July 29, 2016

Mr. David M. Jinkens, City Manager  
City of Avalon  
PO Box 707  
Avalon, CA 90704

Subject: Desalination Plant - Reliable Yield

Dear Mr. Jinkens:

Due to the record drought conditions experienced throughout California and on Santa Catalina Island in particular, and the low water levels in the Middle Ranch Reservoir, Carollo Engineers, Inc. was hired by the City of Avalon to evaluate the reliable yield of the seawater desalination plants operated by Southern California Edison Company - Catalina Island (hereafter, SCE). The following letter presents the findings from this evaluation - however, it can be summarized that:

- When operating alone and treating water from Quarry Wells 1 and 2 (i.e., operating Scenario 2), the new Desalination Plant #2 produces 28,800 gallons per day (gpd) more water than the existing Desalination Plant #1 operating alone.

- There is not adequate capacity from Quarry Wells 1 and 2 to supply seawater directly to both Desalination Plants #1 and #2 simultaneously (i.e., Desalination Plant #1 running independently and Desalination Plant #2 operating by Scenario 2).

- The State of California Department of Drinking Water has recently approved operation of Desalination Plant #2 using brine from Desalination Plant #1 (i.e., Operating Scenarios 1A and 1B). Therefore, the net increase in potable water production capacity achieved by SCE is estimated at 120,000 gallons per day (gpd) when compared to the production from Desalination Plant #1 operating alone. Performance testing should be used to verify that this additional 120,000 gpd from Desalination Plant #2 is achievable.

- Operating Desalination Plant #2 using brine from Desalination Plant #1 (i.e., Operating Scenarios 1A and 1B) in conjunction with Stage 3 water rationing, which is scheduled to begin September 6, 2016, will help conserve and protect Catalina Island’s fresh groundwater supply. However, if the drought persists and freshwater wells are unavailable as a back-up water supply, State regulations may require additional capital improvements be implemented (e.g., redundant Quarry Wells and/or treatment equipment) to ensure a continuous, reliable supply of water to the City.

BACKGROUND

The City of Avalon, California is located on Santa Catalina Island, 30 miles southwest of Long Beach off the coast of Southern California. The City receives potable water from SCE, who operates a community water system to a permanent population of 4,200 through 1,880 active service connections. However, SCE has a seasonal maximum population of 650,000. SCE’s water supply consists of ten (10) fresh groundwater wells and two seawater desalination plants that are supplied water from Quarry Wells 1 and 2.
Due to the record drought conditions that have been experienced through California and on Santa Catalina Island in particular, SCE has instituted Stage 2 water rationing. Stage 2 rationing requires a reduction of water usage by 25 percent and was triggered when the water level in the Middle Ranch Reservoir dropped below 300 acre-feet. The Middle Ranch Reservoir is an outdoor reservoir that recharges the groundwater basin that supplies water to SCE's freshwater wells. The Middle Ranch Reservoir has now fallen below 200 AF, which normally requires Stage 3 rationing, reducing water usage by 50 percent. However, SCE added Seawater Desalination Plant #2 as a new supply, and it has been permitted for operation since March 21, 2016. The addition of Desalination Plant #2 delayed the initiation of Stage 3 water rationing, and Stage 3 water rationing is scheduled to begin September 6, 2016.

Desalination Plant #2 was designed by SCE to operate under three scenarios:

- Scenario 1A - 100% brine feed from the existing RO unit, (with 35 gallons per minute (gpm) of permeate from Desalination Plant #2 recycled, and mixed with the brine to keep total dissolved solids (TDS) concentrations below 50,000 mg/L in Desalination Plant #2’s supply). ¹,²

- Scenario 1B - Blend of brine feed from the existing RO unit and raw seawater from Wells 1 and 2. Allows for taking one or more of the Desalination Plant #1 RO trains out of service while operating the remaining RO trains. The raw seawater that would have been fed to the offline RO train(s) is fed instead to Desalination Plant #2.

- Scenario 2 - 100% raw seawater from Quarry Wells 1 and 2.

Desalination Plant #2 is permitted to operate under each of the three scenarios.

PURPOSE

Faced with the potential for increased water shortage and payment of costs to SCE for implementing Desalination Plant #2, the City of Avalon seeks to better understand the yield and reliability of SCE's two desalination plants. Therefore, the purpose of this letter is to determine the reliable maximum yield produced by Desalination Plants #1 and #2 by evaluating:

- If Quarry Wells 1 and 2 have production capacity limitations affecting short-term and long-term yield of the wells.

- If Operating Scenarios 1A and 1B are necessary for SCE to achieve added production capacity, or if additional seawater supply wells are required.

- Brine disposal permit requirements that may limit brine quality or quantity of discharge.

- State requirements for redundancy of groundwater wells, treatment equipment and availability of spare parts.

¹ Per SCE's Operation and Maintenance Manual for Additional Desal System for the Pebbly Beach Generating Station Catalina Island, CA.
EVALUATION OF QUARRY WELLS No. 1 AND 2 PRODUCTION

Quarry Wells 1 and 2 were constructed in 2002 on the southeast side of Santa Catalina Island. Each well has a maximum pumping capacity of 300 gpm. However, the combined capacity of both wells is limited to about 400 gpm to limit the sand and silt in the seawater pumped from the wells. The wells were redeveloped in 2013, and a video survey of the wells made just prior to redevelopment showed “severe encrustation, mineral scaling, and heavy biological growth throughout the entire wetted portion of each well, as well as free-swimming invertebrates. In places, the horizontal slots of the well screens appeared to be almost completely clogged.” Following redevelopment, an additional video survey was made of each well. In both wells, the movement of the camera brought fine material into the well, which may be an indication that the well's gravel pack may no longer be functioning as needed. Well testing were performed in 2013 and a specific capacity for each well was calculated. Specific capacities measured during future well tests can be compared to those values to determine if well efficiency is decreasing with time.

Because Quarry Wells 1 and 2 have experienced past loss of production efficiency, and because of the possibility that their gravel pack no longer functions as intended, these wells may need to be redeveloped or replaced in the future to ensure that SCE can continue to reliably produce water at their desalination plants. The reliability of Quarry Wells 1 and 2 may become more important should the drought conditions persist and fresh water well production capacity becomes very limited or curtailed.

EVALUATION OF DESALINATION PLANT #1 AND #2 OPERATING CONDITIONS

The gain in production capacity as a result of adding Desalination Plant #2 was evaluated. The net increase in production capacity for each scenario was determined by comparing production capacity of Desalination Plant #1, which is equal to 140 gpm (201,600 gpd), to the production capacity of each scenario. Process flow diagrams for the Desalination Plant #2 operating scenarios are presented in Figures 1A, 1B, and 2. The process flow diagram for Desalination Plant #1 operating by itself (i.e., as it was before Desalination Plant #2 was added) is presented in Figure 3. The flow lines are numbered in the figures, and Table 1 provides the flow rate and water quality in each numbered line.

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3 Letter from Geoscience Support Services Incorporated to Southern California Edison, dated October 25, 2013, Subject – Summary of Redevelopment and Testing of Seawater Intake Wells Santa Catalina Island, CA.
Figure 1A - Process Flow Schematic: Desalination Plants #1 and #2 - Operating Scenario 1A

Desalination Plant #1

Note: Both Quarry Wells #1 and #2 are required for operation.

Figure 1B - Process Flow Schematic: Desalination Plants #1 and #2 - Operating Scenario 1B

Desalination Plant #2

Note: Both Quarry Wells #1 and #2 are required for operation.
Note: Both Quarry Wells #1 and #2 are required for operation.

**Figure 2 - Process Flow Schematic: Desalination Plants #1 and #2 - Operating Scenario 2**

Note: Both Quarry Wells #1 and #2 are required for operation.

**Figure 3 - Process Flow Schematic: Desalination Plant #1**
Table 1  Summary of Desalination Plant Flow Rates and Water Quality

<table>
<thead>
<tr>
<th>Flow</th>
<th>Description</th>
<th>Parameter</th>
<th>Scenario 1A</th>
<th>Scenario 1B</th>
<th>Scenario 2</th>
<th>Desal Plant #1 Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seawater from Quarry Wells</td>
<td>TDS, mg/L</td>
<td>(37,500)&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>(37,500)&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>(37,500)&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>(37,500)&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>1-A</td>
<td>Seawater feed to Cartridge Filters</td>
<td>Flow, gpm</td>
<td>100 - 300</td>
<td>400</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1-B</td>
<td>Seawater feed to Desal Plant 1</td>
<td>TDS, mg/L</td>
<td>(37,500)&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>(37,500)&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>Desal Plant 1 Brine</td>
<td>TDS, mg/L</td>
<td>(57,700)&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>(57,700)&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>--</td>
<td>(57,700)&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>Flow from Break Tank to Plant 2</td>
<td>Flow, gpm</td>
<td>295</td>
<td>295 - 365</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>Desal Plant 2 Total Permeate</td>
<td>TDS, mg/L</td>
<td>(500)&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>(500)&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>(500)&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>Permeate Recycle</td>
<td>Flow, gpm</td>
<td>35&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>Desal Plant 2 Net Permeate</td>
<td>TDS, mg/L</td>
<td>(500)&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>Desal Plant 1 Permeate</td>
<td>TDS, mg/L</td>
<td>No data</td>
<td>No data</td>
<td>--</td>
<td>No data</td>
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<tr>
<td>8</td>
<td>Total Production from Desalination Plant #1 &amp; #2</td>
<td>TDS, mg/L</td>
<td>No data</td>
<td>No data</td>
<td>(500)&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>No data</td>
</tr>
<tr>
<td>9</td>
<td>Brine Discharge</td>
<td>TDS, mg/L</td>
<td>(83,300)&lt;sup&gt;(5)&lt;/sup&gt;</td>
<td>(68,500 - 84,700)</td>
<td>(61,600)</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Net Increase in Production as a Result of Adding Desalination Plant #2</td>
<td>gpm</td>
<td>83</td>
<td>41 – 83</td>
<td>20</td>
<td>--</td>
</tr>
</tbody>
</table>

Notes:


2. Assuming 35% recovery rate from Desalination Plant #1, and based on the Engineering Report mentioning that the Break Tank will receive up to 260 gpm of brine from Desalination Plant #1. “Southern California Edison Operations and Maintenance Manual for Additional Desalination System for Pebble Beach Generation Station, Catalina Island, California” also states that the production rate of the existing Desalination Plant #1 is 140 gpm, with a feed of 400 gpm of seawater, which equals a 35% recovery rate.


5. Assuming 40% recovery rate from Desalination Plant #2, assumption based on Page 13 of the Engineering Report that states: “The GE RO unit (Desalination Plant #2) is designed to produce up to 200 gpm at 40% recovery in Scenario 2.”
Compared to operating Desalination Plant #1 alone, the maximum increase in production capacity after adding Desalination Plant #2 is achieved by Operating Scenario 1A, where 100 percent of the brine from Desalination Plant #1 is fed to Desalination Plant #2. Operating Scenario 1A’s production capacity of 223 gpm (321,120 gpd) is a net increase in potable water production of approximately 120,000 gpd over operating Desalination Plant #1 on its own. Operating Scenario 2 has the lowest increase in production capacity and would net an increase in potable water production of 28,800 gpd.

Since DDW has approved Desalination Plant Operating Scenario 1A, the net increase in production capacity gained from installing Desalination Plant #2 is approximately 120,000 gpd when compared to the production capacity from solely operating Desalination Plant #1. Performance monitoring should be implemented to verify this added production is achieved.

Conceptually, both Desalination Plant #1 and #2 could be operated in parallel, both treating Quarry Well water at their maximum capacities if:

- The combined capacity from Quarry Wells 1 and 2 was 900 gpm, which is greater than the maximum production rate of 400 gpm that currently exists.
- Or, additional wells were constructed with a combined capacity of 500 gpm.

If both plants could operate to treat seawater from Quarry Wells- the combined production capacity would be 432,000 gpd. However, because Quarry Wells 1 and 2 have a combined production capacity limit of 400 gpm, operating both plants in parallel is not an option. Given the existing combined production capacity of 400 gpm from Quarry Wells 1 and 2, Scenario 1A is the option that would result in the largest increase in potable water production (i.e., ~120,000 gpd).

**EVALUATION OF BRINE DISPOSAL PERMIT REQUIREMENTS**

The current NPDES permit allows for up to 0.720 million gallons per day (mgd) of reverse osmosis brine, filter backwash water, untreated seawater, and wastewater from flushing seawater supply pipelines to be discharged into the Pacific Ocean from the Pebble Beach Desalination Plant.\(^4\) The volume of brine produced by the plant decreases from 0.374 mgd (when only Desalination Plant #1 is operating), to 0.255 – 0.346 mgd when Desalination Plant #2 is operating in accordance with the scenarios described above. Operating Desalination Plant #2 will not result in an increase in brine flow and therefore operating Desalination Plant #2 is not expected to result in a violation of the discharge permit’s maximum allowable flow volume.

\(^4\) Order No. R4-2011-0165X / NPDES No. CA0061191: Amendment to the Waste Desalination Plant; issued by the Los Angeles Region, Regional Water Quality Control Board, August 6, 2014 (Tentative)
There will be an increase in the TDS concentration of the brine in every scenario that Plant #2 operates in. The current NPDES permit does not place a limit on TDS concentrations in the flow discharged to the Pacific Ocean, however the permit does state that:

“The previous permit noted that the increase of TDS and other parameters is not expected to result in saline concentrations in the effluent that would result in the degradation of marine life or marine waters. Since there has been no change in the processes used at the Facility, it is not expected that the saline concentrations in the effluent would result in the degradation of marine life or marine waters.”

Seawater TDS concentrations in the area of Santa Catalina Island are approximately 37,000 mg/L. The TDS of brine produced by SCE’s desalination plants ranges from 57,700 to 84,700 mg/L and therefore has a higher density than the seawater near the island. Without proper mixing this dense brine may settle to the ocean floor, causing impacts to benthic marine organisms. Mixing is a function of the brine density and flow rate. Increases in density and decreases in flow rate, like those that result from the operation by Desalination Plant #2 Operating Scenarios 1A and 1B, will result in less mixing. The State of California issued new regulations pertaining to desalination plant brines (Ocean Plan Amendments, May 2015) that may require further evaluation of the outfall’s ability to dilute brine in accordance with the new standards.

Because operating Desalination Plant #2 will result in a 7 to 47 percent higher brine TDS concentration when compared to the previous operation of only Desalination Plant #1, an analysis of brine mixing will be required when the plant’s NPDES permit is renewed. The most recent NPDES permit (August 6, 2014 (Tentative)) was issued prior to Desalination Plant #2 becoming operational. It is not anticipated that the findings of a brine mixing analysis will require flow or operational changes at the Pebbly Beach Desalination Plant, however, capital improvements to the outfall to improve mixing may be required.

EVALUATION OF REDUNDANCY AND SPARE PARTS

The California Code of Regulations (CCR) requires that: “At all times, a public water system’s water source(s) shall have the capacity to meet the system’s maximum day demand (MDD).” Additionally, the CCR requires reliability features to be included in surface water treatment plants including standby replacement equipment available to assure continuous operation and control of unit processes for … filtration and disinfection. Since the Quarry Wells pump groundwater that is under the influence of surface water, these reliability requirements also pertain to SCE’s desalination plants.

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5 California Code of Regulations, Title 22, § 64554
6 California Code of Regulations, Title 22, § 64659
In the context of the State's requirements for reliability, the following are the reliability issues regarding raw water supply and treatment:

- **Water Supply**

  The reliability of SCE’s freshwater wells is being diminished by the current drought. The inability to rely on the freshwater wells increases the need for a reliable inflow of seawater for the desalination plants.

  The two existing quarry wells do not provide any redundant well capacity without also relying on community water supplied by SCE’s freshwater wells. The Quarry Well production rate is susceptible to deterioration from the fouling demonstrated by encrustation and clogging. If either well fails to produce water there is no additional water source to supply the desalination plants with seawater. Installing an additional seawater well will increase reliability of the desalination plants and may be required by State regulations if demands are not curtailed and the current drought persists. An analysis of demands and water supply strategies under drought conditions is required to complete this assessment.

- **Water Treatment**

  Operating both treatment plants under Scenario 1A will produce the greatest amount of finished water, estimated at 223 gpm (i.e., 321,120 gpd). If one treatment plant failed to operate, the finished water flow would be reduced to an estimated flow of 140 to 160 gpm (201,600 to 230,400 gpd). A redundant treatment train will improve the reliability of SCE’s desalination plants and maintain a flow of approximately 223 gpm. This additional treatment train may be required by State law if demands are not curtailed and the drought persists. An analysis of demands and water supply strategies under drought conditions is required to complete this assessment.

  Having sufficient spare parts to replace any critical items at the desalination plants is an alternative to having a redundant treatment train, and would meet the reliability requirement. However, SCE did not provide information regarding the spare parts that are stocked which prevents our assessment regarding reliability using spare parts.

**SUMMARY AND RECOMMENDATION**

The following represents a summary of our analysis of SCE’s Desalination Plant's 1 and 2:

- Desalination Plant #2 is permitted to operate under Scenarios 1A, 1B, and 2. Scenario 1A will produce the greatest total yield. The net production capacity from Desalination Plants #1 and #2 operating under Scenario 1A will be approximately 321,120 gpd, which is an approximate increase of 120,000 gpd of additional production compared to solely operating Desalination Plant #1.

- Quarry Wells No. 1 and No. 2 are not capable of producing enough water to simultaneously operate Desalination Plants #1 and #2 in parallel. Additional Quarry Wells would be required to increase the production capacity. A total production of 432,000 gpd may be achieved with additional Quarry Wells.
• Operation of Desalination Plants #1 and #2 is not limited by the brine discharge as regulated by the desalination plant's current NDPES permit. However, the amendments to the California Ocean Plan that were approved in May 2015 will affect the permit renewal - requiring an additional outfall mixing study, which may conclude that modifications to the outfall system will be required.

• If the drought persists and demands are not curtailed, State regulations may require added reliability features, including additional and a standby Quarry Well(s), standby RO treatment train and a spare parts inventory necessary to maintain production. An additional drought planning and demand study is required to determine what added reliability features may be required.

Please feel free to contact us if you have any questions on these findings.

Sincerely,

CAROLLO ENGINEERS, INC.

[Signatures]

Thomas F. Seacord  
Vice President  
Chief Technologist - Desalination

Kevin Fitzgerald  
Project Engineer

TFS:sjf