Memorandum

# Review of EOA Inc. Technical Memoranda on Chronic Toxicity Monitoring and a Mass Balance Assessment on RO Concentrate Blending with SJ-SC RWF Effluent

November 7, 2017

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| Project Name | Santa Clara Valley Water District RO Concentrate Management Plans | SCVWD Agreement No.<br>SCVWD CAS File No.<br>GHD Project No. | A4034G<br>4691<br>11110722 |
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## 1. Overview

A review has been conducted of the following two Technical Memoranda prepared by EOA Inc.:

- "*Chronic Toxicity Monitoring Results to Assess Impacts of Increased RO Concentrate in SJ-SC RWF from Expanded RO Capacity SVAWPC*" - Technical Memorandum (February 7, 2017).
- "*Impact of RO Concentrate from Expanded SVAWPC on SJ-SC RWF Combined Final Effluent NPDES Permit Compliance*" - Technical Memorandum (February 14, 2017).

For the Chronic Toxicity technical memorandum, the review provides an opinion as to the monitoring program's application in the assessment of potential toxicity of blended SJ-SC RWF effluent with RO concentrate from an expanded SVAWPC. Our comments are limited to general comments regarding the approach and results of the test work, but do not contain opinion from a specialist ecotoxicologist.

For the Mass Balance technical memorandum, the review provides an opinion as to the application of a mass balance model to determine the concentration of pollutants in SJ-SC RWF effluent blended with RO concentrate from an expanded SVAWPC.

In the absence of details of the scope provided to EOA by RMC, and similarly the scope provided to RMC, no comment is offered as to whether the work is likely to satisfy any other requirements.

## 2. Background and Key Assumptions

The review was undertaken in keeping with the following context and understanding:

- The studies were commissioned by the Santa Clara Valley Water District, as a subconsultancy to EOA via RMC.
- Chronic Toxicity technical memorandum

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- The study builds on the mass balance modeling work (see below) to assess the chronic toxicity compliance risks of increasing the percentage of RO concentrate (from an expanded SVAWPC) with SJ-SC RWF effluent.
- The stated objective of the study was to evaluate changes to chronic toxicity test results from an expanded SVAWPC.
- The investigation also considered an alternative indicator organism (*Thalassiosira*), if the current test organism (*Ceriodaphnia*) was considered an unacceptable test organism in future due to salinity toxicity to this fresh water organism.
- It is understood that the primary purpose behind commissioning of the study is to gain an appreciation of the potential NPDES compliance risks if the existing SVAWPC were expanded up to 48 mgd RO permeate production, and the resulting RO concentrate is blended with the SJ-SC RWF effluent is continued.

- Mass Balance technical memorandum
  - The stated objective of the study was to use a mass balance model to predict the impact of RO concentrate on the SJ-SC RWF final effluent quality for the case where RO concentrate from an expanded SVAWPC is returned to the SJ-SC RWF and mixed with normal plant effluent for discharge.
  - It is understood that the primary purpose behind commissioning of the study is to gain an appreciation of the potential NPDES compliance risks if the existing SVAWPC were expanded up to 48 mgd RO permeate production, and blending of the RO concentrate with the SJ-SC RWF effluent is continued.

## 3. Review Comments – Chronic Toxicity Technical Memorandum

Section 3 of this review lists key observations for each section of the Chronic Toxicity Technical Memorandum. Conclusions and recommendations follow in subsequent sections.

### *Background*

[1] The stated premise of the project to use laboratory chronic toxicity testing to predict chronic toxicity issues in an expanded SVAWPC case seems sound.

[2] It is noted that the District is currently undertaking quarterly chronic toxicity testing of the RO concentrate from the existing 8 mgd SVAWPC. Testing is conducted using 100% RO concentrate blended with lab water rather than SJ-SC RWF effluent to "avoid potential confounding effects of intermittent toxicity occasionally observed in 100% effluent". No opinion is offered as to the validity of this approach, although it would seem prudent to undertake some comparative tests with blended RO concentrate and effluent.

[3] Blending ratios in the range of 0.5 to 8% RO concentrate with lab water are currently tested, with a "no toxicity" result for the 2% blend in the series considered as no chronic effects. It is noted that on occasions (summer months), the actual RO concentrate ratio may exceed the 2% blend ratio.

[4] The SJ-SC RWF currently uses the organism *Ceriodaphnia* (freshwater water flea) for chronic toxicity testing per the existing NPDES permit.

[5] For the expanded SVAWPC case, the forecast blending ratios are predicted to increase to 21 to 54% RO concentrate, with reference to the mass balance memorandum (see Section 4). These conditions are predicted to occur during the "worst case" conditions of minimal RWF flow and maximum non-potable recycled water demand by the SBWR (July 2020). The range of blends tested in the study were from 16 to 48%, in increasing increments of 8%. Although the blending ratios tested in this study do not match the blending scenarios presented in the mass balance model, it is noted that they cover a similar range. Additional testing at 54% blend ratio (or higher if the 54% is not considered the "worst case", see Section 4) would be necessary to assess chronic toxicity at these predicted higher blending ratios that may occur from time to time. This would not be necessary if lower blending ratios were definitively shown to demonstrate a chronic toxicity effect, in which case one could assume higher blending ratios would also test positive.

[6] It is noted that a parallel salt control test was used to test the potential of adverse effects on *Ceriodaphnia* from salinity alone. As an extension to this, parallel testing with a marine test organism *Thalassiosira* (noted as one of the dominant phytoplankton naturally found in the San Francisco Bay) was also undertaken to address the potential outcome that salinity toxicity may be an issue with *Ceriodaphnia* and an alternative test species may therefore be required. No opinion is offered as to the validity of this approach.

### *Rounds 1 to 4 Results*

[7] Four rounds of chronic toxicity testing were carried out between February and July 2016, with each round including the three tests described briefly above at different RO concentrate blends between 16 and 48%. It was stated that the results were somewhat variable and that this is not uncommon with chronic toxicity testing.

[8] The results were not reviewed from the perspective of a specialist ecotoxicologist. It is agreed, however, that the results seem to be variable in nature such that drawing definitive conclusions is difficult.

[9] The study states that the results obtained for *Ceriodaphnia* were not definitive about the threshold for salinity alone effecting this species. This conclusion appears appropriate, as different rounds of testing showed chronic toxicity at different blending ratios.

### *Recommendations*

[10] The report concluded that there were some initial indications that RO concentrate blends at the upper end of the ranges tested (40 to 48%) could cause artifactual (saline-induced) toxicity to *Ceriodaphnia*. As per point 9, this conclusion seems appropriate based on the lack of repeatability in the threshold salinity toxicity. It was recommended to undertake additional testing to better define the "no effect" threshold for salinity on *Ceriodaphnia*, with this information to be used to better inform future

negotiations for potential changes to the test species (Sunnyvale example from the 1990's is referenced).

[11] The study concluded that the chronic toxicity results were variable for *Thalassiosira*, with two rounds identifying no statistically significant toxicity at the highest blend ratios while the other two rounds showed varying levels of toxicity. This confirms the conclusion that the results from the study are not definitive.

[12] Further to the comments noted in point 5, the study also concluded that additional testing at higher blending ratios be considered, as it is not possible to predict with certainty the toxicity results from higher RO concentrate blends. Although this seems like a valid conclusion, it may be considered academic if toxicity is observed at lower blending ratios. If future testing is undertaken, then testing the full range of potential blending ratios should be considered if a threshold toxicity value is not yet defined.

[13] The primary conclusion of the report is that additional RO concentrate toxicity testing should be carried out to establish more baseline data. It is proposed to carry out the testing using the same methodology as has already been employed. Although additional testing may provide additional confidence and data in threshold toxicity levels and preferred test organism, it is recommended that the number of tests and the organisms to be tested be reviewed by an independent specialist ecotoxicologist. No additional comments are made regarding the appropriateness of the number of tests or testing methodology that should be applied.

## 4. Review Comments – Mass Balance Technical Memorandum

Section 4 of this review lists key observations for each section of the Mass Balance Technical Memorandum. Conclusions and recommendations follow in subsequent sections.

### *Mass Balance Model*

[14] The basic premise of the study was to use a mass balance model to assess the potential pollutant concentrations in RO concentrate for cases in which the SVAWPC capacity is expanded. In addition, the model further predicts the concentration of pollutants in the SJ-SC RWF effluent water if this RO concentrate flow is blended with the effluent. The model makes allowances for the proportional reduction in effluent flow, and hence increased RO concentrate blending ratio, associated with more of the effluent being diverted to the SVAWPC. Inputs to the model include the following categories, which are discussed below:

- Flow Data
- Water Quality Data
- RO System Performance
- NPDES Effluent Limits for the SJ-SC RWF

[15] The mass balance model assumes that the pollutant constituents are conserved across the MF/RO facility, i.e., the water chemistry that may occur in the facility does lead to having more or less of a particular constituent in solution across the facility. As discussed below, this assumption may not be technically correct, but appears to present a conservative view of pollutant concentrations in the RO concentrate.

[16] The NPDES permit for the SJ-SC RWF imposes both average monthly effluent limits (AMELs) and maximum daily effluent limits (MDELs). It is stated that the AMEL limits are lower and hence more "stringent", as they are calculated based on the average of daily samples collected over a one month period, with compliance samples required to be 24 hr flow proportioned composite samples (except for cyanide).

[17] The proposed methodology of applying a mass balance approach to estimate potential impacts on effluent pollutant loads is considered sound, provided the application of the results considers the limitations and assumptions associated with the approach. On that basis, provided the assumptions are conservative and the limitations are valid and understood, then it follows that the predicted effluent pollutant loads should be conservative and appropriate for planning level discussions. The data are likely to, however, require additional scrutiny to ensure that an appropriate "worst case" is considered. This review will make comments throughout regarding areas where assumptions may not produce a worst case scenario.

### *Flow Data*

[18] The study assessed RO concentrate impacts from SVAWPC expanded RO permeate flows of up to 48 mgd. We understand this is the upper bound of what is currently being considered for expansion of the SVAWPC. The study assumes that the current supply of 8 mgd to the SBWR will continue, and additional permeate flow will be directed for PR uses.

[19] Projected monthly flows from the SJ-SC RWF that were used in the model (Appendix A.1) are based on RMC projections made using monthly average flows from 2015. In addition, projected monthly SBWR flows were based on information from the South Bay Recycled Water Master Plan (Dec 2014) and actual SBWR recycled water for TDS management. For this review, we have not analyzed this data, nor any additional flow data prior to 2015, however we note that 2015 was a drought year and influent flows were at historical low levels. GHD will be undertaking an assessment of SJ-SC RWF flows in subsequent stages of the study. If there were a decline of effluent water being treated by the SJ-SC RWF in the coming years due to, for example, extended drought, then some additional allowance for some reduction in flow over time may be prudent. It is also likely that a reduction of effluent flows into the SJ-SC RWF would put pressure on the ability of the SBWR and SVAWPC to deliver at their maximum rates, with the effluent discharge water quality becoming a limitation.

[20] Based on the RMC analysis, the lowest monthly flow was predicted to be July 2020, and has been selected as a "credible worst case" flow condition for this study. This is based on a predicted maximum SBWR demand and a near minimum final effluent flow. Further to point 15, it would be prudent to look at daily fluctuations over this month and also diurnal fluctuations to assess whether MDEL limits may be at a greater risk to be exceeded. If this risk exists, it may be possible in practice

to manage this by balancing of RO concentrate flows to the effluent, although the ability to do this will depend on the available buffer storage.

[21] Paragraph 4 of the "Flows" section of the EOA TM introduces the variable that either Sunnyvale or Palo Alto secondary treated effluent may be treated at the SVAWPC to reduce the take of effluent from the SJ-SC RWF. Footnote 3 indicated the flows from these plants has essentially the same water quality as the SJ-SC RWF. This assertion should be substantiated, although as this imported flow only represents 25% of the total feed flow, it is unlikely to have a significant effect.

[22] Table 1 of the EOA TM outlines the flow scenarios considered. These appear to be constant with the text descriptions of each of the scenarios. It is noted that as this project develops, it is likely that additional scenarios will evolve. As part of that planning process, revisiting the implications on the final effluent water quality will need to be undertaken.

### *Water Quality Data*

[23] The study included collection of a number of composite samples of RO feed (is this really MF feed?) and RO concentrate which were analyzed for six key priority pollutant metals (Cu, Ni, Hg, Se, Pb and Zn) plus cyanide. There is some discussion on issues with early cyanide sample results and the explanation seems consistent with our general understanding.

[24] Historic SJ-SC RWF data downloaded from the State Water Resources control board were used to define the effluent water quality (Table 2). The study notes that outliers for copper and cyanide are removed from the analysis, with data presented in Appendix A.6. Although the cyanide numbers appear to be clear outlier results, the copper results do not seem to have a strong basis to be excluded as outliers. This is also briefly discussed in Footnote 10. The impact of including these outlier results should have been presented, and should be further considered. In addition, the impact of the use of 99$^{th}$ percentile values which include these outliers should also have been presented, as this has the potential to have to be the biggest risk for MDEL compliance. Note that this is discussed in the first paragraph of page 12, where it is argued that the use of 99$^{th}$ percentile values for copper measured against the MDEL is not a risk, as the measured (but not predicted), undiluted RO concentrate value is actually less than the MDEL of 19 µg/L in the NPDES permit. A similar situation exists for cyanide.

[25] Inclusion of analytical results below the method detection limit (MDL) and DNQ is considered conservative.

### *RO System Performance*

[26] The study adopted an RO flow recovery of 80%. In practice, it may be possible to achieve higher than 80% recovery, and hence recover more permeate than this. In that instance, the concentration of pollutants in the RO concentrate will be higher. This will need to be taken into account in the detailed design phase of the project or during operation, when plant performance may be "pushed" to achieve higher recoveries, and hence higher concentration of pollutants in the RO concentrate.

### *Impact of Membrane Filtration and Cartridge Filtration (MF System)*

[27] The assumptions on MF system flows and pollutant removal seem reasonable.

### *NPDES Permit Limits or WQOs*

[28] The percentile concentrations adopted for comparison with NPDES effluent limits or WQOs are reasonable.

[29] The report concludes that the adoption of 95$^{th}$ and 99$^{th}$ percentile pollutant concentrations combined with the use of minimum monthly final effluent flows (July 2020 forecast) represents a worst case assessment. It is recommended that the issues identified in points 19, 20, 21, 24, and 26 be considered, as additional plausible worst case scenarios are possible.

### *Results*

[30] The report refers to a previous mass balance analysis by EOA Inc (December 9, 2015) which used historic final effluent data to calculate RO concentrate pollutant numbers. This approach identified that a facility producing 32 mgd RO permeate was projected to exceed the MDEL for cyanide, while a facility producing 40 mgd RO permeate would exceed AMELs for both cyanide and copper. In these cases, both 95$^{th}$ and 99$^{th}$ percentile results gave the same outcome. No exceedances were predicted based on average concentrations. This assessment was made both with and without outlier results for cyanide and copper. As we have not seen this December 2015 TM, we do not know whether the analysis assumed continued distribution of 30 mgd of recycled water to SBWR.

[31] The mass balance analysis undertaken for the February 2017 TM used actual RO concentrate values collected during the study. A comparison between the projected results and measured results are presented in Table 2. In many cases, the actual values are (significantly) lower than the original projected values. A number of possible reasons for this are explored:

- Removal in the MF and cartridge filter process – this is plausible, and was also identified as a potential issue for copper in the AqMB validation technical memo, where predicted copper concentrations were higher than actual measured concentrations.
- Differences between projected and actual rejection rates – this is plausible. As the membranes age, the performance of the membranes can change, and the AqMB validation work did suggest some acceleration of membrane degradation. If this is the case, then analysis of metals in the permeate stream would need to be assessed over time to see if this can be verified by mass balance across the MF/RO. In addition, analysis of the MF backwash stream would be required to establish the pollutant load that was present in that stream.

The exact reasons for the differences between the projected and measured RO concentrate and RO feed presented in Table 2 remain as uncertainties in the assessment. Expansion of the sample database for these streams through additional sampling will establish additional background information. However, the actual supplier and membranes used in the expanded plant also have the

potential to deliver different performance outcomes, hence this uncertainty will need to be considered as part of the planning and negotiation of RO concentrate disposal.

### *Nutrient Data*

[32] No comments on this section.

### *Summary and Discussion*

[33] The study concludes that "reasonable estimates for "worst case" pollutant concentrations and minimum RWF final effluent flow available for blending where used". This review is broadly in agreement with this, although further consideration, as summarized in point 28, should be considered.

[34] The study concludes that "copper and cyanide were the most critical parameters for NPDES compliance, followed by nickel and selenium. This review is broadly in agreement with this, although the potential for future reduction in the selenium discharge limit should be further evaluated. This issue is also identified in the report.

[35] The study predicted that, for a 40 mgd total RO permeate, the estimated copper and cyanide concentrations are 64% and 71% of AMEL values, respectively. Nickel and selenium were at 57% and 34% of respective AMEL values. Although the worst case scenario presented predicts a buffer will remain between the compliance limit and the discharge actual water quality, the acceptability of this buffer needs to be assessed in light of the uncertainties associated with the assessment and level of risk that SJ-SC RWF is willing to accept.

[36] The study references "preliminary studies" which have indicated that an effluent dilution credit for conservative pollutants (copper, nickel, etc.) could be technically justified. However, these are not referenced. There is therefore no basis to comment on this observation.

[37] The study lists a range of additional measures that could be adopted to assist with reducing the risk of compliance issues. This included:

- Reduce production rates at the SVAWPC during critical low flow periods
- Seek effluent dilution credits for critical parameters
- Seek credit for water recycling
- Import flows from other plants or export the RO concentrate to other discharges
- Treatment of the RO concentrate
- Beneficial reuse of RO concentrate e.g. constructed wetlands

This review agrees with the range of approaches that could be adopted, with other possibilities also existing e.g. RO concentrate storage as a buffer.

# 5. Recommendations

The work presented in these two technical memoranda is assumed to form part of the information that would be used to assist both SCVWD and SJ-SC RWF in assessing the risks of NPDES permit compliance in the event that an expanded SVAWPC was developed, and the RO concentrate from that expanded facility was co-discharged with SJ-SC RWF effluent water. It is recommended that:

### *Chronic Toxicity Technical Memorandum:*

1. Undertake additional toxicity testing as recommended in the technical memorandum. The testing program should be reviewed by an independent ecotoxicologist.
2. Broaden the range of RO concentrate blending ratios examined, to include a case above 50%.
3. For a portion of the toxicity tests, consider using a blend of RO concentrate and actual effluent for comparison. The "confounding toxicity effects" of using effluent for testing need to be better understood, as the discharge of a combined effluent will be a long-term arrangement.

### *Mass Balance Technical Memorandum*

1. The February 2017 assessment was based on a limited data set of RO concentrate data from the existing SVAWPC. Additional data relevant to future compliance should continue to be collected on a routine basis to expand the baseline of data available. This data, along with ongoing assessment of flow and water quality data from the SJ-SC RWF, should be collated and monitored to continue to verify the assumptions made in the model.
2. It is important to assess a "credible worst case" scenario. A number of issues were identified in point 28 that should be reconsidered as part of defining a credible worst case. The mass balance model should be rerun based on a revised worst case scenario. It is understood that this may assess a highly conservative worst case, but this will reduce the uncertainty of the overall approach and further inform discussions with key stakeholders.
3. Engage with SJ-SC RWF to confirm their acceptance that the effluent flows predicted by RMC represent reasonable forecasts. This is a critical input into the mass balance model and must be accepted by all parties. In addition, daily fluctuations in flow should be considered, particularly during low flow periods (summer) to better understand the uncertainty around the predicted "worst case" scenario.
4. Further investigate the option for additional dilution credit for certain metals.

References

1. Chronic Toxicity Monitoring Results to Assess Impacts of Increased RO Concentrate in SJ-SC RWF from Expanded RO Capacity SCVAWPC Technical Memorandum, February 7, 2017
2. Impact of RO Concentrate from Expanded SVAWPC on SJ-SC RWF Combined Final Effluent NPDES Permit Compliance Technical Memorandum, February 14, 2017.

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