NATIONAL WATER RESEARCH INSTITUTE

Final Interim Report

of the Second Meeting of the

Independent Advisory Panel

on Reviewing the

County of Orange's Nitrogen and Selenium Management Program

(August 24-25, 2006)

Prepared September 8, 2006
Fountain Valley, California

Introduction

In 2005, the County of Orange, California, requested that the National Water Research Institute (NWRI) of Fountain Valley, California, organize an independent third-party advisory panel (Panel) to review and provide guidance on the County's Nitrogen and Selenium Management Program (NSMP). The NSMP is a 5-year work plan to address selenium (Se) and nitrogen in the Newport Bay Watershed, with a focus on surface water contamination resulting from the discharge of contaminated groundwater.

The Panel includes:

- Chair: Brock B. Bernstein, Ph.D., Independent Consultant
- Gerald Combs, Ph.D., Agricultural Research Service, U.S. Department of Agriculture
- Roger L. Hothem, U.S. Geological Survey
- Mohsen Mehran, Ph.D., Rubicon Engineering, Inc.
- Roy A. Schroeder, Ph.D., U.S. Geological Survey
- JoAnn Silverstein, Ph.D., P.E., University of Colorado, Boulder

Short biographies of each Panel member are included in Appendix A.

The Panel met with County representatives, NSMP working group members, and consultants in Anaheim, California, on August 24-25, 2006. An agenda from that meeting is included in Appendix B. The overall charge to the Panel is to assist the NSMP in determining whether to pursue the development of site-specific objectives (SSO) for Se. The meeting began with a half-day tour of the watershed.

This interim report presents the Panel's recommendations on the NSMP's approach for deciding whether to pursue an SSO for Se, based on reviews of written material, presentations, and discussions at the August 2006 meeting. The Panel's comments are organized into seven recommendations that detail specific steps the NSMP should take to decide whether or not to proceed with an SSO for Se.

Recommendations

The Panel understands that the decision regarding whether to proceed with the development of a proposed SSO for Se is a key decision point for the program as a whole. This decision will have fundamental consequences for virtually every aspect of the program. Consequently, the Panel believes that the NSMP should carefully and systematically weigh a number of factors. If the NSMP does decide to pursue an SSO, the Panel believes this would be prudent given the ongoing deliberations among Federal and State agencies to develop a tissue-based criterion for Se. A tissue-based standard recognizes the fundamental relationship between tissue-residue levels and local trophic structure. The site-specific nature of such relationships generally favors developing an SSO at locations where the environment is unique and/or concentrations of Se fall in a gray area where there is uncertainty about their impacts.

1. Justify/validate focus on wildlife

The program's presentations made clear that existing Se regulatory levels are based on the assessment of potential toxicity to aquatic life, while the primary concern in the Newport Bay watershed is the potential risk to wildlife, particularly several threatened or endangered species of birds. The lack of rigorous evidence that the aquatic life approach will necessarily protect wildlife has contributed to efforts at both the State and Federal level to develop a wildlife tissue-based standard as a basis for Se regulation and management. The Panel understands that the Regional Water Quality Control Board is generally supportive of such an approach, provided that a) tissue concentrations of Se can be related to water concentrations, thus providing a basis for managing discharges, and b) it can be shown that tissue concentrations protective of wildlife are also protective of aquatic life.

Therefore, the Panel recommends that the NSMP assess several issues to confirm that a primary focus on wildlife risk, and the associated development of a tissue-concentration approach to Se management, is justified in the Newport Bay watershed. Specifically, the NSMP should develop information to answer the following questions:

a) Does the current aquatic life approach adequately address risks to wildlife?

b) Can a wildlife tissue-based approach be shown to be protective of aquatic life?

c) Can a wildlife tissue-based approach lead to identification of a water quality standard for Se that can provide a basis for managing discharges?

There are also a number of issues that must be resolved related specifically to the threatened and endangered bird species that are a major focus of concern in the watershed:

d) Are populations of threatened and endangered species in the watershed increasing, decreasing, or staying the same?

e) To what extent are threatened and endangered species exposed to Se by feeding in high-selenium areas or on highly contaminated prey (see also Recommendation #4)?

f) How do water quality standards in the California Toxic Rule (and other regulations) relate to criteria for protection under the Endangered Species Act?

g) What are the applicable criteria for assessing risk to threatened and endangered species (e.g., risk to population versus risk to individuals)?

2. Review empirical data from the watershed

The information presented to the Panel at the August meeting, as well as data presented in the program's previous reports, suggest that processes governing Se bioaccumulation

in the Newport Bay watershed may differ from those in other locations. For example, although Se concentrations in some wildlife tissue samples are above background, they may not be as elevated as would be expected, based on data from other watersheds and given Se concentrations in surface waters in the watershed. That is, the bioconcentration model which has been the basis for the current Se water quality standard is based on data from other ecosystems and may not apply to the Newport Bay watershed. Therefore, the program should rigorously examine this apparent inconsistency by addressing the following questions:

a) Are wildlife tissue concentrations in fact significantly lower than would be expected based on the model(s) used in developing existing regulatory levels? (It is worth noting that this is the opposite of the situation in San Francisco Bay, where the presence of a benthic, clam-based food web leads to higher-than-expected Se concentrations in fish tissue.)

b) Is the relationship between Se concentrations in water and wildlife tissue in the Newport Bay watershed different from that in other studied ecosystems?

If answers to the questions in the first two recommendations indicate that a focus on wildlife is feasible and appropriate, and if continued samples in the Newport Bay watershed confirm lower-than-expected wildlife tissue concentrations, then the Panel recommends that the NSMP consider three possible explanations for the lack of selenium bioaccumulation, as proposed in Recommendations #3-5, which may act individually or in combination to limit Se in the foodweb in the Newport Bay watershed.

3. Describe spatial and temporal variability in Se concentrations

Data presented to the Panel indicate that Se concentrations in water are highly variable across the watershed. This variability could help explain lower-than-expected wildlife tissue concentrations in the eggs of birds feeding throughout the watershed (see Recommendation #4) and could also provide opportunities for the development of Best Management Practices (BMPs). Therefore, the program should:

a) Characterize typical aquatic, sediment, and soil conditions, such as oxidative-reduction potential, dissolved organic carbon, and related processes (such as bacterial and plant activity), in the watershed that affect Se cycling and bioconcentration.

b) Develop a quantitative, mass balance-based description of flows and Se loads as a context for examining the foodweb structure characteristic of the watershed (see Recommendation #4).

c) Particularly, identify the role of bacteria and aquatic plants in Se cycling processes in the watershed (see Recommendation #5) and assess the degree to which growth conditions for bacteria and/or aquatic plants may increase or decrease expected risks to wildlife.

4. Describe foodweb structure

Lower-than-expected tissue concentrations in wildlife in the Newport Bay watershed could result from the structure of the foodweb in this locale. The following questions related to foodweb structure should be addressed:

a) Are there key prey species, analogous to the Asian clam (*Potamocorbula amurensis*) in San Francisco Bay, that bioaccumulate Se to high concentrations?

b) How restricted are wildlife diets (i.e., what proportion of the diet of target species is made up of prey organisms with the highest concentrations of Se)?

c) How restricted (or flexible) are wildlife foraging ranges (i.e., what proportion of foraging time is spent in locations with the highest Se concentrations [either in prey tissue or water])?

Question A focuses on the presence (or absence) in the watershed of prey items with elevated concentrations of Se. Questions B and C focus on the degree to which wildlife foraging patterns could reduce the impact of such prey items by, in effect, integrating across a landscape that is patchy with respect to Se concentrations.

5. Assess Se metabolism

The information presented to the Panel showed that speciation studies indicate the presence of only very low concentrations of organic Se compounds in water samples, including those with high concentrations of total Se. Tissue data also suggest that Se concentrations in bird eggs appear to be lower than might be expected based on the concentrations of total Se in the water, particularly in certain locations in the watershed. These observations could be explained by the following scenario.

The research literature on Se metabolism documents that plants (and bacteria) can produce organic Se compounds biologically from both selenate and selenite. Tissue Se concentrations in animals, however, (including at-risk species in the watershed) consist almost exclusively of Se incorporated non-specifically into proteins as the selenoamino acid selenomethionine (SeMet); because the total protein-methionine pool of the body greatly exceeds the amounts of Se consumed, this pool is virtually non-saturable. It is also known that SeMet is synthesized only by plants and microorganisms. Thus, the ability of animals feeding in the watershed to accumulate Se in tissues is directly related to their consumption of SeMet ultimately from plant and/or microbial sources. The absence of this pathway in the Newport Bay watershed, as a result of either unfavorable growth conditions or the absence of key plant and bacteria species, might explain the relatively low bioconcentration of Se observed.

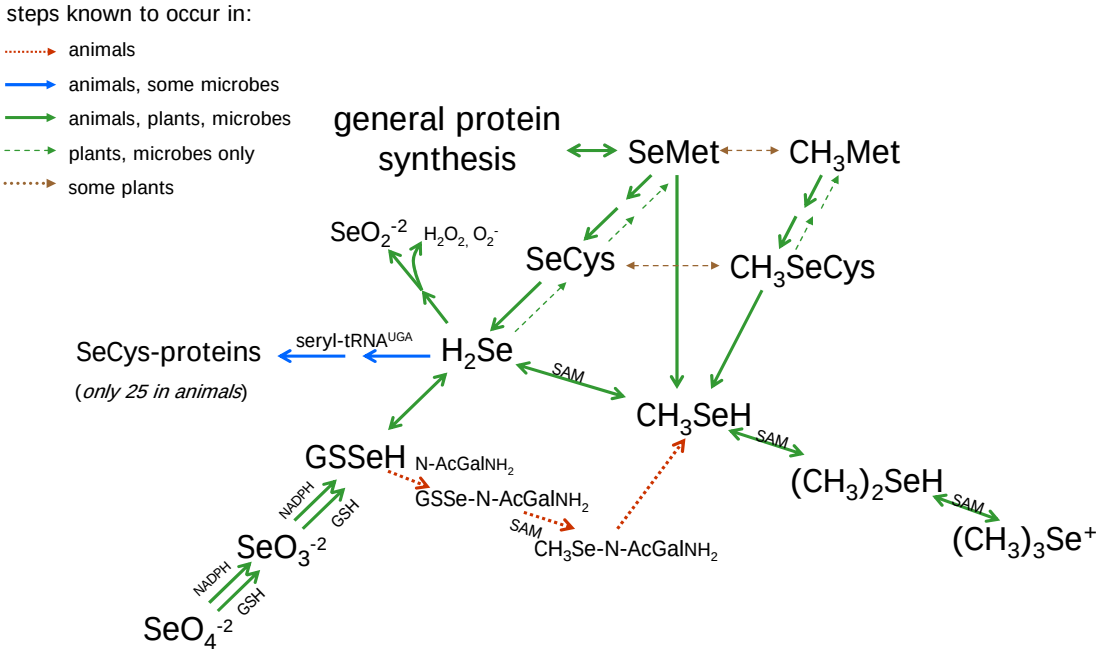
This has a number of implications that may apply to the Newport Bay watershed:

a) The absence of organic Se compounds in water samples indicates the absence of significant contamination from microbial or plant sources capable of converting selenate/selenite to SeMet.

b) The absence of significant amounts of SeMet in the food chain would indicate limited capacity for Se accumulation in the tissues of animals feeding in the Newport Bay watershed. This is consistent with reported observations of relatively low Se in bird eggs.

c) The Newport Bay watershed may differ from others in which Se toxicity problems have occurred in terms of the relative absence of species intermediate in the foodweb that can convert selenate/selenite to SeMet and/or accumulate significant amounts of SeMet.

The following figure summarizes major pathways involved in Se metabolism. The broken arrow lines indicate the SeMet pathway controlled by plant or bacterial activity.



The Panel, therefore, recommends that the NSMP assess the likelihood that this scenario is applicable to the Newport Bay watershed, with the understanding that an in-depth analysis would be beyond the scope of the current decision-making timeframe.

6. Assess potential for active management of Se processes

The Newport Bay watershed offers unique opportunities for the management of Se uptake processes. There are treatment marshes in the watershed, and the Irvine Ranch Water District is planning to install additional marshes in the near future as part of its Natural Treatment System. The design and operation of these marshes afford the

possibility of manipulating the physical, chemical, and biological processes involved in Se speciation and uptake. In addition, they provide an opportunity for the volatilization of Se, particularly by plants.

The Panel believes that the NSMP should, therefore, use the information developed in response to Recommendations #3-5 to examine the potential for using managed water bodies to further reduce the potential for Se bioaccumulation in wildlife in the watershed. If such management strategies are feasible, then this could assist in developing an SSO, taking account of the spatial distribution of treatment marshes relative to locations with elevated Se concentrations.

However, the Panel also notes that ponding of Se-contaminated water can lead to tremendous bioaccumulation and, ultimately, to catastrophic embryotoxicity in a wide variety of species (e.g., Kesterson Reservoir). Managed water bodies have the potential to help solve the problem, but great caution is required to ensure that the problems are not exacerbated by the intended solution.

7. Assess statistical confidence

Addressing each of the six preceding recommendations will require statistical analysis and the evaluation of data, quantitative models (e.g., mass balance, bioaccumulation), and conceptual models (e.g., the Se metabolism figure in Recommendation #5). All such efforts necessarily involve some inherent uncertainty. The NSMP should:

a) Identify sources of uncertainty (e.g., sampling, laboratory analyses, modeling, spatial and temporal variability, use of surrogate species).

b) Estimate the statistical power of conclusions drawn about the presence/absence of specific impacts in the watershed.

c) Estimate the statistical power of comparisons of Se concentrations in water and tissue between the Newport Bay watershed and other locations.

d) Assess the degree to which surrogate species adequately represent risks to threatened and endangered species.

Appendix A: Panel Biographies

Brock B. Bernstein, Ph.D.
Independent Consultant

Brock Bernstein is an environmental scientist and consultant with broad experience in designing and evaluating environmental programs, structuring management and research initiatives, and developing policy. He has field research experience in a range of coastal and oceanic environments, and has also worked on a wide variety of management and policy issues, including the redesign of core compliance monitoring programs for major regional management efforts, the evaluation and/or development of regional assessment programs, and methods to improve fisheries management. In addition, he has served on numerous technical advisory and review committees, including several National Academy of Sciences panels on issues such as improving marine monitoring nationwide and improving the governance and management systems used to manage coastal and ocean resources.

Gerald Combs, Ph.D.
Center Director, Grand Forks Human Nutritional Center, Agricultural Research Service
U.S. Department of Agriculture

Gerald Combs is an expert in nutrition and health, and his research interests include the nutritional biochemistry of minerals and vitamins (especially selenium, vitamin E, and the factors affecting their metabolic functions), ranging from basic biochemical studies to human metabolic and clinical investigations. A prolific author, Combs has written many key research reviews, as well as two leading text/reference books, *The Role of Selenium in Nutrition* (1986) and *The Vitamins: Fundamental Aspects in Nutrition and Health* (1992). He is currently the Center Director of the Grand Forks Human Nutritional Center of the Agricultural Research Service for the U.S. Department of Agriculture., where he directs the functions of the Center and its staff. His team conducts clinical intervention studies and was the first to demonstrate the efficacy of nutritional supplements of selenium in reducing cancer risk.

Roger L. Hothem
Research Wildlife Biologist
U.S. Geological Survey

Roger Hothem has conducted research for the U.S. Department of the Interior for the last 29 years. Early efforts focused on evaluating the effects of selenium and other contaminants on avian reproduction in various regions of California. At present, his primary research emphasis is on measuring, evaluating, and predicting the effects of various anthropogenic contaminants on wildlife, including amphibians, fish, and birds. Examples of his studies include population and food-chain interactions, the transfer of pollutants in the environmental complex, and effects of pollutants on the survival,

reproduction, and behavior of wild species. Recent work includes studies of the effects of contaminants on avian reproduction at Edwards Air Force Base in the Mojave Desert and studies of mercury contamination in birds and amphibians in the Cache Creek, Bear and Yuba River, and Trinity River watersheds. Hothem received a B.S. in Zoology and M.S. in Wildlife Management from Ohio State University.

Mohsen Mehran, Ph.D.
Chief Executive Officer and Principal Hydrologist
Rubicon Engineering Corporation

Mohsen Mehran is the Chief Executive Officer and Principal Hydrologist at Rubicon Engineering Corporation, an environmental, civil, and structural engineering firm and a licensed general contractor. At Rubicon, Mehran is responsible for developing and directing site characterization and remediation projects. He also provides environmental consulting services related to cost allocation and recovery and expert witness testimony cases. For the past 30 years, his research has focused on groundwater flow and migration of chemical constituents in fractured/porous media, with particular emphasis on site restoration, water-resources management, and groundwater/contaminant transport modeling. He has published more than 50 articles related to soil and groundwater investigation/remediation, and has been a faculty member at both the University of California, Davis, and University of California, Berkeley.

Roy A. Schroeder, Ph.D.
Retired Hydrologist
U.S. Geological Survey

Roy Schroeder had worked for the U.S. Geological Survey as a hydrologist for 24 years before retiring in 2002. During that time, he was involved in projects such as studying PCBs in the Hudson River, jet-fuel and gasoline contamination in Orange County and Death Valley, irrigation drainage (including selenium contamination) in the Salton Sea Basin, and the infiltration of municipal wastewater in spreading basins in Los Angeles County. Since retiring, he has continued to work part time as a contract employee through California State University, Sacramento, as well as for others on a volunteer basis. Examples of current research include on-going water-quality sampling in the Russian River and the sampling of desert springs from Palm Springs to Death Valley for a variety of water-quality constituents and stable and radiometric isotopes. He is extensively published and had taught at both the University of Utah and Yale University.

JoAnn Silverstein, Ph.D., P.E.
Professor of Civil and Environmental Engineering
University of Colorado, Boulder

JoAnn Silverstein has been a professor at the University of Colorado, Boulder since 1982. Her teaching interests include environmental engineering (biological process

analysis, design, and wastewater and water treatment) and thermodynamics. Her research projects involve the application of biological processes to water treatment, including: nitrogen transformation, bioremediation of acid mine drainage, wastewater recycling, and nitrate removal from drinking water. She is also interested in research to develop and demonstrate novel water treatment technologies so that they can be deployed in operating facilities. In 2001, the College of Engineering at the University of Colorado honored Silverstein with both the Clarence Eckel Faculty Achievement Award and the Outstanding Faculty Award.

Appendix B: Panel Meeting Agenda

NATIONAL WATER RESEARCH INSTITUTE

Independent Advisory Panel Meeting
County of Orange's
Nitrogen and Selenium Management Program

Meeting Agenda
August 24-25, 2006

Meeting Location:

DoubleTree Guest Suites
Anaheim Resort/Convention Center
2085 S. Harbor Boulevard
Anaheim, CA 92802

Meeting Objectives:

1. Review the draft criteria for a Site-Specific Objective (SSO) determination under the County of Orange's Nitrogen and Selenium Management Program. Develop recommendations on the appropriateness of the proposed criteria.

2. Conduct a preliminary evaluation of the SSO determination based on available data and the limitations of the data.

Thursday – August 24, 2006

8:00 a.m.	Tour of Watershed
11:00 a.m.	Return to Hotel
11:30 a.m.	Welcome and Introductions *Jeff Mosher (National Water Research Institute)* *Brock Bernstein (Panel Chair)*
11:45 a.m.	Status of Current Efforts *Karen Hauptly (County of Orange)*
12:15 p.m.	WORKING LUNCH
12:45 p.m.	Proposed SSO Criteria *Mike Casterline and Ashli Desai (Larry Walker Associates)*

1:15 p.m. Preliminary Assessment of Data
- Statistical significance
- Levels of protection

Gary Santolo (CH2M Hill)

1:45 p.m. Panel: Open Discussion
Brock Bernstein (Panel Chair)

2:45 p.m. BREAK

3:00 p.m. Panel-Only Discussion

5:30 p.m. MEETING ADJOURNS

6:30 p.m. Dinner: Continue Panel-Only Discussions

Friday – August 25, 2006

8:30 a.m. Welcome and Summary of First Day
Brock Bernstein (Panel Chair)

8:45 a.m. Panel Review with County of Orange Staff

10:00 a.m. BREAK

10:15 a.m. Panel-Only Discussion

12:00 noon MEETING ADJOURNS