

LAS VEGAS WATER CONSUMPTION: CONSERVATION POLICY CASE STUDY

Kevin J. Joyce*

Abstract

This paper examines the water consumption in Las Vegas, Nevada and determines actions needed for the city to reduce water usage. I analyze a data set that dates from 1975 to 2002, and includes independent variables such as, temperature, wind, laws in effect, real price, and real income. The data indicates that wind, temperature, real price, and real income, contribute positively and significantly to the water consumption in Las Vegas, while laws, and rain, are consistent with lower usage. These independent variables show many interesting correlations to the dependent variable of water consumption. The results suggest that by increasing from one law to a few laws, increasing price slightly, and continued secondary education on water conservation, it will significantly reduce the amount of water consumed.

These policies will alleviate some of the water consumption, but will probably not cure the overuse of water in Las Vegas.

Keywords: water consumption; conservation policy; over usage

1. INTRODUCTION

Humans need many resources to live. Some of the basic necessities include food and water. Sadly enough, these basic resources are not available for all to consume. They are often subject to common property resource problems. Common property resources are resources that are used jointly by a group of individuals, but for which no private ownership exists.¹ Joint use may often lead to overuse of the resource if no restrictions are placed in

*Ens. Kevin J. Joyce holds a degree in Economics, with Merit, from the United States Naval Academy. He is currently serving as an officer in the United States Navy pending acceptance to graduate school.

¹Hardin, Garret. (1968). "The Tragedy of the Commons," Im. R. Dorfman and N. S. (Eds.), Economics of the Environment, (pp. 6). New York: W.W. Norton and Company.

individual use. To illustrate the idea of a common property resource, a buffet analogy might be used. However, this buffet would not be a normal buffet. The food would only be set out once, and the customers would dine there forever. It is simple to realize that there will be competition by the customers for the food. At the very least, the customers would consume the food too quickly from the group's point of view. The result could be tragic. So how does one overcome the problem of common property resources?

Some economists have theorized that there is no solution to the problem. In Garrett Hardin's, *Tragedy of the Commons*, he posits that there is no "technical" solution to the problem. His theory is that jointly owned or open access resources will eventually be over used--causing a massive ecological disaster. Conversely, there have been many other economists who suggest that real possibilities exist for overcoming the dilemma of common property resources. Many theories rest on the assignment of property rights and others rely on collective management by the group. The first possibility makes sense. To refer back to the buffet example, assigning property rights would enable each customer to their portion of the limited food. With the assigned property rights, customers would not have to worry about other customers over eating or wasting the food. The customers *will* still run out of food; but, by assigning property rights it has

slowed the process of common property resource degradation.

Las Vegas, Nevada, which ironically means "The Meadows," has a common property resource problem. Las Vegas was founded because water was originally abundant. Today, Las Vegas is the fastest growing city in the United States with more than 1.5 million people. Those people reside in an extremely hot and dry desert. Currently, there is a drought in the Las Vegas area. Water is an increasingly scarce commodity, and the overuse is a real concern for the Southern Nevada Water Authority and local government officials.

Why should one examine the overuse of water in the Las Vegas area? This is a major concern for local politicians and residents. Obviously, there is only enough water for so many people. Las Vegas residents need to slow the effects of the common property resource problem. If not, there are great complications that will arise. For instance, with a lack of water, the booming economic structure of Las Vegas would deteriorate. All houses, roads, and casinos, would either reduce or halt production. Drastic measures by the federal government would need to be taken by transporting water into the local area. Nevertheless, government officials are attempting to increase the supply of water for Las Vegas residents. In the meantime, actions need to be taken to restrict use of the limited water that is present.

This paper examines the water consumption in Las Vegas, Nevada and determines actions needed for the city to reduce water usage. The data set dates from 1975 to 2002, and includes independent variables such as, temperature, wind, laws in effect, real price, and real income. The data indicates that wind, temperature, real price, and real income, contribute positively and significantly to the water consumption in Las Vegas, while laws, and rain, are consistent with lower usage. The significant amounts of the independent coefficients show many interesting correlations to the dependent variable of water consumption.

Las Vegas authorities have implemented several measures in an attempt to relieve local water over use. There are three general steps a government can implement to help reduce individual water use. These three actions are: command and control (i.e. strict regulations), price rationing (i.e. raising prices), and a voluntary approach (i.e. water conservation education). This paper examines each individual method that the Las Vegas water authorities are seeking to implement. The paper then attempts to determine which methods are effective in alleviating the common property resource problem in Las Vegas.

The remainder of this paper proceeds as follows. Section 2 provides background information on the current water situation in and around Las Vegas. Section 3 describes the data and

methods that are used in the statistical analysis of water use. Section 4 presents the data analysis results, followed by summary and concluding comments in section 5.

2. BACKGROUND

The Southern Nevada Water Authority (SNWA) is in charge of all the water sources and distributors in the Las Vegas metroplex. It is concerned with the usage and conservation of the water and has already established that there will not be enough water with the influx of people that are entering the city.² Las Vegas receives about 88 percent of its water from the Colorado River with the other 12 percent coming from pumped ground well water.³

Command and control is a direct way to help reduce and regulate the use of water in the Las Vegas area. This requires that certain laws or restrictions be placed upon the resources used. Use of this methodology, allows the government to regulate *when* and *how* the resource, water, is used.

At present, there are not many restrictions on the exact usage of water in Las Vegas. Yet, as early as summer of 2003, there are many regulations that will be enacted. Watering of lawns could be restricted to every other day and at some times only once a week,

² (http://www.snwa.com/html/wr_index.html)

³ (http://www.snwa.com/html/wr_index.html)

during the winter months.⁴ These rules could help in reducing water usage; but, many other rules would also need to be enacted. Some of these include: not being able to wash the car at home, no new turf in residential front yards, prohibited use of mist systems, prohibited use of fountains or any other ornamental water features.⁵

The problem with regulations is that they need to be enforced. This can be very costly and could eventually cost more than the government is willing to pay. George Bennett, SNWA district manager believes that, "Restricting water to one day creates a great level of accountability. People won't tolerate doing their part and letting someone else get away with not doing theirs."⁶ This is a very bold statement that suggests that people in their local neighborhoods will actively regulate themselves and will hold themselves accountable for the greater good. Although an argument in favor of Bennett's thought process could be made on the basis that other neighbors will not tolerate the wasteful behavior due to the inevitable increase in prices in the long run. In spite of this, most people would not think of the long-run extent of their neighbor's usage. Furthermore, they may not expend the energy to explain the process of the long run price increase to their

neighbors. Professor Lotspeich of Indiana University believes that "no voluntary compliance or honest self-reporting should be expected in building the institutions for environmental control."⁷ Professor Lotspeich counters Mr. Bennett's statement and holds a realistic approach about human behaviors.

Not only would it be difficult to enforce because of the sheer size and population of Las Vegas, but it would also be very expensive to monitor all users. Even if enforcement fined users for an excessive use of water, the penalties collected may not exceed the cost of the task force needed to enforce the restrictions.

Price rationing would seem to be the most effective way to ensure that people conserve water. Price rationing occurs when different prices are charged for different amounts of usage. In regards to decreasing water consumption, higher prices would be charged for higher usage. According to Liu Shao, "It is increasingly recognized that water pricing could improve use efficiency and conservation thereby improving both quantitative and qualitative state of water resources."⁸ This methodology usually results in a self-monitoring approach which conserves water. In this method, every individual has an incentive to conserve

⁴ Padgett, Sonya. *Cutting the Flow*. Las Vegas Review Journal, March 10, 2003.

⁵ SNWA Drought Plan

⁶ Padgett, Sonya. *Cutting the Flow*. Las Vegas Review Journal, March 10, 2003.

⁷ Lotspeich, Richard, *Comparative Economic Studies*, Winter 95, Vol. 37 Issue 4, p. 125.

⁸ Liu, Shao. *Journal of Environmental Sciences*, Oct. 2002, Vol. 14 Issue 4, p. 518.

as much water as possible and a disincentive when they waste water.

Currently, the prices in Las Vegas are .98 cents for up to 1000 gallons, 1.42 between 1,000 and 10,000 gallons, 1.92 between 10,000 to 25,000, and 2.27 over 40,000 gallons.⁹ Las Vegas is currently using price rationing to reduce the amount of water used by each individual. It stands to be proven whether or not this is a highly effective method to conserve water in the Las Vegas area.

Another measure that can be attempted to help stop the common property resource problem is education. The reasoning behind this method is that when an individual understands all the implications of excessive water use, they will be compelled to use less water. While the thought is noble, it may well tend to lack in execution. Education is more likely to influence younger generations. Young people are easily influenced and have the ability to establish better habits. Yet, the problem with education is that there is no guarantee that the people will actually behave as they are instructed. "We are certain that education contributes to economic growth but then again so does health care, roads...in any case we cannot quantify the growth enhancing effects of education."¹⁰

⁹ Berns, Dave. "How dry is it?" *Las Vegas Review Journal* October 20, 2002.

¹⁰ Blaug, Mark. *Journal of Human Resources*, Spring89, Vol. 24 Issue 2, p. 331.

Garret Hardin further elaborates on the lack of human response to education. He believes that there are serious questions regarding the ability of education and social pressure to influence behavior is a common property resource situation.

"If we ask a man who is exploiting a commons to desist "in the name of conscience," what are we saying to him [that]... sooner or later, consciously or subconsciously, he senses that he has received two communications, and they are contradictory: 1. (intended communication) "If you don't do as we ask, we will openly condemn you for not acting like a responsible citizen"; 2. (the unintended communication) "If you *do* behave as we ask, we will secretly condemn you for a simpleton who can be shamed into standing aside while the rest of us exploit the commons."¹¹

This thought validates that even the highest forms of education does not ultimately lead to the appropriate action.

The SNWA has attempted conservation education. This water conservation methodology is based upon the customer's voluntary compliance. Within Las Vegas, there

¹¹ Hardin, Garret. (1968). "The Tragedy of the Commons," Im. R. Dorfman and N. S. (Eds.), *Economics of the Environment*, (pp. 14-15). New York: W.W. Norton and Company.

are many such programs: e.g. the company mascot, “Deputy Drip.” The SNWA employs a physical mascot, “Deputy Drip”, to visit elementary and junior high students and educate these students about water conservation. Although this technique does not solve the immediate problem, it is a potentially beneficial program and could produce future high returns for water conservation.

Other programs that the SNWA spends monies on are newsletters, commercials, and H2O: Water Resource Kits.¹² Commercials reach a broad base of the water district’s customers and are full of useful knowledge. The problem occurs when there is no incentive or reprimand to support the conservation of water. Education will not overcome the laziness or forgetfulness of the customer to turn off the sprinkler system. The next section will explain the data and method results.

3. DATA AND METHODS

The data used was used in determining the factors that influenced total water consumption from month to month in Las Vegas. In determining this, monthly data was collected from the Southern Nevada Water Authority¹³ for the period 1975-2002. The dependent variable (water consumption

in millions of gallons) was adjusted for the variations in days of the month. Every month was adjusted for thirty days. The independent variables were number of accounts, average maximum temperature, average wind in mph, average rainfall, a dummy variable if laws were in place, real price, and real income.

The number of accounts displays the number of households or businesses that purchase water. These are *not* the number of individual people that consume water. Las Vegas is known for its massive amounts of tourism. However, the casino industry is not included in the “accounts” variable. All major casinos use a personal ground water system. The number of accounts should have a positive relationship to that of water consumption. More accounts should produce more water consumption.

The temperature variable is measure in degrees Fahrenheit. This variable is the average maximum temperature for all months. Shown in Table 2, the average maximum temperature for all months was 79.8 degrees. Temperature should have a positive relationship to that of water consumption. The hotter the temperature, the more water consumed.

“Wind” was measured in miles per hour. The wind was averaged for each month in the regression. This variable is expected to show a positive relationship to water consumption.

¹² http://www.snwa.com/html/h2o_elementary.html

¹³ George Bennett, SNWA District Manager.

“Rainfall” was measured in inches of precipitation. The rainfall was averaged for each month in the regression. This variable should show a negative relationship to water consumption. More rain should help conserve water.

The “laws” variable was a “dummy” variable that was to account for laws in effect. To further explain, a “0” was used in the regression if there were no restrictions on water usage. A “1” was used if there were restrictions. Restrictions on water use were not implemented until 1991. This variable should have a negative relationship to water usage.

“Real price” accounted for the pricing of water. The prices were converted from nominal prices to real prices to adjust for inflation. All prices were adjusted to the base year of 1996. As real price increases, water consumption should decrease.

In October of 1990 tiered pricing was used. The first 30,000 gallons was priced at .91 cents and any consumption over this consumption level was priced at \$1.01. As seen in Table 1 tiered pricing continues today with even higher prices for higher consumption. The lowest consumption rate was used in the regression for all years that tiered pricing was in effect.

Table 1. Current Water Pricing in Las Vegas¹⁴

<u>Rate Block</u>	<u>Rate</u>
First 5,000 gallons	\$.98
Next 10,000 gallons	\$1.42
Next 25,000 gallons	\$1.92
Over 40,000 gallons	\$1.27

“Real income” accounted for the income of families in the United States. The income variable was also adjusted for inflation, using the GDP deflator, to the base year of 1996. It is expected that more money will generate higher water consumption levels.

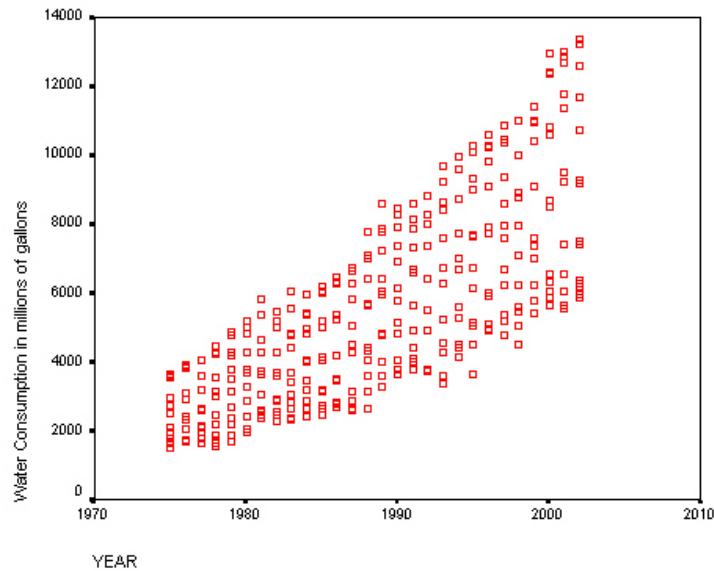
The data was collected from the Southern Nevada Water Authority. The Southern Nevada Water Authority is responsible for “managing all water supplies for Southern Nevada and addressing resource management and conservation programs.”¹⁵ They keep strict records of many types of data that influence water consumption. These data sets enable them to examine their efficiency level. The real income, real price, and GDP deflator, were obtained from the U.S. Bureau of Economic Analysis.¹⁶

Multiple regression Ordinary Least Squares was conducted using SPSS to estimate **Water Use = $\beta_0 + \beta_1 \text{Real price} + \beta_2 \text{Real income} + \beta_3 \text{Laws} + \beta_4 \text{Wind} + \beta_5 \text{Rain} + \beta_6 \text{Temperature} + \beta_7 \text{Accounts} + \epsilon$** .

¹⁴ George Bennett, SNWA District Manager.

¹⁵ http://www.snwa.com/html/about_us.html

¹⁶ www.bea.gov

Figure 2. Year versus Water Consumption

In Figure 2, a simple scatter plot, using SPSS, shows the difference between consumption over time. This graph verifies that more water has been consumed over the years. This is due to the increasing population in Las Vegas. Also, from the graph, it is evident that there are still months where there is consistent lower consumption. These lower consumption months reflect the colder months of the year where users need less water. There still is an

obvious increase in the colder months. This could be accounted for with the increasing population.

Table 2 shows descriptive statistics for the dependent and independent variables. The mean water use in millions of gallons is roughly 5.5 billion gallons of water. The average number of accounts is 135,000. Minimum and Maximum and number of variables are available in Table 2.

Table 2. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Water(mg)	338	1518	13382	5529.1	2763.7
Accounts	338	58480	265426	135033.4	58053.9
(F)	278	52	107	79.8	16.8
(In)	324	0	5	.39	.612
(Mph)	278	5	14	9.3	1.9
Real price	338	.62	1.13	.8963	.10910
Real Income	312	17077.1	26876.4	21871.6	2971.2

4. RESULTS

The OLS regression results are given in Table 3. This table reveals many interesting results. The general F-test had a significance level of zero. This shows that the overall regression is significant. Additionally, the “R square” shows .952. This means that 95.2% of the variation in the dependent variable is explained by the regression. This is a very high “R square” and lets the examiner know that the independent variables explain a significant amount of total water use.

Looking at the individual coefficients, several results were clearly expected. Table 3 displays the results of the coefficients.

The “Accounts” variable was positively correlated and significant. This means the more accounts, or water users, the more water will be consumed. This makes intuitive sense. The coefficient that was reported in the regression was .026. This number shows that with each additional account, 26,000 more gallons of water is consumed. With the population increasing rapidly in Las Vegas, it is easily seen how the consumption rate is easily rising.

The “temperature” variable was also positively correlated. Higher temperatures produce more water consumption. The regression illustrates the higher water consumption with a coefficient of 94.8. This explains that

with a one-degree increase in temperature almost 95 million more gallons of water is consumed. Las Vegas is known for hot and dry temperatures. The water burns off quickly and requires the water user to water plants or shrubbery for longer periods of time. These temperatures do not help the conservation of water.

Wind was another independent variable used in the regression. Wind as a variable might not be as obvious as a variable as temperature. Yet, wind produces excessive runoff on streets and forces homeowners to water their grass for longer durations of time. The wind coefficient that was produced in the regression was 74.1. This coefficient leads to the conclusion that with one mile per hour increase in wind generates 74 more million gallons of water consumed. The regression shows that wind is a substantial factor in excessive water consumption.

The coefficient in the regression for “laws” was -216.3. This variable leads to the conclusion with one more law added to conserve water, 216 billion gallons of water would be saved. The idea of increased regulations would lead to the obvious conclusion that most users would not break the law and consume water at the wrong times. The coefficient in the regression shows this decrease in water consumption due to regulation.

Of particular interest in the regression are the effects of laws, price,

and income. The “law” variable is significant, with a one-tailed test, to the overall regression with a p-value of .097. This significance level shows that it is valid to use in the regression, but very close in not making the .10 significance cutoff level. For purposes of the regression, a dummy variable was used (i.e. 0 or 1) to indicate when laws were in effect. A 0 was used for no laws enforced and a 1 was used for when laws were in effect. There has only been one regulation enforced since 1991 and is still currently enforced in Las Vegas. This regulation is a time restriction on the watering of lawns. This is a very effective process for water conservation. This can be seen within the results of the regression. However, the more regulations that are ratified, the less water will be conserved. The reason behind this theory was explained earlier. The city would lack the ability to enforce all regulations.

Another independent variable that was used to help water consumption was “real price.” Real price shows the effect of water consumption adjusted for inflation. The price coefficient was 2107.5. With a one-dollar increase in price, 2 billion gallons of water is consumed. This coefficient defies the law of economics. The regression shows that higher prices would actually increase consumption. Further analysis was needed to determine the possible problem.

A possible explanation for the

coefficient is an inelastic demand for water. It is possible that even real price increases have not slowed the consumption of water. With the population increase in Las Vegas it creates a high demand for water. Things such as building homes, roads, and supporting infrastructures needed to support the population. With these new productions and the large population of Las Vegas it has created an outrageous demand for water. This creates the need for water *no matter* what price is charged. At some point, much higher, prices will have an effect on water consumption. Prices have not yet reached this point.

Another possible cause of the problem is what is known simultaneity. This occurs when two variables are dependent on one another, and simultaneously determined. The two variables in this case are consumption and price. These two variables can be questioned which one controls the other. Some may say that consumption is driving the price of water. Others may say that the price of water affects the amount of consumption. This could be another factor that leads to the positive coefficient in the “Real price” coefficient.

Another possibility that could exist is known as a missing variable bias. A missing variable bias is when a coefficient is missing from the regression. There are many factors that could not be accounted for in the regression. For instance, one small

example is the massive amounts of tourism that Las Vegas attracts. Obviously, the more tourists, the more water consumed. This is just one example of a variable not accounted for, which could explain why the correlation to “price” is biasing the coefficient of the price increase.

The last likelihood that the coefficient has the wrong correlation is a spurious regression result. This occurs when both “price” and “water use” have simply increased over time and the regression interprets this as a positive effect when really no such correlation exists. Hopefully, the “spurious regression result” was not taken into account in the regression.

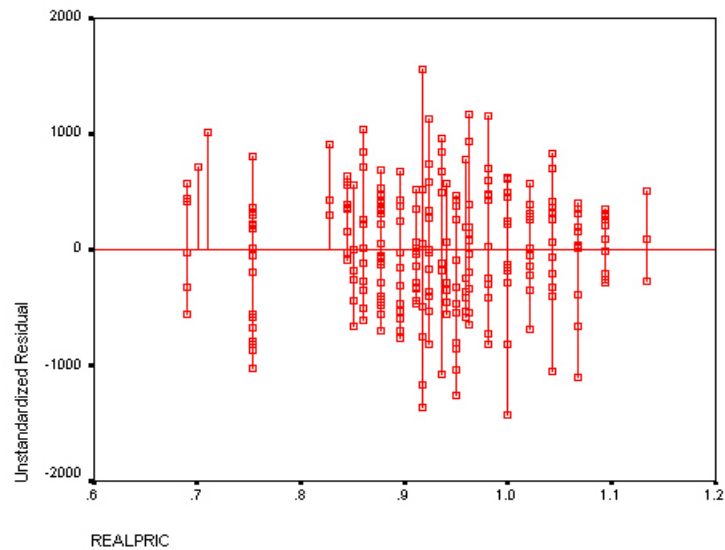
The last variable that was used in the regression was “real income.” With families receiving more monies it enables them to purchase more water. The coefficient for real income was .188. The regression shows that with an increase in one dollar of real income there is an increase of 188,000 gallons of water. The results have shown that with more purchasing power they are able to consume more water.

The Durbin-Watson statistic was a method used to see if autocorrelation existed. The output for the Durbin-

Watson test was .663. This value was lower than the lower critical value of 1.697. This situation reveals that positive first-order serial correlation existed. Serial Correlation in regression refers to the correlation of error term with itself over successive time intervals. Simply put, if there is no autocorrelation then the variables will be independent of each other. In this case it does exist, which causes OLS to underreport the standard errors of the coefficient variable. This tends to make the variables appear more significant than they should. OLS regression does not help with the problem of serial correlation and a better method should be used: Generalized Least Squares (GLS) regression.

Another common problem in Ordinary Least Squares regression that was investigated was heteroskedasticity. Heteroskedasticity seems to be present in the regression. This is shown in Figure 3 with the graph plot of price versus unstandardized residuals. It is present due to the increasing variance of the unstandardized residuals. When heteroskedasticity is not present there is a constant variance. Price may be the weighting factor which produces the heteroskedasticity.

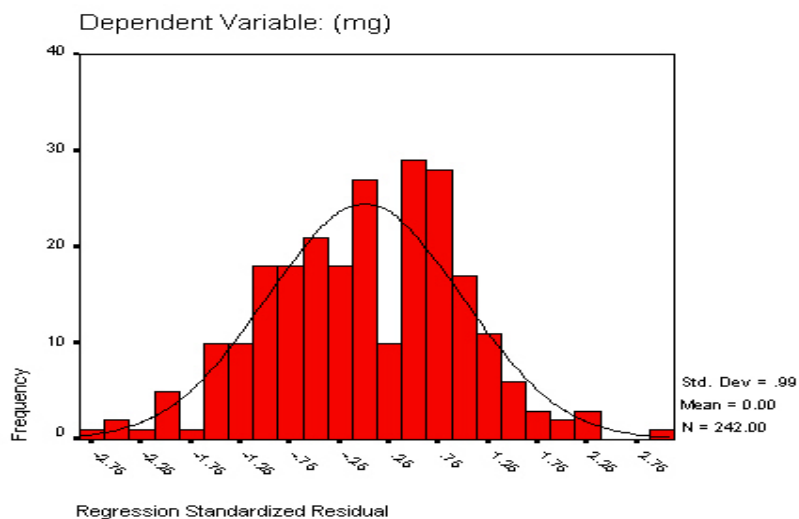
Figure 3. Price versus Unstandardized Residuals



Normality was checked to see if the errors were distributed about zero. The errors from Figure 4 are distributed evenly about zero. The evenly

distributed errors about zero allows the examiner to make inferences based on regression coefficients.

Figure 4. Normality (Standardized Residuals versus frequency)



5. DISCUSSION AND CONCLUSIONS

The regression results raise interesting questions about the future of water policy in Las Vegas. Where will Las Vegas continue to put forth efforts to conserve water? Will the efforts be in higher prices, conservation education, or regulation?

The correct decision will be a combination between all three processes. However, the amount of money and amount of time invested in these activities to conserve water need to be carefully analyzed. Too much or too little of each process could be damaging to the water source.

Drawing from the previous discussion, water still has an inelastic demand in Las Vegas. Although this was not demonstrated, it is economically expected to reduce water usage with an increase in price. This is a simple methodology to employ in the Las Vegas area. Simple, yet there are many other social implications that hinder the city from this method. Raising prices too high raises equity concerns for some users and lower income families unable to afford water. Water should be considered a social good. Everyone needs water to live. This raises the question whether or not the government has the responsibility to ensure prices stay low. Nevertheless,

whether it is the responsibility of the government or not, the City of Las Vegas does need to raise prices to some extent to slow the usage of water.

Education is a tool for the future. The Southern Nevada Water Authority should continue targeting younger generations in school, hoping to see benefits in the long run. Most of these programs are low budget and could possibly be integrated into every classroom in the city. It is questionable how much should be invested in education given the uncertain benefits.

Regulation is the attempt to reduce the laziness and wastefulness of the common water user. The regression shows that laws have generated a significant reduction in water consumption. The city should implement a few, easy to enforce regulations. The fact that “a few” is mentioned is that it is impossible to regulate almost two million people in the city. Rules that are impossible to enforce should not be enacted upon. This makes the few rules that are already in place acceptable to break also. With a few more water restrictions it will be easy for the water user to remember. Not only for the water member, but the city can devise a simple way to monitor these simple regulations.

Table 3. Coefficient and Significance Regression Results

	Constant	Temp. (F)	In (precipi tation)	Accounts	Wind (mph)	Laws	Real Price	Real Income
Water consumption (millions of gallons)	-1216.80 (.000)	94.89 (.000)	-140.55 (.000)	.0261 (.000)	74.12 (.000)	-216.56 (.194)	2107.50 (.000)	0.188 (.000)

p-value in parentheses

Table 4. Model Summary/F Significance

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin- Watson	F	F sig.
.976	.952	.951	527.910	.663	663.85	.000

a Predictors: (Constant), REALINC, (F), (in), REALPRIC, (mph), LAWS, ACCOUNTS

b Dependent Variable: (mg)

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