Comments from California Department of Public Health on the Final Report *of the May 11-12, 2009, Meeting of the* Independent Advisory Panel *for the* City of San Diego Indirect Potable Reuse/Reservoir Augmentation (IPR/RA) Demonstration Project

---

Page 1 "INTRODUCTION"
"For the sake of clarity, the term "**advanced treated recycled water**" will be used throughout the report. Other terms synonymous with advanced treated recycled water include: recycled water, reclaimed water, and repurified water."

COMMENT: Reclaimed water and recycled water can refer to disinfected secondary effluent, filtered and disinfected wastewater, or wastewater treated by advanced treatment, such as reverse osmosis (RO) and advanced oxidation process (AOP) following the conventional wastewater treatment processes. "Advanced treated recycled water" should be used for the latter and is not synonymous with reclaimed water.

Page 4 "GOALS FOR THE PROJECT The Panel recommends the following project goals:
1. Protect public health and the environment.
2. Demonstrate the performance of several appropriate advanced treatment technologies with respect to water quality.
3. Demonstrate the safety and reliability of the advanced treatment technologies.
4. Demonstrate the safety and reliability of introducing advanced treated recycled water into a drinking water reservoir.
5. Demonstrate that wastewater can be managed in a sustainable manner."

COMMENT: While these may be appropriate goals, and in general the report provides some guidance to the City of San Diego, there are few specifics and many undetermined issues for the project to address in the design of the demonstration project. Specifically, the City needs to address monitoring, effectiveness of AOP for pathogen removal, effectiveness of membrane filtration (MF), ultrafiltration (UF) and/or RO in pathogen or chemical contaminant removal, in the demonstration project.

Page 10
"What are the differences in the quality of water, defined in terms of chemical components, from the Colorado River, State Water Project, MWD water delivered to San Diego, water in San Vicente Reservoir, and that which will be produced by the Demonstration Project? Key water quality parameters include minerals, salts, dissolved organic constituents, metals, pathogens, and other contaminants of concern to potential health or environmental risks."

COMMENT: Pathogens are not a chemical component but clearly are very important from a public health standpoint.

Page 11 **"ASSESSMENT OF THE IMPACT OF TRACE CONSTITUENTS**
A study being conducted for the WateReuse Foundation (WRF-06-004) is examining an industry-wide database on the occurrence of a wide variety of water contaminants in wastewaters subjected to various levels of treatment. In the waters studied, 31 pharmaceuticals and seven hormones were assayed using current sensitive analytical methods. The margins of exposure (MOE) for the 14 pharmaceuticals that occurred in one or more of the waters above limits of quantitation (LOQ), typically in the nanogram per liter (ng/L) range, are shown in Figure 4-3."

COMMENT: The California Department of Public Health (CDPH) would be interested in reviewing this information.

Page 11 "The MOE was calculated at the highest concentration reported in the database for each water type. The MOE is the ratio of the lowest therapeutic dose to the dose that would be obtained from drinking the indicated water, using standard assumptions related to water consumption [adult = 2 liters per day (L/day), 10-kilogram (kg) child = 1 L/day]. MOE values are frequently used in risk assessment to compare the lowest dose that results in adverse health effects (LOAEL) to the level to which the general population or a selected sensitive group is exposed. Therefore, the larger the MOE, the less the exposure compared to the lowest therapeutic dose that is used as a benchmark. A MOE value of 1,000 or above from the therapeutic dose as a LOAEL would have an extremely low human health risk, if any. Genotoxic carcinogens would be evaluated by a quantitative risk based approach rather than with MOEs."

COMMENT: This approach may be valid for risk assessment involving certain chemicals, where there is acceptable information on LOAEL or NOAEL. The report does not explain what uncertainty factors are assumed and how those were determined. The report assumes that there are no adverse side effects from therapeutic doses for people needing medical treatment or for healthy persons. For most pharmaceuticals, there are side effects.

Page 11 "As shown in Figure 4-3, even in secondary or tertiary treated wastewaters, drugs do not occur at concentrations that would be of concern. These margins are increased exponentially by treatments that are typically employed in treating water intended for potable reuse. It should be noted that when a chemical was measured in wastewaters prior to treatment and not detected after treatment, the detection limit was utilized rather than zero. Therefore, the very high MOEs reported after RO treatment or tertiary treatment (followed by soil aquifer treatment) are artificially suppressed by this calculation. Note that MOEs for all drugs listed are in the range from 100,000 to 625,000,000."

COMMENT: This approach may be valid for risk assessment for pharmaceuticals, where there is acceptable information on LOAEL or NOAEL; however, there are many other constituents of concern that have unknown health effects. The report does not explain what uncertainty factors were assumed for these pharmaceuticals and how those were determined.

Page 11 EDTA is used widely as a food additive and in detergents and other consumer projects.

COMMENT: Was this meant to say "Products"?

Page 11 "The effectiveness of the treatment barriers that will be employed in the Demonstration Project are illustrated by these data. It is important to realize that based on the removal of these drugs, other chemicals that have similar properties (e.g., molecular weight, charge, and shape) will also be removed by these barriers. Therefore, these treatments will reduce the number of "unknown" chemicals in the product water to a similar extent as the group shown in Figure 4-3. Concern can now focus on the much smaller group of compounds that have low molecular weight and have high toxicological potency [e.g., N-nitrosodimethylamine (NDMA)] that are not well removed by membranes."

COMMENT: Other than NDMA, the report does not recommend other "compounds that have low molecular weight and have high toxicological potency". It would be useful if the report provided some examples of these types of compounds.

Page 12 "CONSTITUENT SOURCE IDENTIFICATION WITHIN WASTEWATER COLLECTION SEWERSHED

One of the concerns related specifically to the Demonstration Project is the fact that the sewershed for the wastewater collection system includes a high density of biotech companies and hospitals. Therefore, the potential exists for wastewater to include different types of constituents than might be present from other sources.

The Panel believes that this scenario is unlikely and poses little risk for the following reasons:

1. The City has an active industrial wastewater control program that will need to be expanded for the NCWRP sewershed before full-scale IPR is implemented. The Orange County Sanitation District in Fountain Valley, California, as well as other agency programs, can be used for guidance. The City is also actively engaged and speaking with relevant dischargers, as well as actively monitoring constituents of concern in the wastewater discharged to the collection system.
2. Most of the companies in the collection area are research and development facilities, a university, and research institutes. While these types of laboratories use and make a large number of different chemicals, these are not produced or released in large quantities; therefore, it is unlikely that any single compound is used in sufficient quantity to reach a significant concentration in San Vicente Reservoir, even without treatment.
3. If any drug did enter the treatment plant, it would most likely be removed by the entire multiple barrier process that also could include RO (see Appendix D).

Given these conditions and safeguards, it is very unlikely that the source of the wastewater will pose a health risk to San Diego residents."

COMMENT: Does this provide sufficient rationale to ensure safe drinking water? This may not provide an adequate basis to make a finding "poses no significant threat to public health". A sufficiently robust and redundant treatment train must be demonstrated.

Page 12-13: **"CONSTITUENT SOURCE IDENTIFICATION WITHIN WASTEWATER COLLECTION SEWERSHED"**

The Committee assumes that it is unlikely that the chemicals discharged from companies in the collection area that are research and development facilities, a university and research institutes will be in such low concentrations that the impact will be insignificant.

COMMENT: The City's source control program should include an assessment of the chemicals used/produced in these operations to confirm that the discharges, if any, of these chemicals are insignificant. The Department highly encourages the City to carry out such an assessment rather than discount the potential impact. The impression one gets from the narrative is that may not be necessary.

Page 14 Section 5 REGULATORY ISSUES

COMMENT: An evaluation/review of the existing North City WRP should be mentioned in the report with respect to its operations; optimization and compliance with existing Regional Waterboard issued permits. The Department recommends the Regional Waterboards involvement in the consideration, development, and operation of IPR/RA projects such as the one proposed by the City of San Diego.

Page 15

"Assuming that any specifications should be health based or environmentally based, other possible principles that would ensure safe drinking water at the tap may be plausible and could be considered in the water quality requirements for reservoir augmentation."

COMMENT: This is the concluding sentence in a section discussing the Framework for regulating IPR by surface water augmentation. It is not clear if the "other possible principles" would be supplements or alternatives to those in the Framework.

Page 19, table 6-1, 1st row

"Control discharge of nutrients and emerging chemical contaminants into reservoir"

COMMENT: Nutrients are not included in the last column.

Page 21 "Membranes for Treatment and RO Pretreatment

From the City's perspective, the goal is to provide a reliable and cost-effective pretreatment for RO treatment; therefore, it is important to understand the benefits and tradeoffs associated with this step. Both MF and UF have demonstrated records of bacteria, viruses, and protozoa removal. It is generally believed that MF alone without disinfection can remove 1-4 logs of bacteria and protozoa, and 0-2 logs of viruses. UF is shown to remove ~4 logs of bacteria and perhaps an equal reduction of viruses. . . . While either MF or UF can provide adequate pretreatment for RO, UF may provide additional disinfection credit, particularly for viruses."

1. COMMENT: While the Department agrees that MF and UF may provide significant pathogen removal benefits, the extent of the pathogen removal benefits must be demonstrated during the demonstration study.

Page 21 "Integrity Testing
The integrity of the MF/UF system is critical to ensuring the adequate removal of particulates. Monitoring of several parameters can be used to evaluate integrity. Online monitoring of pressure changes across the membranes is a good diagnostic tool for detecting breaches in the membranes. In addition, online monitoring of turbidity and UV absorbance could be used to track the performance of the MF/UF system, and to protect RO membrane elements from excessive fouling."

COMMENT: The Department concurs that a monitoring program is necessary to ensure the integrity of the MF/UF system and looks forward to the proposal of the actual monitoring program in the forthcoming engineering report and/or Operations Plan for review and approval.

Page 22 "Reverse Osmosis (RO)

The RO process will provide a barrier for controlling a wide range of contaminants, . . . Although RO is also a highly effective microbial barrier, the disinfection credit that will be allowed by CDPH will depend on test results. Operating parameters that have been used to monitor membrane integrity include operating pressure, TOC, and conductivity. . . . Testing of the RO system performance should include selected trace organic contaminants, as well as TOC as a surrogate for organics removal. Elements that are less efficiently removed by RO, like boron, should be included, as well as specific compounds of concern (like nitrate and nitrite) where target concentrations for the reservoir may be even lower than drinking water standards. Chloramines used for fouling control in the MF/UF and RO systems should be tested through the system to understand the concentration of chloramines needed to control biofouling and understand any role that they might play in the formation of disinfection byproducts, such as NDMA, or any effect that they might have on the efficiency of other processes, like UV photolysis and advanced oxidation, if they are utilized in the treatment train.

The entire treatment train and RO process provide a robust barrier for microbial pathogens. RO treatment perhaps is most efficient in removing protozoa cysts. It should be noted that newer type of RO systems may have significantly improved performance for microbial removal. However, imperfections in the membranes, coupled with the potential for leaks to occur around the seals and connectors, can cause the breakthrough of microorganisms, particularly viruses, if not removed by prior processes in the sequence. Thus, as a precautionary procedure, disinfection following RO treatment will be required. It is important to note that disinfection following RO treatment serves as an additional barrier within the water reclamation facility. Additional data will be useful for assessment following RO treatment.

Both bacteria and viruses are readily controlled by typical disinfection processes (e.g., utilizing chlorine), and these would be especially effective in RO-treated water with low TOC and low disinfectant demand. The organisms of particular concern, therefore, are one-celled parasites such as Giardia and, especially, Cryptosporidium, which is completely resistant to chlorine disinfection and must be removed by filtration or other means."

COMMENT: Using the Membrane Filteration Guidance Manual (MFGM) as guidance to achieve the best available technology (BAT), Direct Integrity Testing (DITs) must meet requirements for resolution, sensitivity, and frequency. The sensitivity of a membrane module is

defined as the maximum LRV that can be reliably verified by a DIT, which must be equal to or greater than the Cryptosporidium removal credit awarded to the module. While there are DITs for MF and UF; there are none established for nanofiltration (NF) or RO.

The plan to demonstrate LRV via RO should be addressed in the engineering report that is submitted for our review and approval. Since there is no established DIT for RO, awarding credit for pathogen removal may not be feasible, thereby putting more emphasis on other membrane processes and disinfection.

Total Dissolved Solids (TDS) removal cannot demonstrate 2-log reduction because the influent wastewater TDS, at approximately 2000, is relatively low compared to seawater desal. Brackish groundwater desal plants generally produce water with a TDS at roughly 300-400.

TOC removal may be a consideration, but a 2-log reduction would mean that starting at average influent of 8 ppm, an 80 ppb effluent would have to be achieved. While technologically feasible, it may not be economically feasible.

Page 23 "UV System
The UV system will provide three functions: disinfection, direct photolysis, and advanced oxidation. It is important that the unit provide treatment that will simulate the full-scale system and ensure that the UV dose is proportional to the flow. As full-scale units like the Trojan UV Phox system do not scale well, a large pilot-scale system rather than a portion of a full-scale UV train may be needed to determine the necessary dose to achieve CDPH requirements."

COMMENT: The Trojan Phox ultraviolet (UV) system at Orange County Water District (OCWD) consists of three reactors per treatment train (8.75 millions of gallons per day [MGD] capacity). Each reactor has two chambers. Each chamber has 72 lamps. Conceivably, if the exact same reactor is used, the capacity of one chamber is 1.46 MGD. OCWD's demonstration project was 5 MGD. The specifics of UV demonstration unit should be addressed in the engineering report that is submitted for our review and approval.

Page 23 "A testing program should be developed to assess the performance and effectiveness of UV for indicator chemicals for each of the functions cited above. Seeded phage testing may be needed to demonstrate disinfection performance. However, validation testing performed by manufacturers like Trojan may already satisfy this need. Testing performed by other agencies may also help to satisfy CDPH requirements. If the UF system is granted sufficient disinfection credit, the UV system testing may be able to focus on only the photolysis and AOP requirements, although in the past CDPH has not accepted membranes in lieu of a discrete disinfection process for groundwater recharge IPR projects."

COMMENT: The disinfection system should provide the primary barrier to viruses. Due to new research, the Department has revised its approach regarding virus removal credit via membranes. Department Testing for virus credit may not have been performed in past Department reviewed reports using a module that was sufficiently conservative from a manufacturer quality control (QC) perspective. This potentially brings into question how to grant credit for virus removal in the future. Therefore, all surface water membrane plants should also have 4-log inactivation of viruses in addition to the membrane removal credit to provide a multiple barrier. The same concern carries over into water reuse. Therefore, the UV (assuming that is the primary disinfectant process) should provide the virus inactivation.

Seeded phage testing may or may not be needed, depending on the design proposed. For instance, if the UV system is designed exactly like one that has already undergone MS-2 testing and the UV system is operated to a standard of 1.2-log NDMA reduction, then the high doses required for photolysis of NDMA are much greater than what is required by the Water Recycling Criteria. The specifics of a detailed UV system monitoring program should be addressed in the engineering report that is submitted for our review and approval.

Page 23 "The draft recharge regulations specify performance requirements for UV photolysis. The UV will need to be capable of at least 1.2-log reduction of NDMA with the same dose of UV that would be provided in the full-scale design, in accordance with the draft recharge regulations. The log reduction is based on comparing the concentration of NDMA derived from source wastewater before and after UV photolysis, and thus is independent of the concentration of NDMA found in the influent or formed by chloramine addition in the recycling plant."

COMMENT: Some research has been demonstrated on photolysis of NDMA, but the Department is not aware of any demonstration work on the degradation by-products of nitrosamines and the feasibility of reduction to safe constituents. The Department would like to see the specifics of a detailed demonstration program on nitrosamines destruction and by-product formation addressed in the engineering report that is submitted for Department review and approval.

In addition, NDMA destruction is dependant on ultraviolet transmittance (UVT). Optimization of the RO process to provide high UVT effluent upstream of the AOP should be considered in the demonstration work.

Page 23 "For AOP, it may be necessary to demonstrate the capability of reducing 1,4-dioxane or another suitable indicator chemical by at least 0.5 log, even if this compound is not present in AWT Demonstration Project feedwater. The 1,4-dioxane serves as a marker for some low molecular weight compounds that could penetrate through RO and resist direct photolysis; however, it may not be reflective of others, such as halogenated hydrocarbons (e.g., TCE, PCE). The inclusion of AOP in the testing program is based on concerns with unknown contaminants and originated with the Independent Advisory Panel for West Basin Municipal Water District's Seawater Barrier Water Conservation Project, which was likely based on experiences at the Groundwater Replenishment System. However, the need for AOP in the AWT treatment process must be established based on the results of the testing program."

COMMENT: AOP is necessary, since some constituents, such as NDMA and 1,4-dioxane can pass through the RO process. More research has been demonstrated on photolysis of NDMA than on the oxidation process of destroying 1,4-dioxane. The Department is not aware of any demonstration work on the degradation by-products of 1,4-dioxane and the feasibility of destruction to constituents that "poses no significant threat to public health". The Department would be interested in reviewing the specifics of a detailed demonstration program on 1,4-dioxane destruction and by-product formation and would suggest this be addressed in the engineering report submitted.

Why TCE and PCE are mentioned is unclear. Due to the difference in rate constants, chlorinated ethanes (e.g., 1,1,1-TCA and 1,1-DCA) are more resistant to AOP than chlorinated ethylenes. Is the panel suggesting surrogates, other than NDMA and 1,4-dioxane, for AOP process control; and if so what is the rationale?

Page 23 "UV irradiation is among the most effective methods for pathogen disinfection in water with low turbidity. However, recent studies showed some viruses are more resistant to UV disinfection than previously expected. The EPA recently recommended that a delivered UV dose of 186 millijoules per square centimeter (mJ/cm2) is required for 4-log inactivation of DNA viruses; prior to January 2006, a UV dose of 40 mJ/cm2 was considered sufficient. In the Groundwater Rule (promulgated in January 2007), it was noted that UV is not sufficient as a stand-alone treatment for 4-log inactivation of viruses. Both of these rules are based on adenoviruses, which are currently thought to be the most UV-resistant class of viruses and are, therefore, used as a standard for viral inactivation requirements."

COMMENT: If the UV system is designed to be operated to a standard of 1.2-log NDMA reduction, then the high doses (actually energy delivered) required for photolysis of NDMA are much higher than what is required for adenoviruses.

Page 24 "The scaling of the UV reactor design will require consulting with UV manufacturers. It may be possible to provide the same UV dose, but given reactor flow dynamics at different velocities, assuring the scalability of the UV system could be critical."

COMMENT: Closed-vessel UV reactor systems are generally not designed to be scalable, but are operated in parallel. Therefore, the demonstration work should use the actual reactor to address flow dynamics and different velocities.

Page 28 "**MICROBIOLOGICAL CONSIDERATIONS** Monitoring Issues
To demonstrate the effectiveness of the treatment technologies for controlling health risks due to microbial pathogens, a robust monitoring program is needed to quantify the levels of bacteria and viruses after each step of treatment.

It is recommended that samples be taken at each step of treatment at a frequency that would provide statistically significant results and tested for fecal indicator bacteria and coliphage. In addition, as fecal indicator bacteria and coliphage are only a small fraction of a microbial community in the wastewater, they are likely below the limit of detection after the first step of treatment; however, other bacteria and viruses may remain in low concentrations. To demonstrate bacterial and viral removal at each step of treatment without artificially inoculating target microbes (bacteria or phages) in the feedwater, total bacterial and viral direct counting using epifluorescence microscopy can be used to indicate the efficiency of bacteria and virus removal during a testing program limited to several months of testing. This method is a common indicator of ecological conditions in the aquatic environment and is used widely in limnology and oceanography research."

COMMENT: The Department would be interested in reviewing the specifics of a "epifluorescence microscopy" monitoring program. Has this method been used in the drinking water context? Please forward the article referenced, "Noble, R.T., and J.A. Fuhrman (1998). "Use of SYBR Green I for Rapid Epifluorescence Counts of Marine Viruses and Bacteria." *Aquat. Microb. Ecol.*, 14 (1998), pp. 113–118". Are there drinking water studies available using this method?

Page 28 "A seeding study is not recommended because seeding conditions can be different from the environmental matrix present in the treatment train. A seeding study can only be performed a limited number of times and is considerably more labor- and time-intensive than the routine monitoring of indicator bacteria, coliphage, and total counts of microbial density."

COMMENT: Seeded testing may or may not be needed, depending on the design proposed. For instance, if the UV system is designed exactly like one that has already undergone MS-2 testing and the UV system is operated to a standard of 1.2-log NDMA reduction, then the high doses required for photolysis of NDMA are much higher than what is required by the Water Recycling Criteria. The Department would be interested in reviewing the specifics of a detailed UV system monitoring program and would like to see these addressed in the submitted engineering report.

Page 28 "The recommended initial monitoring and sampling regime at start-up is shown in Table 6-3. Monitoring frequencies and organisms tested would be reassessed periodically based upon the performance of the AWT Demonstration Plant."

COMMENT: The monitoring program described in Table 6-3 does not include *E. coli.*

Page 33 "RESERVOIR CHARACTERISTICS Detention Time Analysis

In addition to lag time, the detention time also affords opportunity for reduction in wastewater-derived contaminants. While no removal credits are expressly assigned for the reservoir barrier, sufficient information exists to make some predictions about removal of key contaminants. For example, inactivation rate constants for common microbial contaminants are available, as well as rate laws for

biodegradation, photolysis, volatilization, sorption, and settling (e.g., Schwarzenbach, et al (2003). Environmental Organic Chemistry, 2nd ed. John Wiley & Sons, New York, NY. 1000 pp.)"

COMMENT: Please forward the article referenced.

Page 33 "There is merit in selecting two or three different contaminants, found at relatively high levels in the untreated wastewater and/or likely to evade complete removal at the plant if a problem develops, to use as an example and evaluate their loss in the reservoir. These calculations could be done within ELCOM-CAEDYM or separately. In either case, these calculations can highlight the possible role the reservoir can play as an additional treatment process in this water system."

COMMENT: The Department would be interested in reviewing the specifics of a detailed reservoir monitoring program. Since there are so many possibilities, which potential contaminants were envisioned above by the panel as treatment process indicators? This may be best addressed in the engineering report or in the demonstration project design.

Page 33, last paragraph of "Detention Time Analysis"
"Moreover, calculations (as well as monitoring data) demonstrating low concentrations of wastewater-derived contaminants following treatment, dilution, and further loss within the reservoir can also ameliorate concerns about recreational contact with the water."

COMMENT: The relationship between controlling wastewater contaminants and concern with recreation contamination is not clear.

Page 35-36
The "CALIFORNIA DEPARTMENT OF PUBLIC HEALTH REQUIREMENTS FOR RESERVOIR AUGMENTATION"

COMMENT: The draft section has not been sufficiently developed to justify review.

Page 68:

COMMENT: Regarding atrazine, it may be appropriate to use as an indicator to gauge the efficiency of removal of steroid hormones and pharmaceuticals, as mentioned on page 68, but the Panel should be aware that California's MCL is 0.001 mg/L, which is more restrictive than the federal MCL of 0.003 mg/L.