Non–Potable Water Recycling Criteria

Workshop Report

PRESENTED BY
National Water Research Institute

IN COOPERATION WITH
Irvine Ranch Water District
Orange County Water District

Kellogg West Conference Center & Lodge
California State Polytechnic University
Pomona, California

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By

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FOREWORD

The National Water Research Institute (NWRI) was founded in 1991 by a group of southern California water agencies in partnership with the Joan Irvine Smith – Athalie R. Clarke Foundation to create new sources of water through research and technology. NWRI promotes excellence in water through development of programs and projects with collaborative partnerships with private and public sector organizations throughout the United States. Since its inception, NWRI will have invested well over $24 million in water research covering the areas of treatment technology, health effects, water quality improvements, public policy and knowledge management, and public information delivery.

As part of its research development process, NWRI has utilized the Nominal Group Technique (NGT) to provide a forum for knowledgeable professionals to gather and deliberate significant water issues. The NGT method is an intensive experience and provides a rich and robust opportunity for participants to explore issues and reach consensus. The NWRI organized this workshop with its partners, the Irvine Ranch Water District and the Orange County Water District, to reassess the current state-of-the-art relative to Title 22 since its origin in the 1970's. The purpose of this workshop was to address the question: *What priority issues need to be addressed to establish non-potable water recycling criteria to protect public health using cost-effective technology?*

This document reports the results of the creative efforts of all those who participated in the two-day event. Significant effort was exerted to maintain the integrity of each participant's contributions.

The workshop was accomplished through the combined efforts of many individuals. The sponsors wish to thank all the participants, many of whom traveled considerable distance to attend the workshop. Sincere appreciation is extended to William S. Gaither, Ph.D., who masterfully facilitated the participants through the NGT process to its conclusion.

The success of the workshop is in no small part due to the support provided by the professional staff. Special thanks are also extended to Patricia Linsky; Editor; Lucy Segura, Meeting Coordinator/Lead Word Processor; Joe Pezely, Graphics Illustrator; Rob Ames, Editorial/Graphics Assistant; Steve Lyon, Graphics Assistant/Technical Information; and Word Processors Cynthia Krieter and Amy Sebelius. The workshop organizers also want to thank the staff of the Kellogg West Conference Center and Lodge who provided excellent accommodations and meals.

RONALD B. LINSKY
Executive Director
National Water Research Institute
Workshop Secretary

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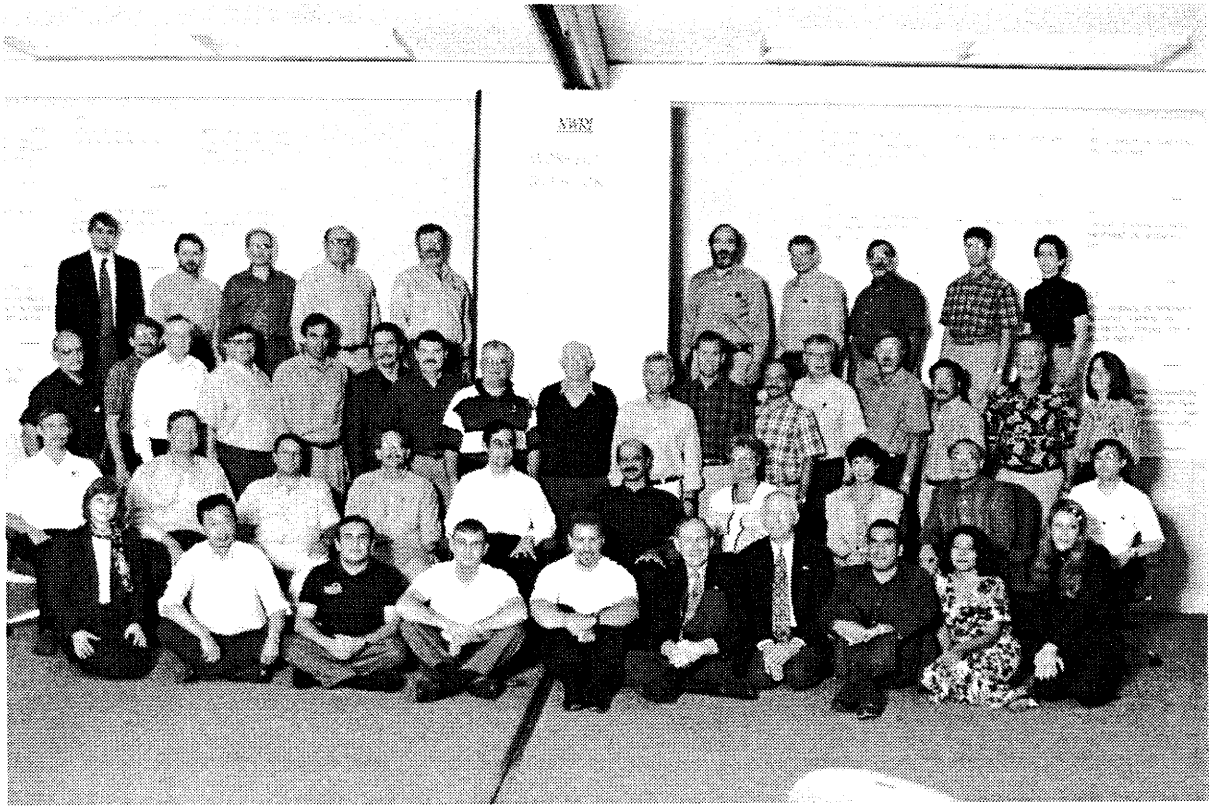
PARTICIPANTS



Top Row: Frank Loge, Richard Harris, Ken Reich, Harvey Collins, Bob Hultquist, Bob Bastian, Harold Bailey, Dave Requa, Steve Duranceau, Hildy Meyers

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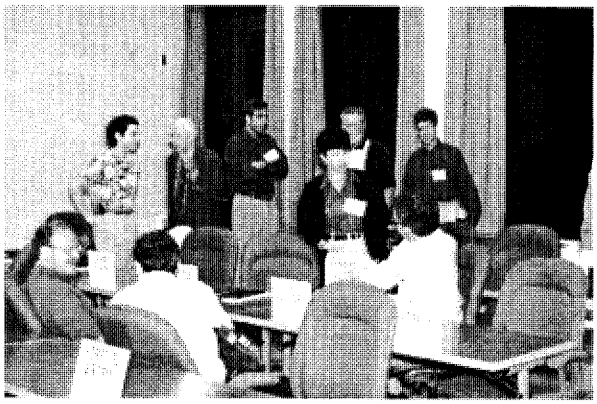


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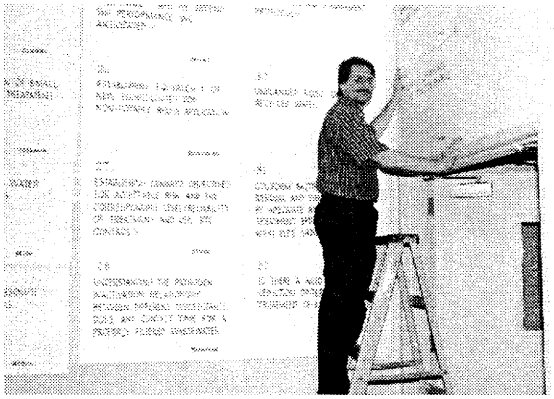

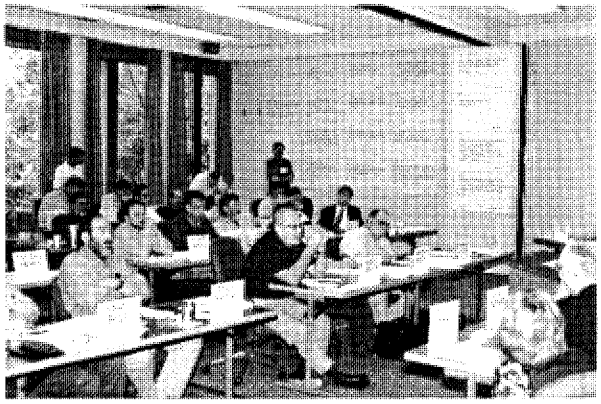

PART 1

Working Groups' Reports


NWRI
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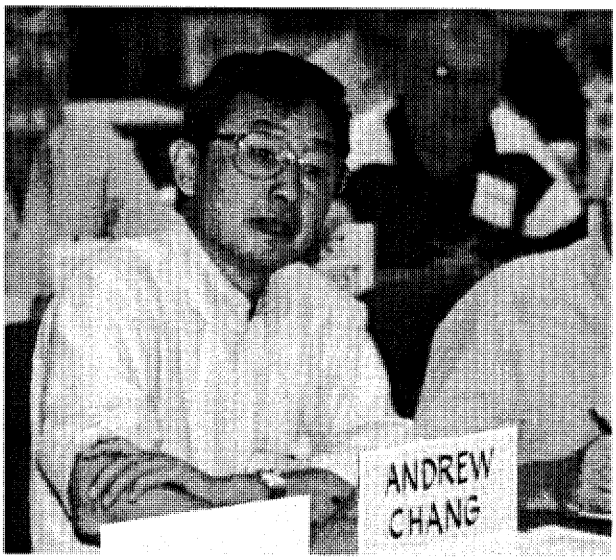
LINSKY

INTRODUCTION

Summary Descriptions of Highest Priority Issues That Need to Be Addressed to Establish Non-Potable Water Recycling Criteria to Protect Public Health Using Cost-Effective Technology

The following summary descriptions of priority issues were prepared by the ten working groups. Each of these ten descriptions represent the first step in consolidating and focusing the highest priority issue areas originated by the participants in the Nominal Group Technique (NGT) workshop presented in Part 2 of this report. Each working group report recommends individuals or organizations that could be members of follow-on Task Forces which would be appointed when and if the process of developing action moves forward. Also, some of the summary descriptions include comments by other participants.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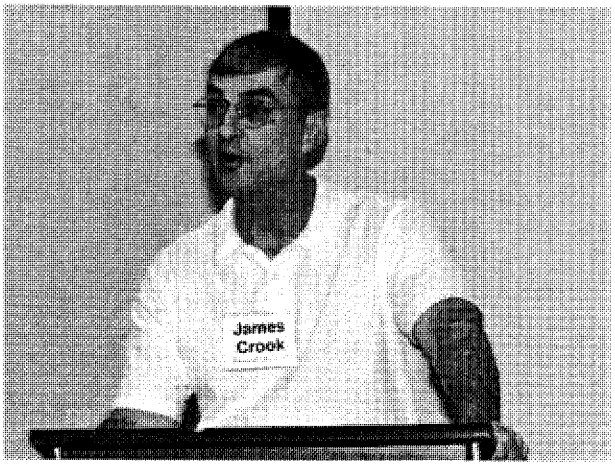
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Adam
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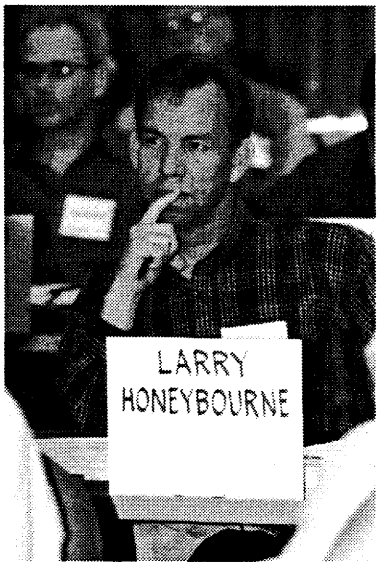

LARRY
HONEYBOURNE

PRIORITY 1

Microbial Risk Assessment Methodologies as a Tool to Help Establish Water Reuse Criteria

WORKING GROUP MEMBERS:

Chang, Crook, Honeybourne, and Olivieri

Issue description:

Current water reuse criteria are based on experience at operating facilities, pilot-plant studies that are site-specific, engineering judgment, and conformance to good practice. As such, they are subjective, inconsistent, and open to criticism as being either overly-conservative or overly-liberal. Because of the many confounding variables and assumptions, it is important to develop a credible risk assessment model applicable to various reclaimed water applications. Regulatory agencies need more refined risk assessment methodology as an aid during criteria development.

The following key issues need to be addressed as part of any microbial risk assessment development:

- When is it appropriate to use current microbial risk assessment methods (i.e., point estimates and epidemiological models)?
- Is it appropriate to use a no-threshold model for microbial risk assessment?
- What is acceptable risk (e.g., does it include a margin of safety; is it based on developing a "comparative baseline")?
- How is treatment plant performance and reliability, including the concept of multiple barriers, addressed within the assessment?
- Can current laboratory methods detect and/or quantify emerging pathogens reliably?
- Are current indicators satisfactory to detect pathogens of concern or adequate treatment? Can coliphage be used?

Importance:

Regulatory agencies would benefit from advanced risk assessment methods as one of the tools to help establish water reuse criteria. Objective, supportable criteria directly related to health risks would improve acceptance of reclaimed water applications by the public and others. Optimum design for a non-potable water reuse project may be derived through assessments of public health risks associated with all design and management options. The integration of public health risk estimates with the cost for treatment technologies allows regulatory decision-making bodies to balance these factors. Risk management is a key element of the regulatory agency decision-making process, and as such, stakeholder groups (e.g., public, industry, environmental, etc.) should be involved early on in the assessment process.

How to overcome or resolve the issue:

- Review and evaluate current risk assessment models and document their advantages and disadvantages.

- Identify information and additional input parameters (e.g., exposure and plant performance and reliability) needed to better estimate the microbial risks associated with reclaimed water.

- Develop a refined methodology that is comprehensive and scientifically supportable.

- Document the accuracy of the model by applying it to past waterborne disease outbreaks where sufficient information is available to test the model.

- Subject the model to peer-review and revise, if necessary.

- Provide a usable risk-assessment model to regulatory agencies that will aid them in developing rational criteria.

- Increase research in detection methodology of emerging pathogens.

Recommended task group membership:

- James Crook - Black & Veatch (Environmental Engineering/Public Health)

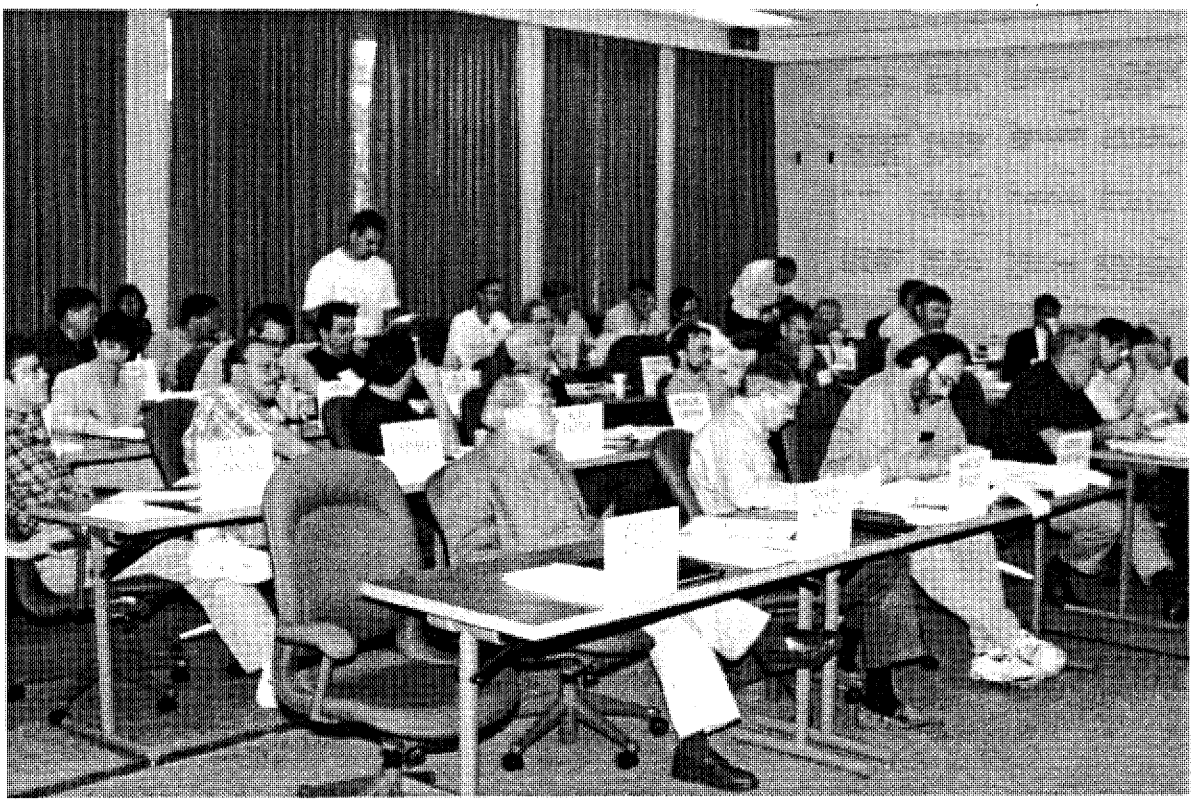
- Adam Olivieri - EOA (Risk Assessment)

- Larry Honeybourne - OCHCA (Public Health)

- Ken Thompson - IRWD (Water Quality)

- Phil Berger -USEPA

- Chuck Haas - Drexel (Modeling)
- Jack Colford - UC Berkeley (Infectious Disease/Epidemiology)
- Mark Sobsey - University of North Carolina (Virology)
- Rick Sakaji -CA DHS (Public Health)




ROBERT
HULTQUIST

PRIORITY 2

Identify Reuse Criteria That Are Both Protective of Public Health and Enable Maximum Flexibility and Efficient Use of Treatment Technologies

WORKING GROUP MEMBERS:

Hultquist, Loge, MacLaggan, and Meyers

Issue description

Assurance of Public Health

- Criteria must be comprehensive to assure safe reclaimed water quality for all possible compliance options.
- Protect against unknown chemicals and infectious agents and those we cannot currently measure/detect.

Consistency Is Needed and Flexibility Is Desirable

- There is a wide variation in how disinfected tertiary treatment is defined.
- The traditional approach to compliance with existing water recycling criteria is to meet both design standards and performance criteria.
- New technology is frequently subjected to a more rigorous standard than conventional technology.
- Water quality objectives in lieu of, or in combination with, performance criteria and/or design and operational criteria may offer greater flexibility and provide for the efficient use of alternative treatment technologies.

Importance:

Water quality parameters such as turbidity, suspended solids, total coliform or fecal coliform (the basis for existing criteria) may not provide a suitable measure of health effects of recycled water. Consideration should be given to establishing water quality objectives that better reflect the ability to remove/inactivate parameters of concern.

Current water recycling criteria do not provide an equitable basis for evaluating the performance of alternative treatment technologies. Consideration should be given to establishing criteria based on specific water quality objectives and/or performance criteria that would provide a consistent measure of the performance of treatment technologies and eliminate the need for certification of new technologies.

Criteria based on water quality objectives and/or performance standards would facilitate understanding of the operational goals and promote selection of the most cost-effective and efficient technologies.

How to overcome or resolved the issue:

Identify the simplest possible set of unambiguous, objective, scientifically-based criteria necessary to fully protect the public. Rigid design and operating criteria that stifle technology development are to be avoided. The focus should be on developing criteria that will support efforts to gain public confidence in water recycling.

Consideration should be given to establishing reuse standards based on water quality objectives in two steps:

- Identifying the chemical and biological contaminants of public health concerns.
- Establishing risk-based standards for these contaminants.

Constituents of concern would include:

- The least sensitive organisms in each class of pathogens.
- A surrogate(s) for contaminants that are difficult to measure directly.
- Possible chemical contaminants.
- Water quality parameters that can interfere with effective treatment (e.g., particulates).

It may be difficult to rely solely on water quality objectives for all classes of microorganisms. The cost of monitoring may be prohibitive, and existing methods of identification may not provide sufficient sensitivity. A single organism may not prove to be the least sensitive for all technologies. Alternative forms of monitoring/surveillance should be considered.

In situations where it is not feasible to rely solely on water quality objectives for specific parameters of concern, it may be appropriate to supplement with surrogate treatment performance standards such as particle size distribution, disinfectant dose (e.g., CT or IT), or log removal. These performance standards should be identified in well-defined studies that demonstrate correlation with a high degree of certainty. Where a correlation cannot be demonstrated satisfactorily, minimum design and operational criteria or other methods of reducing public exposure should be investigated.

We have not been able to rely solely on water quality objectives for microbial contaminants in drinking water. A treatment standard is used that specifies technologies, design and operation standards, and treatment performance standards. A comparable approach may be necessary in establishing standards for non-potable recycled water. There may be lessons in the USEPA efforts to develop the surface water treatment and groundwater rules that should be studied.

This task should include an evaluation of the existing California water reclamation criteria while the proposed research is being conducted. The additional research contemplated herein is directed at increasing flexibility, addressing gaps, providing clarification and greater assurance, and provides for the efficient use of alternative treatment technologies.

Recommended task group membership:

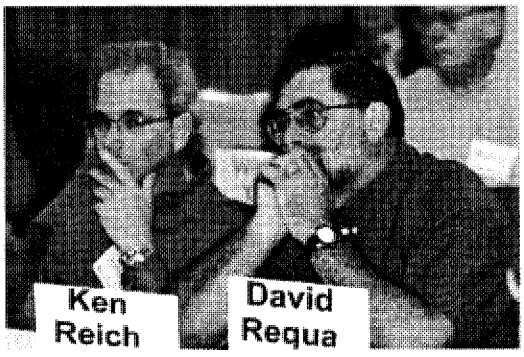
- Frank Loge
- Margie Nellor
- George Tchobanoglous
- Fred Soroushian
- Peter MacLaggan
- David Sedlak
- Jim Crook
- Rhodes Trussell
- Larry Honeybourne
- Rick Sakaji

- Ken Thompson
- Mark Sobsey

Comments

"This task should include some effort directed at providing an evaluation or review of the existing California water reclamation criteria while the proposed research is being conducted. The purpose of this review would be to reinforce our general belief that the existing regulations are protective, and the proposed research is addressing gaps, providing clarification and greater assurance." – Margie Nellor

"Add a separate task as part of the process of setting recycled water as the corollary issue of third-party validation to ensure independent, free from conflict of interest, credibility to final criteria. The need is to provide a "seal" of approval that builds public and consumer confidence, and clearly sets aside technical treatment and safe delivery issues so that projects can be implemented and local political or special circumstances can be dealt with on their own." – Ron Young



PRIORITY 3

Understanding the Pathogen Inactivation Relationship and Performance Parameters for Various Disinfection and Treatment Processes to Develop Cost-Effective Public Health Protection

WORKING GROUP MEMBERS:

Mills, Requa, Thompson, and Yanko

Issue description:

Current disinfection criteria may not represent actual process performance or operating conditions which lead to questions of appropriate levels of public health protection and/or cost effectiveness.

Importance:

- Data developed by the County Sanitation Districts of Los Angeles County over the last 20 years suggest that the Pomona Virus Study may have overestimated disinfection requirements to meet specific virus reduction requirements.
- Work on molecular techniques is suggesting cell culture techniques may not adequately measure disinfection efficiency.
- Removal of virus through filtration and disinfection depends on the concentration of viruses in the secondary effluent (i.e., lower concentrations result in lower removals).
- Laboratory viruses may be more resistant to disinfection than *in-situ* viruses.
- It is suspected that some types of virus are affected differently when subjected to different disinfection processes.
- Conventional filtration virus-removal efficiency, which is dependent on media type, loading rates, coagulant doses, etc., is poorly understood for some pathogens.

- Emerging filtration processes, such as microfiltration, need additional research to understand virus removal efficiency.

- Front-end secondary processes of the wastewater reclamation treatment plant impact the tertiary treatment virus removal efficiency through removal and, apparently, viability of surviving viruses.

- Alternative disinfectants obtain regulatory approval on a case-by-case basis often times requiring expensive pilot testing.

- Previous studies on tertiary treatment processes may not have reflected full-scale treatment plant operations.

How to overcome or resolve the issue?

Research Approach:

- Task 1: Identify and evaluate analytical tools for pathogens with special emphasis on significance and reliability of molecular techniques.

- Task 2: Evaluate what pathogens or surrogates should be used to evaluate the removal efficiency of viruses, *Giardia*, *Cryptosporidium*, and coliform bacteria with attention to the rationale for using the target organism and mechanism of removal.

- Task 3: Develop experimental treatment system to represent actual treatment processes and operational variables to evaluate the effects on pathogen inactivation and removal.

    - Evaluate the impact of common front-end secondary wastewater reclamation treatment processes on pathogen inactivation/stress. Processes to be evaluated should include, but not be limited to: primary/trickling filters, primary/conventional activated sludge and primary/nitrified activated sludge.

    - Evaluate the pathogen removal of common filtration processes. Processes to be evaluated should include, but not be limited to: conventional filtration, direct filtration, and microfiltration. Operational parameters to be evaluated should at least include media type, bed loading rates, and coagulant dosages.

    - Evaluate the pathogen removal efficiency of common disinfection practices. The disinfection practices to be evaluated should include chlorine, chloramines, ozone, and ultraviolet disinfection.

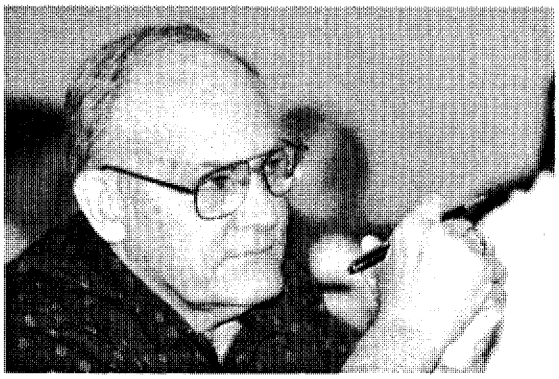
- Task 4: Perform risk assessment review to determine the appropriate pathogen-loading rate for the treatment system evaluation. Develop the analytical methodologies that have the capabilities of evaluating the treatment plant removal performance.

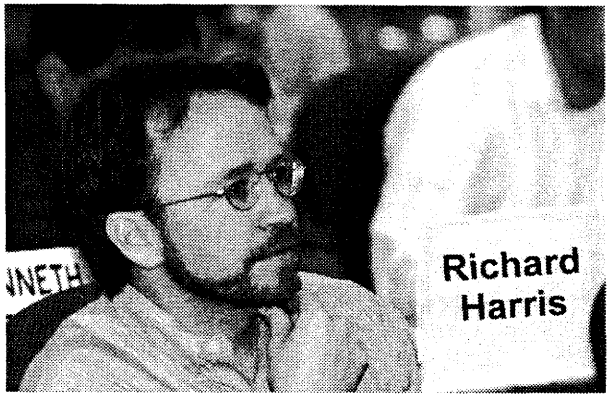
- Task 5: Develop CT/IT tables for each type of disinfectant evaluated and removal credits for each filtration process evaluated.

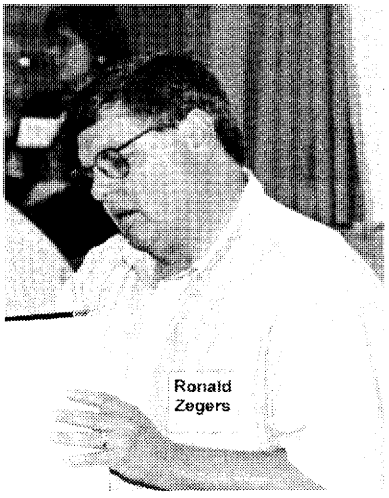
- Task 6: Document the methodologies used for future evaluation of new treatment/disinfection technologies.

Recommended task group membership:

- George Tchobanoglous (Treatment)
- Rick Danielson (Microbiologist)
- Mark Sobsey (Treatment/Microbiology)
- William Yanko (Microbiologist)
- Rick De Leon (Microbiologist)
- Rick Sakaji (Public Health)
- Ken Thompson (Pilot Plant Testing)




Richard
Harris


Ronald
Zegers

PRIORITY 4

Develop a Program to Quantify, Measure, Compare, and Communicate Relative Levels of Safety of Non-Potable Reuse to the Public and Policymakers

WORKING GROUP MEMBERS:

Carnahan, Harris, Stone, and Zegers

Issue description:

There is a need to establish safety equivalency relationships among public health criteria and analogous public activities to expand public education on the rationale of the reuse criteria and best management practices, and their application and use to ensure the safety of non-potable reuse.

There is a need to develop effective communication programs that use descriptive terminology to explain treatment technologies, monitoring system requirements and results, and reliability standards in comprehensive, clear, lay person terms which will improve understanding, support, and confidence in reuse projects.

We need to develop strategies to answer the following questions:

- How does public health protection, as it relates to recycled water use, compare to similar activities associated with alternative water sources?

- How do the safety factors associated with recycled water use compare with other common risks associated with our daily lives?

Importance:

An extremely important issue for continued expansion and success of non-potable water reuse is public understanding and acceptance.

Many viable reuse projects have failed, at least in part, not on insufficient science or technology, but on public perception of their safety.

Tools are needed to effectively communicate the efficacy and appropriateness of varying treatment technologies and processes with appropriate water quality criteria for various reuses.

It is important to develop productive working relationships with environmental stakeholders (e.g., Environmental Water Caucus) to establish environmental responsibility, acceptability, and an understanding of the role for water recycling in water resources management.

Public health officials, recycled water industry representatives, policymakers, and the public at large need to be informed and educated to avoid misinterpretation, misrepresentation, and misunderstanding of recycled water safety.

To ensure the highest public confidence in water recycling, the terminology used in water recycling criteria and by industry professionals and public health offices need to be written for public understanding regarding the level of public health protection provided and relative (comparative) safety concept to support specific reuse applications.

How to overcome or resolve the issue:

Establish a scientific, regulatory, industry, and public relations task force(s) to unite in developing an effective approach and guidance which clearly defines the multitude of safety issues (e.g., treatment level/reliability, monitoring, use-site controls, etc.) considered in project design, operation and approval (i.e., safety assessment rather than risk assessment).

Specifically:

- Identify research needs and conduct research in areas of safety assessment/modeling.
- Develop a resource guidance document of current health effects and safety/risk assessment data in reuse and comparative industries and activities.
- Establish descriptive reuse criteria terminology.
- Issue a statewide "guidance document" by committees of experts to help industry professionals and health officials with their decision.
- Develop strategies for integrating new treatment technology into the development of water recycling standards.
- Provide technical information in readable/understandable form to decision makers and the general public.
- Identify and communicate public health protection/safety/risk.

- Use focus groups, facilitate public forums, and create citizens advisory groups representing all areas of interest.

- Write a proposal for research grant funding.

- Develop specific public education information and tools with a focus on life long learning experiences about recycled water from grade school through senior center programs to bolster public understanding and confidence now and for the future.

Recommended task group membership:

Categories for Task Group Membership:

- Scientific (3)
  - safety/risk assessment modeling expertise
  - medical professional
  - sociologist

- Regulatory (1-2)
  - Department of Health Services
  - local health official

- Technical Industry (1-2)
  - engineer or utility-perspective representative(s)

- Customers (3)
  - recycled water, representing agricultural, landscape and industrial reuse, currently in use

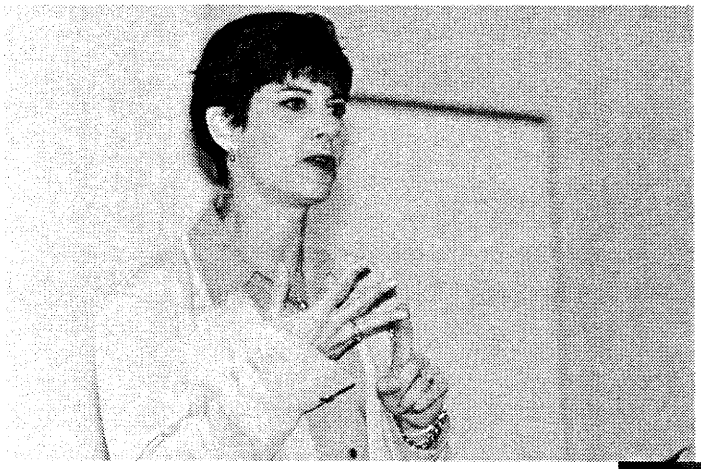
- Citizens Advisory Committee (2-3)
  - general public
  - environmental stakeholders

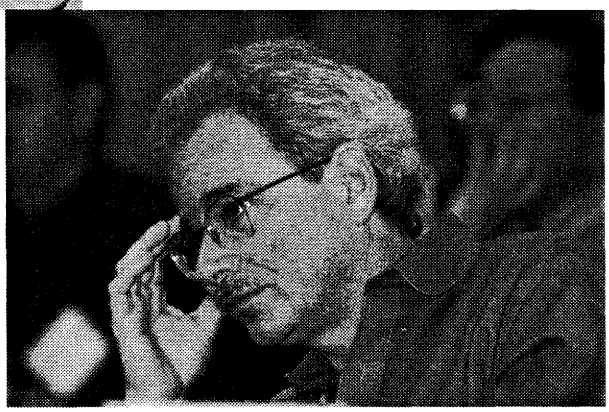
Comments:

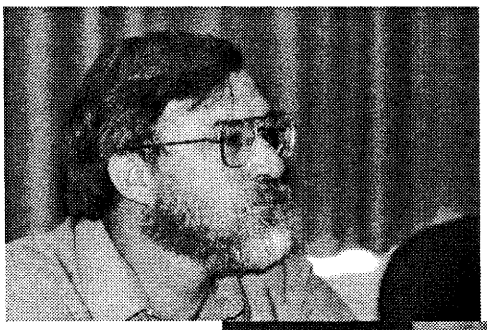
"In discussing the needed broad spectrum of participation, the research may need to reach outside of the traditional folks who are involved (e.g., users, engineers, public health officials) to get a perspective on priority from political groups or special interest groups that are involved in Sacramento (also county supervisors and League of Cities).

"Recommendation may include developing an information outreach foundation similar to (or in conjunction with) ACWA's Water Education Foundation.

"I would be willing to volunteer to help if there is a need or space available on this large team." – Ron Young







PRIORITY 5

Water Quality Standards for Chemical Constituents

WORKING GROUP MEMBERS:

Nellor, Reich, Turek, and York

Issue description:

Planners and practitioners of non-potable reuse must be cognizant of the potential environmental pathways through which inorganics and trace organics may breach the barrier surrounding non-potable reuse and enter water bodies where potable use may take place. This issue should be thoroughly reviewed to determine if there are potential health impacts or if, in fact, some level of removal credit could be conferred when developing a standard. The point of compliance also plays an important role in the development of standards. There is variability from state to state on where compliance with standards is determined. For example, in California standards are applied at end-of-pipe, while in Florida standards are applied at specified groundwater locations. For some of the existing standards, particularly secondary standards and nutrients, there may be some question as to whether the standards are appropriate or applicable for non-potable reuse applications, and a review of those standards is warranted.

Importance:

The issues of standards and their applicability are important because they are needed to protect public health and provide criteria for the design and operation of reuse projects. Existing drinking water standards, both primary and secondary, are typically applied to non-potable reuse projects. In some cases, meeting these standards could restrict the type of recycled water that is used or lead to more expensive treatment to remove the dissolved constituents. There are other constituents in recycled water for which there is little or no information that can be used to develop standards including pharmaceutically-active and endocrine-disrupting chemicals and disinfection byproducts, and research is needed to develop this body of information. Identifying the fate and transport of chemicals is an important element in developing standards. There may also be cases, particularly where constituents are present at low concentrations, where the cause-effect relationship between constituent and health effects is ambiguous, and it may not be possible to develop a standard at this time.

How to overcome or resolve the issue:

The following constituents merit consideration under this priority issue:

- Parameters regulated as drinking water standards (primary and secondary).
- Trace organic compounds, including pharmaceuticals, endocrine disruptors, disinfection byproducts, and volatile organics (VOCs).

Several reuse applications should be investigated:

- Slow-rate agricultural systems.
- Slow-rate landscape irrigation systems.
- Rapid infiltration basins.
- Cooling towers makeup.
- Industrial process water.

The following elements should be included in the overall evaluation:

- Literature Review. The literature should be reviewed to extract information on the parameters of interest, their health effects, occurrence, and fate and transport in the environment.
- Review State Regulatory Programs. Information on existing state programs regulating reuse will be reviewed. The parameters regulated, documented health effects, numeric and narrative standards (their basis and method of detection), and compliance and monitoring provisions (including compliance monitoring locations) will be compiled.
- Monitoring. Data should be collected from full-scale water reclamation plants and their associated reuse sites for the parameters of interest. Monitoring will included influent and effluent sampling at the water reclamation facilities, and groundwater monitoring at multiple, down-gradient wells. Reclamation facilities and reuse sites should be selected to provide various levels of treatment/disinfection and coverage for a range of hydrogeologic conditions. Process and plant effectiveness and reliability should also be assessed as part of this data collection effort.

- Evaluate Fate and Transport. The presence of the parameters of interest in reclaimed water will be assessed. The fate and transport of the materials in groundwater for the irrigation and rapid infiltration basins will be evaluated taking into consideration variability and sensitivity factors. This will enable development of "credits" for removal of constituents for the various types of reuse systems.

- Evaluate the Need for Standards. Based on the literature review, the review of state regulatory programs, the monitoring database, and fate and transport considerations, the potential need for numeric standards or revision to existing standards will be evaluated. If appropriate, recommendations for additional research will be developed.

- Standards Development. Risk assessment techniques will be employed to develop standards for parameters having health significance. A cost-benefit analysis will be conducted in support of this standard setting process.

- Compliance Monitoring Point. Recommendations will be developed for establishing compliance determination points. This will include consideration of mixing zone or zone of discharge concepts. One alternative to be evaluated is the establishment of compliance at end-of-pipe (before discharge to the reuse system) with credits established for anticipated removals/reductions. These "removal credits" will be based on the fate and transport evaluations.

Recommended task group membership:

- Gary Amy, University of Colorado

- Rodger Baird, Sanitation Districts of Los Angeles County

- Bob Cooper, BioVir

- Peter Fox, Arizona State University

- Stuart Krasner, Metropolitan Water District of Southern California

- Audrey Levine, University of South Florida

- Rick Sakaji, California Department of Health Services

- David Sedlak, University of California at Berkeley

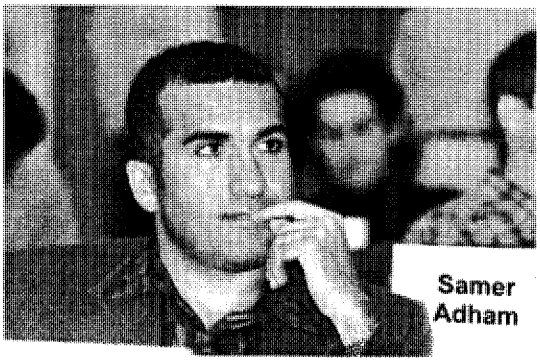
- Mel Suffet, University of California at Los Angeles

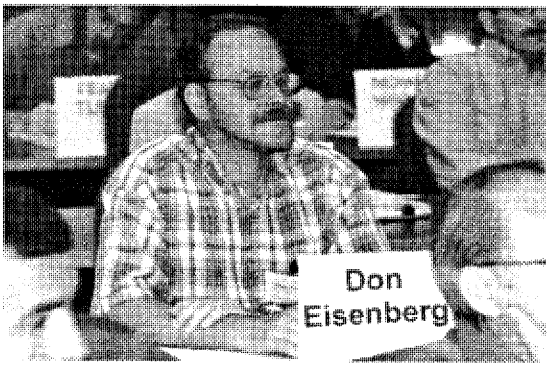
- Jim Symons, retired

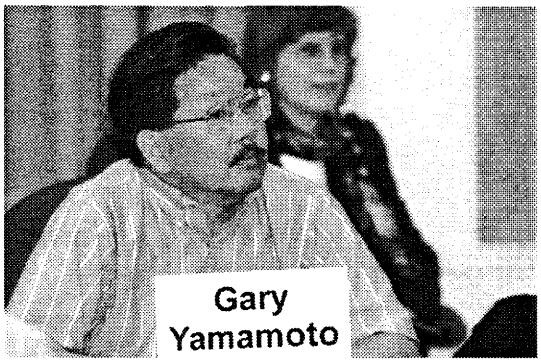
- David York, Florida Department of Environmental Protection

- End Use Representatives (e.g., Cooling Tower Institute, Agricultural Trade Organizations, Golf Course Superintendents Association, Silicon Chip Manufacturers, etc.).

Resources: $500,000 - $1.5 million/two years







PRIORITY 6

Establish a Rational Basis for Demonstrating Equivalent Treatment with Alternative Processes for Pathogen Removal/Inactivation

WORKING GROUP MEMBERS:

Adham, Asano, Eisenberg, and Yamamoto

Issue description:

The regulations were developed to specify a limited set of thoroughly proven treatment processes. The concept of equivalent treatment is a peripheral issue in the existing proposed regulations, and it is not thoroughly addressed. There is a need to agree on how to characterize the performance (effectiveness and reliability) of alternative processes using criteria that are not specific to any particular process.

We have established confidence in many of the treatment processes available to date, but confidence in many of the new technologies is not fully developed. The performance variability and reliability of the treatment method should be part of the criteria rather than log removal issues only.

Regarding pathogen treatment effectiveness, the achievement of 4 logs polio virus may not have the same significance with respect to public health protection as 4 logs removal of bacteriophage. The differences between these organisms with respect to treatment process performance must be better understood, and agreement must be reached regarding how these differences are best addressed when these indicators are used in evaluating equivalent performance.

Importance:

The issue of evaluating equivalent performance has become important because technology is evolving rapidly. Many new technologies may be more cost-effective and more protective than "conventional treatment." With the existing general criteria, it is not clear enough how to evaluate, compare, and approve alternative processes or combinations. The improvement of criteria for demonstrating equivalence will also improve the capability to evaluate and

compare the level of protection provided by conventional facilities that provide full Title 22 treatment.

Various levels of performance are obtained from new technologies as compared to traditional methods. The regulators and the water industry need to fully characterize the new process capabilities before "equivalency" to traditional treatment system can be determined.

Existing proposed regulations allow polio virus and MS2 coliphage to be used as organisms for demonstrating pathogen reduction. The regulations specify 5 logs removal for either organism, but there is no guidance on how or whether to interpret significant differences between the observed removal/inactivation of these organisms. In previous studies what is acceptable to demonstrate equivalency has not been clearly established.

How to overcome or resolve the issue:

- Identify target parameters/indicators that are adequate to address public health protection. This includes investigation of polio virus/MS-2 issues and of alternative indicators/surrogates, and identifying the most appropriate indicators for use in equivalency testing. (Current parameters: coliform, polio virus, MS-2; potential parameters: indigenous coliphage, others?)

- Develop a performance evaluation protocol which includes the following categories:

  - effectiveness of indicator organism removal/inactivation
  - variability of treatment effectiveness
  - reliability of treatment process against failures

  Determine baseline for acceptable performance by testing the protocols at several existing full Title 22 treatment facilities. (Suggested variables: plant capacity, plant location, seasonal sampling.)

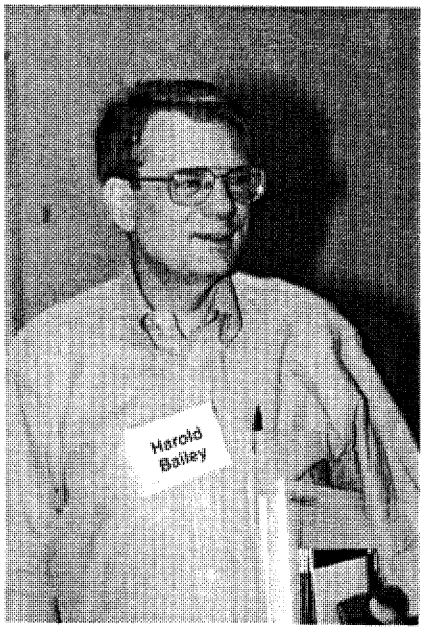
- Apply and compare the baseline performance of the full Title 22 treatment train to selected alternative technologies based on the same protocol, including the three categories listed above.

Recommended task group membership:

- Robert Cooper
- Adam Olivieri
- Robert Hultquist/Richard Sakaji
- George Tchobanoglous

Comments:

"Equivalency of membrane processes (like microfiltration) for direct microbial removal and for enhanced preparation for disinfection must be established relative to direct granular media filtration. Suggested additional members of follow-on task group: Greg Leslie, OCWD." – Michael Wehner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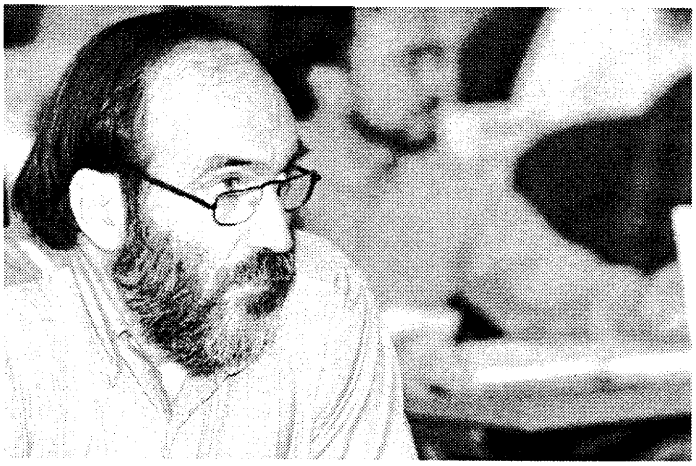


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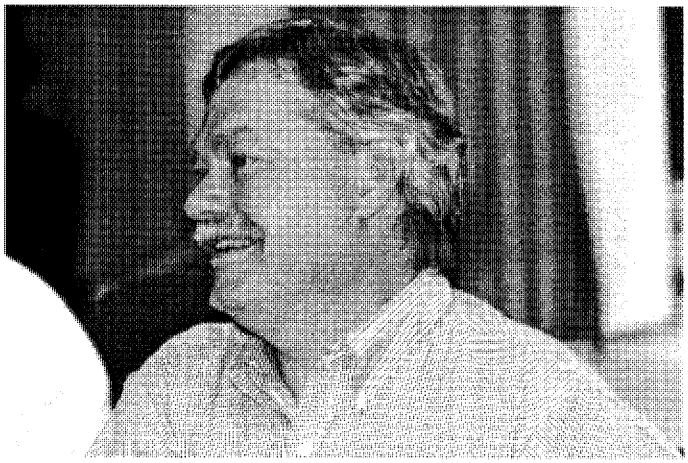


PRIORITY 7

Ensure Recycled Water is Microbiologically Safe for Its Intended Uses

WORKING GROUP MEMBERS:

Bailey, Bastian, Collins, and Young

Issue description:

- Wastewater contains microorganisms that are of public health concern.
- Current regulations may not provide sufficient treatment and quality criteria to reduce public health risk for approved uses to acceptable levels.
- Unintended uses may not be specifically covered in existing or future regulations but can be mitigated by additional protection barriers such as:
  - posting use areas
  - local agency adoption of rules and regulations
  - cross connection control program
  - on-site supervisor requirements
  - public education programs
- Protozoan exposure is controlled by unrestricted use criteria in current California DHS regulations, but not for restricted or landscape uses.
- We need multi-barrier protection for treatment processes beyond secondary treatment (in existing regulations) as required for intended uses.
- We need field verification that recycled water meets the required microbiological quality at the point of use in addition to demonstration of process performance.
- We need disclosure of production of non-spec water to users, as appropriate.
- Several issues referred to in this topic appear better covered in other sections of this report. For example,
  - Work Group report, priority 1
  - microbiological reliability standards and risk assessment methods

- surface water parasite comparisons
- operational performance standards
- reclaimed water discharged to waterways (can best be regulated by NPDES permits)

Importance:

Ensuring recycled water is microbiologically safe for intended uses is important because:

- Public health will be protected.
- Public confidence and acceptance will be easier to obtain.
- Permits will be easier to obtain and maintain.
- A degree of safety for unintended uses will be provided.
- Potential liability exposure will be reduced.
- Customer safety requirements at point of use will be met.
- Customer requirement of knowing product quality will be met.

How to overcome or resolve the issue:

- All protection barriers must be in place.
- Compliance with treatment process and reliability standards.
- Compliance with standards for point of use must be independently verified. (Environmental Management System model.)

Recommended task group membership:

Recommend Task Group Membership. None; however should be included in Priority 2 with input from Priority Groups 1, 3, 6 and 8.

Comments:

"Any discussion or place for regular/annual site visit inspections to ensure administrative protections (signs, etc.) are being maintained. Develop a checklist for regular/annual inspections for administrative protection." – Dave Requa

"If Group #7 defers to the Group #2 team for follow-up, one or more Group #7 members should be included." – Bob Hultquist

PRIORITY 8

Maintain Water Quality in the Reclaimed Water Storage/Distribution System

WORKING GROUP MEMBERS:

Kinshella, Petralia, and Towry

Issue description:

Two issues are of concern relative to the operation of a reclaimed water system. The first is regrowth of coliforms or other indicator organisms. The second issue is system maintenance relative to algae or slime layer growth and the subsequent sloughing.

Once the reclaimed water leaves the plant, no further assessment of quality or safety is performed. Regrowth occurs in the distribution systems, and field measurements show detectable levels of coliforms and other surrogates. Regrowth is a concern, and control methods and operational procedures need to be developed.

Aesthetic problems develop when reclaimed water is in the system for extended periods at elevated temperatures. Systems have experienced foaming and algae growth. The reclaimed water develops odors after extended periods at high temperature in storage/distribution. Maintenance procedures need to be developed and standardized.

Importance:

The health risk associated with regrowth that occurs in recycling distribution systems has not been fully characterized. Since the primary disinfection standards are met at the reclaimed water plant. It is believed that the pathogens of concern (virus and parasites) are not capable of regrowth. Coliforms serve only as an indicator of increased pathogen risk. Also, there may be some concern associated with coliform regrowth not related to pathogens. Gram negative bacteria, like coliforms, can produce endotoxins that are capable of producing gastrointestinal systems. An epidemiology study conducted in Denver for park users who used the parks when the grass was wet showed an increase in gastrointestinal symptoms when fecal coliform and fecal strep levels exceeded 500 per 100 mL, regardless of the water source. Also, if regrowth is a health issue, what maintenance or operation practices are needed for prevention?

The appearance of the reclaimed water is important in developing customer trust in the quality of the product. Deterioration in color, clarity, or odor will lead to question from the customer as to the adequacy of the quality. Water which has been in the "system" too long and foams at the point of use is a problem. These issues point out a need for a maintenance program such as flushing and proper chlorine levels. The program must be adapted to the needs of each utility and its individual storage/distribution systems.

How to overcome or resolve the issue:

Research to determine the operational procedures to best meet the needs of utilities operating reclaimed water storage/distribution systems. Guidelines for the operation and maintenance of these systems should be developed.

Some information has been collected from reclaimed distribution systems, but this has been generally limited to coliforms. Additional pathogen monitoring is needed for a number of case studies that take into consideration different treatment systems and size and water in distribution systems. These data could be used to evaluate if the organisms present in the distribution systems represent regrowth of organisms surviving the treatment process or a new population of organisms. For each subset, research is needed to evaluate the effectiveness of different maintenance and operation techniques to minimize or eliminate regrowth.

Data should be gathered on optimal chlorine levels, dissipation rates, and flushing interval to determine best practices for these systems. Data should be gathered on the frequency of detection and concentration of opportunistic pathogens.

New sensor technologies should be developed for reclaimed water systems for water quality monitoring to assist in identifying and controlling problems associated with storage/distribution systems.

Recommended task group membership:

- Joseph V. Towry
- Paul Kinshella
- Bill Yanko
- Ken Thompson
- Rick Sakaji
- Greg Kirmeyer
- Steve Duranceau

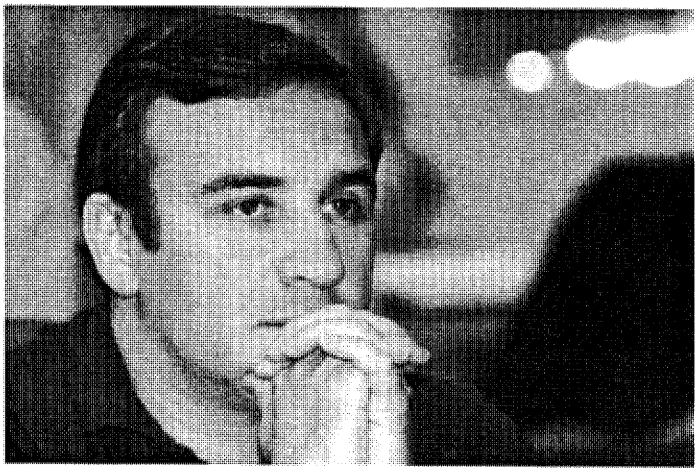
Comments:

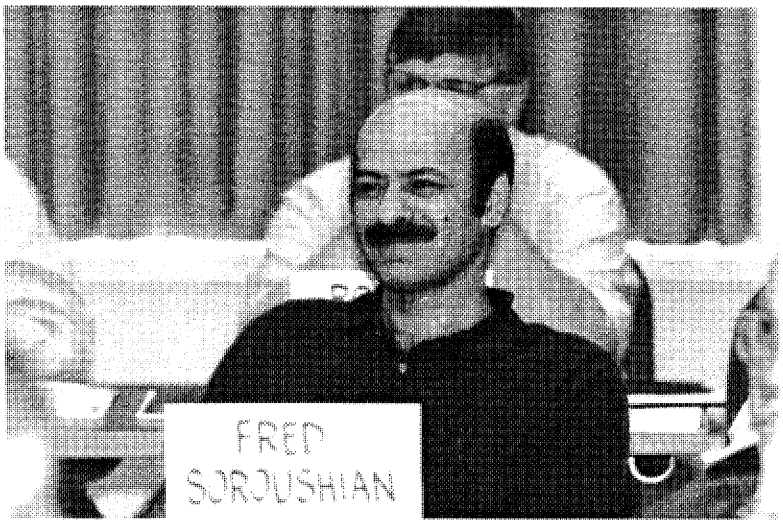
"The scope of work should also address the following issues:

- Develop a guidance manual on the operation and maintenance of water quality in the distribution system and storage facilities.
- Employ pipeline hydraulics and storage recycling practices to reduce nitrification.
- Evaluate treatment practices to enhance the removal of disinfection-demanding substances prior to distribution and storage.
- Evaluate coating technology and its effects on providing an opportunity for protecting bacteria from disinfectant.
- Balance the need to flush the system to maintain residual with possible booster disinfection facilities added to the system.
- Develop guidance on design practices that minimize dead-ends in the distribution system.

"Suggest additional members of follow-on Task Group to include:

- Greg Kirmeyer, Environmental Engineering Science (Bellevue, Washington).
- Steve Duranceau, Boyle Engineering Corporation." – Steven J. Duranceau

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PRIORITY 9

Standardize Protocols for Field Testing of Equipment and Water Recycling Practices

WORKING GROUP MEMBERS:

Ekster, Sakaji, and Soroushian

Issue description:

- Standard testing protocols for establishing effectiveness and reliability of technologies and water recycling practices are not available.
- Performance of full-scale equipment sometimes differ from pilot test results primarily due to hydraulic and other scale-up issues.
- Different water quality monitors may produce different results analyzing water of the same quality due to differences in standard methods employed or application of these methods.

Importance:

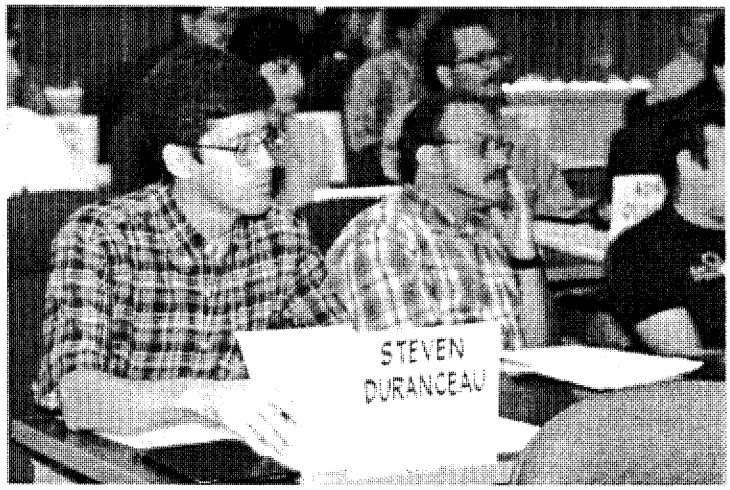
To reduce the cost of water reclamation, we need to allow use of new cost-effective technologies in a timely manner. A well-defined protocol speeds up approval and subjects all new technologies to similar testing and data collection, performance monitoring, and reliability requirements. Consistent and uniform testing approaches ensure public health, reduce redundant testing, and produce transferable results.

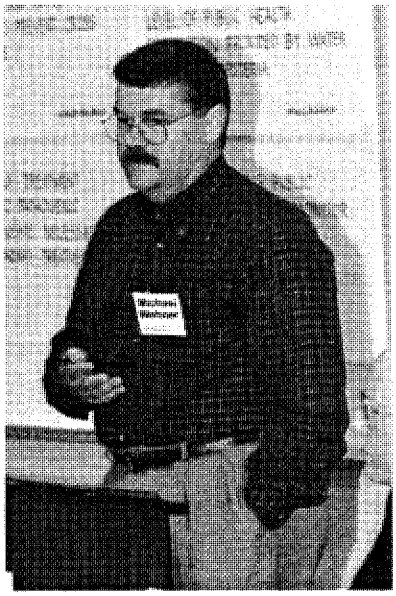
How to overcome or resolve the issue:

Establish an expert panel, develop a strawman, and distribute it to the expert work group that will edit and finalize the testing protocol. Development of NWRI UV disinfection guidelines is an example of this process. The protocol should be updated on a periodic basis. Once the protocol was finalized the feedback process on use of the protocol has to be established for cataloging modifications and future protocol updates. Internet technology could be used for this purpose.

Recommended task group membership:

The expert work group depends on the technology being considered for testing and should be organized by an independent water professional organization such as NWRI, WERF, AWWARF, etc.





PRIORITY 10

Develop New or Improved Real-Time and/or Rapid-Monitoring Strategies to Verify Treatment and Disinfection Reliability

WORKING GROUP MEMBERS:

Duranceau, Griffin, and Wehner

Issue description:

New monitoring systems are needed to ensure continuous safety and reliability of reclaimed water. Coliform monitoring is too slow and does not adequately test for removal or inactivation of pathogens of concern (e.g., viruses and protozoa). More rapid microbial assays to verify disinfection efficacy are needed. Real-time monitoring systems currently available (e.g., turbidity, chlorine residual, and particle counting) need to be improved and supplemented with other online sensor systems to detect treatment system failures and enhance reliability. The sensors can also be used to optimize treatment and help lower operating costs.

New technologies need to be developed that can detect viable pathogens and other water quality parameters on a real-time basis so that water not meeting treatment and quality requirements will not be used.

Importance:

Periodic monitoring is required to detect changes in system chemistry and microbial integrity. Feedback to control water quality has historically been done by batch or discrete interval sampling on the order of days or weeks. Slow feedback inherent in batch sampling and adjustment procedures can lead to overtreatment or overcorrection in treatment. Slow feedback extends the period over which the public can be exposed to microbes and other chemicals. The most effective method would provide for instantaneous, on-line monitoring and surveillance of microbes and other constituents of interest in the system. Consequently, the importance of developing sensor technology includes the following:

- Traditional microbial test methods are too slow, providing results only after the product water has left the plant and been used.

- Public confidence – people need to know that technology is not only used for treatment but also ensures that we can find out immediately if something goes wrong.

- Better performance reliability measures will facilitate development of new treatment technologies.

- Advances in real-time monitoring technologies and strategies can help to reduce costs while providing increased reliability and increased public confidence.

How to overcome or resolve the issue:

The advent of fast response, high sensitivity microelectronics, and affordable computers has allowed the development of instantaneous monitoring devices. This work will be completed along two different, yet integrated, subject areas: improving existing technology, and developing new sensor technology.

In order to implement these phases, a research program is necessary for development and testing of promising new assay systems and sensors for verifying system performance. For example, alternative indicators like coliphage that provide a better measure of virus removal or inactivation are available today. Rapid methods for assay of coliphage offer promise of verifying disinfection system performance in a more timely manner than coliform testing. In addition, systems have reportedly been developed that can identify and quantify *E. coli, Cryptosporidium,* and other organisms in water in real-time using optical properties.

Turbidity, particle counting, and chlorine residual analysis have been historically used to monitor performance of treatment processes. However, these devices still could be improved upon for reliability, consistency, and lower detection levels. In addition, it is anticipated that this work will include an evaluation of the integration of these multiple-technologies with the newer sensor technologies that will also be developed. An evaluation of particle counters, turbidity meters, and chlorine residual analysis or remote sensors will also be included in this work effort.

Relative to developing new sensors, the first major phase of the work is to design the first generation of sensors. The sensors will most likely include, as a minimum, sensor elements for microbes (e.g., HPC, coliform, phages) and chemicals (e.g., BOD, nutrients and electrochemical noise). Also, an evaluation of monitoring UV intensity should also be included. In this phase the geometry and configuration of the sensor elements will be developed. When possible, indicators will also be included into the sensor technology (such as coliform).

The second major phase will be to test the equipment in the laboratory and/or field. Data will be collected from the equipment and compared to traditional methods of analysis.

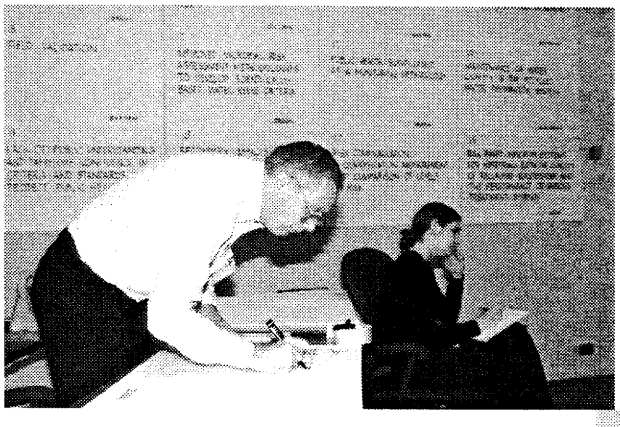
Schedule and Budget

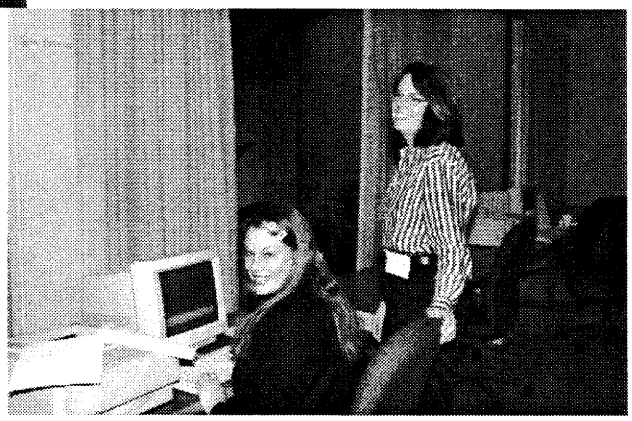
It is estimated that the work effort described herein would require at least two and one-half years at a cost of one-half million dollars.

Major funding from sources such as USEPA and AWWARF will be needed for development of new sensor technology that will permit real time detection of viable pathogens.

Recommended task group membership:

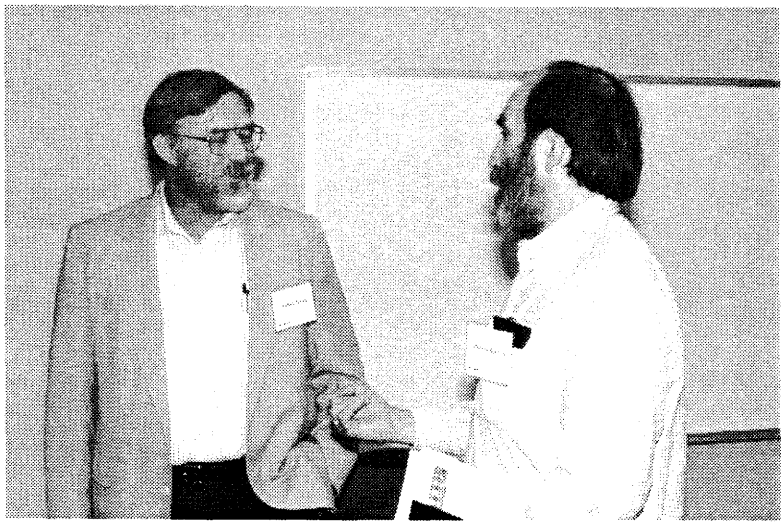
- Steven Duranceau – Boyle Engineering
- Graham Bell – M.J. Shiff & Associates
- Ernie Kartinen - Boyle Engineering
- Greg Leslie – Orange County Water District
- Peter Van der Hoek – Amsterdam Water Supply
- H.F. Scientific
- Coulter Beckman
- Carlos Smith – University of South Florida
- Bob Carnahan – University of South Florida
- Rick Sakaji – DHS
- Richard Harris – EBMUD
- Bob Bastian – EPA
- Ocean Optics – St. Petersburg
- Alex Ekster – San Jose

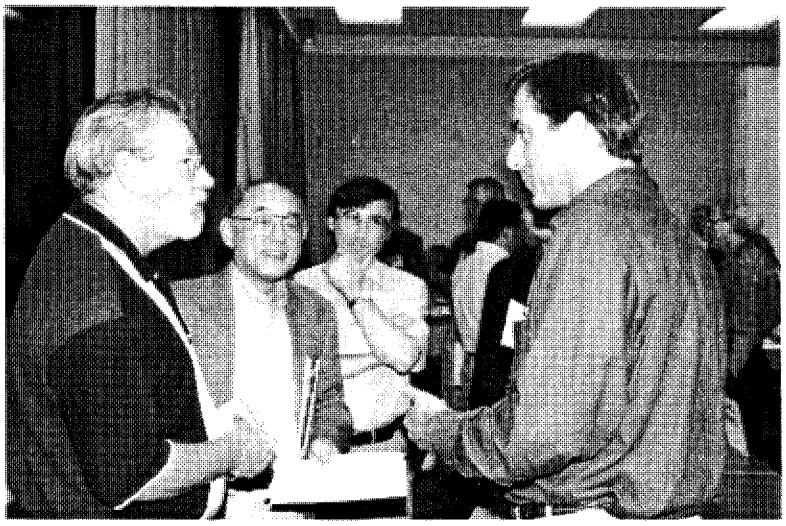




PART 2

NGT Workshop





INTRODUCTION

The Nominal Group Technique (NGT) was developed by Professors Delbecq and Van de Ven in late 1960s at the University of Wisconsin. Their goal was to design a process that would encourage a group of individuals to meet and quickly come to consensus without the usual delays that occur when each participant takes time to establish his or her own credentials before the group, or the dominance of the meeting by one or more highly vocal individual(s). The technique also permits a group of individuals to address a question that could not be resolved satisfactorily by a single individual. This technique has been improved and refined over the past three decades by Dr. William S. Gaither who facilitated this workshop for the NWRI.

Recognized professionals who exhibit significant expertise in the several fields associated with non-potable reuse were identified by the cosponsors and invited to participate in the workshop. (See Appendix C for Participation List.)

Participants were asked in advance to consider the question: ***What priority issues need to be addressed to establish non-potable water recycling criteria to protect public health using cost-effective technology?*** On the first evening (Sunday, May 23rd) workshop guideline and procedures were reviewed. On the second day (May 24th) the NGT was conducted. It comprised three distinct steps:

- Issue identification
- Consolidation of issues into major issue areas, making every effort to avoid overlap between these areas.
- Each participant ranking his or her ten highest priority issues.

The 37 participants identified 97 issues during the course of the morning. Titles of these issues were lettered on large sheets of paper and posted on the workroom wall. After lunch the participants were guided through a systematic discussion in which they boiled the 97 issues down to 25 major issue areas. Some of the major issue areas were given a synthetic title to better describe the several individual issues that comprised the major issue area. At the conclusion of the consolidation process, each participant completed a ranking sheet on which they listed what they considered the ten most important issues in descending order of importance. Also, all detailed issue write-up were edited and approved by the originating author.


NDREW
HANG

PRIORITY 1

Improve Microbial Risk Assessment Methodologies to Develop Scientifically-Based Water Reuse Criteria

ORIGINATORS:

Crook on behalf of himself, Carnahan, Chang, Honeybourne, Hultquist, and Olivieri

The following issues were subsumed under the above title:

Issue title: **Compare Epidemiological Data with Operational History of a Non-Potable Water Reuse Which Should Refine the Risk Assessment Process**

Originator: Carnahan

Issue description:

If epidemiological data can be used to support the use of non-potable recycled water, the public will be more willing to accept a project. Risk access implies a modeling process.

Importance:

If disease incidence can be linked to non-potable recycled water this would enhance the risk assessment process.

How to overcome the issue:

Studies should be conducted.

Issue title: **Assessment of Human Health Risk as a Basis of Planning Non-Potable Water Reuse**

Originator: Chang

Issue description:

- Water reuse is not regulated at the federal level in the U.S. At the local level, regulatory requirements vary from state to state. As a result, the margin of safety may not be the same for all non-potable water reuse projects. Globally, this contrast is even sharper.

- Regulatory requirements for non-potable water reuse are based on the multiple barrier approach of relying on expected performance of wastewater reclamation processes, placement of cross-connection prevention measures, and restrictions to public access along with warnings. Circumstances governing each reuse project are different. Ideally, potential public health risks for non-potable water reuse should be evaluated on a project by project basis.

Importance:

Cost inefficiency is a significant obstacle in implementing non-potable water reuse projects. Regulatory requirements on water quality and site management do not provide much flexibility in planning and designing cost effective and safe non-potable water reuse systems. Optimum design for a non-potable water reuse project may be derived through assessments of public health risks associated with all design and management options.

How to overcome the issue:

- Develop public health risk assessment methodology for non-potable water reuse.

- Compile baseline data required for risk assessment from technical literature.

- Develop a computer code to conduct public health risk assessment for non-potable water reuse.

Issue title: **Improved Microbial Risk Assessment Methodology to Develop Scientifically-Based Water Reuse Criteria**

Originator: Crook

Issue description:

Water reuse criteria are based on experience at operating facilities, pilot-plant studies that are site-specific, engineering judgment, and conformance to good practice. As such, they are subjective, inconsistent, and open to criticism as being either overly-conservative or overly-liberal. The many confounding variables and assumptions associated with microbial risk assessment make it difficult to develop a credible model applicable to various reclaimed water applications. Regulatory agencies need more refined risk assessment methodology as an aid during criteria development.

Importance:

Regulatory agencies would profit from advanced risk assessment methods as one of the tools used to develop rational, scientifically-based criteria. Objective, supportable criteria directly related to health risks would improve acceptance of reclaimed water applications by the public and others. Determination of appropriate treatment and quality criteria will affect project costs.

How to overcome the issue:

- Review and evaluate current risk assessment models and document their advantages, deficiencies, and overall accuracy in determining actual health risks.
- Identify information and additional input parameters needed to better estimate the microbial risks associated with reclaimed water. Based on that, develop refined methodology that is comprehensive and scientifically supportable.
- Document the accuracy of the model by applying it to past waterborne disease outbreaks where sufficient information is available to test the model.
- Subject the model to peer-review and revise, if necessary.
- Provide a usable risk-assessment model to regulatory agencies that will aid them in developing safe and rational criteria.

Issue title: **Are Current Treatment and Quality Criteria Sufficient to Ensure Acceptable Public Heath Risks for Most Sensitive Uses?**

Originator: Honeybourne

Issue description:

- Are current microbial risk assessment methods adequate?
- What is acceptable risk?
- Are treatment plant reliability standards adequate?
- Can current laboratory methods detect and quantify emerging pathogens reliably?
- Are discharges to the sewer by biotech firms adequately regulated?
- Could genetically-altered microbes represent a reason for concern?
- Is the current turbidity standard sufficient to address existing and emerging protozoan pathogens?
- Should there be a requirement for public notification in the event of improperly treated recycled water entering the system?
- Should non-domestic, non-recycled water be regulated if used in a recycled system?
- Are current indicators satisfactory to detect pathogens of concern or adequate treatment? Can coliphage be used?

Importance:

- Public perception of risk associated with origin of recycled water.
- Public demands to know risk.
- Public perceives risk based on voluntary versus involuntary basis.

How to overcome the issue:

- Increase research in detection methodology of emerging pathogens.
- Evaluate existing monitoring data from around state and country to determine treatment plant reliability.

Issue title: **Is There a Risk Level That State Reuse Standards Should Be Designed to Achieve?**

Originator: Hultquist

Issue description:

- The surface water treatment rules hold the annual risk of microbial illness to 10^{-4}.
- The 200 fecal coliform/100mL standard for swimming yields a risk of 8 per 1,000 exposures (10^{-2}).
- Asano *et al* concludes 10^{-2} to 10^{-7} at a 5 log reduction of virus for many uses; 10^{-6} to 10^{-11} for truck farming.
- What risk is appropriate for uses?

Importance:

The risk goal is inversely proportional to treatment level and cost. Risk set too low is a barrier to cost-effective treatment.

How to overcome the issue:

- Determine appropriate risk assessment method.
- Determine risk for uses without reclaimed water and similar exposures.
- Suggest a risk goal.

Issue title: **The No-Threshold Model: Is It Appropriate for Microbial Risk Assessment?**

Originator: Olivieri

Issue description:

The public assumption is that if harm is demonstrated at high doses, then even small doses should be treated the same. This model stems from the chemical paradigm, and microbial assessments can and are conducted following this paradigm.

Importance:

Because we are unable to accurately measure all pathogens and the effects of these pathogens, the chemical paradigm provides comfort. However, we may be dealing with trivial risks and thus facing expenditures of significant public funds without commensurate public health benefit.

How to overcome the issue:

If we proceed on the path of quantifying public health risk associated with microbial pathogens, then three key factors need to be carefully investigated:

- Recognize that microbial risk assessments do not follow the chemical paradigm.
- Develop exposure assessment methodology, since it will drive the risk assessment.
- Develop a "comparative baseline" to allow for determining acceptable risk.

PRIORITY 2

What Kinds of Standards Are Necessary, Feasible, and Best to Assure Safe Reclaimed Water Quality?

ORIGINATORS:

Hultquist on behalf of himself, Ekster, Loge, MacLaggan, Meyers, Nellor, Reich, and Soroushian

The following issues were subsumed under the above title:

Issue title: **Establishing and Monitoring Predisinfected Water Quality Criteria**

Originator: Ekster

Issue description:

The Pomona virus study found no correlation between turbidity and virus removal. Although correlation was established between color and disinfection efficiency, turbidity meters used in this study did not have color compensation and were more sensitive to smaller particles that are presumably easier to disinfect. Regulatory turbidity limitation was established only based on the fact that proper disinfection was always achieved when water turbidity was below 2 NTU. In addition, regulatory turbidity requirements for non-coagulated filter influent are not properly justified; neither criterion was established for meaning of proper coagulation. Finally, readings of the approved on-line turbidity meters may vary as much as 100% when the same water is analyzed.

Importance:

Establishing scientifically-justified water quality criteria prior to disinfection and proper monitoring of these criteria will protect public health and provide public confidence in safety of reclaimed water. In addition, the need to specify types of utilized filters, filtration parameters, and filter influent water quality could be reexamined.

How to overcome the issue:

Correlation needs to be established between water quality parameters such as particle size distribution, TSS, turbidity, presence or organic, and disinfection efficiency for most popular disinfectants (e.g., chlorine and UV). The water quality criteria that can be correlated to

disinfection efficiency and can be reliably and inexpensively monitored have to be used in future regulation. The detail specifications of monitoring methods and applications of these methods have to be established.

Issue title: **What Kinds of Standards Are Necessary, Feasible, and Best to Assure Safe Reclaimed Water Quality**

Originator: Hultquist

Issue description:

- Criteria must assure safe reclaimed water quality for all possible compliance options.
- Flexibility is desirable.
- California criteria now relies upon performance, design, and operational criteria.

Importance:

California regulation complexity is proportional to its flexibility, as is the level of regulator and industry confusion and frustration.

How to overcome the issue:

- Can we rely solely on reclaimed water quality objectives?
- If not, how about relying on a set of performance standards based on surrogates?
- If not, how about comprehensive design and operational criteria based on a study designed to produce the criteria?

Issue title: **Risk-Based Indicator Systems for Assessing Both the Quality of Reclaimed Wastewater and the Performance of Various Treatment Systems**

Originator: Loge

Issue description:

1. What are the chemical and biological contaminants of concern?
2. Establish standards for the chemical/biological contaminants of concern.

3. Optimize existing treatment processes to produce effluents of a desired chemical/biological quality.

4. Develop new treatment technologies to produce effluents of desired chemical/biological quality.

5. Comparative economic analysis of treatment systems.

Importance:

As we move into the coming decades, we can no longer rely on bulk water quality parameters (e.g., turbidity, suspended solids, coliform) to evaluate the quality of reclaimed wastewater. Rather, we will have to develop a new framework for assessing the quality of reclaimed water based on the concentration and occurrence of specific chemical/biological contaminants. I believe we have a fairly good understanding of how to design treatment systems to control biological oxygen demand, suspended solids, and turbidity (bulk water quality parameters), but I believe we do not have a very good understanding of how to design systems to produce a desired chemical/biological quality.

How to overcome the issue:

1. Identify chemical and biological contaminants of concern in water; develop rapid methods of analysis; and develop understanding of partitioning of chemical/biological contaminants between solid and liquid phase.

2. Conduct literature review, risk assessment, and possible epidemiological study.

3. Couple methodologies developed in item #1 with controlled studies of new and existing treatment technologies.

Research in each of the above five areas (see above Issue Description section) will likely be conducted incrementally by different researchers and different funding agencies. I believe the role of NWRI would be to possibly fund some of this research, but more importantly to provide a method of disseminating this information in a logical framework specific to the reclamation fields.

Issue title: **Association of Targeted Organisms with Wastewater Particles**

Originator: Loge

Issue description:

Performance of a disinfection system is directly a function of the concentration of particles with associated targeted organisms.

Importance:

Establishing minimum dose values (e.g., CT or IT) may be overly conservative in the sense that the organism of interest (typically coliform) may associate to a higher degree than bacterial, viral, or protozoan pathogens.

Minimum dose values may be under conservative if the organism of interest (e.g., coliform or seeding coliphage) associate to a lower degree than bacterial, viral, and protozoan pathogens.

Specifying the operation of unit processes is not possible without an understanding of the impact of unit operation on organisms of interest.

Dose is dose until organism particle associated in which case I or C important. Virus removal is not a function of the initial concentration unless particle associated.

How to overcome the issue:

Research in the area of association of pathogens with wastewater particles.

Issue title: **Need for Performance-Based Recycled Water Quality Criteria**

Originator: MacLaggan

Issue description:

The traditional approach to compliance with existing recycled water criteria is to provide minimum technology and meet specific performance criteria. New technology must demonstrate 5-log removal, whereas for conventional technology, demonstration of 5-log removal is not required, and in some cases, not achieved.

Importance:

Requiring a higher standard for new technologies may preclude innovations that could lower the cost and lessen the risk and improve public acceptance of recycled water. Billions of dollars will be invested in recycling in the next decade. An investment in public money of this magnitude should be based on current science.

How to overcome the issue:

Establish an acceptable level of risk for each beneficial use of recycled water and define specific water quality performance criteria that would ensure an acceptable level of public health protection.

Issue title: **Protecting Against Unknowns**

Originator: Meyers

Issue description:

- How to protect against unknown chemicals and infectious agents and those we cannot currently measure/detect.
- How to detect health effects of unknowns.
- The unknown effect of long-term exposure based on short-term studies.

Importance:

Because it asks the question, "How can we be sure of protecting the public's health?"

How to overcome the issue:

Conservation to decrease potable water use resulting in less use of non-potable sources – a partial solution.

Issue title: **Defining Adequate Treatment, Disinfection, and Performance Measures for Non-Potable Reuse**

Originator: Nellor

Issue description:

Based on the existing and proposed recycling criteria and existing policies, there is a wide variation in how one defines a disinfected tertiary effluent. Research is needed to: 1) define what constitutes an appropriate level of treatment and disinfection based on the type of reuse, and 2) determine the best means of measuring that an appropriate level of treatment and disinfection has been achieved.

Importance:

Clarification is needed because many practitioners want certainty for new projects and flexibility for existing projects that may or may not meet any or all of the criteria or policy requirements. There is a body of data from new and old research projects and full-scale operation of recycling projects that is conflicting and may not form a strong enough

foundation to provide this clarification. Also, the public wants to know that these projects are safe, and research is needed to fill in gaps or provide clarification.

How to overcome the issue:

As a first priority, research addressing this issue should be focused on those reuse applications that require the use of disinfected tertiary effluent. A policy decision needs to be made on what model or approach to follow in developing the definition. In other words, should the approach be based on health risk, or based on what a drinking water treatment system can achieve and then determining what wastewater treatment components are comparable (Pomona Virus Study approach). Should these approaches be considered concurrently? If starting out with a health risk based approach, then research is needed to perform the following: 1) hazard identification – the determination of whether a pathogen is linked to a health effect; 2) dose response assessment – the determination of the relationship between the magnitude of exposure and the probability of occurrence of a health effect; 3) exposure assessment – the determination of the extent of human exposure before or after the application of regulatory controls; and 4) risk characterization – the description of the nature and magnitude of risk, including attendant uncertainty.

One area that needs to be emphasized is exposure assessment, which is the qualitative or quantitative determination/estimation of the magnitude, frequency, duration and route of exposure to derive the "real world" dose. It can be done through direct measurement (direct approach), by reconstruction after an exposure (reconstructive approach), or by making estimates of the distribution of the chemical and organism separately (predictive approach). With predictive exposure, you're trying to match/link individuals with the concentration of pathogens/chemicals they are contacting [e.g., making a logical link between the measurement of data and exposure]. It is necessary to perform population characterization as part of this effort which involves identifying the individuals who are exposed and the activities that bring them into contact with the chemical.

Under both of the two approaches, research would be needed to determine what measurement tools are adequate for defining what constitutes an adequately treated water. Are existing surrogate parameters for pathogens adequate? Is there a strong enough relationship between genetic techniques and infectivity testing to use the newer, more sensitive tests? Can techniques be developed to provide real-time monitoring of pathogens (or pathogen surrogates) within the treatment process. Could other measurements be used such as biodegradable fluorescent markers that have a size comparable to pathogens?

The results of this work can be used to determine which treatment combinations and operational performance measures are adequate to provide an acceptable level of risk or how water reclamation plants compare to conventional drinking water treatment systems. It is suggested that this work be done full-scale if possible rather than on a pilot level.

Issue title: **What Constitutes an Exceedance of a Numerical Standard?**

Originator: Reich

Issue description:

Inconsistent use of significant figures in numerical standards leads to confusion when assessing compliance status. If turbidity standard is "2," then is 2.3 a violation or is 2.5 a violation?

Importance:

Must know compliance status real-time. All recycled water producers should be evaluating compliance data in the same manner.

How to overcome the issue:

Develop a uniform significant figure policy and number-rounding process in water-recycling criteria.

Issue title: **Should We Kill the Coliform?**

Originator: Soroushian

Issue description:

Other microorganisms are more resistant to disinfection than total coliform or polio virus. Coliphage, for example, has been proposed for seeding/testing of new technologies for reuse application. Health risk assessment is not performed to establish whether coliphage presence in chlorinated effluent is an indication of virus breakthrough that could be a public health concern.

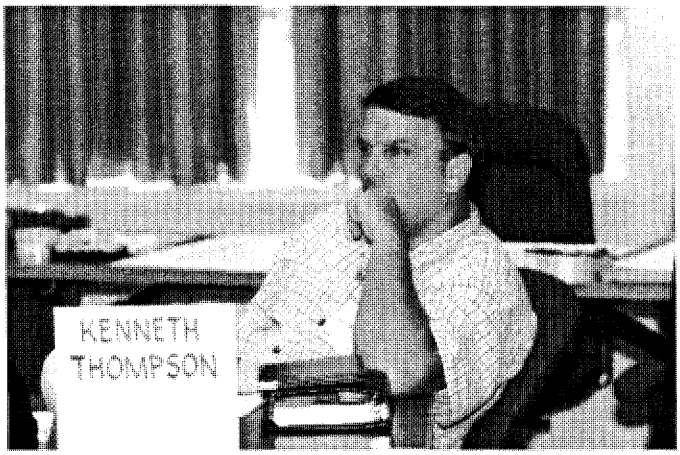
Importance:

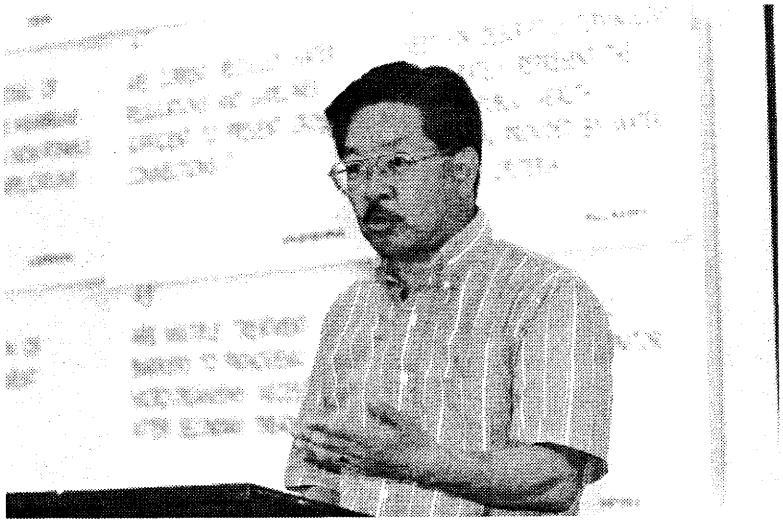
There is a double standard for testing, sizing, and operation of chlorination compared to other disinfection technologies. Seeding studies with coliphage do penalize new technologies since the "conventional process" is not held to the same standard.

How to overcome the issue:

Conduct health risk assessment to select indicator microorganisms that are present in sufficient concentration in filtered effluent for monitoring. Use the same indigenous

microorganisms for performance testing of new technologies. For example, indigenous coliphage is present in adequate concentration in secondary and filtered effluent. Indigenous coliphage is easy to measure and could be used to assess performance of new technologies, as well as monitoring the performance of full scale non-potable reuse facilities.





PRIORITY 3

Understand Pathogen Inactivation Relationships Between Different Disinfectants, Doses, and Contact Times for a Properly-Filtered Wastewater

ORIGINATORS:

Thompson on behalf of himself, Crook, Ekster, Loge, Requa, Yamamoto, and Yanko

The following issues were subsumed under the above title:

Issue title: **Using Seeded Virus as a Surrogate**

Originator: Crook

Issue description:

For high level uses of reclaimed water, regulators require that tertiary treatment remove 5 logs of seeded virus as a demonstration that the product water is essentially pathogen-free. This is based principally on the 24-year-old Pomona virus study, the results of which depended on the site-specific conditions at that facility at that point in time. Virus removal of seeded viruses depends, in part, on the initial seeded virus concentration. Thus, results can vary depending on dose and other site-specific conditions; in addition, it is unclear if less than 5 logs of seeded virus removal can also produce water of acceptable quality.

Importance:

Requiring 5 logs of virus removal can result in different results at different locations. It may result in unnecessary treatment requirements, thus increasing project costs. Current data may not support the use of the 5-log requirement by tertiary treatment. Data for tertiary treatment processes other than media filtration and chlorine disinfection are lacking and, thus, difficult to determine. Other water quality parameters or surrogates for pathogens are needed to indicate acceptable water quality.

How to overcome the issue:

Research is needed to determine combinations of treatment processes and water quality limits that, for high level uses of reclaimed water, produce product water that is essentially free of measurable levels of pathogens. This could include pilot-plant and bench-scale research directed at determining pathogen removal, water quality, and appropriate surrogate parameters. Use different conditions (e.g., vary influent water quality, unit process operational modes, and disinfectant doses, contact times, and residuals). Data from existing operational facilities should be included in the data collection.

Issue title: **Log Removal Versus Residual Concentration**

Originator: Ekster

Issue description:

Removal of virus through filtration and disinfection depends on concentration of viruses in the secondary effluent. The lower concentration of viruses in secondary effluent usually means lower log removal through disinfection and filtration due to the same residual level of viruses in the final effluent.

Importance:

Establishing uniform water quality criteria will better protect public health and at the same time help to design cost-effective innovative technology.

How to overcome the issue:

Look at the possibility of using residual concentrations of viruses or their surrogates instead of log removal.

Issue title: **Association of Targeted Organisms with Wastewater Particles**

Originator: Loge

Issue description:

Performance of a disinfection system is directly a function of the concentration of particles with associated targeted organisms.

Importance:

Establishing minimum dose values (e.g., CT or IT) may be overly conservative in the sense that the organism of interest (typically coliform) may associate to a higher degree than bacterial, viral, or protozoan pathogens.

Minimum dose values may be under conservative if the organism of interest (e.g., coliform or seeding coliphage) associate to a lower degree than bacterial, viral, and protozoan pathogens.

Specifying the operation of unit processes is not possible without an understanding of the impact of unit operation on organisms of interest.

Dose is dose until organism particle associated in which case I or C important. Virus removal is not a function of the initial concentration unless particle associated.

How to overcome the issue:

Research in the area of association of pathogens with wastewater particles.

Issue title: **Establishment of Absolute Standards for Virus Removal**

Originator: Requa

Issue description:

Five-log virus removal is dependent on:

- Type of virus being used (MS2- Polio).
- Initial concentration into treatment process.
- Changes in characteristics over time of treatment process.

Importance:

- Equal comparison of treatment process leading to cost-effective decisions.
- Uniform and standard compliance technique for various processes.
- Compliance during operations.

How to overcome the issue:

- Determine standard indicator organism.
- Develop standard test procedure.
- Develop monitoring methods based upon sound risk and statistical assessment criteria.

Issue title: **Understanding the Pathogen Inactivation Relationship Between Different Disinfectants, Dose, and Contact Time for a Properly-Filtered Wastewater**

Originator: Thompson

Issue description:

- Current proposed regulations in California do not differentiate between chlorine and chloramined efficiency for pathogen inactivation.
- Some regulations that require both 90-minute contact time and 5 mg/L final residual talk about CT but do not fully embrace the concept.
- Alternative disinfectants are handled by exception or a case-by-case basis oftentimes requiring expensive pilot testing.

Importance:

- Utilities building a new reclamation system can have flexibility in the disinfection process in the design and operations without reinventing the wheel each time.
- Plant expansions costs could be reduced by:
  - changing the treatment process
  - modifying disinfectant dose
  - changing type of disinfectant
- Create consistent and fact below standards throughout the state.

How to overcome the issue:

- Develop removal criteria (virus) for different disinfectants over a range of:
  - doses
  - contact times
  - physical chemical parameters (temperature, alkalinity, pH)

- Validate performance either in operations, treatment plants or large pilot plants.

- Disinfectants to be considered, individually or in combinations of, include chlorine, chloramine, ozone and, ultraviolet disinfection.

Issue title: **Should an Effluent Virus Standard Be Established in Lieu of Seeding Studies or Requiring 5 Logs Virus Reduction?**

Originator: Yamamoto

Issue description:

- Log removals for filters are not always comparable. The higher the influent concentration, the easier it is to demonstrate 5-log removals.

- Some filters are not always able to demonstrate 1-log reduction; does that make the filter unacceptable?

Importance:

Evaluating filters is not an exact science. The existing plants built according to the Pomona Virus Study may not be achieving 5-log virus reduction.

How to overcome the issue:

- Develop better virus assay methods.

- Develop dose/illness numbers.

Issue title: **How Do We Determine an Appropriate Level of Disinfection?**

Originator: Yanko

Issue description:

Data developed by the County Sanitation Districts of Los Angeles County (CSDLAC) over the last twenty years suggests the Pomona Virus Study may have overestimated disinfection requirements to meet specific virus reduction requirements. At the same time, work with molecular techniques is suggesting cell culture techniques may not adequately measure disinfection efficiency.

Importance:

Our basic concepts of what constitutes adequate disinfection to protect public health with reclaimed water are based on the Pomona Virus Study and cell culture virus assays. If the pilot plant research was not truly representative, or if virus assays are inadequate, there may be a greater level of uncertainty about disinfection practices then we now believe. Valid risk assessment is dependent on valid data.

How to overcome the issue:

Rethink how we model microorganism inactivation research studies and learn more about genetic-based analyses.

PRIORITY 4

Risk Communication: A Quantification, Measurement, and Comparison of Levels of Risk

ORIGINATORS:

Harris on behalf of himself, Asano, Bastian, Carnahan, Collins, Harris, Loge, MacLaggan, Stone, Wehner, and Zegers

The following issues were subsumed under the above title:

Issue title: **How to Educate Public Health Officials on New Science and Recent Findings**

Originator: Asano

Issue description:

Public health officials need to be educated so that they are not operating on obsolete knowledge and information.

Importance:

Department of Health Services and Regional Boards are having a difficult time accepting "new concepts" and updating regulatory procedures for non-potable water reuse projects.

How to overcome the issue:

Issue statewide "guidance documents" by committees of experts to help health officials with their decision process.

Issue title: **Interpretation of New Monitoring System Results**

Originator: Bastian

Issue description:

Need for guidance on how to interpret results of using new genetic probes and chemical pollutant analyses at the nanogram level.

Importance:

Need to avoid misinterpretation and misunderstanding of results by public.

How to overcome the issue:

Conduct conferences, workgroups, etc.

Issue title: **Lack of Public Understanding and Therefore Confidence in Criteria and Standards to Protect Public Health**

Originator: Carnahan

Issue description:

Public perception and health are major issues. There is a lack of confidence in current systems (e.g., designs and operations).

Importance:

The public must feel safe when non-potable recycled water is used for irrigation or groundwater re-hydration use.

How to overcome the issue:

Develop a strategy for integrating technology into standards development. The public must be satisfied that the standards and criteria used to design a non-potable recycle system will protect their health.

Issue title: **How Can Professionals in the Water Field Prevent Good Projects From Failing Due to Perceived Risks?**

Originator: Collins

Issue description:

Good projects will continue to fail due to political opposition resulting from perceived risks on the part of the public. Thus, it is necessary to make sure that the technical literature regarding a proposed project is made available in readable form so that the decision-makers and the lay public can clearly understand the issues. Furthermore, it is mandatory for professionals to have their fingers on the "pulse of the community" so that questions can be answered before erroneous perceptions of risk and opposition groups are formed.

Importance:

This issue is significant because of the probability that good projects will be defeated due to erroneous perceptions of risk by the public and uninformed decision-makers. Professional people in the water industry are usually not trained in public relations and may also be politically naïve. Therefore, they (we) are poorly equipped to deal with political and environmental controversy.

How to overcome the issue:

- Provide technical information available in readable form to decision-makers and the general public. The need for the project versus alternative projects must be presented.

- Public health risks must be clearly identified and communicated to the public and to the decision makers.

- Compare public health risk of projects with relative risks. Be prepared to discuss the charges of accepting certain risk by "choice" versus having "no choice" which the proposed project might force on the public.

Issue title: **Risk Communication: A Quantification, Measurement, and Comparison of Levels of Risk**

Originator: Harris

Issue description:

- What is considered to be acceptable risk?
- How do recycled water health protections compare to similar public exposure to alternative water sources?
- Criteria need to be based on quantified and equivalent levels of risk for identified users.
- Criteria needs to serve as a communication tool to the public.

Importance:

- The single most important factor for continued expansion and success in reuse is public understanding and acceptance.
- Experience has shown that research and technology alone do not always overcome public fear, perception, and the "yuk factor."
- There is a need to communicate relative risk concepts to the public.
- We need to be careful in establishing and communicating water quality criteria so as not to paint the water recycling industry into a corner where the public expects drinking water quality for every non-potable use.

How to overcome the issue:

- There is a need to establish risk equivalency relationships among public health criteria, analogous activities, and levels of exposure.
- Current regulations do not effectively communicate varying treatment and quality criteria with level of public exposure.

Issue title: **Dissemination of Information to the Professional Community**

Originator: Loge

Issue description:

Research in priority areas will likely be conducted incrementally by different researchers and different funding agencies. The field needs a method of integrating information and dissemination to professional field.

Importance:

Need to provide cohesion in field.

Issue title: **Need for Descriptive Terminology to Accurately Represent the Level of Public Health Protection Provided by Water Recycling Criteria**

Originator: MacLaggan

Issue description:

Monikers like "Full-Title 22," "Disinfected Tertiary 2.2," " Disinfected Secondary 2.2," "Disinfected Secondary 23," and "Secondary Effluent" fail to convey to the general public an understanding of the level or care provided or conversely, the level of risk associated with a recycled water application.

Importance:

To ensure the highest public confidence in water recycling, the terminology used in the water recycling criteria should convey a clear message regarding the level of public health protection provided to support a specific reuse application.

How to overcome the issue:

Establish descriptive titles for all various levels of recycled water authorized under the water recycling criteria that clearly convey a message to the general public of the level of care provided.

Issue title: **Educating the Public to the Safety Factors and Benefits Associated with the Approved Use of Reclaimed Water**

Originator: Stone

Issue description:

Many projects have failed based (at least in part) not on insufficient science/technology but on public perception of their safety or lack thereof.

Importance:

Have we made/developed the necessary support information for industry to clearly present the issues associated with recycled water use which instills public confidence through comprehensive/clear/lay person terms?

How to overcome the issue:

Maybe we need scientific/regulatory/industry and public relations groups to join forces in developing an effective approach to developing guidance which clearly defines the multitude of safety issues (e.g., risk, treatment level/reliability, monitoring, use-site controls, etc.) considered prior to project approval.

Issue title: **Public Education Regarding the Treatment Quality and Reliability Requirements Can Improve Public Confidence and Support**

Originator: Wehner

Issue description:

The public may fear what they do not understand. Development of communication programs that explain treatment technologies, monitoring requirements, and reliability standards can improve understanding and support for projects.

Importance:

Public understanding and support are needed for expanded reuse.

How to overcome the issue:

Develop standard communication tools that any agency could use, or adapt for use, with their own projects and customers. Start with the schools and use public access television, homeowner's groups, etc.

Issue title: **Public Support for Reuse Projects Through Understanding**

Originator: Zegers

Issue description:

- Reuse is a better viable alternative to wastewater discharge.
- Methods need to be developed to provide public input.
- Methods need to be developed to let the public provide direction for reuse.
- An understanding that discharge is someone's drinking water needs to be promoted.

Importance:

- A well-informed public will make the right recommendations.
- Boards will receive public recommendations based on studies and understanding.

How to overcome the issue:

- Use focus groups.
- Facilitate public forums to address the issue of waste discharge versus reuse.
- Create citizen advisory groups representing all areas of interest.

PRIORITY 5

Define Appropriate Chemical Standards for Non-Potable Reuse

ORIGINATORS:

Nellor on behalf of herself, Chang, Duranceau, Reich, and York

The following issues were subsumed under the above title:

Issue title: **Environmental Fate and Transport of Trace Organic Substances**

Originator: Chang

Issue description:

Water quality criteria for non-potable water reuse emphasizes bacteriological standards and assumes other constituents in reclaimed wastewater will not be limiting if the pathogen elimination requirements are met. Trace amounts of disinfection byproducts, pharmaceutically-active ingredients, and hormone-like endocrine disrupters have all been found in reclaimed wastewater. In non-potable water reuse, these substances are not likely to directly affect public health. Through water reuse, these substances however may be introduced into downstream water bodies that are sources for public water supply. Effects of long-term, low-level exposure to trace organic substance are uncertain.

Importance:

The presence of trace organic substances in reclaimed wastewater so far has not resulted in any documented harm. Because of the low concentrations and the ambiguity of their environmental fate and transport, it may not be possible to establish an unequivocal cause-effect relationship between trace organic chemicals and public health. The planners and practitioners of non-potable reuse, however, must be cognizant of the potential environmental pathways through which trace organic chemicals may breach the barrier surrounding non-potable reuse and enter water bodies where potable use may take place. Unless this issue is thoroughly reviewed, the potential long-term public health threat should not be entirely discounted.

How to overcome the issue:

The literature should be reviewed to identify the prevalence of trace organic chemicals in reclaimed wastewater, estimate possible exposure levels through non-potable water reuse, and evaluate potential long-term health hazards.

Issue title: **Identification, Occurrence, and Fate of Reclaimed Water Disinfection Byproducts in the Environment**

Originator: Duranceau

Issue description:

Disinfection of water is the cornerstone of public health. As chemists continue to lower the threshold of chemical detection limits in water, our understanding of chemical processes will continue to grow. Concern about safety, *Cryptosporidium*, and other highly robust microorganisms have motivated the use of alternate disinfection processes. However, our understanding of the fate of disinfection byproducts in the environment is limited.

Importance:

Identifying the occurrence, fate and transport of man-made chemicals in the environment is crucial to long-term public welfare. A balance needs to be maintained between acute and chronic exposures to disinfection byproducts. The need for identifying and assessing the transport and fate of disinfection byproducts is important to understanding the impact of these chemicals on non-potable water reuse in food crops, irrigation, and indirect reuse.

How to overcome the issue:

Identification of the use of disinfection processes that limit the formation and transport of disinfection byproducts is needed. Methods that remove disinfection precursors will be favored over use of alternative chemicals for disinfection.

Issue title: **Defining Appropriate Chemical Standards for Non-Potable Reuse**

Originator: Nellor

Issue description:

Many reclamation plants are required to meet primary and secondary drinking water standards for non-potable reuse projects. Are there standards appropriate in all cases or can alternative standards or methods be developed for reuse projects?

Importance:

The cost consequences of this issue can be significant. As an example, Methylene Blue Activated Substances (MBAS) is currently regulated as a secondary drinking water standard. It was developed at a time when detergents significantly caused foaming in drinking water systems. Since that time, detergents have been reformulated, and foaming issues have essentially been eliminated. However, the standard still applies, and there are significant problems with the analytical test method. This situation can lead to non-compliance at the water reclamation plant and the need for additional (and perhaps) unnecessary treatment. This situation may be exacerbated by the shift from solvent-based industrial/commercial cleaners to water-based (detergent-based) cleaners.

How to overcome the issue:

The basis and need for the standards for non-potable reuse should be revisited. Alternative analytical methods should be evaluated that can provide better measures of system performance and safety.

Issue title: **Develop Product Water Quality Standards**

Originator: Reich

Issue description:

Most non-potable recycling permits in Los Angeles include requirements for recycled water to comply with applicable drinking water standards, such as maximum contaminant levels and action levels. These limits are meant more for the protection of groundwater quality and not the direct public health protection of recycled water users.

Importance:

Meeting drinking water standards could restrict the type of source water (secondary treated) available for tertiary treatment or require expensive treatment to remove dissolved constituents. Future drinking water regulations, such as a revised arsenic standard down to two micrograms per liter, could put more arsenic into the sewer system (source water) from drinking water treatment residuals disposal.

How to overcome the issue:

Development of separate product water quality standards for non-potable recycled water that do not necessarily rely on drinking water standards but will prevent degradation of groundwater quality.

Issue title: **Removal of Contaminants in Land Application Systems**

Originator: York

Issue description:

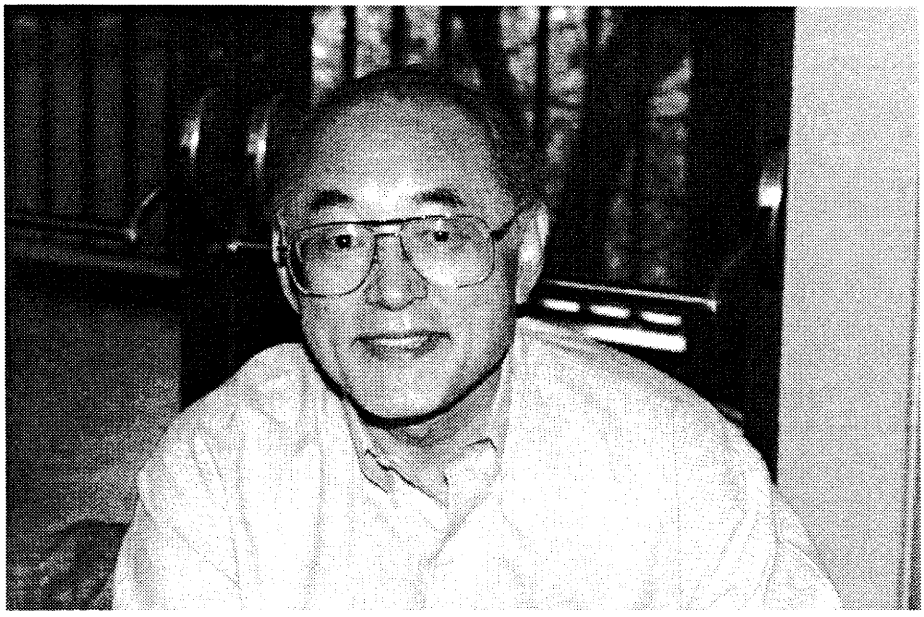
Questions exist about the effectiveness of a range of land application and reuse techniques for removal of pathogens, organic compounds, pharmaceuticals, and endocrine disrupters.

Importance:

These questions may impede implementation of a range of reuse systems.

How to overcome the issue:

Conduct research on the fate of these contaminants in a range of reuse systems. Irrigation systems in which the reclaimed water has received secondary treatment and basic disinfection (200 fecal coliforms/100 mL), landscape irrigation systems (high-level disinfection), and rapid infiltration basins should be evaluated. The reclaimed water and treated percolate should be evaluated for pathogens (enterovirus, *Giardia*, *Cryptosporidium*), a range of indicator organisms, organic compounds, pharmaceuticals, and endocrine disrupters.



PRIORITY 6

Establish Rational Basis for Demonstrating Equivalent Treatment with Alternative Processes for Pathogen Removal/ Inactivation

ORIGINATORS:

Asano on behalf of himself, Adham, and Eisenberg

The following issues were subsumed under the above title:

Issue title: **How Can We Consider Emerging Treatment Technologies in Establishing Non-Potable Water Recycling Criteria**

Originator: Adham

Issue description:

We have established confidence in many of the treatment processes available to date, but confidence in many of the new technologies is not fully developed. The performance of the treatment method should be part of the criteria rather than log removal issues only. For example, two membrane elements can achieve the same log removal of microorganisms, but due to their different casting methods, membrane material, or cleaning methods, one may break much more frequently.

Importance:

We need an effective treatment system that can operate trouble free with high online factor. Various level performance is obtained from new technologies as compared to traditional methods. The regulators and the water industry need to understand the new process capabilities before "equivalency" criteria to traditional treatment system can be developed.

How to overcome the issue:

We need to fully define the capabilities of new technologies.

Issue title: **Establishing Rational "Equivalency" in Pathogen Removal/Inactivation**

Originator: Asano

Issue description:

Is chlorine disinfection using CT value of 450 mg min/L equivalent to 4-log removal of enteric viruses? Furthermore, is the achievement of 4 logs using polio virus the same for bacteriophage with respect to health protection?

Importance:

To adopt a new, untried process or establish "equivalency" in treatment on health protection.

How to overcome the issue:

- Devise a new standardized test for disinfection efficiency. Take an aliquote of sample from filtered effluent, then add 5 mg/L Cl_2 and measure bacteriophage reduction/removal after 90 minutes.
- Establish polio virus and bacteriophage equivalency.

Issue title: **Improve Definition of Equivalent Treatment**

Originator: Eisenberg

Issue description:

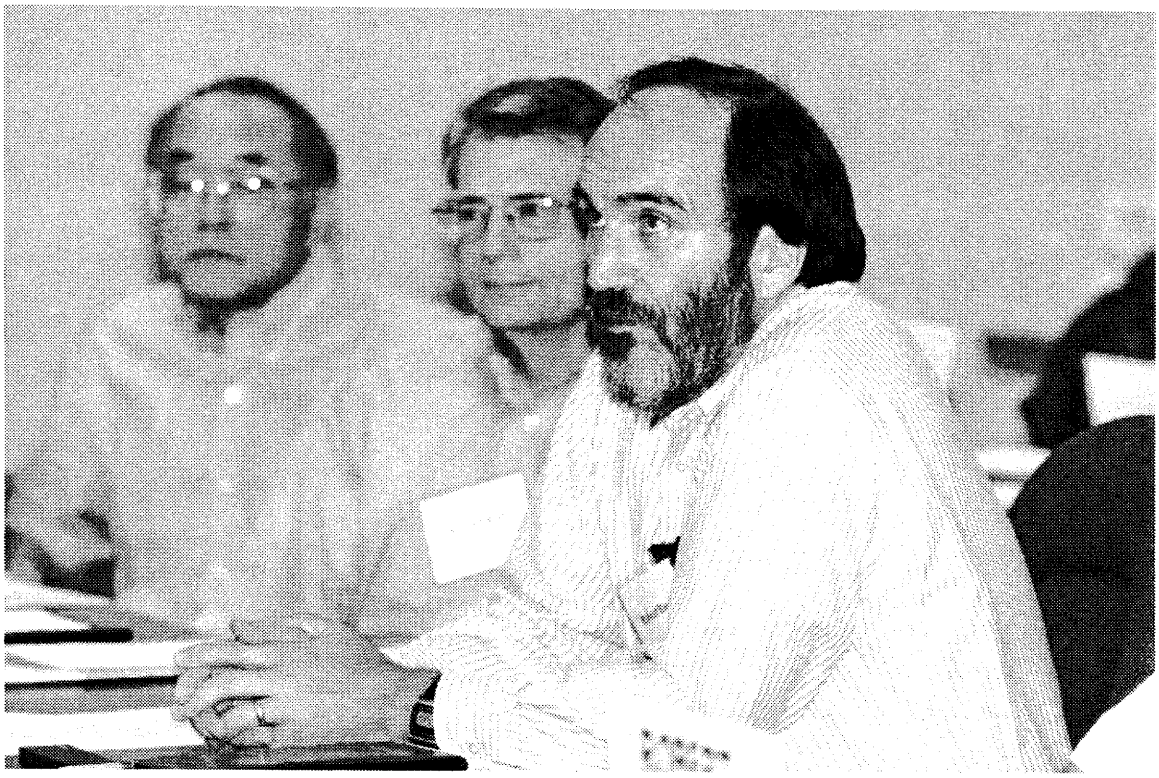
The regulations were developed to specify a limited set of thoroughly proven treatment processes. The concept of equivalent treatment is an afterthought. There is a need to agree on how to characterize the performance (effectiveness and reliability) of alternative processes using criteria that are not specific to any particular process.

Importance:

This has become important because technology is evolving rapidly. Many new technologies may be more cost-effective and more protective than "conventional treatment." With the existing general criteria, it is not clear enough how to evaluate, compare, and approve alternative processes or combinations. The improvement of general criteria will also improve the capability to evaluate and compare the level of protection provided by different conventional facilities.

How to overcome the issue:

Agree upon what to measure and how to characterize the level of public health protection provided by "conventional systems." Characterize that performance sufficiently to develop criteria that can be applied to any unit process or combination. Existing indicators for bacteria and virus may or may not be sufficient. Methods for measuring and comparing reliability certainly need to be addressed.



PRIORITY 7

Ensure That Recycled Water Is Microbiologically Safe in the Event That It Is Consumed by an Unsuspecting Public

ORIGINATORS:

Collins on behalf of himself, Bailey, Bastian, Collins, Honeybourne, Hultquist, Kinshella, Turek, and Yamamoto

The following issues were subsumed under the above title:

Issue title: **What Treatment and Disinfection Processes and Water Quality Standards Are Required to Reduce the Risk of Exposure to Protozoan Parasites?**

Originator: Bailey

Issue description:

The significance of *Cryptosporidium* in water supplies was identified post-1978 and hence was not addressed in Title 22 criteria. As more recycled water is being utilized for all allowed uses, and with the assumption that the population of immune deficient individuals is increasing, the risks of exposure increase. It is assumed that an acceptable level of risk is commensurate with the virus standard incorporated in Title 22.

Importance:

Control of *Cryptosporidium* and other protozoan parasites is needed to minimize exposure through contact with edible crops, incidental ingestion from full body contact in recreational impoundments, or through a direct or cross-connected supply of recycled water to a potable water system or fixture(s). Quantification of the presence of *Cryptosporidium* is possible.

How to overcome the issue:

Collect data from a variety of treatment facilities to access the effectiveness of existing facilities to determine removals. Make a risk assessment of the results.

Issue title: **Field Validation**

Originator: Bastian

Issue description:

Quantify pathogen removal (e.g., bacteria, enteric viruses, protozoans, helminths) of various wastewater treatment processes and combinations of processes for wastewaters with various concentrations of pathogens.

Importance:

Greater consideration of specific technologies would be allowed to meet criteria requirements (i.e., technology-based requirements or numerical limits).

How to overcome the issue:

Coordinate efforts of comparing performance of operating systems using consistent testing protocols for comparison with controlled lab scale evalutions.

Issue title: **Ensuring That Recycled Water Is Microbiologically Safe in the Event That It Is Consumed by an Unsuspecting Public**

Originator: Collins

Issue description:

Health Departments will continue to be concerned about the possibility of direct ingestion of recycled water that is, or may be, microbiologically unsafe. There are several routes of exposure: 1) cross-connections; 2) drinking from hose bibs (even though they are posted with "warning signs," 3) through aerosols or droplets from cooling systems or spray irrigation; and 4) consumption of vegetables and other food products which have been contaminated via irrigation, washing, or other means.

Importance:

The issue is significant because of the potential for disease outbreaks. It is difficult to quantify, but projects can and will be defeated if the health authorities or the general public perceive that disease outbreaks are possible. Furthermore, it is difficult to determine the safety of recycled water because of the scientific problems in identifying and quantifying various pathogens in the laboratory.

How to overcome the issue:

Until such time that better laboratory procedures become available to quickly and accurately detect and quantify pathogens, we will have to continue to depend on specific unit processes or "treatment trains" that are thought to render the recycled water "safe" from a microbiological point of view. The debate must continue regarding the role that different unit processes play in the "treatment train," e.g., filtration, disinfection, etc., as well as the reliability of each unit process. This may require the development of design and operating criteria for the various unit processes to ensure that the treated water will be essentially free of pathogenic organisms. Historically, the alternative of specifying the quality of the treated water hasn't worked.

Issue title: **Are Current Treatment and Quality Criteria Sufficient to Ensure Acceptable Public Heath Risks for Most Sensitive Uses?**

Originator: Honeybourne

Issue description:

- Are current microbial risk assessment methods adequate?
- What is acceptable risk?
- Are treatment plant reliability standards adequate?
- Can current laboratory methods detect and quantify emerging pathogens reliably?
- Are discharges to the sewer by biotech firms adequately regulated?
- Could genetically-altered microbes represent a reason for concern?
- Is the current turbidity standard sufficient to address existing and emerging protozoan pathogens?
- Should there be a requirement for public notification in the event of improperly treated recycled water entering the system?
- Should non-domestic, non-recycled water be regulated if used in a recycled system?
- Are current indicators satisfactory to detect pathogens of concern or adequate treatment? Can coliphage be used?

Importance:

- Public perception of risk associated with origin of recycled water.
- Public demands to know risk.
- Public perceives risk based on voluntary versus involuntary basis.

How to overcome the issue:

- Increase research in detection methodology of emerging pathogens.
- Evaluate existing monitoring data from around state and country to determine treatment plant reliability.

Issue title: **Are Multiple Treatment Barriers to Pathogenic Microorganisms Necessary After Secondary Treatment?**

Originator: Hultquist

Issue description:

For Virus:

- A consequence of the Pomona Virus Study is a 1-log virus removal assumption for certain design and operation conditions.
- The conditions are in the Direct Filtration guide and the draft California criteria.

Importance:

- One-log removal is probably not achieved in practice and cannot be achieved by some filters meeting the conditions.
- California criteria compliance options do not all achieve the same goal.

How to overcome the issue:

Must filtration remove virus or is pre-treatment for effective disinfection sufficient?

Issue title: **Determine Risk From Parasites in Recycled Water Compared to Surface Water Sources Used for Irrigation**

Originator: Kinshella

Issue description:

Many surface water sources are known to have parasites. Does a higher standard for recycled water over surface water reduce overall risk level?

Importance:

This issue goes to public acceptance. We should be able to show recycled water is essentially free of these organisms.

How to overcome the issue:

- Determine removal levels and numbers of organisms in various types of recycled waters.
- Determine number of parasites in various surface water sources.

Issue title: **Operational Performance Standards for Pre-Filtration and Disinfection Processes to Maximize Pathogen Removal Efficiency**

Originator: Kinshella

Issue description:

Operators, especially in smaller plants, often do not have good target numbers for sedimentation and other processes to maximize microbial removal. What should the standard be for turbidity and suspended solids prior to filtration?

Importance:

A higher quality of water prior to filtration will improve filter removal resulting in less microbes after disinfection. The starting virus level is important to the end point after a 5-log reduction.

How to overcome the issue:

Sampling and challenge studies should be undertaken at each unit process in the entire treatment train.

Issue title: **Unplanned Reuse of Recycled Water**

Originator: Turek

Issue description:

Treatment plant recycled water can be discharged to canals, ponds, or river channels as a part of the reuse delivery system. Recycled water is treated to meet the needs of the intended purpose. Treatment plant discharges to public waters can be used by the public for unplanned uses (e.g., swimming, fishing, and wading).

Importance:

Public may come in contact with recycled water that may not meet the regulatory standards for that unplanned reuse.

How to overcome the issue:

- Identify potential unplanned uses as a part of recycled water project development.
- Provide secure discharge locations.
- Educate the public and potential hazards via signage.
- Provide a greater degree of treatment for recycled water.

Issue title: **Is There a Need for Establishing Reduction Criteria for the Treatment of New Pathogens?**

Originator: Yamamoto

Issue description:

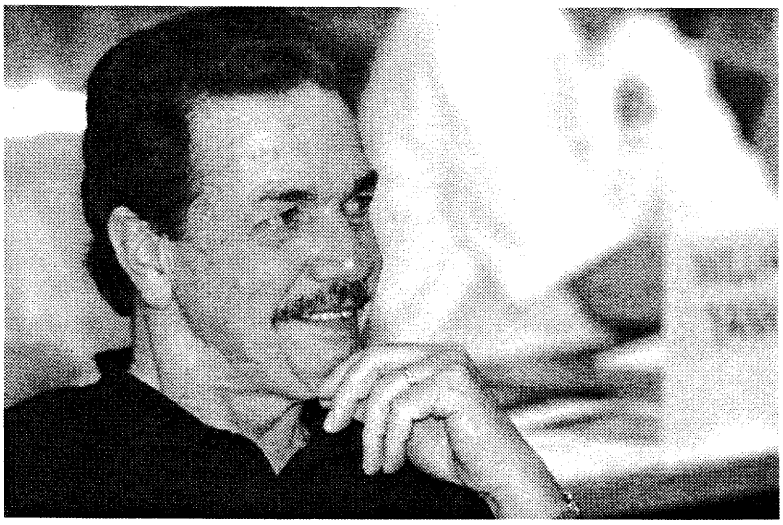
Are the existing water recycling criteria sufficient to protect public health from newly discovered pathogens? Pathogens are *Giardia*, *Legionella*, *Cryptosporidium*, reoviruses. Is there a need to address these pathogens? Is there a lower-turbidity standard needed? Is a new disinfection standard needed?

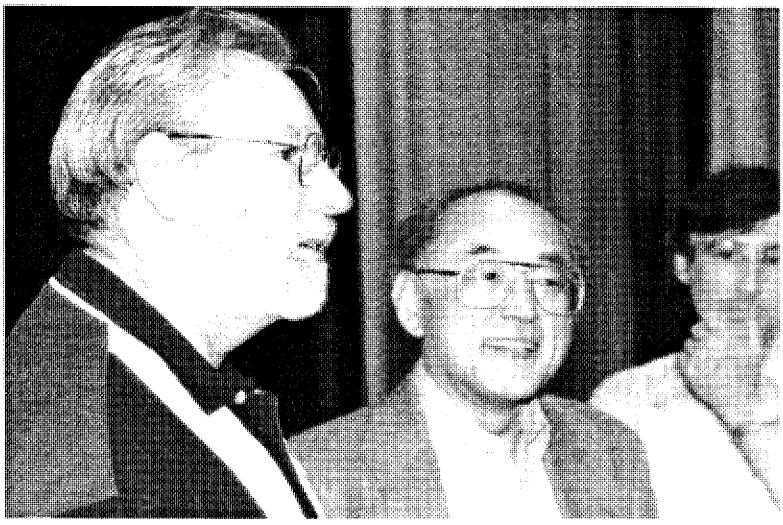
Importance:

At time of developing the criteria (mid- to late-70's), these pathogens were not addressed.

How to overcome the issue:

- Conduct studies to assess removal capabilities.
- Do literature search.
- Establish pathogen level targets.





PRIORITY 8

Maintain Water Quality in the Recycled Water Distribution System

ORIGINATORS:

Kinshella on behalf of himself, Duranceau, Nellor, Petralia, Reich, Towry, and Wehner

The following issues were subsumed under the above title:

Issue title: **Intelligent Pipe and Storage Systems for Reclaimed Water**

Originator: Duranceau

Issue description:

Issues related to the distribution and storage of reclaimed water include concerns over regrowth, nitrification, loss of disinfectant residuals, corrosion, and maintenance costs. A need for developing technologies for use in reclaimed water distribution and storage systems would enhance the operation and maintenance of the system, in addition to maintaining a method to monitor quality throughout the system.

Importance:

The need for reliable, real-time monitoring of the quality of water has increased because of the need to collect information that could be used to increase the quality of the system while reducing the costs of operation. Recently, it has been found that the application of coatings inside reservoirs has a significant impact on nitrification in storage tanks because the nitrifiers can be protected from disinfectant by hiding in the imperfections of the coating itself.

How to overcome the issue:

An investigation into how to develop intelligent systems in reclaimed pipeline and storage systems is required. Development of new sensor technologies for use in non-potable reclaimed water quality monitoring would assist in identifying and controlling problems associated with reclaimed water systems. The development of intelligent data-gathering techniques will improve the reliability of the system and enhance the operation and control of distribution and storage systems.

Issue title: **Maintenance of Water Quality in the Recycled Water Distribution System**

Originator: Kinshella

Issue description:

How do you determine optimum chlorine levels in a large recycled water distribution system? Most recycled water users spray at night. Water may be in the system for days.

Importance:

- Regrowth of pathogens.
- Cost of operation.
- Growth and sloughing of slime layer.

How to overcome the issue:

- Study existing large distribution systems.
- Correlate with lab studies.
- Look at different water qualities (i.e., filtered, nitrified/denitrified).

Issue title: **Distribution System Regrowth**

Originator: Nellor

Issue description:

Once the recycled water leaves the treatment plant, no further assessment of quality or safety is typically performed. We know that regrowth occurs in distribution systems and that field measurements show detectable levels of coliforms and other surrogates. Is regrowth an issue of concern, and if so, how best should it be controlled?

Importance:

The health risk associated with regrowth that occurs in recycling distribution systems has not been fully characterized. Since the primary disinfection standards are met at the recycling plant, it is believed that the pathogens of concern (virus and parasites) are not capable of

regrowth, yet this assumption has not been unequivocally demonstrated. Also, because coliforms are found in distribution systems, there may be some concern associated with coliform regrowth not related to pathogens. Gram negative bacteria, like coliforms, can produce endotoxins, which are capable of producing gastrointestinal symptoms. An epidemiological study conducted in Denver for park users who visited the parks when the grass was wet showed an increase in gastrointestinal symptoms when fecal coliform and fecal strep levels exceeded 500 per 100 mL, regardless of the water source. Also, if regrowth is a health issue, what maintenance or operational practices are needed for prevention that do not result in end-user problems?

How to overcome the issue:

Some information has been collected from recycling distribution systems, but this has been generally limited to coliforms. Additional pathogen monitoring is needed for a number of case studies that take into consideration different treatment systems and size of distribution systems. These data could be used to evaluate if the organisms present in the distribution systems represent regrowth of organisms surviving the treatment process or a new population of organisms. For each subset, research is needed to evaluate their associated health risk, if any. These same case study sites could be used to evaluate the effectiveness of different maintenance and operational techniques to minimize or eliminate regrowth.

Issue title: **Maintenance of a Pathogen-Free Tertiary-Treated Effluent to the Point of Use**

Originator: Petralia

Issue description:

- Current regulation only requires that tertiary-treated effluent be pathogen free at a point in the treatment process.
- How is degradation prevented?
- Should there be standards for the storage of tertiary-treated recycled water to prevent its degradation?
- Should a chlorine residual be required and backflow protection be considered to protect the quality of recycled water?

Importance:

- Given that there are no limitations on exposure, should there not be measures taken to ensure that the recycled water remains pathogen free? Free of chemical contamination?

- Shouldn't the user receive the recycled water product that is essentially the same quality as it was when it left the treatment plant or as required in the waste discharge requirements?

- What are the health risks associated with regrowth?

How to overcome the issue:

Establish standards by either regulation or policy that ensures the integrity of the recycled water.

Issue title: **Is There Any Public Health Significance of Bacterial Regrowth in Distribution Systems?**

Originator: Reich

Issue description:

- Chlorine residual can dissipate rapidly in recycled water distribution systems.

- There are sufficient nutrients to promote regrowth of bacteria in the distribution system prior to use even with minimal residence time. These levels could exceed 10^6 bacteria per milliliter. Effects of large bacterial populations include aesthetic problems with the water (odor) and operational problems for irrigation and industrial use from degraded water quality.

Importance:

Can bacterial pathogens (e.g., *Legionella*) regrow in the distribution system? If so, is there any exposure scenario which might cause an "unacceptable" risk of infection? Bacterial regrowth itself can be quantified, but can risk in this case also be quantified?

How to overcome the issue:

- Conduct research on the regrowth of bacterial pathogens and assess the risk of exposure/infection from non-potable uses of recycled water.

- Maintain chlorine residual in the distribution system of greater than 1 milligram per liter.

Issue title: **Operational and Management Protocols**

Originator: Towry

Issue description:

Non-potable recycling presents a very complex set of issues. The diversity in use from program to program drives the need to develop rigid guideline models.

Importance:

Guideline models would focus on the field operations aspect of reuse and deal with water quality at the user site, system inspection, and the development of equitable policies and procedures for management of the program.

How to overcome the issue:

Develop a document that debuts the best-managed reuse programs that exist globally. The document would have to clearly demonstrate the diversity of the reuse industry.

Issue title: **Does Regrowth of Opportunistic Pathogens in Storage or Distribution Systems Pose a Health Threat?**

Originator: Wehner

Issue description:

Regrowth or recontamination of reclaimed water can occur in storage facilities and distribution systems. Organisms like *Legionella* can be found in reclaimed water systems. Is the relative risk greater with reclaimed water than potable, and how should it be controlled?

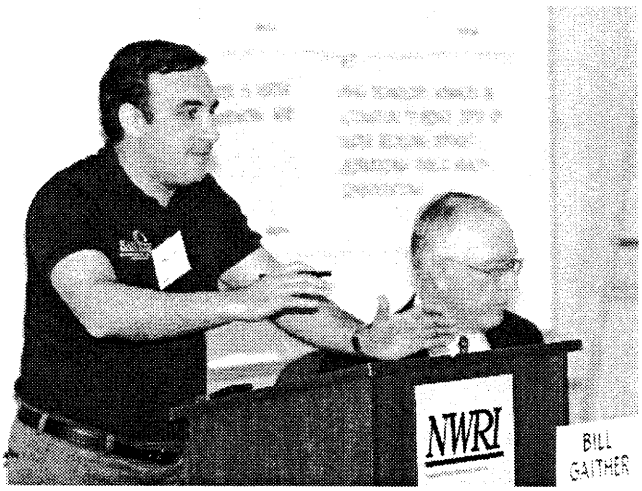
Importance:

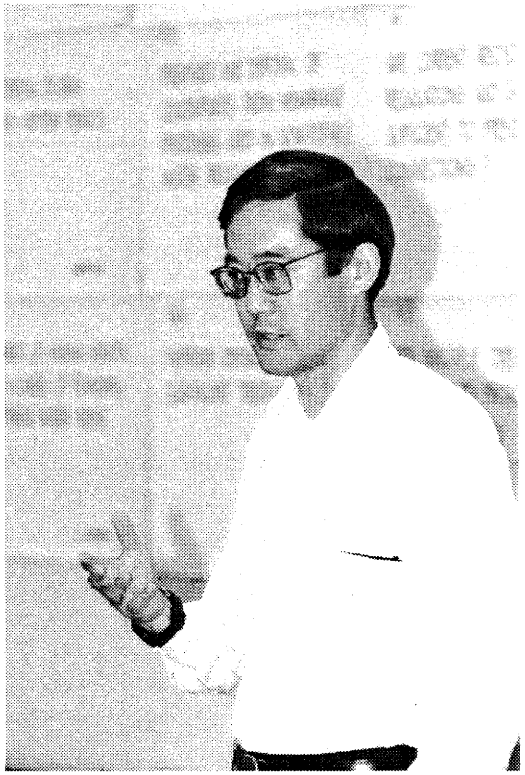
Relative risk is unknown and could affect public confidence.

How to overcome the issue:

- Research relative frequency of detection and concentration of opportunistic pathogens.
- Research concentration of concern for reclaimed water uses and exposures – how much is a problem?

- Control measures for distribution systems may reduce concern – residuals, flushing, retreatment after open storage.





PRIORITY 9

Develop Universal Study Protocols and Universal Monitoring Methods and Their Application

ORIGINATORS:

Ekster on behalf of himself, Carnahan, Harris, Requa, Sakaji, and Soroushian

The following issues were subsumed under the above title:

Issue title: **Establish Criteria for the Design of On-Line Analyzers and Process Controllers Which Might Eliminate the Need for Disinfection or Other Processes**

Originator: Carnahan

Issue description:

Specific criteria must be developed for design of controllers. Spectral analyzers that identify particle size, shape, and constituents currently exist and could minimize the need for disinfection. These analyzers currently measure microbial activity in real time.

Importance:

This would provide a cost-effective method of controlling the technology. The processes could be tailored to produce the quality of water desired. For example, if the filtration processes (multimedia or membrane separate) provide adequate treatment then eliminate any additional treatment.

How to overcome the issue:

Establish a research plan. There is currently a system that can identify and quantify *E. coli*, *Cryptosporidium*, and other organisms in water in real time. This work should be expanded to include a control strategy.

Issue title: **Development of Universal Study Protocols and Universal Monitoring Methods and Their Applications**

Originator: Ekster

Issue description:

Similar studies sometimes produce different results because of the difference in the protocol. Similarly, different monitoring methods and different monitoring equipment may provide different readings analyzing water of the same quality.

Importance:

Compare the results from a variety of studies to avoid conducting duplicate studies and to apply water quality criteria universally.

How to overcome the issue:

- Review the most popular study protocols and find the common ground.
- Review a variety of monitoring methods and applications of those; choose the most reliable and consistent; and use them universally.

Issue title: **Establish Transferable Research, Technology, and Data in Developing Performance-Based Recycled Water Quality Criteria for Equivalent Levels of Exposure**

Originator: Harris

Issue description:

- Acknowledge that technology exists for safe non-potable reuse (measuring treatment effectiveness and reliability should be transferable among new technologies meeting water quality criteria).
- Where is "one size fits all" appropriate?
- Consider national standards and studies.

Importance:

- Reduces agency costs to conduct "sister" studies, economies of scale.
- Enables resources to be focused toward one particular study.
- Provides study "name" recognition among public (e.g., NASA as leader).
- Provides apples-to-apples comparison tool.
- Helps to eliminate "It happens over there; it's not the same as here."

How to overcome the issue:

- Focus on the process.
- Establish a "name brand" recognition for studies to verify/support criteria to be applicable statewide/nationwide.

Issue title: **Establish Uniform Testing Protocol for Ultraviolet (UV) Disinfection Process and Other New Procedures**

Originator: Requa

Issue description:

- Develop testing/monitoring protocol for effectiveness of UV disinfection that is independent of manufacturer/vendor proprietary interests and control. Laboratory/pilot testing results vary from field results.
- Hydrologic issues.
- Type of virus utilized affects results.
- Initial concentration of virus affects results.

Importance:

- UV operations and monitoring needs are dependent on manufacturer and not in the public domain.
- Consistent and reliable comparison methods are required to ensure public health.

How to overcome the issue:

- Reevaluate UV disinfection methodology to develop universal performance criteria.
- Consolidate research from around the country.
- Develop a standard protocol for new processes.
- Think about food and drug regulations as a guide for new processes approval.

Issue title: **From Pilot-Plant to Full-Scale: Are We Getting the Performance We Anticipated?**

Originator: Sakaji

Issue description:

Need to assure treatment tested and evaluated at pilot-scale is achieving the same performance at full-scale and if not, define why not? Errors not observed at pilot may be magnified at full-scale, resulting in poorer final water quality.

Importance:

If the degree of protection we assume to be receiving is not present, the multitreatment barrier to pathogens is weakened. The strength of the multibarrier may be compromised – not its integrity.

How to overcome the issue:

- Develop a process to evaluate and confirm full-scale process performance.
- Model hydraulic performance by computational fluid dynamics; needs to be developed.

Issue title: **Establishing Equivalency of New Technologies for Non-Potable Reuse Application**

Originator: Soroushian

Issue description:

The process for testing, establishing reliability, and approval procedures for new equipment for Title 22 application is not defined. This slows down the approval process. Also, the lack

of a standard process has resulted in some equipment being approved with minimal data, while others have been subjected to substantial testing and performance requirements.

Importance:

To reduce the cost of water reclamation, we need to allow use of new cost-effective technologies in a timely manner. A well-defined process speeds up approval and subjects all new technologies to similar testing, data collection, and reliability requirements.

How to overcome the issue:

- Develop the process for establishing reliability and data collection/analysis to assess performance of new technologies for Title 22 application.
- Apply the process to compare performance of approved and new technologies.
- Refine and standardize the process.
- Follow through with full-scale facilities monitoring.

PRIORITY 10

Develop New, and Improve on, Real-Time Monitoring Strategies to Verify Treatment and Disinfection, Reliability at Point-of-Production and/or Use

ORIGINATORS:

Harris on behalf of himself, Adham, Carnahan, and Wehner

The following issues were subsumed under the above title:

Issue title: **Develop Strategies to Ensure the Treatment Reliability of Water Reclamation Systems**

Originator: Adham

Issue description:

Several treatment strategies are available to reclaim water, but without adequate monitoring continuous safety and reliability of the effluent cannot be ensured. We need to ensure that the treatment process is doing what it is supposed to be doing, and we must push manufacturers to develop best products.

Importance:

Public confidence; people need to know not only that the technology exists but also that we have the ability to find out immediately if something goes wrong.

How to overcome the issue:

Continue to develop and evaluate methods and strategies for monitoring reliability and share this information with the public.

Issue title: **Establish Criteria for the Design of On-Line Analyzers and Process Controllers Which Might Eliminate the Need for Disinfection or Other Processes**

Originator: Carnahan

Issue description:

Specific criteria must be developed for design of controllers. Spectral analyzers that identify particle size, shape, and constituents currently exist and could minimize the need for disinfection. These analyzers currently measure microbial activity in real time.

Importance:

This would provide a cost-effective method of controlling the technology. The processes could be tailored to produce the quality of water desired. For example, if the filtration processes (multimedia or membrane separate) provide adequate treatment then eliminate any additional treatment.

How to overcome the issue:

Establish a research plan. There is currently a system that can identify and quantify *E. coli*, *Cryptosporidium*, and other organisms in water in real time. This work should be expanded to include a control strategy.

Issue title: **Develop New, and Improve on, Real-Time Monitoring Strategies to Verify Treatment and Disinfection Reliability at Point-of-Production and/or Use**

Originator: Harris

Issue description:

Once treatment and disinfection processes have been shown to meet indicator limits, we will need more monitoring/instrumentation tools to verify water quality reliability on an immediate real-time basis.

Importance:

- Measurement results of coliforms or protozoan pathogens are known after the product has left the treatment plant.

- Other indicator organisms may provide a more effective and timely measure of water quality performance.

- As advanced water treatment and analytical methods become more prevalent and costly, advances in real-time monitoring technologies and strategies can help to reduce costs while providing increased reliability and increased public confidence.

- What are other effective means of monitoring/measurement in addition to turbidity and chlorine residual, for instance.

How to overcome the issue:

- Research and technology advances.

- Cost competitiveness innovation.

Issue title: **Coliform Bacteria, Chlorine Residual, and Turbidity May Not Be Adequate Measures of Treatment Effectiveness – What Else Should Be Used?**

Originator: Wehner

Issue description:

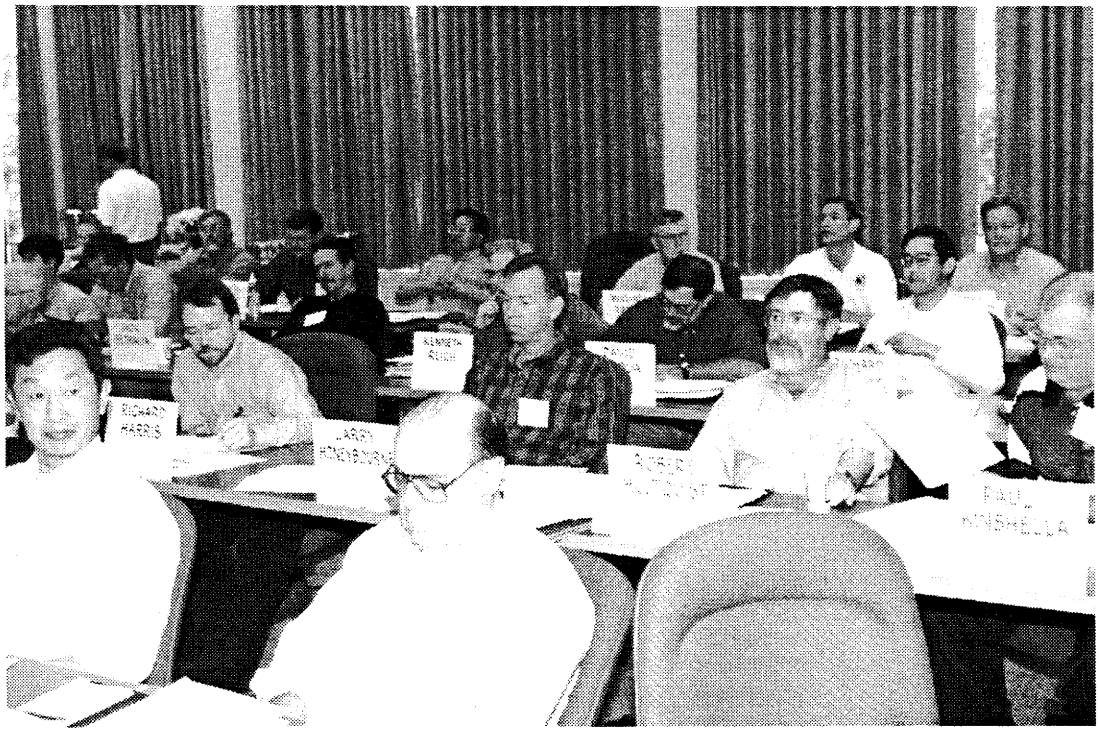
We have always relied on coliform testing to verify disinfection efficacy; chlorine residual and turbidity to verify disinfectant exposure and control of interferences. With primary concern being pathogens like viruses and protozoa, other indicators are needed. With alternative disinfection (UV) – chlorine residual is not appropriate.

Importance:

Risks from non-bacterial pathogens are not adequately addressed by coliforms, chlorine residual and turbidity measurement. Development and approval of new technologies are impaired by lack of adequate measures of performance.

How to overcome the issue:

Evaluate alternative indicators of treatment efficacy that can be used routinely to verify acceptable performance of reclaimed water treatment facilities in controlling viruses and protozoa.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PRIORITY 11

Establish a "Water Is Water" Regulatory Framework and Context

ORIGINATORS:

Requa on behalf of himself, Bastian, Harris, Stone, Yamamoto, and Young

The following issues were subsumed under the above title:

Issue title: **Role of Environmental Management Systems to Reassure Performance of Reuse Systems and Improved Public Acceptance**

Originator: Bastian

Issue description:

Address use of Environmental Management Systems (EMS) developed by the industry to help "raise the bar" and demonstrate continuously improving systems as a means of enhancing system performance and increasing public acceptance.

Importance:

No need to "wait" for the ultimate answer to be created by the regulators.

How to overcome the issue:

Organize an EMS by the "reuse industry" to get on with addressing pending technical issues and public acceptability problems.

Issue title: **Need to Establish Water Quality Criteria for Multiple Non-Potable Sources**

Originator: Harris

Issue description:

Intent is to bring other viable sources into the realm of establishing criteria for the appropriate quality for the appropriate use.

Importance:

This will help with public acceptance of comparable or alternative supplies. This will highlight alternative sources, at possibly lower treatment requirements and cost.

How to overcome the issue:

Need to establish a "water is water" regulatory framework and context to promote the safe use of multiple non-potable water sources for non-potable uses and to equate these sources on consistent levels of relative or acceptable risk and exposure.

Issue title: **Establish a "Water Is Water" Regulatory Framework and Context**

Originator: Requa

Issue description:

Water is the constant; other things being transported by the water are the variables. Is wastewater anything other than an impaired source? Is public acceptance anyone's fault but our own for creating a unique and special regulatory criteria for water recycling?

Importance:

Water of wastewater origin contacts the total water supply directly, indirectly, or accidentally. There is always a risk that someone will come into contact with water of wastewater origin.

How to overcome the issue:

Establish risk exposure criteria for end use of water. Use a consistent framework for all water regulatory criteria.

Issue title: **Defining Needs for Ongoing Regulatory Control and Oversight**

Originator: Stone

Issue description:

Water quality control boards, as permitting authority in California, issue permits for reuse but have no formal oversight program to ensure proper compliance at the treatment facilities and the use sites, where public contact occurs over the long-haul.

Importance:

Not to slight industry, but several instances of misuse have posed significant threats to public health (direct cross connections and the State's Water Resources Department's violations). In California, the potable water program has comprehensive and ongoing oversight to verify compliance and to work with industry on improving programs. Not so within the recycled water program.

How to overcome the issue:

Would need legislative fix to ensure such ongoing oversight, which would quite likely require industry support (if not push) to achieve. Such oversight would certainly help in providing added public confidence as has been clearly demonstrated with the potable water industry.

Issue title: **Governing Boards of Recycling Agencies Need to Be Balanced in Their Approach When Dealing with Supply and Public Health Protection**

Originator: Yamamoto

Issue description:

Agencies, due to shortage of water supply, are pushing the need for as much recycling as possible and are thinking of new types of uses, which in some cases have a high risk to the public. As uses of recycled water become more common and prevalent, these agencies may let their guard down by not being as diligent in controlling the use. Their staff may become confused. The water is safe to use (some say it meets drinking water standards), but agencies need to be cautious with its use. Some agencies may reduce staffing for oversight and review of projects.

Importance:

- Agencies need to have a balanced approach towards supply and public health risk.
- Public health problems need to be prevented.
- Public acceptance of recycled water may be reduced should a major public health problem occur.

How to overcome the issue:

- Educate public and board.
- Develop language for use in presenting risks and supply in balance.

Issue title: **Should Recycling Criteria Be Approved by the Legislature or Statewide Referendum to Finalize and Publicize Criteria and Objectives?**

Originator: Young

Issue description:

- Updating of Title 22 and Title 17 has been ongoing for more than ten years.
- When agreement is not reached, go to the next level up for resolution.
- This high level of approval will provide maximum public debate on issues of policy, direction and criteria.
- This approval will level the playing field to establish a uniform baseline criteria.
- This approach will elevate recycling decision-making within the state and local agencies involved in recycling projects.

Importance:

- Approval at a statewide level will create a public forum for increased understanding and proper level of acceptance.
- Put criteria decision in hands of public and special interest groups that reflect greater perspective as broad based statewide issue.

How to overcome the issue:

- Reduce criteria to the "critical few" non-potable issues and policies of public interest for statewide presentation.
- Acquire political leadership support to provide overarching process.

PRIORITY 12

Develop Methods to Measure and Compare Reliability

ORIGINATORS:

Eisenberg on behalf of himself, Adham, and Sakaji

The following issues were subsumed under the above title:

Issue title: **Develop Strategies to Ensure the Treatment Reliability of Water Reclamation Systems**

Originator: Adham

Issue description:

Several treatment strategies are available to reclaim water, but without adequate monitoring continuous safety and reliability of the effluent cannot be ensured. We need to ensure that the treatment process is doing what it is supposed to be doing, and we must push manufacturers to develop best products.

Importance:

Public confidence; people need to know not only that the technology exists but also that we have the ability to find out immediately if something goes wrong.

How to overcome the issue:

Continue to develop and evaluate methods and strategies for monitoring reliability and share this information with the public.

Issue title: **Develop Methods to Measure and Compare Reliability**

Originator: Eisenberg

Issue description:

Log removal or effluent concentration are incomplete descriptions of plant performance. Reliability is equally important but not well defined. There is a need for standard methods to measure and compare reliability.

Importance:

Public health protection depends on reliability as much as effectiveness. For new technology there is limited operational experience. Regulations need to be clear about how reliability is evaluated, and methods need to be useful for comparison, approval, and regulation.

How to overcome the issue:

- Develop methods and guidance document.
- Test existing conventional and alternative treatment systems.
- Statistical analysis of performance variability should be a major component of the reliability evaluation methods.

Issue title: **What Is "Reliability" and How Do You Use It?**

Originator: Sakaji

Issue description:

Want reliability in our multiple treatment barrier to ensure production of consistent quality. Everyone has a different definition of reliability. Some use the term redundancy to define reliability. Redundancy is a subset of reliability as it ensures that the barrier is never missing. Reliability should ensure water production of a consistent quality.

Importance:

A reliability definition is needed by regulators for risk management decisions.

How to overcome the issue:

- Define reliability as a term in microbial risk assessment.
- Need regulatory agencies to set this definition, but recyclers must accept the definition.
- Develop a definition for reliability by consensus?


MARGARET

PRIORITY 13

Regulate Non-Potable Recycling with Only Numeric Criteria for Each Consumer Product End Use

ORIGINATORS:

Young on behalf of himself, Bastian, Hultquist, Nellor, Thompson, Towry, and York

The following issues were subsumed under the above title:

Issue title: **Establish Minimum Water Quality Criteria for Water Used in Agriculture and for Environmental Enhancement**

Originator: Bastian

Issue description:

Provide objectives to be met in treatment of effluents based on quality regulations of end use for agriculture and environmental enhancement purposes.

Importance:

Create an increased demand for the reclaimed product by setting specific requirements for various end-users of the reclaimed water as an alternative water supply.

How to overcome the issue:

Stimulate establishment of minimum water quality criteria by USDA, Fish & Wildlife, and USEPA for potential uses regardless of source (including impaired sources).

Issue title: **Are Some Uses More Trouble Than They Are Worth?**

Originator: Hultquist

Issue description:

The use with the greatest public exposure or greatest perceived risk drives the requirements for the "best" recycled water quality.

Importance:

The cost is driven up for all agencies wishing or needing, for some reason, to produce the best quality.

Issue title: **Establishing Appropriate Salt Thresholds and Management Practices for Irrigation of Sensitive Crops**

Originator: Nellor

Issue description:

In general, plants are sensitive to salinity in varying degrees. The buildup of salinity in the soil creates osmotic pressure that plants have to work against to extract water. Thus, plants can become stressed due to high salinity. In addition to salinity sensitivity, some plants are sensitive to specific ions in irrigation water. Sodium, chloride, and boron can be detrimental at high concentrations. These ions can be absorbed by roots or leaves and can build up to toxic levels in some plants. Irrigation with higher salinity sources, such as reclaimed water, can be a concern and can be a barrier in the implementation of some reclamation projects or can lead to costly treatment for removal of salinity.

Importance:

We would like to have definitive information on salinity thresholds for sensitive crops (turf and agricultural) and how these thresholds relate to impacts from specific ions and irrigation management practices. For example, we have conducted an extensive literature review for information on chloride tolerance for avocados. In many cases, the articles are not crop or chloride specific but give general information on crop sensitivities to irrigation waters of various qualities. We also learned that when using the literature to assess appropriate chloride thresholds, each study must be scrutinized carefully to identify assumptions and test conditions. Many recommended thresholds are not based on specific studies, but the consensus of agricultural experts. These thresholds are important not only for individual

reuse projects but are used to develop beneficial use objectives used to establish permit and reuse

How to overcome the issue:

We would recommend that this issue be addressed by: 1) performing a literature search on past research associated with use of recycled water or water for irrigation of sensitive turf and agricultural crops; 2) developing a pilot program to study the effects of salinity and specific ions on these crops under different irrigation regimes and soil conditions, and 3) developing a management plan for successful long-term use of recycled water for irrigation.

Issue title: **Developing Strategies to Identify and Reduce Salt Loading into a Wastewater Collection System to Enhance Reclaimed Water Quality**

Originator: Thompson

Issue description:

High total dissolved solid levels and specific ions (e.g., sodium and chloride) impact agricultural, sensitive ornamental landscaping, and industrial/commercial uses (e.g., cooling towers and carpet dying). Agencies with TDS problems are using bandaids, such as blending and leaching to compensate for the problem.

Importance:

Customer satisfaction drives the success of business, and water reclamation is not any different. Unacceptable, non-regulatory driven water quality problems will reduce the use of reclaimed water.

How to overcome the issue:

Need to understand the controlled and uncontrollable salt loadings into the collective system.

- Undertake predictive modeling (multiple source waters, residential contributions, commercial, and industrial contributions).

- Develop effective survey instruments for commercial, industrial, and residential customers.

- Develop field study protocols to validate survey data and modeling predictions.

Issue title: **Reuse Impacts on Agriculture and Landscape**

Originator: Towry

Issue description:

Minimizing impact on ornamental landscape and agriculture irrigated with reclaimed water.

Importance:

From a public relations perspective, the water quality protocols have to include short-term and long-term impacts. Users have to be informed, or the program may not be well-received.

How to overcome the issue:

Develop in-depth studies that will identify tolerance levels and species types that thrive and do well with the water composition.

Issue title: **Study of the Use of Reclaimed Water to Irrigate Edible Crops**

Originator: York

Issue description:

Currently, Florida prohibits the use of direct contact irrigation methods (spray irrigation) of edible crops that are not peeled, skinned, cooked, or thermally produced before human consumption. Demonstration studies are allowed by state rules, but no one has undertaken such a study. A study could pave the way for elimination of this rule impediment.

Importance:

This issue impacts willingness of the agricultural community to use reclaimed water for irrigation of edible food crops. A member of Florida's Environmental Regulation Commission has emphasized the need for the study.

How to overcome the issue:

Conduct a study of the use of reclaimed water to irrigate edible crops. This would involve comparison of reclaimed water irrigation with irrigation using a surface water or groundwater supply. Spray irrigation will be used to irrigate several "salad crops" (crops that are not peeled, skinned, cooked, or thermally produced before human consumption). Water quality

for the two water sources should be compared. In addition, the pathogen content and marketability of the crops produced should be compared.

Issue title: **Regulate Non-Potable Recycling With Only Numeric Criteria for Each Consumer Product End Use**

Originator: Young

Issue description:

Reuse criteria should be numeric standards applied at the point of use without subjective or prescriptive process requirements. The standard would focus on end use, not intermediate treatment processes or intermediaries, for example:

- Standards would directly apply to specific use.
- The standards would drive treatment technology, not the reverse.
- Only essential standards would apply to use (eliminate extraneous).
- Alternate process choice would increase competition and reduce costs.
- New technologies could be used to reduce cost allowing marketplace forces for acceptance, not regulators.

Importance:

- Moves criteria to the end user of the product (recycled water) as the true test of acceptability.
- Gives stakeholders flexibility and opportunity to use innovative treatment processes without regulatory determinations to add costs at process midpoints before end use.
- Reduces costs to consumer.

How to overcome the issue:

- Standards should be set to be commensurate with other non-potable consumable product industries (animal food).
- Standards need to be comparable to environment where water is delivered and used (i.e., residential vs. industrial vs. agricultural).

PRIORITY 14

Establish Minimum Use-Site Controls Corresponding with the Associated Level of Public Exposure and Risk

ORIGINATORS:

Stone on behalf of himself, Honeybourne, Petralia, and Yamamoto

Issue description:

"Use-sites" are locations where the potential for public contact (direct or indirect) occur. These sites should be monitored to ensure that the recycled water delivered to the use-site is of acceptable quality for the anticipated level of public exposure. Associated use-site control measures must be developed and maintained to minimize contact to an appropriate level.

Importance:

Inadequately treated wastewater and insufficient site control measures present a direct threat to public health. Documented occurrences of "mishaps" associated with the above erode the public's confidence in the use of recycled water.

How to overcome the issue:

Correlate risks to various levels of treatment and use-sites, then develop appropriate use-site controls to ensure that defined risk is not exceeded.

The following issues were subsumed under the above title:

Issue title: **Are Current Recycled Water Regulations and Guidelines Sufficient to Prevent Cross Connections?**

Originator: Honeybourne

Issue description:

- Are adequate resources available to conduct comprehensive oversight?
- Public may inadvertently drink recycled water without adequate cross connection oversight.
- Retrofit projects are highest hazard.
- Are there adequate use area controls (i.e., user supervision, ongoing cross connection surveys)?

Importance:

- All treatment and risk assessment criteria are only as good as installation and oversight of recycled water system.
- Several well-publicized cross connection incidents may cause the public to lose confidence in recycled water.
- It is questionable whether epidemiological studies could detect sporadic illness cases. Cross connection control and prevention are critical.

How to overcome the issue:

- Evaluate recent incidents to determine if guidelines and regulations were followed.
- Undertake public outreach and education programs.

Issue title: **Develop Methods of Detecting Cross Connections Between Recycled and Potable Water Systems When They Happen**

Originator: Petralia

Issue description:

Cross connections between dual systems occur. When this happens, the cross connections often exist for a long period of time since mandated inspections, if they are conducted, are at best infrequent (3-4 years).

Importance:

Potable water supply is possibly contaminated with bacteria, protozoans, and chemicals that may pose health risks.

How to overcome the issue:

Conduct research into developing methods that will detect cross connections between recycled and potable water systems.

Issue title: **Establish Minimum Objectives for Acceptable Risk and the Corresponding Level/Reliability of Treatment and Use Site Controls**

Originator: Stone

Issue description:

Current criteria are more than 20 years old. Significant advances have been made with respect to risk assessment, treatment technologies, performance evaluation, and analytical capabilities. Given what we now know, a re-evaluation of what characterizes recycled water as being safe for its intended use is necessary. With such a characterization, a corresponding set of criteria should be developed prescribing minimum treatment objectives to address microbiological and modern chemical concerns.

Importance:

Reevaluating risk and correlating that risk to appropriate treatment methodologies are of importance for ensuring that our requirements are supported by sound, justifiable, and defensible science. With this, promotion of recycled water by industry, and acceptance by manufacturers, and more importantly, the general public will be more successful.

How to overcome the issue:

- Establish acceptable risk (10^{-4}?) and develop a scientifically-justified approach to treatment for attaining the defined risk objective.
- Need a clear indication of what we are basing treatment performance objectives on (e.g., log virus reduction, turbidity, TOC, and/or ???) and develop criteria around effectiveness of demonstrated technologies.

Issue title: **Reducing Risk From Contamination of Drinking Water Supplies From Recycled Water Systems So That a Waterborne Outbreak Does Not Occur**

Originator: Yamamoto

Issue description:

As utilities increase water recycling use in the country, the potential for a waterborne disease outbreak resulting from a cross-connection incident increases. If such an event were to occur in a large municipality, will it set water recycling back considerably? For example, the Milwaukee outbreak resulted in a tighter turbidity requirement to take effect in two years. If the answer to the question is yes, what needs to be done? Cross connections have occurred and will continue to occur in the future because there is insufficient oversight at use areas.

Importance:

- Prevention of waterborne disease outbreaks.
- Minimizing numbers of people getting sick.

How to overcome the issue:

Set new and tighter limits for recycled water or set tighter controls at use areas or a combination of both.

PRIORITY 15

Define "Protecting Public Health" and How to Monitor Ultimate Outcomes

ORIGINATORS:

Meyers on behalf of himself, Griffin, and Olivieri

The following issues were subsumed under the above title:

Issue title: **Public Health Surveillance as a Monitoring Methodology**

Originator: Griffin

Issue description:

The utility of public health surveillance as an element of the long-term monitoring component of programs to use non-potable water has not been defined.

- The literature is strongly supportive. For example, "Every water agency using reclaimed waters...should implement well-coordinated public health surveillance systems to document and possibly provide early warning of any adverse health events associated with exposure to reclaimed water." Issues in Potable Reuse. NRC.

- In public discussions, there seems to be little concern on the part of the public about the use of non-potable water.

Importance:

The use of non-potable water does not end with its distribution for irrigation or other non-potable distribution. Contained contaminants, as well as contaminants acquired in passage through the vadose zone and groundwater, may return in other raw water sources or in other environments, which may result in human contact. If this is, in fact, a significant hazard, monitoring and preventive measures should be incorporated in plans for the use of such water. It not, or if not cost effective, these measures need not be established as criteria for approval.

How to overcome the issue:

- No single surveillance strategy can be recommended or would be feasible for all locations; communities should select a method that meets local needs and is most compatible with existing disease surveillance systems.

- Participation by all stakeholder groups is required (e.g., health providers, public health agencies, wastewater departments, and consumers).

Issue title: **Define "Protecting Public Health" and How to Monitor Ultimate Outcomes**

Originator: Meyers

Issue description:

- What standard is appropriate (i.e., most vulnerable populations: children, immunocompromised, elderly, etc.)?

- How can a standard for protecting public health be quantified?

- How can this be monitored? Epidemiological studies are often not feasible.

Importance:

If effects on the public's health cannot be quantified and monitored, we cannot be sure that the public's health is being protected. Modeling might not be sufficient.

How to overcome the issue:

Encourage public input into standards and monitoring.

Issue title: **Do Title 22 Regulations Protect Public Health?**

Originator: Olivieri

Issue description:

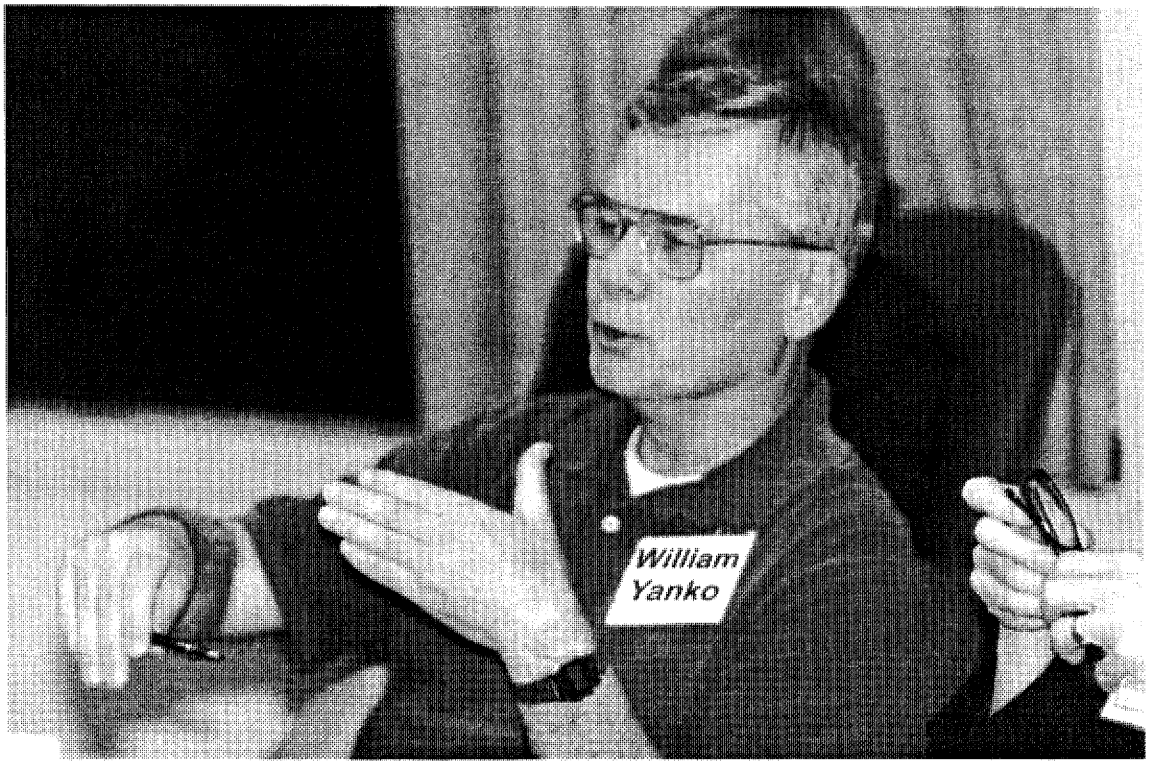
The fundamental question is: Do existing Title 22 regulations adequately protect public health? All other issues stem from addressing this question including establishing a comparative baseline for risk assessment. To answer this question requires the presentation of supporting evidence (e.g., epidemiology, risk assessment, anecdotal).

Importance:

The question is important because it will help define areas of agreement and disagreement (i.e., need to distinguish between fact and construct). Thus, a clear Problem Statement can be written around areas of disagreement.

How to overcome the issue:

- Provide supporting evidence for answer.
- Determine how to communicate to the public and professionals (e.g., regulation, legislation).
- Establish a clear technical approach to evaluate effectiveness and reliability of acceptable treatment systems.


William
Yanko

PRIORITY 16

Genetic Transfer and Antibiotic Resistance

ORIGINATOR:

Yanko

Issue description:

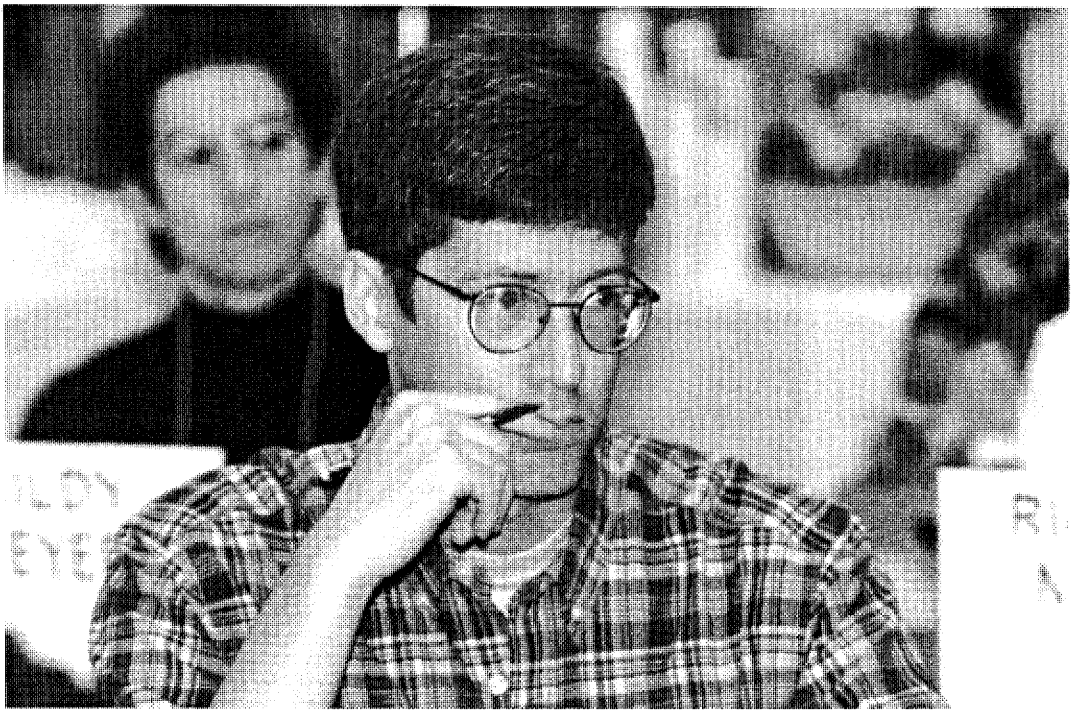
Bacteria are capable of transferring genetic traits from one cell to another. Sewage may provide an environment for the transfer of antibiotic resistance factors, and reclaimed water could theoretically provide a mechanism to increase the spread of antibiotic resistant bacteria. Distribution regrowth may be a factor.

Importance:

The increasing numbers of antibiotic resistant bacteria represent a very real emerging health threat. This issue has been raised by public and legal opposition to the use of reclaimed water. We have no research to specifically address these concerns. It is important to be able to answer legitimate questions to promote public acceptance. Use of reclaimed water should not be a link in the spread of antibiotic resistant organisms.

How to overcome the issue:

Conduct basic research to examine the types and concentrations of antibiotic resistant bacteria in reclaimed water and distribution systems relative to other environments.



PRIORITY 17

Treatment and Disposal of Concentrates From Membrane Processes Used in Non-Potable Water Recycling Applications

ORIGINATOR:

Duranceau

Issue description:

The use of membrane processes has increased in recent years for use in reducing salinity, trace organics, heavy metals, radionuclides, microbials, nutrients, and contaminants in water. Despite the fact that the cost of membrane technology has significantly been lowered primarily as a result of continued technological advances, its use has been limited because of issues related to concentrate disposal.

Importance:

As the pressure for higher quality criteria will increase with time because of public acceptance, and as a result of the increased understanding of secondary impacts of using reclaimed water, the need for advanced treatment of reclaimed water will also continue to increase. Membrane processes offer multi-contaminant treatment opportunities for reclaimed water and its subsequent reuse.

How to overcome the issue:

An investigation into the disposal, treatment, and possible reuse of membrane concentrates is required to delineate criteria and costs. An additional need for achieving regulatory consensus between many different laws is also required to be addressed. The need to control total dissolved solids in reclaimed water will need to be addressed for its long-term use. Pilot and full-scale studies should be implemented to collect further information.

PRIORITY 18

A Uniform Water Recycling Code

ORIGINATORS:

Bailey on behalf of himself, Bastian, Harris, and Zegers

The following issues were subsumed under the above title:

Issue title: **A Uniform Water Recycling Code**

Originator: Bailey

Issue description:

Currently, each state develops its own recycling criteria and standards. In doing so, they take different approaches which ultimately result in different risks for populations who come into contact with the product. A uniform code or set of regulations written in an open format could accommodate changes on a regular basis to keep abreast of emerging risk factors and developing technologies.

Importance:

A uniform program would reduce redundant studies and analysis and increase the efficiency of regulatory processes.

How to overcome the issue:

Establish a task force, perhaps jointly sponsored by WEF, AWWA, and WateReuse Association/Foundation to develop a model code.

Issue title: **Role of Environmental Management Systems to Reassure Performance of Reuse Systems and Improved Public Acceptance**

Originator: Bastian

Issue description:

Address use of Environmental Management Systems (EMS) developed by the industry to help "raise the bar" and demonstrate continuously improving systems as a means of enhancing system performance and increasing public acceptance.

Importance:

No need to "wait" for the ultimate answer to be created by the regulators.

How to overcome the issue:

Organize an EMS by the "reuse industry" to get on with addressing pending technical issues and public acceptability problems.

Issue title: **Establish Transferable Research, Technology, and Data in Developing Performance-Based Recycled Water Quality Criteria for Equivalent Levels of Exposure**

Originator: Harris

Issue description:

- Acknowledge that technology exists for safe non-potable reuse (measuring treatment effectiveness and reliability should be transferable among new technologies meeting water quality criteria).
- Where is "one size fits all" appropriate?
- Consider national standards and studies.

Importance:

- Reduces agency costs to conduct "sister" studies, economies of scale.
- Enables resources to be focused toward one particular study.

- Provides study "name" recognition among public (e.g., NASA as leader).
- Provides apples-to-apples comparison tool.
- Helps to eliminate "It happens over there; it's not the same as here."

How to overcome the issue:

- Focus on the process.
- Establish a "name brand" recognition for studies to verify/support criteria to be applicable statewide/nationwide.

Issue title: **Ten State Standards for Recycled Water Consensus of Regulators**

Originator: Zegers

Issue description:

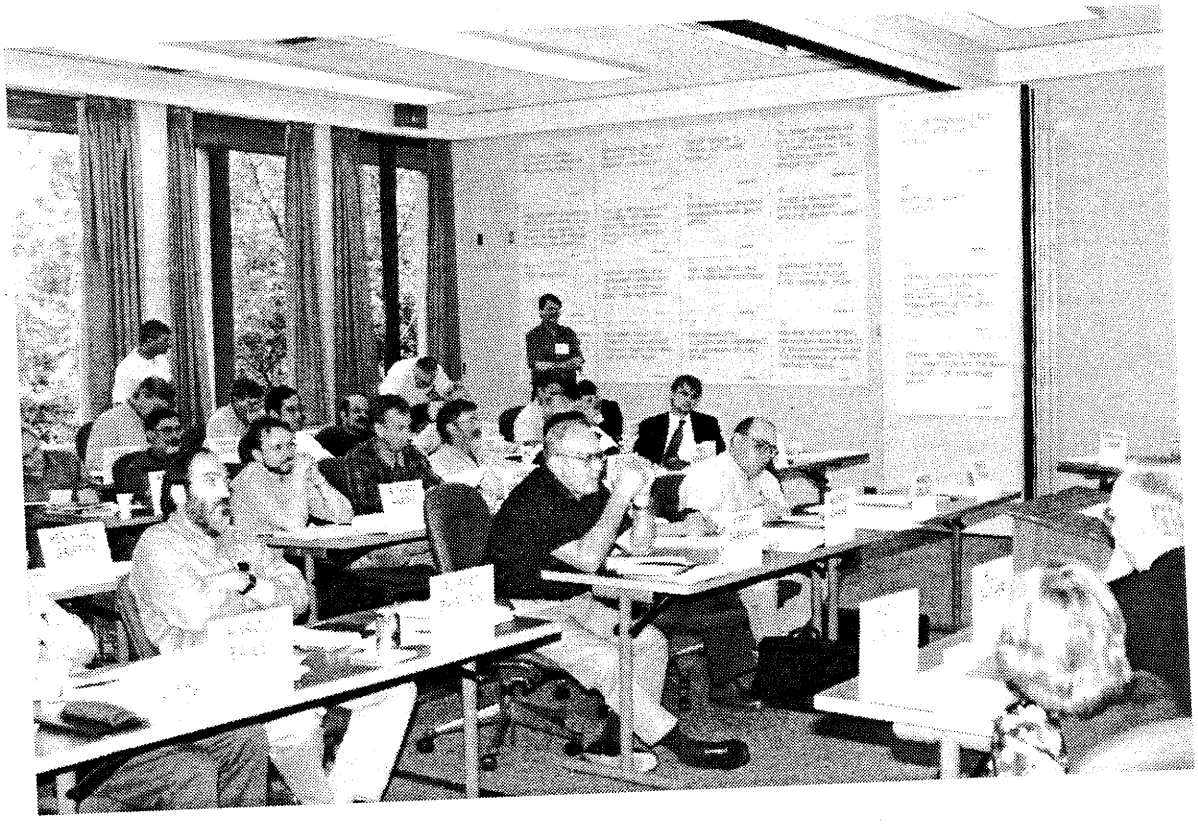
- No common guidelines.
- No regulator consensus.
- Lack of public confidence.

Importance:

- Provides regulator consensus.
- Gives future direction.
- Sets nationwide guidelines.

How to overcome the issue:

- Provide mechanism for regulators or experts to develop standards.
- Provide guidelines for recycle water systems U.S.-wide.



PRIORITY 19

Guidelines for UV Disinfection

ORIGINATORS:

York on behalf of himself and Asano

The following issues were subsumed under the above title:

Issue title: **Guidelines for UV Disinfection**

Originator: York

Issue description:

The guidelines for UV disinfection published by NWRI have proven to be very useful in implementing UV disinfection systems for reuse applications. However, the guidelines were developed for low-pressure UV systems and appear to be very conservative. Many large-scale systems are moving toward use of medium-pressure UV systems.

UV systems offer several advantages over chlorination systems – notably minimization of toxic byproducts and increased safety at the water reclamation facility and the surrounding area. However, UV does not produce a measurable residual. As a result, ensuring effective disinfection becomes a greater concern.

Importance:

The interest in using UV for disinfection for reuse applications is growing rapidly. The development of appropriate guidelines for low-pressure and medium-pressure UV systems for high-level disinfection applications for reuse is needed. This will enable the states to encourage UV applications. Without effective guidelines, implementation of desirable UV systems will be retarded.

How to overcome the issue:

Conduct the needed research and publish expanded guidelines for UV disinfection for high-level disinfection applications. This should address both low-pressure and medium-pressure UV systems. The guidelines should be supported by pathogen data.

Issue title: **How to Educate Public Health Officials on New Science and Recent Findings**

Originator: Asano

Issue description:

Public health officials need to be educated so that they are not operating on obsolete knowledge and information.

Importance:

Department of Health Services and Regional Boards are having a difficult time to accepting "new concepts" and updating regulatory procedures for non-potable water reuse projects.

How to overcome the issue:

Issue statewide "guidance documents" by committees of experts to help health officials with their decision process.

PRIORITY 20

Update the National Guidelines for Water Reuse

ORIGINATOR:

York

Issue description:

The USEPA and USAID published *Guidelines for Water Reuse* in 1992. This has proven to be an important and useful document. Given the document is seven years old, an update would be useful. Several states have new or revised reuse regulations, and much work has been done in the reuse arena during the last seven years.

A clear policy statement from the USEPA on the need for and safety of reuse also would be useful.

The actual guidelines for various reuse activities probably do not merit revision.

Importance:

The *Guidelines for Water Reuse* have served as a valuable resource for states and utilities. An update would make them more useful. In addition, a clear endorsement of water reuse by the USEPA would serve the states and utilities well as they implement reuse programs.

How to overcome the issue:

Reconvene the technical advisory committee and update the *Guidelines for Water Reuse*. The document should contain a clear policy statement and endorsement from the USEPA.

PRIORITY 21

Minimum Criteria for Updated Title 22 Wastewater Reclamation Criteria as Interim Response to Current Health Concerns

ORIGINATOR:

Mills

Issue description:

Many emerging concerns are being raised, e.g., measuring appropriate pathogens, describing acceptable health risk, supporting the need for multiple barriers. To resolve these issues and uncertainties will require considerable time. In the meantime, there is a draft of revised Title 22 regulations that is proceeding through the California adoption process, after at least ten years since a revision of the 1978 regulations was initiated. The 1978 regulations are known to have significant deficiencies. The current draft revision, while imperfect, is a basis for a significant improvement as an interim standard. However, waiting for resolution of new issues may delay adoption of new regulations for several more years.

Importance:

It is difficult to regulate water reuse lacking an adopted standard. Decisions are made on a case-by-case basis leading to inconsistent results. Regulators become susceptible to pressure from competing interests to influence decisions in their favor. In an environment of regulatory uncertainty, approval of new technologies is hindered.

How to overcome the issue:

A short-term strategy may be needed to achieve early adoption of revised regulations:

- Develop agreement on an interim framework for criteria, such as the basic concept of 5-log polio virus removal.
- Identify the key refinements needed in the current draft Title 22 regulations for clarification and a protocol to test new technology.

PRIORITY 22

Proliferation of Small Recycled Water Treatment Plants

ORIGINATOR:

Petralia

Issue description:

Should there be a minimum size (gallons/day) for a treatment plant producing recycled water?

- At what size can a sewage treatment plant be operated in a reliable and cost-effective manner? Should laundromats be in the water recycling business? Should schools and other institutions?
- Who should be responsible for operating small plants?
- Can they be effectively monitored and regulated? If so, by whom? By regional boards? By health departments?

Importance:

Plant reliability is an important health issue when full tertiary treatment is required.

When the plant is owned and operated by a private institution, what agency should monitor for cross connection control?

How to overcome the issue:

- Establish minimum standards for sewage treatment plant size producing recycled water.
- Establish who can operate sewage treatment plants producing recycled water.
- Clearly establish responsibility and authority for cross connection control.

PRIORITY 23

Use Technological Advances in Automation to Reduce Costs of Water Recycling Without Jeopardizing Public Health Consideration

ORIGINATOR:

Thompson

Issue description:

The cost of recycling projects is one of the greatest obstacles for the industry for new programs.

The advances of Scanning Data Acquisition (SCADA) technology allow treatment and distribution systems to be safely operated unstaffed outside the normal working hours. These systems can perform many of the decision-making processes that operators have traditionally made; are often times quicker and unbiased, and can be programmed to sound alarms and perform shutdowns when system trends indicate that failures are eminent.

Importance:

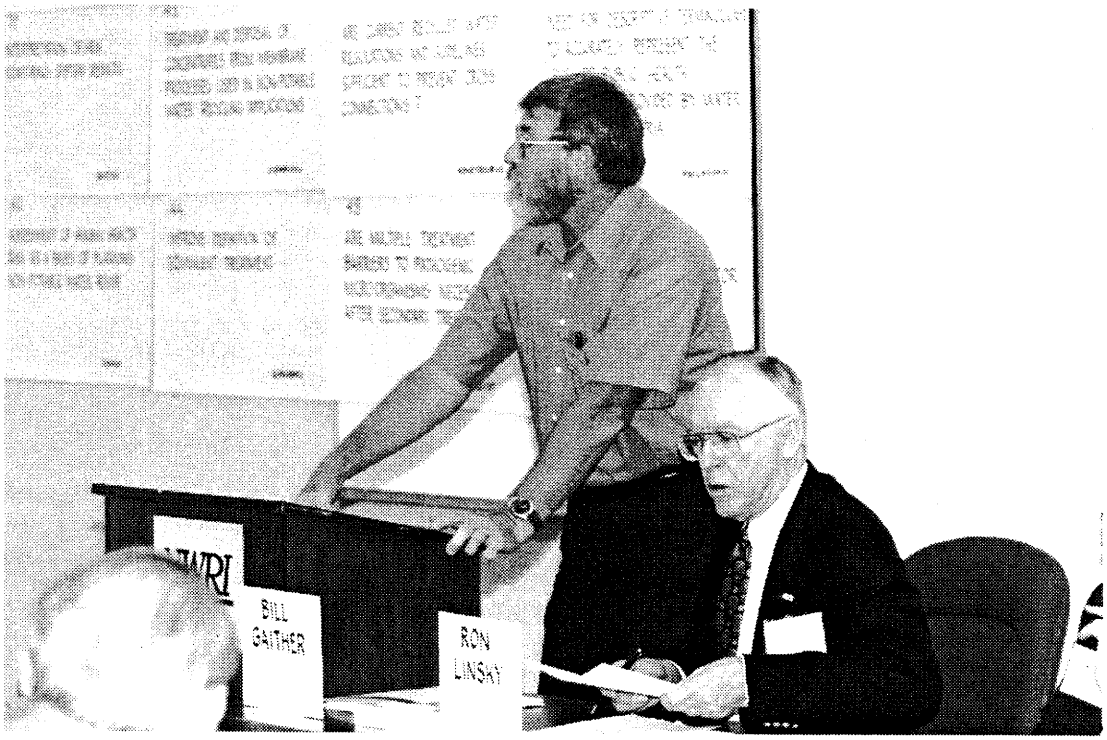
Competitive pressure that both the water and wastewater utilities have experienced in the recent years will be coming to the recycled community as private companies enter into the recycling field.

The public desires lower costs without a loss in service.

How to overcome the issue:

- Develop case studies on recycled water facilities that have leverage automation to reduce costs and develop a benchmark for the industry that is acceptable to the public health agencies.

- Work on developing an interactive smart system for the distribution systems that integrates and optimizes hydraulic and water quality operations.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PRIORITY 24

Impacts of Advanced Water Treatment on Secondary Uses

ORIGINATORS:

Turek on behalf of himself, and Duranceau

The following issues were subsumed under the above title:

Issue title: **Secondary Impacts of Corrosion in Non-Potable Reclaimed Water for Urban and Industrial Reuse**

Originator: Duranceau

Issue description:

Corrosion is a multi-billion dollar problem for many different types of industries. As the need for alternative sources of water for non-potable urban and industrial uses increases, the complexity of secondary impacts of water quality will continue to be an issue. Moreover, the fact that the non-potable reclaimed water purveyor will be held responsible for the quality of water delivered to the user relative to product liability, the need for establishing sound science relative to corrosion control will be important.

Importance:

Non-potable urban and industrial uses of reclaimed water are increasing with time. As available consumptive and other use allowances of surface and groundwater allocations diminish, the need for supplemental sources will increase. However, corrosion has continued to be a significant impediment to maintaining low-cost fire protection, cooling, water, and industrial process water uses.

How to overcome the issue:

The secondary impacts of corrosion on the use of non-potable reclaimed water should be investigated to establish corrosivity index criteria for treatment requirements. Corrosion control goals and stabilization criteria should be developed for each type of use, be it fire protection, chiller water, cooling towers, scrubbers, etc.

Issue title: **Impacts of Advanced Water Treatment on Secondary Uses**

Originator: Turek

Issue description:

Advanced Water Treatment (AWT) incorporated into recycled water production may have impacts on other uses. AWT water not directly used but is recharged may mobilize contaminants in the aquifer. Brine waste and residuals discharged to downstream treatment plants may reduce the use of potential of the recycled water produced by the downstream plant. The downstream plant treatment capacity may be exceeded.

Importance:

Remobilized contaminants in the aquifer may impact drinking water quality used by the public. Reuse of recycled water from a downstream plant in the wetlands may impact plants and animals. Dead or dying plants and animals may impact public health. Brine and residual loading may exceed downstream treatment plant capacity.

How to overcome the issue:

- Conduct research on impacts of aggressive AWT water on aquifer systems.
- Control AWT discharges to downstream plants.

PRIORITY 25

Can We Do a Better Job of Identifying Microbial Survival Strategies?

ORIGINATOR:

Sakaji

Issue description:

Gain a better understanding of how microbes survive in the environment and mechanisms of infection/propagation.

- Impacts selection of surrogates – MS2 (bacteriophage).

- Identifies controlling pathogen for treatment process selection by identifying pathogen with the greatest resistance to inactivation/removal.
  - *Legionella*
  - antibiotic resistance
  - genetic transfer

Importance:

Will help to understand what barriers are needed to prevent transmission of pathogens, i.e., breaking cycle of disease by stopping pathogen transmission.

How to overcome the issue:

Should be incorporated into risk assessment and management strategies. Need to identify data gaps.

STRENGTH OF FEELING OF PARTICIPANTS AND SUBGROUP ANALYSIS

The following five tables show the strength of feeling of the participants and provide a quantitative sense of the degree of agreement (or lack of agreement) about the importance of each issue area. To provide greater insight, the 37 participants were grouped into four sub-categories: academics, consultants, regulators, and utility participants.

The tables give the priority ranking of each major issue area as well as the number of times it was picked, and the total number of points it received. The strength of feeling is expressed as a percentage. For example, if all participants had selected the same major issue area as their highest priority it would have received 10 x 37 = 370 points. In fact, the highest priority issue area was selected as a priority issue by 33 participants who assigned it a total of 225 points. Thus, the Strength of Feeling is 60.8% which is calculated as 225/370 x 100. If no participant selected a particular issue area then its Strength of Feeling will be zero.

TABLE 1

All Issues (25) Ranked by All Participants (37)

Rank	Title	Times Picked/Pts.	Strength of Feeling
1.	Improve Microbial Risk Assessment Methodologies to Develop Scientifically-Based Water Reuse Criteria	33/225	60.8%
2.	What Kinds of Standards Are Necessary, Feasible, and Best to Assure Safe Reclaimed Water Quality?	30/223	60.3%
3.	Understand Pathogen-Inactivation Relationships Between Different Disinfectants, Doses, and Contact Times for a Properly-Filtered Wastewater	29/163	44.1%
4.	Risk Communication: A Quantification, Measurement, and Comparison of Levels of Risk	24/143	38.6%
5.	Define Appropriate Chemical Standards for Non-Potable Reuse	22/140	37.8%
6.	Establish Rational Basis for Demonstrating Equivalent Treatment with Alternative Processes for Pathogen Removal/Inactivation	22/121	32.7%
7.	Ensure That Recycled Water Is Microbiologically Safe in the Event That It Is Consumed by an Unsuspecting Public	25/120	32.4%
8.	Maintain Water Quality in the Recycled Water Distribution System	22/113	30.5%
9.	Develop Universal Study Protocols and Universal Monitoring Methods and Their Applications	17/105	28.4%
10.	Develop New, and Improve on, Real-Time Monitoring Strategies to Verify Treatment and Disinfection Reliability at Point-of-Production and/or Use	17/95	25.7%
11.	Establish a "Water Is Water" Regulatory Framework and Context	17/91	24.6%
12.	Develop Methods to Measure and Compare Reliabiltiy	16/78	21.1%
13.	Regulate Non-Potable Recycling with Only Numeric Criteria for Each Consumer Product End Use	14/67	18.1%
14.	Establish Minimum Use-Site Controls Corresponding with the Associated Level of Public Exposure and Risk	17/63	17.0%
15.	Define "Protecting Public Health" and How to Monitor Ultimate Outcomes	13/56	15.1%
16.	Genetic Transfer and Antibiotic Resistance	6/41	11.1%

Rank	Title	Times Picked/Pts.	Strength of Feeling
17.	Treatment and Disposal of Concentrates From Membrane Processes Used in Non-Potable Water Recycling Applications	6/33	8.9%
18.	A Uniform Water Recycling Code	9/27	7.3%
19.	Guidelines for UV Disinfection	4/26	7.0%
20.	Update the National Guidelines for Water Reuse	7/25	6.8%
21.	Minimum Criteria for Updated Title 22 Wastewater Reclamation Criteria as Interim Response to Current Health Concerns	5/23	6.2%
22.	Proliferation of Small Recycled Water Treatment Plants	4/20	5.4%
23.	Use Technological Advances in Automation to Reduce Costs of Water Recycling Without Jeopardizing Public Health Considerations	3/15	4.1%
24.	Impacts of Advanced Water Treatment on Secondary Uses	3/13	3.5%
25.	Can We Do a Better Job of Identifying Microbial Survival Strategies?	2/8	2.2%

TABLE 2

All Issues (25) Ranked by All Academic Participants (4)

Rank	Title	Times Picked/Pts.	Strength of Feeling
1.	Improve Microbial Risk Assessment Methodologies to Develop Scientifically-Based Water Reuse Criteria	4/34	85.0%
2.	Define Appropriate Chemical Standards for Non-Potable Reuse	4/33	82.5%
3.	Establish Rational Basis for Demonstrating Equivalent Treatment with Alternative Processes for Pathogen Removal/Inactivation	3/25	65.5%
4.	What Kinds of Standards Are Necessary, Feasible, and Best to Assure Safe Reclaimed Water Quality?	3/16	40.0%
5.	Ensure That Recycled Water Is Microbiologically Safe in the Event That It Is Consumed by an Unsuspecting Public	4/14	35.0%
6.	Develop Universal Study Protocols and Universal Monitoring Methods and Their Applications	2/14	35.0%
7.	Minimum Criteria for Updated Title 22 Wastewater Reclamation Criteria as Interim Response to Current Health Concerns	2/13	32.5%
8.	Understand Pathogen-Inactivation Relationships Between Different Disinfectants, Doses, and Contact Times for a Properly-Filtered Wastewater	3/12	30.0%
9.	Regulate Non-Potable Recycling with Only Numeric Criteria for Each Consumer Product End Use	2/11	27.5%
10.	A Uniform Water Recycling Code	2/11	27.5%
11.	Risk Communication: A Quantification, Measurement and Comparison of Levels of Risk	3/10	25.0%
12.	Develop New, and Improve on, Real-Time Monitoring Strategies to Verify Treatment and Disinfection Reliability at Point-of-Production and/or Use	1/7	17.5%
13.	Establish Minimum Use-Site Controls Corresponding with the Associated Level of Public Exposure and Risk	1/6	15.0%
14.	Maintain Water Quality in the Recycled Water Distribution System	2/5	12.5%
15.	Develop Methods to Measure and Compare Reliabiltiy	1/4	10.0%

Rank	Title	Times Picked/Pts.	Strength of Feeling
16.	Establish a "Water Is Water" Regulatory Framework and Context	1/2	5.0%
17.	Update the National Guidelines for Water	1/2	5.0%
18.	Define "Protecting Public Health" and How to Monitor Ultimate Outcomes	1/1	2.5%

TABLE 3

All Issues (25) Ranked by All Consultants (11)

Rank	Title	Times Picked/Pts.	Strength of Feeling
1.	What Kinds of Standards Are Necessary, Feasible, and Best to Assure Safe Reclaimed Water Quality?	10/73	66.4%
2.	Improve Microbial Risk Assessment Methodologies to Develop Scientifically-Based Water Reuse Criteria	9/62	56.4%
3.	Risk Communication: A Quantification, Measurement and Comparison of Levels of Risk	9/51	46.4%
4.	Establish Rational Basis for Demonstrating Equivalent Treatment with Alternative Processes for Pathogen Removal/Inactivation	7/46	41.8%
5.	Define Appropriate Chemical Standards for Non-Potable Reuse	8/46	41.8%
6.	Understand Pathogen-Inactivation Relationships Between Different Disinfectants, Doses, and Contact Times for a Properly-Filtered Wastewater	9/44	40.0%
7.	Develop Methods to Measure and Compare Reliabiltiy	7/36	32.7%
8.	Develop New, and Improve on, Real-Time Monitoring Strategies to Verify Treatment and Disinfection Reliability at Point-of-Production and/or Use	6/36	32.7%
9.	Ensure That Recycled Water Is Microbiologically Safe in the Event That It Is Consumed by an Unsuspecting Public	5/29	26.4%
10.	Establish a "Water Is Water" Regulatory Framework and Context	5/28	25.5%
11.	Define "Protecting Public Health" and How to Monitor Ultimate Outcomes	5/24	21.8%
12.	Maintain Water Quality in the Recycled Water Distribution System	4/23	20.9%
13.	Develop Universal Study Protocols and Universal Monitoring Methods and Their Applications	3/22	20.0%
14.	Treatment and Disposal of Concentrates From Membrane Processes Used in Non-Potable Water Recycling Applications	3/19	17.3%
15.	Genetic Transfer and Antibiotic Resistance	2/13	11.8%
16.	Establish Minimum Use-Site Controls Corresponding with the Associated Level of Public Exposure and Risk	5/10	9.1%

Rank	Title	Times Picked/Pts.	Strength of Feeling
17.	Regulate Non-Potable Recycling with Only Numeric Criteria for Each Consumer Product End Use	2/10	9.1%
18.	Impacts of Advanced Water Treatment on Secondary Uses	2/9	8.2%
19.	Proliferation of Small Recycled Water Treatment Plants	1/7	6.4%
20.	A Uniform Water Recycling Code	4/6	5.5%
21.	Update the National Guidelines for Water Reuse	2/6	5.5%
22.	Use Technological Advances in Automation to Reduce Costs of Water Recycling Without Jeopardizing Public Health Considerations	1/4	3.6%
23.	Guidelines for UV Disinfection	1/1	0.9%

TABLE 4

All Issues (25) Ranked by All Regulators (10)

Rank	Title	Times Picked/Pts.	Strength of Feeling
1.	Improve Microbial Risk Assessment Methodologies to Develop Scientifically-Based Water Reuse Criteria	10/70	70.0%
2.	What Kinds of Standards Are Necessary, Feasible, and Best to Assure Safe Reclaimed Water Quality?	8/55	55.0%
3.	Ensure That Recycled Water Is Microbiologically Safe in the Event That It Is Consumed by an Unsuspecting Public	8/38	38.0%
4.	Develop Methods to Measure and Compare Reliabiltiy	6/35	35.0%
5.	Risk Communication: A Quantification, Measurement and Comparison of Levels of Risk	5/34	34.0%
6.	Develop Universal Study Protocols and Universal Monitoring Methods and Their Applications	6/34	34.0%
7.	Establish Rational Basis for Demonstrating Equivalent Treatment with Alternative Processes for Pathogen Removal/Inactivation	7/30	30.0%
8.	Understand Pathogen-Inactivation Relationships Between Different Disinfectants, Doses, and Contact Times for a Properly-Filtered Wastewater	6/30	30.0%
9.	Define Appropriate Chemical Standards for Non-Potable Reuse	6/30	30.0%
10.	Establish Minimum Use-Site Controls Corresponding with the Associated Level of Public Exposure and Risk	6/29	29.0%
11.	Maintain Water Quality in the Recycled Water Distribution System	5/26	26.0%
12.	Guidelines for UV Disinfection	3/25	25.0%
13.	Establish a "Water Is Water" Regulatory Framework and Context	4/23	23.0%
14.	Define "Protecting Public Health" and How to Monitor Ultimate Outcomes	4/19	19.0%
15.	Develop New, and Improve on, Real-Time Monitoring Strategies to Verify Treatment and Disinfection Reliability at Point-of-Production and/or Use	3/17	17.0%
16.	Regulate Non-Potable Recycling with Only Numeric Criteria for Each Consumer Product End Use	2/12	12.0%

Rank	Title	Times Picked/Pts.	Strength of Feeling
17.	Proliferation of Small Recycled Water Treatment	2/11	11.0%
18.	Minimum Criteria for Updated Title 22 Wastewater Reclamation Criteria as Interim Response to Current Health	2/8	8.0%
19.	Can We Do a Better Job of Identifying Microbial Survival Strategies?	2/8	8.0%
20.	Update the National Guidelines for Water Reuse	2/8	8.0%
21.	A Uniform Water Recycling Code	1/6	6.0%
22.	Genetic Transfer and Antibiotic Resistance	1/1	1.0%

TABLE 5

All Issues (25) Ranked by All Utility Participants (12)

Rank	Title	Times Picked/Pts.	Strength of Feeling
1.	What Kinds of Standards Are Necessary, Feasible, and Best to Assure Safe Reclaimed Water Quality?	9/79	65.8%
2.	Understand Pathogen-Inactivation Relationships Between Different Disinfectants, Doses, and Contact Times for a Properly-Filtered Wastewater	11/77	64.2%
3.	Improve Microbial Risk Assessment Methodologies to Develop Scientifically-Based Water Reuse Criteria	10/59	49.2%
4.	Maintain Water Quality in the Recycled Water Distribution System	11/59	49.2%
5.	Risk Communication: A Quantification, Measurement and Comparison of Levels of Risk	7/48	40.0%
6.	Ensure That Recycled Water Is Microbiologically Safe in the Event That It Is Consumed by an Unsuspecting Public	8/39	32.5%
7.	Establish a "Water Is Water" Regulatory Framework and Context	7/38	31.7%
8.	Develop Universal Study Protocols and Universal Monitoring Methods and Their Applications	6/35	29.2%
9.	Develop New, and Improve on, Real-Time Monitoring Strategies to Verify Treatment and Disinfection Reliability at Point-of-Production and/or Use	7/35	29.2%
10.	Regulate Non-Potable Recycling with Only Numeric Criteria for Each Consumer Product End Use	8/34	28.3%
11.	Define Appropriate Chemical Standards for Non-Potable Reuse	6/31	25.8%
12.	Genetic Transfer and Antibiotic Resistance	3/27	22.5%
13.	Establish Rational Basis for Demonstrating Equivalent Treatment with Alternative Processes for Pathogen Removal/Inactivation	5/20	16.7%
14.	Establish Minimum Use-Site Controls Corresponding with the Associated Level of Public Exposure and Risk	5/18	15.0%
15.	Treatment and Disposal of Concentrates From Membrane Processes Used in Non-Potable Water Recycling Applications	3/14	11.7%

Rank	Title	Times Picked/Pts.	Strength of Feeling
16.	Define "Protecting Public Health" and How to Monitor Ultimate Outcomes	3/12	10.0%
17.	Use Technology Advances in Automation to Reduce Costs of Water Recycling Without Jeopardizing Public Health Considerations	2/11	9.2%
18.	Update the National Guidelines For Water Reuse	2/9	7.5%
19.	A Uniform Water Recycling Code Guidelines for UV Disinfection	2/4	3.3%
20.	Impacts of Advanced Water Treatment on Secondary Uses	1/4	3.3%
21.	Develop Methods to Measure and Compare Reliability	2/3	2.5%
22.	Minimum Criteria for Updated Title 22 Wastewater Reclamation Criteria as Interim Response to Current Health Concerns	1/2	1.7%
23.	Proliferation of Small Recycled Water Treatment Plants	1/2	1.7%

APPENDICES

APPENDIX A

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AWT	advanced water treatment
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
BOD	biochemical oxygen demand
CFD	computational fluid dynamics
CT	concentration time
CSDLAC	County Sanitation Districts of Los Angeles County
DHS	Department of Health Services (State of California)
EMS	Environmental Management System
HPC	heterotrophic plate count
IRWD	Irvine Ranch Water District
IT	(UV) intensity exposure time
L	liter
mg	milligram
MBAS	methylene blue activated substance
min	minute
mL	milliliter
MS2	bacteriophage specific to certain coliform bacteria

NASA	National Aeronautics and Space Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
NWRI	National Water Research Institute
OCHCA	Orange County Health Care Agency
ph	negative logarithm of the hydrogen ion concentration
SCADA	scanning data acquisition
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UV	ultraviolet
VOC	volatile organic compounds
WEF	Water Environment Federation
WERF	Water Environment Research Foundation

APPENDIX B

PREVIOUS NGT WORKSHOPS CONDUCTED BY NWRI

Groundwater Disinfection Rule. Report of a workshop jointly sponsored by the National Water Research Institute (NWRI), and the U. S. Environmental Protection Agency USEPA, in collaboration with the Weston Institute. Virden Conference Center of the University of Delaware, Lewes, DE. June 7-8, 1992: 103p.

Fouling and Module Design. Report of a workshop jointly sponsored by the NWRI and the National Science Foundation (NSF). Virden Conference Center of the University of Delaware, Lewes, DE, October 30 – November 1, 1993: 115p.

Risk Reduction in Drinking Water Distribution Systems. Report of a workshop jointly sponsored by the NWRI and the Environmental Criteria and Assessment Office of the USEPA. Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, Irvine, CA, February 27-28, 1994: 142p.

Establishment of The Middle-East Water and Energy Research and Technology Centre. Report of a workshop jointly sponsored by the NWRI and the Sultanate of Oman through the Worldwide Desalination Research and Technology Survey. Muscat, Oman: September 21, 1994: 29p.

The New River. Report of a workshop jointly sponsored by the NWRI and the County of Imperial, California. Barbara Worth Country Club, Holtville, CA, May 19-21, 1995: English report: 134p., Spanish report: 134p. (Bound in a single volume)

The Santa Ana River Watershed. Report of a workshop jointly sponsored by the NWRI and the Santa Ana Watershed Project Authority. Co-sponsors included: City of San Bernardino Water Department, City of Riverside, Western Municipal Water District, and Orange County Water District. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, August 23-25, 1995: 182p.

Membrane Biofouling. Report of a workshop jointly sponsored by the NWRI, UNESCO Centre for Membrane Science and Technology, and CRC for Waste Management and Pollution Control, LTD. UNSW Institute of Administration, Sydney, Australia, November 15-17, 1996: 176p.

Groundwater Disinfection Regulation. Report of a workshop jointly sponsored by the NWRI and the USEPA. Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, Irvine, CA, January 6-8, 1997: 209p.

Groundwater Disinfection Regulations Benefits Conference. Report of a conference sponsored by the NWRI. Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, Irvine, CA, March 17, 1997: 75p.

Barriers to Harvesting Stormwater. Report of a workshop jointly sponsored by the NWRI, L.A. County Department of Public Works, County of Orange Public Facilities & Resources Department, Southern California Coastal Water Project, and the American Oceans Campaign. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, September 22-24, 1997: 159p.

Barriers to Providing Safe Drinking Water Through Small Systems. Report of a workshop jointly sponsored by the NWRI, Pan American Health Organization, and NSF International/WHO Collaborative Center. Pan American Health Organization Headquarters, Washington, D.C., May 13-15, 1998: English report: 175p., Spanish report: 188p. (Bound in a single volume.)

Conjunctive Use Water Management Program. Report of a workshop jointly sponsored by the NWRI, Association of Ground Water Agencies, and the Metropolitan Water District of Southern California. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, May 27-29, 1998: 157p.

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