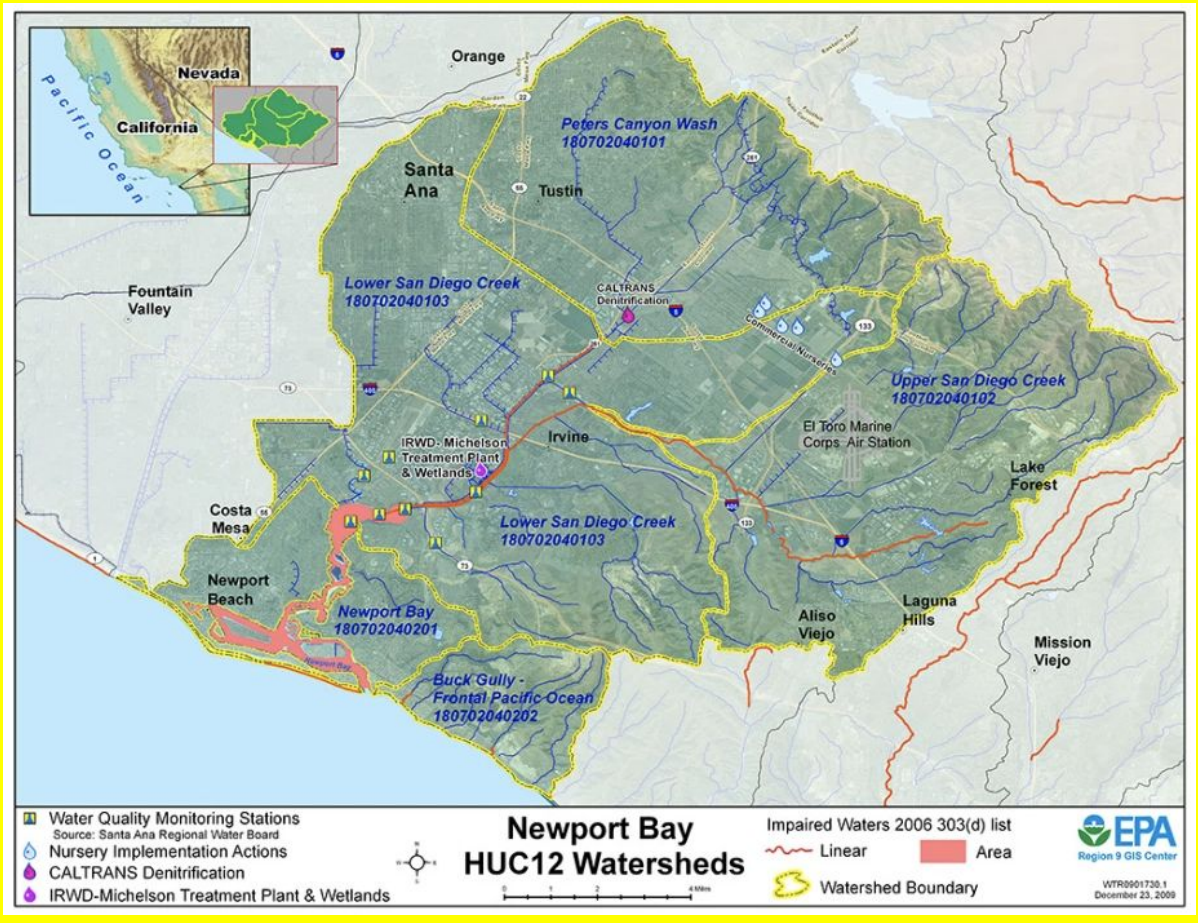
Santa Ana River Basin Watershed Report

Action Plan: (SARA P) Santa Ana River Action Plan



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Mission Statement

SARA P's mission is to reduce and mitigate drought, bacteria and pathogens, and heavy metals through sustainable and efficient methods that will contribute to a safe and clean environment for nearby communities and species.

Introduction

The Santa Ana River watershed drains the largest watershed of Southern California, covering over 2,650 square miles through parts of San Bernardino, Riverside, Orange, and Los Angeles Counties. The watershed consists of high mountain ranges that divide large, dry alluvial valleys. The southern part of the watershed, drained by the San Jacinto River into Lake Elsinore and via Temescal Creek into the Santa Ana River, constitutes 45% of the total area and extends its boundaries as far as Colorado. The river has over 50 named tributaries, with the majority being intermittent streams. As of 2000, about 4.8 million people lived in the Santa Ana watershed. Most of the population is concentrated close to the river in urban areas such as Riverside and Santa Ana.

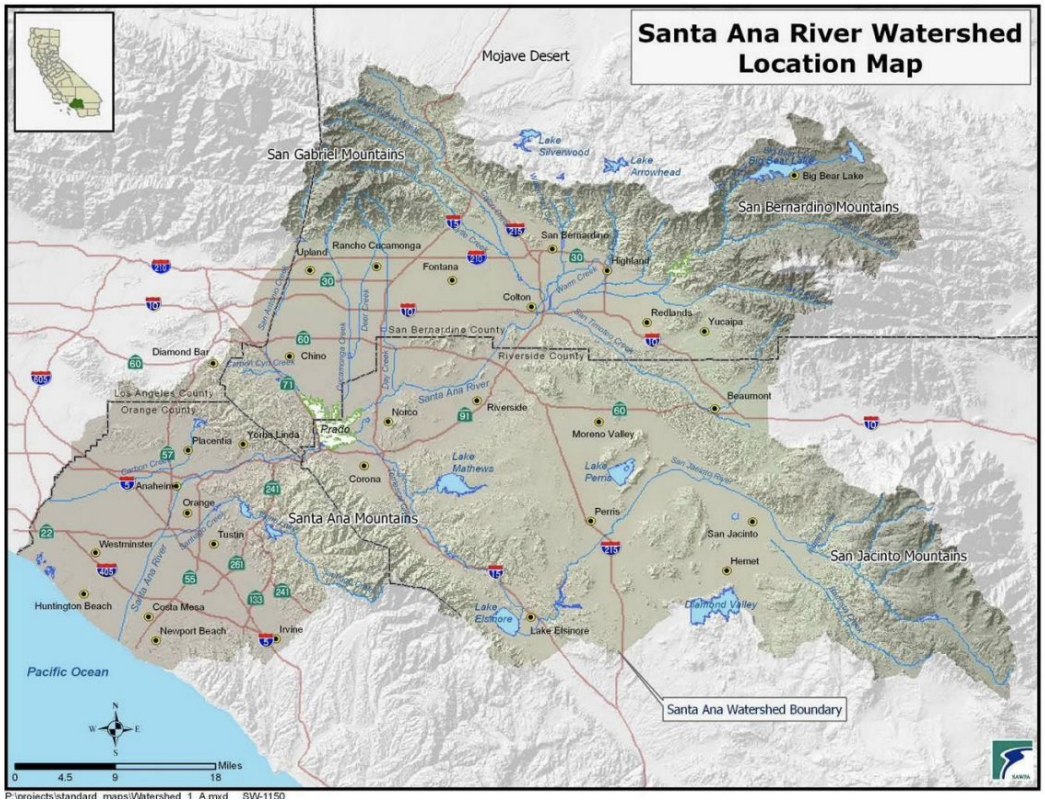

Figure 1: GIS Map of Santa Ana River Watershed

History of the Santa Ana River Basin

People

The Santa Ana River watershed was first habited around 9,000 to 12,000 years ago, close to the Holocene period. The first Native Americans to live in the area were nomadic tribes that were known as hunters and gatherers that traveled to different areas of the continental United States. The ancestors are believed to have originated from the Shoshone and Uto-Aztecan people of the northwestern United States. Eventually, the human population of the watershed reached a peak of about 15,000, and then around 8,000 years ago, the arid climate change led to people staying in places longer than usual, making the people become semi-nomadic. Like many Native American tribes in California, acorns were a staple food, and activities such as fishing and hunting were common. Later on, during the Spanish period, Spanish explorer Gaspar de Portolà led the first expedition towards Southern California, where the Santa Ana River was found and was given its name due to the fact that soldiers had recently celebrated Saint Anne's Day. The name remains today, making it the oldest place name in Orange County. Later on, the "Rancho Period" began, which consisted of large land holdings subdivided into ranchos owned by individuals in the Santa Ana area, making the Santa Ana River valley one of the most prosperous regions in Southern California for many decades.

In the 1980s, California fought for its independence from Mexico in the Mexican-American War. The Santa Ana river played an important role in the victory of the Americans, due to a flood that occurred in 1847 which prevented Mexicans from crossing the river to attack the Americans. This gave the U.S. military enough time to gather enough military personnel, leading to a victorious war. When the California Republic was assimilated into the United States in 1848, American settlers began to move into the Santa Ana River region rapidly. The Mexican ranchos were divided into smaller individual properties, and irrigated agriculture began on a large scale. The city of Santa Ana Viejo, the original location of Santa Ana, was founded during this period. In 1854, Mormons settled and established the city of San Bernardino, gaining prosperity by using water from the river for economic gains in irrigation systems. Also, it is important to note that many were attracted to Southern California due to the California Gold Rush. In 1860, the Santa Ana river served as a conduit for miners traveling to the region, and gold was discovered around the area in that same year. Through the late 19th century, citrus fields covered much of the coastal plain, which led to the naming of Orange County.

Major Floods

Although there were plenty of economic opportunities and prosperity due to the Santa Ana River, there were also many floods that affected the region. In the Great Flood of 1862, heavy rains during winters caused the Santa Ana river to burst its banks, flooding thousands of acres of lands and killing 20-40 settlers. The flow, now calculated as a 1,000 year flood, peaked at roughly 9,000 cubic meters per second (320,000 cu ft/s), over half the average flow of the Mississippi River. For the two years after the flood, an intense drought caused the deaths of thousands of livestock, leading to a detrimental economy for a couple of years. However, years later the conditions of the region returned to normal, making the Santa Ana River region prosperous again, which later aided with the establishment of the cities of Santa Ana and Riverside in 1869 and 1870, respectively.

In 1934 and 1938 another set of devastating floods struck the area, bringing an end to the area's citrus industry. In the Los Angeles flood of 1930, the Santa Ana burst its banks again and flooded Anaheim and Orange up to 4 feet, flooding around 68,400 acres of land, devastating many of the citrus groves and killing around 60 citizens, even though this flood had a flow that was only about one-third of the 1862 flood mentioned earlier. Due to the extreme economic and physical damage of the floods that kept occurring for decades, the U.S. Army Corps of Engineers made the decision to dam and concrete the river in the 1940s, and declared it the greatest flood hazard in the U.S. west of the Mississippi River. The Prado Dam was built in 1941, and was specifically designed to capture floodwaters about 30 miles upstream from the river's mouth. The dam's impoundment, the Prado Flood Control Basin, was designed to handle a 70-year flood. With this protection, the Santa Ana River region became a more attractive place for business, leading to major industrial development and housing boom in the 1950s and 1960s, marking a new transition from an agricultural to an urban area.

The population of the Santa Ana river basin increased dramatically, but concerns of floods were still in place due to urban runoff into the river. Consequently, in 1964 the Santa Ana River Mainstem Project, which consisted of concreting the lower 20.4 miles of the river, was proposed. Construction work began in 1989, and today, the river's channel is essentially an enormous box culvert. A second dam, the Seven Oaks Dam, was completed in 1999 to capture flood runoff from the Santa Ana Canyon. The dam was designed to withstand a 350-year flood. These last projects lead to a more prosperous, safe, and reliable environment for the Santa Ana River basin and its citizens.

Figure 2: The Santa Ana River Flooding in 1938.

Policies and Mandates in Place

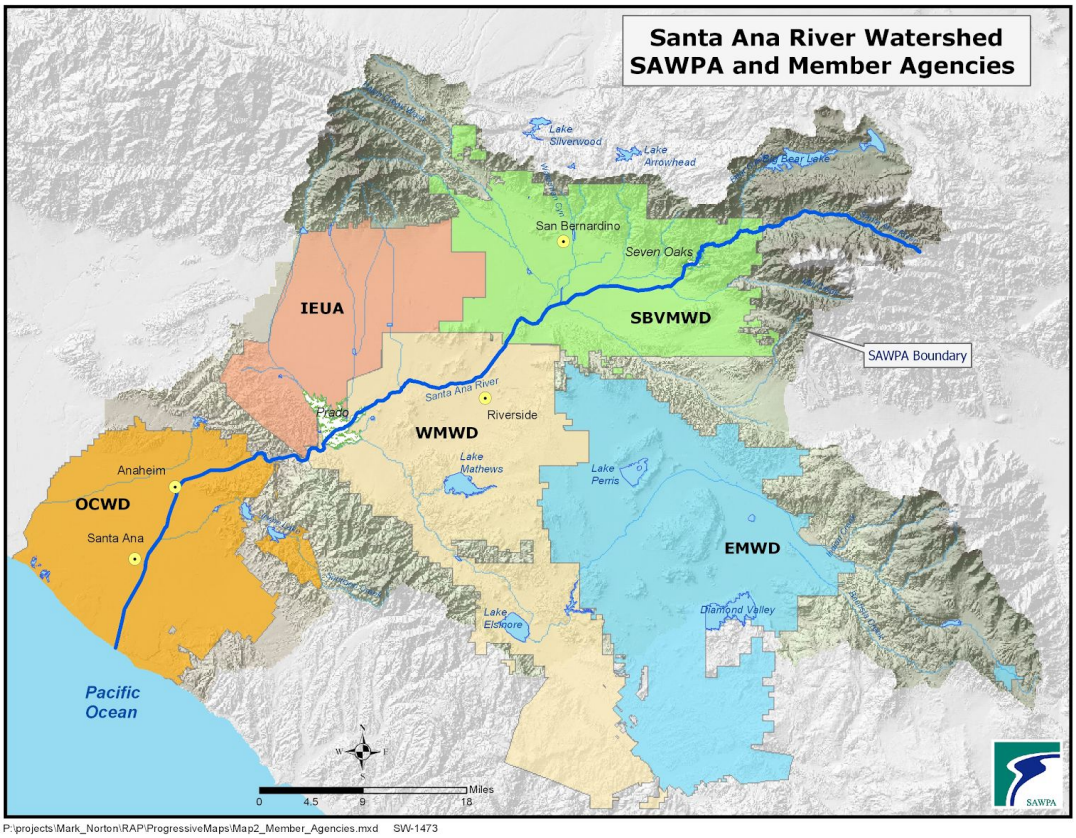

Fig 3. Map of SAWPA and Member agencies and their jurisdiction in the Santa Ana River Watershed

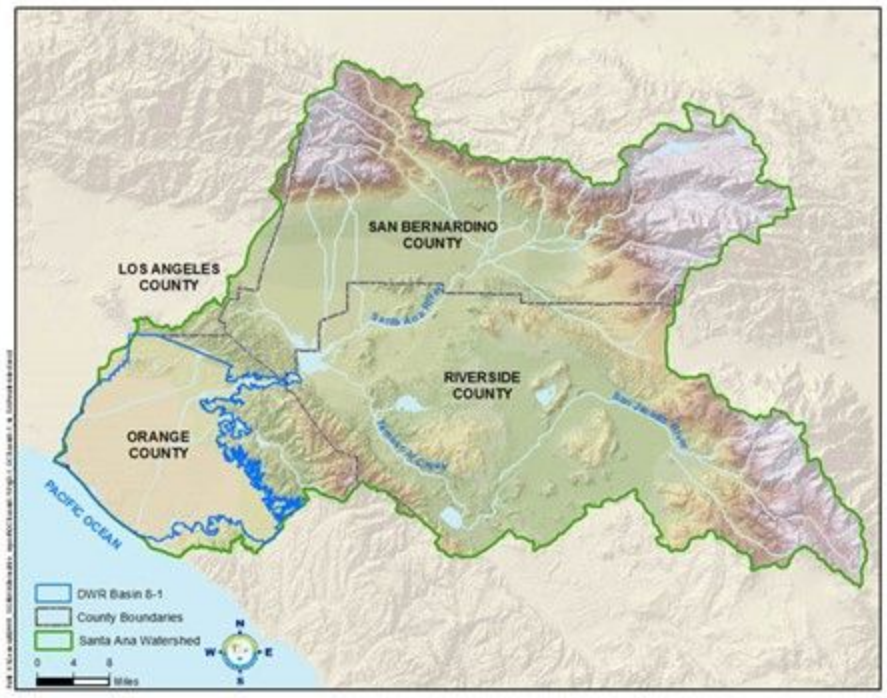

Fig 4. Map of Santa Ana Watershed with the counties that it overlaps with.

The following are policies and mandates that watershed plans must adhere to. Historically speaking, the SAWPA is the first commission dedicated to protecting the Santa Ana watershed. The Santa Ana Water Project Association (SAWPA) serves as a forum roundtable for resolving inter-agency conflicts, addressing regional water issues, and supporting the development of long-term integrated water resource planning through multi-agency agreements and partnerships within the Santa Ana River Watershed.

The Santa Ana Watershed Association (SAWA) develops, coordinates and implements natural resource programs that support a sustainable ecosystem and social benefits from the San Bernardino Mountains to the Pacific Ocean. SAWA is committed to protecting and improving natural areas of the Santa Ana River Watershed through the removal of invasive species, native habitat enhancement, and the protection of endangered and threatened species.

The Drainage Area Management Plan identifies programs and policies, including Best Management Practices (BMPs), to achieve Water Quality Standards in the Receiving Waters. The BMPs can be divided into two categories: ones for existing facilities and ones for New Development and Significant Redevelopment. The DAMP document is constantly being revised to ensure technologies and practices dealing with watershed quality and management are updated. Therefore, watershed plans must incorporate the most updated DAMP document.

Separate counties have also developed their own mandates. For instance, Orange County had updated their OC Plan in 2018. The goals established in The OC Plan are to improve water supply, protect water quality, enhance the environment and habitat, provide flood risk management, improve the quality of life, and address climate change. The OC Plan will accomplish these objectives through an established ranking of projects to help further state and regional goals.

This watershed also adheres to California's Porter-Cologne Water Quality Control Act. It states that each Regional Board must develop and enforce water quality control plans for all areas in the region and to regularly review and revise them as necessary.

Finally, the main goal that all bodies of water in the United States must follow is the Clean Water Act. Its goal is to restore and maintain the chemical, physical, and biological integrity of the Nation's Waters in order to make water sources swimmable and fishable again. This act requires that states adopt water quality standards including those for toxic substances. It also requires that states continue to plan and update water quality standards if necessary

Problems & Proposed solutions

Problem	**Description**	**Causes**
P1: Droughts	Precipitation and runoff values are decreasing while water demand is increasing. Dry periods are becoming more common as climate change is becoming more prominent.	Numerous factors are driven by climate change; such as decreased precipitation and increased average air temperature.
P2: Bacteria and Pathogens	Lack of proper wastewater treatment has led to large areas of the watershed being uninhabitable for many plant and animal species including willows, palms, blue herons, and white egrets.	Urban runoff, as well as untreated or improperly treated wastewater, and leaky sewers and septic tanks. Pet waste and animal manure entering waterways have also increased the amount of bacteria and pathogens in the water.
P3: Heavy Metals	High levels of heavy	Urban runoff has caused

	metals including cadmium, copper, lead and zinc found in the watershed are taken up by fish and thus create unfishable regions.	micro particles of metals to enter waterways. This has only become more severe with the increase in industrialization.

Problem 1: Droughts

Due to Southern California's hot dry climate, droughts are common and long-lasting. The severity of droughts in the Santa Ana watershed continues to increase as temperatures rise. The longest drought in the Santa Ana watershed lasted from December 27, 2011 to March 5, 2019, totaling 376 weeks. The area is currently in an abnormally dry period, as is 30.4% of California.

According to the Santa Ana Watershed Basin Study performed by the U.S. Bureau of Reclamation, annual precipitation and annual runoff is expected to decrease through the year 2070. In the 2050s, there is expected to be a 5.41% decrease in rainfall compared to data from the 1990s. In the 2070s, precipitation is expected to decrease 8.09%. In the 2050s, runoff is also expected to decrease by 10.08% from the 1990s. These data are projected for the most downstream location of the Santa Ana River.

The water demand for the Santa Ana watershed has increased from 0.924 million acre-feet per year (MAFY) to 1.298 MAFY in 2010. It is expected to increase with time to a projected value of 2.178 MAFY in 2050. As conditions get drier and precipitation decreases, more water is needed to complete everyday functions. Agriculture requires much more water for crops as soil becomes depleted.

The 1976-1977 drought caused numerous damaging effects on the state of California. Agricultural activities were forced to halt, and an emergency water pipeline was constructed across the Richmond-San Rafael bridge in Northern California that transported water to other parts of the state. This was the worst drought that California had experienced up to this point. The Santa Ana Watershed Basin Study predicts that a drought worse than the 1976-1977 drought could occur once every 6 to 8 years by the 2050s. A catastrophic drought can possibly occur once every 2 to 4 years by the end of the century. We must act on this issue to ensure the Santa Ana watershed has enough water for humans and animals to prosper.

Figure 5: Dry season at the Santa Ana River, 2013

Goal 1: Reduce Drought Consequences

Water recycling is a method to conserve water that has the potential to perform extremely well in the Santa Ana River watershed. Businesses and municipalities can recycle water that is used in the development of goods or services they provide. Treated wastewater can be used to clean parks and fields. Desalination can also be expanded in the Santa Ana River watershed. Salt water can be treated in desalination plants to drinkable levels, and be used to water crops. All in all, water conservation and the protection of freshwater will lessen the effects of droughts.

Problem 2: Bacteria and Pathogens

Riverside, California contains an immense homeless population in roughly 200 tents beside the Santa Ana River. The Inland Empire Waterkeeper and Rivers and Lands Conservancy are conservation groups that test surface water for bacteria in the Santa Ana River basin. Collected data showed increased E. coli concentrations during a storm in 2018. There was an increase from 730 MPN/100mL (most probable number) to 20000 MPN/100mL during this time. E. coli is one of many types of bacteria with high concentrations in the Santa Ana River basin. In August 2019, two individuals were infected with Shigella after swimming in a section of the Santa Ana River. Shigella is common in shallow water that is contaminated with fecal matter. Due to the dense homeless population along parts of the Santa Ana River, improper sewage systems greatly increase the presence of Shigella and other bacteria in these waters.

The Santa Ana riverbed also houses both native and invasive species, such as willows, palms, cottonwood trees, black mustard bushes, and blue herons. The Santa Ana River is a protected habitat for the Santa Ana sucker fish. Many years of polluted

runoff, improperly treated wastewater, pet waste, and animal manure have caused sections of the Santa Ana River to appear on the EPA's list of polluted waterways. These species are sensitive to changes in water and soil quality. Contaminated wastewater greatly increases bacteria and pathogen concentrations, which cause these plant species to die off.

Figure 6: Santa Ana River closed to public after bacteria outbreak

Goal 2: Reduce Excess Nutrients

Reducing the amount of nutrients within waterways will help ensure that these nutrients do not get to a point of excess. The EPA is currently taking many steps to help reduce nutrient pollution. One way the EPA is doing this is by promoting collaboration between stakeholders by having clear guidelines. If this was more strictly enforced within the Santa Ana River Basin this would help ensure that nutrients were reduced in an orderly fashion with all parties involved making efforts to help. One example of this is when creating healthy communication between stakeholders is enforced farmers move towards less use of pesticides and fertilizers. By reducing fertilizer use, excess nutrients will also begin to decrease. Additionally, the EPA is awarding grants to states for operating nonpoint source management programs. Implementing these types of plans will not only bring in funding, but will also create easier ways for a larger number of people to be able to make an influence.

Problem 3: Heavy Metals

The increasing amount of heavy metals found within the Santa Ana River Basin have caused the EPA to label many California rivers, creeks, and shorelines as impared. The main elements that contribute to these high levels are cadmium, copper, lead and zinc. Although copper and zinc are essential elements for living organisms the elevated levels found in many waterways can have negative effects on the ecosystems

within. Cadmium and lead differ from these essential elements in the fact that even trace amounts can cause serious problems for much of the biology found within these bodies of water.

These heavy metals can affect the ecosystems within the Santa Ana River Basin in various ways. Firstly, cadmium and lead atoms have the ability to substitute for divalent metals and thus interfere at the enzyme binding sites. This can be detrimental in some cases if the divalent metals are, for example, low levels of copper and zinc which are essential for organisms to live. If these organisms do not receive the essential elements they will not survive and thus large groups of organisms may die off, affecting the ecosystem entirely. Additionally, dissolved metals can also affect lower level organisms. These dissolved metals are directly taken up by organisms including algae, plants and planktonic organisms. These metals then bioaccumulate within lower level organisms until they reach a concentration that is harmful, lower concentrations for lead and cadmium higher concentrations for copper and zinc.

A study done in 1998 monitored the total metal results from stormwater coming into the Santa Ana River Basin. The goal of this study was to find data on the concentrations of heavy metals within storfmater inflows. It was found that the concentration in ug/L for cadmium, copper, lead, and zinc were 0.37, 23.3, 14.99, and 93.78 respectively. This study was just one example of an area where heavy metals are entering the Santa Ana River Basin and causing an increase in concentration that is negatively affecting the ecosystems.

There are many different ways that these heavy metals find their way into runoff that reaches the basin. Cadmium, for example, can reach waterways due to erosion and volcanic eruptions and tiny copper particles can be taken up by runoff from brake shoes in automobiles. Additionally, many metals are polluted into water bodies due to human activity. This can include smelting, mining, landfills, and burning fossil fuels. As areas in California become more industrialized the amount of these heavy metals becomes more concentrated and thus this problem continues to increase in severity.

Figure 7: Santa Ana River polluted by heavy metals

Goal 3: Reduce Heavy Metals

The main goal regarding heavy metal concentrations is to clean the waterways in the Santa Ana River Basin enough for swimming and fishing. One way this goal will be achieved is through grants from the EPA to develop plans and goals to clean up the waterways. There are currently many techniques to try and limit the excess of heavy metals in waterways. Most of these techniques are costly and use a lot of energy. One new technique that may be implemented in the Santa Ana River Basin is the use of Metal Organic Frameworks. These MOFs are effective because they create a larger surface area due to how the metal and organic chemicals are interlocked. The use of MOFs is selective and cost effective. One MOF that researchers tested was Fe-BTC. This MOF was treated with dopamine which polymerized the MOF to Fe-BTC/PDA which successfully was used to remove high amounts of heavy metals. By creating specific MOFs for each heavy metal that is of concern within the watershed they could be individually targeted and the concentrations would be effectively decreased.

<u>Summary of Goals</u>

Water recycling is a method to conserve water that has the potential to perform extremely well in the Santa Ana River watershed. Reducing the number of nutrients within waterways will help ensure that these nutrients do not get to a point of excess. By reducing fertilizer use, excess nutrients will also begin to decrease. One way this goal will be achieved is through grants from the EPA to develop plans and goals to clean up the waterways. There are currently many techniques to try and limit the excess of heavy metals in waterways. One new technique that may be implemented in the Santa Ana River Basin is the use of Metal Organic Frameworks. These MOFs are effective because they create a larger surface area due to how the metal and organic chemicals

are interlocked. The use of MOFs is selective and cost effective.This MOF was treated with dopamine which polymerized the MOF to Fe-BTC/PDA which successfully was used to remove high amounts of heavy metals. By creating specific MOFs for each heavy metal that is of concern within the watershed they could be individually targeted and the concentrations would be effectively decreased.

Conclusions

The watershed consists of high mountain ranges that divide large, dry alluvial valleys. Most of the population is concentrated close to the river in urban areas such as Riverside and Santa Ana. Through the late 19th century, citrus fields covered much of the coastal plain, which led to the naming of Orange County. Although there were plenty of economic opportunities and prosperity due to the Santa Ana River, there were also many floods that affected the region. In 1934 and 1938 another set of devastating floods struck the area, bringing an end to the area's citrus industry. The population of the Santa Ana river basin increased dramatically, but concerns of floods were still in place due to urban runoff into the river. SAWA is committed to protecting and improving natural areas of the Santa Ana River Watershed through the removal of invasive species, native habitat enhancement, and the protection of endangered and threatened species. The Drainage Area Management Plan identifies programs and policies, including Best Management Practices (BMPs), to achieve Water Quality Standards in the Receiving Waters. The BMPs can be divided into two categories: ones for existing facilities and ones for New Development and Significant Redevelopment. The goals established in The OC Plan are to improve water supply, protect water quality, enhance the environment and habitat, provide flood risk management, improve the quality of life, and address climate change. This watershed also adheres to California's Porter-Cologne Water Quality Control Act. The main goal that all bodies of water in the United States must follow is the Clean Water Act.. A catastrophic drought can possibly occur once every 2 to 4 years by the end of the century. Businesses and municipalities can recycle water that is used in the development of goods or services they provide. Contaminated wastewater greatly increases bacteria and pathogen concentrations, which cause these plant species to die off. Reducing the amount of nutrients within waterways will help ensure that these nutrients do not get to a point of excess. These heavy metals can affect the ecosystems within the Santa Ana River Basin in various ways. All of these things have an effect on the watershed. The SARA P will help the Santa Ana River watershed.

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