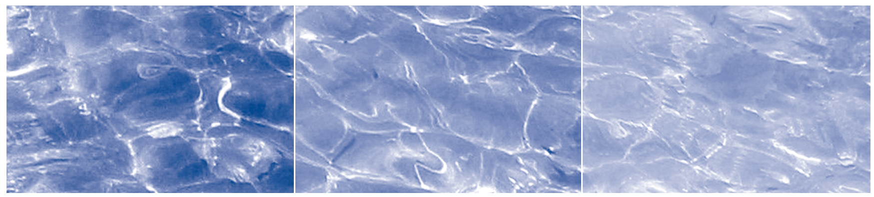

CITY OF SAN DIEGO WATER REUSE STUDY

Final Draft Report March 2006

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Preface

Water is essential to our growing economy and quality of life. The City of San Diego imports approximately 90 percent of its water supply from Northern California and the Colorado River. The City's other water sources are from stored local runoff and water recycling.

Over the past 20 years, the City's conservation programs have helped reduce per-capita water use, but population growth has continued to push up overall water use. Even with continued aggressive conservation efforts, the City projects it could need 25 percent more water in 2030 than today.

The City also faces challenges of ensuring its water supplies are reliable and environmentally sustainable. Existing imported supplies from the Colorado River and Northern California remain subject to reductions due to droughts. In addition, the need to import water, including water transfers, may also have incidental or unintended effects on other California ecosystems.

To address these challenges of growth, reliability and sustainability, the City's Long-Range Water Resource Plan identified the importance of recycled water in the City's overall water supply portfolio. The purpose of this Water Reuse Study is to conduct a comprehensive examination of the City's water recycling opportunities to support our future and our children's future.

Understanding the value and uses of recycled water is of critical importance in making informed choices and decisions. In developing recycled water uses, the City has several choices. Evaluating these choices requires considering more than just costs. Values, such as those listed below, will be at the heart of the public dialogue answering two critical questions: 1) what water recycling opportunities should be pursued?; and, 2) depending on the opportunity, how much water should be recycled?

Recycled water brings value to San Diego because it…

- *enhances the reliability of our water supply;*
- *promotes a sustainable balance with our environment;*
- *is a locally controlled resource;*
- *reduces water diversions from other California ecosystems; and,*
- *is an investment in San Diego's future.*

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1.0 Introduction

This report presents the findings of the City of San Diego (City) Water Reuse Study (Study). The purpose of the Study is to evaluate opportunities available to the City to increase the city-wide beneficial use of recycled water. Together with the results of a broad public outreach and involvement process, the City will use the findings of this report to determine a future course for the implementation of water reuse projects.

1.1 Study Background

Currently, the 1.3 million people living in San Diego use an average of 210 million gallons per day (MGD) of potable water. The City's population is projected to increase 50 percent in the next 25 years. Even with additional water conservation measures, the City projects this population growth will increase demand for potable water by approximately 25 percent, or an additional 50 MGD.

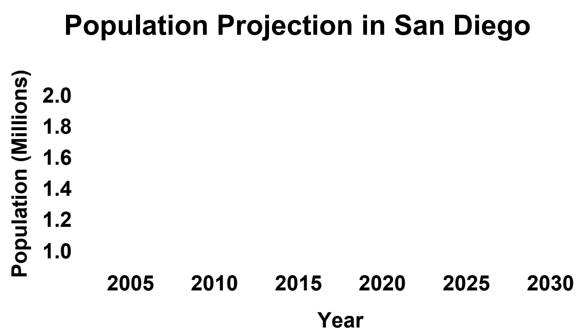

Figure 1-1
San Diego's population is anticipated to increase 50 percent by 2030.

Up to 90 percent of the City's existing water supply is imported from the Colorado River and the California State Water Project. The City has long recognized the need to develop local water supplies to balance and reduce this dependence on imported water.

Many factors outside the City also contribute to our future water needs and the reliability of existing supplies. California's access to surplus water from the Colorado River has been reduced, and recurring droughts in both the western United States and the Colorado River watershed have affected imported water supplies. Competing interests statewide between urban users, agricultural uses and environmental interests are being resolved, but water allocations to each will continue to be adjusted in the future.

In 1997, the City prepared the *Strategic Plan for Water Supply*, and in 2002 updated it with a more detailed *Long-Range Water Resources Plan* (Long-Range Plan). Both documents identified the need for the City to develop additional local water supply sources as a means of providing reliability and protection from water supply shortages. These recommendations were consistent with the sentiment expressed by the San Diego County Grand Jury in a 1999 report on San Diego's water supply. Having noted San Diego's dependence on imported water, the grand jury recommended the development of additional local supplies, including water reuse, quoted as follows:

Water is a scarce commodity in the rapidly growing San Diego region. In the face of increased demand for water from other geographical areas, imported water and water from transfers are not reliable sources of water for the future. Many decisions about water supply for San Diego are made by the state and federal governments and thus out of local control. In order to increase the reliability of its overall water supply, the City of San Diego must expand its supply of local water.

– San Diego County Grand Jury, 1999

The need for local water supply development is echoed by the San Diego County Water Authority (Water Authority) in their *2004 Annual Water Supply Report*, subtitled *Supply Reliability through Diversification*. This report states, "A critical component of future reliability is development and management of local supplies and conservation programs by the Water Authority's member agencies." The report also addresses water reuse by saying, "implementation of water recycling is essential to using the region's water supplies efficiently," and specifically references this Study as an example of what is needed.

The City must diversify its sources of water and increase the use of locally produced water to assure an adequate and reliable supply for the future. One local source of water is already being produced – recycled water.

1.2 Purpose of the Water Reuse Study

On January 13, 2004, the San Diego City Council (Council) directed the City Manager to conduct a study to evaluate options for increasing the beneficial use of the City's recycled water. In Resolution R-298781, included in Appendix A, the Council directed that the study:

- Include a participatory process to discuss/develop reuse opportunities;
- Account for diverse stakeholder viewpoints;
- Be based on sound technical analysis;
- Build upon past City efforts; and,
- Utilize recent knowledge and information gained through growth in the recycled water industry.

The envisioned study would become a planning tool for guiding future recycled water efforts throughout the City. With this charge, the City's Water Department promptly engaged staff and consultants to develop an approach and process. In May 2004, the project kick-off meeting was held, and public participation tasks began.

As part of the planning process, the Study team developed an objective and a mission statement for the project:

> **Objective**
> ***To conduct an impartial, balanced, comprehensive and science-based study of all recycled water opportunities so the City of San Diego can meet current and future water needs.***

Mission Statement
To pursue opportunities to increase local water supply and reliability, and optimize local water assets, through a comprehensive study of recycled water.

1.3 Study Approach

The Study began with a small team of City staff and consultants. The first task was to expand the team into a diverse, participatory group that included stakeholders and noted specialists in the fields of science, technology, health and safety, and economics. Two key groups convened shortly after the project began – an American Assembly-style stakeholder workshop, called the City of San Diego Assembly on Water Reuse (Assembly), and an Independent Advisory Panel (IAP).

City of San Diego Assembly on Water Reuse
Over fifty years ago, President Dwight D. Eisenhower developed the American Assembly process as a means to examine key aspects of public policy questions. Because it brings together academicians, business people, government officials, the media, policy makers, community leaders and other interested individuals, the American Assembly process formed the basis of the participatory stakeholder component of the Study. This format thrives with the sharing of diverse perspectives, experiences and interests, and moves towards consensus in making recommendations for action. At the end of the American Assembly workshop, participants deliberate and develop a statement of majority and minority viewpoints with the goal of composing a finalized, professional and comprehensive report at the process' end.

The City selected its 67 Assembly participants through a city-wide search for key stakeholders such as community leaders, policy makers, water consumers, business leaders, and professionals in various fields of expertise. The Mayor and each Council member suggested names of constituents to participate in the Assembly, and each potential candidate was contacted, provided an overview of the Study and participatory process, and asked if they would commit to their essential role. Thus, a total of 67 participants attended the two workshops held in October 2004 and July 2005. During the October 2004 Assembly, the Study process was reviewed and evaluation criteria established to guide the Study team on how the various reuse opportunities were to be assessed and prioritized. The July 2005 Assembly reviewed the Draft Study Report and thoroughly evaluated each proposed reuse strategy contained therein. With the conclusion of each workshop, Assembly participants issued a written statement, which are included in this document as Appendices B and C.

The Assembly process brought together diverse stakeholders throughout the City to discuss recycled water opportunities.

Independent Advisory Panel

The Independent Advisory Panel (IAP) was established to provide independent oversight and guidance to the Study team. IAP panel members were contracted through the National Water Research Institute (NWRI), which was selected to ensure an unbiased and thorough examination of all possible water reuse opportunities. NWRI's mission is to promote the protection, maintenance and restoration of water supplies and aquatic environments through the development of cooperative research work.

The eleven panelists selected for the Study were renowned experts in the fields of water and wastewater technology, public health, epidemiology, toxicology, microbiology, water quality, economics, environmental engineering and science, public utilities administration and industry regulations from across the United States. The IAP also included a local citizen representative.

IAP workshops were held in July 2004, May 2005 and November 2005. The July 2004 workshop focused on the strengths and weaknesses of the reuse opportunities under consideration, proposed evaluation criteria and the parameters of the research studies on advanced water treatment being conducted. The May 2005 workshop reviewed the Interim Study Report providing significant suggestions regarding the reorganization and enhancement of the Study contents as well as the comprehensive science-based projects. The final IAP meeting in November 2005 gave the Study Team a detailed critique of the Final Draft Water Reuse Report and the Panel issued their findings which are included in Appendix E. The following is an excerpt from the IAP's findings:

> *"It is the unanimous conclusion of the Panel [IAP] that appropriate alternative water reuse strategies for the City of San Diego have been identified, and that these alternatives have been presented clearly so that the citizens of the City of San Diego can make informed choices with respect to water reuse."*

The members of the IAP and their areas of expertise are listed below. Dr. Tchobanoglous chaired the IAP and Dr. Gersberg served as vice-chair.

Richard Bull, Ph.D., Toxicologist, MoBull Consulting (Richland, WA), *Toxicology*

Joseph A. Cotruvo, Ph.D., Risk Assessment, Joseph Cotruvo Associates (Washington, D.C.), *Environmental and Public Health*

James Crook, Ph.D., P.E., Water Reuse Consultant (Boston, Massachusetts), *Environmental Engineering and Regulatory Issues*

Richard Gersberg, Ph.D., Professor and Division Head of Occupational and Environmental Health; Director, Coastal and Marine Institute, San Diego State University, (San Diego, CA), *Ecological Research and Environmental Health*

Christine L. Moe, Ph.D., Associate Professor, Department of International Health, Emory University (Atlanta, GA), *Epidemiology and Microbiology*

James E.T. Moncur, Ph.D., Director Water Resources Research Center and Professor of Economics, University of Hawaii (Honolulu, HI), *Economics*

Derek Patel, M.D., Assistant Clinical Professor of Medicine, University of California San Diego (San Diego, CA), *Clinical Physician specializing in Gastroenterology*

Joan B. Rose, Ph.D., Homer Nowlin Endowed Chair for Water Research, Michigan State University (East Lansing, MI), *Microbiology and Water Quality*

George Tchobanoglous, Ph.D., P.E., Professor Emeritus, University of California, Davis (Davis, CA), *Environmental Engineering*

Michael P. Wehner, Director of Water Quality and Technology, Orange County Water District (Fountain Valley, CA), *Water Quality and Public Utilities Administration*

Fred Zuckerman, Mechanical Engineer, Member of the Tierrasanta Community Council (San Diego, CA), *Local Perspective*

1.4 Methodology

An overview of the four major phases of the Study from inception to completion is displayed in **Figure 1-2**. Stakeholders and the City's public involvement efforts played a significant role in crafting the Study's approach and process.

Stage I – Project Definition

Provided the basis of the Study, the information from which water reuse opportunities could be analyzed was split into two concurrent efforts.

STAGE I (A)
Public Input and Scope Development
Project Definition
Communication Plan
1st Assembly Workshop
IAP Workshop I

STAGE I (B)
Technical Foundation
Data Collection
Supply Evaluation
Science Assessment

STAGEII
Development of Feasible Opportunities
Compilation of Alternatives

STAGEIII
IAP Workshop II
Interim Report
2nd Assembly Workshop

STAGEIV
Final Draft Water Reuse Study Report

Figure 1.2 – Water Reuse Study Methodology Diagram

Stage I (A) – Public Input and Scope Development

In Stage I (A), stakeholder efforts and public involvement took center stage. A broad range of stakeholders were solicited for participation in the first Assembly workshop, which convened in October 2004. July 2004 saw the first meeting of the IAP. Public viewpoints were solicited through community meetings, San Diego Speakers Bureau (Speakers Bureau) presentations, focus groups and surveys. A website (http://www.sandiego.gov/water/waterreusestudy) was developed and debuted on August 5, 2004. The website included Study information, facts and terminology related to recycled water, and a survey where the public could provide their input on recycled water.

Stage I (B) – Technical Foundation

Stage I (B) included tasks designed to form the technical foundation for the Study. Science, health issues, technological advances in water treatment, case studies, distribution system assessment, market studies, and regulatory issues were researched. The resulting information was consolidated into a technical issue paper and provided to both the IAP and the Assembly for review and comment.

Stage II – Development of Feasible Opportunities

Stage II tasks were aimed at consolidating stakeholder contributions, IAP input, and technical information into viable water reuse opportunities. The first Assembly delivered a recommendation to categorize reuse opportunities into non-potable opportunities (such as using recycled water for landscaping and manufacturing) and indirect potable reuse (IPR) opportunities, such as augmenting groundwater or reservoirs that store water used for drinking. These were integrated into reuse strategies to optimize the beneficial use of recycled water.

Stage III – Interim Report and 2nd Assembly

Stage III was predominantly aimed at engaging the Assembly and IAP on the technical analysis and the opportunities and strategies developed in Stage II. An interim report was completed through coordination with the IAP and provided to the Assembly participants for review and comment. The Assembly was charged with crafting a statement, which summarized majority and minority viewpoints on reuse opportunities and proposed strategies that would be included in the Study report.

Stage IV – Final Water Reuse Study Report

Stage IV consolidates the Study process, tasks, and conclusions into one document. The IAP's review and comments on the Final Draft Water Reuse Report is included as Appendix E. Closing of this process will occur when Council accepts the Study Report and determines the best ways to proceed with the proposed alternative water reuse strategies.

2.0 Public Outreach and Education

The Council values the input and opinions of the San Diego community, especially on important policy decisions such as water supply. The findings of the California Recycled Water Task Force (*Water Recycling 2030*, 2003) also noted that successful recycled water projects typically employed key community participation principles. Those principles included:

- Involving the community in all phases of project planning,
- Disseminating adequate and understandable information in many forums,
- Understanding the values and needs of the public, and
- Providing the community with a broad understanding of water supply issues so that they would have a context in which to evaluate recycled water opportunities.

Based on these principles, the Study team proceeded with a public outreach program that focused on engaging the public as well as informing them about water issues. Stakeholders were engaged through the American Assembly-style workshop process, individual interviews, speaking events and web-based tools. These outreach activities are described in detail below.

2.1 City of San Diego Assembly on Water Reuse

The City of San Diego Assembly on Water Reuse (Assembly) process, detailed in Section 1.3, included development of white papers defining key issues, formulation of key policy questions, and facilitated workshops allowing diverse participants to come together for in-depth discussions. These discussions were usually conducted in break-out groups with detailed reports brought back to all the participants of the Assembly in a plenary session. The entire process concluded with the adoption of an Assembly Statement formalizing the views of the participants.

The first Assembly workshop was held over the course of three days in October 2004 and focused on two key questions:

- *What water reuse opportunities should be considered for the City?*
- *What criteria should be used in the Study to evaluate the water reuse opportunities?*

The result of this effort was a 14-page statement composed by the Assembly participants that summarized majority and minority viewpoints. This entire statement is included in Appendix B. The following are four key excerpts from the first Assembly summary statement:

1. **Assembly participants assert strong support for non-potable uses.**

   The Assembly strongly believes that recycled water can and must play a significantly greater role in the City of San Diego providing added water reliability and environmental benefits. As such, the Assembly is unanimous in its support for the expansion of recycled water for non-potable uses.

2. **The majority of Assembly participants support both non-potable and indirect potable opportunities, and outline critical conditions for reuse projects.**

   The majority of the Assembly supports the aggressive and visionary expansion of recycled water for potable and non-potable uses where the opportunities exist. There are critical conditions that must be met for any alternative that will expand this supply. First and foremost, it must be safe and protect public health. While the Assembly offered strong support for indirect potable reuse, there are clearly members of the Assembly and the community who are concerned about the public health effects of indirect potable reuse. This issue will need to be thoroughly explored and the state of knowledge regarding treatment processes, reliability and risk assessed. A clear presentation of the technical information in a readily understandable manner is vital to ensure any public policy decision is well informed. The Independent Advisory Panel will be especially helpful in this regard.

City of San Diego Assembly on Water Reuse participants are allowed to debate and affect every aspect of the Assembly statement. Majority and minority viewpoints are included.

3. **Assembly participants note the importance of information and public participation.**

   It is critically important to the success of any proposal that the Water Department aggressively pursue community outreach and public education activities to foster understanding of the alternatives and issues. A well-informed public will help ensure that any public policy decision of the City Council is sound. Lastly, the Assembly believes strong community and political leadership is necessary to advance the goals and objectives of the study.

4. **Assembly participants weigh in on considerations and evaluation criteria.**

   In the view of the Assembly, the evaluation criteria listed in the white paper are reasonable. The Assembly believes there are certain refinements that would improve the quality of the assessment. In particular, there is a primary concept of "sustainability" that should guide the assessment of the alternatives. Sustainability considerations include public acceptance, protection of public health, cost-effectiveness, protecting and restoring the environment, greater regional water reliability, and diversification of supply.

Of nearly equal importance is the cost-effectiveness of the water supply, imported and recycled. Both direct and avoided costs must be compared on a common basis. The study must be sensitive to those in the community for which water costs represent a substantial economic burden. In this respect, grants, incentives and other external funding must be pursued.

The latter part of the Assembly statement above refers to evaluation criteria. The Assembly was provided with draft criteria and asked to provide input on whether the criteria were appropriate for evaluating recycled water opportunities. Modifications were made such that the criteria reflected the values of the assembled stakeholders and the community they represent. The criteria, with the Assembly revisions incorporated, are included in **Figure 2-1** on the next page.

EVALUATION CRITERIA	OBJECTIVE	PERFORMANCE MEASURE
Health and Safety	To protect human health and safety with regard to recycled water use	Meets or exceeds federal, state and local regulatory criteria for recycled water uses.
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups	Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.
Environmental Value	To enhance, develop or improve local habitat or ecosystems and avoid or minimize negative environmental impacts	Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits required.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water	Increases percent of water recycling and improves local reliability.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs	To meet all customer quality requirements.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions	Level of demand met and opportunities for system interconnections and operational flexibility are addressed.
Cost	To minimize total cost to the community	Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability	Level of difficulty in physical, social or regulatory implementation.

Figure 2-1 – Reuse Opportunities Evaluation Criteria

The Study held its second Assembly workshop over the course of three days in July 2005. This second Assembly focused on three key objectives:

- Reviewing research materials that had been prepared on the various water reuse options covered in the Study's June 2005 Interim Report.
- Reviewing the strategies outlined for increasing water reuse from the two reclamation plants.
- Determining how well each of the evaluation criteria identified from the first workshop were applied to each reuse strategy outlined in the June 2005 Interim Report.

In their statement adopted at the workshop's conclusion, the group gave strong support for indirect potable reuse, a reservoir augmentation process that uses "advanced treated" or "purified" recycled water to supplement imported and runoff water supplies currently stored in the City's open untreated water reservoirs. Again, the statement featured both majority and minority viewpoints and is included as Appendix C. The following are five key excerpts from the second Assembly statement:

1. The Assembly believes the Water Reuse Study provides a useful and appropriate analysis of reuse strategies that can be used to inform policy-makers.

The Assembly reviewed the technical information and believes the Study provides a sound basis for the deliberations and conclusions of the American Assembly. The Assembly is appreciative of the technical support of members of the City's Independent Advisory Panel and Study Team.

2. The Assembly unanimously agrees that current technology and scientific studies support the safe implementation of non-potable and indirect potable use projects.

The Assembly considers advanced treated (purified) water to be superior in quality to other sources (e.g. Colorado River, State Project Water). The Assembly acknowledges that upon the outset of the study, many participants had reservations regarding the safety of the purified water, but have resolved those concerns through review of this Study and the City of San Diego Assembly on Water Reuse process. The participants are confident that the current research and technological advances in water treatment will produce water of higher quality than currently available. Advanced treatment and long term storage, current water quality regulations, standards and regulatory oversight were viewed as reasonable precautions to ensure public health and safety. Some participants of the Assembly recommend that regulations be revised to allow for direct potable use.

3. The Assembly feels that there are no environmental justice issues that would act as a significant impediment to implementation of indirect potable use strategies.

The Assembly concludes that service would be provided to a wide range of social and economic communities. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. The Assembly *believes that with proper information and community participation, any public perception of environmental justice issues can be overcome.*

4. Recommended Strategy for North City

The Assembly participants unanimously support strategy NC-3 (indirect potable use from North City Water Reclamation Plant). This strategy reduces reliance on imported water, has lower long-term costs, resolves current City litigation, distributes water broadly, and leads the City on a path towards water sustainability.

5. Recommended Strategy for South Bay

The Assembly participants expressed strong support for SB-1 and SB-3. The lower cost of SB-1 and the high percentage of water that is developed were attractive. However, SB-1 does not have the sustainability benefits that SB-3 offers and questions remain regarding dependency on a single large user. Many Assembly participants would favorably consider the SB-1 strategy if NC-3 (which emphasizes indirect potable use) is implemented.

The latter two excerpts of the Assembly statement refer to the strategies discussed in Section 7 of this report.

2.2 Public Outreach Activities

The 2003 California Recycled Water Task Force and the Assembly, as noted above, asserted that information, education and outreach are critical in addressing recycled water issues. The Study team embraced the importance of public participation and incorporated additional activities to supplement the Assembly process.

Public participation and briefing tasks began at the inception of the project. The Study team developed handouts, brochures, PowerPoint presentations, and a website. Monthly updates were sent to community members who had expressed interest in its progress, and a video was produced to enhance the outreach program.

Telephone and website surveys provided valuable insight into community viewpoints. By partnering with the San Diego County Water Authority in conducting a telephone survey, the City was able to collect statistically significant information and opinions from City residents. The City's informal online informational survey allowed additional opinions and input to be submitted directly to the Study team. Survey forms were also distributed at speaking engagements to collect opinions from audience members. In addition, focus groups were conducted to provide insight on residents' opinions on recycled water issues.

Telephone Survey

In June 2004, a telephone survey sampled 406 City residents and found that they support efforts to improve reliability and diversity of regional water supplies through the utilization of recycled water. Survey respondents were asked about their support for various non-potable uses of recycled water. These were ranked in the order of respondent support.

Key Survey Findings

- *Non-potable uses of recycled water receive broad-based public support.*
- *Indirect potable reuse projects can garner public support if an intensive information and participatory process is included.*

1. Landscaping along freeways/golf courses
2. Toilet flushing in new buildings
3. Sports fields and parks
4. Electronics manufacturing
5. Industrial processing
6. Landscape multi-family housing
7. Residential front yards
8. Agricultural irrigation
9. School playgrounds
10. Recreational parks

Survey respondents were also asked whether they would support using highly treated recycled water to supplement potable water supply sources – also known as indirect potable reuse or IPR. Without any conditions or further information, 26 percent of City residents favored supplementing drinking water sources with highly treated recycled water. Those not initially in favor were then provided further information explaining the additional treatment steps and regulatory approvals required. After receiving this additional information, a majority of the survey respondents supported the use of highly treated recycled water to supplement potable water supply sources.

Online Survey

An informal online opinion survey was linked to the City Water Department's Water Reuse Study website when the site was launched in August of 2004. Paper copies of the survey were distributed at Speakers Bureau presentations and when received through other means – at presentations, or by facsimile or post – the data was added to the website survey statistics. Although not scientific, the survey was a means to gather public opinion on water recycling.

As of March 31, 2006, 432 surveys had been completed. Respondents were given the option of indicating residency and 89% provided a zip code. 312 of the total respondents provided a zip code within the City of San Diego, equivalent to 72% of the total respondents.

Of the 312 respondents indicating a San Diego zip code, 191 or 61% answered "yes" to the question "Do you favor using advanced treated recycled water as a drinking water source?" and 121 or 39% answered "no." These percentages closely match the overall total responses to this question: 60% "yes" and 40% "no."

Focus Groups

Decision Research, an independent research group, was contracted to conduct two focus groups made up of City residents. Their goal was to explore in detail the participants' viewpoints on recycled water. The focus group results, as with the telephone survey results, substantiated the importance of providing information and dialogue in order to garner support for recycled water opportunities, particularly indirect potable reuse options.

Speakers Bureau

The Study team organized a Speakers Bureau and created presentations specific to the Study. The team promoted the availability of this program to community organizations throughout the City. A PowerPoint presentation or the Study video was used in all presentations where the facility could accommodate visual aids. Brochures and a printed version of the online survey were made available to audience members for their personal use. From September 2004 through March 31, 2006, 135 presentations were made to various organizations. Of these 135, 58 presentations were made to groups located in the various City Council Districts, 41 to groups not specifically identified with a Council District or within San Diego County but outside the City limits, and 36 were to non-community groups, advisory groups, conferences and the like. A sample of organizations that received presentations includes:

135 Speakers Bureau presentations have been made to groups throughout the City.

- Local community planning groups and councils
- Rotary, Kiwanis and Optimists Clubs
- American Association of Retired Persons
- League of Women Voters
- San Diego Association of Realtors
- Science and medical organizations
- College and high school science classes

A full listing of all presentations completed through March 31, 2006 is located in Appendix F.

Media Coverage

The Study team sought media coverage of the Study as a means of informing large groups of the public about recycled water issues in San Diego. The Study team held interviews with major local print media and electronic news reporters, as well as editors and reporters from minority newspapers to keep them informed on recycled water issues and the progress of the Study. Media outlets contacted included the *San Diego Union Tribune*, *La Prensa*, *Asia Journal, Voice and Viewpoint*, and the *Filipino Press*. As of March 31, 2006, there were 29 newspaper articles about or referencing the Study, four television news stories and one radio interview.

Stakeholder Interviews

From the very start of the project, representative community organizations were identified that held a vested interest in the scope and findings of the Study. The Study team recognized the importance of soliciting input from these stakeholders so that their interests and concerns could be taken into account, as they would be with the implementation of a reuse project. Small group or individual interviews were held with a variety of these stakeholders representing planning, environmental, business and activist organizations. As of March 31, 2006, 27 stakeholder interviews had been conducted. A specified format was used for each interview. A full listing of the completed stakeholder interviews is located in Appendix F. A sample of these organizations includes the following:

- Asian Business Association Government Affairs Committee
- San Diego County Medical Society
- Audubon Society Conservation Committee
- San Diego Regional Economic Development Corporation
- Building Owners and Managers Association Government Affairs Committee
- San Diego Association of Realtors Government Affairs Committee
- American Society of Landscape Architects
- Otay Mesa Chamber of Commerce
- South County Economic Development Council
- U.S. Green Building Council
- San Diego County Taxpayers Association
- San Diego-Imperial Counties Labor Council
- Urban League
- San Diego Hispanic Chamber of Commerce

Letters and Resolutions of Support

As a result of various community outreach activities and presentations, many groups have expressed enthusiastic support for the Study efforts. As of March 31, 2006, 22 letters and resolutions of support for the Study were received from community groups and organizations.

Website Visits

Since the Water Reuse Study website was launched August 5, 2004, it has resided as a prominent link on the City's Water Department homepage. Members of the public are directed to the website through the Study's written materials, media stories, educational video and Speakers Bureau presentations. There have been 6,933 visits to the Study's website through March 31, 2006.

Electronic Newsletters

Starting December 2004, an electronic newsletter or mailing list was developed about Study activities and other related recycled water news, and posted on the Study's website. Announcements of the most recent posting of this newsletter, the "E-Update," are periodically distributed to approximately 434* individual e-mail addresses and U. S. mail addresses. E-Updates have subsequently been published monthly since the inaugural edition and are ongoing. (*This figure represented as of March 31, 2006.)

Facility Tours

The Study team arranged tours of the North City Water Reclamation Plant (NCWRP), South Bay Water Reclamation Plant (SBWRP) and the Advanced Water Treatment Research Facility (AWT) at the NCWRP. Educational signage was developed for the AWT tour area. Tour participants included members of the Study's stakeholder group, local water and wastewater officials, members of the media and other interested groups. Sixteen tours were conducted through March 31, 2006 at these various facilities.

Miscellaneous Promotions

- The Study printed an article in the fall 2005 water bill insert newsletter "Waterline" about the City of San Diego Assembly on Water Reuse Workshop II. The article included information about the Workshop II Statement which supported indirect potable reuse options and reached approximately 265,000 San Diego water customers.

- The Study had a one-page notice which identified the Study effort and provided the website address in the County Registrar's Voters Pamphlet for the July 26, 2005, City-wide special election. The voter booklet was mailed to 600,505 registered voters in the City.

- A brief article with photo in the Water Department's 2004 Annual Drinking Water Quality Report featured information about the Study. Again, the article included the Study's website address. There were 565,744 copies of the report direct-mailed in June 2005 to all residents and businesses in the City of San Diego.

- The Study's 25-minute educational video, which was created in-house, has been distributed at various community presentations and to interested parties. Since September 2005, it has been airing continuously on City Cable Access TV, available on both commercial cable providers serving the City of San Diego access channel.

Telephone Hotline and E-mail Account

The Water Reuse Study currently has a dedicated information line (619) 533-4631 and an e-mail account (WaterReuseStudy@sandiego.gov) which are checked and responded to on business days. These were established in June 2004.

2.3 Regulatory and Interagency Meetings

Regulatory agencies have a major impact on developing water reuse opportunities. State and federal regulations dictate treatment needs, water quality requirements, and allowable uses of recycled water. The Study team recognized that regulator participation was crucial in developing realistic opportunities that could be implemented in a reuse project. In addition, the required treatment processes have a major impact on regulatory costs.

The following two agencies were consulted during the Study process:

- California Department of Health Services (DHS)
- San Diego Regional Water Quality Control Board (RWQCB)

These meetings were productive in evaluating the current regulatory environment and determining the level of cooperation that will be needed should the City realize any of the reuse opportunities developed in this Study.

2.4 Council Aide/PUAC Briefings

City leaders were kept apprised of the Study's progress through briefings with aides for the Mayor's office, Council offices, Governmental Relations Department, and through periodic meetings with the Public Utilities Advisory Committee (PUAC). Council members recommended representatives from their districts to participate in the Assembly workshops. A list of the Council office briefings is included in Appendix F.

PUAC briefings were held on the following dates:

- May 7, 2004
- June 21, 2004
- August 16, 2004
- September 20, 2004
- November 15, 2004
- January 6, 2005
- February 14, 2005
- July 18, 2005
- August 15, 2005
- November 4, 2005 (PUAC Public Education Committee)
- November 21, 2005

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3.0 Development and Supply Availability of Recycled Water

This section provides an overview of the history of water reuse in San Diego that began 25 years ago. In addition, this section provides a discussion on how much recycled water is available to San Diego and issues associated with optimizing its use.

3.1 History of Water Reuse in San Diego

Because the City has long recognized the importance of developing its local water resources, it has been a true pioneer in the field of water recycling. Through grants and alternate funding sources the City has been active in the development of water treatment technologies. In 1981, the 25,000-gallon per day Aqua I Pilot Aquaculture Plant began operation in Mission Valley, with the water produced used to irrigate a sod farm adjacent to Jack Murphy Stadium (now Qualcomm Stadium). The 1984 start of the Aqua II Water Reclamation Facility, a second, larger pilot research installation, began treating 180,000 gallons per day of wastewater. This water was sold to the California Department of Transportation (Caltrans) for use in freeway landscape irrigation beginning in 1987.

In 1991, the Aqua III Water Reclamation Facility and Aqua 2000 Research Center were constructed in the San Pasqual Valley, north of Rancho Bernardo, where the Aqua III plant continued to use aquaculture treatment to reclaim wastewater. This facility had the capacity to treat 1 MGD for agricultural use and irrigation. The Research Center continued to study advanced water treatment using a variety of methods until 2001 when the project was discontinued.

The City has been delivering recycled water to customers for non-potable irrigation and industrial uses on a larger scale since the completion of the NCWRP in 1997. NCWRP was a major investment that highlighted the City's commitment to delivering a safe and reliable new water supply to large areas of San Diego. In 2002, the SBWRP was completed to provide the same benefits to the southern portion of the City. Both of these facilities provide a locally controlled, drought-proof supply of recycled water for San Diego.

Chronology of Events Influencing the City's Reclamation Program

The incentive to develop water reuse projects was also driven by wastewater management issues. Since 1963 the City has treated its wastewater at the Point Loma Wastewater Treatment Plant, which provides treatment at the advanced primary level before disposal through an ocean outfall. In 1972, the Federal Clean Water Act (CWA) was adopted, requiring that wastewater plants provide a more advanced form of wastewater treatment known as secondary treatment, but allowing certain ocean dischargers, such as the City, to apply for waivers. Over the course of the 34 years since the passage of the CWA, the City has applied for a waiver, withdrawn the waiver, found itself sued by the U.S. Environmental Protection Agency (EPA) and other environmental organizations, reapplied for and been approved for a waiver, and settled the lawsuit. These events are summarized below:

1963: The City begins treating wastewater at the new Point Loma Wastewater Treatment Plant.

1972: Congress passes the CWA, requiring wastewater treatment plants to provide secondary treatment, but allowing certain ocean dischargers to apply for waivers.

1987: Following the City's withdrawal of its waiver application, the EPA and environmental organizations sue the City for non-compliance with the CWA.

1994: Congress passes the Ocean Pollution Reduction Act (OPRA), allowing the City to reapply for a waiver. The City reapplies and a waiver is granted. The City settles the lawsuit, and begins work to achieve 45 MGD in water reclamation capacity by 2010, a condition of OPRA.

The City has fulfilled its treatment capacity commitment with the completion of the 30 MGD North City Water Reclamation Plant in 1997, and the 15 MGD South Bay Water Reclamation Plant in 2002.

1995: An EPA grant for construction of the City's NCWRP requires the City to attempt to meet a goal of reusing 25 percent of treated flows by 2003 and 50 percent of the plant's treated flow by 2010. Based on anticipated wastewater flows to the NCWRP, the City established reuse goals consistent with the above commitments of 6 MGD by the end of 2003, and 12 MGD by the end of 2010.

2002: The City fulfills the 45 MGD treatment capacity requirement with the completion of the 30 MGD NCWRP in 1997, and the 15 MGD SBWRP in 2002. After allowances for treatment process losses and other on-site uses, these two reclamation plants have recycled water production capacities of approximately 24 MGD and 13.5 MGD, respectively.

2004: The City enters into a Settlement Agreement with environmental organizations, committing to conduct a comprehensive study of opportunities to make beneficial use of the City's recycled water. The Settlement Agreement commits the City to: (a) evaluate improved ocean monitoring; (b) pilot test biological aerated filters as a form of technology to increase solids removal; and (c) study increased water reuse. This Study is intended to investigate methods to augment the City's use of recycled water.

The Water Reuse Study is intended to fulfill part (c) of the Settlement Agreement with environmental stakeholders to study increased water reuse.

Water Repurification Project

Beginning in 1993, the City, in cooperation with the Water Authority, proposed an IPR project called the Water Repurification Project. The project proceeded through various phases of planning, regulatory reviews, and preliminary design prior to being cancelled by Council in

1999. The history of the project is important to any forward-looking evaluation of water reuse opportunities.

The Water Repurification Project proposed to take NCWRP recycled water and deliver it to a new, nearby facility for further treatment. The additional treatment steps would include the use of several advanced treatment technologies including membrane filtration, reverse osmosis (RO), ion exchange (IX), advanced oxidation using ozone, and disinfection. The product of this sophisticated treatment regimen was termed "repurified water." About 20,000 acre-feet per year (AFY) or 18 MGD of repurified water was to be pumped approximately 20 miles to the 90,000 acre-foot San Vicente Reservoir, one of the City's potable water sources, where it would be discharged into the reservoir and blended with imported and local water. The repurified water would have been stored in the reservoir for approximately two years, during which time further natural treatment would occur. San Vicente Reservoir water, augmented by repurified water, would then be treated along with other water sources at the City's Alvarado Water Treatment Plant before being distributed to customers.

The history of the City's Water Repurification Project is important to any forward-looking evaluation of water reuse opportunities.

DHS first granted conditional approval to the project in 1994, and many groups voiced support for the project including the EPA, the Sierra Club, the San Diego Medical Society, the U.S. Bureau of Reclamation, a citizen's advisory panel, and a variety of business and community interests.

Despite this support for the repurification project, public opposition to the project began to emerge. During the 1998 political campaigns, the water repurification project became an issue in several closely contested races. Some members of the public and media began to raise concerns about potable use of recycled water, and project opponents began to characterize the project with slogans eliciting a negative reaction from the public. The project was also inaccurately portrayed as targeting poor and ethnic communities, when in fact the water would have been available to nearly half of the City's residents of a broad socioeconomic range. These factors placed a challenging burden on City policy makers. Subsequently, Council voted to halt the Water Repurification Project.

2000 Updated Water Reclamation Master Plan

Because the City remained committed to beneficially using its recycled water per the goals established as a condition of the EPA grant, an alternate means to proceed was developed. The Water Department initiated the Beneficial Reuse Project that produced the *2000 Updated Water Reclamation Master Plan* (Master Plan) and the numerous planned and implemented system improvements to maximize non-potable use of recycled water.

3.2 North City Water Reclamation Plant Recycled Water Use and Availability

The NCWRP, operated by the City's Metropolitan Wastewater Department, currently treats a wastewater inflow of 22.5 MGD, which is 75 percent of its capacity. Of this amount, approximately 6 MGD of tertiary-treated recycled water is produced and beneficially reused on average each year. The remaining flow is treated to a secondary level and conveyed to the Point

Loma Wastewater Treatment Plant for disposal through an ocean outfall.

The existing distribution facilities in place to serve the northern service area (the recycled water distribution area served by NCWRP) include a 9 million gallon storage tank, two pump stations, and about 66 miles of pipeline, including a large backbone pipeline in Miramar Road. These facilities extend from the coast to the City of Poway (Poway).

North City Water Reclamation Plant Summary Information

• Inflow Design Capacity:	30 MGD
• Maximum Recycled Water Production Capacity (with demineralization and full inflows):	24 MGD
• Existing Beneficial Reuse:	6 MGD
• Total Planned Reuse by 2010 with completion of ongoing reuse projects (distribution system expansion Phases I & II):	9 MGD

As of March 31, 2006, the City provides recycled water to 363 meters connected to the system, including a single connection with Poway that serves an additional 195 customers. Most of the City of San Diego customers (99%) use recycled water for irrigation while a few customers use recycled water for industrial purposes. Large City customers include the NCWRP, the City's Metropolitan Biosolids Center, Caltrans, City Park and Recreation Department, General Atomics, Miramar Landfill, Miramar Nursery, Mitchell International, Motorola, Nissan Design, Pacific Retail Trust, San Diego California Temple, Superior Readymix, Timberland II, University of California at San Diego, the Torrey Pines municipal golf course and the Marine Corps Air Station Miramar golf course. Opportunities exist for perhaps 150 to 200 additional irrigation customers connecting to the existing northern service area system including public parks, freeway medians and private customers, each using between 0.5 to 20 AFY (see Section 5).

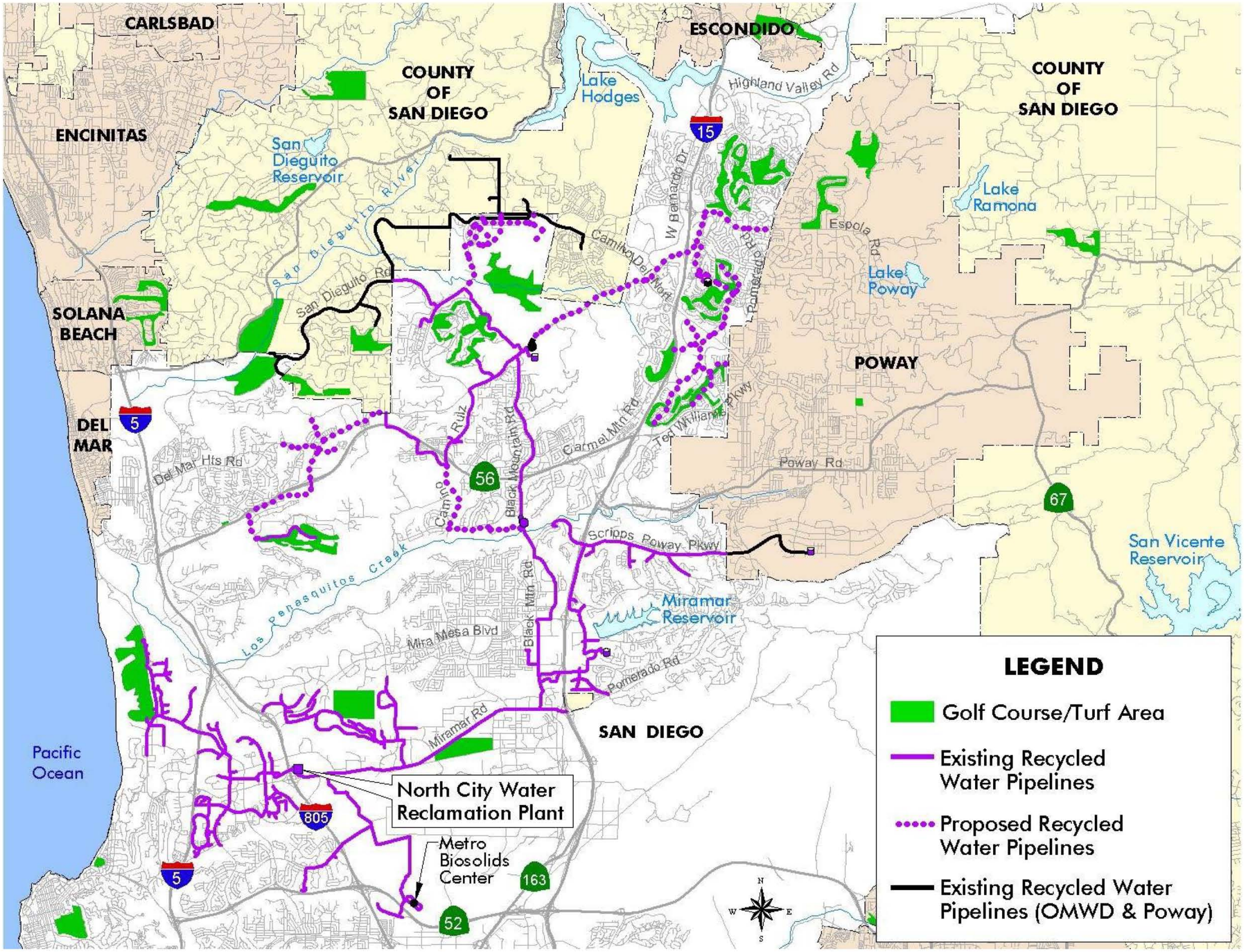
Planned NCWRP Distribution System Expansions

The City is continuing to expand the recycled water distribution system and connect additional customers. Divided into three segments known as Phase I, Phase II and Phase III, this expansion is based on the City's Master Plan completed in 2000. Its major facilities are shown in **Figure 3-1**. The City is currently completing construction of Phase I, and Phase II is in various stages of planning, design or construction. Phase III expansion has not yet been funded and therefore provides an opportunity to reassess this expansion along with other non-potable opportunities (see Section 5).

The City has previously identified three phases of NCWRP distribution system expansion. Phases I and II are ongoing. Phase III remains a future option and is presented for consideration in Section 5 of this report.

New customers will include a golf course, parks, landscape sites, and the Olivenhain Municipal Water District (OMWD).

Figure 3-1 – North City Recycled Water Distribution System



Thirteen miles of pipeline have been installed through the Rancho Peñasquitos community to the Black Mountain Ranch area. In addition, a pump station and a three million gallon reservoir have been constructed. Phase I customers are anticipated to generate a recycled water demand of approximately 1.7 MGD by 2007.

Phase II of the distribution system expansion will provide recycled water service to Carmel Valley and the State Route 56 corridor. The 16 miles of pipeline needed to implement this phase are under various stages of design or construction. Major customers to be served by the Phase II expansion include the Del Mar National Golf Club (formerly Meadows Del Mar), Caltrans, Pacific Highlands Ranch Parks, and the Palacio Del Mar Golf Course. Recycled water use along this corridor is anticipated to generate a recycled water demand of approximately 0.9 MGD when the entire length of pipeline is completed in 2010.

Recycled Water Availability at the NCWRP

The NCWRP is referred to as a 30 MGD facility, based on its ability to treat 30 MGD of incoming wastewater flow. The actual amount of recycled water produced is less than the plant's rated capacity due to internal treatment process uses such as filter backwashing and demineralization. Accounting for these uses, the ultimate recycled water production capacity of the NCWRP is approximately 24 MGD of recycled water.

Of the 24 MGD NCWRP available supply, 7.2 MGD is available for new opportunities in the summer months, and 16.8 MGD is needed to meet existing demands combined with the Phase I and Phase II expansions. This 16.8 MGD total is approximately twice the average annual uses summarized above, as non-potable uses peak during the warm summer months. Additional recycled water produced during off-peak months could be utilized if seasonal storage was available, or included as part of an IPR project. These considerations were taken into account in developing the reuse implementation strategies to maximize recycled water use from NCWRP.

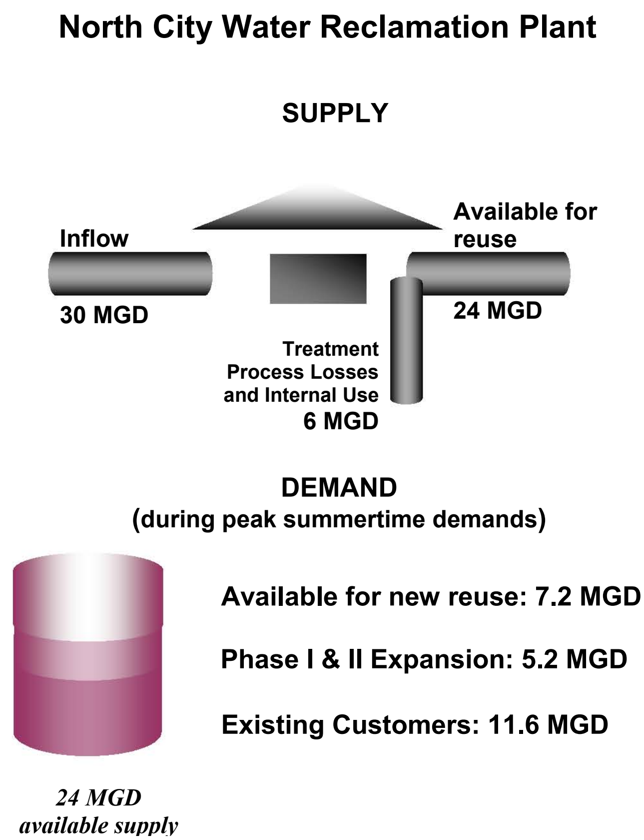


Figure 3-2 - The 30 MGD NCWRP could provide 24 MGD of recycled water (top figure). Of the 24 MGD of recycled water produced, 7.2 MGD is available for new opportunities (bottom figure).

3.3 South Bay Water Reclamation Plant Recycled Water Use and Availability

The 15 MGD SBWRP became operational in the summer of 2002. It currently produces 5 to 6 MGD of secondary treated wastewater that is disposed via the South Bay Ocean Outfall. Certification of the tertiary treatment facilities by the RWQCB was granted in 2004.

South Bay Water Reclamation Plant Summary Information

• Inflow Design Capacity:	15 MGD
• Maximum Recycled Water Production Capacity (with full inflows):	13.5 MGD
• Existing Beneficial Reuse:	1.25 MGD
• Total Planned Reuse with completion of ongoing reuse projects (distribution system expansion to Otay Water District):	7.25 MGD

The distribution system consists of a 30-inch pipeline in Dairy Mart Road that will eventually connect to facilities currently being constructed by Otay Water District (OWD). Construction of facilities was recently completed to deliver 0.7 MGD of recycled water to the adjacent International Boundary and Water Commission (IBWC) Wastewater Treatment Plant.

Planned SBWRP Distribution System Expansions

On October 16, 2003, Council approved an agreement to sell up to 6 MGD of recycled water to the OWD, which will have infrastructure in place to take this water by January 1, 2007. In addition, Caltrans has expressed interest in using recycled water for freeway landscape irrigation at the southern ends of Interstates 5 and 805, and the 905 interchange. The facilities that comprise the distribution system for the South Bay area are illustrated in **Figure 3-3**. Additional potential recycled water customers have been identified and are presented in Section 5 of this report.

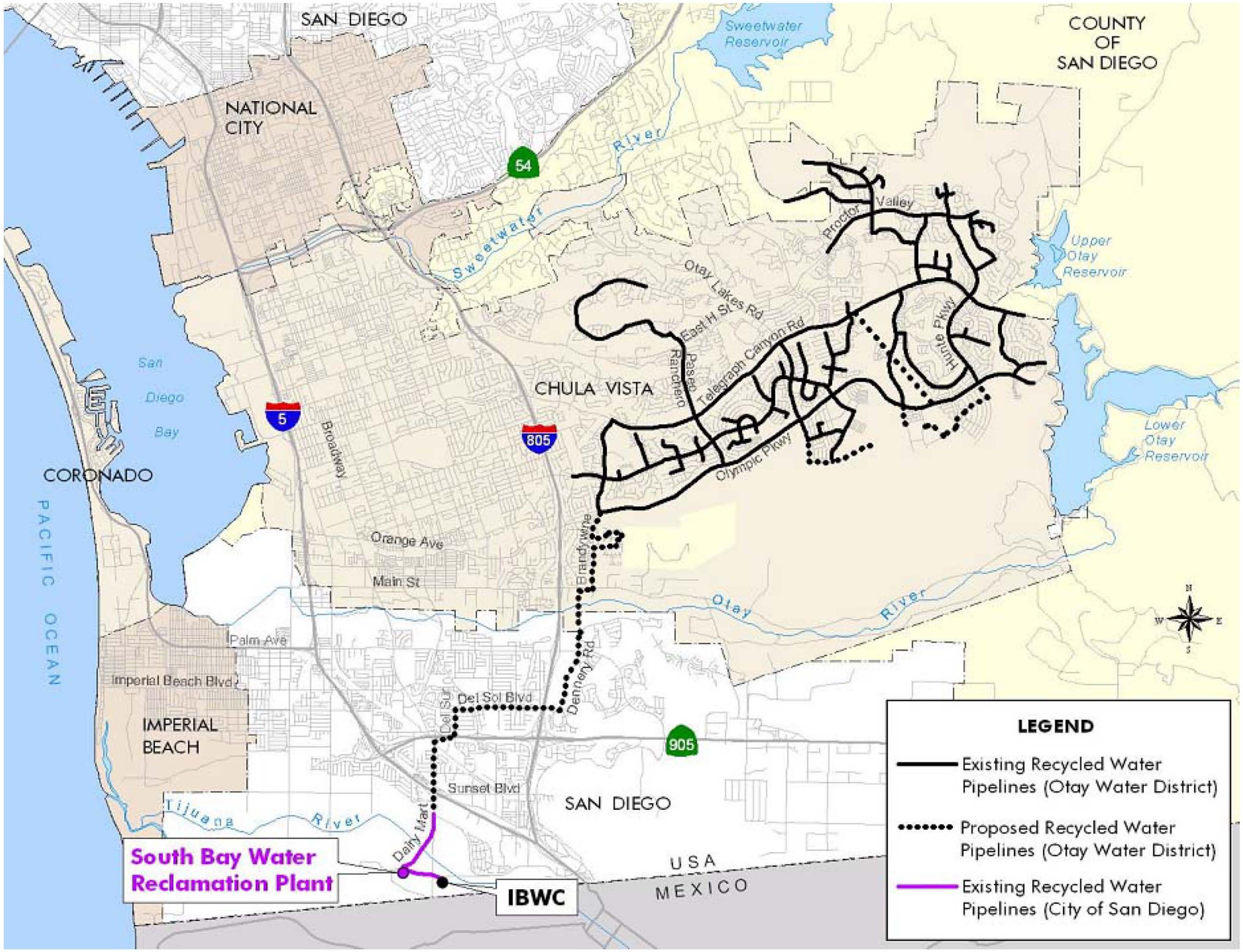


Figure 3-3 – South Bay Recycled Water Distribution System

Recycled Water Availability at the SBWRP

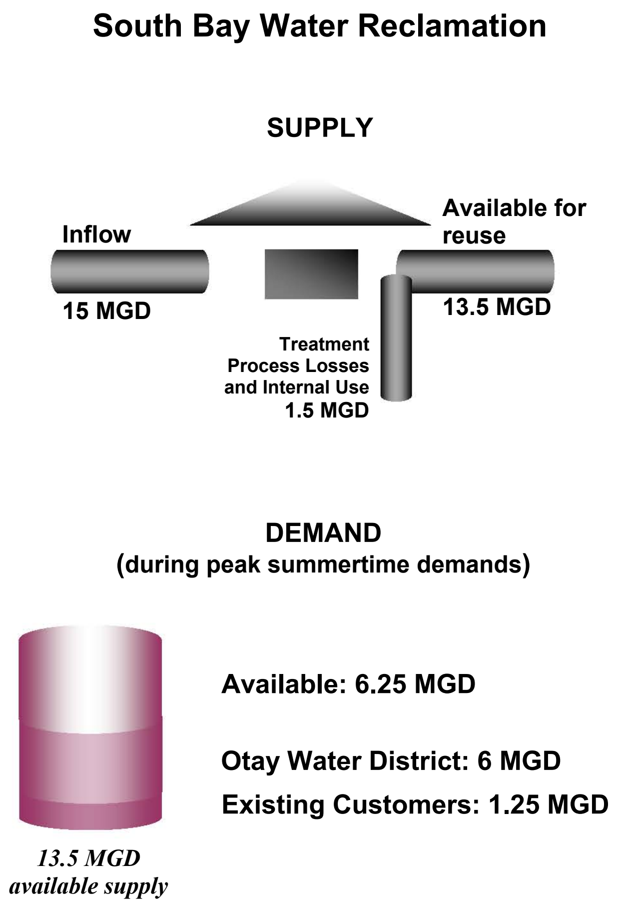


Figure 3-4
The 15 MGD SBWRP provides 13.5 MGD of recycled water (top figure). Of the 13.5 MGD of recycled water produced, 6.25 MGD is available for new opportunities (bottom figure). Note: if demineralization is used there will be less water available to market.

The SBWRP is referred to as a 15 MGD facility, based on its ability to treat 15 MGD of incoming flow. The actual amount of recycled water available is less than this due to internal treatment process uses such as filter backwashing. Accounting for these uses, the ultimate recycled water production capacity of the SBWRP is approximately 13.5 MGD. Because the SBWRP does not require an additional treatment step to reduce the salt content of the recycled water, process loss is less than at NCWRP.

Of the 13.5 MGD SBWRP available supply, 6.25 MGD is available for new opportunities in the summer months. A portion of the SBWRP recycled water supply is committed to existing customers – the SBWRP on-site uses and the IBWC treatment plant. These non-potable uses are constant throughout the year. The City has an agreement to supply OWD with up to 6 MGD. However, recycled water produced during off-peak months could be utilized if seasonal storage was provided or if it were part of an IPR project. These considerations were taken into account in developing the reuse implementation strategies available to maximize recycled water use from the SBWRP.

3.4 New Recycled Water Supply Sources

Mission Valley Plant
A new 5 MGD Mission Valley Plant could be constructed to serve the Central Service Area.

New water reclamation plants are major investments; therefore, it is prudent for the City to maximize existing treatment facilities before considering the construction of new facilities. However, if the City were to consider siting a new treatment facility in an area that is in need of wastewater treatment facilities, or in an area with significant potential demand for recycled water, a satellite reclamation plant could be feasible.

Satellite treatment plants must be in close proximity to large supplies of wastewater to treat and have access to disposal facilities. A location near or adjacent to a large trunk sewer is ideal. For this study, it was assumed that a satellite treatment plant could be constructed in the Mission Valley area. The new plant is conceptualized as a 5 MGD facility that would use membrane bioreactor (MBR) treatment. MBRs are systems that integrate biological degradation of waste with membrane filtration. MBRs require less space and are more automated than conventional treatment facilities, ideal for decentralized treatment. This concept is discussed further in Section 5. The Water Authority completed a regional study on MBR recycled water satellite treatment plants in November 2005. Additional emphasis on such facilities is planned during future recycled water master plan updates.

3.5 Seasonal Storage

Seasonal storage is used to increase the amount of recycled water available for non-potable uses during the hotter, higher-demand months due to warmer weather by storing surplus recycled water in the colder, lower-demand months. Because recycled water supply availability is consistent year-round (due to steady year-round wastewater inflows) plants are maximized in the summer, while excess capacity is created in the winter resulting from cooler temperatures and rainfall, as shown in **Figure 3-5**. Seasonal storage allows excess off-peak supplies to be stored for later use during peak demands, effectively increasing the total amount of non-potable water reuse possible. This situation is relatively common for non-potable recycled water systems. An alternative to seasonal storage is supplementing the recycled water distribution system with raw water or potable water to meet peak demands.

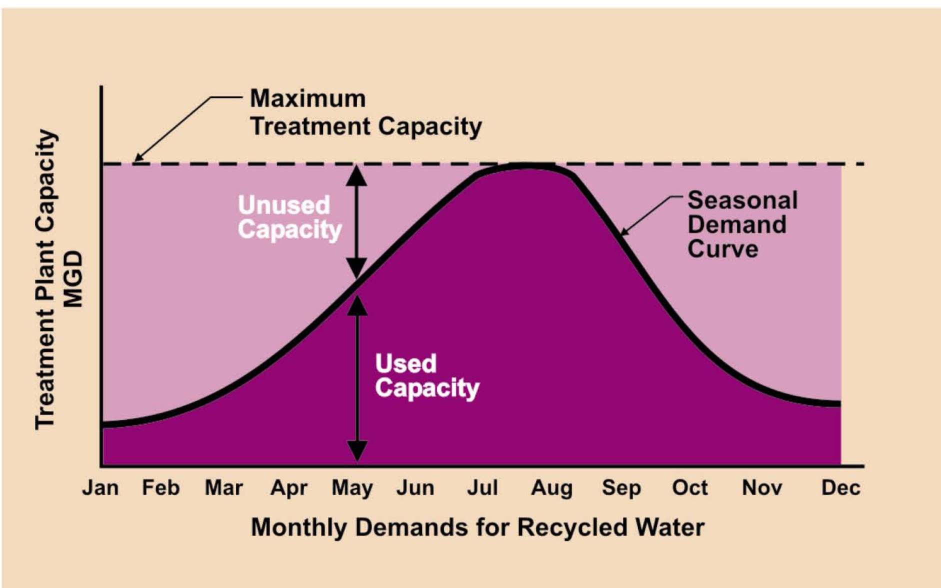


Figure 3-5 – Seasonal Storage of Recycled Water

Seasonal storage is not a use in itself, and the volume of seasonal storage required is dependent on the additional demands put on the system. For seasonal storage to be effective, a significant volume of water must be stored. Because land availability is a critical element of most seasonal storage projects, the addition of a seasonal storage facility is relatively expensive. For this study, potential sites for the construction of earthen basins were estimated to be:

- 40 acres in size for storage of approximately 1,000 AF of recycled water, located on relatively level terrain.
- In relative proximity to the existing or planned recycled water distribution systems.

Groundwater storage of recycled water was also investigated. However, the groundwater basins in San Diego are all designated for potable use by the RWQCB. An amendment to the region's Basin Plan would be required before storage of non-potable recycled water could be permitted to occur in a groundwater basin. According to State regulators, no groundwater basins in California have been permitted for the seasonal storage of non-potable recycled water, therefore, only earthen basins were considered in this study.

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4.0 Overview of Water Reuse Opportunities and Public Health Protection

This section provides an overview of the water reuse opportunities investigated in the Study, as well as a brief description of the treatment technology, regulatory requirements and how public health is protected when recycled water is used. Further detail on these topics is in Appendix G of this report.

With a methodology in place and a diverse team of stakeholders and technical professionals engaged, the Study team developed a slate of reuse opportunities. Opportunities were first framed within the Council resolution authorizing the Study, which stated that the Study should evaluate "*a viable increased water reuse program, including but not limited to groundwater storage, expansion of the distribution system, reservoirs for reclaimed water, live stream discharge, wetlands development, and reservoir augmentation*" (R-298781). The Study team identified a list of reuse project opportunities and presented these to the Assembly and IAP for review. Based on stakeholder input, such opportunities were revised and analyzed, as shown in **Figure 4-1.**

City Council provided framework	Study team defined opportunities	The Assembly & IAP provided criteria	Study team revised opportunities based on input	Study team analyzed opportunities

Figure 4-1 – Development of Reuse Opportunities

4.1 Stakeholder Input on Reuse Opportunities

The Assembly and IAP were asked to weigh in on these reuse opportunities early in the project process with full flexibility for new additions or changes. Participants could and were encouraged to suggest revisions, alternatives, and express the need to emphasize or de-emphasize different project components.

The first key piece of input was a suggestion on how opportunities could be presented. The Assembly suggested separating non-potable and IPR projects to aid in analysis. Additionally, the stakeholders suggested the investigation of specific uses, including:

- Residential front lawn uses,
- Carwashes,

- Commercial laundries,
- Construction activities, such as dust control and soil compaction,
- Street sweeping,
- Toilet flushing,
- Cooling towers and boiler makeup water, and
- Firefighting.

The Assembly participants also emphasized the need for recycled water "*to be safe and protect public health*" as the foundation of a reuse program. Therefore, this section also includes a summary of the science, technology and regulatory issues related to recycled water use. Additional information, as well as the references used herein, is also included in Appendix G.

4.2 Non-potable Reuse Description and Project Types

Non-potable recycled water reuse represents the largest and most successful type of water reuse to date in California. Typically utilizing recycled water that meets California water quality standards for uses that are not associated with drinking water, non-potable reuse plays a leading part in such projects as irrigation, industrial operations and wetlands creation. Non-potable applications have been proven safe, reliable and effective at reducing the need for potable water, particularly during peak summer months. During 2001, the California State Water Resources Control Board estimated that nearly 550,000 AF of water was recycled in California for various uses (**Figure 4-2**). Appendix G provides further details on specific non-potable reuse projects.

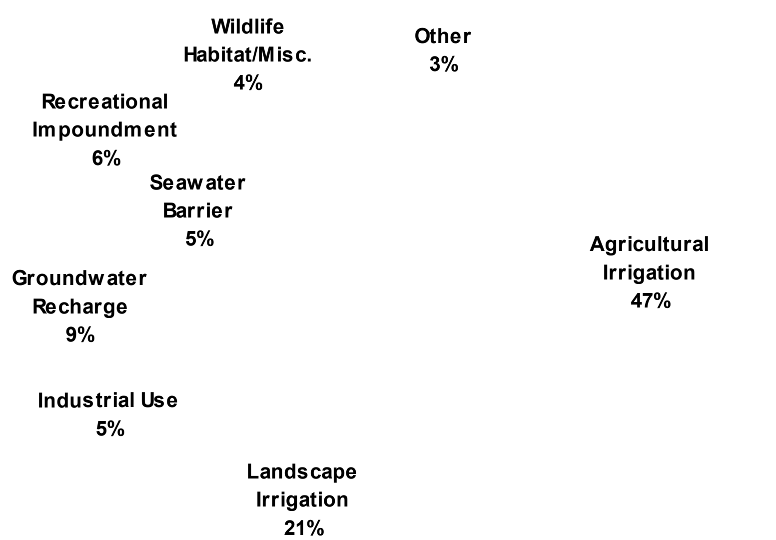

Figure 4-2 – 2001 California Recycled Water Use by Category
Source: Adapted from California State Water Resources Control Board data.

Agricultural and Landscape Irrigation

As illustrated in **Figure 4-2**, the primary non-potable use of recycled water in California is irrigation. In 2001, over two-thirds of all recycled water was used for agricultural and landscape irrigation. When using recycled water for agricultural irrigation, there are some contaminants of concern – primarily salinity, inorganic elements, residual chlorine, and nutrients. Although the presence of nutrients in recycled water is generally appreciated by irrigation customers and can be beneficial to plant growth, excess amounts of salinity are potentially harmful to plants and can have long-term adverse effects on the soil.

Industrial Uses

Approximately five percent of the recycled water use in California is through industry. There are a variety of industrial applications well-suited to recycled water. For many industries, cooling water for commercial air conditioning systems comprises the largest use of recycled water. Power plants (including geothermal energy) and refineries can use substantial amounts of cooling water. The use of recycled water for cooling is beneficial for its suppliers in that it typically has a more constant demand than landscape irrigation. Boiler water make-up is another opportunity, however unless there is a large user such as a refinery, the amount of water used in this process is typically small. Dual-plumbed buildings, where recycled water could be supplied to toilets and urinals, are another option.

Other Non-potable Opportunities

The remaining non-potable uses of recycled water represent either a much smaller amount of overall reuse potential or an application difficult to implement in San Diego. In general, these opportunities include private residential landscape irrigation, wildlife habitat enhancement or wetlands creation, recreational impoundments (lakes or ponds), and other uncommon or specialized uses.

Padre Dam Municipal Water District – Santee Lakes Recreation Preserve uses recycled water.

Private Residence Landscape Irrigation Use

Irrigation of single-family residential lots with recycled water is allowed in California, with the most notable and recent example being in the Northern California El Dorado Irrigation District, just east of Sacramento. Though private residential use of recycled water has been discouraged locally by the San Diego County Department of Environmental Health because of concerns regarding homeowner maintenance and cross-connection control, the El Dorado project overcame these concerns by forming a homeowner's association to manage the use of recycled water for landscape irrigation.

Recreational Impoundment and Wildlife Enhancement Uses

Environmental and recreational applications include wetland restoration and enhancements as well as incidental contact (fishing, boating) and direct contact (swimming, wading) uses. California allows recycled water use for these applications but with restrictions depending upon the likelihood and degree of body contact. Unrestricted recreational uses require disinfected tertiary recycled water and extra monitoring for pathogens such as *Giardia*, *Cryptosporidium* and viruses. In San Diego County, the Padre Dam Municipal Water District uses recycled water in their Santee Lakes Recreation Preserve.

Miscellaneous Uses

Although recycled water is used elsewhere in California for fire protection, snowmaking, construction/dust control, street sweeping, car washes and commercial laundries, these uses are generally small. With the exception of snowmaking, San Diego could use recycled water for these activities if these agencies and commercial enterprises expressed interest and the activities were in the vicinity of recycled water facilities, though it would need to be at the discretion of the City and the specific potential customers. Overall, these uses would tend to be relatively small compared to the potential of the other opportunities presented.

4.3 Indirect Potable Reuse Description and Project Types

The City purchases all of its imported water from the Water Authority, which in turn purchases its water from the Metropolitan Water District (MWD) of Southern California and the Imperial Irrigation District (IID). The water sold by MWD is a blend of Colorado River and California State Project Water, and the blend varies depending on price and supply availability. Approximately 80 to 90 percent of all drinking water in the City originates from these two sources.

California's annual use of Colorado River water has varied from 4.5 to 5.2 million AF over the last ten years. Historic and current use of up to 5.2 million AFY stems from the occurrence of surplus conditions and the availability of water apportioned to, but unused by, Arizona and Nevada. However, both states are approaching full use of their allocations, thereby reducing the likelihood that surplus Colorado River water will be available for purchase by MWD and other California water users.

In order to offset some of these losses to our future water supply, the Water Authority has reached an agreement to purchase up to 200,000 AF of Colorado River water apportioned to the IID. Part of this future supply will come from lining a 23-mile long section of the All American Canal, which currently loses approximately 67,700 AFY of water due to seepage into the ground.

The California State Project aqueduct is 444 miles long, starting from the Sacramento-San Joaquin Delta (Delta) and ending at Lake Perris in Riverside County. The Delta is a region where two of the California's largest rivers meet. Freshwater from the rivers mixes with saltwater from the Pacific Ocean, creating the West Coast's largest estuary. About two-thirds of all Californians and millions of acres of irrigated farmland rely on the Delta for water to supply the State Water Project and the federal Central Valley Project.

Unlike most river-supplied cities, San Diego's source water supply (a blend of local runoff, State Water Project and Colorado River waters), is of fairly good quality. That is not to say it is pristine mountain spring water. A few notable water agencies, including the City of San Francisco which receives 94% of its water from the Hetch Hetchy Reservoir filled with snowmelt from mountains in Yosemite National Park, and New York City, which receives over 90% of its water from highly protected watersheds in the Catskill Mountains, are exempt from federal treatment and filtration requirements prior to delivery to their customer's taps.

Conversely, San Diego's source water is superior to cities receiving water from the Mississippi River, Missouri River, or other rivers flowing through the central portion of the United States that have severely impacted water quality.

The Colorado and Sacramento-San Joaquin Rivers, like most rivers that pass through or near major cities, receive treated municipal wastewater and industrial inflows from upstream cities which blends with the river supply of downstream cities. The City of Las Vegas, for instance, discharges roughly 180,000 AF of tertiary treated municipal wastewater into Lake Mead each year, or about 2% of the total lake volume (as of November 2005 according to the U.S. Bureau of Reclamation volume data for Lake Mead; this percentage varies with lake volume). In addition to Las Vegas, there are about 650 total permitted dischargers, of which 360 are municipal and industrial dischargers into the Colorado River, upstream of the Colorado River Aqueduct intake point. Of these dischargers, 130 are relatively large dischargers (greater than 1.5 AF per day) and account for about 96.8% of the 2,610 AF per day of the total discharge back into the Colorado River. According to a 2004 U.S. Geological Survey (USGS) report on flow in the Colorado River Basin, the average daily river flow between 2001 and 2003 was slightly less than 14,800 AF per day. This roughly equates to discharges from Municipal and Industrial users into the Colorado River equaling 17.6% of the total river flow.

In the Sacramento and San Joaquin Rivers there are 339 permitted dischargers returning about 6,480 AF per day into these rivers (as of June, 2005). There are 137 relatively large dischargers (greater than 1.5 AF per day) along the Sacramento and San Joaquin Rivers accounting for about 98.8% of the total permitted discharges, however, these include agricultural returns as well as permitted municipal wastewater and industrial inflows. According to the California Department of Water Resources, the uninterrupted runoff into the combined Sacramento and San Joaquin Rivers averages about 68,800 AF per day. Therefore, discharges roughly equate to about 9.4% of the total combined river flow.

San Diego fully treats the "raw" or untreated water it receives using a conventional treatment process of chemical coagulation, flocculation, sedimentation, filtration and disinfection. Using this "conventional" treatment process, which most cities in the United States also use, San Diego has always met the water quality standards set by the EPA and DHS Drinking Water Standards. The City successfully removes all regulated chemical compounds and potential bacterial or protozoan pathogens to below the levels mandated for public health reporting to these regulatory agencies. For over 105 years, the City of San Diego Water Department has successfully delivered safe drinking water to all of its customers and continues to surpass all water quality standards set by state and federal public health agencies.

In side-by-side water quality analyses, tertiary treated water produced at the NCWRP has shown to have comparable or lower levels of all regulated chemical compounds compared to raw water supplies at lakes Miramar and Murray. Should the City proceed with an IPR project, such as augmenting a reservoir or groundwater basin with advanced treated water (post tertiary treatment, membrane filtration, reverse osmosis and advanced oxidation/disinfection), the same would hold true. In short: the resulting recycled water would be of superior quality to our current raw water supply.

Whenever a wastewater treatment plant discharges to surface water or groundwater that serves as a drinking water source for downstream cities, a form of IPR occurs, often referred to as unplanned reuse. This kind of reuse of treated wastewater, not necessarily of recycled water quality, has occurred for many decades throughout the United States. DHS does not consider such use IPR unless an individual wastewater discharge comprises more than five percent of the total water supply (California DHS, Bob Hultquist, personal communication, 2005).

In this Study, IPR is defined as advanced treated recycled water that is discharged into either groundwater or surface water that ultimately supplies the same area's drinking water system. Because it is intended for human consumption, this use receives a much higher degree of treatment than recycled water used for non-potable purposes.

The highly treated recycled water blends with the groundwater or surface water (which is usually imported water and local runoff) during a long residence time. The term "indirect" refers to the distinction that the advanced treated recycled water is not plumbed "directly" to the potable distribution system.

All indirect reuse projects in California require extensive planning, permitting and interaction with regulators. In IPR projects, all indications are that the water produced is of higher quality than most surface waters used as sources of drinking water in the US.

As there are no significant rivers in the San Diego vicinity, the City's treated wastewater is discharged to the ocean. To recycle this treated wastewater for IPR there are three basic types of projects that could be employed in San Diego:

- Groundwater recharge-spreading
- Groundwater recharge-injection
- Reservoir augmentation

Groundwater Recharge – Spreading

Surface spreading is a recharge method where recycled water is released into open basins and the water seeps down through the soil into the groundwater basin. It is used generally when enough land area is available, certain soil conditions are present, and if the groundwater basin is "unconfined" (water moves through the basin). Spreading of recycled water for groundwater replenishment has been done in Los Angeles and Orange Counties for many decades. See Appendix G for further details.

Groundwater Recharge – Injection

A more complex means of adding to groundwater resources is through injection. Recycled water injection simply pumps the recycled water down to the groundwater, bypassing the soil percolation step. Because injection introduces recycled water directly into the groundwater, it does not provide the treatment benefits that percolation provides. Accordingly, the injected water must be of higher quality than that used for surface spreading. Some states require treatment to drinking water standards. Injection of recycled water into groundwater basins has been done in Los Angeles County (West Basin Municipal Water District) since 1995 and in Orange County since the 1970's; details are available in Appendix G.

Reservoir Augmentation

Reservoir augmentation adds highly treated recycled water into a water reservoir to increase the overall water supply. Water used in reservoir augmentation projects undergo advanced treatment and disinfection. In addition to the advanced treatment, reservoir augmentation projects also allow the treated water to reside under natural environmental conditions for a period of time. This retention time provides an additional public health barrier, as natural reduction of trace contaminants occurs due to microbial degradation, oxidation, and dilution. The reservoir water would ultimately be pumped out and treated by a potable water treatment plant and used for drinking purposes. Reservoir augmentation has been in use at Occoquan, Virginia since 1978. Additional information can by found in Appendix G.

4.4 Recycled Water and Protection of Public Health

Risk assessment and risk management principles form the basis of California water regulations to protect public health. These regulations cover both the required treatment and allowable uses of recycled water. A multi-barrier treatment approach is recognized as a reliable means to protect public health and provide safe and reliable water supplies.

Risk Assessment and Management

Risk assessment has been defined as "the characterization of the potential adverse health effects of human exposures to environmental hazards" (National Research Council, 1983). Health risk assessments are used to determine if a particular chemical poses a significant risk to human health and, if so, under what circumstances. Risk assessment helps regulators develop consistent, realistic, and prioritized goals for reducing exposure to toxics so that health threats to the public can be reduced to a minimum.

The risk assessment process is typically described as consisting of four basic steps: hazard identification, exposure assessment, dose-response assessment, and risk characterization. Each of these steps is explained in detail in Appendix G. Government regulators turn to specialists to perform or assist with risk assessments. These specialists include scientists with degrees in toxicology (the study of the toxic effects of chemicals) and epidemiology (the study of disease or illness in populations), as well as physicians, biologists, chemists, and engineers. Risk assessments are designed to overestimate rather than underestimate potential risks in order to be conservative of public health.

Risk managers rely on these risk assessments when making regulatory decisions such as setting water quality standards. Because they are responsible for protecting human health, risk managers consider technological, socioeconomic, and political factors when arriving at their decisions.

Setting and Enforcing Standards

Risk assessment and risk management principles are used by both federal and state drinking water regulators. The Safe Drinking Water Act of 1974 requires the EPA to set drinking water standards. In addition, the EPA has developed many Drinking Water Health Advisories that provide guidance on various unregulated contaminants. The World Health Organization also produces "Guidelines for Drinking Water Quality" with comprehensive coverage of health-based values for water components, as well as providing management principles for providing safe drinking water.

States are also free to set their own standards, but state standards must be “at least as stringent as the federal standard”. California drinking water standards are set by the DHS using risk assessment information developed by the California Office of Environmental Health Hazard Assessment (OEHHA). California typically sets more stringent drinking water standards than those established by the EPA. The DHS sets drinking water maximum contaminant levels (MCLs) that carefully balance the health benefits with permit compliance feasibility/cost using the best available information. Water recycling projects that involve human contact (including drinking water) must meet these standards. Typically, the DHS includes drinking water MCL compliance requirements in the operating permits for recycled water projects that involve potential human contact. DHS can take enforcement action where compliance is not achieved.

In addition to establishing drinking water MCLs, DHS has developed enforceable regulations and guidance for recycled water projects. These are part of the permit issuance process the California regulatory agencies require cities and water districts to follow prior to granting approval for a recycling project to operate. The RWQCB issues the permits. DHS consults with the RWQCB and approves the public health and treatment requirements. To ensure that the proposed treatment method, distribution, and monitoring produces recycled water that meets the permit requirements and protects public health, the DHS evaluates every proposed water reuse project on a case-by-case basis.

Multiple-Barrier Approach to Public Health Protection

A multi-barrier water treatment approach is a proven means of protecting public health. Numerous, but not all, contaminants are regulated in drinking water and recycled water. The reason some contaminants are not regulated is because monitoring methods either do not exist or are too complicated for routine monitoring, or there is no reason to believe the contaminants are present to begin with. DHS regulators manage this uncertainty by using what is referred to as a multiple-barrier treatment approach (Velz, 1970; AWWA, 1987). This means that several treatment processes are used in a sequence to remove contaminants. In this manner, if one treatment barrier were to fail, the later independent treatment barriers would still insure proper treatment and removal of contaminants.

The multi-barrier approach is used for both drinking water treatment and recycled water treatment (Davies et al, 2003; Luna et al, 2004). It includes source control (prevention of contaminants from entering the water supply), use of multiple water treatment processes, and water quality monitoring and surveillance. The basis of this approach is to ensure that there are prudent checks and balances in place to minimize the risk of failure and, ultimately, prevent exposure of consumers to unsafe water. A major advantage of the use of multiple-barrier water treatment methods is that the methods can also be effective at removing unknown contaminants.

Source Control

An increasingly important additional barrier against unknowns is the use of source control. Source control requirements are part of the permit process to utilize recycled water as they identify and minimize the introduction of contaminants into the wastewater, eliminating the need for them to be removed through treatment. The City’s Metropolitan Wastewater Department (MWWD) regulates the quality of the wastewater that enters the wastewater system through an enforceable Industrial Wastewater Control Program (City of San Diego, 2005; EPA, 1992). A joint effort between the City, other agencies served by the system, and local industry, the program issues discharge permits, performs inspections, conducts wastewater monitoring, and enforces discharge standards at businesses and industries throughout the service area.

Similarly, the Orange County Sanitation District (OCSD) is adopting an enhanced source water control program that expands the list of pollutants of concern entering the treatment plant to include regulated and newly discovered drinking water contaminants. The OCSD will provide treated wastewater as the source water for the Orange County Water District's (OCWD) advanced treatment Groundwater Replenishment Project.

4.5 Water Treatment Technology

With today's technology, there are many differing individual treatment methods that can be linked together to provide water treatment for recycled water uses. In a multi-barrier approach these methods are carefully selected and placed in a specific order in a treatment plant depending on the required water quality needed. Both public health and the quality of water needed for the specific use guide the level of treatment needed. A more detailed description of water treatment methods and additional references is included in Appendix G.

Water treatment methods can be used to remove or reduce broad classes of contaminants including:

- Microorganisms (disease-causing bacteria, viruses and protozoa),
- Organic chemicals (pesticides, herbicides, trace contaminants),
- Inorganic chemicals (metals, nutrients, and minerals),
- Physical measurements (color, turbidity, and odor), and
- Radiologicals (radioactive substances).

Recycled water treatment methods are specifically designed and sequenced to reduce the amount of these contaminants to levels that consider the end use and protect the health of the public. Importantly, the treatment methods also provide multiple barriers to remove other similar contaminants. The effectiveness of removal depends on the method selected and how it is designed, operated and maintained. The general ability of each of the treatment methods to address classes of contaminants in water is shown in **Table 4-1**.

Non-potable reuse applications generally use source control, primary treatment, secondary treatment, tertiary treatment and chlorine disinfection. Special uses like industrial boiler water supply may require additional treatment to remove inorganic minerals that might damage the boiler.

Because the water will ultimately be consumed by people, IPR projects incorporate advanced water treatment methods (often including additional pretreatment). DHS requires RO and ultraviolet disinfection (UV) plus hydrogen peroxide in IPR projects to address health concerns related to trace organic contaminants, such as pharmaceuticals and personal care products (PPCPs). The City has many years of experience testing RO systems. In fact, results from current tests of these technologies indicate that, together, these processes can reduce trace contaminants in water to below the detection limits of the most sensitive test methods available. Studies conducted to date support both non-potable and IPR as feasible options for the City that can be implemented in a fashion that protects public health.

Table 4-1
Water/Wastewater Treatment Removal of Contaminants

	Contaminant Class						
		Pathogens					
Treatment Method	Particles	Bacteria	Viruses	Parasites	Inorganics	Organics	Radionuclides
Pretreatment	✓				✓	✓	✓
Primary Treatment	✓					✓	
Secondary Treatment	✓					✓	
Tertiary Treatment	✓	✓	✓	✓	✓	✓	✓
Microfiltration	✓	✓		✓			
Ultrafiltration	✓	✓	✓	✓		✓	
Reverse Osmosis	✓	✓	✓	✓	✓	✓	✓
Ion Exchange					✓		✓
Ozone		✓	✓	✓		✓	
UV + Hydrogen Peroxide		✓	✓	✓		✓	
Granular Activated Carbon						✓	
Soil Aquifer Treatment	✓	✓	✓	✓		✓	
Wetlands	✓				✓	✓	
Chlorine Disinfection		✓	✓				

Importantly, while both non-potable and IPR are supported by and allowed under California regulations, successful implementation of projects has only occurred where there is community and political support.

IPR projects produce advanced treated water that could be blended with local runoff and imported water from the Colorado River and the State Water Project. The blended water would then be stored in City-owned raw water reservoirs located in San Diego County. After a period of time, water taken from these reservoirs would be treated by one of the City's three water treatment plants: Alvarado, Miramar or Otay. Alvarado has a present drinking water production capacity of 120 MGD, and current expansion projects will increase its production capacity to 200 MGD. Also under expansion, Miramar will increase its drinking water production capacity from 140 MGD to 215 MGD. Otay has a drinking water production capacity of 34.5 MGD. Upgrades of these treatment facilities include the use of ozone at Alvarado and Miramar, and UV at Otay as primary disinfectants to reduce the amount of chlorine needed, thereby reducing odors, improving taste, and decreasing the production of disinfection byproducts (compounds combined with chlorine) in the water. These upgrades are expected to be completed by 2010.

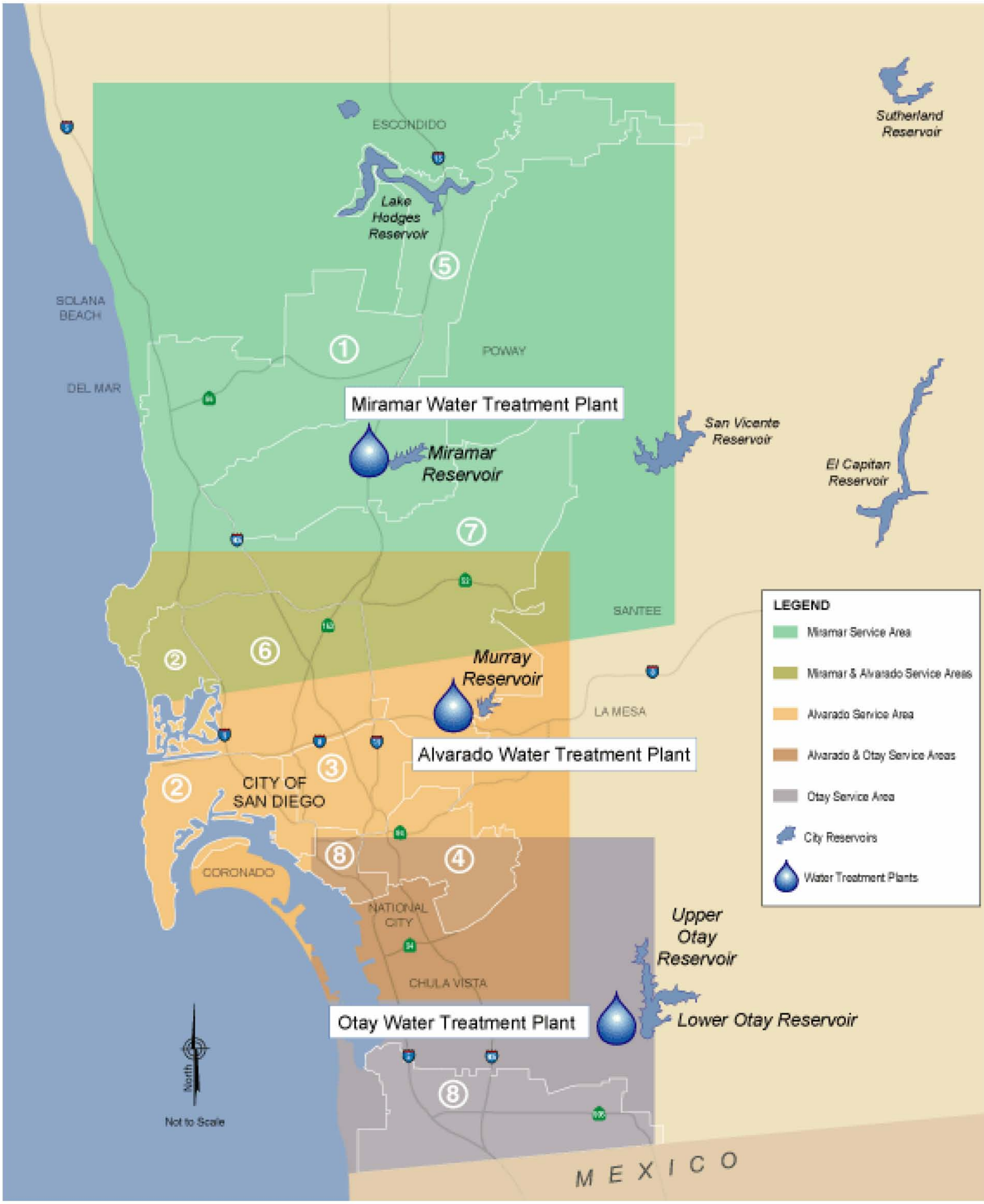

Figure 4-3 – Service areas for City of San Diego Water Treatment Plants (Circled numbers denote City Council Districts)

The service areas for the three City drinking water treatment plants are shown in **Figure 4-3**. Each of these service areas can be expanded to overlap and supplement water from one plant with that of the others. The City also provides water to other agencies outside of the City boundaries, such as the City of Del Mar and the California-American Water Company, which provides water to the City of Imperial Beach.

All of the City's water treatment plants use chemical coagulation, flocculation, sedimentation and disinfection by chloramines, the conventional water treatment process used throughout the United States today. In fact, conventional water treatment was deemed "*one of the most significant public health advancements of the 20th Century*" by the U.S. Centers for Disease Control and Prevention and the National Academy of Engineering (EPA, 2000). Diseases such as cholera and typhoid fever, which in 1900 resulted in more than 16 deaths per year for every 1,000 people living in the United States, have been virtually wiped out due to water filtration and disinfection using chlorine. The City's Water Quality Laboratory continuously tests water quality for compliance with all state and federal regulations. The raw water reservoirs, treatment plants and drinking water distribution systems are sampled and tested by the laboratory with results reported to the EPA and DHS.

4.6 Regulations and Public Health Issues Associated with Non-potable Reuse

City of San Diego Mandatory Reuse Ordinance

On July 24, 1989, Council adopted the Mandatory Reuse Ordinance (O-17327), stating in part that, *"Recycled water shall be used within the City where feasible and consistent with the legal requirements, preservation of public health, safety and welfare, and the environment."* Resolution R-297487, passed by Council on December 9, 2002, authorized City staff to work in conjunction with the PUAC to develop specific criteria to be applied in determining which particular properties would be required to use recycled water for suitable and approved purposes. Customers whose property lines are contiguous with the City's recycled water pipeline alignments and who use significant amounts of potable water for irrigation or industrial uses are likely to be subject to the pending criteria. These criteria were taken into consideration in the development of non-potable reuse opportunities.

The City's proposed Mandatory Reuse Ordinance criteria would require new buildings, constructed in proximity to the recycled water system, with cooling tower or boiler makeup water needs exceeding 5 AFY to plumb these facilities for recycled water. Some existing recycled water customers have already converted their sites. New development that meets the proposed criteria would be identified in the tentative map approval process and required to use recycled water. In addition, the City is evaluating dual plumbing for new schools, commercial, industrial and government buildings to provide recycled water to toilets and urinals. If pursued, the requirement would apply to new buildings in excess of 55 feet in height, projected to have at least 800 occupants or encompass 80,000 square feet. One new building in San Diego has been dual plumbed and another is pending inspection and approval.

Recycled Water Regulations for Non-Potable Uses

Section 13521 of the Porter-Cologne Act grants DHS the authority to set criteria for recycled water use where such use would require specific protection of public health. As a result, DHS developed comprehensive uniform regulations that established acceptable uses of recycled water, water quality, and treatment process requirements to ensure that recycled water use does not pose health risks. DHS also requires engineering reports, design documents, reporting and record keeping to ensure operational reliability of treatment. These requirements are regulated under Title 22 of the California Administrative Code (Title 22, California Code of Regulations, §60301 *et seq.*) and enforced by the RWQCBs. Each RWQCB issues permits for individual projects to conform to the regulations and recommendations adopted by DHS.

California has a number of definitions for differing grades of recycled water based on level of treatment and effluent water quality criteria, the allowable uses for which are listed in **Table 4-2**. The City's NCWRP and SBWRP provide disinfected tertiary recycled water. This is the highest quality of recycled water for non-potable uses as defined in Title 22.

Health and Safety of Non-Potable Uses

California has a long track record of producing safe recycled water for non-potable uses. Non-potable treatment requirements and regulations use the aforementioned risk assessment/ management principles and multi-barrier treatment approach to provide the appropriate levels of treatment and health protection for this specific use. Full-body contact (such as swimming) is allowed with tertiary treated Title 22 water.

The safety of playfields and parks irrigated with recycled water are among the key public health concerns related to the safety of non-potable water. As part of a 2005 WaterReuse Foundation study, James Crook, the study's author, conducted an extensive literature search on the safety of non-potable use of recycled water. The study concluded that the irrigation of parks, playgrounds, athletic fields, and schoolyards with highly treated and disinfected reclaimed water is safe and does not present any known health risks to children, adults or animals that are measurably different than risks associated with irrigation using potable water.

4.7 Regulations and Public Health Issues Associated with Indirect Potable Reuse

Recycled Water Regulations for Indirect Potable Reuse

The only form of IPR currently regulated in California is groundwater recharge, with the permit approval process under the auspices of the local RWQCB. DHS has developed draft regulations for groundwater recharge and uses those regulations as a guideline in setting parameters for other types of IPR projects. DHS provides recommendations to the RWQCB regarding the acceptability of IPR projects and uses the draft recharge reuse regulations as a key part of the approval process.

In addition to compliance with MCLs, DHS draft regulations place additional requirements on IPR projects. These include control of contaminants at the source, multi-barrier treatment methods to control pathogens, inorganic and organic contaminants, treatment standards, recharge methods, extraction well location, and monitoring requirements (see Appendix G for details).

Table 4-2
Allowable Non-potable Uses based on Title 22 Treatment Level

Types of Recycled Water Use	Recycled Water Treatment Level: Disinfected Tertiary	Disinfected Secondary	Undisinfected Secondary
Urban Uses and Landscape Irrigation			
Fire Protection	✓		
Toilet and Urinal Flushing	✓		
Irrigation of Parks, Schoolyards, Residential Landscaping	✓		
Irrigation of Cemeteries, Highway Landscaping		✓	
Irrigation of Nurseries		✓	
Landscape Impoundment	✓	✓ *	
Agricultural Irrigation			
Pasture for Milk Producing Animals		✓	
Fodder and Fiber Crops			✓
Orchards (no contact between fruit and recycled water)			✓
Vineyards (no contact between fruit and recycled water)			✓
Non-Food Bearing Trees			✓
Food Crops Eaten After Processing		✓	
Food Crops Eaten Raw	✓		
Structural Fire Fighting	✓		
Commercial Car Washes	✓		
Commercial Laundries	✓		
Artificial Snow Making	✓		
Soil Compaction, Concrete Mixing		✓	
Environmental and Other Uses			
Recreational Ponds with Body Contact (Swimming)	✓		
Wildlife Habitat/Wetland		✓	
Aquaculture	✓	✓*	
Groundwater Recharge			
Seawater Intrusion Barrier	✓*		
Replenishment of Potable Aquifers	✓*		

*Restrictions may apply

SOURCE: Water Recycling 2030, California's Recycled Water Task Force, June 2003.

DHS will not issue a recommendation for project approval unless the proponent provides extensive evidence that the project will not detrimentally affect human health. Their subsequent recommendations are based on treatment provided, effluent quality and quantity, spreading area operations, soil characteristics, hydrogeology, residence time, and distance to withdrawal.

Beginning with treated recycled water from the NCWRP or the SBWRP, a City groundwater or reservoir augmentation project could then undergo advanced treatment, including membrane filtration, RO, and disinfection. As described in Section 4.4, these combined treatment methods have been shown to be effective barriers against contaminant passage.

Preliminary discussions with DHS representatives (January 2005) indicated that any proposal for a reservoir augmentation project would need to consider recent changes made to the Draft Groundwater Recharge Reuse Regulations (State of California, December 2004). As described above, the new draft's regulations have requirements on organic contaminants (total organic carbon), inorganic contaminants (nitrogen) and source control. In addition, the RWQCB may add more requirements for inflows to a reservoir, particularly with regard to nitrogen. DHS would likely require two treatment barriers for each type of contaminant. As long as the project meets all DHS treatment and reservoir management requirements, introduction of highly treated recycled water into a drinking water source reservoir could be permitted.

Health and Safety of Indirect Potable Reuse

Permitted IPR projects are carefully regulated and protect the public health through:

- Use of advanced water treatment methods that reliably remove contaminants of concern.
- Careful operation and maintenance of those methods.
- Use of multiple monitoring systems to ensure consistently high quality water is produced.

With regard to IPR health and safety issues, the most comprehensive assessment to date was conducted by the National Research Council (NRC: Issues in Potable Reuse: The Viability of Augmenting Drinking Water Supplies with Reclaimed Water, 1998).

The report referenced several large-scale health effects studies of recycled water covering both microbiological and chemical contaminants, noting that these studies identified no obvious adverse health effects associated with IPR in the specific projects examined (Windhoek, South Africa; Los Angeles County, CA; Washington, D.C.; Denver, CO; San Diego, CA; and Tampa, FL). These studies varied widely in approach and should be considered individually (they are discussed further in Appendix G). There were also design drawbacks in each of these studies, which limit their individual and overall usefulness to assess health risks. The studies varied considerably from combinations of simple screening and chemical identification studies to toxicology testing. Only the Denver and Tampa studies addressed a broad range of toxicological concerns.

Nonetheless, the report included several important observations:

- Current projects and studies have demonstrated the capability to reliably produce water of excellent measurable quality.
- In communities using reclaimed water where analytical testing, toxicological testing, and epidemiological studies have been conducted, significant health risks have not been identified.
- The best available current information suggests that the risks from IPR projects are comparable to or less than the risks associated with many conventional supplies.

The general conclusion of the NRC report was that "*planned, indirect potable reuse is a viable application of reclaimed water - but only when there is a careful, thorough, project-specific assessment that includes contaminant monitoring, health and safety testing, and system reliability evaluation*."

IPR projects have been implemented in several communities. The available human health studies are sufficient to convince the DHS and other regulatory agencies that highly treated recycled water can be safely consumed by humans through IPR projects. In California, the West Basin Municipal Water District (El Segundo), the Orange County Water District (Fountain Valley), and the County Sanitation Districts of Los Angeles County (Montebello Forebay) currently operate IPR projects. The latter reuse project started in 1962. Additional studies and community experiences are discussed in Appendix G.

5.0 Non-Potable Reuse Opportunities

Water Reuse Study

In investigating potential non-potable reuse opportunities in San Diego, three service areas were identified within the City as viable (**Figure 5-1**). In each service area, the initial focus was on irrigation and industrial customers because those types of customers generally use significant amounts of water. Any additional non-potable opportunities were targeted in the form of other, smaller potential customers located near existing infrastructure, or captured by branching out to areas currently not served by the existing systems. Wetlands creation projects were investigated for the use of recycled water during winter months to simulate storm events in canyon streams. Seasonal storage facilities were considered in each service area and graywater opportunities were reviewed. Also identified were regional opportunities, including the sale of recycled water by the City to neighboring municipalities or water districts.

5.1 Northern Service Area Recycled Water Opportunities

In December 2000, the City prepared the *Updated Water Reclamation Master Plan* (Master Plan). The Master Plan recommended a three-phase extension of the Northern Service Area distribution system. Phase I and Phase II included expansion of the system north on Black Mountain Road and then west into Carmel Valley. Phase III would provide recycled water service to the Rancho Bernardo area. Infrastructure associated with Phases I and II is currently under construction, in design phases, or completed. The City has not authorized funding for the Phase III system, and this phase remains a potential future project for consideration in this report.

In this study, expansion of the existing Northern Service Area recycled water distribution system centered on four conceptual opportunities:

- The first Northern Service Area opportunity considered evaluates the potential for finding new customers with significant irrigation or industrial demands adjacent to or within a quarter-mile of the existing Phase I and Phase II distribution pipelines. These markets were referred to as "infill" customers. Targeted infill customers included commercial and industrial complexes with large landscaped areas, as well as homeowner association common areas, public parks and school yards.
- The second deliberated opportunity was to extend the existing system to the northeast to serve the Rancho Bernardo area (Phase III Expansion) and the golf courses located there.

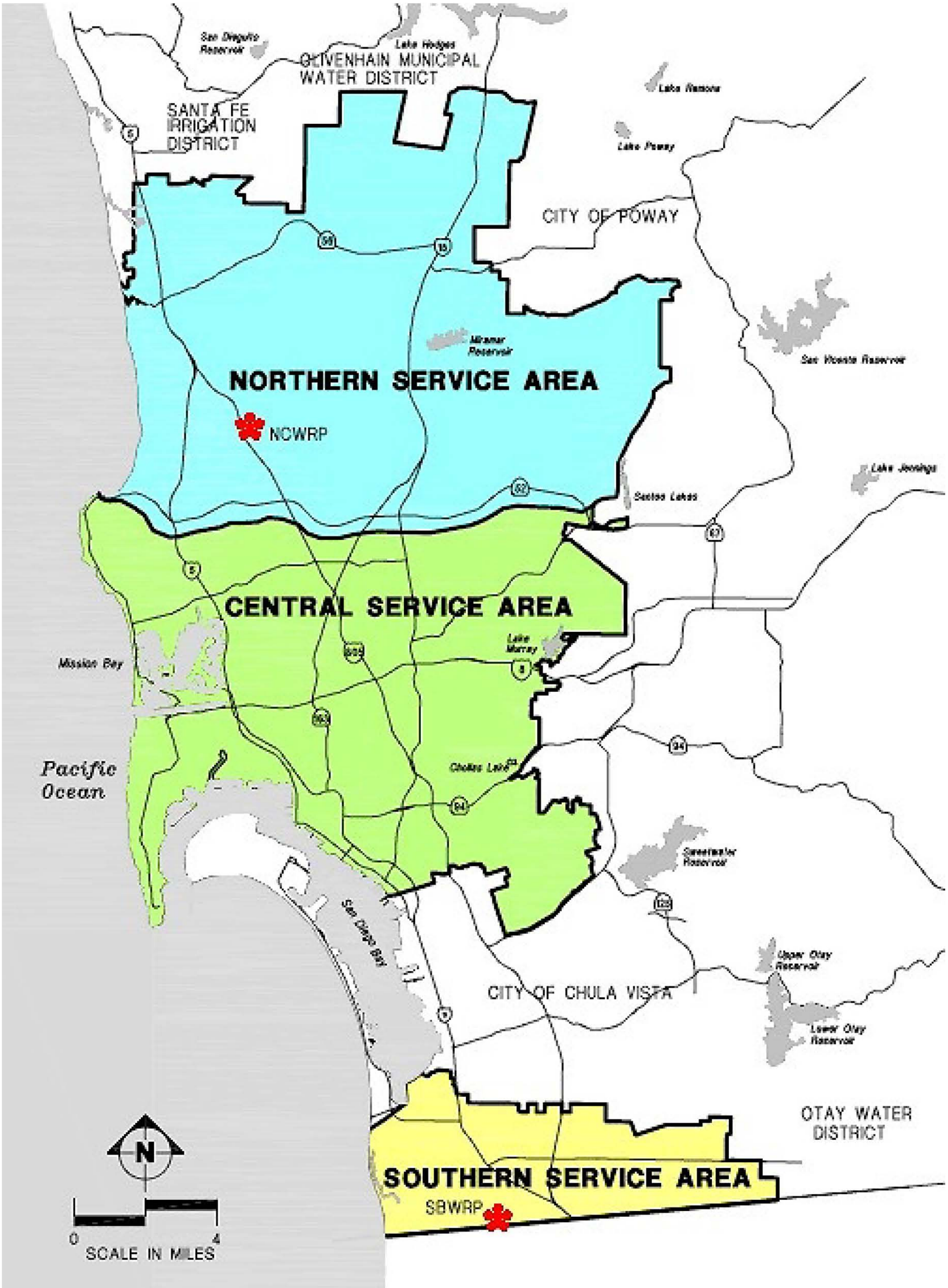

Figure 5-1 – Existing and Proposed Recycled Water Service Areas

- Extending the existing system south to Friars Road to the Central Service Area where it would branch west to Mission Bay Park and south to Balboa Park comprised the third opportunity considered, which would serve additional customers along the way.
- The fourth opportunity was a created wetlands project in Rose Canyon. Through the extension of the existing recycled water system, this opportunity would allow a seasonal discharge of recycled water to Rose Canyon Creek.

These four Northern Service Area non-potable project opportunities are shown in **Figure 5-2.**

Northern Service Area – Infill Customers

When the North City recycled water system was planned, a market assessment evaluated potential recycled water customers based on three key questions:

- Could the customer's existing water use be met with recycled water?
- How much water do they use regularly?
- What is their proximity to planned infrastructure?

The City worked closely with customers who decided to connect to the recycled water system. The first step was designing the customer's on-site upgrades so that any retrofitting – disconnecting the potable water system, replacing irrigation heads, posting recycled water signs, etc. – would be executed well. These designs were submitted for regulatory approval. Upon approval, the customer was disconnected from the potable water system, and all upgrades were constructed, connecting the customer to a recycled water system.

Infill is similar to the retrofit process described above that is used to connect customers to the original recycled water system. Infill is particularly applicable to the Northern Service Area, as the City has made strategic infrastructure investments to move transmission facilities to high water demand areas in northern San Diego. Infill could occur by connecting smaller non-potable customers along these pre-existing transmission facility corridors.

Infill Can Meet 2010 Goal
The 2010 beneficial reuse goal of 12 MGD can be met via infill in the northern service area. There are as many as 300 potential customers within a quarter mile of existing pipelines. Infill has less off-site infrastructure requirements, but on-site retrofits must be considered.

The 2010 beneficial reuse goal of 12 MGD from the NCWRP can be met via infill in the Northern Service Area. A new market assessment identified approximately 300 sites within a quarter mile of the existing Phase I and II recycled water pipelines. Not all of the identified sites may be eligible for conversion to recycled water due to site constraints and/or extensive and costly retrofit requirements, though approximately 150 of these sites have an estimated total average water demand, primarily for irrigation, of 3.6 MGD. This amount will close the gap between usage after Phase I and II are completed and the 12 MGD goal. Significant customers include Marine Corps Air Station Miramar, the Qualcomm industrial complex, and the City's Park and Recreation Department.

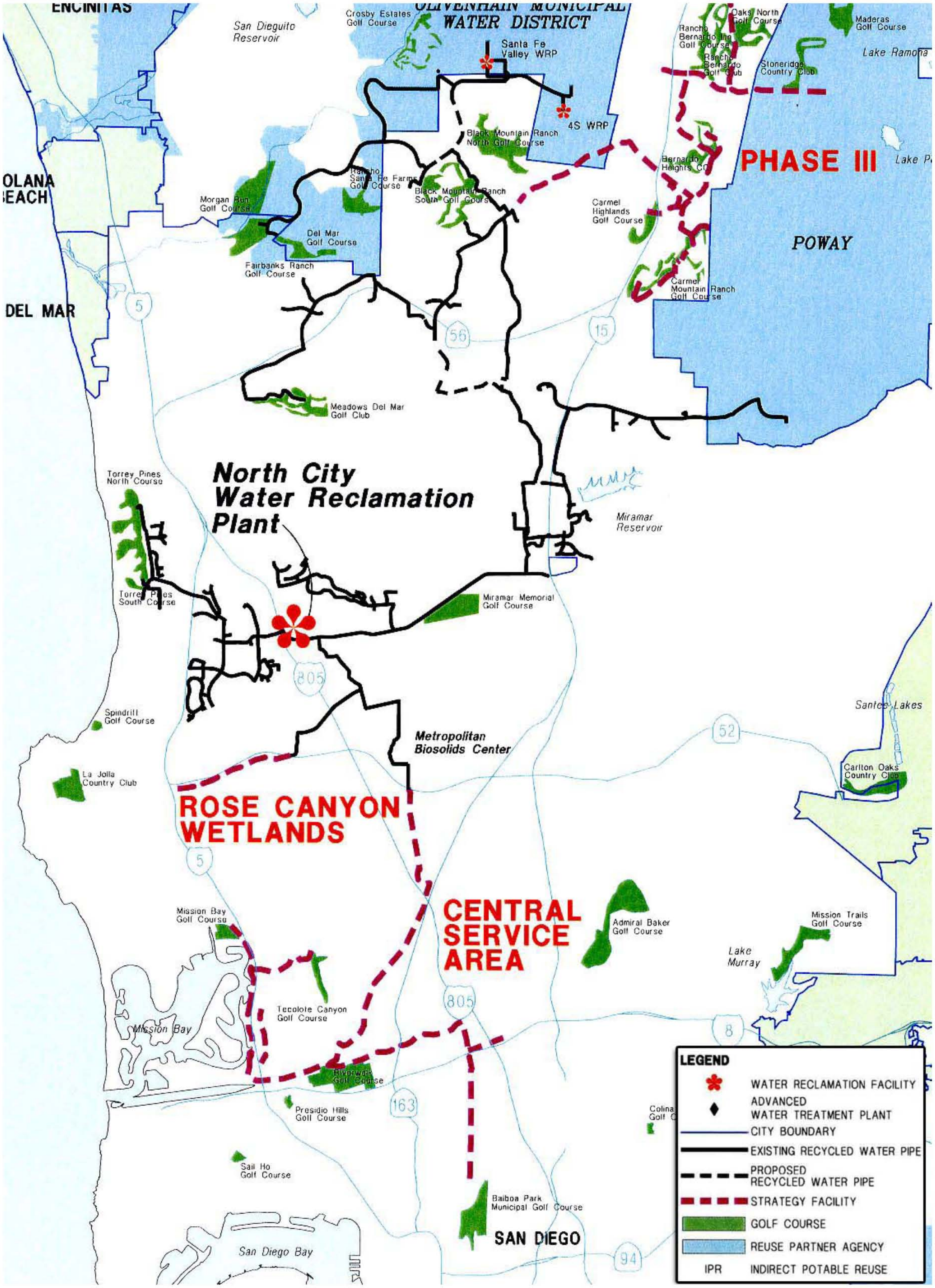

Figure 5-2 – Northern Service Area Non-Potable Reuse Opportunities

Potential customers are located within a quarter-mile to existing and planned pipelines. Although off-site infrastructure requirements are minimal, the customer's on-site retrofit requirements could be extensive depending on the size of the irrigated area.

Northern Service Area – Phase III Expansion

The Phase III expansion was originally proposed in the 2000 Master Plan. This expansion of the system would extend the City's recycled water system into Rancho Bernardo. Originally, the Phase III system started east of Interstate 15 at Sabre Springs, but subsequent technical studies altered the alignment to begin off the Phase II system along Black Mountain Road. The most recently proposed alignment is along the extension of Carmel Valley Road east of Black Mountain. In the Phase III service area, reservoir locations and piping alignments have also been modified from the Master Plan.

The Phase III expansion is aimed at serving six San Diego golf courses, two Poway golf courses, and nearby homeowner associations (HOAs). The expanded system would include approximately 17 miles of pipeline, two separate 2-million gallon reservoirs, and a pump station. In all, 21 customers have been identified, with a total average water demand of 2.5 MGD.

Northern Service Area – Interconnection to Central Service Area

Although the Northern and Central Service Areas are summarized separately in this section, there are opportunities to serve the Central Service Area via the NCWRP. The Central Service Area lies south of the Northern Service Area, bounded by State Route 52 on the north and National City to the south. The largest potential recycled water users in this service area are Balboa and Mission Bay Parks. From a strategic planning approach, within the Central Service Area, these markets would be targeted for conversion to recycled water service first due to the large demands associated with these City-owned parks.

To serve the Central Service Area from the Northern Service Area, a 17-mile, 24-inch diameter pipeline extension is proposed along Convoy Street to Linda Vista Road to Friars Road, west on Friars Road to Mission Bay Park, and east on Friars Road to Qualcomm Way. The pipeline would continue south on Texas, tunneling beneath the San Diego River and Interstate 8, to Balboa Park. Additional potential customers include Riverwalk and Tecolote Golf Courses, the University of San Diego, and Sea World. Their combined estimated average day demand for recycled water would be 2.35 MGD.

Northern Service Area – Seasonal Storage

To maximize the use of recycled water from the NCWRP with a non-potable use strategy, seasonal storage would be needed to provide a means of storing recycled water in the winter for use during summer months. The Study team considered several Northern Service Area seasonal storage opportunities, including groundwater storage and recovery in the San Dieguito Groundwater Basin, and several potential sites for the construction of an excavated earthen basin. Due to the difficulties associated with permitting non-potable recycled water storage in groundwater basins as described in Section 4, the San Dieguito Basin was too costly to merit further consideration. However, several potential earthen basin sites were identified in the Black Mountain area, adjacent to Phase I facilities. Since the Black Mountain area is currently undergoing development, and City-owned properties in the area may not be suitable for an earthen basin site, it is anticipated that construction would be difficult and most likely expensive.

The cost-effectiveness of seasonal storage must be weighed against the cost of supplementing the peak recycled water demands with potable water. The specific volumes of water needed for storage differs for each alternative reuse implementation strategy and are described in Section 7.

Northern Service Area – Wetlands

Wetlands serve as habitat for diverse and endangered species, provide areas for migratory waterfowl along the Pacific Flyway, improve water quality by filtering pollutants, and help reduce flooding. Recycled water has been used successfully in California to create wetlands.

Wetlands serve a number of valuable roles in the California environment. Recycled water has been used to create wetlands, however several issues must be considered.

In San Diego, natural wetlands are usually inundated by water for only a few months per year. Almost all natural freshwater wetlands in San Diego have been built over and are not considered recoverable at this point.

Created wetlands would produce the loss of native upland habitat, resulting in negative environmental impacts. Salt water marshes and their sensitive ecosystems would also be negatively impacted by increased seasonal or year-round upstream flows of freshwater. Environmental groups in San Diego have not generally supported created wetlands or year-round fresh water inputs to an urban or natural ecosystem.

Since wetlands do not usually represent a financial benefit to water agencies, the long-term cost and the negative environmental impacts are likely to outweigh the environmental and aesthetic gains of created wetlands or live stream discharge projects.

The least problematic of the potential sites for a created wetlands project that could be served by the NCWRP were Rose Canyon, Los Penasquitos, San Dieguito River, and De Anza Point (Mission Bay). These sites were investigated closely and it was determined that the sites themselves, much less their receiving waters, could be negatively impacted by freshwater flows.

Rose Canyon was the most attractive opportunity to study further, based on its few environmental constraints associated with freshwater flows and its proximity to existing recycled water facilities. A Rose Canyon recycled water wetland project had also been studied previously. (City of San Diego, 2001)

Rose Canyon is an "L" shaped canyon located in the City. The canyon originates at Marine Corps Air Station Miramar and eventually drains to Mission Bay. The focus of this discussion is on a 1.5-mile stretch of the canyon within the Rose Canyon Open Space Park, running east to west between Genesee Avenue and Interstate 5. This section of the canyon is narrow and relatively undeveloped. Rose Creek meanders through the bottom of this portion of the canyon, which contains many natural upland and wetland habitats and is rich in cultural history. Recycled water would enter the canyon from the base of Erlanger Street, off of Governor Drive, east of Genesee Avenue, where an 8-inch existing recycled water pipeline from the NCWRP ends.

Two potential concepts for environmental reuse projects at Rose Canyon were identified based on a review of available photos, maps, and data. One concept would consist of developing year-round wetlands along the bottom of the canyon. This development would impact existing wetland and upland habitat that would make the project difficult to permit and approve. The project would also need to overcome other environmental concerns associated with the alteration of any seasonal drainage to year-round flow, loss of some unique and sensitive wetland and upland habitats, disturbance to cultural resources, and conflicts with recreational and educational opportunities.

The second concept would comprise of seasonal and/or periodic discharges to Rose Creek. Under this concept, recycled water would be discharged during storms and the wet season in quantities that would not adversely impact habitats or channel integrity. These wet season flows would avoid potential impacts associated with year-round flows and may also provide some benefits to the stream ecology. The concept project would use up to 800 AFY of recycled water during the wet-weather months (approximately 1.5 MGD from November to April), when recycled water supplies are generally available.

An additional factor to consider in evaluating wetlands, in either a year-round or seasonal form, would be the likelihood that once a wetlands project was established, the City would be required by permitting agencies to maintain the flow of water to that project in perpetuity.

Northern Service Area – Groundwater

All of San Diego's groundwater basins are designated for municipal and industrial use. Under this designation, only water treated to an extremely high level can be placed into the basins. The San Diego Basin Plan would also require amending prior to regulatory approval of any possible non-potable groundwater recharge project.

Due to the limited size of the available basins and generally poor quality of San Diego's native groundwater, any blending of highly treated water would result in the need for advanced treatment, such as RO, before it could be added back to the reclaimed water system. In order to meet the State of California's groundwater requirements and the additional treatment to meet water quality requirements, no non-potable groundwater storage projects could be identified that were economically feasible at this time.

5.2 Southern Service Area Recycled Water Opportunities

Upon DHS approval, the SBWRP will provide recycled water for its own on-site uses and for those of the neighboring International Boundary and Water Commission (IBWC) Wastewater Treatment Plant. In 2003, OWD entered into a 20-year agreement with the City to purchase up to 6 MGD of recycled water from the SBWRP by 2007. This recycled water will be used to supplement OWD's existing recycled water supply to serve demands within the Eastern Chula Vista area. OWD is constructing a 30-inch pipeline connection to the City's Southern Service Area distribution system at Dairy Mart Road, shown as an existing pipeline in **Figure 5-3**.

Southern Service Area – Sweetwater Expansion

Expansion of the City's recycled water distribution system in the South Bay area to serve customers in the Sweetwater Authority (a neighboring water district) is also being considered

(**Figure 5-3**). Sweetwater Authority provides water service to National City and the western portions of Chula Vista, and recently completed a recycled water master plan. Potential customers in this area include a proposed power plant, parks, and a redevelopment project along the Chula Vista waterfront. Sweetwater Authority's average annual demand is estimated to be 5.25 MGD.

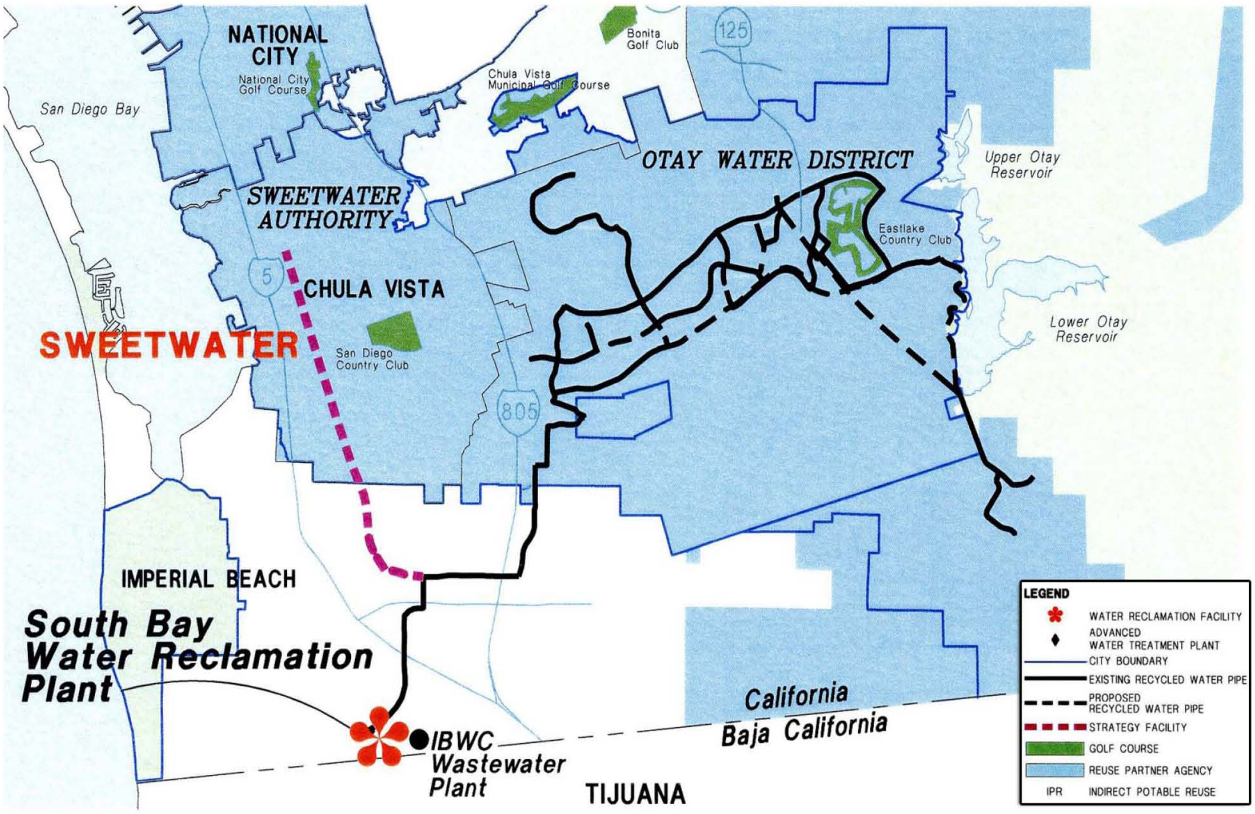

Figure 5-3 – Southern Service Area Non-Potable Opportunities

Southern Service Area – Wetlands

In San Diego, natural wetlands are usually inundated by water for only a few months per year. Almost all of San Diego's natural freshwater wetlands, have been built over and are unrecoverable at this point. The constructed wetlands would produce some loss of native upland habitat, resulting in negative environmental impacts. Salt water marshes and their sensitive ecosystems would also be negatively impacted by increased or year-round upstream flows of freshwater. Environmental groups in San Diego have not generally supported created wetlands or artificial fresh water inputs to an urban or natural ecosystem.

Since wetlands do not usually represent a financial benefit to water agencies, the financial cost and the negative environmental impacts do not generally outweigh the environmental and aesthetic gains of created wetlands.

Potential sites for a created wetlands project in the Southern Service Area included Dairy Mart Road Pond Enhancement, Tijuana River Valley locations, and the South Bay Salt Flats. The Salt Flats were eliminated from consideration due to their distance from the SBWRP and because the property is privately held. It was determined that the Dairy Mart Road site has been studied by San Diego County and enhancement is not considered necessary or desirable there. Tijuana River Valley sites would likely require the conversion of agricultural lands. Freshwater flows from a wetlands project there may negatively impact the Tijuana Estuary. Based on this survey, no potential sites were identified as likely locations for a wetlands project in the Southern Service Area.

Southern Service Area – Seasonal Storage

To maximize the use of recycled water from the SBWRP, seasonal storage would provide a means of storing recycled water in the winter for use during peak summer months. Southern Service Area seasonal storage opportunities evaluated include the pre-established Tijuana Groundwater Basin and other potential sites for the construction of an earthen basin. Because of the difficulties associated with permitting non-potable recycled water storage in groundwater basins, as described in Section 4, the Tijuana Basin was eliminated from consideration.

Adjacent to OWD's distribution facilities, numerous potential sites were identified in the Otay Mesa area. Since these areas are currently undergoing development, and the identified properties are not City-owned, it is anticipated that obtaining the rights to these sites would be difficult and possibly expensive. The cost effectiveness of seasonal storage must be weighed against the cost of supplementing the peak summer water demands with potable water instead of recycled water. The specific volume of water needed for storage is different for each alternative implementation strategy, described in Section 7, and the cost effectiveness of seasonal storage was evaluated as part of the overall strategy proposed.

Southern Service Area – Groundwater

As previously stated, all of San Diego's groundwater basins are designated for municipal and industrial use. Under this designation, only water treated to a high level can be placed into them. The San Diego Basin Plan would also require amending prior to regulatory approval of any possible non-potable groundwater recharge project.

Due to the limited size of the available basins and general poor quality of San Diego's native groundwater, any blending of highly-treated water would result in the need for advanced treatment such as RO before it could be added back to the reclaimed water system. Because a project like this would need to meet the State of California's groundwater requirements and provide the additional treatment to meet general water quality requirements, no non-potable groundwater storage projects could be identified that were economically feasible at this time.

5.3 Central Service Area Recycled Water Opportunities

In the 1990's, the Central Service Area was envisioned to receive recycled water service from a new water reclamation plant in Mission Valley. This proposed conventional recycled water treatment plant and related distribution system was never built. Since then, renewed interest in having a Central Service Area system has emerged due to a number of reasons, including:

- Large, high profile customers such as Balboa Park, Mission Bay Park, and the Riverwalk Golf Course and,

- Treatment technology advances, which have reduced the size and costs of treatment components.

Locating a new recycled water treatment facility in the vicinity of potential Central Service Area customers was evaluated in this study. The City's Metropolitan Wastewater Department (MWWD) provided their projects and future plans, which conceptualized a 15 MGD wastewater plant located in Mission Valley by 2030. This plant could be constructed in conjunction with a reclamation facility to provide recycled water. The recycled water treatment system could take advantage of technological advances in treatment processes and utilize MBRs, as described in Section 3.

A new treatment plant could be sited on a City-owned parcel in Mission Valley on Camino del Rio North. This site is close to a large volume of wastewater via the North Mission Valley Trunk Sewer, and also appears to allow phased construction of the plant, saving initial costs. To serve the Central Service Area markets, a Mission Valley reclamation facility, if constructed, would have a capacity of 5 MGD to serve identified irrigation customers in the Central Service Area. Excess recycled water in winter months could be returned to the North Mission Valley Trunk Sewer or to the adjacent San Diego River as part of a live stream discharge/wetlands creation project, although the latter is discouraged.

Central Service Area
A 5 MGD reclamation plant could be located in Mission Valley to supply customers such as Balboa Park, Mission Bay Park, and the Riverwalk Golf Course.

Since the need for a new wastewater treatment facility in this Central Service Area is not imminent, and the City is concentrating on how to maximize the recycled water it currently produces, this opportunity was not considered viable at this time.

5.4 Regional Opportunities

For recycled water customers beyond the City limits, the City works closely with the Water Authority and local water purveyors to provide service. The City supports the Water Authority's efforts to investigate countywide recycled water systems and the City has also investigated regional opportunities with individual water purveyors. To date, the City has secured agreements with Poway, the Olivenhain Municipal Water District, and OWD for the sale of recycled water.

Countywide Opportunity – San Diego County Water Authority

In March 2002, the Water Authority published the *Regional Recycled Water System Study* that identified recycled water system strategies which would potentially utilize Water Authority and/or local agency facilities. The concepts would provide a balance between recycled water demand and supply in San Diego County. As a result of this analysis, nine project strategies were developed. Two of the proposed strategies involved the City.

The Escondido/Padre Dam/Helix/San Diego/Sweetwater Strategy included the utilization of the Water Authority First Aqueduct to send recycled water flows south from Escondido's Hale Avenue Resource Recovery Facility to Helix Water District, serving Padre Dam and the City demands by converting the East Mission Gorge Interceptor to recycled water use. Service to the Tijuana Valley/Mexico area with 2.32 MGD of recycled water from either Padre Dam or Escondido was also considered. (It was assumed that OWD would be using all of the available supply from the SBWRP, thus none would be available to Tijuana Valley or Mexico.) Neither of these strategies has been or is expected to be pursued by the Water Authority.

On a related note, the Water Authority completed a feasibility study in November 2005, the *Regional Membrance Bioreactor System Study*, that evaluated locations throughout San Diego County to potentially site satellite MBR plants for recycled water production and distribution.

Northern Service Area Regional Opportunity – City of Poway

Since 1998, the City has had an agreement with Poway to provide recycled water via a connection at Scripps Poway Parkway. Based on that agreement, the City would initially provide up to 0.67 MGD (750 AFY) of recycled water to Poway. Upon Poway's request, the City would be obligated to expand its pumping capacity to provide an additional 0.40 MGD (450 AFY), for a total of 1.07 MGD (1,200 AFY). To date, Poway has not requested additional supply. Poway typically purchases approximately 0.45 MGD (500 AFY) of recycled water from the City to provide irrigation within the South Poway Business Park. To increase the supply to high use customers, such as the Stone Ridge and Maderas Golf Courses in northern Poway, would require construction of the City's Phase III recycled water system expansion into Rancho Bernardo.

Northern Service Area Regional Opportunity – Olivenhain Municipal Water District and Santa Fe Irrigation District

In December 2004, the City approved an agreement with the Olivenhain Municipal Water District to provide recycled water via a metered connection at San Dieguito Road. This connection was part of the City's Phase I recycled water system expansion to the Black Mountain Ranch development. The agreement allows Olivenhain Municipal Water District to reserve 0.36 MGD (400 AFY) of capacity in the City's Northern Service Area distribution system for a period of 20 years. Future expansion of Olivenhain's recycled water system or a new service to Santa Fe Irrigation District could increase the demand for recycled water.

Southern Service Area Regional Opportunity – Otay Water District

OWD provides water and wastewater service in south San Diego, including the eastern part of the City of Chula Vista, portions of the City, and unincorporated areas within San Diego County. OWD operates its own water reclamation treatment plant, the 1.3 MGD Ralph W. Chapman Water Recycling Facility. This facility cannot meet all the demands in the OWD recycled water system. Therefore, in 2003, OWD signed an agreement with the City to purchase up to 6 MGD of recycled water from the City's SBWRP by 2007 (also described in section 5.2). To serve demands within their service area, the City's recycled water will supplement OWD's existing recycled water supply. OWD will construct portions of their master plan's recycled water system as new subdivision projects are developed, as well as a pipeline connection to the City's southern service area distribution system at Dairy Mart Road. Future expansion in the OWD system may increase the need for City supply beyond the current 6 MGD commitment.

Otay Water District
Otay Water District has agreed to purchase 6 MGD of recycled water from the City. This needs to occur prior to considering additional regional expansion in their service area.

Southern Service Area Regional Opportunity – Sweetwater Authority

As discussed in the Southern Service Area System expansion section (5.2), the Sweetwater Authority provides water service to National City and the western portions of Chula Vista.

Currently, the Sweetwater Authority does not have reclamation facilities, but has expressed interest in purchasing recycled water from the City. The Sweetwater Authority has recently completed a recycled water master plan. Recycled water could be used as a source of process and cooling water at a proposed local power plant facility. In addition, the Sweetwater Authority is investigating the use of recycled water for irrigation and industrial uses. As the Sweetwater Authority recycled water system master plan progresses, further opportunities for increasing regional usage may emerge.

5.5 Graywater Opportunities

Graywater use is a form of water recycling. It does have distinct differences from the other recycled water opportunities described throughout this study. Usually, graywater systems serve one individual site or home, contrasting municipal recycled water systems that serve communities, businesses, and industry. Graywater is generally domestic wash water, typically from sinks, showers, and clothes-washing machines located in the home or building. Water from toilets, kitchen sinks with garbage disposals, and other sources containing high concentrations of organic waste is termed "blackwater" and is diverted to the sewerage system.

In California, graywater may be used for irrigation on a wide range of sites, ranging from single-family to industrial. Typically, graywater systems require a separate plumbing system, surge tank, transfer pump, and subsurface irrigation system. Graywater is subject to little or no treatment, though there are commercially available systems that include sand filters and settling tanks. The California Graywater Standards were originally developed and adopted in response to Assembly Bill 3518, the Graywater Systems for Single Family Residences Act of 1992. These standards have since been incorporated into the California Plumbing Code (California Code of Regulations, Title 24, Part 5, Appendix G: Graywater Systems). The standards apply to the construction, installation, alteration, and repair of graywater systems for subsurface landscape irrigation. Within city limits, permits are required from both the City and the DHS to construct and operate a graywater system.

Graywater Components

The local permitting authority makes the final determination of what is required for a graywater system. The common components of a system are:

- a separate plumbing system to bring the graywater out of the house,
- a surge tank to temporarily hold large flows from washing machines or bathtubs,
- a pump to transfer the water from the tank to the irrigation system, and
- a subsurface irrigation system to distribute the water to the landscaped area.

In 1995, the California Department of Water Resources developed a Graywater Guide for using graywater in home subsurface landscape irrigation. The guide provides prospective users of a graywater system with guidance on design, installation, and maintenance. The guide also provides education on permits, health safety, and some benefits of graywater use. California graywater regulations estimate the potential exists to capture 40 gallons of graywater per person per day from a local single-family residence for irrigation use. For a family of four, this would amount to 58,400 gallons per year or 78 hundred cubic feet (HCF). The present day cost of water per HCF in San Diego is approximately $2, so use of graywater could amount to a yearly savings of approximately $156 to a family's water bill.

For residents and business owners, whether or not a graywater system will be advantageous depends on site-specific conditions. Typically, it is easier to install graywater systems in new structures as the necessary additional piping would be incorporated into the design from the start. Retrofitting existing structures typically increases installation costs. Clay soil conditions often require homeowners to replace or amend their soil prior to using graywater. These constraints limit the impact graywater use can have on decreasing potable water use for landscape irrigation purposes in San Diego. However, graywater use will be examined periodically to identify any technical or economic changes that increase its viability in San Diego.

5.6 Summary of Non-potable Opportunities that are Brought Forward for Evaluation

All of the non-potable reuse opportunities, types of customers served, quantity of recycled water used, and the facilities required to bring recycled water to the customer in each of the three service areas have been described in previous sections. Although many opportunities were investigated, not all were brought forward for evaluation as components of larger implementation strategies.

A summary by service area of the viable opportunities and the facilities required to deliver the recycled water for non-potable uses is presented in **Table 5-1**.

Table 5-1
Summary of Non-potable Reuse Opportunities

Service Area	Opportunity	Estimated Average Day Demand (MGD)	Estimated Annual Use (AFY)	Customers Served	Facilities Required
Northern	Infill	3.6	3,820	Approx. 150 low demand irrigation and industrial customers adjacent to existing recycled water pipelines	Customers install on-site retrofits
Northern	Rancho Bernardo - Phase III; Seasonal Storage	2.5	2,980	21 irrigation and industrial customers including 8 golf courses	2 2-MG reservoirs pump station 17 miles pipeline
Northern	Interconnection to Central Service Area; Seasonal Storage	2.35	2,640	10 irrigation and industrial customers including Balboa Park and Mission Bay Park	1 MG reservoir 2 MG reservoir 17 miles pipeline
Northern	Rose Canyon Wetlands	1.5 (November to April only)	800	None	480 acres of created wetlands and conveyance pipeline
Southern	Expansion to neighboring water districts	6 5.25	5,760* 5,880	Otay Water District Sweetwater Authority	Pipelines constructed by other agencies

* San Diego-Otay Recycled Water Sales Agreement allows maximum of 6 MGD but limits ultimate annual use to 5,760 AFY.

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6.0 Indirect Potable Reuse Opportunities

Indirect potable reuse (IPR) is the practice of taking recycled water that meets all regulatory requirements for non-potable use, treating it further with several advanced treatment processes to meet potable water standards, and adding it to an untreated potable water supply, usually a water body such as a surface water reservoir or a groundwater aquifer. The term "indirect" refers to the distinction that highly-treated recycled water is not plumbed directly to the potable distribution system. During a long residence time, the highly-treated recycled water blends with the source water, which is usually imported water and local runoff. This process is illustrated in **Figure 6-1**.

Extensive permitting and regulatory interaction is required prior to starting an IPR project. Regulations require the recycled water receive extensive advanced treatment, plus additional natural treatment processes that occur in a groundwater basin, stream or lake. Prior to entering the City's potable water system, the blended source water is treated at a potable water treatment plant or at a wellhead treatment facility. Treatment methods for IPR projects are described in detail in Appendix G.

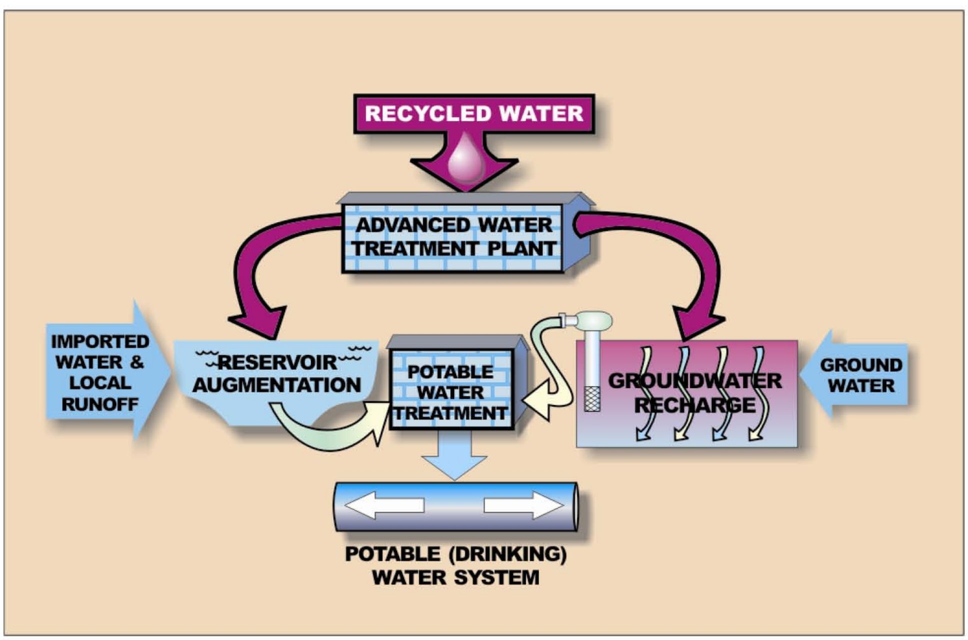

Figure 6-1 – Conceptual Indirect Potable Reuse Process Diagram

6.1 Reservoir Augmentation Opportunities

Reservoir augmentation is an IPR opportunity that involves adding advanced treated recycled water into a surface raw (untreated) water reservoir; the opportunities and constraints of this IPR method have been examined as part of the Study. Regulations require advanced treated water to be stored in the reservoir for a minimum of 12 months to blend with the untreated water within the reservoir and undergo a measure of natural treatment. Consideration was also given to the development of wetlands upstream from the surface water reservoir to provide additional natural treatment processes.

Any wetlands development upstream of a surface water reservoir would eventually result in advanced treated water entering into the City's raw water system and provide a new source of water beyond stormwater runoff and imported water. The option of creating wetlands as an aspect of each reservoir augmentation concept was considered, with certain factors examined, including the steepness of the basin surrounding each reservoir, the amount of time advanced treated water would be retained within a wetland, natural treatment provided, public access, City ownership of the land needed to construct the wetland and increased project cost of adding a wetland.

All nine City reservoirs – Sutherland Reservoir, Lake Hodges, Miramar Reservoir, Lake Murray, San Vicente Reservoir, El Capitan Reservoir, Morena Reservoir, Barrett Reservoir and Lower Otay Reservoir – were evaluated for reservoir augmentation concept projects. Sutherland, Morena and Barrett Reservoirs were determined to be unsuitable due to their distance from the City's existing recycled water facilities. Miramar and Murray Reservoirs were too small for further consideration, even for a small-scale reservoir augmentation project, since retention time requirements would not be met. Of the remaining reservoirs, Hodges and San Vicente Reservoirs underwent further consideration for North City reservoir augmentation opportunities, while Lower Otay Reservoir was considered further for South Bay. In each service area, both large-scale and small-scale reservoir augmentation projects were taken into account.

Northern Service Area – Reservoir Augmentation

The Study team's screening process of the City's nine raw water reservoirs determined that only Lake Hodges, San Vicente and Lower Otay were suitable candidate reservoirs for an IPR project. Lake Hodges is only suitable for a small-scale reservoir augmentation project because it is relatively small and has limited ability to provide the necessary retention time. San Vicente was most suitable for a large-scale reservoir augmentation project due to its large size and ability to provide the appropriate retention time. Drawbacks to San Vicente include its distance from the recycled water supply source. The San Vicente and Hodges proposed projects are shown in **Figure 6-2**.

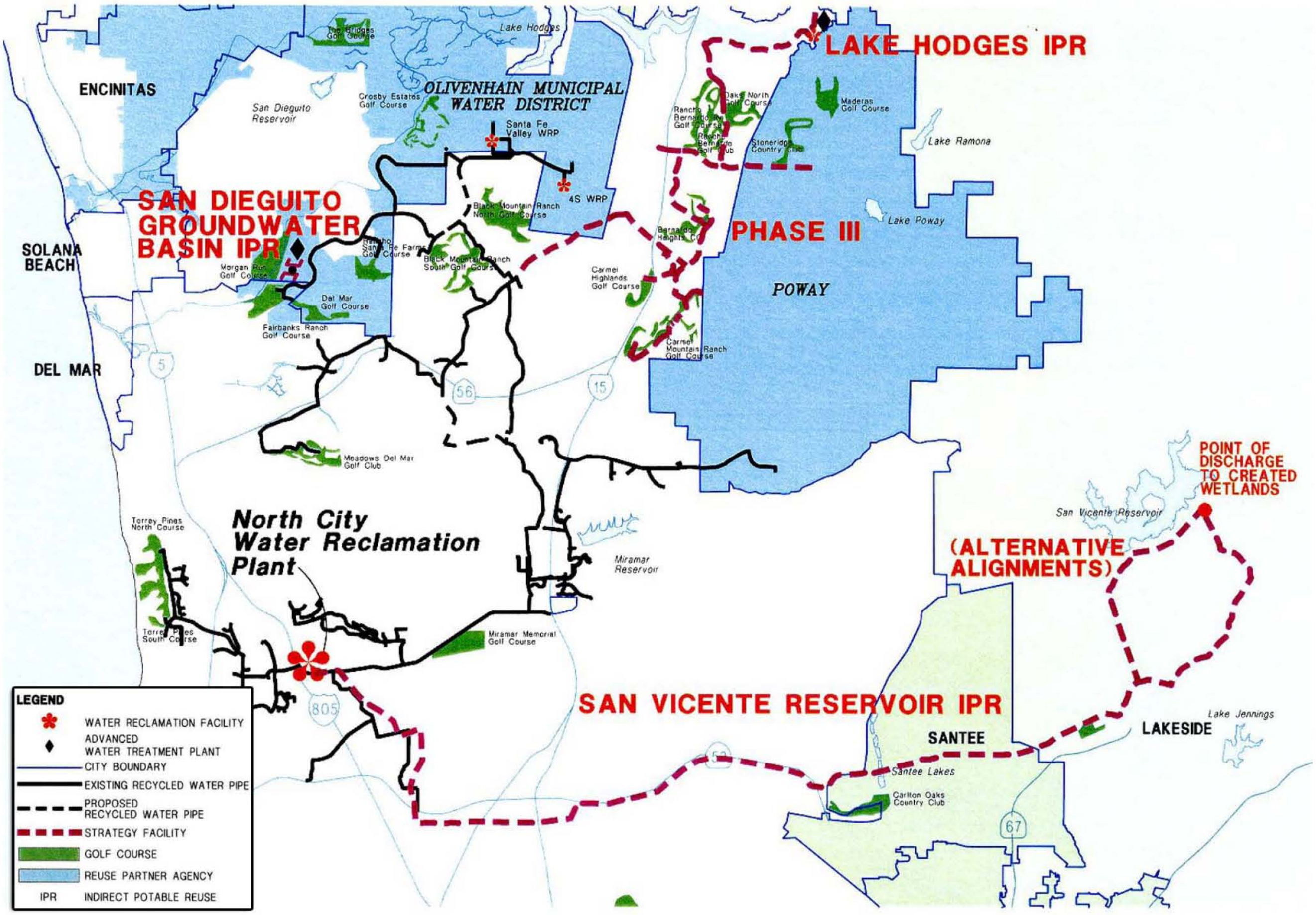

Figure 6-2 – Northern Service Area Indirect Potable Reuse Opportunities

Lake Hodges Reservoir Augmentation Project

A small-scale Lake Hodges reservoir augmentation project would require the implementation of the Phase III expansion of the Northern Service Area recycled water distribution system into Rancho Bernardo (see Section 5). At the northernmost end of the distribution system, an advanced water treatment plant would be sited in close proximity to the reservoir, and the treated water would be conveyed to Lake Hodges. This potential treatment facility would be capable of providing 2 MGD of water to supplement the local runoff and imported water stored in Lake Hodges. This blended water would subsequently be conveyed to drinking water treatment plants that serve both San Diego and North City areas. Upon completion of the Water Authority's Emergency Storage Project (ESP), water from Lake Hodges will also be available for distribution to areas further south, including the City's Alvarado and Miramar Water Treatment Plants. (See Figure 4.3 for the service areas of the City's three water treatment plants.)

The advanced water treatment facility would likely operate 8 to 10 months out of the year. The limited months of operation would be an effect of the seasonality of the Northern Service Area's existing and planned non-potable uses (i.e. a majority of the NCWRP capacity will be needed to serve non-potable uses during summer months for this option). Therefore, the advanced water treatment plant needed for this IPR project would be idle for these months. Brine disposal from the advanced water treatment plant would require new facilities to convey the brine to the City's existing sewer collection system, or north to City of Escondido treatment facilities.

San Vicente Reservoir Augmentation Project

A large-scale San Vicente reservoir augmentation project would include a 16 MGD advanced water treatment facility, located adjacent to the NCWRP. A 23-mile pipeline would be needed to convey the water to San Vicente. An optional wetland could be constructed near the reservoir to add a natural treatment process prior to the water entering the reservoir. Brine disposal would be accomplished by tying into the NCWRP brine disposal facilities. This large-scale project would beneficially maximize the recycled water available from the NCWRP.

The ESP includes at least doubling the volume of water stored in the San Vicente Reservoir. Raising the dam and construction of related water transmission facilities will allow delivering San Vicente water to all City water treatment plants and areas served by those plants. Therefore, the San Vicente reservoir augmentation project provides the greatest potential service coverage. (Figure 4.3 details the service area of the City Water Treatment Plant.)

Southern Service Area Reservoir Augmentation Opportunities – Otay Lakes

Both the small-scale and large-scale reservoir augmentation projects in the Southern Service Area, shown in **Figure 6-3**, involve the Lower Otay Reservoir. Conceptually, these projects would take recycled water from the City's SBWRP, treat it to advanced levels at an advanced water treatment plant, and then convey the water to the Lower Otay Reservoir via the Upper Otay Reservoir. A created wetland above the Upper Otay Reservoir could be constructed to add a natural treatment process prior to the water entering the Lower Otay Reservoir.

From Lower Otay Reservoir, the water would be withdrawn for treatment at the City's Otay Water Treatment Plant and distributed through the City's potable water distribution system to a majority of the South Bay area. Interconnecting pipelines between the City's Otay and Alvarado systems also allow water to be delivered north to the Alvarado Service Area. (Again, Figure 4.3 provides the service areas for the City's water treatment plants.)

The small-scale project would take advantage of the City's 1 MGD of capacity rights in OWD's recycled water distribution system expansion that is currently underway. A 2 MGD advanced water treatment plant would be located near Otay Lakes. Brine flows would be discharged into a trunk sewer belonging to the City of Chula Vista and eventually treated at the City's Point Loma Wastewater Treatment Plant.

The large-scale 5.5 MGD advanced water treatment plant would be located adjacent to the SBWRP. A 16-mile pipeline would be constructed to convey water to the reservoir, and brine would be discharged to the South Bay Outfall. This large-scale project beneficially maximizes the recycled water available from the SBWRP.

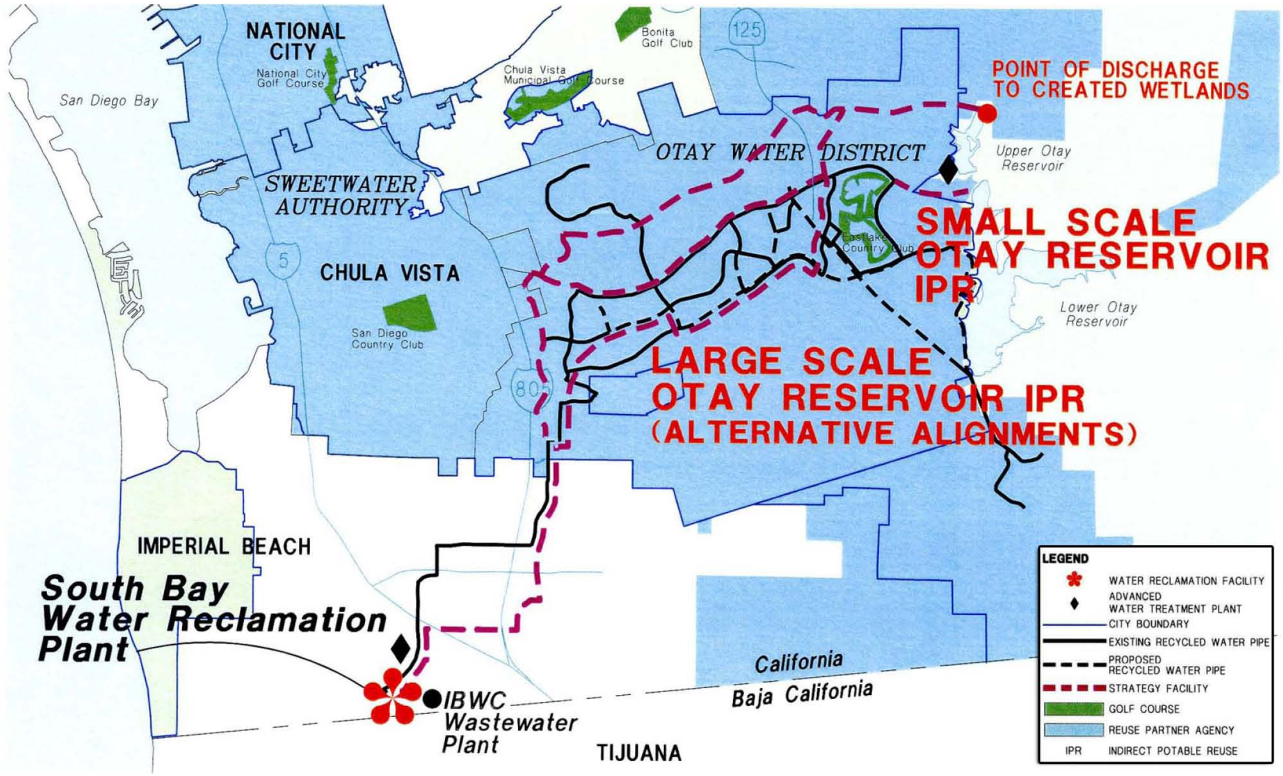

Figure 6-3 – Southern Service Area Indirect Potable Reuse Opportunities

6.2 Groundwater Recharge Opportunities

Advanced treated water may also be added to groundwater. Through direct injection into the aquifer via wells, or placed in spreading basins and allowed to percolate into the aquifer. The advanced treated water could blend with the groundwater and undergo natural treatment processes within the basin. The blended water would eventually be extracted, treated, and added to the potable water system (drinking water supply). This practice, referred to in the Study as groundwater recharge, must also meet minimum retention time and stringent water quality criteria as determined by RWQCB and DHS. Once extracted, a significant level of additional treatment may be necessary to achieve the required drinking water quality depending on the existing groundwater quality conditions.

The Study evaluated the feasibility of an IPR project using the City's existing groundwater basins. The San Pasqual, San Dieguito, Santee/El Monte, Mission Valley, San Diego Formation and Tijuana Groundwater basins were considered. Of these basins, San Dieguito was the only basin suitable for considering a groundwater recharge project at this time. The main factors taken into account for evaluating suitability were basin size, jurisdictional and economic issues, and overall water quality.

Domestic water use and insufficient retention time rendered the San Pasqual basin infeasible at this time. The Mission Valley basin displays certain benefits, such as simpler institutional issues and an improved ability to get water into and out of the basin, however, it is generally too narrow and shallow, and there are no planned recycled water conveyance facilities from either the Northern or Southern Service Areas to support it. Similarly, the Santee/El Monte basin is remote from existing City facilities. Sufficient hydrogeological information is not currently available on the San Diego Formation, making a determination regarding its suitability for an IPR project difficult. Finally, the Tijuana basin water quality is compromised by sewage and untreated industrial discharges at the international border, so extracted water from the Tijuana basin is of extremely poor quality. In addition, the basin has extensive riparian vegetation and extraction of groundwater could have a significant environmental impact on this habitat. These conditions severely limit the ability of the Tijuana basin to be used for an indirect potable groundwater recharge project.

The San Dieguito Basin was selected for further evaluation due to its size, proximity to a larger recycled water source and its current degraded quality and limited use. The San Dieguito Basin groundwater recharge concept, shown in **Figure 6-2**, entails conveying NCWRP recycled water to an advanced water treatment plant located adjacent to the basin. The water produced at the 2.2 MGD plant, based on draft DHS requirements, would be blended with 1.6 MGD of potable water and then piped to spreading basins over the San Dieguito groundwater basin. The water would percolate into the ground and mix with groundwater to recharge the basin. After regulatory requirements are met, the water would be extracted, treated, and distributed into the City's potable water system at the Del Mar Heights Pipeline. The project would also have the ancillary benefit of significantly improving the water quality of upstream portions of the basin.

Additional considerations of the San Dieguito groundwater recharge concept include the need to blend the advanced treated recycled water with imported water, the need for brine disposal and the number and complexity of agreements that would be required with neighboring and overlying local agencies and municipalities, as well as affected property owners. Several golf courses and horse ranches are located in this low-lying valley and use the groundwater through on-site wells. The permitting of a groundwater recharge project in a basin designated for potable uses is anticipated to require an amendment to the RWQCB's Basin Plan, a lengthy and tedious process. Given the challenges associated with implementation, this opportunity is not considered viable at this time.

6.3 Summary of Indirect Potable Reuse Opportunities Brought Forward for Evaluation

All of the potential opportunities, including the quantity of recycled water used, and the facilities required for proposed reservoir augmentation and groundwater recharge projects in each of the service areas, were outlined in the previous section. Although many were investigated, not all were brought forward, for evaluation as components of larger implementation strategies.

A summary by service area of the viable opportunities and the facilities required to deliver the recycled water for indirect potable uses is provided in **Table 6-1**.

Table 6-1
Summary of Indirect Potable Reuse Opportunities

Service Area	Opportunity	Estimated Average Day Demand (MGD)	Estimated Annual Use (AFY)	Customers Served	Facilities Required
Northern	Reservoir Augmentation – Lake Hodges	1.6	1,800	Potable water customers – North City and San Diego	Phase III recycled water extension 2 MGD advanced water treatment plant Brine disposal pipeline and connection to Escondido Hale Avenue Resource Recovery Plant
Northern	Reservoir Augmentation – San Vicente	9.4	10,500	Potable water customers – throughout City	16 MGD advanced water treatment plant 23 mile pipeline
Southern	Reservoir Augmentation – Otay Lakes	4.9	5,500	Potable water customers – throughout central and southern portions of the City	5.5 MGD advanced water treatment plant 16 mile pipeline

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7.0 Assessment of Reuse Opportunities

This analysis is consolidated into a combination of reuse opportunities, which are referred to as *strategies*. These strategies offer the San Diego public and Council a set of diverse reuse options for both the North City and South Bay systems. Decision charts, which could be referred to as roadmaps for each strategy's implementation, are included to summarize facilities and reuse volumes and were developed to help answer the primary study questions of: (1) which water recycling opportunities to pursue; and, (2) depending on the opportunity, how much water to recycle. Supporting text includes the benefits of each strategy, the value of recycled water, detailed costs for each strategy, and information on other water supply options.

In summary, this chapter:

- Revisits valuing recycled water as part of a diversified water supply portfolio and looks beyond unit costs when considering recycled water projects;
- Consolidates the opportunities listed in Sections 5 and 6 into six individual implementable strategies. Three strategies each are presented for North City and South Bay;
- Maps out the implementation of each strategy by steps;
- Presents detail of individual strategy costs along with the evaluation criteria established at the first Assembly workshop;
- Presents other water supply costs;
- Summarizes the conclusions for each strategy.

7.1 Recognizing the Value of Recycled Water

Understanding the uses and long-term value of recycled water is critical to making informed choices and decisions. The public, stakeholders, and policy makers have a challenging role in discussing and debating the strategies presented. Recycled water is a valuable asset – one that provides a locally controlled water supply, enhances supply reliability by diversifying supply sources, and enhances sustainability by limiting water diversions from other California ecosystems. Based on these benefits, the public and policy makers have been asked to determine the role of water reuse in San Diego's future.

7.2 Overview of Alternative Implementation Strategies

Six alternative implementation strategies were developed by combining individual opportunities from Sections 5 and 6 into a logical sequence of projects. Three opportunities are for the North City system and three are for the South Bay system. The strategies were developed to provide:

- A balanced and diverse set of both non-potable and indirect potable opportunities that represent the broad policy options available,
- A range of project steps that add new increments of recycled water usage within each strategy,
- A geographically balanced mix of projects.

Each strategy begins with the City's existing and planned projects, and then adds projects over a series of steps. The steps are not specifically defined in time, but for review purposes generally could be considered as approximately five-year increments from 2010 to 2025. The projects included in each step were organized based on a number of considerations, including:

- Maximizing the use of recycled water based on available supplies at each step,
- Selecting a lower cost project before a higher cost project, and
- Maximizing the ability to build upon existing or a previous step's infrastructure.

Most strategies can be pursued step-by-step all the way through to their final step or to some intermediate step. Some strategies maximize reuse in one large-scale project, while other strategies increase use gradually through smaller increments.

For each strategy, a summary table based on the evaluation criteria established at the first Assembly workshop was developed. The summary includes a description of the criteria with associated objectives and performance measures. A brief discussion is provided regarding those measures specific to the strategy.

7.3 North City Strategies

The City remains committed to completing the Phase I and II expansion of the North City recycled water distribution system. The City has also decided to pursue the infill opportunity described in Section 5. Infill provides the best approach to meet the City's Northern Service Area goal of beneficially using 12 MGD (13,400 AFY) by 2010. Other opportunities are more costly and/or cannot be completed by 2010. Therefore, infill is shown as the first component in each North City strategy.

Description of North City Strategies

The components in each North City strategy, referred to as NC-1 through NC-3, are summarized in the following paragraphs. After each component summary is a strategy decision chart and two-page summary for each strategy. The two-page summary includes a figure displaying strategy components, text summarizing strategy details, primary strategy benefits, amendment of recycled water usage, implementation issues, and analysis of evaluation criteria developed at the first Assembly workshop.

NC-1: The NC-1 Strategy includes only non-potable projects similar to the City's existing recycled water program. This strategy includes infill, Phase III expansion into Rancho Bernardo, and expansion of the system south into the Central Service Area. A seasonal storage project is included to increase supplies. NC-1 includes a created wetlands project in Rose Canyon.

NC-2: The NC-2 Strategy includes a mixture of non-potable and IPR opportunities. NC-2 starts off identical to NC-1 with infill and Phase III expansion. A small-scale IPR project at Lake Hodges and a seasonal storage project to meet peak demands for non-potable uses completes this strategy.

NC-3: The NC-3 Strategy includes infill and a large-scale IPR opportunity at San Vicente Reservoir that fully utilizes all of the remaining available recycled water supply.

Summary of North City Strategies

The resulting volume of reuse and associated costs vary per step and per strategy. The total reuse at the last step also varies between strategies depending on the approach and specific opportunities. **Table 7-1** summarizes the total reuse achieved for each opportunity in each strategy, both in AFY and as a percentage of the NCWRP's production capacity.

Table 7-1
Reuse Quantities for North City Strategies

Reuse Project Components	Recycled Water Use By Strategy (AFY)		
	NC-1	NC-2	NC-3
Reuse[1]			
Existing System (including Phases I and II)	9,440	9,440	9,440
Infill	3,820	3,820	3,820
Rancho Bernardo Phase III	2,110	2,110	-
San Vicente IPR (16 MGD Plant)	-	-	10,500
Central Service Area (CSA)	1,120	-	-
Lake Hodges IPR (2 MGD Plant)	-	1,800	-
Seasonal Storage	2,390	870	-
Wetlands	800	-	-
Subtotal Demands	*19,680*	*18,040*	*23,760*
Supply			
NCWRP Supply	26,880	26,880	26,880
Demineralization supply credit[2]	-	-	670
Advanced treatment process loss[2]	-	-635	-3,790
Subtotal Supply	*26,880*	*26,245*	*23,760*
Treatment Capacity Utilized, %	**73**	**69**	**100**

1 Project reuse volumes assume the availability of seasonal storage as needed to supply peak summertime uses.
2 Supply credits and losses were used to account for water lost as part of treatment processes. For IPR opportunities, demineralization is not needed at NCWRP (resulting in a supply credit), but losses will occur at the advanced water treatment plant (resulting in a loss of supply).

North City Decision Chart

A decision chart of North City strategies is presented in **Figure 7-1**. Unit costs, the estimated effect on a typical monthly residential water bill, reuse volumes, and the proposed implementation plan are also shown. The decision chart is intended to help answer the following primary study questions: (1) which water recycling opportunities to pursue; and, (2) depending on the opportunity, how much water to recycle.

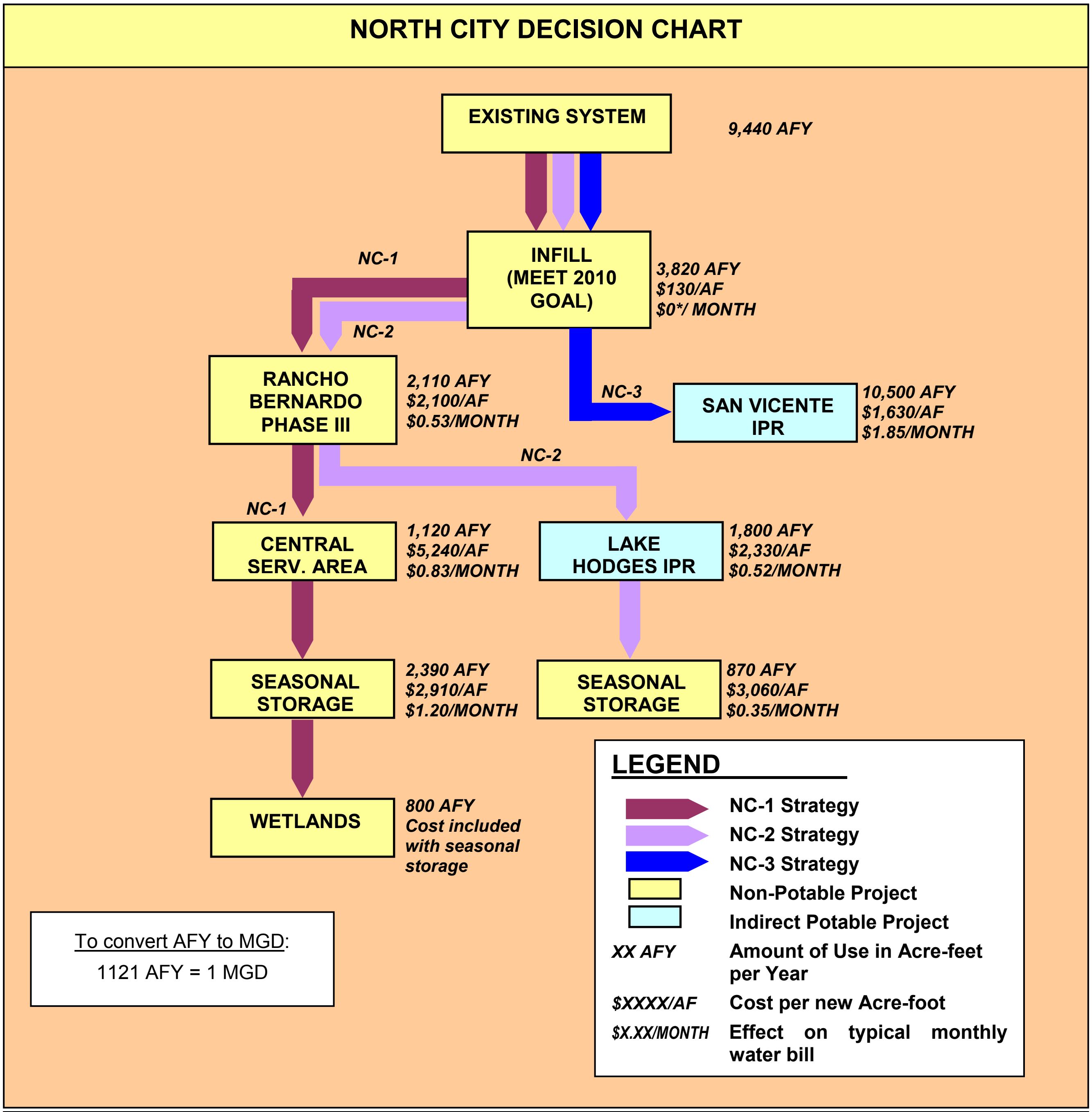

Figure 7-1 – The decision chart summarizes potential water reuse strategies for the North City Water Reclamation Plant. All strategies for North City start with meeting the City's 2010 goal via infill. The NC-1 strategy includes non-potable opportunities. The NC-2 strategy includes a mix of both non-potable and indirect potable reuse opportunities. The NC-3 strategy is predominantly an indirect potable reuse opportunity. Costs are shown for each strategy.
* Increased recycled water sales are projected to offset project costs.

North City Strategy NC-1 Two-Page Summary

Project Description

Expansion of the non-potable system to serve infill, Phase III Rancho Bernardo, the Central Service Area, and Rose Canyon wetlands.

Primary Benefit of this Strategy

NC-1 provides the lowest initial capital cost and lowest unit cost through the second step of the strategy. However, if the desire is to maximize use of the available recycled water supply, subsequent steps have higher unit costs and make this alternative comparatively more expensive. This strategy appears to be the appropriate choice if the driving decision factors are to minimize initial capital outlays and to commit to a non-potable reuse approach.

Implementation:

- Infill to serve new customers within one-quarter mile of the existing distribution system (up to 3,820 AFY).
- Phase III expansion of the existing system into Rancho Bernardo to primarily serve golf courses (up to 2,110 AFY) .
- Expansion into the Central Service Area to serve Mission Bay and Balboa Parks (up to 1,120 AFY).
- Through the initial implementation steps, purchase raw or treated potable water to meet summer demand peaks. Subsequent development of recycled water seasonal storage would store surplus recycled water during the winter for use in the summer.
- Use of excess recycled water in winter months for a created wetland in Rose Canyon (800 AFY).

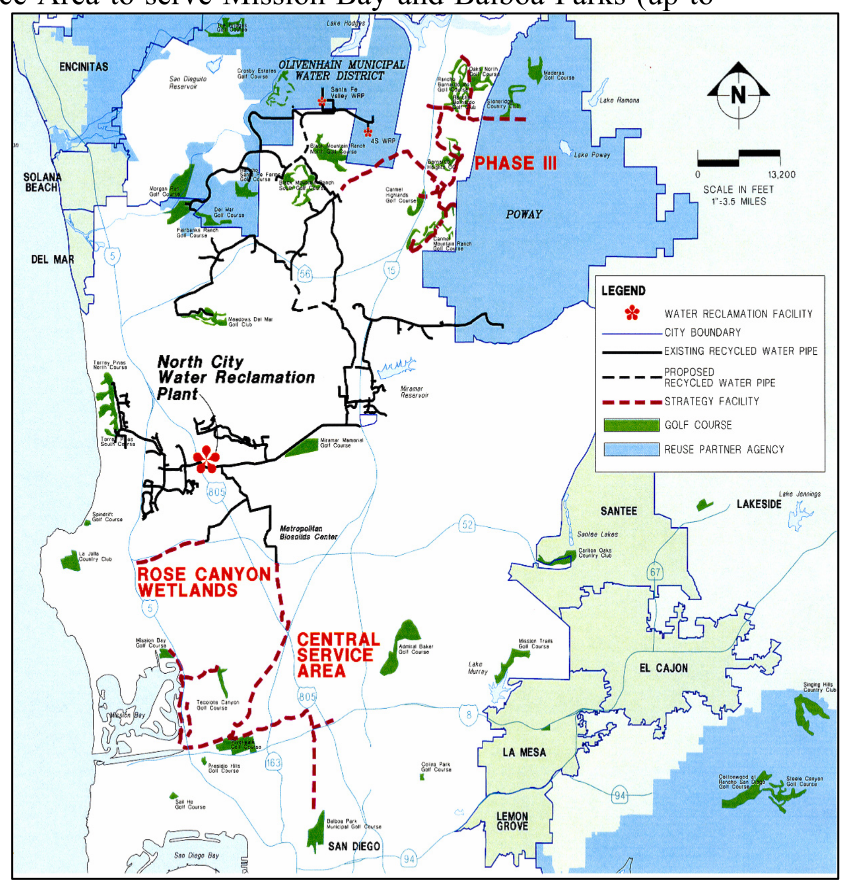

Figure 7-2 - North City Strategy NC-1

NC-1 – Evaluation Criteria Detail		
Criteria	**Objective and Performance Measure**	**Discussion**
Health and Safety	To protect human health and safety with regard to recycled water use. Meets or exceeds federal, state and local regulatory criteria for recycled water uses.	City's non-potable service of recycled water meets federal, state and local regulatory criteria and has been safely operated since 1997.
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups. Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.	**Human Need:** Non-potable recycled water distribution system serves a human need by replacing potable water use. However, the system's distribution system is limited and not everyone directly benefits from recycled water use. **Public Perception:** The public in general perceives that non-potable use of recycled water is preferable to indirect potable reuse.
Environmental Value	To enhance, develop or improve local habitat or ecosystems and avoid or minimize negative environmental impacts. Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits are required.	Offsets discharge of wastewater to the ocean. Negative environmental impacts due to construction are temporary.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water. Increases percent of water recycling and improves local reliability.	Up to **19,680 AFY** of recycled water is reused in this strategy. This amounts to approximately **73%** of the available recycled water from the NCWRP.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs; to meet all customer quality requirements.	Use of non-potable, recycled water for irrigation provides the benefit of nutrient value to irrigated areas. City ensures TDS to be equal or less than 1000 mg/l.
Technical Feasibility	To assess the physical implementation of the strategy.	The facilities must be built in a cost-effective and timely manner.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions. Level of demand met and opportunities for system interconnections and operational flexibility are addressed.	Recycled water treatment and distribution systems are not operated with redundancy of facilities in mind. Outages of recycled water service are more likely to occur than in a potable water system.
Cost	To minimize total cost to the community. Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).	See Section 7.5 for Cost Discussion.
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability. Level of difficulty in physical, social or regulatory implementation.	Non-potable recycled water projects are generally easier to implement than indirect potable projects as they require less regulatory permitting. These types of projects have a regulatory framework to follow and general public support.

Figure 7-3 NC 1 – Evaluation Criteria Detail

North City Strategy NC-2 Two-Page Summary

Project Description

Expansion of the non-potable system to serve infill and Phase III Rancho Bernardo, followed by a small-scale IPR project at Lake Hodges.

Primary Benefit of this Strategy

Strategy NC-2 provides the opportunity to switch from non-potable to IPR. This strategy appears to be the appropriate choice if the driving decision factor is to minimize initial expenditures, while still having the ability to accomplish an IPR project.

Implementation:

- Infill to serve new customers within one quarter-mile of the existing distribution system (up to 3,820 AFY).
- Phase III expansion of the existing system into Rancho Bernardo to primarily serve golf courses (up to 2,110 AFY).
- Small-scale IPR project at Lake Hodges (1,800 AFY).
- Through early implementation steps, summer peak can be met with purchased potable or raw water. Subsequent development of recycled water seasonal storage would store surplus recycled water during the winter for use in the summer.

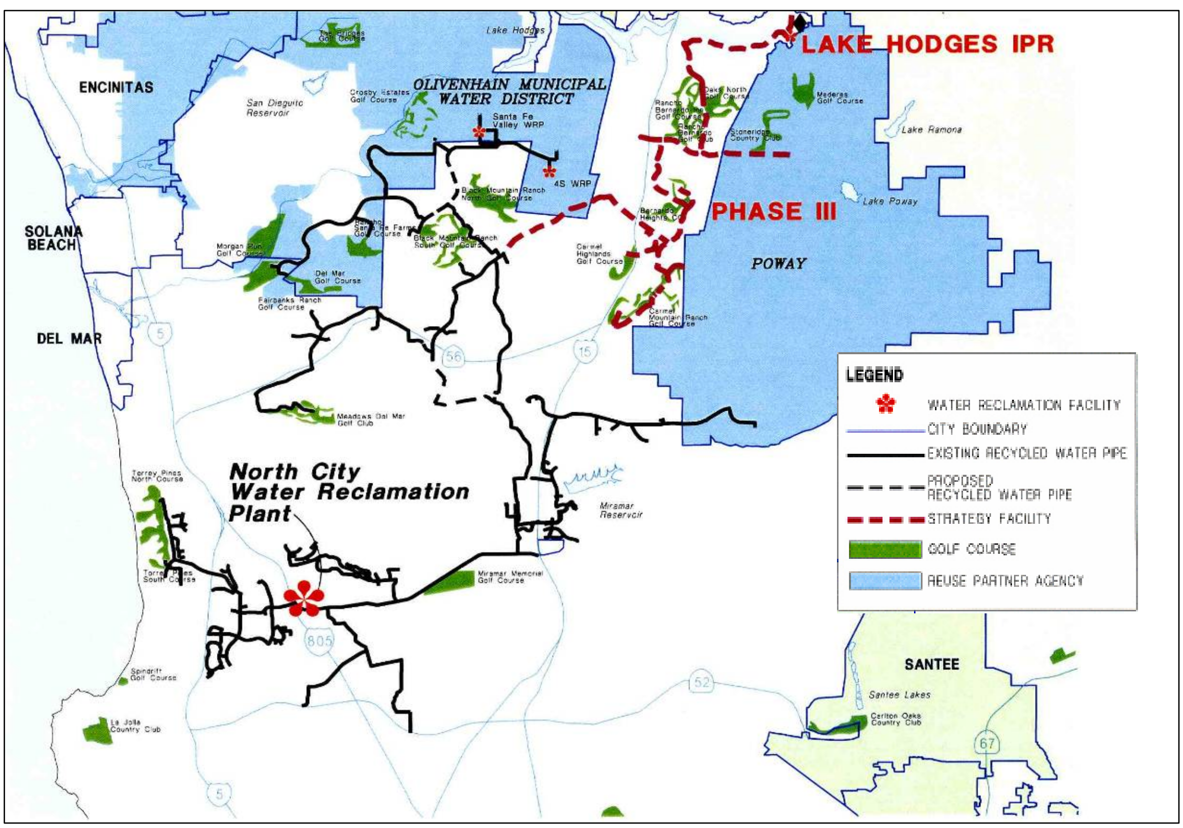

Figure 7-4 North City Strategy NC-2

NC-2 – Evaluation Criteria Detail		
Criteria	**Objective and Performance Measure**	**Discussion**
Health and Safety	To protect human health and safety with regard to recycled water use. Meets or exceeds federal, state and local regulatory criteria for recycled water uses.	City's non-potable service of recycled water meets federal, state and local regulatory criteria and has been safely operated since 1997. New IPR projects would be designed to meet federal, state and local regulatory requirements.
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups. Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.	**Human Need:** Both non-potable and IPR provide water to the community, but IPR projects distribute the purified water to a greater number of people. **Public Perception:** Non-potable uses are highly supported based on the findings of the Study's public outreach efforts, but IPR projects are not as high.
Environmental Value	To enhance, develop or improve local habitat or ecosystems and avoid or minimize negative environmental impacts. Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits are required.	Offsets discharge of wastewater to the ocean. Negative environmental impacts due to construction are temporary.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water. Increases percent of water recycling and improves local reliability.	Up to **18,040 AFY** of recycled water is used in this strategy. Including advanced treatment process uses for the IPR components, the complete strategy utilizes approximately **69%** of the available recycled water from the NCWRP.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs; to meet all customer quality requirements.	Treatment methodology and monitoring will ensure appropriate water quality for intended uses: non-potable or indirect potable.
Technical Feasibility	To assess the physical implementation of the strategy.	The necessary facilities must be built in a timely and cost-effective manner.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions. Level of demand met and opportunities for system interconnections and operational flexibility are addressed.	IPR project provides operational reliability as it takes full advantage of the redundancy of the City's potable water distribution system and increases the use of water produced at the City's water reclamation plants.
Cost	To minimize total cost to the community. Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).	See Section 7.5 for Cost Discussion.
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability. Level of difficulty in physical, social or regulatory implementation.	IPR project is anticipated to be more difficult to implement due to regulatory and social issues. Extensive public outreach effort will be required to implement the IPR component of this strategy. The Lake Hodges IPR project has additional hurdles since the first inline water treatment plants are not City facilities.

Figure 7-5 NC 2 – Evaluation Criteria Detail

North City Strategy NC-3 Two-Page Summary

Project Description

Expansion of the non-potable system to serve infill, followed by a large-scale San Vicente Reservoir IPR project sized to maximize available supplies.

Primary Benefit of this Strategy

NC-3 maximizes the available North City water supply in one step through IPR. For a strategy that fully maximizes use of the available recycled water supply, it provides the lowest overall unit cost. Accomplishing this, however, involves the highest initial capital costs. This strategy appears to be the appropriate choice if the driving decision factors are to maximize recycled water use and have the lowest ultimate unit cost.

Implementation:

- Infill to serve new customers within one-quarter mile of the existing distribution system (up to 3,820 AFY).
- Large-scale 16 MGD capacity San Vicente Reservoir Augmentation (IPR) project to utilize the wintertime supply from the NCWRP, after other non-potable uses (10,500 AFY).
- Small amount of potable water may be needed to meet summer demand with purchased potable water.

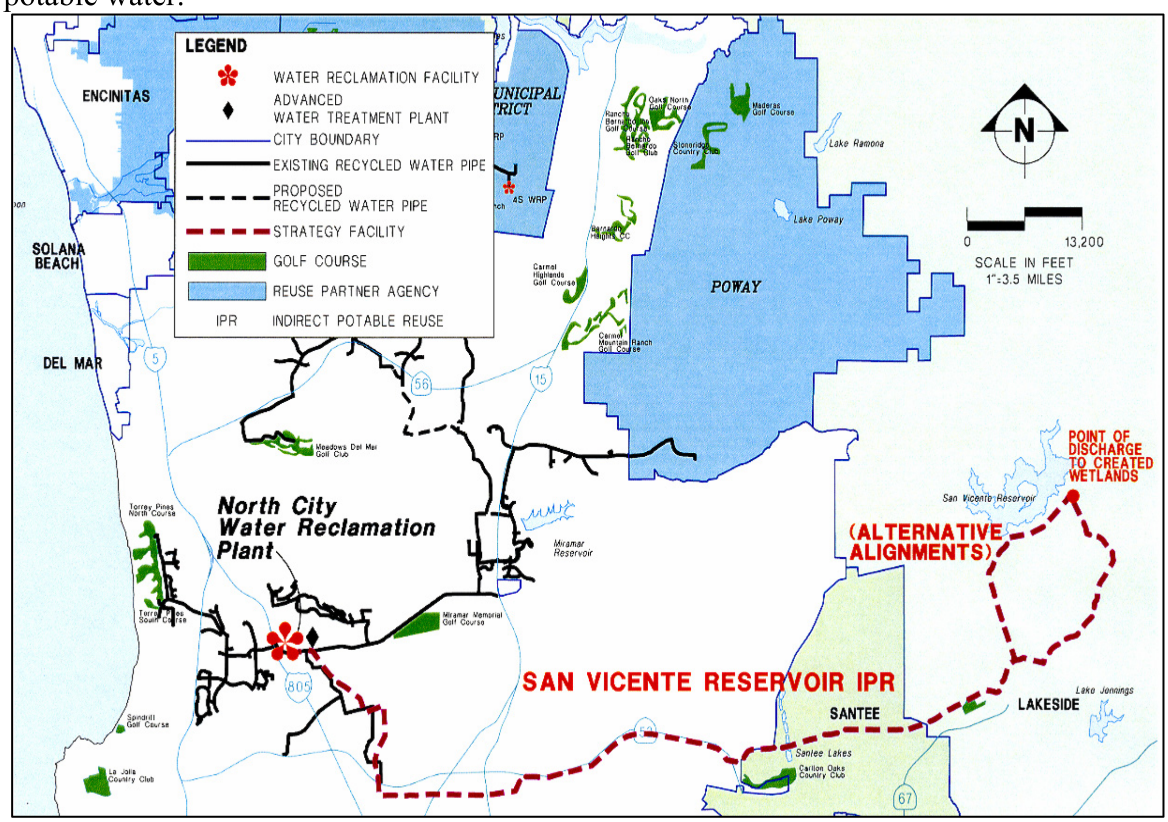

Figure 7-6 North City Strategy NC-3

NC-3 – Evaluation Criteria Detail		
Criteria	**Objective and Performance Measure**	**Discussion**
Health and Safety	To protect human health and safety with regard to recycled water use. Meets or exceeds federal, state and local regulatory criteria for recycled water uses.	City's non-potable service of recycled water meets federal, state and local regulatory criteria and has been safely operated since 1997. New indirect potable project would be designed to meet federal, state and local regulatory requirements.
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups. Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.	**Human Need:** Both non-potable and IPR provide water to the community, but IPR projects distribute the purified water to a greater number of people. **Public Perception:** Non-potable uses are highly supported based on the findings of the Study's public outreach efforts, but IPR projects are not as high.
Environmental Value	To enhance, develop or improve local habitat or ecosystems and avoid or minimize negative environmental impacts. Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits are required.	Offsets discharge of wastewater to the ocean. Negative environmental impacts due to construction are temporary. Wetlands associated with IPR projects are generally acceptable to environmentalists.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water. Increases percent of water recycling and improves local reliability.	Up to **23,760 AFY** of recycled water is used in this strategy. Including advanced treatment process uses for the IPR components, the complete strategy achieves **100 %** utilization of the available recycled water from the NCWRP.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs; to meet all customer quality requirements.	Treatment methodology and monitoring will ensure appropriate water quality for intended uses: non-potable or indirect potable.
Technical Feasibility	To assess the physical implementation of the strategy.	The necessary facilities must be built in a timely and cost-effective manner.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions. Level of demand met and opportunities for system interconnections and operational flexibility are addressed.	IPR project provides operational reliability as it takes full advantage of the redundancy of the City's potable water distribution system and increases the use of water produced at the City's water reclamation plants.
Cost	To minimize total cost to the community. Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).	See Section 7.5 for Cost Discussion.
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability. Level of difficulty in physical, social or regulatory implementation.	IPR project is anticipated to be more difficult to implement due to the regulatory and social issues. Extensive public outreach effort will be required to implement the IPR component of this strategy.

Figure 7-7 NC 3 – Evaluation Criteria Detail

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7.4 South Bay Strategies

All South Bay strategies include the existing uses at the South Bay and IBWC treatment plants. In addition, the City plans to fulfill their 6 MGD commitment to the OWD by 2007. Therefore, existing uses and service to OWD are shown as the first components in each South Bay strategy.

Description of South Bay Strategies

The paragraphs below summarize the components in each South Bay strategy, referred to as SB-1 through SB-3. Following the component summary is a strategy decision chart and two-page summary for each strategy. The two-page summary includes a figure displaying strategy components, text summarizing the strategy details, primary strategy benefits, strategy usage, implementation issues, and analysis of evaluation criteria developed at the first Assembly workshop.

SB-1: The SB-1 Strategy includes only non-potable projects similar to the City's existing recycled water program. After serving OWD, SB-1 proposes to serve Sweetwater Authority with the remaining available recycled water supply.

SB-2: The SB-2 Strategy includes a small-scale IPR opportunity at Otay Lakes, following the baseline OWD project.

SB-3: The SB-3 Strategy includes a large-scale IPR opportunity at Otay Lakes, following the baseline OWD project, which maximizes use from the SBWRP in one step.

Summary of South Bay Strategies

The resulting volume of use and costs vary per step and per strategy. The total use at the last step also varies between strategies depending on the approach and specific opportunities. **Table 7-2** summarizes the total use achieved for each opportunity in each strategy, and the percent of SBWRP capacity utilized.

Table 7-2
Reuse Quantities for South Bay Strategies

Reuse Project Components	Recycled Water Use By Strategy (AFY)		
	SB-1	SB-2	SB-3
Reuse[1]			
SBWRP onsite usage	560	560	560
IBWC onsite usage	840	840	840
Otay Water District	5,760	5,760	5,760
Sweetwater Authority	5,880	-	-
Otay IPR Small-Scale (2 MGD Plant)	-	1,800	-
Otay IPR Large-Scale (7.5 MGD Plant)	-	-	5,500
Subtotal Demands	*13,040*	*8,960*	*12,660*
Supply			
SBWRP Supply	15,120	15,120	15,120
Demineralization supply credit[2]	-	-	-
Advanced treatment process loss[2]	-	-640	-1940
Subtotal Supply	*15,120*	*14,480*	*13,180*
Treatment Capacity Utilized, %	**86**	**62**	**96**

1 Project reuse volumes assume the availability of seasonal storage as needed to supply peak summertime uses.

2 Supply credits and losses were used to account for water lost as part of treatment processes. For IPR opportunities, demineralization is not needed at SBWRP (resulting in a supply credit), but losses will occur at the advanced water treatment plant (resulting in a loss of supply).

South Bay Decision Chart

A decision chart of South Bay strategies is presented in Figure 7-8. Unit costs, the effect on a typical monthly residential water bill, reuse volumes, and the proposed implementation plan are also shown. The decision chart is intended to help answer the following primary study questions: (1) which water recycling opportunities to pursue and (2) depending on the opportunity, how much water to recycle.

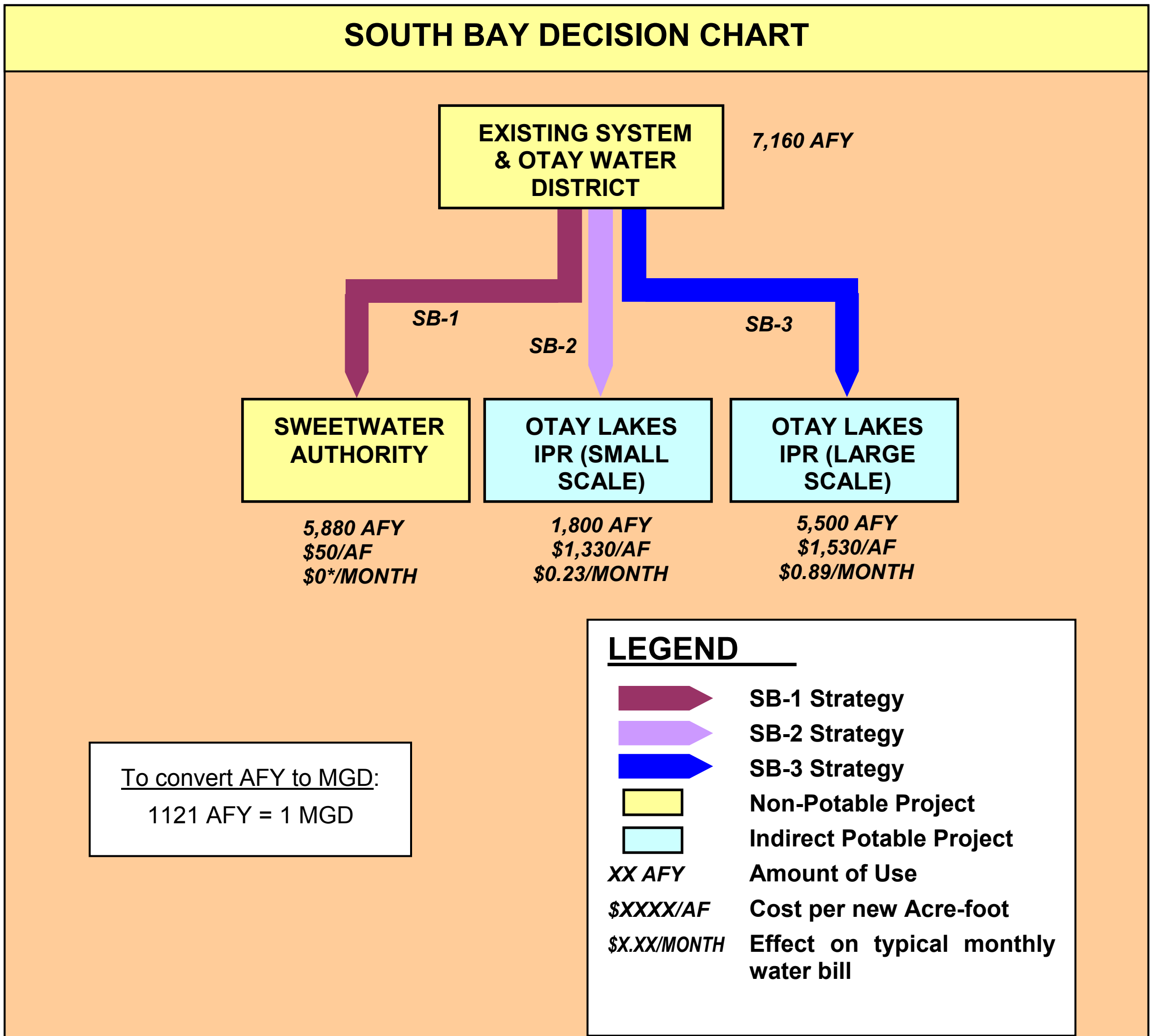

Figure 7-8 – This decision chart summarizes potential water reuse strategies for the South Bay Water Reclamation Plant. All strategies for South Bay start with serving planned San Diego and Otay Water District customers. The SB-1 strategy includes non-potable opportunities. The SB-2 strategy includes a small-scale indirect potable reuse project at Otay Lakes. The SB-3 strategy is a larger scale indirect potable reuse opportunity at Otay Lakes. Costs are shown for each strategy.
* Increased recycled water sales are projected to off-set project costs.

South Bay Strategy SB-1 Two-Page Summary

Project Description

Expansion of the non-potable system to serve OWD and Sweetwater Authority.

Primary Benefit of this Strategy

Strategy SB-1 results in the lowest initial capital cost and lowest unit cost of all South Bay strategies. This strategy appears to be the appropriate choice if the driving decision factor is to minimize expenditures, even if the use occurs outside City service areas.

Implementation:

- Existing System and OWD (up to 7,160 AFY).
- Expansion of the existing system to serve Sweetwater Authority and its customers (up to 5,880 AFY).

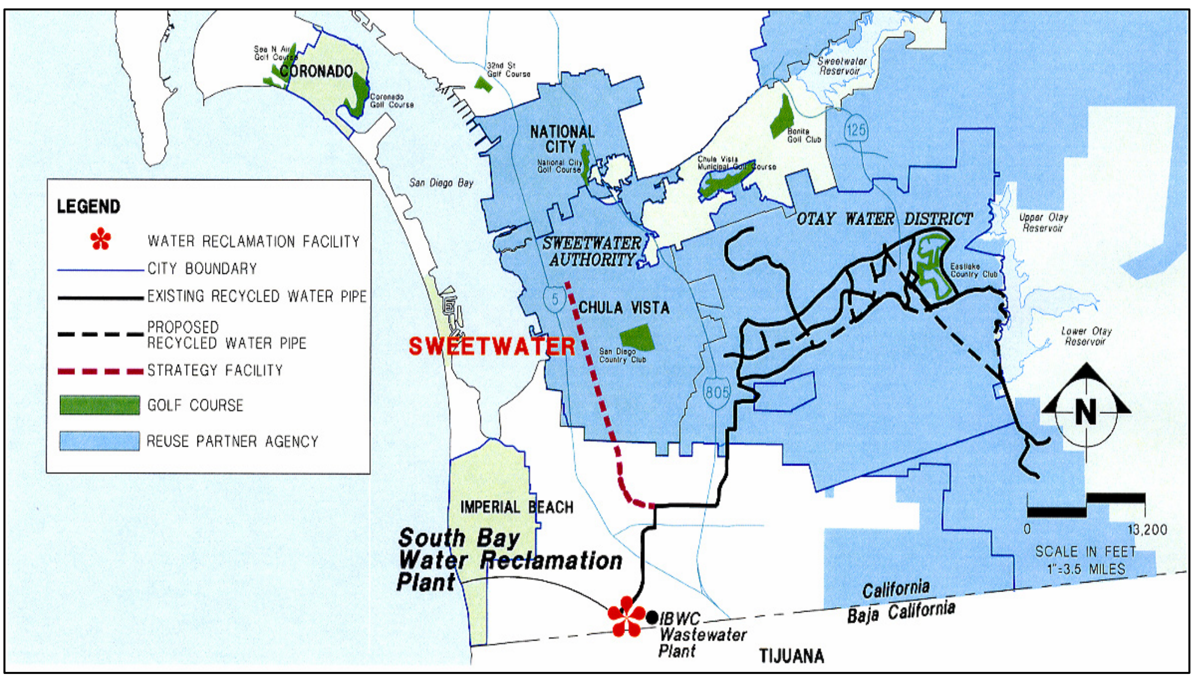

Figure 7-9 South Bay Strategy SB-1

SB-1 – Evaluation Criteria Detail		
Criteria	**Objective and Performance Measure**	**Discussion**
Health and Safety	To protect human health and safety with regard to recycled water use. Meets or exceeds federal, state and local regulatory criteria for recycled water uses.	City's non-potable service of recycled water meets federal, state and local regulatory criteria and has been safely operated since 1997.
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups. Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.	**Human Need:** Non-potable use serves a human need by replacing potable water use. However, the system's distribution system is limited and not everyone directly benefits from recycled water use. **Public Perception:** The public in general perceives that non-potable use of recycled water is preferable to IPR.
Environmental Value	To enhance, develop or improve local habitat or ecosystems and avoid or minimize negative environmental impacts. Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits are required.	Offsets discharge of wastewater to the ocean. Negative environmental impacts due to construction are temporary.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water. Increases percent of water recycling and improves local reliability.	Up to **13,040 AFY** of recycled water is used in this strategy. This amounts to approximately **86%** of the available recycled water from the SBWRP.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs; to meet all customer quality requirements.	Use of non-potable, recycled water for irrigation provides the benefit of nutrient value to irrigated areas. City ensures TDS to be equal or less than 1000 mg/L.
Technical Feasibility	To assess the physical implementation of the strategy.	The necessary facilities must be built in a timely and cost-effective manner.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions. Level of demand met and opportunities for system interconnections and operational flexibility are addressed.	Recycled water treatment and distribution systems are not operated with redundancy of facilities in mind. Outages of recycled water service are more likely to occur than in a potable water system. This scenario takes advantage of a new regional interconnection with Sweetwater Authority.
Cost	To minimize total cost to the community. Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).	See Section 7.5 for Cost Discussion.
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability. Level of difficulty in physical, social or regulatory implementation.	The implementation of this strategy relies upon a new large customer moving into the Sweetwater Authority Service Area.

Figure 7-10 SB-1 – Evaluation Criteria Detail

South Bay Strategy SB-2 Two-Page Summary

Project Description

Expansion of the non-potable system to serve OWD, followed by a small-scale IPR opportunity at Lower Otay Reservoir.

Primary Benefit of this Strategy

Strategy SB-2 includes a mix of non-potable uses and a small-scale IPR project. This strategy appears to be an appropriate choice if either of the driving decision factors are to retain use of the South Bay recycled water within the City, or if the projected non-potable uses envisioned in strategy SB-1 do not come to fruition.

Implementation:

- Existing System and OWD (up to 7,160 AFY).
- A small-scale IPR project at Lower Otay Reservoir with created wetlands located upstream of the Upper Otay Reservoir (1,800 AFY).

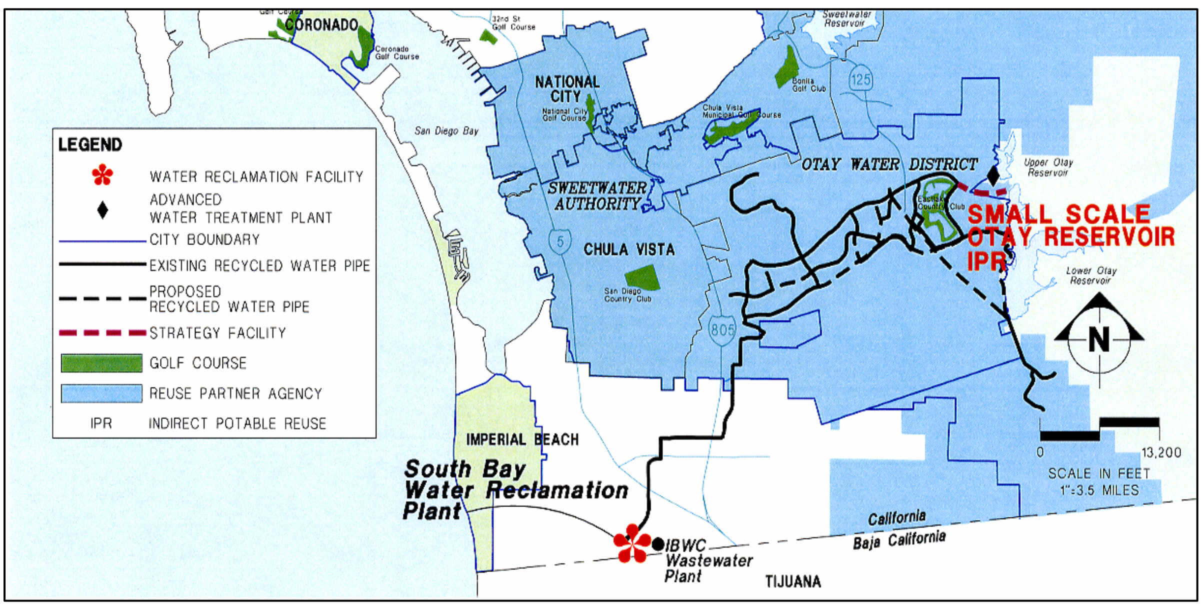

Figure 7-11 South Bay Strategy SB-2

SB-2 – Evaluation Criteria Detail		
Criteria	**Objective and Performance Measure**	**Discussion**
Health and Safety	To protect human health and safety with regard to recycled water use. Meets or exceeds federal, state and local regulatory criteria for recycled water uses.	City's non-potable service of recycled water meets federal, state and local regulatory criteria and has been safely operated since 1997. New indirect potable project would be designed to meet federal, state and local regulatory requirements.
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups. Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.	**Human Need:** Both non-potable and IPR provide water to the community, but an IPR project distributes purified water to a greater number of people. **Public Perception:** Non-potable uses are highly supported based on the findings of the Study's public outreach efforts, but IPR projects are not as high.
Environmental Value	To enhance, develop or improve local habitat or ecosystems and avoid or minimize negative environmental impacts. Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits are required.	Offsets discharge of wastewater to the ocean. Negative environmental impacts due to construction are temporary. Wetlands associated with an IPR project are generally acceptable to environmentalists.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water. Increases percent of water recycling and improves local reliability.	Up to **8,960 AFY** of recycled water is used in this strategy. Including advanced treatment process uses for the IPR components, the complete strategy utilizes approximately **62%** of the available recycled water from the SBWRP.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs; to meet all customer quality requirements.	Treatment methodology and monitoring will ensure appropriate water quality for intended uses: non-potable or indirect potable.
Technical Feasibility	To assess the physical implementation of the strategy.	The necessary facilities must be built in a timely and cost-effective manner.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions. Level of demand met and opportunities for system interconnections and operational flexibility are addressed.	An IPR project provides operational reliability as it takes full advantage of the redundancy of the City's potable water distribution system and increases the use of water produced at the City's water reclamation plant.
Cost	To minimize total cost to the community. Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).	See Section 7.5 for Cost Discussion.
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability. Level of difficulty in physical, social or regulatory implementation.	An IPR project is anticipated to be more difficult to implement due to regulatory and social issues. Extensive public outreach efforts will be required to implement the IPR component of this strategy.

Figure 7-12 SB-2 – Evaluation Criteria Detail

South Bay Strategy SB-3 Two-Page Summary

Project Description

Expansion of the non-potable system to serve OWD, followed by a large-scale IPR opportunity at Lower Otay Reservoir.

Primary Benefit of this Strategy

Strategy SB-3 includes a mix of non-potable uses and a large-scale IPR project. This strategy appears to be an appropriate choice if the driving decision factors are to retain use of the South Bay recycled water within the City, or if the projected non-potable uses envisioned in strategy SB-1 do not come to fruition.

Implementation:

- Existing System and OWD (up to 7,160 AFY).
- A large-scale IPR project at Lower Otay Reservoir with created wetlands located upstream of the Upper Otay Reservoir (5,500 AFY).

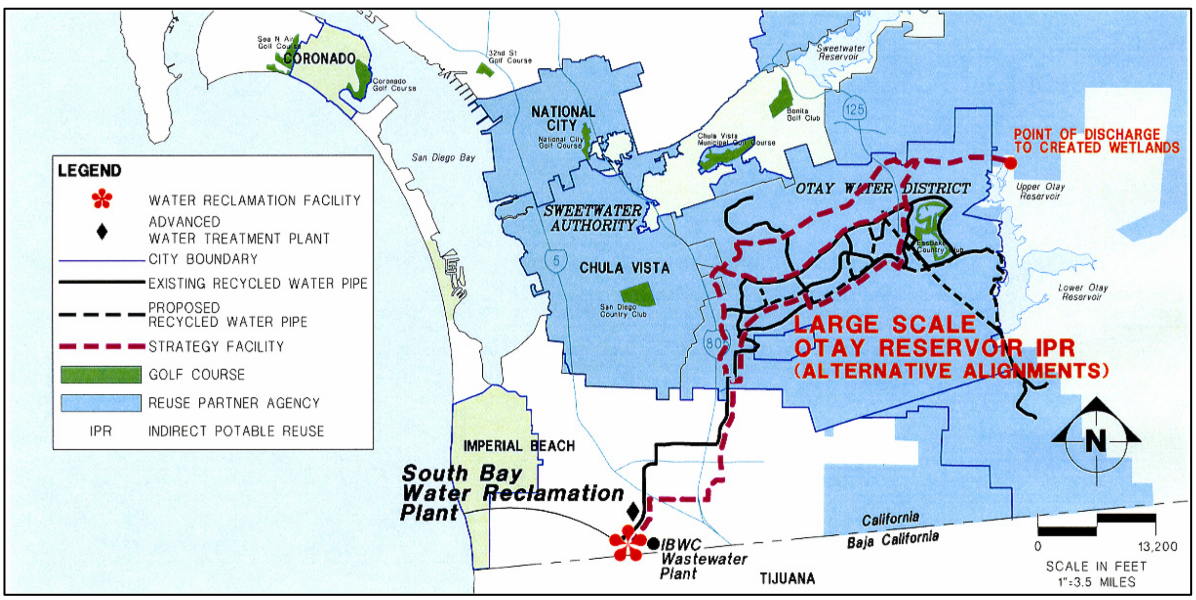

Figure 7-13 South Bay Strategy SB-3

SB-3 – Evaluation Criteria Detail		
Criteria	**Objective and Performance Measure**	**Discussion**
Health and Safety	To protect human health and safety with regard to recycled water use. Meets or exceeds federal, state and local regulatory criteria for recycled water uses.	City's non-potable service of recycled water meets federal, state and local regulatory criteria and has been safely operated since 1997. New indirect potable projects would be designed to meet federal, state and local regulatory requirements.
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups. Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.	**Human Need:** Both non-potable and IPR provide water to the community, but an IPR project distributes purified water to a greater number of people. **Public Perception:** Non-potable uses are highly supported based on the findings of the Study's public outreach efforts, but IPR projects are not as high.
Environmental Value	To enhance, develop or improve local habitat or ecosystems and avoid or minimize negative environmental impacts. Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits are required.	Offsets discharge of wastewater to the ocean. Negative environmental impacts due to construction are temporary. Wetlands associated with an IPR project are generally acceptable to environmentalists..
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water. Increases percent of water recycling and improves local reliability.	Up to **12,660 AFY** of recycled water is used in this strategy. Including advanced treatment process uses for the IPR components, the complete strategy utilizes approximately **96%** of the available recycled water from the SBWRP.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs; to meet all customer quality requirements.	Treatment methodology and monitoring will ensure appropriate water quality for intended uses: non-potable or indirect potable.
Technical Feasibility	To assess the physical implementation of the strategy.	The necessary facilities must be built in a timely and cost-effective manner.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions. Level of demand met and opportunities for system interconnections and operational flexibility are addressed.	An IPR project provides operational reliability as it takes full advantage of the redundancy of the City's potable water distribution system and increases the use of water produced at the City's water reclamation plant.
Cost	To minimize total cost to the community. Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).	See Section 7.5 for Cost Discussion.
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability. Level of difficulty in physical, social or regulatory implementation.	An IPR project is anticipated to be more difficult to implement due to regulatory and social issues. Extensive public outreach efforts will be required to implement the IPR component of this strategy.

Figure 7-14 SB-3 – Evaluation Criteria Detail

7.5 Cost Evaluations

Cost Evaluation Overview

As part of the Reuse Study, costs the City would incur for each of the six strategies, and for every step of each strategy, were evaluated. All costs are presented on a common basis in 2005 dollars[2]. This report highlights three key measures of project costs:

- **Capital Costs:** Capital costs are an estimate of the City's initial capital outlay for project construction and implementation exclusive of operations and maintenance costs. These costs include all costs for project planning, permitting, design, construction, and construction administration.

- **Unit Costs:** The unit cost of water delivered provides a common basis for comparison among projects with differing reuse volumes. The analysis is based on the total equivalent annual cost of each project, including capital and operating costs. Capital costs are amortized over a 40-year term at an interest rate of 6 percent. The 40-year term is representative of the average economic life of the mix of capital facilities presented. Unit costs are then calculated by dividing total equivalent annual costs by the annual volume of recycled water put to beneficial use. Finally, the resulting value is adjusted to account for various incentive credits and avoided costs, as described later in this section.

- **Impact on Typical Monthly Residential Water Bill:** This measure is an estimate of the impact on a typical monthly City residential water bill necessary to fund the reuse projects over a 40-year finance period. The actual rate effect may vary due to differences in financing, funding grants, and other factors, but this measure nevertheless provides a reasonable estimate for evaluation and comparison purposes.

As with the other evaluations presented in this section, this cost evaluation data is intended to help inform the Council, stakeholders, and the public regarding the City's decisions of which strategy to pursue and how far the strategy should be pursued. While costs are a key evaluation factor, as noted in the preface of this report, there may be other factors that could lead the City to select a more costly alternative over a less costly one. In addition, the City fully intends to pursue State and local grant funding for any options selected or decided upon by the Council. The costs presented herein do not reflect or assume grant funding.

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[2] Construction costs are referenced to an Engineering News Record Los Angeles Construction Cost Index of 8193 (January 2005).

Cost Evaluations – North City Strategies

Reuse volumes, capital costs, unit costs, and rate effects for each phase of the three North City strategies are summarized below.

North City water reuse volumes are shown in **Table 7-3**, along with the total annual volume, in acre feet, of recycled water used for each strategy. There are three section headings: (1) "Incremental Use of New Projects" lists the amount of new recycled water added by new projects within a particular step; (2) "Cumulative Use of New Projects" lists the total volume of recycled water added by all of the new projects; and (3) "Cumulative Total Use of New and Existing Projects" lists the total volume of reuse of all the new and existing projects.

Table 7-3
North City Reuse Volumes (AFY)

Strategy	Step 1	Step 2	Step 3	Step 4
Incremental Use of New Projects				
NC-1	3,820	2,110	1,120	3,190
NC-2	3,820	2,110	1,800	870
NC-3	3,820	10,500	-	-
Cumulative Use of New Projects				
NC-1	3,820	5,930	7,050	10,240
NC-2	3,820	5,930	7,730	8,600
NC-3	3,820	14,320	-	-
Cumulative Total Use of New and Existing Projects				
NC-1	13,260	15,370	16,490	19,680
NC-2	13,260	15,370	17,170	18,040
NC-3	13,260	23,760	-	-

Note: Refer to Figures 7-3 through 7-5 on preceding pages for components included in each step.

Table 7-4 summarizes the capital costs for the new North City projects in 2005 dollars. There are two section headings: (1) "Incremental Cost of New Projects" lists the additional capital costs added by new projects within a particular step; and (2) "Cumulative Cost of New Projects" lists the total capital costs added by all of the new projects up to a given step.

Table 7-4
North City Capital Costs

Strategy	Step 1	Step 2	Step 3	Step 4
Incremental Costs of New Projects				
NC-1	$27,600,000	$50,400,000	$65,100,000	$141,600,000
NC-2	$27,600,000	$50,400,000	$65,100,000	$45,200,000
NC-3	$27,600,000	$210,000,000	-	-
Cumulative Costs of New Projects				
NC-1	$27,600,000	$78,000,000	$143,100,000	$284,700,000
NC-2	$27,600,000	$78,000,000	$143,100,000	$188,300,000
NC-3	$27,600,000	$237,600,000	-	-

Unit costs for the new North City projects in dollars per acre-foot are summarized in **Table 7-5**, based on a 40-year term at 6-percent interest. There are two section headings: 1) "Incremental Unit Costs of New Projects" lists the individual unit costs of each new project addition; and 2) "Melded Unit Costs of New Projects" lists the weighted average or melded unit costs of all of the new projects up to a given step.

Table 7-5
North City Unit Costs ($/AF)

Strategy	Step 1	Step 2	Step 3	Step 4
Incremental Unit Costs of New Projects				
NC-1	$130	$2,100	$5,240	$2,910
NC-2	$130	$2,100	$2,330	$3,060
NC-3	$130	$1,630	-	-
Melded Unit Costs of New Projects				
NC-1	$130	$830	$1,530	$1,960
NC-2	$130	$830	$1,180	$1,370
NC-3	$130	$1,230	-	-

Table 7-6 presents the approximate increase to a typical monthly residential water bill that would be necessary to fund each strategy. There are two section headings: (1) "Incremental Effect of New Projects" lists the individual rate effect of each new project addition; and (2) "Cumulative Effect of New Projects" lists the cumulative or total rate effect of all of the new projects up to a given step.

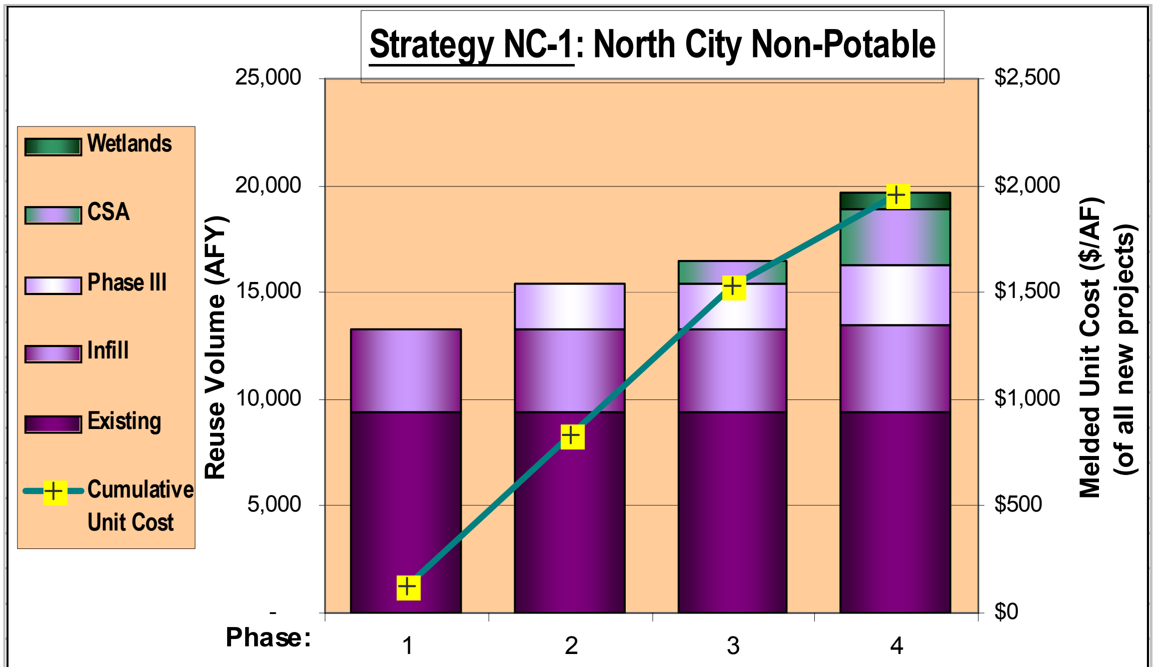
Table 7-6
North City Estimated Monthly Rate Increase to Typical Residential Water Bill ($/mo)

Strategy	Step 1*	Step 2	Step 3	Step 4
Incremental Effect of New Projects				
NC-1	$0	$0.53	$0.83	$1.20
NC-2	$0	$0.53	$0.52	$0.35
NC-3	$0	$1.85	-	-
Cumulative Effect of New Projects				
NC-1	$0	$0.31	$1.13	$2.34
NC-2	$0	$0.31	$0.82	$1.17
NC-3	$0	$1.63	-	-

* Increased revenue from new customers are projected to offset the cost for this step.

Volume and cost data specific to each strategy are also presented in **Figures 7-3, 7-4,** and **7-5** for strategies NC-1, NC-2, and NC-3, respectively. These cost charts provide a graphical representation of costs in relation to the steps and reuse volume of each strategy. In the graph, the columns represent the individual project opportunities in each strategy. The legend to the left of the columns identifies each project. The height of the column is the volume of reuse, measured on the left axis labeled "Reuse (AFY)". The graphed line overlapping the columns represents the cumulative unit cost per step, measured on the right axis labeled "Average Cost per AF (for new projects)."

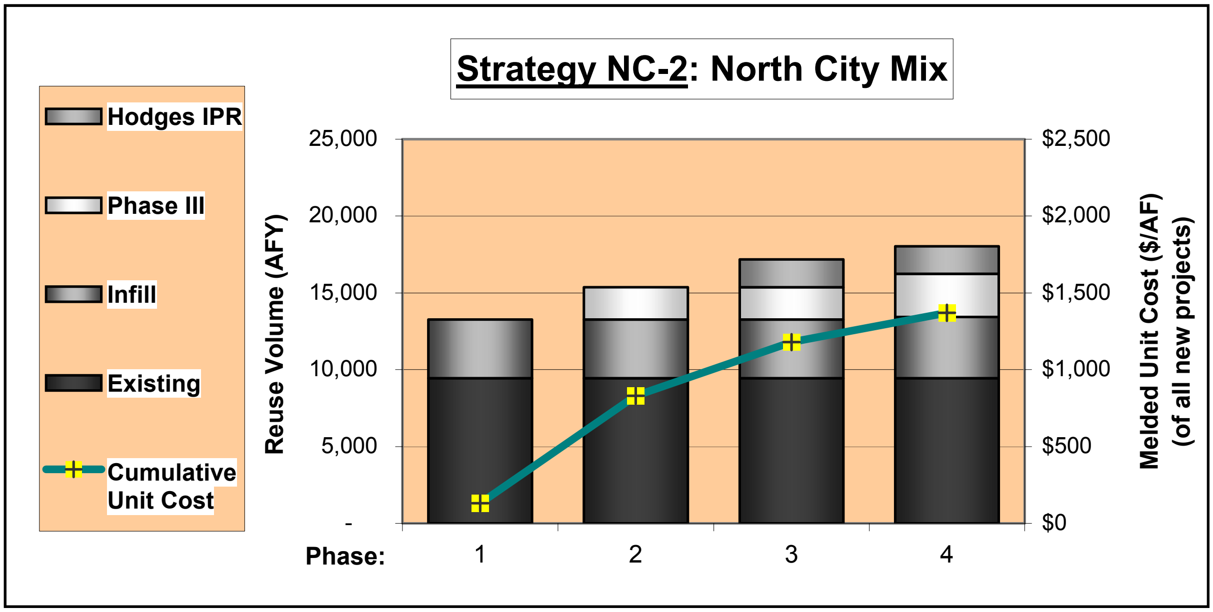
The tabular data below the graph includes reuse volumes, capital costs, unit costs, and the effect of the projects on a typical monthly residential water bill. The costs and the "new increment" reuse volumes shown in the supporting tables reflect new projects only, exclusive of existing projects such as the City's Phase I and Phase II North City distribution system expansions.



Reuse Volume, by Phase:					w/ Seasonal Storage*
-- New Project Use (Increase by Phase)	(AFY)	3,820	2,110	1,120	3,190
	(MGD)	3.4	1.9	1.0	2.8
-- Total (Cumulative) (Including Existing)	(AFY)	13,260	15,370	16,490	19,680
	(MGD)	11.8	13.7	14.7	17.6
Incremental Costs of Individual New Projects, by Phase:					
-- Capital Cost	($)	$27,600,000	$50,400,000	$65,100,000	$141,600,000
-- Unit Cost	**($/AF)**	**$130**	**$2,100**	**$5,240**	**$2,910**
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$0.31	$0.83	$1.20
Cumulative Costs of All New Projects, by Phase:					
-- Capital Cost	($)	$27,600,000	$78,000,000	$143,100,000	$284,700,000
-- Unit Cost (Melded)	**($/AF)**	**$130**	**$830**	**$1,530**	**$1,960**
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$0.31	$1.13	$2.34

Figure 7-15 – Volume and Cost Summary for Strategy NC-1

* As NCWRP inflow volume increases over time, reuse volume will correspondingly increase.



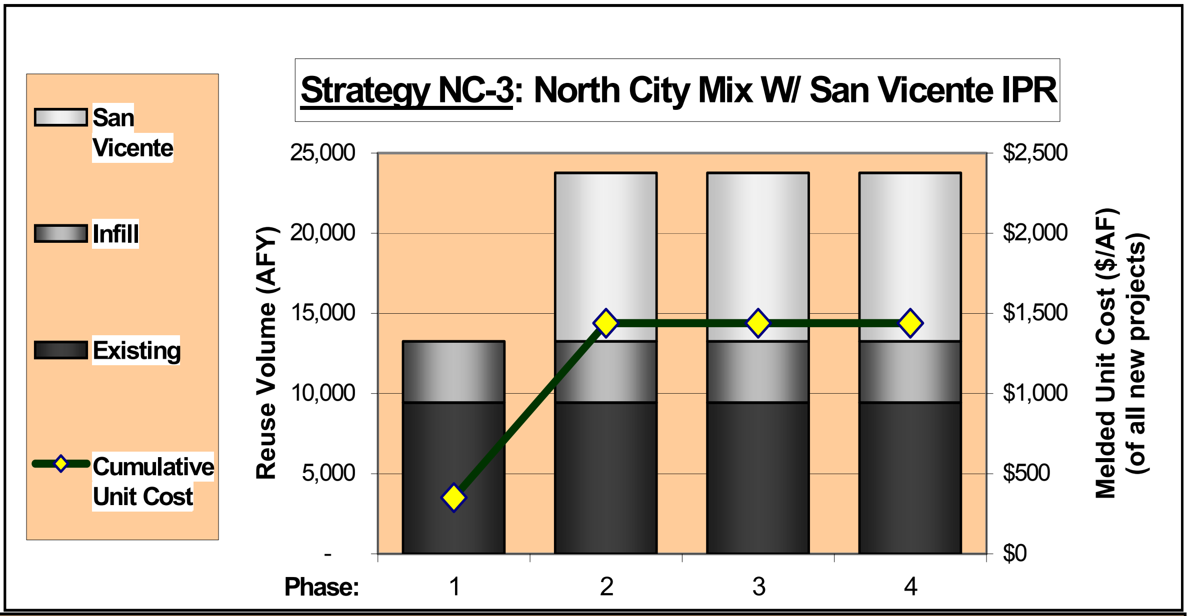
Reuse Volume, by Phase:					w/ Seasonal Storage*
-- New Project Use (Increase by Phase)	(AFY)	3,820	2,110	1,800	870
	(MGD)	3.4	1.9	1.6	0.8
-- Total (Cumulative) (Including Existing)	(AFY)	13,260	15,370	17,170	18,040
	(MGD)	11.8	13.7	15.3	16.1

Incremental Costs of Individual New Projects, by Phase:					
-- Capital Cost	($)	$27,600,000	$50,400,000	$65,100,000	$45,200,000
-- Unit Cost	**($/AF)**	**$130**	**$2,100**	**$2,330**	**$3,060**
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$0.31	$0.52	$0.35

Cumulative Costs of All New Projects, by Phase:					
-- Capital Cost	($)	$27,600,000	$78,000,000	$143,100,000	$188,300,000
-- Unit Cost (Melded)	**($/AF)**	**$130**	**$830**	**$1,180**	**$1,370**
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$0.31	$0.82	$1.17

Figure 7-16 – Volume and Cost Summary for Strategy NC-2

* As NCWRP inflow volume increases over time, reuse volume will correspondingly increase.



Reuse Volume, by Phase:					
-- New Project Use (Increase by Phase)	(AFY)	3,820	10,500	0	0
	(MGD)	3.4	9.4	0.0	0.0
-- Total (Cumulative) (Including Existing)	(AFY)	13,260	23,760	23,760	23,760
	(MGD)	11.8	21.2	21.2	21.2

Incremental Costs of Individual New Projects, by Phase:					
-- Capital Cost	($)	$27,600,000	$210,000,000	-	-
-- Unit Cost	**($/AF)**	**$130**	**$1,630**	-	-
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$1.63	-	-

Cumulative Costs of All New Projects, by Phase:					
-- Capital Cost	($)	$27,600,000	$237,600,000	$237,600,000	$237,600,000
-- Unit Cost (Melded)	**($/AF)**	**$130**	**$1,230**	**$1,230**	**$1,230**
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$1.63	$1.63	$1.63

Figure 7-17 – Volume and Cost Summary for Strategy NC-3

* As NCWRP inflow volume increases over time, reuse volume will correspondingly increase.

Cost Evaluations – South Bay Strategies

Reuse volumes, capital costs, unit costs, and rate effects for each step of the three South Bay strategies are summarized below.

South Bay water reuse volumes are shown in **Table 7-7**, along with the total annual volume, in acre-feet, of recycled water that is used for each strategy. There are three section headings: (1) "Incremental Use of New Projects" lists the amount of new recycled water added by new projects within a particular step; (2) "Cumulative Use of New Projects" lists the total volume of recycled water added by all of the new projects; and (3) "Cumulative Total Use of New and Existing Projects" lists the total volume of reuse of all the new and existing projects.

Table 7-7
South Bay Reuse Volumes (AFY)

Strategy	Step 1	Step 2	Step 3	Step 4
Incremental Use of New Projects				
SB-1	0	2,860	4,990	450
SB-2	1,800	1,260	710	450
SB-3	0	6,760	710	450
Cumulative Use of New Projects				
SB-1	0	1,600	5,880	-
SB-2	1,800	1,800	1,800	-
SB-3	0	5,500	5,500	-
Cumulative Total Use of New and Existing Projects (Including OWD)				
SB-1	4,740	7,600	12,590	13,040
SB-2	6,540	7,800	8,510	8,960
SB-3	4,740	11,500	12,210	12,660

Table 7-8 summarizes the capital costs of the new South Bay projects in 2005 dollars. There are two section headings: (1) "Incremental Cost of New Projects" lists the additional capital costs added by new projects within a particular step; and (2) "Cumulative Cost of New Projects" lists the total capital costs added by all of the new projects up to a given step.

Table 7-8
South Bay Capital Costs

Strategy	Step 1	Step 2	Step 3	Step 4
Incremental Costs of New Projects				
SB-1*	$0	$1,000,000	-	-
SB-2	$21,600,000	-	-	-
SB-3	$0	$96,100,000	-	-
Cumulative Costs of New Projects				
SB-1*	$0	$1,000,000	-	-
SB-2	$21,600,000	-	-	-
SB-3	$0	$96,100,000	-	-

* Increased revenue from new customers are projected to offset the cost for this step.

Unit costs of the new South Bay projects in dollars per acre-foot are summarized in **Table 7-9**, based on a 40 year term at 6-percent interest. There are two section headings: (1) "Incremental Unit Costs of New Projects" lists the individual unit costs of each new project addition; and (2) "Melded Unit Costs of New Projects" lists the weighted average or melded unit costs of all of the new projects up to a given step.

Table 7-9
South Bay Unit Costs ($/AF)

Strategy	Step 1	Step 2	Step 3	Step 4
Incremental Unit Costs of New Projects				
SB-1*	$0	$50	-	-
SB-2	$1,330	-	-	-
SB-3	$0	$1,530	-	-
Melded Unit Costs of New Projects				
SB-1*	$0	$70	-	-
SB-2	$1,330	-	-	-
SB-3	$0	$1,530	-	-

Note: Refer to Figure 7-6 through 7-8 on succeeding pages for components included in each step.
* Increased revenue from new customers are projected to offset the cost for this step.

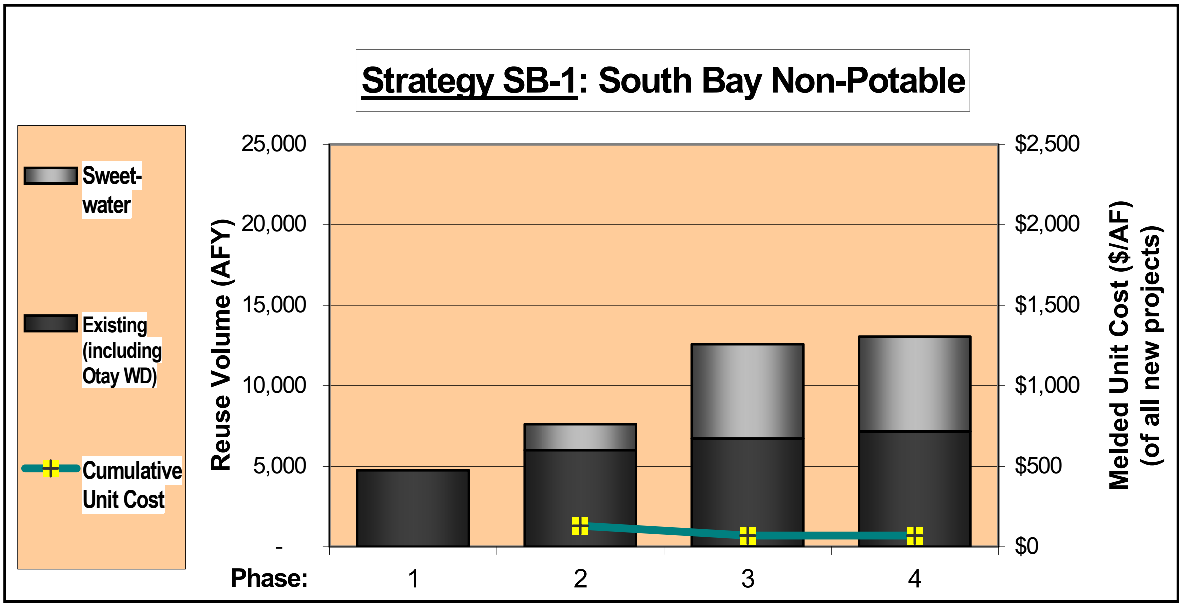
Table 7-10 presents the projected increase to a typical monthly residential water bill that would be necessary to fund each strategy. There are two section headings: (1) "Incremental Effect of New Projects" lists the individual rate effect of each new project addition; and (2) "Cumulative Effect of New Projects" lists the cumulative or total rate effect of all of the new projects up to a given step.

Table 7-10
South Bay Estimated Monthly Rate Increase to Typical Residential Water Bill ($/mo)

Strategy	Step 1	Step 2	Step 3	Step 4
Incremental Effect of New Projects				
SB-1	$0.00	$0.00	-	-
SB-2	$0.23	-	-	-
SB-3	$0.00	$0.89	-	-
Cumulative Effect of New Projects				
SB-1	$0.00	$0.00	-	-
SB-2	$0.23	-	-	-
SB-3	$0.00	$0.89	-	-

Volume and cost data specific to each strategy are also presented in **Figures 7-6, 7-7,** and **7-8** for strategies SB-1, SB-2, and SB-3, respectively. These cost charts provide a graphical representation of costs in relation to the steps and reuse volume of each strategy. In the graph, the columns represent the individual project opportunities in each strategy. The legend to the left of the columns identifies each project. The height of the column is the volume of reuse, measured on the left axis labeled "Reuse (AFY)". The graphed line overlapping the columns represents the cumulative unit cost per step, measured on the right axis labeled "Average Cost per AF (for new projects)."

The tabular data below the graph includes reuse volumes, capital costs, unit costs, and the effect of the projects on a typical monthly residential water bill. The costs and the "new increment" reuse volumes shown in the supporting tables reflect new projects only, exclusive of existing projects such as sales to the OWD.



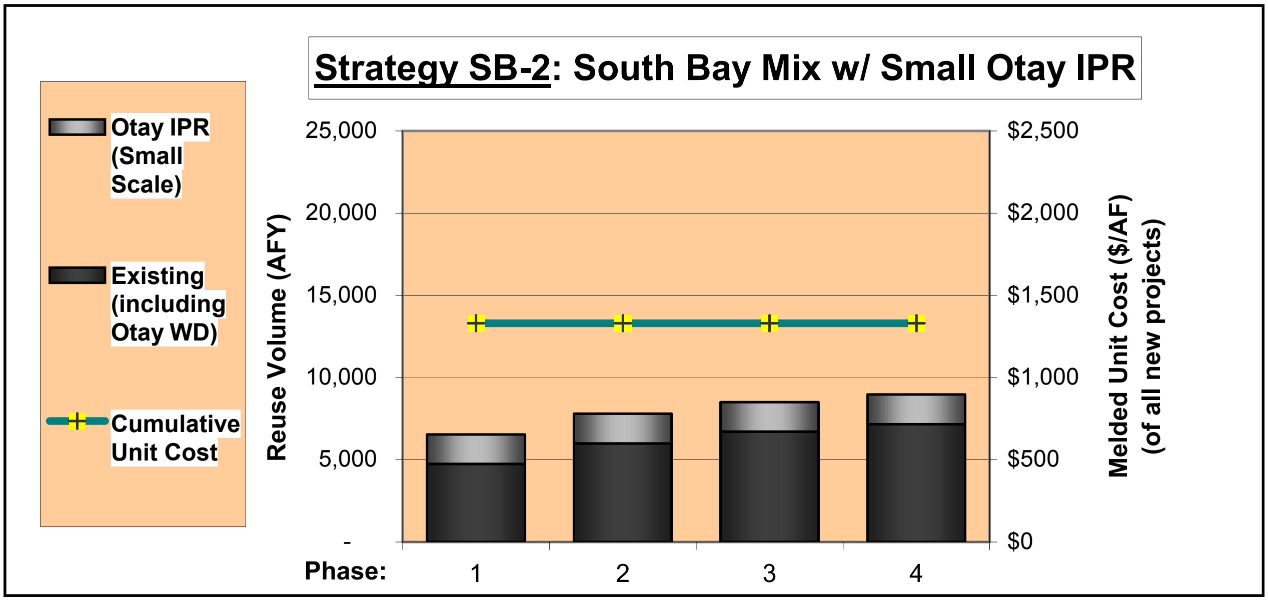
Reuse Volume, by Phase:					
-- New Project Use (Increase by Phase)	(AFY)	0	2,860	4,990	450
	(MGD)	0.0	2.6	4.5	0.4
-- Total Use (Cumulative) (Including Existing)	(AFY)	4,740	7,600	12,590	13,040
	(MGD)	4.2	6.8	11.2	11.6

Incremental Costs of Individual New Projects, by Phase:					
-- Capital Cost	($)	$0	$1,000,000	$0	-
-- Unit Cost	**($/AF)**	**$0**	**$130**	**$50**	**-**
-- Increase to Typical Residential Water Bill	**($/mo)**	$0.00	$0.00	$0.00	-

Cumulative Costs of All New Projects, by Phase:					
-- Capital Cost	($)	$0	$1,000,000	$1,000,000	$1,000,000
-- Unit Cost (Melded)	**($/AF)**	**$0**	**$130**	**$70**	**$70**
-- Increase to Typical Residential Water Bill	**($/mo)**	$0.00	$0.00	$0.00	$0.00

Figure 7-18 – Volume and Cost Summary for Strategy SB-1

* As SBWRP inflow volume increases over time, reuse volume will correspondingly increase.



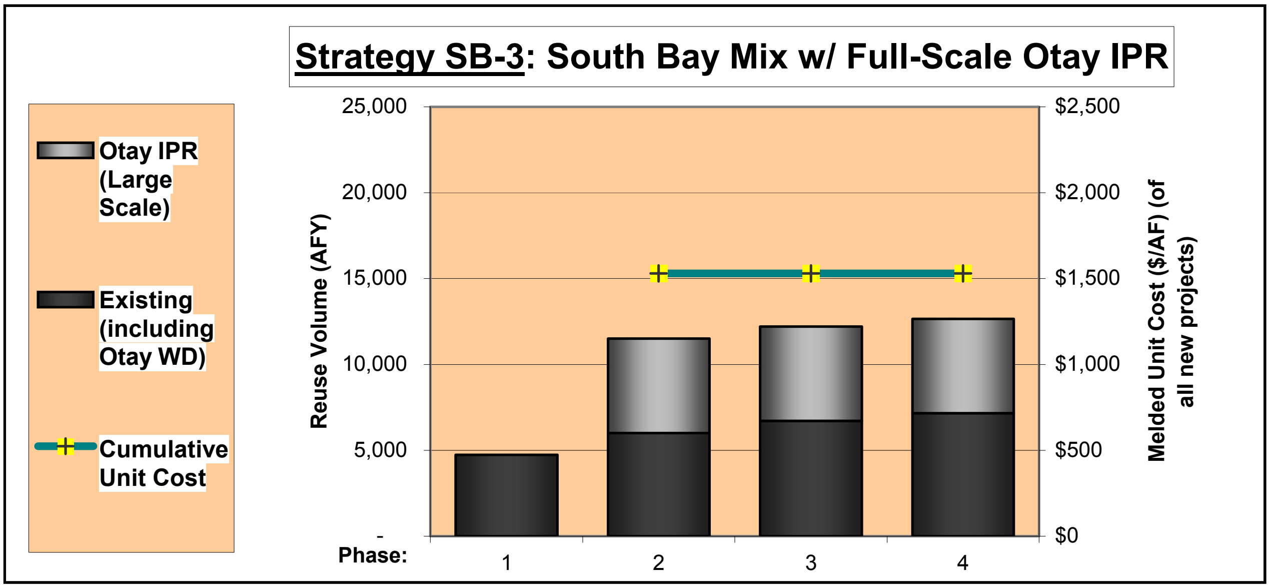
Reuse Volume, by Phase:					
-- New Project Use (Increase by Phase)	(AFY)	1,800	1,260	710	450
	(MGD)	1.6	1.1	0.6	0.4
-- Total (Cumulative) (Including Existing)	(AFY)	6,540	7,800	8,510	8,960
	(MGD)	5.8	7.0	7.6	8.0

Incremental Costs of Individual New Projects, by Phase:					
-- Capital Cost	($)	$21,600,000	-	-	-
-- Unit Cost	**($/AF)**	**$1,330**	-	-	-
-- Increase to Typical Residential Water Bill	**($/mo)**	$0.23	-	-	-

Cumulative Costs of All New Projects, by Phase:					
-- Capital Cost	($)	$21,600,000	$21,600,000	$21,600,000	$21,600,000
-- Unit Cost (Melded)	**($/AF)**	**$1,330**	**$1,330**	**$1,330**	**$1,330**
-- Increase to Typical Residential Water Bill	**($/mo)**	$0.23	$0.23	$0.23	$0.23

Figure 7-19 – Volume and Cost Summary for Strategy SB-2

* As SBWRP inflow volume increases over time, reuse volume will correspondingly increase.



Reuse Volume, by Phase:					
-- New Project Use (Increase by Phase)	(AFY)	0	6,760	710	450
	(MGD)	0.0	6.0	0.6	0.4
-- Total (Cumulative) (Including Existing)	(AFY)	4,740	11,500	12,210	12,660
	(MGD)	4.2	10.3	10.9	11.3

Incremental Costs of Individual New Projects, by Phase:					
-- Capital Cost	($)	$0	$96,100,000	-	-
-- Unit Cost	**($/AF)**	**$0**	**$1,530**	-	-
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$0.89	-	-

Cumulative Costs of All New Projects, by Phase:					
-- Capital Cost	($)	$0	$96,100,000	$96,100,000	$96,100,000
-- Unit Cost (Melded)	**($/AF)**	**$0**	**$1,530**	**$1,530**	**$1,530**
-- Increase to Typical Residential Water Bill	($/mo)	$0.00	$0.89	$0.89	$0.89

Figure 7-20 – Volume and Cost Summary for Strategy SB-3

* As SBWRP inflow volume increases over time, reuse volume will correspondingly increase.

Incentive Credits and Avoided Costs

The actual cost of each alternative implementation strategy to the City will likely be, in most cases, less than the straight sum of the component project capital and operating costs. Two factors that could contribute to this cost reduction are:

- **Incentive Credits:** The first factor that could reduce the City's cost is the availability of incentive credits for water reuse projects. These monetary credits are provided by the MWD and the Water Authority as a means of promoting the development of water reuse and other alternative local water supply projects.

- **Avoided Costs:** The second factor that could reduce the City's cost for water reuse projects is the potential for these projects to offset other water and wastewater capital and operating costs that the City would otherwise incur. Economists call such cost offsets avoided costs. Avoided costs can be credited to the cost of the water reuse project, reducing its effective cost to the City as a whole. Some avoided costs are ***direct*** cost offsets, in that they place real dollars in the City's accounts concurrent with the operation of the project. Other avoided costs are ***indirect*** cost offsets, in that they avoid or lessen the need for some possible future project, or provide other benefits that do not directly put real dollars in the City's accounts.

Reuse credits and avoided costs are summarized in **Tables 7-11** and **7-12**. **Table 7-11** describes each credit or avoided cost factor, and **Table 7-12** summarizes the net dollar effect for each of several categories of projects. These credits and avoided costs are factored into the unit cost and rate effect data presented in the previous cost tables and figures.

Table 7-11
Summary of Reuse Incentive Credits and Avoided Costs

Cost Component	Description	Dollar Amount	Direct or Indirect?
Incentive Credits:			
1. Water Authority Credit	Financial incentive program by Water Authority. Designed to encourage development of reuse projects.	**$100/AF savings**, all projects	Direct
2. MWDSC Credit	Financial incentive program by the MWD. Credit amount is per the City's agreement with Metropolitan.	**$250/AF savings**, all projects except wetlands and sales to other agencies	Direct
Avoided Facility Operating and Capital Costs:			
3. Avoided Wastewater Operating Costs	The NCWRP reduces the plant's discharges to Point Loma, saving operations costs to and through Point Loma. No similar savings accrue at the SBWRP because the facility has its own ocean outfall.	**$60/AF savings**, all North City projects	Direct
4. Incurred Wastewater Operating Costs	To produce recycled water, the City incurs additional operating costs to operate the tertiary filters at both the NCWRP and SBWRP, and also the demineralization facility at the NCWRP. The latter does not apply for reservoir augmentation projects.	**$100/AF cost**, all North City except reservoir augmentation (IPR) **$50/AF cost**, all other	Direct
5. Avoided Wastewater Capital Costs	At the NCWRP, recycled water put to beneficial use reduces the wastewater inflow to Point Loma. However, this does not offset any capital costs because the City is required to maintain full wet-weather backup flow disposal capacity to convey NCWRP flows to Point Loma. At the SBWRP, recycled water reduces the flow of treated wastewater out the ocean outfall, but does not offset any capital costs.	**$0/AF savings,** all projects	Indirect
6. Avoided Water Treatment Plant Capital Costs	Some projects may offset the need for the City to expand its water treatment plants, or may allow existing plants to treat a higher percentage of the City's total potable supply. Eligible projects are all types except wetlands creation, which does not offset a potable water demand, and reservoir augmentation, which does not reduce water treatment plant capacity requirements. At the NCWRP, existing and planned summertime uses already utilize approximately 18 MGD of the plant's 24 MGD capacity. Thus the potential treatment plant cost offset for new projects is limited to the remaining 6 MGD of capacity. At the SBWRP, all of the contemplated new uses are either uses outside the City, or are Reservoir Augmentation projects, and do not offset any City treatment plant costs. Based on the City's actual costs to expand the Miramar Filtration Plant ($167,000,000 for 75 MGD), the City values treatment capacity at approximately $2,200,000 per MGD.	**$2,200,000 savings per MGD of summertime use**, first 6 MGD of additional qualifying North City summertime use	Indirect
7. IPR Water Quality Benefit	IPR projects will produce water that has a lower TDS concentration than existing imported water supplies. This reduction assists the City with water reclamation efforts and groundwater management efforts by reducing the need for expensive demineralization processes, and benefits the City's customers by extending the life of water heaters and other household fixtures. The value of this benefit has been estimated based on data from the 1999 Salinity Management Study (MWD, U.S. Bureau of Reclamation). The analysis assumes that IPR projects will produce water with a TDS approximately 400 mg/L less than imported water.	**$200/AF savings**, All IPR projects	Indirect

Table 7-12
Summary of Cost Credits by Category of Reuse

Cost Component	Direct / Indirect	Types and Locations of Reuse ($/AF)						
		Recycled Supply from NCWRP				Recycled Supply from SBWRP		
		Title 22 (except wetlands)	Wetlands	Reservoir IPR	Ground-water IPR	Title 22	Sale to others (Title 22)	Reservoir IPR
1. SDCWA Credit	Direct	$100	--	$100	$100	$100	--	$100
2. MWDSC Credit	Direct	$250	--	$250	$250	$250	--	$250
3. Avoided Wastewater Operating Costs	Direct	$60	$60	$60	$60	--	--	--
4. Incurred Wastewater Operating Costs	Direct	($100)	($100)	($50)	($100)	($50)	($50)	($50)
5. Avoided Wastewater Capital Costs	Indirect	--	--	--	--	--	--	--
6. Avoided Water Treatment Plant Capital Costs	Indirect	$13 M capital credit to first 6 MGD of new reuse	--	--	--	--	--	--
7. IPR Water Quality Benefit	Indirect	--	--	$200	$200	--	--	$200
TOTALS – DIRECT:		$310	($40)	$360	$310	$300	$(50)	$300
TOTALS – INDIRECT:		See No. 6 credit	--	$200	$200	--	--	$200

Cost Considerations Regarding Supplemental Water or Seasonal Storage to Meet Peak Summer Demands

To meet peak summer demands, some strategies require either supplemental purchases of imported water, or seasonal storage. These are factored into the summary cost tables earlier in this section.

In some of the strategies, the summertime peak demand for recycled water exceeds the recycled water production capacity of the corresponding water reclamation plant. When this peak demand occurs, the cost tables and figures presented earlier in this section include the costs for the City to do one of two things:

Supplement: One option is to supplement the recycled water supply with purchased imported water. This option does not maximize the volume of water reused, but is generally less expensive than providing seasonal storage, even after accounting for water purchases as an operating cost of the strategy.

Seasonal Storage: The other option is to provide seasonal storage. This option maximizes the volume of water reused, but is generally more expensive than supplementing with imported water.

Because of the high cost of seasonal storage, that option has been deferred until the last steps of the implementation strategies. Should less expensive seasonal storage opportunities become available to the City, or should summer peak demands turn out to be different than forecasted, the City could re-evaluate this decision. The cost tables and figures presented earlier in this section include the costs for supplemental water purchases or seasonal storage as required.

Comparison of Water Reuse Project Costs with Other Sources of New Water

One of the main benefits of developing additional uses of recycled water is that these uses help to reduce the City's need to purchase imported water or to develop other water supplies to meet its growing demands. Every acre-foot of beneficially used recycled water is an acre-foot of imported water that the City does not need to purchase. Other water supplies include imported water, seawater desalination and water transfers.

The City purchases imported water from the Water Authority, which in turn purchases a majority of its water from the MWD. The Water Authority's current treated water rates are $526 for treated municipal and industrial (M&I) water, consisting of a $431/AF MWD cost of supply, and a $95/AF Water Authority charge. Untreated M&I water rates are $444/AF, consisting of the $349/AF MWD untreated rate, and a $95/AF Water Authority charge.

The City mostly purchases untreated water, at a current price of $444/AF, and treats this water at its own treatment plants prior to distribution to customers. Accounting for costs to operate the treatment plant, the City's current average cost to purchase and treat water is approximately **$500/AF**.

The City's current average cost to purchase and treat water is approximately $500/AF.

In their efforts to serve increasing demands, both the Water Authority and MWD are pursuing new sources of supply, including seawater desalination and water transfers. These new supplies are often more expensive than existing supplies, and as such may represent the true marginal cost of water, and the more appropriate point of comparison for water reuse costs.

Seawater Desalination: Continued improvements in desalination technology have lowered costs to the point that many water agencies up and down the coast of California are evaluating seawater desalination projects as a possible means of supplementing their water supplies. Locally, the Water Authority is continuing to investigate the possibility of building a 50 MGD or larger seawater desalination facility at the Cabrillo power plant in Carlsbad. This proposed facility can be used as a basis for estimating the unit costs of desalination.

The Carlsbad project, as currently proposed, would involve the construction and operation of a desalination plant by a private developer. In 2003, the developer offered to sell water from the proposed plant to the Water Authority for a set price of slightly less than $800/AF, exclusive of conveyance, and with the price indexed to several factors, (including power costs) to provide mechanisms for escalation. Since that time, the Water Authority and the plant developer have had difficulty agreeing on the actual terms of the agreement, and the project remains in the negotiating stage. Accounting for construction price inflation over the past two years, and accounting for the negotiating difficulties encountered to date, it is reasonable to assume that the 2005 price for a project agreement

A reasonable comparative cost for seawater desalination in San Diego County is approximately $1,400/AF.

acceptable to both the developer and the Water Authority will be approximately $1,000 to $1,100/AF, exclusive of conveyance. Based on capital and operating cost numbers reported by the Water Authority in their preliminary analysis of project conveyance facilities, the unit cost of conveying this water back to the Water Authority aqueduct system would be approximately $300 to $400/AF. Combining the average estimates for treatment and conveyance, a reasonable comparative cost for seawater desalination in San Diego County is approximately **$1,400/AF**. This figure does not include any incentives, grants or credits.

Water Transfers: In 2003, the Water Authority completed its efforts to secure a long-term water transfer agreement with the IID. The agreement provides for IID to transfer 200,000 AFY of water to the Water Authority, starting with 20,000 AF in 2004 and ramping up to the full 200,000 AF over the course of approximately ten years. As part of the overall package of implementing agreements, the Water Authority also obtained rights to approximately 77,000 AFY of water that will be conserved by the lining of the All American and Coachella Canals. The Water Authority estimates that its current cost of transferred water, before treatment, is $534/AF. The Water Authority is also incurring related project costs for mitigation of project environmental and socioeconomic effects in the Imperial Valley. In addition, over the long-term the Water Authority will incur additional costs to provide the transmission capacity to deliver this water to San Diego County. Finally, the City will incur additional costs to treat this water at one of the City's water treatment plants Accounting for these additional project costs, the Study suggests that a reasonable comparative cost for water transfers in San Diego County is approximately **$800/AF**.

A reasonable comparative cost for water transfer costs is approximately $800/AF.

7.6 Evaluation Summary

The principal findings from the preceding evaluations of the six strategy alternatives are as follows:

1. **All of the presented alternatives are feasible.** For both the North City and South Bay systems, there is a range of reuse strategies that are feasible from an engineering, scientific, and regulatory perspective. For the IPR strategies, public acceptance will depend on the City's commitment and ability to garner public support through an extensive public involvement program.

2. **The City faces choices between non-potable and indirect-potable uses.** The strategies differ in their type of use, specifically, between those that exclusively pursue non-potable uses and those that include IPR. In deciding which strategies to pursue, the City will need to weigh the merits of each type of use.

3. **The City faces choices in deciding how far to pursue a selected strategy.** Within each strategy, there are implementation steps that add new units of use, usually at progressively higher and higher incremental costs. In deciding how far along each strategy to advance, the City will need to weigh these costs with water supply reliability, sustainability, and other values suggested in the preface of this report.

4. **Specific North City strategy findings include:**

- **NC-1** has the lowest initial capital cost and lowest unit cost of all North City strategies through the second step of the strategy. However, if the desire is to fully maximize use of the available recycled water supply, subsequent steps have higher unit costs and make this alternative comparatively more expensive. This strategy appears to be the appropriate choice if the driving decision factors are to minimize initial capital outlays and to commit to a non-potable reuse approach.
- **NC-2** includes the opportunity to switch from non-potable to IPR. This strategy appears to be the appropriate choice if the driving decision factor is to minimize initial expenditures, while still having the ability to accomplish an IPR project.
- **NC-3** maximizes the available North City water supply in one step through IPR. For a strategy that fully maximizes use of the available recycled water supply, it provides the lowest overall unit cost. However, this strategy has the highest initial capital costs. This strategy appears to be the appropriate choice if the driving decision factors are to maximize recycled water use and have the lowest ultimate unit cost.

5. **Specific South Bay strategy findings include:**

- **SB-1** has the lowest initial capital cost and lowest unit cost of all South Bay strategies. This strategy appears to be the appropriate choice if the driving decision factor is to minimize expenditures, even if the use occurs outside City service areas.
- **SB-2** includes a mix of non-potable uses and a small-scale IPR project. This strategy appears to be an appropriate choice either if the driving decision factor is to retain use of the South Bay recycled water within the City, or if the projected non-potable uses envisioned in strategy SB-1 do not come to fruition.
- **SB-3** includes a mix of non-potable uses and a large-scale IPR project. This strategy appears to be an appropriate choice either if the driving decision factor is to retain use of the South Bay recycled water within the City, or if the projected non-potable uses envisioned in strategy SB-1 do not come to fruition.

7.7 Next Steps

This Study simply assesses the advantages, constraints, and values of the different water reuse opportunities available to the City. The Study does not seek to recommend a specific strategy.

This report was reviewed by the Assembly and the IAP. Both of these groups have issued written statements commenting on the Study's analysis and findings, and are included as Appendices B, C and E.

This report was presented to the PUAC on August 21st, 2005; their resolution has been included as Appendix D. The Study will be presented to the City's Natural Resources and Culture Committee and subsequently to Council for their consideration and direction as to the City's future course of water reuse development.

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8.0 Glossary of Terminology and Abbreviations

Acre-foot (AF): A unit commonly used for measuring the volume of water, equal to the quantity of water required to cover one acre to a depth of one foot. An acre-foot is 325,851 gallons and is considered enough water to meet the needs of two families of four for one year.

Advanced Treatment: Additional treatment provided to remove suspended and dissolved substances after conventional secondary treatment. Often this term is used to mean additional treatment after tertiary treatment for the purpose of further removing contaminants of concern to

public health. This may include membrane filtration, reverse osmosis (RO), advanced oxidation, and disinfection with ultraviolet light (UV) and hydrogen peroxide (H_2O_2).

AF: Acre-foot.

AFY: Acre-feet per year. The amount of water (in acre-feet) used, bought or produced in one year.

City of San Diego Assembly on Water Reuse: American Assembly-style workshop that brought together diverse stakeholders to examine public policy questions and recommend action.

Aquifer: A geologic formation that stores water and yields significant quantities of water to wells or springs.

Assembly: City of San Diego Assembly on Water Reuse.

Augmentation: The process of adding recycled water that has received advanced treatment to an existing raw water supply (such as a reservoir, lake, river, wetland, and/or groundwater basin) that could eventually be used for drinking water after further treatment.

Avoided costs: The cost savings that may accrue to a water provider if a given water reuse project delays or eliminates the need for a water or wastewater system improvement project.

Beneficial use (of water): A use of water resulting in appreciable gain or benefit to the user, consistent with state law, which varies from one state to another. In California, beneficial uses of waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural, and industrial supply, power generation, recreation, aesthetic enjoyment, navigation, as well as preservation and enhancement of fish, wildlife, and other aquatic resources or preserves. (Water Code, Section 13050(f)).

Blending: Mixing or combining one water source with another.

Caltrans: California Department of Transportation.

City: City of San Diego.

Contaminant: An undesirable substance not normally present or an unusually high concentration of a naturally occurring substance in water, soil or other environmental medium.

Costs: The capital and operating expenses of constructing and operating a water reuse project. They usually consist of (1) Capital costs, the initial expenditures to design and construct project facilities; and (2) Operating costs, the ongoing annual expenses associated with operating the project, including labor, material, and energy costs.

Costs of Inaction: The costs of not implementing a proposed project. For reuse projects, these costs may include the cost of obtaining other water supplies to meet a community's needs.

Council: The City Council of San Diego.

CWA: Federal Clean Water Act.

Demineralization: A process that removes dissolved minerals from water. In some cases, a percentage of water is demineralized and blended back in with the original source water to dilute the level of dissolved solids in the source water.

Detention time: In storage reservoirs, the length of time water will be held before being used.

DHS: California Department of Health Services.

Direct Injection: Injecting recycled water through an injection well directly into a groundwater basin. If the water will later be used for drinking, the recycled water will receive advanced treatment prior to injection.

Direct potable reuse: The addition of advanced treated recycled water (purified water) directly to a potable water distribution system.

Disinfection: Removal or inactivation of any organism.

Disinfection By-Products: (1) Chemicals that are formed when a disinfectant such as chlorine is added to water that contains organic matter, usually from decaying plant or animal material. (2) Compounds that form when chlorine combines with naturally occurring or pollution-derived organic, carbon-based materials, such as the acids from soils or decaying vegetation and bromide (salt).

Drinking Water: See "Potable Water".

Endocrine Disrupting Compounds (EDCs): Chemicals that can interfere with the normal hormone function in humans and animals.

EPA: U.S. Environmental Protection Agency.

Epidemiological: Dealing with the scientific study of the incidence, control and spread of disease in a population.

Emergency Storage Project (ESP):, a multi-facility program being implemented by the San Diego County Water Authority to increase raw water storage capacity in San Diego County.

ESP: See "Emergency Storage Project."

Firm supply: A water supply is considered firm if it is a reliable source for a community, either by legal rights or by natural availability. Recycled water is usually considered to be a firm supply as its source remains available even during dry years.

Graywater: Wastewater from household bathroom or restroom sinks, clothes washers, bathtubs, or showers. Graywater may undergo minimal on-site treatment and may be used for underground irrigation when permitted by local health officials.

Groundwater: Water beneath the Earth's surface that could supply wells or natural springs.

Groundwater Basin: A groundwater reservoir, defined by an overlying land surface and the underlying aquifers that contain water stored in the reservoir. In some cases, the boundaries of successively deeper aquifers may differ and make it difficult to define the limits of the basin.

Groundwater Recharge: Naturally or artificially adding water back into a ground water basin by allowing the water to seep through the ground or by injection.

HCF: Hundred cubic feet, equal to 748 gallons.

IAP: Independent Advisory Panel formed by the National Water Research Institute to provide technical oversight of the Water Reuse Study.

IBWC: International Boundary and Water Commission.

IID: Imperial Irrigation District.

Imported Water: Water transported from one region or area to another.

Indirect Potable Reuse (IPR): The blending of advanced treated recycled water into a natural water source (groundwater basin or reservoir) that could be used for drinking (potable) water after further treatment.

Infill: Increase water reuse demand through connection of large users within 1,320 feet (quarter-mile) of the existing reclaimed water pipeline.

IPR: Indirect potable reuse.

IX: Ion exchange.

MBR: Membrane bioreactor (a type of biological wastewater treatment process).

MCL: Maximum Contaminant Level as defined in the EPA Drinking Water Standards.

MF: Microfiltration.

MG: Million gallons.

MGD: Million gallons per day.

M&I: Municipal and Industrial.

Microfiltration (MF): The separation or removal from a liquid of particulates and microorganisms in the size range of 0.1 to 2 microns in diameter. (A micron is a millionth of a meter. A sheet of ordinary 20-weight copier paper is about 90 microns thick.)

Multi-Barrier Approach: Treatment barriers designed to remove various types of contaminants using independent processes, insuring that treatment will not be compromised if any process were to fail.

Multiple Treatment Barriers: Each barrier is designed to provide substantial protection with redundant barriers for each type of treatment. A requirement for multiple barriers assures the overall water treatment process will remain effective if one treatment barrier were to fail.

MWD: Metropolitan Water District of Southern California.

MWWD: City of San Diego Metropolitan Wastewater Department.

National Pollutant Discharge Elimination System (NPDES): The program established by the Federal Clean Water Act that requires all sources of pollution discharging into any "waters of the United States" to obtain a permit issued by the Environmental Protection Agency or a state agency authorized by the federal agency. The NPDES permit lists permissible discharges and/or the level of cleanup technology required for wastewater.

NCWRP: North City Water Reclamation Plant.

Non-potable Reuse: Includes all recycled water reuse applications except those related to drinking water.

NPDES: National Pollutant Discharge Elimination System.

NRC: National Research Council.

NWRI: National Water Research Institute.

O&M: Operation and Maintenance.

Ocean Outfall: A large pipeline used to dispose of treated wastewater several miles offshore.

OEHHA: Office of Environmental Health Hazard Assessment (State of California).

Operational reliability: The reliability of the City's water treatment and distribution systems to avoid upsets and to continue to serve customers even with individual system elements out of service for maintenance or repair.

OPRA: Federal Ocean Pollution Reduction Act**.**

OWD: Otay Water District.

Pathogens: Disease-causing organisms (generally viruses, bacteria, protozoa, or fungi).

Peak: An identified period of time when the maximum amount of water is used.

Peroxide (H_2O_2): Hydrogen peroxide.

PhACs: Pharmaceutically-active compounds.

PPCPs: Pharmaceuticals and personal care products.

Potable Water: Synonymous with *drinking water*. Specifically, fresh water that meets the level of quality as established in the EPA Drinking Water Standards.

Poway: City of Poway.

Primary Treatment: The removal of particulate materials from domestic wastewater, usually by allowing the solid materials to settle as a result of gravity. Typically, the first major stage of treatment encountered by domestic wastewater as it enters a treatment facility. Also, any process used for the decomposition, stabilization, or disposal of sludge produced by settling.

PUAC: Public Utilities Advisory Committee.

Purified water: Water that undergoes advanced treatment to a water quality suitable for augmentation to a drinking water source.

Reclaimed Water: The end product of wastewater reclamation that meets water quality requirements for biodegradable materials, suspended matter, toxicants, and pathogens. Reclaimed water is sometimes another name for recycled water.

Recycled Water: Reclaimed water that meets appropriate water quality requirements and is reused for a specific purpose.

Repurified Water: Recycled water treated to an advanced level suitable for augmentation to a drinking water source.

Residence Time: See "Detention Time."

Reverse Osmosis (RO): A common water filtration process that uses a semi-permeable membrane which allows water to pass through it, while removing contaminants.

RO: Reverse osmosis.

RWQCB: Regional Water Quality Control Board (State of California).

Secondary Treatment: Treatment following primary treatment. Removal of biodegradable organic matter and suspended solids from wastewater. Disinfection is usually the final stage of secondary treatment.

SBWRP: South Bay Water Reclamation Plant.

SDCWA-ESP: San Diego County Water Authority-Emergency Storage Project. See "Emergency Storage Project."

Soil-Aquifer Treatment: The process of water being purified by percolating through soil and into an underground aquifer.

Stakeholders: Individuals and organizations who are involved in or may be affected by a proposed action, such as construction and operation of a water recycling project.

Study: City of San Diego Water Reuse Study.

Supply Reliability: The reliability of the City's combined sources of supply of water under a variety of hydrologic and other conditions.

TDS: Total Dissolved Solids.

Tertiary Treatment: Treatment beyond secondary treatment typically involving the removal of residual particulate matter by granular media, surface, or membrane filtration.

Title 22 Treatment (Title 22): A method of tertiary wastewater treatment approved by DHS for many water reuse applications. Title 22, Chapter 4 of the California Code of Regulations, outlines the level of treatment required for allowable uses for recycled water, including irrigation, fire fighting, residential landscape watering, industrial uses, food crop production, construction activities, commercial laundries, road cleaning, recreational purposes, decorative fountains, and ponds.

Total Dissolved Solids (TDS): A measure of the amount of material dissolved in water (mostly inorganic salts). An important use of the measure involves the examination of the quality of drinking water. Usually expressed in milligrams per liter (mg/l).

UF: Ultrafiltration.

Ultrafiltration (UF): A membrane filtration process that falls between reverse osmosis (RO) and microfiltration (MF) in terms of the size of particles removed. UF removes particles in the 0.002 to 0.1 micron range, and typically removes large organic molecules, while allowing smaller molecules to pass.

Ultraviolet Treatment (UV): The use of ultraviolet light for disinfection.

UV: Ultraviolet treatment.

Water Authority: San Diego County Water Authority.

Water Reclamation: (1) The treatment of water of impaired quality, including brackish water and seawater, to produce a water of suitable quality for the intended use. (2) A term synonymous with *water recycling*.

Water Recycling: The process of treating wastewater for beneficial use, storing and distributing recycled water, and the actual use of recycled water.

Water Reuse: Synonymous with *water recycling*.

Wetland: An area periodically inundated by surface water or groundwater. Wetlands support plant and animal life, filter pollutants in stream courses, provide flood control and erosion prevention, and may provide recreational opportunities.

EQUIVALENCIES:

1 Hundred Cubic Feet (HCF) = .00230 Acre Feet (AF) = 748 gallons

1 AF = 435.6 HCF

1 AF = 43,560 cubic feet (cf)

1 AF = 325,851 gallons

1 cf = 7.48 gallons

1 million gallons per day (mgd) = 1,121 AF per year

1 AF is approximately the amount of water needed to serve two families of four for a year.

One family of four typically uses 18 HCF per month or 450 gallons per day.

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Appendix A
City Council Resolution R-298781

(R-2004-440)

RESOLUTION NUMBER R-__298781__

ADOPTED ON __JAN 13 2004__

RESOLUTION OF THE CITY COUNCIL REGARDING THE STUDY OF INCREASED ASPECTS OF WATER REUSE

WHEREAS, the Council of the City of San Diego adopted Resolution No. R-291210 on January 19, 1999, directing the City Manager not to spend any monies on water repurification until options for such reuse of water are evaluated and further direction is given by the Council; and

WHEREAS, the State of California in June 2003 issued a report entitled "Water Recycling 2030: Recommendations of California's Recycled Water Task Force," which called for a community-based process to evaluate a wide range of potential uses of recycled water; and

WHEREAS, on October 10, 2003, the City Manager issued City Manager's Report No. 03-203 entitled "Status Report on City of San Diego Long-Range Water Resources Plan (2002-2030)," which identified reclaimed water as an important source of a locally produced water supply and identified the City's two water reclamation plants: the North City Water Reclamation Plant and the South Bay Water Reclamation Plant, as important sources of reclaimed water to reduce the City's imported potable water demand; and

WHEREAS, the City's Natural Resources and Culture Committee on November 19, 2003 heard a full presentation on Alternative Water Sources, including testimony on the recently issued "Water Recycling 2030: Recommendations of California's Recycled Water Task Force" and unanimously recommended that the City Manager conduct a study of all aspects of increased water reuse; NOW, THEREFORE,

-PAGE 1 OF 2 -

BE IT RESOLVED, by the Council of the City of San Diego, that the City Manager is directed to conduct a study of one year duration evaluating all aspects of a viable increased water reuse program, including but not limited to groundwater storage, expansion of the distribution system, reservoirs for reclaimed water, livestream discharge, wetlands development, and reservoir augmentation. The study and report of same shall include a general assessment of costs and benefits of such projects including, but not limited to, consideration of public health, public acceptance, water costs, water supply reliability issues, compilation of research/studies concerning reservoir augmentation, and information concerning potential impacts of pharmaceuticals, endocrine disruptors, personal care products, and additional constituents of the wastewater stream on water quality and health. The study and report, when completed, shall be calendared before the Natural Resources and Culture Committee for such action as it deems appropriate.

APPROVED: CASEY GWINN, City Attorney

By Ted Bromfield
Ted Bromfield
Senior Deputy City Attorney

TB:mb
11/20/03
Or.Dept:NRC
R-2004-440

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Appendix B
American Assembly I Statement

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AMERICAN ASSEMBLY I STATEMENT

Regarding Water Reuse Goals, Objectives, Options and Criteria

City of San Diego
Water Reuse Study 2005

American Assembly Workshop I
October 6, 7 and 29, 2004

American Assembly I Statement
Regarding Water Reuse Goals, Objectives, Options and Criteria

October 6, 7 and 29, 2004

San Diego, California

I. Introduction

The City of San Diego has been tasked through City Council Resolution R-298781 to conduct an impartial, balanced, comprehensive and science-based study of all recycled water opportunities so the City of San Diego can meet current and future water needs.

Recycled water is municipal wastewater that has been treated to a high level so that it can be reused for a variety of beneficial purposes.

The mission of the study is stated below:

To pursue opportunities to increase San Diego's water supply reliability and optimize local water assets, through an open and comprehensive study of recycled water with the involvement of the community.

The five primary goals of the study are:

1. To identify and develop opportunities for uses of recycled water that protect public health and safety.
2. To identify and develop opportunities for recycled water that are cost-effective, environmentally sustainable and reflect public values through a fair and unbiased evaluation.
3. To partner with residents, media, businesses, industries, organizations, schools and government to assist public policy makers in making informed, value-based decisions on how to best use recycled water.

4. To educate the public to expand the public's awareness, knowledge and involvement, and present information in a way that is understandable and accessible to all San Diegans.
5. To provide sound technical, environmental, and economic evaluations of the opportunities, with plans, to submit to the City Council for consideration.

Reuse opportunities will be examined through public involvement sessions and an Independent Advisory Panel of experts will review, critique and provide recommendations on study efforts.

A group of community leaders and stakeholders participated in an American Assembly in San Diego, California in October 2004 to debate and validate the goals, objectives and evaluation criteria (values) for study consideration and, ultimately, any City Council policy decision. The intent of this first American Assembly workshop was to discuss and document community viewpoints and issues related to recycled water use and ensure that the study examines those issues.

The assembled group addressed six questions:

1. Have the appropriate goals and objectives been identified?
2. Are there other goals and objectives that should be considered?
3. What water reuse opportunities should be considered?
4. What are the key considerations associated with these reuse opportunities?
5. What should the study team investigate?
6. Are the values presented appropriate for comparing the reuse opportunities?

The delegates to the American Assembly debated and recorded their perspectives on recycled water use alternatives. This American Assembly Statement reflects a spectrum of consensus views of the assembled delegates and was affirmed in plenary session. Significant minority viewpoints are included.

II. Summary Statement

The Assembly strongly believes that recycled water can and must play a significantly greater role in the City of San Diego providing added water reliability and environmental benefits. As such, the Assembly is unanimous in its support for the expansion of recycled water for non-potable uses.

The majority of the Assembly supports the aggressive and visionary expansion of recycled water for potable and non-potable uses where the opportunities exist. There are critical conditions that must be met for any alternative that will expand this supply. First and foremost, it must be safe and protect public health. While the Assembly offered strong support for indirect potable reuse, there are clearly members of the Assembly and the community who are concerned about the public health effects of indirect potable reuse. This issue will need to be thoroughly explored and the state of knowledge regarding treatment processes, reliability and risk assessed. A clear presentation of the technical information in a readily understandable manner is vital to ensure any public policy decision is well informed. The Independent Advisory Panel will be especially helpful in this regard.

Of nearly equal importance is the cost-effectiveness of the water supply, imported and recycled. Both direct and avoided costs must be compared on a common basis. The study must be sensitive to those in the community for which water costs represent a substantial economic burden. In this respect, grants, incentives and other external funding must be pursued.

It is critically important to the success of any proposal that the Water Department aggressively pursue community outreach and public education activities to foster understanding of the alternatives and issues. A well-informed public will help ensure that any public policy decision of the City Council is sound. Lastly, the Assembly believes strong community and political leadership is necessary to advance the goals and objectives of the study.

III. Evaluation Criteria (Values)

In the view of the Assembly, the evaluation criteria listed in the white paper are reasonable. The Assembly believes there are certain refinements that would improve the quality of the assessment. In particular, there is a primary concept of “sustainability” that should guide the assessment of the alternatives. Sustainability considerations include public acceptance, protection of public health, cost-effectiveness, protecting and restoring the environment, greater regional water reliability, and diversification of supply. In assessing reuse opportunities and alternatives, the Reuse Study must describe and communicate the consequences of not maximizing the use of this water. These consequences include the need to obtain other water supplies, or barring this to incur supply shortages.

Specific evaluation criteria are listed in the table below.

Table 3-1

Evaluation Criteria for Assessment of Reuse Options

Criteria	Objective	Performance Measure
Health and Safety	To protect human health and safety with regard to recycled water use	Meets or exceeds federal, state and local regulatory criteria for recycled water uses
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups	Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.
Environmental Value	To enhance, create or improve local habitat or ecosystems and avoid or minimize negative environmental impacts	Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits required.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water	Increases percent of water recycling and improves local reliability.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs	To meet all customer quality requirements.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions	Level of demand met and opportunities for system interconnections and operational flexibility are addressed.
Cost	To minimize total cost to the community	Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability	Level of difficulty in physical, social or regulatory implementation.

Health and Safety

The safety of recycled water, whether for potable or non-potable uses, is the paramount issue. The primary objective of all projects considered under the Reuse Study is to protect human health. It is essential that recycled water meets or exceeds applicable federal, state, regional, and local regulations. The use of recycled water as a source of supply must incorporate stringent monitoring requirements to ensure that health standards are met and public health is protected. Treatment goals may be established that are more stringent than regulatory limits as safety factors to make certain that the regulatory limits are never violated. Assembly delegates offered strong support for indirect potable reuse, however, there are members of the Assembly and the community that will require convincing evidence of the safety of indirect potable reuse to garner their support.

Social Value

Recycled water has the potential to enhance the quality of life in San Diego by providing a firm source of supply even in drought conditions. Recycled water must be made available at equal levels of service to all socioeconomic groups within the region so that these benefits can accrue to all. A carefully conducted reuse planning effort that includes thorough public outreach and community participation can also increase public trust in the region's water supply.

Environmental Value

Reuse alternatives must seek to sustain, enhance, or create local ecosystems, and to avoid or minimize adverse environmental effects with a goal of a net environmental benefit. The study must summarize key anticipated environmental effects for consideration by policy makers and stakeholders. The study must also identify the environmental documentation and permitting issues associated with each reuse alternative.

Local Water Reliability

The City should seek to substantially increase the percentage of its water supply derived from recycled water, thereby offsetting the need for imported water and enhancing the reliability of the City's supply. The Study shall address reuse goals that go beyond the goal established in its current Long-Range Water Resources Plan. Reuse opportunities that offset the need for imported water would be valued higher than opportunities that do not offset imported water supplies.

Water Quality

Certain users of recycled water have specific water quality needs. For example, salt tolerance of plants is an important criterion for irrigation uses. Certain industrial uses of recycled water are extremely sensitive to the amount of total dissolved solids. Further treatment of recycled water at the point of use may be required to provide finished water quality that is compatible with the intended use.

Operational Reliability

The Assembly delegates were generally comfortable with the Operational Reliability evaluation criteria. Timing of projects was identified as an important consideration.

Cost

While cost is an important issue for the Assembly delegates, it should not necessarily be the determining factor. The cost analysis must be comprehensive and allow comparison among opportunities identified and other water supply options (such as desalination, conservation, etc.). Initial costs, such as capital/ construction, design and environmental permitting are important components of overall project feasibility. Avoided costs (predominantly related to the water and wastewater systems) and costs of inaction must be considered. Ongoing costs, such as operation, maintenance and public outreach must also be considered. Costs must be put in terms that consumers understand.

The delegates felt grant and other funding must be pursued. One viewpoint on grant funding noted that grant money is still taxpayer money and it may not be a complete offset. Costs shall also address incentives (e.g. revolving loan funds) and customer cost considerations (e.g. meters and dual piping). Cost incentives to customers, as well as an opposing viewpoint of whether low cost water devalues recycled water, should be pursued. Costs must also consider rates and revenue and the impacts and benefits to non-users of recycled water.

Ability to Implement

The study must evaluate the viability of the various alternatives including the determination of potential fatal flaws. The political and public acceptability of each alternative must be assessed.

IV. Reuse Options

The Assembly believes that the reuse options discussed in the white paper are appropriate for assessment but must be expanded to consider additional opportunities. Recycled water comprises approximately 6 MGD of the City's water supply and is anticipated to reach 12 MGD by 2010, based on current planning. The Assembly believes that this number should be expanded. The study must assess the ability of the city to use the full 45 MGD of existing recycled water capacity. The study must also assess the viability of expanding the system to maximize the feasible reuse of wastewater and minimize ocean discharge. The list of options for assessment shall include:

Non-Potable Reuse Options

Non-potable reuse encompasses all recycled water applications that do not involve blending with the public water supply. Examples of non-potable reuse are irrigation of golf courses and parks; most agricultural irrigation; industrial use for cooling towers and boilers; car washes and commercial laundries; and flushing of toilets and urinals. It can also include enhancement opportunities through environmentally beneficial live stream discharge or creation of wetlands.

Distribution System Expansion Opportunities. Opportunities to further expand recycled water service within the City, as well as to interconnect with adjacent municipal or agency operated recycled water systems, must be developed as part of the Reuse Study.

Maximizing use of recycled water from existing treatment plants is very important. Distribution system expansion could result in substantial savings in the cost of and need for imported water. Opportunities to further expand recycled water services within the City and interconnect with adjacent municipal or agency operated recycled water systems must be developed as part of the Reuse Study.

The Assembly delegates generally agreed with the opportunities associated with expanding the North City and South Bay distribution systems. The type of use, proximity to existing infrastructure, quantity used, water quality and system costs necessary for construction of separate piping systems needs are important considerations. Customer costs are equally important considerations in distribution system alternatives.

Delegates also suggested additional distribution opportunities including residential irrigation, increased usage for fire fighting, street/storm-drain cleaning application, and construction site dust suppression. Public/private partnerships with key stakeholders/customers should be considered to increase the distribution of recycled water. Use of recycled water at regional (e.g. Balboa and Mission Bay Parks) and City neighborhood parks, as well as at other City properties, can serve as important examples to other potential users of recycled water. Distribution system expansion to local military bases could increase the potential for year-round use of recycled water. Interagency, regional and/or international opportunities that do not limit recycled water use to within City borders also should be assessed.

Seasonal Storage Opportunities. By providing seasonal storage the City could produce a constant flow of recycled water year round and store the off-season flows to meet peak irrigation demands during the summer months. Opportunities for seasonal storage include groundwater recharge and recovery, pumped storage/energy recovery and a dedicated recycled water reservoir. The Assembly encouraged the Study Team to investigate and evaluate possible reservoir and aquifer locations where seasonal storage could be located.

Wetlands Creation and Live Stream Discharge Opportunities. The Water Reuse Study must investigate using recycled water for discharge to existing streams (live stream discharge) as well as the creation or enhancement of wetlands. Seasonal discharge to replicate historic stream flows, and offstream wetlands creation opportunities in the vicinity of sources of recycled water supply, must be considered. Assembly delegates expressed concerns that wetlands development needs to consider historic environmental conditions and maintenance requirements. Most Assembly delegates recognized the benefit of creating areas where the public could observe wildlife and take advantage of recreational opportunities.

Water transfer of recycled water. The Reuse Study must identify opportunities and constraints of conveying recycled water outside of the San Diego region to the Salton Sea or to other areas. The transfer of recycled water could be in exchange for other water that would be conveyed to San Diego in the existing conveyance system or the recycled water could be sold and the funds used to purchase additional imported water (if available) or to develop other sources of local water such as desalination.

Satellite reclamation water plants. The Reuse Study must identify opportunities and constraints of constructing small recycled water plants adjacent to current and future locations that have potential recycled water demand, yet may be too far from the recycled water distribution system to receive recycled water in the future. Technology such as Membrane Bio-Reactors (MBR's) may be appropriate technology for satellite recycled water plants and can produce recycled water on demand.

Gray Water Opportunities. The Reuse Study shall investigate legal and physical opportunities and constraints of gray water use, with emphasis on ways and means that individual residential and commercial users may be able to utilize gray water on their property. This may require revising existing laws or ordinances.

Potable Reuse Options

Indirect Potable Reuse

Indirect potable reuse is the practice of taking recycled water that meets all regulatory requirements for non-potable use, further treating it with several advanced treatment processes and adding it to an untreated surface water or groundwater supply. This water may be subject to further treatment or disinfection in order to meet potable water standards.

The Assembly was supportive of exploring indirect potable reuse. Concerns over the health effects of small concentrations of contaminants that might be left in the product water after extensive treatment must be addressed. One of the opportunities for reusing water is to further treat wastewater from the North City and South Bay Reclamation Plants for indirect potable reuse. This opportunity, however, carries some of the greatest challenges.

Experts and members of the public alike agreed that multiple barriers of treatment between the recycled water source and the potable use option are crucial for protecting public health and for increasing public acceptance. It is important that a time element be included in any potable reuse option so that the monitoring system in place can detect any changes in treatment efficiency and preclude water that may not meet internal goals or regulatory requirements from entering the potable system. Also, detention times in groundwater aquifers and surface water reservoirs are important issues that the study shall consider.

Extensive and systematic monitoring systems are needed to ensure compliance with regulations and to reassure the public that the quality of the potable reuse product is maintained at all times. A sophisticated monitoring system should be considered part of a good insurance policy for the success of the reuse projects and the results should be made public frequently.

Surface Water Opportunities. The Reuse Study must identify opportunities and constraints for using purified water to augment existing surface water reservoirs. The Study should also consider the creation and enhancement of wetlands upstream of a surface water reservoir to further enhance the water's quality through natural treatment prior to its entry into the reservoir.

Groundwater Opportunities. The Reuse Study shall identify opportunities and constraints for delivering purified water to local groundwater basins for subsequent extraction and use as a potable water supply. These evaluations shall consider the possible use for reclaimed water to create seawater intrusion barriers. The evaluations shall also address options for moving water into the groundwater basin, including spreading and injection/extraction operations.

Direct Potable Reuse

Direct Potable Reuse Opportunities. Direct potable reuse would entail the use of purified water followed by distribution in the potable supply system without any intervening natural treatment such as through a wetland or percolation into a groundwater basin. While direct potable reuse is currently prohibited in California (although it is practiced elsewhere), there was some sentiment from the American Assembly to include this as a future option. There are public health and safety reservations among some of the participants regarding direct potable reuse.

100% Direct Potable Reuse Opportunities. The study shall address upgrade requirements for all existing water reclamation plants to produce only water that meets direct potable reuse requirements. The study shall consider the cost differential between installing and maintaining a dual distribution system (including dual meters) vs. upgrading the existing reclamation facilities to produce potable water.

V. Public Outreach and Education

The Assembly delegates viewed public outreach and education as a critical component of any future City water reuse effort. They felt that it was important for residents to know the source and quality of their water and have a basic understanding of how recycled water fits into San Diego's local water supply. There was consensus that education is a key aspect to achieving public acceptance of increased water reuse. Further, the group felt that a flexible, aggressive and multi-dimensional education and outreach strategy is needed.

The Assembly delegates indicated that an effective education and outreach program must be included in school curricula (K-12 and college), involve the media, neighborhood and community groups and provide information on water use, sources and availability, water conservation, and the full water cycle (source, treatment, usage, treatment, discharge, reuse). Colorado River and California Aqueduct water quality must be compared to potable, recycled and purified water quality. Also, the group thought that showcasing local reclaimed water projects and facilities, as well as water treatment plants, would be a positive technique.

The Assembly delegates expressed concern over terminology such as "reuse", "recycling", "repurification", and "reclaimed water", noting that the "re-" component in these words had possible negative connotations. The delegates suggested that the City consider using alternative terminology in their public outreach program.

VI. Appendix

Investigations

The Assembly noted special investigations that should be conducted in the evaluation of the alternatives. These investigations included:

- Case Studies – the experiences of other communities that have undertaken various types of recycled water projects should be assessed. This includes any positive or negative experiences. Treatment technology used, risk issues and how they were dealt with, economics, public acceptance and other issues should be documented.

- Latest treatment studies – the assessment should consider the latest advancements in water treatment technology including cost, effectiveness, risks, etc.

- Grant funding – the Assembly believes that external funding should be leveraged to minimize the rate impact on ratepayers.

- Beneficiaries – the Assembly is interested in an evaluation of the beneficiaries of particular alternative courses of action. For example, decision to construct a particular project/approach might have benefits to labor, manufacturers, builders, etc. and these should be outlined.

- Biological effects/live stream discharge – wetlands creation may inundate areas that are not naturally inundated year round affecting species that require periodic dry conditions. This must be considered in the assessment of wetland creation opportunities.

Glossary

Avoided costs: The cost savings that may accrue to the City if a given water reuse project delays or eliminates the need for a water or wastewater system improvement project. For example, a reuse project might meet enough of a growing communities peak summer water supply to eliminate the need for a new water system pipeline that would otherwise be needed.

Contaminant: A substance in the water that is of public health or welfare concern; also an undesirable substance not normally present or an unusually high concentration of a naturally occurring substance. (E.g. viruses, bacteria, pathogens, antibiotics, hormones, dissolved minerals, including salts)

Costs: The capital and operating costs of building and operating a given water reuse project. Capital costs are the initial cost to design and construct project facilities. Operating costs are the ongoing annual costs of operating the project, including labor and material costs for operations and maintenance and energy costs for pumping.

Costs of Inaction: The Assembly delegates want make sure the study considers the costs to the City of not implementing reuse projects. These costs include the costs of obtaining other water supplies.

Direct potable reuse: The addition of advanced treated recycled water (purified water) directly to the potable water distribution system.

Firm supply: Water supplies are called firm if they are reliable both legally and hydrologically. For example, some surface water supplies are subject to reduction during dry years and therefore cannot be counted on as firm supplies. Reclaimed water is usually considered to be a firm source of supply because it remains available even under during dry years.

Gray water: Wastewater from a household or small commercial establishment that does not include water from a toilet, kitchen sink, dishwasher or water used for washing diapers.

Indirect potable reuse: The addition of advanced treated recycled water (purified water) to a natural water source (groundwater basin or reservoir) that could be used for drinking water after further treatment.

Multiple treatment barriers: A series of physical or chemical treatment processes that are expected to provide substantial protection to public health by assuring that the water treatment process remains effective even if one treatment barrier fails.

Operational reliability: The reliability of the City's water treatment and distribution systems to avoid upsets and to continue to serve customers even with individual system elements out of service for maintenance or repair.

Purified water**:** Recycled water treated to an advanced level suitable for augmentation to a drinking water source.

Recycled water: (same as Reclaimed water) The end product of wastewater reclamation that meets water quality requirements for biodegradable materials, suspended matter, and pathogens. This water meets appropriate water quality requirements and is reused for a specific purpose.

Supply Reliability: The reliability of the City's combined sources of supply under a variety of hydrologic and other conditions.

Equivalencies

1 Hundred Cubic Feet (HCF) = 0.002 Acre Feet (AF) = 748 gallons

1 AF = 435.6 HCF

1 AF = 43560 cubic feet (cf)

1 AF = 326,000 gallons

1 cf = 7.48 gallons

1 million gallons per day (mgd) = 1120 AF per year

1 AF is approximately the amount of water needed to serve two families of four for a year.

One family of four would typically use 18 HCF per month, or 450 gallons per day.

Attendees

Water Reuse Study 2005
American Assembly I Participants

First Name	Last Name	Group Represented
Armando	Abad	Naval Facilities Engineering Command
Greg	Alabado	Mayor's Advisory Board
Elaine	Allen	San Diego Association of Realtors
Joseph	Arlotto	Zoological Society of San Diego
Diana	Bergen	UCSD
Bobbette	Biddulph	Association of Environmental Professionals
Betsy	Brennan	Community Representative CD-1
Vernon	Brinkley	Skyline/Paradise Hills Planning Committee
Lee	Campbell	Community Representative CD-7, Tierrasanta Community Council
Roger	Cazares	Mayor's Advisory Board
Herman	Collins	State Recycled Water Task Force - Public Education Sub-Committee and Collins Strategic Group
Brian	Cooney	Community Representative CD-3
Dr. Aurora	Cudal	Council of Philippine American Org. of San Diego County
Bush	Cze	Mayor's Advisory Board
Betty	Dehoney	Association of Environmental Professionals
George	Diefenthal	Community Representative CD-3, Talmadge Maintenance Assessment District
Bishop Roy	Dixon	Community Representative CD-4
James	Endicott	San Diego Association of Realtors
Ed	Fletcher	Mayor's Advisory Board
Lois	Fong-Sakai	Asian Business Association
Terese	Ghio	Community Representative CD-1, BIOCOM
Marco	Gonzalez	Community Representative CD-6, San Diego Bay Council
Dawn	Guendert	San Diego Regional Chamber of Commerce
Dr. Gerald	Handler	Community Representative CD-1
W. William	Harvey	Community Representative CD-2
Kathy	Haynes	American Society of Civil Engineers
Rob	Hutsel	San Diego River Park Foundation
Bill	Jacoby	San Diego County Water Authority
Ed	Kimura	Sierra Club
Ben	Kline	Industrial Environmental Association
Josh	Knoefler	Community Representative CD-1, San Diego Regional Chamber of Commerce
Michelle	Krug	Community Representative CD-4
Walter	Lam	Alliance for African Assistance
Tiong	Liem	Asian Business Association
Jose	Lopez	Community Representative CD-7, Neighborhood Association Fox Canyon

First Name	Last Name	Group Represented
Joni T.	Low	Community Representative CD-5
Yolanda	Lujan	Community Planning Group CD-4
Richard	Lujan	Community Planning Group CD-4
Fred	Maas	Community Representative CD-1, Black Mountain Ranch
Andrew	Manzi	Community Representative CD-6
Brian	Maynard	California Landscape Contractors Association
Shawn	McMillan	Taiwanese Chamber of Commerce
Richard	Miner	Community Representative CD-3, Cherokee Point Resident
Chuck	Morgan	UCSD
Wayne	Nelson	Otay Mesa/Nestor Planning Committee
Dr. Joseph	Parker	Mayor, CWA Boardmember
Jim	Peugh	Community Representative CD-2, San Diego Audobon Society
Ken	Richardson	San Diego Regional Chamber of Commerce
Cathy	Ripka	Community Representative CD-5
Steven	Satz	Community Representative CD-3, Uptown Planners
E. Javier	Saunders	Mayor, CWA Boardmember
Glen	Schmidt	American Society of Landscape Architects
Catherine	Strohlein	Community Representative CD-2, Pacific Beach/Mission Bay Planning Committee
Judy	Swink	Community Representative CD-2, Mission Bay Park
Fred	Thompson	Mayor, CWA Boardmember
Yen	Tu	Mayor, CWA Boardmember
Claudia	Unhold	Community Representative CD-5, Miramar Ranch North Planning Committee
Muriel	Watson	Revolting Grandmas
Simon	Wong	Asian Business Association

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Observers

First Name	Last Name	Group Represented
Dr. Rick	Gersberg	Independent Advisory Panel and San Diego State University School of Public Health
Ron	Linsky	National Water Research Institute - formed the Independent Advisory Panel
Tom	Richardson	RMC – representative for Bay Council
Mike	Thornton	San Diego Elijo JPA
Fred	Zuckerman	Independent Advisory Panel and Tierrasanta Community Council

Appendix C
American Assembly II Statement

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CITY OF SAN DIEGO
AMERICAN ASSEMBLY STATEMENT II

City of San Diego
Water Reuse Study 2005

American Assembly Workshop II
July 11, 12 and 14, 2005

American Assembly II Statement
Regarding the Water Reuse Study 2005

Adopted on July 14, 2005

San Diego, California

Introduction

The City of San Diego has been tasked through City Council Resolution R-298781 to conduct an impartial, balanced, comprehensive and science-based study of all recycled water opportunities so the City of San Diego can meet current and future water needs.

The mission of the Water Reuse Study 2005 (Study) is: *To pursue opportunities to increase San Diego's water supply reliability and optimize local water assets, through an open and comprehensive study of recycled water with the involvement of the community.*

The five primary goals of the Study are:

1. To identify and develop opportunities for uses of recycled water that protect public health and safety.
2. To identify and develop opportunities for recycled water that are cost-effective, environmentally sustainable and reflect public values through a fair and unbiased evaluation.
3. To partner with residents, media, businesses, industries, organizations, schools and government to assist public policy makers in making informed, value-based decisions on how to best use recycled water.

4. To educate the public to expand the public's awareness, knowledge and involvement, and present information in a way that is understandable and accessible to all San Diegans.
5. To provide sound technical, environmental, and economic evaluations of the opportunities, with plans, to submit to the City Council for consideration.

A group of community leaders and stakeholders were asked to participate in an American Assembly regarding "Water Reuse Goals, Objectives, Options and Criteria" for the City of San Diego. An American Assembly workshop was conducted in October 2004, and the participants provided input to the City on the key issues and evaluation criteria for the assessment of recycled water use opportunities.

Since that workshop, the Study team has integrated American Assembly recommendations, stakeholder input and technical information to develop potential strategies for both non-potable and indirect potable use. An Independent Advisory Panel of experts provided insight, critique, and recommendations regarding these strategies. A summary of the proposed strategies and analysis is presented in the Water Reuse Study 2005.

The second American Assembly workshop was held in July 2005 to discuss the Study and provide input to the City Council on the identified strategies. American Assembly participants (Assembly) are listed in Appendix A. Members of the Independent Advisory Panel were in attendance. The Assembly discussed the six strategies identified in the Study. The strategies represent non-potable uses, mixed non-potable/indirect potable uses and indirect potable uses for both the South Bay Water Reclamation Plant study area and the North City Water Reclamation Plant study area.

The six strategies are:

South Bay Strategy 1 (SB-1) expands the South Bay Water Reclamation Plant's current non-potable system for Otay Water District and Sweetwater Authority non-potable uses (e.g. landscape irrigation and industrial water uses). A total of 13,040 acre-feet per year (AFY) of water would be developed by this strategy.

South Bay Strategy 2 (SB-2) is a "mixed use" strategy that involves expansion of the non-potable system to serve Otay Water District, followed by a small-scale indirect potable use project at Otay Reservoir. A total of 8,960 AFY of water would be developed by this strategy.

South Bay Strategy 3 (SB-3) represents an indirect potable use option and involves expansion of the non-potable system to serve Otay Water District, followed by a full-scale indirect potable reuse opportunity at Otay Reservoir. A total of 12,660 AFY of water would be developed by this strategy.

North City 1 Strategy (NC-1) expands the non-potable system to serve infill customers located adjacent to the existing system, as well as Phase III Rancho Bernardo, the Central Service Area, and a Rose Canyon wetlands project. A total of 19,680 AFY of water would be developed by this strategy.

North City Strategy 2 (NC-2) involves expansion of the non-potable system to serve infill, Phase III Rancho Bernardo, and a small-scale indirect potable reuse project at Lake Hodges. A total of 18,040 AFY would be developed by this strategy.

North City Strategy 3 (NC-3) expands the non-potable system to serve infill, followed by a large-scale San Vicente indirect potable use project sized to maximize available supplies. A total of 23,760 AFY would be developed by this strategy.

The Assembly discussed and recorded their perspectives on the reuse strategies. The Assembly assessed each strategy's performance against evaluation criteria approved in the first American Assembly workshop (see Appendix B). This Assembly Statement reflects consensus views of the participants and was affirmed in plenary session. Significant minority viewpoints are included.

American Assembly II Statement

The Assembly believes the Water Reuse Study 2005 provides a useful and appropriate analysis of reuse strategies that can be used to inform policy-makers. The Assembly reviewed the technical information and believes the Study provides a sound basis for the deliberations and conclusions of the American Assembly. The Assembly is appreciative of the technical support of members of the City's Independent Advisory Panel and Study Team.

The Assembly unanimously agrees that current technology and scientific studies support the safe implementation of non-potable and indirect potable use projects. The Assembly considers advanced treated (purified) water to be superior in quality to other sources (e.g. Colorado River, State Project Water). The Assembly acknowledges that upon the outset of the study, many participants had reservations regarding the safety of the purified water, but have resolved those concerns through review of this Study and the American Assembly process. The participants are confident that the current research and technological advances in water treatment will produce water of higher quality than currently available. Advanced treatment and long-term storage, current water quality regulations, standards and regulatory oversight were viewed as reasonable precautions to ensure public health and safety. Some participants of the Assembly recommend that regulations be revised to allow for direct potable use.

The American Assembly participants believe that the City of San Diego must maximize the beneficial use of local water resources. The City of San Diego has invested $480 million developing one of the most sophisticated water reclamation systems in the country. The City must take a leadership role to become a national model and further optimize our investment by implementing large-scale water purification. Maximizing local water resources increases water reliability by reducing our dependence on imported water supplies, has important environmental benefits, and is sustainable. Sustainable solutions may not have the lowest initial costs but represent an investment in San Diego and improve the quality of life for future generations. The Assembly believes that indirect potable use broadens the possible uses of this resource and is the most flexible approach to maximize the beneficial use of the City's water resources.

The Assembly believes that the costs of the strategies are affordable and equitable, and considers the strategies to be a necessary investment in our future. The Assembly recognizes that the impacts of rate increases to all customers must be considered and managed. The City should pursue grants and other available sources of state and federal funding to decrease costs to ratepayers. The strategies become more financially attractive as costs of imported water rise over the next decade.

The Assembly feels that there are no environmental justice issues that would act as a significant impediment to the implementation of indirect potable use strategies. The Assembly concludes that service would be provided to a wide-range of social and economic communities. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. The Assembly believes that with proper information and community participation, any public perception of environmental justice issues can be overcome.

The City can choose between non-potable and indirect potable uses. The Assembly strongly supports indirect potable use projects. Non-potable uses are supported to varying degrees.

Indirect potable use - The Assembly is nearly unanimous in their support for indirect potable use. The Assembly feels that this approach creates a new, sustainable supply of high quality water owned by the City. The Assembly believes that the science and technology is protective of the public's health and safety. The public and political perceptions must be addressed. The Assembly acknowledges that a small percentage of the public may not initially accept this approach.

Mixed indirect and non-potable uses - Mixed indirect and non-potable uses received varying degrees of support. The Assembly feels that the mixed approaches do not go far enough to optimize public benefits through indirect potable use.

Non-potable uses - A majority of the Assembly agrees that non-potable approaches meet the evaluation criteria. South Bay non-potable uses are noted as being more attractive due to lower costs. Although non-potable uses are supported, a majority of the Assembly believes that continuing expansion of the recycled water distribution (purple pipe) system is an expensive investment for the amount of water developed, and limits the range of uses of the water. The Assembly has concerns regarding the projected use and expansion of non-potable water distribution systems, the operational challenges current non-potable customers are having, and the need for costly dual piping systems and backflow prevention. New or enhanced wetlands might be possible with this option but further research is required.

The Assembly believes that public perception is a critical issue needing significant and sustained outreach efforts to improve understanding and public acceptance of advanced treated (purified) water. Public acceptance of purified water can be improved by informing, engaging and listening to the public. Assembly participants had varying degrees of knowledge about water reuse when they attended the first American Assembly. They also held differing opinions on the safety and acceptability of purified water. Through a process of reviewing the information, becoming informed on the issues, attaining a level of comfort with the science, and an opportunity to tour a reclamation and advanced purification plant, Assembly participants now advocate the City pursue an indirect potable reuse strategy.

Components of a successful communications strategy must focus on:

- Explaining how the treatment process ensures the safety of the purified water
- Comparing the quality of purified water vs. imported water to drinking water standards, as imported water contains treated wastewater, runoff and discharges from agricultural, mining and industrial sources. (Currently, there are more than 620 discharge permits issued to entities along the Colorado River. Source: Colorado River Salinity Control Forum, 2002).
- Conveying the importance of sustainable, locally produced water availability
- Emphasizing potential benefits to local ocean water quality and protection of beaches
- Emphasizing water reliability to San Diego now and in the future
- Engaging well known local leaders as spokespersons
- Conducting reclamation and advanced purification plant tours
- Partnering with schools
- Tailoring outreach activities for pursued strategies
- Working with the media including TV news and radio personalities

Recommended Strategy for North City

The Assembly participants unanimously support strategy NC-3 (indirect potable use from North City Water Reclamation Plant). This strategy reduces reliance on imported water, has lower long-term costs, resolves current City litigation, distributes water broadly, and leads the City on a path towards water sustainability.

Recommended Strategy for South Bay

The Assembly participants expressed strong support for SB-1 and SB-3. The lower cost of SB-1 and the high percentage of water that is developed were attractive. However, SB-1 does not have the sustainability benefits that SB-3 offers and questions remain regarding dependency on a single large user. Many Assembly participants would favorably consider the SB-1 strategy if NC-3 (which emphasizes indirect potable use) is implemented.

ASSEMBLY CLOSING STATEMENT

The Assembly appreciates the opportunity to participate in this American Assembly on water reuse opportunities and to provide guidance to the San Diego City Council. The Assembly believes that properly designed and operated advanced water treatment processes, coupled with a diligent and publicly accessible water quality monitoring program, produce water of exceptional quality that is protective of public health. The Assembly participants are prepared to work with elected officials and the public in communicating the Assembly's adopted position on the findings of the Water Reuse Study 2005. In addition, the Assembly would like to participate in public outreach and education efforts on water reuse issues.

Attendees

Water Reuse Study 2005
American Assembly I Participants

#	First	Last	Participant Identification
1	Elaine	Allen	Community representative, North Park resident
2	Joseph	Arlotto	Zoological Society of San Diego
3	Lee	Campbell	Community Representative CD-7, Tierrasanta Community Council
4	George	Diefenthal	Community Representative CD-3, Talmadge Maintenance Assessment District
5	Ed	Fletcher	Mayor's Advisory Board
6	Lois	Fong-Sakai	Asian Business Association
7	Drew	George	U.S. Green Building Council – San Diego Chapter
8	Terese	Ghio	Community Representative CD-1, BIOCOM
9	Marco	Gonzalez	Community Representative CD-6, San Diego Bay Council
10	Dawn	Guendert	San Diego Regional Chamber of Commerce
11	Dr. Gerald	Handler	Community Representative CD-1
12	William	Harvey	Community Representative CD-2
13	Kathy	Haynes	American Society of Civil Engineers
14	Rob	Hutsel	San Diego River Park Foundation
15	Ed	Kimura	Sierra Club
16	Michelle	Krug	Community Representative CD-4
17	Tiong	Liem	Asian Business Association
18	Maria	Mariscal	San Diego County Water Authority
19	Shawn	McMillan	Taiwanese Chamber of Commerce
20	Richard	Miner	Community Representative CD-3, Cherokee Point Resident
21	Chuck	Morgan	UCSD
22	Wayne	Nelson	Otay Mesa/Nestor Planning Committee
23	Jim	Peugh	Community Representative CD-2, San Diego Audubon Society
24	Phil	Pryde	San Diego State University
25	Mark	Robak	Metro Commission/Otay Water District
26	Javier	Saunders	Mayor, CWA Boardmember
27	Glen	Schmidt	American Society of Landscape Architects
28	Woo-Jin	Shim	Council Representative CD-1
29	Judy	Swink	Community Representative CD-2
30	Fred	Thompson	Mayor, CWA Boardmember
31	Muriel	Watson	Revolting Grandmas
32	Mayda	Winter	Metro Commission/City of Imperial Beach
33	Todd	Webster	Community Representative CD-3
34	Simon	Wong	Asian Business Association
35	Don	Wood	Citizen's Coordinate for Century 3, Water & Energy Committee

Evaluation Criteria for Assessment of Reuse Opportunities

Adopted in the American Assembly I Statement

Criteria	Objective	Performance Measure
Health and Safety	To protect human health and safety with regard to recycled water use	Meets or exceeds federal, state and local regulatory criteria for recycled water uses
Social Value	To maximize beneficial use of recycled water with regard to quality of life and equal service to all socioeconomic groups	Comparison of beneficial uses and their effect on human needs and aesthetics, as well as public perception.
Environmental Value	To enhance, create or improve local habitat or ecosystems and avoid or minimize negative environmental impacts	Comparison of environmental impacts and/or enhancements, environmental impacts avoided, and permits required.
Local Water Reliability	To substantially increase the percentage of water supply that comes from water reuse, thereby offsetting the need for imported water	Increases percent of water recycling and improves local reliability.
Water Quality	Meets or exceeds level of quality required for the intended use and customer needs	To meet all customer quality requirements.
Operational Reliability	To maximize ability of facilities to perform under a range of future conditions	Level of demand met and opportunities for system interconnections and operational flexibility are addressed.
Cost	To minimize total cost to the community	Comparison of estimated capital improvement costs, operational costs, and revenues for each reuse opportunity, as well as comparison of estimated avoided costs such as future regional water and wastewater infrastructure costs and costs to develop alternative water supplies (e.g. desalination).
Ability to Implement	To evaluate viability or fatal flaws and assess political and public acceptability	Level of difficulty in physical, social or regulatory implementation.

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Appendix D
Public Utilities Advisory Commission Resolution

PUBLIC UTILITIES ADVISORY COMMISSION

RESOLUTION NUMBER PUAC-2005-10

ADOPTED ON NOVEMBER 21, 2005

WHEREAS, the Public Utilities Advisory Commission for the City of San Diego [the Commission] met on November 21, 2005; and

WHEREAS, at that meeting the Commission was given a presentation concerning the City of San Diego Water Reuse Study 2005 - American Assembly Workshop II Statement 2005; and

WHEREAS, after considering the presentation and receiving answers to Commission members' questions, a Motion was made by Commissioner Nelson and seconded by Commissioner Schmidt; NOW, THEREFORE,

BE IT RESOLVED, that the Commission, by a vote of seven yeas and one nay, reports to the City Council and Mayor, that in the opinion of the Commission, the City Manager and staff have completed the studies designated in San Diego City Council Resolution R-298781 adopted on January 13, 2004 regarding the study of the increased use of recycled water.

BE IT FURTHER RESOLVED, that the Commission urges the City Council and Mayor to: (a) adopt the City of San Diego Water Reuse Study 2005 - American Assembly Workshop II Statement as the City's policy on water reuse, specifically the strategies for North City and South Bay including reservoir augmentation and indirect potable reuse; (b) direct City staff to develop as soon as possible a scope of work and strategy to implement the policies, strategies, and projects described in the City of San Diego Water Reuse Study 2005 - American Assembly Workshop II Statement; and (c) direct City staff to report to the Commission not less than annually on implementation of

City Water Reuse policies, strategies, and projects described in the City of San Diego Water Reuse Study 2005 - American Assembly Workshop II Statement.

APPROVED: MICHAEL J. AGUIRRE, City Attorney

By

James W. Lancaster,
Deputy City Attorney

JWL:jwl
11/23/05
Or.Dept:PUAC
PUAC-2005-10

Appendix E
Findings of the
Independent Advisory Panel

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NWRI

National Water Research Institute

Jeffrey J. Mosher
Acting Executive Director
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Fountain Valley, California
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www.NWRI-USA.org

December 1, 2005

Ms. Marsi A. Steirer
Deputy Director
City of San Diego Water Department
600 B Street, Suite 700, MS 907
San Diego, CA 92101-4518

Dear Ms. Steirer:

The National Water Research Institute (NWRI) is pleased to transmit this letter on the findings of the Independent Advisory Panel (Panel) to assist the City of San Diego, California, with its study of water reuse opportunities, as directed by the Council of the City of San Diego (City Council).

The Panel determined that a thorough technical review of viable water reuse strategies has been conducted by the City and the proposed water reclamation technologies will produce water that will meet or exceed all health and safety requirements.

Background

On January 13, 2004, the City Council passed resolution No. R-298781, titled *Resolution of the City Council Regarding the Study of Increased Aspects of Water Reuse,* which directed the City Manager to conduct a one-year study to evaluate "all aspects of a viable increased water reuse program, including but not limited to groundwater storage, expansion of the distribution system, reservoirs for reclaimed water, livestream discharge, wetlands development, and reservoir augmentation."

As part of the study process, the City of San Diego requested that NWRI organize a neutral third-party Panel to review the drafts of the reports prepared by the City and its consultants and to offer suggestions for clarifying and improving the study.

Panel Activities

The Panel met on July 13-14, 2004, and again on May 15-16, 2005, in San Diego, California, to listen to a series of comprehensive presentations by the City's staff and consultants regarding the City's water reuse program. The Panel also completed its review of the first draft report of the *City of San Diego Water Reuse Study 2005* (dated May 5, 2005) at the May 2005 meeting, and offered significant suggestions for reorganizing the draft report and recommendations to enhance its technical content.

Based on input from the Panel, a revised interim report draft of the *City of San Diego Water Reuse Study 2005* (dated June 15, 2005) was prepared by the City's consultants to reflect the Panel's comments and concerns. It was also distributed to attendees of the second City of San Diego Assembly on Water Reuse, held on July 11, 12, and 14, 2005. Two Panel members attended this Assembly. The revised interim report was later reviewed by the Panel, which provided additional comments and suggested revisions to the City.

In November 2005, the City submitted the *City of San Diego Water Reuse Study 2005 Draft Report* (November 2005) to the Panel for review. This version of the report reflects the Panel's comments and suggestions regarding the interim report, as well as input from participants attending the second Assembly.

A third Panel meeting took place in San Diego, California, on November 30-December 1, 2005, to review the current status of the study and suggest revisions to the November 2005 report. The Panel's final observations and findings are summarized in this letter.

Findings

The City's staff and consultants are to be commended for the positive and thoughtful approach they used to address the many challenges associated with bringing this complex study to completion in an orderly and timely manner. The Panel believes that the *Water Reuse Study 2005 Draft Report* is responsive to the mandate set forth in the City Council Resolution. The Panel is also pleased with the responsiveness of the City's staff and consultants to the comments and recommendations made by the Panel. The Panel recognizes that:

1. The *Water Reuse Study 2005* has been conducted in a transparent manner with full disclosure. The City's staff has made an effort to engage the public and elicit input through a Speaker's Bureau (98 presentations were made to a wide range of community groups, as of November 15, 2005), a website with an online survey (which has received 5,875 visits), and two Assembly workshops to further engage stakeholders and interested parties (which were attended by a total of 67 citizens and stakeholder representatives).

2. The City's staff has made full public disclosure on both the objectives of the study and reuse opportunities prior to developing the strategies for increasing water reuse.

3. The City's staff has consulted with public health agencies to ensure that the water produced would meet and exceed all health and safety requirements for all designated uses, including indirect potable reuse.

More specifically, the Panel finds that:

1. The *San Diego Water Reuse Study 2005* has been conducted in a scientific manner. To that end, a thorough review of scientific literature, other water reuse projects, and current technologies has been completed. In addition, research studies were completed to answer critical questions regarding appropriate treatment technologies (e.g., reverse osmosis).

2. Because of the location of existing wastewater treatment plants and the distances involved, it is appropriate to consider alternative water reuse strategies for the northern and southern service areas.

3. The water reuse alternatives identified in the *San Diego Water Reuse Study 2005* reflect technically feasible and viable reuse opportunities available to the City of San Diego.

4. The criteria used to evaluate viable alternative water reuse strategies are reasonable and rational.

5. Water produced with the technologies that have been evaluated, including membrane systems and advanced oxidation, will meet health and safety requirements for any of the water reuse strategies.

6. Recycled water is a valuable asset that should be utilized effectively as an alternative source of water.

Conclusion

It is the unanimous conclusion of the Panel that appropriate alternative water reuse strategies for the City of San Diego have been identified, and that these alternatives have been presented clearly so that the citizens of the City of San Diego can make informed choices with respect to water reuse.

Respectfully submitted by the Independent Advisory Panel,

George Tchobanoglous, Ph.D., P.E.
Panel Chair

James Crook, Ph.D., P.E.

Richard Gersberg, Ph.D.

James E.T. Moncur, Ph.D.

Joan B. Rose, Ph.D.

Fred Zuckerman

Richard J. Bull, Ph.D.

Joseph A. Cotruvo, Ph.D.

Christine L. Moe, Ph.D.

Derek Patel, M.D.

Michael P. Wehner

cc: Jeffrey J. Mosher, NWRI

Appendix F
List of Public Outreach Activities

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Water Reuse Study
Public Outreach - Speaker's Bureau Presentations

Date	Format	Individual/Group	Category
09/18/04	Speakers Bureau	AARP La Jolla/Scripps Ranch Group [CD N/A]	Socioeconomic
09/20/04	Speakers Bureau	Darnall Community Council Group [CD 3]	Community Group
09/21/04	Speakers Bureau	Retired Public Employees Association - East Cty Group [CD N/A]	Socioeconomic
09/29/04	Speakers Bureau	Clairemont Hills Kiwanis Club [CD 6]	Civic
10/01/04	Speakers Bureau	Retired Public Employees Association - Chapter 29 [CD N/A]	Socioeconomic
10/01/04	Speakers Bureau	San Diego Regional Chamber of Commerce Recycled Water Task Force [CD N/A]	Business
10/13/04	Speakers Bureau	Kensington Optimist Club [CD 3]	Civic
10/19/04	Speakers Bureau	San Ysidro Planning Group [CD 8]	Community Planning Group
10/25/04	Speakers Bureau	Pacific Beach Community Planning Group [CD 2]	Community Planning Group
10/28/04	Speakers Bureau	Citizens for Century 3 "C-3" [CD N/A]	Environmental; planning
11/01/04	Speakers Bureau	Paradise Hills Neighborhood Watch Council [CD 4]	Community Group
11/02/04	Speakers Bureau	Biology Class at Southwestern College [CD N/A]	Education
11/03/04	Speakers Bureau	Mission Valley Unified Planning Group [CD 6]	Community Planning Group
11/03/04	Speakers Bureau	Biology Class at Mesa College [CD N/A]	Education
11/09/04	Speakers Bureau	The Metropolitan Club [CD 2]	Civic
11/09/04	Speakers Bureau	Mission Valley/Hillcrest Lions Club [CD 6]	Civic
11/09/04	Speakers Bureau	Eastern Area Community Planning Group [CD 4]	Community Planning Group
11/10/04	Speakers Bureau	College Area Community Planning Group [CD 7]	Community Planning Group

Date	Format	Individual/Group	Category
11/16/04	Speakers Bureau	Metro Wastewater Staff of the SBWR Plant [CD N/A]	Employee Group
11/16/04	Speakers Bureau	San Diego Association of Realtors [CD N/A]	Business
11/18/04	Speakers Bureau	Water CIP/Planning Employees and Consultant Teams [CD N/A]	Employee Group
11/18/04	Speakers Bureau	El Cerrito Community Council [CD 7]	Community Group
11/23/04	Speakers Bureau	Kearny High School Science Connections and Technology Focus Classes - 10th grade [CD N/A]	Education
11/24/04	Speakers Bureau	Kearny High School Science Connections and Technology Focus Classes - 10th grade [CD N/A]	Education
12/04/04	Speakers Bureau	Lake Murray Kiwanis Club [CD 7]	Civic
01/04/05	Speakers Bureau	American Airlines Vanguards [CD N/A]	Socioeconomic
01/11/05	Speakers Bureau	University Community Planning Group [CD 1]	Community Planning Group
01/12/05	Speakers Bureau	Midway Community Planning Group [CD 2]	Community Planning Group
01/12/05	Speakers Bureau	Otay Mesa/Nestor Community Planning Committee [CD 8]	Community Planning Group
01/12/05	Speakers Bureau	Kensington/Talmadge Planning Committee [CD 3]	Community Planning Group
01/13/05	Speakers Bureau	Industrial Environmental Association [CD N/A]	Business
01/18/05	Speakers Bureau	Clairemont Mesa Community Planning Group [CD 6]	Community Group
01/19/05	Speakers Bureau	Tierrasanta Community Council [CD 7]	Community Group
02/07/05	Speakers Bureau	Mira Mesa Town Council [CD 5]	Community Group
02/08/05	Speakers Bureau	BioCom Tour of NCWRP and Board Meeting [CD N/A]	Business
02/10/05	Speakers Bureau	Skyline Hills Community Association [CD 4]	Community Group
02/17/05	Speakers Bureau	Rancho Bernardo Community Planning Group [CD 5]	Community Planning Group

Date	Format	Individual/Group	Category
02/17/05	Speakers Bureau	Knox/Lincoln Community Council [CD 4]	Community Group
02/22/05	Speakers Bureau	Navajo Community Planners [CD 7]	Community Planning Group
02/22/05	Speakers Bureau	Chollas View Neighborhood Council [CD 4]	Community Group
02/22/05	Speakers Bureau	Mira Mesa Community Planning Group [CD 5]	Community Planning Group
02/23/05	Speakers Bureau	Kaiser Permanente MD and Medical Staff - In-Service Educational - Panel [CD N/A]	Business
02/28/05	Speakers Bureau	Linda Vista Community Planning Group [CD 6]	Community Planning Group
03/17/05	Speakers Bureau	Mission Valley Community Council [CD 6]	Community Group
03/18/05	Speakers Bureau	La Jolla/Golden Triangle Rotary Club [CD 1]	Civic
03/30/05	Speakers Bureau	San Diego Greater Chamber of Commerce Infrastructure Committee [CD N/A]	Business
04/05/05	Speakers Bureau	League of Women Voters [CD N/A]	Civic
04/05/05	Speakers Bureau	Green Building Industry Council [CD N/A]	Business
04/07/05	Speakers Bureau	Oak Park Community Council [CD 4]	Community Group
04/08/05	Speakers Bureau	Metropolitan Wastewater Commission & TAC [CD N/A]	Government
04/13/05	Speakers Bureau	Old Town Community Planning Committee [CD 2]	Community Planning Group
04/20/05	Speakers Bureau	Torrey Pines Rotary Club [CD 1]	Civic
04/21/05	Speakers Bureau	Pacific Beach Kiwanis Club [CD 2]	Civic
04/26/05	Speakers Bureau	Rancho Bernardo Lions Club [CD 5]	Civic
05/11/05	Speakers Bureau	San Diego County Science Advisory Board [CD N/A]	Government

Date	Format	Individual/Group	Category
05/20/05	Speakers Bureau	Public Utilities Advisory Commission [CD N/A]	Government
05/24/05	Speakers Bureau	Pt. Loma Kiwanis Club [CD 2]	Civic
06/07/05	Speakers Bureau	Miramar Ranch North Planning Committee [CD 5]	Community Planning Group
06/08/05	Speakers Bureau	Tierrasanta Kiwanis Club [CD 7]	Civic
06/09/05	Speakers Bureau	San Diego County Hispanic Chamber of Commerce [CD N/A]	Ethnic; business
06/14/05	Speakers Bureau	Rancho Bernardo Sunrise Rotary Club [CD 5]	Civic
06/15/05	Speakers Bureau	San Diego Downtown Breakfast Rotary Club [CD 2]	Civic
06/23/05	Speakers Bureau	Allied Gardens Optimist Club [CD 7]	Civic
07/06/05	Speakers Bureau	Peninsula Lions Club [CD 2]	Civic
07/18/05	Speakers Bureau	Public Utilities Advisory Commission [CD N/A]	Government
07/19/05	Speakers Bureau	San Diego Greater Chamber of Commerce Water Sub-committee [CD N/A]	Business
07/20/05	Speakers Bureau	NR&C Committee of the City Council [CD N/A]	Government
07/27/05	Speakers Bureau	City 10 City Delegates to the San Diego County Water Authority [CD N/A]	Government
08/04/05	Speakers Bureau	Uptown San Diego Sunrise Rotary Club [CD 2]	Civic
08/04/05	Speakers Bureau	Metro Commission [CD N/A]	Government
08/05/05	Speakers Bureau	State Dept. of Health Services [CD N/A]	Government
08/10/05	Speakers Bureau	Mission Beach Town Council [CD 2]	Community Group
08/11/05	Speakers Bureau	CIP/Policy Semi-Annual Employee Business Meeting [CD N/A]	Employee Group

Date	Format	Individual/Group	Category
08/15/05	Speakers Bureau	Public Utilities Advisory Commission [CD N/A]	Government
08/16/05	Speakers Bureau	University of San Diego Environmental Law Class Paralegals [CD N/A]	Education
08/16/05	Speakers Bureau	General Managers of the San Diego County Water Authority [CD N/A]	Government
08/24/05	Speakers Bureau	Olivenhain Municipal Water District Board Meeting [CD N/A]	Government
09/01/05	Speakers Bureau	Coronado Optimist Club [CD N/A]	Civic
09/07/05	Speakers Bureau	United Food & Commercial Workers (Retiree Group) [CD N/A]	Socioeconomic
09/07/05	Speakers Bureau	Helix Water District Board Meeting [CD N/A]	Government
09/14/05	Speakers Bureau	US Green Building Council "Build Green San Diego 05 Conference" [CD N/A]	Business
09/18/05	Speakers Bureau	WateReuse National Symposium Panel Presentation [CD N/A]	Business
09/19/05	Speakers Bureau	WateReuse National Symposium Panel Presentation [CD N/A]	Business
09/20/05	Speakers Bureau	City Council of National City [CD N/A]	Government
09/21/05	Speakers Bureau	Vista Irrigation District Board of Directors [CD N/A]	Government
09/21/05	Speakers Bureau	Surfrider Foundation [CD N/A]	Civic, Environmental
09/27/05	Speakers Bureau	American Society of Civil Engineers - San Diego [CD N/A]	Business
10/11/05	Speakers Bureau	Otay Water District Board Meeting [CD N/A]	Government
10/11/05	Speakers Bureau	Rancho Bernardo Community Council Government Relations Subcommittee [CD 5]	Government
10/12/05	Speakers Bureau	Carmel Mountain Ranch Community Council [CD 5]	Community Group
10/19/05	Speakers Bureau	WateReuse Association - San Diego Chapter Meeting [CD N/A]	Business

Date	Format	Individual/Group	Category
10/26/05	Speakers Bureau	San Dieguito Water District [CD N/A]	Government
10/27/05	Speakers Bureau	New Water Recycling City Employee Orientation [CD N/A]	Employee Group
10/27/05	Speakers Bureau	San Diego County Water Authority Board of Directors [CD N/A]	Government
11/04/05	Speakers Bureau	Public Utilities Advisory Commission - Public Education Committee [CD N/A]	Government
11/07/05	Speakers Bureau	Valley Center Municipal Water District Board Meeting [CD N/A]	Government
11/07/05	Speakers Bureau	Greater Skyline Hills Neighborhood Council [CD 4]	Community Group
11/08/05	Speakers Bureau	Paradise Hills/Skyline Hills Community Planning Group [CD 4]	Community Planning Group
11/08/05	Speakers Bureau	Carmel Valley Community Planning Board [CD 1]	Community Planning Group
11/10/05	Speakers Bureau	Del Mar Mesa Community Planning Board [CD 1]	Community Planning Group
11/15/05	Speakers Bureau	Torrey Hills Planning Board [CD 1]	Community Planning Group
11/15/05	Speakers Bureau	Greater San Diego Chamber of Commerce Water Subcommittee [CD N/A]	Business
11/17/05	Speakers Bureau	Friends of Downtown [CD 2]	Civic
11/21/05	Speakers Bureau	Public Utilities Advisory Commission [CD N/A]	Government
11/21/05	Speakers Bureau	South Bay Irrigation District – Board of Directors [CD N/A]	Government
11/30/05	Speakers Bureau	Barrio Logan Redevelopment Project Area Committee [CD 8]	Community Group
12/08/05	Speakers Bureau	Torrey Pines Community Planning Board [CD 7]	Community Planning Group
12/13/05	Speakers Bureau	Santee Optimist Club [CD N/A]	Civic
12/14/05	Speakers Bureau	San Diego Regional Chamber of Commerce Recycled Water Task Force [CD N/A]	Government
12/15/05	Speakers Bureau	Santa Fe Irrigation District [CD N/A]	Government
01/03/06	Speakers Bureau	City of Coronado – City Council [CD N/A]	Government
01/10/06	Speakers Bureau	Ramona Municipal Water District Board Meeting [CD N/A]	Government

Date	Format	Individual/Group	Category
01/11/06	Speakers Bureau	San Diego County Science Advisory Board [CD N/A]	Government
01/19/06	Speakers Bureau	Coalition of Neighborhood Councils - EMAT [CD 4]	Community Group
01/24/06	Speakers Bureau	City of El Cajon - City Council Meeting [CD N/A]	Government
01/24/06	Speakers Bureau	Downtown San Diego Lions Club [CD 2]	Civic
02/01/06	Speakers Bureau	City of Imperial Beach - City Council Meeting [CD N/A]	Government
02/07/06	Speakers Bureau	City of Poway - City Council Meeting [CD N/A]	Government
02/08/06	Speakers Bureau	San Diego Science and Technology Commission [CD N/A]	Government
02/14/06	Speakers Bureau	Padre Dam Municipal Water District [CD N/A]	Government
02/28/06	Speakers Bureau	Chollas View Neighborhood Council [CD 4]	Community Group
03/01/06	Speakers Bureau	Mission Valley Unified Planning Group [CD 6]	Community Planning Group
03/06/06	Speakers Bureau	Naval School of Health Sciences [CD N/A]	Education
03/06/06	Speakers Bureau	Citizens Coordinate for Century 3 “C-3” [CD N/A]	Civic
03/13/06	Speakers Bureau	WateReuse Association, California Section 2006 Annual Conference, Paper: Speakers Bureau [CD N/A]	Business
03/13/06	Speakers Bureau	WateReuse Association, California Section 2006 Annual Conference, Paper: Stakeholders Group [CD N/A]	Business
03/13/06	Speakers Bureau	WateReuse Association, California Section 2006 Annual Conference, Paper: Recycled Water Quality [CD N/A]	Business
03/14/06	Speakers Bureau	City of Chula Vista City Council [CD N/A]	Government
03/15/06	Speakers Bureau	Paradise Hills Village Council [CD 4]	Community Group
03/15/06	Speakers Bureau	City of San Diego Employees Training Class [CD N/A]	Employee Group
03/15/06	Speakers Bureau	Science, Connections & Technology High School – Advisory Team [CD N/A]	Education
03/17/06	Speakers Bureau	Building Industry Association of San Diego County [CD N/A]	Business

Date	Format	Individual/Group	Category
03/21/06	Speakers Bureau	San Diego County Science Advisory Board [CD N/A]	Government
03/21/06	Speakers Bureau	City of Lemon Grove City Council [CD N/A]	Government
03/28/06	Speakers Bureau	Community Planners Committee [CD N/A]	Community Planning Group

Water Reuse Study
Public Outreach – Stakeholders Interview

Date	Format	Individual/Group	Category
08/09/04	Stakeholder Interview	Asian Business Association Government Affairs Committee	Ethnic; business
08/23/04	Stakeholder Interview	Tom Gehring, Exec. Director, San Diego County Medical Society	Health
08/30/04	Stakeholder Interview	Audobon Society Conservation Committee	Environmental
09/09/04	Stakeholder Interview	Ed Kimura, Sierra Club	Environmental
09/09/04	Stakeholder Interview	Anne Wayman, American Assembly Participant	Business
09/10/04	Stakeholder Interview	Brian Cooney, American Assembly participant nominated by Council District 3	Business
09/11/04	Stakeholder Interview	Erik Bruvold, San Diego Regional Economic Development Corporation	Business
09/13/04	Stakeholder Interview	Ed Fletcher, American Assembly participant nominated by Council District 4	Business
09/13/04	Stakeholder Interview	Building Owners and Managers Association	Business
09/15/04	Stakeholder Interview	San Diego Association of Realtors Government Affairs Committee	Business
09/16/04	Stakeholder Interview	Michael Bardin, Scripps Health	Business
09/16/04	Stakeholder Interview	Lee Campbell, American Assembly participant, Tierrasanta Community Council	Business
09/17/04	Stakeholder Interview	DJ Taylor, President, American Society of Landscape Architects	Business
09/17/04	Stakeholder Interview	William Harvey, American Assembly participant nominated by Council District 2	Business
09/20/04	Stakeholder Interview	Judy Swink, American Assembly participant nominated by Council District 2, Mission Bay Park Committee, C-3	Business
09/22/04	Stakeholder Interview	Steven Satz, American Assembly participant nominated by Council District 2	Business
09/23/04	Stakeholder Interview	Cathy Ripka, American Assembly participant nominated by Council District 5	Business
09/27/04	Stakeholder Interview	Claudia Unhold, American Assembly participant nominated by Council District 5	Business
03/23/05	Stakeholder Interview	San Diego County Taxpayers Association	Business
03/29/05	Stakeholder Interview	Otay Mesa Chamber of Commerce	Business
04/05/05	Stakeholder Interview	US Green Building Council	Business
04/29/05	Stakeholder Interview	South County Economic Development Council Transportation & Infrastructure Committee	Business

Date	Format	Individual/Group	Category
05/23/05	Stakeholder Interview	Linda Caballero-Merit, Hispanic Chamber of Commerce	Business
05/27/05	Stakeholder Interview	Dave Van Cleve, The Nature Conservancy	Environmental
06/01/05	Stakeholder Interview	Kris Hartnett, San Diego Building & Construction Trades Council	Business
06/01/05	Stakeholder Interview	Jerry Butkiewicz, San Diego-Imperial Counties Labor Council	Business
06/09/05	Stakeholder Interview	Cecil Steppe, San Diego Urban League	Business

Water Reuse Study
City Council Aide Briefings

Date	Format	Individual/Group	Category
08/06/04	City Council Aide Briefing	Betsy Brennan (CD1); Lora Folsom (CD2); Steve Hill (CD3); Khoa Nguyen (CD5); Dan Coffer (CD7)	City Council
09/15/04	City Council Aide Briefing	Jamie Foxx-Rice (CD 8)	City Council
09/27/04	City Council Aide Briefing	Tom Story (Mayor's Office)	City Council
10/22/04	City Council Aide Briefing	Tom Story (Mayor's Office); Lora Folsom (CD2); Dan Coffer (CD7)	City Council

Water Reuse Study
Media Briefings

Date	Format	Individual/Group	Category
03/11/05	Media Briefing	La Prensa San Diego	Ethnic; business
03/22/05	Media Briefing	Asia Journal	Ethnic; business
04/07/05	Media Briefing	Filipino Press	Ethnic; business

Appendix G
Science, Technology, and Regulatory Issues

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Science, Technology, and Regulatory Issues

The study of water reuse alternatives for the City of San Diego included an assessment of the science, technology and regulatory issues related to recycled water use. The published literature on recycled water use is extensive representing thousands of articles. This assessment has examined and summarized the key issues. There are four major areas for San Diego's public and policy makers to consider when planning expansion of the City's water reuse program:

1) ***What do we know about recycled water and public health risk?*** Principles of risk assessment and risk management are discussed in **Section 1**. The use of these principles by the U.S. Environmental Protection Agency (EPA) and the State of California to set drinking water regulations that recycled water projects must meet is discussed.

2) ***How is recycled water regulated and used in California?*** The State agencies that set and enforce regulations are discussed in **Section 2** as well as the standards that must be met in order for recycled water to be put to various beneficial uses.

3) ***What water treatment methods are used to protect public health?*** **Section 3** reviews the types of contaminants found in water and how water treatment is used to produce water suitable for recycling. The concept of the "multi-barrier treatment approach" as the basis of recycled water regulation is presented.

4) ***What have public health studies shown? What have been the experiences of other communities?*** Other communities have implemented recycled water projects and addressed risks. The results of some of the key health effects studies are summarized in **Section 4**. **Section 5** summarizes indirect potable (IPR) reuse experiences of other communities.

Section 6 provides conclusions of the assessment and **Section 7** lists references from the literature that were used in the assessment and in this summary.

Section 1 Recycled Water and Protecting Public Health

Risk Assessment, Risk Management and Drinking Water Regulations[1]

To understand how public health is addressed in recycled water use, this section provides background on risk assessment and risk management and how they are used to establish standards for recycled water use. These principles form the basis of regulations that govern how recycled water must be treated and how it can be used.

Risk Assessment

Risk assessment has been defined as "the characterization of the potential adverse health effects of human exposures to environmental hazards" (NRC, 1983).

Health risk assessments are used to determine if a particular chemical poses a significant risk to human health and, if so, under what circumstances. Risk assessment helps regulators develop consistent and realistic goals for reducing exposure to toxics so that priorities can be established, and health threats to the public can be reduced to a minimum. Estimating the risks posed by toxic chemicals in the environment involves the compilation and evaluation of complex sets of data. Government regulators, therefore, turn to specialists to perform or assist with risk assessments. These specialists include scientists with degrees in toxicology (the study of the toxic effects of chemicals) and epidemiology (the study of disease or illness in populations) as well as physicians, biologists, chemists, and engineers.

The EPA is the leading environmental risk assessment agency at the federal level. The World Health Organization with support from the International Program for Chemical Safety prepares Guidelines for Drinking Water Quality, and also guidance for water reuse. In California, the Office of Environmental Health Hazard Assessment (OEHHA) in the California Environmental Protection Agency (Cal/EPA) has the primary responsibility for developing procedures and practices for performing health risk assessments. OEHHA's health risk assessments are used by the Department of Health Services to develop California's drinking water standards. The State of California is generally more aggressive in identifying and responding to perceived health threats than other states. California will frequently address problems before they are addressed by the EPA. These agencies' decisions take into account the seriousness of potential health effects along with the economic and technical feasibility of measures that can reduce the health risks.

Risk Assessment Process
The risk assessment process typically consists of four basic steps: hazard identification, exposure assessment, dose-response assessment, and risk characterization.

[1] The risk assessment and risk management discussion was drawn and adapted from *A Guide to Risk Assessment*, California Office of Environmental Health Hazard Assessment

Step 1 Hazard Identification – In the first step, scientists determine the types of health problems a chemical could cause by reviewing studies of its effects in humans and laboratory animals, as well as what is known about similar chemicals (structure/activity relationships).

Depending on the chemical, these health effects may include short-term ailments, such as headaches, nausea, and eye, nose, and throat irritation, or chronic diseases, such as cancer. Effects on sensitive populations, such as pregnant women and their developing fetuses, the elderly, or those with health problems (including those with weakened immune systems), must also be considered. Responses to toxic chemicals will vary depending on the amount and length of exposure. For example, short-term exposure to low concentrations of chemicals may produce no noticeable effect, but continued exposure to the same levels of chemicals over a long period of time may eventually cause harm.

An important step in hazard identification is the selection of key research studies that can provide accurate, timely information on the hazards posed to humans by a particular chemical. The selection of a study is based upon factors such as whether the study has been peer reviewed by qualified scientists, whether the study's findings have been verified by other studies, and the species tested (human studies provide the best evidence). Some studies may involve humans that have been exposed to the chemical, but most have to rely largely, if not entirely, upon studies with laboratory animals.

Human data can be useful but are often limited for evaluating human health risks associated with chemical exposures. Human epidemiologic studies typically retrospectively examine the effects of chemical exposure on people, such as environmental exposures to large population groups, or employees exposed to varying concentrations of chemicals in the workplace. Drinking water epidemiology studies for chemical risk evaluation are especially difficult to rely on because the exposures involved are usually so minute (parts per billon or parts per trillion), and not continuous.

Epidemiology studies include descriptive and analytical types. Descriptive studies are used to summarize disease information and assess geographical or patterns of disease occurrence over time. These must be interpreted cautiously because they do not attempt to assess all of the possible contributing or confounding factors. Analytical studies are much more detailed and quantitative and can include cohort or follow-up, and case-control studies that match cases of disease with people in similar circumstances who do not have the disease. However, even these studies usually contain uncertainties, especially when relatively slight associations are observed, which is frequently the case.

Occupational studies sometimes offer a greater potential to identify associations between exposures and disease because the exposures in the workplace are often much larger than in the general environment, and more information may be available about worker populations. However, occupational studies can also have weaknesses including:

- They generally measure the effects of chemicals on healthy workers and do not consider children, the elderly, those with pre-existing medical conditions, or other sensitive groups.
- Exposure of workers to other chemicals at the same time as well as other lifestyle considerations may also influence and complicate the results.

When ethically possible, controlled laboratory studies using human volunteers are better able to gauge some health effects, because chemical exposures and effects can then be measured with precision. Prescription drugs must receive some level of testing in humans before they are approved for use, however, most other chemicals cannot receive that type of testing. Case reports of an industrial or accidental exposure in which individuals were unintentionally exposed to a chemical may sometimes provide useful information. Human studies would be ideal for risk assessment, so risk assessors make every effort to use them when they are available, which, however, is not very frequent. Usually they provide some information to supplement animal studies.

Because the effects of the vast majority of chemicals have not and cannot be studied in humans, scientists often rely on animal studies at very high doses to evaluate a chemical's health effects. Animal studies have the advantage of being performed under controlled laboratory conditions with genetically similar test animals that reduce part of the uncertainty that arises from human epidemiological studies. Animal tests are conducted at high doses to increase the potential that an effect will be detected. Those high doses must then be extrapolated to the much lower doses that humans are exposed to attempt to predict if a human will be affected and to what extent. Scientists must determine whether a chemical's health effects in humans are likely to be similar to those in the animals tested. This is complicated, because, in fact, even a mouse study does not always predict what will happen in a rat and *vice versa*. Although effects seen in animals can also occur in humans, there may be subtle or even significant differences in the ways humans and experimental animals react to a chemical. Comparison of human and animal metabolism may be useful in selecting the animal species that should be studied, but it is often not possible to determine which species is most like humans in its response to a chemical exposure. However, if similar effects were found in more than one species of animal, the results would strengthen the likelihood that humans may also be at risk. Risk assessors frequently use the most sensitive animal species to project to human effects so as to be cautious and be less likely to underestimate the possible human effects.

Step 2 Exposure Assessment – In exposure assessment, scientists attempt to determine how long people were exposed to a chemical; how much of the chemical they were exposed to every day, whether the exposure was continuous or intermittent, and how people were exposed—through breathing, skin contact, eating, drinking water and other liquids. All of this information is combined with factors such as breathing rates, water consumption, and daily activity patterns to estimate how much of the chemical was taken into the bodies of those exposed. To estimate exposure levels, scientists rely on air, water, and soil monitoring; human blood and urine samples; or computer modeling.

Although monitoring of a pollutant provides excellent data, it cannot cover all situations, and is costly. For those reasons, scientists often use computer modeling, which applies mathematical equations to describe how a chemical is released and to estimate the speed and direction of its movement through the surrounding environment. Drinking water exposures are some of the most predictable and quantifiable types and have less uncertainty than most other environmental exposures.

To accurately assess the range human exposures, scientists make assumptions in order to estimate human exposure to a chemical. To avoid underestimating actual human exposure to a chemical, scientists often look at the range of possible exposures. For example, people who jog in the afternoon, when urban air pollution levels are highest, would have much higher exposures to air pollutants than people who come home after work and relax indoors. Basing an exposure estimate on a value near the higher end of a range of exposure levels (closer to the levels experienced by the jogger than by the person remaining indoors) provides a realistic worst-case estimate of exposure. These kinds of conservative assumptions, which presume that people are exposed to the highest amounts of a chemical that can be considered credible, are referred to as "health-protective" assumptions.

Step 3 Dose-Response Assessment – In dose-response assessment, scientists evaluate the information obtained during the hazard identification step to estimate the amount of a chemical that is likely to result in a particular health effect in humans.

An established principle in toxicology is that "the dose makes the poison." For example, table salt is essential to life in small quantities, can cause illness in large doses, and complicate certain chronic diseases at moderate quantities in sensitive individuals (e.g. people with high blood pressure). Scientists perform a dose-response assessment to estimate how different levels of exposure to a chemical can impact the likelihood and severity of health effects. The dose-response relationship that is assumed to occur at exposures too low to study in humans or animals is thought to be different for many chemicals that cause cancer than it is for those that cause other kinds of health problems.

Cancer Effects – For chemicals that cause cancer by genotoxic mechanisms (i.e., interaction with DNA), the general conservative assumption in risk assessment has been that any exposures may have some risk unless there is clear evidence otherwise. In other words, even a very low exposure to a cancer-causing chemical may have some finite (albeit very small) risk of cancer if the chemical happens to alter cellular functions in a way that could cause cancer to develop. It becomes a matter of trying to predict a probability. Scientists use mathematical models based on studies of animals exposed to high levels of a chemical to attempt to project the risk of cancer developing in a diverse population of humans exposed much lower levels (perhaps a million times less). The uncertainty in these estimates is very large and a function of the assumptions that must be made in the modeling due to the lack of a complete understanding of the mechanism of the toxic effect. These assessments give upperbound risk values, and the lowerbound risks could be zero. They are designed to be conservative and more likely to overestimate rather than underestimate the human risks. These risks are usually so low that they would not be detectable by epidemiology studies. Continuing research is being conducted toward trying to improve the understanding of mechanisms of chemical toxicity and the validity of risk extrapolation models.

Non-cancerous Effects – Non-cancerous health effects (such as asthma, nervous system disorders, birth defects, and developmental problems in children) typically become more severe and frequent as exposure to a chemical increases. One goal of dose-response assessment is to estimate levels of exposure that pose only a low or negligible risk for noncancer health effects. Scientists analyze studies of the health effects of a chemical to develop this estimate. They take into account such factors as the quality of the scientific studies, whether humans or laboratory animals were studied, and the degree to which some people may be more sensitive to the chemical than others. The dose level that causes no adverse effect in the most sensitive animal species is usually divided by a large uncertainty (safety) factor to arrive at a 'safe' value for human exposure i.e. unlikely to result in any adverse effect under normal conditions.

Step 4 Risk Characterization – The last step in risk assessment brings together the information developed in the previous three steps to estimate the risk of health effects in an exposed population. In the risk characterization step, scientists analyze the information developed during the exposure and dose-response assessments to describe the resulting health risks that are expected to occur. This information is presented in different ways for cancer, noncancer, and microbial risk health effects, as explained below.

Cancer Risk – This is often expressed as the maximum number of new cases of cancer projected to occur in a population of one million people due to exposure to the substance over a 70-year lifetime. For example, a cancer risk of one in one million means that in a population of one million people, not more than one additional person would be expected to develop cancer during their lifetime as the result of the exposure to the substance causing that risk. These are not actuarial risks i.e. counting actual cancer cases; they are hypothetical projections. Cancer risks presented in risk assessments are often inappropriately compared to the actual incidence of cancer in the general U.S. population (about 300,000 cases for every one million people), or to the risk posed by all harmful chemicals in a particular medium, such as the air. The cancer risk from breathing current levels of pollutants in California's ambient air over a 70-year lifetime has been estimated/projected to be 760 in one million.

Non-cancerous Risk – This is usually determined by comparing the actual level of exposure to a chemical to the level of exposure that is not expected to cause any adverse effects, even in the most susceptible people. Levels of exposure at which no adverse health effects are expected are called "health reference levels," and they generally are based on the results of animal studies. Health reference levels are set much lower than the levels of exposure that were found to have no adverse effects in the animals tested. This approach helps to ensure that real health risks are not underestimated. Adjustments are made for possible differences in a chemical's effects on laboratory animals and humans; the possibility that some humans, such as children and the elderly, may be particularly sensitive to a chemical; and possible deficiencies in data from the animal studies.

Depending on the amount of uncertainty in the data, scientists may set a health reference level as little as 10 times lower if good human data are available, but usually from 100 to 1,000 times lower than the levels of exposure observed to have no adverse effects in animal studies. Occasionally, a factor as large as 10,000 might be used if the data base is extremely weak. Exposures above the health reference level are not necessarily harmful, but the risk of toxic effects increases as the dose increases. If an assessment determines that human exposure to a chemical exceeds the health reference level, further investigation is warranted.

Microbial Risk – A quantitative assessment that attempts to follow the same basic steps as chemical risk assessment – 1) hazard assessment, 2) exposure assessment, 3) dose-response analysis, and 4) risk characterization. Alternative (but similar) protocols have been published (ILSI, 1996, 2000) that are specifically designed to apply to waterborne pathogens. However, microorganisms function in ways that are very different from chemicals, e.g. they are alive and they reproduce. Some of the differences between microorganism risk and chemical risk assessment include:

- As few as one microorganism of certain types has the potential to cause infection. For chemical agents, it is likely that far more molecules are necessary to have a health effect.
- There may be a wide range of susceptibilities across a population (which could also be true for chemicals).
- Once infected, an individual may infect others and produce illness through person-to-person contact unrelated to water.
- Prior exposure to a particular microorganism (via water or other routes) may induce partial or complete immunity in an individual.

Microbial risk assessment, like risk assessment in general, has many inputs that are uncertain. These include 1) uncertainty about the best dose-response model for the pathogen or indicator organism of interest, 2) lack of data about pathogen behavior at low doses and susceptible populations, 3) assumptions about water consumption and other water-related exposures, and 4) uncertainty about occurrence and concentration of pathogens or their relationships to indicators in water.

Risk Management: How Health Risk Assessment Is Used

Risk managers rely on risk assessments when making regulatory decisions, such as setting drinking water standards. Risk managers are responsible for protecting human health, but they must also consider public acceptance when arriving at their decisions, as well as technological, economic, social, and political factors. For example, they may need to consider how much it would cost to remove a contaminant from drinking water supplies or how seriously the loss of jobs would affect a community if a factory were to close due to the challenge of meeting regulatory requirements that are set at the most stringent level. Health risk assessments can help risk managers weigh the significance of a risk, and the benefits and costs of various alternatives for reducing exposure to chemicals.

One of the most difficult questions of risk management is: How much risk is acceptable? While it would be ideal to completely eliminate all exposure to hazardous chemicals, it is usually not possible or feasible to remove all traces of a chemical once it has been released into the environment. The goal of most regulators is to reduce the health risks associated with exposure to hazardous pollutants to a negligibly low level. The EPA uses a metric in setting drinking water standards for carcinogens that nominal lifetime risks in the range of from 1 per 10,000 to 1 per 1,000,000 are safe and protective of public health. The World Health Organization sets drinking water guidelines for genotoxic carcinogens at the nominal 1 per 100,000 risk level and advises nations that they may choose other values for standards considering technological and economic factors.

Risk managers generally presume that a one-in-one million risk of cancer from life-long exposure to a hazardous chemical is an "acceptable risk" level because the risk is extremely low compared to the overall cancer rate. If a drinking water standard for a cancer-causing chemical were set at the level posing a "one-in-one million" risk, it would mean that not more than one additional cancer case (beyond what would normally occur in the population) would potentially occur in a population of one million people drinking water meeting that standard over a 70-year lifetime. It is important to realize that these risk levels are still very low compared to the average cancer risk in a human lifetime (approximately 1 in 4)

Actual regulatory standards for chemicals or hazardous waste cleanups may be set at less stringent risk levels, such as one in 100,000 (not more than one additional cancer case per 100,000 people) or one in 10,000 (not more than one additional cancer case per 10,000 people). These less stringent, but still minute, hypothetical risk levels are often due to economic or technological considerations. Regulatory agencies generally view these higher risk levels to be acceptable if it is not feasible or financially reasonable to reduce the risks further.

Setting Standards

The principles of risk assessment and risk management are used by both federal and state drinking water regulators. Federal drinking water standards to control the level of contaminants in the nation's drinking water are set by the EPA as required by the Safe Drinking Water Act (passed in 1974 and amended in 1986 and 1996). Water recycling projects that involve human consumption of the water must meet drinking water standards as well as other requirements. These standards are part of the Safe Drinking Water Act's "multiple-barrier" approach to drinking water protection. The multiple-barrier approach includes assessing and protecting drinking water sources; applying appropriate (and often redundant) treatment technologies, making sure water is treated by qualified operators; and protecting the distribution system. These barriers ensure that tap water in the United States is safe to drink and will be discussed in more detail in later sections.

In California, the EPA has delegated drinking water standard implementation and enforcement to the state. Other states are also free to set their own standards but their standards must be at least as stringent as the federal standard. California drinking water standards are set by the California Department of Health Services (DHS) using risk assessment information developed by the California Office of Environmental Health Hazard Assessment (OEHHA, described in more detail below). To this end, California generally sets more stringent drinking water standards than those established by the EPA.

Process for Setting Federal Standards – IPR projects must produce water that meets or surpasses drinking water standards**.** The EPA is required to follow several steps to determine whether setting a standard for a particular contaminant is appropriate, and if so, what that standard should be. Peer-reviewed science (studies reviewed and accepted by the scientific community as valid) and other data support an intensive evaluation. This evaluation looks at occurrence of the contaminant in drinking water; how much of the contaminant humans are exposed to and risks of adverse health effects for both healthy and sensitive people (like infants and the elderly), the contribution to the total exposure (food, air, dermal), by our ability to measure the contaminant, the ability of water treatment methods to control the contaminant, and the impacts of regulation on water systems and the economy, and always protection of public health.

After reviewing health effects studies, the EPA sets a Maximum Contaminant Level Goal (MCLG). This is the maximum level of a contaminant in drinking water at which 'no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety'. MCLGs are non-enforceable public health goals (these are similar to California's "public health goals" discussed later). Since MCLGs consider only public health and not the limits of detection and treatment technology, sometimes they are set at a level that water systems cannot meet. For carcinogens and a few other substances, the MCLGs are set at zero, as an ideal goal.

Once the MCLG is determined, the EPA sets an enforceable standard. In most cases, the standard is a Maximum Contaminant Level (MCL), the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. The MCL is set as close to the MCLG as feasible. Feasible is defined as the level that may be achieved with the use of the best available technology, treatment techniques, and other means which the EPA finds are available, taking cost into consideration. If monitoring for the contaminant is not technically and economically feasible, a *Treatment Technique* is set instead. This is an enforceable method that public water systems must follow to ensure control of a contaminant.

As part of the determination of an MCL or Treatment Technique, the EPA completes an economic analysis to determine whether the benefits of potential standards justify the costs. If not, the EPA may adjust the MCL for a particular class or group of systems to a level that "maximizes health risk reduction benefits at a cost that is justified by the benefits." EPA is careful to keep the risk assessment process of setting a MCLG which involves careful consideration of the best science available separate from the risk management process of setting an MCL which involves balancing feasibility and economics.

Process for Setting State Drinking Water Standards – OEHHA is required to establish a Public Health Goal for every contaminant in drinking water for which there is an existing or state proposed MCL (State of California, Safe Drinking Water Act, 1996). Public Health Goals are concentrations of drinking water contaminants that pose no significant health risk if consumed for a lifetime. They are set by OEHHA using the process described above.

Health and Safety Code §116365(a) requires DHS to establish a drinking water contaminant's maximum contaminant level (MCL) at a level as close as is technically and economically

feasible to its Public Health Goal. Similar to the federal process, DHS conducts an in-depth risk management analysis that evaluates the technical and economic feasibility of regulating a chemical contaminant. The State regulatory process is summarized in **Figure 1** below.

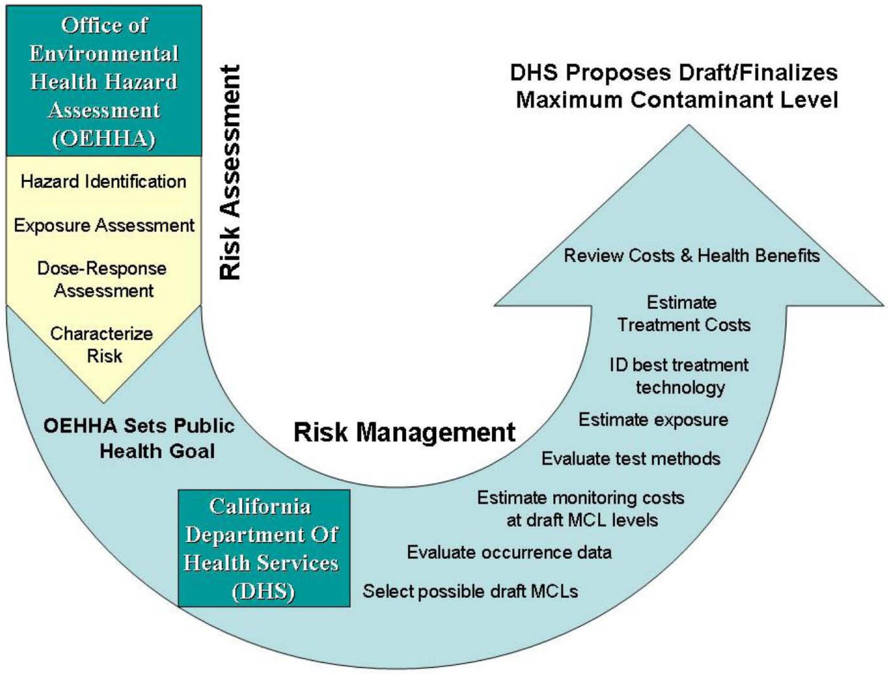


Figure 1 – California Process for Setting Drinking Water Standards

DHS:

- Receives the Public Health Goal from OEHHA.
- Selects possible draft MCL concentration or concentrations for evaluation.
- Evaluates the occurrence data.
- Evaluates available analytical methods and estimates monitoring costs at one or more draft MCL concentration(s).
- Estimates population exposures at those concentrations.
- Identifies best available treatment technologies.
- Estimates treatment costs to meet the draft MCL levels.
- Reviews the costs and associated health benefits (health risk reductions) that result from treatment.
- Proposes the draft MCL concentration or selects from the possible draft MCL concentrations considered previously.

Proposed regulations are released for a 45-day public comment period. DHS considers the comments, modifies the proposed regulations as appropriate and submits the regulation package (including responses to public comments), to the Office of Administrative Law. The Office of Administrative Law has 30 working days to review the regulation and approve or reject it. Once approved, it is filed with the Secretary of State and becomes effective 30 calendar days later.

Section 2 Recycled Water Regulations and Uses

California has developed enforceable regulations in addition to issuing guidance and recommendations. These regulations and guidance documents are part of the permit issuance process the California regulatory agencies require cities and water districts to follow prior to gaining approval for a recycling project to operate. The regulation of recycled water is found in several State documents. These are briefly described below.

Porter-Cologne Act

While the history of California water use and protection regulations extends back to the early years of the 20^{th} Century, the heart of today's current regulations is the landmark 1969 Porter-Cologne Water Quality Act. Sections of the Act were used as the basis for the 1972 Federal Water Pollution Control Act, commonly known as the CWA.

Under "Porter-Cologne", the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs) are given the authority to preserve and enhance beneficial uses of the State's waters. Beneficial uses include all the uses we make of water supplies including fishing, swimming, boating, irrigation, drinking water, etc. The Act is contained in the California Water Code, Division 7 – Water Quality, and has been modified and amended through the years to address new issues and concerns affecting water use, clean water, water conservation, reuse, and water quality. RWQCBs issue the recycled water permits under State law but rely on the advice and consent of DHS regarding public health.

Health and Safety Code

In California, Part 12 of the Health and Safety Code contains the California Safe Drinking Water Act, which addresses health aspects of drinking water. The Porter-Cologne Act refers to the Health and Safety Code and defers to its interpretation of what is harmful or hazardous to human health (hence the involvement of DHS). The water produced by indirect potable reuse projects must also comply with the California Safe Drinking Water Act requirements.

California Code of Regulations

The provisions of both the Porter-Cologne Act and the Health and Safety Code are included as enforceable regulations in the California Code of Regulations (CCR) under *Title 22 – Social Security*. Relevant topics under this heading include water recycling criteria and water permits.

State Guidance and Policy Statements

While the CCR contains established and enforceable regulations, the DHS has issued a number of guidance documents addressing water recycling. Several are listed below:

- *California Health Laws Related to Recycled Water* (State of California, June 2001)
- *Guidelines for the Preparation of an Engineering Report for the Production, Distribution, and Use of Recycled Water* (State of California, March 2001)
- *Treatment Technology Report for Recycled Water* (State of California, September 2004)

State Regulation of Water Recycling

While regulations mandate that water for consumption be of the highest quality and safe to drink, non-potable or non-consumptive uses also require high quality water that must be treated to standards appropriate for its intended use.

Regulation of Recycled Water for Non-Potable Uses – Section 13521 of the Porter-Cologne Act grants DHS the authority to set criteria for recycled water use where such use would require specific protection of public health. As a result, DHS developed comprehensive uniform regulations that establish acceptable uses of recycled water, water quality, and treatment process requirements to ensure that recycled water use does not pose health risks, use area requirements, engineering report requirements, reporting and record keeping requirements, and design requirements to ensure operational reliability of treatment. These requirements are regulated under Title 22 of the California Administrative Code (Title 22, California Code of Regulations, §60301 *et seq.*) and enforced by the RWQCBs and each issues permits for individual projects to conform to the regulations and recommendations adopted by DHS.

California has a number of definitions for differing grades of recycled water based on level of treatment and effluent water quality criteria. The basic water quality criteria for recycled water in most water recycling permits are the MCL of chemicals and microbes allowed in drinking water. These standards generally apply to both non-potable and indirect potable uses of recycled water.

Proposed Draft Groundwater Recharge Regulations for Indirect Potable Reuse – The indirect use of recycled water to augment potable supplies is permissible under California law and is currently allowed through groundwater recharge using direct injection or surface spreading and, potentially, through addition to surface water reservoirs (State of California, 2001, 2004). The DHS evaluates every proposed project on a case-by-case basis to assure that the proposed treatment method, distribution and monitoring produces recycled water that is protective of public health.

The DHS has issued draft groundwater recharge reuse regulations (December 2004). The draft regulations are applicable to all groundwater recharge reuse projects which the State defines as "one that uses recycled water and has been designed, constructed, or operated for the purpose of recharging by infiltration or injection of recycled water, a groundwater basin designated in the Water Quality Control Plan for use as a source of domestic water supply."

The draft regulations require the control of contaminants at the source, multi-barrier treatment methods to control pathogens, inorganic and organic contaminants, treatment standards, recharge methods, extraction well location, and monitoring requirements. DHS is currently accepting comments on the draft regulations. While this is only a draft rule, DHS is incorporating the rule in their issuance of mandatory permits that recycled water producers must obtain from the State prior to operation. In addition to groundwater recharge projects, key parts of these draft rules would be applied to reservoir augmentation projects as well (DHS, personal communication, January 2005).

Although regulations related to groundwater recharge projects are still in the proposal stage, guidelines and criteria in place reflect a conservative approach by the DHS toward short-term and long-term health concerns.

Non-Potable Uses for Recycled Water

The California State Water Resources Control Board estimates that nearly 525,000 acre-feet of water were recycled in California in 2001 (State of California, 2002). This includes both non-potable uses (such as irrigation) and indirect potable use, such as groundwater recharge. The City produces recycled water that is primarily used for irrigation and industrial processes. The percentage breakdown for each category of use within the state of California during 2001 is illustrated in **Figure 2**.

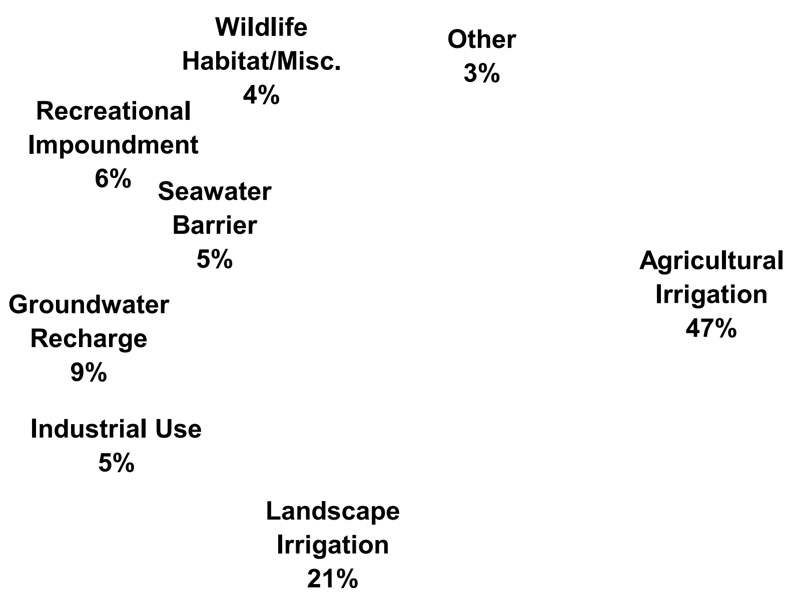


Figure 2 – Year 2001 California Recycled Water Use by Category
Source: Adapted from SWRCB data

Irrigation – As illustrated in **Figure 2**, the primary non-potable use of recycled water in California is irrigation. The primary constituents of concern when using recycled water for agricultural irrigation are salinity, sodium, inorganic elements, chlorine residual, and nutrients. Many of these can be harmful to plants or have long-term adverse effects on the soil. A number of recent references provide detailed information regarding recommended contaminant limits for recycled water for irrigation (EPA, 2004).

While irrigation water is not directly consumed, there may be indirect human contact and thus it is subject to regulations regarding pathogen loads and public health. California classifies recycled water based on level of treatment based primarily on the level of pathogen removal

(*e.g.*, "disinfected secondary-2.2 recycled water", "disinfected tertiary recycled water,") and then stipulates appropriate irrigation uses. For example, only disinfected tertiary recycled water (the highest level of treatment for irrigation uses) is allowed for irrigating root crops (food) or schoolyards. Food crops, where the edible portion is above ground and does not contact water, may use a lesser grade (disinfected secondary-2.2 recycled water).

The California State Water Resources Control Board *2001 Municipal Wastewater Recycling Survey* (State of California, 2002) lists 173 water reclamation facilities in California providing recycled water for agricultural irrigation and 98 facilities providing recycled water for landscape irrigation. In San Diego County, 16 facilities provide recycled water for some type of irrigation use, including the City of San Diego's North City Water Reclamation Plant. The cities of Carlsbad, Escondido, Fallbrook, Oceanside, Ramona, Olivenhain, among others, distribute recycled water for irrigation.

Cooling Water – For many industries, cooling water for commercial air conditioning systems comprises the largest use of recycled water. The water quality issues associated with cooling water use include corrosion, biological growth, and scaling; many of the same issues that are present with potable water. The same treatment methods used to manage these issues in potable water systems are often used in these recycled water systems (for example, corrosion inhibitors, biocides, etc.).

Recycled water produced by the West Basin Municipal Water District in Los Angeles County is distributed locally to over 100 customers, representing a wide range of beneficial irrigation and industrial uses. Two large refineries, Chevron and Mobil, use West Basin's recycled water in their cooling towers.

Irvine Ranch Water District converted a new office building in 2002 to recycled water use in two air conditioning cooling towers.

The Delta Diablo Sanitation District Recycled Water Facility in Antioch provides up to 8,600 acre feet per year of tertiary treated recycled water to two power plants for cooling tower makeup. The City of Benicia and the Valero Refinery are pursuing a recycled water project that would divert a significant fraction of the City's reclamation treatment plant effluent to the refinery. The largest potential application of recycled water identified at the refinery is the cooling towers, but other potential refinery applications include use as boiler feed water.

East Bay Municipal Utility District's North Richmond Water Reclamation Plant produces recycled water for three cooling towers located at ChevronTexaco's Richmond refinery. The City of Glendale supplies its own steam power plant with recycled water for cooling.

Water for Boilers – Another industrial use for recycled water is the replacement of evaporated water in commercial boilers. This is water used to replace the water lost to steam generation or evaporation. Often additional treatment of the recycled water is required to further reduce hardness and other inorganic contaminants that form scale in these systems (like that formed in hot water heaters over time). Generally, higher boiler operating pressures require higher quality water. Some municipalities even offer a range of recycled water qualities for industrial uses, charging a premium for very high quality (RO treated) boiler-ready water.

West Basin Municipal Water District's Boiler Feed Recycled Water Supply Program produces 4.3 MGD of two grades of high purity recycled water for Chevron Refinery's high pressure and low-pressure boilers in the City of El Segundo.

Fire Protection – The use of recycled water in fire protection is particularly problematic because of the large fluctuation in volume of water necessary for fire fighting and the enormous infrastructure required to support it. Recycled water for firefighting would have to be stored in large reservoirs and the distribution system would have to be able to maintain the pressures required by the fire fighter agencies. Water quality issues include corrosion products and biological growth as well as pathogenic considerations (fire fighting may produce breathable mists). In California, only disinfected tertiary recycled water is allowed for structural fire fighting, while lesser quality water may be used for non-structural fire fighting, such as forest fires.

The City of Livermore pumps recycled water to its Doolan Tank Reservoir where it is stored for irrigation, fire protection, and fire suppression uses. Water recycling agencies that have significant storage capacity can use their recycled water for fire protection and fire suppression.

Interior Sanitary Uses – Recycled water may be employed in commercial building sanitary uses such as flushing toilets and urinals and priming drain traps. While water quality is less important for this use, the water must still be disinfected tertiary treated recycled water to assure there is no risk of human exposure to pathogens in the water.

The first dual-plumbed new office building was built in San Rafael in the mid-1990s. Recycled water is supplied to this building by the Marin Municipal Water District. Irvine Ranch Water District provides recycled water for interior sanitary use in at least 11 high-rise buildings in Irvine, California. These office buildings, in addition to Irvine Ranch Water District's headquarters building and operation center buildings, are using recycled water for toilet and urinal flushing. The Inland Empire Utilities Agency's Administration Headquarters in Chino uses recycled water for their urinals and toilets.

Other Industrial Processes – Recycled water can be used by other industries including pulp and paper, chemical processing, petroleum refining, and textiles. The quality of water required for each of these businesses is use dependent. Some are capable of using water of fairly low quality, while others demand water that is highly treated. Parameters of concern include inorganic contaminants, hardness, alkalinity, total dissolved/suspended solids, and color.

Several carpet mills have converted their carpet dyeing process from domestic to recycled water. One conversion in Irvine alone saves 500,000 to one million gallons of potable water per day. Tuftex Industries' carpet dyeing operation in Santa Fe Springs is the largest recycled water user in the Central Basin Municipal Water District area, using 108 million gallons annually.

Environmental/Recreational Use – Environmental and recreational applications include wetland restoration and enhancements as well as incidental contact (fishing, boating) and direct contact (swimming, wading) uses. Both contaminant levels (especially nutrients) and pathogens are considerations. California allows recycled water use but restricts its application depending upon the likelihood and degree of body contact. Unrestricted recreational uses require

disinfected tertiary recycled water and extra monitoring for pathogens.

The City of Arcata's Marsh and Wildlife Sanctuary uses recycled water for wetlands, ponds, and related wildlife habitat. The recycled water flows through five marshes in the 170-acre sanctuary, where natural organisms filter the water before it is released into Arcata Bay.

The Padre Dam Municipal Water District provides recycled water to the 190 acre Santee Lakes Recreation Preserve that includes lakes, bird habitat, and recreational opportunities for camping, fishing, hiking and picnicking.

The San Jacinto Multipurpose Constructed Wetlands occupy 26 acres through which secondary-treated recycled water flows through an arrangement of marsh and open water segments, removing nitrogen before it is blended with additional recycled water and made available for irrigation at nearby farms, a duck club and the San Jacinto Wildlife Area.

Behind Prado Dam in Riverside County, 465 acres of constructed wetlands receive nearly 50 percent of the flow of the Santa Ana River, which itself consists primarily of tertiary treated recycled water from upstream wastewater treatment plants. Natural treatment occurring in the wetlands allows this water to be used for groundwater recharge downstream of the dam.

Since 1988, Union Sanitary District has been providing secondary effluent to assist in a marsh restoration project on the Hayward Shoreline along San Francisco Bay. Treated wastewater effluent is the only freshwater source to the marsh. The marsh was created when 172 acres of deteriorating salt flats were restored into a five basin system. Studies have documented the cleansing effect of the wetland on certain metals. The East Bay Regional Park District has counted over 200 different species of birds utilizing the marsh.

Other Uses – Given the increasing scarcity of potable water, recycled water has also been used in decorative fountains and water features, commercial laundries, dust suppression, backfill consolidation, and artificial snowmaking. Each of these applications has its own individual requirements from both a water quality and pathogenic consideration.

The Arizona Snowbowl Ski Resort was given the go-ahead for creating artificial snow using recycled water. The U.S. Forest Service has approved the use of recycled water to make snow to keep the Arizona Snowbowl Ski Resort open, mostly based on economic reasons. The Arizona Department of Environmental Quality (as well as the California Department of Health Services) allows tertiary-treated recycled water to be used for snowmaking.

In 1993, a Marin Municipal Water District customer was the first car wash in the state to convert to recycled water.

Indirect Potable Reuse for Recycled Water

IPR is recycled water that is purposely discharged into either groundwater or surface water that ultimately supplies a public drinking water system (NAS, 2004).

Discharge of wastewater to surface lakes and rivers is common in the United States and many of these waters serve as sources of drinking water supply. Whenever a wastewater treatment plant discharges to surface water or groundwater that serves as a drinking water source for downstream cities, indirect potable reuse occurs. This kind of reuse of treated wastewater has occurred for many decades throughout the United States. Every wastewater plant discharging into the Mississippi River contributes to the water supply for downstream cities. Similarly, wastewater treatment facilities operated by cities in the Colorado River basin or in the Sacramento/San Joaquin Delta discharge back to the rivers, and river water is subsequently delivered to Southern California, treated and distributed to water districts through the region.

There are three basic types of IPR projects: groundwater spreading, groundwater injection and reservoir augmentation which are described below. The only form of potable reuse currently regulated in California is groundwater recharge with the permit approval process under the auspices of the local RWQCB. However, DHS provides important recommendations to the RWQCB regarding the acceptability of a project. DHS will not issue a recommendation for project approval unless the proponent provides extensive evidence that the project will not be detrimental to public health. The DHS recommendations are based on treatment provided, effluent quality and quantity, spreading area operations, soil characteristics, hydrogeology, residence time, and distance to withdrawal.

Groundwater Recharge – Spreading – Surface spreading is a direct recharge method where recycled water is released into open basins and the water seeps down into the groundwater basin. It is used generally when enough land area is available, certain soil conditions are present, and if the groundwater basin is "unconfined", that is water moves through the basin. Again, depending on soil conditions, water quality may improve considerably as the water moves down through the soil and across the basin.

Since 1962, the County Sanitation Districts of Los Angeles County, the Los Angeles County Department of Public Works, and the Water Replenishment District of Southern California have teamed in a cooperative project to replenish a local groundwater aquifer with recycled water. One of the largest programs of its kind, the project has spread approximately one million acre-feet of recycled water, reducing the overdraft condition of the basin by roughly two-thirds and also reducing the area's dependence on imported water supplies.

Victor Valley Wastewater Reclamation Authority spreads 3 MGD into nine percolation ponds that recharge the Mohave River groundwater basin.

A major groundwater spreading system called the Groundwater Replenishment System is being built by the Orange County Sanitation District (OCSD) and the Orange County Water District (OCWD). Treated wastewater currently discharged into the ocean will undergo microfiltration, reverse osmosis and ultraviolet light treatment. The recycled water will be pumped to storage lakes near the Santa Ana River for percolation into the groundwater basin and ultimate consumption by Orange County residents.

Groundwater Recharge – Injection – Another method of adding to groundwater resources is through injection. Recycled water injection simply pumps the recycled water down to the groundwater, bypassing the soil percolation step. Because direct injection introduces recycled water directly into the groundwater it does not provide the treatment benefits that percolation provides. Accordingly, the injected water must be of higher quality than that used for surface spreading. Some states require treatment to drinking water standards prior to injection.

The Los Angeles County Department of Public Works operates a series of injection wells along the coast, referred to as the “West Coast Basin Seawater Intrusion Barrier”. These wells inject water along the barrier to ensure that the water level near the ocean stays high enough to keep the seawater from seeping into the local aquifers. A combination of 50 percent imported potable water and 50 percent of West Basin Municipal Water District’s (WBMWD’s) advanced treated recycled water is injected into the seawater barrier. The DHS recently granted conditional approval to increase the blend to 75 percent recycled water based upon the technical work of WBMWD, a review by a scientific expert panel and installation of ultraviolet light (UV) treatment on the water (Rich Nagel, personal communication, 2004).

Since 1976, OCWD has been operating Water Factory 21, an internationally renowned groundwater recharge and seawater barrier project. This effort was initiated to protect the groundwater basin from saltwater intrusion – which previously had encroached as far as five miles inland – and to replenish the local aquifers, which supply 75 percent of the water needs for nearly 2 million residents.

The project includes a 15 mgd advanced reclamation treatment plant with 23 multi-point injection wells that deliver water into four separate aquifers. The injection water is a blended combination of RO and UV-treated water, carbon adsorption-treated water, and deep well water. This is being replaced by the Ground Water Replenishment System described above.

Reservoir Augmentation – Reservoir augmentation adds highly treated recycled water directly to a water reservoir to increase the overall water supply. Water used in reservoir augmentation projects would undergo advanced treatment (typically membranes) and disinfection. In addition to the advanced treatment methods used, reservoir augmentation projects also allow the treated water to reside under natural environmental conditions for a period of time. This provides an additional public health barrier, as natural reduction of trace contaminants due to microbial degradation, oxidation and dilution occurs. The reservoir water would ultimately be pumped out and treated by a potable water treatment plant and used for drinking purposes.

Allowable recycled water uses and treatment level requirements are depicted in **Table 1** (State of California, June 2003). **Table 1** reflects the concept that the higher the likelihood of human contact with the recycled water, the higher the degree of required water treatment.

Table 1
Treatment Levels for Allowable Recycled Water Uses

Types of Recycled Water Use	Recycled Water Treatment Level Disinfected Tertiary	 Disinfected Secondary	 Undisinfected Secondary
Urban Uses and Landscape Irrigation			
Fire Protection	✓		
Toilet and Urinal Flushing	✓		
Irrigation of Parks, Schoolyards, Residential Landscaping	✓		
Irrigation of Cemeteries, Highway Landscaping		✓	
Irrigation of Nurseries		✓	
Landscape Impoundment	✓	✓ *	
Agricultural Irrigation			
Pasture for Milk Producing Animals		✓	
Fodder and Fiber Crops			✓
Orchards (no contact between fruit and recycled water)			✓
Vineyards (no contact between fruit and recycled water)			✓
Non-Food Bearing Trees			✓
Food Crops Eaten After Processing		✓	
Food Crops Eaten Raw	✓		
Commercial/Industrial			
Cooling & Air Conditioning – w/ cooling towers	✓	✓ *	
Structural Fire Fighting	✓		
Commercial Car Washes	✓		
Commercial Laundries	✓		
Artificial Snow Making	✓		
Soil Compaction, Concrete Mixing		✓	
Environmental and Other Uses			
Recreational Ponds with Body Contact (Swimming)	✓		
Wildlife Habitat/Wetland		✓	
Aquaculture	✓	✓ *	
Groundwater Recharge			
Seawater Intrusion Barrier	✓ *		
Replenishment of Potable Aquifers	✓ *		

* Restrictions may apply

Source: WaterRecycling 2030, California's Recycled Water Task Force, June 2003.

Section 3 Recycled Water Treatment Technology

Numerous contaminants are regulated in recycled water, but not all contaminants. This is because either monitoring methods do not exist, are too complicated for routine monitoring, are very costly, or there is no reason to believe the contaminants are present to begin with.

Public health professionals manage this uncertainty by using what is referred to as a multiple-barrier treatment approach. This approach is used for drinking water treatment as well as recycled water treatment (Davies et al, 2003; Luna et al, 2004). The basis of this approach is to ensure that the water treatment methods used have reasonable checks and balances to minimize the risk of failure and, ultimately, prevent exposure of consumers to water that presents a health risk.

It is important to understand the nature of water treatment methods before we discuss the multi-barrier approach in more detail. The following text presents an overview of water treatment.

Typical Recycled Water Treatment Methods

The following paragraphs provide an overview of the various treatment methods commonly used to produce recycled water of various qualities and end uses. There are several treatment methods that can be linked together to provide water treatment for recycled water uses. These methods are placed in sequence in a treatment plant depending on the required water quality needed. As a result of different levels of treatment, recycled water is suitable for different uses. The level of treatment is guided by the need to be protective of public health and the quality of water needed for the end use. These levels of treatment are briefly described below. The reader is referred to Wastewater Engineering: Treatment and Reuse (Tchobanoglous et al, 2002), Water Treatment Principles and Design (Montgomery, 1985) or Integrated Design and Operation of Water Treatment Facilities (Kawamura, 2000), for a detailed description of water and wastewater treatment methods,

Pretreatment – Pretreatment methods include the use of source control to minimize the introduction of contaminants into the wastewater that must then be treated to remove. The City's Metropolitan Wastewater Department regulates the quality of the wastewater that enters the wastewater system through an enforceable Industrial Wastewater Control Program (City of San Diego, 2005; EPA, 1992). The program is a joint effort between the City, other agencies served by the system, and local industry to control contaminants before they enter the wastewater system. The Program issues discharge permits, performs inspections, conducts wastewater monitoring, and enforces discharge standards at businesses and industries throughout the entire service area.

More than 1,900 industries and businesses in the service area have been identified as potential dischargers of prohibited wastes or toxic pollutants. The job of protecting the wastewater quality (for reuse or ocean discharge) begins by eliminating or pretreating contaminants at their source, before they enter the wastewater stream. The EPA has identified a list of priority pollutants that are either prohibited or strictly limited in discharges to the wastewater system. Some of the common toxic pollutants include arsenic, benzenes, chloroform, cyanide, phenols, pesticides, and heavy metals such as cadmium, chromium, copper, lead, mercury, nickel, silver and zinc.

Some of the types of local industry that are regulated to prevent contaminants from entering the wastewater system include aerospace manufacturing, metal forming, casting and finishing, pharmaceutical manufacturing, hospitals and medical centers, film processors, laundries, dry cleaners, and a variety of laboratories.

Through this program new contaminants used and discharged into the wastewater system by industry and business can be identified and managed to control their impacts on recycled water.

The Groundwater Replenishment System of the OCWD receives treated wastewater from the OCSD, which is further treated by OCWD to IPR requirements. This project will have an expanded Source Control Program to address new pollutants of concern in the wastewater stream. It is likely that DHS would require similar elements in other IPR projects. OCSD is developing an updated list of pollutants of concern to include drinking water standards and establishing a task force committee consisting of members from OCWD, OCSD, DHS, and the regulated communities. The expanded program includes:

- Expanded Wastewater Discharge Regulations to develop new regulatory provisions and local limits, where applicable, for the new regulated pollutants.
- Expansion of the permit and enforcement.
- Revising the industrial wastewater permits (point source) to include standards and requirements to control the new pollutants of concerns (i.e. NDMA, 1,4-dioxane, tritium, and 1,2,3 tri-choloropropane).
- Developing and implementing a new permitting program to control the non-point (commercial and residential) wastewater sources
- Developing and implementing a new compliance screening, follow-up and enforcement actions proceedings.
- Developing and implementing a screening mechanism to determine the potential and upcoming pollutant of concern
- Developing a new inventory program to document the chemicals used within manufacturing processes of the industrial users (permittees).
- Expansion of the sampling and monitoring program to include conducting investigative sampling and monitoring to identify the potential source discharge of the new pollutants of concern

The West Basin Municipal Water District has the following language in the DHS "Findings of Fact" as part of their conditional permit for increasing the injection percentage of recycled water into the groundwater basin to 75 percent (State, of California Public Summary, December 10, 2002):

The West Basin shall develop a Source Control Implementation Plan for proactive source control. This plan should include, but is not limited to the following elements: 1) monitoring of raw influent water from LA Bureau of Sanitation Hyperion Plant in addition to West Basin influent; 2) proactive plan for maintaining an inventory of compounds discharged into the City's *wastewater collection system so that new compounds of concern can be evaluated rapidly; 3)*

analysis of percent reduction through each West Basin plant process for all drinking water MCL's; 4) spike or seed studies for possibly constituents of concern determined by the DHS; 5) investigation program focused on the identified target compounds and their potential ability to persist through the treatment systems; 6) cooperative Memorandum of Agreement with the City of Los Angeles to address the source(s) of persistent constituents of concern, including evaluation of all chemicals and parameters listed in Attachment 1, and develop an comprehensive outreach program; and 7) time schedule for implementation of the preceding elements. The required Source Control Implementation Plan supplementing the source control program shall be provided to the Department by June 30, 2005 for review and approval, before expanded barrier operations may commence. A Memorandum of Agreement between West Basin and the City of L.A specifying responsibility of the Source Control Implementation Plan shall be signed and agreed upon by both parties following approval of the SCIP by DHS. All above elements must be implemented prior to increasing the monthly running average RWC to 100 percent. No expanded plant operations may begin without Department approval of the Source Control Implementation Plan and signature of the Memorandum of Agreement between West Basin and the City of Los Angeles.

Primary Treatment – Primary treatment removes materials that are suspended in the water. In most large treatment plants, this is done by first passing the water through screens and skimmers and then through large tanks (sedimentation tanks) where heavier materials settle out of the water. This is the method by which suspended solids are removed at the City's two water reclamation plants. After this treatment, the water is called primary effluent. Such an effluent is suitable for ocean disposal in special circumstances. Some removal of pathogens occurs in primary treatment.

Secondary Treatment – Additional biological treatment of the primary effluent is what allows water to be recycled for some types of irrigation and industrial uses. Secondary treatment removes biodegradable organic matter and pathogenic microorganisms. Naturally occurring bacteria and other microorganisms help break down the waste materials in the water. For this reason it is sometimes referred to as *biological treatment*. Secondary effluent has much lower levels of both biodegradable organic matter and pathogenic microorganisms than primary effluent, and it meets EPA standards for discharge to most rivers, estuaries and the ocean. DHS also allows its use for watering of a limited number of crops (e.g., watering of food crops where the water does not contact the edible portion, or animal food and fiber crops).

Tertiary Treatment **–** The City's water reclamation plants use tertiary treatment which consists of filtration through sand and/or other filter material, followed by disinfection, usually with chlorine, after secondary treatment. The filtration step removes particles from the water that might protect harmful microorganisms from the disinfectant. It also removes many of the microorganisms themselves. Following filtration, disinfection is used to further reduce pathogens. Tertiary treatment is required where human contact is anticipated (such as on parks and golf courses).

Advanced Treatment Methods

More advanced water treatment methods may be used in water recycling when very specific contaminants must be removed. Advanced treatment may be necessary where certain contaminants affect the intended end use (for example, salt removal may be needed where the water is going to be used in boilers that concentrate salt), or the recycled water will enter a drinking water supply, such as a groundwater basin or surface water reservoir.

The treatment methods used to produce recycled water for special applications may include membrane filtration (either microfiltration (MF) or ultrafiltration (UF)), reverse osmosis (RO), ion exchange (IX) treatment, advanced oxidation, granular activated carbon (GAC), soil aquifer treatment, wetlands treatment, and disinfection.

The water quality goals that can be achieved using these technologies include:

- salinity reduction or salt removal,
- pathogen destruction and removal,
- chemical destruction and removal, and
- ammonia and nitrate reduction to remove nutrients that may promote algae growth in reservoir

Adams et al (2002) found that certain processes associated with advanced treatment (powdered activated carbon and RO) followed by oxidation with chlorine or ozone were effective in removing seven common antibiotics. Ternes et al (1999a, 1999b, 2002) also found that ozonation and granular activated carbon (GAC) treatment were effective in removing certain pharmaceutical compounds. Huber (2003) reported that advanced oxidation processes including ozonation are effective in reducing pharmaceuticals in drinking water. Similarly, the City is seeing very promising results in treatment tests on RO and UV + peroxide which will be discussed later.

Membrane Filtration (microfiltration or ultrafiltration) – In IPR projects, membrane filtration is most commonly used as a pre-treatment step for RO. It is also used to replace sand and other filter media filtration in the tertiary treatment method described above.

Filtration membranes have actual holes or “pores”. The pores in the membrane are very small such that larger particles or contaminants are filtered out. Engineers choose the pore size of the membrane based on the desired level of treatment or the size of the contaminant that must be removed. The categories of membranes typically used for RO pretreatment are microfiltration and the smaller pore-size ultrafiltration. Membrane filtration does not remove dissolved constituents like salts.

Membrane filters have recently supplanted more traditional forms of filtration (like sand filters) because they can be installed in a smaller area, are more easily automated, and may be more reliable.

Reverse Osmosis (RO) – RO may be used in water recycling treatment when the intended use requires very low levels of salts and other dissolved compounds. It is a very good barrier against inorganics, organics and microorganisms (Montgomery, 1985; Kawamura, 2000; Tchobanoglous et al, 2002; Agenson et al, 2003). For instance, use of tertiary treated recycled water for industrial boilers would not be practical because the levels of salts in the recycled water would cause severe damage to the boilers. RO, a water treatment method by which salts can be removed to very low levels, is commonly used to make recycled water acceptable for these types of salt-sensitive uses. RO is a common method used for desalination of seawater or other salt-laden waters.

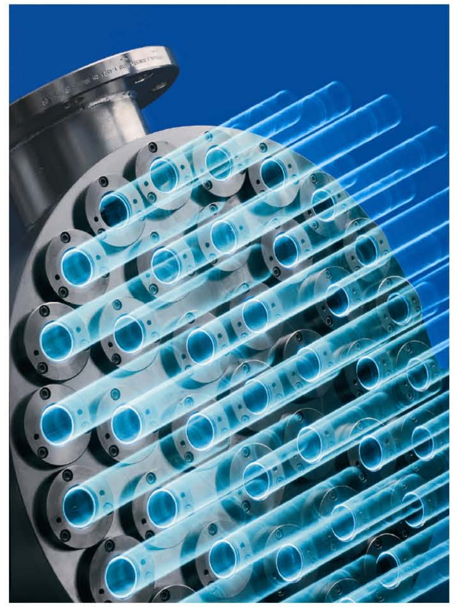
Removal is accomplished by the diffusion of water through a thin membrane. RO membranes, have smaller spaces than microfiltration and ultrafiltration membranes through which water can travel. RO uses pressure to push water through the membrane, leaving contaminants behind. Huang and Sedlak (2001) found that RO removes more than 95 percent of estrogenicity (a hormone mimicking effect) from wastewater effluent, and RO was considered effective for removal of all types of tested endocrine disrupting compounds (EDCs), pharmaceuticals and personal care products (PPCPs) (Snyder et al, 2003, 2004).

Because of its effectiveness at removing contaminants, RO has emerged as a common treatment method for IPR projects. The draft proposed regulations for direct injection into groundwater require RO treatment and UV + peroxide addition. These processes would be required for reservoir augmentation (DHS, personal communication, 2005).

Ion Exchange (IX) – IX is commonly used for calcium and magnesium (softening) and sometimes nitrate removal in drinking water treatment, and for producing ultra-high purity water for industrial uses such as semiconductor manufacturing. IX is commonly used in home water softeners (to reduce the hardness of water) and in the production of bottled drinking water. It uses special resin beads that remove a particular ion in the water, "exchanging" it with another specific ion from the surface of the beads. In the example of home ion exchange water softeners, the resin removes calcium and magnesium (naturally occurring minerals that make water form scale on plumbing fixtures) and exchanges those minerals with sodium on the beads. Once the beads are full of calcium and magnesium, a sodium chloride (salt or brine) solution is rinsed through the ion exchange resin. The sodium replaces the calcium and magnesium making a fresh resin to be used again. The brine solution must then be disposed.

Advanced Oxidation – Another relatively recent treatment advancement is advanced oxidation. Virtually all man-made chemicals can be removed by oxidation (bleaching is a form of oxidation), but sometimes oxidation alone is too slow to be practical. The basic idea of advanced oxidation is to use a combination of treatment chemicals in water to create hydroxyl radicals, which is essentially the water molecule, H_2O, without one of the hydrogen atoms. These hydroxyl radicals are quick-reacting oxidizers that can destroy organic chemicals depending on how the process is designed. Also, advanced oxidation methods can be designed to kill disease-causing microorganisms.

There are two methods of advanced oxidation that are most common. The first produces hydroxyl radicals by reacting hydrogen peroxide (H_2O_2) with ozone. The MWD is installing this treatment method at the Robert Skinner Water Filtration Plant, which serves treated drinking water to San Diego County. It is very effective at destroying algae-produced organic compounds that give the water an earthy-musty taste and odor and helps kill disease-causing microorganisms that can occur in lakes and rivers. Ternes et al (2002) examined the elimination of selected pharmaceuticals (bezafibrate, clofibric acid, carbamazepine, diclofenac) during drinking water treatment processes at lab and pilot scale and in real waterworks. In lab-scale experiments, 0.5 mg/L ozone was shown to reduce the concentrations of diclofenac and carbamazepine by more than 90 percent, while bezafibrate was eliminated by 50 percent with a 1.5 mg/L ozone dose.



UV Lamps by
WEDECO Ag Water Technology

The second method exposes the hydrogen peroxide to UV, which breaks the hydrogen peroxide into hydroxyl radicals, which then reacts with many organic molecules. This method is used commonly to destroy organic contaminants at hazardous waste sites. It is very effective against many trace organics (it is also used as a powerful disinfectant). OCWD is currently using advanced oxidation with UV and hydrogen peroxide in their recycled water to control N-nitrosodimethlyamine (NDMA) with great success (Soroushian et al, 2001). Subsequent work has demonstrated the effectiveness of UV + peroxide on 1-4 dioxane as well. West Basin Municipal Water District has also observed significant destruction of NDMA (Nagel et al, 2001). Recent pilot testing at the NCWRP have confirmed the effectiveness of UV and hydrogen peroxide on local recycled water.

Granular Activated Carbon (GAC) – GAC is effective at removing many organic contaminants in drinking water. The extent of removal depends on the contaminant. EPA evaluated the various components of the drinking water treatment process and identified granular activated carbon as the method to be used for the removal of endocrine disrupting compounds from drinking water (EPA, 2001). GAC is considered Best Available Technology for several organic endocrine-disrupting compounds (EPA, 2001), and removal efficiency was considered "good" to "excellent" for a variety of EDCs and personal care products (Snyder et al, 2003).

GAC filters in home water treatment units are quite common, however, most of those systems primarily remove the chlorine taste rather than significant amounts of organic chemicals, especially if they are not replaced frequently. GAC is not commonly used in utility drinking water treatment, as it can be a relatively expensive solution to removing organic contaminants. Part of the cost of using GAC is related to the need to periodically remove the carbon from the treatment plant and reactivate it in high temperature ovens to destroy the organics attached to the carbon.

GAC is also a porous media that can provide filtration or allow biofilm development. Biofilms can help biodegrade organic contaminants. GAC and more frequently, powdered activated carbon, are sometimes used in drinking water treatment to remove taste and odor compounds produced by algae in lakes and rivers.

Soil Aquifer Treatment – Water recycling projects, which have indirect potable reuse as their goal, use advanced water treatment. A common and effective form of advanced water treatment practice is soil aquifer treatment (AwwaRF, 2001; Asano et al, 2004, Drewes et al, 2003).

In soil aquifer treatment, the recycled water is first treated using tertiary and sometimes advanced methods as described above and then released into basins (such as dry river beds) where it slowly seeps into the groundwater. The water is ultimately pumped up and used (including for drinking purposes). Studies conducted over the past forty years have shown that a broad variety of organic and inorganic constituents are removed from the water as it seeps and moves through the soil. This method of treatment is used in Los Angeles and Orange Counties, California and elsewhere. It can be very effective at removing both organics and microorganisms (Bouwer et al, 1981; Anders, 2004; Snyder et al, 2004; Gerba et al, 1991).

Preliminary assessments suggest that advanced wastewater treatment plants and soil aquifer treatment systems effectively reduce the concentrations of Pharmaceutically Active Compounds (PhACs), but not always to concentrations below detection limits (Sedlak et al, 2005).

Wetlands Treatment – Many contaminants that are released into natural water environments can be removed or degraded by natural processes (Gearheart et al, 1988). Degradation by sunlight (Boreen et al, 2003; Horne 2000), uptake by plants (Horne 1995, 2000, 2003) and biodegradation can occur for some contaminants. Gersberg et al (1987) examined the survival of several indicators of viral pollution applied in primary municipal wastewater to artificial wetland ecosystems and found substantial removal possible. Taking advantage of these processes by constructing treatment wetlands is an option to help remove nutrients, metals, pesticides, and pathogens from urban runoff or wastewater.

Constructed wetlands can treat large volumes of water and can remove pollutants down to low levels but their effectiveness depends on how they are designed, operated, and maintained. In addition to reducing pollutants to low levels, constructed wetlands can enhance wildlife habitat, aesthetics, recreation, and property value. Natural wetlands, on the other hand, are generally not efficient at removing pollutants because the residence time (the time the water remains in the wetland) is often too short for effective treatment.

Treatment wetlands are not perfect however. Some contaminants appear to resist biodegradation especially when they are present at very low concentrations. Engineered treatment wetlands do not appear to have a large effect on concentrations of pharmaceuticals (Sedlak et al, 2005). Wetlands can also increase the concentration of some water contaminants. For example, recycled water treated by RO and discharged into wetlands would have such low levels of organic carbon to start with that the water would actually pick up organic carbon from decaying vegetation as well as salts (due to water evaporation in the wetlands).

A summary of contaminant removal capability for surface and sub-surface wetlands is shown in **Table 2** below (Horne, 2003).

Table 2
Comparison of the Strengths and Weaknesses of Free-Surface and Sub-Surface Wetlands (Horne, 2003)

Parameter	Free-surface wetland	Sub-surface wetland
Hydrology	Fast flow 10^{-2} cm/s	Slow flow 10^{-4} cm/s
Clogging	No	Yes
Sediment Removal	Good	Moderate
BOD removal	Moderate	Moderate-poor
P removal	Poor	Poor
N removal	Excellent	Moderate?
NH_4 to NO_3	Poor	Poor
Insect vectors (e.g. mosquitoes)	Need control	None present
Heavy metals	Moderate	Moderate
Pesticides	Good?	unknown
Vegetation types	Bulrush, cattail, common reed, duckweed, water grasses	Cattail, reeds, grasses, wide variety of plants
Vegetation diversity	Low	High
Recommended use	Large volumes, water features	Small systems, warm summers

Disinfection – Disinfection is used in water treatment to protect the public health by killing waterborne disease-causing microorganisms. The most commonly used disinfectant in the United States is chlorine. The broad use of chlorine with filtration to treat drinking water in the United States was largely responsible for the elimination of such waterborne disease epidemics as cholera and typhoid. Specific disinfection standards exist in drinking water treatment plants today to ensure that all water that is produced has achieved required levels of disinfection. There are also minimum chlorine residual requirements to ensure the water remains safe to drink while it travels through the distribution system to the consumer's tap.

Removal of Contaminants by Treatment

The treatment methods discussed in the previous section have varying abilities to remove contaminants in water. These contaminants can be broken into broad classes, which will be discussed briefly in the following text.

The broad classes of contaminants water treatment methods remove or reduce include:

- Organic chemicals (including trace contaminants)
- Inorganic chemicals
- Microorganisms
- Physical measurements
- Radiologicals

Recycled water treatment methods are specifically designed to reduce the amount of these contaminants to levels that reliably meet existing drinking water standards. The treatment methods that are used remove or reduce the target contaminants for which they are designed but they also provide a barrier for other similar contaminants.

Organic Chemicals – Most of the organic materials in wastewater originate from plants, animals, along with some man-made organic compounds in the waste stream. Many organics are proteins, carbohydrates, or other forms that are biodegradable, which means they can be consumed and broken down by microorganisms.

Some organic chemicals pose a risk of adverse health effects or environmental damage, even at relatively low concentrations. Accordingly, water recycling projects are designed, operated and regulated to reduce the amount of organics to levels that health regulators deem safe for human consumption.

Advances in laboratory analysis methods allow us to detect more chemicals and at smaller and smaller concentrations in our environment. In some cases, our ability to detect contaminants has outstripped our understanding of their human health significance.

An example of this is the current scientific debate over the significance of the occurrence of classes of organics referred to as PPCPs and EDCs in the environment (Daughton, 2004). These include common substances that many people consume daily such as caffeine, aspirin, birth control pills, antibiotics, and other drugs.

These substances may be found in our rivers, streams, lakes, drinking water and wastewater – usually at very low levels. In 1999 and 2000, the U.S. Geological Survey (USGS) tested 139 streams in 30 states for 95 wastewater-related pharmaceuticals, hormones and other wastewater contaminants (Kolpin et al, 2002). The sampling locations were biased toward stream receiving discharges from urban areas or stockyards. Samples were analyzed using new methods capable of detecting concentrations in the nanogram per liter (part per trillion) range. There are no drinking-water standards or health advisories for 81 of the compounds. The USGS study detected one or more of the compounds in 80 percent of the samples; half of the streams contained seven or more compounds, and one sample contained 38 compounds. Eighty-two of the 95 compounds were detected at least once nationwide. The most frequently detected compounds at trace levels included steroids (including cholesterol), nonprescription drugs (such as caffeine, nicotine metabolites, and pain relievers), and DEET, the active ingredient in many insect repellents. Detergents, steroids, and plasticizers generally were detected at the highest concentrations, however, most were less than 1 microgram per liter (part per billion). Antibiotics were detected in more than half of the samples.

The relationship of human diseases of the endocrine system and exposure to environmental contaminants is poorly understood and scientifically controversial (EPA, 2005). The primary concern over these substances in wastewater has focused on effects to aquatic life and mostly where wastewater that has not received advanced treatment is released into lakes or rivers, in other words, not IPR projects where advanced water treatment is present (Harries et al, 1996, 1997; Desbrow et al, 1998; Witters et al, 2001).

But scientists also wonder what effect, if any, these low levels of substances might have on humans. These substances occur at levels far lower than what some might take for therapeutic benefit. For example and to provide a sense of scale, a person with a headache might take a 200-milligram ibuprofen tablet. The untreated wastewater stream might have levels of ibuprofen at 1,000 times lower, and in a river that receives wastewater discharges, ibuprofen levels might be a million times lower. A person would have to drink over 30 Olympic-sized swimming pools filled with river water to ingest the same amount of ibuprofen found in a 200-milligram tablet. In fact, this level is so small that ibuprofen typically cannot be detected by the most advanced analytical methods in RO treated recycled water.

The World Health Organization (WHO, 2002) examined the state of the science regarding endocrine disruption and concluded:

- There is sufficient evidence available to conclude that adverse, endocrine-mediated effects have occurred in some wildlife populations.
- There is weak evidence to suggest that human health has been adversely affected by exposure to endocrine active chemicals,
- Many examples of adverse human health effects have been observed at high exposure levels. Further study is required to determine effects of low dose exposure and exposure during critical developmental periods (in utero, childhood, adolescence).

The EPA has attempted to develop requirements and methods for the screening and testing of thousands of pesticides, commercial chemicals, and environmental contaminants for their potential to disrupt the endocrine system through the Endocrine Disruptor Screening Program (EDSP). EPA has some data on endocrine-disrupting pesticides, however, few data are available for most of the estimated 87,000 chemicals produced today to allow for an evaluation of endocrine associated risks. The science related to measuring and demonstrating endocrine disruption is relatively new and validated testing methods are still being researched. The reader is referred to the EPA website for more information on the EDSP (http://www.epa.gov/scipoly/oscpendo/edspoverview/index.htm).

We cannot say that trace levels of PPCPs and EDCs cause human health problems. However, we cannot dismiss the concern because some contaminants might be able to produce health effects at very low levels. So, how do we manage this potential risk in drinking water and recycled water? DHS manages this uncertainty by establishing guidelines and requirements during the permitting process that consider and control trace organics in water (State of California, 2004). They require IPR projects to use advanced water treatment methods (like RO and ozone or UV oxidation) as these methods have been shown to be effective in removing these substances from both wastewater and drinking water. Monitoring requirements also exist for certain of these substances in recycled water used for IPR. It is interesting to note that none of these requirements currently apply to conventional drinking water source waters from rivers that receive upstream waste discharges. A combination of advanced water treatment processes being tested by the City is currently reducing these contaminant levels to below our ability to detect them.

Inorganic Chemicals – Inorganic chemicals in untreated wastewater include minerals, metals, and salts from both residential and nonresidential sources. Most inorganic substances are relatively stable, and not amenable to breaking down in wastewater, however many have very high removal rates in membrane treatment methods like reverse osmosis and are therefore of little concern in indirect potable reuse projects. Drinking water regulations for inorganic chemicals must be met for IPR projects.

Microorganisms – Prevention of microbial water borne disease is by far the greatest concern of all water supplies. Pathogens that are capable of causing disease like certain bacteria, viruses and protozoa are present in wastewater and often in high numbers (Rose, et al, 1991, 1996, 2001). For this reason, the primary purpose of water treatment is to remove or inactivate pathogens. Recycled water treatment is capable of large reductions in pathogen concentrations. Properly operated treatment methods are capable of removing pathogens to levels below our detection capability. However, recycled water used for non-potable purposes cannot be deemed "pathogen-free". Studies have demonstrated that *cryptosporidium parvum* (a pathogen that causes gastroenteritis) that are capable of causing infection can pass through primary, secondary and tertiary water treatment processes and adequate disinfection and monitoring is needed to insure public health is protected (Gennaccaro et al, 2003; Clancy et al, WERF, 2005).

Pathogens are controlled by instituting preventive technologies so that they will not appear in the finished drinking water. Because it is often difficult and expensive to directly measure microorganisms (including pathogens) routinely in water, substitute measurements are used to demonstrate the effectiveness of the treatment system.. *Indicator bacteria,* such as the total coliform group and more directly fecal coliforms or E. coli, and certain viruses are used to assess the potential presence of bacteria and virus in drinking water, recycled water, and wastewater. Protozoan pathogens require different measurements. Recycled water must meet coliform and other standards to be deemed safe for different uses. The National Research Council (NRC, 2004) published an extensive review of indicators for waterborne pathogens as well as specific recommendations to improve the use of indicators as indirect measures of waterborne disease risk to consumers of water. According to the NRC "a single, unique indicator or even a small set of microbial water quality indicators cannot meet this diversity of needs and applications, what is required is development and use of a "tool box" in which the indicator(s) and method(s) are matched to the requirements of a particular microbial water quality application." In practice wastewater treatment systems and recycling projects use multiple treatment barriers coupled with monitoring systems (including indicator bacteria and viruses) to provide assurance that the product water is safe for its intended and permitted use.

Physical Characteristics – Physical characteristics include temperature, color, clarity (which may be caused by turbidity and particulate matter), and odor. Conventional drinking water and wastewater treatment improves physical characteristics of water significantly (though characteristics like temperature may not be changed significantly). Advanced tertiary and membrane treatment processes such as RO can dramatically improve most physical characteristics. This is important to assure public acceptance of the water for its intended use.

Radiologicals – Radioactive substances emit energetic waves and/or particles that can cause both carcinogenic and non-carcinogenic health effects. Radioactive substances in water systems can affect individuals through several pathways: 1) direct contact, 2) ingestion, 3) inhalation, or 4) external exposure to the contaminated water. While most radiation occurs naturally, and is regulated, intentional and non-intentional releases of radioactive substances from industrial sources (such as hospitals and pharmaceutical companies) into wastewater systems can occur. IPR projects must measure and meet drinking water standards for radioactive substances.

Use of Multiple Barrier Treatment for Indirect Potable Reuse

Drinking water treatment as regulated by the DHS uses a "multiple- barrier approach" (Velz, 1970, AWWA, 1987). Each of the treatment barriers is designed by engineers to be as independent as possible such that, if one temporarily fails, the others ensure the safety of the water. Also, because each treatment barrier is not equally effective for every contaminant, barriers are selected, designed and built to produce the desired end water quality in the aggregate. In general, the lower the chances of human contact with the water, the less elaborate the water treatment. Since IPR involves human consumption of the water, California law requires very high levels of treatment and monitoring.

The multi-barrier treatment approach also provides significant protection against unknown or unmeasured contaminants. Technologies remove a range of substances, not just those that are identified. For example, a group of contaminants called nitrosamines received significant attention as potent carcinogens produced by the conversion of nitrite (from cured meats and other sources) in the stomach (NAS, 1992), and also found in some foods.. There are several nitrosamines that are chemically similar, differing only by the length and composition of the organic side-chain attached to the nitrosamine group. One of them, NDMA, has a California standard (notification level) associated with it. N-nitroso*diethyl*amine, or NDEA, is believed to potentially co-occur with NDMA but there are no occurrence data available Further, NDEA may present a similar health risk (IRIS, 2004). The water treatment technology (UV + hydrogen peroxide) that is effective for NDMA destruction in wastewater (Soroushian et al, 2001) is also likely to be effective for NDEA because it is structurally similar to NDMA. Thus, while there is no standard or routine monitoring for NDEA, the treatment method used to control NDMA also controls NDEA (and many other unknowns).

Another example is harmful bacteria and viruses. Physical removal processes (like filtration or RO) are broadly effective against these organisms, not just the ones we can detect. Similarly, disinfection (by chlorine, ozone, UV, etc.) works against all these organisms. Disinfection effectiveness can vary by the type of organism but the "treatment barrier" provides broader protection against health risks beyond the ones we know about.

No single treatment method is an absolute barrier to pathogens or chemical contaminants. A series of treatment methods that includes RO treatment is the most aggressive and thorough approach. Combinations of the treatment methods detailed above can be configured to meet all current and draft water quality regulations in existence both in California and elsewhere.

To comply with the DHS requirements for IPR, and to protect public health and safety, a City reservoir augmentation project would begin with treated high quality recycled water from the NCWRP or the SBWRP and would be configured to provide additional advanced treatment as indicated in **Figure 3-1** below.

As shown in the figure, the required IPR treatment train could follow two paths: reservoir augmentation or groundwater recharge. Either train would use RO followed by advanced oxidation. The advanced oxidation process would provide high levels of additional disinfection and destruction of organic chemicals. Ion exchange (IX) is included only as an optional treatment based on the results of recent full scale plant studies at OCWD and West Basin Municipal Water District that show modern membranes are so effective at nitrate rejection that IX is not required. GAC is an optional process that could provide yet another organics removal barrier. It is not typically included in IPR projects but could be if the community deems additional barriers are desirable and affordable. Wetlands treatment could be added but, given the high quality of the water entering the wetland, it is likely that the water quality would be degraded in a wetland due to plant decay products, wildlife fecal contamination and salt increase due to evaporation of water through plants.

The treatment process train as depicted in **Figure 3** is capable of producing an exceptionally high quality of water in comparison to virtually any existing drinking water treatment plant in the United States.

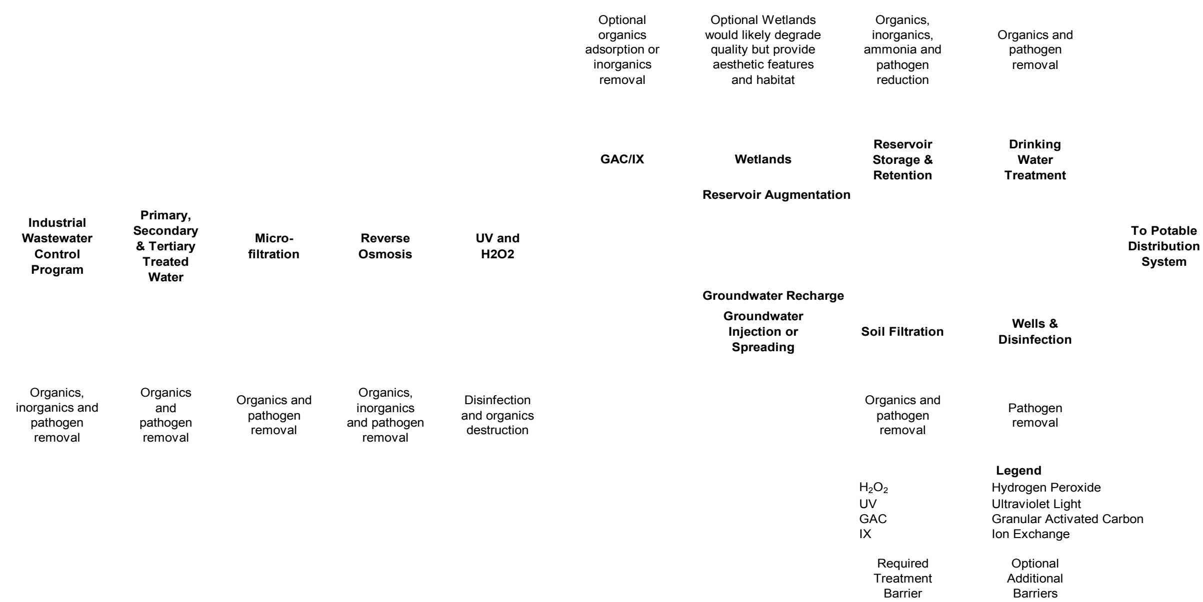


Figure 3 – Multi-barrier Treatment Methods for Indirect Potable Reuse

The water treatment methods are selected to produce a water quality that more than meets the regulatory requirements for the expected end use of the water (in the example above, IPR).

The use of multiple treatment barriers is the basis of all recycled water regulation. A major advantage of the use of multiple barrier water treatment methods is that the methods can also be effective at removing unknown contaminants that are similar in chemical structure or behavior to the ones we actually know about.

The general potential of different treatment methods to remove classes of contaminants in water is shown in **Table 3**. The effectiveness of the method depends on the nature of the contaminant, the design of the method as well as how it is operated.

Table 3
Treatment Method Contaminant Control Potential
(box indicates method can reduce indicated contaminant)

Treatment Method	Contaminant Class						
		Pathogens					
	Particles	Bacteria	Viruses	Parasites	Inorganics	Organics	Radionuclides
Pretreatment	✓				✓	✓	✓
Primary Treatment	✓					✓	
Secondary Treatment	✓					✓	
Tertiary Treatment	✓	✓	✓	✓	✓	✓	✓
Microfiltration	✓	✓		✓			
Ultrafiltration	✓	✓	✓	✓		✓	
Reverse Osmosis	✓	✓	✓	✓	✓	✓	✓
Ion Exchange					✓		✓
Ozone		✓	✓	✓		✓	
UV + hydrogen peroxide		✓	✓	✓		✓	
Granular Activated Carbon						✓	
Soil Aquifer Treatment	✓	✓	✓	✓		✓	
Wetlands	✓				✓	✓	
Chlorine Disinfection		✓	✓				

Advanced Treatment Research in Support of the Water Reuse Study 2005

As a part of the Water Reuse Study 2005, new pilot testing projects are being performed to examine several important treatment method advancements made in the past ten years (Montgomery Watson Harza, October, November, and December, 2004). These projects address some of the public health concerns expressed by stakeholder groups and during public input sessions. These projects will assess the quality of San Diego's tertiary treated water and the ability of advanced treatment technologies to improve the quality of our local water and to eliminate possible EDCs and PPCPs.

The City has a long history of research and testing of technologies for the treatment of water and wastewater. Several of these projects have been funded by EPA grants, dating back to the early 1970's and the passage of the Clean Water Act. These projects are collectively referred to as the Total Resource and Recovery projects (refer to the "Health Effects Study" prepared by the Western Consortium for Public Health, 1992, for a review of these early studies). Specifically, the City Water Department has tested and performed certification studies on RO membranes for more than 15 years and is presently continuing this work using low pressure RO membranes and advanced oxidation to determine the destruction of representative chemicals that may be of human health concern or believed to be difficult to remove by conventional treatment. For more information on EDCs and PPCPs please refer to "Occurrence Survey of Pharmaceutically Active Compounds" (Sedlak et al, 2005).

The City and the Water Authority pursued a Water Repurification Project (Project) to increase local water supply reliability. The proposed project would have used advanced water treatment on recycled water from the NCWRP, stored the treated water in the San Vicente Reservoir, treated that water again at a drinking water treatment and finally, distributed the water in the potable system. After reviewing the project plan, DHS gave conditional approval in 1994, to move forward with the Project. To address DHS conditions of approval, pilot testing of the proposed advanced water treatment processes was conducted in 1995 (Trussell et al, 2000).

Relatively recent improvements in treatment equipment include the use of state-of-the-art spiral wound hollow fiber RO membranes in place of cellulose acetate membranes, and the use of ultraviolet light instead of ozone in the advanced oxidation process. Preliminary testing shows that the current processes have much greater removal efficiencies and will reliably produce much higher quality water using fewer treatment steps.

The pilot treatment evaluation is designed to accomplish specific goals including:

- Review the current state of knowledge of issues related to: the integrity of RO membranes, effectiveness of RO membranes, RO operating parameters and optimization of UV + peroxide (advanced oxidation) for destruction of EDCs.
- Evaluate the performance of advanced water treatment methods consisting of ultrafiltration followed by RO followed by a combination of UV + peroxide on current treated wastewater from the NCWRP.
- Assess the effectiveness of new RO membrane technologies for water recycling;
- Perform field testing of direct and indirect integrity measuring methods for RO membranes.
- Determine the impact of hydrogen peroxide + UV on representative EDCs and PPCPs.

Advanced Water Treatment Performance Evaluation – The current pilot testing is being conducted in three phases. Phase I testing was designed to study monitoring methods and the integrity of RO membranes during operation, using equipment from four different manufacturers. Reliable water treatment requires membranes that do not have leaks or tears and have high "integrity" to prevent the passage of contaminants "around" membranes into the treated water. Phase II testing was designed to evaluate the best performing membranes from Phase I at a higher rate of water recovery (in other words, increasing the stress on the membranes by forcing more water through them). Phase III examined the ability of monitoring methods to detect very small membrane integrity problems.

The main purpose of this work is to gain a better understanding of the ability of advanced water treatment methods to remove contaminants present in NCWRP water that may represent a water quality concern if they are not removed. To this end, a comprehensive monitoring program is being used that also looks at contaminants that are not usually monitored or regulated.

The membrane treatment methods were operated based upon membrane studies previously conducted by the project team along with recent testing at OCWD, West Basin Municipal Water District both in California, and the City of Scottsdale, Arizona. In addition, the project team worked closely with membrane suppliers to fine tune operating conditions. The UV operating conditions were determined with a goal of at least a 90 percent removal of the test contaminant, NDMA, that was added after RO and before UV treatment.

A wide variety of inorganic and organic compounds are being measured using the best analytical equipment and methods available today. The data represented in this report are from the initial two rounds of comprehensive sampling, with additional rounds of sampling scheduled to take place over summer 2005. In general, inorganic substance monitoring includes metals, minerals, hardness, silica and physical parameters such as color, odor and turbidity. The specific organic contaminants of concern include a wide range of herbicides, pesticides, semi-volatile and volatile chemicals (compounds were selected from California's Drinking Water standards and draft ground water recharge reuse regulations). Also, a target list containing twenty-nine EDCs and PPCPs were measured entering and leaving each of the advanced water treatment processes. The selected list is believed to be a good indicator for such compounds since a broad range of chemical structures are represented. The list contains contaminants that are commonly found in secondary treated wastewater such as caffeine and ibuprofen along with others found in the environment or that have been shown to pass through reverse osmosis membranes. Though many of these are not currently regulated, many appear in the Draft California groundwater recharge reuse regulations (State of California, December, 2004).

Results – The tertiary treated water from the NCWRP was fed to the advanced treatment pilot facility. Testing to date suggest that the feed water is relatively constant and does not have much seasonal variation, based on an analysis of historical plant data. The product water from NCWRP is considered to be of excellent quality relative to similar treatment facilities across the country as initial testing has found few contaminants in comparatively low concentrations. The advanced water treatment pilot processes removed inorganic and organic contaminants to levels near or below detection limits of the most sophisticated test methods currently available. All measured contaminants in the RO/UV + peroxide treated water were either not detectable or well below federal and California drinking water standards.

In these tests, RO has been shown to provide an effective barrier against contaminant passage. The addition of UV + peroxide to breakdown chemical contaminants was also shown to be an effective barrier. Of the large number of regulated organic contaminants monitored in the water treated with RO and UV + peroxide, only low-level concentrations were detected for trihalomethanes (chloroform and similar compounds). Trihalomethanes are formed to some degree in all waters that are disinfected with chlorine. The trihalomethane levels detected were well below regulatory limits and were about 10 times lower than occur in most chlorinated drinking water systems in the United States.

The monitoring results included twenty-nine specific EDCs and PPCPs and showed that most compounds were effectively removed to below the level of detection (e.g., one part per trillion). Eight compounds that were not reduced to below the limit of detection by RO alone, and the one compound that remained detectable after advanced oxidation are reported in Table 4. This compound was triclosan and is probably due to a soap residue in the sample bottles. Triclosan is a common ingredient in antibacterial soap, used by most laboratories to wash sample bottles and other glassware. At the concentrations being tested, it is very difficult to rinse sample bottles completely free of triclosan, so only new sample bottles will be used in future rounds of testing. One of the main conclusions that can be drawn from this data is the benefit of a multi-barrier treatment train. Although RO effectively reduced the concentration of all monitored compounds by well over 99 percent, the remaining trace detectable concentrations were further reduced to below the level of detection of one part per trillion, by the advanced oxidation process.

Table 4
Preliminary Results from Pilot Scale Testing for Removal of Endocrine Disrupting Compounds and Pharmaceutically Active

Compound	RO Feed	3/25/2005 RO Permeate	% Removal	RO Feed	RO Permeate	4/13/2005 % Removal	UV/H2O2 Product	% Removal
Trimethoprim	427	2.2	99.5	335	2.6	99.2	<1.0	>99.7
Acetaminophen	<1.0	<1.0	NA	<1.0	1.2	NA	<1.0	NA
Sulfamethoxazole	834	3.7	99.6	787	3.6	99.5	<1.0	>99.9
Meprobamate	279	1.5	99.5	256	1.5	99.4	<1.0	>99.6
Carbamazepine	254	1.6	99.4	309	2,4	99.2	<1.0	>99.7
DEET	164	<1.0	>99.4	375	2.6	99.3	<1.0	>99.7
Iopromide	717	<1.0	>99.9	681	1.4	99.8	<1.0	>99.9
Triclosan	127	453	-256.7	334	172	48.5	194	41.9

* One part per trillion is equivalent to one drop of dye in 500,000 barrels of water.

** Compounds all results are in parts per trillion (ppt), the lowest detectable level was 1.0 ppt*

NA – Below detection limit, not possible to calculate percent removal or slight increase noted within analytical variability of the method.

The pilot test results to date show that advanced water treatment methods are capable of removing or reducing contaminants in NCWRP water to easily meet drinking water standards and, where standards do not exist, produce high quality water. Additional testing is ongoing and all results will be made available when routine quality control measures are complete, and the grant funding agencies have reviewed the complete set of data.

Operation Reliability and Monitoring

The NRC report (1998) reached several key conclusions regarding the safe, reliable operation of a potable reuse water system:

- Potable water reuse systems should employ independent multiple barriers to contaminants, and each barrier should be examined separately for its efficacy for removal of each contaminant.
- The multiple barriers for microbiological contaminants should be more robust than those for many other forms of contamination, due to the acute danger such contaminants pose at high doses even for short time periods.
- Systems should monitor process performance to keep critical processes under tight control.

- Utilities using surface waters or aquifers as environmental buffers should take care to prevent "short-circuiting," by which influent treated wastewater either fails to mix with the ambient water fully or moves through the system to the drinking water intake faster than expected.
- Risk management strategies should be used to reduce the risk from the wide variety of synthetic organic chemicals that may be present in municipal wastewater and consequently in reclaimed water (stringent industrial pretreatment and pollutant source control programs)
- Potable reuse operations should have alternative means for disposing of the reclaimed water in the event that it does not meet required .standards.
- Every water agency using reclaimed waters as drinking water 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.
- Operators of water reclamation facilities should receive adequate training.

Section 4 Summary of Key Health Effects Studies

Non Potable Reuse

Although there have been no confirmed outbreaks of infectious disease from the use of properly treated and managed recycled water in the U.S., the potential for infection is still a concern (Crook, 1998). Tanaka (Tanaka, 1998) used a microbial risk model and concluded that when filtered secondary effluent (tertiary treatment) was chlorinated at about 10 mg/L there was virtually no difference in the probability of enteric virus infection between recycled or domestic water used for golf course irrigation, crop irrigation, or groundwater recharge. Similar observations were made for the use of chlorinated secondary effluent and the recycled water from contact filtration with chlorine doses of below 5 mg/L.

In another quantitative microbial risk assessment (Rose and Gerba, 1991), concluded that "well operated plants with secondary treatment, filtration, and disinfection will produce a quality of recycled water which can be used for unrestricted irrigation, while maintaining an adequate margin of safety by limiting the population exposed to these waters containing low levels of pathogens."

The State of Florida used quantitative microbial risk assessment to develop guidelines for *Giardia, Cryptosporidium*, and enteric viruses in recycled water used for residential irrigation and public access areas (York et. al, 2003). An annual acceptable risk of infection of 1×10^{-4} was used in the analysis. In 1999, Florida began to require periodic monitoring for *Giardia* and *Cryptosporidium* in recycled water systems.

A five-year study in Monterey County, California determined that process controls required by *CCR* Title 22 (coagulation, flocculation, filtration, and disinfection) were sufficient to exclude the possibility of residual pathogen content in recycled water used for irrigation of food crops (Sheikh, 1990).

The findings of the study are summarized included:

- No enteric viruses were detected in the recycled water or recovered from crop samples during the entire 5-year study.
- Aerosols generated from sprinkler irrigation did not contain bacteria of wastewater origin.
- Medical monitoring of project staff did not reveal any adverse health impacts.

In a 1997 follow-up to this study, a monitoring program called the Tertiary Water Food Safety Study was conducted to test the continued validity of the earlier field pilot project (Sheikh, 1997, Sheikh, 1998). This study did not detect any *Salmonella*, *Cyclospora, E. Coli* 0157:H7, *Cryptosporidium*, or *Legionella* in any of the samples of disinfected tertiary recycled water. Based on the data collected, *Giardia* in the influent were reduced by 5 to 6 logs through the treatment plant. The authors concluded that the *Giardia* cysts remaining in the tertiary recycled water were non-viable.

The County Sanitation Districts of Los Angeles County demonstrated that *Giardia* cysts found in disinfected tertiary recycled water were probably not capable of causing infection (Garcia, 2002).

Potable Reuse

Human health and environmental risks typically associated with contaminated drinking water and other surface and subsurface water supplies are well documented regarding *untreated or partially treated wastewater* (Blumenthal et al, 2001; Higashitani et al, 2003; Isaac-Renton et al, 1996; Kindzierski et al, 1994). Studies of advanced treated wastewater effluent in rats and human populations (Condie et al, 1994a, 1994b; Frerichs, 1984) had shown no health effects. The Condie et al (1994a) study specifically examined RO treated wastewater. Other studies suggest that adverse environmental impacts associated with the aquatic disposal of untreated industrial effluents can be mitigated by treatment with RO (Dube et al, 2000, 2001; Hewitt et al, 2002).

Relatively low concentrations of some trace organic contaminants in incompletely treated waste stream discharges have been linked to adverse environmental impacts such as the feminization of aquatic wildlife, wildlife birth defects and other impacts (Dube et al, 2000, 2001; Giesy et al, 2000; Harries et al, 1996, 1997; Hayes et al, 2002; Jones et al, 2004). However, scientists have been unable to conclude these trace levels represent a human health concern, especially in advanced treated wastewater where trace contaminants are at low nanogram per liter concentrations or not detectable at all.

Virtually all scientific studies have limitations that are often imposed by the costs of conducting such studies. Also, there are a variety of potential health effects that any study can assess. Accordingly, the studies that are available to learn from are rarely directly comparable. However, as a body of information, they are important to consider when making decisions about IPR in a community.

Potable Reuse Health Issues Identified in the National Academy of Sciences Report – In 1998 the NAS issued a comprehensive report – *Issues in Potable Reuse: The Viability of Augmenting Drinking Water Supplies with Reclaimed Water (NAS, 1998)*. Authored by NAS' Committee to Evaluate the Viability of Augmenting Potable Water Supplies with Reclaimed

Water, the report built on the NRC 1982 report, *Water Quality Criteria for Water Reuse* but emphasized the public health aspects of potable reuse of recycled water.

The report referenced several large-scale health effects studies of recycled water covering both microbiological and chemical contaminants (Windhoek, South Africa; Los Angeles County, CA; Washington, D.C.; Denver, CO; San Diego, CA; and Tampa, FL), noting that these studies identified no obvious adverse health effects associated with indirect potable reuse in the specific projects examined. These studies varied widely in approach and should be considered individually (and are discussed further below). There are also design drawbacks in each of these studies, which limit their individual and overall usefulness to assess risk. The studies varied considerably from combinations of simple screening and chemical identification studies to toxicology testing. Only the Denver and Tampa studies addressed a broad range of toxicological concerns.

The report made several observations including:

- Several IPR projects in the United States generally produce reclaimed water that meets or exceeds the quality of the raw waters those systems would use otherwise, as measured by current standards.
- Current potable reuse projects and studies have demonstrated the capability to produce reclaimed water of excellent measurable quality and to ensure system reliability.
- In communities using reclaimed water where analytical testing, toxicological testing, and epidemiological studies have been conducted, significant health risks have not been identified.
- . . . the best available current information suggests that the risks from IPR projects are comparable to or less than the risks associated with many conventional supplies.
- The requirements for IPR systems thus should exceed the requirements that apply to conventional drinking water treatment facilities.

The general conclusion of the NAS report was that "planned, indirect potable reuse is a viable application of reclaimed water—but only when there is a careful, thorough, project-specific assessment that includes contaminant monitoring, health and safety testing, and system reliability evaluation**."** Also, the report recommends "that water agencies considering potable reuse fully evaluate the potential public health impacts from the microbial pathogens and chemical contaminants found or likely to be found in treated wastewater through special microbiological, chemical, toxicological, and epidemiological studies, monitoring programs, risk assessments, and system reliability assessments."

Studies Evaluated in the 1998 NAS Report

Montebello Forebay, Los Angeles County toxicological studies (Nellor et al, 1984) – In 1978, a five-year study of the potential health effects resulting from spreading recycled water in the Montebello Forebay was started. Study topics included 1) determining microbial and chemical constituents in the tertiary-treated recycled water and the replenished groundwater, 2) conducting toxicological testing of various recharge waters and imported drinking water, and 3) conducting epidemiological studies of populations ingesting groundwater influenced by the spreading project.

Two short-term genetic toxicity tests (Ames *Salmonella* test and mammalian cell transformation assay) were performed using waters concentrated by factors of 10,000 to 20,000. Substances concentrated in the water were found to be capable of producing changes in the DNA of bacteria. This change is called mutagenic activity. Mutagenic activity was highest in storm water runoff followed by dry weather runoff, recycled water, groundwater, and imported drinking water. No relation was observed between percent reclaimed water in wells and observed mutagenicity of residues isolated from wells.

Montebello Forebay epidemiological studies – The first epidemiological study was initiated in 1979 and examined health outcomes from 1969 – 1980 (Frerichs, 1984). The second studied health outcomes from 1987 – 1991 (Sloss et al, 1996), while the third examined birth outcomes from 1982 – 1993 (Sloss et al, 1999). The first two studies used an ecologic design where the incidence of a health outcome in one geographical area was compared to that of another area. In this case, areas known to use groundwater replenished with recycled water were evaluated against control areas where water supplies had not been impacted by the replenishment project, but possessed demographic features similar to the recycled water areas.

Populations in the first two studies exceeded one million people, divided roughly in half between exposure to recycled water and control groups. Census tracts were divided into exposed areas and control areas. Water quality and hydrogeologic data were used to model the estimated percentage of recycled water in potable water supply wells serving the population potentially impacted with recycled water in their water supply. The percentage of recycled water that populations were exposed to over the thirty-year study period ranged from 0 to 31 percent for the water systems in the Montebello Forebay area. Each census tract was then assigned into one of four (or five in the second study) exposure categories: high and low recycled water areas, and two control areas.

The studies concluded that there was no evidence of consistently higher rates of adverse health outcomes (general or specific mortality or morbidity) in the population who lived in the areas receiving higher percentages of recycled water. Short-term and long-term health outcomes included occurrence of infectious diseases, adverse birth outcomes, and cancer incidence. No consistent dose-response relationship was observed between exposure to recycled water and illness rates. In 1987, a Science Advisory Panel on Groundwater Recharge with Reclaimed Water issued a review of the Montebello Forebay health effects studies endorsing the continuation of the Montebello Forebay replenishment project.

The third epidemiological study (that of birth outcomes only) was not complete at the time the NRC report had been published. It was an extension of the original OLAC study of birth outcomes occurring in the Montebello Forebay populations between 1969 and 1980, focusing on the years 1982 though 1993. A cohort study using a Zip-code-level of surrogate exposure was designed to examine the association between residence in areas being served different percentages of recycled water in their potable water and several adverse birth outcomes.

Outcomes were classified into 24 categories: infant mortality, four related to prenatal development, and 19 for various types of birth defects.

The study's authors concluded that the rate of adverse birth outcomes was similar in the Montebello Forebay regions receiving recycled water when compared to the control group not receiving any recycled water. Further, within the exposed populations, the rate of these outcomes was similar in groups receiving "high" and "low" percentages of recycled water. Several limitations inherent in the study design were noted:

- There was no data on individual exposure to recycled water.
- Potential confounding factors such as cigarette smoking, alcohol consumption, and occupational exposures were assumed to be equal in the exposed and control cohorts.
- High population mobility could hamper detecting an effect.

Potomac Estuary Experimental Wastewater Treatment Plant (James M. Montgomery, Inc., 1983) **–** Beginning in 1980, the Army Corps of Engineers managed a two-year testing program of a demonstration drinking water treatment plant in Washington, D.C. The influent to the plant, a 50:50 blend of secondary-treated wastewater effluent and Potomac estuary water, simulated the water quality conditions that could occur in Potomac estuary drinking water treatment plant intakes in the event of a severe drought. The blended water received additional treatment with GAC, and post-disinfection chlorination. Two short-term genetic toxicity tests were conducted on organic extracts concentrated from the Potomac Estuary Experimental Wastewater Treatment Plant influent water, the product water, and finished water from three local conventional drinking water treatment plants. Organic concentrates were used in Ames *Salmonella* and mammalian cell transformation tests. Results showed low levels of mutagenic activity in the Ames test, with GAC treated water exhibiting less activity than the local drinking water. The cell transformation test showed a small number of positive samples with no difference between GAC treated water and finished drinking water.

Denver Potable Water Reuse Project (Lauer et al, 1990) – The health effects testing program for the Denver Potable Reuse Demonstration Project, the results of which were published in 1993, was designed to evaluate the relative health effects of highly treated recycled water in comparison with Denver's drinking water. A two-year animal study revealed no toxicologic, carcinogenic, reproductive, or developmental effects that could be attributed to the recycled water or Denver drinking water. The studies found that the quality of recycled water from the Denver Potable Reuse Demonstration Plant equaled or exceeded that of the existing drinking water supply and that it exceeded all federal and state standards for definable constituents (Lauer and Rogers, 1993; Condie, 1994a, 1994b).

Tampa Water Resource Recovery Project (CH_2M Hill, 1993) – In the 1980s, the City of Tampa, Florida evaluated advanced tertiary-treated, denitrified recycled water as an alternative for augmenting its surface water supply. Toxicological testing of finished water produced from four different unit process methods was completed in 1992. A short-term toxicity test was used to screen for mutagenicity.

The concentrate from the treatment train with GAC had the lowest mutagenic activity. Further toxicological examination included more mutagenicity testing, carcinogenicity assays, fetotoxicity, and subchronic toxicity. Ames *Salmonella,* micronucleus, and sister chromatid exchange tests of up to 1000x organic concentrates at three dose levels were conducted. No mutagenic activity was observed in any of the samples. *In vivo* testing included mouse skin initiation, strain A mouse lung adenoma, 90-day subchronic assay on mice and rats, developmental toxicity study on mice and rats, and reproductive study on mice. All tests were negative, except for some fetal toxicity exhibited in rats, but not mice, for the advanced water treatment sample.

Total Resource Recovery Project (Western Consortium for Public Health, 1996) – Between 1988 and 1990, the City compared genetic effects in recycled water concentrates and their potable water supply. 150-600x organic concentrates were used in Ames *Salmonella* test, micronucleus, 6-thioguanine resistance, and mammalian cell transformation testing. The Ames test showed some mutagenic activity, but recycled water was less active than drinking water from the Miramar Plant. The micronucleus test showed positive results only at the high (600x) doses for both treatments. *In vivo* fish biomonitoring (28-day bioaccumulation and swimming tests) showed no positive results. Baseline reproductive health and vital statistics were collected.

Windhoek, South Africa ((Isaacson and Sayed, 1988) – Introducing direct recycled water use in Windhoek prompted an epidemiological study to assess health effects of drinking recycled water directly. An analysis of more than 15,000 episodes of diarrheal diseases, jaundice and death between August 1976 and March 1983 found no relationship to drinking water source. Because of Windhoek's unique environment and demographics, these results cannot be extrapolated to other populations in industrial countries

Santa Ana River Water Quality and Health Study (2004)

The Santa Ana River Water Quality and Health Study (NWRI, 2004) was started by the OCWD in 1994 to address questions about the use of Santa Ana River (SAR) water (which is a wastewater effluent dominated river for recharging the Orange County groundwater basin). The study was designed to provide scientific information to help address concerns frequently expressed by DHS regarding the use of reclaimed water to recharge groundwater subsequently withdrawn for potable use. Researchers from several universities, research institutions and government agencies participated in the study. OCWD commissioned a Scientific Advisory Panel to assess the SAR Water Quality and Health Study. The study examined microbial risk, organic carbon, toxicology, and health effects. The Scientific Advisory Panel ultimately concluded that no chemicals of wastewater origin were identified at concentrations that are of public health concern in the SAR, in water in the infiltration basins, or in nearby groundwaters.

The discovery of new contaminants (NDMA and 1,4-dioxane, both carcinogens) in untreated wastewater, recycled water and groundwater recharged with recycled water is driving the addition of UV + hydrogen peroxide treatment in many recycling projects (including in Orange County and at West Basin). UV + hydrogen peroxide has been shown to be very effective at destroying these compounds.

Pomona, OLAC and Monterey Health Effects Studies

The Pomona Virus Study in the 1970's, the Orange County and Los Angeles County (OLAC) Health Effects Study and the Monterey Wastewater Reclamation Study for Agriculture in the

1980's served to provide a technical basis for development of regulations and guidelines for irrigation, recreational impoundments, and groundwater recharge.
The Pomona Virus Study was conducted by the County Sanitation Districts of Los Angeles County in the mid-1970's to determine what type of water treatment was necessary to control waterborne pathogens in recycled water used in recreational lakes and to evaluate more cost-effective options to meet the requirements in the California Wastewater Reclamation Criteria at that time.

The Monterey Wastewater Reclamation Study for Agriculture began in 1980 and was designed to evaluate the safety and feasibility of irrigating food crops (many eaten raw) with tertiary-treated municipal wastewater. The study results showed that use of this recycled water for food crop irrigation is safe and acceptable.

The Pomona Virus Study and the Monterey Study (Sheikh, 1990, 1998, 1999) provided evidence that effective virus removal can be accomplished using several different tertiary treatment methods and disinfection with chlorine. The latter study also showed that food crops that are eaten uncooked could be irrigated with appropriately treated recycled water without adverse environmental or health effects.

The County Sanitation Districts of Los Angeles County conducted another investigation in the 1980's evaluating potential health effects associated with groundwater recharge of recycled water in the Montebello Forebay. The study included water quality characterization, epidemiological investigations, and toxicity testing. The study's findings that no measurable adverse impacts on the area's groundwater or the health of the population ingesting the water from wells downstream of the recharge basins was further evaluated by an independent panel of experts selected by the State of California, who concluded that the risks associated with the Districts' groundwater replenishment project were minimal and probably no different from those of commonly used surface waters (Asano and Levine, 1996). The study provided a technical basis for establishing statewide criteria for groundwater recharge.

San Diego Health Effects Study

Laying the groundwork for the eventual proposal to augment the San Vicente Reservoir with advanced treated recycled water (Water Repurification Project), the City conducted a health effects study (Cooper et al, 1992) for what was then termed the San Diego Total Resource Recovery Project. The primary objective of the study was to determine if "an advanced water recycling treatment system could reliably reduce contaminants of public health concern to levels such that the health risks posed by any proposed IPR of the treated water are no greater than those associated with the present water supply". The Health Advisory Committee formed by the City to address potential public health issues associated with the Total Resource Recovery Project ultimately concluded that "the health risks associated with the use of the Aqua II Advanced Water Treatment Facility water as a raw water supply is less than or equal to that of the existing City raw water..."

There was also a reproductive survey, vital statistics collection and neural tube defects baseline study associated with the San Diego Total Resource Recovery Program published in 1990 (Molgaard et al, 1990). The baseline study could serve as a basis for future comparative work.

In May 1993, the State of California created the Potable Reuse Committee to examine the feasibility and safety of potable reuse of advance treated recycled water. This committee eventually generated a report proposing a framework for regulating IPR for surface water augmentation in 1996 (State of California, 1996). The committee recommended six criteria to be met before this type of project would be approved:

- Application of Best Available Technology.
- Maintenance of appropriate retention times based on reservoir dynamics.
- Maintenance of operational reliability to meet primary drinking water standards.
- Compliance with State of California criteria for groundwater recharge for direct injection with recycled water.
- Maintenance of reservoir quality.
- Provision for an effective source control program.

For the City's proposed Water Repurification Project, DHS used the then-current Draft Ground Water Recharge regulations as a starting point for regulatory review. Because the reservoir augmentation project would not include the soil filtration barrier of a ground water recharge project, DHS looked to the City to propose and demonstrate how reservoir processes and operations could provide substitute barriers of equal effectiveness. This led to the development of the retention time, dilution, and short-circuiting prevention conditions.

In May 1994 an independent panel of experts on drinking water and public health that was convened to review the Water Repurification Project proposal gave it their endorsement. DHS gave its approval, conditioning the approval on additional virus testing in August 1994. A special panel of prominent citizens convened that fall to review the proposal and concluded: "There is sufficient information available to determine the suitability of water repurification as a supplement to the San Diego region's water supply. Additional planning, economic analysis and environmental studies should proceed."

Technical studies continued including a siting analysis, pilot scale study of advanced treatment methods, and a reservoir hydrodynamic study. In the late summer and fall of 1995, pilot work was done to confirm virus removal as requested by DHS. These studies culminated in the preparation of the City's Water Repurification Report in 1996.

Additional health effects studies using a larger advanced pilot treatment facility were conducted which corroborated the findings of the 1992 health effects study.

A "Blue Ribbon Panel" of drinking water and public health experts was convened in 1998 by the NWRI. The panel included individuals who had served on the earlier independent advisory panel as well as some additional individuals prominently recognized in the drinking water and environmental/health community. In their September 1998 report, the panel found the project to be a, "…safe and appropriate supplemental drinking water supply for the City of San Diego." However, City Council adopted a resolution to terminate the project on May 18, 1999.

Lessons Learned From Assessment of Indirect Potable Reuse Projects

While case studies are necessarily site specific, they collectively provide a high level of comfort that IPR projects can be designed and implemented in a fashion that meets conservative State regulatory requirements and guidelines and can therefore be deemed safe by health authorities. Even with State health regulator support, community acceptance and support is most critical. The following text discusses IPR projects across the U.S. that provide useful insight into the practice.

Recycling in the City of San Diego

The City's Total Resource Recovery Project sought to show the feasibility of using natural systems combined with advanced treatment of recycled water to provide a water supply equivalent to or better than imported water supplied to the region. The goals of the program were to:

- Demonstrate treatment methods that would provide effective advanced treatment of recycled water.
- Examine the health effects of using highly treated recycled water.
- Examine the reliability of the water treatment process train.
- Construct and successfully operate a full-scale plant to provide a quality of water sufficient to be a raw water supply.

In 1974, RO pilot testing began (Aqua I) for demonstration and to provide irrigation water for the stadium's sod farm.

A technical advisory committee was appointed in 1981 to guide the work plan for a demonstration plant, called Aqua II. Phase 1 included pilot testing to examine total resource recovery through an aquatic treatment pond system and an advanced treatment plant. In 1985, a health effects study was added to the program.

The advanced treatment train included a package water treatment plant followed by RO membranes, carbon adsorption treatment, UV treatment and an aeration tower. The investigators concluded that the combination of treatment methods could reliably produce water that could be safely used as a raw water supply. Final water quality met or surpassed all national drinking water standards.

In 1994, the City committed to implementing a water reclamation program with capacity to treat 45 MGD by 2010. The original Water Repurification Project concept involved both non-potable and indirect potable reuse. The proposed water treatment methods included: 1) MF or UF; 2) RO; 3) IX; 4) ozone/peroxide contactor; 5) chlorination; and 6) dechlorination prior to discharge into the San Vicente Reservoir. In addition to removing chemical contaminants, these methods provided additional barriers and protection from pathogens.

Including a reservoir as one of the reuse project's multiple barriers would take advantage of natural treatment, dilution, and water retention time. Modeling of water behavior in the reservoir indicated that recycled water could short-circuit through the reservoir but that there was still a substantial residence time with the current reservoir capacity to take advantage of natural treatment and dilution.

The health risk of drinking water treated from the San Vicente Reservoir after augmentation with recycled water was concluded to be no greater than drinking water treated from non-augmented sources (Western Consortium for Public Health, 1996, Olivieri et al, 1996).

Recent discussions with California DHS regarding indirect potable reuse – Preliminary discussions with DHS representatives in January 2005 indicated that any new proposal for a reservoir augmentation project would need to consider the changes made to the Draft Ground Water Recharge regulations (State of California, December 2004) since approval of the City's 1998 Water Repurification Project. As described above, the new draft regulations have more strict requirements on total organic carbon, nitrogen, and source control. In addition, the RWQCB may add more requirements for inflows to the reservoir, particularly with regard to nitrogen. DHS would likely require two treatment barriers for each type of contaminant. As long as the project meets all DHS treatment and reservoir management requirements, introduction of highly treated recycled water into a drinking water treatment plant source reservoir could be permitted.

Section 5 Other Community Experiences

Montebello Forebay Groundwater Recharge Project, Los Angeles County

The oldest and most successful planned IPR project continues to expand because of its history of leadership in recycled water research and the project's advanced water quality monitoring program. This recycled water spreading project, begun in 1961, has contributed over the years numerous landmark recycled water treatment and health effects studies that have advanced other such projects, and increased our knowledge in the area of operations, maintenance, and water quality monitoring.

In the County of Los Angeles, the Montebello Forebay Groundwater Recharge Project is part of the San Gabriel River Conservation System. Today runoff, impounded water from canyon dams, recycled water from three County Sanitation Districts of Los Angeles County (CSDLC) treatment plants, and imported surface water can be directed to spreading grounds at points along the length of the river for the purpose of groundwater recharge in the San Gabriel Valley and the coastal plain.

The planned use of recycled water for groundwater recharge in the Montebello Forebay began in 1962. Today, three treatment plants designed, built, and operated by the CSDLC provide recycled water for spreading in the Rio Hondo and San Gabriel recharge basins. CSDLC's goal is to recycle as much water as possible.

Recycled water quality must comply with all drinking water standards established by DHS as determined by a running annual average.

Three major health effects studies and many water quality and operational research studies have been conducted on this reuse project over the years. The focal point of these studies was the Montebello Forebay. The first epidemiological study was initiated in 1979 and examined health outcomes from 1969 – 1980 (Frerichs, 1984). The study found no evidence of adverse health effects.

In 1987, a Science Advisory Panel on Groundwater Recharge with Reclaimed Water, created by the same state water agencies that created the 1975 expert panel, reviewed the OLAC Health Effects Study and endorsed the continuation of the Montebello Forebay recycled water spreading project. A second study of cancer incidence, mortality and incidence of infectious disease health outcomes from 1987 – 1991 (Sloss et al, 1996) and a third study examining birth outcomes from 1982 – 1993 (Sloss et al, 1999) were completed. The studies have shown no evidence of adverse effects.

Occoquan Reservoir Replenishment, Virginia

The Occoquan Reservoir is the principal water supply source for over one million people in Fairfax County, Northern Virginia. The 1,475-km2 (570 sq-mile) Occoquan Watershed was largely rural until the 1960's. Rapid growth led to water quality problems in the reservoir. The Upper Occoquan Sewage Authority (UOSA) water reclamation plant has added recycled water to the Occoquan Reservoir since 1978. The Occoquan Reservoir is a water source for the Fairfax County Water Authority's drinking water treatment plant. Recycled water from the UOSA water reclamation facility is discharged into Bull Run, a tributary of the Occoquan Reservoir, and then travels approximately six miles downstream to the reservoir. In periods of drought the plant supplies up to 90 percent of the reservoir's inflow. The water quality of the recycled water discharge is typically better than the water quality in the receiving stream and in the reservoir. After entering the reservoir, the water is then carried an additional 20 miles to the Fairfax County Water Authority's drinking water treatment plant inlet. The reclamation plant's discharge into the reservoir was at first a source of considerable controversy. Studies on the quality of the water are regularly conducted. These have established that the water from the plant is comparable to and may be better than the reservoir's other water sources.

One study investigated UOSA's treatment methods as barriers to pathogenic as well as alternative and traditional-indicator microorganisms. Samples were collected once a month for one year from eight sites within UOSA's advanced water reclamation plant. The eight sites were monitored for indicator bacteria total and bacteria, viruses and protozoa. Overall, the plant was able to achieve 99.999 percent to 99.99999 percent reduction of bacteria, 99.999 percent reduction of enteroviruses, and over 99.99 percent reduction of protozoa. No enteroviruses or fecal coliforms were detected in the final effluent. All measurements indicated that the recycled water was of a better quality than the water in the reservoir.

The Virginia State Water Control Board imposes strict conditions requiring that recycled water be monitored by an independent water monitoring agency. In addition, they require that any plant expansion be carried out in stages of no greater than 4 MGD. However, in more than 25 years of operation, there have been no water quality issues of health concern. Due to its 25 year track record of having consistently achieved good quality discharges, UOSA was given approval by the Virginia State Water Control Board to increase the plant capacity from 27 to 46 MGD instead of in 4 MGD increments.

Occoquan is often cited by water industry professionals as the longest running potable reuse project in the U.S. Occoquan is viewed as successful for two reasons:

- There was a serious water-quality problem to be solved and the project solved this problem creating very visible improvement.
- Water-quality credibility was achieved by forming a separate water quality authority, which continues to monitor and report on water quality.

West Basin Municipal Water District, El Segundo, California

The West Basin Municipal Water District is a wholesaler of treated, imported water to cities and other water systems in southwest Los Angeles County. The need to import drinking water became a critical issue in the 1950's when excessive groundwater pumping caused intrusion of ocean water into the potable water aquifers of the West Coast groundwater basin. A complex network of injection wells, called the West Coast Basin Seawater Intrusion Barrier, was constructed beginning in the 1960's by Los Angeles County to prevent any additional intrusion. Up until the mid-1990's, imported water was used as the sole source of injection water. In a major drinking water conservation effort, West Basin Municipal Water District built a water recycling facility to provide tertiary-treated recycled water for irrigation and industrial applications in their service area and advanced water treatment methods to replace a portion of the imported water injected for seawater intrusion control.

The approval process for using 100 percent recycled water underwent substantial expert and public review. A Blue Ribbon panel evaluated the treatment methods and water quality objectives and made a number of recommendations, many of which were incorporated into the DHS draft groundwater recharge criteria. Numerous studies were conducted that examined the occurrence, removal, and groundwater transport of total organic carbon, regulated priority pollutants, pathogens, disinfection byproducts, and trace contaminants, tentatively identified compounds, and pharmaceuticals.

The engineering report noted that, with the exception of ammonia concentrations, the recycled water exhibited superior water quality to the surface water supplies which they would replace (treated surface water from MWD), and represented an overall improvement in the protection of public health in this IPR project.

West Basin recently received regulatory approval from the DHS to increase the percent of advanced treated recycled water that can be injected into the groundwater to 75 percent (a staged approach to ultimately move to 100 percent recycled water, Rich Nagel, personal communication, 2004).

Las Vegas, Nevada

Since the 1950s, recycled water from Las Vegas has been discharged into the Las Vegas Wash, located between the Las Vegas metropolitan area and Lake Mead. Return flow credits permit a Colorado River water user to use and reuse the same water until it finally evaporates or sinks into the ground. Since Lake Mead is the primary source of drinking water for the Las Vegas region, as well as the destination for the region's recycled water, the principle of return flow credits allows Las Vegas to withdraw more than the 300,000 acre-feet from Lake Mead. For example, in

2001, approximately 420,000 acre-feet was withdrawn from the lake, with 120,000 acre-feet of return flow credits from the return of recycled water.

An additional concern has been raised by environmental groups in the area. Originally, the relatively small quantity of water discharged into the Las Vegas Wash created a wetlands and encouraged the establishment of a varied wildlife population. Wetlands vegetation helps clean the water that comes from the valley by filtering the water and further reducing pollutants as the water travels toward Lake Mead. The waterway also became a major rest area for migrating birds traveling through the western U.S. The increased quantity of water discharge has changed the habitat in recent years, and the wetlands areas are being destroyed by erosion. This has had a negative impact on the pollutant reduction that occurs in the wash; it is eliminating the wildlife habitat as well as producing additional sediment deposits in Lake Mead. The fact that the wetlands were artificially created by humans does not reduce the concern for their ongoing destruction. Erosion control features are now being constructed in the wash to slow water flow and control erosion.

Public health is always a concern when a potable water source includes recycled water. In the case of the Las Vegas Wash discharge, there is a large capacity for natural treatment and dilution in the cycle of water discharge through Las Vegas Wash to Lake Mead. At capacity, the lake holds approximately 28 million acre-feet of water, and even during severe droughts such as 2004, the reservoir holds approximately 14 million acre-feet of water. The 120,000 acre-feet of discharge (at 2001 flows) from the Las Vegas area is treated and disinfected to secondary treatment standards, then passes through the wetlands and stream beds of the Las Vegas Wash prior to reaching the lake, which holds more than 100 times the annual discharge.

Gwinnett County, Georgia

In 1995, Gwinnett County approved a new 20 MGD reclamation treatment plant called the North City Advanced Water Reclamation Facility (NCAWRF). This project is an example of IPR because numerous drinking water treatment intakes for the metropolitan Atlanta area are located downstream of the proposed discharge point. The proposed treatment included advanced secondary treatment for nutrient removal, membrane filtration, multi-media and activated carbon filters, and ozone disinfection.

The major public issue surrounding the proposed discharge of recycled water into Lake Lanier, a major source of drinking water for the metropolitan Atlanta area, was the potential aesthetic impacts such a discharge may have on the commercial and recreational activities around the lake. The idea of introducing recycled water into the lake close to the intake of a major drinking water treatment plant created relatively little public response compared to the environmental and economic concerns.

In 1999, the regulators delayed issuing a discharge permit for expansion of the NCAWRF until they could establish water quality standards for the lake. One year later, in early 2000, the standards were released; in November of the same year the State issued a National Pollutant Discharge Elimination System (NPDES) permit to Gwinnett County. Eventually, environmentalists and lakeside residents sued the county and state regulators, arguing that the discharge permit issued by the State for the expansion and discharge into the lake established treatment standards that were not as stringent as the plant's proposed capability based on the water quality produced in the already operating 20 MGD facility.

The plaintiffs' fear is that the water will eventually degrade the lake putting recreational users and habitat at risk. The concept of IPR does not seem to be the major issue, primarily because there are already other wastewater dischargers around the lake. The quality of these return flows is considered by many people (but not all) to be "cleaner" than the current lake quality with respect to drinking water quality, but not necessarily for maintaining the ecological health of the lake. The recycled water discharged into Lake Lanier would contain nutrients like phosphorus that may encourage the growth of algae and other aquatic plants.

An administrative law judge ruled against the environmental groups in September 2002, but a Hall County Superior Court judge reversed that ruling in March 2003. The Georgia State Supreme Court later struck down the permit that had been issued by the State ruling that Gwinnett County's discharge permit would not protect water quality in Lake Lanier. The Court stated that "the clear and unambiguous language of Georgia's anti-degradation rules require the permittee to use the 'highest and best (level of treatment) practicable under existing technology'". In the meantime, Gwinnett County has asked the regulators for a temporary permit to discharge 9 MGD into the Chattahoochee River above the 20 MGD already permitted for Gwinnett's existing reclamation plant.

Dublin San Ramon Services District, California

Dublin San Ramon Services District (DSRSD) proposed an IPR project using groundwater injection as the best and most cost-effective means to resolve their wastewater disposal problem created by rapid growth in their service area (Requa, D., personal communication, November 2004). The recycled water was to be injected into wells in Livermore but the majority of the water withdrawn would be delivered to Pleasanton and Dublin. The Environmental Impact Report process included an extensive public involvement program and an analysis of alternatives including local stream discharge and a seasonal storage reservoir. The DSRSD Board of Directors subsequently approved the project and moved ahead with design and construction.

The Pleasanton community believed that they were bearing the brunt of other communities' growth problems. In the face of strong public opposition, and when the need for additional wastewater treatment capacity was eliminated with approval for expansion of the ocean outfall, DSRSD withdrew the IPR component of their project and advanced the non-potable aspects of the project.

DSRSD entered into an agreement with the City of Pleasanton in which Pleasanton agreed not to challenge the project if DHS and the RWQCB approved the project. Upon completion of construction, DSRSD was approved to place the project into operation by these agencies. Ultimately, two of the agencies that were to receive the water withdrew their support of the project due in large part to their perception that public support of the project had been lost.

DSRSD dropped the project since it was no longer required to provide wastewater service, even though surveys indicated that a majority of the residents supported or accepted the project. Although the injection project that would have provided recycled water for IPR did not proceed, DSRSD has gone forward with non-potable reuse of this water supply.

The experience suggests that IPR projects are permittable in California. Community support is essential. Also, it could be inferred that a water supply agency is better suited to sponsor a water reuse project because water resource benefits are primary and wastewater disposal aspects are secondary. Public outreach and involvement should be thorough and continue throughout the development and construction of a project.

Orange County Groundwater Replenishment System

OCWD built Water Factory 21 in the 1970's to produce recycled water for injection into the groundwater to create a seawater intrusion barrier. The OCWD is proceeding with design and construction of a significant expansion/upgrade with advanced treatment technology. The number of seawater intrusion injection wells will be increased, a pipeline to deliver recycled water to the Anaheim Forebay (upper part of groundwater basin where current SAR spreading operations occur). According to Ruetten (2003):

The program has experienced success to date as OCWD has identified a clear set of problems that are perceived to be significant enough to warrant expansion of GWR and indirect-potable reuse These include protection of the aquifer against seawater intrusion, decreasing dependence on imported water supplies, improving drought resistance and reducing wastewater discharges to ocean beaches. In addition, they are using state-of-the-art treatment processes including reverse osmosis, have an established track record (with Water Factory 21) of being proactive with respect to emerging water-quality issues, have established themselves as a credible source of water quality information and their communication program is diligent and consistent.

These factors have fostered feelings of trust and credibility and are the basis for the success of the project so far. The only apparent water-quality issue that is still open is the desire by some key audiences to get the Department of Health Services (DHS) officially involved in the pre-treatment standards that govern the wastewater treatment plant.

Section 6 Conclusions

Based upon an assessment of the issues, studies and experiences, indirect potable and non-potable reuse projects can be implemented and can meet water quality and public safety goals.

The available human health studies are sufficient to convince the DHS that highly treated recycled water can be safely consumed by humans through IPR projects. Accordingly, DHS has permitted several such projects in the state, making California a leader in this area.

Permitted IPR projects protect the public health through:

- Use of advanced water treatment methods that reliably remove contaminants of concern.
- Careful operation and maintenance of those methods.
- Use of multiple monitoring systems to ensure consistently high quality water is produced.

Numerous science-based, health effects studies and regulations support IPR. While additional studies can and will be conducted in the future, these studies provide evidence of the safety of recycled water. While IPR is supported by and allowed under California regulations, successful implementation of projects has only occurred where there is community and political support.

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