MEMORANDUM

Date:	**5/3/2019**	Project No.:	**PNNL-28673**
To:	**California Public Utilities Commission**	Internal Distribution:	**File/LB**
From:	**Homer, Juliet S**		
Subject:	**Categorization of potential distributed energy resource (DER) opportunities in water and wastewater systems in California**		

This document provides a high-level categorization of potential distributed energy resource (DER) opportunities in water and wastewater systems in California. In this effort and document, DER include distributed generation resources, energy efficiency, and demand response. This is consistent with the DER definition used in other California Public Utility Commission (CPUC) proceedings and in Pub. Util. Code §769. DER opportunities for water and wastewater utilities that exist outside of utility operations, such as solar panels or distributed wind turbines, are not addressed.

Figures 1 and 2 show the water and wastewater DER opportunity areas by unit process. The highlighted unit processes have the potential for providing DER services. Table 1 provides a brief description of each unit process.

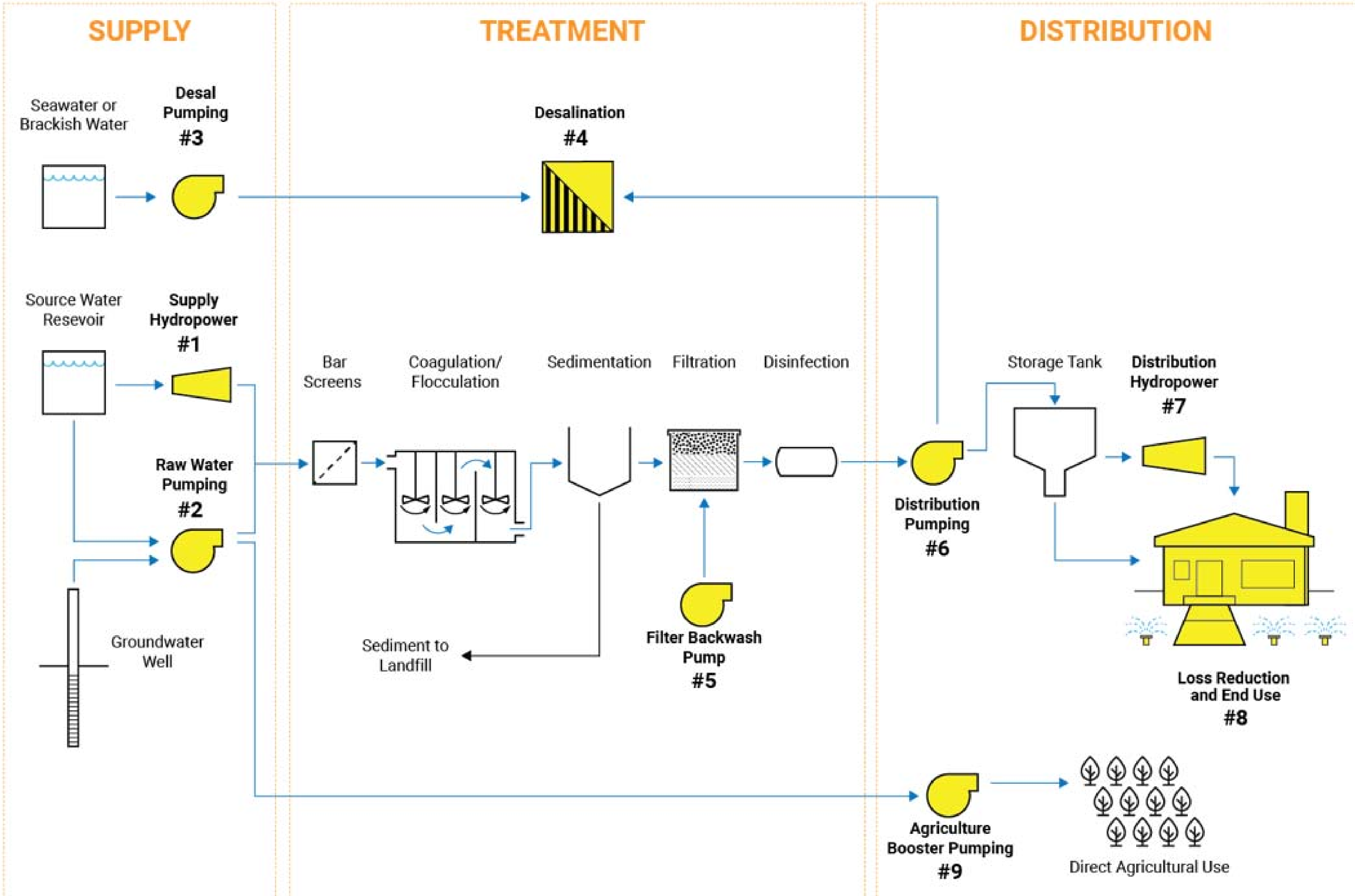

Figure 1. Water system unit processes – yellow highlighted items have the potential to provide DER services
Adapted from Sparn and Hunsberger (2015)

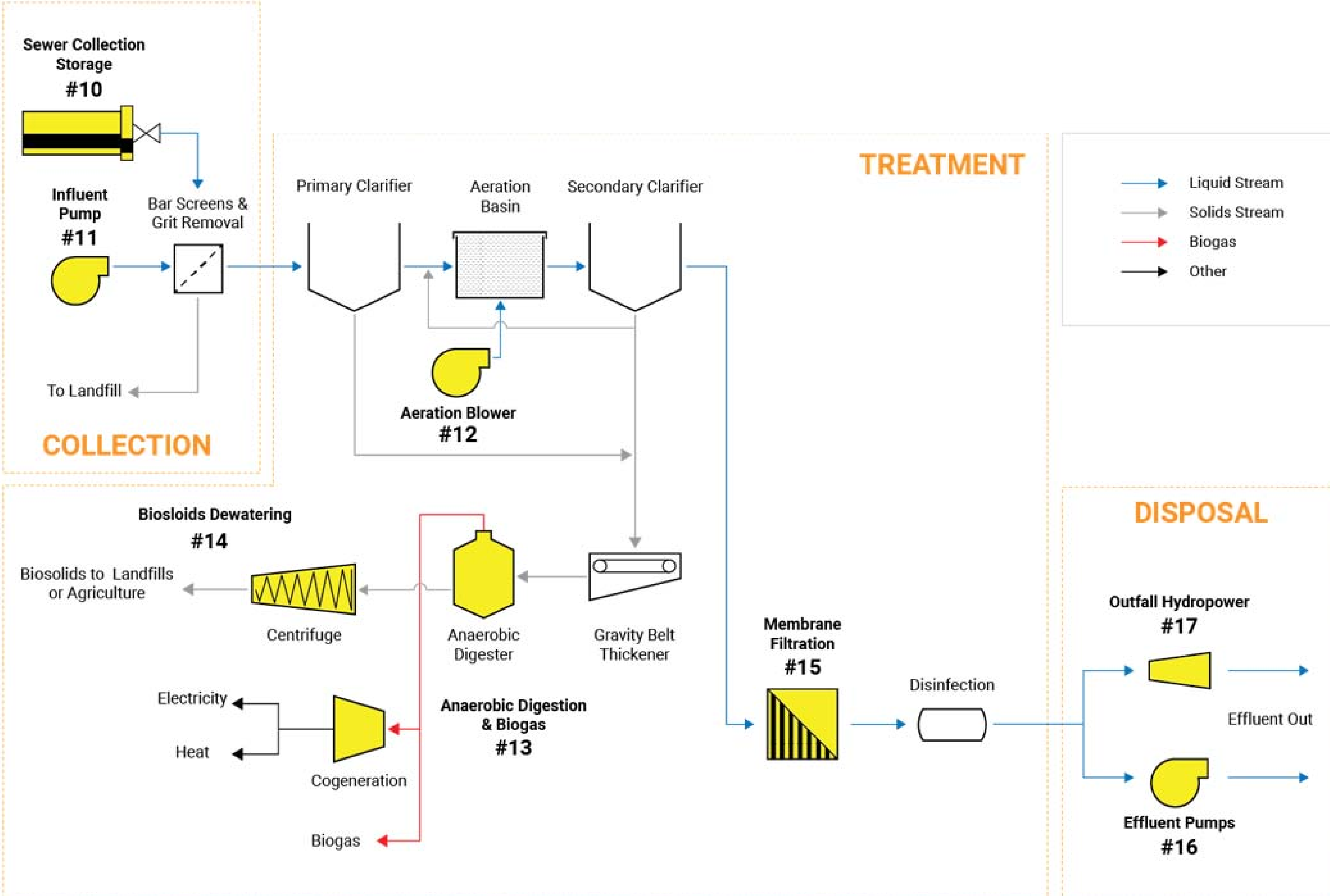

Figure 2. Wastewater system unit processes – Yellow highlighted items have the potential to provide DER services
Adapted from Sparn and Hunsberger (2015)

Table 1. Description of DER opportunities

Water	Supply	#1 Supply hydropower generation – In-conduit hydropower generated from potential energy within water collection piping
		#2 Raw water pumping – Surface and groundwater pumping to acquire and deliver water to treatment plants or agricultural applications
		#3 Desalination pumping – Pumping to bring seawater or brackish water to desalination facilities
	Treatment	#4 Desalination – Pumping to pressurize desalination membranes to achieve desalination
		#5 Filter backwash pumping – Pumping to fluidize and backwash filters in water treatment processes
	Distribution	#6 Distribution pumping – Pumping to deliver treated water to points of use
		#7 Distribution hydropower – In-conduit hydropower generated from potential energy in water distribution piping
		#8 Loss reduction and end use – Water efficiency measures that reduce water losses or reduce water end use requirements
		#9 Agriculture booster pumping – Additional pumping to deliver water to agricultural applications
Wastewater	Collection	#10 Sewer collection storage – Using excess capacity in the sewer collection system to store wastewater to allow for full or partial plant shutdowns in response to demand response events
		#11 Influent pumps – Pumping to bring raw wastewater into treatment plants
	Treatment	#12 Aeration blowers – Aeration blowers used to aerate wastewater as part of the wastewater treatment process
		#13 Anaerobic digestion and biogas – Anaerobic digestion used to break down solids during the wastewater treatment process. Biogas is created during anaerobic digestion.
		#14 Biosolids dewatering – The process of dewatering sludge generated during wastewater treatment, often accomplished through the use of high power centrifuges
		#15 Membrane filtration – Membranes used to filter treated wastewater, often for the purpose of water reuse
	Disposal	#16 Effluent pumps – Pumps to pump treated wastewater out of the treatment process to either disposal or reuse
		#17 Outfall hydropower – Hydropower generated from potential energy at the point of discharge from the wastewater treatment process

The following sections provide overviews of different categories of potential DERs.

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Hydropower – (applies to: water supply #1, water distribution #7, and wastewater treatment plant outfall #16)

Hydropower units can be placed at various points in water and wastewater systems, including in-conduit hydropower units associated with source water conveyance and water distribution systems as well as hydropower units located at wastewater treatment plant outfalls. In-conduit hydropower units can be located throughout a water distribution network, particularly in places where pressure reducing valves are installed or at turnouts on large diameter water transmission pipelines. Hydro units at the point of wastewater discharge, called wastewater treatment plant outfalls, are also an emerging technology.

Hydro units can function in a variety of ways and provide generating capacity for peak demands and reserves (i.e. contingency, replacement, flexibility), and other grid services such as frequency response, load following, load leveling, and voltage support, depending on the individual designs and pressure head available. There are, however, important practical considerations relative to equipment wear and tear that need to be taken into account when operating hydropower units outside of standard operating conditions.

Pumping – (applies to: raw water #2, desalination pumping #3 and #4, filter backwash #5, water distribution #6, wastewater influent #10, membrane filtration #14, and wastewater effluent pumping #15)

Energy benefits from water pumping can be achieved through the use of variable frequency drive pumps, which can provide energy efficiency and grid support, or by shifting pumping patterns to provide flexibility. Utilizing variable frequency drives allows for the potential to decrease load at a given time by having pumps run at lower speeds and can allow for the water utility to participate in markets such as regulation services. Pumps used at raw water pump stations and distribution pump stations are locations of interest for adjusting pumping practices. Load leveling or arbitrage may also be an opportunity. Even when variable frequency drive pumps are not present, in some cases pumping times can be moved away from peak electricity demand periods if sufficient storage or operational flexibility exists.

During raw water pumping, there is potential to provide generating capacity and ancillary grid services when there is a series of reservoirs/tanks. In finished water pumping, pumping the potable water to tanks and reservoirs is flexible, and many utilities already pump at night during off-peak times.

Loss reduction and end use (see item #8)

Water loss reduction measures and end-use efficiency reduces the water that must be supplied, pumped, treated, and distributed as well as the commensurate energy associated with each step in the process. Water efficiency measures primarily generate energy benefits and can to the extent energy savings coincide with peak demand periods, they can also provide capacity benefits.

Sewer collection storage (see item #9)

Depending on the configuration of the wastewater treatment plant and sewer collection system, all or part of the plant can be shut down to reduce demand during times of stress for the grid. Sewer collection storage entails using excess capacity in the sewage collection system to store raw wastewater and turn off complete treatment plants for periods of time. Sewers and treatment plants in some areas are designed to accommodate both wastewater and storm water flows. Storm water flows can exceed wastewater flows by an order of magnitude or more. During dry periods, significant excess capacity may exist in combined sewer systems, which can be used to store wastewater for treatment later, at off-peak times. When possible, a shutdown might occur for 5–10 hours if a combined sewer/storm water system can accommodate several days' worth of influent storage. Sewer collection storage allows for a reduction in energy use associated with all treatment processes during the time the plant is not running, and thus provides flexibility and capacity to the grid.

Aeration blowers (see item #11)

Aeration blowers are one of the largest users of energy in water or wastewater systems. Air pumped into wastewater through aeration blowers creates the conditions necessary for aerobic bacteria to break down the waste. Efficiency equipment can be added to aeration blowers and, to a limited extent, aeration loads and timing can be adjusted. For instance, the load for variable- and multispeed aeration blowers can be reduced or aeration tanks can be over-oxygenated before a capacity event. In this way, aeration blowers have the potential to provide flexibility and efficiency to the grid.

Anaerobic digestion & biogas (see item #12)

Anaerobic digesters at wastewater facilities are used to break down sludge created during the wastewater treatment process. In the process of anaerobic digestion, biogas is created, which typically consists of 40–60% methane. If the biogas produced from the digesters is not flared, it can be used for energy purposes, such as to power blowers, engines, or fuel cells. Additional treatment of the gas might be required. Wastewater utilities can utilize this biogas in an onsite combined heat and power (CHP) system to offset their energy costs. If they are using a CHP system, the device can either be operated in a steady manner to consistently provide energy, or the wastewater facility can switch to their CHP system during times of peak demand. Biogas can also be used for onsite heat or be injected into natural gas pipelines. Thermal hydrolysis, a mechanism that increases the amount of biogas produced with anaerobic digesters, consists of high heat and pressure followed by a sharp decompression, which creates more food for the microbes in the digesters. In addition, in some areas, food waste, fats, oils, greases, and crop residues are brought to wastewater treatment plants and added to anaerobic digesters to increase the amount of methane produced.

<u>Biosolids dewatering</u> (see item #13)

Biosolids dewatering is another process in wastewater treatment that uses a significant amount of energy. Bacteria that digest organic matter in wastewater are settled out of the treatment process and, prior to disposal, as much water as possible is removed from the biosolids. Often, very large and energy-intensive centrifuges are used to remove water from the biosolids or sludge. These centrifuges are not operated continuously, but rather intermittently as needed, once the amount of biosolids builds up to the point where a batch can be processed. There is, or could be, some flexibility in the timing of centrifuge operations. In addition, efficiency measures can be applied to dewatering equipment. In this way, biosolids thickening has the potential to provide flexibility and efficiency to the grid.

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<u>Next Steps</u>

Future deliverables in this project will provide energy use characterization of each unit process, more detail on grid services that might be provided by the identified unit processes; a characterization of maturity and practical feasibility; and an order-of-magnitude estimate of DER potential that may be achievable in California through water and wastewater systems, informed by case studies in California and beyond.

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References:

Sparn B and R Hunsberger. 2015. *Opportunities and Challenges for Water and Wastewater Industries to Provide Exchangeable Services*. NREL/TP-5500-63931. National Renewable Energy Laboratory. Golden, CO. https://www.nrel.gov/docs/fy16osti/63931.pdf