Lesson 6: California Drought and Conservation

Overview
This lesson discusses the drought and climate in Los Angeles. Students will investigate the cause of the drought using climate data to understand the various factors at play. This will lead into a discussion about using Low Impact Development and Green Infrastructure to help alleviate the drought while also improving water quality.

Objectives
Students will:
- Understand California's drought status and how it is affected by climate change.
- Learn about the significance of LID/green infrastructure and how it is used in both Australia and LA County.
- Discuss both the benefits and drawbacks of changing existing infrastructure for LID implementation.

NGSS Standards Addressed (Click here for complete standards)
HS-LS2- 7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-ESS3- 1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3- 4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

CCSS Standards Addressed
ELA/Literacy
RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
Mathematics
MP.2: Reason abstractly and quantitatively.
HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

Materials
- Classroom whiteboard/overhead projector

Focus Discussion: Causes of the California Drought (5 min)

Explain that a drought is a prolonged period of low rainfall and that California has been in a drought since 2011. In lesson 3, we mentioned that the 30-year average rainfall for Los Angeles was about 15 inches. Explain that although Los Angeles received above average rainfall in 2016 at about 18 inches, we are still in drought. *Show the drought monitor maps for various dates to help students visualize how the severity of the drought has changed over time.*

Ask students:

- Why is Los Angeles still experiencing drought conditions even though it received above average rainfall in 2016?
    - *Multiple years of above average rainfall is necessary to make up for the past years of minimal rainfall. Los Angeles is also highly urbanized with a high percentage of impermeable surfaces such as roads and buildings, so most of the rainfall gets washed into the ocean rather than replenishing groundwater supplies.*
- Why do you think most of the rainfall gets washed into the ocean rather than replenishing our own water supply?
    - *Infrastructure in L.A. is primarily designed to prevent flooding, so most of the infrastructure we currently have in L.A. is designed to drain the water out of the urban areas and into the ocean as fast as possible. This design, along with the high percentage in impermeable surfaces in L.A., prevents adequate infiltration to allow our aquifers to recharge. L.A. has begun to invest in stormwater capture infrastructure, but these systems are very expensive and require increased public awareness and strong political will to pay for.*
- What are other climate factors that could be affecting the severity of the drought?
    - *Warmer temperatures due to climate change also add to the severity of the drought. We will discuss this in the next section.*
- How do you think that drought connects to water quality concerns, such as those we learned about in the previous lesson?
    - *Less dilution of waterways, more pollutant build-up, higher temperature and less oxygen, etc.*

- Drought Monitor Maps: http://droughtmonitor.unl.edu/MapsAndData/ComparisonSlider.aspx
- U.S. Climate Data for Los Angeles: http://www.usclimatedata.com/climate/los-angeles/california/united-states/usca1339

Discussion: Analyzing Precipitation Patterns and Climate Change (10 mins)

Help students investigate the causes of the drought using climate data in the provided

graphs. Explain that California has naturally variable precipitation levels, but that climate change is intensifying the drought. Ask students:

- If we looked at average precipitation in California over the past 100 years, what kind of trend would we expect to see in the graph? *Students might say they would expect a negative trend because of the drought, but precipitation is not unnaturally low because California has always had high variability over the long term (show Figure 1 and point out the black line that shows large variability in precipitation levels).*

- What is the general predicted precipitation trend for the next 100 years (show Figure 1 and point out the various colored lines which each represent predictions of future average precipitation)? *Most predicted precipitation levels for the next 100 years do not show a positive or negative trend. This means that although low precipitation is a major cause of the drought, there are other factors at play that are magnifying the current problem.*

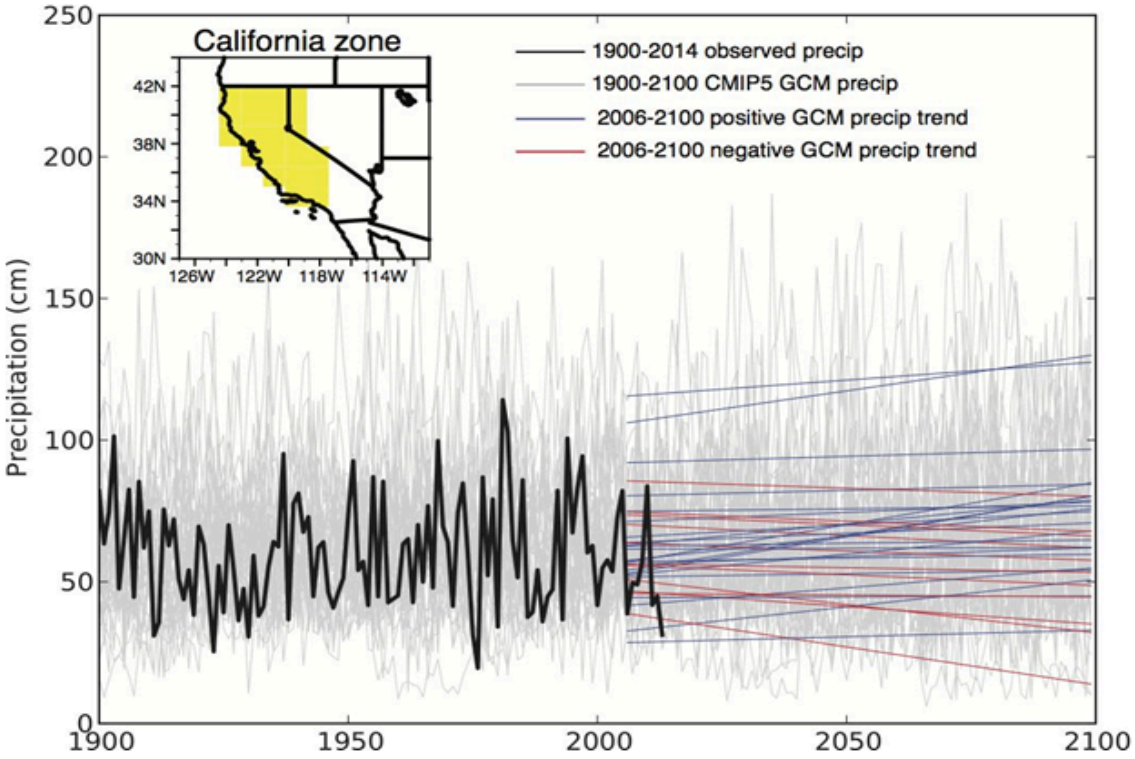

***Figure 1**: Observed and expected precipitation levels in California from 1900-2100.*

- How can climate change magnify the drought?
  - *Increased evaporation - higher temperatures due to climate change increase evaporation which removes more water from the surface and soil. This is measured*

using the Palmer Modified Drought Index (PMDI) which measures drought by looking at both precipitation and evaporation levels - refer to Figure 2 for next question.

- What trend does the California PMDI show for the past century (show Figure 2)?
  - *The PMDI shows a negative trend which means that evaporation (yellow bars) is greater than precipitation (green bars). This indicates that California is losing more water than it is gaining which explains why we are in the most severe drought in California history. Scientists say that climate change is the cause of up to 20% of the drought (For reference - http://earthsky.org/earth/has-global-warming-worsened-california-drought)*

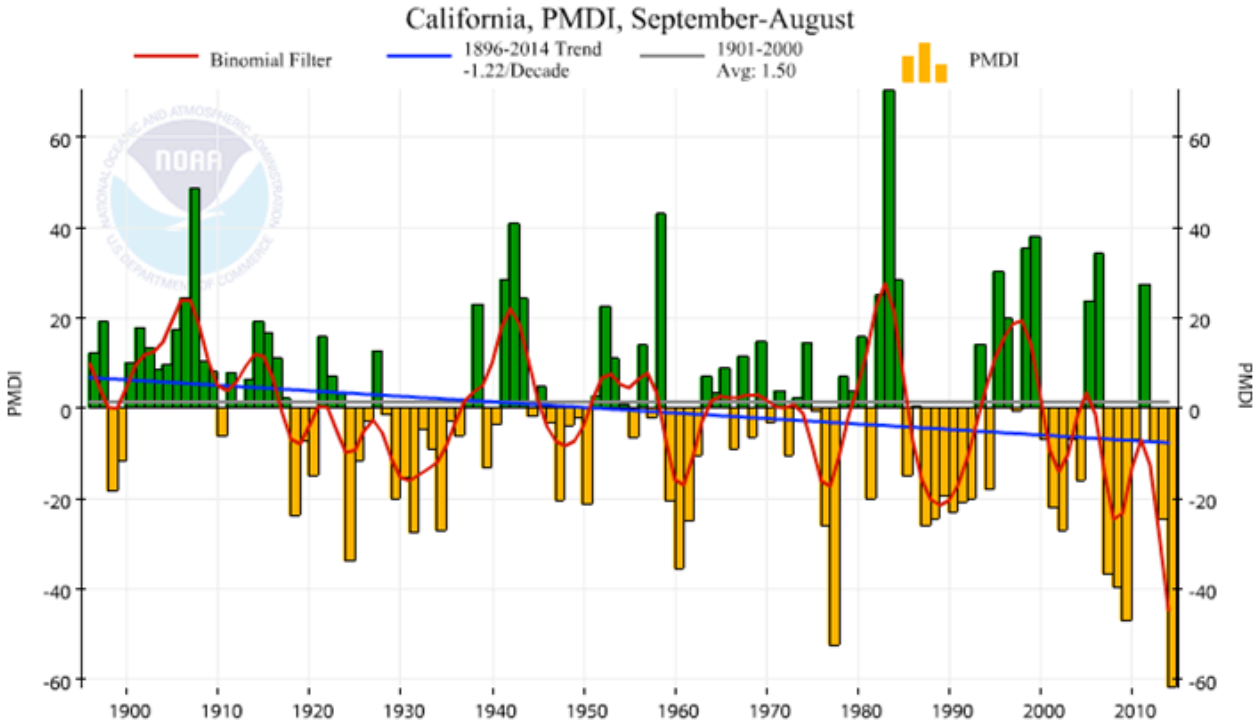

FIgure 2: Palmer Modified Drought Index from 1896-2014.

Discussion: Green Infrastructure/Low Impact Development (10 minutes)

Explain to students that there are alternative methods to conservation that can also help increase our water supply and also treat our urban runoff. Briefly define what Low

Impact Development (LID) is:

- Low Impact Development (LID) is a method of stormwater management that utilizes infiltration through natural drainage systems infiltration to capture and clean rainwater and urban runoff.
- Green infrastructure is almost used interchangeably with LID, but while LID is specifically for water treatment, green infrastructure can help improve a broader range of issues such as air pollution, wildlife conservation, and other ecosystem services.

Where does this water go? How much is this saving?

Harvested rainwater, and recycled wastewater and stormwater is used for supplementing our water supply to be used where there is a low chance of human ingestion (ex: watering lawns, flushing toilets). This saves us hundreds of millions of gallons of drinking water each year.

Examples of LID:

- Permeable Pavement:
  - Allows for stormwater to quickly infiltrate into the ground, providing filtration treatment and eliminating impervious concrete. Treatment levels vary depending on engineering.
- Bioswales/Biofilters/Rain Gardens
  - Drains and filters stormwater like permeable pavement. Different layers of soils and plants allow for more immediate treatment of stormwater and may remove metals and other pollutants depending on the engineering. Also provides green spaces in cities.
- Rain barrels
  - Rainwater harvesting method to collect rain that washes off residential roofs. By storing the water directed through rain gutters into the rain barrel, residents can connect their hoses to this and use it to water their lawns/plants.

Case Study: Victoria, Australia **(10 minutes)**

Victoria is a state in Australia with the second-highest population in the county of nearly 6 million people. Australia has parallels to Southern California in that it also went through a long-lasting drought, known as the Millennium Drought (1995-2012). To help the people through the impact of the drought, the government and the people came to an agreement that they needed to find alternate sources of water.

What's unique is that the public has accepted the importance of conserving water and changing their infrastructure to take advantage of the rain. This is how their government was able to implement this system--through building public support for changes in urban planning and design. The public supported an initiative to build 10,000 raingardens across Melbourne. They began in 2008 and completed construction near the end of

2013.

Some working examples in LA County are in residential areas and can be done in your own front yard: an example is the Elmer Avenue Neighborhood Retrofit
- 5.4 million gallons of stormwater is infiltrated every year
- Reduces 60% of lead, 33% of copper, and 18% of total suspended solids concentrations, improving the water quality.
- Also is important as a public education tool

LA County adopted the Low Impact Development Ordinance back in 2011:
- The goal is to **reduce impervious surfaces** for businesses and residences
- Newly developed or redevelopment projects must now try to reduce runoff
- Capture rainwater before it needs to be treated
- Create a stormwater mitigation plan for approval

Almost 40% of LA County's requirements for treating urban runoff would be met by implementing LID projects on existing public land. LA County's current priority level:
1. Infiltration Systems
2. Biofiltration/Retention systems
3. Stormwater capture and reuse

Ask the students for their opinions. Could they see themselves doing this in their own front yard? Their school? Can they think of any reasons why we may not be doing this?

Southern California has a lot of potential for stormwater capture.
- Common arguments include that the region does not see enough rainfall to make a full investment on potentially expensive infrastructure retrofits.
- While we are in a period of drought, the LA region is used to swinging between hot and dry summers, and wet and cold winters. Think of this past winter—we've been getting much-needed rainstorms. However, we have also been forced to release lots of water from our reservoirs because we don't have adequate infrastructure to help capture rainwater.
- Both political opposition and negative public perception of alternate water supplies slow down progress of these practices.
- Another issue is that cities don't have the funding to afford the expensive infrastructure changes required to fully integrate captured stormwater and rainwater into their water systems.
- The amount of time it takes to make infrastructure retrofits is certainly a concern. However, Melbourne Water managed to build 10,000 rain gardens between 2008 and 2013, and most of them were on small scales on sidewalks and in front of houses.
- The Natural Resources Defense Council has argued that stormwater capture could

potentially provide more than 253,000 acre-feet of water for Los Angeles County after every inch of rainfall — or nearly 40% of the city of Los Angeles' annual water use.

For more info: http://www.lastormwater.org/green-la/low-impact-development/

Activity: Benefits/Drawbacks Grid **(15 minutes)**

Materials:

- Whiteboard/overhead projector (to write answers as students call them out)
- Benefits/Drawbacks Grid worksheet (or students can use lined paper)

For this activity, you will have your students create a grid contrasting both the benefits and drawbacks of implanting low-impact development to assess their understanding of this lesson. This can be completed together with the entire class so you can guide responses and spur discussions, or in small groups of 4 students.

If done in small groups of students (recommended), give the groups 7 minutes to discuss amongst themselves and fill out the Benefits/Drawbacks Grid as best as they can. Set up a large Benefits/Drawbacks grid on a whiteboard/projector for the whole class to see. Then, spend the last 8 minutes discussing their answers with the whole class, and fill in the grid with their answers. Be sure to use this time to ask them to elaborate on their answers to see if they understand the material.

If done as a whole class, start with the large Benefits/Drawbacks grid on the board.

Low Impact Development Benefits/Drawbacks Grid

Discuss with your group and fill out the chart as best as you can. Make sure to come up with as many examples as possible. As an extra challenge, try to also think outside the box for other reasons why there may be pros and cons to LIDs. Be prepared to discuss your answers with the class.

Benefits	Drawbacks
Ex: an LID like a green street can help bring plant life back to a neighborhood	Ex: green streets can also require regular maintenance, which can be an added cost.