PALMDALE RECYCLED WATER AUTHORITY (PRWA)
HELD AT CITY OF PALMDALE
CITY HALL COUNCIL CHAMBERS
38300 SIERRA HIGHWAY, SUITE B
PALMDALE, CALIFORNIA
REGULAR MEETING AGENDA NO. 29
DECEMBER 21, 2016
7:00 P.M.
www.cityofpalmdale.org
www.palmdalewater.org.

WELCOME

NOTE: Materials related to an item on this Agenda submitted to the Palmdale Recycled Water Authority Board of Directors, or after distribution of the agenda packet, are available for public inspection at the City of Palmdale City Hall, located at 38300 Sierra Highway, Suite A, Palmdale, California, and at the Palmdale Water District, 2029 East Avenue Q, Palmdale, California during normal business hours and will also be available at the meeting. Those items provided by others at the meeting will be available at City Hall during normal business hours.

A **three-minute time limit** will be imposed on all speakers other than staff members.

In accordance with the Americans with Disabilities Act of 1990, if you require a disability-related modification or accommodation to attend or participate in this meeting, including auxiliary aids or services, please call the Palmdale Water District at least 48 hours prior to the meeting.

Your courtesy is requested to help our meeting run smoothly. If you'll be kind enough to follow these simple rules, we can make the best possible use of your time and ours:

- Please refrain from public displays or outbursts such as unsolicited applause, comments, cheering, foul language, or obscenities.
- Any disruptive activities that substantially interfere with the ability of the Board of Directors to carry out its meeting will not be permitted and offenders will be requested to leave the meeting.
- Please turn off or mute your cell phones and mobile devices.

1. CALL TO ORDER.

2. **PLEDGE OF ALLEGIANCE.**

3. **ROLL CALL: DIRECTORS JAMES C. LEDFORD, JR., KATHY MAC LAREN, ROBERT ALVARADO, FRED THOMPSON, AND HELEN VELADOR**

4. **CONSENT CALENDAR:**

4.1 Approve the Minutes from the previous meeting held on November 16, 2016. (Staff Reference: Secretary Smith)

Call for Public Comments

Staff Recommendation: Move to approve the minutes from the November 16, 2016. (Voice Vote - Requires a majority to approve.)

5. **ACTION CALENDAR:**

5.1 Review the four applicants for the appointment of the Public Member of the Board of Directors. (Staff Reference: Executive Director LaMoreaux)

Call for Public Comments

Staff Recommendation: Review the four applicants for the appointment of the Public Member of the Board of Directors and make a recommendation. (Voice Vote - Requires a majority to approve.)

6. **NON-AGENDA ITEMS - PUBLIC COMMENTS:** This portion of the Agenda allows an individual the opportunity to address the Board of Directors on any subject regarding Palmdale Recycled Water Authority business. Under state legislation, no action can be taken on items not specifically referenced on the Agenda. **PLEASE NOTE: A three-minute time limit** will be imposed on each speaker other than staff members.

7. **REQUESTS FOR NEW AGENDA ITEMS:**

8. **INFORMATIONAL REPORT OF THE BOARD OF DIRECTORS, EXECUTIVE DIRECTOR, AND ASSISTANT EXECUTIVE DIRECTOR.**

9. **ADJOURNMENT** to **January 18, 2017** at **7:00 p.m**. at the City of Palmdale City Hall Council Chambers located at 38300 Sierra Highway, Suite B, Palmdale, California.

Complete packets can be viewed at City Hall, located at 38300 Sierra Highway, Suite A, Palmdale, California; Palmdale Water District, 2029 East Avenue Q, Palmdale, California, and the Main Library, located at 700 East Palmdale Boulevard, Palmdale, California. You can also view the Agenda for the Palmdale Recycled Water Authority on the City's website at www.cityofpalmdale.org or the Palmdale Water District website at www.palmdalewater.org.

Thank you for attending your Palmdale Recycled Water Authority meeting. If you have any further questions, please contact the Secretary's Office at (661) 267-5151, Monday through Thursday, 7:30 a.m. to 6:00 p.m., closed every Friday.

PALMDALE RECYCLED WATER AUTHORITY

BOARD MEMORANDUM

DATE: December 14, 2016 — **December 21, 2016 Board Meeting**

TO: BOARD OF DIRECTORS

FROM: Mr. Dennis LaMoreaux, Executive Director, PRWA

RE: **AGENDA ITEM NO. 5.1** – DISCUSSION, REVIEW, AND RECOMMENDATION REGARDING THE APPOINTMENT OF THE PUBLIC MEMBER OF THE BOARD OF DIRECTORS.

Recommendation:

Palmdale Recycled Water Authority (PRWA) staff recommends the Board review the four applicants for the appointment of the Public Member of the Board of Directors.

Background:

The Joint Powers Agreement of the PRWA directs that both members of the PRWA to jointly appoint a fifth director. Beginning November 27, 2016 the position was published in the Antelope Valley Press and posted on both Members' websites announcing that the PRWA was accepting applications for the Public Member position. Applications were accepted until the close of business of December 8, 2016.

Four interested people submitted applications for this position and all four applicants reside within the PRWA boundaries. The four applicants are listed alphabetically as follows:

Daly, Scott
Granai, Stephanie Joanne
Mazariegos, Junior G.
Velador, Helen

Financial Impact:

The Public Member may choose to receive $150.00 per authorized meeting attending and reimbursement for training expenses.

Supporting Documents:

The applications submitted by the four applicants are attached. Personal information has been redacted.

Application

for

Scott Daly

RECEIVED

2016 NOV 30 PM 2: 48

City Clerk Dept.

CITY OF PALMDALE
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PALMDALE WATER DISTRICT
PWD
ESTABLISHED 1918

Palmdale Recycled Water Authority (PRWA)
Public Member Application

Please Print or Type:

Name: SCOTT DALY

Address:

City: PALMDALE Zip Code: 93550 Home Phone:

Occupation: RETIRED Bus. Phone:

Why are you interested in this position? THE USE OF RECYCLED WATER WILL BECOME MORE IMPORTANT EACH YEAR. I WOULD LIKE TO BE INVOLVED IN HELPING DECIDE THE BEST WAY TO USE IT.

Considering your previous experience and activities in business, labor, professional, social or other organizations, indicate what you feel are the most important experiences and abilities that qualify you for this position. I HELPED IMPLEMENT THE SAMPLING, TESTING AND CHLORINATION PROGRAM FOR THE POTABLE TANKS/RESERVOIRS AND RECYCLED TANKS. I HAVE 25 YEARS OF SUPERVISORY EXPERIENCE AND CUSTOMER SERVICE.

Have you had previous public service experience on a commission or public body? If so, indicate the public agency, title of position, and duties. CITY OF GLENDALE WATER QUALITY WEEKLY MEETING, WATER SYSTEM SUPERVISOR I. DISCUSSED WATER QUALITY ISSUES AND WAYS TO DEAL WITH THEM.

What do you hope to accomplish as a Palmdale Recycled Water Authority Member? I HOPE TO HELP TO GET RECYCLED WATER USED IN AS MANY PLACES AS POSSIBLE IN PALMDALE.

In your opinion, what is the goal of the Palmdale Recycled Water Authority and what benefit does it provide to the citizens of Palmdale? THE GOAL SHOULD BE TO EXPLORE AND IMPLEMENT THE USE OF RECYCLED WATER IN AS MANY AREAS OF PALMDALE AS POSSIBLE. DOING THAT WOULD CUT DOWN ON THE USE OF POTABLE WATER.

List your education, highest year completed, and degrees, if any? 18 UNITS AT CITRUS COLLEGE OF WATER RELATED CLASSES TO PASS MY 4 YEAR APPRENTICE PROGRAM FOR THE GLENDALE, CA DWP.

REASONABLE ACCOMMODATIONS: Based on your understanding of this PRWA position, will you require any special accommodations to apply and/or participate as a member? ___ Yes X No

If yes, what reasonable accommodations would be necessary to assist you in this area?

In Case of Emergency:

Whom should we notify?

____ ______________________

Name Relationship to Applicant

Home Phone:____________________________ ~~Work~~ Phone. ______________

Physician's Name:________________________ Phone: __________________

Do you have any medical history that we should be aware of in the event of an emergency? (Allergies, medications, etc.)

N/A

____

Agreement

The City of Palmdale and Palmdale Water District are equal opportunity employers and do not discriminate in hiring or employment upon any basis prohibited by law, including race, color, creed, religion, age, sex (including pregnancy, childbirth and related medical conditions), cancer, national origin, genetic characteristics, genetic information, ancestry, sexual orientation, gender, gender identity, gender expression, marital status, veteran status, disability, or any other basis protected by applicable law. None of the questions or information sought in this application are intended to discriminate based upon any status protected by law. If you need reasonable accommodation in completing this application, or in any other part of the application process, please contact the Palmdale City Clerk's Office at 661/267-5151.

I certify that all statements on this application are true and complete to the best of my knowledge. I hereby authorize the City of Palmdale to investigate any information contained in this application. I understand that as part of the final selection process I will be required to pass a livescan fingerprint scan submission via the California Department of Justice. I understand that information collected during this background check will be limited to that appropriate to determining my suitability for particular types

of work and that such information collected during the check will be kept confidential. I understand that false or misleading statements shall be sufficient grounds for disqualification from this position.

I hereby agree to the Agreement set forth on this 28 day of NOVEMBER, 20 16.

Signature:
Scott Daly

If you wish, you may attach a copy of your resume to this application.

Please return the completed application to the Office of the City Clerk, City of Palmdale, 38300 Sierra Highway, Suite C, Palmdale, CA 93550. For additional information, you may call the City Clerk's office at (661) 267-5151.

SCOTT DALY

Palmdale, CA 93550 US

⍰ Executive Summary

•I worked as a cook for a company named Bob's Big Boy, in Glendale, CA, from 06/1971 to 09/1971.

•I worked as a stock clerk for a company called Bond Clothing, in Glendale, CA, from 12/1972 to 05/1973

•I worked as a shipping/receiving clerk for a company named Veeder-Root, in Glendale, CA, from 06/1973 to 09/1974.

• I worked as an inventory control & receiving clerk for a company named Van Luit Wallpaper, in Los Angeles, CA, from 09/I974 to 12/1976.

•I worked for the City of Glendale Parks and Rec. Dept., in Glendale, CA, from 02/1977 to 11/1977.

• I worked for the city of Glendale DWP, in Glendale, CA, from 12/1977 to 11/1998.

• I worked for the city of Glendale Water Quality section, in Glendale, CA, from 11/1998 to 07/2010.

⍰ Achievements

•25 years supervisory experience.

•25 years' experience getting employees to work water together as a team.

•25 years' experience in job scheduling.

•25 years' experience in customer service dealing and solving water quality problems.

•25 years' experience in inventory control and parts ordering for jobs.

•3 1/2 years shipping/receiving clerk experience.

•Helped implement and supervise the water quality field crew for all sampling, testing and chlorination of potable tanks, reservoirs and distribution system and the recycled water tanks.

•Made sure all sampling, that was required by the CA State Dept. of Public Health Title 22 was completed in a timely manner.

•Obtained my State of California Dept. of Public Health T3 Water Treatment Operator license (#9965) and my Grade D2 Water Distribution Operator license (#2118)

▯ Employment History

Water System Supervisor 1

City of Glendale Water Quality ▯

November, 1998 — July, 2010 (11 years 8 months)

•I supervised 2 full-time and 2 part-time employees

•Scheduled the daily, weekly, monthly, quarterly, bi-annual and annual sampling of potable distribution system

•Took bacterial, TTHM/HAA5, and any other water samples, required by the CA State Dept. of Public Health, for the potable tanks, reservoirs, & potable distribution system

•Tested the potable water for CL2, NO2, NO3, NH3 and recycled water for CL2

•Chlorinated potable tanks/reservoirs and recycled water tanks

•Took bacterial water samples for any potable water main & service repairs, new water main installations and recycled water tanks

•Filled out the CA State Dept. of Public Health monthly report

•Made sure that all water sampling, required by the CA State Dept. of Public Health for different constituents in the water, were tested in the appropriate time period

•Filled out yearly work evaluations on the employees that I supervised

•Kept a running inventory of sampling bottles, testing supplies and chlorine (liquid & powder)

•Reordered when inventory got low

•Tested each new order of liquid CL2 for % strength

•Tested all sampling machines to make sure they were calibrated properly

•Dealt with customer service complaints.

Water System Supervisor 1

City of Glendale DWP ⍰

June, 1985 — November, 1998 (13 years 5 months)

•I supervised 2-7 employees

•Did job scheduling

•Ordered parts and supplies necessary to perform the scheduled jobs

•Installed and repaired potable water mains, gate valves & water services

•Installed and repaired fire service lines and fire hydrants

•Cleaned and disinfected the inside of potable tanks and reservoirs. Changed water meters

•Filled out asphalt or cement patch repair and water meter change reports

•Filled out employee yearly work evaluation reports

•Inspected new water main, water service and fire hydrant installation, by private contractor, to replace aging water infrastructure for two years

•Dealt with customer service complaints.

Maintenance Worker/Apprentice/Mechanic

City of Glendale DWP ⍰

December, 1977 — June, 1985 (7 years 6 months)

•Helped with the installation & repairs of potable water mains, gate valves & water services

•Helped with the installation & repairs of fire service lines & fire hydrants

•Changed water meters

•Was in a water apprentice program for 4 years during the above time period

Maintenance Worker

City of Glendale Parks & Rec. ⍰

February, 1977 — November, 1977 (10 months)

•Helped take care of the grounds at different parks

•Weeded, trimmed bushes & trees, mowed & edged lawns.

•Did custodial work at Brand Park Art Studios and American Legion building which consisted of vacuuming carpets, mopping & waxing floors, cleaning sinks & toilets, dusting & polishing furniture and counter tops

•Also had to set up tables & chairs at the Art Studios for different classes.

Inventory Control & Receiving Clerk

Van Luit Wallpaper ⍰

September, 1974 — December, 1976 (2 years 3 months)

•Kept inventory records of wallpaper reels in stock

•Used forklift to take out 625 yd. wallpaper reels, to printing machines, to have colors and designs put on when requested

•Used forklift to unloaded pallets of blank 625 yd. wallpaper reels, from delivery trucks, and put in stock

•Kept accurate records of all stock on hand.

Shipping/Receiving Clerk

Veeder-Root ⍰

June, 1973 — September, 1974 (1 year 3 months)

•Unloaded delivery trucks

•Checked invoices to make sure delivered merchandise was correct

•Put merchandise in stock

•Got packages ready for afternoon pickup

•Made sure invoices were correct for items being shipped

•Helped load trucks with items to be shipped

•Had shipping invoices signed by driver.

Stock Clerk

Bond Clothing ⍰

December, 1972 — May, 1973 (6 months)

•Unpacked packages of clothes and restocked shelves and tables, on the sales floor.

•Priced the items to go on the sales floor.

Cook

Bob's Big Boy ⍰

June, 1971 — September, 1971 (3 months)

•Cooked meals for lunch and dinner.

⍰ Education

Glendale High School, Glendale, CA USA

•High School Diploma

Glendale College, Glendale, CA USA

•1 year Bookkeeping, 3 units Algebra/Trigonometry, 1 year Photography

Citrus College, Glendora, CA USA

•Took the 6 required classes for the water apprentice program.

•The classes were:

•Water Treatment 1 & 2

•Water Distribution 1 & 2

•Water Hydraulics

•Water Supervision

⍰ Download resume file

Application

for

Stephanie Joanne Granai

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2016 DEC -7 PM 5:39

City Clerk Dept.

CITY OF PALMDALE
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PALMDALE WATER DISTRICT
PWD
ESTABLISHED 1918

Palmdale Recycled Water Authority (PRWA)
Public Member Application

Please Print or Type:

Name: Stephanie Joanne Granai

Address:

City: Palmdale Zip Code: 93552 Home Phone:

Occupation: Automotive Service Bus. Phone: X

Why are you interested in this position? I have served my community in the past and seek to be able to encourage all residents to get more involved.

Considering your previous experience and activities in business, labor, professional, social or other organizations, indicate what you feel are the most important experiences and abilities that qualify you for this position. My experience as a Commissioner allows me to view and form opinions objectively. My history gives me the ability to form well thought out views, not single issue concerns.

Have you had previous public service experience on a commission or public body? If so, indicate the public agency, title of position, and duties. (I served as a commissioner on the LA County Commission on HIV. I held the SPA 1 Service Provider Rep seat for many years. It is a planning body that is for planning, allocation, coordination & delivery of HIV/AIDS services.

What do you hope to accomplish as a Palmdale Recycled Water Authority Member?

I would bring awareness to residents about what PRWA does and the benefits it brings. I would bring the voice of the consumers to the table.

In your opinion, what is the goal of the Palmdale Recycled Water Authority and what benefit does it provide to the citizens of Palmdale? To recover, treat and distribute recycled water to specific districts to be used in a way that not only conserves California water, but lowers local tax rates for Palmdale residents.

List your education, highest year completed, and degrees, if any?

Antelope Valley College - video production & design

REASONABLE ACCOMMODATIONS: Based on your understanding of this PRWA position, will you require any special accommodations to apply and/or participate as a member? ___ Yes _X_ No

If yes, what reasonable accommodations would be necessary to assist you in this area?

In Case of Emergency:

Whom should we notify?

Name Relationship to Applicant

Home Phone: Work Phone: X

Physician's Name: Phone: X

Do you have any medical history that we should be aware of in the event of an emergency? (Allergies, medications, etc.)

no

Agreement

The City of Palmdale and Palmdale Water District are equal opportunity employers and do not discriminate in hiring or employment upon any basis prohibited by law, including race, color, creed, religion, age, sex (including pregnancy, childbirth and related medical conditions), cancer, national origin, genetic characteristics, genetic information, ancestry, sexual orientation, gender, gender identity, gender expression, marital status, veteran status, disability, or any other basis protected by applicable law. None of the questions or information sought in this application are intended to discriminate based upon any status protected by law. If you need reasonable accommodation in completing this application, or in any other part of the application process, please contact the Palmdale City Clerk's Office at 661/267-5151.

I certify that all statements on this application are true and complete to the best of my knowledge. I hereby authorize the City of Palmdale to investigate any information contained in this application. I understand that as part of the final selection process I will be required to pass a livescan fingerprint scan submission via the California Department of Justice. I understand that information collected during this background check will be limited to that appropriate to determining my suitability for particular types

of work and that such information collected during the check will be kept confidential. I understand that false or misleading statements shall be sufficient grounds for disqualification from this position.

I hereby agree to the Agreement set forth on this 7 day of December, 2016.

Signature:

If you wish, you may attach a copy of your resume to this application.

Please return the completed application to the Office of the City Clerk, City of Palmdale, 38300 Sierra Highway, Suite C, Palmdale, CA 93550. For additional information, you may call the City Clerk's office at (661) 267-5151.

Application

for

Junior G. Mazariegos

RECEIVED

2016 DEC -8 PM 3:34

City Clerk Dept.

Palmdale Recycled Water Authority (PRWA)
Public Member Application

Please Print or Type:

Name: Junior G. Mazariegos

Address:

City: Palmdale Zip Code: 93550 Home Phone:

Occupation: Land Development & Entitlements Technician Bus. Phone:

Why are you interested in this position?

Please See Attached Document

Considering your previous experience and activities in business, labor, professional, social or other organizations, indicate what you feel are the most important experiences and abilities that qualify you for this position.

Please See Attached Document

Have you had previous public service experience on a commission or public body? If so, indicate the public agency, title of position, and duties.

Please See Attached Document

What do you hope to accomplish as a Palmdale Recycled Water Authority Member?

Please See Attached Document

In your opinion, what is the goal of the Palmdale Recycled Water Authority and what benefit does it provide to the citizens of Palmdale?

Please See Attached Document

List your education, highest year completed, and degrees, if any?

Currently I am a senior at the University of California, Irvine where I am double majoring in Earth System Science (B.Sc.) with a Concentration in Hydrology and Terrestrial Ecosystem and Urban Studies (B.A) with a concentration in Community Development.

REASONABLE ACCOMMODATIONS: Based on your understanding of this PRWA position, will you require any special accommodations to apply and/or participate as a member? ___ Yes _X_ No

If yes, what reasonable accommodations would be necessary to assist you in this area?

In Case of Emergency:

Whom should we notify?

Name Relationship to Applicant

Home Phone: Work Phone:

Physician's Name: N/A Phone: N/A

Do you have any medical history that we should be aware of in the event of an emergency? (Allergies, medications, etc.)

Agreement

The City of Palmdale and Palmdale Water District are equal opportunity employers and do not discriminate in hiring or employment upon any basis prohibited by law, including race, color, creed, religion, age, sex (including pregnancy, childbirth and related medical conditions), cancer, national origin, genetic characteristics, genetic information, ancestry, sexual orientation, gender, gender identity, gender expression, marital status, veteran status, disability, or any other basis protected by applicable law. None of the questions or information sought in this application are intended to discriminate based upon any status protected by law. If you need reasonable accommodation in completing this application, or in any other part of the application process, please contact the Palmdale City Clerk's Office at 661/267-5151.

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of work and that such information collected during the check will be kept confidential. I understand that false or misleading statements shall be sufficient grounds for disqualification from this position.

I hereby agree to the Agreement set forth on this 8 day of December, 2016.

Signature:

If you wish, you may attach a copy of your resume to this application.

Please return the completed application to the Office of the City Clerk, City of Palmdale, 38300 Sierra Highway, Suite C, Palmdale, CA 93550. For additional information, you may call the City Clerk's office at (661) 267-5151.

Junior G. Mazariegos

| Palmdale, CA | 93550

Education:

University of California, Irvine **Expected Graduation Date: Summer 2017**

Bachelors of Science, Earth System Science

Concentration in Hydrology & Terrestrial Ecosystems

Bachelors of Arts, Urban Studies

Concentration in City & Community Development

Work Experience:

Orange County Public Works

Consultant for OC Development Services **July 2016 – Present**

- Receive and review Building, Landscaping, and Grading applications from customers; assess scope of project and relevant permit requirements; educate customers regarding necessary permits and general code compliance of proposed projects.
- Verify that projects have obtained all necessary approvals; verify professional and contractor licensing.
- Calculate and verify valuations and fees; accept payments; issue permits as authorized.
- Maintain records and prepare reports as required.
- Assist in completing permit applications by explaining building permit requirements; assist and advise the general public in matters relating to building requirements and status of submitted projects.
- Track plan check applications from submission until approval; route plan checks to appropriate personnel
- Calculate Public Facility Fees for commercial, industrial, and other locations.

TAIT & Associates Inc.

Land Development and Entitlements Technician **July 2016 – Present**

- Prepare permit submittal packages in accordance with jurisdictional requirements
- Submit permit packages via online systems, fax, or in person.
- Communicate with jurisdictional employees to understand any changes in permitting requirements
- Communicate with jurisdictions, the Construction Supervisor, and Engineering Team members to resolve any redline issues

TAIT Environmental Services **October 2015 – July 2016**

Environmental Technician

- Responsible for inspecting and removing products that are deemed as hazardous by the State of California from a large retail chain distribution center.

W. M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory, UC Irvine **September 2013 – March 2016**

Laboratory Assistant, Department of Earth System Science

- Create pyrex and quartz tubes used in standards and faculty experiments
- Prepare reaction tubes (composed of Zn, TiH_2, and Fe) that are used for CO_2 graphite reduction for radiocarbon analysis.
- Processed dissolved inorganic carbon samples for radiocarbon and stable isotope analysis
- Managed laboratory inventory
- Responsible for laboratory equipment training

Research Experience:

Undergraduate Research Assistant, Czimczik Lab **March 2013 – March 2016**

Senior Thesis: Measuring Radiocarbon and Stable Isotopes of Groundwater to Monitor Anthropogenic and Natural Recharge within the Orange County Coastal Basin

- Bi-weekly groundwater sampling
- Conduct pH and salinity measurements
- Extract the CO_2 of dissolved inorganic carbon from groundwater for ^{14}C and ^{13}C analysis.
- Prepare samples for stable water isotope analysis
- Mange and interpret isotopic analysis results

Study Evaluating the Stability of Permafrost Carbon

- Analyze soil samples for pH, density, and isotopic concentrations of Nitrogen and Carbon from Svalbard, Greenland
- Utilized the W.M Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory & the Stable Isotope Ratio Mass Spectrometry (IRMS) Facility for Data Collection

Publications:

Mazariegos, J., Walker, J., Xu, X., Czimczik, C., (2016) *Tracing Artificially Recharged Groundwater Using Water and Carbon Isotopes.* Radiocarbon. p. 1-15 (DOI:1 0.1017/RDC.2016.51*)*

Radiocarbon, 2016, p. 1–15 DOI:10.1017/RDC.2016.51
Selected Papers from the 2015 Radiocarbon Conference, Dakar, Senegal, 16–20 November 2015

TRACING ARTIFICIALLY RECHARGED GROUNDWATER USING WATER AND CARBON ISOTOPES

Junior G [redacted] • Jennifer C [redacted]* • Xiaomei [redacted] • Claudia I [redacted]

Department of Earth System Science & W. M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory, University of California, Irvine, CA, 92697-3100, USA.

ABSTRACT. We conducted an isotopic analysis of groundwater in Orange County, California, USA, around the Talbert Seawater Injection Barrier to determine if recycled water, used to artificially recharge local aquifers, carries a unique isotopic signature that can be used as a tracer. From September 2014 to April 2015, we collected groundwater from six privately owned wells within the coastal groundwater basin, along with various surface waters. All water samples were analyzed for their stable isotopic composition ($\delta^{18}O$, δD), the $\delta^{13}C$ and ^{14}C signature of the dissolved inorganic carbon (DIC) pool, DIC concentration, pH, and salinity. The DIC of groundwater mixing with recycled water is enriched in ^{14}C above natural background levels, with varying signal strength through time, depleted in $\delta^{13}C$, and low in DIC concentration. Water isotopes further suggest that recycled water is a mixture of Colorado River water and regional groundwater. In contrast, groundwater found further away from the injection barrier has carbon and water isotope composition consistent with regional groundwater and Santa Ana River water. Our findings imply that recycled water injected through the Talbert Barrier is isotopically unique, and that ^{14}C enrichment may be used as an intrinsic tracer of artificial recharge within the basin.

KEYWORDS: aquifer, recycled water, replenished water, radiocarbon.

INTRODUCTION

California has long faced water supply challenges (Hundley 2001). Currently, the state is in the midst of an unprecedented water crisis caused by recent environmental changes in the Bay-Delta ecosystem, severe drought, and unsustainable groundwater withdrawal to supply agriculture and a rising population (Frederiksen 1996; Famiglietti 2014). As a result, many water districts are incorporating artificial recharge and the use of treated wastewater ("recycled water") into their management plans (Gleick 2000). Recycled water gives water agencies a reliable local water source that can be used to increase artificial recharge, while reducing cost and dependence on imported water supplies.

Artificial recharge is an engineered process that uses surface infiltration or direct injection to replenish groundwater supplies, allowing excess water to be stored in an aquifer for future use. Typically, surface infiltration is enhanced through the use of percolation ponds, diversion basins, ditches, dry streambeds, and other retention structures. These features increase the amount of time surface water is in contact with the unsaturated zone, allowing for increased infiltration. However, in areas where the surface is not permeable enough for percolation, or withdrawal far exceeds recharge, it may be necessary to use direct injection, i.e. using injection wells to directly pump water into the aquifer. This has been a common replenishment strategy for management agencies combating seawater intrusion (Hudson et al. 1995; Johnson and Whitaker 2003; Herndon and Markus 2014).

Understanding the spatial and temporal mixing of this water within the aquifer system is difficult due to the complexity of the underground geological setting. Therefore, the use of tracers is crucial in determining the heterogeneity of hydraulic conductivity, which is needed for predicting residence times and mixing of injected water. Traditional pulse-and-chase methods require adding a tracer to a recharge supply, followed by close monitoring of nearby wells to detect the tracer. While this strategy is effective, it requires adding chemicals such as ionized

*Corresponding author. Email: jclehman@uci.edu.

substances (e.g. common salt), organic dyes, gases (^{133}Xe and ^{85}Kr), or fluorocarbons (CCl_3F and CCl_2F) to aquifers that often serve as drinking water supply (Davis et al. 1980; Clark et al. 2014). This requires careful planning and permitting.

Using the *intrinsic* isotopic signatures of the water itself, and its constituents, allows for an alternative tracer method that does not require the addition of artificial substances. In this study, we analyzed the stable isotope composition ($^{18}O/^{16}O$, $^{2}H/^{1}H$) of groundwater, the stable and radioactive isotope compositions ($^{13}C/^{12}C$ and $^{14}C/^{12}C$, respectively) of dissolved inorganic carbon (DIC), and chemical properties (DIC concentration, pH, and salinity) to trace artificial recharge with the ultimate goal of improving the understanding of the recharge dynamics of an aquifer experiencing both natural and artificial recharge.

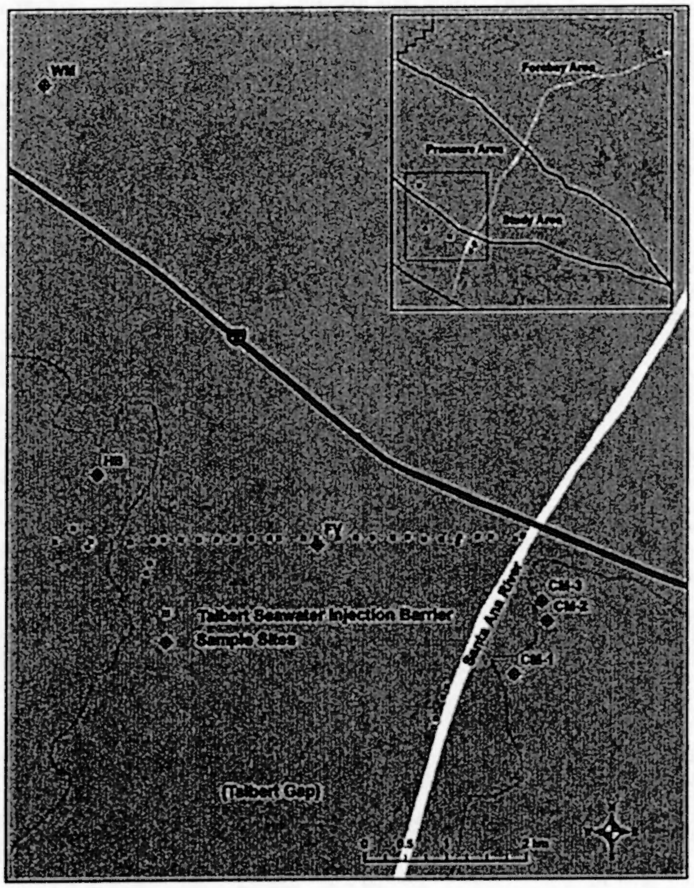
Hydrological Setting

Our study was conducted in Orange County, California, a densely populated urbanized region with a Mediterranean climate (Figure 1a). The Orange County Groundwater Basin (basin) consists of a dynamic coastal aquifer system that covers a surface area of approximately 906 km^2 with the capacity to hold about 81 km^3 (66 million acre feet) of fresh groundwater (OCWD 2015). However, the local groundwater agency manages the basin within an operating range of approximately 0.62 km^3 (500,000 acre feet) of usable storage, which supplies about 70% of the local water supply (OCWD 2015). The basin is vertically subdivided into three aquifer systems: the Shallow, Principal, and Deep aquifers. Geographically, the basin is partitioned into two regions: the Forebay Area and the Pressure Area (Figure 1a).

The Forebay Area is largely composed of unconfined aquifers compromised of relatively coarse-grained unconsolidated sediments (sands and gravels) that allow for surficial groundwater recharge through percolation basins and within the Santa Ana River (SAR) channel. Forebay recharge sources include SAR base and storm flows, imported water, and purified recycled water from Orange County Water District's Groundwater Replenishment System (GWRS) (Santa Ana River Watermaster 2014). In contrast, the Pressure Area is a region in which the aquifers are less connected to surface waters due to the presence of intervening aquitards comprised of fine-grained sediments (silts and clays), resulting in a more confined aquifer condition (Figure 1b). The coastal edge of the Pressure Area is bounded by the Newport–Inglewood Fault Zone, which acts as a groundwater barrier protecting the Principal and Deep aquifer systems from seawater intrusion. However, due to the meandering of the ancestral SAR over the last 40,000 yr, a 4-km-wide geological gap was eroded and permeable sediments were subsequently deposited, forming a low lying region known as the Talbert Gap. Portions of the Talbert Gap are connected to the Pacific Ocean and also merged with the uppermost Principal aquifer zones (OCWD 2015).

As a result of agricultural pumping during the first half of the 20th century, and municipal pumping due to urbanization and population increase in the second half, declining groundwater levels led to seawater intrusion into the Shallow aquifer system (Johnson and Whitaker 2003). In response, the local groundwater management agency built a seawater intrusion barrier (Talbert Seawater Injection Barrier, Figure 1) in 1975. The barrier comprises a series of injection wells drilled along the Talbert Gap that pump water directly into the Shallow and Principal aquifer systems, maintaining a hydraulic mound or pressure ridge that prevents seawater intrusion (OCWD 2015).

(a)



(b)

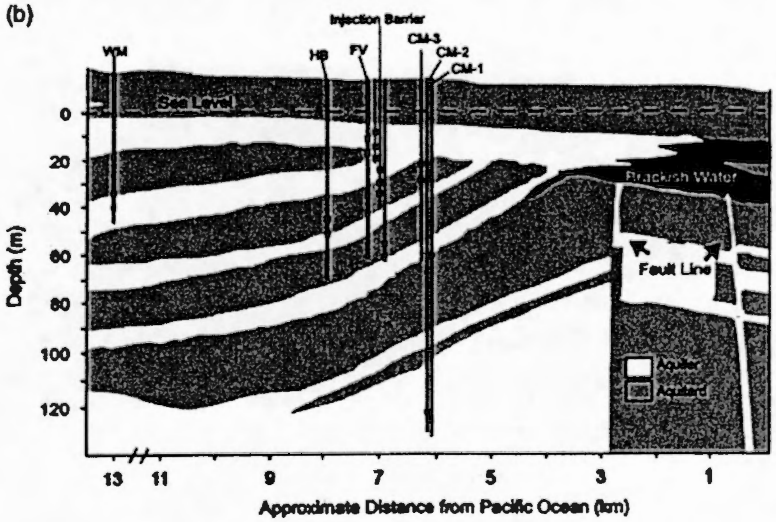


Figure 1 (a) Sampling sites (open circles) in Orange County, California. Filled squares indicate the location of the Talbert Injection Barrier wells. The shaded lines delineate topographical formations. (b) Cross-section view of the aquifer system in the Pressure Area, modified from OCWD (2014). The hash marks on the wells indicate the depth of the well screenings (i.e. the depth interval from which the wells draw groundwater).

The source water for the injection barrier has varied over the years. In the past, a mixture of local groundwater, recycled water, and imported waters (from both the Colorado River Project and California State Water Project) were used in a mixed blend (OCWD 2015). However, since December 2009, injection water has consisted of nearly 100% recycled water. Currently, about 0.04 km^3 (32,950 acre feet) of high-quality recycled water is allocated to the injection barrier annually (OCWD 2014). This recycled water is thoroughly treated wastewater that, after secondary treatment, has undergone three additional advanced treatment processes: microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide addition (OCWD 2014). The source of water to the wastewater treatment system is mainly from the local drinking water supply, which is a mixture of the local groundwater and imported water.

Although investigations on water and carbon isotopes had been carried out in this groundwater aquifer system before (Hudson et al. 1995; Davisson et al. 1996, 1998, 1999), no systematic studies were conducted in the last 20 yr. However, many changes have occurred, such as the construction of a new and advanced recycled water treatment plant (operational since 2008) that utilizes improved treatment processes and has much higher treatment capacity, as well as changes in water sources and proportions for injection. Here, we revisit wells at different distances from the injection barrier, and show that measuring water isotopes together with both the stable and the long-lived radioactive carbon (with a half-life of 5730 yr) isotopes provides a powerful means to track recycled water through the aquifer system over decades.

MATERIALS AND METHODS

Water Sampling

Groundwater samples ($n = 50$) were collected every 2 weeks from six routinely producing, privately owned wells from September 2014 to April 2015 in the basin's Pressure Area. Surface water samples were collected from recharge sources: SAR ($n = 2$) and the California State Water Project (SWP) ($n = 1$). Additionally, municipal tap water ($n = 1$) and local precipitation ($n = 1$) were also collected.

All water samples for carbon (^{14}C, δ^{13}C) and water (δ^{18}O, δD) isotope analyses were collected in 60-mL clear borosilicate glass vials with 0.125 silicone/PTFE and black Viton septa (Sigma-Aldrich, St. Louis, MO, USA). To avoid contamination, vials and septa were acid-washed in a 10% HCl solution, rinsed three times with 18.2 MΩcm (Milli-Q) water, and vials were then baked at 550°C for 2 hr. During sampling, all vials were filled and allowed to overflow three times their volume. Vials were filled, capped with no headspace, and analyzed within 1 week to minimize the exchange of DIC with atmospheric CO_2. The following is sampling information for specific wells/locations:

- At production wells (WM, FV, and CM-1 to -3), groundwater was collected from wellhead spigots. To flush possibly stagnant water, each well was allowed to run through the open spigot uninterrupted for 5 min prior to collection.
- At sampling site HB, groundwater samples were collected in two different locations due to well site access issues. At the start of the study, samples were collected at an irrigation spigot supplied by a tank that is fed by the well. Later, water samples were taken directly from the well spigot. These data are reported as averages for the site.
- Surface water samples from the SAR were collected near Featherly Regional Park, in Yorba Linda. In addition, the SWP was sampled in Palmdale on an exposed part of the aqueduct. All surface water samples were sampled using a 10-L bucket with a piece of

silicone tubing permanently attached to the base. The bucket was lowered into the water and rinsed three times before sample vials were filled through the silicone tubing.

- Local municipal tap water was collected in a residence within the study area. In addition, local precipitation was captured on a balcony of a building at UC Irvine.

pH and Salinity Measurements

The pH was measured in the laboratory using 40 mL of water with a portable pH meter (Eco Tester pH 2, Oakton, Vernon Hills, IL, USA). Salinity was measured using a hand-held salinity refractometer with automatic temperature correction (RHS-10ATC, Westover Scientific, Bothell, WA, USA).

Water Stable Isotope Measurements

$\delta^{18}O$ and δD were analyzed using 1-mL aliquots of water on a High Temperature Conversion Elemental Analyzer (TC/EA) coupled to an isotope ratio mass spectrometer (IRMS, Delta Plus XL, Thermo Fisher Scientific, Waltham, MA, USA). All measurements were performed at the Center for Isotope Tracers in Earth Science (CITIES) at UC Irvine using a series of NIST certified and internal lab calibrated standards. The δ notation is a per mill (‰) expression relative to the V-SMOW standard. The analytical precision of the analysis is 0.1‰ for $\delta^{18}O$ and 1‰ for δD, based on long-term measurements of secondary standards.

Dissolved Inorganic Carbon (DIC) Extraction and Carbon Isotope Measurements

For ^{14}C and $\delta^{13}C$ analyses, the DIC of each water sample was extracted using a rapid headspace-extraction approach (Gao et al. 2014). The method was modified by injecting 20 mL of ultra-high-purity (UHP) N_2 gas into the vials through the septa using a gas-tight syringe while the vial was inverted. Simultaneously, a second needle was pierced into the septa. The pressure from the injection of N_2 gas pushed 20 mL of water out of the vial through the second needle, creating the headspace required for the extraction. Samples were acidified with 0.5 mL of 85% H_3PO_4 and heated at 75°C for 2 hr. Afterwards, the headspace volume (about 23 mL) was extracted using an air-tight 60-mL syringe and injected into a vacuum line through a septa port. The CO_2 was cryogenically purified and quantified manometrically, and then converted to graphite via closed-tube zinc reduction (Xu et al. 2007). All ^{14}C measurements were performed alongside processing standards and blanks at the W M Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory (KCCAMS). ^{14}C results are expressed as percent modern carbon (pMC) relative to the primary ^{14}C oxalic acid I standard (HOxI), following Stuiver and Polach (1977). The analytical precision is 2–3‰ for modern samples, based on long-term measurements of secondary standards.

For $\delta^{13}C$ analysis, the purified DIC-CO_2 was subsampled on the vacuum line, injected into a UHP He-filled Exetainer® (Labco, Lempeter, UK) vial using a gas-tight syringe, and analyzed via a Gas Bench II linked to an IRMS (Delta plus XP, Thermo Fisher Scientific). The fractionation introduced by the headspace extraction method is relatively small (<~0.2‰, Gao et al. 2014). The δ notation is a per mill (‰) expression relative to the V-PDB standard. The precision is ~0.2‰ based on long-term measurements of secondary standards.

DIC concentration was calculated from the CO_2 extraction yield on the vacuum line, headspace extraction efficiency (Gao et al. 2014), and Henry's law (CO_2 solubility in water) (Diamond and Akinfiev 2003).

RESULTS AND DISCUSSION

pH and Salinity

The pH of all groundwater samples ranged from 7.0 to 8.5, whereas that of surface waters (SAR & SWP) ranged from 7.9 to 8.8 (Table 1). On average, groundwater samples had a pH of 7.8 ± 0.4, which is consistent with values reported by an earlier study (Hudson et al. 1995). All groundwater samples (as well as the SAR and SWP) had a salinity of ≤1 ppt, indicating there is likely no influence of seawater intrusion affecting our sample sites.

Water Isotope Composition (δD and $\delta^{18}O$)

The isotopic composition of the SAR water was -49 ± 4‰ for δD and -7.3 ± 0.7‰ for $\delta^{18}O$ ($n = 2$, Table 1). This is typical for river systems in regions that are fed by both local and distant precipitation (Williams and Rodoni 1997). The SWP water had relatively light isotopic values of –74‰ for δD, and –11.0‰ for $\delta^{18}O$ ($n = 1$, Table 1). Municipal tap water had the most negative values, with a δD of –100‰ and $\delta^{18}O$ of –12.2‰, indicating it was likely sourced from the Colorado River Water Project (Coplen and Kendall 2000). In addition, coastal rainwater isotopes collected on March 10, 2015 had values of –41‰ for δD and –7.3‰ for $\delta^{18}O$ ($n = 1$). However, the groundwater sampling region is typically recharged by precipitation falling further inland than our rainwater sample collection site. Therefore, the recharge is likely isotopically enriched compared to our precipitation sample.

Groundwater showed a variable range in water isotope values ranging from –50 to –64‰ for δD and from –7.1 to –9.1‰ for $\delta^{18}O$ (Figure 3a-b, Table 1). This agrees with a previous study (Williams 1997), which found that groundwater in the basin is a mixture of water from four sources: "local" recharge from coastal precipitation (isotopic range: δD = –58 to –40‰, $\delta^{18}O$ = –8.3 to –5.7‰), referred to here as "precipitation"; "native" recharge from the SAR drainage (isotopic range: δD = –63 to –56‰, $\delta^{18}O$ = –9.3 to –8.3‰), referred to here as "SAR"; "recent" recharge from SAR water that has experienced increased evaporation due to diversion of SAR flow into retention structures and percolation basins (isotopic range: δD = –61 to –59‰, $\delta^{18}O$ = –8.3 to –8.1‰), referred to here as "modern SAR"; and "Colorado" recharge which is a mixture of native water and water imported from Colorado State Project water (isotopic range: δD = –82 to –60‰, $\delta^{18}O$ = –10.5 to –8.6‰). The isotopic ranges of these four source waters are illustrated in Figure 2.

The groundwater isotopes from sample wells generally fell within two groups. At well WM, which is further inland and more distant from the injection barrier than the other wells, groundwater was generally heavier, with a δD of -53 ± 1‰ and $\delta^{18}O$ of -7.6 ± 0.3‰ ($n = 9$). All other wells displayed lighter water isotope ratios, with the lightest values measured at well HB (δD of -61 ± 2‰ and $\delta^{18}O$ of -8.5 ± 0.3‰, $n = 10$). This suggests that groundwater produced by WM was mainly recharged by local precipitation (Figure 2). Wells within 1.5 km of the injection barrier generally had δD values < –52‰ and $\delta^{18}O$ values < –8‰, suggesting the water came from mixtures of the lower SAR recharge and was possibly influenced by isotopically light, imported Colorado water (Figure 2). Our water isotope data agrees with the salinity measurements in that no detectable influence of seawater intrusion was found.

DIC Isotope Composition (^{14}C-DIC and $\delta^{13}C$-DIC)

The ^{14}C-DIC signature of the surface waters was similar to that of the current atmospheric $^{14}CO_2$ (102 pMC; X Xu, unpublished data), with 98.7 ± 0.2 pMC (average ± SD, $n = 2$) for SAR and 84.6 pMC for SWP water ($n = 1$). Groundwater ^{14}C-DIC ranged from

Table 1 Overview of isotopic compositions, pH and DIC concentration of analyzed water samples. Value in bracket next to the well label is the well depth at where water was drawn.

KCCAMS	Date MM/DD/YYYY	$\delta^{18}O$ ‰	δD ‰	$^{14}C^{a}$ pMC	$\delta^{13}C$ ‰	pH	DIC mmol/L
WM [45.4 m]							
150072	11/07/2014	–7.6	–54.6	93.34 (0.21)	n.m.	7.8	n.m.
150073	11/07/2014	–7.5	–54.0	94.03 (0.22)	n.m.	8.1	n.m.
150082	11/21/2014	–7.8	–54.4	93.30 (0.21)	–13.9	7.7	5.7
151619	12/05/2014	–7.6	–54.5	92.47 (0.21)	–15.0	7.4	5.0
151625	12/22/2014	–7.1	–51.8	93.42 (0.19)	–13.8	7.4	5.9
152498	01/09/2015	–7.4	–52.6	92.79 (0.15)	–13.7	7.5	5.0
153050	01/26/2015	–7.2	–51.9	92.90 (0.00)	–13.4	7.2	6.7
156062	02/06/2015	–8.1	–53.3	92.82 (0.16)	–13.5	7.3	7.0
156072	02/20/2015	–7.5	–52.2	93.05 (0.13)	–13.7	7.3	6.7
156085	03/06/2015	–8.0	–50.1	92.92 (0.14)	–13.5	7.3	5.8
HB [74.4 m]							
144319	09/01/2014	–8.7	–63.5	326.77 (0.98)	n.m.	7.8	n.m.
144320	09/01/2014	–8.7	–64.7	330.24 (0.83)	n.m.	8.1	n.m.
148334	10/22/2014	–8.3	–61.6	259.09 (0.70)	n.m.	n.m.	n.m.
148335	10/22/2014	–8.3	–63.4	258.79 (0.68)	n.m.	8.5	n.m.
150074	11/07/2014	–8.7	–62.9	215.45 (0.58)	n.m.	7.7	n.m.
151621	11/21/2014	–8.6	–63.4	284.11 (1.01)	–16.5	8.0	1.2
151620	12/05/2014	–8.4	–60.6	292.14 (0.84)	–16.1	8.4	1.1
152500	01/09/2015	–8.3	–58.3	135.86 (0.23)	–16.4	7.4	2.9
153048	01/26/2015	–7.7	–57.3	124.00 (0.19)	–16.1	7.1	3.2
153049	01/26/2015	–8.2	–60.3	161.00 (0.26)	–16.1	6.8	2.3
156059	02/06/2015	–8.5	–57.7	144.88 (0.24)	–16.2	7.4	3.4
156057	02/06/2015	–8.1	–57.2	154.54 (0.23)	–16.3	7.5	3.1
156058	02/06/2015	–8.4	–58.4	154.37 (0.23)	–16.3	7.5	2.6
156070	02/20/2015	–8.1	–60.0	270.75 (0.60)	–16.4	7.6	1.2
156068	02/20/2015	–8.6	–60.2	198.75 (0.41)	–16.6	7.3	1.9
156069	02/20/2015	–10.2	–61.5	197.84 (0.37)	–16.5	7.3	1.7
156081	03/06/2015	–8.2	–57.9	142.65 (0.22)	–16.4	7.3	2.9
156084		–9.1	–58.7	182.97 (0.34)	–16.6	7.0	2.0
CM-1 [1.40.8 m]							
151621	12/08/2014	–8.5	–59.1	123.27 (0.23)	–14.1	8.2	3.3
151626	12/22/2014	–8.5	–59.8	120.79 (0.23)	–14.8	7.9	4.3
152501	01/12/2015	–8.3	–58.5	118.47 (0.23)	–14.2	7.8	3.5
156063	02/09/2015	–8.6	–57.6	117.86 (0.17)	–14.4	7.8	3.8
156075	03/02/2015	–8.1	–57.2	119.74 (0.17)	–14.4	n.m	3.5
156096	03/23/2015	–9.0	–59.7	119.63 (0.18)	–15.0	7.9	4.1
156101	04/13/2015	n.m.	n.m.	120.93 (0.18)	–14.5	7.9	4.1
CM-2[140.2 m]							
151623	12/08/2014	–8.5	–57.8	96.95 (0.18)	–14.1	8.1	3.4
151627	12/22/2014	–7.6	–54.0	95.06 (0.18)	–14.5	8.0	3.1
152502	01/12/2015	–8.6	–59.2	97.10 (0.16)	–13.8	8.1	2.6
156065	02/09/2015	–7.7	–51.6	97.96 (0.14)	–14.1	8.0	3.2
156076	03/02/2015	–8.4	–57.8	94.09 (0.13)	–14.2	8.4	2.7
156097	03/23/2015	–9.1	–59.9	102.02 (0.15)	–14.4	8.2	3.1

Table 1 (*Continued*)

KCCAMS	Date MM/DD/YYYY	$\delta^{18}O$ ‰	δD ‰	$^{14}C^{a}$ pMC	$\delta^{13}C$ ‰	pH	DIC mmol/L
156102	04/13/2015	n.m.	n.m.	139.50 (0.15)	–14.5	8.2	3.5
CM-3 [61.0 m]							
151624	12/08/2014	–8.6	–60.6	174.36 (0.36)	–13.6	8.2	2.4
152503	01/12/2015	–8.4	–59.7	153.43 (0.26)	–14.0	7.9	3.2
156066	02/09/2015	–8.3	–58.3	165.68 (0.26)	–13.9	7.5	3.0
156077	03/02/2015	–8.4	–59.7	179.10 (0.29)	–13.9	8.0	2.9
156098	03/23/2015	–9.1	–63.0	167.57 (0.30)	–14.2	7.9	3.0
156103	04/13/2015			169.43 (0.31)	–14.0	8.1	3.5
FV [65.2 m]							
150078	11/13/2014	–8.4	–62.5	128.85 (0.31)	–15.3	7.9	1.0
152504	12/30/2014	–8.3	–58.1	118.14 (0.19)	n.m.	8.0	1.0
Santa Ana River (SAR)							
156079	03/05/2015	–6.8	–45.9	98.89 (0.15)	–11.9	8.0	3.5
156095	03/22/2015	–7.9	–51.2	98.54 (0.19)	–13.1	7.9	4.4
CA State Water Project (SWP)							
156093	03/22/2015	–11.0	–73.5	84.62 (0.13)	–10.5	8.8	1.4
Municipal Tap Water							
144313	07/14/2014	–12.2	–100.3	85.62 (0.20)	n.m.	n.m.	n.m.
Local Precipitation							
n.a.	03/10/2011	–7.3	–41.4	n.m.	n.m.	n.m.	n.m.

Notes: n.m. = not measured, n.a. = none assigned, [a] values in brackets are the analytical errors (1σ) for the ^{14}C analyses, which were mainly calculated from the counting statistics, fluctuations during measurement, and background corrections.

92.5 to 328.5 pMC. With the exception of two wells (HB and CM-2), ^{14}C-DIC values were generally stable over the study duration (Figure 3c).

Groundwater production well WM had the lowest abundance of ^{14}C-DIC, with an average of 93.0 ± 0.4 pMC ($n = 9$, Figure 3c, Table 1). This, in addition to the water isotopes, suggests that WM represents the unaltered background signature of native groundwater in the Shallow aquifer within the Pressure Area of the basin. Based on the water isotopes, the dominant source of groundwater to this well is natural recharge (local precipitation), as it does not appear to be influenced by the injection barrier that is about 6 km away.

Production wells FV and CM-1 also displayed stable, although slightly elevated, ^{14}C-DIC values of 123.5 ± 7.6 ($n = 2$) and 120.1 ± 1.8 pMC ($n = 7$), respectively. In contrast, the DIC in production wells HB and CM-3 was found to be significantly enriched in ^{14}C at all times, averaging 219.4 ± 69.7 pMC ($n = 10$) and 168.3 ± 8.8 pMC ($n = 6$), respectively (Figure 3c). Although groundwater at some sites was significantly enriched in ^{14}C, exceeding contemporary atmospheric $^{14}CO_2$ values, all measured levels are well below drinking water standards.

Our results confirm those of a previous study (Hudson et al. 1995), which found the presence of high ^{14}C-DIC near the injection barrier. The ^{14}C enrichment had been attributed to transient pulses of elevated ^{14}C in the recycled water supply, which entered the groundwater through the injection barrier (Hudson et al. 1995). Remineralized carbonate scale from pipes within the recarbonation pond of the previous recycled water treatment plant had a ^{14}C signature of 402 pMC, further supporting this hypothesis (Hudson et al. 1995). The ultimate source of the

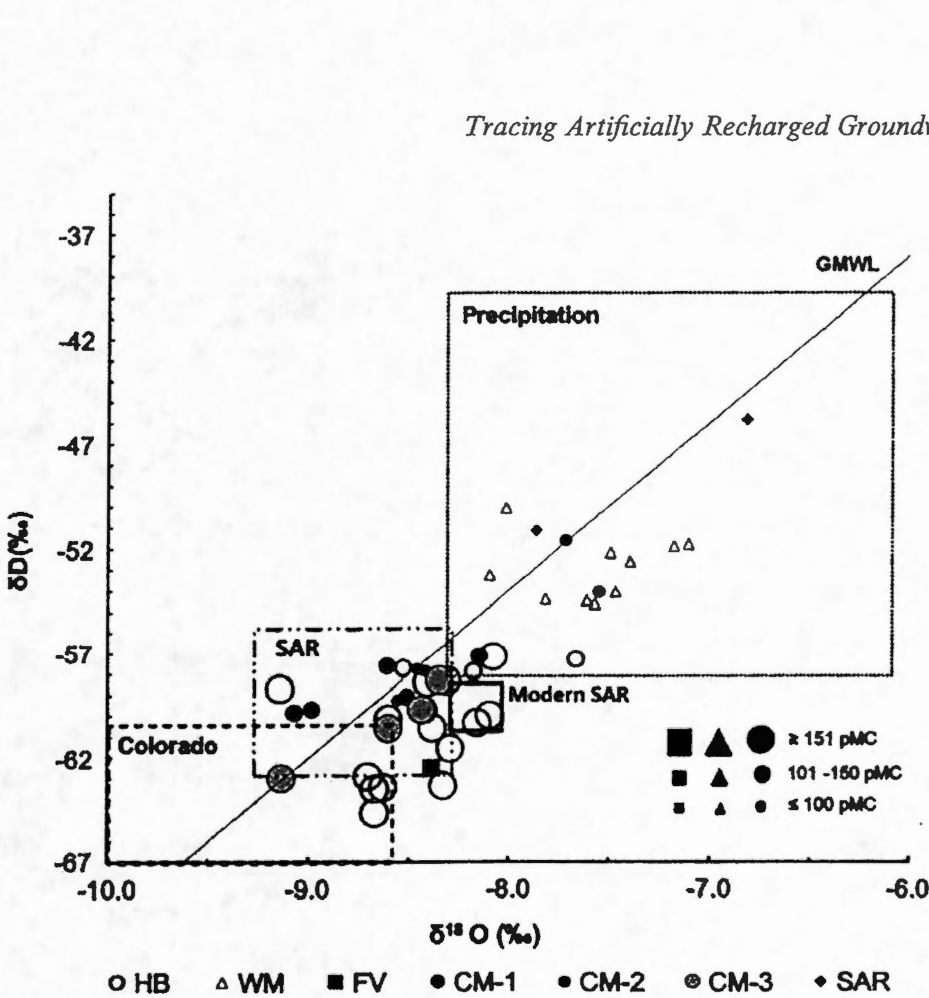


Figure 2 δD vs. $\delta^{18}O$ of groundwater samples collected for this study. The line represents the global meteoric water line. ^{14}C signatures are indicated by symbol size. Sources of recharge and their isotopic ranges are interpreted according to Williams (1997). "Precipitation" represents recharge from local coastal precipitation, "SAR" refers to recharge along the lower river watershed, "modern SAR" is recharge from SAR water that has experienced evaporation caused by recent human interference with the river flow, and "Colorado" refers to recharge water that is a mixture of both Colorado River water and natural groundwater.

elevated ^{14}C has not been fully determined. However, there are known ^{14}C tracer manufacturers located within the service area of the sanitation district supplying source water to the treatment plant. In addition, recent studies have found that both secondary treatment effluent and sludge are enriched in ^{14}C (165–251 pMC; Tseng et al. 2015).

The $\delta^{13}C$-DIC signature of all groundwaters ranged from –13.3 to –16.5‰ (Table 1). In contrast, the $\delta^{13}C$-DIC signature of surface waters was enriched (SAR and SWP: –10.4 to –13.1‰), likely due to exchange with regional atmospheric CO_2, which typically has enriched $\delta^{13}C$ signatures between –8.5 and –10.5‰ (X Xu, unpublished data). During the study, the $\delta^{13}C$ signature for each groundwater production well was relatively stable and somewhat distinct (Figure 3d). The DIC at both HB and FV wells was significantly depleted in $\delta^{13}C$ (–16.3 ± 0.2‰ and –15.3‰, respectively) when compared to the average $\delta^{13}C$ of –14.1 ± 0.4‰ of the other wells. This indicates that the wells HB and FV have a higher input of organic-matter-sourced C. Additional factors that can impact the $\delta^{13}C$ in groundwater are the exchange between DIC and CO_2 gas (atmospheric and soil gas) and carbonate dissolution (Hudson et al. 1995).

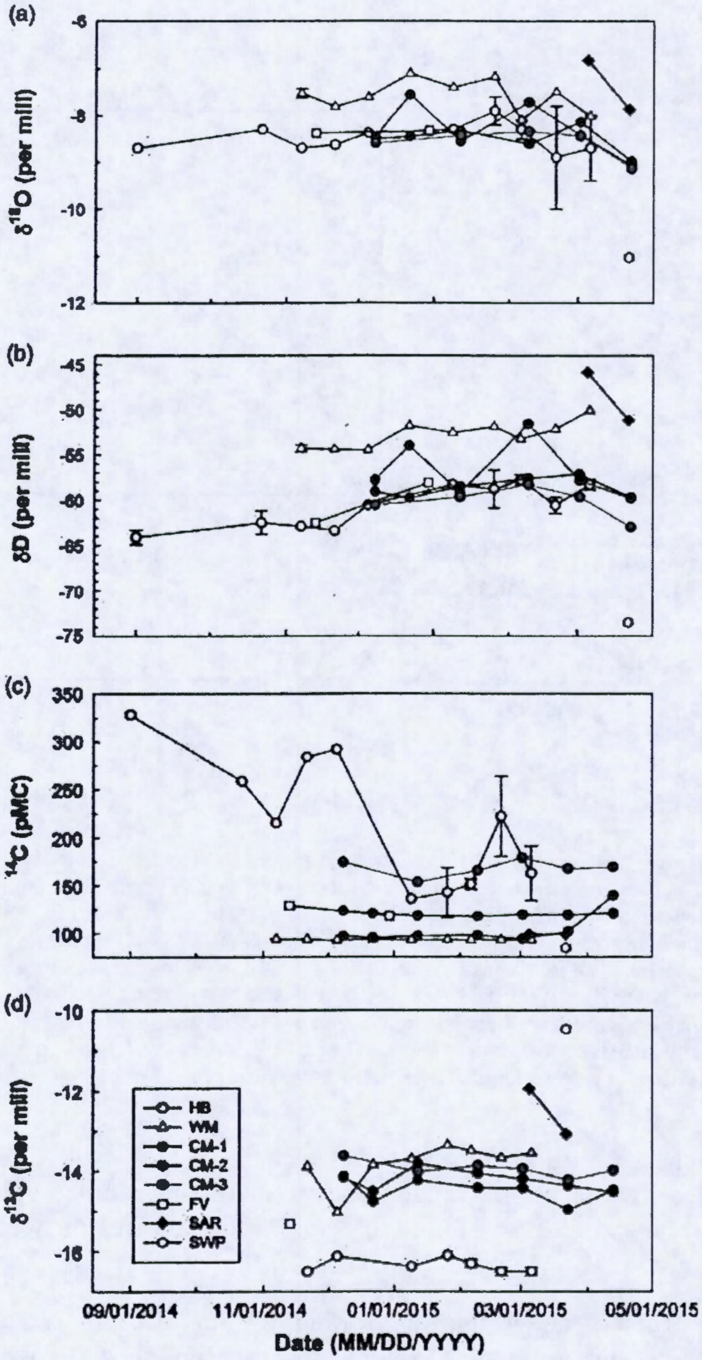


Figure 3 Time series of water isotopes (a) $\delta^{18}O$ and (b) δD, and of (c) ^{14}C-DIC and (d) $\delta^{13}C$-DIC from September 2014 to April 2015 for groundwater production wells (HB, WM, CM-1, CM-2, CM-3, FV) and surface waters (SAR, SWP).

When comparing $\delta^{13}C$ vs. ^{14}C-DIC signatures (Figure 4), the groundwater samples generally fall along a mixing line of the elevated ^{14}C carbonate scale found in treatment plant pipes ($\delta^{13}C \approx -29.5‰$, $^{14}C \approx 402$ pMC; Hudson et al. 1995), air ($\delta^{13}C \approx -8‰$, $^{14}C \approx 102$ pMC), and carbonate ($\delta^{13}C \approx 2‰$, $^{14}C \approx 0$ pMC). We hypothesize that the ^{14}C and ^{13}C signatures of

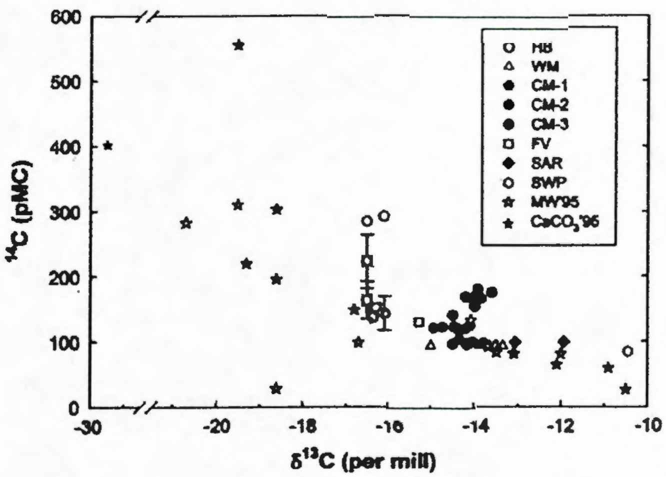


Figure 4 $\delta^{13}C$ vs. ^{14}C of DIC in groundwater samples collected in this study, and of DIC in groundwater (open stars) and carbonate scale from the previous recycled water treatment plant (closed star) reported by Hudson et al. (1995).

organic material are imparted onto the DIC of the recycled water during the treatment processes. In the past, CO_2 gas produced from lime regeneration was used to adjust the pH of recycled water during the recarbonation process (Davisson et al. 1999). This would imply that groundwater with depleted ^{13}C would more likely have an enriched ^{14}C content, as was observed in well HB.

Temporal Variations

Several wells showed significant temporal variations in their ^{14}C-DIC, most notably in HB. The ^{14}C-DIC content reached a maximum of 330.2 pMC in September 2014, before falling to a minimum of 124.2 pMC in January 2015, after which it increased to 270.8 pMC in February (Figure 3c). Several factors may control these dynamics: (1) changes in recycled water injection rates at the injection barrier, (2) changes in basin-wide water withdrawal and recharge together affecting the hydrostatic balance and the groundwater flow paths, and thereby changing the proportions of source waters to wells near the injection barrier, and (3) fluctuations in the ^{14}C signature of waters coming into the wastewater treatment plant.

During 2014, there were two major shutdowns of injection in the barrier, a 26-day shutdown from June 7 through July 2, 2014 and a 9-day shutdown from October 18 to 26, 2014 (OCWD 2014). However, water isotopes did not covary with the ^{14}C-DIC signature, suggesting no significant changes in water sources. Thus, the more likely explanation for the variation of ^{14}C-DIC is changes in the ^{14}C end-member of the injection water with time. Unfortunately, we did not have access to monitor the injection water directly. Nonetheless, the ability to detect such significant changes demonstrates the sensitivity of the ^{14}C measurement and its potential utility as a tracer for the injected recycled water, in conjunction with the stable isotopes.

Mixing of Recycled Water with Local Groundwater (^{14}C Keeling Plot)

A Keeling plot is a two-end-member linear mixing model. It was originally applied to model isotopic mass balance in atmospheric studies (Keeling 1958, 1961); however, it is now commonly used in many other fields, such as ecosystem (Pataki et al. 2003) and oceanography studies (Walker et al. 2014). The model is based on the conservation of mass and isotopes when mixing occurs between two end-members, specifically a low concentration background C component (C_{bg}) and a high concentration source C component (C_s) (Equations 1–2):

$$C_t = C_{bg} + C_s \tag{1}$$

$$\delta_t C_t = \delta_{bg} C_{bg} + \delta_s C_s \tag{2}$$

where C_t, C_{bg}, and C_s, and δ_t, δ_{bg} and δ_s, are the concentrations and carbon isotopic ratios of the total, background, and source, respectively. If δ_{bg} and δ_s remain constant during the sampling period, the isotopic composition of the source C can be obtained from the intercept δ_s (Equation 3):

$$\delta_t = C_{bg}\left(\delta_{bg} - \delta_s\right)\left(1 / C_t\right) + \delta_s \tag{3}$$

The ^{14}C-DIC signature vs. 1/DIC concentration (1/[DIC]) is shown as a Keeling plot in (Figure 5). With the exception of the FV well, all sites generally fall on the same mixing line, showing that as [DIC] decreases, ^{14}C-DIC generally increases. A model II linear regression (excluding the FV well) indicates that the high [DIC] source water (the *y* intercept), a close representative of the unaltered groundwater for the aquifer, has a ^{14}C-DIC signature of 45.8 ± 8.6 pMC (equivalent to a mean ^{14}C age of 6300 ± 1500 yr BP). The Keeling plot further implies that the other end-member could have come from the injection water, which is inferred to have a low [DIC] and high ^{14}C signature. This is evident when comparing well HB, which showed the highest ^{14}C-DIC signature and lowest average [DIC] of 2.2 ± 0.8 mmol/L ($n = 10$), to WM, which had the lowest ^{14}C-DIC signature and a higher average [DIC] of 6.0 ± 0.8 mmol/L ($n = 8$, Table 1).

Davisson et al. (1999) also found evidence that the injection water is undersaturated in calcite and likely causes carbonate dissolution within the aquifer. This matches well with the observation that all groundwater samples fall on a mixing line of the elevated ^{14}C precipitate and carbonates (Figure 4). Addition of calcite CO_3^{-2} to the DIC pool would cause a decrease in the ^{14}C signature, suggesting that the ^{14}C signature of the injection water is likely higher than is

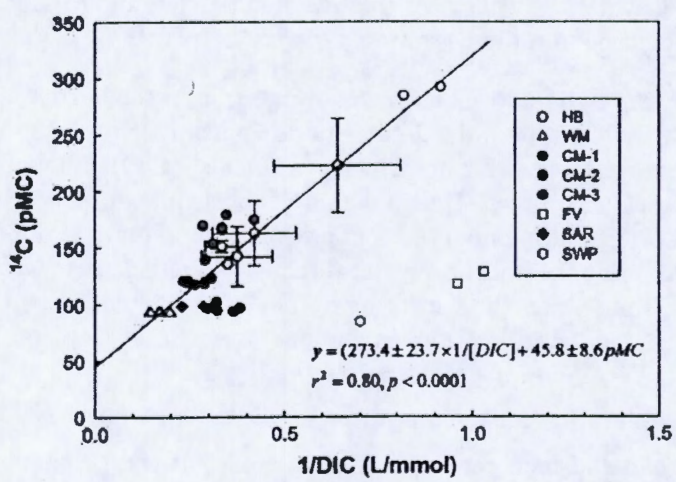


Figure 5 ^{14}C-DIC Keeling plot constructed for groundwater production wells.

measured in the groundwater, or could be estimated from a two-end-member system. Carbonate dissolution would also cause an increase in δ^{13}C-DIC. This matches well with the observation from Figure 4, that as ^{14}C signatures decrease, δ^{13}C generally increase.

The exception of well FV may be explained by its much shallower screened depth interval and close proximity to the injection barrier. Chloride concentration data from water district monitoring wells suggest that shallow wells in the vicinity of the injection barrier are extremely sensitive to seasonal fluctuations in groundwater levels, causing groundwater flow to occasionally shift between landward and seaward (OCWD 2014), thereby possibly changing source waters to the wells. Although the ^{14}C-DIC signature at FV was still enriched, it was probably influenced by more recent injection water from the expanded and upgraded treatment facility that does not feature recarbonation or a separate pulse event with a different ^{14}C signature.

Tracing Recycled Water by Coupling Water and C Isotopes

Coupled water and ^{14}C isotope mixing models further corroborate the relation of enriched ^{14}C-DIC to the injection barrier (Figure 2). Enriched levels of ^{14}C-DIC (denoted by symbol size) are associated with water recharged from "Colorado," "SAR," or "modern SAR," yet never local "precipitation." This is likely a result of local groundwater mixing with injection water. Prior to 2009, the injection water itself was a mixture of local groundwater, treated wastewater, and Colorado River water; however, since then it has been comprised solely of recycled water produced at the new facility.

In summary, both the previous studies (Hudson et al. 1995; Davisson et al. 1996, 1999) and our observations indicate that the recycled water is generally characterized by relatively light δ^{13}C-DIC and elevated ^{14}C-DIC signatures. This ^{14}C-enriched DIC likely originates from CO_2 oxidized from organic materials in the treatment plant, even though some of this CO_2 had likely been removed during the post-treatment degassing used in the newer treatment facility. Some CO_2 can remain and be equilibrated into DIC when the pH is adjusted to approximately 8.5 in the end product. Also, because of the advanced treatment processes and partial degassing procedure, the current recycled water (produced since 2008) has low DIC content compared to the local groundwater.

We expect that the level of elevated ^{14}C in this recycled water can vary greatly due to the change in the amount of ^{14}C in the waste stream and its mixing with other carbon sources within the aquifer system, such as other water sources and the underlying geological substrate. The recycled water is generally depleted in both ^{18}O and D, because its source waters are blended with isotopically light Colorado River and SAR waters. The water isotopes could be decoupled from the carbon isotope signatures depending on the sources and relative proportions of blended waters.

CONCLUSION

Our study shows that the isotopic analysis of water and DIC may be an effective and noninvasive approach for tracing the fate and long-term (years to decades) temporal dynamics of recycled water and thus provides an additional tool for groundwater management. Particularly in the Orange County coastal aquifer system, the existence of long-lived ^{14}C enrichment provides an additional intrinsic tracer that allows following the interactions of recycled water for decades.

The challenge remains to establish the isotopic end-member signatures of recycled water used at the injection barrier and to investigate its variability. Future studies are also needed to investigate whether ^{14}C enrichment is a typical occurrence in recycled water from metropolitan areas.

Alternatively, non-^{14}C-enriched recycled water may also be used to understand the mixing of recycled water with older groundwater found at greater depth. We hope that this approach of coupling ^{14}C with ^{13}C and water stable isotopes as an environmental intrinsic tracer will improve the capability and efficiency of using ^{14}C in water related studies for more than just apparent age of groundwater.

ACKNOWLEDGMENTS

We would like to thank the entire UC Irvine KCCAMS facility, especially J Southon, D Zhang, S Holden, and C Elder for their support in sample measurements and data interpretation. In addition, we would like to thank the anonymous owners of the privately owned production wells for providing access. We thank T Gullickson and S Suchenski for their logistical support in groundwater sampling. We would also like to thank R Detwiler (UC Irvine) and R Herndon, J Dadakis, and T Sovich (OCWD) for providing feedback on the manuscript, as well as two anonymous reviewers. Funding for this research was provided by the UC Irvine KCCAMS Facility and the UC Irvine Undergraduate Research Opportunities Program.

REFERENCES

Clark JF, Morrissey S, Dadakis J, Hutchinson A, Herndon R. 2014. Investigation of groundwater flow variations near a recharge pond with repeat deliberate tracer experiments. *Water* 6(6):1826–39.

Coplen TB, Kendall C. 2000. Stable hydrogen and oxygen isotope ratios for selected sites of the U.S. Geological Survey's NASQAN and Benchmark Surface-water Networks. (No. USGS Open File Report 00-160). Reston: US Geological Survey.

Davis SN, Thompson GM, Bentley HW, Stiles G. 1980. Ground-water tracers—a short review. *Groundwater* 18(1):14–23.

Davisson ML, Hudson GB, Niemeyer S, Beiriger J, Herndon R. 1996. Report on the feasibility of using isotopes to source and age-date groundwater in Orange County water districts Forebay region (No. UCRL-ID–123953). Livermore: Lawrence Livermore National Laboratory.

Davisson ML, Hudson GB, Moran JE, Niemeyer S, Herndon R. 1998. Isotope tracer approaches for characterizing artificial recharge and demonstrating regulatory compliance (No. UCRL-JC-129656). Livermore: Lawrence Livermore National Laboratory.

Davisson ML, Hudson GB, Esser BK, Herndon RL. 1999. Tracing and age-dating recycled waste water recharged for potable reuse in a seawater injection barrier, southern California, USA. International Atomic Energy Agency (IAEA) Symposium on Isotope Hydrology in Water Resources Management, May 1999. Vienna: IAEA.

Diamond LW, Akinfiev NN. 2003. Solubility of CO_2 in water from −1.5 to 100°C and from 0.1 to 100 MPa: evaluation of literature data and thermodynamic modelling. *Fluid Phase Equilibria* 208(1–2):265–90.

Famiglietti JS. 2014. The global groundwater crisis. *Nature Climate Change* 4(11):945–8.

Frederiksen HD. 1996. Water crisis in developing world: misconceptions about solutions. *Journal of Water Resources Planning and Management* 122(2):79–87.

Gao P, Xu X, Zhou L, Pack MA, Griffin S, Santos GM, Southon JR, Liu K. 2014. Rapid sample preparation of dissolved inorganic carbon in natural waters using a headspace-extraction approach for radiocarbon analysis on accelerator mass spectrometry. *Limnology and Oceanography: Methods* 12(4):174–90.

Gleick PH. 2000. A look at twenty-first century water resources development. *Water International* 25(1):127–38.

Herndon R, Markus M. 2014. Large-scale aquifer replenishment and seawater intrusion control using recycled water in Southern California. *Boletín Geológico y Minero* 125(2):143–55.

Hudson GB, Davisson ML, Velsko C, Niemeyer S, Esser B, Beiriger J. 1995. Preliminary report on isotope abundance measurements in groundwater samples from the Talbert Injection Barrier Area, Orange County Water District (No. UCRL-ID–122450). Livermore: Lawrence Livermore National Laboratory.

Hundley N Jr. 2001. *The Great Thirst: Californians and Water—A History*. Berkeley: University of California Press.

Johnson TA, Whitaker R. 2003. Saltwater intrusion in the coastal aquifers of Los Angeles County, California. In: Cheng H-D, Ouazar D, editors. *Coastal Aquifer Management: Monitoring, Modeling, and Case Studies*. Boca Raton: Lewis Publishers. p 29–48.

Keeling CD. 1958. The concentration and isotopic abundances of atmospheric carbon dioxide in rural areas. *Geochimica et Cosmochimica Acta* 13(4):322–34.

Keeling CD. 1961. The concentration and isotopic abundances of carbon dioxide in rural and marine air. *Geochimica et Cosmochimica Acta* 24(3):277–98.

OCWD. 2014. Groundwater Replenishment System Annual Report. URL: http://www.ocwd.com/media/3488/2014_gwrs_annual_report_final.pdf.

OCWD. 2015. Orange County Water District Groundwater Management Plan 2015 Update. URL: http://www.ocwd.com/media/3503/groundwatermanagementplan2015update_20150624.pdf.

Pataki DE, Ehleringer JR, Flanagan LB, Yakir D, Bowling DR, Still CJ, Buchmann N, Kaplan JO, Berry JA. 2003. The application and interpretation of Keeling plots in terrestrial carbon cycle research. *Global Biogeochemical Cycles* 17(1):1022.

Santa Ana River Watermaster. 2014. Forty-Third Annual Report of the Santa Ana River Watermaster for water year October 1, 2012–September 30, 2013. URL: http://www.wmwd.com/DocumentCenter/View/2117.

Stuiver M, Polach HA. 1977. Discussion: reporting of ^{14}C data. *Radiocarbon* 19(3):355–63.

Tseng LY, Robinson AK, Xu X, Southon J, Rosso D. 2015. Radiocarbon dating of municipal wastewater: effect on greenhouse gas emission quantification. Oral presentation. American Chemical Society Western Regional Meeting, San Marcos, CA, USA.

Walker BD, Guilderson TP, Okimura KM, Peacock MB, McCarthy MD. 2014. Radiocarbon signatures and size-age-composition relationships of major organic matter pools within a unique California upwelling system. *Geochimica et Cosmochimica Acta* 126:1–17.

Williams AE. 1997. Stable isotope tracers: natural and anthropogenic recharge, Orange County, California. *Journal of Hydrology* 201(1):230–48.

Williams AE, Rodoni DP. 1997. Regional isotope effects and application to hydrologic investigations in southwestern California. *Water Resources Research* 33(7):1721–9.

Xu X, Trumbore SE, Zheng S, Southon JR, McDuffee KE, Luttgen M, Liu JC. 2007. Modifying a sealed tube zinc reduction method for preparation of AMS graphite targets: reducing background and attaining high precision. *Nuclear Instruments and Methods in Physics Research B* 259(1): 320–9.

Using intrinsic tracers to determine
coastal aqu

Jennifer Walker[1], Ted Johnson[2], Michael Land[3], Brendan

1. University of California, Irvine 2. Water Replenishment District of Sou, Ca

Introduction

The coastal aquifer in Los Angeles Basin serves as a main water supply for over 6 million residents. Recharge is received from several sources, including natural recharge from precipitation and a local ephemeral rivers, as well as anthropogenic recharge through percolation ponds and direct injection wells using recycled wastewater. Fulfilling current and future water demands, while protecting the aquifer from overdraft and seawater intrusion, requires a detailed understanding of the subsurface hydraulic connectivity and the infiltration extent at recharge points. This is difficult to determine due to the complexity of the subsurface geology, and also because the recharge water is mixing with preexisting groundwater. Carbon (C) as DIC (dissolved inorganic carbon) in both source waters are undergoing biogeochemical changes, such as atmospheric CO_2 inputs, carbonate dissolution and inputs from organic matter. We use the δ^{13}C-DIC and ^{14}C-DIC signatures from groundwater collected from several monitoring wells to determine recharge source and C sources to the DIC pool. Using a mass balance model we attempted to calculate mixing ratios of recharge water and determine the hydraulic connectivity.

Sampling & Measurement

Data for sites WM and CM was previously published (1). For all other sites, groundwater wells were pumped 3 times their volume to purge stagnant water. 60 ml of water was collected free of headspace in an acid washed vial with a septa cap. In a N_2 glove bag, 20 ml of sample was removed to create a headspace in the vial. Samples were acidified with 0.5ml of 85% H_3PO_4 using a gas tight syringe, and heated to 70°C for 2 hrs (2). The CO_2 was converted to graphite using a sealed-tube zinc reduction method (3) and analyzed at the UC Irvine Keck-CCAMS facility. δD and δ^{18}O analyses were completed at the UCSC Stable Isotope Lab.

Source Modeling

Modeled source contributions to were calculated using the MixSIAR v. 3.1, which uses a Bayesian model framework to calculate probability distributions. Using isotopic data, source proportions to a mixture are estimated based upon advanced linear mixing models which incorporate uncertainty in source values, categorical and continuous covariates, and prior information (3). Input to the model included the δ^{13}C and ^{14}C of groundwater DIC. Source mean and uncertainties are shown in Table 1. There was no correction for ^{14}C decay or ^{13}C fractionation. To ensure the convergence, the model was ran with maximum possible iterations.

Table 1: Source Uncertainty Input

Sources	Mean ^{14}C	Mean δ^{13}C
Atm CO_2	101 ± 2	-9.5 ± 0.5
Carbonate	0 ± 10	0 ± 2
Modern OC	100 ± 10	-25 ± 2
Old OC	0 ± 20	-25 ± 2

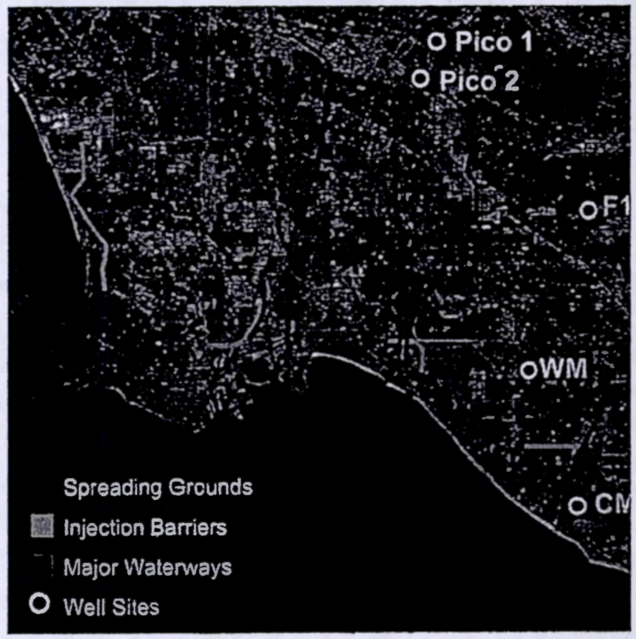
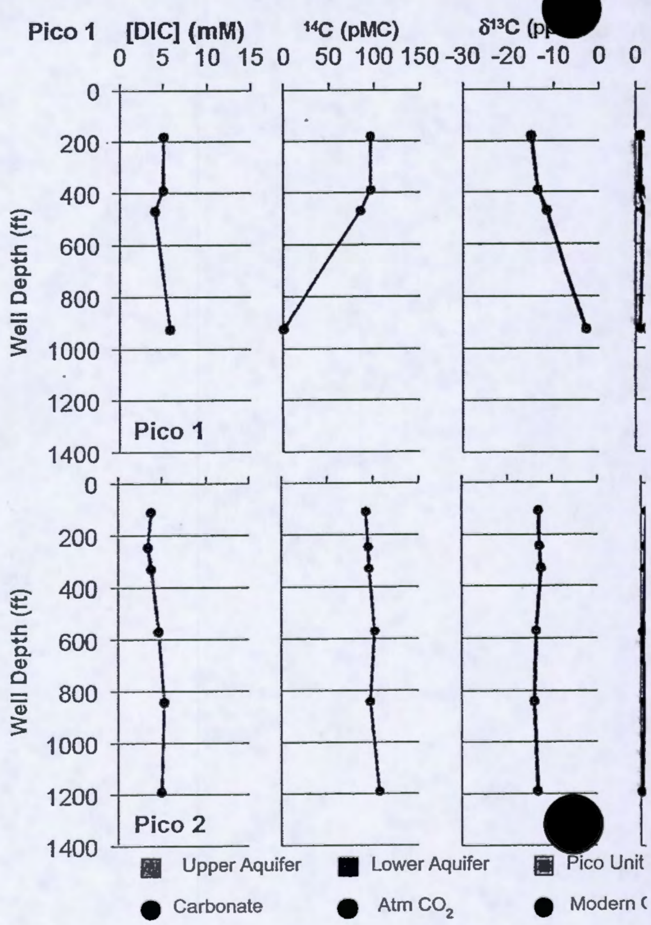


Figure 1: Major waterways and sources of recharge to the LA B



References: 1) Mazariegos et al. (2016) Tracing artificial recharged groundwater using water and carbon isotopes. Radiocarbon 1-15. 2) Gao et al. (2014) Rapid sample preparation of dissolved inorganic carbo method for preparation of AMS graphite targets: reducing background and attaining high precision. Nuclear Instruments and Methods in Physics Research B, 259: 320-329. 4) B. C. Stock and B. X. Semmens (20 the Central and West Coast basins, Los Angeles County, California. USGS Water-Resources Investigations Report 03-4065.

Using intrinsic tracers to determine subsurface groundwater mixing in a coastal aquifer system

Jennifer Walker[1], Ted Johnson[2], Michael Land[3], Brendan Neel[4], Junior Mazariegos[1], Claudia Czimczik[1], Xiaomei Xu[1]

1. University of California, Irvine 2. Water Replenishment District of Southern California 3. USGS, California Water Science Center 4. Orange County Water District

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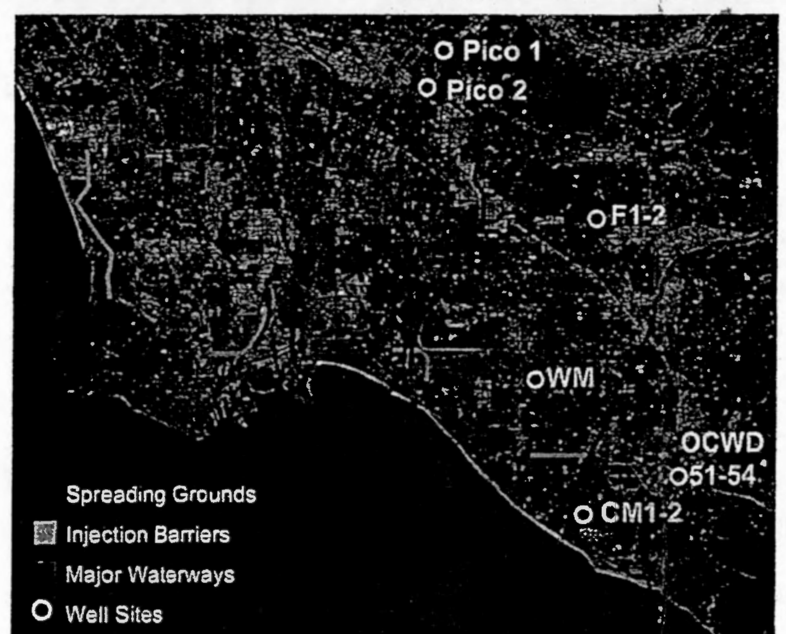


Figure 1: Major waterways and sources of recharge to the LA Basin

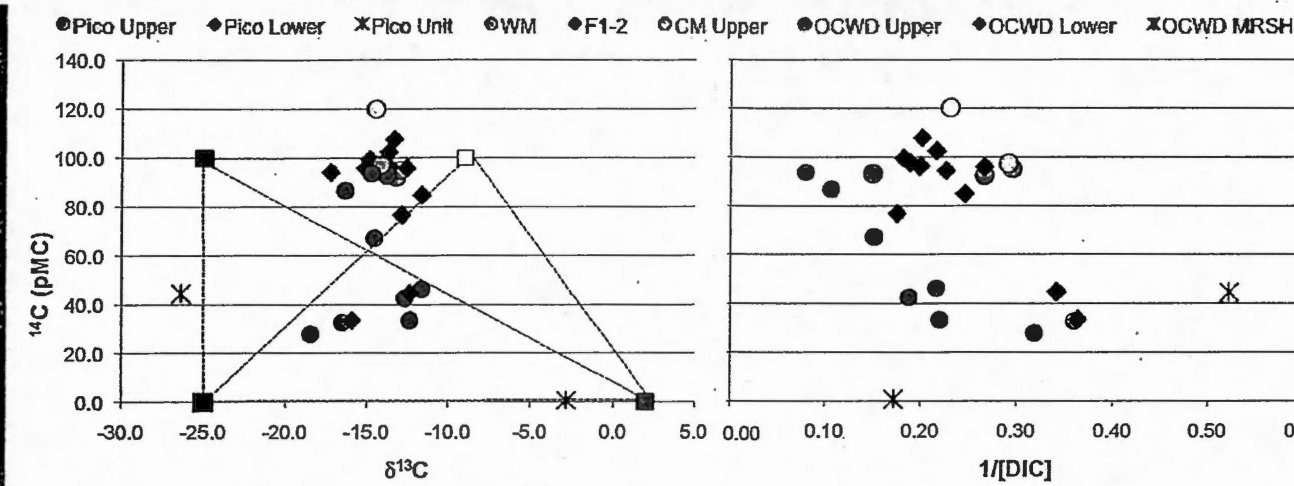


Figure 2: ^{14}C vs. $\delta^{13}C$ shows that the majority of samples fall on a mixing line of modern OC and atm CO_2. Some wells within the Newport Mesa exhibit mixing with old OC. The OCWD-MRSH well may serve as a more realistic end-member of old OC input.

Figure 3: Keeling plots suggests that C from the Upper Aquifer is mixing into the Lower Aquifer, with the exception of wells in the Newport Mesa. The outlying wells (Pico Unit & OCWD-MRSH) fall off all mixing lines due to significant inputs of carbonate and old OC, respectively.

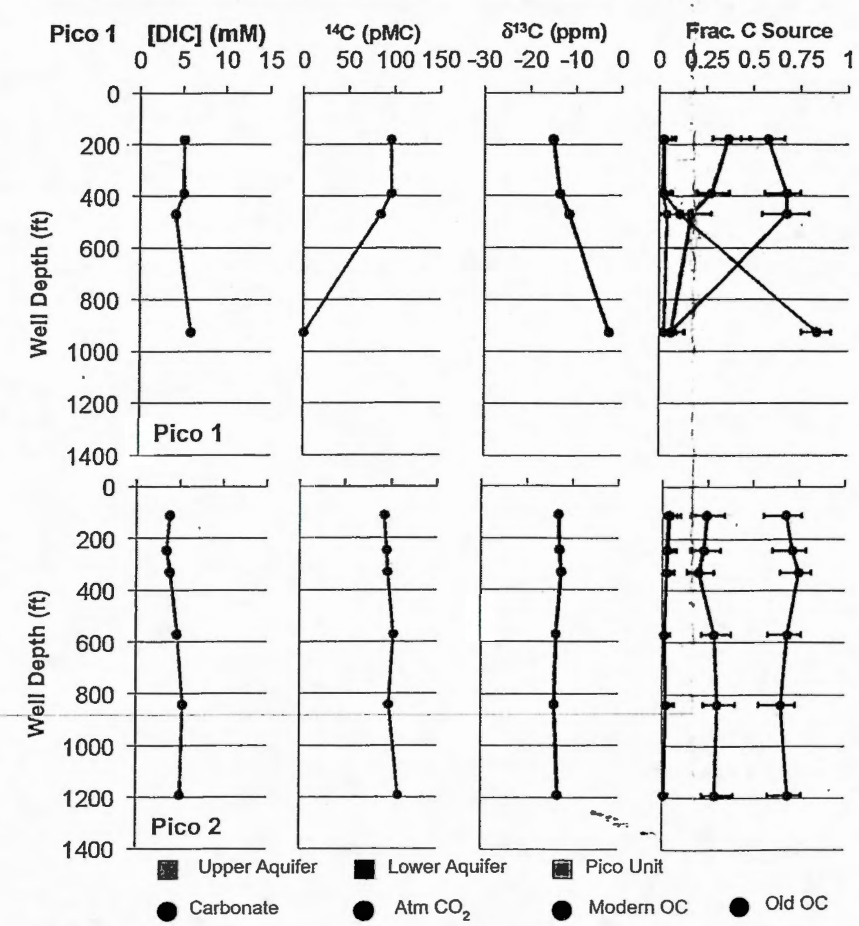
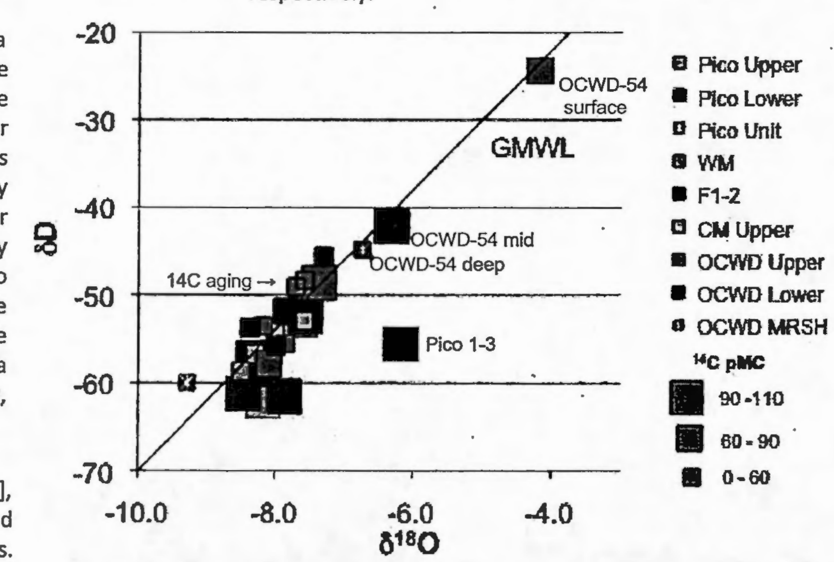


Figure 4 (right): $\delta^{18}O$ vs. δD shows a variety of waters supply recharge to the basin. Generally values fall within the range expected for precipitation or surface water recharge. The exceptions are the Pico Unit which is isotopically light, and isolated from the other depths. Well OCWD-54 is isotopically heavier, with each depth appearing to be isolated. ^{14}C aging can be seen in the OCWD Upper Aquifer. Generally the Lower Aquifer is confined with a uncorrected 14C age of 5600 (YBP, 50pMC).

Figure 5 (left): Examples of well [DIC], ^{14}C and ^{13}C isotope profiles and modeled median source contributions profiles. Error bars represent the 5% and 95% confidence intervals. Near the spreading grounds (Pico 1 & 2) recent recharge penetrates from the Upper Aquifer throughout the Lower Aquifer. Values are identical to previous data collect in 1995 (5). C source contribution at most depths is dominated by atm CO_2. In the Newport Mesa region (not shown) the Upper Aquifer are being recharged in isolated regions.



Future Work

- Incorporation of more sample sites, especially in the mid-basin lower aquifer and SW coastal boundary, the current analysis is limited spatially due to our availability of sample sites and is likely influenced by local geological effects
- Include of $\delta^{18}O$ and δD isotopes to incorporate the water source of recharge

Acknowledgments: This work would not have been possible without support from the W.M. Keck Carbon Cycle Facility at UC Irvine. A special thanks to Carla Mendez, Noel Leanos-Mejia, and Dachun Zhang for help with laboratory analysis, and the WRD and OCWD field teams for sample collection.

References: 1) Mazariegos et al. (2016) Tracing artificial recharged groundwater using water and carbon isotopes. Radiocarbon 1-15. 2) Gao et al. (2014) Rapid sample preparation of dissolved inorganic carbon in natural waters using a headspace-extraction approach for radiocarbon analysis on accelerator mass spectrometery. L&O:Methods 12(4):179-90. 3) Xu X. et al. (2007) Modifying a sealed tube zinc reduction method for preparation of AMS graphite targets: reducing background and attaining high precision. Nuclear Instruments and Methods in Physics Research B, 259: 320-329. 4) B. C. Stock and B. X. Semmens (2013). MixSIAR GUI User Manual. Version 3.1. https://github.com/brianstock/MixSIAR. doi:10.5281/zenodo.56159. 5) Reichard E. et al. (2003) Geohydrology, geochemistry and groundwater simulation optimization of the Central and West Coast basins, Los Angeles County, California. USGS Water-Resources Investigations Report 03-4065.

Application

for

Helen Velador

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City Clerk Dept.

Palmdale Recycled Water Authority (PRWA)
Public Member Application

Please Print or Type:

Name: ~~Helen~~ PH Velador

Address:

City: Palmdale Zip Code: 93550 Home Phone:

Occupation: retired Superior Court Employee Bus. Phone:

Why are you interested in this position? Want to see Palmdale residents utilize recycled water in hopes of lowering their water bills, as well as Retain natural and potable water. in the Antelope Valley area.

Considering your previous experience and activities in business, labor, professional, social or other organizations, indicate what you feel are the most important experiences and abilities that qualify you for this position. Over 20 years working in the legal and law enforcement fields.

Have attended several seminars in regards to water conservation and recycled water.

Completed Recycled Water Site Supervisor training, Los Angeles County

Have you had previous public service experience on a commission or public body? If so, indicate the public agency, title of position, and duties. yes, Palmdale Recycled Water Authority. Duties include developing, promoting, constructing and installing, manage recycled water resources.

What do you hope to accomplish as a Palmdale Recycled Water Authority Member? Participate in the developing, promote and maintaining of the Antelope Valley's natural Resource, water. In this arena it is the use of recycled water.

In your opinion, what is the goal of the Palmdale Recycled Water Authority and what benefit does it provide to the citizens of Palmdale? To provide and maintain recycled water to Palmdale citizens. This option would allow Palmdale citizens to irrigate their homes, which would assist in lower monthly water bills.

List your education, highest year completed, and degrees, if any?

High School graduate

currently in process of obtaining Associate Degree

REASONABLE ACCOMMODATIONS: Based on your understanding of this PRWA position, will you require any special accommodations to apply and/or participate as a member? ___ Yes _X_ No

If yes, what reasonable accommodations would be necessary to assist you in this area?

In Case of Emergency:

Whom should we notify?

____

Name Relationship to Applicant

Home Phone:______________________ Work Phone: ______________

Physician's Name:______________________ Phone: ______________

Do you have any medical history that we should be aware of in the event of an emergency? (Allergies, medications, etc.)

N/A

____

Agreement

The City of Palmdale and Palmdale Water District are equal opportunity employers and do not discriminate in hiring or employment upon any basis prohibited by law, including race, color, creed, religion, age, sex (including pregnancy, childbirth and related medical conditions), cancer, national origin, genetic characteristics, genetic information, ancestry, sexual orientation, gender, gender identity, gender expression, marital status, veteran status, disability, or any other basis protected by applicable law. None of the questions or information sought in this application are intended to discriminate based upon any status protected by law. If you need reasonable accommodation in completing this application, or in any other part of the application process, please contact the Palmdale City Clerk's Office at 661/267-5151.

I certify that all statements on this application are true and complete to the best of my knowledge. I hereby authorize the City of Palmdale to investigate any information contained in this application. I understand that as part of the final selection process I will be required to pass a livescan fingerprint scan submission via the California Department of Justice. I understand that information collected during this background check will be limited to that appropriate to determining my suitability for particular types

of work and that such information collected during the check will be kept confidential. I understand that false or misleading statements shall be sufficient grounds for disqualification from this position.

I hereby agree to the Agreement set forth on this 7 day of December, 2016.

Signature: Helen P. H. Velador

If you wish, you may attach a copy of your resume to this application.

Please return the completed application to the Office of the City Clerk, City of Palmdale, 38300 Sierra Highway, Suite C, Palmdale, CA 93550. For additional information, you may call the City Clerk's office at (661) 267-5151.