environment, which consist mainly of wetlands.



Development of freshwater withdrawals in million gallons per day



Housing development leading to sealed surfaces and excessive water use

On one hand, the population growth and the housing development caused an immense increase in the total water use as shown in the graphic above. As one could afford a private garden, people consequently wanted to irrigate their plants. In Florida, about 50% of the water consumed by a household is used for irrigation. This means, that half of the drinking water that is at the disposal for a domestic home is used to spray over lawn, bushes or other plants. Also the use of water for aesthetic reasons such as fountains in public or private spaces consumes a huge amount of water. On the other hand, by constructing streets and houses in general, the surface of the Floridian peninsula got sealed continuously. This transformation of the land surface causes alterations to the evaporation of the rainwater and the amount of water draining into the soil, called runoff.



Spreaded housing development

The development in Florida happens not in a centralizing way but spreads over wide parts of the landscape. This causes more built-on land with sealed surface. Depending on the size and the type of the building (residential, industrial etc), different types of stormwater systems exist.



Streets as the primary urban element

Due to the large street networks, streets count as a big provider of impervious surface as it seals large parts throughout the state. Therefore, one may encounter large stormwaterpools especially at intersections of highways and roads to support the runoff.



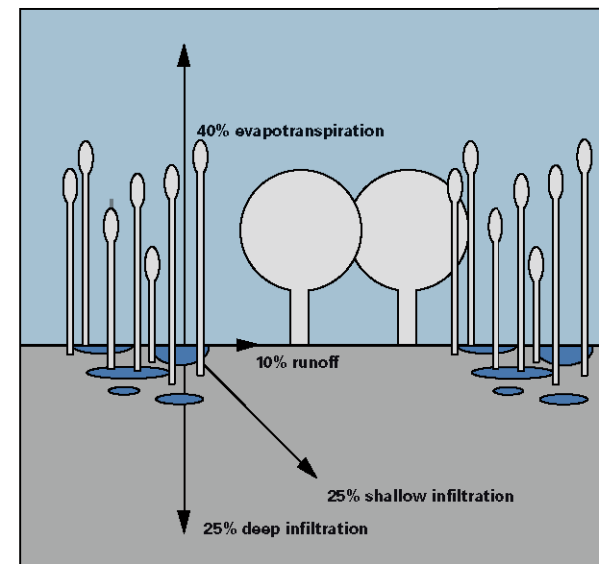
Non-regional specific lawn

St. Augustine grass is the most popular lawn in Florida but it needs a lot of water and does not withstand droughty sites. Some home developers urge their inhabitants to plant this kind of lawn, although its high need of water.

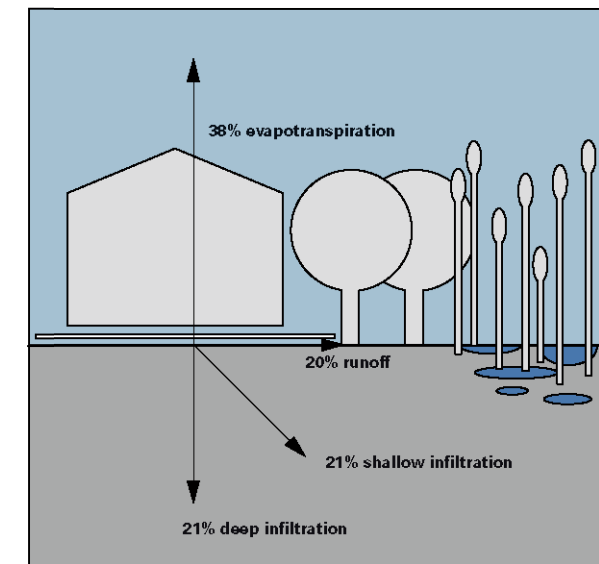


Decorative use of water

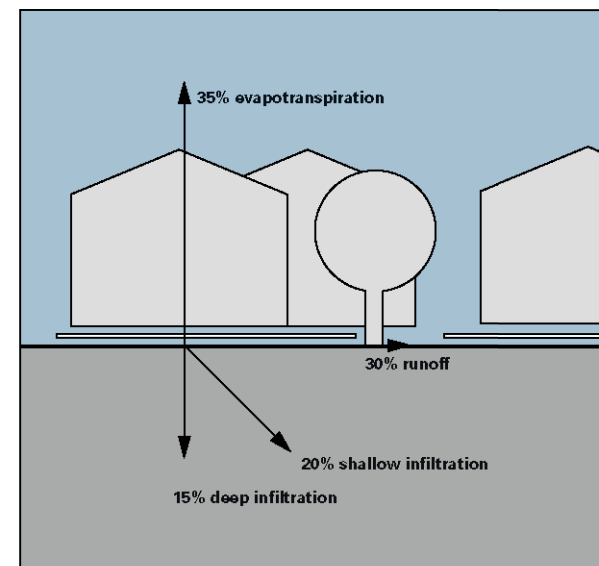
In Florida, one encounters water everywhere and in different forms. What catches one's eye is the fact that many fountains act as an embellishment of the public space. The impression is given that water is available to a sufficient extent.



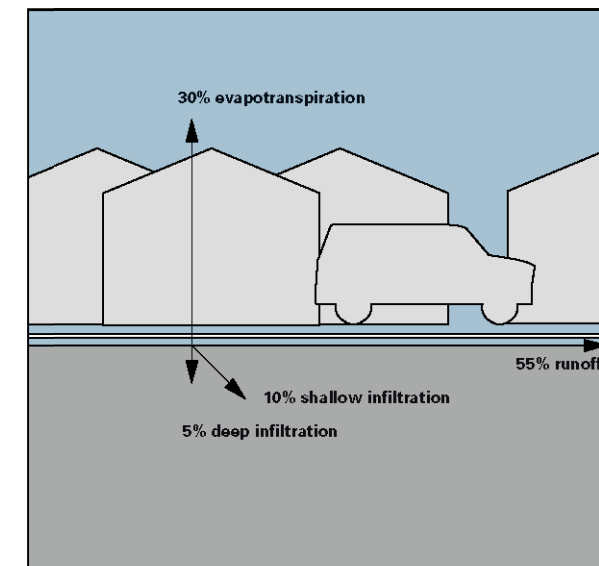
Natural Ground Cover



10-20% impervious surface



35-50% impervious surface

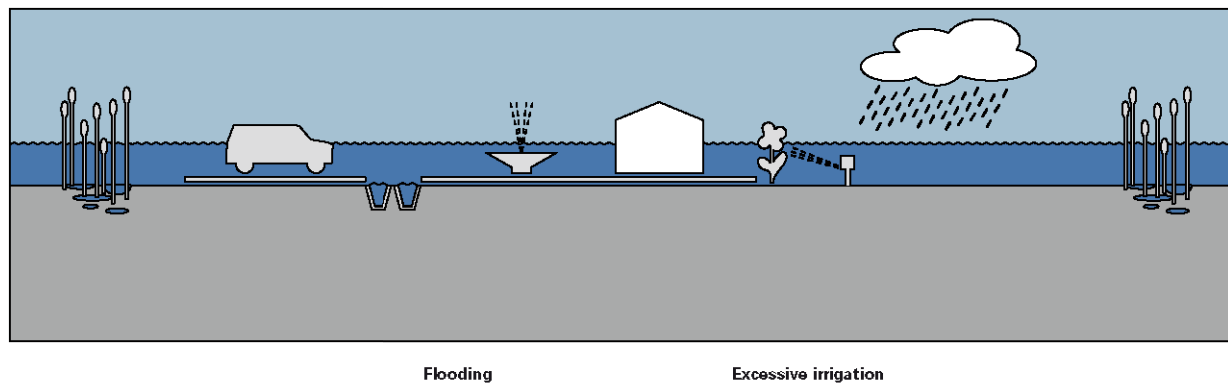


75-100% impervious surface

Runoff and impervious surfaces related to the landuse

As heavy rainfall occurs, the runoff can be retained to drain into the soil by different kinds of impervious surfaces such as streets or buildings. Depending on the degree of imper-

viousness of the surface, the evapotranspiration, infiltration and runoff can vary strongly and therefore cause diverse consequences on the quantity of runoff.



Consequences of transformed land surface

By draining the wetlands, new urban, industrial and agricultural areas could develop throughout Florida. Through the fact of making the landscape usable for housing, but also industry, a growth of sealing the surface was recognizable not only in zones where buildings started to spread but also along the huge network of roads and highways. Those changes had a considerable impact on the runoff characteristics as seen above, so challenges grew concerning the water balance. The consequences of growing impervious surfaces were flooded properties and roads. Only with a strictly organized concept of stormwater runoff systems, the problems due to impervious surfaces could be contained nowadays. Also due to larger properties and gardens, lawns were irrigated in excessive ways and therefore consumed huge amounts of water.

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Tampa Bay Flood Prone Area

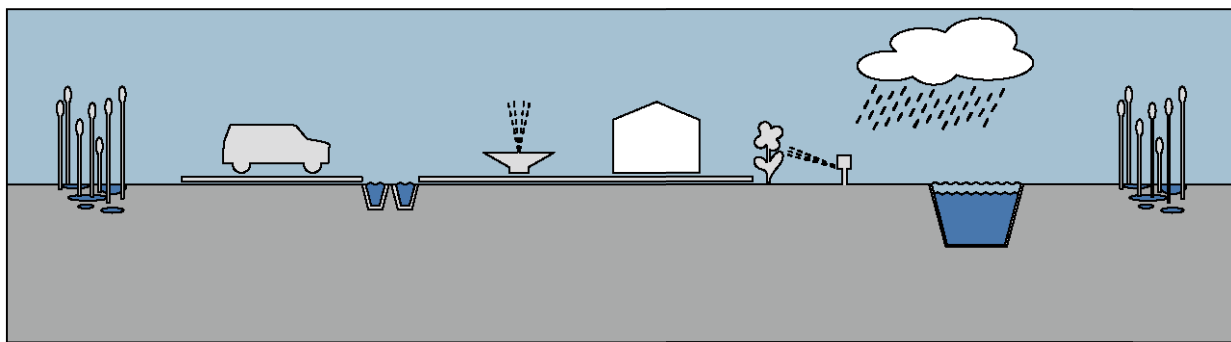
Flooding hazard

Due to the combination of intense rainfall and sealed surfaces, Florida became an area with an accumulation of severe floods. The extent of insurance to pay for a property may vary strongly depending on its chance of having a flood there. The FEMA (Federal Emergency Agency) releases maps of flood prone areas that identify zones that may be flooded during a 100 year storm event. Those properties are required to carry flood insurance.



Excessive irrigation

In a typical Florida household, the water used to irrigate the lawn makes over 50% of the total water consumption. Also, homeowners water their plants during midday, when the temperature is highest and due to evaporation, the water amount that sprays out of an irrigation system doesn't match the amount finally draining into the soil.



Florida friendly plants Stormwater pond

Step towards controlled water practices

When the rain falls down on impervious surfaces, the runoff flows into ditches or swales which send it to a stormwater pond where the water can finally drain into the ground. A stormwater pond is primarily designed to prevent the surrounding area from flooding.

Laws require property holders and developers to have stormwater ponds which results in a landscape consisting of a mixture of buildings, streets and the obligatory lakes. The floridian territory displays many waterbodies, many of them existing due to the requisite of stormwater ponds.

Considering the lavish use of water, different programs aim to minimize this water use by recommending variable solutions such as micro irrigation or the use of specific lawns and plants. Also, water shortage restrictions can be declared in dry season. For example, landscape irrigation can be limited to two days a week.



Stormwater pond as flood protection

Beside its main purpose to prevent floods, a stormwater pond also removes pollutants from the water draining into the groundwater. In the past, due to the continuous growth of impervious surfaces, stormwater runoff became a primary source of pollution. Therefore, in the 1980s the floridian legislature made laws requiring the treatment of stormwater in stormwater ponds.



Aquascaping as decorative and filtering element

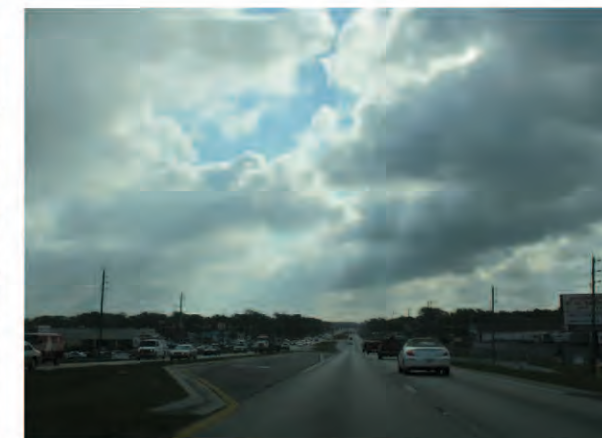
Landscaping the shoreline of a pond is called Aquascaping. Those specific plants help to filter the pollutants contained in stormwater runoff. Further they can serve as a provider for a broad habitat.



Florida friendly landscaping and microirrigation with reclaimed water

This program recommends using low maintenance plants and environmentally sustainable practices. It gives hints on how and when to water specific plants efficiently.

Also the precise application of water to a plant can improve the efficiency of irrigation. By watering plants using microirrigation, the water is directed to the root and therefore a lot of water can be saved in comparison to water sprayed over plants. Further, irrigation with reclaimed water is being suggested by different organisations to save on drinking water.



Evacuation roads

Another kind of protection from flooding consists in organizing the territory in order to be able to evacuate inhabitants in case of an emergency such as an approaching hurricane. Evacuation Route signs are found in coastal areas to point residents where to escape during severe storms.

AGRICULTURE WITHDRAWAL VS RECHARGE

This enormous economic branch transplants huge amounts of water. Agriculture represents the highest water consumer in Florida. This chapter tells a story which starts at the process of enabling to plant something by controlling the amount of water that has to be drained from the surface and applied to the crops. But as immense water amounts are needed to irrigate the Floridian crops, alterations in the ground can happen as the water table sinks. This fact can lead to catastrophic consequences delineated in this chapter. To replenish the aquifer, different techniques are applied.

Sinkhole

Well

Groundwater

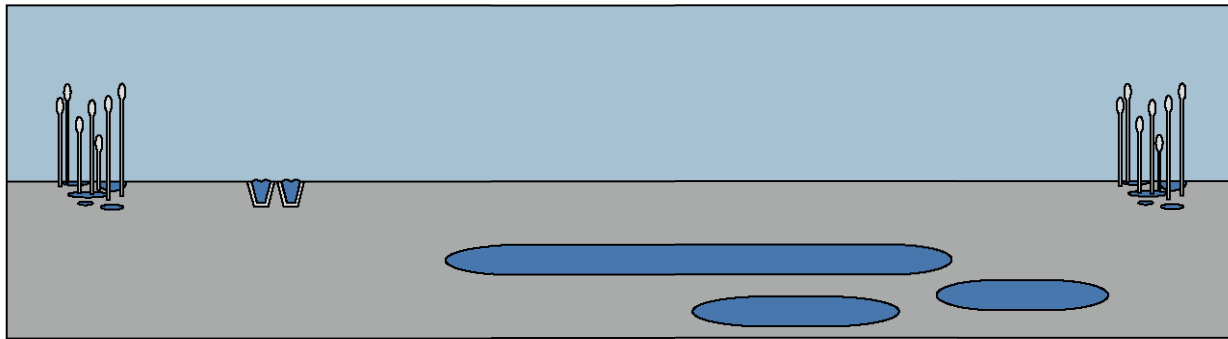
Agriculture

Irrigation

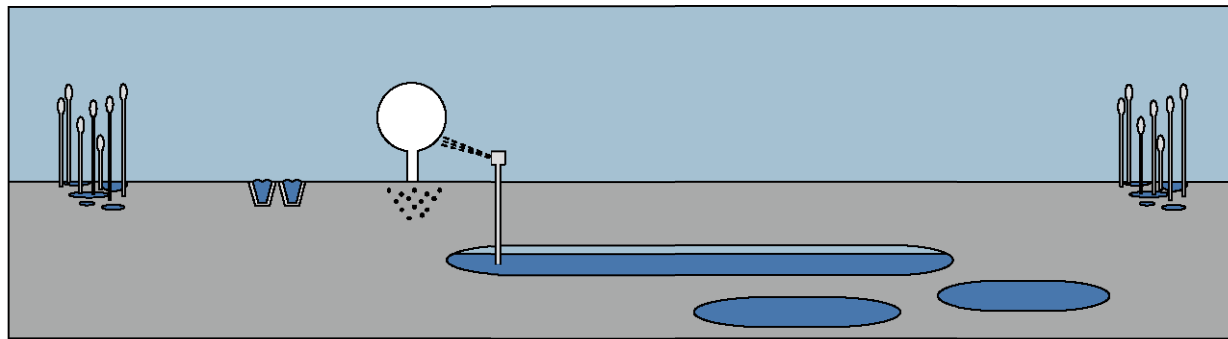
Fertilizer



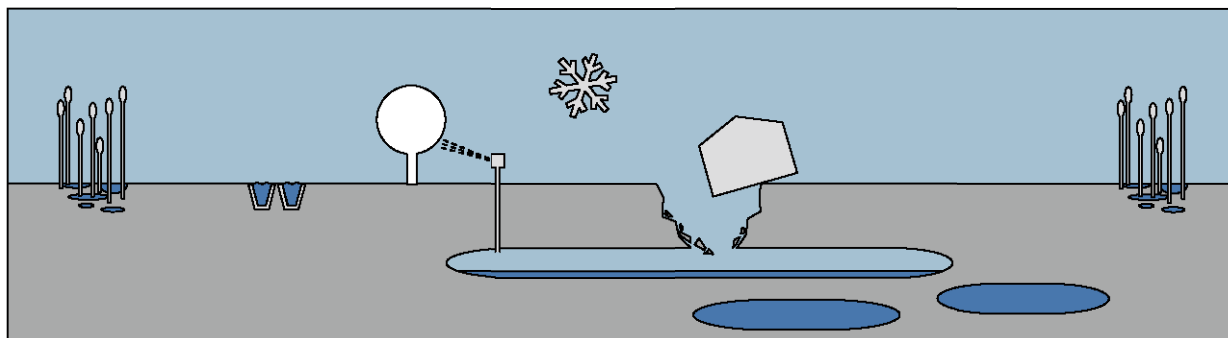
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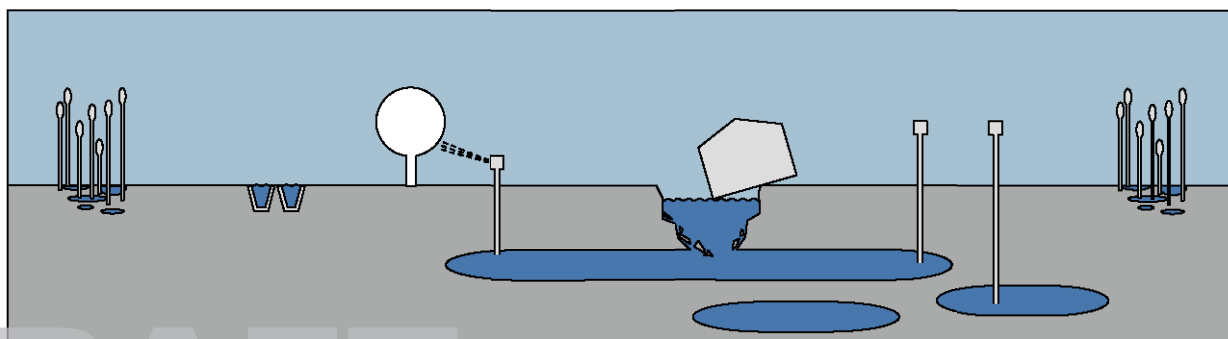
Drainage of water landscape



Cultivating the water landscape



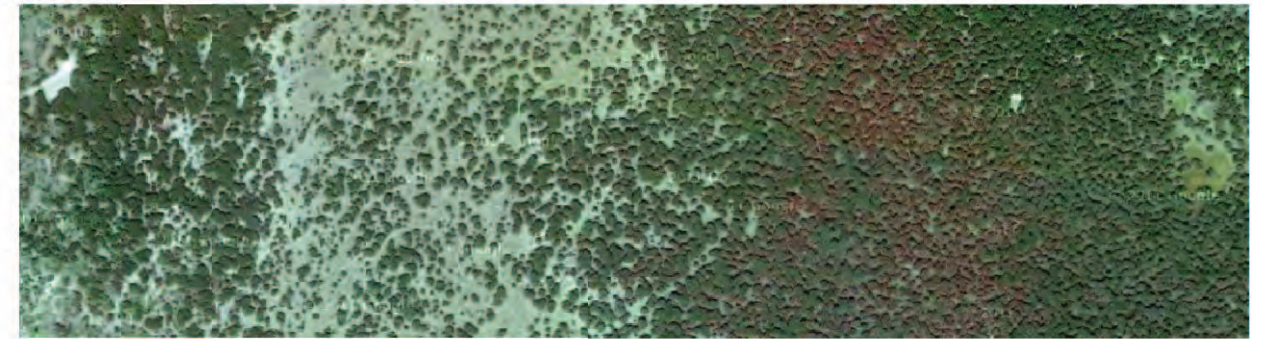
Excessive irrigation due to cold snap leads to sinkhole



Wells to recharge and stabilize the underground reservoir

Story about agriculture and water; from aquifers to sinkholes

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Wetland areas inbetween drained surfaces



Agricultural landscape

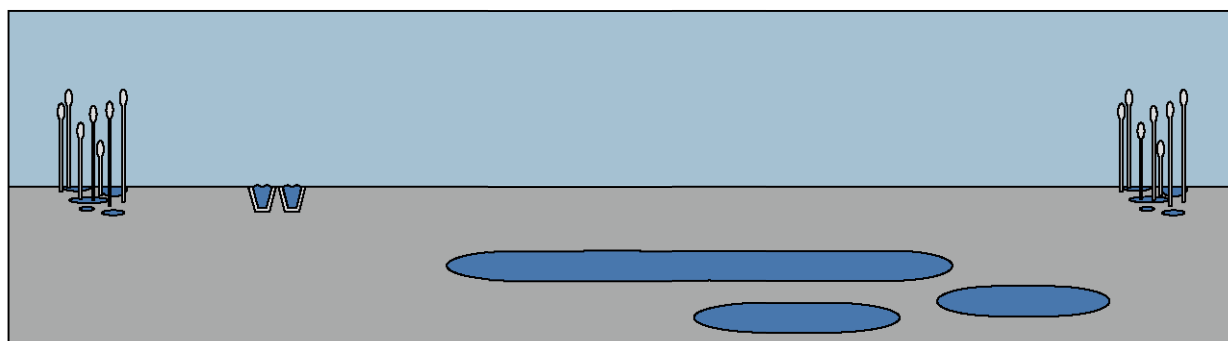


Sinkholes become lakes



Sinkholes as a repetitive and continuously growing phenomenon

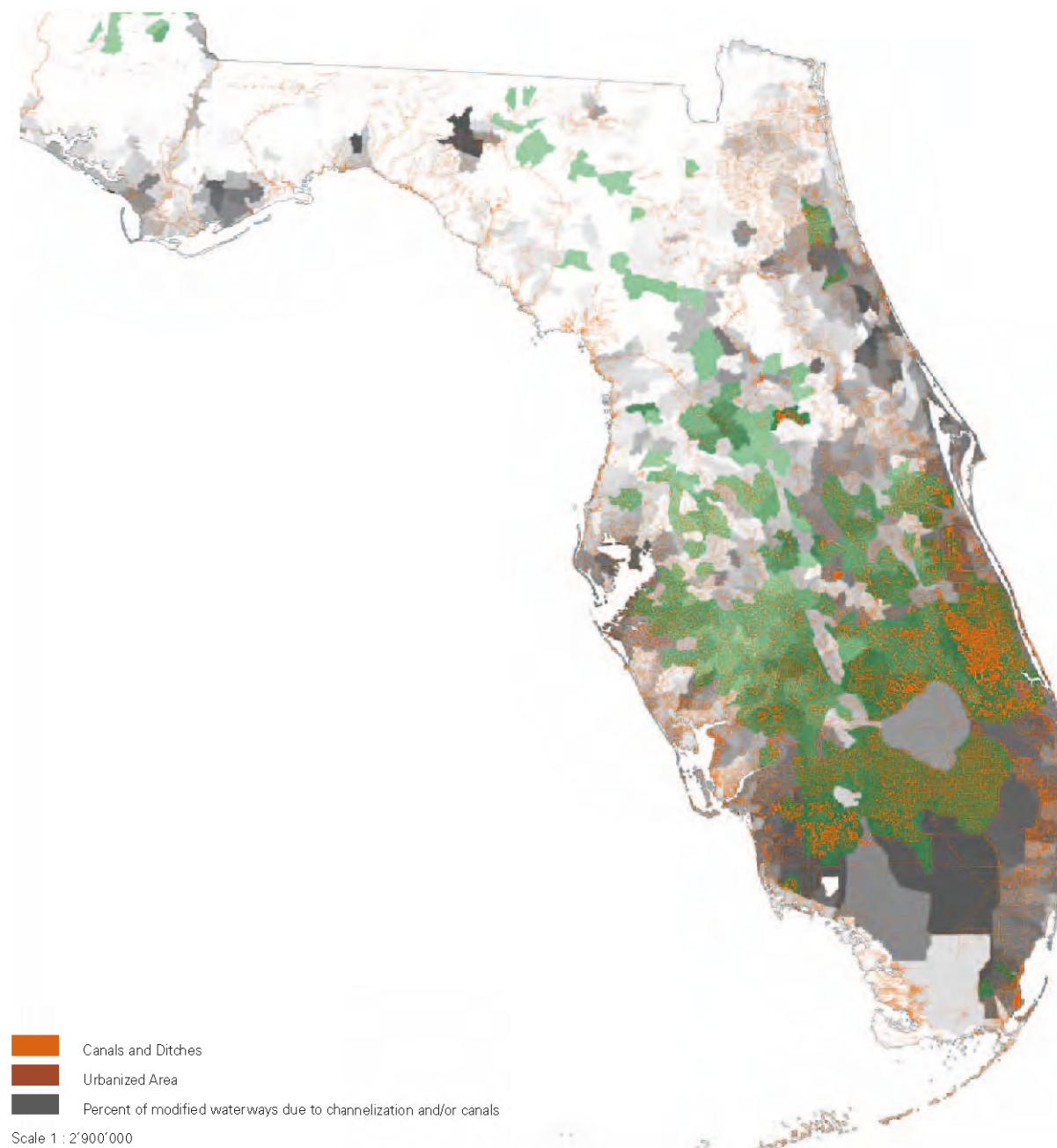
100m



Drainage

Enabling agricultural landuse

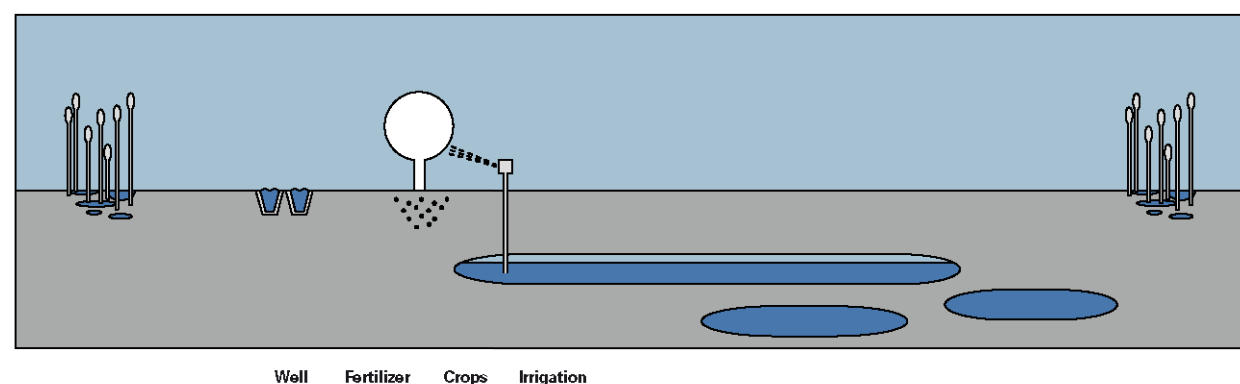
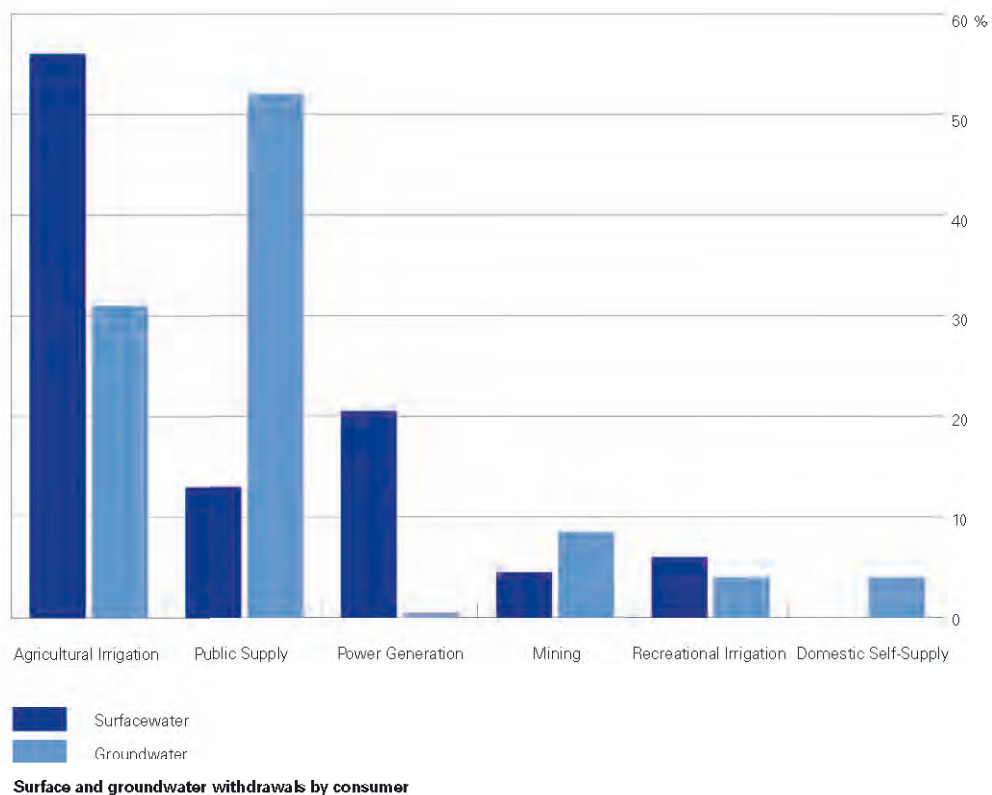
As a starting point, agriculture in Florida had the problem of having a landscape inundated by water. Wetlands covering most of the areas, agriculture could not set its foot to Florida without a major transformation of the water landscape. Ditches and canals allow to controll the conduct and drainage of the water which is fundamental for agricultural cultivation.



The draining system of agricultural land

This major transformation of the water landscape consists in building dikes and canals to be able to get rid of the excess water of the ancient Floridian landscape. Only

by draining the land, it got suitable for agriculture, which became an immense branch of economic activity counting about 47'500 farms which cultivate and cover about 9.25 million acres of land



Cultivating the water landscape

Irrigation of an area that large explains why agriculture uses 42% of the total withdrawn freshwater in Florida. With this amount, it consumes more water than the public supply. Beside surfacewater, the irrigation of the crops also depends largely on groundwater. 31% of the total groundwater withdrawal account for agricultural irrigation. But the connection of agriculture towards groundwater is not only a story about freshwater withdrawals, but also about consequences in natural damages such as the development of sinkholes or the intrusion of saltwater into the aquifer. Also a closer look at groundwater contamination is made in this chapter.



Wells for groundwater pumping

To make irrigation possible through groundwater, it needs to be pumped through wells. Those wells can vary in size and depth. Many areas obtain good irrigation water from shallow aquifers. But also from the upper Floridian Aquifer, the most dependable water source, where wells range from 250 to 1,000 feet, water to irrigate the crops can be pumped up.



Citrus watering

Florida accounts for about 70% of the total citrus production of the U.S. Citrus farming uses the microirrigation technique. Compared to overhead sprinkler systems, it saves a lot of water.



Flood irrigation of sugarcane

Especially the irrigation of the sugarcane needs huge amounts of water. The growers irrigate and drain their fields by the method of subirrigation. Subirrigation means that a new watertable is created above an existing one or above an impermeable soil layer by pumping water into open ditches. Afterwards, it gets drained and the process is inverted.



Fertilizer stresses the groundwater

Fertilizer is responsible to a great extent for the growth of agricultural production. On the other hand, the different nutrients included in it drain into the soil, consequently the groundwater may get contaminated. Phosphate, one kind of nutrient, is gained in phosphate mining areas in central Florida.



Crop protection through icy insulation

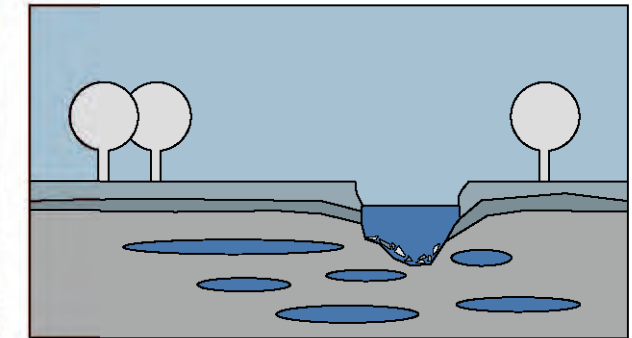
To protect the crop, farmers spray water over the plants during the night when temperatures fall below the freezing point. This insulates the base of the trees and concentrates the moisture in the fruit. Unfortunately, this technique needs huge amounts of water.



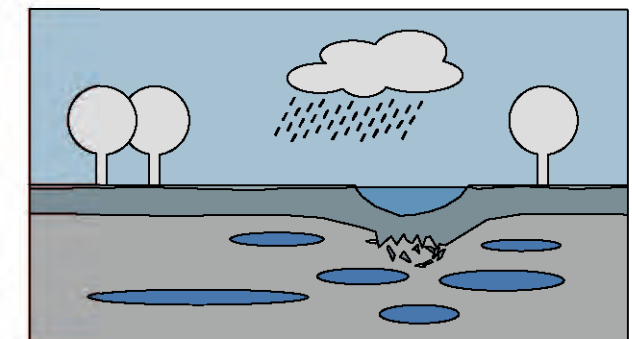
Accumulation of sinkholes

As the freeze of the early 2010 occurred on several consecutive nights, farmers had to spray their crops repeatedly during the night to protect them from getting damaged. The enormous amount of water withdrawn from the aquifer resulted in a severe drop of the groundwater table in the subjacent aquifer which had the consequence that several sinkholes started to open up.

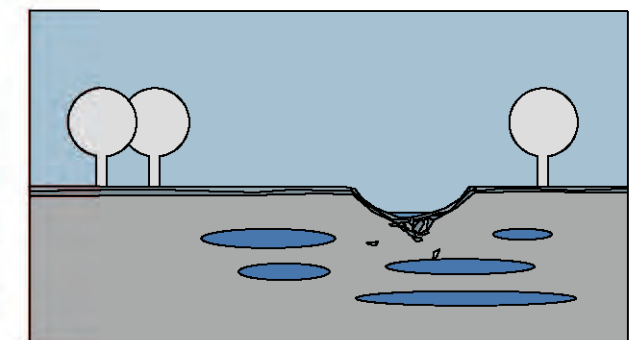
In general, the urban development accelerates the formation of sinkholes as urbanization causes alterations of the drainage flows, increasing water use and redistributions of the soil. Therefore, insurances assume, that since 1930, the amount of sinkholes caused by humans have doubled.



Collapse sinkhole



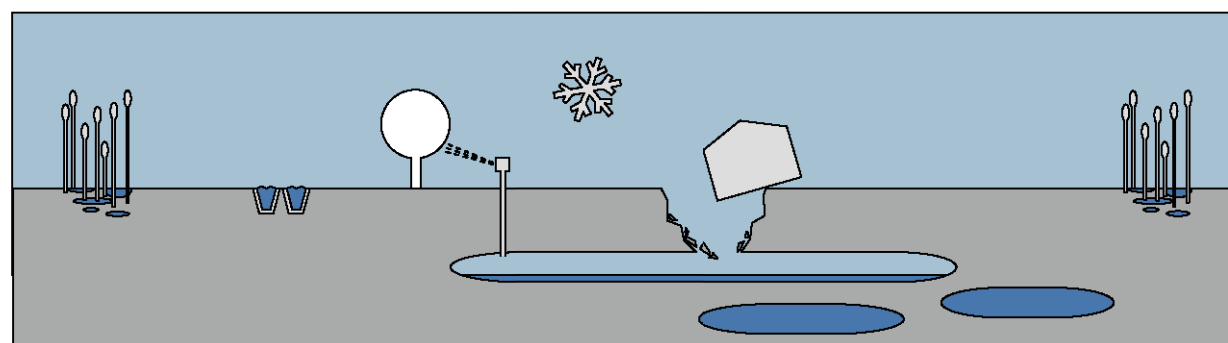
Solution sinkhole



Subsidence sinkhole

Types of sinkholes

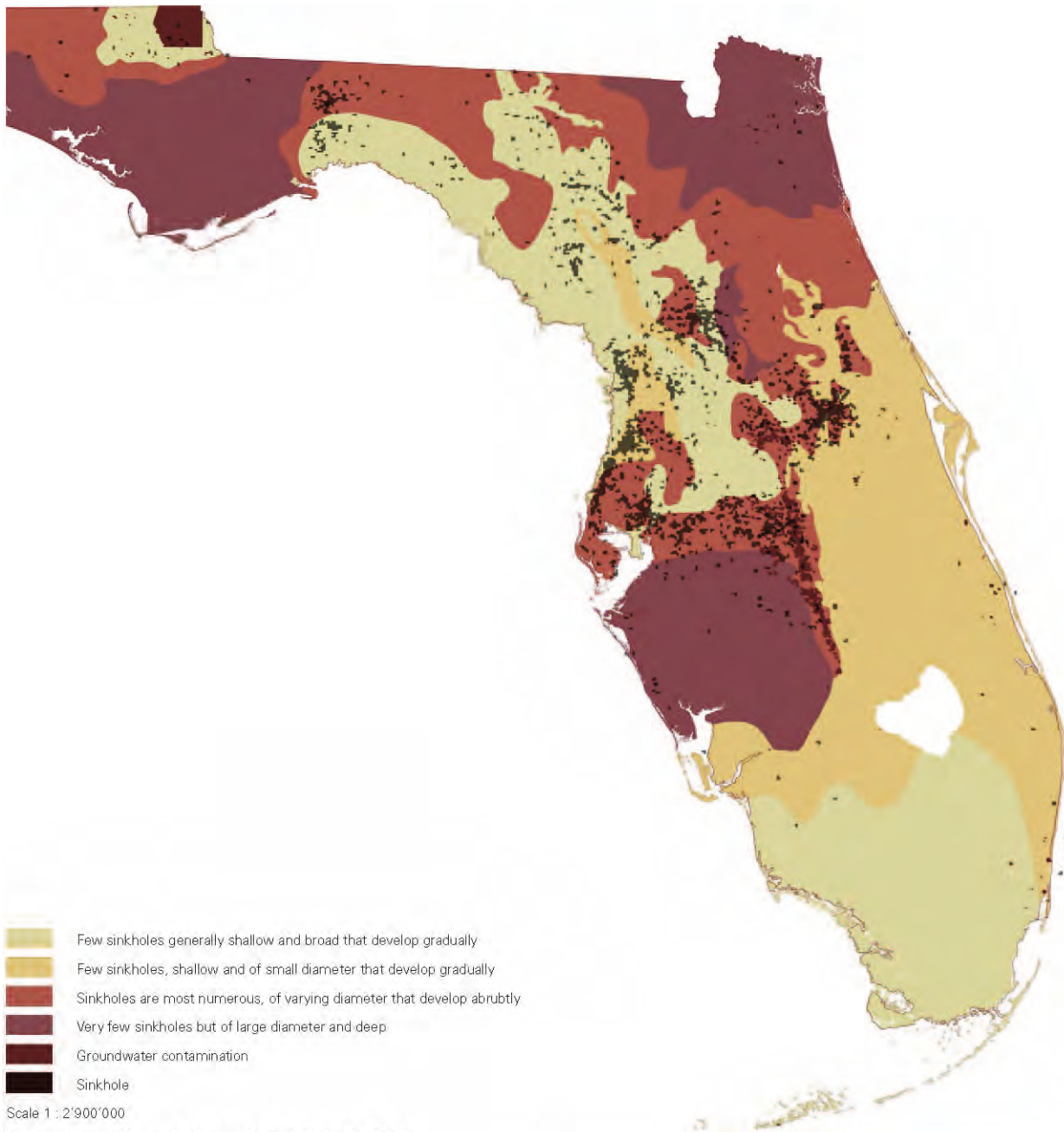
One distinguishes between the common collapse, the solution and subsidence sinkholes. A collapse sinkhole forms suddenly where the overburden is thick and the cavity's roof breaks through frequently due to fluctuations in the watertable. A solution sinkhole develops if the surface is dissolved slowly by erosion from wind, rain and surface water. It causes a growing depression in the surface. The subsidence sinkhole develops gradually. The overburden is thin and covers a layer of sand and gravel which erodes continually and forms a depression.



Excessive irrigation Frost Sinkhole Contamination

Excessive irrigation due to cold snap leads to sinkholes

Due to climate changes, frost occurs in regions, where it used to be warm enough all year long. A city with the name of Frostproof attests the frostfree region in central Florida. But in 2010, a freeze which lasted for several days made farmers fight against the loss of their crops. Therefore, irrigation was increased. Those protection measures had far reaching consequences in the ground. High amounts of water withdrawn from the aquifer can also result in another phenomenon called saltwater intrusion.



Different topographic conditions enabling sinkholes in Florida

The sinkhole topography

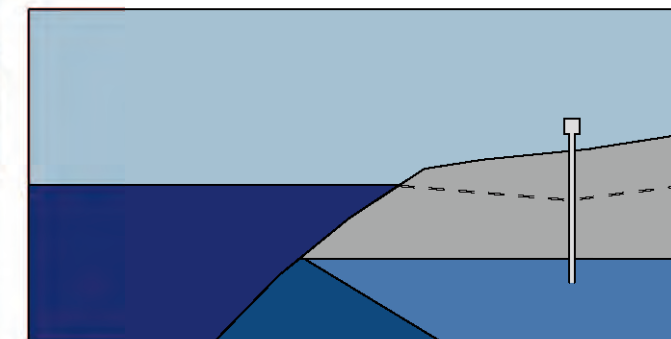
Florida's natural karst topography leads to the development of sinkholes. As the groundwater moves through the aquifer it erodes voids and cavities. When the watertable then starts to drop, those voids and cavities collapse due to lack

of support through the water. Consequently, on the surface sinkholes may develop and a direct connection between the surface and the groundwater is created. Therefore it is a major form of replenishing the aquifer.



Reduced spring flow

Spring flows have reduced in many floridian springs. In the past decades, an increase of water use through a growing population has caused a reduction of the level of the aquifers. As a consequence, the spring connected to those aquifers have reduced stream flows.

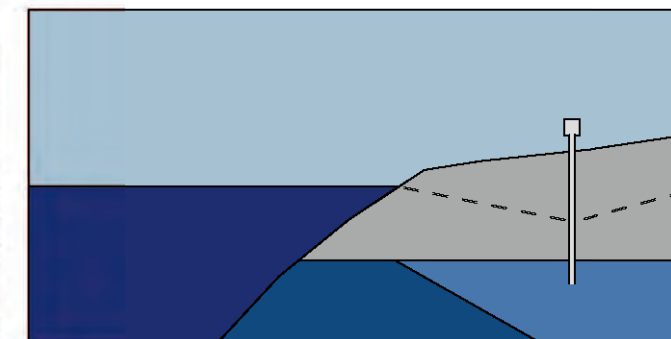


Well pumping groundwater from aquifer declining hydrostatic pressure



Groundwater contamination

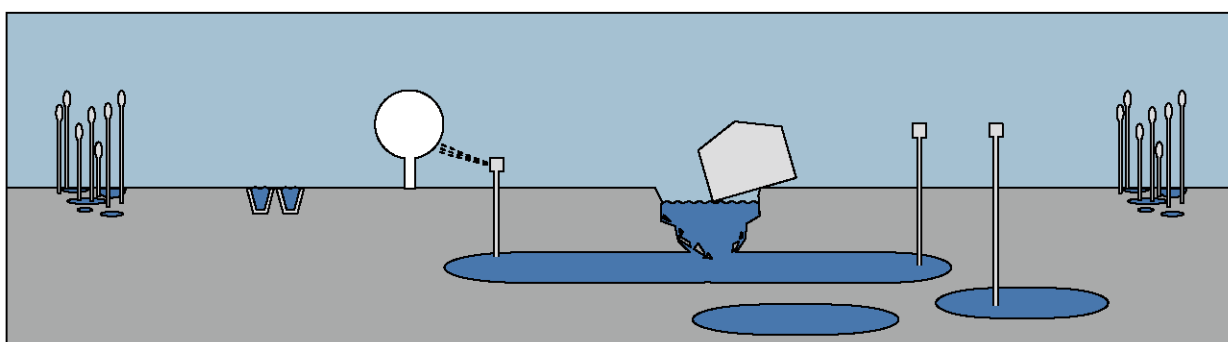
A collapse sinkhole represents a direct connection between the surface and the subjacent aquifer. Therefore it may cause groundwater contamination as pollutants can drain directly to the aquifer. Some people use sinkholes to store their garbage and waste which causes contamination as rainwater runoff can collect in the sinkhole and drain into the groundwater. In december 2010, a 13 meter deep and 23 meter wide sinkhole opened under a landfill in eastern Hillsborough County.



Saltwater flows into aquifer and groundwater becomes brackish

Saltwater intrusion

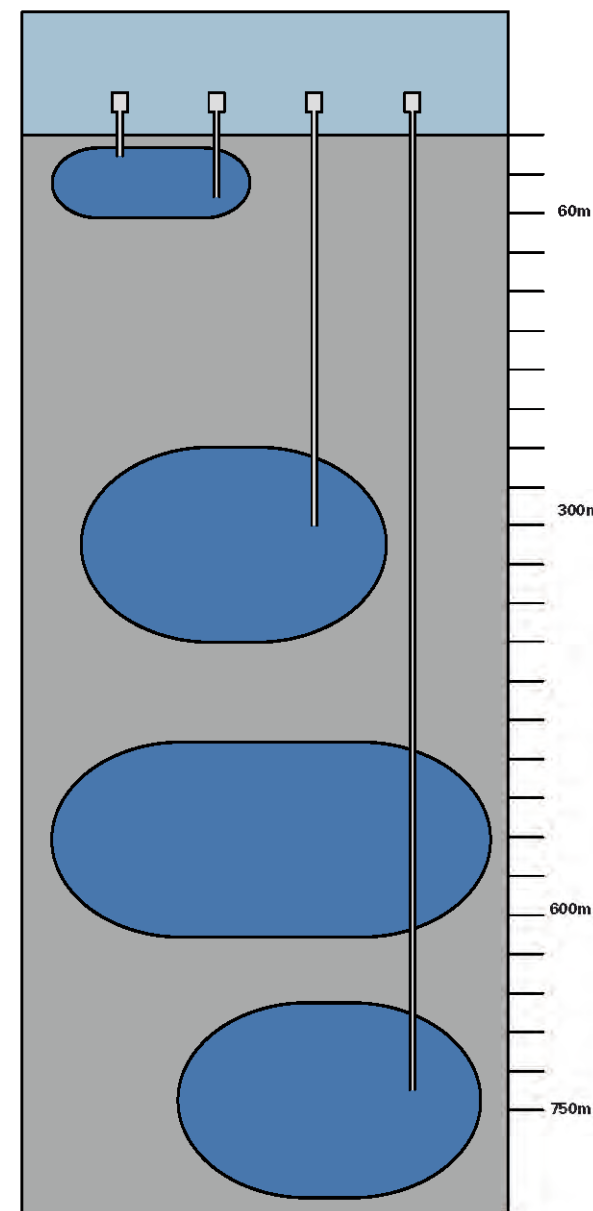
This groundwater phenomenon may occur either naturally when a storm/hurricane pushes saline water into the aquifer's freshwater or through human interaction. As groundwater is pumped out of the aquifer through wells, the water table sinks and the hydrostatic pressure declines. Therefore, in coastal areas, saltwater from the ocean can be pulled into the aquifer. The freshwater then is contaminated by saltwater. A mix of fresh- and saltwater can occur. This mixture is called brackish water. Therefore, saltwater intrusion poses a problem to the drinking water, as brackish or saltwater isn't potable and would have to run through desalination treatment to be usable again.



Aquifer refill ASR

Wells to recharge and stabilize the underground reservoir

As too much water is withdrawn from the aquifer through different types of wells, either above-mentioned sinkholes or saltwater intrusion may happen, another scenario is that the groundwater level sinks and no water gets through the well anymore. To avert this from happening different kind of aquifer recharge systems exist. Natural aquifer recharge happens through wetlands, lakes or urban runoff. Except for the wetland, the lakewater or urban runoff can contain pollutants which will then drain into the groundwater. Beside those natural draining processes, techniques have been invented to recharge the aquifer.



Different depths of wells depending on the use of the withdrawn water

Artificial recharge

Natural recharge happens through infiltration of the rainwater. Artificial recharge may be used to store treated sewage effluent and excess stormwater runoff for later use. This water is pumped into areas below the Floridian Aquifer.



Aquifer storage and recovery

In times of excessive availability of water as in the rainy season during summer, treated or untreated water is injected into the aquifer. This water already has to meet Florida's drinking water quality standards. If needed during drier seasons, the water can be withdrawn through the same well and be pumped into the water supply system. ASR stores water that would have been lost to the tides or to evaporation. Therefore it is a very important feature to manage the water supply as it balances the demand for water.

INDUSTRY - STRAIN OF URBANIZED SURFACEWATER

This chapter tells the story of the water flowing from the spring through different surfacewaterbodies towards the bay. On its way, the water meets different sorts of industries. One major user is the phosphate mining which withdrawals and releases surfacewater. Also, surfacewater is used to supply large areas with freshwater. Therefore, a big infrastructural system is set into place to gain and treat water. The water flowing into the bay finally comprises different traces of the various forms of water use.

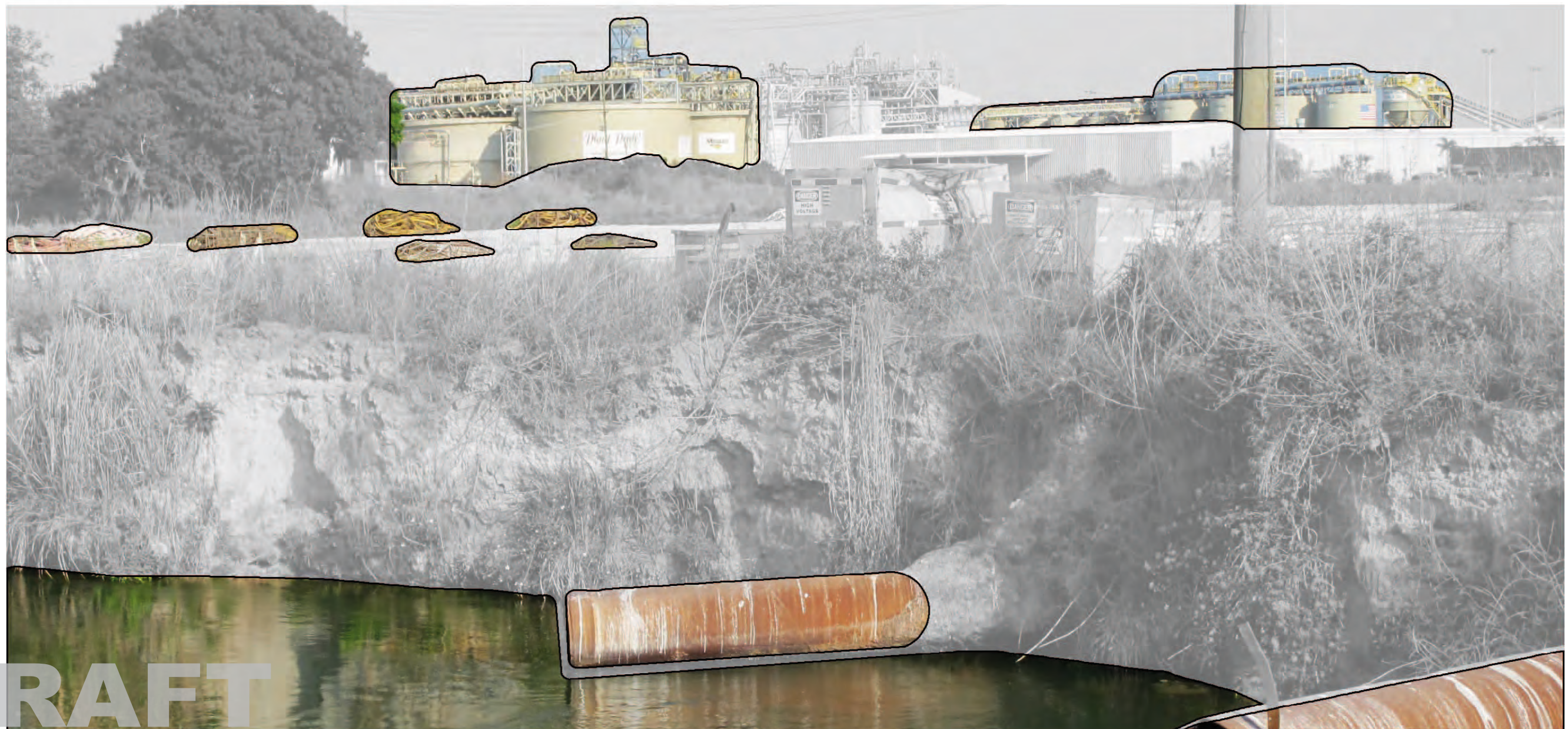
Surfacewater

Water Quality

Phosphate Mining

Water Supply

Water Treatment



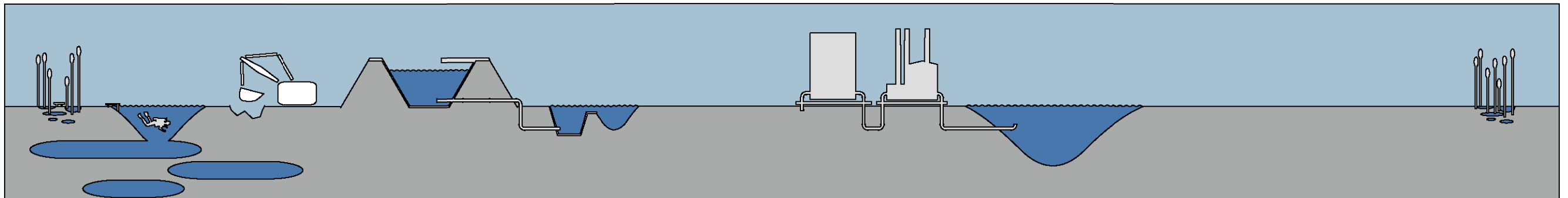
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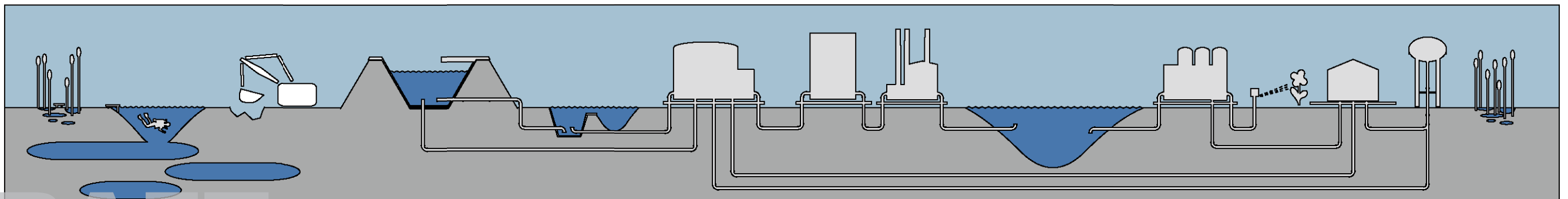
Affected surfacewater due to human impact



Phosphate mining



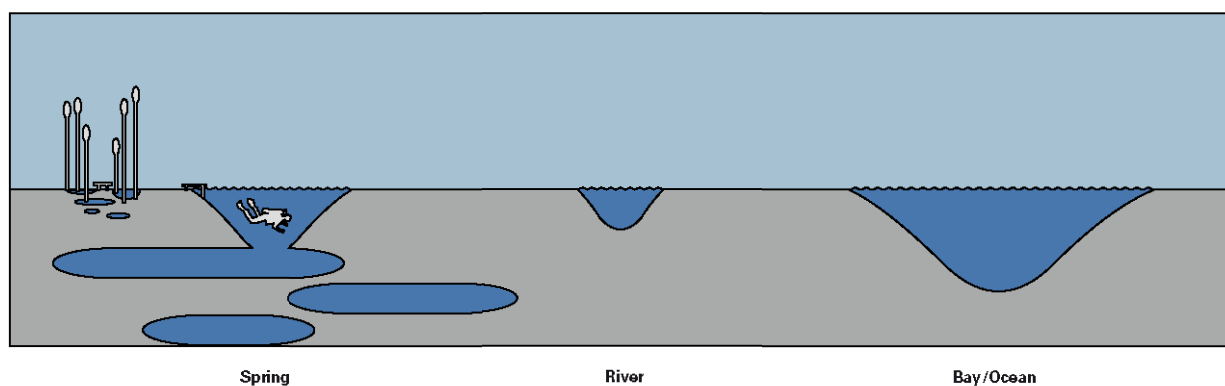
Water supply facilities



Water treatment facilities

Story about Industry and water; strain of urbanized surface water

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Affected surfacewater due to human impact

The different kinds of surfacewater in Florida have gone through some major changes, which have mainly a connection to the urbanization of the landscape. A seizure of the surfacewater happened to be able to supply and satisfy human activities. Those can be leisure activities but also the supply of drinking water from the surfacewater source. The use of surface water as a water supplier is believed to grow in the future as the steady growing demand for freshwater may not be satisfied with groundwater anymore. Also, by somehow urbanizing the surfacewater, dangers of contamination are presented in this chapter.



Diver exploring the depths of a spring



The Hillsborough River



The Alafia River



Springs as funparks

Florida's springs have been a major attraction for people for hundreds of years and still are today. Some springs developed a fun park like concept to attract people. The Weeki Wachee Spring offers for example underwater theater plays. Beside fertilizer, such leisure activities can lead to pollution of springwater. The South West Florida Water Management District supports passive use of springs, such as fishing, wandering around but it doesn't suggest active leisure use for springs as the above-mentioned underwater theater.

River as water supplier

The Tampa Bay area has two major natural watercourses called the Hillsborough River and the Alafia River. The City of Tampa's drinking water is mainly based on treated water from the Hillsborough river. As upstream Alafia River, mining companies are located, the fluoride concentration is 10x higher than in other rivers. Fluoride strengthens bone and teeth but in exceeding quantities it damages not only the human body but also the habitat.



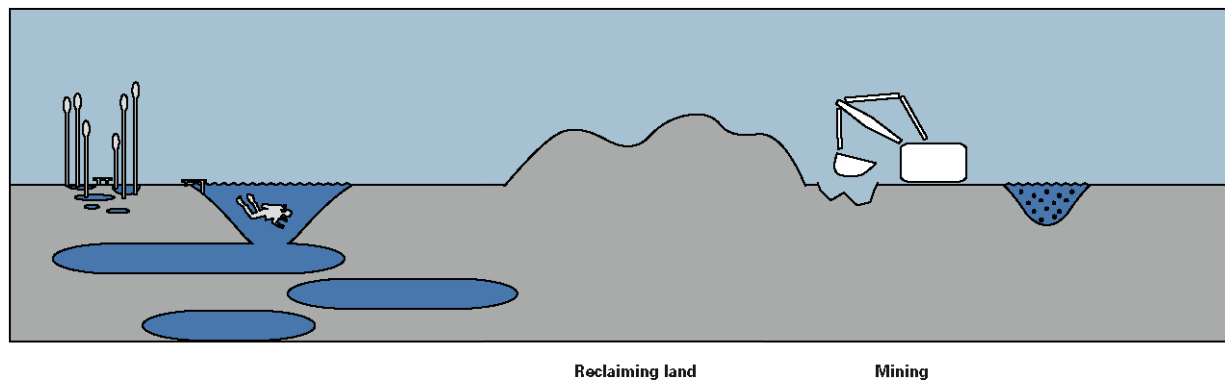
Lake as attractive urban component

There are several thousand lakes in Florida. Some of them were naturally formed, mostly through erosion like sinkholes, some of them were artificially made whether for aesthetic pleasure, flood control, stormwater treatment, irrigation, fishing or recreation and more.



Ocean as touristical attraction and final destination of the water flow

With a coastline of over 1'100 miles, the ocean is a major attractor for floridian tourism but also for. Tampa Bay is Florida's largest open-water estuary with about 400 square miles. An estuary is a water body where freshwater mixes with saltwater. Tampa Bay knows pollution through stormwater runoff containing fertilizer as well as through atmospheric depositions from cars and power plants. An excessive amount of nutrients causes a growth of algae which takes the oxygen out of the water and endangers the habitat.



Water flowing through the phosphate mining industry

Phosphate is mined to use in the production process of agricultural fertilizer. In Florida, phosphate mining occurs especially in the so-called Bone Valley in central Florida. The area, which includes Hillsborough, Polk, Hardee, Manatee and Desoto County mines over 90 percent of Florida's phosphate. There are 27 phosphate mines covering more than 491,900 acres of land in Florida. Mining is a major floridian industry and uses huge amounts of water for the mining process. On the other hand, mining companies claim to recycle up to 95% of the water.



Land changes through digging and watering

Annually, 4000 to 6000 acres of land are disturbed by phosphate mining, about 25 to 30% of the disturbed areas are wetlands, which means that along with the high water use comes a destruction of Florida's natural water landscape.



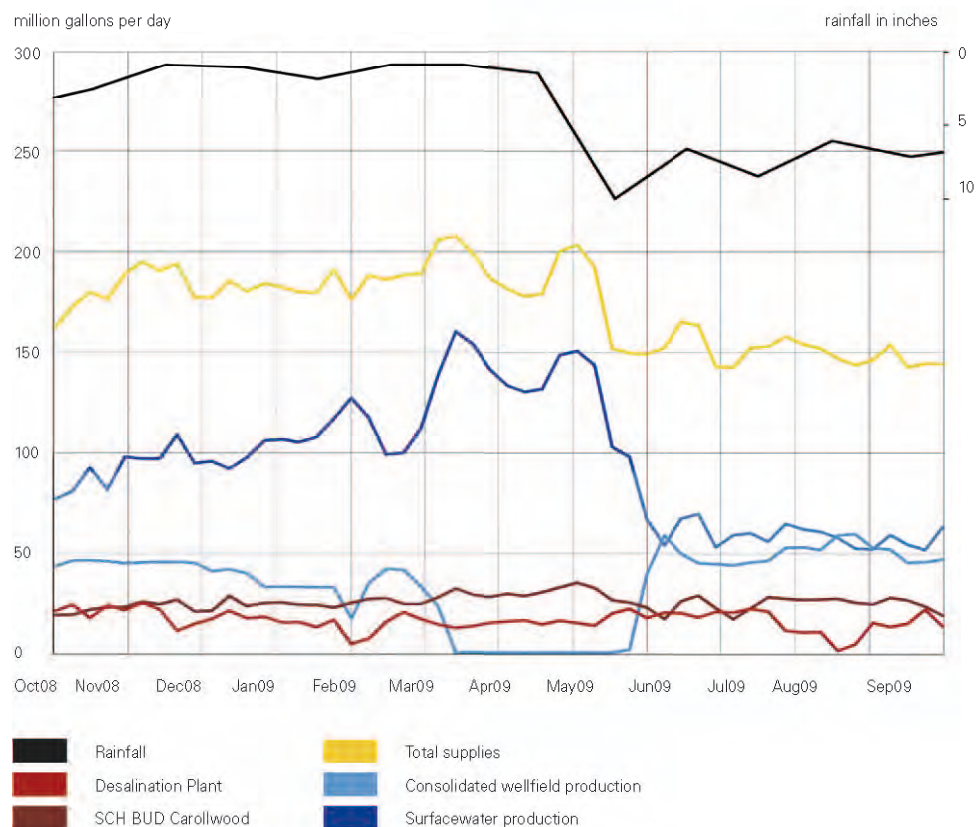
Water as main element of mining procedure

The mining industry accounts for about 8.5% of the total groundwater withdrawals and about 4.5% of the total surfacewater withdrawals in Florida. The matrix (phosphate, clay and sand mix) is mixed with water to create a slurry which gets pumped to the washing plants where the phosphate is separated from the other materials. Waste products settle then in huge ponds. Those processes change the concentration of natural materials which results in making them hazardous. This concentration influences the ecosystem in the bay, as the pollutants flow over the river into the bay.

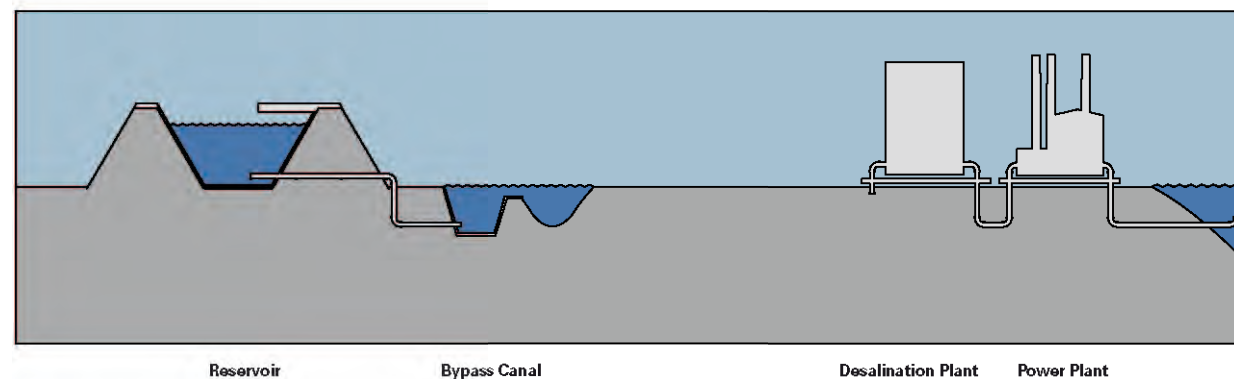


Renaturation of reclaimed land

About 71% of the phosphate mined land since 1975 have been reclaimed. Annually, an average of 4000 to 5000 acres is reclaimed and since 1996, for every acre that is mined, another acre has to be reclaimed. Concerning the quality of reclamation, only destroyed wetlands have to be restored to their original condition. Reclaimed land may be used for recreation, pasturage, industry or homes.

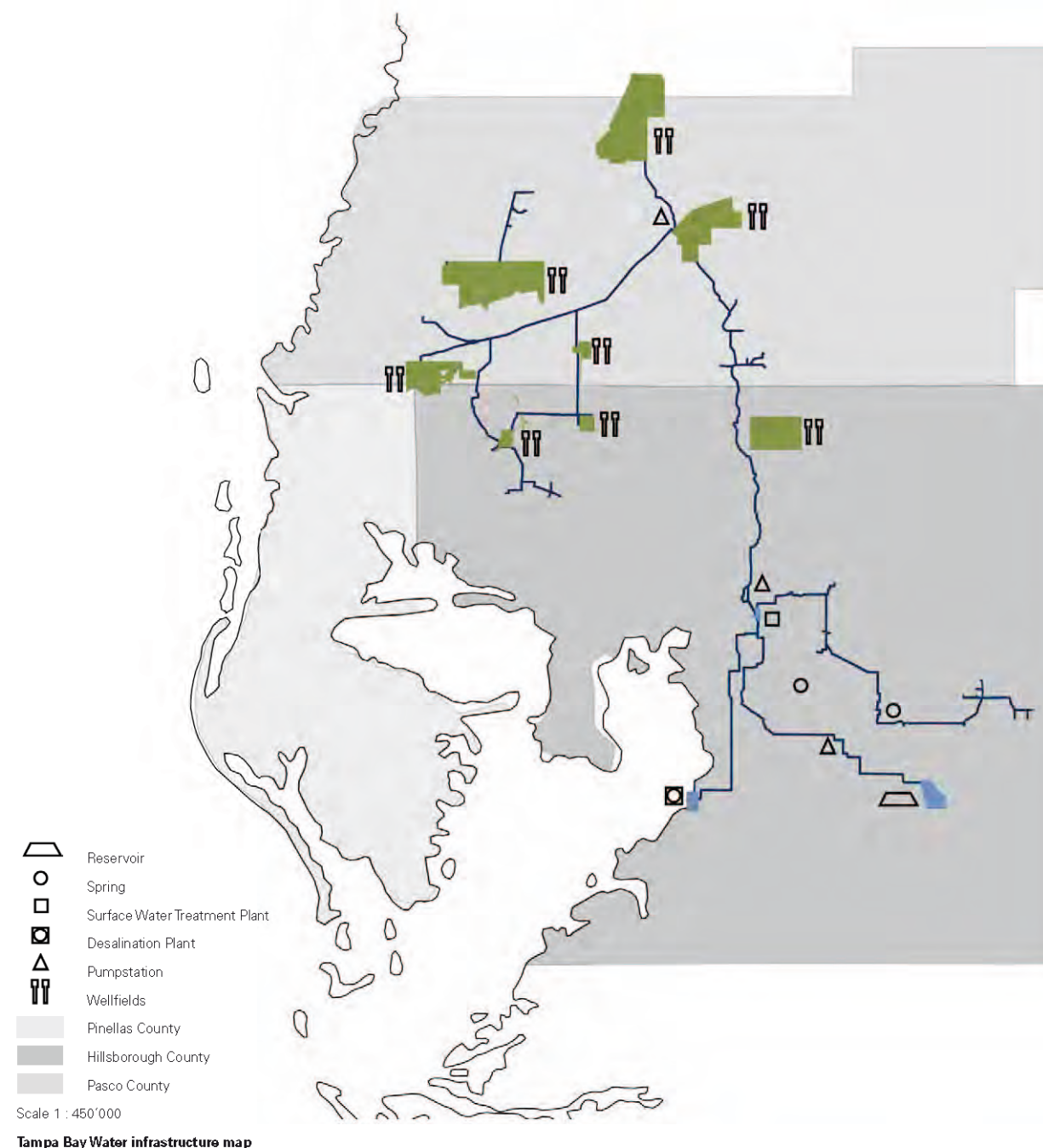


Water supply mix produced weekly in 2009



The water supply industry

To supply a state like Florida with freshwater, some efforts are required. Due to seasonal changes of precipitation, the availability of water can change. To balance this availability, different infrastructures are set in place. The source of the water running out of the tap in a household in the Tampa Bay area may vary a lot depending on the season. From October through April, the amount of rainfall are high and therefore, surfacewater production is high as well. When there's less rain during summer, groundwater is withdrawn from the aquifer and sent to the different users. Beside the seawater desalination plant, also the C. W. Bill Young Reservoir as well as the Tampa Bypass Canal help to balance the varying water amount.



- Reservoir
- Spring
- Surface Water Treatment Plant
- Desalination Plant
- Pumpstation
- Wellfields
- Pinellas County
- Hillsborough County
- Pasco County

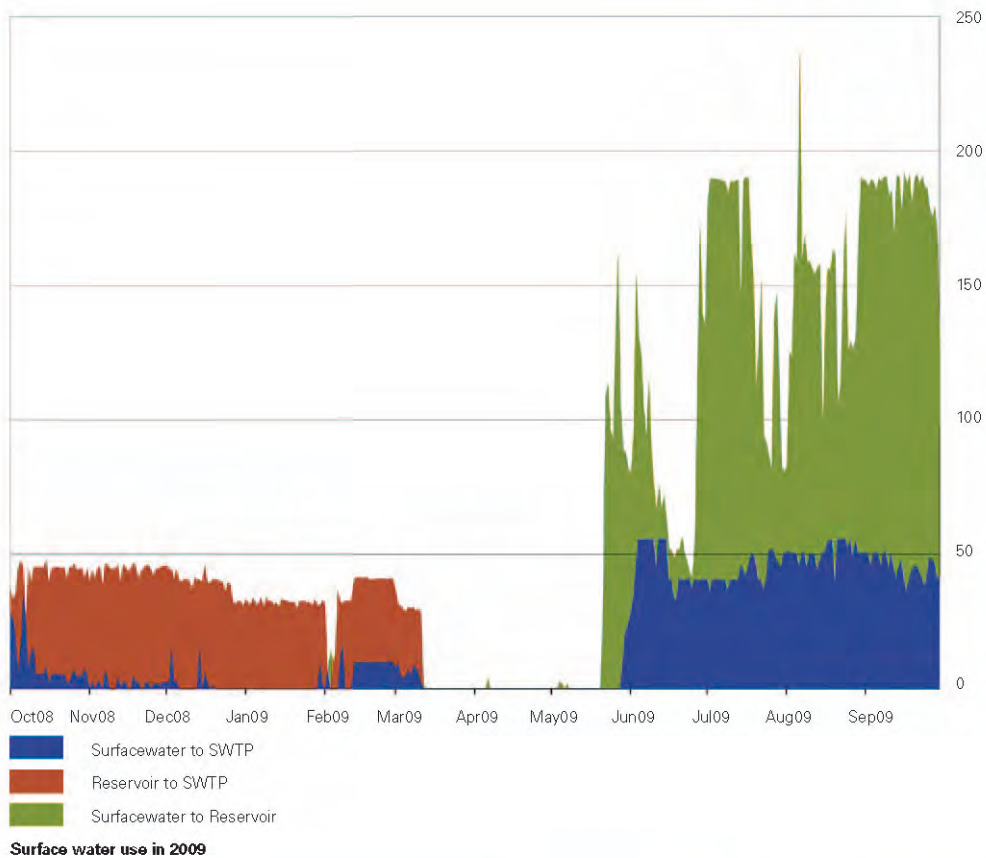
Scale 1 : 450'000

Tampa Bay Water infrastructure map

Tampa bay water

Tampa Bay Water is a wholesaler of water and is considered as a government but it has no governmental powers. They deliver drinking water to 3 counties - Hillsborough, Pinellas and Pasco - and 3 cities - New Port Richey, St.Petersburg and Tampa. To be able to deliver water to over 2,4 mio people, they have a whole system of water infrastructure helping them to be able to satisfy the de-

mand. Their sources of drinking water are groundwater at different wellfields, surfacewater including the Alafia and Hillsborough River, the Bypass Canal, the C.W. Bill Young Reservoir and the Tampa Bay Desalination Plant. The City of Tampa for example, can supply their own with Hillsborough River water, but during drought, they buy water from Tampa Bay Water.



C.W. Bill Young Regional Reservoir

This reservoir stores surplus water from the Alafia and Hillsborough River and the Bypass Canal. When water is needed during dry times, the reservoir water is pumped to the Surface Water Treatment Plant. Air that gets pumped into the reservoir at 10 positions in the reservoir. This is to mix the water and keep it from fouling.



Reparation

In 2006, cracks began to appear in the reservoir. When the reservoir carries less water, water pressure from underneath the concrete structure damages the walls of the reservoir. This shows that original calculations were flawed. Repair works are expected to cost nearly the same as the original cost of the infrastructure which was about \$146 million.



Wellfield

A wellfield is a location, where multiple wells bring groundwater to the surface. Several wellfields in the Tampa Bay area are installed and used by Tampa Bay Water to pump groundwater out of the different aquifers. Variable types, depths and sizes exist depending on different factors.



Tampa Bypass Canal

This 14-mile long waterway connects the Hillsborough River to the Bay and serves as flood protection but as well as water supply for the area.



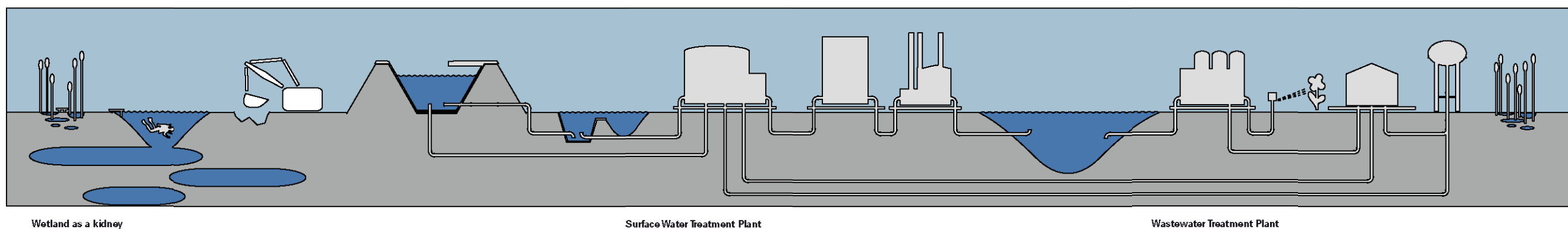
Desalination plant

This plant is a drought-proof water supply infrastructure for the Tampa Bay area. It can provide up to 10% of the regions need of water. The plant treats seawater through a reverse osmosis process and finally gets water with drinking water quality. Desalinated water from this plant is sent to the Surface Water Treatment Plant where it is mixed with other water sources but not treated. Also, minerals and salt are added to it.



Warm water from power station

The Big Bend Power Station withdraws and discharges seawater from Tampa Bay to cool the power plant. After this, The Tampa Bay Seawater Desalination Plant which is close by, catches parts of the warm water and treats it to drinking water.



The water treatment Industry

This industry either treats raw water to make it drinkable or it treats wastewater until it is clean enough to discharge it into a surfacewater body. Considering the Tampa Bay area, we look at their surface water treatment plant and their wastewater treatment plant. The Surface Water Treatment Plant SWTP of the city of Tampa treats water of the above-presented resources, blends and mixes them,

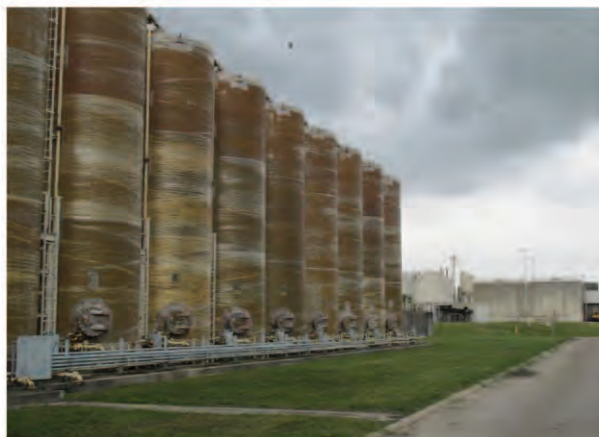
then pipes and sells the drinking water to the 6 local governments. The wastewater treatment plant WWTP treats sewage water from the whole city. Different programs aim to inform people about the use of reclaimed water from the WWTP to use as irrigation water.



Tampa Bay Regional Surface Water Treatment Plant

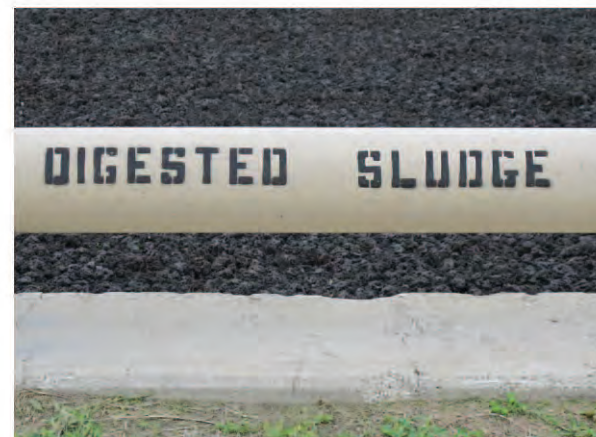
This plant serves as hub for the water supply infrastructure of Tampa Bay Water. It primarily treats riverwater from the Hillsborough and the Alafia river and the Bypass Canal, but it also treats part of the groundwater pumped in wellfields.

Desalinated water is only mixed but not treated at this plant. After treatment, the water is sent to the city where the government has different take-off points. Water that gets treated here, is used within 24 hours.



Howard F. Curren Advanced Wastewater Treatment Plant

This facility treats all wastewater from the City of Tampa. It can process up to 96 mgd. After Treatment, the cleaned water is either discharged to the bay or used as reclaimed water for irrigation or cooling. Only a very restricted area in the south of Tampa is tapped with reclaimed water to use for irrigation for example. Also, to be able to access the reclaimed water network which allows reuse, the customer has to pay for the installation of the systems and the pipes. Nevertheless, Pinellas County has a 100% reuse of reclaimed Water for irrigation or commercial and industrial use.



Water treatment byproducts

Beside delivering reclaimed water, this WWTP also produces electricity by burning methane gas that forms during the cleaning process. It generates about 25% of the total consumed electricity of the facility. Also the sludge used to clean the water in both the WWTP as well as the SWTP finally digests and gets converted to fertilizer.



Water tower as storage tank

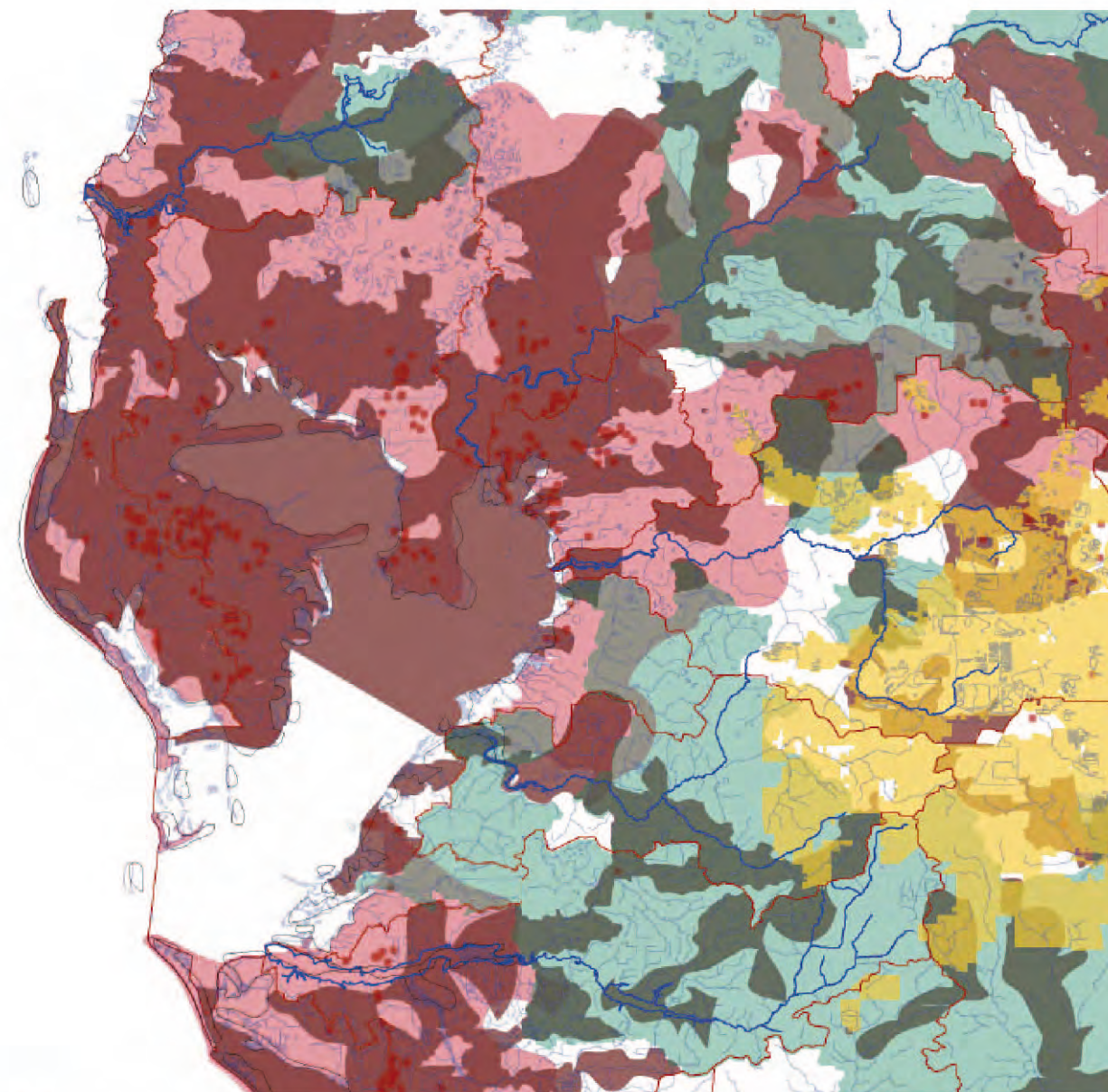
The excess water that the city receives is stored in water towers. In case that demand of water is suddenly increasing, those towers can deliver the stored water. They serve to balance the short term demand of drinking water.



Constructed Wetlands As Nature's Kidney

Among other functions such as flood control or habitat provider, wetlands filter pollutants and act as a kidney for Florida's water. Beside naturally existing wetlands, artificially constructed wetlands started to be built in Florida for

wastewater treatment. During this biofiltration, microorganisms remove about 90% and plants remove 7 to 10 % of the pollutants.



- Urban area
- Mining area
- Agricultural land
- Polluting facilities
- Major rivers
- Poor water quality

Scale 1 : 450'000

Surface Water Treatment Plant

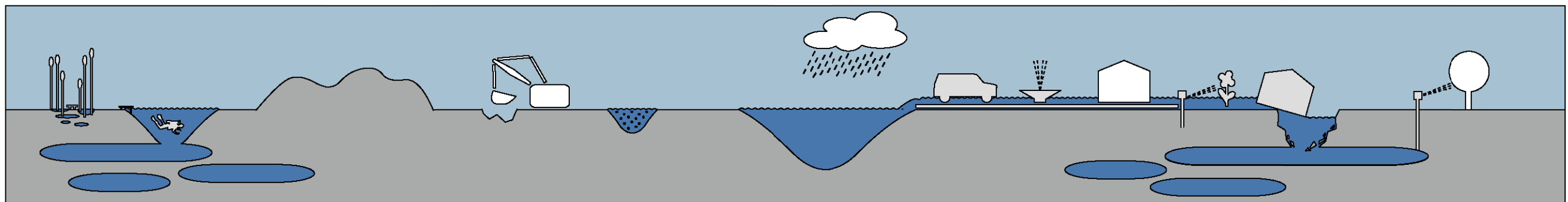
Water quality in the bay area

The above-pictured map shows the quality of the water in Tampa Bay which is rather poor. Impacts from the main water users pollute the water flowing into the bay. Urban areas account for contaminated runoff or polluting facilities, agricultural areas have fertilizer added to the water on one hand, on the other hand by irrigating in excessive ways,

they support the building of sinkholes which again leads to groundwater contamination. And the mining industry as well as the agriculture causes a blend of the water with an excessive amount of nutrients which then cause growth of algae. Algae take the oxygen out of the water and endanger the habitat of the bay.

URBANIZATION OF WATER LANDSCAPE - DEMAND FOR HYPER-CONTROL

While doing this work, we discovered that the water of the Floridian peninsula represents a rather complex topic with a huge amount of interconnectivities. The complexity of the Floridian watersystem leads to the fact that every change to the conditions will result in several consequences which can be rather severe. On the one hand, water gets banned from the surface, on the other hand water is a often used decorative element. This balancing act requires an enormous technical and organisational effort with the goal to be able to regain control over the water.



Large spatially defining effect due to rapid transformations

Rapid transformations which arose through the settlement lead inevitably towards a massive disruption of the watercycle. As explained in the previous chapters, the quantitative as well as the qualitative consumer behaviour lead towards contamination and topographic transformations as sinkholes. The landuse seems to be objecting with the former climatic conditions and cannot contain the chang-

es. Especially the pace of the territorial settlement and manipulation is responsible for the fact that the user doesn't adapt to the regional specific conditions. The aftermath, which consists in direct hazards for people, are inevitably new territorial conditions where mankind has to react to.



Water as a forceful limit

Already in its original condition the water acted as a generator of borders and limits. Rivers, lakes and the sea defined the land. The map from Bellin already shows clearly this fact that water divides and organises the territory. By humans taking over the authority, those borders were adjusted, newly regulated and controlled.

Not only in a spacial sense the water has its limits. Also considering nowadays role of the water as a product, has limits. Although we believe to find ourselves in a state with an exuberance of water, this work shows that qualitative good water is rather scarce than freely available.



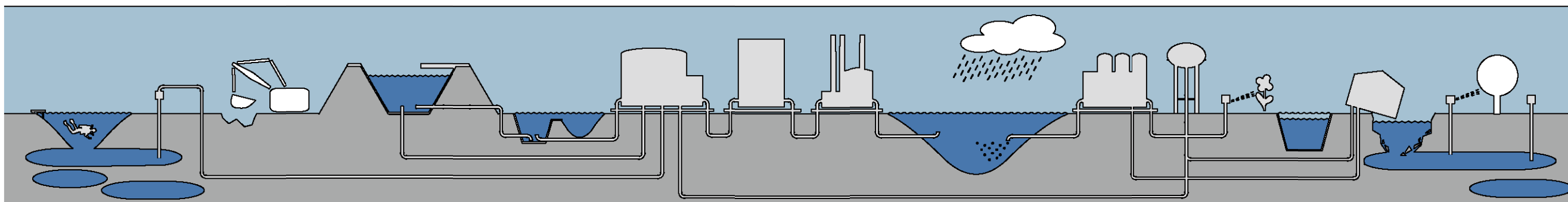
Drainage/sealing as watercage

Drainage and the resulting sealing of the surface have led to the fact that no natural balance can be obtained anymore and a devastating aftermath can develop. By avoiding the rainwater from draining on one hand areas are flooded, on the other hand groundwater doesn't get the automatic recharge that it needs. This has consequences on the surface of the earth, as the reduction of pressure from underneath can lead to a collapse. To work against those difficulties, complex and expensive installations have to be set in place retroactively.



Excessive water use

As the country of endless opportunities in Florida also seems to be the land of the endless water quantity, and the population growth was rapid and intense, a almost lavish consumption of water developed. For all primary elements of territorial occupation as agriculture, housing, power generation leisure etc water is fundamental. Through the use as well as through transformation from clean to filthy water the ecosystem is strained and destabilized. On one hand resources are burdened and on the other hand, a supplementary effort is needed for treatment.



Wish of total control through complex artificial water network

The consequence from the past transformations and their impact to the landscape lead to a utterly strong control over all activities. Mankind has to try to control and balance the new formed water system as ancient nature used to. As the new constructions differ this widely from any natural situation, enormous time, cost and effort are needed to reestablish a balance. Floridians achieve pioneering work to achieve this new balance by for example installing reservoirs. Even tough miscalculations led to cracks and expensive reparations, those acts show an urgent necessity for industrial intervention. The

effort to balance this new formed territorial system has its limits. Mankind produces, modifies and sells water even though the water in the city becomes a product and seems to be succumbing to total control of the humans, the water still has en neoumous force and inner autonomy which escapes to any human control. Therefore, the Floridians influences wth his acts, as we all do likewise, the watercycle, but is not abe to control the aftermath.



Tendence towards total control by institutionalizing the water

The control over the water has to be organised. The different jurisdictional instances and institutions establish strict and clear rules how to use water efficiently at least in terms of quantity. But it seems that the different organisations do not agree on the fact that the set of problems concerning water quality and contamination should start at the earliest possible point of influence as the water exits the soil, so that no excessive and disproportionate effort of water treatment is needed to be set into place and the natural environment suffers.



Tendence towards total control by industrializing the water

As showed in this work, the balancing act through industrial treatment of the water is enormous. Using technical instruments, emptied storage tanks can be replenished, contaminated water can be conveyed away or cleaned, already used water can be recycled and phases of water shortage can be balanced. Even originally natural elements as wetlands are nowadays artificially planed and set into place.

This begs the question if this industrialization of the water landscape represents a sustainable strategy or if maybe the strategies of urban development should be thought through again and vthe behavioral pattern or the sonsumerism of water should be reconsidered and adapted to regionally specific conditions.

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INSTITUTIONS

University of South Florida, Tampa
University of Florida, Gainesville