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Direct Potable Reuse In El Paso, Texas: Pioneering Water Resource Sustainability In A Large Urban Utility

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DIRECT POTABLE REUSE IN EL PASO, TEXAS: PIONEERING WATER RESOURCE SUSTAINABILITY IN A LARGE URBAN UTILITY

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DIRECT POTABLE REUSE IN EL PASO, TEXAS: PIONEERING WATER RESOURCE SUSTAINABILITY IN A LARGE URBAN UTILITY

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Chapter 1: Introduction

El Paso, Texas, is mostly serviced by a large water utility that is nationally respected as being innovative and progressive in water resource sustainability. The El Paso Water Utilities Public Service Board changed its name to El Paso Water in the middle of 2016 and will be referred to as (EPWU) in this thesis. The state of Texas has a population that is projected to grow by 73% from approximately thirty million in 2020 to fifty million by 2070. This expected population increase is in part the reason why the Texas Water Development Board unanimously agreed in 2016 to a 2017, 62.9 billion dollar water plan to begin strategically solving the state's growing water concerns (Blaney, 2016). The United States (US) Southwest is also projected to experience significant population increases (including the Paso del Norte region) and this will result in more demand for water in these areas. Direct potable reuse (DPR) is a seldom implemented water resource approach that has the potential to add millions of gallons of water to the overall supply and is at the heart of this thesis. EPWU would ideally like to start designing a 'first of its kind' full-scale DPR facility in early 2017 with construction beginning in 2018 or 2019 and completion happening by 2020. The proposed implementation of DPR in El Paso, Texas, is deserving of a rigorous analysis of pros and cons related to DPR, and the challenges associated with EPWU's progression towards implementation of DPR.

In this three part introduction I will:

- Present some reasons as to why DPR might be beneficial and needed.
- Explain what DPR is and why the proposed EPWU project is deemed to be first of its kind.
- Compare DPR to other water resource strategies.

- Begin the discussion of EPWU being a large utility that has the potential to pioneer DPR on a national scale.
- Set up the rest of the thesis by analyzing various DPR factors related to treatment issues, financial issues, public perception issues, regulatory/political issues, and other issues, based on the review of literature.

Methodology

This thesis started with a review of scholarly literature regarding direct potable reuse. To assemble the literature, these search words used: direct potable reuse; advanced water purification; potable water recycling; sociology and direct potable reuse; and DPR implementation. The literature review yielded recent and historical components, both globally and nationally, about different types of potable water reuse strategies and paradigms. Key topics emerged, including treatment issues, financial issues, public perception issues, regulatory and political issues, etc. The thesis was narrowed to focus on analyzing the following case studies: Big Spring, Texas, the first place in the US to implement DPR; Wichita Falls, Texas, the second place in the US to implement DPR and subsequently decommission DPR one year later; Southern California, a region with implementation of multiple indirect potable reuse (IPR) facilities and non-implementation of DPR (but potential future implementation); and El Paso, Texas, where potential implementation of DPR on a large-scale and in a first-of-its-kind capacity is moving ahead as an extra water resource means.

The Big Spring case study utilized scholarly articles, newspaper and periodical articles, and an interview with the Interim Water and Wastewater Treatment Manager, Chad Tidwell. The Wichita Falls case study utilized scholarly articles, newspaper and periodical articles, and an interview with the Utilities Operations Manager, Daniel Nix. The Southern California case study

utilized scholarly articles, newspaper and periodical articles, and an interview with the Assistant General Manager of the Orange County Water District, Mike Wehner.

The El Paso case study was an extensive analysis of all the DPR factor issues related to the planned implementation by EPWU of full-scale DPR utilizing scholarly articles, newspaper and periodical articles, multiple interviews with those who could be considered to have an expert opinion of DPR (including utility and non-utility sources), interviews with local urban users who were not experts but still have cultural knowledge of water in the Paso del Norte region, a quasi-experimental classroom activity, and a section showing how EPWU seemingly is incorporating social marketing to persuade end users that DPR is a good thing to do.

In order to better understand DPR in El Paso interviews with people having extensive knowledge of the topic were elicited. The expert opinion portion of this thesis included interviews with Edmund Archuleta, the Director of Water Initiatives at the University of Texas El Paso (UTEP). Mr. Archuleta retired in 2013 after twenty-four years as the President and C.E.O of EPWU. The interview occurred on September 24, 2015. Kristina D. Mena (MSPH, PHD) associate professor and the program head of Environmental and Occupational Health Sciences at The University of Texas Health Science Center at Houston, School of Public Health (El Paso Regional Campus). Water quality issues and concerns are her research topics of specialty. The interview occurred on November 4, 2015. Christina Montoya-Halter, the Marketing and Communications Manager at EPWU. The interview occurred on February 5, 2016. Shane Walker, a civil engineer and assistant professor at UTEP. He specializes in water and wastewater treatment. The interview occurred on April 21, 2016. Rabbi Ben Zeidman who addressed religious concerns about consumption. The online interview occurred on September 2, 2016. Two lectures that occurred at UTEP were drawn upon. One involved Susan Richardson

who discussed possible contamination concerns regarding treating wastewater effluent. The lecture occurred on February 18, 2016. The other lecture involved Brad Udall who discussed issues related to the evolving water crisis in the American Southwest. The lecture occurred on April 4, 2016. All of the expert opinion interviews and the lectures are described in the text. Full transcripts of the expert opinion interviews can be found in Appendix I. It should be noted that some of the expert opinion interviews did involve people who could be considered to be parties with self-interested concerns when it comes to DPR implementation.

The social marketing portion of the thesis was intended to discuss the apparent desire of EPWU to socially legitimize DPR. Ajzen's *Theory of Planned Behavior* in conjunction with case studies conducted by Nancarrow et al., (2008) in two Australian cities using multiple wastewater use variables to model intended behavior was cited. Legitimacy strategies as described by scholarly articles were used to compare anticipated DPR/advanced water purification variables found at the epwu.org website to suggest that what EPWU has done can be related to social marketing.

Three classroom experiments were conducted at UTEP. This was done to comparatively analyze a 2013 telephone survey conducted by UTEP for EPWU that stated that 77% of the people surveyed were strongly in favor of supporting an advanced water purification facility (El Paso Water Utilities Advanced Purified Water Telephone Survey, 2013). In my work, all three classes were given the same questionnaire asking the same three questions. The first classroom activity was a positive and negative DPR language power point presentation executed on April 8, 2016 in a cultural anthropology undergraduate class with twenty-six respondents. The second classroom activity was a positive only DPR language power point presentation executed on April 11, 2016 in a Gender undergraduate class with thirty respondents. The third classroom activity

was a negative only DPR language power point presentation executed on April 11, 2016 in a Social Inequality undergraduate class that had twenty-five respondents. Details about the classroom experiment presentations and survey can be found in chapter four. The classroom experiment was limited to undergraduate students, some of whom are already parents of young children, but other sub-populations are not fully represented.

In order to further assess local attitudes toward DPR, twelve in-depth interviews were conducted with urban water users living in different areas of the Paso del Norte region. The twelve interviews were part of a larger United States Department of Agriculture (USDA) study and the complete questionnaire can be found in Appendix II. The twelve interviewees were asked fifty-one questions about their water use habits. Here I focused on responses to potable reuse from a diverse cross-section of urban water users. Question number fifty was a two part question that asked: 1) what are your thoughts about direct potable reuse? 2) are you for or against direct potable reuse? I also used question number thirty-five which asked: what are your perceptions of how future climate will impact water in our region? I did try to get as much information out of the people interviewed by asking them: 'is there anything else you can think of'? Or, following up whether or not they are for or against DPR with asking them 'why'? Information about social characteristics of interviewees and full responses to DPR-related questions can be found in Appendix II.

Part One - Water Reuse

Water has multiple uses. Water scarcity issues are related to drought, population growth, amplified municipal, industrial, and agricultural demands; these factors compel water reuse application. The US population grew from seventy-six million people in 1900 to two hundred eighty-two million people in 2000, a 240% increase (US Census, 2010, as cited by the

Committee on the Assessment of Water Reuse, 2012). More people will lead to elevated water demands. The 21st century has witnessed areas of vigorous population growth in the US. The Southwest is one of those areas, and in parts of the US Southwest "water demand has already surpassed water supplies" (Sanchez-Flores et al., 2016, p.2). Another water related concern in the Southwest is the issue of climate change. Brad Udall, a senior scientist/scholar at Colorado State University, stated during a lecture at the University of Texas El Paso (UTEP) about the evolving water crisis in the American Southwest, that "climate change is water change" (Udall, 2016, Lecture). Mr. Udall's lecture discussed how heat drives the water cycle, that 2015 was the hottest year on record, and that higher temperatures will lead to precipitation coming in the form of rain and not snow (Udall, 2016, Lecture). Colorado Rocky Mountain snowpack is a crucial element to the water supply for millions of people in the Southwest.

The Paso del Norte region of Las Cruces, New Mexico, El Paso, Texas, and Ciudad Juarez, Chihuahua, Mexico, is a growing area of more than three million people and a has a population that increased almost 50-fold from 1900 to 2000 (Ward et al., 2007). The Paso del Norte population is expected to nearly double again by 2020 (Ward et al., 2007). It is a region that obtains river water that originates at the headwaters of Southern Colorado and then goes from the Upper Rio Grande Basin and extends six hundred miles through New Mexico to the border cities of El Paso, Texas, and Ciudad Juarez, Mexico, on its way to the Gulf of Mexico (Ward et al., 2007). The Southern Colorado snowmelt runoff is stored approximately one hundred twenty-five miles north of El Paso at the Elephant Butte Reservoir in New Mexico (Espinola, 2016, part one). Elephant Butte has been a primary water supply source for EPWU for many years, but the utility realized the need to reduce dependency on river water when Elephant Butte became less than 10% full at one point because of drought (Espinola, 2016, part one). The

rapid population growth in the Paso del Norte region, “in conjunction with increased demands by all users, will further intensify the competition for limited water resources” (Ward et al., 2007, p.238). The Rio Grande Basin is endangered because the area of supply is small and water concerns in these areas will lead to increased conflict potential (Udall, 2016, Lecture). Part of avoiding future water resource conflict will include new and innovative water supply paradigms.

Water supply pressures are leading to a new era of water management approaches in the US, and these strategies are mainly taking the forms of water consumption reduction through water conservation, “technological change, and seeking new sources of water” (Committee on the Assessment of Water Reuse, 2012, p.10). Municipal wastewater effluent, also called reclaimed water, is produced from households, offices, hospitals, industrial and commercial facilities, and is transmitted through a collection system to a wastewater treatment plant (Committee on the Assessment of Water Reuse, 2012). Wastewater effluent reuse is an untapped water source that should be considered to enhance the nation’s future water supply portfolio (Committee on the Assessment of Water Reuse, 2012). There is great potential for municipal wastewater effluent reuse because the US uses only around 7% of this reclaimed water beneficially (WateReuse Association, 2014). “Water reuse as a water augmentation strategy for potable use will require a more structured and standardized framework to guarantee future water availability for urban populations” (Sanchez-Flores et al., 2016, p.2). Potable (drinkable) water reuse can take the form of indirect potable reuse, direct potable reuse, or de facto potable reuse. Indirect potable reuse (IPR) augments the raw water supply with treated wastewater put into an environmental buffer such as surface water sources or groundwater (EPA, 2012, as cited by Gerrity, Precson, Trussell, R. S. & Trussell, R.R, 2013). Direct potable reuse (DPR) augments the raw water supply by introducing reclaimed water directly into a drinking water treatment

plant that is located near an advanced wastewater treatment facility system, without the use of any environmental buffer (EPA, 2012, as cited by Ishii, Boyer, Cornwell & Via, 2015). De facto reuse is a situation where the drinking water supply has wastewater effluent being used but is not officially recognized as a water reuse project (Committee on the Assessment of Water Reuse, 2012). There are three main stages of treatment involved in wastewater treatment: 1) Primary – removes a portion of the suspended solids and organic matter from the wastewater 2) Secondary – biological treatment that removes biodegradable organic matter and suspended solids, and usually includes some form of disinfection and 3) Advanced Treatment – a tertiary treatment process that has filtration and disinfection, removes nutrients, and provides further removal of biodegradable organics, suspended solids, dissolved solids and/or trace constituents removal (Committee on the Assessment of Water Reuse, 2012, Box 2-2).

The legal framework for wastewater reuse in potable circumstances is uneven and non-standardized, especially in direct reuse applications (Sanchez-Flores et al., 2016). In 1992, the federal government developed water reuse guidelines, however enforcement is limited to the regulations established under the Clean Water Act of 1972 and the Safe Drinking Water Act of 1974 (Sanchez-Flores et al., 2016). "Recent federal protocols and research have just started to open discussions regarding the development of federally standardized regulations and guidelines, specifically for water reuse for potable uses (EPA, 2012; NRC, 2012, as cited by Sanchez-Flores et al., 2016, p.2). Currently, there are no federal regulations guiding DPR criteria (EPA, 2012; NRC, 2012; Tchobanoglous et al., 2015; Tchobanoglous et al., 2011, as cited by Sanchez-Flores et al., 2016). Places that do want to implement DPR are gaining approval through their state on a case-by-case basis (Sanchez-Flores et al., 2016), and although the thought of DPR is becoming more alluring, not many places in the US are scheduled to put DPR into practice anytime soon.

Part Two - Proposed DPR Implementation in El Paso, Texas

As previously discussed, Texas is set to spend many billions of dollars to strategically solve its water supply afflictions, and this should include DPR. In El Paso, the proposed DPR facility is referred to as Advanced Water Purification and the project is part of an 885 million dollar sustainability plan that will include expanding desalination and starting a water importation project (Espinola, 2016, part one). DPR is often the less expensive option compared to desalination, and it is competitive in cost when compared to importing water (Mattingly, 2016). In addition to economic feasibility, DPR has the benefit of being a local and sustainable water supply. Treatment, financial, regulatory, political, and other DPR factors are important issues for water officials to figure out, but public perception and public acceptance of DPR may well be the most critical aspects of DPR implementation. Engaging public support is often a core concern for water officials and management in places wanting to go online with full-scale DPR. EPWU has the goal of implementing full-scale DPR by 2019/2020. John Balliew, CEO of EPWU, has stated; "I have learned that these projects don't fail because of the technology, they fail due to poor public perception" (Espinola, 2016, part two, p.9). The idea of drinking wastewater is a repulsive thought for many people and is often referred to as the 'yuck factor,' which is a phrase commonly associated with DPR. "The disgust associated with the idea of drinking wastewater, still governs the decision making of water augmentation strategies" (Ormerod & Scott, 2012, as cited by Sanchez-Flores et al., 2016, p.4). For example, the city of Brownwood, Texas, received Texas Commission on Environmental Quality (TCEQ) approval to begin their DPR project, but due to public backlash over the idea construction did not start (Martin, 2014). I have found no current reports of DPR construction in Brownwood.

The Windhoek Goreangab water reclamation plant in Windhoek, Namibia, Africa first implemented DPR in 1968 and is the pioneer of DPR (du Pisani, 2006). The Windhoek advanced wastewater treatment plant receives secondary effluent from the Gammans wastewater treatment plant and has incorporated four different treatment process configurations since 1968 (Committee on the Assessment of Water Reuse, 2012). One of the main innovations to come out of the Windhoek plant is that it uses a multiple barrier treatment system which is a popular water treatment method used today (du Pisani, 2006). When water reuse strategies are drawn upon, such as what EPWU has done with applying reused water for irrigating golf courses, municipally owned parks, etc…the community becomes accustomed to the advantages of improved reliability and drought resistance of the water supply that reused water provides (Committee on the Assessment of Water Reuse, 2012). EPWU has been operating the Fred Hervey Reclamation Plant, an IPR facility, since 1985. IPR has a perceived psychological advantage over DPR because as the director of innovation and environmental stewardship at American Water, a national water and wastewater utility, Mark LeChevallier, explains: IPR has the "kiss of nature" (Dahl, 2014, p.A334). DPR adds to the overall local water supply and has been around since 1968, but has only been implemented in two places in the US: Big Spring, and Wichita Falls, Texas.

EPWU has been accredited for their water portfolio diversity and is nationally recognized as being a leader in water resource sustainability. EPWU is proposing to have a full-scale DPR facility in operation by 2019/2020. This project will be historical as it is on the edge of becoming a "first-of-its-kind DPR facility in the Northern Hemisphere" (Espinola, 2016, part one, p.1) and the "crowning jewel" (Espinola, 2016, part one, p.2) of EPWU's water treatment plants. It will be 'first of its kind' for multiple reasons. It would be the "largest direct water reuse project in the

US" (Blaney, 2016, p.1). It would supply to about three times as many people as does the Windhoek plant in Namibia, and unlike the Windhoek plant that uses maturation ponds and water blending prior to distribution (Committee on the Assessment of Water Reuse, 2012) EPWU will be the first to put purified water directly into the distribution system. Once the reused water is purified, it has finished its process (Montoya-Halter, 2016, Interview). As Dr. Shane Walker, a civil engineer and assistant professor at UTEP who specializes in water and wastewater treatment states, "EPWU has decided that to dirty up purified, pristine water by putting it through an environmental buffer is counter-productive" (Walker, 2016, Interview). The Big Spring, Texas, plant has expansion plans (Martin, 2014) and is technically DPR, "but the water goes through a concrete ditch and is not put directly into the distribution system" (Walker, 2016, Interview). The DPR plant in Wichita Falls, Texas, was intended to be an emergency plan from the beginning and was set up to easily transition to an IPR facility by using a thirteen mile above ground pipeline to connect the treated wastewater to the drinking water plant and used a fifty-fifty mix of treated effluent and raw water (Martin, 2014). Big Spring and Wichita Falls never planned to go 'pipe to pipe' or 'flange to flange' as EPWU is preparing to do.

Shortly after Big Spring and Wichita Falls implemented what is technically DPR, Jeff Mosher, executive director of the National Water Research Institute which administers expert panels, and is working with EPWU, predicted that "most of the interest in DPR systems will come from smaller communities where reservoir or groundwater systems are meager or lacking and where direct reuse will loom as the only viable option" (Dahl, 2014, p.A334). EPWU is a large utility that does have ample groundwater systems, as well as seasonal river water, IPR and desalination options, contradicting Mr. Mosher's predictions. EPWU seems eager to pioneer true pipe to pipe DPR and lead the evolution of DPR as a safe and efficient water resource

sustainability method. If DPR is found to be economically feasible and technologically safe, EPWU has the potential to influence more places launching DPR projects. However, "people have been trained for generations to provide separation in both time and space between their wastes and their water supplies, and therefore the public is concerned about the safety of using wastewater effluent for domestic purposes" (Committee on the Assessment of Water Reuse, 2012, pp.16-17). DPR as a 'new' and somewhat untested technology being initiated in El Paso will in all fairness create high levels of public anxiety, especially at first, and the historical component of 'first of its kind' DPR implementation may itself cause not only public anxiety but disapproval in El Paso. This thesis emphasizes the importance of public perception and public acceptance of DPR from a sociological outlook and discusses dynamics as to why the community of El Paso is set to lead the way with a 'first of its kind' DPR project.

Part Three - Plan of Action

DPR was examined in terms of treatment issues, financial issues, public perception and acceptance issues, regulatory and political issues, and other issues. These DPR factors will be analyzed to gain an understanding of the potential limiting factors and the potential positive outcome factors in relation to the EPWU plan to become one of the first of its kind DPR facilities in the US by 2019/2020. Case studies regarding Big Spring, Texas, considered to be the first area in the US to implement DPR; Wichita Falls, Texas, the second area in the US to implement DPR and then decommission it one year later; Southern California, an area of non-implementation of DPR with many IPR facilities in use; will be utilized in conjunction with the DPR factors that emerged from the review of literature to help identify emerging features of the El Paso case. Given that DPR implementation in El Paso has not yet occurred, the focus of the El Paso case

will be on identification of potential issues, predictions, and projections, rather than a retrospective analysis.

The Literature Review found in the next chapter discusses the following DPR factors:

Treatment Issues

- Implementing DPR is challenged by financial constraints, treatment objectives, regulatory permitting, and public acceptance.
- Wastewater is full of microorganisms, and it is the intestinal related pathogens that can cause infections in humans, creating a health risk related to DPR.
- Primary and secondary wastewater treatment used in the DPR treatment process will reduce microbial pathogens, but will not eliminate them.
- A major DPR health concern relates to the many emerging organic compounds such as pharmaceuticals and other endocrine disrupting compounds that are extremely resistant to biological degradation, and their occurrence is often reported in wastewater.
- DPR needs to use disinfection processes and this may lead to undiscovered, potentially hazardous, disinfectant by-products.
- DPR augments the raw water supply (up to millions of gallons of water per day) by introducing reclaimed water directly into a drinking water treatment plant.
- Because of advancements in biological and chemical treatment technology to remove impurities, wastewater effluent should be reused, not disposed of.
- Advanced oxidation technology can eliminate environmental releases of endocrine disrupting pharmaceuticals in treated wastewater.
- Advanced technology allows for real-time monitoring of DPR water quality before it is released into the drinking water supply.

- Singapore uses DPR for its NEWater program that produces highly treated reclaimed and recycled wastewater and then bottles it for drinking consumption.

Financial Issues

- There will be a cost increase passed along to the consumer with the implementation of DPR.
- DPR is a less costly, lower energy consumptive drinking water technology compared to IPR and desalination.
- California uses multiple IPR and desalination facilities and has proposed that a billion dollar DPR facility be built to counter population growth and historic drought.
- "DPR has the potential for higher water recovery, a higher quality product, and lower treatment costs since the water is of local origin and can theoretically be treated at a single facility with a single collection and distribution system" (Leverenz et al., 2011; NRC, 2012, as cited by Gerrity et al., 2013, p.324).

Public Perception Issues

- DPR has been referred to as 'toilet to tap' and is currently not allowed in California.
- The perceived 'yuck' and 'ick' factors are major obstacles related to the public acceptance of DPR.
- For many people there is a psychological barrier that DPR is not safe.
- Psychologically speaking, when it comes to DPR people want a separation in both time and space between their wastes and their water supplies.
- The public wants to be absolutely convinced that DPR implementation is safe and necessary.

- The public perceives DPR to be an alternative water system that is a radical change from the social norm.
- There is a possibility that many people will never fully accept DPR because it lacks an environmental buffer component to minimize the psychological barrier.
- Many people do not want to think about DPR being implemented under any circumstance.
- Communities with serious water supply concerns are starting to consider that DPR could be an asset.
- Public participation related to DPR implementation may facilitate a desire for more people to increase their involvement with local politics and participatory water resource management.
- Social legitimization of DPR is increasing as technological advances in microfiltration, reverse osmosis membranes, UV disinfection, and advanced oxidation, along with consistent marketing, becomes more prevalent.
- Will water purification technology used for DPR equal or surpass the psychological barrier inherit to the thought of drinking bodily waste?

<u>Regulatory/Political Issues</u>

- To implement DPR in more areas, new laws may need to be created, resulting in extra regulation criteria having to be met.
- Many people have the perception that there is a lack of authoritative regulatory public health protection concerning DPR implementation.

- Establishing national water reuse regulations might be advantageous because the EPA could use internal experts that have various skill sets, and the reduction of local regulatory decision-making may improve efficiency.
- In the 1970's, the EPA did a two year study in Denver, Colorado, at an advanced wastewater treatment DPR pilot-plant that showed no adverse health effects related to toxicology due to reclaimed water exposure. (Note: DPR was not implemented in Denver because of politically linked tribulations)
- Part of implementing DPR in the Big Spring, Texas, area in 2013, and in Wichita Falls, Texas, included developing DPR guidelines that meet TCEQ standards.
- In 2012, the Committee on the Assessment of Water Reuse, assembled by the National Research Council, discussed the need for water management strategies to change by increasing water conservation efforts, technological change, and searching for new water sources such as DPR.

Other Issues

- Although DPR has been implemented in a few places both globally and nationally, many communities dealing with water scarcity concerns related to drought, population increases, etc…, have not started building DPR facilities.
- DPR is a viable method to combat drought, population increases, and other factors that strain water resources.
- The Windhoek Goreangab reclamation plant in Windhoek, Namibia (considered to be the birthplace of DPR) has been productively using effluent reclamation as a water use strategy to enhance water supply since 1968.

- The potential for municipal wastewater effluent reuse is great because the US uses only around 7% of this reclaimed water beneficially (WateReuse Association, 2014).

Table 1: These DPR factors are organized in the following way, cross-cutting the case studies:

DPR-Factors	Big Spring, Tx. DPR-Implementation	Wichita Falls, Tx. DPR-Implementation and Decommission	Southern California. IPR and Non-Implementation of DPR	El Paso, Tx. Potential of DPR-Implementation
Treatment Issues	Treats up to two million gallons of wastewater effluent per day.	Treated up to ten million gallons of wastewater effluent per day.	In 1976, OCWD built the first large-scale permanent potable reuse system in the US, and in 2008, created the largest IPR project in the world.	EPWU will use a multi-barrier process to purify wastewater effluent and add up to ten million gallons of water per day to the drinking supply.
Financial Issues	The DPR facility had an initial cost of $14 million.	The Wichita Falls plant had microfiltration and reverse osmosis treatment in place and spent $13 million for a pipeline.	MWDSC serves millions of people and has started planning to implement a giant DPR facility at a cost of around $1 billion.	The proposed full-scale DPR facility has an estimated cost of $100 million.
Public Perception Issues	Held public meetings, did news releases on T.V. and radio, and did talks at civic clubs.	Received some ridicule at first. Made a video about DPR safety, held public meetings, and worked with local media to promote DPR.	Many water officials trying to get DPR in California believe the biggest concern related to DPR implementation is the perceived 'yuck factor' by the general public.	Encouraged people to tour the DPR-pilot facility and uses an informative website that provides video links explaining what EPWU is proposing with its DPR project.
Regulatory and Political Issues	Broke new ground for DPR amidst a general lack of regulatory guidance.	Played a major role in educating water providers about DPR being safe and reliable.	DPR is not allowed in the state of California.	Started a DPR pilot facility to test processes that will meet water quality requirements, and will need TCEQ

				approval.
Other Issues	Went online with the first US-DPR facility in May 2013.	Went online with the second US-DPR facility in June 2014 and decommissioned it in July 2015.	San Diego is following Orange County's lead by voting in 2014 to move ahead with a full-scale IPR project.	EPWU is planning on implementing a large, full-scale DPR facility by 2019/2020.

EPWU has used IPR since 1985 and would like to take a leadership role again when it comes to potable reuse with the potential implementation of DPR by 2019/2020. Overcoming social acceptance problems is a major obstacle for DPR implementation, but progress is being made. For example, in a 1998 report by the National Research Council (NRC), it was recommended that using reclaimed water for potable purposes should be an option of last resort (NRC, 1998, as cited by Sanchez-Flores et al., 2016), however, in their 2012 report the NRC stated that "potable reuse should be considered not a last-resort option but a real alternative for future water demand" (Miller, 2015; NRC, 2012, as cited by Sanchez-Flores, 2016, p.5). Is DPR going to be a good thing for El Pasoans, and are the DPR factors, predictions, and projections pointing to a positive or negative outcome? In my quest to evaluate the pros, cons, and challenges of DPR implementation in El Paso, I try to create a well-informed and balanced thesis that will discuss DPR as a water supply alternative.

Chapter two is a review of the literature about DPR and is intended to give the reader an understanding of how the various types of potable water reuse can relate to one another, and how different communities decide to apply, or not apply, different methods of water reuse. Chapter three describes DPR implementation in Big Spring, and Wichita Falls, Texas, and IPR and non-DPR implementation in Southern California to compare and help identify the emerging features of the El Paso case. Chapter four analyzes the emerging DPR factors in the El Paso case. Chapter

four will discuss expert opinion about potential DPR implementation in El Paso through interviews; describe the influence that the apparent social marketing by EPWU may have in relation to public perception of DPR; present a classroom experiment related to DPR that was conducted in three different college level classes, using both positive and negative language in one class, positive only language in one class, and negative only language in one class, to comparatively analyze the class experiment questionnaire data results to that of a telephone survey that EPWU conducted in 2013 about starting an advanced water purification facility in El Paso; and establish reasoning as to why the cultural knowledge of water and DPR from the urban user in El Paso, via in-depth interviews, should be taken into consideration by EPWU as it moves forward with the potential 'first of its kind' DPR realization. I will tie these DPR factors together in the concluding chapter.

Chapter 2 – Literature Review

The literature on potable reuse has both historical and recent components that are global and national. The literature about potable reuse often discusses topics linked to indirect potable reuse (IPR) and direct potable reuse (DPR). IPR has been implemented in more places than DPR and its applied use is more widely accepted than is DPR. IPR will be comparatively discussed with DPR in this literature review but DPR is the main topic of concern. IPR has a lengthy historical foundation compared to DPR and IPR has numerous facilities currently in operation. DPR is starting to be considered by more communities as a way to augment the local water supply but DPR implementation remains controversial. Before the first US-DPR facility went online at the Big Spring, Texas, pilot facility in May 2013 for the cities of Big Spring, Odessa, Snyder, and Midland, the available literature could only speculate as to the level of impact DPR might encompass. After Big Spring implemented DPR, and Wichita Falls, Texas, followed suit by implementing DPR in July 2014, the available literature could now analyze some DPR implementation data. This literature review will describe potable reuse factors associated with treatment issues, financial issues, public perception issues, regulatory and political issues, and other issues, to gain knowledge of the role DPR necessitates as a potential water resource.

In 1996, J. (Hans) van Leeuwen published an article about the beneficial aspects of using reclaimed sewage to lessen the water demands being placed on the environment by humans. One of the main goals of the article was to suggest that using the resource of reclaimed water was needed to help counteract water pollution because the technology to remove impurities from effluent by using biological and chemical treatments was advancing and the effluent should be reused, not disposed of. This would help prevent pollution and provide an additional water source. It is interesting that water reclamation at this time was being associated with the

reduction of water pollution. “While resource limitation is the obvious motivation for water reuse, pollution prevention is not so obvious” (van Leeuwen, 1996, p.234). The idea was that the left over nutrient load from secondary effluent disposal can lead to excessive nutrient eutrophication and it would be much more costly to remove the discharged nutrients rather than to reuse the effluent thus avoiding eutrophication. This article discusses the South African Water Act of 1956, including Namibia in southwest Africa, which began indirect reuse of effluents as a water use strategy to enhance water supply. It was the Windhoek Goreangab reclamation plant in Windhoek, Namibia, that originally pioneered DPR (du Pisani, 2006).

The van Leeuwen (1996) article discusses desalination being a more costly technology than using sewage to produce drinking water. Some of the modern technologies being used in current DPR processes and pilot facilities, such as ultrafiltration, ozonation and membrane filtration, are mentioned as being used in the 1970’s. A consistent theme concerning potable reuse with all of the reviewed literature is the use of DPR to combat drought, population increases, or other factors that strain water resources. The Windhoek facility started using water reclamation in 1968 to combat severe drought and when Windhoek gained independence in 1990 the city experienced a population boom that put a lot of pressure on water resources (du Pisani, 2006). Windhoek needed to augment its water supply and constructed a new, larger, reclamation plant. One of the results from the new plant was to use a multiple barrier system, a method that is popular today. To pay for the new reclamation plant Windhoek took a twenty year loan from the European Investment Bank, ensuring international water sector involvement, and maintenance with the African facility (du Pisani, 2006).

Cain (2011) suggested that DPR is a method to augment freshwater drinking resources in areas where water scarcity issues are a concern. Two years after J. (Hans) van Leeuwen’s 1996

article about the beneficial aspects of using reclaimed sewage to lessen the water demands being placed on the environment by humans, the 1998 National Resource Council Report considered DPR to **not** be a practical option (Cain, 2011). Technological advances and increased demand for water accessibility led to rethinking the option of DPR implementation as a water resource. Cain (2011) discussed IPR use in Northern Virginia for over thirty years and the implementation of IPR in Orange County, California, as sustainable options, but stated that DPR is the most sustainable option. Cain (2011) believed that DPR reality in the US was not a question of if, but when, and credits California's role in DPR's future development. Cain (2011) does not mention DPR or IPR efforts in Texas. EPWU has been using IPR since 1985 (WateReuse Association, 2014). Cain (2011) discussed three case studies related to DPR: 1) Windhoek, Namibia in southwest Africa, considered to be the birthplace of DPR 2) Singapore's NEWater program, which produces highly treated, reclaimed and recycled wastewater and then bottles it for drinking consumption, and 3) Denver, Colorado, which feared an imminent water crisis in the 1960's and in 1970 constructed an advanced wastewater treatment pilot plant that would use secondary effluent for eventual drinking water use. The US-EPA was involved and Denver's final treated effluent met US-EPA drinking water standards (Cain, 2011). A two year study showed no adverse health effects related to toxicology due to reclaimed water exposure, and a public opinion study of Denver customers showed an 84% DPR acceptance rate if safety and quality parameters were certain, however, "DPR was not implemented due to fragmented political consensus" (Cain, 2011, p.13). This effort was quite progressive at the time and it is poignant that in the end DPR was not implemented in Denver, and to an extent answers one of my integral inquiries as to why more water stressed communities do not use DPR; politically related tribulations.

In 2012, the National Research Council assembled a committee for the assessment of water reuse and published the book, Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater. The book takes an extensive look at many critical components of water management to address water supply needs. The committee was tasked to address six topics of concern: 1) contributing to the nation's water supplies 2) assessing the state of technology 3) assessing risks 4) costs 5) barriers to implementation, and 6) research needs. The committee set forth in chapter one to help people create new models and distinct concepts that have the potential to improve existing conventional water supply limitations through new water management strategies and water reuse. Chapter one presents escalating populations, climate change, and intensifying development as drivers for water reuse education and implementation. The US has built numerous water infrastructure sites, mainly dams and aqueducts, in the 20th Century (Morgan, 2004, as cited by the Committee on the Assessment of Water Reuse, 2012). Despite projected water demand boost needs, water supply infrastructure construction has noticeably lessened in recent decades (Graf, 1999; Gleick, 2003, as cited by the Committee on the Assessment of Water Reuse, 2012). In part, the decreasing rate of water infrastructure construction can be attributed to thinning river flows not previously claimed by other users, growing concern about unfavorable impacts of stream ecology confinement, and an improved understanding of the problems irrigated agriculture has on water quality (National Research Council, 1989, as cited by the Committee on the Assessment of Water Reuse, 2012). Water management strategies need to change by increasing water conservation efforts, technological change, and searching for new water sources (Committee on the Assessment of Water Reuse, 2012). DPR implementation would fit this mold of technological change and

searching for new water sources in order to potentially lead to conserving water, and is clearly a water supply infrastructure option that is being explored more frequently than ever before.

Chapter two of the 2012 National Research Council's book about water reuse provides historical information about sewage and municipal wastewater treatment. Before water pipeline installation, few cities had systems to dispose of liquid waste, and often "feces and urine were collected in privy vaults or cesspools" (Billings, 1885, as cited by the Committee on the Assessment of Water Reuse, 2012, p.21). Sewer usage was limited to mostly densely populated areas for flood prevention, and in many cities the discharge of human waste into sewers was illegal (Billings, 1885, as cited by the Committee on the Assessment of Water Reuse, 2012). Pressurized potable water introduction and sufficient freshwater supply availability led to the flush toilet's popularity growth, and the lack of capability for privy vaults, cesspools, and gutters to handle the large volumes of liquid waste resulted in construction in the late 1800's of sewer systems in populated areas that would combine the sewers to transmit both sewage and storm water runoff from the city to waterways (Committee on the Assessment of Water Reuse, 2012).

Gerrity et al. (2013) published an article about global potable reuse treatment trains with the intent to explain some of the advantages and limitations associated with water reuse. Treatment trains are the stages of wastewater treatment (primary, secondary, and tertiary or advanced treatment) which are meant to be used in conjunction with one another to maximize outcomes (Committee on the Assessment of Water Reuse, 2012). Applying potable water reuse is challenged by financial constraints, treatment objectives, regulatory permitting, and public acceptance (Gerrity et al., 2013). Making a case for DPR, water reuse experts are questioning the need for environmental buffers found in de facto reuse and IPR; with some believing that it is more appropriate to switch to engineered storage buffers (Leverenz et al., 2011, as cited by

Gerrity et al., 2013). Cost may become one of the selling points of DPR over other applications. Transporting IPR to the environmental buffer area involves considerable cost and energy consumption. For example, a proposed IPR system in San Diego will pump treated water more than twenty miles to discharge it into the San Vicente Reservoir and then it will flow back into the metropolitan area (Gerrity et al., 2013). "DPR has the potential for higher water recovery, a higher quality product, and lower treatment costs since the water is of local origin and can theoretically be treated at a single facility with a single collection and distribution system" (Leverenz et al., 2011; NRC, 2012, as cited by Gerrity et al., 2013, p.324).

With the implementation of DPR in the Big Spring, Texas, area in May 2013, wastewater reuse has taken a step towards setting a precedent in the US to diversify techniques to address water demand. The US National Research Council has recommended DPR consideration to help meet future water needs (Guo et al., 2014). Public acceptance of DPR will continue to be a major concern for more communities implementing DPR in the future. The cost of DPR implementation is another concern that will need to be attended to as more communities potentially put DPR into service in the future. As the water infrastructure in general begins to age in the US, an opportunity to re-evaluate municipal water administering has presented itself. Part of this water management re-evaluation may very well include the construction of DPR facilities. If millions of dollars are going to be invested in constructing an advanced water purification treatment facility (another name for DPR) that is producing safe water of a high quality; why put that water back into an environmental buffer that will cost additional money to do so? EPWU has decided not to do this, and this topic will be discussed in detail as part of chapter four's El Paso case study.

In California, the energy cost per unit water is approximately twenty times higher for delivery than the treatment process itself, going up to almost forty times higher in San Diego (Cohen et al., 2004; Wolff et al., 2004, as cited by Guo et al., 2014). “The applicability of distributed DPR systems will likely depend in part on local topographic, demographic, and hydrologic characteristics, on needs for reductions in energy consumption for water conveyance, and on projected increases in water demand” (Guo et al., 2014, p.233). It is important that drinking water utilities where communities are pursuing DPR have satisfactory funding and the technological capability to manage the treatment systems (Dahl, 2014).

In 2014, the San Diego, California, city council unanimously voted to construct a multi-billion dollar facility to treat wastewater reuse (Wiseman, 2014). With proximity to an abundance of sea water, California has invested heavily in desalination, which is considered a ‘new’ source of water but is different than water reuse (Wiseman, 2014). Due to the high energy cost of desalination, water reuse has a perceived economic advantage (Wiseman, 2014). San Diego is the eighth largest US city with approximately 3.1 million people and imports around 80% of its water from Northern California and the Colorado River via immense piped aqueducts (Wiseman, 2014). Delivery reliability has been problematic in San Diego because of prolonged drought and court-ordered pumping restrictions that have intensified new water source needs (Atkinson, 2014). To be clear, California is much more comfortable implementing IPR and it is debatable as to if or when DPR would go online anywhere in California. If comparing DPR realization between Texas and California, Texans appear “far more willing to do what has to be done” (Wiseman, 2014, p.3).

When the nation’s first DPR facility was built in 2013 in Big Spring, Texas, which treats up to two million gallons of wastewater effluent per day, the goal was not to make history; it was

related to severe drought (Martin, 2014). One of the main reasons that IPR was not an option in Big Spring, Texas, is because the Big Spring area has over sixty inches a year of evaporation (Martin, 2014). Wichita Falls, Texas, implemented DPR in July of 2014 because an extra water source need presented itself in 2011 when the two reservoirs, Lake Arrowhead and Lake Kickapoo, that almost entirely supply Wichita Falls with their drinking water, fell to 55% capacity due to severe drought conditions (Dahl, 2014). Although Big Spring, Texas, was using DPR at the time of the DPR implementation in Wichita Falls, Texas, the Big Spring facility was a pilot facility and both the state of Texas and the federal government had little to no regulation regarding DPR implementation. Operations manager for the Wichita Falls Public Works Department, Daniel Nix, met with the Texas Commission on Environmental Quality (TCEQ) to develop guidelines that would be safe for human consumption (Dahl, 2014). The original intent of the DPR facility in Wichita Falls was to be a temporary solution and then transition to an IPR facility because IPR will recoup almost 100% of the wastewater effluent as compared to 66% to 70% recovery with DPR, due to treatment process water loss (Martin, 2014). The Wichita Falls DPR plant was decommissioned one year later in July, 2015 (Mancha, 2015) and will be discussed in full detail as a case study in chapter three.

DPR Technology, Innovation and Health Concerns

In the late 1800's, discharged human waste into sewage systems received little to no treatment because the treatment methods were considered too expensive (Billings, 1885, as cited by the Committee on the Assessment of Water Reuse, 2012). The untreated waste ended up in drinking water systems and resulted in downstream neighbors being subjected to increased waterborne mortality rates (Tarr et al., 1984, as cited by the Committee on the Assessment of Water Reuse, 2012). Engineers and public health scientists campaigned for drinking water

treatment system installation, and the need for required sewage treatment by upstream communities (Hazen, 1909; Sedgewick, 1914, as cited by the Committee on the Assessment of Water Reuse, 2012). Less than 5% of US municipal wastewater had any treatment before discharge in 1900, (Tarr et al., 1984, as cited by the Committee on the Assessment of Water Reuse, 2012) increasing to 55% in 1940 via wastewater treatment plants (EPA, 2008, as cited by the Committee on the Assessment of Water Reuse, 2012). As part of the Clean Water Act of 1972 the majority of water treatment plants in the US were equipped with primary and secondary treatment (Committee on the Assessment of Water Reuse, 2012). Effluent from the increasing number of wastewater treatment plants being built did start to create some new problems for the safety of downstream users, so wastewater effluent is usually disinfected, and then discharged (Committee on the Assessment of Water Reuse, 2012). There are historical scenarios that need to be considered when discussing public acceptance concerns related to DPR. Historical water related health concerns for many people is a psychological barrier that leads to the belief that DPR is **still** not safe, and is not worth investing in. Water treatment technologies for reused water that have been around for decades experience cycles of popularity (Gerrity et al., 2013). For example, reverse osmosis technology is not new technology but has recently become more economically feasible (Gerrity et al., 2013) and is a major component of the advanced water purification process. Often, the technology being incorporated is related to addressing new classes and groups of contaminants (Gerrity et al., 2013). In 2013, California's only potable reuse treatment train allowed for groundwater injection was a full advanced treatment that would include microfiltration, reverse osmosis, and ultraviolet/H2O2 (Gerrity et al., 2013).

The 1968 Windhoek, Namibia, example of DPR is a standard for DPR study and analysis. Since its inception, the Windhoek facility treatment train has been upgraded numerous

times (Tchobanoglous et al., 2011, as cited by Gerrity et al., 2013). There are target criteria that have been established, and if not met, the manager of the facility is penalized monetarily, (du Pisani, 2006, as cited by Gerrity et al., 2013) and if the absolute water criteria fail to be met, the water will not go into the distribution system (Tchobanoglous et al., 2011, as cited by Gerrity et al., 2013). The system in Big Spring, Texas, would include a bypass design that would be initiated if any critical control points were to fail (Gerrity et al., 2013). It is paramount for DPR facilities to maintain quality control in order to prevent pathogen intrusion (Wingender & Flemming, 2011; Biyela et al., 2012; Buse et al., 2012, as cited by Gerrity et al., 2013). Primary and secondary treatments reduce microbial pathogens but do not eliminate them (Committee on the Assessment of Water Reuse, 2012). Wastewater reuse must take into consideration the health risks associated with microbial pathogens as well as the substances that constituents may turn into during treatment (Committee on the Assessment of Water Reuse, 2012). Advanced wastewater treatment may be capable of reducing both microbial pathogens and chemicals that may pose health risks, but assurance that the product water is always safe for consumption is another matter, and the product water safety is dependant in large part to monitoring (National Water Research Institute, 2010). It would be advantageous, and possibly even a needed requirement for DPR water to have real-time online monitoring, and there needs to be a means for instantaneous response that would prevent the release of product water into a drinking water supply that is not of acceptable quality (National Water Research Institute, 2010).

Conventional primary and secondary wastewater treatment can remove most organic contaminants through biological degradation. However, many emerging organic compounds such as pharmaceuticals and other endocrine disrupting compounds are extremely resistant to biological degradation, and their occurrence is often reported in treated wastewater (Carballa et

al., 2004; Lishman et al., 2006; Al-Rifai et al., 2007, as cited by Wu and Englehardt, 2015). Ozone-based treatment is a strong and simple method to treat and disinfect wastewater, however, ozonation use alone is often not enough, and the addition of H2O2 can accelerate production of the more reactive hydroxyl radicals that is necessary to attain a high degree of mineralization (Kusic et al., 2006, as cited by Wu and Englehardt, 2015). Ozone/H2O2 is referred to as the peroxone process, and is thought to be an alluring technology when a high degree of chemical oxygen mineralization demand is preferred for water reuse and reclamation (Wu and Englehardt, 2015). In relation to an expected higher level of initial contamination in wastewater sources compared to conventional source waters, potable reuse systems are being examined more carefully by water regulators (Etchepare and van der Hoek, 2015). Multi-barrier treatment systems are being applied because they can reach the high levels of chemical and microbial contaminant removal that will satisfy established drinking water regulations (Wu and Englehardt, 2015). It is assumed that DPR technology will be based on advanced oxidation to provide mineralization of organics so that no endocrine-disrupting pharmaceuticals are released into the environment because advanced oxidation technology can eliminate environmental releases of endocrine disrupting pharmaceuticals in treated wastewater (Guo and Englehardt, 2015). In 2014, the Texas Water Development Board started a study to be completed in 2017 that will use a constructed engineered wetland to research and evaluate how endocrine disrupting compounds can be abridged or removed from treated wastewater effluent (Mancha, 2015).

Public Perception and Acceptance of DPR Implementation

In 1996, J. van Leeuwen believed that potable reuse's major barrier was that of overcoming the psychological aspects of drinking treated waste directly. Many scientists and engineers believe only IPR should be used as a water reuse technology. This coincides with IPR

being more widely used in areas that are dealing with water scarcity concerns. In the 1970's, water reclamation pioneer Van Vuuren stated that "water should be judged not by its history, but by its quality" (du Pisani, 2006, p.83). Public confidence and acceptance of potable reuse is a tricky problem, especially concerning DPR. Public skepticism related to potable reuse health risks is a scenario that utilities must be prepared to deal with and realize that this skepticism will affect public decision-making (Committee on the Assessment of Water Reuse, 2012). "People have been trained for generations to provide separation in both time and space between their wastes and their water supplies, and therefore the public is concerned about the safety of using wastewater effluent for domestic purposes" (Committee on the Assessment of Water Reuse, 2012, pp.16-17). There is a chance that many people will never become fully accepting of DPR. The fact that IPR has an environmental buffer element to it is one of the reasons that public acceptance of IPR implementation is more prevalent compared to the public acceptance of DPR. An environmental buffer is viewed as being natural, divides the reused water from its history, may decrease contaminant concentration, and allow more time to pass before the reclaimed water is introduced into the water supply (Committee on the Assessment of Water Reuse, 2012). The Australian Research Council found that people have more confidence in drinking water from alternative sources, such as DPR, if scientists and experts are employed to convey information, whereas friends and family are most influential in raising doubts about drinking from alternative sources (Dolnicar and Hurlimann, 2009). Nancarrow et al. (2009) found that there was better likelihood that a person would drink recycled water if they "had lesser negative emotions about the scheme, felt pressure from others to do so, thought the scheme was fair to a variety of users, and if they thought the health risks were low" (Nancarrow et al., 2009, p.3201).

Municipal wastewater reuse can increase total available water resources considerably, yet water reuse contribution potential will vary by region (Committee on the Assessment of Water Reuse, 2012). Areas with greater water stress will most likely be more accepting of DPR as a reuse alternative. Many times public acceptance of DPR can be most strongly related to a lack of alternatives. In 2012, the National Research Council projected that the distinction between direct and indirect applications should be eliminated in favor of using the single concept of potable reuse instead (Gerrity et al., 2013). This might make it easier to market DPR to more communities for future application.

Mark LeChevallier, director of innovation and environmental stewardship at American Water, a national wastewater utility, believes that purified wastewater may be cleaner than surface or groundwater, and suggests that the main benefit of IPR is a psychological one (Dahl, 2014). IPR has a perceived 'kiss of nature' element to it because "you put water into a reservoir, it goes down into the ground, it mixes, and people don't see the line of sight between treated wastewater and their drinking water" (Dahl, 2014, p.A334). If water supplies begin to have trouble keeping up with increasing demand, "thirsty populations may learn to overcome their squeamishness" (Abrams, 2015, p.46). California has a lack of authoritative regulatory public health protection when it comes to potable wastewater reuse and is awaiting a regulatory proposal concerning DPR by the end of 2016 (Dahl, 2014). Data Instincts, a public outreach consulting firm, has found that using a third-party expert panel can help with community confidence to raise awareness and acceptance of reuse projects (Espinola, 2016, part one). EPWU has established a panel of experts that guided the pilot facility and will continue to guide the El Paso DPR project.

Implementation of a full-scale DPR facility will be directly linked to public perception and public acceptance. “DPR is recognized as an alternative water system that the public perceives as a radical change, and as such, has demanded inclusion of sociological expertise” (Ishii et al., 2015, p.4). Positive correlation to DPR includes, trust in water-related authorities, knowledge and information, education level, perceptions of good water quality, and recycled water experience (Ishii et al., 2015). Negative correlation to DPR almost always includes health concerns and perceived risks (Dolcinar et al., 2011, as cited by Ishii et al., 2015). A survey done by Ishii et al. (2015) in four major US metropolitan areas (Georgia, Texas, California, Florida) about water reuse, or ‘purified water’ as was the term used in the survey, found the most significant results about public perception of DPR were: 1) “the potential for DPR and associated advanced water treatment to improve current tap water supplies and ameliorate existing concerns, specifically with regard to microbial contaminants and taste/smell” 2) “the need to foster community trust in water and wastewater treatment facilities, regulators, and local officials in order to strengthen support for alternative water systems” 3) “community-specific drivers for implementing DPR in a given setting” (Ishii et al., 2015, p.23). Additionally, 56% of respondents agreed that purified water as drinking water is a good idea for society and 62% showed above neutral comfort levels when it came to drinking purified water (Ishii et al., 2015). I would suggest that the results may have been different if ‘purified water’ was changed with different water reuse terminology such as reclaimed, recycled or treated wastewater, all of which can apply to DPR. Language and terminology use is certainly a chief means to market DPR implementation favorably in order to gain public acceptance.

Public Participation and Management Related to DPR

Large water reuse projects involve legal complexities and regulatory framework covering many sectors that affects various stakeholders, and is currently being recognized as a valid element of water resources management (Committee on the Assessment of Water Reuse, 2012). Water reuse project planning includes public participation and evaluation and this public involvement will influence reuse project modes and whether the project will move forward (Hartley, 2006, as cited by the Committee on the Assessment of Water Reuse, 2012). Potable reuse projects are in need of public participation because issues of public health, public finance, local land use, regional environmental protection, and economic growth should be taken into consideration (Committee on the Assessment of Water Reuse, 2012). Communities in arid regions are witnessing a change in attitude about wastewater from it being a liability to it becoming an asset, and discussion about who has legal rights to use treated effluent is growing (Committee on the Assessment of Water Reuse, 2012). State water law controls wastewater for reuse, but mounting water scarcity issues are leading to downstream water users needing states to address differing interests in wastewater (Committee on the Assessment of Water Reuse, 2012).

Participatory planning involving stakeholder inclusion in the decision-making process allows project managers the ability to facilitate constructive social learning, lessen and resolve conflicts, bring forth local knowledge to be used, and reach greater stakeholder acceptance of water management decisions (Guest et al., 2009). Collaboration across stakeholder sectors will need to build on the expertise of a wide-ranging set of disciplines in the planning and design process because as the water industry ascertains new technological solutions, these technological adaptations will not be implemented "unless greater attention is given to stakeholder interests as a central element of a sustainable planning and design paradigm" (Guest et al., 2009, p.6129). Participatory system dynamics can link natural resource use and management to science, policy

options, local knowledge, social concerns, and can improve collaboration synergy among casual relationships (Beall et al., 2011).

Natural resource management is becoming more complex and public input to the decision-making process is becoming viewed as a valuable asset (Beall et al., 2011). A qualitative study using multiple case studies in Australia by Dolnicar and Hurlimann in 2009 found that Australians would drink recycled and desalinated water out of necessity, but if there was a complete lack of background information given to them, the acceptance level of drinking water from alternative sources was very low. This would suggest that public participation will equal increased knowledge of a water resource topic such as DPR and bolster the public acceptance rate. Public participation may also be a method to clarify an issue and help avoid misinterpretation if the issue is problematic. For example, Beall et al. (2011) describes how through a participatory workshop, facilitators were able to shift perception from "tell us when we are going to run out of water" to "what would we do as a community if we knew" (Beall et al., 2011, p.728). Environmental participatory modeling projects should be used to help a group of people gain a better understanding of ways to manage the resource of concern, facilitate discussion on how to best address the concern, and communicate personal values (Beall et al., 2011).

The EPA announced a new drinking water strategy in 2010 to expand public health protection for drinking water with one of the main points being to partner with states in order to have more public water systems monitoring and data sharing (Committee on the Assessment of Water Reuse, 2012). This could be beneficial for DPR implementation in more communities if the areas using DPR find it to be safe to health and financially feasible. The capability of existing drinking water regulations related to unregulated trace organic contaminants could be

problematic as municipal wastewater effluent use may increase the microbial risk of unknown contaminants (Committee on the Assessment of Water Reuse, 2012). Theoretically, social and cultural perception of risk is a standardized response based on social biases and cultural structures (Bickerstaff and Walker, 2003; Douglas, 1992; Freudenburg and Pasor, 1992; Short, 1984, as cited by Ormerod and Scott, 2012) whereby some risks are familiar while others may not be recognized or are suppressed, depending on assumptions and moral values (Ormerod and Scott, 2012). Acceptable risks by scientists are in part shaped by professional training (Sims and Baumann, 1976, as cited by Ormerod and Scott, 2012) and are different than community risk evaluation because each group utilizes different rationalities, norms, and beliefs (Douglas, 1992; Tulloch and Lupton, 2003, as cited by Ormerod and Scott, 2012).

There is not a state that regulates all potential reclaimed water applications (Committee on the Assessment of Water Reuse, 2012). There is a possibility that national water reuse regulations will be developed. Advantages of doing this would include improved efficiency to develop risk-based regulations by the EPA versus individual states, the EPA could use internal experts that have various areas of expertise, and national regulation use may lead to the reduction of local regulatory decision-making support problems related to public health or environmental stances (Committee on the Assessment of Water Reuse, 2012). Disadvantages would include new laws needing to be created, which could be difficult, and in order to address national variation the standards may end up being very conservative, resulting in extra obstacles for states with less stringent regulations (Committee on the Assessment of Water Reuse, 2012).

Municipality consideration of DPR often correlates with increased localized drought parameters. As areas move out of drought conditions, even if for short periods of time, the idea of DPR implementation quickly loses its viewed necessity. Almost a year after the Emergency

Reuse Pipeline DPR facility went online in Wichita Falls, Texas, because of historic drought, the first of its kind facility is being decommissioned due to the lakes that are the primary source of water refilling (Jerome, 2015). The facility is being transitioned into an IPR treatment plant (Jerome, 2015). California has a large IPR facility in Orange County operating, but does not allow DPR. However, unlike Wichita Falls, Texas, which is transitioning from DPR to IPR, California is arranging the plans for what may become the largest DPR facility in the world to counter population growth and historic drought, at a proposed cost of one **billion** dollars (Jerome, 2015). Mike Markus, the general manager of the Orange County Water District, believes that using recycled wastewater "makes sense from an energy point of view, compared to the cost of bringing in imported water from the North Colorado, the energy cost is about half, and compared to using sea water, it is about a third" (Abrams, 2015, p.45). The IPR water that comes from the plant is in essence distilled, but is not allowed to be sent directly to the consumer, which would be DPR water, because of regulations (Abrams, 2015). An environmental buffer is as much of a facilitator to add time to wastewater getting to the tap, as much as it is a method to remove contaminants, but direct use of the water (DPR) has no margin of error compared to indirect use (IPR) of the recycled water (Abrams, 2015). Drinking water regulations are guided by the Safe Drinking Water Act and do not have specific regulations to monitor treated wastewater for drinking water, and according to Peter C. Grevatt, director of the EPA Office of Ground Water and Drinking Water, potable reuse regulations are not currently being considered by the EPA (Dahl, 2014).

The implementation of DPR, globally and nationally, has not led to a rush on DPR facilities being built. California is analyzing many options to better manage water resources. DPR is definitely one of the methods under serious consideration. Public acceptance of potable

reuse involves building a legitimacy framework through communication strategies and public education development campaigns to improve the understanding of the best methods to market potable water reuse (Harris-Lovett et al., 2015). Harris-Lovett et al. (2015) believe that legitimacy is "a key concept in sociology and innovation studies-acknowledges that creating widespread trust in an innovation depends on strategies that not only target individual psychology, but also address aggregate sectorial and societal rules, norms and conventions" (Harris-Lovett et al., 2015, p.7553). Establishing legitimacy for a technology like potable reuse may not be possible in areas in which the technology does not fit the social beliefs of the community (Harris-Lovett et al., 2015). DPR is not a new technology, but the lack of DPR implementation can put it into a similar socio-technical category of new technology, and therefore needs legitimization (Geels, 2002, as cited by Binz et al., 2016). Technological legitimization of potable water reuse depends on advances in key components such as microfiltration, reverse osmosis membranes, UV disinfection, and advanced oxidation, but the marketing of this technology is restricted to an extent because of a lack of public acceptance (Binz et al., 2016). Harris-Lovett et al. (2015) divides legitimacy into three types: 1) pragmatic legitimacy (e.g., support of a potable reuse project arising from the participation of community members on the project's advisory board) 2) moral legitimacy (e.g., support for potable water reuse systems that have operated for a long time without problems) 3) cognitive legitimacy (e.g., people familiar with solid waste recycling may think of potable water reuse as another desirable form of recycling) (Harris-Lovett et al., 2015, pp.7553-7554).

EPWU is currently pursuing DPR implementation of advanced purified water by 2019 or 2020. Part of EPWU's managing process includes gaining critical support through public participation (Espinola, 2016, part one). It has become necessary for EPWU and the community

of El Paso to form a partnership to address water resource scarcity concerns (Espinola, 2016, part two). EPWU is trying to reduce river and aquifer dependency and has incorporated many water resource tools to provide water to the city, including the world's largest inland desalination plant, the thirty year old Fred Hervey IPR plant, an arsenic-removal facility believed to be the largest one in the US, totaling eight treatment plants in all, but the DPR project is considered to be the 'crowning jewel' (Espinola, 2016, part one). The proposed DPR plant in El Paso is comparable to the Windhoek facility in Africa because it will be built as a separate DRR facility, yet the El Paso facility would produce approximately 50% more potable water than the Windhoek facility (Espinola, 2016, part one). One of the key DPR points for John Balliew (EPWU/CEO) is that "effluent is a resource you already own, you don't have to go out and buy it, and with the systems we have now, direct potable reuse is completely feasible" (Espinola, 2016, part one, p.2). In 2014, EPWU approved a five-year rate plan that will increase water bills by 40%, in part to pay for the proposed one hundred million dollar DPR facility that would add ten million gallons of potable water per day (Espinola, 2016, part one).

Literature Review Conclusion and Further Study

What is next for DPR? Will the US federal government set forth regulations and standards concerning DPR? If so, when? Better coordination between federal and non-federal bodies is important for dealing with long-term research needs related to water reuse (Committee on the Assessment of Water Reuse, 2012). Will California's public reaction fears to DPR and contentedness with only implementing IPR change? If so, when? Environmental buffers can play a role in ensuring public acceptance of potable water reuse projects, but the "historical distinction between direct and indirect water reuse is not meaningful to the assessment of the quality of water delivered to consumers" (Committee on the Assessment of Water Reuse, 2012,

p.54). There is a need for updated DPR literature as to why DPR implementation in the US is noticeably more controversial than IPR.

Water reuse process costs related to process scale are insufficient and limited by the current deficiency in literature related to potable water reuse design experience, resulting in the "specificity of cost information to site characteristics and technological developments" (Guo et al., 2014, p.224) being murky and in need of improved clarification. The optimal scale of DPR system distribution, along with studying the costs of emerging processes, needs continued research (Guo et al., 2014). Participatory modeling development in the future and water management modifications, along with finding ways to decrease future conflict, may be used to support communities with sustainable water resource management needs (Beall et al., 2011). Public knowledge of water treatment is important to boost informed decision making (Committee on the Assessment of Water Reuse, 2012). How does the issue of public trust relate to health risk concerns? DPR related engineered storage buffers may provide a way to assess real-time public health concerns and should be studied further (Gerrity et al., 2013). Would a DPR facility be safer from terrorist attack because it would be easier to secure as the entire facility is on site, unlike an IPR plant that will likely have the environmental buffer component located elsewhere?

Changing public perception has been a priority for water resource managers who believe in using DPR, and public acceptance will continue to be a needed priority in the future. Potable water reuse legitimacy must demonstrate beneficial aspects to the end users of the water (Harris-Lovett et al., 2015). Is technological innovation legitimacy being overlooked in El Paso because people living in the desert southwest know that water scarcity is an ongoing issue? In California, the 'yuck' or 'ick' factor has been a main obstacle for DPR implementation for many years. As

the possibility for DPR implementation gains traction in California; is cost going to be the next DPR impediment? Or, will it continue to mainly be related to the issue of deficient public acceptance? Additional research work is needed to determine if trace constituents in wastewater effluent can be effectively controlled and prevent accumulation (Guo and Englehardt, 2015). Future development models of participatory system dynamics as they relate to water management decisions may decrease the potential for conflict and needs extra analysis.

An additional research topic to be studied would be the impact of providing the public with detailed regulatory information that would specifically address the elevated rigidity levels imposed on DPR compared to existing regulations for current tap water supplies (Committee on the Assessment of Water Reuse, 2012). A new era in water resource sustainability is here. The literature shows that DPR technology has been around for many years, and yet DPR is also considered to be a new technology, and a promising source of 'new' water. Institutions need to become more proactive and flexible to avoid new technology mistakes that sometimes happen (Abrams, 2015) in order to make sure that DPR implementation does not acquire negative associations to it that will hinder its overall public acceptance, now and in the future.

Chapter 3 – Case Studies of DPR in Big Spring, Texas, Wichita Falls, Texas, and Southern California

As potable water reuse becomes more prevalent throughout the US, it is important to understand the historical function of reclaimed water reuse to help counter population growth, water scarcity, and climate change. “Potable water reuse is not a new concept, but it has become a prime opportunity to provide high-quality drinking water in water-short areas where alternatives are not sufficient for population needs” (Asano and Cotuvo, 2004, as cited by Cotuvo, 2015, p.2). IPR has better public acceptance of potable reuse and is implemented in more places than is DPR, but DPR is currently gaining traction as a viable method to add ‘new’ water to the overall water supply. Both IPR and DPR water reuse strategies will “require a more structured and standardized framework to guarantee future water availability for urban populations” (Sanchez et al., 2016, p.2). Increased framework structure and standardization are important water reuse strategies and places that have implemented water augmentation techniques through water reuse should be analyzed. This chapter’s case study plan of action includes discussing: The first DPR facility that was implemented in the US in Big Spring, Texas; DPR implementation and subsequent decommission approximately one year later in Wichita Falls, Texas; IPR and non-implementation of DPR in Southern California.

3.1: Big Spring, Texas

In May 2013, Big Spring, Texas, went online with the first US – DPR facility. The Colorado River Municipal Water District (CRMWD) estimates that the reclaimed wastewater effluent from Big Spring and the surrounding areas of Odessa, Snyder, and Midland, produces approximately two million gallons per day of advanced treated water that is combined with additional raw water from surface water reservoirs (Mancha, 2015). The city of Big Spring

provides reclaimed water to the CRMWD and then that facility re-introduces the reclaimed water to the drinking water supply (Tidwell, 2016, Interview). This is different than what EPWU is planning on doing with its scheduled DPR implementation in 2019/2020. Dr. Shane Walker, a professor of civil engineering at UTEP who specializes in water and wastewater treatment, stated during our interview that what EPWU is proposing "is different than the Big Spring, Texas, water treatment plant, which is technically DPR, but the water goes through a concrete ditch and is not put directly into the distribution system and then the treated effluent is added to the raw water from a lake and treated again. It is not 'pipe to pipe' as will be done in El Paso" (Walker, 2016, Interview). The DPR project for the Big Spring area started in 2002 as CRMWD was looking for possible ways to provide safe and clean water during the region's worst drought in decades (Martin, 2014). As John Grant, the general manager of CRMWD, stated in his interview with Laura Martin; "we didn't even intend for it to be a DPR project, we were just looking for new water supplies in our area" (Martin, 2014, p.1). Grant also stated that "we weren't able to build any more surface reservoirs because we physically had no more room, most of the fresh ground water had already been developed, and IPR wasn't an option because we get over sixty inches a year of evaporation" (Martin, 2014, p.1). CRMWD did a pilot program for six months before construction in order to be considered as proper equipment for the DPR facility (Tidwell, 2016, Interview).

Educating the public about DPR in the Big Spring area was important in gaining public support. Grant declared that getting people past the 'yuck factor' was not as difficult as some expected because the people living in West Texas have a better appreciation of water than people living in other parts of the country (Martin, 2014). CRMWD held public meetings, did news releases on television and radio, and did talks at civic clubs (Martin, 2014). Also, locals relied on

bottled water because of low quality source water (Kay, 2015) which could suggest that people in the Big Spring region were not that attached to their raw tap water in the first place. According to Grant, DPR in Big Spring was intended to be a permanent solution to drought for the district's 250,000 customers living there and that most "don't even know it's there anymore" (Espinola, 2016, part two, p.6).

The fourteen million dollar facility produces a final product that consists of 20% recycled water and 80% raw water (Espinola, 2016, part two). The annual operation cost is around $720,000 (Guo et al., 2014). Amidst rapid population increase in the area, CRMWD has set out to "reclaim 100 percent of the water, 100 percent of the time" (EPA, 2012, as cited by Sanchez-Flores et al., 2016, p.20). There is a general lack of regulatory guidance related to DPR (Gerrity et al., 2013). The Big Spring facility broke new ground for DPR use, especially in Texas. Although it is not 'pipe to pipe' DPR, the Texas Water Development Board looks to the Big Spring facility to study and assess DPR potential in Texas, including technical challenges as well as future research needs of water reuse in Texas and monitoring guidelines (Mancha, 2015).

3.2: Wichita Falls, Texas

One year after Big Spring, Texas, went online with their DPR facility in May 2013, Wichita Falls, Texas, located 230-240 miles northeast of Big Spring, went online with the second DPR facility in Texas and in the nation in June 2014. It is important to note that the Wichita Falls DPR plant was decommissioned one year later in July 2015 (Mancha, 2015) and it will be discussed further as to why. The Wichita Falls DPR facility was touted as the first of its kind in the nation at the time it opened (Jerome, 2015) and was able to treat up to ten million gallons of wastewater effluent per day (Martin, 2014). Wichita Falls, similar to Big Spring, mixes its treated effluent with raw water, resulting in a 50-50 mix, and utilizes a thirteen mile

aboveground pipeline to connect the drinking water plant and the wastewater treatment facility (Martin, 2014). This, like the DPR facility in Big Spring, is different than the El Paso plan to implement 'pipe to pipe' DPR.

Wichita Falls experienced its worst single year drought in 2011, and this combined with one hundred days over one hundred degrees and 40% below normal precipitation, dropped lake levels from 87% to 60% (Kay, 2015). The Wichita Falls DPR facility was meant to be a temporary solution from the beginning (Martin, 2014). Daniel Nix, utilities operations manager for Wichita Falls Public Works department believed that Wichita Falls would run out of water by the summer of 2013 (Kay, 2015). "DPR was only intended as a temporary Emergency Project, and IPR was our long-term permanent project" (Nix, 2016, Interview). Nix stated that "we moved faster because of necessity, but we did a ton of analysis of available peer-reviewed articles, used research from the Water Research Foundation, AWWA, and the WateReuse Association… we looked at EPA guidelines and we had very long discussions with the State of Texas on surface water treatment rules" (Espinola, 2016, part two, p.5). Texas, like every other state in the US, does not have regulations and rules for DPR, and permitting and regulation challenges involved getting TCEQ approval, as well as meeting the Clean Water Act drinking water standards whereby wastewater had to be treated and turned into a very high quality water source (Martin, 2014). River system guidelines were applied to wastewater effluent systems because Texas thought this would be a good foundation to move forward with the project (Espinola, 2016, part two). Part of the price (thirteen million dollars for a pipeline) and speed of implementation was related to the fact that Wichita Falls did not need to build a new DPR plant because one of their source water lakes is brackish and therefore already had microfiltration and

reverse osmoses treatment in place (Martin, 2014). TCEQ has awarded Wichita Falls' drinking supply its highest possible rating (Kay, 2015).

When Wichita Falls decided to implement DPR out of water scarcity concerns related to severe drought in 2014 the city was on the receiving end of national ridicule. A Bloomberg News headline about the topic read "Brushing Teeth With Sewer Water Next Step as Texas Faces Drought," and compared the Wichita Falls project to a scenario in Oregon which had water officials flush thirty-eight million gallons of water from a reservoir because someone was known to have urinated in it, stating that "we're not drought-stricken Texas" (Satija, 2014, p.2). National Public Radio discussed how the drought-stricken town of Wichita Falls turned to toilets for water, and NBC's Today Show talked about the topic and the fact that some residents of Wichita Falls deem it to be just plain gross (Satija, 2014). Time will tell if El Paso receives ridicule for implementing DPR by the planned 2019/2020 date. Similar to Big Spring and Wichita Falls that made educating the public about DPR a priority, EPWU is very much concerned with overcoming the 'yuck factor' related to the public perception of DPR through public education. Wichita Falls keyed in on making a video about the DPR project that had the safety of drinking recycled water by having utility representatives, doctors, and experts from local universities speak about the disinfection process (Martin, 2014). Additionally, Wichita Falls held public meetings with the press and the *Wichita Falls Times Record News* did a column called "Lifeline" that consisted of two hundred fifty articles in one year about water, conservation, drought, and reuse (Espinola, 2016, part two).

Nix believes that implementing DPR has influenced public perception of DPR "in a very positive way in Wichita Falls" (Nix, 2016, Interview). "When we discontinued the DPR operation in July 2015, there was a large public outcry not to stop the project" (Nix, 2016,

Interview). The fast-tracked emergency DPR project in Wichita Falls has transitioned to an IPR project with the end of the historic drought in that area (Sanchez-Flores et al., 2016). Wichita Falls will use the twelve mile pipeline that was used as part of the DPR project that carried the treated wastewater for the more permanent IPR project (Jerome, 2015). Dismantling the DPR system and adding a permanent pipeline to Lake Arrowhead will provide the city with 100% lake water instead of the 50-50 blend of lake water and treated wastewater effluent (Ingle, 2015). IPR will have almost a 100% recovery rate compared to the 66% to 70% DPR recovery rate as some of the water is lost during the DPR treatment process (Martin, 2014). Texas Water Development Board Chairman, Bech Bruun, acknowledged that "Wichita Falls has played a huge role in educating water providers around the state that direct potable reuse is a safe and reliable source of water supply" (Ingle, 2016, p.2). Wichita Falls is scheduled to complete their current IPR project by October, 2017 (Nix, 2016, Interview). During the year of DPR implementation Wichita Falls produced approximately two billion gallons of treated water (Kay, 2015).

3.3: Southern California

Back in July of 1985 the City of San Diego conducted a Health Effects Study "to investigate if the City's advanced wastewater treatment system (Aqua II) could reliably reduce contaminants of public health concern to levels that the health risks posed by an assumed potable use of the treated water are not greater than those associated with the present water supply" (Olivieri et al., 1996, p.285). (Aqua II) was a pilot wastewater treatment system located in the Mission Valley area of San Diego, California, that was designed to upgrade secondary effluent water to potable reuse quality (Olivieri et al., 1996). The Health Advisory Committee concluded that "the health risk associated with the use of the (Aqua II) water as a raw water supply is less than or equal to that of the use of the existing raw water supply" (Olivieri et al., 1996, p.295).

Fast-forward thirty years to 2015 and despite many years of accolades associated with IPR implementation in Orange County, that will be discussed further in this chapter, DPR is barred in California (Jerome, 2015) with only individual DPR projects possibly happening legally on a case-by-case basis (Wehner, 2016, Interview). San Diego, the eighth largest US city, receives less than eleven inches of rain per year and imports 85% of its water supply from the Colorado River and Northern California is only now working towards IPR implementation on a facility that can deliver fifteen million gallons of water per day with an expected completion date of 2023 (Atkinson, 2014). However, the Southern California counties of Los Angeles, San Diego, and Orange County are facilitating many important IPR projects and researching the "feasibility of developing regulations for DPR by the end of 2016" (EPA, 2012, as cited by Sanchez-Flores et al., 2016, p.12).

Some of the limited DPR implementation in Southern California is due to regulation issues related to the lack of state and federal criteria, some of it is due to financial issues, but most of it is due to public perception and public acceptance. In 2004, San Diego surveyed residents about potable reuse and two to one were opposed to the idea (Dahl, 2014). Mike Wehner, Assistant General Manager of the Orange County Water District, considers "the biggest concern from the general public to be the 'yuck factor', which is not a new concern and not surprising given public discomfort with the concept of sewage in their drinking water" (Wehner, 2016, Interview). No matter what the treatment process is, public revulsion related to the 'ick' factor of drinking toilet water will remain a repulsive thought for many people (Abrams, 2015). In the 1990's, the Upper San Gabriel Valley Water District in Los Angeles proposed an IPR project. The project was inaccurately coined 'toilet to tap' by a public relations group that

represented the Miller Brewing Company, which used the district's groundwater, and the IPR project failed drastically because of public opposition (Espinola, 2016, part two).

In 1976, the Orange County Water District (OCWD) built the first large-scale, permanent potable water reuse system in the US as a response to rapid urban development that was happening south of Los Angeles and leading to the degradation of the local groundwater basin (Luthy and Sedlak, 2015). The groundwater's quality was being diminished as excessive groundwater extraction was causing coastal seawater to encroach into the basin, leading to inland drinking water wells being closed miles inland, and the adoption of district water policy that would reverse the damage being done through increased freshwater recharge (Luthy and Sedlak, 2015). The OCWD engaged a state-of-the-art treatment system for water reclamation that would inject the reclaimed water into a seawater barrier (Committee on the Assessment of Water Reuse, 2012). The project was known as Water Factory 21 (referring to twenty-first century technology) and utilized a sequence of advanced water treatment technologies (Luthy and Sedlak, 2015). Water Factory 21 was the first project in the nation to use reverse osmosis technology to treat wastewater (Atkinson, 2014). The OCWD expanded Water Factory 21 in the mid-1990's from fifteen million gallons per day production to thirty-five million gallons per day, and at the same time, the Orange County Sanitation District, located next to the OCWD, began working with the OCWD to increase the production to seventy million gallons per day (Atkinson, 2014). In 2008, the OCWD project became the largest operational IPR facility in the world, using secondary effluent from the Sanitation District, with plans to again expand the project from seventy million gallons per day to one hundred million gallons per day (Atkinson, 2014). About 70% of the water supply withdrawn in the OCWD's service area comes from groundwater, with the other water coming from the Colorado River and Northern California (Committee on the Assessment

of Water Reuse, 2012). The OCWD service area has a massive groundwater basin and currently has little incentive to pursue DPR, however, elsewhere in Orange County, in areas outside of the OCWD service area that are not blessed with a large groundwater basin, it may make more sense to move to DPR (Wehner, 2016, Interview). Things could change in Orange County as the state moves forward with the development of regulations (Wehner, 2016, Interview).

The OCWD continuously tries to get the public past the perceived 'ick' factor by hosting tours of the facility where people can see how the water is collected and purified (Hollow, 2016). Convincing the public to accept potable reuse, specifically IPR, has been in full force since 2011 in San Diego as the Public Utilities Department of San Diego hired a nationally recognized consulting firm to help educate the public about the project (Atkinson, 2014). By 2014, 79% of survey respondents in San Diego supported diversifying drinking water strategies, including using recycled water, and the San Diego Council unanimously voted to move ahead with a full-scale IPR project (Dahl, 2014). IPR applications where treated reclaimed water is reintroduced into the environment can reframe and even eliminate the public's mental association with its wastewater origin (Gerrity et al., 2013). In many instances knowing the history of water is more important to people than is the actual quality of the water, and public preference for 'natural' IPR water over direct advanced treated DPR wastewater, can occur (Committee one the Assessment of Water Reuse, 2012). This correlates with the belief that the primary benefit of IPR may be more psychological than actual. As stated by Mark LeChevallier, director of innovation and environmental stewardship at American Water, a national water and wastewater utility; when "you put water into a reservoir, it goes down into the ground, it mixes, and people don't see the line of sight between treated wastewater and their drinking water, giving it the kiss of nature" (Dahl, 2014, p.334).

The concept of legitimacy in a sociological and innovation studies framework "acknowledges that creating widespread trust in an innovation depends on strategies that not only target individual psychology, but that also address aggregate sectorial and societal rules, norms and conventions" (Harris-Lovett et al., 2015, p.7553). Analytically, legitimacy related to potable reuse can be categorized into three key types: Type 1 (Pragmatic Legitimacy) "support of a potable reuse project arising from the participation of community members on the project's advisory board" (Harris-Lovett et al., 2015, p.7553). For example, OCWD informed community and business leaders about the benefits of using a potable reuse system (Harris-Lovett et al., 2015). Type 2 (Moral Legitimacy) "support for potable water reuse systems that have operated for a long time without problems" (Harris-Lovett et al., 2015, p.7553). For example, OCWD can show a record of safe and reliable operations spanning three decades (Harris-Lovett et al., 2015). Type 3 (Cognitive Legitimacy) "people familiar with solid waste recycling may think of potable reuse as another desirable form of recycling" (Harris-Lovett et al., 2015, p.7554). The OCWD uses positive language by calling their technology 'Groundwater Replenishment System' and promotes itself as one of only a few places that successfully established potable water reuse (Harris-Lovett et al., 2015). The importance of this framework can be related to the fact that IPR has been legitimized socially as an acceptable water conservation method in Southern California while DPR has not, however, that may change in the near future in Southern California.

Fueled by relentless, record drought in Southern California, establishing DPR implementation in California is gaining momentum (Jerome, 2016). It is true that using reclaimed water for drinking, no matter how well cleaned, will be met with caution by public health officials and public resistance, but potable reuse technology has been proven to be safe and effective, and uses less energy than importing water from hundreds of miles away (Hollow,

2016). Hillary Godwin, a professor at UCLA Fielding School of Public Health, co-authored a study published in the *American Journal of Public Health* showing that recycled water uses half of the energy that it takes to transport water from other sources, and that delivering water to residents emits around four million tons of greenhouse gasses a year (Hollow, 2016). The potential in California to expand potable water reuse is there. A 2014 WateReuse study estimated that "by 2020, over 2,300 MGD in treated wastewater will be discharged to surface waters or the ocean and of this amount, over 1,000 MGD could be used for either indirect potable reuse or DPR" (Mattingly, 2016, p.1). The Metropolitan Water District of Southern California (MWDSC), which serves nineteen million people in twenty-six cities, including parts of Los Angeles, San Bernardino, Riverside, Orange and San Diego counties, stated at an international water conference that they thought the area was immune to drought, but as a result of the severity of the current drought, MWDSC is rethinking this "false sense of security that we could manage a drought" (Steinberg, 2016, p.28). The MWDSC is an enormous water importer that believes water importing "no longer looks like a long-term solution for regional water challenges" (Jerome, 2015, p.1). In 2015, the MWDSC announced it began planning for a "giant plant that would likely be the world's largest in a 'toilet to tap,' or direct recycling water reuse project" (Steinberg, 2016, p.28). Based on similar projects, the MWDSC believes that the DPR project will cost about one billion dollars (Jerome, 2015). Palatability of DPR to the general public is still going to be a major concern, but all forms of recycled water use are gaining better acceptance in California, and many educational efforts are currently in place to help ease recycled water use hesitations (Jerome, 2016). Professionals in the water industry have praised recycled water use for years and the public may be starting to realize the benefit of using DPR as much as the need to do so. In California, extreme, prolonged drought may have the beneficial

result of establishing DPR as a practical and safe method to establish a 'new' water source in a time of need, for now and in the future.

As much as Southern California could use the millions of gallons of water per day that DPR would provide, the statewide implementation of DPR will not begin regulation and permitting until 2017 at the earliest (Espinola, 2016, part two). DPR continues to be a possible viable water supply option (San Diego Water Authority, 2016) and with the cost of importing 85% of its water supply from the Colorado River and the Northern California Bay Delta tripling over the last fifteen years in San Diego, the City of San Diego is planning on increasing the number of demonstration Pure Water Program facilities that apply potable reuse to seven facilities will start construction of Phase 1 (North City) in 2019 (sandiego.gov, 2016). The Pure Water San Diego Program is a multi-year program that intends to provide one-third of San Diego's local water supply by 2035 through proven technology that will clean recycled water to produce safe drinking water (sandiego.gov, 2016). However, the City of San Diego's Pure Water Program is merely conducting a study at their advanced water treatment demonstration facility to support DPR application (San Diego Water Authority, 2016). To be clear, DPR refers to a fairly wide range of potable reuse options, and in California "any potable reuse without a significant environmental buffer is considered 'direct' potable reuse, including water taken directly from an advanced wastewater purification facility into a potable water distribution system; water from an advanced wastewater purification facility into the intake of a drinking water treatment plant; or water from an advanced wastewater purification facility into an engineered storage facility or environmental buffer that is too small to be considered IPR under California criteria" (Wehner, 2016, Interview). "The less direct of these options, which involve subsequent treatment by a

drinking water treatment plant, are likely to be pursued before any truly flange to flange type DPR systems in California" (Wehner, 2016, Interview).

Chapter 3 – Summary

The DPR facility in Big Spring services approximately 250,000 customers with a 20% recycled water to 80% raw water mix got the DPR ball rolling when it started the first DPR facility in the US in May 2013, and along with the Wichita Falls DPR facility which activated their DPR plant using a 50-50 mix of recycled and raw water in June 2014 as a temporary Emergency Project, established a framework for DPR implementation and signaled the beginning of the social acceptance of DPR (Sanchez-Flores et al., 2016). The lack of standardized regulations may not be the ultimate determining factor as to whether or not DPR is implemented, but it does hinder DPR realization in many places, especially in Southern California. In Texas, the TCEQ does grant DPR projects on a case-by-case basis, as it did with Big Spring and Wichita Falls. El Paso is planning on going online with a full-scale 'flange to flange' DPR facility by 2019/2020 and will need TCEQ approval. This is roughly the same time that the state of California will be establishing regulation criteria of using 'flange to flange' DPR and as discussed in the Southern California case study, IPR facilities are currently being built in places such as San Diego County while DPR is still in a possibility phase. Texas is showing that a case-by-case basis can be a path to DPR implementation amidst a lack of standardized regulation criteria at the federal level. The planned DPR facility by EPWU, as discussed in chapter four's El Paso case study, may add to the signs of social acceptance of DPR and increase the chances of Southern California potentially intensifying DPR implementation on an enormous echelon.

Chapter 4 – Case Study of DPR in El Paso, Texas

As El Paso, Texas, embarks on initiating a 'first of its kind' DPR facility in the Northern Hemisphere, this chapter will describe limiting DPR factors and potential DPR factors that point in the direction of a positive outcome. This will include a spirited discussion about public perception of DPR and the importance of public acceptance of DPR in El Paso by the scheduled DPR implementation date of 2019/2020. The El Paso chapter will discuss public perception and acceptance of DPR by the general public because the general public often wants more information about DPR and feels an increased level of uncertainty that goes with that perceived lack of information. In comparison, expert opinion does have more information and knowledge about DPR and is far more confident that using DPR is a positive technological innovation that should be put into practice. The El Paso case study will depict treatment, financial, public, and other DPR issues in relationship to the emerging El Paso case including predictions and projections of potential DPR implementation in El Paso.

In 2014, Jeff Mosher, executive director of the National Water Research Institute, predicted that most of the attention to DPR would come from "smaller communities where reservoirs or groundwater systems are meager or lacking and where direct reuse will loom as the only viable option" (Dahl, 2014, p.A334). This outlook is evolving to embrace larger communities that are not in need of using direct reuse because it is the only viable option. El Paso County is a community of nearly one million residents that does have multiple viable water resources. In 1985, EPWU under the tutelage of Edmund Archuleta, President and CEO of EPWU for twenty-four years until retirement in 2013, helped establish the Fred Hervey Water Reclamation Plant which was "one of the first, if not the first, in the world to use IPR" (Archuleta, 2015, Interview). El Paso's leadership of IPR is recognized both locally and

nationally and has influenced other communities to consider using IPR as a practical water sustainability project. EPWU is not planning to implement DPR because it is the only viable option, nor is EPWU planning on using DPR like the Wichita Falls, Texas, case that was meant to be a temporary Emergency Project. EPWU is continuing to lead the way in the evolution of water reuse by poising itself to be the largest user of DPR in the US.

Meeting El Paso's water needs is being done by EPWU through harmonizing its water resources of river water, quality groundwater, brackish groundwater, and reclaimed water from its four wastewater plants. The reclaimed water is used for irrigation, industrial processes, and aquifer recharge, with some of the water getting discharged into the river (epwu.org, 2016). El Paso receives seasonal river water allocations, and during drought conditions these allocations are lowered, resulting in increased underground aquifer pumping. To help meet El Paso's future water needs in an arid environment EPWU decided to turn to DPR to supplement local drinking water supplies by starting an Advanced Water Purification Pilot Facility. After irrigation and industrial obligations are met, the remaining discharged water will be purified to drinking quality at the Bustamante Wastewater in Far East El Paso, and used as an additional drought-proof source of water that will help preserve underground aquifer water and conserve freshwater (Montoya-Halter, 2016, Interview). As Dr. Walker states; "DPR improves drinking water sustainability and resiliency, adds confidence to the probability of having water in the future and improves drinking water reliability" (Walker, 2016, Interview). The state of the art pilot facility, which ended its pilot phase on January 28, 2016, was estimated by EPWU as being "a critical step towards developing a safe and reliable, drought-proof and sustainable water supply" (epwu.org, 2016). The pilot facility tested processes to guarantee the purified water will meet water quality requirements, as well as safety and regulatory requirements, using a multi-barrier

process. The purification process will use a cleaned water source, and then the water will go through membrane filtration, nanofiltration, reverse osmosis, ultraviolet light with advanced oxidation, and granular activated carbon filtration (epwu.org, 2016). EPWU will need Texas Commission on Environmental Quality (TCEQ) approval of the proposed plans and specs of the full-scale DPR/Advanced Water Purification Facility that is meant to add up to ten million gallons of purified water per day. EPWU will continue to fine-tune real-time water quality monitoring as well as seek out the third-party panel of expert's recommendations that are an intricate part of receiving TCEQ approval (Espinola, 2016, part one). EPWU has made engaging the public a priority when it comes to the potential full-scale implementation of DPR with an advanced water treatment facility. The public was encouraged to tour the Advanced Water Treatment Pilot Facility to learn about what DPR in El Paso will necessitate. EPWU has a user friendly and informative website that provides a lot of information about water use in El Paso and utilizes videos to explain many aspects of what EPWU does, including the proposed DPR process. The full-scale DPR/Advanced Water Purification Facility will include two additional steps to what the Pilot Facility process involved: 1) adjustment of the water's pH level to match El Paso's current water quality, minimizing pipe corrosion potential, and 2) disinfection of the water with free chlorine to provide a finishing barrier for any pathogens remaining in the water (epwu.org, 2016).

4.1: Expert Opinion of DPR

People involved with water treatment and wastewater treatment are often very confident that DPR is safe and should be utilized. The current CEO of EPWU, John Balliew, believes that not only is DPR "completely feasible" (Espinola, 2016, part one, p.2) because there is not a need to go out and buy effluent, but also because "the technology we have now is more than capable

of taking that effluent and turning it into the best quality drinking water in the system today" (Espinola, 2016, part one, p.2). Mr. Archuleta believes that El Paso is being proactive as a city in its preparation for DPR and that "DPR should be viewed as a tool that should be added to the toolbox" (Archuleta, 2015, Interview). Dr. Kristina Mena is an associate professor and the program head of Environmental and Occupational Health Sciences at The University of Texas Health Science Center at Houston, School of Public Health (El Paso Regional Campus). Her expertise is in the area of water quality issues and public health. Dr. Mena is on the panel assembled by the National Water Research Institute that works with ARCADIS, a national consulting group that oversaw and evaluated EPWU's DPR/advanced purified water pilot program that ended January 28, 2016. The panel is independent of EPWU to help increase public confidence that the data will be unbiased. According to Dr. Mena, EPWU is a very progressive utility that is trying to avoid water loss and need by taking a proactive approach and she "feels strongly that El Paso should implement DPR because it is a good solution in this arid region for water sustainability" (Mena, 2015, Interview). She also stated that "the risk assessment is showing that DPR water being produced will meet the safety guidelines of the water produced now" (Mena, 2015, Interview). Dr. Walker asserts that the DPR process that EPWU is proposing "will undoubtedly produce safe drinking water" (Walker, 2016, Interview). It is important to do more than pray for rain and it must be recognized that the best new and future water is water you already have (Archuleta, 2015, Interview). "One of the most important concepts to take into consideration is that DPR is a drought resiliency insurance policy" (Walker, 2016, Interview).

Getting past the 'yuck factor' is a hurdle for any community that wants to go online with DPR, and El Paso is no exception. Mr. Archuleta believes that DPR in El Paso needs public support and that public perception is an important factor when discussing DPR. Dr. Mena

mentioned that more information makes it easier for people to get past the 'yuck factor.' Mr. Archuleta believes public perception of DPR is site specific (by state for example) and Dr. Walker agrees that regional perception is a factor, stating that in his opinion Texas is leading the way when it comes to DPR because "Texans are tough" (Walker, 2016, Interview). There is always a health risk related to DPR but as Mr. Archuleta asserts, better technology has led to safer water for people and the environment. According to Christina Montoya-Halter, the Marketing and Communications Manager for EPWU, TCEQ approval will only happen after a lengthy testing process (Montoya-Halter, 2016, Interview). Many people and organizations are providing guidelines to mitigate health risks associated with DPR, but there will never be zero risks related to DPR (Walker, 2016, Interview).

The planned additional step of using more free chlorine by EPWU as part of the DPR disinfection process does potentially increase certain health concerns. I attended a lecture on February 18, 2016 by Dr. Susan Richardson. She is a chemistry and biochemistry professor at the University of South Carolina, and former chemist in the National Exposure Research Laboratory for the US Environmental Protection Agency. She discussed disinfection by products (DBP's) related to drinking water. The lecture was titled The Next Generation of Drinking Water Disinfection By-Products: Occurrence, Formation, Toxicity, and New Links with Human Epidemiology. During the lecture she defined epidemiology as the "study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control health problems" (Medical Dictionary for the Health Professionals and Nursing, Farlex, 2012, as cited by Richardson, 2016). During her lecture, Dr. Richardson described how drinking water DBP's are formed unintentionally as a reaction when disinfecting and making water safe to use with substances such as chlorine, chloramines, ozone, etc… and

how DBP's also form from things such as pesticides, pharmaceuticals, estrogens, textile dyes, algal toxins, parabens, etc… Treating effluent for drinking water leads to increased chlorine disinfection reaction combinations and more DBP concerns, such as bladder cancer, reproductive health risks, and developmental health risks. The lecture did raise some problematic issues related to the regulation of DBP's. Regulation costs money and new classes of DBP's are currently being introduced and studied, but the EPA only regulates eleven DBP's even though there are more than eleven DBP's, and as Dr. Richardson stated, "little is known about occurrences and toxicity of the unregulated DBP's" (Richardson, 2016, Lecture). She did tell the audience that unlike Europe, which is involved with learning the health impacts of long-term exposure to DBP's in drinking water with a study called HiWATE, the EPA works in "slow and mysterious ways" (Richardson, 2016, Lecture). When it comes to water contamination, people can become sick quickly, and it is worrisome that the EPA may not be equally quick to react. New chemical introduction into local water supplies, such as recently created pesticides, means that there is potential for new health risk concerns that will need to be met. There should always be disquiet if DPR related health risks were to increase because of an alteration in existing DPR stability, and society needs a governing entity that is able to react quickly and decisively, not slowly and mysteriously. A lack of confidence by many in the general public over regulatory concerns is in part what leads to public trust anxiety and can manifest itself into uncertainty and indecision about DPR implementation.

An inquisitive aspect to potential DPR implementation in El Paso, and the El Paso case, relates to religious law. The question of whether or not DPR water would be kosher was posed to me on more than one occasion when I would ask people their opinions about DPR. I asked Rabbi Ben Zeidman of Temple Mount Sinai in El Paso about this. He was unsure about the particulars

of what DPR involved. I defined DPR for him and told him that EPWU is preparing to go online with DPR by 2019/2020. Rabbi Zeidman looked into the topic and got back to me a few days later with the following thoughts. Reform Judaism is not bound to the structures of orthodox, legal Jewish tradition. They are guidelines and an important part of all Jewish heritages, but do not rule the day. Historically, Judaism legal literature teaches good governance of human society, and part of fulfilling the will of GOD is treating the relationship between people and the land as a covenant, emphasizing proper land stewardship (Troster, 2009). Modern Jewish environmental writing began in the early 1970's, and Jewish environmental writing using specific sustainability language started in the early 1990's, connecting classic elements of sustainability to GOD's ownership of Creation and human stewardship of Creation (Troster, 2009). "Reform Judaism looks to human beings as those who are present to care for the earth and ensure she is sustained because the Book of Genesis commands us to tend the earth, so, anything that protects the earth's resources is an initiative that we would cherish" (Zeidman, 2016, Online Interview). "Judaism holds many traditional theological concepts, values, and actions that the modern Jewish environmental movement has connected with the value of sustainability" (Troster, 2009, p.257). This type of ideology is the attitude that EPWU will be seeking during their pursuit to implement DPR, and EPWU will hope to influence many El Pasoans to take a similar stance when it comes to DPR as a water resource sustainability method.

Expert Opinion – Summary

The emerging El Paso case has the potential to influence other places to implement DPR, especially if El Paso generates a positive DPR outcome similar to what it has done with IPR. There is no question that other communities are already looking to implement DPR in the future as conservation is the first water resource, then reuse, and then recycling (Walker, 2016,

Interview). El Paso is further along than other communities when it comes to water sustainability methods. “EPWU’s advanced water purification facility will absolutely lead to other places implementing DPR” (Montoya-Halter, 2016, Interview). “We are ahead of the game here in El Paso when it comes to using tools such as desalination and eventually DPR” (Archuleta, 2016, Lecture). The El Paso case has the potential to influence and establish DPR regulations for other regions as well. The proposed El Paso DPR facility is different than other places such as Big Spring, Texas, and Wichita Falls, Texas, which sends purified water to a conventional water treatment facility. “The El Paso facility will be the first to put purified water directly into the distribution system, and once the reused water is purified it has finished its process” (Montoya-Halter, 2016, Interview). “DPR is an added method for avoiding the worst case scenario of running out of water” (Archuleta, 2015, Interview). Expert opinion has very little to no uncertainty when it comes to DPR in general, and those involved are seemingly waiting for El Paso’s planned implementation of DPR with energetic anticipation. Complete expert opinion interviews can be found in Appendix I.

4.2: Social Marketing Related to DPR

Public perception and acceptance of wastewater reuse is a main component of DPR implementation. People want to feel they have been given enough information about DPR to make a first-rate decision in relation to DPR consumption. Places comparable to El Paso that are moving forward with DPR implementation must concern themselves with social behavior change as DPR has rarely been put into operation and has not been socially legitimized. As stated in the literature review, “people have been trained for generations to provide separation in both time and space between their wastes and their water supplies, and therefore the public is concerned about the safety of using wastewater effluent for domestic purposes” (Committee on the

Assessment of Water Reuse, 2012, pp.16-17). Similar to EPWU, other communities wanting to go online with DPR are turning to social marketing as a conduit to persuade people to increase water conservation and augment the water supply through DPR implementation.

Commercial marketing is tasked with promoting a product or service to the consumer with the intent of giving the consumer perceived value of the product or service, ultimately increasing the likelihood of the consumer to purchase the product or service (Evans et al., 2014). "Social marketers use the same powerful idea in a different way – not to sell products and services for the benefit of the marketer but to promote socially beneficial causes and behaviors for the benefit of the audience" (Hastings, 2007, as cited by Evans et al., 2014, p.18). Social marketing can be used to promote more environmentally sustainable lifestyles and contribute to the idea of anti-consumption (Peattie and Peattie, 2009). Responsible consumption should conceptually utilize social marketing by taking into "account the welfare of society, as well as the interests of consumers and business shareholders" (Prothero, 1990, as cited by Peattie and Peattie, 2009, p.261). As people decide about DPR, social marketing can be used by water management to persuade a community to accept wastewater reuse and create a positive perception of DPR. Nancarrow et al. (2008) asked; "So why is it that people can see the logic in using recycled water but remain reluctant to use it?" (Nancarrow et al., 2008, p.486). Ajzen's *Theory of Planned* Behavior states that a "person's behavior can be predicted from his/her behavioral intention" (Ajzen, 1985, as cited by Nancarrow et al., 2008, p.486) and uses the following factors to help answer why people see recycled water use logic, but remain reluctant to use it:

- Emotion: positive or negative feelings toward recycled water, for example the 'yuck' factor.

- Attitudes: belief that supporting recycled water will lead to positive outcomes.
- Subjective Norms: pressure and influence from other people to support recycled water.
- Risk Perceptions: the perceived level of risk associated with using recycled water.
- Perceived Control: the control a person feels they have over quality of their source water.
- Knowledge: the level of knowledge a person has about water issues and using recycled water.
- Trust: the level of trust a person has regarding the managing authorities implementing recycled water.
- Responsibility: a personal evaluation of individual responsibility, the community, and the authorities to make sure that future water availability is ample.
- Environmental Obligation: personal obligation to protect the environment.
- Intended Behavior: behaving in a way that intends to support or reject using recycled water.

Nancarrow et al. (2008) tested Ajzen's *Theory of Planned Behavior* through case studies in two Australian cities, developed a model of the factors that drive community intended behavior, and found that "Attitudes was the only variable to have a significant direct relationship with Intended Behavior" (Nancarrow et al., 2008, p.489). Trust did not show a significant direct outcome on Intended Behavior, but Trust did have a direct significant effect on Risk Perceptions, specifically health risk (Nancarrow et al., 2008). These are variables that can help to understand a person's emotional reaction to DPR and ultimately be used to overcome the challenges associated with influencing a person's decision-making, but a "person's emotional reaction to a recycled water scheme can be deeply entrenched and hence can be difficult to influence" (Nancarrow et al., 2008, p.490).

The ‘marketing mix’ or four ‘Ps’ of *place*, *price*, *product*, and *promotion*, are used in social marketing as they are in commercial marketing (Borden, 1964, Kotler and Lee, 2008, as cited by Evans et al., 2014). Social marketing pursues social goals by employing the same tools, techniques, and concepts that commercial marketing uses (Andreasen, 1995, as cited by Peattie and Peattie, 2009). Social marketing can be defined as “the use of marketing principles and techniques to influence a target audience to voluntarily accept, reject, modify, or abandon a behavior for the benefit of individuals, groups, or society as a whole” (Kotler et al., 2002, p.394, as cited by Peattie and Peattie, 2009, p.262). At the heart of social marketing is the promotion of a specific proposition (Peattie and Peattie, 2003, as cited by Peattie and Peattie, 2009). Proposing that ‘recycling is good for the environment,’ or ‘littering is bad for the environment’ are examples of specific propositions meant to influence a target audience. Places that aspire to implement DPR are emphasizing that using recycled wastewater is a good idea and a good thing to do. For social marketing to effectively target anti-consumption, the ‘marketing mix’ of the four ‘Ps’ could be modified by using *propositions* instead of products, *accessibility* instead of place, *costs of involvement* instead of price, and *social communication* instead of promotion because this type of model orients itself more to communicating with the consumer than it does centering around a product (Peattie and Peattie, 2009). It is important for entities such as EPWU that want DPR implementation consider audience point of view, including the barriers to change that they may face, and as attitudes and behaviors are being changed through social marketing, it is also important to maintain these new attitudes and behaviors once adopted (Peattie and Peattie, 2009), advancing the goal of having DPR become an accepted and normalized lifestyle change.

A key element to garnering public acceptance of DPR can be related to changing the behavioral unease that many feel when it comes to drinking DPR water. Effective social marketing is a feasible method to make this aspiration a reality. EPWU seems to be strategically using social marketing when it comes to DPR. EPWU hired a consulting firm, and as discussed in the literature review, was advised that if the topic of drinking sewage comes up the response should be; "No, that's not remotely what we are talking about. We are talking about starting with water that has been cleaned twice, if not three times. You're not talking about sewage" (Espinola, 2016, part one, pp.4-5). At the website www.epwu.org/water/purified water.html, there is information about what the anticipated full-scale DPR/advanced water purification facility will involve, including the following information:

*Note – Observation related to the possible social marketing by EPWU with consumption reduction models are in parenthesis to emphasize that what EPWU is publishing resembles social marketing.

- Advanced water purification transforms highly treated wastewater into fresh drinking water. (Proposition/Product)
- Advanced water purification extends nature's water cycle, which circulates the earth's water from the atmosphere to earth and back again. (Proposition/Product and Social Communication/Promotion)
- EPWU will send cleaned water to a purification plant, rather than downstream for other users. (Accessibility/Place)
- Purified water is the highest quality drinking water produced. (Proposition/Product)

- As drought conditions continue, El Paso's river allocations are decreasing. (Accessibility/Place)
- EPWU balances water resources – river water, water from underground aquifers, and cleaned water from wastewater plants. (Accessibility/Place and Proposition/Product)
- When drought reduces river flows, EPWU pumps more water from the aquifers but the aquifers are not replenished quickly and the water they contain is not infinite. (Accessibility/Place)
- Accelerated pumping is not sustainable for prolonged periods of time. (Social Communication/Promotion)
- Other options for increasing water resources will be very costly. (Costs of Involvement/Price)
- Mandatory water restrictions would reduce water use, but they would impact the city's economy. (Costs of Involvement/Price and Accessibility/Place)
- Purified water is a sustainable, cost effective resource that can provide long-term relief for El Paso. (Costs of Involvement/Price and Proposition/Product)
- Water produced by the purification facility will be purer than tap water. (Accessibility/Place and Proposition/Product)
- The water quality will be monitored and regulated by TCEQ. (Proposition/Product)
- An independent advisory panel will assist staff throughout the project, including health professionals, scientists, and engineers with expertise in areas such as

public health, risk and assessment, and treatment processes. (Social Communication/Promotion)

- An ongoing outreach program is educating the public about water purification and the project. (Social Communication/Promotion)

Part of the apparent social marketing related to DPR that EPWU is integrating into its overall marketing campaign should be to establish a framework for localized societal legitimacy of DPR. Carol Nemeroff, a professor of social and behavioral sciences at Maine's Lewiston-Auburn College worked with the Orange County water department in California to conduct a study examining the reaction people have to drinking reclaimed water and concluded that three types of people emerged: "the first is willing to try it, another sits on the fence until further informed, and a final rejects the concept out of hand" (Abrams, 2015, p. 47). It is imperative for EPWU to meet the challenge of persuading the public of the benefits of DPR early and often until it becomes socially legitimized like IPR has become. As discussed in the Southern California case study section, Suchman (1995) divided legitimacy into three basic categories: 1) pragmatic legitimacy, 2) moral legitimacy, and 3) cognitive legitimacy (Harris-Lovett et al., 2015). EPWU does appear to be engaging legitimacy strategies. *Pragmatic legitimacy* is being conveyed to the public that it is in the end users best interest to apply DPR as a sustainable water source in an arid environment. *Moral legitimacy* can be related to EPWU guarding the welfare of the public by making sure that the community does not run out of water through utilizing progressive water sustainability tactics. *Cognitive legitimacy* appears to be happening as EPWU regularly promotes the DPR process as advanced water purification that treats the recycled water to bottled water standards. Harris-Lovett et al. (2015) suggest that achieving all three types of

legitimacy is critical for long-term acceptance as public confidence may deteriorate over time if each legitimacy strategy is not completely trusted.

Social Marketing – Summary

Similar to 'green marketing' and 'environmental marketing,' social marketing efforts to educate, promote, and change behavior on a social level. Social marketing is evolving in new directions but the main interest is to have two-way communication, interaction, and relationship building (Peattie and Peattie, 2009). Social marketing is a strategy that can offer behavior change and EPWU appears to be using social marketing to influence and persuade the public to become accepting of DPR implementation. I am not aware of a DPR marketing slogan being proffered by EPWU, but it seems like a good idea if an interesting and motivating one can be produced, and I would not be surprised that as we get closer to the 2019/2020 date to go online with a DPR facility in El Paso, a catchy marketing slogan is initiated to make DPR/advanced purified water seem like a safe and wise choice.

4.3: Classroom Experiment Linked to DPR

I conducted three classroom experiments at the University of Texas at El Paso (UTEP) with the goal of acquiring data that would allow me to compare EPWU's claim that 77% of those surveyed by telephone in 2013 were strongly in favor for a DPR/advanced water purification plant to that of UTEP undergraduate student responses to possible DPR implementation in El Paso by 2019/2020. I wanted to find out how much of a difference positive or negative terminology can make in influencing personal opinion and public perception of DPR implementation. I made sure that both of the PowerPoint slides used for my presentations were factually accurate with the difference between the two presentations being the use of either positive or negative language terminology. EPWU seems to be in the midst of a public marketing

campaign to gain public acceptance of DPR and will only use certain terminology when describing DPR/ advanced water purification. For one of the classroom presentations I described DPR using both positive and negative terminology, and then positive only terminology for one classroom presentation, and negative only terminology for the other classroom presentation.

In 2013, EPWU contracted the Institute for Policy and Economic Development at the University of Texas at El Paso to "conduct survey research on issues related to the current and future water supply in the City of El Paso" and provide "a snapshot of the awareness and perceptions of City of El Paso households with respect to current water sources, quality of drinking water, and households' support for a possible advanced purified water treatment plant" (EPWU Survey, 2013, p.1). A point of comparison between my classroom experiments and the EPWU survey involved question #10 – *With recent technological advances, EPWU is exploring the possibility of taking treated wastewater that is acceptable for irrigation purposes and treating it again at an advanced purification plant to make the water safe for drinking. What would be your level of support for this project?* The choices for the respondents were: (^Strongly in Favor ^Somewhat in Favor ^Somewhat Opposed ^Strongly Opposed)

If the answer was ^Strongly in Favor, then question #14 would be asked. If not, additional information was provided. This included describing the multi-stage treatment process that involves using membrane filtration, advanced filtration, and advanced oxidation. Also provided was the definition of **membrane filtration**: this process filters out particles larger than one thousandth the diameter of a human hair and is used to make baby food, purify medicines, and fruit juices (*Note – this definition seems to help relate technology to safety) and the definition of **advanced oxidation**: this process uses ultraviolet light, similar to concentrated sunlight, in conjunction with hydrogen peroxide to break apart and oxidize contaminants (*Note – this seems

to give DPR a bit of the 'kiss of nature' element that makes IPR seem more publically acceptable). After the additional information was provided, the respondent for question #11 was then asked – *Considering this information, what would be your level of support for this project?* If ^Strongly in Favor was not answered, a regulatory statement of: water from an advanced purified treatment plant will meet and exceed federal and state drinking water regulations and will be a sustainable water supply for El Paso, was made. After the additional information was provided, the respondent for question #12 was asked – *Considering this information, what would be your level of support for this project?* If ^Strongly in Favor was not answered, a financial aspect was provided as question #13 asked – *An alternative source of drinking water is importing it from other places. If importing water is more costly than purifying water, what would be your level of support for an advanced purified treatment plant?* At this point the person conducting the interview would record the final answer and move on to question #14. The survey was ostensibly probing for a ^Strongly in Favor response.

In the survey results portion of the telephone interview it is stated that "fifty-five percent of respondents were strongly in favor for an advanced purified water treatment plant and after providing three additional blocks of information about the plant, this level of support increased to 77 percent" (EPWU Survey, 2013, p.2). The survey method used by EPWU whereby DPR was presented as 'advanced purified' water points to a specific desired response outcome. The survey method could have been more open-ended. For example, a range of questions could explore different ways of characterizing the water source, such as stating the fact that the 'advanced purified' water is in part reclaimed sewage that is being reused to add to the drinking water supply. EPWU was surveying people about their feelings toward building a DPR/advanced purified water treatment plant with limited reference to the fact that it is reclaimed and treated

sewage water that is going to be added to the drinking water supply. The term ‘toilet to tap’ is often used as a DPR moniker because it designates where the reclaimed wastewater originates. I did not use the term ‘toilet to tap’ as part of my positive language only presentation because this term seems to instantly paint a negative picture of what DPR is. It is used mainly by the media to grasp the reader’s attention and is rarely, if ever, used by EPWU.

The two PowerPoint presentations contained the following slide information:

Positive Language Presentation:

Title – Direct Potable Reuse (DPR)

> El Paso, Texas, is planning on implementing DPR by 2019/2020.

> DPR is the advanced water purification of treated wastewater effluent that will add millions of gallons of water per day to El Paso’s water supply.

> DPR is a needed tool to conserve water in a desert environment.

> DPR is an investment that will save future water in the El Paso area and save money because there will be less of a need to do costly water importation or deeper groundwater pumping.

> Advanced DPR technology has led to the belief by experts that DPR is safe to human health.

> DPR approval in El Paso is being based on the data provided by an independent panel of board members from different parts of the nation, who have various backgrounds of expertise.

> The DPR pilot-plant facility has been successfully completed and over the next few years El Paso Water Utilities (EPWU) will be doing more DPR testing for increased safety.

>EPWU is being progressive with DPR implementation and is leading the way nationally in future water conservation efforts.

Negative Language Presentation:

Title – Direct Potable Reuse (DPR)

>El Paso, Texas, is planning on implementing DPR by 2019/2020.

>DPR is referred to as 'toilet to tap' because it adds treated reclaimed sewage directly to the drinking water supply.

> DPR is barred in California, mainly due to the perceived 'yuck factor.'

> Few places in the United States use DPR even though many US cities are dealing with drought conditions and water resource concerns.

> Wichita Falls, Texas, implemented DPR but discontinued it after only one year.

> Some public health experts believe that there are safety risks to human health connected to DPR implementation.

> DPR will lead to increased use of disinfection chemicals; the disinfectant by-products are potentially hazardous to human health.

> DPR implementation by the El Paso Water Utilities is part of the reason that water rate hikes are happening in 2016.

All three classes were asked to fill out the same questionnaire containing the following questions:

1) Is water important to you? (Please explain your answer in one or two sentences)

2) What are your feelings and opinions about drinking and using DPR water?

3) Are you against using DPR, or in favor of using DPR?

(Answer using the following Likert Scale)

(1=Very Much Against)(2=Against)(3=Undecided)(4=In Favor Of)(5=Very Much In Favor Of).

Results:

*Note – It is important to state that I decided to include an (**Undecided**) option for the respondents, unlike the EPWU telephone survey which did not.

On April 8, 2016, I did my presentation showing both (**positive and negative**) PowerPoint slides. Twenty-six people responded and the Likert Scale used for question #3 showed the following:

- 11.5% = (Very Much Against)
- 7.7% = (Against)
- 46.2% = (Undecided)
- 30.8% = (In Favor Of)
- 3.8% = (Very Much In Favor Of)

On April 11, 2016, I did my presentation showing (**only negative**) PowerPoint slides. Twenty-five people responded and the Likert Scale used for question #3 showed the following:

- 16% = (Very Much Against)
- 12% = (Against)
- 44% = (Undecided)
- 16% = (In Favor Of)
- 12% = (Very Much In Favor Of)

On April 11, 2016, I did my presentation showing (**only positive**) PowerPoint slides. Thirty people responded and the Likert Scale used for question #3 showed the following:

- 3.3% = (Very Much Against)
- 3.3% = (Against)
- 33.3% = (Undecided)

- 43.3% = (In Favor Of)
- 16.8% = (Very Much In Favor Of)

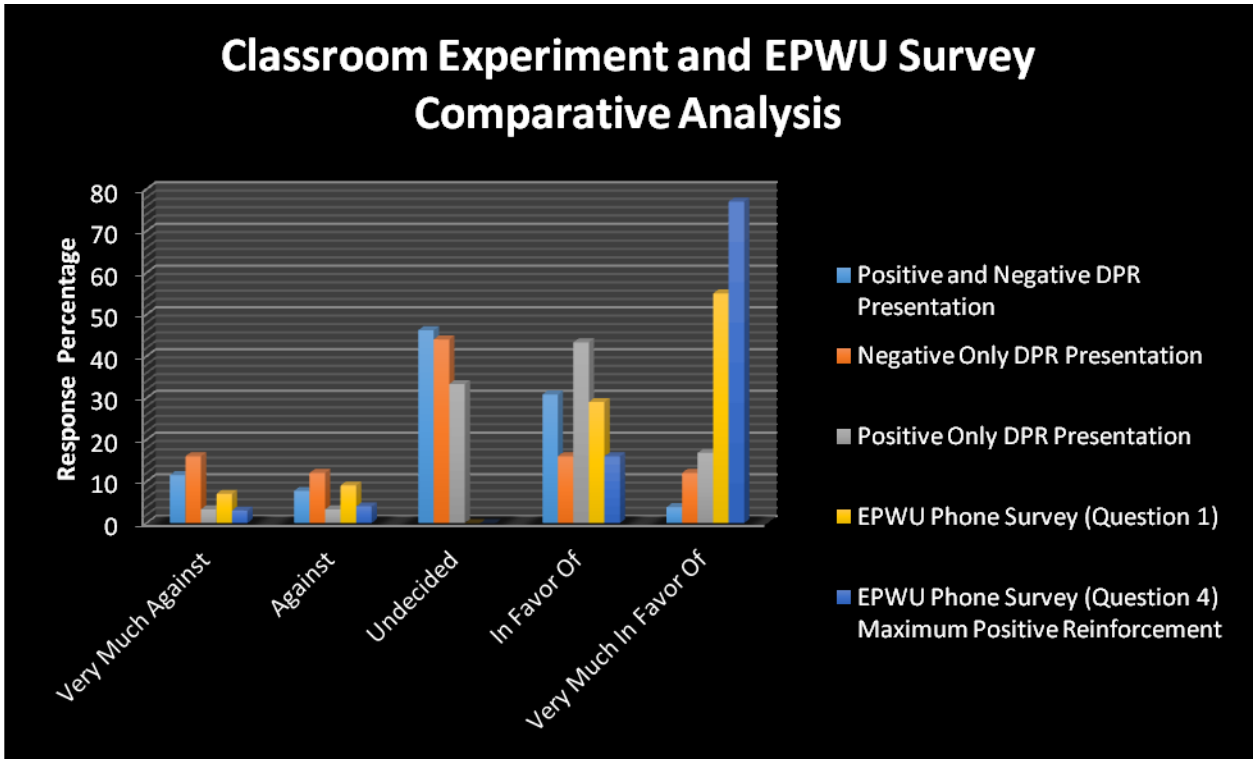

Figure 1: Classroom Experiment

The EPWU Phone Survey (Question 1) represents question #10 that was described earlier. EPWU Phone Survey (Question 4) represents question #13, also described earlier. (Question 1) and (Question 4) relate to the EPWU phone survey being a progressive series of questions that would provide additional information if the most desired outcome of ^Strongly in Favor was not given. I paired the data results the following way:

- (Very Much Against) with ^Strongly Opposed
- (Against) with ^Somewhat Opposed
- (In Favor Of) with ^Somewhat in Favor

- (Very Much in Favor Of) with ^Strongly in Favor
- (Undecided) was an option added to the classroom experiments and was not a provided option by the EPWU telephone survey to its respondents.

The Likert Scale results used for the classroom PowerPoint presentations showed a prevalence of indecision as the (Undecided) option had the highest percentage response in the **positive and negative** presentation at 46.2% and the **negative only** presentation at 44%. The **positive only** presentation did not show the (Undecided) option be the highest percentage response as those (In Favor Of) was at 43.3% while those who were (Undecided) was at 33.3%. The (Undecided) option at 33.3% is still a comparatively high percentage but it does show that indecision can be lessened when only positive DPR terminology is used. If the results of (Against and Very Much Against) are combined into a category of (**Oppose**), and (In Favor Of and Very Much in Favor Of) are combined into a category of (**Support**) and the undecided option is removed from the results; the presentation with both **positive and negative** terminology showed that 19.2% oppose DPR and 34.6% support DPR, suggesting that when given both positively and negatively termed information people living in this area are willing to use DPR as a way to conserve water more than they are not willing to do so. If the same combination of (Against and Very Much Against) equals (**Oppose**) and (In Favor Of and Very Much in Favor Of) equals (**Support**) is used for the **negative only** presentation, and taking out the undecided option, a curiously equal amount of people are opposed to implementing DPR as are those who support DPR; both at 28%. Using the same (**Oppose**) and (**Support**) combinations for the **positive only** presentation, and taking out the uncertain option, the positive only presentation showed that only 6.6% oppose DPR implementation compared to 60.1% who support it, suggesting that the apparent influence of using only positive DPR language and

terminology reinforcement can have is considerable. The predominance of respondents who chose the undecided option could be of value to EPWU because these are people who could be swayed to accept DPR in the future.

Response Remarks:

I am providing a portion of the remarks that the respondents made concerning the non-Likert Scale questions and some of their comments to provide additional information as to why the respondents answered the way that they did.

*Note - All of the respondents stated that (**Yes**) water is important to them.

Both Positive and Negative Presentation

- This class had a person state that they believed indirect potable reuse (IPR) is a much safer process than direct potable reuse (DPR) and that it is not a wise idea to add wastewater directly to our taps. The curious part about this is that I did not mention IPR at all during the presentation, and makes me wonder; how flexible are people going to be in the future about possibly changing their mind once it is made up about DPR? (Against)
- Being a parent, I would like to make sure my child is being exposed to safe water. (Undecided)
- It seems it would cause just as many problems as solutions. (Undecided)
- I hate it because I know somehow it is bad for your health. (Very Much Against)
- If it came to a point where it was the only option then we would have to learn to accept it. (Undecided)
- It may sound gross but what is needed is needed in order to save water. (Very Much In Favor Of)

- I believe it is a good idea and would clean our water and make it taste better. (In Favor Of)
- I strongly disagree. It does not matter how many experts say it is safe; it is not! (Very Much Against)
- If it is tested and deemed to be safe, I would have no problem with it. (In Favor Of)
- I do not like the idea because I do not trust the government. (Very Much Against)
- How will it affect pregnant women? (Undecided)

Negative Only Presentation

- The DPR water should be clean and well-filtered at least. It should not be contaminated with any harmful chemicals. (Very Much In Favor Of) – This remark is another one that makes me wonder about a person whose mind is already made up about DPR and how it will not be changed.
- The 'yuck factor' is the most influential part in my opinion about using DPR water. (Against)
- I feel discouraged about the whole thing. (Undecided)
- We need much more research before using it. (Very Much Against)
- It is pretty disturbing to think you would be using the same water from your toilet to drink or wash dishes or anything else. (Very Much Against)
- The water utilities company should find other solutions to solve the water issues the city is facing. There is no need to destroy the human well-being. (Very Much Against)
- I don't care for it. I would not drink it myself. I also have children and would not want them to drink it. (Very Much Against)

- I feel that DPR water would be a good system to implement because it would be a better way to recycle it. (In Favor Of)
- I don't think I would feel comfortable with anyone drinking or using DPR. I don't think the benefits outweigh the risks given the information we were provided. (Against)
- Not fond of it. Anything can go wrong. (Against)

Positive Only Presentation

- It is important to understand where and how our water is purified. (In Favor Of) – I found this remark to be interesting because of the use of the word 'purified.' It is definitely an affirmative DPR keyword that must be used to positively influence the public.
- From the information shown to us, I feel that using DPR water will definitely help the future of water supply in El Paso. (In Favor Of)
- I do have some reservations about using such water but would welcome this method if it is proven to be safe by extensive research. (Undecided)
- In the case of drought, DPR may be the only viable option to provide clean water. (In Favor Of)
- As long as the water is cleaned thoroughly and is safe to drink, I don't see a problem using DPR water. In favor to help the environment. (In Favor Of)
- It is helpful for the environment. I think it is worth the shot. (Very Much In Favor Of)
- I think DPR is a great way to add more water to our water supply and I feel safe drinking it because I know the water goes through many processes. (Very Much In Favor Of)
- It is innovating and crucial. It should definitely be implemented in order to save water, help the environment, and avoid drought. (Very Much In Favor Of).

- I am a little skeptical about it. It sounds like a good idea, but like everything else that is new, it will take some time to get used to. (Undecided)
- It should not be used for drinking, period. (Very Much Against)
- I am not sure if it is safe. (Undecided)
- I think that if DPR is safe then it is a useful conservation tool/use of water. (In Favor Of)

Classroom Experiment - Summary

The 2013 EPWU telephone survey brought forth some compelling information. The result for the type of water normally used for drinking at home showed that 40% of respondents drink bottled water, 36% drink tap water, and 24% drink filtered tap water. In other words 64% of respondents do not directly drink tap water, which makes me wonder; what would these numbers go to after DPR implementation, and does this mesh with the 77% who are strongly in favor of supporting an advanced purification water plant? It seems that water quality is a concern if approximately two-thirds are paying extra to not drink the water that comes straight from the tap. The survey results for who is trusted the most to provide reliable information about the quality and safety of tap water showed that 33% trust a scientific expert the most, 32% trust staff from the health department the most, 22% trust staff from EPWU the most, 6% trust a medical doctor the most, and 7% trust a combination of factors the most, other, or did not specify. The result of those (^Strongly in Favor) of supporting an advanced water purification plant based in the El Paso area showed that West Side residents went from 57% on the first question (#10 in the phone survey) to 76% on the fourth question (#13 in the phone survey), Central Area residents went from 60% on the first question to 82% on the fourth question, Northeast Area residents went from 52% on the first question to 77% on the fourth question, East Side residents went from 49% on the first question to 72% on the fourth question, and Mission Valley Area residents

went from 60% on the first question to 82% on the fourth question. The Mission Valley Area is the closest area to the location of the proposed DPR facility, yet had the highest percentage of those strongly in favor of supporting a DPR facility along with Central Area residents. East Side residents had the lowest overall support of those who are strongly in favor of a DPR facility.

My research suggests that when asked about DPR many people are often undecided about wanting DPR implementation and would like to have more information about DPR. The three UTEP classroom experiments demonstrated how the (Undecided) response had the highest overall percentages when the presentation had both positive and negative information, and negative only information. The positive only information presentation did yield a higher percentage for the (In Favor Of) response compared to the (Undecided) option which does show the prospective to influence public perception and acceptance of DPR through affirmative language use. The EPWU survey did not take public indecision about DPR implementation into consideration, and the methodology of following lesser desired responses with added persuasive information and repeated questioning while pushing people toward a favorable opinion resembles a social marketing approach meant to sway public perception of DPR and encourage public acceptance of DPR by promoting a high approval rate of those who favor building a DPR/advanced water purification facility.

4.4: Cultural Knowledge of Water and DPR from the Urban User

Negative public opinion about DPR continues to be a water management challenge for areas in need of more water sources. One way that water managers and water decision makers at EPWU can better influence public perception and acceptance of DPR is to become aware of the cultural beliefs that persist among the growing urban population of water users in El Paso and the surrounding Paso del Norte Region. The relationship between cultural knowledge, which is a

"set of learned and shared beliefs, perceptions, and understandings of a group" (Garro, 1986, Romney et al., 1986, Weller, 2007, Weller et al., 1986, as cited by Gartin et al., 2010, p.2) to ethnoecological knowledge, which people use to "understand, navigate, and utilize local environmental resources" (Gragson and Blount, 1999, Nazera, 1999, as cited by Gartin et al., 2010, p.2) can use the concept of ethnohydrology, a domain of ethnoecological knowledge to examine "locally situated, cultural knowledge of water" (Gartin et al., 2010, p.1). This local knowledge of water and the related perceptions of the urban water user, or urban ethnohydrology (Gartin et al., 2010) can form a public agreement that a method to conserve water, such as DPR, is a necessary and acceptable practice. For example, EPWU chief technical officer Gilbert Trejo remembered as a child water utility employees talking about water conserving behavior in the 1980's at South Loop Elementary School in El Paso and then putting those water conservation suggestions to use (Espinola, 2016, part two). I use this idea of urban ethnohydrology in synchronization with twelve in-depth interviews that I conducted from July 11th, 2015 to January 11th, 2016 to consider whether or not there is a cultural element as to why El Paso, a community with a large Hispanic and Latino/Latina population, is scheduled to implement a 'first-of-its-kind' DPR facility in the Northern Hemisphere as early as 2019. What are some thoughts, opinions, and concerns of people living in an area that is planning on implementing DPR by 2019/2020? The interviewees lived in areas ranging from Ciudad Juarez in Mexico, Las Cruces and Anthony, New Mexico, West, East, Far East El Paso, and Socorro, Texas. Seven were female and five were male. Information about the twelve interviewees and their responses can be found in Appendix II.

The essence of the interviews revolved around perceptions of how future climate will impact water in our region, general thoughts about DPR, and being for or against DPR. There

was a noticeable pattern of future climate impacting water in our region in a negative way. Interviewee #1 believed that there will be fighting over water in the Paso del Norte region and that Juarez, Mexico, will get the short end of the stick with poorer people in Juarez losing all access to water. There is alarm by those interviewed that intensified drought and higher temperatures will lead to water scarcity, unpredictable climate extremes, declining water supply, and the cost of water will go up. The unease seemed to be warranted by those interviewed because as interviewee #9 believed, our future climate will have a major impact on our water and we do not seem to be realizing how much impact it is going to have on our daily lives. Interviewee #10 stated burn baby burn…the writing is on the wall; based on snowpack in Colorado, it will get colder later and hotter earlier and the snowpack run-off is happening at a different time and this has thrown the cycle off. Interviewee #12 wondered if future climate impacting our water is a crisis here, or if we will one day have to get water from somewhere else. This perception that future climate will have a negative impact on water, by all of those interviewed, may lead to the discernment of DPR as a water resource to avoid conflict by helping augment the overall supply, and present an opportunity by EPWU to tout DPR as a water resource method that will provide an optimistic vision of water impact related to future climate.

Initial thoughts and responses about El Paso using DPR by those interviewed were only slightly more optimistic than the perceptions of how future climate will impact water in our region. Even when there was some optimism, the responses had an element of negativity coupled with indecisive anxiety. Interviewee #1 said "I wouldn't want that; no, no, no. The water is bad enough as it is. Maybe it is better, who knows." Other mixed emotion interview replies included; if it is needed to be done then I am okay with it, but reusing wastewater is not a good thing to think about (#4), I'm not sure how I feel about DPR, if the technology is there then okay, but it

should be studied because it could end up spreading a lot of disease (#6), my first thought is that I don't want to be drinking toilet water, but I'm assuming EPWU employees are drinking the same water and it is safe; I don't want to think about it too much (#7), I would not accept it very willingly and I only agree with it in extreme cases. There were those interviewed that had more negative impressions of DPR; it does not sound well, and I would not want to drink it myself (#3), it seems like a bad idea (#5), it should not be implemented, and I am shocked to think that it is (#8). Interviewee #10 was the most positive and receptive to DPR and stated, "I don't have a problem with it because it is being proven to be safe and it replenishes the water table level. I think it is a good idea and needs to be done." Based on the responses of being for or against DPR, I would sort six (half) of the replies into an (undecided) category, four into a (for) category, and two into an (against) category.

Cultural Knowledge of Water - Summary

Water related issues are a concern to these interviewees who live in the Paso del Norte region. Three of the interviewees thought that it is somewhat important to conserve water, four thought that it is very important to conserve water, and five thought that it is extremely important to conserve water. The fact that the highest response pertaining to conserving water was the belief that it is extremely important to do so shows that these interviewees tend to feel water conservation in this area is an important topic of concern and this may benefit potential DPR implementation in El Paso because there is an openness to place water conservation as an extremely important issue. Seven of the people interviewed were interested in future water a great deal; while five people were interested in future water a very great deal. Except for one person, all were either Hispanic in culture or a mix of Hispanic with another ethnicity or ethnicities. When it came to being for or against DPR: Four female respondents were undecided

or uncertain, one female was skeptical, none of the females interviewed were against DPR, and two of the females were for it. One male was undecided, two males were against it, and two males were for it. Half of those interviewed were uncertain or undecided about DPR implementation for this area, which seems to be a fairly common apprehension as it was a similar situation with the results of the UTEP classroom experiments. Many people want to be sure that such a new (first of its kind) water resource application is going to be safe for all involved and feel that they have not received enough information to undoubtedly be for DPR or against DPR, whilst to a lesser extent there are those who are undoubtedly for DPR or against DPR for various reasons. A key for EPWU to sway public perception to willingly accept DPR as a needed method to augment the local water supply will be to continue using positive reinforcement tactics and strategies, persuade the undecided consumer to become comfortable with the idea of DPR, and try to change the attitude of those who are against DPR implementation.

Chapter 4 - Summary

The application process to implement DPR in El Paso will not be going to a public vote as only board recommendation by a panel of experts along with TCEQ approval will be needed (Montoya-Halter, 2016, Interview). EPWU increased water rates in 2016, in part to pay for the yet to be built DPR facility that will have an estimated cost of one hundred million dollars (Montoya-Halter, 2016, Interview). Mr. Archuleta believes that DPR is a good investment because “efficient water delivery adds to economic development, growth, and prosperity for the community” (Archuleta, 2015, Interview) and that “DPR technology and innovation will have a role in future water because DPR is more feasible and doable than implementing other techniques to acquire new water sources such as piping water from far away areas” (Archuleta,

2016, Lecture). EPWU has decided that to dirty up purified, pristine water by putting it through an environmental buffer is counterproductive, and therefore the 'pipe to pipe' concept of DPR is going to be used (Walker, 2016, Interview). The 'pipe to pipe' method that will have the DPR facility be its own individual plant that will use treated effluent from the Bustamante Wastewater Treatment Plant to purify the reclaimed water at the advanced water treatment facility and then pump the purified final product directly into the distribution system (Walker, 2016, Interview) is in part what makes it 'first of its kind.' The facility will be located in far Southeast El Paso near the border with Mexico. No area in El Paso will get only purified DPR water. On the hottest days, the most purified DPR water produced will be ten million gallons per day, or about 6% of the total needed (Montoya-Halter, 2016, Interview). The farther away from the DPR facility a person resides, the more blended the water you receive will be. For example, UTEP is approximately twenty miles away from the facility and according to Dr. Walker; no DPR water will get to UTEP.

EPWU has multiple beneficial factors going for it. EPWU has national recognition. Daniel Nix stated, "I think that the El Paso project is going to be a huge success and will serve the community well, and the new DPR facility will be a great continuation of El Paso's leadership in innovative methodologies in water resource management" (Nix, 2016, Interview). "The city has a pretty substantial history of indirect potable reuse through groundwater injection, which provides El Paso some of the same advantages that OCWD had from Water Factory 21 in the 1970's" (Wehner, 2016, Interview). EPWU has relative administrative simplicity in that it is the main water utility in El Paso serving less than a million residents compared to the complexity of Southern California that has many millions of residents to serve as well as having multiple water districts and water utilities. EPWU is working with the TCEQ in a state that has previously

approved DPR in Big Spring and Wichita Falls, and has drinking water regulatory guideline precedence to work with. EPWU services a community that does have a level of uncertainty and concern about the thought of using DPR but the general public is also very aware that the need for water accessibility and sustainability in this arid region is important. Many times DPR implementation failure in other areas is due to public acceptance concerns and EPWU wants the community to know what DPR is all about (Montoya-Halter, 2016, Interview). EPWU is working in conjunction with an element of expert opinion that will have a pro-DPR skew and their connection to the project will be very influential as final decisions are made and state approval is sought after.

Chapter 5 - Conclusion

The demand for potable water will increase in areas that have expanding populations, and if these areas are also prone to drought conditions related to climate change, future water resource management strategies will become paramount. Water scarcity needs will stretch available water resources and necessitate 'new' or 'unconventional' alternative water sources (Sanchez-Flores et al., 2016). Both water supply and demand are changing (Udall, 2016, Interview). The sophistication of today's treatment technologies and water quality monitoring in water treatment systems to ensure that safe drinking water conditions are met has lead to a level of protection that "exceeds anything imaginable in the middle 20th century" (Committee on the Assessment of Water Reuse, 2012, p.17). DPR can be viewed as a stabilizing force directly related to water use and consumption, but new water projects, such as DPR, can have substantial uncertainty (Udall, 2016, Interview). DPR should be viewed as a water resource sustainability tool that ought to be added to the toolbox (Archuleta, 2015, Interview) and is considered a path forward (WateReuse, 2014), but public confidence in DPR implementation is lacking.

Big Spring, Texas, in conjunction with CRMWD, will deservedly receive credit as being the first in the nation to successfully go online with DPR. Wichita Falls, Texas, went online with DPR with more ambiguous results as DPR was decommissioned one year after implementation, but it was always intended to be a temporary fix until the planned implementation of the IPR facility went into production, and as Daniel Nix states; "the citizens have embraced water reuse as part of our permanent water management strategy" (Nix, 2016, Interview). Southern California's IPR and non-DPR situation is much more complex than what is going on in Texas.

The San Diego Water Authority public agency has twenty-four member agencies and serves 3.1 million residents (San Diego County Water Authority, 2014). Eleven of the member

agencies have indicated intent to implement potable reuse projects (San Diego Water Authority, 2016). The Metropolitan Water District of Southern California (MWDSC) is a regional wholesaler of water that delivers water to twenty-six member agencies including fourteen cities, eleven municipal water districts, one county water authority, and provides water to more than nineteen million people, making it the largest treated drinking water distributor in the US (mwdh2o.com, 2016). The success of IPR in Orange County and other areas of Southern California have not led the realization of DPR in Southern California.

The fear of public DPR backlash is seemingly outweighing the need for the extra water DPR could provide. The Pure Water San Diego Program is a bit confusing and potentially intentionally deceptive. Potable reuse at San Diego's Pure Water Program is repeatedly described, but DPR is rarely mentioned, and is done so in ways such as simply stating that the city is conducting a study to support DPR. The need for more drinkable water unmistakably exists in Southern California, but DPR use is not yet regulated and not allowed. Recall that California regulation of DPR refers to a wide range of potable reuse options, but 'flange to flange' or 'pipe to pipe' DPR is not happening, and although individual DPR projects could legally happen on a case by case basis, it will probably take at least five years to develop DPR criteria in California (Wehner, 2016, Interview). California seems to be blurring the lines of what IPR and DPR treatment are while making *potable reuse* the preferred terminology. This may be the best, or even only, way to achieve public acceptance of DPR in Southern California. I believe that Southern California will implement DPR in the future, and may even do so on a very large scale without overwhelming public acceptance.

As discussed throughout this thesis, public acceptance of DPR is often an obstacle to implementation. "The limited number of DPR projects is likely related to their perception as

options of last resort for water utilities suffering from water scarcity" (Sanchez-Flores et al., 2016, p.13). Caution is a common reaction to DPR implementation at this point in time. People want to be absolutely sure that DPR will be safe and that it is necessary. It would be quite a setback to put a DPR facility into practice only to have it fail. Bad things can happen when drinking water contamination occurs via waterborne disease. In the 1990's, there were two isolated cases of cryptosporidiosis outbreaks. One was in Milwaukee, Wisconsin, in 1993, which led to 100 deaths and more than 403,000 infections (MacKenzie et al., 1994, as cited by Gerrity et al., 2013) and one was in Las Vegas, Nevada, in 1994, which led to 20 deaths and over 100 infections (EPA, 2001, as cited by Gerrity et al., 2013). In both of these outbreaks the source of contamination was never definitively identified, but both were believed to be due to drinking water contamination from sewer overflows in Milwaukee and upstream wastewater effluent discharge in Las Vegas (Gerrity et al., 2013). "Although the potable reuse treatment train is essentially capable of removing all contaminants of concern to undetectable levels, a poorly maintained distribution system compromises that high level of quality and creates conditions conductive to opportunistic pathogens and pathogen intrusion" (Wingender & Flemming, 2011; Biyela et al., 2012; Buse et al., 2012, as cited by Gerrity et al., 2013, p.334). In 2013, the civil engineers society gave a grade of 'D' to US drinking water systems, in part because of the amount of money that is needed to improve old leaky pipes and the up to $1.3 trillion needed to repair water and wastewater systems, including the serious need to upgrade wastewater treatment systems (Webber, 2016).

As discussed in the El Paso case study, those with extensive knowledge of DPR have high levels of trust that it is safe. Much of the confidence by those who have DPR expertise is tied to the assurance that today's technology to purify wastewater is sound. People who are not

as familiar with DPR or the DPR process, have high levels of uncertainty, indecision, and apprehension, and often want more information about the subject. The most interesting finding interconnected to my classroom experiment was how many people felt inadequately informed to make a confident decision about DPR implementation in El Paso. The response option of undecided had the highest percentage of response for the both positive and negative language presentation and equaled 46.2% of the results. The undecided response option for the only negative language presentation equaled 44% of the response results. The only positive language presentation had the highest response percentage of 43.3% equaling the in favor of option, but the undecided option had the next highest response percentage at 33.3%. Although EPWU did a telephone survey to establish the level of approval water users in El Paso have regarding building a DPR facility, indecision by undecided water users was not taken into consideration and I consider this to be an oversight because as discussed in the social marketing portion of the El Paso case, a "person's emotional reaction to a recycled water scheme can be deeply entrenched and hence can be difficult to influence" (Nancarrow et al., 2008, p.490). Examples of this can be witnessed in the classroom experiment response remarks where one person stated that IPR is a much safer process than DPR and that it is not a wise idea to add wastewater directly to our taps even though I did not mention IPR at all during the presentation. Another person stated that they were very much in favor of using DPR because the water should be clean, well filtered, and not contaminated with any harmful chemicals, but the curious part about this response is that it was made after I gave the presentation where I only used negative DPR terminology. Both of these remarks are examples of people who have their minds made up about DPR and are not likely to be changed, whereas those who are undecided about supporting or opposing DPR implementation are the people that EPWU should be discovering and targeting in order to

persuade them that DPR is a good idea, before other influences lead to them forming negative opinions about DPR.

During my interviews with urban water users, as well as casual conversations with others about DPR, there is usually interest and curiosity about DPR mixed diffidence about what it involves or means. If I start out by saying that El Paso is hoping to establish an advanced water purification facility in the next few years, there is positive feedback, but as soon as I interject 'toilet to tap' into the conversation the mood changes to a sense of no-way, not a good idea, and a quite clear idea of what DPR is seems to be formed. In my considered opinion, it is a reasonable reaction for El Pasoans to experience DPR linked apprehension because so few places use DPR facilities. As an El Pasoan, I speculate about the necessity of DPR and sometimes have the feeling that I am a test-subject for DPR. However, like many El Pasoans I know that EPWU has a good track record of water treatment and monitoring. Plus, there is a need to use as many safe and effective water resources as possible because a lot of people in the Paso del Norte region rely on the same water sources. In this arid environment potable water access can be as much of a quantity issue as it is a quality issue.

As I have been researching the topic of DPR over the last year, it has become clear that what EPWU wants to do with its desired DPR project has the prospect to be more than just 'first of its kind' in the US; it has the potential to lead the way in the evolution of future water reuse in the US. EPWU is not planning to turn to DPR as a solution to an emergency water accessibility crisis; instead, the idea is to use DPR as a drought resiliency insurance policy (Walker, 2016, Interview). The lack of DPR regulatory guidelines is usually considered to be a hindrance to DPR implementation. Dr. Walker (2016) stated that he believes the reason more communities are not implementing DPR is "mainly due to politics and regulations, especially the lack of

established regulations" (Walker, 2016, Interview). Currently, there are not any national standards for water reuse, but Texas is looking into setting water reuse standards (Archuleta, 2015, Interview) and the DPR project that EPWU is proposing could help establish criteria of which wastewater treatment methods will work to meet the Clean Water Act and the Safe Drinking Water Act requirements. Accelerate H2O is a new statewide water initiative for Texas that was started in San Antonio, Texas, and is bringing people together to pursue water challenges in Texas in four important areas: 1) desalination 2) water conservation 3) water reuse, and 4) smart water (smart technology in water management) (Archuleta, 2016, Lecture). Accelerate H2O seeks to establish a hub in El Paso because "El Paso has a major role to play in streamlining water efficiency by using tools such as inland desalination and eventually DPR, to name a few" (Archuleta, 2016, Lecture).

Access to water is a freedom that all people should have because it essential to life. People in a natural state need water to survive. People in societal settings need water to survive. Taking away one's ability to freely harvest safe water takes away one's freedom. I believe that indeed our modern society has lost this freedom as we now pay for water, and access to water for most people is impossible otherwise. It is to the point where most people do not concern themselves with how to access water only that the water delivered is of a certain level of quality. The social component of life related to water need has overcome the natural one. Jean Jacques Rousseau's idea of the 'state of nature' and the chasm between the social and the natural comes to mind because this chasm affects human freedom and happiness. Rousseau declared that the state of nature, "no longer exists, which perhaps never did exist, and probably never will exist; and of which it is, nevertheless necessary to have true ideas in order to form a proper judgment of our present state," (Rousseau, 1950, as cited by Zeitlin, 1990, p.18). The technology to

provide clean water to the majority is controlled through various forms of power over nature by those living within an established society. When mentioning Rousseau it seems only appropriate to add Thomas Hobbes to the mix. Hobbes said that "the state of nature is one in which force and fraud prevail; in that state, there is no right or wrong, no just or unjust, for those are social, not natural, qualities that men acquire only in Society" (Zeitlin, 1990, p.20). DPR is a form of control for those few who actually get to control water access and delivery. Is the use of DPR, or any water management implementation for that matter, related to a need for power? Or, is it related to what Hobbes defines as power in his 1651 book Leviathan whereby power is a "present means to obtain some future apparent Good," (Zeitlin, 1990, p.20) culminating in a desire to do something good and keep social peace?

Is using only certain terminology when trying to achieve public acceptance of DPR fraudulent? The use of certain pro-DPR terminology such as saying that reclaimed and recycled water is pure water, or purified water, or advanced purified water, suggests the need to influence, persuade, and possibly even trick the general public to accept DPR. The idea of combining the DPR process and the IPR process into one procedural term of Potable Reuse would help with DPR's uneasy public perception; but is such deception necessary if DPR is proven to be safe and could keep millions of gallons of water in the local supply? If DPR "has the potential for higher water recovery, a higher quality product, and lower treatment costs since the water is of local origin and can theoretically be treated at a single collection and distribution system" (Leverenz et al., 2011; NRC, 2012, as cited by Gerrity et al., 2013, p.324), then the challenges of DPR application should be fully analyzed in any area with water scarcity worries. Municipal wastewater reuse does have the potential to add considerable amounts of water to the total available water supply. The Southwest is an area where DPR has recently gained importance, yet

the primary obstacles of acceptance and promotion of DPR projects are related to the "lack of historical assessments of the proportion of wastewater effluent that has actually been reused for potable uses (NRC, 2012; Rock et al., 2012, as cited by Sanchez-Flores, 2016, p.4), and the potential health risks associated with uncertainties in the reliability of treatment systems that produce purified water that meets all of the required drinking standards" (EPA, 2012; Miller, 2015, as cited by Sanchez-Flores, 2016, p.4). Water utilities need to stay diligent in using water resources as productively as possible to avoid water sustainability problems. In order to evade a water supply emergency, more places need to be innovative in their approach to provide water to the community. EPWU is taking the route of being proactive with the planned 2019 or 2020 implementation of DPR as a method to augment the local drinking water supply by starting a full-scale DPR facility.

For over three decades water treatment technology has been improving and although DPR is a less common wastewater reuse method compared to IPR and other nonpotable uses, it is proving to be safe in meeting drinking water standards. DPR as an unconventional water resource appears to have greater challenges on the managerial and public policy levels than on the technological level (Sanchez-Flores, 2016). I find it enthralling to consider the future of DPR in El Paso since it is a work in progress. Some of the allure includes the following questions: Will DPR be implemented by 2019 or 2020, or will unforeseen obstacles delay the project? Will DPR implementation in El Paso not happen at all? Will DPR in El Paso face ridicule, or become recognized as a pioneer, or both? Will DPR become a critical component in the evolution of water reuse if EPWU does implement DPR? It is going to be interesting to follow the DPR process in El Paso over the next few years, and in my considered opinion a full-scale advanced water purification/DPR facility will be implemented by the EPWU goal of 2020, and this facility

will provide DPR attainment guidance to other communities searching for an extra water source that can boost their overall water supply.

Further Study

It is important to describe limitations of the thesis. The full-scale DPR facility would be built near the Bustamante Wastewater Treatment Plant in far southeast El Paso near the Mexico border. At this site, wastewater had been released to farmers further downstream. Interviews were not conducted with people in the agricultural sector. What financial and political impacts will the planned advanced water purification facility have on downstream users? The impact of DPR on the water balance as a whole was not part of this thesis. Will a lack of downstream effluent be adjusted through more groundwater pumping by those living outside of the EPWU territory? DPR will be a good thing for EPWU as a method to augment future water supplies, but it is more costly water than existing river and groundwater sources. I did not do a financial analysis of DPR, nor did I examine possible impacts on water costs. What will the social justice concerns related to cost impacts be for those having water affordability problems?

Skepticism of DPR goes beyond just dealing with the 'yuck' factor. There are uncertainties about possible trace chemicals that are not removed from wastewater but rather are returned to the drinking water; this needs to be recognized as a DPR possibility. While I report one expert opinion lecture by Dr. Richardson about disinfectant by-products and chemical contamination, this topic is beyond the scope of this thesis. Expert opinion has a level of self-interest attached to it, with a risk of imposing their will on all users. As confident as expert opinion is that DPR is all good, my classroom experiments and interviews with urban users showed that there is a substantial degree of ambivalence related to indecision about DPR implementation in the general public. It would be interesting to have recorded data from more

than twelve in-depth interviews and have classroom experiments outside of sociology and anthropology classes to differentiate results. Would extra information given to a different group of interviewees still have an outcome that showed a prevalence of feeling undecided about DPR implementation? Is living in an arid environment the main reason EPWU does not seem to be dealing with a level of public backlash that may disrupt the progress being made to implement DPR by 2020? Or, is there something else at play leading to a mostly Hispanic population being the potential pioneers of large-scale DPR use? Brownwood, Texas, received TCEQ approval and funding to begin construction on a DPR facility in 2012 but did not start because of public backlash. Is there a scenario in El Paso that could lead to a similar outcome? DPR has the potential to become more of an option for places dealing with water scarcity concerns and it is going to be an interesting topic in El Paso over the next few years.

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Appendix I – Expert Opinion Interviews

Interview with Ed Archuleta

Edmund Archuleta is the Director of Water Initiatives at the the University of Texas El Paso (UTEP). He is working to make UTEP the University of choice for students interested in learning resource management in a water-scarce world. Mr. Archuleta retired in 2013 after twenty-four years as the President and C.E.O of the El Paso Water Utilities (EPWU). He made it a major concern to increase and improve all components of water use in the El Paso, Texas, area. Mr. Archuleta was very welcoming, informative, and pleasant to converse with while granting me the following interview on September 24, 2015.

1) What do you believe are the most important aspects of DPR that I should learn about for my MA project? Can you identify key issues that I should be researching?

2) What do you believe are the most important aspects of DPR that the public should consider?

3) Should El Paso implement or not implement DPR? (Why?)

I believe that these three questions were answered in the following discussion:

Direct Potable Reuse (DPR) is new, so to speak. It is important to know that we need to understand how to get to potable drinking water. We need wastewater treatment knowledge. The technology, including natural and engineered barriers is there for successful DPR. In El Paso the ARCADIS – Pilot Program at the Bustamante Wastewater Treatment Plant is leading the way for a large municipality and hopes to incorporate DPR by the year 2020, with the intent of adding 10 million gallons of water to the overall system per day, ultimately accounting for 10% of El Paso's annual need. It does not surprise me that El Paso is one of the proactive cities preparing for DPR. I helped establish the Fred Hervey Water Reclamation Plant in Northeast El Paso in 1985. The Fred Hervey Water Reclamation Plant was one of the first, if not the first, in the world

to use Indirect Potable Reuse (IPR) and Aquifer Storage Recovery (ASR) systems. IPR is similar to DPR in that they both use treated wastewater. IPR water flows through purple pipes to places like golf courses and parks. IPR water does not directly go into the system as there is a natural source barrier, such as a lake, river, or groundwater area, and then the water is pumped out of the aquifer. Places such as the Fred Hervey Water Reclamation Plant, the Bustamante Wastewater Treatment Plant, and the Jonathon Rogers Water Treatment Plant, are looking at the best treatment use. DPR should be viewed as a tool that should be added to the toolbox. El Paso is as ready as any city to implement DPR. I advise reading the book *Water Reuse*, published by the National Research Council of Science and Engineering.

4) If El Paso implements DPR, what percentage do you believe should be added to the drinking water supply? (I do not recall a specific answer given for #4.)

5) Have you taken part in DPR discussions? (Explain under what context.)

Yes, at the national level and the global level. It was at a San Diego, California water use meeting about DPR that I heard the term "toilet to tap." I knew that a term like this would be bad for public acceptance and knowledge of DPR. I remember discussing water reuse strategies in 1980 and it being considered the strategy of last resort, mainly because of the lack of technology. Now we have better technology and a better understanding of the hydrological cycle. For the most part, people don't know where their drinking water comes from. There has been a history of de facto reuse for many years. Take the Mississippi river for example. By the time the water in the Mississippi river reaches New Orleans, Louisiana from Minnesota, the water has been used and reused many times by many people.

6) How would you get people past the perceived "yuck factor"?

DPR needs public support. The days of (DAD) Decide – Announce – Defend, no longer exist. Public perception is an important factor when discussing DPR. Take bottled water for example. Bottled water companies have convinced people that bottled water is better water. Bottled water seems safer to people, but it is rare that people get sick from municipal water. Public perception is often site specific (by state for example). Surveys should be done because different concerns exist in different areas. The level of water need in California is taken into consideration when discussing DPR. Focus groups with a quality panel of experts should be involved. Increased public education about the high levels of technology being utilized should be emphasized to customers. Places like the Fred Hervey Water Reclamation Plant should be promoted as a positive example, with years of credibility, to show how successful water reuse can be. Raising public awareness of water treatment facilities through tours is important as well.

7) Do you believe that DPR is safe for the health of people?

Yes. There have been many health studies about chemicals in water. As with many things, there is always a risk. The health challenge related to DPR, and water treatment in general, is to make sure treatment works for specific waste and contaminants. For example, some areas have higher arsenic levels and this should be considered when implementing water treatment processes. Established technology is there to be used. Wastewater in the 1970's was not treated and led to disease and contamination. Better technology now has led to safer water for people and the environment than in the 1970's and 1980's. Today's technology uses membrane filtration, activated carbon filtration, and other ultra filtration steps. Water testing now can detect parts per trillion.

8) Do you believe that it is economically feasible for El Paso to implement DPR?

Yes. Water is subsidized and EPWU water is very affordable in my opinion. A single bottle of bottled water costs approximately the same as 1,000 gallons of EPWU water that is delivered to your residence. It is a reassurance to pay for flood control that will reclaim storm water for reuse, and it should be used. DPR is a similar investment. Efficient water delivery adds to economic development, growth, and prosperity for the community. DPR is an added method for avoiding the worst case scenario of running out of water.

9) Who monitors EPWU's water quality? (Who sets the standards?)

EPWU self monitors to an established set of Environmental Protection Agency (EPA) high quality standards as part of a large compliance system. Two main laws are taken into consideration; the Clean Water Act and the Safe Drinking Water Act. Reports are submitted to the state of Texas, and problems will be recycled back for improvements. There are steps to ensure water quality. Water that is put into streams involves the EPA. DPR water involves the Texas Commission on Environmental Quality (TCEQ). There are currently not any national standards for water reuse, but Texas is looking into setting standards. I believe the DPR pilot plant will produce proper standards.

10) Are there any other topics or pointers you can give me?

Water is often taken for granted. Larger data bases will need to be created. Water blending is important, as well as learning about the costs of power during times of peak demand. Do more than pray for rain. The best new and future water is water you already have. Reuse water.

Interview with Kristina D. Mena

Conducted on 11/4/2015

Kristina D. Mena (MSPH, PHD) is an associate professor and the program head of Environmental and Occupational Health Sciences at The University of Texas Health Science Center at Houston, School of Public Health (El Paso Regional Campus). Water quality issues and concerns are her research topics of specialty. I was fortunate to interview Dr. Mena because she is very well informed about the topic of direct potable reuse (DPR) and is willing to inform others about her knowledge of DPR.

Meeting Questions:

1) I have heard that you are on a committee for El Paso Water Utilities (EPWU) that is considering direct potable reuse (DPR). Is this accurate?

I am on an advisory panel that was assembled by the National Water Research Institute (NWRI) to oversee the pilot project for the proposed implementation of DPR in the El Paso, Texas area. I do not work for EPWU. The NWRI works with ARCADIS, which is a national consulting group that sets the agenda, oversees and evaluates the pilot program. The advisory panel consists of people from outside of the El Paso area who have a diversity of expertise, and meet here in El Paso. My area of expertise for the panel is public health; others are engineers, public and marketing people, etc… The panel works independently of EPWU in order to give unbiased presentations of the data results.

- I mentioned that I heard 2020 was the goal timeline to implement DPR in the El Paso area. Dr. Mena responded that she was not sure of an exact date for DPR implementation, but believed that there was a possibility that the implementation could occur sooner than 2020.

2) What do you believe are the most important aspects of (DPR) that I should learn about for my MA project? Can you identify key issues that I should be researching?

The key issues include: water source, quality treatment, quality output. For all of the associated challenges with DPR you should compare data from other places that use DPR. Compare their settings and geography. Compare the populations of areas using DPR. Compare who will be served by DPR, and get data about their perceptions of DPR.

3) What do you believe are the most important aspects of DPR that the public should consider?

EPWU is a very progressive utility that is nationally recognized and is trying to avoid water loss and need. Sustainability is an important concern and driver that has led to a proactive approach. Although some people will care more than others about DPR, EPWU is constantly informing the public about water issues. Community engagement is important to talk about what DPR is going to entail. How DPR treated, and what the differences are to the available tap water now should be considered.

4) Should El Paso implement DPR? (Why or why not?)

Yes. I feel strongly that El Paso should. It is a good solution in this arid region for water sustainability.

5) If El Paso implements DPR, what percentage of DPR water do you believe should be added to the drinking water supply?

I am not sure because we are in the pilot phase. As with anything, there are many factors involved with risk perception. You want public acceptance of DPR, and the research and data that I have viewed shows that DPR will not pose a human health risk.

6) Do you believe that DPR is safe for people's health?

Yes, because of the water treatment data from the pilot studies. This is an area of study for me and the risk assessment is showing that DPR water being produced will meet the safety guidelines of the water produced now.

7) How would you get people past the perceived "yuck" factor?

Through community engagement (having a dialogue with the public and getting their feedback). Everyone is different. There will be a range of responses. Some people will think it is a great idea, some will want more information. More information makes it easier for people to get past the "yuck" factor. It would be helpful if people could take tours of the wastewater treatment plant. Christina Montoya is the Vice President of communications at EPWU. She has data on what the public thinks about DPR and would be able to tell you if a tour of the wastewater treatment plant exists.

8) Do you believe that it is economically feasible for El Paso to implement DPR?

Yes. However, I don't deal with the economic side. John Balliew, the President and CEO of EPWU would be the person to talk to about this question. I believe there would be a cost factor, but the goal is to save money down the road.

9) Have you taken part in DPR discussions? (Please explain under what context)

Yes. In addition to the advisory panel with NWRI, ARCADIS, and EPWU, I have helped the WateReuse Foundation for 14 or 15 years.

10) (If you are on the EPWU committee) How would you describe the EPWU committee? (Composition, meetings, responsibilities)

We have about three meetings in a year and offer insight from our perspective and expertise. We make recommendations and the plans for the next meeting. I believe the advisory panel is going really well, and things seem to be moving forward in a timely manner.

11) (If you are on the EPWU committee) Is the public invited to participate at EPWU committee meetings?

I don't know. Christina Montoya would be the best person to ask about this question. When ARCADIS last met, there were a lot of people in attendance, but I am not sure who they were.

12) (Related to question 11) If yes, is it an objective to increase public participation, and in what ways?

If no, why is that?

That is up to EPWU. From what I have seen, EPWU has been open and straightforward with what they are doing.

13) Is there any participatory decision making involved?

You would have to ask others at EPWU.

14) Is there any recorded public testimony in documents or minutes at meetings?

I don't know if anyone is taking official minutes. We are tasked with making written recommendations (output of meetings). We document recommendations to the agenda. ARCADIS takes notes for their records.

15) Are there any other topics or pointers you can give me?

Ask EPWU about the ways that they have open forums. Find out how long the pilot program is going to last. Set up interviews with John Balliew, Shane Walker, Christina Montoya, and Eleanor Torres (on the advisory panel and works with the public in a place with DPR).

Interview with Christina Montoya-Halter

I conducted an interview with Christina Montoya-Halter on Friday February 5th 2016, about the topic of direct potable reuse (DPR). She is the Marketing and Communications

Manager for El Paso Water Utilities (EPWU) Public Service Board. Full-scale DPR is expected to go online in El Paso sometime in 2019 or 2020. Most of my questions were not categorically answered; rather she informed me as to what she felt were the important concepts to comprehend. I believe that part of this is due to the fact that EPWU is only comfortable using certain terminology and is very careful to use only those terms. For example, direct potable reuse is not a preferred term. The term advanced water purification is preferred, but she did state that it means the same thing as DPR. Another term that is not preferred is sewage water, with the term wastewater being preferred. I did use the term filtration as it relates to being part of the DPR process. She stated that only the final process of the multi-barrier process was filtration. I inferred by her reaction to my using the word filtration that the term filtration is non-satisfactory to EPWU because the term purification is such a critical part of public perception and public acceptance of DPR in El Paso and purified water sounds more striking than does saying filtered water. Stating that filtration is going on is an oversimplified statement because there is a disinfection process that uses ultraviolet light and advanced oxidation. Plus, the full-scale facility will use chorine to add a pathogen disinfecting barrier.

The main information that I gained from our interview includes:

Who will get DPR water in El Paso?

No one in El Paso will get only purified water. On the hottest days, the most purified water produced will be ten million gallons per day, or about 6% of the total needed. Homes and businesses are supplied with potable water from river and groundwater sources. “The used water is cleaned at wastewater plants and reused for irrigation and industrial processes, but some of the water is discharged into the river and used again downstream” (www.epwu.org) After irrigation and industrial obligations are met, the remaining discharged water will be purified to drinking

quality at the Bustamante Wastewater Plant in far east El Paso, and used as an additional, drought proof source of water that will help preserve aquifers and conserve freshwater. The Bustamante Wastewater Plant is located twenty miles to the east of the UTEP main campus. It is near the Jonathan Rogers Water Treatment Plant which treats river water for drinking. Location is a key element to the levels of DPR water that people can expect to receive. The farther away from the advanced water purification facility you reside, the more blended the water you receive will be. The EPWU website states that DPR/advanced purified water will go to the Mission Valley area of El Paso, and that was confirmed during the interview.

Issues concerning the Texas Commission on Environmental Quality (TCEQ)

TCEQ approval will only happen after a lengthy testing process. Currently, the pilot facility testing period has ended and EPWU is awaiting TCEQ review. After the full-scale facility is designed and built, EPWU will still have to undergo more data testing before going online. A couple similar DPR wastewater treatment plants in Texas have been approved by TCEQ.

Do you believe DPR is a win-win situation for the consumers?

The reason for the Bustamante Wastewater Treatment Plant is to have an additional water source and is a crucial part of sustainability. The technology is absolute and proven by an outside panel of experts.

Why do you believe more places do not implement DPR?

EPWU's advanced water purification facility will absolutely lead to other places implementing DPR. El Paso is further along than other communities. It is the next step to the Fred Hervey Water Reclamation Plant that has used reclaimed water for thirty years. What EPWU is proposing is different than other places such as Big Spring, Texas, and Wichita Falls,

Texas, which sends purified water to a conventional treatment facility. The El Paso facility will be the first to put purified water directly into the distribution system. Once the reused water is purified it has finished its process. Funding and getting grants are big issues for advanced water purification (DPR) facilities. The estimated cost is one hundred million dollars. Many times failure in other areas is due to public acceptance concerns. EPWU wants the community to know what it is all about.

Summary:

DPR in El Paso will not be going to a public vote. Only board approval is needed. EPWU increased water rates this year. Part of the water rate increase is to pay for the advanced water purification (DPR) facility which has yet to be approved by the TCEQ. EPWU states that a November 2013 survey of 1,000 households in El Paso concluded that 84% of the respondents favored building an advanced water purification facility. I was sent a copy of the 2013 *EPWU Advanced Purified Water Telephone Survey* from Christina Montoya-Halter. I discuss the telephone survey as part of the class experiment section.

Shane Walker Interview

I interviewed Dr. Shane Walker on April 21, 2016. Dr. Walker is a civil engineer and assistant professor at UTEP. He specializes in water and wastewater treatment. I asked him seven questions during the interview.

1) Do you believe DPR should be implemented in El Paso to augment the water supply?

I think it is a good idea. It improves drinking water sustainability and resiliency. DPR adds confidence to the probability of having water in the future and improves drinking water

reliability. DPR is not drought-proof because there is a need for an original water source, but it is drought resilient.

2) What are your opinions about DPR implementation being safe in El Paso?

This process will undoubtedly produce safe drinking water. DPR in El Paso is designed to meet all drinking water quality standards as well as the consideration of currently unregulated contaminants. EPWU has a legacy of providing safe water and does extra things that other places do not. For example, EPWU replaces water pipes based on their age not their perceived need for replacement or repair.

3) Do you have any health concerns that would be related to DPR in El Paso?

No, this treatment process is designed to remove all three categories of drinking water contaminants. 1) Physical: suspended solids, turbidity, color, taste, and odor. 2) Chemical: removal of heavy metals, salts, nitrates, pharmaceutical and personal care products. 3) Microbiological: pathogens (helminthes, protozoa, cryptosporidium) bacteria (E. coli) and viruses. Many people and organizations are providing guidelines to mitigate health risks for DPR water. It should be mentioned that there will never be zero risks related to DPR.

4) Do you believe other communities will implement DPR in the future?

For sure. There is no question that other communities already are. Conservation is the first water resource, then reuse, then recycling.

5) How far will the DPR water travel from the facility? UTEP is twenty miles away; will the DPR water travel that far?

It will not get to UTEP. DPR is always going to supplement the water supply, but on different levels. El Paso has two seasons. (I was referred to the EPWU website to better understand this idea which explained that the Paso del Norte area relies on two groundwater

aquifer sources and river-water allowances during the summer). They are expanding the Jonathan Rogers Water Treatment Plant (where the DPR water will be piped to after being purified) with a north pipe that will deliver DPR water to the entire east-side of El Paso.

6) Why do you believe that more communities have not implemented DPR?

I believe it is mainly due to politics and regulations, especially the lack of established regulations. There are more technological advancements being used and therefore it takes more work, and is more costly than other alternatives. Regionally, some people have more of a problem with the perceived 'yuck' or 'ick' factor, for example California. I believe Texas is leading the way when it comes to DPR because "Texans are tough."

7) What are some important aspects that I should consider when researching DPR implementation in El Paso?

EPWU has decided that to dirty up purified, pristine water, by putting it through an environmental buffer is counter-productive. So, the 'pipe to pipe' concept of DPR is going to be used. The DPR facility in El Paso is going to be its own individual plant that will use treated effluent from the Bustamante Wastewater Treatment Plant to purify the reclaimed water at the advanced water treatment facility, and then pump the purified final product directly into the water distribution system. This is different than the Big Spring, Texas, water treatment plant, which is technically DPR, but the water goes through a concrete ditch and is not put directly into the distribution system. The treated effluent is added to the raw water from a lake and treated again. It is not 'pipe to pipe' as will be done in El Paso. EPWU has been meeting drinking water standards with indirect potable reuse (IPR) for over thirty years at the Fred Hervey Plant. One of the most important concepts to take into consideration is that DPR is a drought resiliency insurance policy.

Online Interview with Rabbi Ben Zeidman

Conducted on September 2, 2016.

1) Do you have any concerns based on religious law about DPR?

2) What are your overall thoughts about DPR implementation in El Paso by 2019/2020? (A process that is likely to occur at a Far East El Paso treatment plant)

Answer: In Reform Judaism we are not bound to the strictures of orthodox, legal Jewish tradition. They are guidelines and an important part of our heritage, but they do not rule the day. So… Reform Judaism looks to human beings as those who are present to care for the earth and ensure she is sustained (the Book of Genesis commands us to tend the earth). So, anything that protects the earth's resources is an initiative we would cherish. That only becomes complicated if it has a negative impact (economically or otherwise) upon a population. I don't know much about DPR but my impression is that instituting it would not require demolishing a poor neighborhood to create a plant just because that land is cheaper… etc…

Suggested References:

http://www.greenfaith.org/religious-teachings/jewish-statements-on-the-environment/judaism-and-sustainability-rabbi-lawrence-troster-1

http://www.haaretz.com/jewish/the-jewish-thinker/green-judaism-balancing-sustainability-and-tradition-1.383959

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Appendix II – Cultural Knowledge of Water Interviews

Interview #1: Conducted with an (18 to 30) year old female living in Ciudad Juarez, Chihuahua, Mexico, whose ethnic background is Hispanic and Mexican. She stated that it is very important to conserve water and that future water interests her a great deal.

Interview #2: Conducted with a (31 to 40) year old female living in Las Cruces, New Mexico, whose ethnic background is Hispanic (Mexican and Puerto Rican). She stated that it is extremely important to conserve water and that future water interests her a very great deal.

Interview #3: Conducted with a (61 and above) year old male living in Las Cruces, New Mexico, whose ethnic background is Hispanic (dad Hispanic and mother White). He stated that it is extremely important to conserve water and that future water interests him a very great deal.

Interview #4: Conducted with a (41 to 50) year old female living in Anthony, New Mexico, whose ethnic background is Hispanic (Mexican decent). She stated that conserving water is very important to extremely important to her because she has been hearing that the supply will run out and she does not want to risk that happening. Future water interests her a great deal because she has children.

Interview #5: Conducted with an (18 to 30) year old female living in West El Paso (Upper Valley), whose ethnic background is Hispanic (Mexican, Polish, Lebanese). She stated that it is somewhat important to conserve water and that future water interests her a great deal.

Interview #6: Conducted with a (41 to 50) year old male living in West El Paso (Upper Valley), whose ethnic background is Hispanic and White. He stated that it is very important to conserve water and that future water interests him a very great deal.

Interview #7: Conducted with a (61 and above) year old female living in East El Paso, whose ethnic background is White. She stated that it is very important to conserve water and that future water interests her a very great deal.

Interview #8: Conducted with a (61 and above) year old male living in East El Paso, whose ethnic background is Mexican American/White. He stated that it is somewhat important to conserve water and that future water interests him a great deal.

Interview #9: Conducted with a (61 and above) year old female living in East El Paso, whose ethnic background is Hispanic and White. She stated that it is extremely important to conserve water and that future water interests her a very great deal.

Interview #10: Conducted with a (61 and above) year old male living in East El Paso, whose ethnic background is Hispanic. He stated that it is very important to conserve water and that future water interests him a great deal.

Interview #11: Conducted with a (41 to 50) year old male living in Far-East El Paso, whose ethnic background is Spanish. He stated that it is somewhat important to conserve water and that future water interests him a great deal.

Interview #12: Conducted with an (18 to 30) year old female living in Socorro, Texas in El Paso County, whose ethnic background is Hispanic/Latina. She stated that it is extremely important to conserve water and that future water interests her a great deal.

*Each interviewee was asked the following questions:

- What are your perceptions of how future climate will impact water in our region?
- What are your thoughts about DPR?
- Are you for or against DPR?

What are your perceptions of how future climate will impact water in our region?

#1) There will be fighting over water in the Paso del Norte area. I believe that Juarez will get the short end of the stick. The poorer people in Juarez will lose all access to water. Some companies may leave while others, such as maquiladoras, will get special treatment.

#2) Water will become scarcer due to intensified drought and higher temperatures.

#3) How people take care of all resources must be thought out and it needs to be a bigger issue for more people.

#4) If we don't get enough rain people still need to spend to get water for drinking and plants.

#5) Many places are getting hotter leading to more evaporation going on.

#6) If it keeps getting hotter we will need to use more water because it evaporates more. Increased conservation needs to be promoted.

#7) It is very unpredictable and there is a need to be prepared for the extremes.

#8) I believe that there will be episodes of drought and flooding, supply will continue to decline, and cost will go up.

#9) I believe in global warming and it factors into water supply and evaporation rates and this will impact our water quality and quantity in the future. Our future climate will have a major impact on our water and we don't seem to be realizing how much impact it is going to have on our daily lives.

#10) Burn baby burn…the writing is on the wall. Based on snowpack in Colorado, it will get colder later and hotter earlier. Run-off is at a different time and this has thrown the cycle off. Farmers will have to adjust. Different areas are getting more snow than normal while others are getting less than normal.

#11) I believe that the climate is changing. Summers are getting hotter and the winters are getting shorter. If heat increases continue we will use more water and it will impact water and electricity use a lot.

#12) We will keep having drastic changes that will affect humans around the world in a negative way. I guess it will have a negative impact. I don't know if it is a crisis here, or if we will one day have to get water from somewhere else.

What are your thoughts about DPR?

#1) I wouldn't want that. No, no, no. The water is bad enough as it is. Maybe it is better; who knows?

#2) It is kind of hard to stomach the idea (pun intended), but I think we have the technology that is capable of creating safe drinking water. I believe it will be a huge public perception hurdle. I think education is the key.

#3) It doesn't sound well. I would not want to drink it myself.

#4) If it is needed to be done I am okay with it. I have heard how they re-clean it but it might still have things like medication in it, but I'm not sure if that is true. Reusing wastewater is not a good thing to think about.

#5) I'm not sure exactly what it is, but it seems like a bad idea.

#6) I think that non-potable reuse is a good idea to help conserve water. I'm not sure about how I feel about DPR. If the technology is there, then okay, but it should be studied because it could end up spreading a lot of disease.

#7) My first thought is that I don't want to be drinking toilet water, but I'm assuming EPWU employees are drinking the same water and it is safe. I'm thinking that they know what they are

doing. I don't want to think about it too much. Being in a desert, we need to reuse all of the water we can. Who oversees EPWU? How do they prove that it is safe?

#8) It is not a good idea because the negative effects have not been tested enough. It should not be implemented, and I am shocked to think that it is.

#9) I know some of it cannot be used for everything and I'm not sure what you can or cannot use it for. If they can prove nobody will get sick from it that will make a big difference to me.

#10) My understanding is that they use sewer water, treat and filter it, then put it back into the ground, and is then used by the public as everyday water. I don't have a problem with it because it is being proven to be safe and it replenishes the water table level. I think it is a good idea and needs to be done.

#11) I'm concerned with the safety issue. Do we have the technology to do that? We need to trust that the technology is there to clean the water right. For example, the space station is effective in cleaning all the reused water because of technology. When people are in space for years at a time they have to be able to clean and reuse water. A trust was built there because they did it for so long and proved it can work.

#12) I would be interested in finding out how it is going in places that are doing it. I would not accept it very willingly. I only agree with it in extreme cases.

<u>Are you for or against DPR?</u>

#1) I am not sure.

#2) I am for it in that I think it is necessary.

#3) I am against it.

#4) Right now I'm skeptical because of health concerns. I do think they need to make sure it is being done properly because we are paying for the service. I wonder how careful and effective the process is going to be.

#5) I'm undecided and would need more information about it.

#6) I'm undecided because I'm not totally sure that it will be safe.

#7) I am more for it than I am against it.

#8) I'm totally against it.

#9) I need to feel it is safe and necessary and I would like to study it more. Also, I would like to find out what others have to say about it.

#10) I'm totally for it.

#11) I'm for it.

#12) I would be reluctant to use it and would like to have more information about it.

Complete Household and Urban Water User Interview Questions

Personal Information – Coding:

#1) Age and Gender: (18 to 30) – (31 to 40) – (41 to 50) – (51 to 60) – (61 and above)

#2) Where do you live? (Specifically)

#3) What is the approximate size of your residence?

#4) How many people live in your residence?

#5) What is your annual family income: (0 to 15,000) – (15,000 to 30,000) – (30,000 to 50,000) – (50,000 to 80,000) – (80,000 and above).

a) What is your highest level of education completed?

#6) What is your ethnic background? (Can give more than one answer):

a) What is your preferred language? (English, Spanish, both, Other_____)

b) Were you born in Mexico? (How about your mother, father, or any grandparents?)

#7) How is your water supplied? (Can have multiple answers)

a) Piped from utility? (Utility name)

b) Do you own a well?

c) Do you receive truck deliveries? If so, is it for all of the water that you use, or drinking water only?

d) Do you go to pick up water? If so, is it for all the water that you use, or bottled drinking water only?

<u>Water Usage and Water Concern Questions:</u>

#8) What are your feelings and ideas about water as it relates to the following?

a) Your yard?

b) Plants?

c) Air temperature in the house?

d) Swimming pool?

e) Personal cleanliness?

f) Kitchen cleanliness?

g) Drinking Water?

#9) Is water important to you?

a) How do you value water in your home/work/business/interests?

b) Water quantity?

c) Water quality?

#10) Do you use water to grow plants or food? If so, do you choose specific ones for a particular reason?

a) How do you water your yard? (Method-type)

b) Do you have specific garden areas?

c) How do you water plants in pots? (Method-type)

#11) Approximately:

a) How many showers do you take per week, and for how long?

b) How many times do you wash dishes per week?

c) How many times do you wash clothes per week?

d) How many times do you use water for cooking per week?

e) How many times do you flush the toilet per day?

#12) Have you purchased water conserving appliances? If yes, why? If no, would you like to or plan on doing so in the future?

#13) Overall, which part of your home life do you believe uses the most water?

#14) Do you own a swimming pool? Do you use it? Why or why not?

a) If you ever owned a home that did not have a swimming pool; do you believe that you used (More) or (Less) water at that time?

b) Does the amount of water that you use for the swimming pool concern you?

#15) What is your estimated monthly water bill?

a) In Summer:

b) In Winter:

#16) Do you believe your water bill is reasonable? Why or why not?

a) When you have to pay the water bill; do you have to limit other purchases (such as groceries)?

#17) Would lower water prices influence where you live?

#18) What kind of air conditioning do you use? Are you satisfied with this type of air conditioning?

#19) Does energy cost, or water use factor into the type of air conditioning system that you use?

#20) Do you believe that your water supply is safe to consume? Why or why not?

#21) What kind of drinking water do you use? Why?

#22) How important is it for you to conserve water?

Not important – Not very important – Somewhat important – Very important – Extremely important – No opinion.

#23) What reasons do you have to conserve water?

#24) What measures do you take to conserve water?

#25) Does your water usage concern you now: (More, Less or the Same) than in the past?

#26) Do you plan on using (More, Less or the Same) amount of water in the future?

#27) Have you deliberately altered your water usage? If so, how and, why?

#28) If your water bill was to become so costly that you had to conserve water, what would you do?

#29) Have you changed your landscaping in order to conserve water?

<u>Policies and Legal Issues Questions:</u>

#30) Is future water of interest to you?

Not at all – A little – A great deal – A very great deal – No Opinion

#31) What do you think will be main future changes in water quantity and quality?

#32) How do you see these changes impacting your home/business/work/interests?

#33) What do you believe are the main causes for future changes in water?

#34) What are your perceptions of future climate?

#35) What are your perceptions of how future climate will impact water in our region?

#36) Do you seek information about water issues?

a) Where do you get information on water issues?

#37) Do you seek information on climate issues?

a) Where do you get information on climate issues?

#38) How do you see the demands for water changing among agricultural, urban/industrial, and environmental users in the future?

#39) Under current projections of water supply, can future water demands be adequately met in our region?

#40) What is your vision for the future in terms of how water will be allocated and used in our region?

a) What, if anything, will have to change to realize this future vision?

#41) Do the solutions to meeting future water challenges lie in technology, management, policy, or other?

#42) What measures do you believe the authorities or the city should take to conserve water?

#43) Do you believe there should be more information available about water concerns and issues?

a) Do you believe the city should provide more information about water concerns and issues?

#44) How likely are you to go to a website that gives information about water policy issues and concerns?

#45) Does hearing about places such as California implementing extreme water restrictions concern you? Why or why not?

#46) Do you believe water conditions will become as critical in the Paso del Norte region as they currently are in California?

#47) Have you ever reported someone for wasting water?

#48) If you wanted to report someone for wasting water, how would you go about reporting them? Who would you turn to?

#49) Have you ever attended a public policy making meeting? If yes, why? If no, what reasons would make you want to attend?

#50) What are your thoughts about direct potable reuse (DPR)?

a) Are you for or against DPR?

#51) May we view one of your water bills?

Comments:

Vita

My name is Paul Brian Guerrero. I was born and raised in El Paso, Texas, to Paul and Mary Ellen Guerrero, also lifelong residents of El Paso. I graduated from Eastwood High School in El Paso and then earned a Bachelor of Multidisciplinary Studies from the University of Texas at El Paso (UTEP). Water related topics and issues are both important and interesting to me. I am licensed by the Texas Commission on Environmental Quality as a Class II Water Treatment Specialist and sold water purification equipment for over ten years in the El Paso area. My thesis committee is made up by outstanding mentors who are some of the most successful and influential employees at UTEP. Dr. Heyman provided exceptional guidance which led to a thesis that turned out better than I could have anticipated two years ago when I started the program. Dr. Hargrove provided support and played and intricate role in my deciding to concentrate on the topic of direct potable reuse. Dr. Campbell has very simply helped me more than anyone to successfully garner a Bachelor's degree, and he was the strongest advocate in my pursuit to earn a Master's degree.

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This thesis was typed by Paul Brian Guerrero.