Frequently Asked Questions

Division of Water Quality / Ocean Desalination

1. What is seawater desalination?

Seawater desalination uses ocean water as a supplement to traditional water supplies. Seawater desalination is a water treatment process that starts by pumping seawater through subsurface coastal wells or directly from the ocean through screened intakes. Seawater is then sent to a facility where it goes through various treatment processes to remove the salts and minerals to produce freshwater suitable for human uses, including drinking water.

Several technologies are available to desalinate water, but the most common for large scale desalination facilities in California is reverse osmosis membranes. Reverse osmosis technology removes particles and ions in the seawater that are larger than 0.0001 microns to over 0.001 microns depending on the membrane. The resulting desalinated water is so pure that minerals are added back to make it suitable for distribution and human consumption. For every two gallons of seawater, a facility typically produces approximately one gallon of freshwater and one gallon of high salinity brine that includes salts, minerals, and other compounds and ions removed in the treatment process. The actual ratios will depend on the type and efficiency of the treatment technologies used at a facility. Brine waste is typically twice as salty as the original ocean water and is usually disposed back into the ocean.

Some coastal communities may need seawater desalination facilities for their water supplies. Although desalination can provide an important alternative source of potable water for some coastal communities, surface water intakes and discharges associated with facilities that desalinate seawater can have significant impacts on aquatic life and beneficial uses. The environmental impacts associated with the construction and operation of seawater desalination facilities are summarized in Question 4 along with how these facilities are regulated to minimize the environmental impacts in Question 6.

2. How are the Water Boards addressing the state's water challenges?

The State and regional water quality control boards (Water Boards) continue to coordinate with local, regional, tribal, and federal entities and interested persons and entities (e.g., water utilities, sanitation agencies, non-governmental organizations) on actions to ensure the state's long-term water resilience and ecosystem health through implementation of the state's Water Resilience Portfolio, California's Water Supply Strategy: Adapting to a Hotter, Drier Future (Water Supply Strategy), and Human Right to Water. These documents acknowledge that there is no single solution to the state's water challenges and include broad and diverse approaches to enhance water resilience by:

- maintaining and diversifying water supplies
- protecting and enhancing natural ecosystems
- improving physical infrastructure to store, move, and share water more flexibly
- promoting integrative water management.

Communities may be able to maintain and diversify their water supplies through increasing storage capacity for water, improving conservation of and efficient use of water, and accessing new water sources through recycled water production, stormwater capture, and brackish and seawater desalination. Water affordability and environmental justice impacts should be considered when evaluating water supply options for a community.

The Water Boards are continuing to work on implementation of the Water Supply Strategy, such as actions to expand the use of brackish water desalination and improve the planning and permitting process for seawater desalination facilities. The State Water Board released a report in January 2024 that identified areas in California with the highest potential for brackish groundwater desalination projects, potential impediments to bringing brackish groundwater desalination online, and recommendations for next steps. Please see Water Supply Strategy Deliverable: Groundwater Basins with Potential for Brackish Groundwater Desalination report for more information.

In January 2024, the State Water Board also released the Seawater Desalination Interagency Group's Final Seawater Desalination Siting and Streamlining Report to Expedite Permitting (Report) to fulfill directives set by the Water Supply Strategy. In January 2023, State Water Board staff convened a Seawater Desalination Interagency Group, comprising state and federal agencies to establish criteria agreed upon by multiple state and federal permitting entities for the efficient and timely approval of coastal desalination projects to help address increasing threats to California's water supply while protecting coastal marine environments. The Report has no regulatory force or effect, but includes interagency recommendations. The draft Report was released for public comment in July 2023 and on July 21, 2023, staff held an informational webinar to share the impetus and approach for developing the draft Report and provide an overview of its recommendations, including presentations from some of the interagency partners involved in this collaborative effort. State agencies incorporated this feedback in the final Report released in January 2024 and are committed to continue to improve permitting efficiency for seawater desalination projects.

The Water Supply Strategy directs the State Water Board to consider amendments to the seawater desalination requirements in the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) and identify potential available mitigation sites to streamline permits that meet the recommended siting and design standards for projects located in the identified priority areas. State Board staff will initiate outreach for this project in summer 2024.

3. What is the difference between seawater and brackish groundwater desalination?

Some coastal communities may consider brackish groundwater or seawater desalination projects to augment their water supplies. The primary difference between the two types of desalination is the salinity or total dissolved solids in the source water (Table 1), but there are other differences and similarities between the two water supply options. Brackish groundwater and some seawater desalination facilities can pump water into the facility through wells or subsurface intakes that do not harm marine life. However, subsurface intakes will not be feasible in all areas due to hydrogeologic conditions and consequently some seawater desalination facilities will need to pump water through screened surface intakes that have significant marine life mortality over the operational lifetime of the facility.

Brackish groundwater desalination and seawater desalination typically use the same or similar technologies to separate salts from freshwater, including reverse osmosis membranes. However, seawater includes significantly higher salts, minerals, and other particles than brackish water. The higher the salt content in the water, the higher the pressure needed to pump the water through the reverse osmosis membranes, which results in higher energy use and costs. Both types of desalination facilities produce brine waste, but brackish desalination brine is significantly less salty than seawater and seawater desalination brine (Table 1). Consequently, brackish desalination brine is typically discharged to the ocean where it passively mixes or is discharged into a sanitary sewer system. Seawater desalination brine is typically twice as salty as seawater and must be diluted or actively mixed when discharged to the ocean to prevent harm to marine life (see Question 4).

Table 1. Comparison of brackish groundwater and seawater desalination.

Desalination Type	Brackish Groundwater	Seawater
Intake Type	Wells	Subsurface or surface
Source Water Salinity[1]	1,000 - 15,000 mg/L	32,000 - 35,000 mg/L
Energy Use[2]	1.0 - 1.5 kWh/m^3	3.5 - 4.5 kWh/m^3
Brine Salinity[1,3]	2,000 - 30,000 mg/L	64,000 - 70,000 mg/L
Cost per acre foot[4]	$840 - $1,700	$1,900 - $4,100

[1]Total dissolved solids, [2]Voutchkov, 2018; Kim et al., 2019; Szinai et al., 2021, [3]Staff Report, 2015, [4]Cooley and Phurisamban, 2016.

Overall, seawater desalination facilities will have greater impacts on marine life and require higher energy use for the operational lifetime of the facility compared to brackish groundwater desalination facilities. Seawater desalination facilities have longer planning and permitting timelines and costs relative to brackish groundwater desalination facilities due to the additional treatment, environmental analyses and review, and mitigation required. The environmental impacts and strategies to reduce environmental impacts associated with seawater desalination facilities are described further in Question 4.

While brackish groundwater desalination facilities may have many benefits over seawater desalination facilities, brackish groundwater desalination may not be feasible in all areas in California (see Water Supply Strategy Deliverable: Groundwater Basins with Potential for Brackish Groundwater Desalination report for more information.). Therefore, water planners should evaluate all water alternatives and apply an integrated water resource management framework when assessing options to optimize the use of environmentally and economically sustainable water supplies.

4. What are the environmental impacts of seawater desalination?

Marine Ecosystems in California

California’s coastline is home to some of the most biologically rich and diverse ecosystems in the world. These areas have intrinsic value, cultural significance, and serve numerous ecological and socioeconomic functions. The unique oceanographic conditions and physical environment off the California coast support a broad array of marine habitats and organisms. One teaspoon (5 ml) of seawater can contain millions of living organisms. From life invisible to the naked eye such as viruses, bacteria, microalgae, to larger organisms such as eggs and larvae – these creatures play an important role in maintaining ecological balance and supporting the marine food web in the California and beyond (Calbet, 2024). Healthy ecosystems support an abundance of marine life and may be “blue-carbon ecosystems” that store carbon and help to mitigate the impacts of climate change. Some habitats such as kelp forests, eelgrass beds, surfgrass beds, rocky reefs, shellfish beds, and deep-sea habitats are highly productive and/or ecologically significant and may require special protections. Some of these habitats are protected in designated Marine Protected Areas or Areas of Special Biological Significance. Other habitats may be important for state and federally managed species, such as market squid spawning grounds, which can have impacts on commercial and recreational fisheries.

The construction and operation of seawater desalination facilities can negatively affect marine life and coastal ecosystems. Consequently, owners or operators proposing new or expanded seawater desalination facilities must use the best available site, design, and technology feasible to minimize intake and mortality of all forms of marine life (Water Code 13142.5, subdivision (b), and more information in Question 6). A summary of construction, intake, and discharge-related impacts to marine life and other environmental impacts is provided below. As described below, some facilities may not be able to avoid intake and mortality of marine life. Full compensatory mitigation is required for any marine life mortality associated with the construction and operation of the facility. Additional information can be found in section 8.5 of the State Water Board 2015 Final Staff Report (Staff Report).

Seawater Desalination Construction Impacts

Construction-related intake and mortality of all forms of marine life is relatively limited. The duration of construction will vary from project to project based on the design and configuration of the intake and discharge. Physical disturbances may occur when constructing seawater desalination facilities, such as impacts to nesting shorebirds and communities of benthic ocean organisms. Construction-related impacts will, for the most part, only last for the duration of construction. Some construction-related impacts may be avoided or minimized through the use of Best Management Practices. For example, construction-related impacts to nesting birds can be avoided by adjusting the timing of construction to avoid nesting season. Impacts can also be minimized if construction occurs away from sensitive habitats and areas of high habitat productivity. Other construction-related disturbances and marine life mortality will be unavoidable and will require mitigation. See Section 8.3.1.1.1 of the Staff Report for more information.

Seawater Desalination Intake Impacts

Seawater desalination facilities must pump ocean water through subsurface ocean wells or screened surface intakes. Subsurface intakes are the preferred intake method for seawater desalination facilities in California under the Ocean Plan, but they cannot be used at all locations due to site-specific hydrogeologic conditions.

Subsurface intakes extract ocean water from beneath the seafloor or from coastal wells. As the water is pumped into the facility, the seafloor or coastal sediments provide a natural barrier to marine organisms, making these intakes the most environmentally friendly option. Additionally, subsurface intakes provide initial filtration and pretreatment for suspended sediments, dissolved or suspended organic compounds, harmful algal blooms, pathogens, and debris. This gives subsurface intakes a significant environmental advantage over screened surface water intakes because harm to marine life is minimized during the operational lifetime of the facility.

Screened surface intakes withdraw seawater through 1.0 mm or smaller slot size screens. Organisms may become trapped against surface water intake screens by the suction power of the surface water intakes, referred to as impingement. Impingement can be avoided by using 1.0 mm or smaller slot size cylindrical wedgewire screens with an intake velocity of no more than 0.5 feet/second to allow juvenile and adult mobile marine life to swim away. Smaller organisms in the water column such as algae, plankton, fish larvae, and eggs, that pass through surface water intake screens are drawn into the facility and will perish when exposed to the high pressure of a desalination system. This process is referred to as entrainment and is unavoidable when using a screened surface intake. Impingement and entrainment result in the loss of biological productivity over the operational lifetime of a facility. The severity of the impacts of impingement and entrainment on the sustainability of a specific species and health of an ecosystem depends on a number of factors that are difficult to quantify such as reproduction rates, natural mortality rates, and the percentage and ages of affected populations. For these reasons, screened surface intakes are only allowed when subsurface intakes are infeasible. Screened surface intakes also require additional siting, design, technology, and mitigation requirements as well and additional environmental studies compared to subsurface intakes. See section 8.3.2 of the Staff Report for more information.

Seawater Desalination Discharge Impacts

Seawater desalination facilities typically dispose of brine by discharging it into the ocean, which can negatively impact water quality and marine life. Brine discharges behave differently than traditional wastewater effluent because brine is denser than the ambient receiving waters and tends to sink to the seafloor. Consequently, brine discharges can form a physical barrier that prevents adequate mixing of dissolved oxygen. These conditions can result in anoxic zones and hypoxia in the benthic organisms. In addition, exposure to elevated salinity can result in toxicity and other negative physiological effects such as osmotic stress or shock, endocrine disruption, and developmental abnormalities.

Seawater desalination facilities must discharge brine consistent with the requirements in the Ocean Plan, including the narrative receiving water for salinity:

> "*Discharges shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured no further than 100 meters (328 ft) horizontally from each discharge point. There is no vertical limit to this zone*."

The Ocean Plan requires facilities to use the best available site, design, and technology feasible to dispose brine to minimize intake and mortality of all forms of marine life. When discharging brine into ocean waters, it is important to dilute the waste stream as quickly as possible and as close to the point of discharge as possible to minimize the effects of the elevated salinity on marine life. There are several different methods of discharging brine. In California, the preferred method of disposing brine to minimize intake and mortality of marine life is to dilute brine with treated wastewater that would otherwise be discharged to the ocean prior to discharging the commingled mixture. Multiport diffusers are the next preferred method for disposing of brine because they rapidly mix brine with seawater diluting the brine within a relatively small area. However, multiport diffusers can cause marine life mortality as a result of the turbulent mixing. Discharge impacts and technology are described in greater detail in section 8.6.2 of the Staff Report. Facilities must quantify and mitigate any discharge-related marine life mortality that occurs as a result of exposure to hypersaline and anoxic conditions, and shearing stress from turbulent mixing.

Other Environmental Impacts

There are other environmental impacts from seawater desalination facilities that must be evaluated and mitigated such as energy use, greenhouse gas emissions, air quality, cultural resources, and others discussed in section 12.1 of the Staff Report. The California Environmental Quality Act (CEQA) requires public agencies to evaluate and disclose the potential environmental impacts of proposed activities, including activities related to seawater desalination facilities, and to reduce or avoid significant environmental impacts to the extent feasible. Seawater desalination facilities that are properly sited and designed will better minimize environmental and socioeconomic impacts. Seawater desalination facilities can also continue to minimize on-site energy use by maximizing onsite renewable energy use, optimizing energy efficiency as new technologies (e.g., energy recovery devices) become available, and maintaining treatment equipment.

5. How many seawater desalination facilities are in California?

As of June 2024, California has eight operational seawater desalination facilities, seven small (<1.0 million gallons potable water produced per day) and one large (50 million gallons of potable water produced per day). See the Seawater Desalination Facilities map on our Ocean Desalination webpage. The Doheny Ocean Desalination Project, in Dana Point, is under construction and is anticipated to be operational by 2028, producing up to 5 million gallons of potable water a day. The Seawater Desalination Interagency Group is conducting early consultations with project proponents for one additional proposed new seawater desalination facility in the City of Marina, and one pilot project in the City of Fort Bragg.

6. How do the Water Boards regulate seawater desalination facilities?

The six coastal regional water quality control boards (identified in Question 8) in coordination with the State Water Board implement state and federal laws and regulations governing the construction and operation of desalination facility intakes and discharges into the state’s ocean waters. Examples include the federal Clean Water

Act, Porter-Cologne Water Quality Control Act California Environmental Quality Act, and the Water Quality Control Plan for Ocean Waters of California (Ocean Plan), which was established to preserve and enhance California's territorial ocean waters for the use and enjoyment of the public. The Ocean Plan establishes water quality objectives for California's ocean waters and provides the basis for regulation of wastes, including brine, discharged into California's coastal waters. Chapter III.M of the Ocean Plan provides direction to the regional water boards for permitting seawater desalination facilities, including making a determination pursuant to California Water Code section 13142.5, subdivision (b), which states:

> "*For each new or expanded coastal powerplant or other industrial installation using seawater for cooling, heating, or industrial processing, the best available site, design, technology, and mitigation measures feasible shall be used to minimize the intake and mortality of all forms of marine life.*"

Regional water board permit writers issue permits for seawater desalination facilities consistent with state and federal laws and regulations through issuance of a determination pursuant to Water Code section 13142.5, subdivision (b) and Waste Discharge Requirements that may also serve as National Pollutant Discharge Elimination System permits. The State Water Board can also issue a drinking water permit for seawater desalination facilities that serve as potable water supply. Additional information on state and federal laws and regulations governing seawater desalination facilities can be found in Sections 5 and 6 of the Staff Report.

The Water Supply Strategy directs the State Water Board to "consider amendments to the Desalination Policy in its Ocean Plan to streamline permits that meet the recommended siting and design standards for projects located in the identified priority areas." State Water Board staff is coordinating with the regional water boards, state and federal agencies, Tribes, environmental justice groups, and other interested persons and entities to start the process of considering potential amendments concerning seawater desalination facilities.

Interagency Coordination

Additionally, numerous local, state, and federal agencies also have regulatory requirements for seawater desalination facilities to ensure they are constructed and operated to minimize environmental and socioeconomic impacts. Coordination with other agencies plays a significant role in planning and permitting seawater desalination facilities. In 2020, at the State Water Board's direction, the State Water Board and six coastal regional boards entered into an interagency Memorandum of Agreement with:

California Coastal Commission

California State Lands Commission

California Department of Fish and Wildlife

Monterey Bay National Marine Sanctuary

National Marine Fisheries Service's West Coast Region

The Memorandum of Agreement memorializes the relationship among agencies to coordinate timely and effective review of environmental documents and permits or lease applications for proposed seawater desalination facilities and demonstrates the state's ongoing commitment to interagency coordination.

7. How can I stay informed?

If you have any questions, please email us at DWQ-OceanDesal@Waterboards.ca.gov or look out for announcements on our Ocean Desalination webpage. You can also subscribe to the California Ocean Plan (COP) email list to receive notifications and the latest updates.

Additional information on the Water Boards' implementation of the Water Supply Strategy can be found here: https://www.waterboards.ca.gov/water-supply-strategy/index.html.

8. Who should I contact if I am interested in proposing a new or expanded seawater desalination facility in California or have questions about my existing permit?

Region 1 – North Coast
northcoast@waterboards.ca.gov
(707) 576-2220

Region 2 – San Francisco Bay
(510) 622-2300

Region 3 – Central Coast
centralcoast@waterboards.ca.gov
(805) 549-3147

Region 4 – Los Angeles
(213) 576-6600

Region 8 – Santa Ana
region8info@waterboards.ca.gov
(951) 782-4130

Region 9 – San Diego
rb9_questions@waterboards.ca.gov
(619) 516-1990

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