



State Water Resources Control Board

- TO: Concur, Inc.
- FROM: Phil Crader Deputy Director DIVISON OF WATER QUALITY
- **DATE**: 5/12/2025

SUBJECT: RESPONSE TO *FINAL DESALINATION SUBSURFACE INTAKE PANEL REPORT* DATED APRIL 29, 2024

This memo documents the State Water Resource Control Board's (State Water Board's) response to the *Final Desalination Subsurface Intake Panel Report* (Final Report) submitted by Concur, Inc. on April 29, 2024, under grant agreement number D2215001. The State Water Board Division of Water Quality recommends that this memo, which contains additional and important context, should be considered alongside the Final Report.

The State Water Board entered into a grant agreement with Concur, Inc. to convene a Panel to develop guidance and recommendations to assist proposed seawater desalination facility owners or operators in preparing information for the regional water boards to review when evaluating subsurface intake feasibility as required by the Water Quality Control Plan for Ocean Waters of California (Ocean Plan). The Panel was to consider, at a minimum, the factors listed in Chapter III.M.2.d.(1)(a)i. of the Ocean Plan, such as geotechnical data, hydrogeological information, benthic topography, oceanographic conditions, project life cycle costs, facility energy use, and design constraints (engineering, constructability).

The Final Report proposes a methodology more broadly focused on the overall permitting process for projects rather than a technical methodology for evaluating subsurface intake feasibility considering the factors listed in Chapter III.M.2.d.(1)(a)i of the Ocean Plan. Accordingly, the State Water Board recommends that potential desalination facility owners or operators may use the Final Report as a high-level guide on some of the technical factors for assessing subsurface intake feasibility but should not consider this to be the sole guide for preparing analyses to comply with the Ocean Plan requirements for evaluating subsurface intake feasibility.

E. JOAQUIN ESQUIVEL, CHAIR | ERIC OPPENHEIMER, EXECUTIVE DIRECTOR

The State Water Board has the following comments on the Final Report.

1) The Final Report focuses largely on procedural and permitting elements of subsurface intake feasibility rather than scientific and technical studies for analyzing feasibility.

The Panel had a "very narrow focus – to provide technical guidance to project proponents evaluating SSI feasibility" (Final Report, page 1). The Final Report proposes a methodology for collecting and presenting information without a focus on data and analyses or the technical and scientific elements of subsurface intake feasibility. The proposed methodology focuses on the timing and sequencing of preparing information, and identifies procedural recommendations to regulators that are not currently implementable under the Ocean Plan and could lead to confusion among the public and project proponents if interpreted as existing procedure.

The Panel describes in Appendix D of the Final Report that the proposed SSI [Subsurface Intake] Feasibility Evaluation is presented "within the context of the overall permitting process that a project proponent of a seawater desal plant would likely need to complete" (Appendix D, page D-1). The Panel stated that it included this context because it provides the "necessary background for specifying certain key attributes of any project that a project proponent may decide to pursue" and because it emphasizes "the magnitude and effort likely required before a proposed project plan is sufficiently detailed and 'mature' to subject the project to the feasibility assessment currently being considered by the Regional Board" (Appendix D, page D-1).

The proposed methodology in the Final Report, presented as a decision tree in Section 4, describes steps to gather and present information in stages: preplanning (stage 1) scope of work development (stage 2), desktop evaluation (stage 3), intermediate feasibility assessment and a go-no go decision point (stage 4), pilot testing (stage 5), and final feasibility assessment (stage 6). These stages do not describe the scientific and technical studies necessary to analyze subsurface intake feasibility. For example, in stage 3, desktop evaluation, the Final Report lists relevant data that could be used by a project proponent, such as aerial photographs, topographic maps, and current and historic well water levels, but does not describe in detail the evaluation or analysis that should be conducted to determine if a subsurface intake is feasible.

The Final Report generalizes information about subsurface intake feasibility and defers site-specific decisions on data and analyses to later dates and to experts retained by project proponents.

The Final Report does not differentiate levels of effort or degrees of accuracy for various stages of the feasibility assessment. While the Final Report states that the "the coastal geology of California (e.g., geological units and aquifers locally present) is sufficiently well known to guide initial evaluations of SSI [subsurface intake] options" (section 4.3, page 38), it also states that field studies are "highly site-specific, depending upon intake type and location and the amount and quality of data already available," that the "project

proponent technical teams should include an expert(s) in the various techniques to design a field testing program that efficiently meets the project data needs," and that "issues need to be resolved in consultation with the appropriate regulatory agency" (section 4.6.1, page 48).

The Final Report states that if the desktop analysis confirms the need for field studies, then "collection of additional site-specific data on local geology, hydrogeology, aquifer hydraulic parameters, water quality, and land uses" would be required (section 4.6.1, page 47). However, the Final Report does not describe the types of data or the physical site conditions that would require data to be collected, does not provide recommended criteria to use for determining whether additional data collection is necessary, and does not indicate what values would indicate that a subsurface intake is feasible.

While the Panel stated that it "intentionally avoided very prescriptive guidance," project proponents need more technical guidance to assist in determining feasibility.

3) The Final Report appears to focus more on describing challenges and barriers to subsurface intakes rather than developing an analytical approach to determine feasibility or other solutions to navigate the challenges.

The Final Report focuses on the challenges associated with subsurface intakes, such as cost, financing, and limited evidence of their use, without presenting the necessary scientific and technical analysis to determine whether such challenges exist (e.g., specific models, data collection, and desktop analyses). Based on recommendations from three Scientific Advisory Panels, and an external scientific peer review, the State Water Board identified subsurface intakes as the preferred intake technology because they are the best method for minimizing intake and mortality of all forms of marine life. An owner or operator can only use screened surface intakes if subsurface intakes are not feasible. The Final Report identifies challenges associated with subsurface intakes, but does not provide project proponents with guidance, direction, or approaches to work through these challenges.

For example, the Final Report focuses on the challenge associated with subsurface intakes as it relates to capacity limitation for "large-scale facilities;" and states that there is a relatively limited application of subsurface intakes producing more than 10 million gallons per day (MGD), which creates a financial risk for facility owners that makes the technology economically infeasible. The Final Report concludes that costs associated with subsurface intakes may be higher than surface water intakes because of "uncertainty given their relatively limited application at a scale above 10 MGD of produced water" (section 6.2, page 63). No citation was provided for this statement. The focus on large-scale facilities does not consider the feasibility of installing subsurface intakes for medium or small-scale facilities.

The Final Report's discussion of permittability focuses on permitting barriers rather than potential streamlining benefits associated with the use of subsurface intakes. Where the

potential benefits of subsurface intakes in the context of permittability include 1) the Water Boards and Coastal Commission are generally supportive of subsurface intakes (per Ocean Plan, 1314.25(b), and Coastal Act provisions), and 2) while some aspects of subsurface intake review will take time (e.g., initial hydrogeological studies), subsurface intake review will generally not require a year or longer entrainment study and development of marine life mitigation for operational mortality from intakes.

The Final Report often mentions financial risk of subsurface intakes as a reason they would be economically infeasible. For example, the Final Report states that "the ability to secure project financing will affect project life cycle costs, as well as overall project feasibility" (section 3.5.1, page 3) and "Uncertainty surrounding the reliability and performance of SSI for large desalination facilities (those producing more than 10 MGD of treated water) may also affect the ability of project applicants to obtain necessary project financing (see Section 5.3.2)" (section 3.5, page 2). The Ocean Plan requires consideration for project life cycle costs and states, "Subsurface intakes shall not be determined to be economically infeasible solely because subsurface intakes may be more expensive than surface intakes." And that "Subsurface intakes may be determined to be economically infeasible if the additional costs or lost profitability associated with subsurface intakes, as compared to surface intakes, would render the desalination facility not economically viable."

The Final Report makes assumptions that all facilities will require larger production capacities to be economically feasible, which appears to bias the Final Report against subsurface intakes and does not include citations to recent scientific literature. The Final Report does not provide options to reduce costs to navigate this challenge, nor does it provide specific direction for project proponents or the Water Boards to make this determination regarding economic viability. The Final Report's discussion of cost does not include information on the potential cost savings from subsurface intakes that result from reduced environmental analyses requirements, faster permitting times, lower or no pre-treatment costs, operational savings over the project's lifecycle, and significantly reduced mitigation costs.

4) The Final Report conflates existing permitting processes and proposed permitting reforms.

The proposed methodology in the Final Report may cause confusion to project applicants when preparing information to submit to the regional water boards. For example, in section 4.5.1, page 42, the Final Report states that "there are many components of the desalination project that will already have been vetted by the Regional Board and potentially other agencies." The statement is based on the Panel's interpretation of the *Seawater Desalination Siting and Streamlining Report to Expedite Permitting*, which summarizes changes that have been proposed to the Water Boards' permitting program rather than existing state requirements.

FINAL DESALINATION SUBSURFACE INTAKE PANEL REPORT

PREPARED BY THE SUBSURFACE INTAKE EXPERT PANEL

FACILITATED AND CONVENED BY CONCUR, INC

JUNE 2024

FINAL DESALINATION SUBSURFACE INTAKE PANEL REPORT

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FINAL

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LIST OF ACRONYMS AND ABBREVIATIONS

ASBS	Areas of Special Biological Significance
CEQA	California Environmental Quality Act
FA	Feasibility Assessment
gpm	gallons per minute
HDD	horizontal wells that are directionally drilled borings
kWh/MG	kilowatts per million gallons
MGD	million gallons per day
MLD	million liters per day
MPA	Marine Protected Area
NOAA	National Oceanic and Atmospheric Administration
O&M	operations and maintenance
Ocean Plan 2019	Water Quality Control Plan for the Ocean Waters of California
OMB	Office of Management and Budget
Regional Board	Regional Water Quality Control Board
Report	Desalination Subsurface Intake Panel Report
SDI	Silt Density Index
SIG	seabed infiltration gallery
SOW	Scope of Work
SSI	subsurface intake(s)
State Board	State Water Resources Control Board
SWRO	seawater reverse osmosis
SWQPA	State Water Quality Protected Area
the Panel	an independent panel of subject matter experts knowledgeable on relevant feasibility issues for desalination projects
TOR	Terms of Reference

EXECUTIVE SUMMARY

Introduction

In response to the Governor of California's proposed water supply plan for California,¹ and the recent policy goals of accelerating the permitting process for water projects given uncertainties related to meeting California's future water supply needs, the State Water Resources Control Board (State Board) has been tasked with preparing an amendment to the *Water Quality Control Plan for the Ocean Waters of California* that will guide permit applicants in evaluating the feasibility of subsurface intakes (SSI[s]) for proposed seawater desalination facilities.

The *Water Quality Control Plan for the Ocean Waters of California* (Ocean Plan 2019) requires that SSIs be incorporated into desalination projects unless the applicant can demonstrate to the State Board's satisfaction that SSI technology is not "feasible" (Ocean Plan 2019, Section III.M.2.d.(1)). The definition of "feasible" in the Ocean Plan is "*capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social and technological factors*" (Ocean Plan 2019, Appendix I). This definition of "feasible" is the same as that established earlier in the California Environmental Quality Act (CEQA) in 1969. This feasibility determination for an intake system for new or expanded desalination facilities is one of multiple tasks required for any applicant of a Water Code section 13142.5(b) determination leading to the issuance of a permit. The required tasks are established in the Plan (Ocean Plan 2019, Chapter III, M), and include among other requirements that the applicant (i.e., owner or operator of the desalination facility) must "evaluate a reasonable range of nearby sites, including sites that would likely support subsurface intakes".

Currently, the Ocean Plan 2019 does not provide extensive criteria or guidance on the scientific and technical studies necessary to assess the feasibility of an SSI. The State Board determined that an independent panel of experts could provide guidance to desalination permit applicants on conducting feasibility assessments for SSI, and that the information compiled could be used to inform possible future amendments to the Ocean Plan 2019.

In late 2022, the State Board retained CONCUR, Inc., a California-based firm specializing in facilitation and mediation processes, to select the Panel members with State Board approval, manage and coordinate the Panel's deliberations, and oversee the preparation of a technical report to be submitted consistent with the contractual obligations between the State Board and CONCUR. The Panel was initially convened in May 2023 and deliberated in a series of approximately biweekly conference calls over eleven months to identify key issues, conduct joint fact-finding activities, and develop a draft and final report. The Panel's scope of work to provide advice to the State Board on an SSI feasibility assessment methodology for SSI options is detailed in the Terms of Reference (TOR) in Appendix A.

The primary task for the Panel, as specified in the TOR, was to prepare a methodology for conducting a feasibility assessment applicable to a wide range of subsurface and ocean conditions found in California and that is adaptive to new or emerging SSI technologies across a range of potential scales of operation.

¹ The Governor's proposed plan can be accessed at <u>California's Water Supply Strategy Aug 2022</u>.

This Executive Summary provides a condensed summary of the results of the Panel's deliberations consistent with the TOR. The Panel addressed several questions posed in the TOR, in the context of the four factors defining feasibility. These included the following with additional clarification provided:

- How should a proposed desalination permit applicant complete this analysis? (e.g., what is the process to be followed consist with the terms in the Ocean Plan 2019, Chapter III, Section M?)
- What modeling is necessary for determining subsurface intake feasibility? (e.g., what groundwater modeling will be needed to assess potential impacts to aquifers near the site for a given SSI?)
- What components of a geophysical survey (including lithologic data) are needed to determine subsurface intake feasibility?
- What key characteristics should be considered for the known subsurface intake technology types? What are known information gaps in subsurface intake technologies?
- What criteria should be used to determine whether additional data collection is necessary? (e.g., what level of accuracy is needed to define key system design parameters that determine feasibility?)
- What metrics and criteria should be used to evaluate test well data for subsurface feasibility? (e.g., how do test well data inform the need for and range of parameters to be used in groundwater modeling?)
- What readily available data can be used to evaluate a reasonable range of sites? (e.g., what should a project proponent search for to define a range of sites that will provide the desired water quantity and also will likely support an SSI?
- What is a reasonable shelf life for various data types? (e.g., which type of data is likely variable over time requiring regular characterization?)

These specific questions have been addressed throughout this Report within the context of a proposed methodology that provides a framework for permit applicants to follow to conduct an SSI feasibility assessment consistent with the Ocean Plan 2019, Chapter III, section M. While the Panel has a narrow focus—to provide technical guidance to project applicants and the State Board for conducting feasibility assessments for SSIs— it is important to recognize that the intake option is just one technical component of a desalination facility and that all components are significantly interrelated.

It is also critical to recognize that design and evaluation of SSI-site combinations² are highly site specific and involve technically complex issues. Therefore, it is assumed that permit applicants will retain a technical team with expertise in SSIs, hydrogeological testing, environmental impact analyses, permitting in California, cost estimating, and other project technical disciplines. The Panel has intentionally avoided very prescriptive guidance as found in standard textbooks or design manuals, while comprehensively defining the type of data and other information needed to determine the feasibility of the SSI for a given site and design hydraulic capacity.

Report Summary

This *Desalination Subsurface Intake Panel Report* (Report) contains six sections, providing a comprehensive evaluation of factors that should be considered by any applicant pursuing a desalination project:

- Section 1 summarizes the context for completion of an SSI Feasibility Assessment (FA), which is just one component of the overall permit process. The Panel covered this topic in detail because there are several tasks that must be completed before initiating the SSI FA. These tasks will guide/constrain the scope of the FA step by screening the range of sites and SSI combinations that have reasonable likelihood of being feasible alternatives.
- Section 2 provides a detailed review of the SSI technologies that have most commonly been used to date worldwide even though the number of desalination facilities using SSI is limited, particularly in larger scale (e.g., greater than 20 MGD intake capacity) applications (Global Water Intelligence, 2024). This section also addresses the hydrogeological properties that must be characterized to assess the applicability of the SSI to meet project objectives.
- Section 3 covers general feasibility factors identified in the Ocean Plan 2019 considered relevant to evaluating the feasibility of each of the SSI technologies for a given site.
- Section 4 presents the methodology recommended for conducting the SSI FA consistent with directives in the Ocean Plan 2019. This includes a decision tree diagram that provides a framework for completion of the FA, highlighting the critical points where the applicant would request interim guidance from the designated Regional Water Quality Control Board (Regional Board) to proceed through each stage of the FA process. The remainder of Section 4 provides details on the recommended sources and methods for obtaining the data and information needed for completion of the FA, and thereby addressing several of the questions noted above from the TOR.
- Section 5 describes the final stage of the FA, including recommendations on applying the Ocean Plan 2019 feasibility factors in documenting the final outcome of the FA and submittal of this final report to the Regional Board for final feasibility determination.
- Section 6 provides Panel recommendations on topics related to the permitting process for desalination facilities that address the issues that may delay completion of the FA and thereby put at risk an overall permit application.

 $^{^{2}}$ The term SSI-site combination refers to the combination of the selected SSI technology and the location of the SSI(s).

Framework for SSI FA Methodology

The Panel's recommended methodology for the SSI FA is shown in Figure ES-1.



Figure ES-1: Conceptual Decision Tree for Conducting an SSI Feasibility Assessment (key decision points for feasibility interim guidance with Regional Board guidance noted: see text for explanation of figure)

This process and decision tree diagram illustrates the sequential process an applicant could follow in conducting the FA consistent with the requirements in the Ocean Plan 2019. Six stages are proposed, with each stage requiring frequent interactions with the applicable Regional Board. Stages 1 through 3 can be considered a screening process to determine which SSI-site combination should proceed to the next stage with a specified intake capacity. As noted in Section 1 of this Report, and based on the recent draft report to streamline the permitting process for water supply projects (Draft California Seawater Desalination Interagency Group 2023), some permit approvals will precede the initiation of the FA, during which time several key project attributes will be presented to regulatory agencies in a conceptual project proposal, and in particular an agreed-upon intake capacity. While it is noted that this 2023 report has not yet been approved, any project proponent interested in making a request for a permit would need to complete these initial studies before initiating the overall permitting process. The intent of this proposed stepwise methodology is to minimize the applicant's risk of having to restart the review of multiple new site-SSI combinations.

The transition to Stages 4 and 5 would require Regional Board guidance, and the applicant would then consider the need for additional data for completing the FA; either additional field studies or final pilot tests at an appropriate scale. Details on the types of technical data needed, sources of that data and appropriate methods for collecting the field data, performing modeling, or conducting pilot studies are compiled in Section 4 of the Report, including technical data needed to assess factors related to the environmental, social, and economic assessment of feasibility, as identified in the Ocean Plan 2019.

Stage 6 of the proposed methodology would consist of analysis and documentation of data collected to complete the FA. The applicant would then meet with the Regional Board to agree on the contents of the final report presenting the outcome of the assessment and, following submittal and approval of the final report, proceed to the next phase of the overall permitting process. The Panel recognizes that this methodology would require substantial involvement of Regional Board staff but provision of interim guidance will be an essential component of a timely and successful permit application.

Factors in Assessing SSI Feasibility

Table ES-1 summarizes examples of technological, environmental, social, and economic factors that the Panel recommends be applied throughout the SSI FA process, with the application of these factors in making a feasibility determination for the proposed seawater intake as one of the steps in the overall permitting process for a desalination project.

Table ES-1: General Feasibility Factors				
Factor Type	Feasibility Considerations			
TECHNOLOGICAL				
Constructability (Ocean Plan, p. 46, and benthic topographic, geotechnical data, and oceanographic conditions, p. 46)	The site-SSI combination should be capable of providing the desired volume of desalinated water. It must be possible to physically construct the system in project site vicinity. Physical conditions at the site should be stable enough so that the system could operate reasonably consistently over its planned lifetime (commonly taken as at least 30 years). Ability to obtain permits associated with the SSI from other agencies to extent needed, e.g., land use permits in a reasonable time frame.			
Reliability (not specifically covered in the Ocean Plan)	The raw water must be of suitable quality, which is herein assumed to be similar to local seawater that has not undergone fluid-rock interactions adverse to the treatment process (e.g., iron and manganese leaching). Ability of the intake to function and ability to access for O&M performance. Ability to rehabilitate the intake, for example to address clogging, and availability of known and proven technologies.			
Risk of system failure (not specifically covered in the Ocean Plan)	Owner of the system should have confidence that the subsurface intake system will meet design goals before committing to constructing a full-scale intake system and treatment plant. Pilot testing of the intake system should be able to be conducted if necessary. System should not be vulnerable to adverse geological and human processes including sediment erosion and deposition and spills. Practicable and affordable options should be available to maintain and repair system if required.			
ENVIRONMENTAL (covered in the 2019 Ocean Plan under hydrogeology, presence of sensitive habitats, and presence of sensitive species, Chapter III, p. 46)	 SSI implementation (e.g., siting, construction, operation, maintenance) should avoid, to the maximum extent feasible, the disturbance of sensitive habitats and sensitive species, and ensure that the intake structures are not located within an MPA or SWPA. Specific environmental factors for feasibility consideration identified in the Ocean Plan include: Sensitive habitats Sensitive species Indirect effects, if SSI operations intercept a coastal freshwater aquifer, or aquiferdependent sensitive habitats (wetlands) and/or associated sensitive species. 			
SOCIAL	Water affordability			
ECONOMIC (Project life cycle cost and energy use in Ocean Plan, p. 46)	Construction and operation (life cycle) costs for a given intake type should be competitive with that of other subsurface intake types and not be so high as to render a desalination project not economically viable. The perceived project engineering risk should be low enough that financing can be obtained (based on use of the technology at other comparable locations and at similar design capacities). Additional incremental life cycle costs associated with subsurface intakes (relative to surface intakes or other water supply alternatives) should not cause an undue economic burden for low-income households in the form of significant increases in the cost of basic water services. Any additional incremental costs should also not result in delayed investments necessary to meet regulatory requirements that protect public health. Contractor market should be competitive with multiple potential bidders for projects. Subsurface intake should not be significantly more energy intensive (i.e., have a greater carbon footprint) than other intake options based on annual energy use assessments			

Details of how these factors should be applied are presented in Sections 4 and 5. Some threshold criteria that must be met to demonstrate feasibility include the following:

- Technological: The project site and SSI combination should be capable of reliably providing the desired volume of desalinated water, sufficiently resilient against natural hazards such as sea level rise, capable of construction, and have no deleterious impacts on local aquifers or wetlands based on results of appropriate level of modeling (See Section 4).
- Environmental: Construction of the SSI system should not result in unacceptable impacts to sensitive habitats and species within the zone of influence of the SSI footprint, including the indirect impacts that might result to coastal freshwater aquifer-dependent habitat and associate species and must avoid location near Marine Protected Areas (MPA) and State Water Quality Protection Areas (SWQPAs).
- Economic: Capital and life cycle costs should be within a range that allows for likely available financing of the project. Typically, capital costs for SSIs are higher than open ocean intakes but these costs can be offset by lower operating costs and potential reduction in other costs. These benefits of SSI would be incorporated into the life cycle cost analysis.
- Social: Water supply affordability is the chief issue of social impact concern. Any incremental life cycle costs associated with SSIs (relative to other intake options) should not result in undue economic burden on communities.

Policy Recommendations

The Panel provides the following recommendations on issues that will impact the ability of an applicant to obtain a permit for a desalination plant. Some additional information supporting these recommendations is included in Section 6 of this Report. These recommendations recognize the stated desire by the State to expand options for communities on the California coast to include seawater desalination plants as part of their long-term plans to meet future demand for potable water sources:

- 1. Obtaining a permit from the Water Boards for a desalination project in California requires a project proponent to complete multiple tasks before obtaining a Regional Water Board Water Code section 13142.5(b) determination under Chapter III.M.2.a.(1) of the Ocean Plan. The completion of these tasks may require several years. Thus, the Panel recommends that the evaluation of subsurface intakes be streamlined for completion within a maximum of three years. Given that the preceding tasks will constrain the intake capacity, site, and applicable SSI combinations to be evaluated in the FA step, this recommended duration should be achievable absent the need for scaled pilot tests with the assumption that regional boards will have sufficient resources to provide interim guidance at identified transition points with the six proposed stages of the FA process.
- 2. Life cycle costs and thus unit prices for water delivered by a desalination plant will likely be higher than costs for other sources of water supply based on the experience of Panel members. In some cases, life cycle costs comparing open intakes with SSI may be lower due to lower pretreatment costs prior to membrane treatment (i.e., reverse osmosis) and other factors outlined in Section 3.5.2. However, the use of an SSI may increase overall life cycle costs and uncertainty. given their relatively limited application at a scale above 10 million gallons per day (MGD) of produced water and associated financial risk. These economic consequences may pose significant challenges to obtaining financing for some desalination facilities. One option that could be considered by the State is to provide some form of financial instruments that would mitigate the financial risks associated with early adopters using SSIs at scales larger than have been demonstrated, namely design capacity larger than 10 MGD (equivalent to approximately to 20 MGD intake capacity.
- 3. The Panel understands that recent policies from several agencies addressing environmental justice concerns over water rates require that any permit applicant must conduct an affordability assessment to evaluate the impacts of incremental costs on low-income ratepayers. The Panel supports this policy, and it should be noted in any future changes to the Ocean Plan.
- 4. Given the potential for subsurface connectivity between coastal wetlands or coastal freshwater aquifers and SSI source waters, the Panel recommends that this concern receives careful consideration both during the analyses conducted in the FA and during post-construction monitoring of source-water salinity. Regular reporting on source-water salinity should be required in any plant operating plan if there is a risk of impacts inferred from groundwater modeling studies of the site-SSI combination. (See Section 4 in this Report).

1. INTRODUCTION

Currently, the *Water Quality Control Plan for the Ocean Waters of California* (Ocean Plan 2019) does not provide detailed criteria or guidance on the scientific and technical studies necessary to analyze the feasibility of a subsurface intake (SSI) currently required for any seawater desalination project in the state. If a project applicant determines that such an intake at the proposed project site is not feasible and obtains agreement from the appropriate Regional Water Quality Control Board (Regional Board), then a screened open ocean surface intake may be considered. The State Water Resources Control Board (State Board) is considering amending the Ocean Plan 2019 to provide more direction to prospective permit applicants on the complex issue of determining the feasibility of an SSI option for a desalination facility at potential sites along the California coast.

The State Board determined that an independent panel of experts who are both subject matter experts as well as knowledgeable on relevant feasibility issues for desalination projects (the Panel) could advise the State Board on the scientific and technical studies necessary to analyze the feasibility of an SSI for a future update to the desalination provisions in the Ocean Plan 2019. The State Board intends that the Panel's advice may help clarify this SSI Feasibility Assessment (FA) process for future applicants and may use the information compiled by this Panel to develop additional materials and recommendations which may be included in the possible amendment to the Ocean Plan 2019.

The State Board entered into an agreement, D2215001, with CONCUR, Inc., to provide convening, facilitation, and project management services to support the Panel's work. The Terms of Reference (TOR) defining the scope of the Panel's activities and deliverables and details of the convening and facilitation process used by CONCUR, Inc., and the Panel are summarized in Appendices A and B.

This *Desalination Subsurface Intake Panel Report* (Report) was prepared by the seven Panel members selected by CONCUR, Inc. State Board staff evaluated the range of technical expertise of proposed Panel members to ensure appropriate experiential coverage. Short resumes for the Panel members are provided in Appendix C.

While the Panel has a very narrow focus—to provide technical guidance to project proponents in evaluating SSI feasibility within the context of the overall permit process —it is important to recognize that the intake option is just one technical component of a desalination facility and that all components are significantly interrelated (see Section 1.3). Furthermore, the overall permitting process for a desalination project requires a lengthy series of technical analyses and discussions with many stakeholders to conclude that desalination is an acceptable option for meeting water supply needs for the intended community, including providing a form of insurance against unforeseen drought conditions (i.e., providing an option to address resilience against an uncertain climate future). The Panel also considered the recent policy goals of accelerating the permitting process for water projects given the future uncertainties in meeting future water supply needs in California (California Seawater Desalination Interagency Group 2023 and Office of the Governor 2022).

1.1 <u>Statement of Panel Goal</u>

The Panel was given the charge to identify a scientifically sound approach for conducting FAs of SSI technologies currently used throughout the world, potentially applicable to coastal conditions in California. (TOR in Appendix A). The Panel was asked to develop the contents of a technical methodology for evaluating SSI feasibility that could be used by the State Board to include in a possible amendment to the Ocean Plan 2019. The members of the Panel were selected based on their knowledge and expertise in relevant technical subject areas, with particular focus on the elements of feasibility of SSI, where "feasible" is defined in the Ocean Plan 2019. "Feasible" means "*capable of being accomplished in a successful manner within a reasonable period of time, taking into account technological, environmental, social, and economic factors*" (Ocean Plan 2019). Specifically, the Panel was asked to consider factors as specified in the Ocean Plan 2019, in assessing feasibility of the SSI. As stated in the plan, these include:

- *"geotechnical data, hydrogeology, benthic topography, oceanographic conditions, presence of sensitive habitats,*
- presence of sensitive species, energy use for the entire facility; design constraints (engineering, constructability), and
- project life cycle cost. Project life cycle cost shall be determined by evaluating the total cost of planning, design, land acquisition, construction, operations, maintenance, mitigation, equipment replacement and disposal over the lifetime of the facility, in addition to the cost of decommissioning the facility. "

The Panel has thus developed its proposed methodology by incorporating the factors identified in the Ocean Plan 2019 that will need to be considered by any applicant for a permit for a desalination facility. The Panel interprets the Ocean Plan 2019 factors as consistent with CEQA criteria, in the sense that each factor identified in the Ocean Plan 2019 addresses either technical issues (geotechnical data, hydrogeology, benthic topography, oceanographic conditions, energy use for the entire facility, design constraints), environmental issues (presence of sensitive habitats, presence of sensitive species), or economic issues (project life cycle costs).

However, the Panel recognizes that the Ocean Plan requires that a project proponent requesting a Water Code section 13142.5(b) determination provide sufficient information that allows the appropriate regional water board to assess a range of relevant issues that will impact the feasibility of any proposed SSI – site combination. In particular, the Ocean Plan (Ocean Plan 2019, Chapter III, Section M) states that the proponent (owner or operator) shall evaluate a *"reasonable range of nearby sites, including sites that would likely support subsurface intakes"*. For each site, in addition to considering whether subsurface intakes are "feasible", the proponent must also consider a) whether the identified need for desalinated water is consistent with applicable water planning documents, b) whether the various components of the proposed facility can feasibly avoid "impacts" to sensitive habitats and species, c) the direct and indirect effects of construction and operation on all forms of marine life, d) whether sufficient data on geologic, hydrogeologic and seafloor topographic conditions allow for assessing the mortality impact on all forms of marine life, e) the availability of wastewater to dilute the brine discharge and f) assuring that the intake and discharge structures are sited to avoid any salinity impacts to a Marine Protected Area (MPA) or State Water Quality Protected Area (SWQPA). As can be inferred, all of these factors are

consistent with an assessment of feasibility focusing on four overall factors, namely technical considerations, environmental impacts, social issues and economics.

Thus, any project proponent must undertake a substantial effort to provide the necessary information to allow the regional water board to complete the 13142.5(b) determination. The Ocean Plan states;

"The regional water board shall first analyze separately as independent considerations a range of feasible* alternatives for the best available site, the best available design, the best available technology, and the best available mitigation measures to minimize intake and mortality of all forms of marine life."

The Panel recognizes the intent of the Ocean Plan to minimize impacts to all forms of marine life of any new or expanded desalination facilities and has therefore considered the feasibility assessment in a holistic framework.

1.2 <u>Context for Feasibility Assessments of Subsurface Intakes within Overall</u> <u>Permitting Process</u>

The FA for subsurface seawater intakes can be considered within the context of the overall permitting process that a project proponent ("proponent") for a seawater desalination facility would need to complete. As detailed in the Ocean Plan 2019, the process begins with the proponent, either an owner or operator for a new or expanded facility, submitting a request for a Water Code section 13142.5(b) determination. (Ocean Plan 2019, Chapter III.M.2). This request must contain sufficient information to allow the Regional Water Board to conduct the necessary analyses to complete the determination. Thus, early in the permitting process, several critical parameters that will impact the range of appropriate SSI(s) types for a range of sites well as the potential feasibility of the SSI options for a range of design capacities are evaluated.

The extent of the overall permitting process, including permitting components under the regulatory authority of agencies that contributed authorship to the report, is described in the *Draft Seawater Desalination Siting and Streamlining Report to Expedite Permitting* dated July 2023 (California Seawater Desalination Interagency Group 2023). This draft Siting and Streamlining Report contains broad planning recommendations for project applicants that, if followed, are most likely to result in more efficient permitting timelines under existing policy. Although this process for streamlined and expedited permitting may change, the Panel assumes that the draft report content is consistent with the Ocean Plan with the anticipated process to streamline permitting for desalination projects.³ Details on the permitting track are provided in Appendix D. It should be stressed that this streamlined approach is still under consideration and thus the Panel has attempted to make recommendations consistent with the current Ocean Plan permitting process for new or expanded seawater desalination facilities.

³ The final report was issued in December 2023 and based on the Panel's review, the content is consistent with the draft report reviewed by the Panel and referenced in this document.

Based on the Panel's review of the *Draft Seawater Desalination Siting and Streamlining Report to Expedite Permitting* dated July 2023 (California Seawater Desalination Interagency Group 2023) and considering the permitting guidance in the Ocean Plan (Ocean Plan 2019, Chapter III.M), five activities will likely need to be completed prior to initiation of the SSI FA:

- 1. Complete an integrated water resource management process or utilize an applicable adopted urban water management plan to demonstrate that seawater desalination is a necessary alternative water source and determine the initial plant size or desired design capacity for sizing the intake system for a range of potential likely feasible site(s). This requirement is consistent with the Ocean Plan requirements (Chapter III.M.2(b).
- 2. Prepare a preliminary project description, including plant size (design capacity), potential sites and identify any land use issues, potential subsurface seawater intake option(s), and a complete preliminary/conceptual feasibility evaluation. This would lead to a reasonable range of sites for further analysis that have attributes suitable for an SSI. This requirement is also consistent with the Ocean Plan requirements (Chapter III.M.2(b).
- 3. Conduct meetings with applicable Regional Board and other relevant agencies to identify information needs and key issues related to all components of the desalination project, including the intake options, and identification of design criteria to use in face of natural hazards, such as sea level rise. This step is consistent with the Ocean Plan guidance on completion of the 13142.5(b) determination indicating the need for consultation with other state agencies such as the Coastal Commission, the State Lands Commission and the Department of Fish and Wildlife (Ocean Plan, Chapter III.M.2 (a).4). Concurrent reviews would be desirable to minimize delays in the permitting process.
- 4. Conduct meetings with community groups, tribes, and other interested parties to identify information needs and key issues that will need to be addressed in the formal SSI FA process. This step is not explicitly identified in the Ocean Plan, but given the increased importance of environmental justice concerns in the past few years in California, these meetings appear essential to increase the likelihood of a successful permit application.
- 5. Revise preliminary project description based on these meetings and proceed with the Water Code determination process.

These prerequisites could help to streamline the conceptual development phase of the Water Code section 13142.5(b) determination and ensure that key attributes of the proposed desalination project are adequately specified and deemed viable options before the project applicant initiates the SSI FA process, which would include Regional Board review of any scope of work in conducting the assessment. Importantly, the project applicant may experience a more streamlined permitting process if they work collaboratively with Regional Boards to evaluate these preliminary components and also get input from other stakeholders to identify key concerns about the project.

Meeting these prerequisite recommendations should reduce the duration and cost of the SSI FA because many of the feasibility issues will have been identified and the scope of work developed to initiate the FA would provide a plan of action to address these issues that would be supported by relevant permitting agencies and other stakeholders. Thus, it is apparent that substantial work

by the applicant and relevant regulatory agencies, as well as other stakeholders, would likely limit the range of sites available for SSI implementation, given the design capacity needed to meet the proposed facility's water supply goals. The Panel recommends that the goal of these initial studies and meetings initiated by the project proponent, for a proposed intake capacity, is to identify those SSI-site combinations that will have the greatest probability of meeting the Ocean Plan goal of "the best available site, the best available design, the best available technology and the best available mitigation measures" that minimizes any deleterious impacts to all forms of marine life.

Thus, in proposing a methodology to assess the feasibility of an SSI, the Panel has made the following assumptions:

- All parties will agree on the target hydraulic intake capacity for the desalination facility that will satisfy community needs and will be consistent with the applicable water supply management plan.
- The SSI FA will be confined to a few (less than five) site-SSI combinations that are determined during the early permitting process to provide the greatest probability of achieving the target water supply goal and supporting a technologically feasible SSI option.
- It is also assumed that sufficient data are available to consider impacts from construction on the marine environment and overall energy requirements consistent with the goal of completing accurate life cycle cost analyses of alternatives under consideration for one or more sites in the proposed screening process during the initial stages of the SSI FA.

1.3 <u>Review of Desalination Facilities</u>

To assess the feasibility of SSI, it may be helpful to some readers with limited experience with desalination to understand how the SSI is integrated into a seawater desalination facility. The key engineered components of any desalination system are fully described in numerous documents (e.g., National Academy of Sciences 2008). The components include 1) an intake technology (e.g., surface or subsurface intake options), 2) pretreatment technologies to prepare the seawater for removal of dissolved solids (primarily sodium and chloride ions), 3) a dissolved solids removal technology (e.g., thermal or membrane techniques), and 4) a disposal technology for the waste stream for the removal process (e.g., concentrated solutions of dissolved ions or "brine"). The brine is generally discharged offshore through pipelines with diffuser ports that are intended to enhance mixing and thus reduce the concentration of dissolved solids to meet standards established in the Ocean Plan 2019.

As noted, the State Board has determined that SSI technologies are required for any new or expanded coastal desalination facility unless it is demonstrated that the technology is not "feasible" at the range of sites considered for the hydraulic design capacity required. The Ocean Plan defines the factors that need to be considered, including "geotechnical data, hydrogeology, benthic topography, oceanographic conditions, presence of sensitive species, energy use for the entire facility, design constraints (engineering, constructability), and project life cycle cost." Thus, in preparing a request to a water board for a Water Code 13142.5(b) determination, any project proponent will need to select for assessment a combination of project sites, hydraulic design

capacities⁴ and SSI technologies that are most reasonably likely to be determined as feasible by the Regional Board.

Section 2 of this Report provides an overview of the numerous technical options that are defined as SSI technologies and a brief analysis of the likely geologic settings, ocean topography and hydrogeologic conditions that would be compatible with the technology, thus defining some of the SSI-site combinations that project proponents may consider. Appendix E provides additional technical details on these SSI technologies. This overview also provides a context for the recommendations as presented in Sections 4 and 5 of this report for data needs that should be used to assess the feasibility factors as applied to the SSI for the proposed site and hydraulic design capacity.

⁴ In this Report, "feedwater capacity" refers to the volume of water drawn in through the intake and "product water capacity" refers to the volume of treated water that is produced at the treatment facility.

2. OVERVIEW OF SUBSURFACE INTAKE SYSTEMS FOR DESALINATION FACILITIES

2.1 Introduction

SSIs can be divided into two types: those that use extraction wells and those that use trenches and galleries. The type of intake that is most appropriate for a given system capacity and location is highly dependent upon site-specific hydrogeological and environmental conditions. The optimal system type for a location will be able to reliably provide the required flow of seawater at a suitable quality, have lower total costs (construction and operational) than other SSI options, and not cause adverse environmental impacts during construction or operation that cannot be mitigated. Following are summaries of the main SSI system types most used worldwide.

2.2 Well Intake Systems

The use of engineered wells for extraction of seawater or mixtures of seawater and less saline waters in aquifers is a widely used technology option that meets the definition of an SSI system. The four well designs include 1) vertical wells similar to traditional groundwater extraction wells located near the shoreline, 2) Ranney (also called horizontal collector) wells, which are typically used to extract water from beneath river sediments to provide freshwater supply to communities located near such surface water bodies, 3) slant wells drilled to avoid impacts to regional aquifers that are in hydraulic communication with the seawater, and 4) horizontal wells situated beneath the ocean bottom. A brief description of each of these technologies is presented below.

2.2.1 Vertical Wells Along the Coast

Shallow vertical wells producing from beach deposits and nearshore shallow rock (beach wells) have been used to supply feedwater for small desalination facilities worldwide (Figure 2-1). Vertical wells are used for raw water supply where transmissive strata connected to the sea are present along the coast. The nearshore strata may consist of permeable sands and gravels or high -transmissivity sedimentary rocks that crop out in, or are just shallowly buried beneath, an adjoining marine water body. An example of the latter is the intake system for the W.E.B. Aruba desalination plant, in which the production wells are completed in a high-transmissivity coastal limestone (Manahan et al. 2010).

Wells producing from beach deposits typically provide high-quality water (i.e., with low levels of particulate matter and thus low turbidity), with Silt Density Index (SDI)⁵ values of less than 2. In California, Marina Coast Water District operated a beach well to supply their desalination facility in the 1990s. This well was approximately 60 feet deep, produced from medium-grained sand, and had a production rate of approximately 400 gallons per minute (gpm) (Fugro West, Inc. 1996). The currently operating desalination facility in Sand City, California, uses shallow (approximate 60 feet deep) beach wells to provide feed water for the small (product water capacity of approximately 0.3 million gallons per day [MGD]) facility. These wells have consistently produced flow rates between 200 and 300 gpm (Feeney 2006).⁶

Vertical wells obtain water from a 360-degree area around the well. The water produced from beach wells will be derived from both inland and offshore sources, with the ratio between these sources depending on the well location and the hydrogeologic setting. A feasibility factor relevant to this technology is the extent to which extractions could cause landward drawdowns in the local aquifer and adversely impact coastal wetlands or other sensitive environments. Groundwater flow modeling is required to assess onshore drawdowns.



Figure 2-1: Conceptual Diagram of the Beach Well (from Missimer et al. 2013)

Deep vertical wells tapping a deeper, regional aquifer that overlain by a confining unit(s) may also be used for raw water supply. The source of the produced water would be a blend of native ground water, induced vertical leakage from the ocean, and horizontal flow from the outcrop of the sediments or rock on the seafloor. The blend would be a function of the distance to the subsea outcrop and the vertical leakage through the aquitard.

⁵ The Silt Density Index (SDI) is a measure of the combined turbidity and particulate matter in the raw water. Membrane warranties are based on a specific maximum average SDI value. Since membrane replacement is a major operational cost, the lower the SDI the better.

⁶ In this report, "feedwater capacity" refers to the volume of water drawn in through the intake and "product water capacity" refers to the volume of treated water that is produced at the treatment facility.

The number of wells required to obtain a given raw water flow depends on the obtainable yield of individual wells and well construction (well efficiency). The production rate or yield per well will be determined by the aquifer transmissivity and well spacing (which controls interference between wells). Wellfield yield may also be controlled by the length of the beach (coastal area) that is available for well construction and the minimum well spacing required for managing well interference.

Coastal groundwater pumping can have either a positive or negative impact on landward, freshwater-bearing parts of aquifers. Pumping on the seaward side of the saline-fresh groundwater interface can create a hydraulic barrier that protects the freshwater resources. On the contrary, freshwater drawn to the production wells could be a lost resource. Groundwater modeling is used to evaluate both well interference and potential impacts to freshwater resources.

2.2.2 Horizontal or Ranney Collector Wells

A horizontal or Ranney collector well consists of a large diameter (typically 18 feet) caisson from which lateral perforated spokes (laterals) are advanced toward or under a proximate water body (Figure 2-2). Collector wells have been used for the development of drinking water sources from rivers in the United States for over 80 years. Typical installation involves advancement of 200- to 300-foot-long laterals into the coarse gravels underlying riverbeds. In these geologic settings, discharge rates of 10 to 15 MGD of feedwater capacity per collector well can be achieved. Collector wells have also been used for production of seawater, however, the experience is much more limited and, because materials are finer-grained, per well yields are significantly less.

The basic hydrogeological requirement for a horizontal collector SSI is the presence at the coast of a thick interval of permeable sand or gravel that is hydraulically well-connected to the sea. Historically, horizontal collector wells have been installed in unlithified sediments. However, a horizontal collector for sea water supply was proposed for an expansion of the Turkey Point nuclear power plant in Miami-Dade County, Florida, in which the laterals would be installed in the extremely high transmissivity Biscayne Limestone.

The major advantage of horizontal collectors is that a single system can have the capacity of several vertical wells. Collector wells each have a single pumping system versus the multiple pumps required for a vertical well system of the same capacity. An additional advantage over conventional vertical wells is that the location of the structure that contains pumping equipment is offset from the source water location by the length of the lateral. Horizontal well yields are significantly higher than those of conventional wells because the effective radius of the well can be measured in tens of feet rather than inches.



Figure 2-2: Conceptual Diagram of the Collector Well (from Missimer et al. 2013)

The largest capacity intake system for a seawater reverse osmosis (SWRO) desalination facility using horizontal well technology is located at the PEMEX Salina Cruz Refinery, Mexico, with three wells of 4 MGD (15.1 million liters per day [MLD]) of feedwater capacity each yielding a total production capacity of about 12 MGD (45.4 MLD) (Voutchkov 2005). This is consistent with the assessment and design work performed by Staal, Gardner and Dunne/Ranney Corporation (1992) in Marina, California, which suggested a per-well yield of 4 MGD of feedwater capacity for collectors producing from shallow beach sands.

2.2.3 Slant or Angle Wells

Advanced drilling technology has allowed the construction of conventional wells at an angle. Although it is believed that angles as small as 10 degrees from horizontal can be achieved, the only known example to date (as of late 2023) of a successful slant well designed as an intake system for an SWRO plant was drilled at an angle of 22 degrees in Dana Point, California (USBR 2009, GeoScience 2012). The ability to construct wells at an angle allows the perforated portion of the well to be placed closer or under an adjacent water body and more effectively induce vertical flow through the overlying beach sands from this water body into the well. The amount of flow derived directly from the overlying water body is a function of the depth of overlying beach sands and the vertical hydraulic conductivity of these materials. An additional advantage of slant wells is that multiple wells could be drilled from a single drilling pad, reducing the footprint of the system compared to multiple vertical wells.



Figure 2-3: Conceptual Diagram of the Slant Well (from Missimer et al. 2013)

The main hydrogeological requirement for slant wells is the presence of a transmissive coastal aquifer that is hydraulically well-connected to the overlying sea.

As noted, only one slant well has been known to have been successfully constructed for seawater desalination in the world to date, although a major installation to provide 20 MGD of feedwater capacity is under consideration in the Monterey Bay area. When the successful Dana Point well was built and tested in 2006, it was test pumped at 2,000 gpm and displayed a well efficiency of 95%. Recent longer-term testing of the completed test well in 2012 documents the reduction in well efficiency⁷ over time from the original value of 95% in 2006 to 52% in 2012 (GeoScience 2012). Given this observed reduction in efficiency over a short period, the long-term performance of the technology has yet to be confirmed.

2.2.4 Horizontal Wells

Horizontal wells are directionally drilled borings (HDD) that fan outward from a common location on the shoreline (Figure 2-4). Their construction involves drilling a borehole a shallow depth beneath the seafloor, which exits the seafloor at a distance offshore. A permeable flexible casing is then pulled back to the shore from the exit point. Feedwater is derived from the ocean through vertical infiltration through the seafloor. The productivity of the wells is the function of the permeability of the overlying sediments comprising the seafloor.

⁷ Well efficiency is a measure of the head loss across the screened area of the well. High rates of head loss cause greater pumping costs and can lower individual well yields.

The hydrogeological requirement for horizontal wells is the presence of permeable, unlithified sediments at least several hundred feet offshore and the horizontal boundaries are highly site specific. It is also important that the offshore topography be flat to gently sloping and that there are no deeper valleys or holes in which the casing is exposed. The nearshore environments should also be relatively stable and not subject to major storms that could either erode away the sediments relied upon for filtration or more deeply bury the system.

Horizontal wells have been used with some success in the desalination facility in Alicante, Spain, where the HDD array was originally sized for 45 MGD. However, actual performance has been lower and water quality problems have occurred (Rachman et al. 2014).



Figure 2-4: Conceptual Diagram of the HDD Wells (from Neodren 2014)

2.3 Galleries

Galleries produce seawater by downward flow through an engineered sand filter system. The uppermost layer is typically native sand. The main geological requirement is that subsea sediments have a sufficiently high hydraulic conductivity to allow water to readily pass and that the seabed sediments are stable and subject to neither erosion nor significant sediment deposition. Natural physical and biological processes are relied upon to prevent clogging of the sediment-water interface.

2.3.1 Beach (Surf Zone) Galleries

Gallery intake systems are designed based on the concept of slow sand filtration. However, there are differences in how the gallery intake systems function within the seawater environment. In freshwater systems, a surface film forms on slow sand filters, called the "schmutzdecke" (i.e., dirty layer in German), which is biologically active and is a key part of the treatment process (Huisman and Wood 1974, Hendricks 1991, Hendricks 2011). Slow sand filters have a long history of successful operation for treatment of water for potable purposes worldwide. As a result of the bioactive layer formation, most of the reduction of the concentrations of particulate and dissolved water constituents that require some removal prior to reverse osmosis treatment occurs within the upper few inches of the filter surface.

In seawater gallery systems, the upper part of the beach is churned by physical and biological processes preventing formation of this upper biologically active layer. Beach (surf zone) gallery intake systems are a type of slow sand filter that is constructed beneath the intertidal zone of the beach (Figure 2-5). Beach galleries are self-cleaning and treatment occurs throughout the uppermost 2 to 6 feet of the gallery (unpublished research conducted at the King Abdullah University of Science and Technology, Saudi Arabia in 2014). Flow rates through slow sand filters are very low (3 to 5 meters per day or 0.015 to 0.15 gpm per square foot of bed area) and thus, no damage to biota is expected.

Beach galleries are constructed with a series of sand layers, finest at the top with a progressive increase in grain size with depth. The top layer is constructed with the native sand on the beach so that the gallery is compatible with it. The lowest layer is gravel and is used as a support and water collection layer. Seawater is pumped from the bottom layer using a header pipe and a series of screens. While slow sand filters rely upon gravity to operate, a beach gallery is pumped to create suction head and pull the water through the filter allowing adjustments to be made to infiltration rate. Increases or decreases in suction pressure can be made to make the inflow rate constant.

The key geological requirements for a beach gallery are a stable beach environment (neither eroding or prograding) and near surface sands that are relatively permeable (i.e., are clean rather than muddy sands). Upon completion of construction, the gallery is located below the natural sand surface and would not be observed by the public using the beach.

A key aspect of a beach gallery system is that it underlies the surf zone of the beach, fully or in part. This means that the active infiltration face of the filter is continuously cleaned by the mechanical energy of the breaking waves and is therefore self-cleaning (Maliva and Missimer 2010). Also, the location within the intertidal zone allows the gallery to be continuously recharged with no impact on the inland shallow aquifer system.



Figure 2-5: Conceptual Diagram of the Beach Gallery (from Maliva and Missimer 2010)

2.3.2 Seabed Galleries (or seabed infiltration galleries, SIGs)

A seabed gallery or seabed infiltration gallery (SIG) is constructed offshore in a stable location. It is another engineered and constructed filter that uses the concept of slow sand filtration, with the uppermost layer being the part of the filter that contributes most to treatment of the infiltrating water.

The largest SIG system in operation worldwide is the Fukuoka in Japan, with a capacity of about 27.2 MGD (103 MLD; (Figure 2-6) (Hamano et al. 2006, Shimokawa 2012). A significant SIG test facility had been constructed and tested at the City of Long Beach, California (Wang et al. 2007, Wang et al. 2009).

There are several different configurations that can be used in the design of a SIG with implications for system reliability. The Fukuoka SIG has one collection pipe leading from the pumping station on the coast to the offshore SIG. It is a single cell design with no backup pump or means of conducting maintenance during operation. The operation of the Fukuoka SIG has been very successful over the last 14 years with no maintenance of the gallery surface and production of seawater with a very low SDI (Shimokawa 2012, Sesler and Missimer 2012), resulting in very infrequent cleaning of the membranes.



Figure 2-6: Conceptual Diagram of SIG in Fukuoka, Japan (from Pankratz 2006)

The geological requirement for a SIG is stable, sandy bottom. The system area should not be the location of significant sediment erosion or deposition, which could either exhume or bury the gallery.

SIGs should also have robust designs that can withstand any extreme natural events, such as earthquakes and harmful algal blooms. The Fukuoka SIG operated without interruption through an earthquake in 2005. The SIG showed only a temporary increase in the SDI but continued to provide high quality seawater to the SWRO plant. (It should be noted that the Fukuoka facility was constructed under a government program in Japan that covered it as an experimental design and was not subject to a standard engineering risk assessment for financing.)

To further increase reliability, SIGs can be constructed as modular systems using a series of gallery cells, each equipped with a pump. This allows shorter distance collection systems to be used to improve flow balance within the gallery and allows a high percentage of the SWRO facility to operate in the event of a pump failure or some clogging of a cell. An example of a SIG design with multiple cells is shown in Figure 2-7, which illustrates a preliminary design for a very large capacity SWRO facility (140 MGD) in Saudi Arabia.

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The engineered filter used in a SIG contains multiple layers with an upper active layer and several layers that gradually increase the grain size to transition into a basal (lower layer), high permeability collection layer (Figure 2-7). Similar to a beach gallery system, the upper layer is where particulate matter accumulates. Biological activity (bioturbation) by burrowing and deposit-feeding organisms prevents a low-permeability organic-rich layer from developing on the sea floor.



Figure 2-7: Conceptual Design of a SIG for the Shuqaiq SWRO Plant, Red Sea, Saudi Arabia (from Mantilla and Missimer 2014)

2.3.3 Tunnel Intakes

A tunnel intake was recently constructed to provide some or all of the 34.3 MGD of feedwater required to operate the Alicante II SWRO plant in Spain (Rachman et al. 2014). This system contains a tunnel underlying the beach area. The tunnel contains a series of collectors, commonly drilled upward into the overlying aquifer (Figure 2-8). The laterals contain screens that are open to the aquifer and yield water to the tunnel as it is pumped. It operates in a manner similar to a vertical Ranney collector system.

The main geological requirement is a thick interval of permeable sediments below the seabed into which the lateral screens can be installed. The underlying strata should be suitable for tunneling.

The tunnel system lies fully beneath the surface. The induced vertical flow of seawater produces water with a quality essentially identical to seawater and without inducing impacts to the shallow aquifer landward of the beach.

Tunnel systems have very large construction costs, a very limited track record of successfully installed systems, and great risks, as their performance cannot be accurately evaluated in advance of the financial commitment to construct a full-scale system. For these reasons, they are not a viable option for most desalination plants.



Figure 2-8: Conceptual Diagram of a Tunnel Intake System Proposed for a Southern California SWRO Plant
3. FEASIBILITY FACTORS

3.1 Introduction

CEQA, adopted in 1969, defines feasible as "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors" (Section 21061.1). This is the same definition of "feasible" is adopted for use in the Ocean Plan 2019. The Ocean Plan also identified additional factors to be considered in the feasibility evaluation of SSI. It is noted that the process for determining feasibility is defined in the Ocean Plan (Ocean Plan 2019, Chapter III, section M) and for the purposes of this Report, the CEQA process is not directly applicable. For purposes of listing all factors, this citation from the Ocean Plan 2019 is repeated here:

"The regional water board shall consider the following factors in determining feasibility of subsurface intakes:

- geotechnical data, hydrogeology, benthic topography, oceanographic conditions, presence of sensitive habitats,
- presence of sensitive species, energy use for the entire facility;
- design constraints (engineering, constructability), and
- project life cycle cost.

This section provides an overview of the various components of each of the four feasibility factors (economic, environmental, social, and technological factors). These additional factors specified in the Ocean Plan for assessing SSI feasibility are encompassed within these four factors. Sections 4 and 5 provide a more in-depth discussion of the Panel's recommendations for evaluating feasibility across these different factors at different guidance decision points during the proposed stages of the overall SSI FA (See Section 4.2). These recommendations address the multiple questions posed by the State Board as part of the TOR for this Report (Appendix A).

3.2 General Feasibility Factors

The feasibility of an SSI system depends on a series of general conditions (Table 3-1) as well as conditions specific to the intake type (described in greater detail in Appendix E) and some project specific factors. The proposed SSI FA methodology (Figure 4-1) is a sequential process in which the feasibility of potential SSI types and sites are evaluated across a range of guidance decision points and as more site-specific data becomes available. At each decision point, a recommendation for Regional Board review would be made for the system type and each site under consideration. A negative recommendation means that an alternative intake type and site or sites should be considered, not necessarily that a specific SSI is not viable for a desalination plant. Regional Board consultation and review would be incorporated into these discussions at all stages of the process. The Panel recognizes that at these interim stages of the process, no formal decisions can be made. Any proponent would, however, be asking for informal guidance to assess the need for additional information, studies or the potential for pilot tests to demonstrate whether the SSI- site combination is likely a feasible option as is discussed in detail in Section 4.2.

For a given capacity, a SSI-site combination must meet all the relevant feasibility factors, or the proponent is likely to consider such combination as infeasible. For example, if there is not enough available beachfront land to construct the required number of vertical wells, then the vertical well option is not feasible regardless of how well it meets other criteria. Suboptimal conditions could impact system economics by requiring mitigation and overdesign to meet desired system reliability. These general feasibility factors incorporate the elements that constitute the Ocean Plan 2019 definition of "feasible."

Risk is a factor that incorporates multiple dimensions in this process. It is a difficult factor to evaluate because individuals and organizations vary in their risk tolerance. It would be an unacceptable risk (i.e., resulting in a negative recommendation for the proponent of a desalination project) to incur high capital and life-cycle costs without confidence that the SSI-site combination will provide the required quantity and quality water, a decision that rests on the risk tolerance of the proponent and would also be a consideration by the Regional Board. Confidence would increase if the intake type had a proven track record (particularly in geologic and coastal conditions similar to the proposed project site and region) or pilot testing could be practicably performed at a project-specific scale that allows for assessing technical and economic feasibility. Confidence can also be increased if there are known options for dealing with foreseeable problems. For example, with vertical wells, if well yields turn out to be less than anticipated in the design phase, then a fallback option is to construct additional wells or perhaps modify the design of new wells.

Table 3-1: General Feasibility Factors					
Factor Type	Feasibility Considerations				
TECHNOLOGICAL					
Constructability (Ocean Plan, p. 46, and benthic topographic, geotechnical data, and oceanographic conditions, p. 46)	The site-SSI combination should be capable of providing the desired volume of desalinated water. It must be possible to physically construct the system in project site vicinity. Physical conditions at the site should be stable enough so that the system could operate reasonably consistently over its planned lifetime (commonly taken as at least 30 years). Ability to obtain permits associated with the SSI from other agencies to extent needed, e.g. land use permits in a reasonable time frame.				
Reliability (not specifically covered in the Ocean Plan)	The raw water must be of suitable quality, which is herein assumed to be similar to local seawater that has not undergone fluid-rock interactions adverse to the treatment process (e.g., iron and manganese leaching). Ability of the intake to function and ability to access for O&M performance. Ability to rehabilitate the intake, for example to address clogging, and availability of known and proven technologies.				
Risk of system failure (not specifically covered in the Ocean Plan)	Owner of the system should have confidence that the subsurface intake system will meet design goals before committing to constructing a full-scale intake system and treatment plant. Pilot testing of the intake system should be able to be conducted if necessary. System should not be vulnerable to adverse geological and human processes including sediment erosion and deposition and spills. Practicable and affordable options should be available to maintain and repair system if required.				
ENVIRONMENTAL (covered in the 2019 Ocean Plan under hydrogeology, presence of sensitive habitats, and presence of sensitive species, Chapter III, p. 46)	 SSI implementation (e.g., siting, construction, operation, maintenance) should avoid, to the maximum extent feasible, the disturbance of sensitive habitats and sensitive species, and ensure that the intake structures are not located within an MPA or SWPA. Specific environmental factors for feasibility consideration identified in the Ocean Plan include: Sensitive habitats Sensitive species Indirect effects, if SSI operations intercept a coastal freshwater aquifer, or aquifer-dependent sensitive habitats (wetlands) and/or associated sensitive species. 				
SOCIAL	Water affordability				
ECONOMIC (Project life cycle cost and energy use in Ocean Plan, p. 46)	Construction and operation (life cycle) costs for a given intake type should be competitive with that of other subsurface intake types and not be so high as to render a desalination project not economically viable. The perceived project engineering risk should be low enough that financing can be obtained (based on use of the technology at other comparable locations and at similar design capacities). Additional incremental life cycle costs associated with subsurface intakes (relative to surface intakes or other water supply alternatives) should not cause an undue economic burden for low-income households in the form of significant increases in the cost of basic water services. Any additional incremental costs should also not result in delayed investments necessary to meet regulatory requirements that protect public health. Contractor market should be competitive with multiple potential bidders for projects. Subsurface intake should not be significantly more energy intensive (i.e., have a greater carbon footprint) than other intake options based on annual energy use assessments				

3.3 <u>Technological Factors</u>

The primary technological factors to be addressed in meeting the Ocean Plan 2019 definition of feasibility are the type of equipment, materials, and methods that are used to construct and operate the design components of the desalination facility (Chapter III.M.2.d): as they relate to 1) constructability, 2) system reliability, and 3) risk of system failure, including all components of the desalination system affected by the intake structure. These factors all contribute to design constraints that must be addressed by the proponent, and rely on assessment of geotechnical data, hydrogeologic, benthic topography, and oceanographic conditions for evaluation. Constructability can be defined considering a range of issues, such as use of standard construction techniques (e.g., vertical wells) versus one of a kind or never used construction methods (e.g., construction of elements and installation of subsurface infiltration galleries). System reliability factors would include operational efficiency (i.e., continuous versus intermittent operation) and ability of the intake structure to remain in operation during occurrence of natural hazards such as storms, earthquakes, or rising sea level. The reliability analysis is time-dependent and durability of the system over time would need to be addressed. Reliability analysis must also consider the ease of operation and maintenance (O&M) procedures that would be used to maintain the desired level of continuous operation or target durations of shutdown for O&M purposes. Finally, a risk analysis of various failure modes under a range of scenarios would address the likelihood of failure. The failure risks will vary depending on the intake technology, site conditions, and probability of occurrence of natural hazards.

3.3.1 Constructability

Constructability is the most basic of the technical SSI FA criteria. The selected SSI system must be able to be constructed at the chosen site. Constructability depends on both the ability to construct the SSI system and the ability to achieve the target design capacity. Using vertical beach wells as an example, constructability will depend on target design capacity, individual well yields (and thus the total number of wells required), and the area (length) of the beach available for well construction.

3.3.2 Reliability

The issue of system reliability permeates through the other factors that control feasibility. Reliability can be a factor used to compare different SSI-site alternatives for a given capacity or as a stand-alone factor to assess feasibility. Quantifying this factor is a design decision made in the early stages of assessing feasibility of various sites and usually relies on professional judgment and experience. A desalination plant requires a continuous supply of treatable seawater to produce the desired quantity of water specified in the conceptual design phase. Commonly, site geology controls the technical feasibility of designing, constructing, and operating an SSI system with respect to reliability for a given hydraulic design capacity.

Several scenarios that can disrupt the reliable operation of an SSI are not considered material in considering this factor in the SSI FA. For example, temporary interruptions in water production caused by potential operational issues such as an electric power outage, a pump failure, or a failure of a raw water transmission line are generally easily reparable. Even longer-term impacts caused by storm or earthquake damage are not considered to be sufficient justifications for declaring an SSI type not feasible. In Florida, for example, hurricanes have caused the loss of well sites through tidal surge or building damage, but the facilities are typically repaired within a few weeks to months. Shorter term interruptions in the raw water supply can be mitigated by use of treated -water ground storage. Longer term water supply interruption can be mitigated by using utility interconnects, assuming that an entire region is not impacted by a specific event.

Generally, if an SSI technology at a given site has the potential to fail for more than one year, or the failure could be permanent, such an option would be considered infeasible due to unacceptable reliability. For a given site, an earthquake could cause catastrophic damage such that further rebuilding of a particular intake type or any SSI would be precluded. Further erosion of nearshore environments may lead to a permanent loss of one or all SSI types because of the impacts to the beach and offshore seabed. SSI types at greater depth and further offshore, such as seafloor infiltration galleries, are less likely to be affected by erosion.

Reliability also depends upon the ability to economically restore the performance of a system; for example, if the capacity declines due to clogging. The methods used to restore the performance of vertical wells are well known and in California there are numerous contractors available who could relatively quickly perform the work at a non-prohibitive cost. On the contrary, the effort and cost to restore the performance through reconstruction of an offshore gallery would likely be prohibitive. In summary, reliability is highly site specific in terms of how this factor should be estimated but at a minimum, a qualitative analysis is needed for any intake proposed.

3.3.3 Risk of System Failure

A serious technological feasibility factor for project applicants is the potential for technical failure of SSI. The future owner of the system should have confidence that the SSI system will meet design goals before committing to constructing a full-scale intake system and treatment plant. In addition, risk of failures due to natural hazards should also be carefully assessed.

3.3.4 Permittability

The applicant will need to assess the likelihood of obtaining a permit to ensure funding and support of some stakeholders. All required federal, state, and local regulatory approvals must be obtainable for the selected subsurface system type-site combination. The inability to obtain any required permit or approval is considered a barrier that must be addressed early in the overall permitting process. The duration of the permitting process may also be considered as a general technical feasibility factor. As an extreme example, a decade or longer permitting process could delay a desalination project to the extent that an applicant may be forced to seek other water supply options.

3.4 Environmental and Social Factors

An overarching goal of the Ocean Plan 2019 is to "minimize intake and mortality of all forms of marine life" associated with desalination facilities (Ocean Plan 2019, Section IIIM.2.a(2). Specific to subsurface intakes, the Ocean Plan identifies two specific environmental factors for consideration in determining the feasibility: the presence of sensitive habitats and the presence of sensitive species (Ocean Plan 2019, Section IIIM.2.d(1)(a)(i)). The Ocean Plan provides considerations for intake technology (subsection d. (1)(a)) – requiring subsurface intakes unless the State Board determines that they are not feasible; and. requires that 'installation and maintenance of a subsurface intake shall avoid, to the maximum extent feasible, the disturbance of sensitive habitats, and sensitive species (subsection d.(1)(b). The Ocean Plan also states that, with respect to facility siting, the applicant should "ensure that the intake and discharge structures are not located within an MPA or SWOPA, with the exception of structures that do not have a marine life mortality associated with the construction, operation, and maintenance of the intake structure (e.g., slant wells) (Subsection 2(b)(7)). The Board has determined that subsurface intakes are environmentally superior and preferable to open water/surface impacts with respect to operational effects on marine life mortality. Applicants must still address marine life mortality effects for the construction and maintenance of subsurface intakes and, thus, must avoid siting within designated MPA or SWQPA areas, per the requirements of the Plan.

The Ocean Plan establishes that SSI are the preferred alternative over surface screened intakes because they substantially minimize environmental effects on the marine environment with respect to impingement and entrainment, which result in marine life mortality. The Ocean Plan indicates that SSI are preferred over surface intakes and are required unless determined to be infeasible for use with a proposed desalination project (Chapter III, Section M.2.d.(1)(a)(ii)). The Final Staff Report Including the Final Substitute Environmental Document, Adopted May 6, 2015, prepared by the State Board (2015) on the proposed desalination amendment to the Ocean Plan clearly establishes that SSI eliminate the impacts of impingement and entrainment caused by surface intakes, which are the main environmental impacts to marine life. These impacts create an ongoing "lifecycle" effect on marine life intake and mortality:

"Subsurface intakes collect water that has filtered through sandy sediments or fractured rock, which act as a natural filter excluding organisms and thus eliminates impingement and entrainment impacts. (MWDOC 2010; Missimer et al. 2013; Hogan 2008; Pankratz 2004; Water Research Foundation 2011) This gives subsurface intakes a significant environmental advantage over surface water intakes because mitigation for surface intake entrainment will have to occur throughout the operational lifetime of the facility." [emphasis added] (Ocean Plan 2019, Section 8.3.2)

"Subsurface intakes typically have greater construction-related effects but negligible intake related mortality." (Ocean Plan 2019, Section 8.4.2)

"Since subsurface intakes eliminate impingement and entrainment, they can be sited nearby the SWQPA [State Water Quality Protection Areas] or MPA [Marine Protection Areas] without adverse operational impacts; however, construction of a facility or its components could lead to disturbances like increased turbidity or re-suspension of contaminants in sediments that may adversely affect a SWQPA or MPA. Surface intakes have a greater potential to impact marine resources and/or water quality within a SWQPA or MPA." [emphasis added] (2019 Ocean Plan 2019, Section 8.4.4)

Mitigation requirements are also defined in the Ocean Plan 2019 (Section M.2.e):

"Mitigation for the purposes of this section is the replacement of all forms of marine life or habitat that is lost due to the construction and operation of a desalination facility after minimizing intake and mortality of all forms of marine life through best available site, design and technology. The regional water board shall insure that an owner or operator [applicant] fully mitigates for the operational lifetime of the facility and uses the best available mitigation measure feasible to minimize intake and mortality of all forms of marine life."

The applicant can propose to mitigate project effects by completing a mitigation project (Mitigation Option 1) or by participating in an approved fee-based mitigation program. In light of the Ocean Plan requirements, environmental factors could raise questions of feasibility for a subsurface intake if the applicant is not able to demonstrate it can substantially avoid disturbance to sensitive habitats and/or sensitive species. Further, the feasibility of a proposed subsurface intake also depends on the applicant's ability to provide appropriate mitigation requirements and options. Because subsurface intake, by design, avoid the operational impacts of marine life intake and mortality associated with open, surface intakes, the mitigation needs for a desalination project with SSI are substantially less than those employing surface/open water intakes. Mitigation needs for SSI facilities are limited to construction and maintenance effects and, in most cases, are not expected to represent a significant feasibility issue.

The chief environmental concerns with respect to determining the feasibility of an SSI-site combination or for comparison of various SSI-site combinations for a project are described below:

• Effects on sensitive marine habitats and sensitive species. While direct effects on marine populations and productivity are reduced by the elimination of entrainment and impingement, marine habitats and species could be impacted during the construction and maintenance phase of SSI. The Ocean Plan 2019 states that project proponents are not required to evaluate or mitigate mortality that results from intake-related SSI operations. Specifically, per the Ocean Plan 2019 III.M.2.e(1)(a): "An owner or operator with subsurface intakes is not required to do an ETM/APF analysis for their intakes and is not required to mitigate for intake-related operational mortality." However, mortality during the construction and maintenance must still be evaluated, minimized, and mitigated.

• Indirect effects of SSI operation include the potential for hydraulic connectivity between SSI and coastal freshwater aquifers and/or coastal wetlands; this potential is very site-specific. The risk of hydraulic connectivity to coastal aquifers and environments is specific to SSI (it is not a consideration for surface intakes). SSI operations may intercept or interfere with adjacent onshore freshwater aquifers, and in turn, affect the aquifer-dependent sensitive wetland habitats and/or species that can be supported by such coastal aquifers. Indirect environmental effects can occur either through water withdrawal and aquifer drawdown or by causing or exacerbating seawater intrusion. On the contrary, in some cases it may be possible to site and design an SSI facility to benefit a coastal freshwater aquifer by providing a barrier to seawater intrusion through creation or enhancement of a seaward hydraulic gradient.

There are a range of other environmental effects and environmental regulatory and compliance consistency questions associated with construction, maintenance, and operation of an SSI that must be addressed under other regulations that apply to a desalination project. The Regional Boards are directed in the Ocean Plan to consult with other state agencies involved in some aspect of permitting a desalination facility, including but not limited to: California Coastal Commission, California State Lands Commission, and California Department of Fish and Wildlife. Among the relevant regulations administered by these and other agencies are the California Coastal Act, the California Endangered Species Act (CESA), and the California Environmental Quality Act (CEQA).

Though not identified in the Ocean Plan 2019 as key environmental factors for SSI feasibility consideration, the following three topics areas are highlighted as potential environmental issue areas that may also factor into the overall ability of a desalination project to secure all necessary approvals and permits: effects on cultural resources, tribal resources, and public shoreline access and recreation disruption or displacement – particularly if impacts disproportionally effect disadvantaged communities. It may be difficult or impossible to avoid or adequately mitigate project effects on these resource/issues if they are not addressed early in the process, during project development and design. Quickly reviewing each of the SSI project implementation phases (siting, construction, operation, maintenance) helps narrow potential environmental and social questions about overall project feasibility to a select few alternatives.

The siting/site selection phase for the SSI is expected to have been completed prior to initiation of the SSI FA, during which time multiple site-SSI combinations capable of providing the target design capacity will have been evaluated through desk top studies. This screening could result in further consideration of more than one site-SSI combination. The goal of the screening process should be to reduce the number of combinations being considered in subsequent stages of the FA. Site selection should consider the feasibility factors identified here and will be confirmed during the SSI FA for proximity and potential to affect the sensitive resources noted.

Construction impacts are generally short-term and temporary, ending once construction is complete, though the construction period for an SSI facility may be extensive, taking multiple years to complete. Depending on the type of SSI proposed, there will be some landside facilities as well as marine and/or subsurface facilities, such that construction impacts may occur on the beach or landward along the shoreline as well as in the intertidal and subtidal marine environment. Typical environmental effects occurring during the construction phase include noise/vibration, air quality degradation (dust or other pollutant emissions from equipment and earthwork), increased truck traffic, traffic circulation disruption, access or use disruption to open space/recreation areas, potential removal and/or disturbance of sensitive habitats, sensitive species, designated cultural resources, tribal cultural resources, and a disproportionate impact on disadvantaged communities.

In many cases these construction effects can be minimized through commonly available and applied mitigation measures. From review of past examples (including from personal professional experience) of environmental review and permitting of other major water supply and marine infrastructure projects in general, and desalination projects in specific, there are known, feasible mitigation measures available to address many environmental effects of facility construction and maintenance.

With respect to project operation, selection of an SSI rather than a surface intake eliminates adverse operational impacts due to the impingement and entrainment of marine microorganisms, which is highly significant for surface intake operations. However, SSI may be hydraulically connected to nearby freshwater aquifers, and as a result, may in turn affect aquifer-dependent coastal wetlands, thus introducing a potentially significant impact that is not an issue for surface intake operations. The potential for effect on freshwater supply is a technical issue; the potential adverse affect on associated sensitive habitats and/or associated sensitive species is an indirect environmental effect. This potential operational effect is both site-specific and SSI-design specific; it requires careful attention during project development and the subsequent SSI FA. If it is shown to be a potential issue for a specific SSI project, then the applicant will need to develop an operational management and monitoring plan to avoid adverse effects; -ongoing monitoring of intake operation would include monitoring the salinity of the source water. The extent to which this factor should be assessed is discussed in detail in Section 4.

Maintenance phase activities are similar in nature to construction activities with respect to potential disruption of the SSI facility site for tasks such as equipment maintenance, replacement, and/or sand field "cleaning." The duration and scope of maintenance activity would be much less than the construction phase, but it would be recurring at some interval. The issues of concern identified above for the construction phase also apply to maintenance activities.

These environmental issues are reviewed below in the context of project implementation phases (siting, construction, operation, and maintenance). The focus here is on data needs to assess the relative impacts of the SSI-site combination on environmental and social feasibility factors.

3.4.1 Sensitive Coastal and Marine Habitat and Sensitive Species

In general, SSI can be carefully sited to determine the least environmentally disruptive location and avoid areas with sensitive habitat and species, specifically the MPA and SWQPAs. In addition, restricting the construction period to be as short as possible and seasonally appropriate can minimize impacts. Nevertheless, construction of onshore SSI facilities, such as beach wells, has the potential to disrupt breeding habitat, foraging grounds, or vegetation (Water Research Foundation 2011), and offshore construction of SSI has the potential to disrupt benthic communities for the duration of the construction, although benthic community structure is expected to return after the construction is completed. Notable environmental impacts associated with SSI are related to construction and maintenance, with the magnitude and nature of those environmental impacts varying depending on the type of SSI. For example, vertical beach well intakes will disturb relatively little surface area and require minimal maintenance, whereas offshore infiltration galleries can require complete substrate replacement.⁸ However, habitat sensitivity as well as the degree to which the habitat supports special status species, rather than simply area affected, are chief considerations. The extent of potential adverse effect can only be assessed at a site-specific level rather than categorically by SSI type.

Sensitive marine habitats that should be considered prior to siting a desalination facility include kelp beds, eelgrass beds, surf grass beds, rocky reefs, oyster beds, market squid nurseries, and foraging grounds and reproductive habitat for state and federally managed species. Per State Water Board policy, sensitive species considered include aquatic-dependent birds that could be adversely affected if foraging is restricted by construction and/or maintenance activities. These biologically diverse habitats provide shelter for larval recruitment, settlement, and development (Moyle and Cech 2004, Allen and Horn 2006). In addition, the State has designated specific biological resource areas as defined in the Ocean Plan 2019, with specific protections and constraints on marine facilities siting and/or potential environmental effects:

- Areas of Special Biological Significance (ASBS) are those areas designated by the State Board as ocean areas requiring protection of species or biological communities to the extent that maintenance of natural water quality is assured. All ASBS are also classified as a subset of State Water Quality Protection Areas. ASBS are also referred to as State Water Quality Protection Areas—Areas of Special Biological Significance (SWQPA-ASBS).
- Marine Managed Areas are named, discrete geographic marine or estuarine areas along the California coast designated by law or administrative action, and intended to protect, conserve, or otherwise manage a variety of resources and their uses. According to the California Public Resources Code (§§ 36600 et seq.), there are six classifications of marine managed areas: State Marine Reserves, State Marine Parks, State Marine Conservation Areas, State Marine Cultural Preservation Areas, State Marine Recreational Management Areas, and State Water Quality Protection Areas.

⁸ Substitute Environmental Document for Desal Amendment to Ocean Plan, p. 64.

3.4.1.1 Mitigation of Adverse Marine Habitat and Species Effects

The Ocean Plan 2019 includes specific requirements for mitigation, which is defined for the purposes of Chapter III.M.2.e. as the replacement of all forms of marine life or habitat that are lost due to the construction and operation of a desalination facility after minimizing intake and mortality of all forms of marine life through best available site, design, and technology. As discussed above, because SSIs avoid the intake impingement and entrainment impacts associated with the operation of surface intakes that drive substantial marine mitigation needs, the potential mitigation needs to address SSI construction and/or maintenance effects are not expected to be substantial or trigger concerns about the availability of suitable mitigation sites or approaches for some sensitive habitats that could represent an obstacle to achieving fully compensatory mitigation.

3.4.2 Coastal Wetlands and Freshwater Aquifers

Depending on siting and operational design, SSI operation has the potential to interfere with freshwater aquifers and coastal wetlands by drawing freshwater into the intake and/or by creating and/or exacerbating seawater intrusion into the freshwater aquifer. As noted above, there may be instances where SSI operation is designed to serve a beneficial purpose to protect or remedy a seawater intrusion issue. However, if this is not the case, then depending on the intake location and operational design, it may or may not be feasible to mitigate interaction with and impact to an adjacent freshwater aquifer through modification of pumping volumes or timing. If groundwater models, developed based on hydrogeological data, indicated that operation of an SSI would adversely impact a freshwater aquifer which, in turn, could adversely impact an associated coastal wetland through withdrawals or by causing/exacerbating seawater intrusion, this could eliminate that SSI option in the proposed location. For this reason, evaluation of this potential operational effect must be conducted early in the overall SSI FA process to confirm no significant effects on a nearby freshwater aquifer. This evaluation is further detailed as part of Stages 3 and 4 in Section 4. Further, as conditions may change over time, it is recommended that intake water salinity be monitored continuously through the plant's operational life with appropriate reporting to the regional board tracking performance.

3.5 <u>Economic Factors</u>

Economic feasibility is typically concerned with whether the benefits of a proposed investment justify the costs. Within the context of water supply projects, costs are ultimately borne by the households and businesses benefiting from the investment (i.e., water customers). This in turn raises additional concerns related to the affordability of water services for these customers. If there are significant increases in the life cycle costs associated with SSIs (relative to surface intakes), this could also pose challenges for project proponents, depending on their financial capability, and/or otherwise affect the economic viability of the overall project. Uncertainty surrounding the reliability and performance of SSI for large desalination facilities (those producing more than 10 MGD of treated water) may also affect the ability of project applicants to obtain necessary project financing (see Section 5.3.2). These various aspects should be considered when evaluating the economic feasibility of SSI facilities.

Within the context of permitting for SSI technologies, the State has determined that surface intake technologies result in greater adverse effects to marine life. The Ocean Plan 2019 cites life cycle costs and economic viability as key economic feasibility factors, stating:

"Subsurface intakes shall not be determined to be economically infeasible solely because subsurface intakes may be more expensive than surface intakes. Subsurface intakes may be determined to be economically infeasible if the additional costs or lost profitability associated with subsurface intakes, as compared to surface intakes, would render the desalination facility not economically viable."

3.5.1 Economic Feasibility Assessment

To determine economic feasibility for a given site-SSI combination, proponents should first carefully define a baseline alternative against which to compare potentially feasible SSI intake alternatives. In most cases, the baseline alternative will be a desalination facility with a surface intake against which alternative SSI alternatives can be evaluated and compared. However, if for some reason a surface intake would not be technically viable at the project location (or infeasible for other reasons), feasibility would then need to be cast in comparison to the next most viable water supply alternative.

Key excerpts from the Ocean Plan 2019 confirm that the economic feasibility of SSI technologies should be considered within the context of the benefits and costs for surface intakes. For example:

II.M.2.d.1.(a) Subject to Section L.2.a.(2), the regional water board in consultation with State Water Board staff shall require subsurface intakes* unless it determines that subsurface intakes* are not feasible* based upon a comparative analysis of the factors listed below for surface and subsurface intakes.*

III.M.2.d.1(a)(i) The regional water board shall consider the following factors in determining feasibility of subsurface intakes:* geotechnical data, hydrogeology, benthic topography, oceanographic conditions, presence of sensitive habitats,* presence of sensitive species, energy use for the entire facility; design constraints (engineering, constructability), and project life cycle cost. Project life cycle cost shall be determined by evaluating the total cost of planning, design, land acquisition, construction, operations, maintenance, mitigation, equipment replacement and disposal over the lifetime of the facility, in addition to the cost of decommissioning the facility. Subsurface intakes* shall not be determined to be economically infeasible solely because subsurface intakes* may be more expensive than surface intakes. Subsurface intakes* may be determined to be economically infeasible if the additional costs or lost profitability associated with subsurface intakes,* as compared to surface intakes, would render the desalination facility* not economically viable. In addition, the regional water board may evaluate other site- and facility-specific factors.

III.M.2.d.1(a)(ii) If the regional water board determines that subsurface intakes* are not feasible* for the proposed intake design capacity, it shall determine whether subsurface intakes* are feasible* for a reasonable range of alternative intake design capacities.

Once the baseline is established, the economic analysis can proceed as follows:

- Estimate and compare project life cycle costs associated with the proposed SSI alternative(s) and the baseline surface intake option (or other water supply alternative). This assessment should include costs associated with plant design, construction, and operations through the expected life of the project (see Ocean Plan definition of life cycle costs above). Costs should be analyzed in accordance with current federal and, if available, state, or local guidance. Federal guidance is found in the Office of Management and Budget's (OMB) Circular A-4: Regulatory Analysis (OMB 2023). Additional detail and considerations for cost analysis, including typical cost comparisons for open and SSI, can be found in the subsequent section.
- Compare the life cycle benefits and costs of SSI alternatives to the baseline alternative. To the Panel's knowledge, the state has not established methods for quantifying or valuing the environmental (marine life) benefits associated with SSI relative to surface intakes. However, the mitigation costs associated with surface intakes (to account for impacts for marine life) should be included in the life cycle cost assessment for the surface intake alternative. The relative magnitude of all other non-quantified/monetized benefits across viable alternatives (including the baseline surface intake alternative) should be qualitatively assessed and compared. The assessment of alternative options should include any additional environmental and/or social benefits and costs associated with SSI alternatives (again, relative to the baseline alternative). If the benefits seemingly justify the costs, but the costs of desalination facilities with SSIs significantly outweigh the surface intake options, the next step is to examine the relative impacts on rate payers (e.g., determine whether a substantial number of low-income customers will see increases in their bill that exacerbate affordability challenges, relative to alternatives). Most utilities considering the construction of a desalination plant would likely conduct semi-regular rate/cost of service studies and should be able to easily examine the rate increases that would be necessary to cover the costs associated with alternative intake options (or at least the expected annual cost per household associated with SSI versus surface intake alternatives). In evaluating the rate increases necessary to make the project economically viable, applicants should balance revenue requirements against the likelihood that users will reduce usage (i.e., examine elasticity or apply elasticity assumptions to forecast demand) or cease paying utility bills, causing the yield of the revenues from the rate increase to be less than expected or desired, potentially causing the community to experience "rate shock."

Further, there is extensive documentation and guidance on analyzing household affordability of water sector services, and relatively simple approaches can be applied (see for example, Raucher et al. 2019). For example, projected rate increases can be evaluated and compared within the context of historical increases. Applicants can also use socioeconomic data (e.g., from the United States Census American Community Survey) to assess the associated affordability burden for low-income households, as well as the prevalence of households that would likely face additional or exacerbated affordability challenges as a result of incremental rate increases (see Raucher et al. 2019, Clements et al. 2023 for approaches to examining affordability).

Another key consideration is the financial capability of the utility to take on additional debt (i.e., the incremental debt associated with SSI) and ensuring that (often limited) financial resources are targeted to yield the greatest benefit (in line with the United States Environmental Protection Agency's Integrated Planning Approach). For example, throughout California, many utilities are facing costs associated with increased regulatory requirements, aging infrastructure, lead service line replacements, and more. Any additional costs that may be associated with SSI should be evaluated within this context; they should not result in a delay of investments necessary to meet regulatory requirements designed to protect public health. Finally, the ability to secure project financing will affect project life cycle costs, as well as overall project feasibility. As detailed previously, SSI systems have not been implemented at large-scale desalination facilities (i.e., systems with 10 MGD capacity or greater based on data from Global Water Intelligence 2024 DesalData). Uncertainties related to project approval and performance coupled with increased costs will likely make it difficult to secure financing if the project has identified a need for a large-scale system. Without financing, some projects may not be able to move forward. This issue is further addressed in Section 5.3.

3.5.2 Intake Life Cycle Cost Guidance

The project proponent should develop cost estimates for alternative intakes and should consider the full project life cycle. Engineering cost estimates for all SSI-site combinations which could include beach wells, Ranney collectors, slant wells, horizontal wells, beach galleries, seabed galleries, tunnel intakes, and/or the baseline surface intake (or other water supply) alternative. Per the Ocean Plan 2019, a life cycle cost estimate requires "evaluating the total cost of planning, design, land acquisition, construction, operations, maintenance, mitigation, equipment replacement and disposal over the lifetime of the facility, in addition to the cost of decommissioning the facility." Energy costs for operating intake alternatives should be included (see Section 3.5.3). Published data that may be useful in informing or validating project costs includes *Desalination Project Cost Estimating and Management* (Voutchkov 2018a), the Global Water Intelligence Desalination database, (Global Water Intelligence, 2024), and publicly available budget/costing information from similar facilities.

This section contains an overview of key issues, trends, and broadly applicable rules of thumb related to SSI life cycle costs. Summarizing guidance on calculating life cycle costs is beyond the scope of this expert panel but many resources can be found, including online guidance (e.g., for water systems like (North Dakota Water Commission, 2020) or other applications) and textbooks (e.g., (Eschenburg 2011)). Government resources related to asset management may also be helpful, including those identified by the U.S. EPA for water and wastewater systems (US EPA, 2020). Online tools and commercial software packages may also be useful.

An analysis of empirical costs from SWRO systems across the world indicates that intake construction typically represents between 4.5 to 6.5% of the total construction costs (Voutchkov 2018a). As shown in Figure 3-1, Voutchkov summarizes cost data for different intake structures, both onshore and offshore, based on systems installed around the world. The costs shown in Figure 3-1 are illustrative and may easily vary by about 30% for similar facilities due to local conditions. Costs include well pumps and auxiliary equipment (e.g., electrical and controls) as well as site preparation. These estimates do not include costs for monitoring wells, piping to reach the treatment facility, nor do they account for changes to the treatment plant design that may depend on intake selection (e.g., pre-treatment). Surface intakes and sometimes SSI may require a separate pump station which is also not included. Many configurations of potential SSI described in Section 2 are not shown due to lack of available data.



Figure 3-1: Representative Capital Cost Curves for Selected Seawater Desalination Intakes Based on Global Analysis (adapted from Voutchkov 2018a). The x-axis is intake flow rate in MGD and the y-axis shows costs in \$1000s. Open onshore intakes are shown in dark blue with circle markers. Open offshore intakes with concrete tunnels are in orange with triangle markers and for HDPE pipe on the ocean floor are teal with square markers. Note: Offshore intake costs are linearly related to pipe length. Costs shown assume an intake of 600 meters. Vertical wells are light blue with no marker. Horizontal and Ranney wells are in blue with diamond markers. An inset highlights costs for smaller capacity systems up to 15 MGD.

Offshore deep concrete tunnels are the most expensive to construct, but, if a desalination facility can co-locate with a facility that already has an existing intake, costs can be reduced by 60–80% (Voutchkov 2018a). For subsurface systems, vertical wells are the cheapest option based on capital cost but have historically been considered impractical at capacities above about 5 MGD of intake flow. HDD and Ranney wells have been used at higher capacities and, based on a study of many systems globally, are typically 20 to 30% more expensive to construct, though many site specific conditions could affect these costs. Infiltration gallery costs are highly variable and typically higher than other SSI alternatives. Subsurface wells may also have a shorter useful life than open intakes, which are expected to last 50 years or more based on past examples globally (Voutchkov 2018b). Depending on well construction, subsurface conditions, and well maintenance practices, wells may need to be replaced every 10-15 years (Voutchkov 2018b).

Capital costs are well documented across many projects allowing cost curves like Figure 3-1 to be developed. However, capital costs are just one component of life cycle costs which should include operational, repair/rehabilitation, and decommissioning costs as well. Operational costs should include energy costs, chemical and membrane costs, labor, and routine maintenance. Costs for environmental mitigation, whether capital or operational, should be included. Costs for addressing equipment or system failures or deterioration should be estimated as repair/rehabilitation costs. When possible, decommissioning costs should be included, though limited data exist and costs can be very uncertain as they are dependent on timing. These costs vary significantly depending on siting, system design, facility size, and other factors. No publicly available generalized guidance on estimating the costs associated with operational, repair and rehabilitation, mitigation or decommissioning of SSIs was identified during the preparation of this report.

Due to the long life of water treatment facilities, operational costs tend to dominate the overall life cycle costs depending on the discount rate used. As a result, subsurface intakes that reduce operational costs associated with the intake, as well as downstream in the treatment process, may accommodate much higher intake capital costs without significant impact on the overall life cycle cost of the water produced at the facilities. Operational cost savings associated with SSI have been documented and may be relevant to applicants' decision making. The sources of savings include reduced maintenance costs relative to an open ocean intake; reduced costs for recovering and releasing marine species from screens; reduced or avoided chemical costs savings associated with coagulation and chlorination/ dechlorination; reduced or avoided electricity costs for pretreatment; and reduced cleaning and extended life of membranes. Higher water quality (e.g., lower levels of dissolved organic carbon which can cause membrane fouling) may also allow the treatment plant to operate at a higher overall efficiency. Operational costs for plants with SSI may be 10–30% lower than those with surface intakes, depending on plant capacity and operational life (Missimer et al 2013).

Depending on influent water quality, a facility may be able to downsize or eliminate pretreatment processes; in some cases this may offset some or all of the additional costs of the SSI (Missimer et al. 2013). Key water quality parameters that will affect treatment costs are dissolved organic carbon and particulates. Cost differences in downstream treatment and other processes for facilities with SSI vs. surface intakes should be reflected in the life-cycle cost analysis.

Anecdotal evidence from projects reviewed by the State Water Board previously confirm that SSIs can be the less expensive alternative at smaller scales, especially when the costs associated with other parts of the facility are considered. The analysis of the 5 MGD Doheny project proposed by the South Orange County Water Authority concluded that "*For the size of the Doheny Desal Project*, slant wells are less expensive than open intakes which also require pretreatment systems to remove sediments and organic materials. Slant wells provide highly filtered water via the natural filtration process provided by the marine aquifer, thus avoiding the cost of having to construct and operate conventional pretreatment strainers, filtration and solids handling/disposal facilities. It has been determined from the results of the extended pumping test that the use of a slant well intake system will avoid the need for conventional pretreatment costs estimated at \$56 million in capital and about \$1 million in O&M costs, thus reducing the costs compared to other sites *by more than* \$300 per AF." (SOCWA 2014; emphasis added).

3.5.3 Energy Use

The energy intensity, or energy required per volume of water treated, of operating an intake is driven by site-specific factors, including the elevation change, distance of the intake to the plant, and piping diameter, configuration, and material. These factors, listed in order of their typical contribution to energy requirements, make up a parameter referred to as the total dynamic head, which is reported in units of length (i.e., feet or meters). Rao et al. (2018) estimated that a typical energy intensity for intakes was approximately 4 kilowatts per million gallon (kWh/MG) per foot of head if using state-of-the-art high efficiency pumps. This is a rule-of-thumb estimate that applies to all intakes. It can be used to ballpark energy use but should not be the basis for a formal energy analysis for SSI alternatives.

SSIs will require more energy to operate if water is being pumped from a greater depth, increasing the total dynamic head. Intakes that draw water from farther offshore will have higher energy intensities than beach wells as will intakes serving treatment facilities that are located farther inland. Intakes that utilize a higher number of smaller diameter pipes (e.g., Ranney wells or galleries) will typically have higher energy intensities than alternatives that use a single, larger pipe. The magnitude of these differences will be dependent on the design.

Compared to conventional local surface water and groundwater supplies, which require an average of 1,300 kWh/MG of electricity in the United States (estimated using method similar to Pabi et al. 2013), seawater desalination is a relatively energy intensive process. Three large seawater desalination treatment plants (greater than 3 MGD) with surface intakes operating the in the United States have reported energy consumptions between 11,0000–14,000 kWh/MG (Quon et al. 2022). Most of this energy is used in the reverse osmosis treatment process. For these three plants, the energy consumption associated with their surface intakes was estimated to be about 5% of the total facility energy use. Though there could be higher energy needs for SSI, and there will be differences between SSI alternatives, for most facilities these differences in energy requirements are not likely to significantly affect the overall facility energy use directly.

4. SUBSURFACE FEASIBILITY ASSESSMENT METHODOLOGY/TOOL

4.1 <u>Background/Context</u>

As summarized in Appendix A and noted in Section 1.2, prior to initiation of the SSI FA, a project proponent for either new or expanded desalination facilities will have completed several studies needed to prepare a conceptual design of the project before submitting a request for a Water Code section 13142.5 determination to the appropriate regional board. Based on the Panel's review of the process outlined in the Ocean Plan 2019 (Chapter III, M) and recent documents regarding streamlining the permitting process (California Seawater Desalination Interagency Group 2023), the Panel envisions that the overall process leading to a final permit decision on a new or expanded seawater desalination facility would require the applicant to complete at least the nine major tasks listed below to provide sufficient information needed by the regional board and other regulatory entities to agree on whether the proposed project should be permitted. While guidance on how to conduct the feasibility assessment of the SSI-site combination is the major focus of the next two sections in this Report, the FA cannot be isolated from many other factors that will determine overall success of the determination request. The Panel therefore proposes the following sequence of tasks that will precede the initiation of the FA. Tasks 1 through 4 would be completed by the project proponent before requesting a water board determination and before the proponent initiates the SSI FA tasks.

Once the proponent has submitted a request for the water board determination (Task 5), the SSI FA would be undertaken in Tasks 6 and 7, before the overall desalination project moves to the final determination decision in Tasks 8 and 9. These final tasks would address all other components of the proposed seawater desalination project such as including all issues surrounding brine discharge.

Major Tasks of Desalination Permitting Preceding Initiation of the Feasibility Assessment

- 1. Per Ocean Plan, determine that the identified need for desalinated water is consistent with applicable urban water management plans or equivalent. This task will determine the hydraulic design capacity for the facility.
- 2. Prepare a preliminary project description identifying all factors to be considered for overall permit process consistent with the Ocean Plan. This document would include identification of a reasonable range of sites and SSI combinations that would likely support subsurface intakes.
- 3. Conduct meetings with all relevant agencies to determine information needs to complete the permit process.
- 4. Conduct meetings with relevant stakeholders to determine any additional information needs and update project description.
- 5. Submit revised project description as part of the request to the applicable water board for a Water Code section 13142.5 (b) determination.
- 6. Prepare work plan (scope of work) for Regional Board review and approval to proceed to SSI FA.

- 7. Conduct the SSI FA for one or more sites and submit report to Regional Board .
- 8. Finalize permit application, assuming SSI is determined to be feasible by Regional Board.
- 9. Submit final permit application to all agencies and stakeholders concurrently.

4.2 <u>Overview of Methodology</u>

The key activities associated with Tasks 6 and 7 form the basis for what the Panel is naming the proposed "methodology" for the SSI FA. Figure 4-1 provides a process and decision tree diagram summarizing the stages comprising Tasks 6 and 7, with key interim guidance points noted. The following text provides a brief description of each stage in Figure 4-1. More details are provided in the subsequent sections with links between these sections and Figure 4-1 listed. The SSI FA outlined in Figure 4-1 and described below is iterative in nature and similar analyses are expected to be performed at different stages of the SSI FA, with refined information taken into consideration as more data are collected.

4.2.1 Stage 1: Preplanning Before Initiation of the SSI Feasibility Assessment

A planning meeting with the appropriate Regional Board to agree on the scope of the SSI FA would initiate the SSI FA process. As noted, this meeting will be preceded by numerous meetings with regulatory agencies and other stakeholders to reach agreement on key project attributes.

For the planning meeting to be fruitful, the project applicant should be able to present a conceptual level project design. Prior to the initiation of meetings, the project applicant should have completed an initial review of likely feasible sites for the location of the desalination facility, including the location of any offshore SSI. The project applicant's team should include an expert in SSI technologies who is familiar with the various SSI options and their geologic, hydrogeologic, and site requirements and potential environmental impacts. A screening-level review of available relevant site characterization data and literature information should be completed to identify a suite of potentially feasible site and SSI type combinations that will be targeted for initial investigation.

The planning meeting would confirm the site or sites and the SSI technologies to be considered, as well as the target design capacity (i.e., permeate capacity from a reverse osmosis unit). It is assumed that all stakeholders support the need for a desalination facility of the desired capacity. The planning meeting would also identify regulatory issues that could constrain SSI implementation and would have to be addressed in the permitting process.

More details describing these sources of readily available data and other questions for completion of Stage 1 are provided in Section 4.3. At the "Start Feasibility Assessment" point on Figure 4-1, the outstanding issue being investigated in applying the proposed methodology is simply the feasibility of the subsurface seawater intake for the proposed site and hydraulic capacity taking into consideration the economic, environmental, social, and technological factors including the additional factors specified in the Ocean Plan 2019.

4.2.2 Stage 2: Approval of Scope of Work for the FA by Regional Board

The project proponent would prepare and submit a work plan (scope of work) for conducting the SSI FA. The level of detail presented in the proposed work plan would be determined in Stage 1 meetings with the Regional Board. As discussed previously, the SOW could include an evaluation of multiple potentially viable site-SSI combinations generated during the studies conducted by the proponent prior to submitting the determination request to the regional board. Some suggestions for the content of a work plan are presented in Section 4.3. Regional Board review and suggested modifications to the SOW would follow, leading to approval of the work plan.

4.2.3 Stage 3: Desktop Evaluation of SSI-Site Combination(s) and Go/No-Go Technical Analysis

As part of Stage 3, the applicant would conduct a desktop feasibility screening, including technical analysis based on readily available data for the conceptual design for the site-SSI combinations agreed to in Stage 2. The applicant should also conduct a hazard assessment for selected site(s) and screened SSI technology combinations based on available data and design constraints determined by prevailing practice on accounting for impacts of natural hazards such as earthquakes and sea level rise. Additional details on the data and information to be considered and the methodology for the desktop evaluations are provided in Section 4.5. The Panel recommends that Stage 3 provide for screening of the multiple site-SSI combinations to reduce the number of alternatives that would be considered in subsequent stages of the proposed methodology.

A go/no-go analysis for the site-SSI combinations being considered will be performed as part of Stage 3. If, following Regional Board review, a no-go decision is the outcome of this analysis for a particular site-SSI combination, an alternative site-SSI combination may be considered and a return to Stage 2 would be required for that alternative The Panel considers that Stages 1 through 3 could be conducted by the applicant fairly quickly, and thus multiple SSI-site combinations could be screened to arrive at the most optimum combination for further evaluation that would be consistent with the goal of the Ocean Plan to minimize harm to all forms of marine life. An interim report prepared by the proponent for Regional Board review and guidance would then lead to Stage 4 in the FA process for the site-SSI combinations that have passed this screening stage.

4.2.4 Stage 4: Intermediate Feasibility Assessment

Following the desktop evaluation and discussions with the Regional Board, the project proponent would recommend whether additional field investigations are needed to support an intermediate feasibility determination based on the results of Stage 3 for the remaining site-SSI combinations. Key issues in making this decision are presented in Section 4.6. If the parties agree that additional field studies are needed, the proponent would prepare a scope of work for data collection and would request Regional Board approval. Following completion of the field investigations and data analysis, the intermediate feasibility determination would be completed. The outcome of this decision could be additional data collection, the need for pilot studies, or proceeding to the final feasibility decision stage, a decision that would require the approval of the Regional Board may require evaluation of other SSI-site combinations, which would require returning to Stage 2. Additional details on the field investigations and methodology for performance of the intermediate SSI FA are provided in Section 4.7.

The project applicant may also determine at this point that no site-SSI combination is feasible, based on the evidence compiled. As noted in Figure 4.1, this decision could lead the proponent to consider returning to Stage 2 and proposing new site-SSI combinations for Stage 3 screening. The Panel suggests that this outcome would be unlikely if prior studies and dialogue with the Regional Board have exhausted all possible alternatives. However, the Panel recognizes that this is a possible outcome following Stage 3 and this is noted with a dashed line leading to a return to Stage 2. Alternatively, the proponent could prepare a report recommending a surface intake for Regional Board review and final determination on feasibility of the intake component before proceeding with Tasks 8 and 9 as noted above for a final Water Code determination for a new or expanded desalination facility.

4.2.5 Stage 5: Pilot Testing at Appropriate Scale

If the intermediate feasibility determination is affirmative, the applicant will determine whether pilot scale tests are required and, if so, will prepare a scope of work for pilot scale tests for review and approval by the Regional Board. Completion of pilot testing would provide additional data for analysis of the technical and economic feasibility of the project. If no pilot tests are needed, the process would proceed to the final FA (Section 4.2.6). The Panel recognizes that this decision will depend on numerous factors and because of the cost and duration of such pilot tests, the proponent will have to provide convincing evidence that such tests are not necessary for a final feasibility determination. Additional details on the analysis for making the recommendation on whether pilot scale testing is needed, development of the pilot test work plan and implementation strategies for the pilot test for all SSI technologies are provided in Section 4.7.

4.2.6 Stage 6: Final Feasibility Assessment

The final SSI FA for the chosen combination of hydraulic capacity, site and SSI technology would address the four feasibility factors (technical, economic, environmental, and social) identified in the Ocean Plan (See Section 3). In addition to the life-cycle cost analysis, the economic analysis should include an assessment of the ability to finance (and/or the increased costs associated with financing) the project. As noted in Figure 4-1, following Stage 6, if the proposed SSI type-site combination is considered infeasible, with Regional Board approval, the permit applicant could proceed with the permitting process for a surface intake. It is assumed that the proposed SSI -site combination has emerged as the only potentially viable option for implementation of a seawater desalination facility, thus reducing the probability of returning to Stage 2.

The Panel is of the opinion that projects involving multiple intake options that combine SSI and surface intakes, as proposed in the Ocean Plan 2019 (Chapter III, M.2 (d),(1a),ii) would not be feasible from a technical and economic perspective. Furthermore, having to consider multiple intake options at this stage of the FA would result in long delays in the permit process. Such options could be considered in Stage 2 and be evaluated during the screening process in Stage 3.



Figure 4-1: Proposed Decision Tree for Conducting an SSI Feasibility Assessment (key guidance points for Regional Board feasibility determination noted: see text for explanation of Figure)

Suggested content and recommended data needs for each of the six stages are detailed below, with the decision process associated with this methodology illustrated in the proposed process flow and decision tree diagram, Figure 4-1. The Panel proposed process flow for the FA decision provides a framework for advising project proponents of the type and quality of data needed to make recommendations to the regional board on the path forward during the FA process The Panel believes that this sequence of tasks is consistent with the requirements outlined in Ocean Plan, Chapter III, M. to provide the regional board with sufficient information to conduct the necessary analyses prepared by the project proponent to reach an agreement on the feasibility determination for the selected site-SSI combination. The following subsections address the details of the data needs to be provided by the proponent.

4.3 <u>General Methodology Considerations</u>

In the first stage of the FA process, an applicant should start the process by assembling a project team that has expertise in the design and construction of SSI, local subsurface and marine geology, environmental impact assessments in coastal areas, and the California permitting established by all agencies who would be involved with such a project (see for example the Memorandum of Agreement (MOA) regarding interagency coordinated review of environmental documents and permit applications for seawater desalination facilities, July, 2020). The applicant team is expected to develop initial concepts for preferred SSI types and potential sites based on the proposed desalination plant location and local onshore and offshore conditions. The coastal geology of California (e.g., geological units and aquifers locally present) is sufficiently well known to guide initial evaluation of SSI options.

As noted, the applicant should identify all the permits and approvals that could be required, and local agency contacts. It is critical to obtain input from regulatory agencies on their data requirements and preferences before the start and throughout the data collection efforts and application submittals. Hence, frequent discussions with regulatory agencies are a key element of the methodology and a detailed schedule for these meetings should be a key component of the work plan prepared by the applicant and approved by the Regional Board. The field testing and surveying program developed must address three main data categories: 1) evaluation of the physical feasibility of SSI options (i.e., ability to be constructed and reliably provide the required amount and quality of water), 2) design of the SSI, and 3) assessment of environmental impacts associated with the construction and operation of the SSI.

The proposed decision tree for conducting a feasibility assessment (Figure 4-1) is a sequential effort in which each stage reveals data needs to be addressed in the subsequent stages and is progressively more focused and requires greater effort and associated costs. If at any point in the investigation an SSI option is found to not be feasible (i.e., a no-go recommendation is made), then an alternative SSI type or site may be considered. The general sequence is to start with a desktop ("data mining") study to obtain available existing data relevant to the proposed project. The desktop study may be followed by field testing and surveys, which, for example, might involve test wells and borings, geophysical surveys, and biological or cultural resource surveys. A subsequent project phase could be the construction and operational testing of a pilot SSI system.

The sufficiency of data collection is highly project specific and involves two basic considerations. First, the applicant team must obtain sufficient data to provide confidence that the SSI is feasible as a reliable water supply option and as needed for the system design. Second, sufficient data needs to be collected to support the feasibility conclusions of the project applicant team, which is required to obtain permits and regulatory approvals. The first consideration is a matter of design team professional judgement; the latter is determined through communications with regulatory agencies. The criterion for determining whether additional data collection is necessary is whether the needs of the design team and project reviewers are met.

Reliability ties into the concept of risk, which can be considered the probability that an SSI will not perform as intended or cause unacceptable adverse environmental impacts. The risks associated with SSIs are very hard to quantify because of uncertainties inherent in natural systems and for many SSIs a limited long-term operational record. Operational data do not exist, for example, to estimate the probability that a slant well would lose a specified percent capacity over a given time frame. Risks also depend on mitigation options available. Risks can be reduced with additional data collection (e.g., pilot testing) and by the identification of system-specific mitigation options. For example, the risks associated with a loss of capacity in vertical wells can be reduced by proactively developing well rehabilitation plans and by either installing or having plans for the installation of back-up wells.

Individuals and institutions vary in their risk tolerance, which makes it difficult to quantify what is an acceptable risk. For SSIs, any plausible risk of the failure of the SSI that could force a prolonged desalination plant shutdown will likely be unacceptable.

The scope of work for SSI investigations will include both general and project specific elements. General issues include coastal hydrogeology (e.g., presence and characteristics of local aquifers), shoreline stability (e.g., whether the beach is locally retreating or prograding), the physical and legal availability of land for construction of an SSI system, and identification of any environmental issues that could constrain system construction and operation. Each SSI type also has some specific data requirements. Clearly, the data requirements for evaluating a vertical well option will be greatly different from those for a beach or offshore gallery. Hence, field testing options are discussed below with respect to SSI types.

The most fundamental common characteristic for SSI feasibility is that the required flow rate of seawater can be physically obtained reliably for the duration of a desalination project. The field and pilot testing necessary to make this determination will vary between projects. Typically, the feasibility of SSI requires the presence of relative high permeability strata hydraulically connected to the sea be present.

Numerical modeling can be an integral element of the SSI FA and system design, but the purpose and types of modeling varies between system types. For systems utilizing wells, hydraulic and solute-transport groundwater modeling is utilized to evaluate pumping impacts (drawdowns), the source of water (landward contribution of fresher groundwater), and well interference and thus optimal well spacing. For gallery type systems, hydraulic modeling is used to evaluate potential infiltration rates and gallery size (area). Widely used public-domain modeling codes appropriate for SSI investigations include MODFLOW and MODFLOW-USG (groundwater flow; Harbaugh 2005; Panday et al. 2013), MT3DMS (solute-transport; Zheng and Wang 1999), and SEAWAT (density-dependent groundwater flow; Langevin et al. 2008).

4.4 <u>Planning Meeting with Appropriate Regional Board and Preparation of</u> <u>Scope of Work (Stages 1 and 2)</u>

This stage in the overall process flow would entail meetings with the Regional Board and other relevant agencies from the interagency group to initiate preparation of the scope of work. By this point in the permitting process, as noted in Section 1.2, many of the key issues such as desired hydraulic design capacities (both the needed withdrawal rate and the production rate or capacity), designated site or sites and potential appropriate SSI technologies to formulate a number of alternative combinations for consideration should have been agreed to by relevant agencies including the Regional Board. The outcome of the meeting would include identification of any Regional Board concerns on the conceptual design of the project that would need to be highlighted in the scope of work including the need to show that sufficient site characterization data were available to allow use of a desktop evaluation. The scope of work should also include what type of desktop evaluation would be proposed as part of the SSI FA and should include a list of relevant site characterization data and literature information on the selected SSI technology that have been compiled and will be used as a basis for the desktop evaluation (see Section 4.5 for potential data sources).

The objective of the planning meeting(s) is to reach agreements and directions to guide the applicant in the evaluation of SSI technology types and locations. It is critical for an applicant to avoid using assessment methods that are not considered acceptable (adequate) by the Regional Board and any other agency having jurisdiction over a project and not providing information or testing required for the agencies to perform their project reviews.

4.5 <u>Desktop Evaluation (Stage 3)</u>

Once the scope of work has been approved, the applicant would proceed to perform the desktop evaluation to assess the feasibility of the proposed site-SSI combination. More than one combination could be evaluated as well as multiple hydraulic capacities, although the range of options will likely be constrained based on conceptual decisions made earlier prior to initiating the permitting process. This matrix would identify the optimum combination for the next phase of the SSI FA, and assuming a "go" recommendation, as noted in Figure 4-1, various pathways would follow.

A desktop study is a purposeful gathering of data that allows an evaluation of the feasibility of some engineering design that can be applied to a variety of large complex projects. The term "desktop" is used because this type of study does not involve any extensive use of fieldwork, particularly aquifer testing and analysis. It may include some fundamental fieldwork, such as a site visit, well inventories, and general observations of conditions that could preclude the use of SSI types. Presumably, literature reviews would identify worldwide experiences with use of the selected SSI technology in similar geologic and ocean surface conditions that would be relevant to the desktop evaluation.

A large amount of relevant data is available, often on-line, on coastal geology and physical and environmental conditions, including:

- Recent aerial photographs (Google Earth)
- Historical aerial photographs (University of California Santa Barbara Library)⁹
- Recent and historical topographic maps (United States Geological Survey)¹⁰
- California coastal topography (LIDAR) and landcover (National Oceanic and Atmospheric Administration [NOAA])¹¹
- California geological map and geological hazard maps (California Geological Survey)¹²
- California bathymetric maps (United States Geological Survey, California State Waters Map Series Data Catalog)¹³
- Seafloor maps (California State University, Monterey Bay)¹⁴
- California beach cliff erosion rates (University of California at San Diego)¹⁵
- California well completion reports (California Department of Water Resources)¹⁶
- Current and historic well water level and quality data (United States Geological Survey)¹⁷

Numerous technical reports prepared by government agencies (e.g., United States Geological Survey, Department of Water Resources) and technical papers can be obtained via internet searches. For example, the results of a modeling study of shoreline responses to climate change in Southern California (Vitousek et al. 2017) was obtained via a basic internet search.

Each of the above data types address specific SSI information needs. The local stability of the coast and beach can be evaluated through a review of time series of recent and historical aerial photographs and topographic maps. The historical data may, for example, indicate areas undergoing rapid erosion which are unsuitable for coastal construction. Topographic and land cover maps may assist in determining the optimal SSI sites in a given area and locations that should be avoided.

Information on local geology and hydrogeology can be obtained from geologic maps and various governmental reports. Well completion report may include geological logs that can be used to evaluate potential local geology and hydrogeology and in the preparation of geological cross-sections. Well completion reports may also contain information on well yields and water quality.

⁹ Available at <u>California Aerial Photography: by County | UCSB Library</u>

¹⁰ Available at <u>Topographic Maps | U.S. Geological Survey</u>

¹¹ Available at <u>NOAA: Data Access Viewer</u>

¹² Available at Department of Conservation Map Server and Geologic Map of California

¹³ Available at <u>USGS Data Series 781: California State Waters Map Series Data Catalog</u>

¹⁴ Available at <u>USGS Data Series 781: California State Waters Map Series Data Catalog</u>

¹⁵ Available at <u>California Cliff Erosion Viewer - Coastal Processes Group</u>

¹⁶ Available at <u>Well Completion Reports from California Department of Water Resources</u>

¹⁷ Available at <u>USGS Groundwater Data for California</u>

Sea floor and bathymetric data are needed for feasibility assessment of offshore SSI types. For seabed galleries, information is needed on the nearshore water depth and subsea topography and on the seabed sedimentology—types of sediments present and whether the seabed is locally undergoing erosion or net deposition.

Existing data have variable "shelf lives." Data on subsurface geology do not change over time. Data on dynamic processes, such as aquifer water levels, shoreline position, biological activity, and near coastal bathymetry, are subject to change, which applicants should take into account when relying on the data. Projections of climate change impacts also have a limited shelf life as they are superseded by more up-to-date models.

There are no standard shelf lives for any data type. The technical professionals involved in SSI projects are expected to evaluate data quality (including shelf lives) and be able to defend the use of any existing data in feasibility assessments and subsequent project design. If needed data are judged to not be reliable because of age or other factors, then recommendations should be made for project specific data collection.

4.5.1 Conceptual Feasibility Assessment

As noted above, there are many components of the desalination project that will already have been vetted by the Regional Board and potentially other agencies (California Seawater Desalination Interagency Group 2023). Some of the other components include the documented approval of a buyer for the desalinated water (e.g., a letter of interest), identification of the project owner and developer with documentation of experience and financial security, a pre-determined location for the desalination facility (i.e., above ground features of the facility and connections to the SSI), a description of the environmental issues related to the site being evaluated, a listing of the required environmental permits required, and a pre-determined range of costs (e.g., unit costs for delivered water) that will be acceptable to community stakeholders.

4.5.2 Technical Aspects of a Subsurface Intake Desktop Evaluation

4.5.2.1 Criteria for Assessment of Go/No Go Recommendations

During a desktop evaluation, sufficient information may be available for a go/no-go recommendation by the applicant on whether to proceed with further investigation of some SSI-site combinations. Go-No Go decisions as part of the desktop and later evaluation stages for given SSI-site options are to be based on the professional judgement of the project applicant's team (subject to Regional Board review) of whether an option can be physically constructed and reliably operated and/or its costs, environmental impacts, and reliability relative to other SSI-site options. Each step of the feasibility investigation methodology is intended to narrow the range of feasible SSI-site combinations and eventually come to a project-specific preferred option (final selection).

A no-go decision for an SSI-site combination would lead to the consideration of alternative SSIsite combinations. Only after all plausible SSI-site combinations have been determined by the Regional Board to not be feasible would the permitting process for a surface intake commence. The Panel assumes that an initial screening of SSI-site combinations will have been completed well before the process in Figure 4-1 begins. It is expected that a project applicant team will include staff with expertise in SSIs and will have identified potential sites and have considered potential viable SSI types before starting the process (discussions with regulatory agencies). For example, a conceptual level initial screening by the applicant for a small capacity desalination plant may indicate that vertical wells in a given location would likely be the preferred SSI option and the desktop investigation would target obtaining information relevant to well construction. However, the decision diagram is intentionally designed to explore other combinations that may arise during the feasibility assessment component of the permitting process for the facility.

Any SSI-site combination that cannot meet all of the critical criteria listed in Table 3-1 may be found to not be feasible after applying the four feasibility categories (i.e., technological, environmental and social, and economic factors). The Panel expects that much of these analyses will be completed by the project proponent and will again precede the beginning of the use of this FA methodology.

Reliability—The applicant will need to demonstrate that an SSI can provide the necessary raw water quantity (i.e., hydraulic capacity) to operate the plant at full design capacity under all situational operating conditions. The selected SSI type should provide improved quality of the raw water provided to the SWRO unit in the desalination facility compared to open ocean intakes, based on studies referenced in this report. However, the applicant may need to confirm this fact as needed to support comparative cost-benefit analysis of the various SSI-site combinations.

Constructability—This technological factor is critical for SSI technologies because construction in the marine environment can be difficult and time-consuming. Any chosen SSI option must have a viable path for design and successful construction. If a specialized technology is required to build the desired intake type, this technology with the associated equipment must be available for use at the desired location within a reasonable time frame. Again, the duration of construction is another critical factor that can cause an early no-go decision within the framework of the desktop evaluation.

Acceptable cost and ability to finance—The issue of cost is complex, and costs may be uncertain at an early evaluation stage prior to initiating the SSI FA process. As noted in Section 1, approval of a desalination project will require many review stages and presumably an approximate feasibility level cost estimate (e.g. +/- 100%) will be completed by the applicant. Regional Board review of this estimate is recommended. For the desktop study, the applicant should have a sense of the cost differential for potential intake options (relative to a baseline or surface intake option) and the resulting water cost per household, as well as the potential for obtaining financing for the SSI under consideration. Communities may have a cost threshold that cannot be exceeded based on ability or willingness to pay for treated water by the users in the absence of government subsidies. In past work, SSI costs up to 30% above conventional intake capital costs have been found to be acceptable to most water users (e.g., utilities and their customers) (Missimer et al. 2012). The precise threshold will depend on a community's financial resources and ability and/or willingness to pay for desalinated water. It will also depend on additional factors such as the urgency of meeting an immediate need for potable water and/or the need for other investments (e.g., environmental mitigation costs).). In addition, any selected SSI type must be able to be permitted within the framework of California and federal rules and regulations in a "reasonable time frame" as discussed previously, and which is also stated in the definition of "feasible" in the Ocean Plan 2019. These permits generally address the environmental and social impacts that are anticipated for any desalination project. Any permitting process that involves an unrealistic timeframe (more than one decade) also likely makes the project infeasible. However, under emergency conditions declared by the Governor, a more accelerated permitting process could be approved by the Executive Chair according to the desalination amendment to the Ocean Plan 2019 (Chapter III.M.1.a).

4.5.2.2 Technical Scope of the Desktop Study

A complete list of known and evaluated SSI types is covered in Section 2 of this report. A series of tables shows the evaluation criteria based on many components of the process for each of the options (Appendix E). In a desktop study, the go/no-go decision for each of the SSI types and site options would be made. The evaluation of each intake type is commonly a straight-forward process. For example, no SSI type can be designed and constructed in rocky shoreline and offshore location, an issue that would be resolved in Stage 2 or 3. Greater complexity occurs when using conventional wells as intakes, beach galleries, angle wells, horizontal wells, and offshore galleries.

Once one of the viable options is selected for further analysis, the desktop study should focus on feasibility criteria for the SSI type based on the use of an evaluation matrix. An example of this type of matrix is given below. This table also includes an importance factor listed in brackets after the evaluation type. Commonly, each criterion is evaluated using a value of 10 for the highest and 1 for the lowest and the importance factor is multiplied times the selected number to weight the relative importance of each criterion based on local and state preferences. The Panel is agnostic regarding the most optimum weighting system that should be used by the applicant, but the State Board may have a preferred method.

The project-specific criteria and scoring is usually performed by the applicant's expert team and done in a transparent manner to allow for review by regulatory agencies. For large projects, it can be quite useful to have a panel of 5 to 10 external experts to perform the analysis independently with the ultimate choice coming from the highest net score from the panel.

Intake Type	Reliability (5)	Permittability (2)	Constructability (2)	Incremental Cost (1)
Beach wells				
Ranney wells				
Beach gallery				
Angle wells				
Horizontal wells				
Water tunnel				
Offshore gallery				

This table is an example only. Other feasibility factors could be added and used for the Go/No Go recommendation at multiple sites and a range of hydraulic capacities if appropriate as part of an early screening study prior to initiation of this assessment. Typically, the selection of the SSI type-site-hydraulic capacity combination will be made early in the conceptual design of the project and the need for such scoring exercises to reduce the number of possible options will be minimized.

4.5.2.3 Completion Time and Cost of Desktop Studies to Evaluate Subsurface Intake Feasibility for Desalination Plants

The timeframe required to complete a desktop study to determine the possible feasibility of using an SSI system is partially dependent on the proposed capacity of the desalination plant and the type of geology of the shoreline and offshore area for the selected site. However, a typical desktop study should be completed in 3 to 6 months depending in part on the number of SSI-site combinations evaluated. The general cost range should be \$100,000 to \$200,000 (2023 dollars). These estimates are based on the professional judgment of Panel members.

4.5.3 Hazard Assessment

To fully assess risk and feasibility of an intake, the potential impact of natural hazards on constructability and reliability of a site-specific intake needs consideration. Natural hazards include shoreline erosion/accretion, tsunamis, earthquakes, and harmful algal blooms. Additional hazards are contaminant spills and ocean pollution in general. The hazard assessment is performed as part of the desktop evaluation (Figure 4-1) and may later be refined if relevant additional data are obtained during the field studies.

4.5.3.1 Beach, Shoreline, and Nearshore Erosion/Accretion Events

Since many SSI are constructed on the beach or immediately offshore of it, they are susceptible to beach erosion and changes in nearshore morphology in general. Conventional beach wells, Ranney wells, beach galleries, and horizontal wells would be most vulnerable. This risk is changing with climate change and the impacts of sea-level rise, likely or predicted increase in storm surges, and likely or predicted increase in maximum wave heights including erosion and flooding of shorelines.

The risk of flooding is being addressed through emerging policy to set back new developments from the shoreline. The risk of shoreline erosion is a factor in the design and longevity of any SSI infrastructure on the beach and is highly site-specific. Where rapid beach erosion is occurring, beach galleries could be eliminated as an option based on the necessity to maintain a stable shoreline. Ranney wells and beach wells, which need to be close to the water, could be isolated from their pipe/pumping infrastructure.

Alternatively, if wells are located further away from the ocean water, the risk of impacting freshwater aquifers and/or coastal wetland habitats increases. Angle wells are least likely to be affected as the pumping station can be located far enough back from beach dynamics (and could be relocated in the event of unexpected changes). In contrast, horizontal wells, beach galleries and seabed galleries are all designed to be close to the sediment-water interface in shallow water and thus susceptible to erosion or accretion, which can occur in seasonal cycles, interannual cycles (e.g., El Nino events), or in association with rising sea levels. Erosion threatens the infrastructure close to the sediment-water interface and accretion of sand above the well screens would alter the yield of the well.

Erosion/accretion may occur naturally, in response to coastal development, in association with a rise in the mean sea level (i.e., "sea-level rise"), or in association with a change in the wave/wind climate dynamics.

Significant site-specific erosion/accretion during the lifetime of the intakes system would necessitate redesign of pumping systems or the galleries, resulting in higher costs for this option. Historical beach erosion rates may be evaluated using a time series of historical aerial photographs and there are some published reports on historical and modelled future beach and coastal erosion (e.g., Vitousek et al. 2017). Site-specific modeling of sediment transport may be required if the SSI site area is identified as having a high risk of morphological change (e.g., if erosion is severe enough to impact an SSI).

Analysis of beach erosion/accretion could inform design and risk assessment of intakes and support infrastructure such as pumps, conveyance piping, and electrical connections. An SSI would be deemed to be infeasible based on this technical factor if any part of the infrastructure could or would be irreparably damaged or destroyed based on the life-expectancy of the of the facility, which is typically 30 years. Critical infrastructure projects may be subjected to hazards evaluation over a longer period -75 to 100 years – in most instances.

4.5.3.2 Sea Level Rise

Sea level rise can result in the inundation of coastal infrastructure and can accelerate coastal erosion. The recent rejection of a permit for the Huntington Beach desalination project included concerns related to sea-level rise (California Coastal Commission 2022). A recent report from the State of California (California Ocean Protection Council 2018) provides sea-level rise predictions for 12 tide gages along the coast of California, with 30-year rises of 1 to 2 feet. More recently an update on scenarios and observation-based assessments from NOAA (2022) provides similar 30-year estimates of sea-level rise for the coast of California.

However, there is significant concern that concurrent changes in winds, waves, and storm surges may greatly increase flooding and shoreline erosion. The State of California recently published a draft update (California Ocean Protection Council 2024), which can be used by project applicants. This projects a statewide average increase in sea level rise of 0.8 feet in the next 30 years and anticipates a rise between 1.6 and 3.1 feet by 2100. In addition to the applicant factoring risk and uncertainty in design and costs, local and State planning agencies are developing policies for resilience that may result in permits that require setbacks from the shoreline and low-lying lands near the shoreline. Such setback requirements would affect project design and costs. An applicant would also have to address requirements from the California Coastal Commission regarding local coastal programs affecting land use.

4.5.3.3 Tsunamis

The California coast is subject to tsunamis, which could damage or destroy any type of SSI. Nevertheless, historical tsunamis have been small or moderate along most of the California coastline and the hazard could be effectively mitigated by reinforcing any infrastructure on the beach (e.g., well vaults) or concrete buildings in the back-beach areas. These are also areas susceptible to wave action during storm surges and increased wave action with sea-level rise. Therefore, tsunamis are not considered a major additional factor in assessing the technical feasibility of SSI.

4.5.3.4 Earthquakes

The impact of earthquakes will be on structures, the design of which is well guided by existing earthquake codes. Thus, the impact of earthquakes on beach infrastructure should be minimal if the design is appropriate. However, earthquakes can lead to landslides, liquefaction, lateral spreads, and localized uplift. Geological, topographic, and hazard maps should be viewed during the desktop investigation. Beach wells, Ranney wells, and beach galleries should not be constructed in areas where there is a sandy beach adjacent to a cliff or steep slope. Similarly, the infrastructure for slant wells and horizontal wells, and pumping stations for offshore galleries should not be located in landslide hazard areas that are potentially subject to these geologic processes. Subsea SSIs should not be located in areas prone to offshore landslides.

Where known faults transect the beach, care should be taken in design of all SSI types to avoid areas where there is anticipated vertical movements of land surface and/or severe lateral displacement. This issue should again be addressed during the design of a specific intake type and in high hazard areas should be addressed during the desktop study.

4.5.3.5 Water Quality Hazards

Coastal water quality can deteriorate suddenly either during the bloom of toxic algae, or due to accidental spill of toxic material (including oil spills). In addition to the need to shut down an intake to preclude or minimize entrainment of toxins, dense algal blooms are comprised of small particles that can clog the surface layers of sand, reducing flow rates. Similarly, turbid plumes (e.g., muddy river outflow) can result in sediment clogging above shallow gallery intakes. Most SSI are commonly immune from algal bloom impacts. In the case of the Sur well intake in Oman, the facility continued to operate during a number of algal blooms that were considered to be moderate to minor (Missimer 2024). The presence of potential water quality hazards should be investigated through a review of local land uses and geography/sedimentology (from aerial photographs and a site reconnaissance. Information on present and past harmful algal blooms is available Harmful Algal Blooms on the California (HABs) Portal (https://mywaterquality.ca.gov/habs/).

4.6 Field Studies and Intermediate Feasibility Assessment (Stage 4)

4.6.1 Field Studies—Overview

The desktop study would provide the basis for determining the need and type of additional data required for a more refined SSI FA and intake system design for the selected SSI-site-capacity combination. As shown in Figure 4-1, assuming the combination is deemed likely feasible after the desktop evaluation and the need for field studies confirmed, the subsequent field studies phase would involve the collection of additional site-specific data on local geology, hydrogeology, aquifer hydraulic parameters, water quality, and land uses. Field data may be needed to address a number of uncertainties in assumptions made in the conceptual design, including:

- Confirmation of system unit capacity (e.g., yield per well or unit area of a gallery) assumed in the desktop evaluation and so modifications of design can be made as appropriate.
- Development of hydraulic and/or solute-transport numerical models to assess any impact on regional and local freshwater aquifers and coastal wetlands. The need for modeling will depend on professional judgement and Regional Board concurrence regarding likely impacts and level of accuracy needed to apply groundwater models. Modeling would likely be required if a system could potentially impact a Sustainable Groundwater Management Act-medium priority basin or an adjudicated basin.
- Confirmation of conceptual system design (e.g., depth of wells or well screens; location and sizing or galleries).
- Evaluation of water quality in subsurface pore waters that may impact well capacity (e.g., iron and manganese levels).
- Evaluation of coastal dynamics that could impact long-term system operations (e.g., coastal erosion or beach progradation, longshore sediment transport, or generation of sediments that could reduce the life-span of infiltration galleries).
- Performance of a local bathymetric survey if an offshore SSI is under consideration.
- Biological surveys to determine baseline conditions as part of environmental impact assessments of construction activities.

Where modeling is required to assess SSI physical feasibility and impacts, the field testing program should also focus on the data needs for the model. Depending upon the system type, data will be needed on aquifer, and beach and seabed sediment hydraulic properties. These properties would include the following:

- Hydraulic conductivity of the shallow and deeper sediments, which can be estimated using methods such as aquifer pump testing, grain-size analysis, core analyses, and permeameter testing. Subsurface hydro stratigraphy, which can be evaluated based on borehole drilling and geophysical surveys.
- Offshore stratigraphy, which can be estimated based on offshore sub-bottom profiling and geophysical bathymetry surveys.
- Groundwater conditions and flow, which can be estimated based on monitoring well installation and water level measurements.

The project proponent technical teams should include an expert(s) in the various techniques to design a field testing program that efficiently meets the project data needs. It is critical to understand the advantages and limitations of each field method in terms of both the type and quality of information obtained.

The scope of work of field studies programs is highly site-specific, depending upon intake type and location and the amount and quality of data already available. The scope of work for field studies also has financial constraints as projects normally have budgetary limits, which are related to the size (capacity) of projects. It is recognized that resources will never be available to do all the testing that could be relevant to a project. Hence, it is necessary to prioritize field programs, focusing on the most needed data versus data that could be useful but are not critical. Again, this is dependent on site-specific conditions, particularly geology and thus the Panel does not encourage a highly prescriptive approach to assessing data needs. This issue would need to be resolved in consultation with the appropriate regulatory agency.

A deep toolbox of aquifer characterization methods is available, recently reviewed by Maliva (2016) and Brassington (2023), and the applicant's project team should include a professional hydrogeologist who can develop a cost-efficient, project-appropriate testing program in support of any modeling required to assess potential impacts on regional aquifers. Because any negative impacts on regional aquifers may not be acceptable for SSI-site combinations, field studies in support of modeling have a high degree of importance. Where impacts to freshwater aquifers and sensitive environments is a critical concern, a groundwater modeling study would need to be carefully reviewed by external experts independent of the project proponent.

Some elements of these field studies are common to multiple intake types:

- Site inspection—examination of site and vicinity for natural and anthropogenic features that could impact construction and sensitive areas that could be impacted by system construction and operation, including the proximity of coastal wetlands.
- Coastal dynamics—inspection for evidence of coastal erosion or progradation or storm damage that could impact the integrity and operation of an intake. Field inspections should augment review of historical data (e.g., time series of aerial photographs).
- Biological surveys—determine baseline conditions including assessment of whether threatened or endangered species or sensitive environments (e.g., wetlands) are present that could be impacted by intake construction and operation. This assessment would need to conform with requirements identified in the Ocean Plan for specific species of concern.

Following the decision tree in Figure 4-1, the results of the field studies would be used to revisit the assumptions applied in the desktop study leading to an intermediate determination on feasibility of the SSI-site combination or combinations If is jointly determined by the Regional Board and the project proponent that a SSI-site combination is likely feasible without pilot testing, the applicant could proceed directly to the final SSI FA decision point (Stage 6). If uncertainties remain in critical design decisions for the SSI (for example, a new or rarely used SSI technology never applied anywhere in the world at the proposed hydraulic capacity) then the cost and delays required to complete pilot tests could be considered.

Once the decision has been made to proceed with pilot testing, various considerations must be taken into account depending on site-specific and technology specific factors as discussed in Section 4.8. For the purposes of the guidance to be provided to project proponents, the Panel recommends that the construction and testing of a single unit (e.g., well) of a multiple unit intake system or a partial unit of final system design (e.g., small area of beach gallery with the same construction as a full-scale system) would be considered as sufficient scale to complete the feasibility determination. The workplans for the field testing would require an approved scope of work and approval for required permits.

4.6.2 Field Studies Elements for Subsurface Intake Types

The following summarizes some of the investigation techniques appropriate for each of the main SSI types. The Panel recommends that project proponents consider these as reasonable options for data collection.

4.6.2.1 Vertical Wells

The primary focus of field testing for vertical wells is obtaining data on potential well yields and water quality and data on aquifer hydraulic parameters and hydrogeology that are needed for groundwater model development.

The main element of field studies for vertical well intake systems is the construction of one or more test wells to obtain data on local hydrogeology, well yields, and subsurface water quality. The determination of the number of test wells is highly system and site specific and depends on system capacity, well yields and number of wells required. The wells may be either small diameter wells that are to be later used as monitoring wells or larger diameter wells that may be subsequently used as production wells (i.e., pilot systems). If there is high confidence that vertical wells are feasible and the best option, then installing an actual production well may be the best course of actions. Where there is uncertainty, installing a smaller, less expensive well first may be prudent.

Well construction may be proceeded by test borings or cores to obtain hydrogeological data to be used for the SSI FA and for the design of wells (e.g., identification of transmissive intervals to be screened). Borehole geophysical logging can also provide valuable data on subsurface hydrogeology. Natural gamma ray, resistivity/induction, and sonic logs can provide information on lithology (e.g., location of clay layers and porosity). Preferred test boring methods provide high-quality continuous samples with good depth control, such as sonic or wireline cores. Standard penetration test (SPT) borings are widely performed for geotechnical investigations of unconsolidated materials but are less suitable for well design.

Step-drawdown and constant-rate pumping (performance tests) are performed to determine the well specific capacity (pumping rate divided by drawdown), aquifer hydraulic properties (transmissivity, storativity, and leakance) and to obtain water samples for analysis. Constant- rate pumping tests are preferably using one or more observation wells in addition to the pumped well. For a very small project, a single observation well may be sufficient.

For large capacity intake systems that will include numerous production wells (typically several MGD), multiple test borings and/or wells should be installed and tested along the anticipated wellfield alignment to evaluate hydrogeological heterogeneity.
Groundwater modeling should be performed to evaluate potential system yields and the effects of various well spacings. In some instances, an existing groundwater flow model may be used (and updated as needed with newly collected data) if it extends to and beyond the coast. A key consideration is a determination of the source of the pumped water, particularly whether there is a significant landward contribution of fresher water. Groundwater modeling may be performed using the MODFLOW code with a water budget analysis performed to evaluate the landward contribution. If large salinity differences occur near the wellfield, then the density-dependent SEAWAT code is recommended.

A positive result would be a demonstration that the target raw seawater flow could be obtained from an acceptable number of wells (based on available beach frontage and cost per well).

4.6.2.2 Horizontal (Ranney) Collector Well

The primary focus of field testing for horizontal (Ranney) collector wells is obtaining detailed on local hydrogeology to determine whether the collector can be constructed and the depths of transmissive strata into which to install laterals, Data on aquifer hydraulic parameters are also needed for modeling of potential system capacity

The field studies for horizontal (Ranney) collector wells are similar to that for vertical wells with perhaps the need for more detailed vertical resolution of the depths of transmissive strata in which laterals are to be installed. Hence, lithological sampling methods with high vertical resolution, such as sonic coring, are recommended. Geophysical logging might potentially bring value for resolving high and low permeability intervals, but there may not be a clear geophysical signal if a site is underlain by a thick interval of largely homogenous beach sands.

Horizontal collector wells involve a much larger investment than a single vertical well. Therefore, it is imperative to optimize their location and design. Multiple borings should be installed in the general project area to identify the most favorable location (potential highest yields). Once a preferred location is identified, borings (cores) should be taken in the caisson and laterals area and a test well(s) installed for evaluation of the production zone transmissivity.

Horizontal collector wells also draw in water from all directions, although the seaward contribution can be maximized by preferentially installing laterals in the seaward direction. Groundwater modeling should also be considered for evaluating potential system performance and water sources. Modeling procedures have been developed for specifically for simulating the complex geometries of horizontal collector wells (Bakker et al. 2005, Moore et al. 2012).

Beach dynamics are also critical as the objective is to install laterals beneath the sea. A rapidly prograding beach could strand the laterals landward. Rapid erosion could compromise the collector structure. Hence, field inspections should also evaluate evidence for shoreline instability or migration.

4.6.2.3 Slant Wells

The primary objective of field testing for slant wells is the identification and characterization of a suitable production zone. Field testing for slant wells is complicated by the screened interval being located subsea offshore. The results of testing near the shore are thus extrapolated seaward. The field-testing program for slant wells is thus comparable to that for vertical wells. For example, the initial testing program for the Doheny Beach slant well involved the drilling of four vertical exploratory wells on the beach using the sonic drilling method, two of which were completed as nested monitoring wells (Geoscience 2023).

The borings/cores should intersect the entire thickness of the potential production zone and by completing the bore/core holes as monitoring wells, some hydraulic testing is possible (e.g., pumping or slug tests). The test well or boring program should also allow for the collection of groundwater samples with depth as deep fresh or brackish groundwater zones may extend offshore.

The intent of slant wells is to obtain seawater via downward flow. Hence, shallow subsea seafloor sediments should be sufficiently permeable to allow for infiltration of sea water. Offshore sampling would allow for characterization of seafloor sediments. Piston cores taken from a boat is a commonly used method to obtain undisturbed samples of unlithified seabed sediments.

Although slant wells are intended to maximize the oceanic contribution of the produced water, there may still be some induced seaward flow from the coast. Because of their depth, mixing of waters with different chemistries may also be of concern. For example, mixing of waters with different redox states can lead to the release of iron and manganese into produced waters, which could necessitate additional pretreatment.

The test well program is critical for obtaining data on aquifer hydraulic properties and water quality. However, well yields from onshore vertical wells do not necessarily equate with potential yields from offshore slant well production zones (although they provide a strong indication of what may be achievable). Hence, pilot testing is required to evaluate actual well yields.

Groundwater modeling is necessary to evaluate the source of produced water. An analytical method was developed for modeling the drawdowns from slant wells (Zhan and Zlotnik 2002). More practically, the multi-node well (MNW2) package for MODFLOW is suitable for simulating slant wells (Konikow et al. 2009).

4.6.2.4 Horizontal Wells

Horizontal wells consist of a screen or permeable casing installed at a shallow depth below the seabed. Key design issues are that the seabed sediment should be sufficiently permeable to achieve target well yields, the entire screen or permeable casing should not initially be or later become exposed on the seafloor, and rock should not be present near surface that could impede the horizontal drilling process. Hence, the focus of field testing is on characterizing the shallow subsea strata along the potential length of horizontal wells. It is not practical (short of pilot testing) to determine well yields. Instead, field testing should focus on identifying favorable conditions, which would be a flat of evenly sloping, uniform seafloor underlain by relatively high permeability sand or gravels.

Field testing should focus on characterizing the seafloor and near seabed sediments. Field study elements may include some or all of the following:

- Seafloor topographic/hydrographic survey
- Side-scan sonar survey
- SCUBA diving inspection (for collection of surface sediments, evaluation of seabed cover—amount of vegetation—and whether seabed topographic irregularities are present)
- Grab sample, piston, or vibracore sampling. Collected core samples could be tested for vertical hydraulic conductivity.
- Permeability estimates from core and grain size analyses

4.6.2.5 Beach Galleries and Trenches

Beach galleries or trenches produce water by downward flow, hence field testing focuses on characterizing the shallow beach sediments.

Beach galleries or trenches are, by definition, constructed beneath the intertidal zone of a beach. Hence, the trench area is only intermittently exposed for sample collection and testing. The key data requirements are the hydraulic properties of the beach sands, particularly their vertical hydraulic conductivity. Hydraulic conductivity can be estimated from grain-size analyses of sand samples collected at various depths to the top of the proposed gallery or trench, or from cores. Undisturbed core samples (preferred) or packed sediment columns could be laboratory tested for vertical hydraulic conductivity.

Vertical hydraulic conductivity can also be measured using a falling-head infiltrometer, which is essentially a pipe with a beveled edge driven into the sand to the target depth. The pipe is filled with water and hydraulic conductivity is calculated from the measure rate of decline of water level. Laboratory analyses of core samples and infiltrometer tests are generally preferred as they provide the most direct measure of vertical hydraulic conductivity.

Beach galleries and trenches are especially sensitive to changes in the beach location. Progradation can result in the gallery becoming stranded in the supratidal zone. Erosion can exhume the gallery. In addition to the review of historical data (e.g., time series of aerial photographs) for evidence of shoreline migration, the project area should be inspected for evidence of changing beach position or past extreme erosional events. Consideration of sea-level rise and increases in waves storm surges resulting from climate change using predictive models or SLR maps should also be considered in evaluating the placement of beach galleries and trenches.

Groundwater flow models can be a valuable tool for beach gallery and trench design as far as determining <u>potential</u> system yield, for example, per unit area of gallery. Local groundwater flow models of beach galleries and trenches can be developed using site-specific data on the hydraulic conductivity of beach sands and estimated values for gravel packs. The initial modeling results will have considerable uncertainty, but still be useful for preliminary design. The models should be calibrated and validated using operational data from a pilot system with the calibrated model used for final design.

4.6.2.6 Seabed Galleries (or Seabed Infiltration Galleries)

As is the case for beach galleries, seabed galleries also produce water primarily by downward flow and thus field investigations focus on the properties of the shallow sediments. Key issues are the current properties of shallow subsea sediments and how their thickness and composition could change over time by various sedimentological processes (erosion and deposition). Field data collection for seabed galleries is greatly complicated by the gallery sites' being located offshore. Galleries are essentially engineered slow sand filters that are topped by natural seabed sediments, which are either anthropogenically replaced or naturally returned. The typically finer grained seabed sediments have a large impact on the rate of seawater infiltration into the gallery. Field studies thus focus on characterizing surficial sediments and identifying the optimal location of the gallery. Seabed sedimentological processes are important as the gallery should neither be the site of sediment accumulation, which could more deeply bury the gallery, or erosion, which could exhume the gallery. The desktop and field studies should also evaluate whether local human activities could impact the gallery (e.g., anchoring, bottom trawl fishing).

Potential elements of field studies for seabed galleries include:

- Seafloor topographic/hydrographic survey
- Side-scan sonar survey
- Submarine current measurements (e.g., acoustic doppler current profilers)
- SCUBA diving inspections
- Grab sample, piston, or vibracore sampling
- Permeability estimates from core and grain size analyses
- Observation of human activities in gallery area (e.g., boat traffic that could drag an anchor or fishing vessels that are trawling)

4.6.3 Intermediate Feasibility Determination

The completion of field studies is an important go/no-go decision point for SSI projects (Figure 4-1) as sufficient data would be available to make an informed decision as to whether the selected SSI system is capable of providing the target production capacity. The field investigation results should also provide data for the development of site-specific flow and transport groundwater models needed for evaluation of system performance, environmental impacts, and design. The data on system performance and construction can be used to update economic analyses completed in the early conceptual phase of the project. Estimates of costs and benefits of the project should be revised based on the new information obtained. Thresholds reflecting customer willingness and ability to pay more for water and for financing the project should be reevaluated.

If the results of the field-testing program are favorable, then pilot testing could be implemented if needed to confirm validity of design assumptions that significantly impact cost and performance of the SWRO.

If the results of the field-testing program are unfavorable (e.g., target water flow is not achievable, or the system would have a low reliability or cause unacceptable or unmitigable environmental impacts), then this would be sufficient evidence that the selected site SSI combination is infeasible. The applicant may then consider a few options as noted on Figure 4-1. One option is to propose or search for an alternative SSI system type or location and then return to the desktop evaluation phase or field testing phase to assess the feasibility of an alternative SSI-site combination. Another option would be to proceed to the final SSI FA to confirm or reject the infeasibility decision. A more aggressive option, if all viable SSI-site combinations have been evaluated, and shown to be infeasible, is to request permission from the Regional Board to initiate the permit review of a surface intake.

4.7 <u>Pilot System Testing (Stage 5)</u>

4.7.1 Introduction

Pilot testing involves the construction and testing of a version of the SSI system at an appropriate scale. The pilot system should have the same design and construction parameters as the final system. The scale must be sufficient to allow for the evaluation of actual system performance in terms of produced water quantity and quality. Pilot testing is critical for large projects in that it can provide assurance that a full-scale intake system will work as intended before the financial commitment is made for design and construction of the system. For economic evaluations, pilot testing can allow for more accurate estimates of system construction and operational costs and it reduces uncertainties and thus risks.

The decision to perform pilot testing and the required scope of work is highly project specific and is dependent on the system type and size. For very small-capacity systems, the pilot system would be, to a large degree, the final system. For example, where the needed raw water could be provided by one or two beach wells, the pilot wells would likely serve as the final SSI. Pilot testing could be performed using temporary wellheads, pumps, and piping, with construction of the final above-ground infrastructure deferred until system performance is confirmed.

For large-scale systems (e.g., exceeding 5 MGD), more extensive and expensive pilot testing may be required. Projects involving offshore construction tend to be much more expensive than construction on land. For example, the construction of a pilot shallow seabed gallery at Long Beach in the 2000s was then a multi-million-dollar investment and the current cost to remove the system is \$5,000,000 (Ruiz 2022).

Because of the expense and duration of pilot testing, the Panel recommends that pilot testing should only be required by the Regional Board if the following criteria are met:

- Field tests indicate that the costs of the SSI could be substantially reduced with pilot testing of a modular unit of the SSI (e.g., one gallery of a SIG).
- Updating the desktop evaluation using the data from the field tests further confirms the likely feasibility of the SSI under all reasonable scenarios for beach erosion and other natural hazards.
- The SSI option has never been tested worldwide in similar geologic and surface hydrologic conditions and pilot testing can be shown to have a high likelihood of reducing costs or environmental impacts.

Regardless of regulatory requirements, an applicant may choose to perform pilot testing to reduce risk.

SSI systems have modular designs in which capacity is increased by the construction of additional units (modules). Pilot systems should, where possible, be constructed so that they will serve as a unit for the final system and not present an additional cost or require immediate decommissioning. Pilot testing investments increase where the intake system involves one or a small number of large capacity units. For example, pilot testing of a vertical beach well system (i.e., the construction and testing of an initial well) will be much less expensive than the construction of a horizontal collector system. The net additional costs for pilot testing also increase where there are large mobilization costs.

The duration of pilot testing programs may depend on project schedule and budget. Pilot SSI systems should be pumped for as long as possible (weeks or months or longer) at their design rate to evaluate changes in performance due to clogging and other causes and the stability of water chemistry. Pumping, instrumentation and controls, and piping systems should ideally be designed for remote control and monitoring. Monitoring salinity of intake water can also be done in pilot tests. The total duration of pilot testing could be more than four years (approval of work plans, construction permits and completion of construction, two years of operation and one year of reporting and regulatory review).

4.7.2 Pilot Testing Options for Intake Types

Pilot testing options for each of the SSIs discussed in Section 2 are summarized in Table 4-1. Vertical, slant, and horizontal well pilot systems would involve the construction and testing of a single well. Horizontal collector systems involve a small number of large-capacity collectors and pilot testing would involve considerable up-front investment of constructing the first collector.

Pilot testing of a beach gallery would entail construction of a small area gallery system in the same position on the beach as the final system. Construction is complicated by the temporary inundation by tides and waves, and shallow depth to water during low tides. Water-filled dams may be a cost-effective means of isolating an area of the beach to allow for dewatering during construction (e.g., AquaDam 2023). Temporary sheet piling is a more expensive option.

Seabed galleries are a difficult and expensive intake option for pilot testing because it involves subsea construction. Galleries constructed adjacent to a beach could utilize water-filled dams or sheet pilings for dewatering during construction, such as was done at Long Beach. Construction in deeper water is much more complex and expensive. Indeed, the high cost of pilot testing seabed galleries and confirming their local performance is a detriment to their implementation.

System Type	Pilot System	Guidance	Comment
Vertical well	Single well	One or more test production wells and associated monitoring well(s).	Multiple well drilling contractors are available and involve standard drilling methods. Relatively low costs.
Slant well	Single well	Pilot system would be initial well.	Few contractors are available with experience and drilling equipment. Greater complexity and higher costs than vertical wells.
Horizontal well	Single well	Construction of first horizontal well.	Very few experienced contractors, no existing project in California. Involves subsurface construction with high associated costs.
Horizontal (Ranney) collector	Single collector	Final-designed collector would be required.	Very high costs as complete collector needs to be constructed.
Beach gallery	Small-scale gallery or initial gallery	Pilot gallery could be either a small-scale system not to be used as part of the final system or the initial gallery of a multiple gallery system.	Construction in the intertidal zone can be challenging especially if there is high wave energy. Regulatory approval for construction on a beach may be difficult.
Seabed gallery	Small-scale gallery or initial gallery	Pilot gallery could be either a small-scale system not to be used as part of the final system (nearshore system) or the initial gallery of a multiple gallery system.	High construction costs if in shallow subtidal (accessible from beach) and very high costs in deeper offshore (not accessible from beach).

Table 4-1: Pilot Testing Option

5. FINAL FEASIBILITY ASSESSMENT PHASE (STAGE 6)

As depicted in Figure 4-1, Stage 6 incorporates the final analysis of the SSI-site combination that has passed the intermediate feasibility determinations with Regional Board approval. At this final stage, the applicant will have received approval to document the analyses completed through Stages 2 through 5 as applied to the general and site-specific feasibility factors. The Panel assumes that only one option of an SSI-site combination has met the general feasibility factors as summarized in Table 3-1 as well as any site-specific feasibility factors using the appropriate analytical tools and data identified in Sections 4.3 to 4.7. These factors would have included technological (reliability, and constructability, including permittability), environmental, and social thresholds as well as addressing other factors identified in the Ocean Plan. The final factor determining feasibility, both within the CEQA and Ocean Plan 219 definition of "feasible" and because of financing challenges as noted, is economics, with the acknowledgement that the Ocean Plan explicitly requires consideration of life cycle costs as well as consideration of overall energy requirements. This Section provides a discussion of each of the analyses recommended in applying these four factors, namely technological, environmental, social, and economics for the final stage of the FA leading to a final report for submittal to the appropriate Regional Board. As noted, this would complete the FA portion of the intake system for the proposed facility as part of the request from a project proponent for a water code determination as specified in the Ocean Plan 2019.

5.1 <u>Technological Factors</u>

5.1.1 Reliability

The issue of reliability must be carefully considered in this final SSI FA because reliability of the SSI technology directly impacts the system cost and is a risk factor in obtaining financing for the project (see Section 5.3.2). At this stage of the SSI FA, however, it is expected that reliability of the SSI-site combination has been evaluated at each phase of the decision tree process outlined in Figure 4-1, based on the collection and assessment of a range of data, including hydrogeological and geotechnical factors.

5.1.2 Constructability

Constructability is perhaps the most basic of the SSI FA criteria associated with technology related factors. Constructability depends on both the ability to construct the SSI system and to achieve the target raw water flow. Using vertical beach wells as an example, constructability will depend on target system capacity, individual well yields (and thus the total number of wells required), and the area (length) of the beach available for well construction. By this point in the FA, however, the selected SSI will have met any constructability requirements.

5.1.3 Duration of Permitting Process

Although this factor is not strictly a technology factor, it does impact the constructability, and hence the overall feasibility of the proposed SSI-site combination. As noted earlier in this report, the duration of the SSI FA could lead to a prolonged overall project permit process rendering the project infeasible. In this context, the Panel recommends that this component of the overall permit process not exceed three years unless extensive pilot testing is justified with an overall goal of less than seven years. (See recommendations in Section 6.) Significant delays can also affect the life cycle costs and increase the risk of financial failure.

5.2 Environmental and Social Factors

The principal environmental issues to be addressed in Stage 6 of the FA are: 1) construction and maintenance effects on sensitive marine habitats and species, and 2) impact on adjacent freshwater aquifers, either through withdrawals that affect sensitive habitats such as coastal wetlands, and/or by causing or exacerbating seawater intrusion. Because impingement and entrainment impacts on SSI during the operational phase of an SSI project need not be accounted for according to the Ocean Plan 2019, the primary environmental concerns are related to item 1 above. Impacts to adjacent aquifers should have been addressed by Stage 6 as discussed in Section 4. However, in preparing the final report, the applicant should revisit the modeling results developed in either the evaluations in Stage 3 or following field studies where sufficient hydrogeological information will have been obtained following guidance presented in Section 4.7.

Social factors to be evaluated in Stage 6 the impacts on water rates for low income or other disadvantaged communities will need to be assessed and acceptable mitigation developed to avoid project rejection by these groups. As noted earlier, this issue will arise early in the conceptual development of the project and the issue may have already been addressed and resolved before initiation of the FA. Nonetheless, the applicant will need to document these factors in a final report as part of completion of Stage 6.

5.3 **Economic Factors**

5.3.1 Life Cycle Cost/Benefit Assessment

For the final SSI FA, applicants should revise the estimate of project life cycle costs and benefits with information obtained from the desktop evaluation, field studies collecting additional site data, and/or data obtained from pilot studies. The types and amount of data needed to ensure accurate life cycle cost estimates were discussed in Section 4.

5.3.2 Financing

Project financing could also affect the viability of the project and will affect costs per household/water rates. Financial institutions are risk adverse. Commonly, large-scale infrastructure projects of all types undergo value-engineering and financial and physical failure risk assessments before lending institutions "rate" a project for consideration of funding. Because most large-capacity desalination plants use some type of surface intake system, this component of the desalination facility is considered to be the least risky option by most lenders. A database created by Global Water Intelligence shows that no seawater desalination plant over a capacity of 10 MGD has been constructed with a subsurface intake in the last 10 years due to financial risk (GWI DesalData, 2024). The link, however, is that financing for the overall desalination project could be a risk if the capital cost of the SSI results in greater financial risk and ultimately leads to a decision of infeasibility in this final stage of the SSI FA. For small-capacity systems (less than 2 MGD), this risk is much lower.

When a large-capacity desalination facility undergoes a technical risk assessment to assess potential mechanical or process failures, all components of the project are reviewed to assess if they are the best available technology and whether they have been proven to be effective at the capacity to be used in the facility at other similar locations. A problem occurs when any component of the desalination facility under review is being implemented at a scale not found in any other facility in the world that could be considered a practical demonstration of the effectiveness of the technology.

Well intake systems are most commonly used to provide feedwater for relatively small (less than 5 MGD) capacity SWRO treatment systems. The world's largest vertical well intake system (Sur, Oman) has an intake capacity of 21.2 MGD which feeds a SWRO plant providing a permeate capacity of 10 MGD (Missimer et al. 2015). All other well intake system types have capacities lower than this system (commonly less the 5 MGD). The world's largest offshore gallery system (Fukuoka, Japan) has a capacity of 27.2 MGD (Missimer et al. 2015). No large capacity SWRO intakes have been constructed using Ranney wells or beach galleries. There may be some larger capacity well system intakes that have been constructed or expanded since 2014. However, no large-capacity desalination plant with a capacity greater than 50 MGD with SSI exists anywhere in the world today (Missimer 2024).

SSIs produce a much higher quality water compared to shoreline or in-water intakes and few failures have occurred (Missimer et al. 2013). However, they have not been constructed at a large-scale because, based on the committee's experience and expertise, financers are often risk averse and therefore may be hesitant to finance the first test case at a rate that is economically palatable to the developers. The long-term reliability of all SSI technologies is unproven from a financial risk perspective if the scale of the technology has not been proven to function for the life-expectancy of the project. Financiers respond to perceived risk by increasing the interest rate they charge to offset the risk, requiring greater contingencies as part of the contract, and/or by denying financing outright.

To illustrate this point, the Panel considered the baseline costs of a hypothetical 25 MGD capacity SWRO plant with a total cost of \$215 million, including a conventional open intake costing \$10 million, originally described in Missimer et al. 2013, with debt financed at a rate of 5% for 30 years. Using a capital recovery factor for these assumed conditions (Eschenbach 2011), the annualized cost would be about \$14 million. The capital costs if an SSI is installed are assumed to be roughly 2.5 times more expensive than the conventional intake (\$20.5 million) based on the cost guidance published in (Voutchkov 2018a). With the same financing terms (5% interest over 30 years), the annualized capital costs of using SSI increases 7% over the baseline case and may, as noted in Missimer et al. 2013, be offset by avoiding pre-treatment and/or operational savings.

However, capital expenses increase more significantly if the financing terms require a higher interest rate to compensate for the project's perceived risk, a consideration that was not analyzed in the Missimer et al. 2013 paper. For example, using the assumptions above, capital expenses increase 20% above baseline if the interest rate is increased to 6%. Requiring higher contingencies in addition to a higher interest rate would increase costs further. These increased costs to address the financing risk may make a project infeasible.

This financial analysis is intended to illustrate how finance charges connected to financial risk can affect project feasibility from an economic perspective regardless of the SSI-site combination. Data used is hypothetical but within realistic ranges. Further, cost increases considered feasible by a project applicant will be case specific. Applicants proposing larger capacity systems should discuss financing terms with a lender early in the feasibility assessment and/or identify financing mechanisms that allow for more risk (e.g., grants) to ensure the financial analysis of the project reflects real-world conditions.

Despite the risks, first-of-a-kind intake systems do get built occasionally. The large capacity offshore gallery intake in Fukuoka, Japan was able to be constructed because of a national initiative that migrated the risk of operation from the individual project to the government. If the State of California wants to require the use of SSI systems for large capacity desalination facilities, the State may need to consider providing alternative financing instruments (grants or insurance) in the case of a system failure or significant deterioration of performance to assure project feasibility or other forms of financial guarantees that overcome the cost impacts of the use of SSI technologies in larger scale systems. Two preliminary designs for offshore gallery intakes were developed for Neom in Saudi Arabia for a 528 MGD SSI (2023) and another north of Dubai (Jebel Ali 2009) for a 68.6 MGD intake. Both designs were rejected based on engineering risk and cost. (Missimer, 2024, personal communication).

5.3.3 Customer Affordability

The costs associated with desalination facilities will be passed on to water utility customers in the form of increased rates. In some communities, and for some households, this will result in an increased burden on household budgets. Significant national and California-specific research has been conducted to help utilities and municipalities examine the effects of increased rates on low-income households and Disadvantaged Communities (see for example Raucher et al. 2019, Clements et al. 2023, Teodoro 2018).

To examine the impact of SSI costs on water customers, the applicant can undertake an affordability assessment. The first step is to determine the annual cost per household under SSI and surface intake alternatives (including financing costs) - this should have been evaluated as part of the desktop study and can be further refined in this Stage. The next step is to better understand the extent and prevalence of affordability challenges in the affected community, and how or whether incremental SSI costs will exacerbate those challenges. Common metrics include the Household Burden Indicator (HBI; Raucher et al. 2019), which compares baseline water and wastewater bills (in this case with and without incremental costs) to the 20th percentile income level in a community (with costs greater than 5% to 7% indicating affordability challenges). More involved metrics, such as the Affordability Ratio (Teodoro et al. 2018) compare household water costs as a percentage of discretionary income (income minus basic expenses) for households earning the 20th percentile income (with 10% as a suggested threshold). Socioeconomic data can also be used to determine the percentage of households with income levels that present affordability challenges, and how this percentages changes under various intake alternatives (based on suggested cost to income ratios). Affordability should be examined within the context of future rate increases associated with other planned investments.

Another key consideration is ensuring that (often limited) financial resources are targeted to yield the greatest benefit. For example, throughout California, many utilities are facing costs associated with increased regulatory requirements, aging infrastructure, lead service line replacements, and more. Any additional costs associated with desalination facilities using SSIs (compared to surface intakes) should be evaluated within this context. These costs should not result in a delay of investments necessary to meet regulatory requirements designed to protect public health.

Ideally, affordability will have been examined as part of the initial assessment to evaluate desalination as a viable water supply source. Costs (and costs per household) should be considered throughout each stage of the SSI FA. At the final feasibility stage, this analysis should be focused on the effects of incremental costs on low-income customers and disadvantaged communities overall.

6. SUMMARY OF PANEL RECOMMENDATIONS FOR STATE BOARD CONSIDERATION

In response to the State Board request as specified in the TOR (Appendix A), the Panel has undertaken a review of relevant policy documents containing guidance on the overall permitting process for desalination projects with an emphasis on procedures presented in the Ocean Plan for new or expanded facilities. In this final section of the Report, the Panel provides a summary of recommendations for consideration by the regulatory agencies based on the documents reviewed and on personal experience of Panel members. The overall objective of this effort was to provide guidance to project proponents on just one component of the overall desalination facility, namely the intake system. But the broader goal of the study was to increase the options for California coastal communities to expand their water supply sources by considering seawater desalination as a viable source given the growing concerns of climate change on drought conditions in the State of California.

The seawater desalination option faces many challenges but establishing a regulatory program that streamlines permit applications could address one concern, and that is permit reviews that result in such long duration that any project becomes "infeasible" because it is unlikely to be completed "in a reasonable time frame". In Figure 4-1, the Panel has proposed a decision tree approach to the SSI FA and each of the key transition points (e.g., how many site-SSI combinations should be evaluated in the FA?) will require that a permit applicant provides sufficient detailed analyses of each of the four feasibility factors, but at different levels of detail depending on the stage within the decision tree (See Figure 4-1 and the six stages of decision-making), such that the regional board can provide guidance on the path forward. This approach is consistent with the process outlined in the Ocean Plan (Chapter III, M), but the Panel's proposed methodology provides a more detailed road map for the FA process.

As noted, each of these transition points will require Regional Board guidance on the path forward. The Panel has provided guidance on the analyses required by an applicant, the types of data needed, resources to obtain available data and techniques to obtain site specific data in Sections 4 and 5 of this report. The following summarizes the Panel's recommendations for State Board considerations on actions that could be taken by the State to streamline the SSI FA task and increase the likelihood of a timely permit process for applicants.

6.1 <u>Duration of Feasibility Assessment Within Context of Overall Permitting</u>

Obtaining a permit from the Water Boards for a desalination project in California requires a project proponent to complete multiple tasks before obtaining a Regional Water Board Water Code section 13142.5(b) determination under Chapter III.M.2.a.(1) of the Ocean Plan. As noted throughout this Report, the proposed SSI FA methodology, consisting of six stages of data gathering and analysis and documentation would represent only a portion of the overall permit application by the project proponent for new or expanded seawater desalination facilities, focusing only on the ultimate design of the intake system. Although there have been a few recent examples of successful approval of SSI intakes in California (Doheny, Catalina and Cal-Am) as feasible options, the overall permitting process has been slow, due to other factors.

Thus, reaching agreement between a project proponent and the regulatory agencies on an overall permit will be complex, lengthy, and costly as has been shown by recent experiences with the Huntington Beach and the Cal-Am projects. If pilot tests are required at a relevant scale compared to the desired hydraulic design capacity of the facility, further delays could occur in the overall permitting process. In comparison, international experience of the Panel members is that large-scale desalination projects generally take three to seven years to go from concept to operation.

The Panel estimates that completion of the tasks required prior to the SSI FA may require two to five years depending on scale and type of SSI based on recent experiences of Panel members at Huntington Beach and the Monterey case study. The SSI FA could add an additional two to ten years depending on the need for pilot tests at scale in addition to field studies with the maximum duration caused by the likely need for field and pilot tests. Thus, the **Panel recommends that the FA for subsurface intakes be streamlined for completion within a maximum of three years**.

Given that tasks associated with Stages 1 and 2 in the proposed methodology will constrain the capacity, site, and applicable SSI combinations to be evaluated in the FA step, this recommended duration should be achievable absent the need for scaled pilot tests with the assumption that regional boards will have sufficient resources to provide interim guidance at identified transition points with the six proposed stages of the FS process.

One provision of the Ocean Plan that adds considerable complexity to the design of and feasibility of an SSI is the required evaluation of combinations of subsurface and in-water intakes if the SSI-site combination is considered infeasible. (Ocean Plan 2019, Chapter III, M,d(a),(ii)). This provision of the Ocean Plan assumes that an applicant can make numerous conceptual designs until one combination becomes "feasible." The Panel has not considered this option in the proposed methodology because it is not a practicable design alternative. If the SSI-site combination of subsurface and surface intakes would require performance of a new SSI FA which would result in long permit delays and severely restrict the permittability of the desalination project. The Panel therefore recommends that this requirement be modified in any future amendments to the Ocean Plan 2019.

6.2 <u>Recommendations on Addressing Economic and Financing Factors</u>

Life cycle costs and thus unit prices for water delivered by a desalination plant will likely be higher than costs for other sources of water supply based on the experience of Panel members. The use of an SSI may increase or decrease overall life cycle costs, depending on site specific issues, and may increase uncertainty given the relatively limited application of SSIs at a scale above 10 MGD. In some cases, life cycle costs comparing open intakes with SSI may be lower for the SSI due to lower pretreatment costs prior to membrane treatment (i.e., reverse osmosis). However, for larger systems, these economic consequences may pose significant challenges to obtaining financing for new desalination facilities at this scale. The ability to obtain financing for a seawater desalination project using an SSI is dependent on the required plant and intake capacities. Any plant capacity over 10 MGD may jeopardize financing based on engineering design risk. Lack of financing is a significant risk to the applicant and can be a critical factor leading to an infeasibility determination in Stage 6 of the SSI FA. Based on the issue of engineering risk, the financing of a desalination project becomes questionable when the desired capacity of the SSI type being used is greater than any such other example in the world. Therefore, well intakes with a feedwater capacity greater than 20 MGD or an offshore SSI gallery greater than 26 MGD (i.e., the largest gallery worldwide) are subject to possible denial of financing.

If the added cost of using an SSI causes the overall cost of product water to the consumer to exceed their ability to pay, in the opinion of the Panel, the use of an SSI is not feasible without financial assistance or subsidies. One option that could be considered by the State is to provide some form of financial instruments that would mitigate the financial risks associated with using SSIs at scales larger than have been demonstrated, namely design capacity larger than 10 MGD.

Project proponents should conduct an affordability assessment to evaluate the impacts of incremental costs above the current water rates on low-income ratepayers as part of evaluation of the economic factors for SSI feasibility at an early stage of the development of a conceptual design of the facility and prior to initiating a formal permit request. This will be crucial in obtaining early acceptance of the permitting process and increasing the likelihood of a successful permit application.

6.3 <u>Recommendations Regarding Environmental Considerations</u>

The State of California evaluated the environmental impacts associated with various intake types and concluded that the environmental impacts of an SSI are lower than surface intake systems, such as canals, channels, velocity caps, existing in-water pipes, or passive screens. Thus, the Ocean Plan 2019 states that "An owner or operator with subsurface intakes is not required to do an ETM/APF analysis for their intakes and it is not required to mitigate for intake-related operational mortality", and the applicant need only evaluate environmental impacts from construction and maintenance of the SSI in the FA.

However, the applicant will need to recommend compensatory mitigation through expansion, restoration, or creation of the effected habitats for impacts of construction and system maintenance. The availability of suitable mitigation sites / approaches is a question for some sensitive habitats and could pose a delay in the permit process. These mitigation concerns should be addressed in the earliest stages of the FA process, preferably during Stages 1 and 2. The Panel recommends that the mitigation options for the various site-SSI combinations being considered in the screening process be addressed by both the project proponent as well as the relevant regulatory agencies to provide an early path to resolve the mitigation challenges as early as practicable in the overall permitting process.

6.4 <u>Recommendations Regarding Potential Impacts on Local Aquifers and</u> <u>Wetlands.</u>

Given the potential for subsurface connectivity between coastal wetlands or coastal freshwater aquifers and SSI source waters, the Panel recommends that this concern receive careful consideration both during the analyses conducted in the FA and during post-construction monitoring of source-water salinity. Monitoring of water levels in coastal wetlands and water levels and salinity in coastal aquifers should be required in any plant operating plan if there is a risk of impacts inferred from modeling studies of the site-SSI combination (see Section 4 in this Report).

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APPENDIX A Terms of Reference

TERMS OF REFERENCE (ADOPTED BY THE PANEL)

Submitted September 22, 2023 deemed complete by State Board Staff September 25, 2023

Introduction: The Terms of Reference document outlines the charge, issues to be addressed, objectives, guiding principles, and proposed approach for the development of guidance to assist agencies and applicants in evaluating the feasibility of subsurface intakes for proposed seawater desalination facilities. The approach includes recruitment criteria for the Panelists and proposed Panel process, including a schedule of key milestones for the Panel's deliberative process.

Recruitment Criteria: The Science Advisory Panel (Panel) will be recruited based on the following considerations and criteria. Panel members are recruited based on their demonstrated technical and professional expertise within the fields of geotechnical data, hydrogeology, benthic ocean topography, facility energy use, facility engineering, and economics. Considerations for panel recruitment include members record of publication and analysis, their expertise in providing policy-relevant advice to support public deliberations, experience and willingness to work in a multidisciplinary setting to develop and accept attribution for a unified or pooled Panel work product, and experience providing support to address technically complex water resources projects and policy decisions.

Purpose: The purpose of the Panel is to meet the terms and expectations articulated by the State Water Resources Control Board in the project scope, and to objectively identify the ideal scientific approach for conducting subsurface intake feasibility assessments. The Panel is to develop a methodology of analyses necessary to evaluate the feasibility of subsurface intakes for proposed seawater desalination projects. Currently, the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) lacks sufficient criteria or guidance for the scientific and technical studies necessary to analyze subsurface intake feasibility. The Panel is to develop a recommended analytical approach to evaluate the feasibility of subsurface intakes for proposed seawater desalination projects based on their knowledge and expertise in relevant subject areas.

Substantive Issues to Be Addressed by the Panel: The objective is to develop a concise methodology, lending itself to operation in a variety of permit applications and organizational permit decisions specific to the Ocean Plan and Water Board process for permitting seawater desalination subsurface intakes.

The methodology should be applicable to a wide range of ocean conditions found in California, and adaptive to new or emerging subsurface intake technologies at a range of potential scales of operation. Issues to be addressed by the Panel include: the criteria by which suitability of subsurface intakes can be evaluated, the relative importance of various analytical considerations, the type and level of detail of information to be mobilized including the recommended spatial resolution of data, specific data sources that meet these criteria, potential methodologies for ranking alternate sites for suitability, and address the appropriate spatial scale and analytic approach to address the Ocean Plan guidance to evaluate "a reasonable range of nearby sites"

The Panel's draft and final report should, prospectively, provide responses to the following questions:

- How should a proposed desalination project applicant complete this analysis?
- What modeling is necessary for determining subsurface intake feasibility?

- What components of a geophysical survey (including lithologic data) are needed to determine subsurface intake feasibility?
- What key characteristics should be considered for all of the known subsurface intake technology types? What are known information gaps in subsurface intake technologies?
- What criteria should be used to determine whether additional data collection is necessary?
- What metrics and criteria should be used to evaluate test well data for subsurface feasibility?
- What readily available data can be used to evaluate a reasonable range of sites?
- What is a reasonable shelf life for various data types?

The Panel will develop advice aimed at providing greater clarity to meet the challenge faced by applicants when conducting subsurface feasibility assessments. The State is intending that the Panel's advice will help clarify this process for future applicants, and will use the information gathered through this panel to develop additional materials and recommendations.

The proposed methodology to be articulated by the Panel should be based on acceptable levels of scientific rigor applicable as professional standards to the fields of expertise represented by panel members. The Panel should focus on being thorough and objective. The aim is for the Panel to advise State staff; the intention is for the eventual guidance developed by staff to be concise and digestible, with the State to develop this guidance.

State Board Staff Strawman Document: State Water Board staff evaluated several subsurface feasibility assessments conducted to date for proposed California seawater desalination facilities and developed a preliminary concept strawman document to support deliberations of the Subsurface Intake Panel. The criteria for inclusion in this document are 1) elements common to all subsurface feasibility assessments or 2) elements that staff thought may be useful components of a subsurface feasibility evaluation. This document is intended as a strawman to spark discussion and assist the Panel in identifying the critical components of a subsurface feasibility evaluation.

As part of the Panel's charge, the State Board would like the Panel to consider the strawman and use it to inform their recommendations. This strawman document is not intended to prescribe the Panel's recommendations.

Potential Support for Ocean Plan Amendment: State staff may use the panel's objective findings, in concert with stakeholder input and other relevant information, to amend the Ocean Plan. The Panel will create a report that would inform a future proposed amendment to the Ocean Plan desalination provisions to improve criteria for studies necessary to demonstrate subsurface intake feasibility.

Guiding Principles:

- 1. The Panel will strive to bring forward and synthesize the best available information.
- 2. The Panel will work in a collaborative fashion with fellow Panelist, the State Board staff, peer agencies, and supporting staff and contractors.
- 3. Panelists will be asked to accept authorship and attribution of their work.

- 4. Panelists will strive to arrive at a unified recommendation to the State Board.
- 5. While a unified Panel recommendation is desired, CONCUR will work with the panelists to devise a process to accurately summarize divergent views in the event they arise during the Panel deliberation.
- 6. When interacting and communicating with resource agency colleagues, Panelists will strive to convey information and the logic of their recommendations in a clear accessible manner. The Panel's work product will include specific references where applicable.
- 7. The Panel should recognize that their work on this assignment may be iterative in nature, meaning that new panelists, new information, and new suggestions and policy direction may enter the process before completion of the process.
- 8. As the Panel's work proceed, panelists may confer with colleagues and other experts but all contacts with media, other organizations to be with Concur or with State Board staff

Proposed Approach:

- 1. This effort is structured as a joint fact-finding process. The aim is to share and clearly state starting assumptions, identify and reference key data sets, arrive at a synthesis of interpretations, and clearly communicate findings. This panel's work rests on the intention to bring a collaborative approach among members of a multidisciplinary panel to objectively synthesize the best available scientific information.
- 2. The flow of the Panel's work will include an iterative series of framing discussions, deliberations, drafting of text, review of text, and refinement in consultation with State Board and peer agency staff. Discussions will take place in a virtual format such as Zoom or Team. In some cases, the Panel may meet in a hybrid format, with some members in person and others engaging via digital platforms.

The precise format and arrangements of each meeting will be guided by the Panel Workplan. The schedule is as follows:

Period	Step	
Mid-Late August	First-second draft of sections	
Early September	Second-third draft of sections	
Mid-September	Initial integrated draft	
Late September	Revised integrated draft	
Early–Mid October	Second revision-integrated draft	
Mid–Late November	Complete draft report	

Panel Report Drafting Schedule (confirmed by the Panel)

- 1. The CONCUR team will serve as the Secretariat for this drafting process and will manage the flow of written documents among Panelists
- 2. Core participants in this effort will include Panel members, and the Convening Team (consisting of State Board staff and the CONCUR team). Other participants will include senior leadership of the State Board staff, and members of the Agency Advisory Group (comprised of representatives from agencies listed in the Seawater Desalination Interagency Memorandum of Agreement).
- 3. Once core members of the Panel are identified, they should be engaged in review of this draft Terms of Reference and are invited to propose additional detail or clarifications as may be helpful.
- 4. The Panel, once constituted, may choose to elect a Panel Chair and Co-Chair.
- 5. Core Panelists, once appointed, should be included in a review of disciplinary coverage on the Panel to pinpoint any gaps.
- 6. The State Water Resources Control Board will designate a Point of Contact for the Panel's operation.
- 7. Panel member contact with outside organizations should be communicated via the CONCUR team or State Board staff.

APPENDIX B Panel Purpose, Selection, and Process

PANEL PURPOSE, SELECTION, AND PROCESS

Impetus for the Panel: Currently, the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) lacks sufficient criteria or guidance for the scientific and technical studies necessary to analyze subsurface intake feasibility. The State Board is seeking the advice of an independent expert panel aimed at providing greater clarity to meet the challenge faced by applicants when conducting subsurface feasibility assessments. The State intends that the Panel's advice will help clarify the feasibility assessment process for future applicants. The State will then use the information gathered through the panel to develop additional materials and recommendations.

Contract with CONCUR Inc: The State Water Resources Control Board entered in an agreement, D2215001 with CONCUR Inc. to provide convening, facilitation, and project management services to support the Panel's work.

Panel Purpose: Consistent with the impetus for the Panel, the Panel's charge is to objectively identify the ideal scientific approach for conducting subsurface intake feasibility assessments. Based on Panel members' knowledge and expertise, the Panel is to develop a methodology and analytical approach to evaluate the feasibility of subsurface intakes for proposed seawater desalination projects.

The objective is to develop a concise methodology that can be used in a variety of permit applications and organizational permit decisions specific to the Ocean Plan and Water Board process for permitting seawater desalination subsurface intakes. The intent is for the methodology to be applicable to a wide range of ocean conditions found in California, and adaptive to new or emerging subsurface intake technologies at a range of potential scales of operation.

The State is hoping that the panel advice will help clarify the process of conducting subsurface intake feasibility assessment for future applicants. The State will use the information gathered through this panel to develop additional guidance and recommendations.

Substantive Issues to Be Addressed by the Panel: Issues to be addressed by the Panel include: the criteria by which suitability of subsurface intakes can be evaluated, the relative importance of various analytical considerations, the type and level of detail of information to be mobilized including the recommended spatial resolution of data, specific data sources that meet these criteria, potential methodologies for ranking alternate sites for suitability, and the appropriate spatial scale and analytic approach to address the Ocean Plan guidance to evaluate "a reasonable range of nearby sites".

Panel Recruitment Criteria and Selection Process: Panel members were recruited by CONCUR based on their demonstrated technical and professional expertise within the fields of geotechnical data, hydrogeology, benthic ocean topography, facility energy use, facility engineering, and economics. Considerations for panel recruitment included members' record of publication and analysis, expertise in providing policy-relevant advice to support public deliberations, experience and willingness to work in a multidisciplinary setting to develop and accept attribution for a unified Panel work product, and experience providing support to address technically complex water resources projects and policy decisions.

Prospective Panel members were invited to submit Statements of Interest. Their Statements of Interest were reviewed and discussed by the CONCUR team and State Board staff. State Board staff concurred with the selection of the Panel members listed below. Contracts were developed for each Panel member and initial Panel work began in the spring of 2023.

Panel Members and Expertise: The seven-member multidisciplinary panel includes the individuals listed below. Brief CVs of Panelists are provided in Appendix C.

Panelist	Affiliation	Disciplinary Expertise
Janet Clements	President, One Water Econ	Water and natural resource economics, integrated
		water resource management, climate vulnerability
		and adaptation planning
Mike Kavanaugh	Senior Consultant, Geosyntec	Water quality management and wastewater
	Member, National Academy of	treatment, hazardous waste management,
	Engineering	sustainability and site remediation
John Largier	Director, University of California-	Environmental oceanography related to marine
	Davis Bodega Marine Laboratory	reserves, desalination, river plumes, coastal
		power plants, fisheries and mariculture
Robert Maliva	Principal Hydrologist, WSP	Geology, hydrology, desalination technology,
		alternative water supply and disposal systems
Thomas Missimer	Hydrologist and Geologist, Florida	Geology, hydrology, water management,
	Gulf Coast University	desalination and water quality
Leslie Moulton-Post	President and CEO, Environmental	Environmental program management,
	Science Associates	CEQA/NEPA compliance, environmental
		permitting, water resources planning
Jennifer Stokes-Draut	Research Scientist, Lawrence	Economic and environmental implications of
	Berkeley Laboratory	complex infrastructure systems including
		innovative and integrated water systems, life-
		cycle assessment, systems analysis

Panel Work Program and Approach: The Panel began its work with an initial orientation call with State Board staff, and with the review of a "Strawman" concept document for evaluation of subsurface intake feasibility developed by State Board staff.

Review of the Strawman was followed by development of short memos from panelists reflecting on the Strawman document, and then followed by development of a potential outline for a Panel report. After review and refinement, the outline was adopted by the Panel. Next, individual Panelists took on lead responsibility for drafting sections of the report corresponding to their expertise. Sections were compiled into a complete draft that was reviewed and edited by Panelists with support from CONCUR.

The Panel and the CONCUR team convened regular check-in work sessions, generally at twoweek intervals, and lasting about 45 minutes over an approximately six month period from May through November, 2023. At each meeting, we reviewed the most recently contributed text, discussed key issues, noted gaps, and devised a gameplan for the next sections to be drafted or for interim review steps.

APPENDIX C Short Resumes of Panel Members

Janet Clements Mike Kavanaugh John Largier Robert Maliva Thomas Missimer Leslie Moulton-Post Jennifer Stokes-Draut

Janet Clements

President, One Water Econ

EDUCATION AND REGISTRATIONS

MS, Agricultural and Resource Economics, Colorado State University, 2006 BS with honors, Natural Resources, The Ohio State University, 2000

PROFESSIONAL EXPERIENCE

President, One Water Econ, Loveland, Colorado, 2022-Present

Director, Water Economics and Planning, Corona Environmental Consulting, Louisville,

Colorado, 2020 – 2022; Senior Economist 2017 - 2020

Managing Economist, Abt Associates (formerly Stratus Consulting), Boulder, Colorado, 2015–2017; Senior Economist 2011–2014; Senior Associate 2008–2011

Associate, BBC Research and Consulting, Denver, Colorado, 2006–2008

Associate Planner, Trinity County Planning Dept., Natural Resources, Weaverville, California, 2001–2004

AmeriCorps Member, Watershed Stewards Program, Hayfork, California, 2000-2001

AFFILIATIONS

EPA Environmental Finance Advisory Board, 2022-Present

NOAA Proposal Review Panel for the Climate and Societal Interactions, Adaptation Sciences Program, 2022

AWWA Project Advisory Committee: Thinking Outside the Bill, 2021

WEF Stormwater Management Conference Advisory/Planning Committee, 2020, 2021 Independent Scientific and Technical Advisory Panel to Provide Input on Feasibility of

Alternative Intake Technologies for Proposed Desalination Facility at Huntington Beach, 2014–2015

REPRESENTATIVE PROJECTS

- The Business Case for Investing in Water in Oregon. Oregon Water Resources Department. 2023.
- Guidance and Tools for Assessing the Co-benefits of Green Stormwater Infrastructure. The Nature Conservancy (TNC), in Partnership with the Green Infrastructure Leadership Exchange. 2022–Present.
- Ecosystem Service Valuation of National Coastal Resilience Fund Projects. National Fish and Wildlife Foundation. 2022–Present.
- Accessing Capital Markets to Support Watershed Health and Manage Wildfire Risk. Water Now Alliance and U.S. Forest Service. Ongoing.
- Economic Benefits and Impacts of Charlotte Water's Infrastructure Investments and Services by Charlotte Water. Charlotte Water. 2022.
- Benefit Cost Tool for Analyzing Watershed Protection Efforts in the Consumnes River Basin (CA). Radbridge and Freshwater Trust. 2022.
- Framework and Tool for Quantifying and Monetizing the Benefits and Cost of Green Stormwater Infrastructure (GSI). The Water Research Foundation (WRF). 2021.

- Framework for Incorporating Affordability Considerations into the Assessment of Proposed National Drinking Water Regulations (2021 2022). American Water Works Association (AWWA).
- New York City Sustainable Rate Structure and Affordability Assessment. New York City Department of Environmental Protection. 2021- present.
- Economic Impacts and Benefits of Alternative Green and Gray Infrastructure Approaches for the DC Clean Rivers Project. DC Water. 2020.
- Framework for Evaluating Economic Feasibility and Affordability of Proposed Drinking Water Regulations in California. Southern California Water Coalition. 2020.
- Leveraging Private Capital for GSI Implementation in Great Lakes Communities. Great Lakes Protection Fund. 2017-2019.
- Recommendations to U.S. EPA on Assessing Affordability for Federal Policies. AWWA, National Association of Clean Water Agencies (NACWA), and Water Environment Federation (WEF). 2019.
- Market-based solutions for implementing GSI on Private Property in Los Angeles County. TNC. 2019.
- Incentive Programs for GSI on Private Property: Lessons Learned. WRF. 2018.
- National MS4 Needs Assessment Survey. WEF. 2018.
- Navigating Legal Pathways to Rate-Funded Customer Assistance Programs. This effort was funded by AWWA, NACWA, WEF, WRF, AMWA, and National Association of Water Companies. 2017.
- Benefit-Cost Analyses for Water Utility Proposals to the State of California (2008–2014).
- Evaluating Customer Assistance Programs for Multi-family Residential and Other Hardto-Reach Customers. WRF. 2017.
- Guidelines for Evaluating the Socioeconomic Benefits of Meteorological and Hydrological Services. USAID, World Bank, and World Meteorological Organization. 2017.
- National MS4 Needs Assessment Survey. WEF. 2018.
- Navigating Legal Pathways to Rate-Funded Customer Assistance Programs. This effort was funded by AWWA, NACWA, WEF, WRF, AMWA, and National Association of Water Companies. 2017.
- Madera Canal Capacity Restoration Feasibility Study (2014 2016). U.S. Bureau of Reclamation.
- Guidelines to Help Water and Wastewater Utilities Conduct Cost Effectiveness Analyses and Maximize Efficiency, Reuse, and Recapture Project Elements in Applying for CWSRF. NRDC. 2015.
- Assessing the Value of Clean Water in Northeast Ohio Cleveland Water Alliance and Northeast Ohio Regional Sewer District. 2015.
- Benefit-Cost Analyses for Water Utility Proposals to the State of California (2008–2014).
- Value of Water Supply Reliability in the Commercial, Industrial, and Institutional Sectors (2015). WRF.

Michael C. Kavanaugh, PhD, PE, BCEE, NAE

Recently retired; formerly Senior Consultant, Geosyntec Consultants, Inc.

EDUCATION AND REGISTRATIONS

PhD, Civil/Sanitary Engineering, University of California, Berkeley, 1974

MS, Chemical Engineering, University of California, Berkeley, 1964

BS, Chemical Engineering, Stanford University, 1962

Professional Chemical Engineer, No. 3498, State of California (since 1978)

Board Certified Environmental, (BCEE), certified by the American Academy of Environmental Engineers and Scientists (AAEES); annually certified in Water Supply and Wastewater, Sustainability, and Hazardous Waste Management and Site Remediation

PROFESSIONAL EXPERIENCE

Geosyntec Consultants, Oakland, California, 2010–2024 Malcolm Pirnie, 1997–2009 Environ, 1994–1997 James M. Montgomery, 1977–1994 Instructor at ETH, Zurich, 1972–1976 Visiting Professor, UC Berkeley, 1977 Consulting Professor, Civil and Environmental Engineering, Stanford University, 1985–2019

REPRESENTATIVE PROJECTS

- Member, Expert Panel, California Coastal Commission. Poseidon Independent Scientific and Technical Advisory Panel (ISTAP), 2014–2015. Phases 1 and 2. Preparation of report on feasibility of subsurface intake systems desalination plant in Huntington Beach, California.
- Member, Advisory Committee, Division of Earth and Life Studies (DELS), National Research Council (2016–2024); DELS oversees operation of 11 boards including the Water Science and Technology Board, Board on Ocean Studies, and Board on Earth Sciences Research.
- Reviewer of many National Academy Reports, including 2015 report on desalination.

RELEVANT PUBLICATIONS

- Kavanaugh, M., and N. Kresic. 2008. "Large urban groundwater basins; water quality threats and aquifer restoration." Chapter 6, in *Groundwater Management in Large River Basins*. IWA Publishing.
- Boller, M.A., and M.C. Kavanaugh. 1995. "Particle Characteristics and Headloss Increase in Granular Media Filtration." *Water Research*, 29, 4, 11-39-1149.

REPRESENTATIVE AWARDS AND HONORS

Designated as Distinguished Expert by the California Council on Science and Technology (CCST), 2018

Elected Fellow, Water Environment Federation, 2013

Abel Wolman Distinguished Lecture, Washington, D.C., 2012

Elected Member, Academy of Distinguished Alumni, Department of Civil and Environmental Engineering, UC Berkeley, 2012 Elected to National Academy of Engineering (NAE), 1998

John L. Largier

Professor of Oceanography and Director of Bodega Marine Laboratory, University of California, Davis

EDUCATION AND REGISTRATIONS

PhD, Oceanography, University of Cape Town, South Africa, 1987 BSc with honors, Applied Mathematics, University of Cape Town, South Africa, 1983 BSc, Physics and Applied Mathematics, University of Cape Town, South Africa, 1981

PROFESSIONAL EXPERIENCE

University of California, Davis, 2004–Present University of Cape Town, South Africa, Department of Oceanography Senior Lecturer, 1995-1999 Distinguished Professor, Department of Environmental Science & Policy, 2004-Director, Bodega Marine Laboratory, 2022-Associate Director, Coastal & Marine Sciences Institute, 2014-University of California, San Diego, Scripps Institution of Oceanography Research Oceanographer, 1988-2004 Lecturer, 1992-2004 Research Associate, 2004-2007 International Research Associate, 2000-2012 National Research Institute for Oceanology (CSIR), South Africa, Researcher, 1984–1988

REPRESENTATIVE PROJECTS

- International Collaboration: Beyond research collaboration, enhance graduate education and engaged scholarship through environmental oceanography in comparable marine environments off Chile, Spain, Portugal, Mexico, South Africa, Kuwait, Australia, and New Zealand.
- Coastal Ocean Observing Systems: Developed Bodega Ocean Observing Node www.bml.ucdavis.edu/boon/ as founding node of the Central and Northern California Ocean Observing System (CeNCOOS) to provide information to regional community and ocean users; BOON operations include HF radar mapping of surface currents, permanent coastal moorings, shore stations, and routine boat-based surveys (also seasonal monitoring in estuaries); lead CeNCOOS HFR surface current mapping.
- Honors & Awards: Distinguished Scholarly Public Service Award, UC Davis (2012), Annual Riley Memorial Lecture, Dalhousie University, Canada (2008), Fellow, Leopold Leadership Program (Earth Leadership Program, 2001).
- Service to Profession: Advising State/Federal/Local governments: Sonoma County Water Agency, California State Parks, Ocean Protection Council, Greater Farallones National Marine Sanctuary (NOAA), Central & Northern California Ocean Observing System (CeNCOOS/NOAA), San Francisco Bay Conservation and Development Commission (BCDC), Southern California Wetlands Recovery Project, West Coast Panel on Ocean Acidification and Hypoxia (CA/OR/WA/BC), Marine Life Protection Act (Dept Fish & Wildlife, CA), Clean Beach Task Force (Dept Water Resources, CA), Coastal Zone Management Policy (Environment Affairs & Tourism, S Africa), Academic societies.
• Consulting: Advised proponents and agencies on environmental impacts of wastewater discharge, once-through cooling, and desalination.

RELEVANT PUBLICATIONS

- Basdurak, N.B. and J.L. Largier. 2023. "Wind effects on small-scale river and creek plumes." Journal of Geophysical Research: Oceans 125(7), e2019JC015737.
- Largier, J.L. 2022. "Rip Currents and the Influence of Morphology on Wave-Driven Cross-Shore Circulation." *Treatise on Geomorphology*, 2nd Edition, Volume 8, 100-121, Elsevier.
- Fellowes, T., A. Vila-Concejo, S. Gallop, R. Schosberg; V. de Staercke, J. Largier. 2021. "Decadal shoreline erosion and recovery of beaches in modified and natural estuaries." *Geomorphology* 390.
- Harvey, M., S.N. Giddings, E.D. Stein, J.A. Crooks, C. Whitcraft, T. Gallien, J.L. Largier, L. Tiefenthaler, H. Meltzer, G. Pawlak, K. Thorne, K. Johnston, R. Ambrose, S.C. Schroeter, H.M. Page, and H. Elwany. 2020. "Effects of elevated sea levels and waves on southern California estuaries during the 2015-2016 El Niño." *Estuaries and Coasts* 43:256-271
- George, D.A., J.L. Largier, G.B. Pasternack, P.L. Barnard, C.D. Storlazzi, L.H. Erikson. 2019. "Modeling sediment bypassing around idealized rocky headlands." *Journal of Marine Science & Engineering* 7(40); doi:10.3390/jmse7020040.
- Lipa, B., D. Barrick, S. Saitoh, Y. Ishikawa, T. Awaji, J. Largier, and N. Garfield. 2011. "Japan tsunami current flows observed by HF Radars on two continents." *Remote Sensing* 3(8), 1663-1679.
- White, J.W., K.J. Nickols, L. Clarke, and J.L. Largier. 2010. "Larval entrainment in cooling water intakes: spatially explicit models reveal effects on benthic metapopulations and shortcomings of traditional assessments." *Canadian Journal of Fisheries & Aquatic Sciences* 67:2014-2031, doi:20.1139/F10-108.
- Largier, J.L., J.W. White, L. Clarke, and K.J. Nickols. 2008. Assessment of Larval Entrainment by Cooling Water Intake Systems: Models of Larval Dispersal and Recruitment Incorporating Coastal Boundary Layer Flow. Report for Water Intake Structure Environmental Research (WISER) Project to California Energy Commission, 92.
- Kim, J.H., S.B. Grant, C.D. McGee, B.F. Sanders, J.L. Largier. 2004. "Locating sources of surf zone pollution: a mass budget analysis of fecal indicator bacteria at Huntington Beach, California." *Environmental Science & Technology* 38 (9), 2626-2636.
- Largier, J.L. 2003. "Considerations in estimating larval dispersal distances from oceanographic data." *Ecological Applications* 13(1) Supplement: S71-S89.
- Smith, J.A. and J.L. Largier. 1995. "Observations of nearshore circulation: rip currents." *Journal* of Geophysical Research 100 (C6), 10967-10975.
- Del Bene, J.V., G. Jirka, and J. Largier. 1994. "Ocean brine disposal." Desalination 97, 365-372.

Robert G. Maliva, PhD, PG

Senior Vice President and Principal Hydrogeologist, WSP USA

EDUCATION AND REGISTRATIONS

PhD, Earth Sciences, Harvard University, 1988MA, Geology, Indiana University, Bloomington, 1984BA, Geological and Biological Sciences, State University of New York at Binghamton, 1982

PROFESSIONAL EXPERIENCE

WSP USA, Fort Myers, Florida, 2016–Present
Courtesy faculty; Florida Gulf Coast University; 2018–Present
Schlumberger Water Services, Fort Myers, Florida, 2007–2016
CDM, Fort Myers, Florida, 2002–2007
Missimer International, Inc., Fort Myers, Florida, 1995–2004
ViroGroup Inc., Miami Lakes, Florida, 1992–1995
University of Miami, Miami/Fort Lauderdale Area, 1991–1992
Research Associate; University of Cambridge, United Kingdom, 1989–1991
University of Miami, Rosenstiel School of Marine and Atmospheric Sciences; 1988–1992

REPRESENTATIVE PROJECTS

- Over 30 years of consulting work on water supply projects including the raw water supply and concentrate disposal for brackish groundwater and seawater desalination systems.
- Managed numerous conventional and alternative water supply projects including raw supplies for brackish groundwater and seawater desalination facilities.
- Collaborated on various research projects on water supply and hydrogeology.
- Conducted research on the petrology and chemistry of carbonate rocks.

REPRESENTATIVE AWARDS AND HONORS

Legacy Award, ENR Southeast, 2019 Best Paper Award, journal Palaois, SEPM Society for Economic Geology, 1989

RELEVANT PUBLICATIONS AND PATENTS

- Maliva, R.G., S. Manahan, M. Thomas, S. James, and R. Taylor. 2022. "Challenges and solutions to developing alternative water supplies in Central Florida: Polk Regional Water Cooperative Experiences." *Florida Water Resources Journal* 73(2): 64-69. February.
- Missimer, T.M., and R.G. Maliva. 2017. "Environmental issues in seawater reverse osmosis desalination: Intakes and outfalls." *Desalination* 343, 198-215.
- Maliva, R.G., and T.M. Missimer. 2015. "Well intake systems for SWRO systems: design and limitations." In *Intakes and Outfalls for Seawater Reverse-Osmosis Desalination Facilities*. Eds. T.M. Missimer, B. Jones, and R.G. Maliva. Springer: Berlin.

- Maliva, R.G., and T.M. Missimer. 2015. "Self-cleaning beach intake galleries: Design and global applications." In *Intakes and Outfalls for Seawater Reverse-Osmosis Desalination Facilities*. Eds. T.M. Missimer, B. Jones, and R.G. Maliva. Springer: Berlin.
- Missimer, T.M., R.G. Maliva, and T. Pankrantz. 2015. "Innovations in design and operation of SWRO intake systems." In *Intakes and Outfalls for Seawater Reverse-Osmosis Desalination Facilities.* Eds. T.M. Missimer, B. Jones, and R.G. Maliva. Springer: Berlin.
- Missimer, T.M., N. Ghaffour, H.A. Dehwah, R. Rachman, R.G. Maliva, and G. Amy. 2013. "Subsurface intakes for seawater reverse osmosis facilities: Capacity limitation, water quality improvement, and economics." *Desalination* 322: 37–51.
- Maliva, R.G., and T.M. Missimer. 2010. "Self-cleaning beach-gallery design for seawater desalination plants." *Desalination and Water Treatment* 13: 88–95.

Thomas M. Missimer, PhD, PG

Executive-in-Residence, Professor Emeritus, College of Engineering, Florida Gulf Coast University

EDUCATION AND REGISTRATIONS

PhD, Marine Geology and Geophysics, University of Miami, 1997 MS, Geology, Florida State University, 1973 BA, Geology, Franklin and Marshall College, 1972

PROFESSIONAL EXPERIENCE

Eminent Scholar; Florida Gulf Coast University, 2018–Present Courtesy faculty; Florida Gulf Coast University; 2014-2018 Visiting professor; King Abdullah University of Science and Technology, Saudi Arabia, 2011– 2014

Missimer & Associates, Inc., Missimer International, Inc., CDM, Missimer Groundwater Science, Inc., Schlumberger Water Services, 1976–2010

REPRESENTATIVE PROJECTS

- Consulting work on 27 desalination faculties worldwide, 10 subsurface intake systems for seawater desalination plants.
- Conducts research in desalination; design and modeling of BWRO wellfields; teaching groundwater hydrology and solute transport; SWRO biofouling.
- Conducted research in assessment of SWRO innovative intake designs to reduce membrane biofouling rates.
- Conducted research in various aspects of seawater desalination; intake design, economics, innovative designs with geothermal linkage to electricity generation and desalination.

REPRESENTATIVE AWARDS AND HONORS

Best Paper Presentation Award, 1991, World Conference on Desalination and Water Reuse, International Desalination Association, Washington, D.C.

RELEVANT PUBLICATIONS AND PATENTS

- Dehwah, A.H.A., and T.M. Missimer. 2016. "Subsurface intake systems: green choice for improving feed Seawater quality at SWRO desalination plants, Jeddah, Saudi Arabia." *Water Research* 88: 216-224.
- Missimer, T.M., N. Ghaffour, A.H.A. Dehwah, R. Rachman, R.G. Maliva, and G.L. Amy. 2013. "Subsurface intakes for seawater reverse osmosis systems: capacity limitation, water quality improvement, and economics." *Desalination*, v. 322, p. 37-51.
- Ghaffour, N., T.M. Missimer, and G. Amy. 2013. "Technical review and evaluation of the economics of desalination: Current and future challenges for better supply sustainability." *Desalination* 309: 197-207.

- Dehwah, A.H.A., and T.M. Missimer. 2013. "Technical feasibility of using gallery intakes for seawater RO facilities, northern Red Sea coast of Saudi Arabia: The king Abdullah Economic City site." *Desalination and Water Treatment* 51(34-36): 6472-6481.
- Maliva, R.G., and T.M. Missimer. 2011. "Improved aquifer characterization and the optimization of the design of brackish groundwater desalination systems." *Desalination and Water Treatment* 31: 190–196.

Leslie Moulton-Post

President and CEO, Environmental Science Associates, Inc (ESA)

EDUCATION AND REGISTRATIONS

BA, Human Biology (environmental planning and estuarine science emphasis), Stanford University, 1981

PROFESSIONAL EXPERIENCE

President / CEO, Environmental Science Associates (ESA), 2016–Present California Water Practice Leader, ESA, 2000-2016 Environmental Consultant; ESA, 1984-2000

AFFILIATIONS

California Water Education Foundation, Board Member, 2019–Present El Porvenir (nonprofit supporting water and sanitation solutions for rural Nicaraguans), Board Member, 2013–2023

Member: Association of Environmental Professionals, CA WateReuse, CalDesal organizations

REPRESENTATIVE PROJECTS

- President/CEO of Environmental Science Associates (ESA); 2016–Present. Directs strategic development of 700-person employee-owned environmental consulting firm. Continues professional practice providing strategic project and environmental permit planning and program management for water, wastewater, and water reuse projects across California.
- California Water Practice Leader; ESA; 2000-2016. Directed professional consulting team providing broad range of environmental science, planning, compliance and program management services to water, wastewater and water reuse clients across California. Served in Project Manager, Project Director, Lead Technical Analyst and Principal-in-Charge roles for environmental review and permitting programs for major water/wastewater system infrastructure programs. Areas of expertise include: CEQA, NEPA, environmental permitting (state, federal, and local regulations) and environmental program management from project development through permitting to construction, mitigation, and ongoing adaptive management and compliance monitoring and report. See key projects listed below under relevant experience.
- Environmental Consultant; ESA, 1984-2000. Technical analyst and project manager for environmental impact analysis and permitting.
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RELEVANT PROJECTS

- Department of Energy, "National Alliance for Water Innovation (NAWI)'s Energy-Water Desalination Hub" 2020-2024. PI: Peter Fiske, LBNL, https://www.nawihub.org/about A \$130+ million interdisciplinary partnership between LBNL, UC Berkeley, & other academic, national lab, & industry partners. ROLE: Deputy Topic Area Lead for Data, Modeling, and Analysis (DMA), one of four research topic areas in the hub, tasked with assessing costs and technical performance of desalination systems and technologies.
- National Science Foundation Engineering Research Center, "Reinventing the Nation's Urban Water Infrastructure" (ReNUWIt) 2012-2020. PI: Richard Luthy, Stanford, http://www.renuwit.org/ A \$10 million interdisciplinary partnership between UC Berkeley, Stanford, & others. ROLE: Research related to life-cycle costs and environmental impacts of innovative water systems, including desalination and reuse.
- Life-cycle cost and environmental analysis; urban water innovation; desalination and reuse; sustainable infrastructure; system analysis; food-energy-water-carbon nexus; water finance, management and policy.

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APPENDIX D

Context for Feasibility Assessments of Subsurface Intakes within the Overall Desalination Permitting Process

CONTEXT FOR FEASIBILITY ASSESSMENTS OF SUBSURFACE INTAKES WITHIN OVERALL DESALINATION PERMITTING PROCESS

Appendix D provides an interpretation by the Review Panel (Panel) of the likely sequence and timing of the SSI Feasibility Evaluation within the context of the overall permitting process that a project proponent of a seawater desal plant would likely need to complete. This interpretation is based on the Panel's review of the recently published "Draft Seawater Desalination Siting and Streamlining Report to Expedite Permitting" dated June 2023 while considering the apparent sequence of steps for permitting a new or expanded desalination facility as outlined in the 2019 Ocean Plan, Chapter III, Section M.

Each of the process steps listed below reflects the sequence of actions that would likely be required by any proponent of a seawater desalination project located on the California coastline. The California Ocean Plan, including the Desalination Amendment (2019), specifies that seawater desalination projects must use a subsurface seawater intake (SSI) technology rather than a screened open ocean intake to provide the desired plant capacity, unless it can be demonstrated that all applicable SSI technologies are "not feasible" using the definition of "feasible" as specified in the Ocean Plan and in the California Environmental Quality Act (CEQA).

While the Terms of Reference for this Panel defines a relatively narrow scope for addressing the feasibility issue, the overall context of the likely permitting process provides a necessary background for specifying certain key attributes of any project that a project proponent may decide to pursue obtaining the necessary permits from relevant regulatory agencies as well as approval or support from applicable stakeholders such as community groups, tribal interests and environmental justice concerns as reflected in any impacts on access to affordable drinking water. Much of this effort by the project proponent would need to occur before initiating a request for a permit from the appropriate regional water board. This context assists both project proponents and State agencies in determining the likely timeframes, transition points and potential non-technical challenges that must be addressed to migrate through a successful permitting process, assuming that the chosen SSI has been found to be "feasible".

The following brief listing is not expected to be comprehensive in terms of individual actions needed nor is the list intended to follow the exact details of the overall permitting process. It should be noted that the sequence of events listed below have been inferred from the contents of the recent draft document outlining a proposed process intended to streamline and presumably reduce the timeline for the overall permitting process. Since the plan is a draft and not yet approved by the State Board, all actions should be considered as a preliminary interpretation of the plan. The purpose of this Appendix is to emphasize the magnitude and effort likely required before a proposed project plan is sufficiently detailed and "mature" to subject the project to the feasibility assessment currently being considered by the Regional Board. Regardless of the final contents of the streamlined process, the Panel opines that many decisions will have to be agreed to by many parties prior to the initiation of the feasibility assessment. This context also serves as a foundation for the Panel's recommendations for the technical components of such an assessment given the likely duration and cost of the overall permitting process, as well as uncertainties of successful application.

Step 1: Complete integrated water resource management process

- a. Project proponent will likely need to justify seawater desalination as necessary alternative for meeting water supply resource deficient or reliability criteria and time frame for justification.
- b. Prepare Water Supply and Demand Assessment
 - i. Would need to demonstrate that project is cost effective and supports affordable water rates and access to safe drinking water for all communities.
 - ii. Analysis should be based on Department of Water Resources' Guidebook for Urban Water Management Plans 2025.
- c. Specify desired output and determine hydraulic capacity (i.e., desired production rate) of plant
- d. Propose site(s) that are likely candidates for intake and facility locations.
- e. Obtain approval of project concept and size by all relevant agencies, including Department of Water Resources. This action will require preparation of a report summarizing the conceptual design of the facility and a listing of a reasonable range of sites and SSI combinations for consideration in the FA.

Step 2: Prepare preliminary project description identifying all factors to be considered in formal permit application (to be used for pre-application meetings with all relevant agencies; this report would include more details that in the conceptual design report)

- a. Identify potential sites and land use issues
- b. Size of plant based on approval from Step 1
- c. Identify likely subsurface intake option(s)
- d. Complete preliminary feasibility assessment of site/technology viable combinations desktop assessment of relevant factors
 - i. Hydrogeologic setting can impacts to local aquifers be eliminated? Is groundwater modeling needed?
 - ii. Constructability
 - iii. Coastal hazards determine time frame and modeling needs to assess sea level rise and climate change
 - iv. Preliminary cost estimates (50% +/-), including evaluation of impacts on water rates
- e. Address issues arising from potential impacts to marine life of construction of intake and discharge infrastructure
- f. Identify potential mitigation options for construction environmental impacts
- g. Assess brine disposal options
- h. Identify appropriate Community groups and tribal entities

Step 3: Pre-application, multi-agency meetings to identify information needs

a. Identify all agencies according to regulatory agencies Memorandum of Agreement (MOA) 2019

Step 4: Pre-application meetings with community groups, tribes, other interested parties

a. Identify all key issues that may require additional analysis in permit application.

Step 5: Revise preliminary plan as appropriate based on results of pre-application meetings and obtain regulatory approval from lead agency to proceed to SSI Feasibility Assessment

Step 6: Conduct Feasibility Evaluation of subsurface intake system for proposed site or sites, and scale based on steps 1 to 5 (evaluation based on four factors defining feasibility [constructability; risk and reliability; environmental impacts; economics] with an emphasis on any additional factors identified in the 2019 Ocean Plan, which must be considered in any feasibility assessment.

- a. Workplan submittal and agreement on SOW with regional board
- b. Data collection from existing data sources
- c. Desktop screening tool application and determination of need for additional studies
- d. Field studies to close data gaps for feasibility evaluation
- e. Pilot tests at scale (if needed)
- f. Final assessment, reporting, and recommendation to regional board

Step 7: Prepare permit applications assuming Board concurrence on feasible option

(If not feasible, proceed to alternative path for permit applications for surface intake option).

Step 8: Permit application submitted concurrently to all agencies listed in MOA

- a. Water Board determination Water Code 13142.5(b)
- b. Land Lease application
- c. NPDES permit application
- d. CEQA document preparation
- e. Coastal Development application
- f. Community groups and tribe

The Feasibility Assessment process is summarized in Step 6 above, an abbreviated sequence of subtasks that a project proponent would need to undertake with concurrence by the relevant Regional Board. The duration of each of these steps, decision points and inter regulatory interactions and communications are not easily determined but some discussion of these issues should be considered for inclusion into the final regulatory guidance document which may be prepared by the Board. Some recommendations on these points have been included in this Panel Report (See Section 4). These recommendations are presented visually in Figure 4.1 with additional details on the various proposed stages as noted in the text.

APPENDIX E System Type Specific Feasibility Factors

SYSTEM TYPE SPECIFIC FEASIBILITY FACTORS

Vertical Beach Wells

Vertical (beach) wells are perhaps the simplest alternative intake system type and have the great advantage of employing a very well-established technology. They also have the advantage of being a highly modular option as capacity can be readily increased by the construction of additional wells. The main feasibility factors for vertical wells are summarized in Table E-1. The most important physical factor is the presence of a suitable aquifer along the coast, which has sufficiently high transmissivity and connection to the sea to provide the required volume of seawater. System costs depend largely on well capacity and thus the number of wells required to provide a given volume of raw water.

Factor Type	Feasibility Considerations
Physical	Coastal aquifer transmissivity should be sufficiently high to provide target well yields.
	Production zone should be hydraulically well connected to the ocean so that wells are
	producing seawater
	Sufficient physically and legally accessible well sites should be available along the beach
	for required number of wells
Raw water	Wells will draw in water from 360° around each well. Raw water chemistry may vary from
quality	seawater and be adversely impacted due to landward contribution and fluid-rock interactions
Reliability	Wells are prone to a loss of capacity due to clogging, with screened wells having the
	greatest risk.
	Vertical well rehabilitation involves well known and proven technologies, but rehabilitation
	may not completely restore wells
Environment	Well construction can limit beach access (area must be cordoned off) and drilling sites are
impacts	unsightly.
	Possible impacts to onshore (beach) ecosystems during construction.
	Wells may draw in fresh groundwater with associated loss of resource.
	Drawdowns could impact local wetlands.
Risks	Well yields are uncertain in advance. However, vertical wells can be readily pilot tested by
	constructing and testing an initial well(s).
	Vertical wells are a very well established and understood technology.
	Additional wells can be constructed to provide additional and back-up capacity or to
	replaced failed wells.
	Wells can be impacted by erosion and thus should be located in stable areas.
Costs	Competitive marketthere are many well drillers who could construct wells.
	System costs will depend on number of wells and spacing

Table E-1: Vertical Wells Feasibility Factors

Slant Wells

Slant wells have the advantages that multiple wells can be drilled from a single launching point, a longer screen-length in the production zone may allow for greater well yields, and the position of the screen subsea may allow for the production of mostly seawater, minimizing impacts to adjoining fresh groundwater resources and coastal ecosystems. The wells are more difficult and expensive to construct than vertical wells, there are fewer contractors capable of constructing them (the slant well technology applied to seawater intakes is patented), and there is a very limited track record—just the Dana Point and Monterrey test wells.

Factor Type	Feasibility Considerations
Physical	Coastal aquifer transmissivity should be sufficiently high to provide target well yields.
	Production zone should be hydraulically well connected to the ocean.
	A physically and legally accessible launch site(s) at the required distance from the shore
	should be available.
	Slant wells are more difficult to construct than vertical wells, particularly the emplacement
	of an adequate filter pack.
Raw water	Wells may draw in water from the landward direction, but slant wells will tend to draw in a
quality	greater proportion of seawater than vertical wells.
	Deeper semiconfined aquifers used for production zones may have chemically reducing
	conditions with associated metals (e.g., iron, manganese) mobilization. Mixing of waters
	with different redox states can result in adverse fluid-rock interactions (e.g., clogging and
	water quality deterioration).
Reliability	Slant wells, like vertical wells, are prone to a loss of capacity due to clogging. Test wells
	experienced significant loss of capacity.
	Well rehabilitation would involve similar known technologies as used in vertical wells, but
	their effectiveness in slant wells is uncertain
Environment	The well drilling area will be disturbed and drilling operations are unsightly. Use of fewer
impacts	launch areas is advantageous.
	Possible impacts to nearby onshore ecosystems during construction.
	Completed wells can be made minimally aesthetically intrusive, above ground elements
	(wellhead piping) can be enclosed in a small well house or fenced enclosure.
	Wells can draw in fresh groundwater with associated loss of resources. However, this is of
	lesser of concern than with vertical wells.
	Drawdowns could impact local wetlands, which would also be a lesser concern than with
	vertical wells.
Risks	Slant wells are more expensive to construct. Pilot testing in involves a large investment.
	Slant wells do not have an operational track record—there are no operational systems with
	long -term data.
	Additional wells can be constructed to provide additional or back-up capacity or to replaced
	failed wells.
Costs	Not a competitive market—technology is patented.
	System costs will depend on number of wells and spacing.

Table E-2: Slant Wells Feasibility Factors

Horizontal Wells

Horizontal wells are screens or permeable casing (Neodren microporous pipe) installed by directional drilling from a common location (launch point) on the shoreline. The screens/pipes fan out at a shallow depth below the seafloor. The main advantage of offshore horizontal wells is that large capacities can be obtained from an array of wells extending from a single launch point, reducing the surface footprint of the systems. As the wells are shallow, the feedwater is derived essentially entirely from the ocean through vertical infiltration through the seafloor. The productivity of the wells is the function of the permeability of the overlying sediments. The systems require stable offshore conditions as they could be impacted by offshore erosion or sediment build up.

Factor Type	Feasibility Considerations
Physical	Shallow offshore sediments should be sufficiently permeable to achieve target well yields.
	A rocky seabed is not acceptable.
	The offshore topography should be level or gently sloping. Depressions should not be
	present in which a screen may be exposed.
	Offshore sedimentation regime should be stable so that neither exposure of the wells by
	erosion or their deeper burial occurs.
	A physically and legally accessible launch site(s) at the required distance from the shore
	must be available.
	Neodren technology does not require a separate filter pack which simplifies construction.
	However, the entire pipe must be sufficiently buried.
Raw water	Wells will tend to draw entirely seawater, impacts of coastal freshwater aquifers is not a
quality	concern.
	Systems provide water quality improvement benefits, but inadequate operational data is not
	publicly available to fully quantify. Some pretreatment may still be required.
Reliability	Wells lose capacity due to clogging.
	It is uncertain whether or how the microporous Neodren pipe can be rehabilitated.
Environment	The well drilling area will be disturbed and drilling operations are unsightly. Use of one
impacts	launch area is advantageous.
	Possible impacts to nearby onshore ecosystems during construction.
	Systems involve offshore construction, but any impacts will be temporary
	The launch area can be made less aesthetically intrusive by enclosure in well house or
	fenced enclosure.
	Long-term onshore environmental, hydrological, and human impacts would be negligible.
Risks	Pilot testing of a single well would involve a large investment
	If near offshore sedimentological conditions are favorable, then there is confidence that the
	concept is viable as there are operational systems (technology has a track record).
	Systems will lose capacity over time and is uncertain whether means are available to restore
	capacity (short of installing additional wells).
Costs	Not a competitive market—Neodren technology is patented (Catalana de. Perforacions).
	System cost will depend on the number of horizontal wells.

Table	E-3:	Horizontal	Wells	Feasibility	Factors
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Horizontal (Ranney) Collector Well

A collector well consists of a large diameter (typically 18 feet) caisson from which usually 200 to 300 ft long lateral perforated spokes are advanced out from the caisson toward a proximate water body. Horizontal collector wells have been used for freshwater supply since 1993 and hundreds have been constructed, so the technology is mature. However, its use as an alternative seawater intake is very limited (PEMEX Salina Cruz Refinery, Mexico system). Horizontal collectors are normally installed in unlithified sediments with the laterals installed in coarse-grained, high permeability strata. An unusual proposed large seawater horizontal collector system in Miami-Dade County, Florida, would be installed in limestone. The extremely high transmissivity Biscayne Aquifer to be used may represent extraordinary conditions.

The major advantage of horizontal collector systems is a large capacity (usually 4 to 5 MGD or greater). A single collector would have the capacity of several vertical wells and have a single pumping system.

Factor Type	Feasibility Considerations
Physical	Typically requires the presence of a shallow, coarse-grained unlithified aquifer at the shore
	that is suitable for the installation of the caisson and has high-permeability strata needed to
	obtain sufficient yields from the laterals.
	Due to restrictions on the lengths of laterals, the caisson and pump station need to be located
	close to the shore. The shoreline at the system location should not be retreating or rapidly
	prograding.
	A physically and legally accessible caisson location at the required distance from the shore
	must be available.
Raw water quality	Laterals extending seaward would tend to produce seawater, whereas laterals located
	landward or parallel to the beach could produce varying amounts of water from the
	landward direction. Some impacts to coastal freshwater aquifers are possible (site specific).
	System would be expected to provide water quality benefits (filtration).
Reliability	If hydrogeological conditions are favorable, horizontal collectors have had high reliabilities.
	Laterals may clog (as is the case for all wells) and rehabilitation would require temporary
	shutting down of the entire collector.
Environment	Local disturbances at and around the collector site during construction. Construction of a
impacts	single collector is less disruptive than for multiple separate vertical wells.
	The collectors are usually housed in a building which can be intrusive on a beach. The
	building can be constructed to be less aesthetically objectionable.
	Landward drawdowns and associated environmental impacts are possible.
	Landward freshwater could be drawn toward collector
Risks	Pilot testing of a small-scale system is not practical—the caisson and at least one lateral
	would have to be constructed. A large financial commitment is thus required before there is
	assurance the system will operate as planned.
	Systems will lose capacity over time due to clogging of the laterals. It is uncertain how
	effective rehabilitation would be to restore capacity. Caisson could be designed with extra
	ports to install additional laterals in the future.
Costs	Horizontal collector system can be an economical alternative to multiple vertical wells.
	Poorly competitive market-very few contractors in this niche market.

Table E-4: Horizontal (Ranney) Collector Well Feasibility Factors

Beach Galleries and Trenches

Beach gallery and trench intake systems are types of slow sand filter that are constructed beneath the intertidal zone of a beach. The galleries and trenches are covered with native beach sand with the intention that the presence of the buried structures not be visible. The pumping system can be constructed a sufficient distance landward so as to not impact beach activities or be visually intrusive. Breaking wave action and the activities of organisms prevent the development of a clogging layer (i.e., they are self-cleaning; Maliva and Missimer, 2010). A key technical requirement is that a beach be stable. If erosion is occurring, then the gallery or trench may be partially or completely exhumed. If a beach is prograding, then the gallery could become stranded onshore.

Some very small-scale systems have been reportedly constructed on islands, but a large-scale system has not been constructed to date. Systems are scalable as additional gallery units can be constructed to increase capacity.

Factor Type	Feasibility Considerations
Physical	Requires the presence of a sandy beach that is neither significantly retreating or prograding.
	The beach sands should be sufficiently permeable so as to not impede infiltration and flow
	into underlying engineered layers—silty and muddy areas should be avoided.
Raw water quality	Systems would produce only seawater.
	System would be expected to provide water quality benefits (filtration).
	High geochemical stability expected.
Reliability	Good reliability would be expected if the beach is stable.
	Clogging potential is unknown. If clogging does occur within the interior of the gallery or
	trench, then there is very limited opportunity for remediation short of reconstructing the
	system.
Environment	Large local impacts on and adjoining the beach during construction.
impacts	Construction would locally exclude public use of the beach, which could impact local
	businesses.
	No adverse environmental impacts would be expected during operation, a system would be
	essentially invisible.
Risks	No large operational system exists, there is no proven long-term track record for the
	technology.
	Pilot testing is possible for a large-scale system, but could be expensive because of the
	difficulties of construction on a beach with significant wave action.
	The long-term performance of systems is unknown and there is little that can be practically
	done to restore capacity if clogging is internal. Clogging at the sediment-water interface can
	be remediated.
Costs	Large-scale construction in the intertidal zone can be very costly particularly if sheet piling
	is required.
	Requires company with marine construction capability.

 Table E-5: Beach Gallery or Trench Feasibility Factors

Seabed Galleries (or Seabed Infiltration Galleries)

Seabed galleries (or seabed infiltration galleries, SIGs) are also engineered slow sand filters that are constructed offshore, within the subtidal zone. Systems can be constructed immediately seaward of the beach, where they are just shallowly submerged during low tide, or further offshore. An advantage of a subtidal location compared to an intertidal location is that infiltration is continuous. A very large (≈ 27.2 MGD) SIG system has been operational in Fukuoka, Japan, since

2005. A 300,000 gpd shallow subtidal demonstration system project has recently completed testing by the Long Beach Water Department at Junipero Beach.

Factor Type	Feasibility Considerations
Physical	Requires the presence of a sandy seabed that is neither subject to significant erosion or
	sediment deposition, nor likely to be disturbed by storms.
	The shallow sands should be sufficiently permeable so as to not impede infiltration and flow
	into underlying engineered layers—silty and muddy areas should be avoided.
	Off-shore construction is much more challenging and expensive than construction on land.
	Gallery site should not be susceptible to disturbance by human activities (e.g., anchors,
	fishing).
Raw water quality	Systems would produce only seawater.
	Systems would be expected to provide water quality benefits (filtration).
	High geochemical stability expected.
Environment	Large local temporary impacts on and adjoining the beach during construction for shallow
impacts	subtidal systems.
	Temporary disturbance of the seabed during construction.
	No adverse environmental impacts would be expected during operation, as a system would
	be essentially invisible.
Risks	A large financial commitment would be required before performance is determined. Pilot
	testing for a large-scale system (such as was done for the Long Beach demonstration) would
	be very expensive (at least several million dollars) and much more so for a deeper offshore
	system.
	Clogging potential is unknown. If clogging does occur within the interior of the gallery,
	then there is very limited opportunity for remediation short of reconstructing the system.
	Surficial (at sediment-water interface) clogging may be prevented by benthic organisms.
	Otherwise, surfaces could be mechanically cleaned.
Costs	High costs associated with subsurface construction.
	Requires company with marine construction capability.

Table E-6: Seabed Gallery Feasibility Factors

APPENDIX F Contract Requirements and Deliverables

CONTRACT REQUIREMENTS AND DELIVERABLES

CONCUR Inc. Acknowledgement of Contract Requirements

In submitting this Report, CONCUR makes the following acknowledgements:

Description of Funding: "Funding for this project has been provided in full or in part by the United States Environmental Protection Agency and the State Water Resources Control Board under the Federal Water Quality Management Planning Program (Clean Water Act section 205[j]). The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use."

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Acknowledgement: Not a commitment to fund any eventual construction/implementation project.

We acknowledge and understand that the Recipient's receipt of funding under this grant is not a commitment to and does not obligate the State Water Board to provide funding for any eventual construction/implementation project.

Note Regarding the Quality Assurance Project Plan: This report <u>does not</u> include environmental monitoring or measurement; hence provisions pertaining to the Quality Assurance Plan listed below <u>do not apply</u>.

Quality Assurance Project Plan

If the Project includes any environmental monitoring or measurement, the Recipient shall also prepare, maintain, and implement a Quality Assurance Project Plan (QAPP) in accordance with the State Water Board's Surface Water Ambient Monitoring Program's (SWAMP) QAPP and data reporting requirements, the SWAMP Quality Assurance Program Plan Guidelines, and the USEPA QAPP, EPA AQ/R5, 3/01. Water quality monitoring data includes physical, chemical, and biological monitoring of any surface water. Electronic submittal of data collected in accordance with SWAMP shall be required. The QAPP shall be submitted to the State Water Board or Regional Water Board's Quality Assurance (QA) Officer for review and a decision regarding approval prior to the Recipient implementing any sampling or monitoring activities. The Recipient shall submit a pdf version of the final QAPP, approved by USEPA, to the Grant Manager. No monitoring may occur prior to QAPP approval. Any costs related to monitoring data collected prior to and not supported by the approved QAPP will not be reimbursed. Guidance for preparing OAPP available the is at: http://www.waterboards.ca.gov/water issues/programs/swamp/tools.shtml#qa

Additional Representations and Warranties

In submitting this report, CONCUR Inc confirms that;

- 1. The Recipient has not made any untrue statement of a material fact in its application for this financial assistance, or omitted to state in its application a material fact that makes the statements in its application not misleading.
- 2. The Recipient agrees to fulfill all assurances, declarations, representations, and commitments in its application, accompanying documents, and communications filed in support of its request for funding under this Agreement.
- 3. The execution, delivery, and performance by Recipient of this Agreement, including all incorporated documents, do not violate any provision of any law or regulation in effect as of the date set forth on the first page hereof, or result in any breach or default under any contract, obligation, indenture, or other instrument to which Recipient is a party or by which Recipient is bound as of the date set forth on the Cover Page.
- 4. There are, as of the date of execution of this Agreement by the Recipient, no pending or, to Recipient's knowledge, threatened actions, claims, investigations, suits, or proceedings before any governmental authority, court, or administrative agency which materially affect the financial condition or operations of the Recipient, the Revenues, and/or the Project.
- 5. There are no proceedings, actions, or offers by a public entity to acquire by purchase or the power of eminent domain any of the real or personal property related to or necessary for the Project.
- 6. The Recipient is duly organized and existing and in good standing under the laws of the State of California. Recipient must at all times maintain its current legal existence and preserve and keep in full force and effect its legal rights and authority. Within the preceding ten years, the Recipient has not failed to demonstrate compliance with state or federal audit disallowances.
- 7. Any financial statements or other financial documentation of Recipient previously delivered to the State Water Board as of the date(s) set forth in such financial statements or other financial documentation: (a) are materially complete and correct; (b) present fairly the financial condition of the Recipient; and (c) have been prepared in accordance with GAAP. Since the date(s) of such financial statements or other financial condition of the Recipient adverse change in the financial condition of the Recipient, nor have any assets or properties reflected on such financial statements or other financial documentation been sold, transferred, assigned, mortgaged, pledged or encumbered, except as previously disclosed in writing by Recipient and approved in writing by the State Water Board.
- 8. The Recipient is current in its continuing disclosure obligations associated with its material debt, if any.
- 9. The Recipient has no conflicting or material obligations.

- 10. The Recipient has sufficient real or personal property rights necessary for the purposes of this Agreement, not subject to third party revocation, which rights extend at least to the Records Retention End Date of this Agreement, except as disclosed to the State Water Board. The Recipient has disclosed to the State Water Board all proceedings, actions, or offers of which the Recipient has knowledge or belief that may in any way affect the Recipient's ability to access or legally possess all of the property necessary for the purpose of this Agreement, including any proceedings, actions, or offers to lease, purchase, or acquire by eminent domain any of the real or personal property related to or necessary for the Project.
- 11. The Recipient and its principals, to the best of the Recipient's knowledge and belief, are not presently debarred, suspended, proposed for debarment, declared ineligible, or otherwise excluded from participation in any work overseen, directed, funded, or administered by the State Water Board program for which this grant funding is authorized; nor have they engaged or permitted the performance of services covered by this Agreement from parties that are debarred or suspended or otherwise excluded from or ineligible for participation in any work overseen, directed, funded, or administered by the State Water Board program for which this grant funding is authorized.

Web Content Accessibility

In correspondence dated December 18, 2023, CONCUR was requested to ensure that any data, plans, drawings, specifications, reports, computer programs, operating manuals, notes, and other written or graphic work submitted to the State Water Board or uploaded directly to any State internet website or database in the performance of this Agreement comply with the accessible content requirements set forth in Government Code sections 7405 and 11135; section 508 of the federal Rehabilitation Act (29 USC 794d) and the regulations promulgated thereunder (36 CFR part 1194); and the most current Web Content Accessibility Guidelines published by the Web Accessibility Initiative of the World Wide Web Consortium at a minimum Level AA success criteria. The final version of the SSI Panel Report will comply with the above web content accessibility requirements.

<u>Contract Deliverables as Required under Exhibit A-5 of Agreement</u> DD2215001

The following contract deliverables have been completed:

- Task 1.2.1.4 Ensure that grant requirements are met through completion of quarterly reports submitted to the Grant Manager
 - January through March, April 2023
 - April through June, 2023
 - July through September, 2023
 - October through December 2023
 - January through March 2024
- Task 1.2.3.1 Provide the Grant Manager with five (5) to eight (8) suggested members of the panel as principal investigators with their areas of expertise.

- Task 1.2.3.2 Draft the Panelist invitation language that includes a list of duties and send drafts to the Grant Manager for approval. This text was developed in the spring of 2023 and approved by the Grant Manager.
- Task 1.2.3.3 Transmitted a complete set of executed contracts signed by all Panelists. Executed contracts were transmitted to the Grant Manager, as well as related Certifications, documenting no Conflicts of Interests.
- Task 1.2.2.1 Final Terms of Reference document adopted by the Panel and deemed complete by State Board Staff September 25, 2023.
- Task 1.2.4 Facilitation of the Panel's Work. CONCUR handled this task consistently over the duration of the contract, maintaining regular contact with all members of the Panel since their appointment, and reinforced with regular check-in calls. This effort has continued through check-in calls convened in January through April.
- Task 1.2.4.1 Coordinate and Oversee the Panel's Development of Final Work Program. As planned in our approach, the work program was developed over the course of several Panel Check-in meetings.
- Task 1.2.4.2. Arrange Meetings and Conference Calls to Support the Panel's Work. Meetings were convened on dates listed below for which meeting summaries were transmitted.
 - May 11, 2023 Kick-off call; initial briefing with State Board staff
 - May 31, 2023 Subsurface Panel Check in Meeting Panel Meeting
 - June 21, 2023 Subsurface Panel Check in Meeting
 - July 5, 2023 Subsurface Panel Check in Meeting
 - July 12, 2023 Subsurface Panel Check-in Meeting
 - July 26, 2023 Subsurface Panel Check-in Meeting
 - August 30, 2023 Subsurface Panel Check-in Meeting
 - September 6, 2023 Subsurface Panel Check in Meeting
 - September 30, 2023 Subsurface Panel Check-in Meeting
 - October 11, 2023 Subsurface Panel Check-in Meeting Check-In
 - October 25, 2023 Subsurface Panel Check-in Meeting
 - November 1, 2023 Subsurface Panel Check-in Meeting
 - November 8, 2023 Subsurface Panel Check-in Meeting
 - November 29, 2023 Subsurface Panel Check-in Meeting
 - January 5, 2024 Subsurface Panel Check-in Meeting
 - January 17, 2024 Subsurface Panel Check-in Meeting
 - January 25, 2024 Subsurface Panel Check-in Meeting
 - March 22, 2024 Subsurface Panel Check-in Meeting

- April 3, 2024 Subsurface Panel Check-in Meeting
- April 17, 2024 Subsurface Panel Check-in Meeting
- April 21, 2024 Subsurface Panel Check-in Meeting
- Task 1.2.4.3 Assemble and synthesize draft documents. CONCUR has worked with the Panel to develop and synthesize draft documents over the course of this project, including draft and revised report outlines, draft and revised Terms of Reference text, and draft and revised Report text. CONCUR has also circulated Meeting summaries for review by the Panel prior to their transmittal to State Board staff.
- Task 1.2.5.1. Develop a Draft Schedule for the Panel's working meeting. (The draft schedule is a component of the adopted the Work Plan).
- Task 1.2.5.2 Develop a Process to Document Dissenting Views with the Panel. CONCUR developed and transmitted a memo detailing process to document dissenting views, in the even they arise. As of the submittal of the Final Report, no dissenting views were expressed. Moreover, all Panelists accepted authorship and attribution of the full report.
- Task 1.2.6.2.1 Prepare a draft agenda for the Panel's work scoping and deliberations meeting. This agenda was devised, reviewed by the Contact Manager, and approved.
- Task Number 1.2.7.1 Draft Report. The draft report was transmitted on November 21, 2023 before the November 30 Agreement deadline. While State Board staff acknowledged receipt of this transmittal, the document was deemed incomplete by State Board staff relative to contract requirements. A revised draft report was transmitted on January 30, 2024 to represent a complete draft consistent with all contract requirements. The Revised Draft Report was received by State Board staff.
- Task Number 1.2.7.2 Final Report. The Final Report was transmitted on April 29, 2024 consistent with the deadline from State Board staff.