NOTES FOR CONSIDERING CLIMATE CHANGE IMPACTS ON WASTEWATER SYSTEMS, CALIFORNIA

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1 Introduction

Climate Change is neither a scientific question, nor an issue for our future. Our climate is already substantially different than it was even 30 years ago. 2014 was the hottest year on record, and 2015 is on track to beat that record. In our new and warming climate, increasing greenhouse gas levels in the atmosphere trap heat, and this heat has major consequences for not only weather, but for global chemical cycling, global biology, and our own lives and safety.

In this changing climate, storms are more intense, precipitation patterns are changing, and droughts grow deeper and longer. Wastewater systems in California must adapt to challenges posed both by water conservation during drought years, where waste is highly concentrated, and, for agencies which also manage stormwater flow, unusually high flow volumes when the rains fall.

Seas are rising, and will continue to rise at an accelerating rate well beyond the 21st century. As a consequence, coastal development, including critical infrastructure, will experience increasingly frequent and severe coastal flooding. Areas that currently experience infrequent flooding will be inundated more often, and areas along our shorelines which have not previously flooded may begin to flood. Many wastewater facilities are already experiencing challenges related to sea level rise. As new infrastructure projects are planned along the shoreline, or existing assets are modified or improved, the potential for flooding due to rising sea levels – in combination with storm surge and wave hazards – must be evaluated.

Building in system resilience now reduces risk and establishes a safer, more reliable system for the future.

2 Key Terms and Definitions

Adaptation The practice of planning for anticipated climate change and developing strategies to address potential impacts.

Asset Property, often a facility or structure (or a component of the facility or structure) which has particular value. In this context, an asset is typically a physical component of an physical, ecological, or social system, such roads, bridges, tunnels, sewers, pump stations, etc. Natural resources, including open space, parks, and habitat, are also assets which may be considered in adaptation planning.

Climate Climate is often defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities (such as temperature, air pressure, humidity, precipitation, and wind) over a period of time ranging from months to thousands of years. The classical period is 3 decades, as defined by the World Meteorological Organization (WMO). Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate Change Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, wind patterns, or sea level rise, among others, that occurs over several decades or longer.

Climate Impact The physical manifestation of a short- or long-term climate stressor, such as flooding, degradation, damage, or destruction.

Climate Stressor The component of climate (e.g., sea level rise, storm surge, precipitation, temperature) or event (e.g., extreme storm) that causes short- or long-term stress or impact to an asset, system, or community over time.

Consequence Something that happens to an asset or facility as a result of a particular climate impact or a combination of climate stressors. In a practical sense, consequence often considers damage, disruption, and/or costs to repair or replace.

Exposure The exposure of an asset is the degree to which an asset is susceptible to hazards (i.e., depth of flooding due to sea level rise, storm surge and wave run up).

Sensitivity The degree to which an asset is, or could be, affected (i.e., temporary flooding causes minimal impact, or results in complete loss of asset or shut-down of operation) by a climate stressor, if exposed to that stressor.

Risk The potential chance of damage, disruption, injury or loss as a result of exposure to a climate impact or stressor. Risk is often considered a combination of the cost of the impact or stressor and the likelihood that the impact will occur.

Vulnerability The degree to which an asset may be physically or functionally impacted by a climate stressor. Vulnerability is a combination of exposure, sensitivity, and adaptive capacity.

3 Climate Science Overview from the National Climate Assessment

Adaptation to climate change begins with an understanding of the current state-of-the-science. Climate science is continually being updated, revised, and strengthened. Although there is no doubt, for instance, that sea levels have risen and will continue to rise at an accelerated rate over the coming century, it is difficult to predict with certainty what amount of sea level rise will occur at any given time in the future. The uncertainty increases over time (e.g. the uncertainties associated with 2100 projections are greater than with 2050 projections) because of uncertainties in future greenhouse gas (GHG) emissions trends, the evolving understanding of the sensitivity of climate conditions to GHG concentrations, and the overall predictive capability (i.e., skill) of climate models.

Given these uncertainties, climate change planning must rely on the best available science at the present time. Each new climate change vulnerability assessment should begin with a review of the current state-of-the-science related to the climate stressor under consideration (e.g., sea level rise), and should build upon previous work. Responsible and responsive climate planning will also include a framework for reviewing and updating climate change assumptions and decisions over time. Delaying climate change vulnerability and risk assessments and adaptation strategy development and implementation until climate change science is more certain will result in irresponsible development and could unnecessarily endanger human health and wellbeing.

While appropriate and up-to-date sources should be considered for each geographic region and project, the National Climate Assessment of 2014 provides an overview, at a broad scale, of the changes expected in the U.S. Southwest, including California, Nevada, Utah, Colorado, Arizona, and New Mexico.

The National Climate Assessment is a summary, produced by a team of more than 300 experts and guided by a 60-member Federal Advisory Committee. The report was extensively reviewed by the public and experts, including federal agencies and a panel of the National Academy of Sciences. Broadly, expected changes in this region include:

Heat

- The Southwest is the hottest, driest part of the United States. Climate change is making the region even hotter, and increasing competition for the most precious resource: water.
- The last decade was the hottest on record in the region. If carbon pollution continues to go up, average temperatures could increase 9 degrees Fahrenheit by the year 2100.
- Across the Southwest, heat waves are expected to become longer, more intense, and more lethal. Arizona already has the highest rate of deaths from heat stress in the United States.
- Cities are especially vulnerable to heat waves, when spikes in air conditioning use can lead to blackouts.

Drought and Fires

- Drought is expected to become more frequent, intense, and longer-lasting in the region's major river basins.
- Snow is already melting earlier, with less late-season snow than before. These trends are expected to continue. Reduced snowmelt puts the region's water supply at risk.
- Climate change has contributed to a dramatic spike in forest fires, leading to billions of dollars in damages.
- Warm winter temperatures have led to pine beetle outbreaks, which kill trees. Since 1984, pine beetles and forest fires have together killed 20 percent of the trees in Arizona and New Mexico.
- The frost-free season is now 21 days longer than it was in the early 20th century. Fewer days with frost results in changes to snowpack, and stresses the capacity of existing reservoirs to meet water storage needs.

Sea Level Rise

- Over the past century, sea level has already risen by up to 8 inches along the Southwest coast. Flooding has already damaged infrastructure like California's Highway 101.
- Sea level rise poses a threat to infrastructure like highways, bridges, power plants, and sewage treatment. It also poses a threat to the region's ports, which handle half the country's incoming shipping containers.

4 Adaptation Planning

Many state and local governments are already preparing for the impacts of climate change through "adaptation," the practice of planning for anticipated climate change and developing strategies to address potential impacts. While adaptation planning can take many forms, the process follows some basic steps (see Figure 1):

Step 1. Science Review. Planning efforts can no longer rely on historical weather patterns or ocean levels, or even the rates of sea level rise observed over the past century. Instead, they must incorporate the latest climate science to identify relevant projections of future climate variables in order to respond appropriately to a changing climate.

Adaptation planning requires consideration of uncertainty and risk, because the science supporting climate change projections has many underlying uncertainties. As such, a robust adaptation plan requires that potential adaptation strategies be revisited as the science progresses and projections are updated. In this step, climate parameters of concern (e.g. sea level, precipitation, or heat) are identified, and mapped for the appropriate region, across a range of time scales, or by climate thresholds, such as specific sea levels.

Figure 1. Adaptation Planning Framework

Step 2.Asset Inventory. In order to assess vulnerability or estimate risk, the assets to be considered must be defined. An asset inventory consists of gathering geographic (location), condition, and other data for a defined set of assets to be considered. An asset inventory may be as broad as a city, or an entire wastewater system, or be limited to only a few select assets of concern.

Step 3. Vulnerability Assessment. In this step, the vulnerability of each asset is considered relative to each climate variable of concern. Vulnerability is a combination of exposure, sensitivity, and a concept called adaptive capacity. Vulnerability considers only whether an asset is likely to be impacted by a climate stressor, not what the consequence will be from that damage.

Step 4. Risk Estimate. A risk estimate allows managers to consider the costs of climate impacts. Risk is often considered to be a combination of the likelihood of impact and the potential types and magnitude of the consequences of that impact. Assets which are rated as vulnerable in Step 3 are considered in this step. Many types of consequence can be considered, and may include failure propagation (such as when a pump station failure causes upstream flooding), economic costs, social impacts, or environmental impacts. Physical damage and service disruption are frequently used to estimate the magnitude of consequence.

Steps 5 and 6. Adaptation Planning and Implementation. During these phases, potential adaptation strategies are developed for assets, projects, or community features that are identified as priorities during Steps 3 and 4. Given that the science of climate change is continually evolving, projects should adopt a planning horizon based on the functional lifespan, which is often longer than the design life, and include appropriate adaptation strategies to accommodate a range of potential climate impacts.

In many instances, it is not feasible or cost effective to design and build for long-term potential sea level rise. In this case, a project could be designed and constructed to account for likely mid-century sea level rise, while it is also built with the ability to adapt to more severe sea level rise scenarios should seas rise more quickly than current projections. An alternate approach would be to build resilience to *likely* sea level rise by 2100 now, while identifying the adaptation strategies needed to build resilience to the *upper range* sea level rise estimate for 2100. The adaptation plan for the asset or project should include the level of sea level rise appropriate for near-term project planning and implementation, and the adaptation strategies that can be implemented over time if sea level rise exceeds, or is anticipated to exceed, the original estimate.

The adaptation plan should clearly lay out the triggers or time horizons for implementation of the identified adaptation strategies, and the plan should include a means to monitor and respond to changes in the science or the condition of the asset. This approach can reduce the near term cost of project implementation, while providing for future flexibility and adaptation potential. The adaptation plan should include funding mechanisms necessary for implementation of future adaptation strategies.

Incorporating projected climate impacts into wastewater planning is complex, and it often extends beyond jurisdictional and political boundaries. In practice, development of an Adaptation Plan is not the end of the planning process, but the beginning of the implementation process. For complex utilities and large communities, successful adaptation may take many years, and even decades. Adaptation Plans should include clear accountability and trigger points for bringing adaptation strategies online, both in the near and long term.

Step 7. Monitor. Because climate science is a relatively new field that is subject to change as new information and studies become available, as greenhouse gases continue to build in the atmosphere, and as our complex globe adjusts, a robust Adaptation Plan should include a process for reviewing, updating, and incorporating the latest, best-available science.

Adaptation also requires monitoring for the climate thresholds identified as risk triggers. For example, if an adaption plan notes that an additional adaptation strategy should be brought online when sea level rose by 20”, monitoring of local sea levels is required.

As adaptation strategies are implemented, our combined knowledge bank of lessons learned and successful practices will grow. Continued monitoring, adjustments, and communication of such lessons is our best hope for a safe and successful transition into our shared future.

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