GROUNDWATER

101

LOST PINES
GROUNDWATER
CONSERVATION DISTRICT

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GROUNDWATER 101

INTRODUCTION

Groundwater is an important part of the water supply in Texas.

50%

OF ALL TEXANS **DEPEND ON GROUNDWATER** FOR DRINKING WATER

20%

OF ALL PUBLIC SUPPLY OF WATER COMES FROM **GROUNDWATER**

But what is groundwater?

This guidebook provides a basic understanding of groundwater – what it is, how much groundwater is out there, where it comes from and goes, and how it is managed.

WHAT IS GROUNDWATER?

Groundwater is water that is located beneath the ground surface in soils and geologic formations. More specifically, groundwater is water that fills in the pore space between particles, gravels, and rock fractures that make up the earth. Since all groundwater moves in the subsurface, a little understanding of geology is helpful. The geology of the basin is made up of many materials that can have many different shapes and forms as seen in Image 1 below.

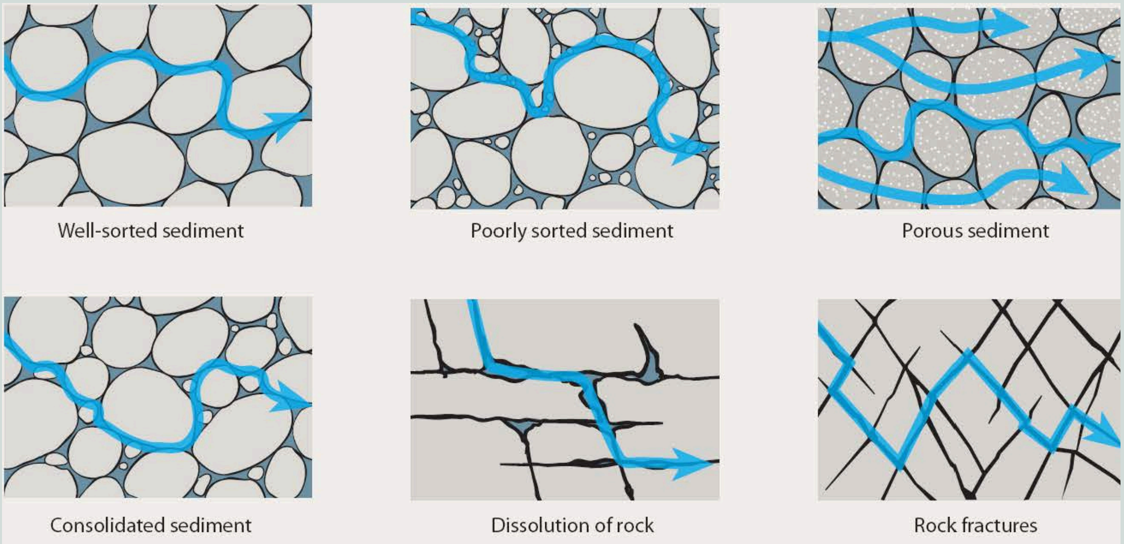

Image 1: Groundwater in diferent sediments and rocks.

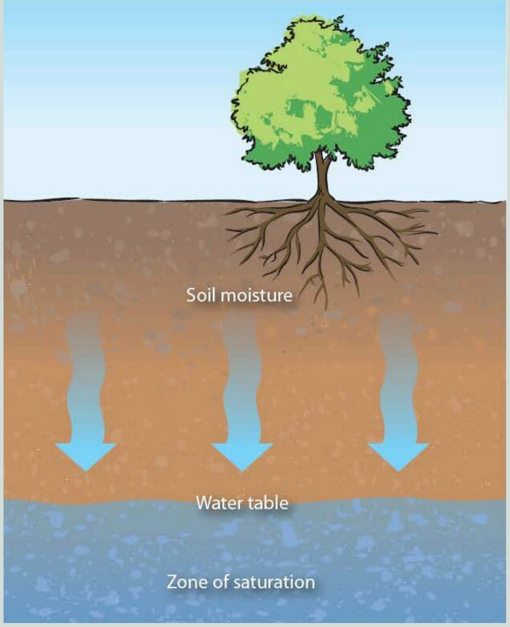

Image 2: Soil moisture percolating down to the water table and accumulating in the zone of saturation below.

For example, there can be loose materials with a lot of pore space, fractured hard rocks that can fill with water, or even porous sediment that allows water to move through. In the subsurface, where the pore space is completely filled with water, is called groundwater or the zone of saturation as seen in Image 2. Directly above the subsurface is the unsaturated zone. This is where there is soil moisture and the pore spaces might be wet but they are not completely filled with water. The boundary between the unsaturated zone and groundwater is called the water table.

WHAT IS AN AQUIFER?

The subsurface or saturation zone is also known as an aquifer. Aquifers are sands, gravels, permeable sedimentary rocks, heavily fractured rocks, and karst – all saturated permeable geologic units that transmit significant quantities of water. It must be permeable enough to yield economic quantities of water to wells to actually be considered an aquifer. There can be major aquifers, which produce large quantities of water over a large area, or minor aquifers, which can produce large quantities over a small area or small quantities over a large area. In Texas there are 9 major aquifers and 21 minor aquifers. The Lost Pines Groundwater Conservation District (LPGCD) is home to six of the nine major aquifers and seven of the 21 minor aquifers, alluviums, and formations.

CONFINED VS UNCONFINED

As shown in Image 3, there are two types of aquifers: unconfined and confined. A confined aquifer is the typical aquifer – below the land surface and saturated with water. An unconfined aquifer has groundwater that is in direct contact with the atmosphere through open pore spaces of the overlying soil or rock.

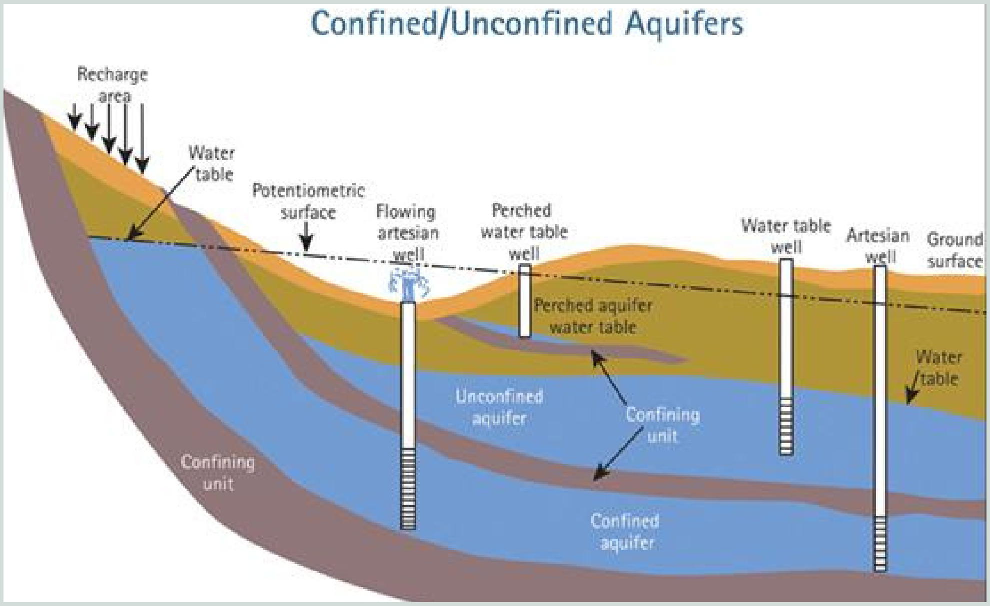

Image 3: Confined and unconfined aquifers.

The zone below the water table is the aquifer. It is recharged from streams and rainfall. It might discharge elsewhere into a stream, in which case it would be a gaining stream; if the water table is too low, the stream will discharge into the aquifer, in which case it would be a losing stream.

AQUIFERS

PERCHED WATER TABLES

A perched water table is a type of unconfined aquifer as seen in Image 4. More specifically, a perched water table is groundwater that is separated from the main groundwater body by an unsaturated zone. It is also typically recharged from the land surface from rainfall that percolates down until it hits a unit that is less permeable than the surrounding materials. In a perched aquifer, water literally piles up on less permeable material, because it can’t move through fast enough as it is being recharged.

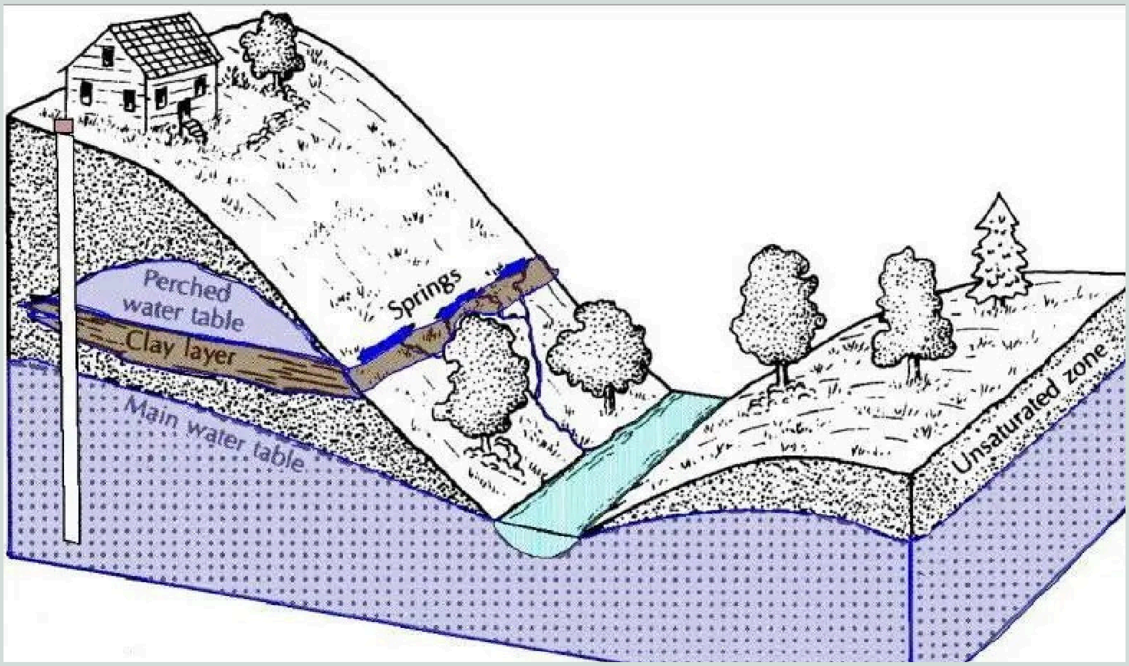

Image 4: A perched water table.

These perched water tables, in many cases, are relatively shallow, anywhere from a foot to five feet thick. Whether or not a perched water table can be used for economic purposes really depends on the local conditions. Perched water tables are not generally used for large production wells, but sometimes are used for domestic wells. In addition, since perched water tables are generally shallow and the first groundwater to be encountered, they are the most vulnerable to any contamination that’s coming down from the surface.

AQUIFERS

AQUITARDS

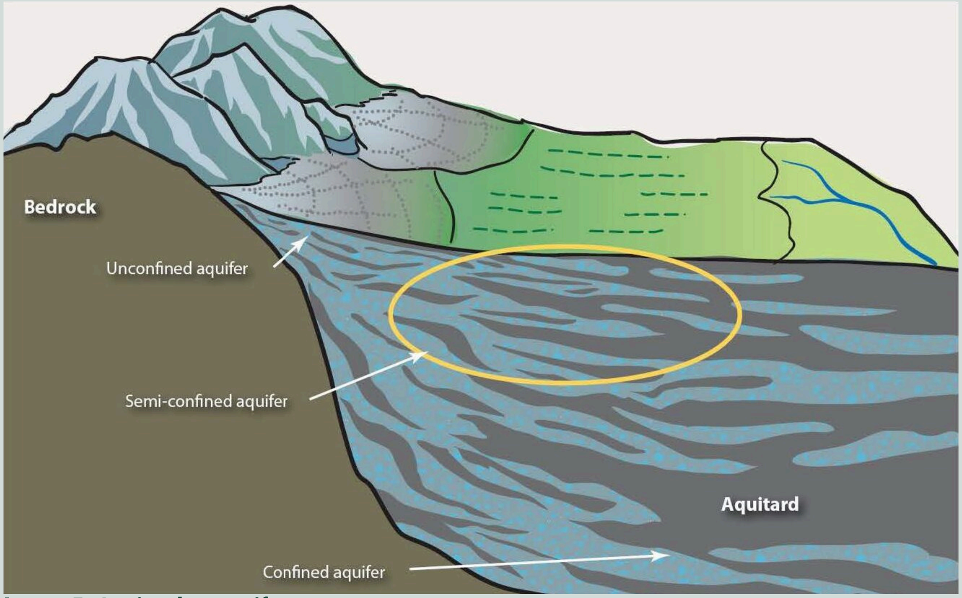

Image 5: Aquitard vs aquifer.

As previously discussed, aquifers are geologic units that provide a significant amount of groundwater. However, an aquifer in one region may actually be considered an aquitard in another region as it may not be the most productive unit and instead be a slower moving groundwater geologic body.

For example, you may have a fine sand unit sandwiched between clay. The clay does not move a lot of water but the sand does move a lot of water, so that sand would be the aquifer. But in another region, you might have that fine sand sandwiched between a lot of gravel which really moves water very fast, and the sand in that context becomes what we call an aquitard, which is something that actually makes water move slower relative to what would be called the aquifer there. So what is an aquifer is not tied to the particular material, but instead is relative to the other material in a region. The more permeable material in a region is called the aquifer and the less permeable material is considered an aquitard, as seen in Image 5.

ARTESIAN WELLS

An artesian aquifer is a confined aquifer that has groundwater surrounded by layers of impermeable rock or clay which apply positive pressure to the water contained within the aquifer.If a well is sunk into an artesian aquifer, water would rise until equilibrium is reached; such a well is called an artesian well, at least as long as the pressure remains. If the well is flowing for a long time, the pressure will go down and eventually the artesian well would be lost, unless there is more supply coming in.

HOW MUCH
GROUNDWATER IS THERE?

In Texas, the total estimated quantity of fresh and brackish to saline groundwater is 16.8 billion acre-feet, equivalent to 11 billion olympic size swimming pools. 12.6 billion acre-feet are from major aquifers and 4.24 billion acre-feet are from minor aquifers. But, how much water an aquifer holds does not depend on the total volume of the aquifer, but instead the porosity of the material – the more pores, the more water. The size, shape, regularity, and continuity of the pore space determines how much water can be extracted or stored in the aquifer. It can also determine how fast water can move through the pore space and how contaminants are distributed in the subsurface.

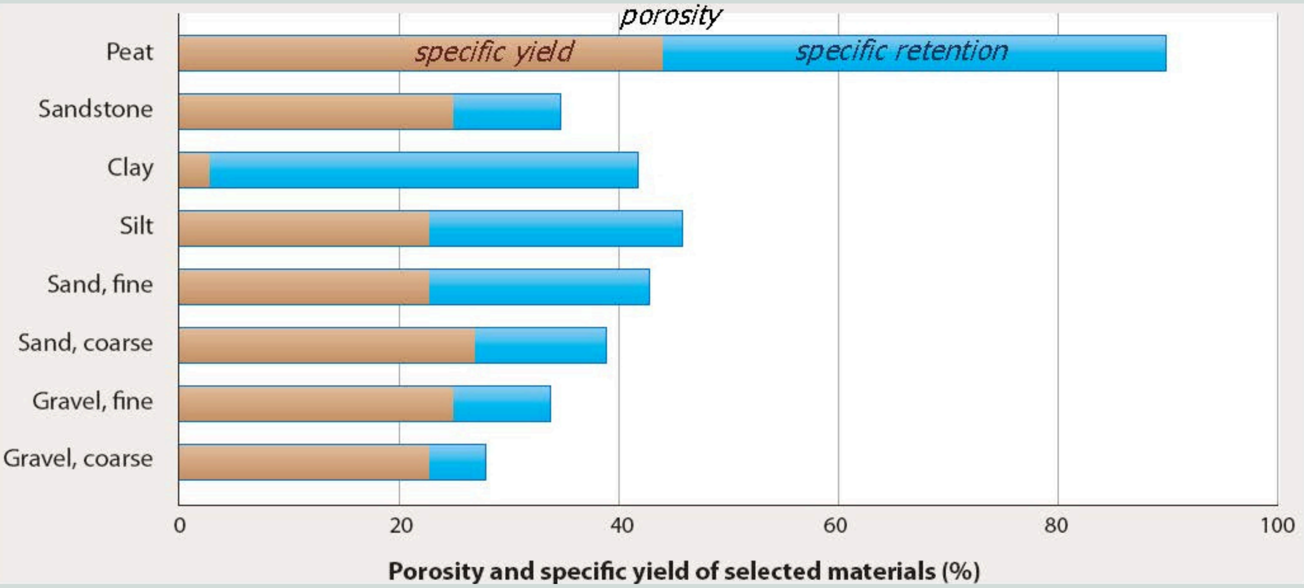

Image 6: Porosoity and specific yield of different materials.

Groundwater that is available for domestic wells or irrigation water, or that is flowing to a spring or providing base flow, is the water that is flowing out of the connected pore spaces or connected fracture spaces. Specific retention is the amount of water remaining as moisture in the sediments when the aquifer is drained. Specific yield is the amount of water that is available for pumping when sediments or rocks are drained out due to the lowering of groundwater near a well. Specific retention and specific yield vary greatly for different materials shown in Image 6. For example, in a flowerpot, the potting soil is mainly peat soil and very porous. If you filled the flowerpot with water, the specific yield would be the amount of water that would come out the hole in the bottom of the pot. For potting soil, also called peat, the specific yield is about 40 percent. The amount of water left behind in the soil is the specific retention and is the water the plants use until it is watered again. The specific retention is very high in peat soils and clay soils. In fact with clay, the specific retention is so much that the clay will yield very little, even though it has a lot of water.

AQUIFERS IN THE

LOST PINES GROUNDWATER CONSERVATION DISTRICT

As stated earlier, and seen in Image 7, the Lost Pines Groundwater Conservation District (LPGCD) is home to six of the nine major aquifers in Texas and seven of the 21 minor aquifers, alluviums, and formations in Texas. The major aquifers in the LPGCD include the Carrizo-Wilcox Aquifer, the Hooper Aquifer, the Simsboro Aquifer, the Calvert Bluff Aquifer, the Queen City Aquifer, and the Sparta Aquifer. The various minor aquifers and alluviums present in the LPGCD yield either relatively small quantities of water or quantities of water with poor quality. These include the Colorado River Alluvium, the Trinity Aquifer, the Yegua-Jackson Aquifer, the Midway Group, the Reklaw Formation, the Weches Formation, and the Cook Mountain Formation.

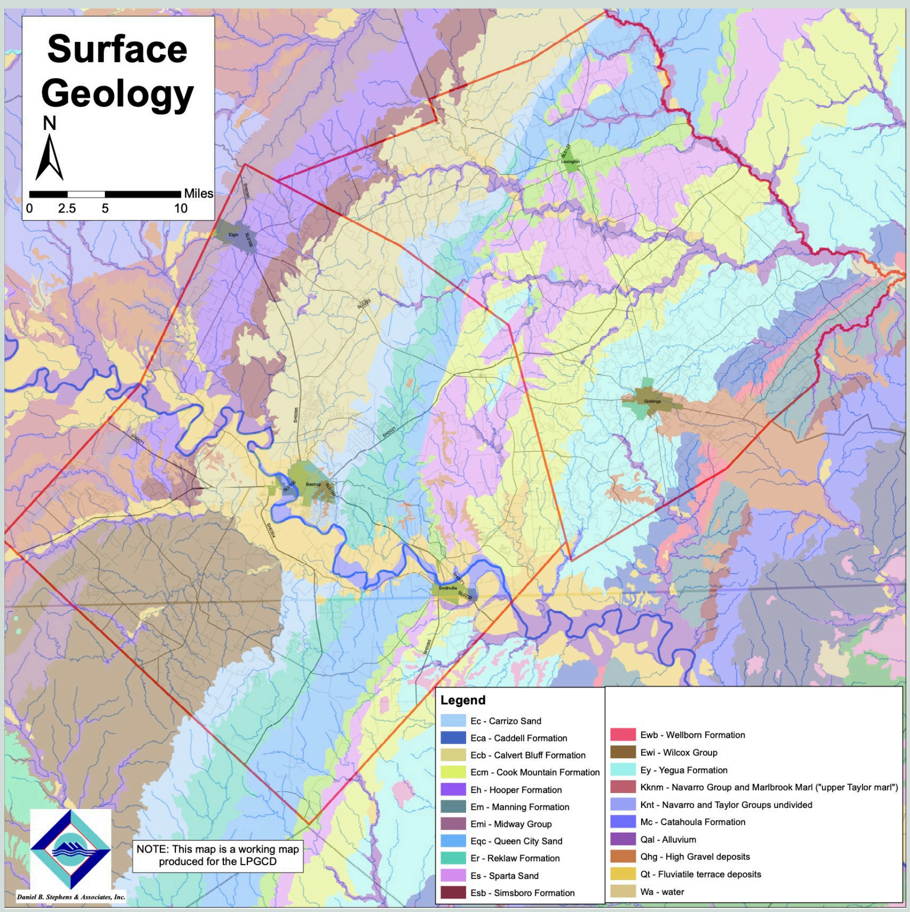

Image 7: Major and minor aquifers in Lost Pines Groundwater Conservation District.

HOW MUCH DOES GROUNDWATER FLOW?

Groundwater moves from higher elevations to lower elevations and from areas of higher pressure to areas of lower pressure. That does not always mean downward. Water flows from a place with high pressure to a place with low pressure, and that can be uphill, such as in an artesian well.

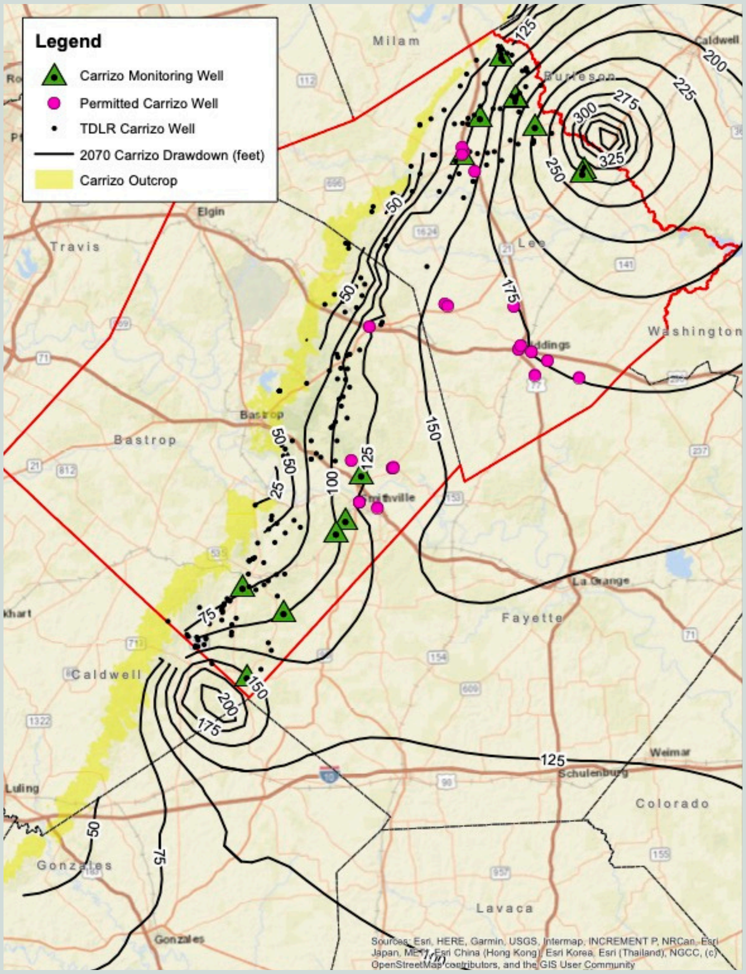

Image 8: Groundwater Availability Map (GAM) of the Carrizo Aquifer.

Image 8 shows groundwater availability models (GAMs) of a Texan aquifer. Similar to a topographic map, the contour lines indicate all the places where water level is at that level. A GAM allows us to actually draw a direction in which water is moving and allows us to give an understanding of the direction of groundwater flow. To make water level maps, we need many water level measurements over time to understand what the dynamics are of this water table surface that then determines in which direction groundwater is flowing. Water level maps are critical to our understanding of the levels and direction of groundwater flow.

HOW FAST DOES GROUNDWATER FLOW?

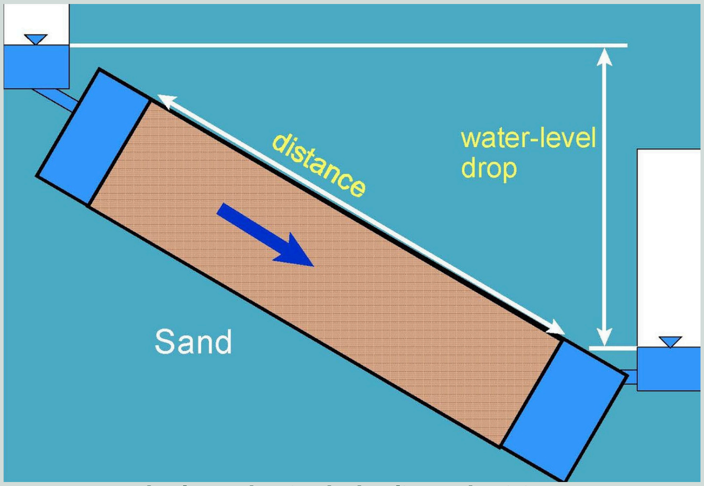

Image 9: Sand column showing hydraulic conductivity.

Think of a lab experiment where there is a column of sand as shown in Image 9. At the top and bottom of the column there is a water beaker where the level is kept constant by some sort of overflow mechanism. As a result of keeping the water level constant at the top and constant at the bottom, it is observed that water flows through the sand at a certain velocity. This allows for the measurement of that velocity by looking at how much water is flowing out of the beaker on a continuous basis.

If instead of sand, the column is filled with clay or loam, which is a much finer material, as shown in Image 10, there will still be water coming out, but it will be much, much slower. The loam material in this column is tighter and denser, which means the pores are much smaller than sand pores. Therefore, the water experiences more friction and comes out at a slower pace in the loam material than in the sand material. The capacity of a geologic material, in this case sand and loam, to transmit water is called the hydraulic conductivity. Hydraulic conductivity is an intrinsic property of the geologic material through which groundwater is flowing.

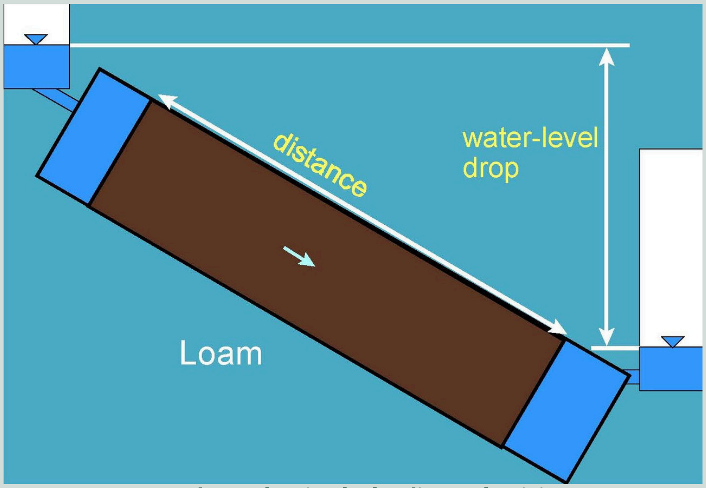

Image 10: Loam column showing hydraulic conductivity.

HOW FAST DOES GROUNDWATER FLOW?

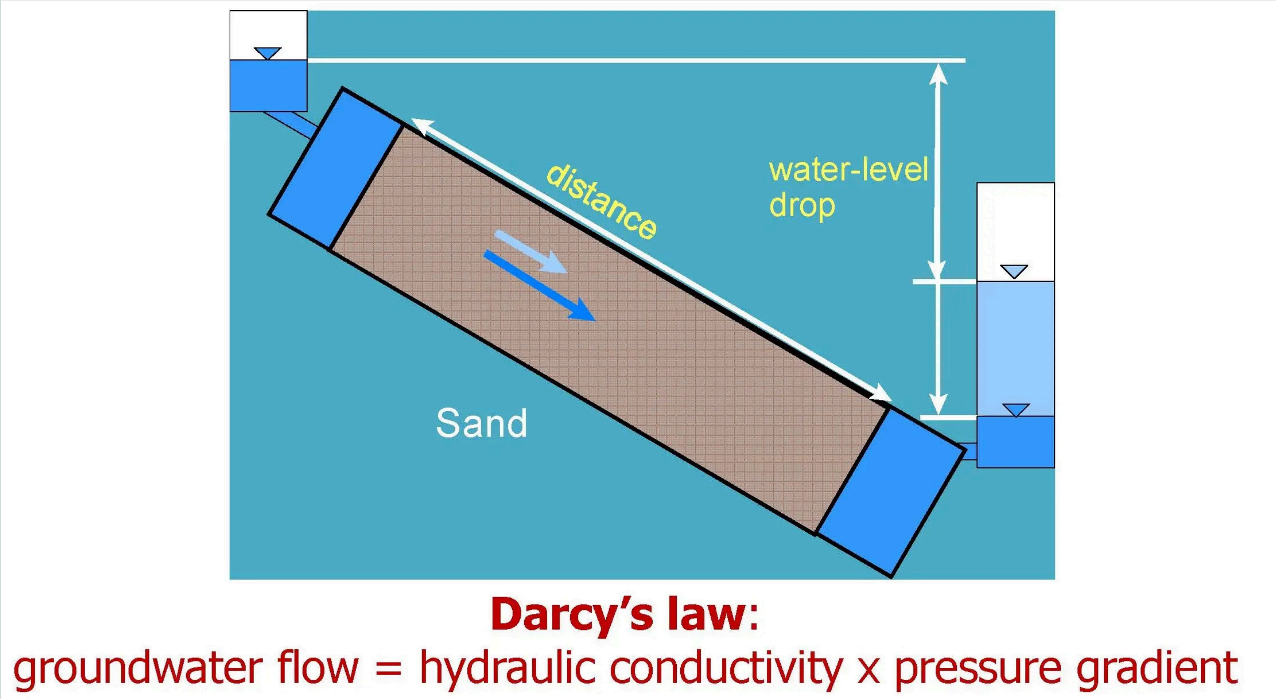

Image 11: Column of sand showing Darcy's Law.

Another factor in determining how fast groundwater flows is the gradient of the water level. Supposing that the water level on the downhill side of the column is raised, the difference in water level between the inside and outside parts of the sand column is less than it was before. Furthermore, the distance will be less than it was in the previous experiment. Therefore, there is less water flowing through. The shallower the radiant between the pressure on one point and the pressure at another point, the slower the water flows. This shows that the flow of water is a function of both the hydraulic connectivity and the gradient of the water level. This is also known as Darcy's Law which says that groundwater flow is equal to the gradient in hydraulic head or pressure gradient multiplied by the hydraulic conductivity. As seen in Image 11, Darcy's Law describes the fundamental relationship for understanding how fast and how much groundwater moves.

WHERE DOES GROUNDWATER COME FROM?

The water cycle, also known as the hydrologic cycle and shown in Image 12, describes the continuous movement of water on, above, and below the surface of the Earth. The land surface is the grand separator or the critical zone. When water is precipitated, some of it will runoff and some of the water will stay in the snow for the season or in glaciers for many years. Some of the water will sit in the soil and then be taken up by plants that evapotranspire it back into the atmosphere. Then some of the water actually percolates down into the water table. Water that percolates down into the water table is what we know as groundwater and will flow to the lowest point and eventually either discharge into a lake, stream, or ocean.

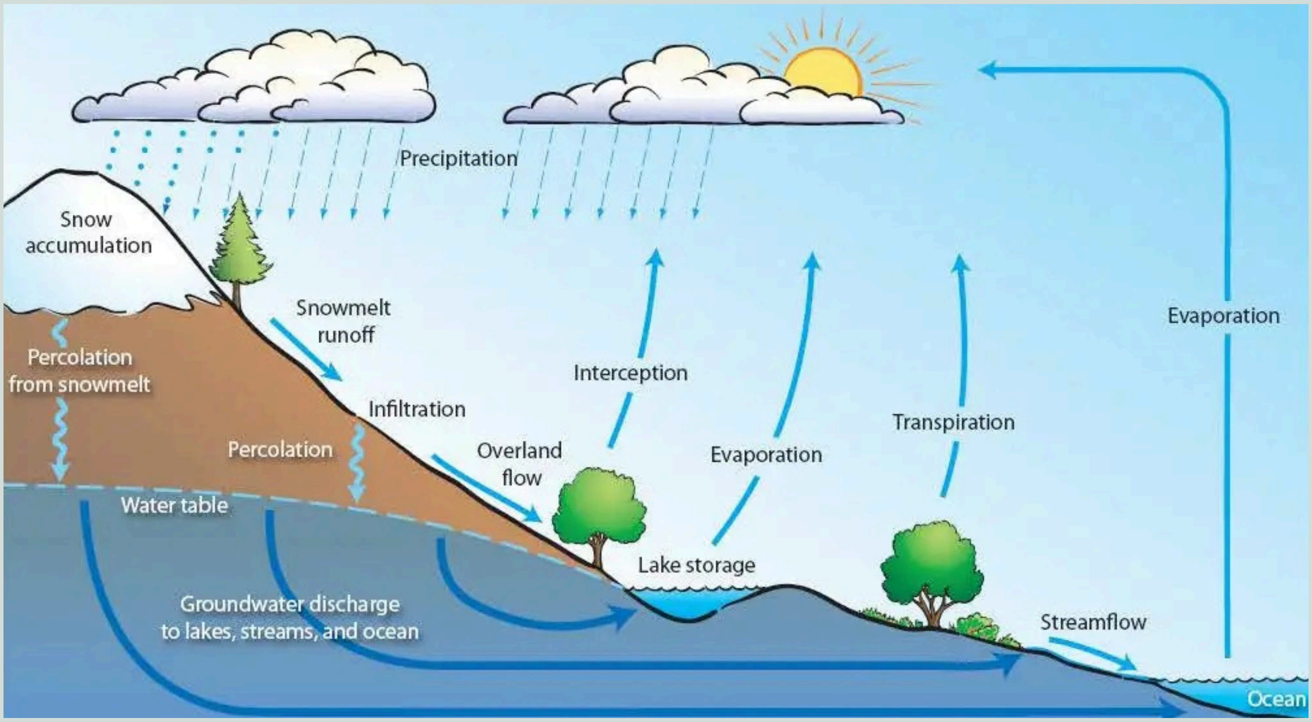

Image 12: The Hydrologic Cycle.

WHERE DOES GROUNDWATER COME FROM?

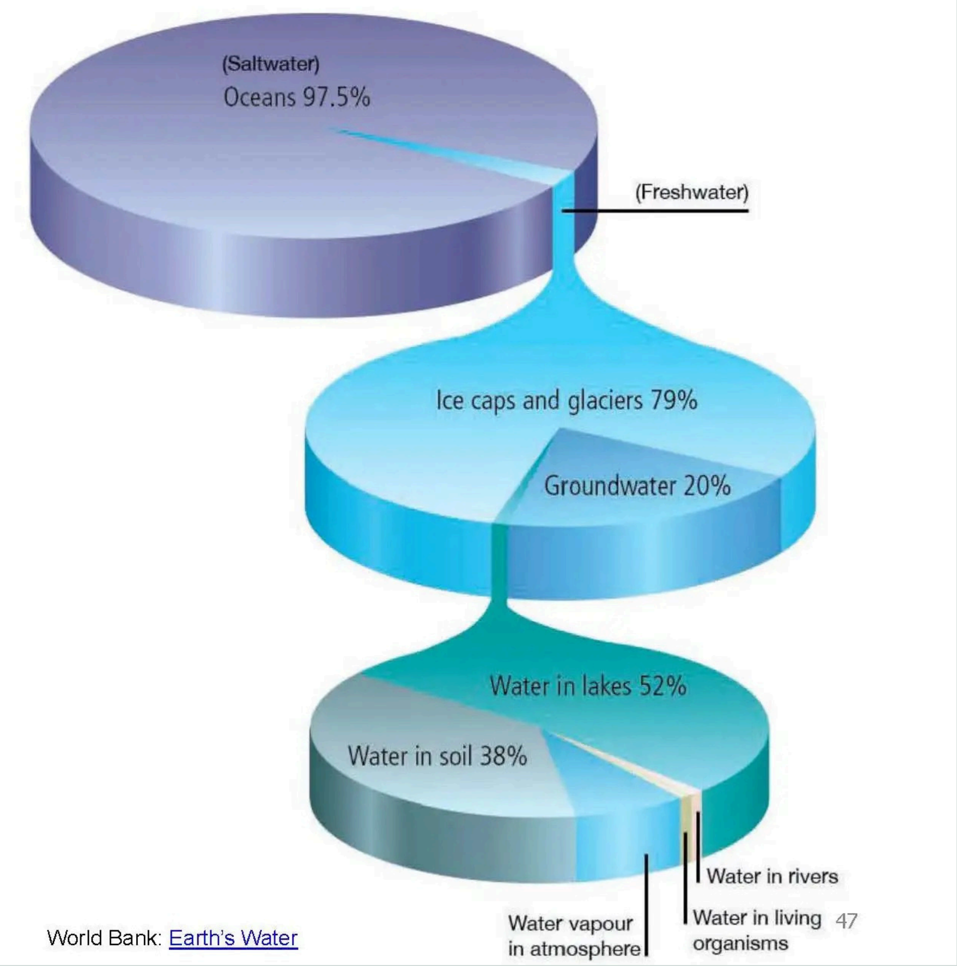

Image 13: Earth's water.

It is important to note that the super majority of water on earth is saltwater as shown in Image 13. Only 2.5 percent of all the water on earth's surface is freshwater. The majority of that, 79 percent to be exact, is held in ice caps and glaciers. However, the other 20 percent is groundwater. Water not in the ocean, glaciers, or groundwater like soil water, water in lakes, and water in rivers is a tiny fraction of all of the earth's water. Therefore, groundwater is actually a really big part of the hydrologic cycle.

WHERE DOES GROUNDWATER GO?

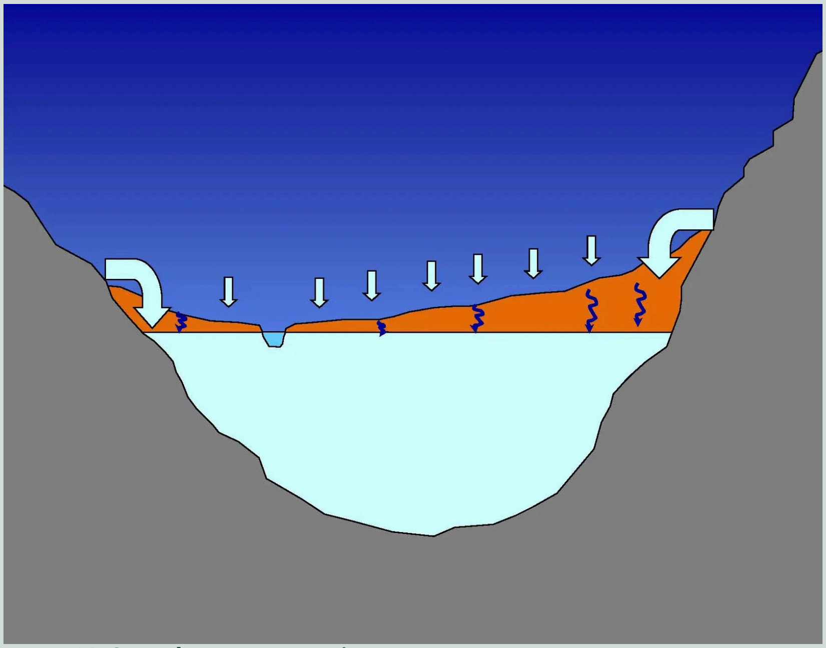

Image 14: Groundwater pre-pumping.

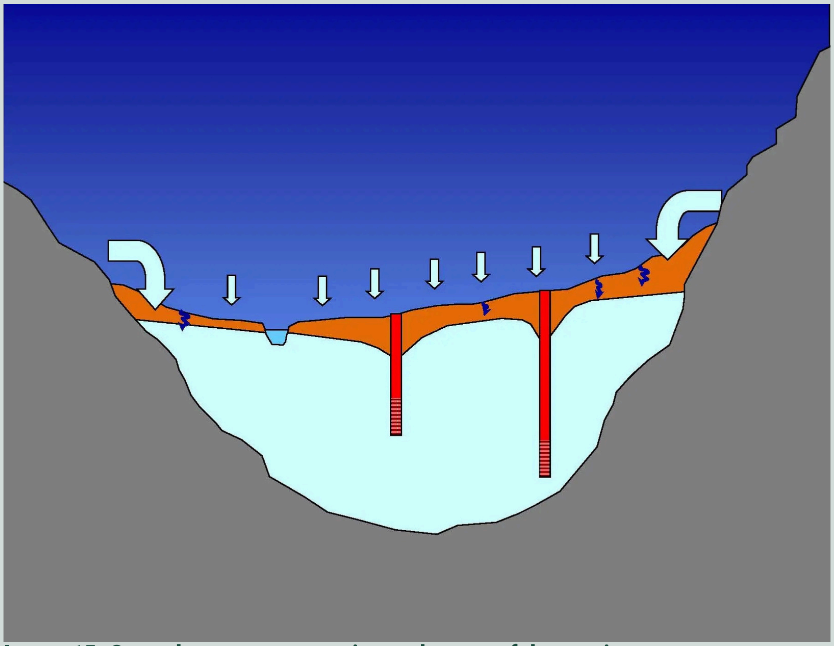

Image 15: Groundwater post-pumping and cones of depression.

In the early 20th century, we started pumping groundwater which creates a cone of depression. A cone of depression, as seen in Image 14 and Image 15 is essentially the lowering of the water table that happens near a well during pumping. Large quantities of water is pumped during the summer for irrigation and to provide cities and domestic wells with water which develops cones of depression. Over the winter, pumping is stopped or slowed and the aquifer is recharged. Often, it goes back and forth, and under ideal conditions, that doesn't change. However, in a lot of places in Texas, more water is taken out in the summer than is recharged in the winter and as a result, the cone of depression gets deeper and deeper. This results in not only a lowered water table, but also the disconnection of rivers from the water table.

HOW IS GROUNDWATER MANAGED?

GROUNDWATER CONSERVATION DISTRICTS - GCD

Water rights in Texas are dependent on the water source. Surface water is owned by the state and requires the permission of the state to access. Groundwater, however, generally belongs to the landowner who is allowed to pump and capture whatever water is available, regardless of the effects on neighboring wells. In Texas, this is known as the Rule of Capture. However, there are limits to the Rule of Capture which is managed by Groundwater Conservation Districts (GCDs). A GCD is a local unit of government authorized by the Texas Legislature and ratified at the local level to manage and protect groundwater. There currently are 99 confirmed GCDs in Texas, one of which is the Lost Pines Groundwater Conservation District (LPGCD).

Texas law authorizes GCDs to modify the Rule of Capture and regulate groundwater production. GCDs manage groundwater by creating a plan and setting rules to limit groundwater production through well spacing and tract size requirements, permitting of non-exempt water wells, controlling land subsidence, preventing degradation of water quality, preventing the waste of groundwater, keeping records of groundwater production and use, and by coordinating planning with regions, surface water entities, and stakeholders in groundwater management areas (GMAs).

HOW IS GROUNDWATER MANAGED?

GROUNDWATER MANAGEMENT AREA - GMA

A Groundwater Management Area (GMA) is an area delineated and designated by the Texas Water Development Board (TWDB) for joint planning and managing groundwater resources. Each area is composed of individual groundwater conservation districts. The decisions for current GMAs include groundwater availability using data collected from regional member districts and defining the quantity of allowed groundwater production. The LPGCD is currently a member of GMA 12 which also includes Fayette County GCD, Brazos Valley GCD, Post Oak Savannah GCD, and Mid-East Texas GCD.

DESIRED FUTURE CONDITION - DFC

A Desired Future Condition (DFC) is the desired, quantified condition of groundwater resources, such as water levels and spring flows or volumes, within a management area at one or more specified future times as defined by a GMA as part of the joint planning process. DFCs matter because they influence policy making and resource management decisions. DFCs are also used to determine future groundwater availability and help in evaluating well permit applications. DFCs are updated every five years and may be established for major or minor aquifers as well as alluviums and other geologic formations.

HOW IS GROUNDWATER MANAGED?

DFC PROCESS

The DFC process for a GMA and its member GCDs involves a series of collaborative steps aimed at balancing groundwater production with conservation and sustainability. The process begins with joint planning meetings where stakeholders can actively participate and provide input. This engagement is crucial as it shapes the proposals for the DFC. Following these discussions, the GMA proposes to adopt the DFC. Each GCD then holds a public hearing, accompanied by a 90-day public comment period, ensuring transparency and community involvement. After considering the public feedback, the GMA officially adopts the DFC and submits an explanatory report along with model files to the Texas Water Development Board (TWDB).

The TWDB reviews the submission to ensure it is administratively complete. Once approved, the Modeled Available Groundwater (MAG) figures are calculated using Groundwater Availability Models (GAMs). GAMs estimates future trends in the amount of groundwater available in an aquifer. GAMs include comprehensive information on each aquifer, such as: recharge; geology and how that conveys into the framework of the model; rivers, lakes and springs; water levels; aquifer properties; and pumping. After the MAG is determined and approved by the TWDB, the GMA is notified. Subsequently, each district adopts the DFC and updates their management plans and rules to align with the newly established conditions. This process emphasizes stakeholder engagement and regulatory compliance at each step.

Creating or assessing a DFC requires considering nine critical factors: aquifer uses and conditions, the state water plan, hydrologic conditions, environmental impacts, land subsidence, socioeconomics, property rights, feasibility, and any other relevant information. These factors ensure a comprehensive approach, balancing the highest practicable level of groundwater production with the need for conservation, preservation, protection, recharging, waste prevention, and subsidence control. This balancing act is essential for sustainable groundwater management, addressing both immediate water needs and long-term environmental health.

HOW IS GROUNDWATER MANAGED?

REGIONAL WATER PLANNING GROUP - RWPG

In addition to GMAs, Texas also has 16 regional water planning groups (RWPGs) that serve as part of the state water planning process to represent a variety of interests and develop a regional water plan. All of the regional water plans are compiled to help develop the state water plan. The latest state plan was adopted in 2012. The LPGCD is a member of two RWPGs: Region G which consists of Brazos and Lee County; and Region K which consists of Lower Colorado and Bastrop County.

GROUNDWATER 101
CONCLUSION

Groundwater is a vital resource for Texas, playing a crucial role in the state's water supply for both public consumption and agricultural needs. With half of all Texans relying on groundwater for drinking water, understanding the complexities of this resource is essential. This guide has provided a comprehensive overview of groundwater, from its basic definitions and types to the mechanisms of its flow and management.

Groundwater is found in aquifers, which are geological formations that can store and transmit water. These aquifers can vary greatly in size, capacity, and quality, with Texas hosting a diverse range of both major and minor aquifers. Understanding the nature of these aquifers, including the concepts of unconfined and confined aquifers, perched water tables, and artesian wells, helps us appreciate the variability and potential of groundwater resources.

Effective groundwater management is critical for ensuring the sustainability of this precious resource. In Texas, Groundwater Conservation Districts (GCDs), like the Lost Pines Groundwater Conservation District (LPGCD), Groundwater Management Areas (GMAs), and the Texas Water Development Board (TWDB) play pivotal roles in regulating groundwater use. Through the implementation of Desired Future Conditions (DFCs) and Modeled Available Groundwater (MAG) figures, these entities strive to balance groundwater extraction with conservation efforts, ensuring that future generations will continue to have access to clean and reliable water.

The collaborative approach to groundwater management, involving stakeholders from various sectors and communities, underscores the importance of shared responsibility in protecting this resource. By understanding the principles outlined in this guide and engaging in the management processes, individuals and communities can contribute to the sustainable use and preservation of groundwater in Texas.

In conclusion, groundwater is an indispensable part of Texas' water infrastructure. Its management requires a nuanced understanding of geological, hydrological, and regulatory frameworks. As we move forward, continued education, effective regulation, and community involvement will be key to maintaining the health and availability of our groundwater resources. Together, we can ensure that this vital resource remains a cornerstone of environmental and economic well-being in the Lost Pines Groundwater Conservation District.

LOST PINES

GROUNDWATER CONSERVATION DISTRICT

124

THOUSAND RESIDENTS SERVED

We serve the residents of Bastrop and Lee County

We provide FREE water well monitoring and well water quality analysis to Bastrop and Lee County residents.

Our Purpose

The LPGCD is the state's preferred method of groundwater management in the Bastrop and Lee Counties. Per Texas Water Code Section 36.0015, LPGCD is to manage groundwater by balancing all property interests and providing for the preservation, protection, recharging, and prevention of waste of groundwater.

We are mandated by the state to provide educational programs to the public relating to the problems and issues concerning water management.

- **We manage 3,473 registered wells in our district.**
- **The two largest water uses are for municipal and irrigation purposes.**
- **There are six major aquifers in our district.**
- **Our District's water needs are estimated to increase by 46% by 2070.**

BOARD OF DIRECTORS

The Lost Pines Groundwater Conservation District is governed locally by ten citizens, five from each county, who have been appointed by their respective County Commissioners Courts to serve as directors for a term of four years.

Elvis Hernandez, President
Kay Rogers, Vice President
Mike Simmang, Secretary/Treasurer
Sheril Smith
Melissa Cole
Tom Arsuffi
Nick Textor
Herb Cook
Nancci Phillips-Burgess
Debra Phillips

LOST PINES GROUNDWATER CONSERVATION DISTRICT

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