Las Vegas:
Direct Potable Reuse

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Table of Contents

Abstract

Water scarcity in Las Vegas, Nevada has been an issue for decades and is forecasted to become worse. The city, completely encompassed by desert, must draw its water from the Colorado River, as do several West Coast states. In fact, ninety percent of Las Vegas's water supply comes from Lake Mead which is directly connected to the Colorado River. Due to the ongoing drought and over drafting by states, the water level of Lake Mead is decreasing while the population consistently increases. Eventually, hard decisions will have to be made concerning Las Vegas's water use.

Instead of examining stricter conservation, which the city is already implementing, this thesis will look at the possibility of water recycling for drinking purposes. This process is known as potable reuse. Las Vegas currently sends its treated wastewater back to Lake Mead, in the form of return-flow credits; the city's then allowed to draw more water than their allotted amount from Lake Mead. This thesis will argue that the opportunity for direct potable reuse (DPR) may be a better option to supplement Las Vegas's water supply in the future. According to George Tchobanoglous, a leading expert in the field of water reuse, DPR is "a reuse practice in which purified municipal wastewater is introduced into a water treatment plant intake (after treatment to at least near drinking water quality) … or directly into the water distribution system after meeting drinking water standards which has been proposed by others." (EPA Reuse Guidelines 2012).

The Las Vegas Valley Water District's practice of water recycling for nonpotable purposes has been highly successful. Reclaimed water is being treated and used for irrigation of golf courses and other turf facilities. Therefore, viable drinking water is not depleted by these practices. Unfortunately, as water scarcity becomes more prevalent in the coming decades, the conventional drinking water supply may not be enough to sustain the potable need. Although the general public supports nonpotable water reuse, using recycled wastewater for drinking water presents a hard social stigma to overcome. People are not comfortable with the idea of drinking water that has been previously used. This thesis will also explore the challenges of public perception, and possible ideas to make a program of this type successful.

1. Background

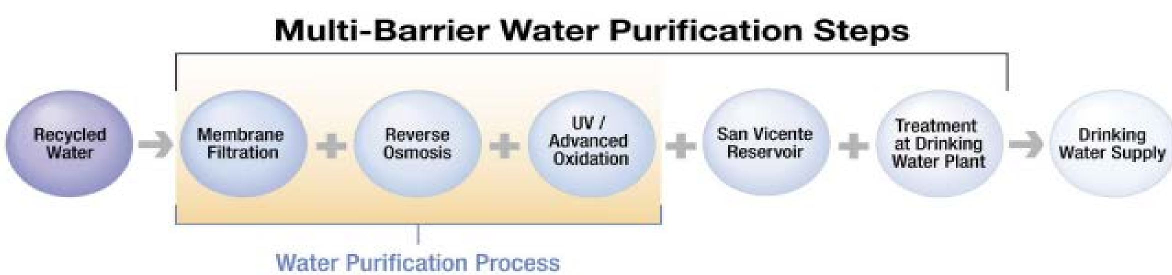
1.1 Nonpotable Reuse

Nonpotable reuse is any use of recycled water that is not consumed by the public. There are three main uses of recycled water: irrigation, industrial cooling, and groundwater recharge. Irrigation is one of the main uses of recycled water. Farmers use this recycled water to irrigate their crops in areas where water for this purpose is hard to find. Several businesses also use nonpotable reuse water sources to irrigate their properties. For example, according to the United States Golf Association the average 18 hole golf course uses four acre feet of water per acre annually. If the golf course has 80 acres of turf that must be maintained, this results in saving 360 acre feet of potable water by using non potable recycled resources (Lyman). Industry also uses recycled water for cooling purposes. Cleaned wastewater is a viable alternative to pumping viable drinking water through their equipment. Groundwater recharge is the third nonpotable reuse option. This has multiple benefits including increasing resources that may be oversubscribed and, for coastal states in particular, water pumped back into the ground can flush out salt water seeping into aquifers from the ocean.

When proposing using recycled water for any of the aforementioned reasons, there is little resistance. As long as the water is cleaned to state standards, this resource can be used in situations where “new” drinking water (from a lake, river, or aquifer) is not necessary. The Environmental Protection Agency has a minimum standard for quality of water after waste water treatment or before drinking water distribution, but each state can choose to go above and beyond that standard for their own water resources ("Drinking Water Contaminants”). This creates further expansion of the available water supply. Potable reuse, however, faces intense scrutiny because the water is for human consumption.

1.2 Potable Reuse: Indirect

There are two types of potable water reuse: indirect and direct. Indirect potable reuse (IPR) is slightly more accepted than direct potable reuse (DPR). IPR is the "augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes normal drinking water treatment" ("Guidelines for Water Reuse"). IPR starts with the conventional water supply as it is blended and treated to be distributed into the public water supply. After use, waste water is sent to conventional wastewater treatment. Then the cleaned water, normally discharged to an environmental buffer, is sent to advanced treatment, where membrane filtration and oxidation take place. This cleans the wastewater to an advanced tertiary level, one level cleaner than nonpotable reuse ("Guidelines for Water Reuse"). Treatment is shown in the chart below, explaining San Diego's IPR treatment process. The San Vicente Reservoir step can be replaced with any environmental buffer. ("Water Purification Demonstration Project")



("Water Purification Demonstration Project")

Membrane filtration involves filtering the recycled water through membranes with "pores that are large enough for water to pass through, but small enough to prevent particles such as suspended solids, bacteria, and protozoa from passing through" ("Section B: Advanced Water Purification Facility"). Next the water is sent through energy intensive osmosis, forcing the water through smaller pores in a different membrane, where water leaves in similar quality as distilled water. The final step of the advanced purification is UV/Advanced Oxidation. Hydrogen peroxide is added to the water and then the water is "exposed to UV light" ("Section B: Advanced Water Purification Facility"). Advanced oxidation takes place when the UV light "breaks chemical bonds and converts hydrogen peroxide into reactive particles known as hydroxyl radicals. These hydroxyl radicals destroy low molecular weight contaminants such as 1,4-dioxane that are known to penetrate the reverse osmosis membrane. In this way, advanced oxidation destroys trace contaminants that may have passed through the reverse osmosis process" ("Section B: Advanced Water Purification Facility"). Water is then released to an environmental buffer for holding. An environmental buffer can include a reservoir or groundwater aquifer. Within the buffer, the recycled water is able to mix with ground or surface

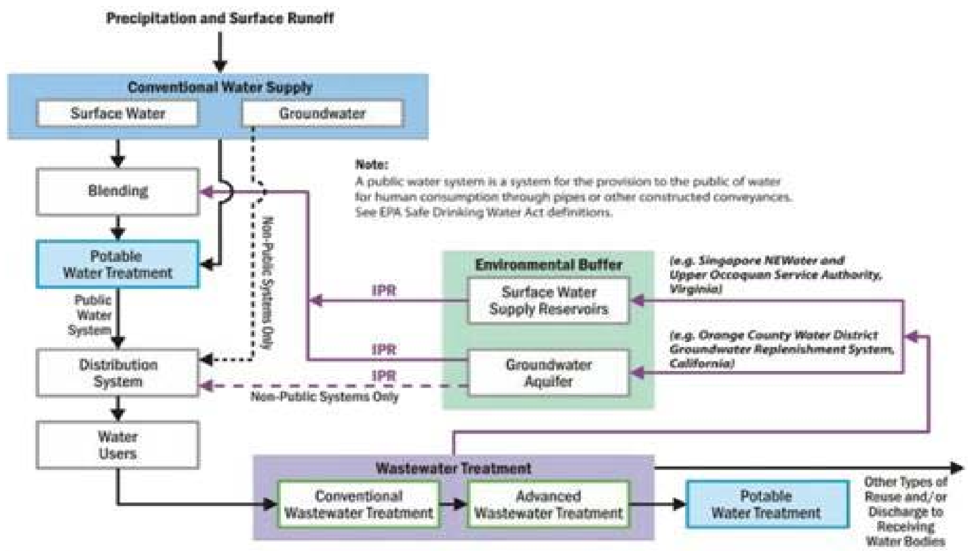


Figure 3-7
Planned IPR scenarios and examples

("Guidelines for Water Reuse")

water already present. A retention time of six months is required in order to ensure "full pathogen die off" (Macler). Holding time establishes further protection from system failure.

Finally, water (both recycled and original source) is pulled from the environmental buffer and sent to a drinking water treatment center, after which it will be distributed.

IPR is very similar to traditional wastewater discharge. Conventional wastewater is treated and then sent downstream from the community and its drinking water supply, often in a river. This allows a community downstream to gather this water to use for their own purposes. Indirect potable use loops its treated water back to an environmental buffer that directly supplies the community with its drinking water. (Blomquist) There is a purpose identified by the community that they will use that recycled water for, so they do not allow it to travel downstream or be discharge into the ocean. The buffer tends to be stationary, such as a reservoir, aquifer, or lake. An important concept to grasp is there is no "new" water being used by a community. Whether it is recycled or not, all water, except perhaps from the melting glaciers, has at some point been someone's wastewater. Even rain and snow are condensed from evaporated water that included treated waste water discharge. This is the biggest argument for potable reuse.

As of now, "water reclamation and reuse standards in the United States are the responsibility of state and local agencies—there are no federal regulations for reuse" ("Guidelines for Water Reuse"). Essentially this means states must decide on a case by case basis whether to allow water reuse or not. In California, the National Water Research Institute has been trying to establish criteria for years. The problem constantly run into is the difficulty in deciding, "how clean is clean [and] how safe is safe" (Macler). Recycled wastewater is treated, often more strictly than traditional wastewater, but the question remains, how much additional treatment makes the water safe enough to reuse.

Two major success stories of IPR are San Diego and Singapore. Due to drought conditions, court ordered pumping restrictions, and the fact that ninety percent of the city's water is imported, new sources of water are in high demand for San Diego. ("Water Purification Demonstration Project") In response, the city conducted a study over the last four years concerning the feasibility of IPR on a large scale, known as The San Diego Water Purification Demonstration Project. Public perception was a particularly tricky issue during this study. The phrase "toilet to tap" originated from this project, causing serious public backlash to overcome. In 2004, the San Diego Water Authority found in a poll that sixty-three percent of those asked opposed water reuse. A successful education campaign, alongside water shortages, caused the public opposition to fall to twenty-five percent by 2011. (Barringer) The future of IPR in San Diego is bright, and by 2020 "could account for 7 percent of the total in the city's main reservoir" according to Marsi Steirer, the deputy director of San Diego's public utility agency (Barringer).

Internationally, Singapore's NEWater facility is an indirect potable reuse success story. Although the majority of recycled water is used for nonpotable purposes, a small percentage is allowed retention time to mix with water in a reservoir, eventually being pulled for drinking water distribution. Singapore's NEWater has "passed more than 100,000 scientific tests and surpasses World Health Organization requirements, a testimony of its high quality and reliability" ("NEWater"). Currently this water makes up around thirty percent of the country's water supply. By 2060, reclaimed water should be around fifty-five percent of the nation's water ("NEWater"). These statistics show IPR will only increase in Singapore in the coming decades.

1.3 Potable Reuse: Direct

Direct potable reuse (DPR) is "the introduction of reclaimed water (with or without retention in an engineered storage buffer) directly into a water treatment plant, either collocated or remote from the advanced wastewater treatment system" ("Guidelines for Water Reuse"). As shown by the diagram, direct and indirect potable reuse come from the same source and undergo the same treatment process.

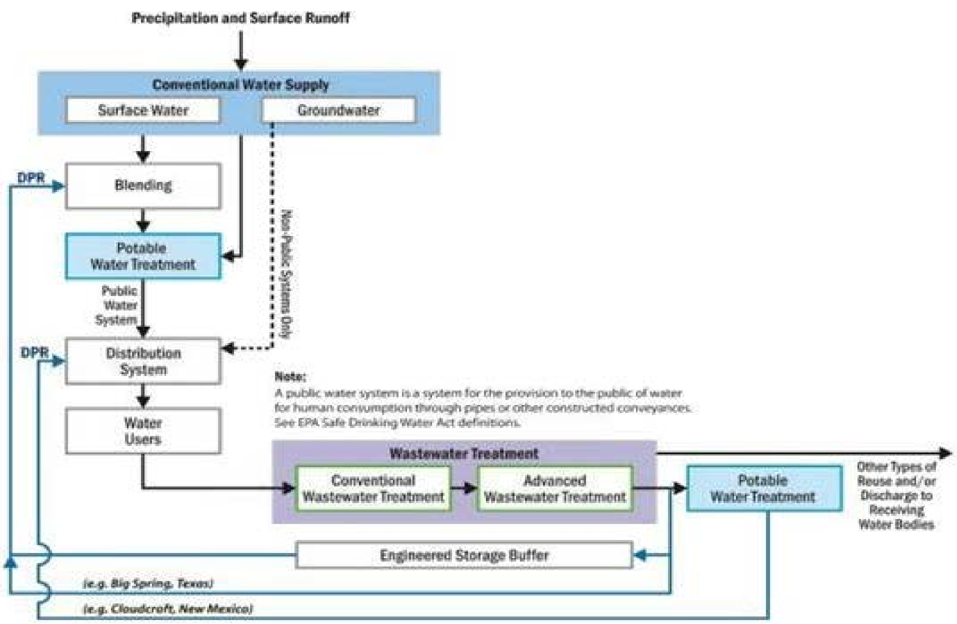


Figure 3-8
Planned DPR and specific examples of implementation ("Guidelines for Water Reuse")

Wastewater from users is sent to a treatment facility where it is put through conventional wastewater treatment and then advanced wastewater treatment. The difference is the lack of environmental buffer in DPR. During DPR, as the definition suggests, wastewater leaves the treatment facility to go directly into the drinking water treatment facility, where it is often blended with surface or ground water. There is no retention time. Some experts are wary of this process due to the lack of environmental buffer (Macler). People in favor of implementing direct potable reuse would argue retention time is unnecessary because drinking water standards are tight. The Environmental Protection Agency has specific maximum levels of known contaminants, both natural and manmade, that are allowed in a water system after treatment. Contaminants must be below that threshold for the water to be considered safe ("National

Primary Drinking Water Regulations”). Drinking water, whether it is recycled or not, will not leave the drinking water facility until it meets these regulations. The protection provided by sending the water to a lake or reservoir first is a redundant step, wasting time and water (to evaporation).

1.4 Water Scarcity in the Western United States

The majority of the water supply for the West is taken from “the [Colorado] river and its tributaries - including the Green, Gunnison, San Juan, Virgin, Little Colorado, Bill Williams, and Gila rivers - and the lands these waters drain,” making up the Colorado River Basin ("Hoover Dam Frequently Asked Questions: The Colorado River”). Seven states (Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming) draw water from this source, along with Mexico; it serves twenty-five million people annually. In 1922, the seven states wanting to use the Colorado River Basin as a resource were required to sign the Colorado River Compact, establishing water allotments for each state based on population at that time. Mexico is not part of the compact; it is apportioned 1,500,000 acre-feet annually which is subject to change ("Hoover Dam Frequently Asked Questions: The Colorado River”). The basin is divided into two: the Upper and Lower Basin. Nevada, California, and Arizona pull water from the lower basin, and unlike the upper basin states, never reached an agreement on the amount allotted for each state. In 1964, the Supreme Court decided for the lower basin states granting 4,400,000 acre-feet to California; 2,800,000 acre-feet to Arizona; and only 300,000 acre-feet to Nevada due to population at the time. With all seven states and Mexico pulling a total of 16.5 million acre-feet from the Colorado River Basin and the worst drought on record still continuing in the West, this water source is becoming severely oversubscribed ("Hoover Dam Frequently Asked Questions: The Colorado River”).

Extreme drought in the Western states has brought this issue to national light in recent years. No one knows how long this drought will last. As of now, 2013 is California's driest year on record ("2013 Is California's Driest Year On Record"). In the coming decades, Texas all the way to Southern California will be extremely dry (Macler). Less rainfall and snowfall due to dry conditions will lead to decreased water resources. Recharge of aquifers, rivers, and reservoirs, which are already being over drafted, will be limited. Along with the drought, increasing population in the West have pushed the water supply to above its carrying capacity. Historically when water was no longer available, cities dried up and people moved to new places (Macler). This is no longer happening. People are choosing to live in places like San Diego or Las Vegas with limited fresh water resources available.

Four main solutions to this impending water crisis are being discussed: increased conservation, finding and draining new sources, desalination, and water reuse. Conservation is already being implemented in states such as Nevada and California. Much stricter conservation, if possible, could help to relieve some of the water stress. Reducing per capita usage (gallons per person per day) seems to be the answer several cities are looking towards. To put this in perspective, in California the statewide per capita usage is reported as two hundred gallons per day. In some areas, like Palm Springs, per capita usage can be found as high as seven hundred gallons a day. It is important to note that per capita usage is for one person, so if there is a household of three, their collective household water usage at that rate would be twenty-one hundred gallons a day. More water is used in places like Palm Springs for irrigation purposes. Since most people in this area are well-off they can afford to spend extra money on landscaping (Macler). In order to make a big impact on saving water, per capita usage in areas such as these would have to be reduced.

Another possible band-aid to Western water scarcity is finding new sources of water, or draining existing sources of water not currently under their jurisdiction. Though it is unlikely new sources will be found in the United States, recently Nevada proposed a plan to import water from other state's sources. If absolutely necessary, water from sources such as the Great Lakes could be imported to the Western states; the situation would have to be dire before this was even considered.

Desalination is the third possible solution to water scarcity. This is the process of taking water from the ocean and using high levels of energy to remove the salt, making it drinkable ("The USGS Water Science School"). As great of an idea as this sounds, considering seventy percent of the Earth is covered with water and 96.5 percent of that water is held by the oceans, i.e. salt water (water.usgs.gov/edu/earthhowmuch.html), desalination is an extremely expensive and energy intensive process. Even if funding is provided, the issue of where the extra energy should come from is a politically charged issue, not easily solved.

The final solution, and possibly the way of the future is water reuse. According to the New York Times, "if coastal communities used advanced treatment procedures on the effluent that is now sent out to sea, it could increase the amount of municipal water available by as much as 27 percent" (Barringer).

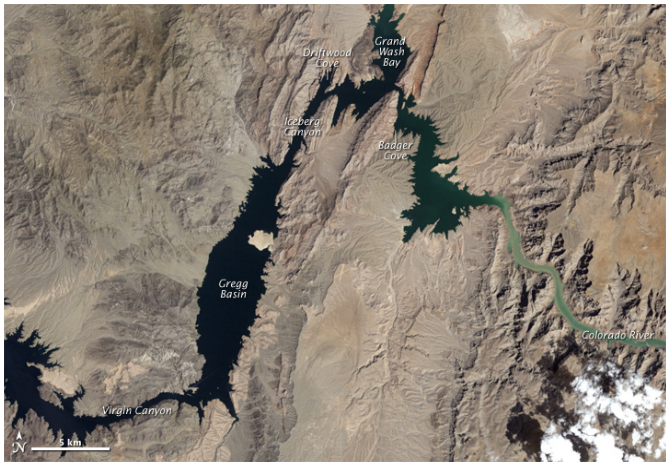
2. Clark County, Nevada Case Study

Clark County, Nevada was chosen as the area of interest for an experimental direct potable reuse program because of the increased need for new water options and current public understanding of water

scarcity in this region. Clark County is located in Southwest Nevada and includes the cities of Las Vegas, Henderson, North Las Vegas, Boulder City, and Mesquite (“About Clark County”). The map above shows the entirety of Clark County. Las Vegas is in the center.

2.1 Water Situation in Clark County

Ninety percent of Clark County’s water must be imported from the Colorado River, with the other ten percent coming from groundwater sources (“Las Vegas Valley Water District”). The current allotment of water for Nevada from the Colorado River is 300,000 acre-feet. This is equivalent to about two percent of the river’s total resources (Quenching Las Vegas’ Thirst). Colorado River Basin allotments for West Coast states have not changed since the Colorado River Compact, and due to a small state population in 1922, the two percent given to Nevada was adequate at the time, but with increasing populations is no longer enough (Quenching Las Vegas’ Thirst). In 2012, two million residents in Clark County along with Las Vegas tourists used 311,910 acre feet of water ("Las Vegas Valley Water District Annual Statistical Summary "). This surpasses Nevada’s Colorado River allotment without accounting for the rest of the state. According to the Las Vegas Valley Water District Annual Statistical Summary, of those 311,910 acre feet, 71.5% of water use (232,825 acre feet) was for residential and hotel purposes while only 14.2% went to irrigation, showing that the majority of water for the Las Vegas Valley Water District went to some type of potable use. It is important to note that the 232,825 acre feet used for Clark County potable purposes, if all pulled from the Colorado River, would be 74% of the Nevada’s total allotment. The majority of Clark County’s water is taken from Lake Mead which is a reservoir filled by the Colorado River ("Water-Quality Monitoring at Lake Mead, Arizona and Nevada”). Lake Mead is a current source of focus due to the fact that the water level



has dropped more than one hundred feet since January 2000 (“Southern Nevada Water Authority”). Cause for concern is rising with the claim that the water level will continue to drop.

Worst case scenario, if climate change is as expected and future water use from the Lake Mead is not curtailed, there is a fifty percent chance that this critical reservoir could be dry by 2021 (Quenching Las Vegas' Thirst). Another worry revolves around the increasing population of Clark County. Las Vegas currently is home to roughly thirty percent of the population for Clark

Lake Mead 2010

‘Water Level Changes in Lake Mead”)

(city), Nevada”). If populations continue to grow along with increased tourism, water resources will be more strained than ever in the coming decades. To ensure continued economic success of Las Vegas, one of America’s fastest growing cities (Tanner), residential resources will have to be the top priority, leaving less water for agricultural purposes (Blomquist). According to former Colorado River Commission member Richard Bunker, “For [Nevada] to survive, Las Vegas must be successful” (Quenching Las Vegas’ Thirst), so this is an issue Nevada wants to address.

2.2 Solutions to Clark County Water Scarcity

The Las Vegas Valley Water District has already put in place conservation practices for the county in order to ensure efficient use of current water allocation. All residents must abide by a water schedule for irrigating their plants and lawns ("Mandatory Watering Schedule"). When a resident signs up with the Las Vegas Valley Water District for water, they are automatically placed in a watering group that mandates when they can water their lawns and plants. During the winter, each group is given one day a week that it may water. The watering schedule is more lenient during the fall and spring months, allowing watering to occur on three assigned days per week. Finally, the water schedule no longer applies during the summer as residents are able to water any day of the week regardless of watering group. This mandatory curtailment helps to ensure excessive watering does not take place ("Mandatory Watering Schedule"). In addition to the watering schedule, time restrictions are put into place to decrease water lost from evaporation during the hottest months of the year. From May 1 until October 1, landscape watering is prohibited between eleven in the morning until seven at night. If either the watering group schedule or general time constraints are not followed, a water waste fee of eighty dollars is given. Each additional violation results in a doubling of the previous fee ("Conservation Measures"). These fees provide incentives to residents to abide by the water restrictions, guaranteeing the success of the program as a conservation tool. Another way to reduce landscape irrigation is the practice of xeriscaping (Quenching Las Vegas' Thirst). Essentially, this is the practice of replacing grass where it is not needed with rocks or naturally occurring desert plants that do not need watering. The Las Vegas Valley Water District provides rebates to transform a yard into what it calls a "zero-scape." ("Conservation Measures").

Per capita reduction is another goal of the Las Vegas Valley Water District. Water use per person has already decreased from 314 gallons per capita per day (GPCD) in 2002 to 222

GPCD in 2011. The new reduction goal is to reach 199 GPCD by 2035 (“Conservation Measures”). This has the possibility of saving forty-six million a day GPCD in Clark County alone. If those resources are saved, the question will now be asked, “what to do with the saved water?” (Macler). Should these unused resources be allocated to residential use? If they are, this would allow the county the ability to build more houses, therefore serving as a detriment to water conservation to current residents who may not want more residents in their area (Macler).

Conservation is not the only tactic the Las Vegas Valley Water District is currently employing to deal with water scarcity in the region. One of the proudest claims of the Southern Nevada Water Authority is that “southern Nevada currently reclaims all of its waste water” (“Southern Nevada Water Authority”). This feat is accomplished by return-flow credits (“Return Flow Credits”) and direct nonpotable reuse (“Las Vegas Valley Water District”). Return-flow credits are the process of returning treated waste water to Lake Mead. Depending on how much water is returned, the same amount of water can be drawn from Lake Mead for the county, allowing more than the apportioned amount of water to be taken from the Colorado River (“Return Flow Credits”). Las Vegas alone is able to use 440,000 acre feet a year because of this system (Quenching Las Vegas’ Thirst). Although this seems similar to indirect potable reuse, it is not because the water only goes through normal waste water treatment and then is released to Lake Mead where several counties, and states, can take it. Another practice of reuse by the Las Vegas Valley Water District is the direct nonpotable reuse of waste water for irrigation purposes (“Las Vegas Valley Water District”). Treated waste water is cleaned and then distributed to irrigate “golf courses, parks, [and] other large turf facilities”; golf courses are the main consumer of this resource (“Las Vegas Valley Water District”). This practice frees up potable water imported from Lake Mead that would have been used for irrigation. Allocation from the

Colorado River is not extended as with return-flow credits because the water is not first flowing back to Lake Mead ("Return Flow Credits"). Finally, another important fact is the Las Vegas strip, although seemingly water intensive, actually recycles all of its water that is used for fountains and water fixtures (Quenching Las Vegas' Thirst). The only water lost in this system is from evaporation or if it is physically removed.

The third and most controversial solution to water scarcity in this county is pumping millions of gallons of water from rural Nevada to Southern Nevada through a new proposed pipeline (Ryan). Building this 263 mile pipeline would be a short term solution to a long term problem with detrimental effects. The infrastructure needed for this project is expensive, around $6.5 billion (Ryan). Additionally, the pipeline would be harmful to ecosystems resulting "in severe and irreversible impact to natural resources, wildlife, fish and the imperiled sage grouse" (Ryan). While satisfying water needs for the present, no one knows how sustainable this project will be. Will it last for the next fifty years, the next century? Establishing sustainable water solutions is a smarter step in addressing water scarcity.

3. Direct Potable Reuse in Las Vegas

Las Vegas Valley Water District has not considered potable reuse. For the foreseeable future, at least five years, return-flow credits should be enough to maintain the water system (Enus, Krizmanic, and Chau). Las Vegas should invest in a direct potable reuse project to assess the feasibility of eventually implementing this process on a city wide scale. Due to public perception issues and few prior examples of direct potable reuse to follow, the city should start with a confined study before supplementing Las Vegas' water supply with this practice.

3.1 Benefits

Direct potable reuse makes sense for the city of Las Vegas. Relying on the city's own treated waste water would make Las Vegas one step closer to water self-sufficiency (White). The amount of water imported from Lake Mead would decrease due to an increase in the use of recycled water. This is beneficial in two ways: ideally no new water sources would be needed, even as population increases, so the pipeline from rural Nevada could be put to rest and the water level of Lake Mead would decrease at a slower rate. Strict conservation practices and nonpotable water recycling are already in place, yet Las Vegas still faces a future of water shortage. Those measures are not enough. Unfortunately, the water returned through the return-flow credit program is put back into Lake Mead where 800,000 acre feet of water evaporate each year ("Water Level Changes in Lake Mead"). Considering the amount of water currently needed for Clark County is approximately 330,945 acre feet each year, salvaging those resources through direct potable reuse, where evaporation is not a consequence, could be extremely valuable.

3.2 Reuse Feasibility

Two researchers in the field of reuse agree that direct potable reuse is possible: Bruce Macler, a toxicologist with Region 9 of the Environmental Protection Agency and Bill Blomquist, Dean of the School of Liberal Arts at Indiana University-Purdue University Indianapolis. Two notable examples of direct potable reuse are the NASA space station and the city of Big Spring, Texas.

Big Spring, Texas is the first city in the nation to pursue direct potable water reuse to supplement its current water supply. As of February 2013, Lake Grapevine levels had dropped to forty percent of capacity, forcing the city to make the decision to go ahead with the idea of a direct potable reuse system (White). This reuse system will eventually provide two million gallons of water a day for the residents of Big Spring, Texas, helping to stabilize the water supply (White). Since Federal guidelines for direct potable reuse do not exist, the Texas Water Development Board has contracted with an engineering firm to decide guidelines for the plant (White). Health is not a concern for the people drinking this water as long as it "has gone through proper treatment processes" as described earlier (White). Several other Texas cities are starting to look into the possibility of direct potable reuse facilities for water supply as well (White). Although examples of direct potable reuse are not as numerous as indirect potable reuses, the consensus continues to be that it is a feasible option. Deciding this system is possible and safe is one thing, but convincing the public to support it is a whole other issue to be dealt with in order to be successful.

3.3 Public Perception

Direct potable reuse tends to have a negative connotation. People are not able to see past the so called "yuck factor" of waste water being treated and then distributed for potable purposes. Traditional waste water treatment processes discharge the effluent downstream, where another municipality collects its drinking water. This is hard to justify to the public who cannot shake the image of drinking directly from a toilet when thinking about direct potable reuse. Even if people were able to positively grasp the concept of direct potable reuse, a new barrier emerges in the form of a source factor. A survey study completed in the United Kingdom "found people more willing to use recycled water from their own waste water than from second parties or a common public source" (Jeffery). Even if the public is able to be convinced that waste water can be treated to the point of safe potable reuse, the next step is helping them to realize that the same clean water will result from waste water that is not theirs.

Perceived health risks are a large part of the public perception barrier. Another result from that same United Kingdom study is that "while the public has reported trusting university-based scientists and the medical community on technical and health issues related to water reuse, preliminary survey evidence showed people trust their own personal impressions of water quality (often based on the water's cloudiness or turbidity) more than these experts" (Jeffrey). If proper treatment is conducted, direct potable reuse water will be just as safe as regular drinking water "based on significant advances in treatment technology and monitoring methodology in the last decade and health effects data from IPR [indirect potable reuse] projects and DPR [direct potable reuse] demonstration facilities" ("Guidelines for Water Reuse"). People still may be wary based on their own physical perceptions of the water

Another layer to implementing direct potable reuse is the "fear of the unknown." Since Las Vegas would be one of the first cities to implement direct potable reuse, it can be scary for the general public. Residents may be thinking "why do we have to do this when on one else has taken reuse to this direct of a process?" Part of this uneasiness comes from breaking the social norm of traditional waste water discharge and drinking water sources. Cass Sunstein, a leading scholar in the field of behavioral economics and co-author of the well-known behavioral influence book *Nudge*, defines a social norm as "social attitudes of approval and disapproval, specifying what ought to be done and what ought not to be done" (Sunstein pg. 906-983). An example of a social norm is the understood principle that strangers do not talk to each other in an elevator. If someone was to violate this expectation, we expect people would feel uncomfortable. Changing someone's views on water resources is affected by this same existence of social norms. Everyone expects drinking water to come from a river or mountain spring; this is how it *should* be. Challenging this highly accepted norm, especially when the rest of the country still upholds it, is difficult. Residents of Las Vegas need to start thinking in the mentality of "good enough for them, good enough for me" (Blomquist).

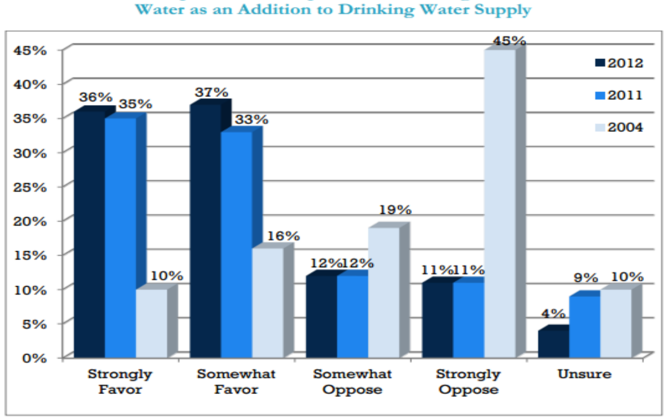
One final public perception problem that is unique to Las Vegas needs to be addressed: direct potable reuse is “most feasible in relatively closed communities” (Blomquist). Direct potable reuse will require a high level of public understanding and commitment. While it may be possible to convince residents of the necessity of additional water resources for Las Vegas, tourists may not feel the same way. Las Vegas is a major tourist destination with a total of 39,668,221 visitors in 2013 (“Stats and Facts”). If tourists were to find out the water they are using was directly recycled from the city’s waste water, they might be concerned about health risks, just as the residents were, but with no public education campaign to assure them. Tourism numbers could decrease at first, until public understanding as a country was more widely spread.

To change the social norm in Las Vegas, the city needs to implement methods of gaining public approval. Modeling their campaign after San Diego’s public approval strategy for their indirect potable reuse project is a good place to start.

3.4 San Diego Indirect Potable Reuse Public Approval Campaign

In 2004, the city of San Diego conducted a water reuse study. Five years later in 2009, San Diego expanded their study into the Water Purification Demonstration Project. Relying on the foundations of public outreach and education, the city was able to increase approval for indirect potable reuse from 26% in 2004 to 73% in 2012.

Figure E - 1: 2012 Public Opinion Poll – Opinion about Using Advanced Treated Recycled Water as an Addition to Drinking Water Supply



Clearly, their efforts were successful. The first step to their public approval campaign was for the City's Public Utilities Department to develop an outreach plan. Four main points were decided upon to present to City residents:

- San Diego needs to develop local, reliable, and sustainable sources of water to lessen our dependence on imported water due to multiple factors affecting California's water supply.
- The Water Purification Demonstration Project is examining the use of water purification technology on recycled water to determine the feasibility of full-scale reservoir augmentation in the future.
- The water produced by the purification process goes through multiple steps of advanced treatment and will be tested to meet all water quality, safety, and regulatory requirements.
- No purified water will be added to the San Vicente Reservoir or San Diego's drinking water system during the Demonstration Project.

These four ideas became the basis of the public outreach program.

Next the department researched what the public already knew about reuse. They conducted interviews with one hundred and five stakeholders to determine "their level of awareness about the Demonstration Project and the advanced purification process, interviewers sought to learn the best way to provide information about the Demonstration Project…and what kind of information the stakeholder would need to more clearly understand the purification process." In addition to the interviews, the department distributed public opinion polls to four hundred people simply asking whether they favored water reuse or not. Finally, San Diego State University conducted a study on public knowledge of reuse, providing this information to the department.

After initial findings of where the public stood on the topic of water reuse, the department developed and distributed education and outreach materials to increase public understanding. Using these materials, the department presented the information in multiple ways. First, they created an “easy-to-understand fact sheet” to issue to the public. This sheet pushed the idea that a local, reliable source of water was crucial for San Diego. Easy to follow visual representations of the treatment and distribution processes, along with basic facts about the project were all included on the sheet. All fact sheets were available in English, Spanish, and Vietnamese and given out at stakeholder interviews presentations and community events. Furthermore, copies of the fact sheet could be found at the Advanced Water Purification (AWP) facility after tours were conducted, city libraries, city council offices, the Mayor’s office, and the project website. Making this simple version of information about the reuse and the project in general so widely available was a key element to the public outreach program. FAQ sheets were also offered alongside the fact sheets. The public also received a smaller version of the fact sheet. This fact card was “business card-sized” providing a portable and quick reference with key points and contact information about the project. These cards “reduced confusion and fostered clarity” among the public. Information provided in an easy to understand and quick format would be essential to Las Vegas’ public outreach.

San Diego used other materials to increase public awareness of the project including the project website, electronic updates on the status of the project, a newsletter, PowerPoint presentations, posters, a facility brochure, a media kit for local and national media, tabletop display units for community events, and online white papers that provided in depth information about the project. Three additional tools were innovative ways to access the residents of San Diego that could be a successful part of Las Vegas’ outreach efforts. First, inserts announcing the opening of the AWP facility and available tours were circulated in residents’ water bills for three months. This allowed access to 275,000 residents around the city. All inserts were bilingual reducing the barrier to understanding the information. Presenting the information on water reuse while people are already considering their water bill provided an excellent opportunity to reach a large portion of the community. Second, a children's activity page was created "to incorporate children in the educational process." This worksheet "introduced the concepts of water purification while engaging them in fun activities such as a maze, word search, and crossword puzzle. A solutions page was also developed for teachers and parents to check the children's work and to provide them with the correct answers." Finally, the AWP facility produced a virtual tour video allowing people to see the process of water purification without having to visit the facility themselves. This video is found on the project website, YouTube, and on a DVD at the public library.

Alongside the push for getting information about the project in the hands of the residents, outreach and tours were a key element to this public perception campaign. Presentations were given to any interested group and informational booths were set up at community events. Tours of the AWP proved to be successful in gaining public support for the project. These were offered weekly and one Saturday of every month. Overall, 3,200 guests have toured the facility including: local elected officials (mayor and city council members), Federal officials (state representatives and senators, the EPA, Department of the Interior, the Office of Management and Budget, and Senate Appropriations Subcommittee for Energy and Water Development members), residents, and media representatives. When asking individuals who toured the facility it was found that tours were beneficial to understanding the water purification process. Tours would be an integral part to Las Vegas' campaign.

In September 2011, the WateReuse Association awarded the Demonstration Project the honor of "Public Education Program of the Year" for its outreach efforts. Even after employing public outreach methods similar to San Diego, Las Vegas will more than likely need supplementary influential tactics in shifting public thinking because direct reuse programs are new territory in the world of water.

3.5 Using Authority to Influence Public Opinion

One additional tool of influence that should be used in the public campaign is authority. In his book on persuasion, Dr. Robert B. Cialdini explains that "our obedience frequently takes place in a click, whirr fashion, with little or no conscious deliberation. Information from a recognized authority can provide us a valuable shortcut for deciding how to act in a situation…because their positions speak of superior access to information and power, it makes great sense to comply with the wishes of properly constituted authorities" (Cialdini). Humans are constantly searching for short cuts when making decisions due to limited time and attention span for a particular problem. Trusting an authority figure's opinion is a short cut, according to Cialdini, which is extremely effective. This could be used to influence public perception in Las Vegas for a direct potable reuse program. One idea is to have a prominent public figure drink a glass of the reused water on TV, therefore proving that if it is safe enough for that authority figure to drink, it must be acceptable for the public as well (Attari). Residents would succumb to this influence possibly without even realizing it.

3.6 Using Scarcity to Influence Public Opinion

Another idea to push in the public campaign is scarcity. Once again Cialdini provides insight on the influence the impression of scarcity can have on people's decisions. "As opportunities become less available, we lose freedoms; and we hate to lose the freedoms we already have" (Cialdini). This is a direct result of the psychological reactance theory that states "when increasing scarcity—or anything else—interferes with our prior access to some item, we will react against the interference by wanting and trying to possess the item more than before"

(Brehm). Las Vegas residents already know the feeling of giving up water freedoms due to strict conservation regulations such as the mandatory watering schedule. Framing direct potable reuse as a tool to gain back some of those freedoms could influence people to view the process more favorably since it would decrease scarcity. Additionally, presenting the case that water scarcity will continue to worsen as time goes on will further invoke a sense of urgency among Las Vegas residents.

4. Conclusion

The city of Las Vegas could face Lake Mead, their main source of water, drying up by 2021. Due to feasibility and lack of evaporation and retention time, direct potable reuse could be the solution Las Vegas needs. The main barrier of public perception could be overcome by combining a traditional public education campaign with the influence tools of use of authority and emphasizing scarcity. In order to ensure the future of the fastest growing city in the United States, considering another water source to supplement the current supply should be the next step the city takes to ensure a sustainable water supply.

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