ANALYSIS OF PER CAPITA WATER USE PATTERNS AMONG COMMUNITIES WITH VARYING DEGREES OF COMMERCIAL ACTIVITY

by

Robert J. Eustice III

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Frederick Bloetscher, Department of Civil, Environmental, and Geomatics Engineering, and has been approved by the members of his supervisory committee. It was submitted to the faculty of the College of Engineering & Computer Science and was accepted in partial fulfillment for the requirements for the degree of Master of Science.

SUPERVISORY COMMITTEE:

Frederick Bloetscher, Ph.D.
Thesis Advisor

Diana Mitsova, Ph.D.

Panagiotis Scarlatos, Ph.D.

Yan Yong, Ph.D.
Interim Chair, Department of Civil, Environmental,
and Geomatics Engineering

Mohammad Ilyas, Ph.D.
Dean, College of Engineering & Computer Science

Deborah L. Floyd, Ed.D.
Dean, Graduate College

2/6/2015
Date

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ABSTRACT

Author:	Robert J. Eustice III
Title:	Analysis of Per Capita Water Use Patterns Among Communities with Varying Degrees of Commercial Activity
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Thesis Advisor:	Dr. Frederick Bloetscher
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Water supply managers often look for easily applied metrics to determine where water use can be curtailed. Unfortunately, the one-size-fits-all mentality comes with a price of failing to fully grasp the consequences decision-making based on such metrics. One issue that water supply regulator like to use is per capita water use. Per capital water use is often used to show where there is "wasted" water use, such as excessive irrigation. However such a metric may not be truly applicable depending on other economic factors. A heavily industrial area may add to apparent per capital use, but actually is an economic development activity. The focus of this project is to look at various water utilities and their per capital usage with the intent of discerning whether or not a better metric could be developed that consider the economic development activities of the region and water use.

DEDICATION

I would like to dedicate this manuscript to my family. Their unwavering support and love has allowed me to get this far. Thank you. Nothing is beyond our reach.

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INTRODUCTION

Estimates indicate that from 1950 to 1980, demands for water increased steadily across all sectors, with 1980 being the peak water use year. However, since 1980, withdrawals declined. Despite the overall decline, the built environment demands continued increase after 1985. Total domestic and public withdrawals consistently increased during the 1960 to 2005 period, rising from 16 bgd in 1960 to 32 bgd in 1995 and 43 bgd in 2005, although the per capita usage dropped slightly (Hoffman, Feeley, & Carney, 2005; Solley, Pierce, & Perlman, 1998). Reduced water consumption in the other sectors result from better agricultural practices, more efficient cooling and reduced per capita use as a result of revisions to the plumbing standards in 1992.

The Energy Information Administration (EIA) project, assuming the latest Census Bureau projections in its reference case, the U.S. population to grow by about 70 million in the next 25 years. In addition to an overall increase in the demand for power due to population increases, Macknick, Newmark, Health, and Hallett (2012) identified climate change, population growth, and demographic shifts as significant uncertainties expected to exacerbate the challenges associated with managing both the supply and demand of water and energy. In the US, the energy sector uses 39% of the water withdrawals on an annual basis for cooling, immediately behind the 40% used by agriculture (General Accounting Office, 2012, Lisk, Greenberg, & Bloetscher, 2012). Urban demands account for 12.6% of water use (Bloetscher and Muniz, 2012; Sanders & Webber, 2012). As demands for limited water resources continue to grow among all sectors, and as pressures

on financial resources increase, there are benefits and synergies that can be realized from integrated planning for both water and electric utilities and for their respective stakeholders and communities. From the water industry perspective, energy is needed to extract, treat, and distribute water, resulting in water and wastewater utilities being among the largest users of power on the power grid. As a nation, the United States devotes nearly 4%, or 164 million Mega-Watt-hours (MWH), of our electrical energy generation, to handle, lift, move, pressurize, distribute, and treat water and wastewater (Barker, 2010; Burton 1996; Mead et al., 2009). In water and wastewater utilities, more than 80% of the electrical energy use is for pumping, and the remainder is for treatment. Pumping less has been viewed as a positive water and energy conservation practice, but the impacts of per capita usage patterns has not been considered in this overarching viewpoint.

Per capita water use and water use patterns have been the subject of studies going back as far as Whitman (1932). Holdren and Ehrlich (1974) outlined rising per capita material consumption, and how technologies have made civilization a global ecological force. Vickers (2001) completed a landmark study that broke down domestic water use into pieces and identified irrigation as a major user. Hall, Mice, Hooper, and Postle (1988) looked at per capita water use in southwest England and more recently Gleick (2003) and Solley et al. (1998) have looked at water uses in the United States with an eye toward sustainability. But all of these studies the per capita consumption has been a focus without identifying how other issues might play into those estimates.

For example, in 2006, among utilities in southeast Florida, there are drastic differences in water use per capita (for example, North Lauderdale is only 82 gpcd while

Fort Lauderdale is 201 gpcd – see Table 1). Many utilities fit in the range from 70 to over 250 gpcd. Irrigation is often identified as one of the reasons while per capita water use is higher, but that does not explain the differences in Table 1 since few of the users of these systems have irrigation users connected to the potable water system. None of these utilities has a large unaccounted for water so the figures do not indicate that any of these utilities is wasting water. The question is where this water is used if it is not irrigation or loss. To resolve the issue with varied water use, it is useful to know how per capita water use discretized.

Table 1

Examples of Differences in Per Capita Usage

Utility	Population	ADF (MGD)	gpcd
Margate	60,402	6.77	112.1
Broward County	64,209	9.30	144.8
N. Lauderdale	33,167	2.72	82.0
Tamarac	55,108	6.25	113.4
Ft. Lauderdale	237,492	47.81	201.3

Residential customers typically use about half of their water inside the home (Mayer & Deoreo, 1999). The America Water Works Association estimated that this amounts to about 78 gallons per capita per day (gpcd) (Mayer & Deoreo, 1999), while Vickers (2001) puts this figure between 45 and 70 gpcd. For comparison, Meeroff and Scarlatos (2008) found that south Florida residential neighborhoods typically have daily demands on the order of 70-380 gpcd, which include irrigation, car washing, and multiple

fixtures. Findings in water use permits for Dania Bach in 2008 indicated both single and multi-family users used 70 gpcd, while the figures were 67 and 58 gpcd in 2012 (F. Bloetscher, personal communication, September 1, 2014). Miami-Dade Water and Sewer District reports an average indoor consumption of 103 gpcd because of limited irrigation area (more urbanized) and outdoor usage of 55 gpcd (Bestard, 2008). It is important to recognize that the 100-150 gpcd national average represents residents living in metered conditions, and who are responsible for paying monthly water bills. However, neighborhoods vary.

Research conducted for Broward County utilities by Florida Atlantic University found that for much of the County service area (excepting economically disadvantaged multi-family use areas with very low usage rate in Deerfield Beach and Pembroke Park, and the beach which had high usage), the average water use was 6000 gallons per month. The average household size was 2.26 people is 89 gpcd. 89 gpcd is an acceptable number for south Florida and close to the 87 gpcd reported in Mayer and Deoreo (1999). The beach is an area that uses potable water for irrigation of high value properties and pools so they are noticeably higher. However, these issues not withstanding, water resource planners tend to look to address water demands through per capita water use as the means to address long-term supply limitations.

The concept of limited water sources has two root causes: (1) demands on existing sources from economic growth and population, and (2) uneven or deficient rainfall patterns. Much literature exists about the latter, but the impact of economic growth on water demands has had limited study except at the macro level as noted previously. There is the need to understand the water use patterns when the potential

water supplies are over-allocated, not managed optimally or subject to environmental changes that impact their reliability. Limiting water use or the lack of water supplies has long been known to impact the ability of a community to attract economic activity, but no studies of the usage patterns has been conducted.

The issue has critical impact in southeast Florida where, despite copious rainfall, "drought" has been a term frequently heard in the news and with south Florida water managers. South Florida receives an average of nearly 60 inches of rain each year. Seventy percent of the annual rainfall occurs in the summer months (June to September; see Figure 1), which creates distinctive wet and dry seasons.

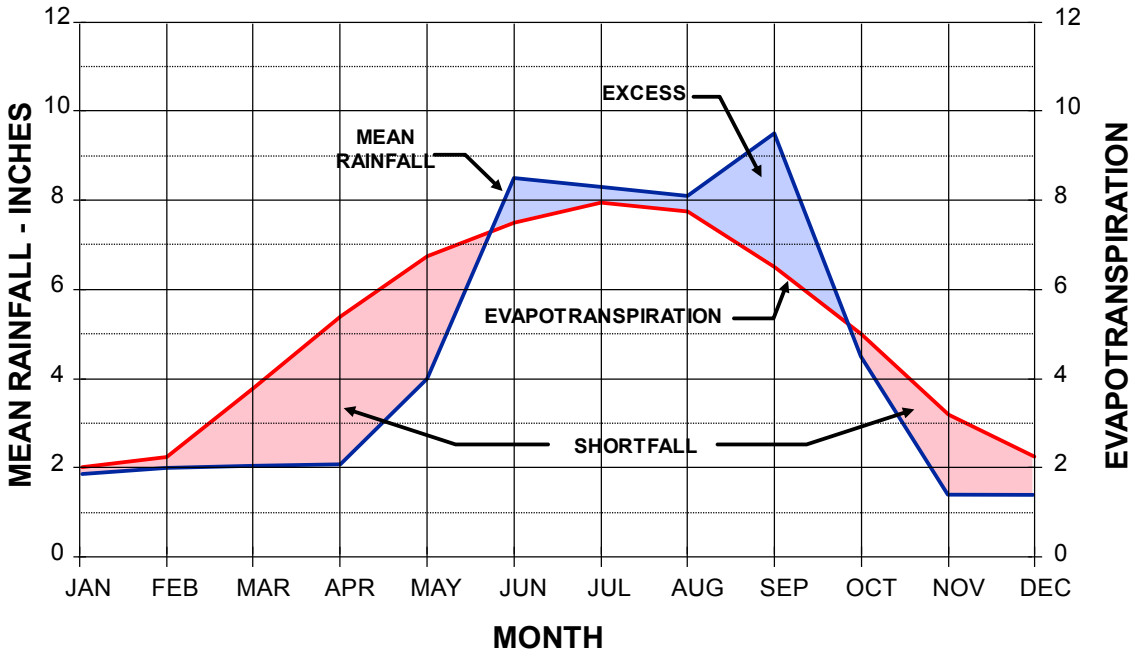


Figure 1. Comparison of typical evaporation and precipitation in south Florida (based on the time period 1972-1989) (Bloetscher, Muniz, & Witt, G. M., 2005).

In south Florida, water supply, water quality and Everglades ecosystem health are intrinsically linked, and it is that linkage that creates the potential for "drought" periods. The peninsula relies on surficial groundwater for water supplies, so when attempting to evaluate the water supply for southeast Florida, one must look at the entire southern portion of the peninsula of Florida. Historically there were no barriers or canals to direct or control the path of water (see Figure 2). The canal system permanently reduced groundwater levels along the coast (which enabled the urban development that exists today – see Figure 3, which shows the canals in the SFWMD and the post-drainage modification changes to Figure 2). At present, 60 billion gallons per day is sent to tide (Berry et al., 2011). As a result of reduced groundwater levels, combined with lessened historical flows to the Everglades and less water standing in the Everglades during the summer months, the Biscayne Aquifer does not recharge as it once did. The change in the land use along the coast has resulted in water falling on impermeable land where the water collects in pools or runs off rapidly where development has taken place, further reducing the potential for recharge (Bloetscher & Muniz, 2008). Runoff from impermeable regions often results in large-scale flooding because the storm intensity (rate of rainfall). The solution has been to add canals to discharge this excess runoff to the ocean to minimized flooding, which reduces available fresh water supplies during the dry season, which coincides with increased winter population and peak irrigation season for lawns and agriculture. Significant expenditures are required to protect the coastal areas, but even with the improvements, adequate protection to south Florida from recurrent "droughts" may not occur during the drier months of winter and spring when

crops fail and saltwater intrusion potential to coastal wellfields is highest (Berry et al., 2011).

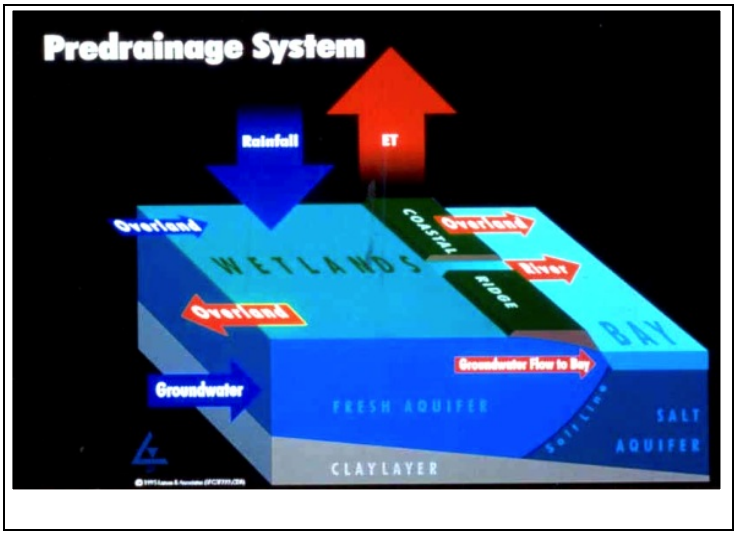


Figure 2. Pre-drainage/historical drainage pattern (SFWMD, FDEP, & FDACS, 2008).

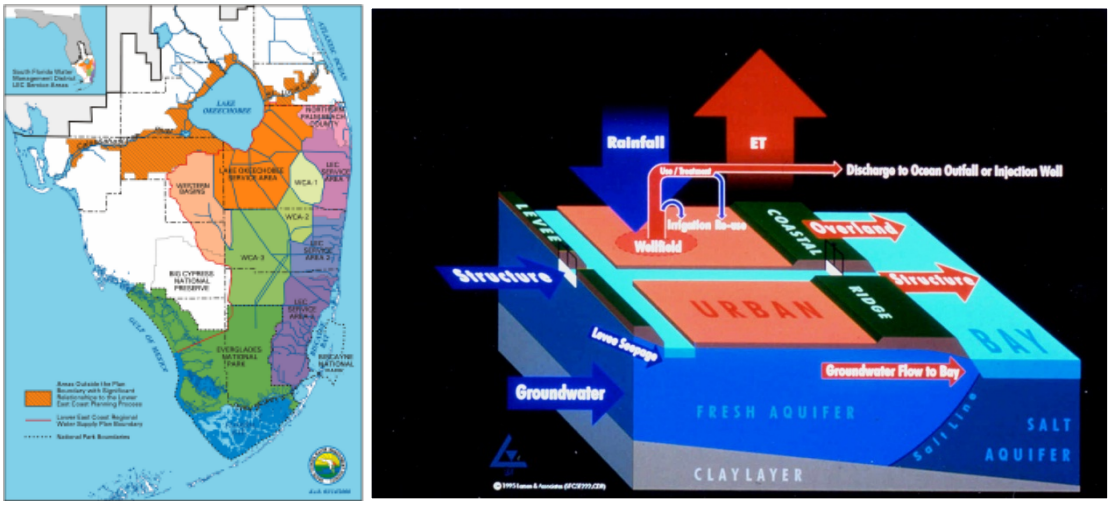


Figure 3. South Florida Water Management District LEC service area (SFWMD, FDEP, & FDACS, 2008).

One of the reasons for water availability, is that water was "controlled," north of Lake Okeechobee. Large-scale cattle ranches and milk operations were started. Unfortunately, runoff from these operations, which contained nutrient rich waters, ran off into the Kissimmee River and ultimately dumped into Lake Okeechobee (Bloetscher & Muniz, 2008). South of the lake, the Everglades Agricultural Area (EAA) has developed to include hundreds of thousands of acres of sugar cane and other vegetable farming operations. Until a recent federal court decision ordered the practice to cease, highly nutrient laden summer flood water was being diverted, from the EAA back into the lake. However, while these projects have prevented flooding in the urban corridor and agricultural areas, there are other impacts, including dramatic effects on the ecosystem health of the Everglades and also on quality of south Florida's potable water supplies (Bloetscher & Muniz, 2008). By the 1980s, it was obvious that a number of critical species were declining and that changes in the ecosystem had likely caused these impacts. At the same time, problems with saltwater intrusion, drawdown impacts along the eastern edge of the "controlled Everglades," greater urban populations and an inability to consistently recharge canals from Lake Okeechobee, created water supply reliability issues for southeast Florida residents (Bloetscher & Muniz, 2008).

The SFWMD is tasked with the management and protection of regional water resources, including competing interests of water quality, flood control, natural systems and water supply. The State of Florida, via the SFWMD, has committed billions of dollars to reversing the impacts of the drainage projects of the 1920s and 1940s by restoring natural flows and levels as a part of an agreement with the federal government called the Comprehensive Everglades Restoration Plan (CERP).

Just as the improvements were being started, 2004 and 2005 were active storm seasons. In 2004, four hurricanes impacted south Florida, while in 2005, three more impacted the area. There were no significant storm events affecting the area since. Concurrently, the SFWMD indicated that 2006 started a drier period, although the lack a precipitation appears to have been primarily in the upper Kissimmee Basin. Unfortunately algal blooms and the fear of a hurricane hit in 2006 caused the South Florida Water Management District to discharge 3 feet of water off Lake Okeechobee in September 2006, which coincided with the start of the dry season and a lack of rainfall north of the lake. The result was that the lake levels continued to fall throughout 2006 and 2007 to their lowest levels (see Figure 4).

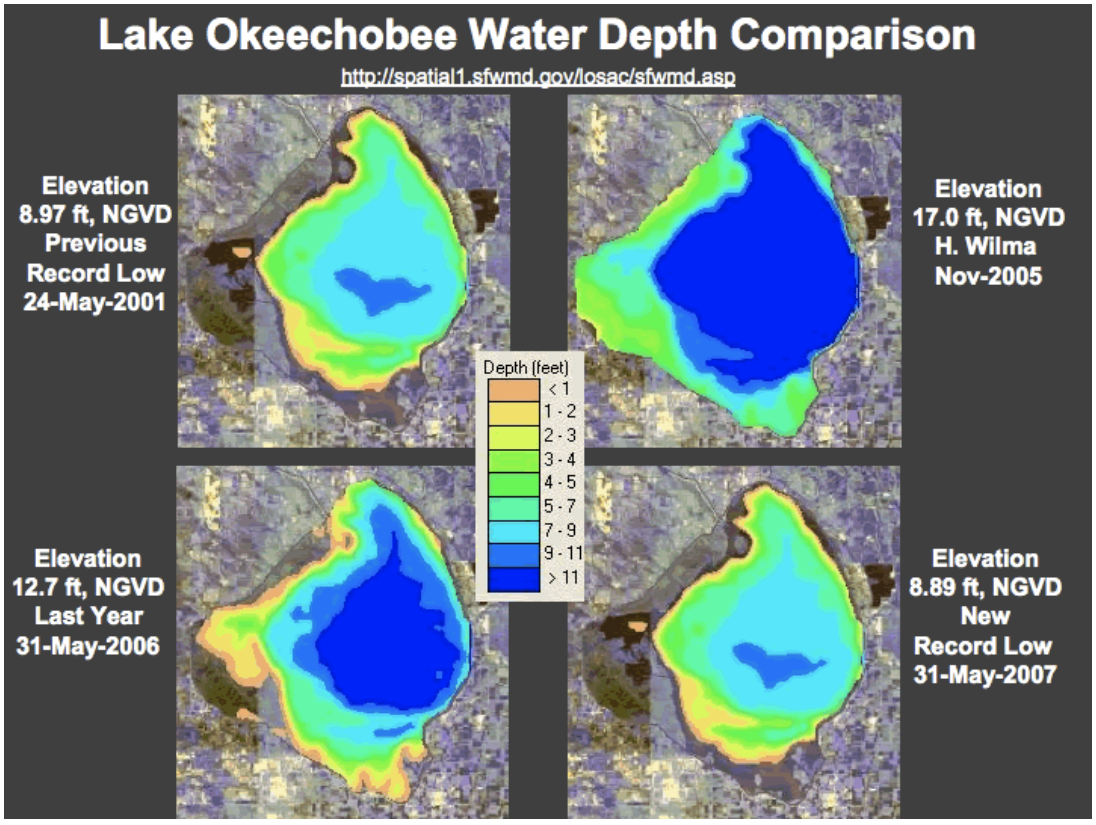


Figure 4. Lake Okeechobee Water Levels 2001 to 2007 (SFWMD, FDEP, & FDACS, 2008).

Rains in the summer of 2007 halted the drop in lake levels for a time, but the SFWMD operations staff decided to stack water north of Lake Okeechobee in 2007 and into 2008. The intent ostensibly was to maintain aquifer levels as high as possible for agricultural operations north of the lake (personal communication), but the net result appears to be that Lake Okeechobee has received no real influx of water from the summer of 2006 (note in 2006, the federal courts supported the Seminole Tribe of Florida and other interested parties to prevent back-pumping of excess agricultural water to the lake without an NPDES permit as well which eliminated the only other source of water to the lake other than rainfall) to 2008. With no influx of water, and evaporation rates exceeding rainfall amounts, the lake levels continued to decline. The decrease triggered water use restrictions according to SFWMD policy in the spring of 2006.

In early 2007 the SFWMD felt compelled to impose stricter limitations on the use of "Everglades water" if it is to protect the Everglades. To address the immediacy of the ecosystem concerns, the SFWMD Governing Board adopted the Regional Water Availability Rule. The salient features of the Regional Water Availability Rule include the following: future water demands over and above the "base condition water use" cap will have to be provided from alternative water sources (AWS) or offset with reuse or storm water (also considered AWS). The "base condition water use" is defined as the five-year historical, highest twelve-month pumpage from this wellfield. Utilities needing water supplies were required to seek sources that are not dependent upon the Everglades for recharge. One significant implication for southeast Florida residents was no new Biscayne Aquifer water. However the rule did not consider impacts associated with economic activity. Most of the utilities met lowered demands in 2008 and 2009 when the

economy crashed. But the impact of these rules has not been assessed since, nor were their impacts on economic activity assessed.

Figure 5 shows the annual precipitation pattern for the State of Florida based on data gathered at Spatial Climate Analysis Service at Oregon State University (Prism Climate Group, 2014). What is important to note is that the range in rainfall in changes from west to east. The western areas (WCA 3, which is rain gauge station STA 3A) receive under 50 inches of rain per year on average, while the coastal area gets 58-60 inches per year on average. The impact of this data is that the recharge area for the Biscayne aquifer, the remnant Everglades in the water conservation areas, did not receive the appropriate rainfall, which is in keeping with research that indicates that climactic conditions may be reducing rainfall in the Florida peninsula (Freas, Bailey, Muneavar, & Butler, 2008). Unfortunately this rainfall does not occur evenly throughout the calendar year, so it is difficult to argue that drought conditions apply when summer rains may be adding 10 inches per month to rainfall totals along the developed along the coast. Rainfall total for the coastal areas do not reflect drought conditions.

In an effort to standardize conservation strategies in south Florida, the South Florida Water Management District, utilizes the consumptive use permit to require utilities to provide a program. There are six required programs, and five optional programs that do not overlap with the required programs. The required programs are:

- Public Information Program. A public information program is a critical element for promoting water conservation. The program should focus on water-efficient landscaping practices and efficient indoor use of water.

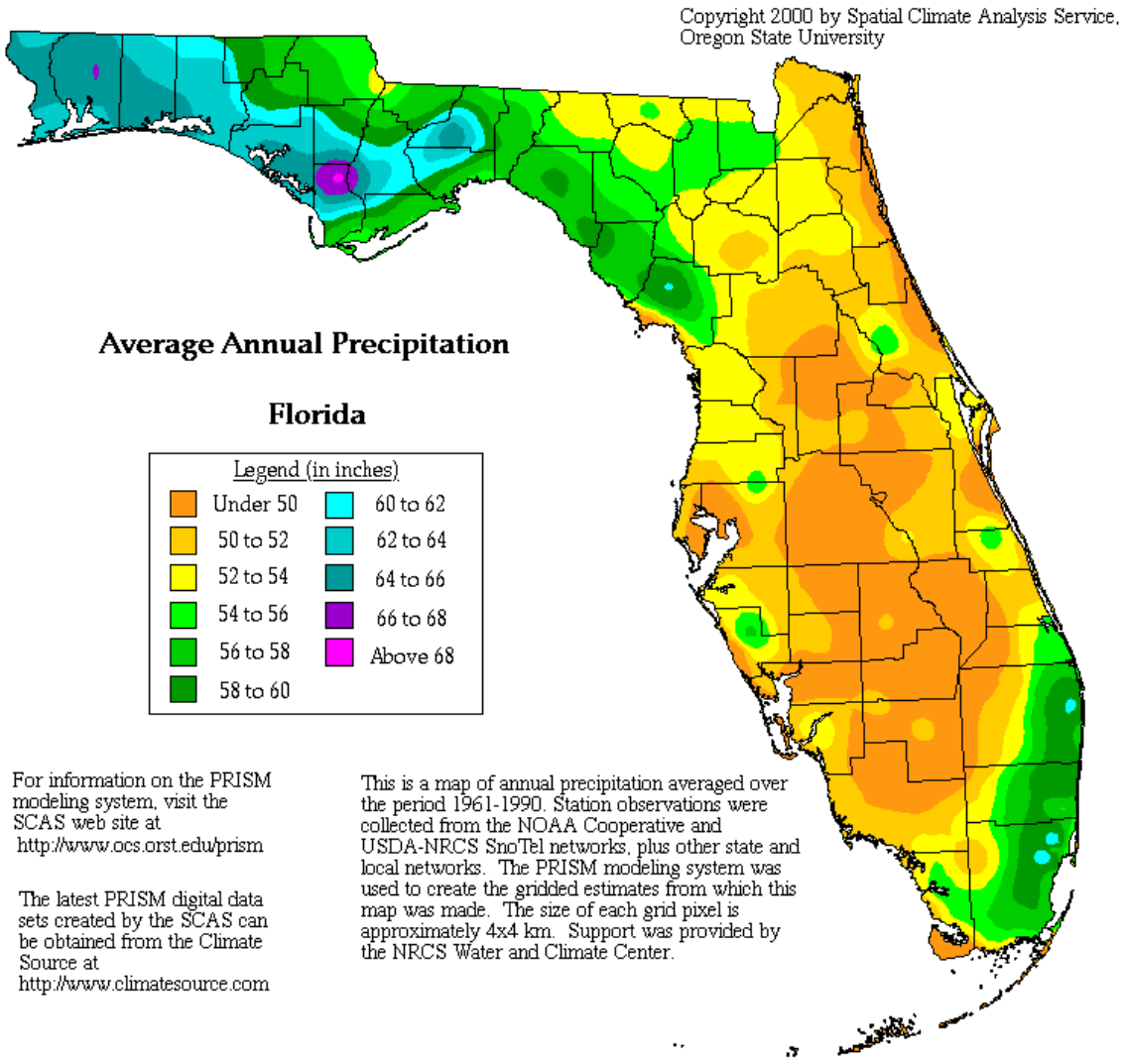


Figure 5. Precipitation map for Florida (source: Prism Climate Group, OSU).

- Plumbing Fixture Efficiency Standards. The SFWMD encourages that low volume plumbing fixture standards should be adopted by all local governments. Low volume standards provide that no greater than 1.6 gallons/flush be allowed for toilets, 2.75 gallons/minute for showerheads, and 2.2 gallons/minute for faucets, at 80 psi.

- Florida Friendly Landscape (the old xeriscape) Landscape Ordinance. A Florida Friendly landscaping ordinance, which promotes water conservation, should be adopted by all local governments in South Florida. The SFWMD has developed a Model Landscaping Code to assist local governments and utilities in this effort. This ordinance, as well as information and assistance, is available on request.
- Permanent Irrigation Ordinance. The District recommends that non-agricultural landscape irrigation be limited to the hours of 4:00 p.m. to 10:00 a.m.
- Leak Detection. All utilities with greater than 15 percent unaccounted-for water losses should enact a leak detection program, including water auditing procedures, in-field leak detection efforts, and leak repair.
- Conservation Rate Structure. A rate structure that promotes water conservation should be adopted by all utilities.

Optional or suggested conservation measures are as follows:

- Metering of all customers.
- Reuse of wastewater for irrigation purposes.
- Pressure control on the potable system.
- Filter backwash water recycling at water treatment plants (where applicable).
- Elimination of potable water use for HVAC systems.

None of these deal with water use that might increase per capita water use as a result of non-residential activity or economic development.

The question raised in this report is how per capita water use varies with per capital economic activity, and which economic activities might exert the most impact on overall per capita water use. The tri-county area of southeast Florida will be used as the test case since, for the most part Broward and Miami-Dade County water users rely on wells for irrigation, while a different pattern exists in Palm Beach County. No prior literature on this subject was present in the literature review.

METHODOLOGY

Data Collection

The methodology for collecting the copious data needed for this analysis is to translate raw data and data files into an ArcGIS format. A geographical information system (GIS) is a computer system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. The benefit of using GIS for this project is that a GIS system allows us to create data layers these layers permit a query to be performed which will allow investigators to answer specific questions.

Table 2 shows the layer and the data sources. These sources and the data will be outlined in the following paragraphs.

Table 2

Data Sources

Description	Source	Date	File Name	File Format
Public Water Supply Utilities Annual Progress Reports	Patrick Martin, SFWMD	2/27/2014	Per_Capita_Summaries_ For_FAU_Student	Xls
Shape File of Broward County	Diana Mitsova, Ph.D.	2/10/2014	Browardcities	shp
Shape File of Palm Beach County	Diana Mitsova, Ph.D.	2/10/2014	CITY_BNDRY	shp
Shape File of Miami-Dade County	Diana Mitsova, Ph.D.	2/10/2014	MUNICIPALITY_POLY	shp

Water Use Data

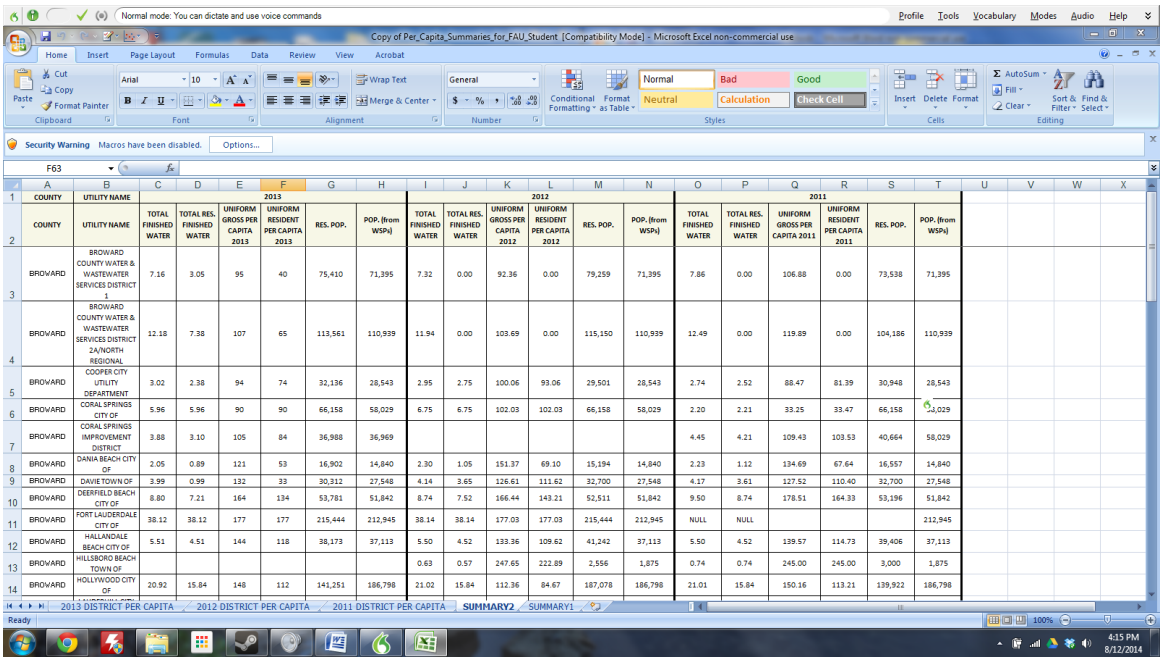
Water use data was collected by contacting South Florida water management District and speaking with Patrick Martin, who is their senior water supply analyst. Utilities that exist within South Florida Water Management District are subject to a mandatory report each year called public water supplies utilities annual progress report. Mr. Martin was able to provide these reports for Palm Beach County, Broward County, and Miami-Dade County. In his e-mail he notes that all data is assumed to be correctly entered by the utility provider. In Figure 6, a screenshot can be seen of the original provided data provided to the South Florida Water Management District. The spreadsheet provides:

- The utility names and which counties they fall into,
- the population, and
- total finished water for 2013.

In addition, Patrick Martin also provided a geographical information system file which contained the service area of the utilities. Figure 7 shows the original GIS files for modification. Also there is no data within the attributes section to the GIS file provided.

Geographical Information System Files

The geographical information system files within this research where obtained from contacting Dr. Mitsova from the Urban Planning department at Florida Atlantic University. Dr. Mitsova was able to share Palm Beach, Broward, and Miami-Dade County ArcGIS maps through a USB transfer of files. The original data for Palm Beach County, Broward County, and Miami-Dade County can be found in Figure 8, Figure 9, and Figure 10, respectively, with a combined view in Figure 11.



COUNTY	UTILITY NAME	2013 TOTAL FINISHED WATER	2013 TOTAL RES. FINISHED WATER	2013 UNIFORM GROSS PER CAPITA 2013	2013 UNIFORM RESIDENT PER CAPITA 2013	2013 RES. POP.	2013 POP. (from WSPs)	2012 TOTAL FINISHED WATER	2012 TOTAL RES. FINISHED WATER	2012 UNIFORM GROSS PER CAPITA 2012	2012 UNIFORM RESIDENT PER CAPITA 2012	2012 RES. POP.	2012 POP. (from WSPs)	2011 TOTAL FINISHED WATER	2011 TOTAL RES. FINISHED WATER	2011 UNIFORM GROSS PER CAPITA 2011	2011 UNIFORM RESIDENT PER CAPITA 2011	2011 RES. POP.	2011 POP. (from WSPs)
BROWARD	BROWARD COUNTY WATER & WASTEWATER SERVICES DISTRICT 1	7.16	3.05	95	40	75,410	71,395	7.32	0.00	92.36	0.00	79,259	71,395	7.86	0.00	106.88	0.00	73,538	71,395
BROWARD	BROWARD COUNTY WATER & WASTEWATER SERVICES DISTRICT 2A/NORTH REGIONAL	12.18	7.38	107	65	113,561	110,939	11.94	0.00	103.69	0.00	115,150	110,939	12.49	0.00	119.89	0.00	104,186	110,939
BROWARD	COOPER CITY UTILITY DEPARTMENT	3.02	2.38	94	74	32,136	28,543	2.95	2.75	100.06	93.06	29,501	28,543	2.74	2.52	88.47	81.39	30,948	28,543
BROWARD	CORAL SPRINGS CITY OF	5.96	5.96	90	90	66,158	58,029	6.75	6.75	102.03	102.03	66,158	58,029	2.20	2.21	33.25	33.47	66,158	58,029
BROWARD	CORAL SPRINGS IMPROVEMENT DISTRICT	3.88	3.10	105	84	36,988	36,969							4.45	4.21	109.43	103.53	40,664	58,029
BROWARD	DANIA BEACH CITY OF	2.05	0.89	121	53	16,902	14,840	2.30	1.05	151.37	69.10	15,194	14,840	2.23	1.12	134.69	67.64	16,557	14,840
BROWARD	DAVIE TOWN OF	3.99	0.99	132	33	30,312	27,548	4.14	3.65	126.61	111.62	32,700	27,548	4.17	3.61	127.52	110.40	32,700	27,548
BROWARD	DEERFIELD BEACH CITY OF	8.80	7.21	164	134	53,781	51,842	8.74	7.52	166.44	143.21	52,511	51,842	9.50	8.74	178.51	164.33	53,196	51,842
BROWARD	FORT LAUDERDALE CITY OF	38.12	38.12	177	177	215,444	212,945	38.14	38.14	177.03	177.03	215,444	212,945	NULL	NULL				212,945
BROWARD	HALLANDALE BEACH CITY OF	5.51	4.51	144	118	38,173	37,113	5.50	4.52	133.36	109.62	41,242	37,113	5.50	4.52	139.57	114.73	39,406	37,113
BROWARD	HILLSBORO BEACH TOWN OF							0.63	0.57	247.65	222.89	2,556	1,875	0.74	0.74	245.00	245.00	3,000	1,875
BROWARD	HOLLYWOOD CITY OF	20.92	15.84	148	112	141,251	186,798	21.02	15.84	112.36	84.67	187,078	186,798	21.01	15.84	150.16	113.21	139,922	186,798

Figure 6. Original water use data provided by SFWMD.

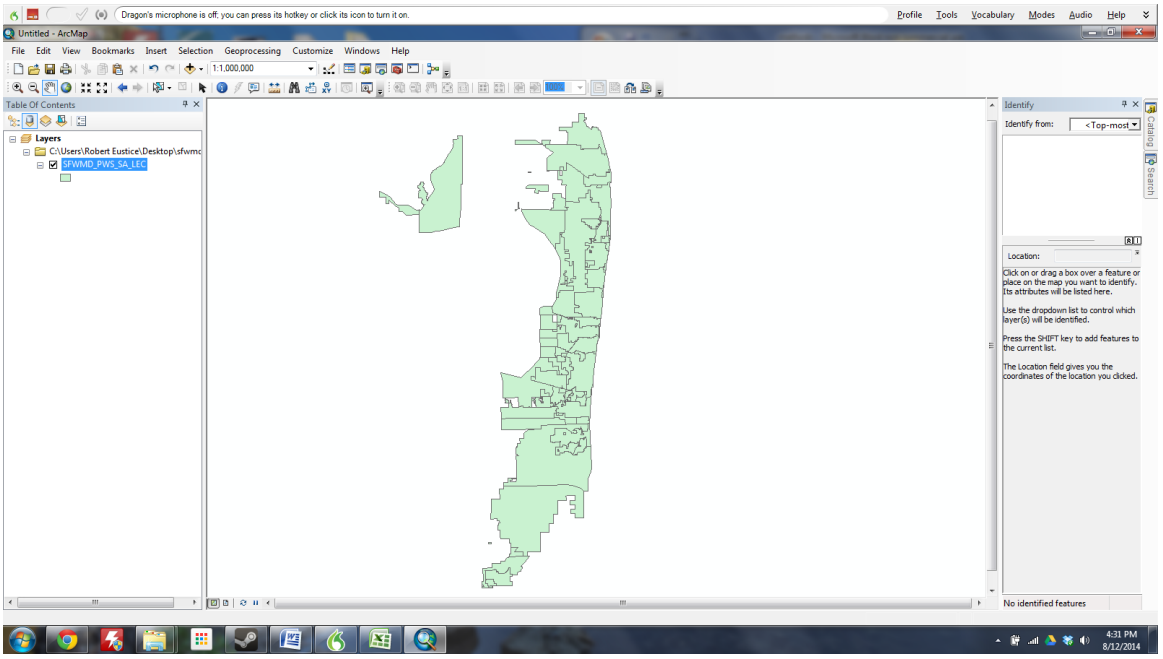


Figure 7. Original SFWMD GIS files.

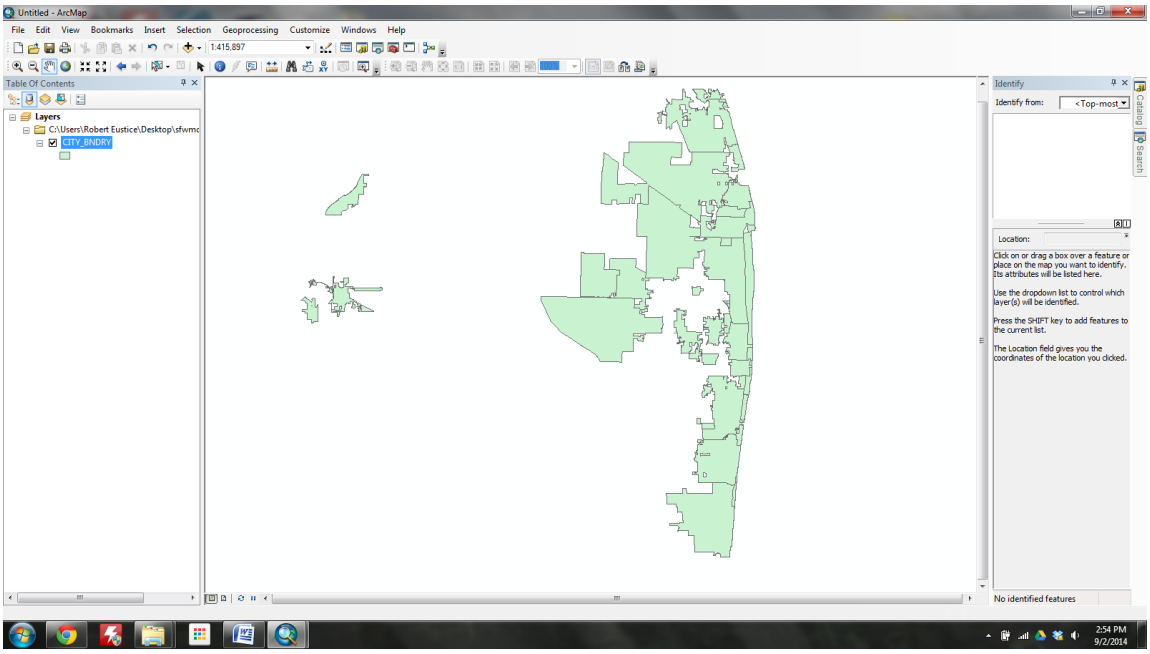


Figure 8. Original Palm Beach County GIS files.

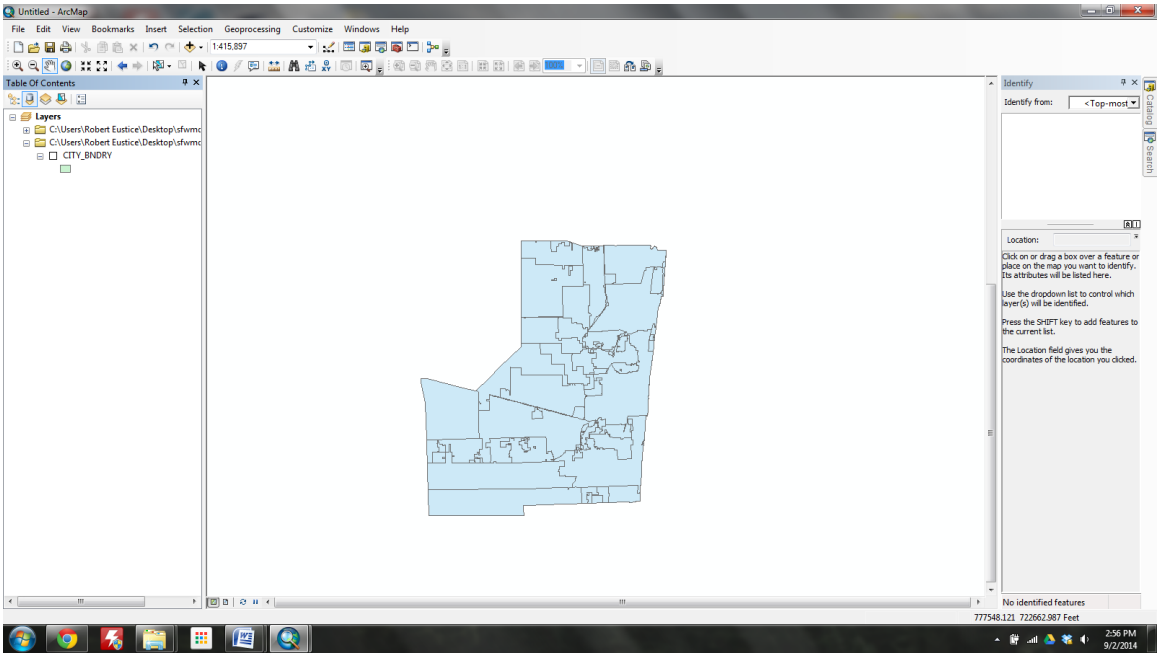


Figure 9. Original Broward County GIS files.

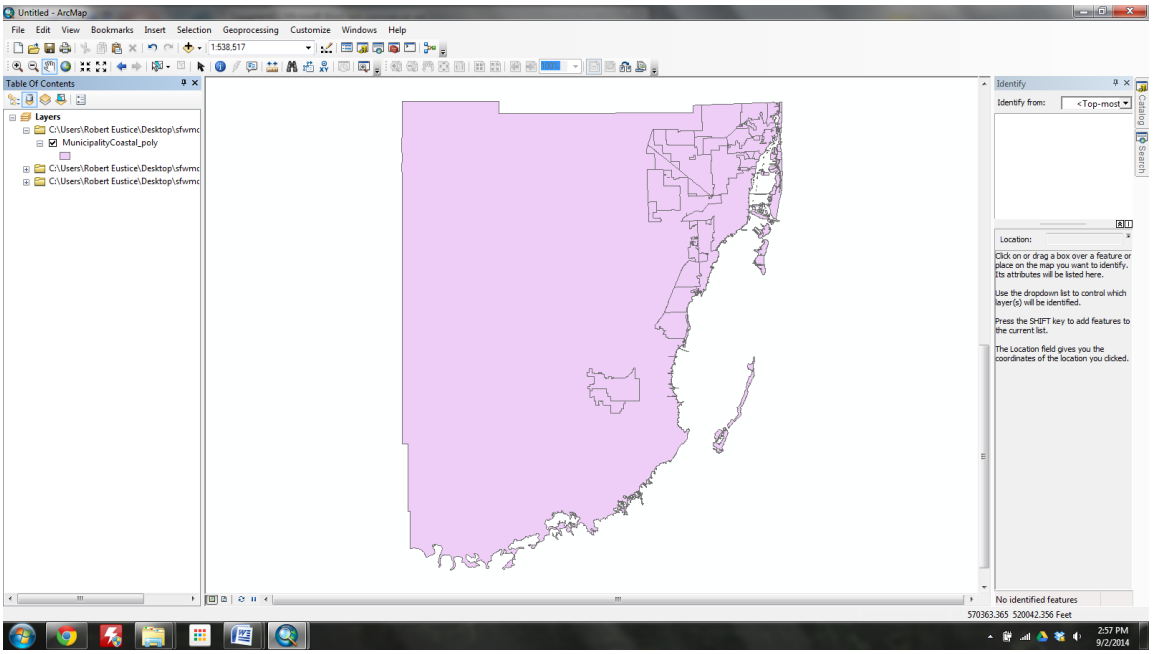


Figure 10. Original Miami-Dade County GIS files.

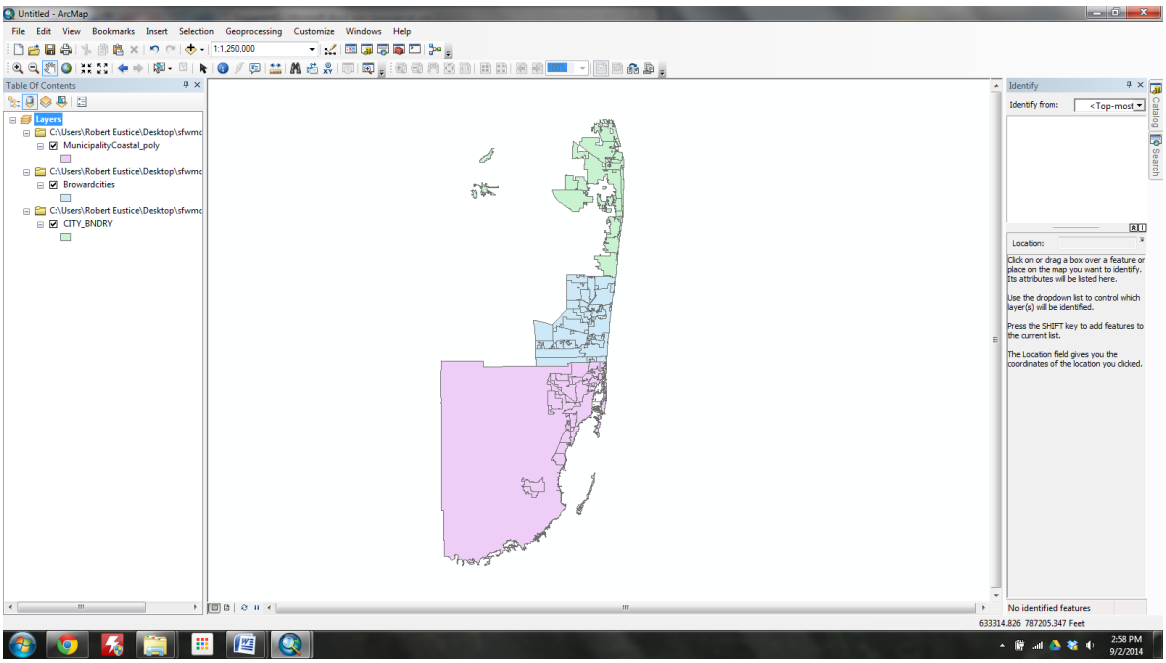


Figure 11. Combined Original Palm Beach, Broward, and Miami-Dade GIS files.

This research will also utilize information stored in each counties shape file that can be located in the attribute table. Attribute table has each cities name that corresponds

to the polygon and that helps make up the County. By right clicking on the cities layer located within the table of contents section of arc GIS, there will be a drop down menu with the title attributes table. Clicking on this will open a new window, which will look like Figure 12. The names found within this area will be utilized in the search for economic data through the American FactFinder website powered by the Census Bureau.

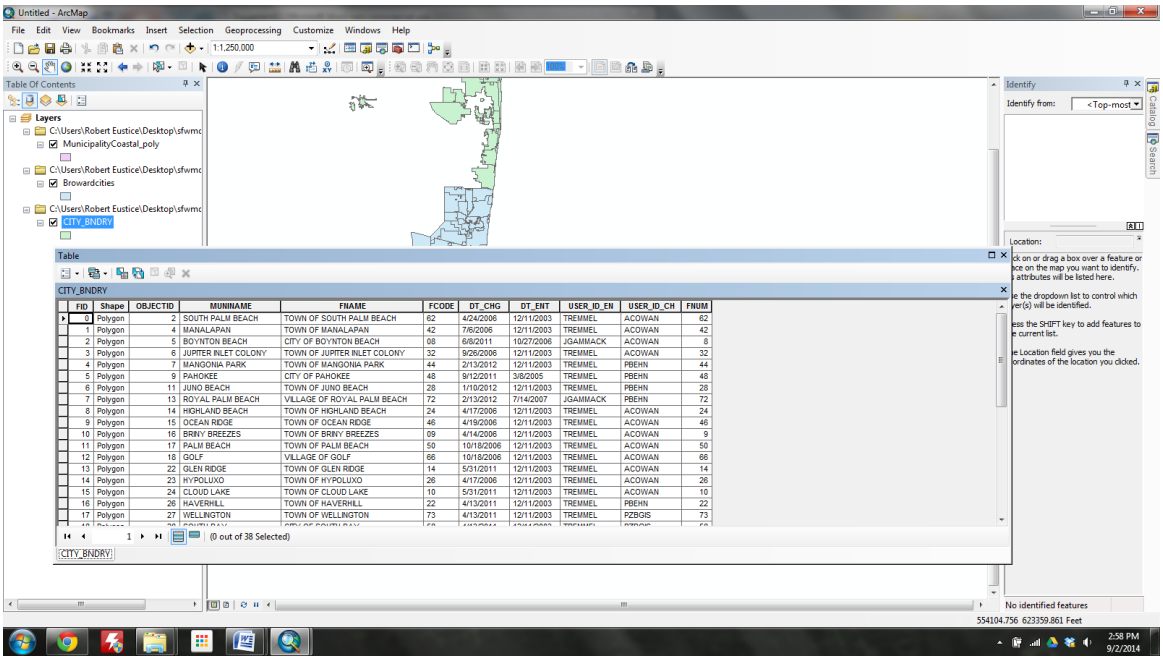


Figure 12. Palm Beach County attributes table of city names.

Economic Data

The United States Federal Census was used to find the needed economic data associated to the economic activity of a given city. The first step to locate this information would be to either Google® American Fact Finder, or to go to http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml. Following the given link above, it will take you to a site, which looks like Figure 13.

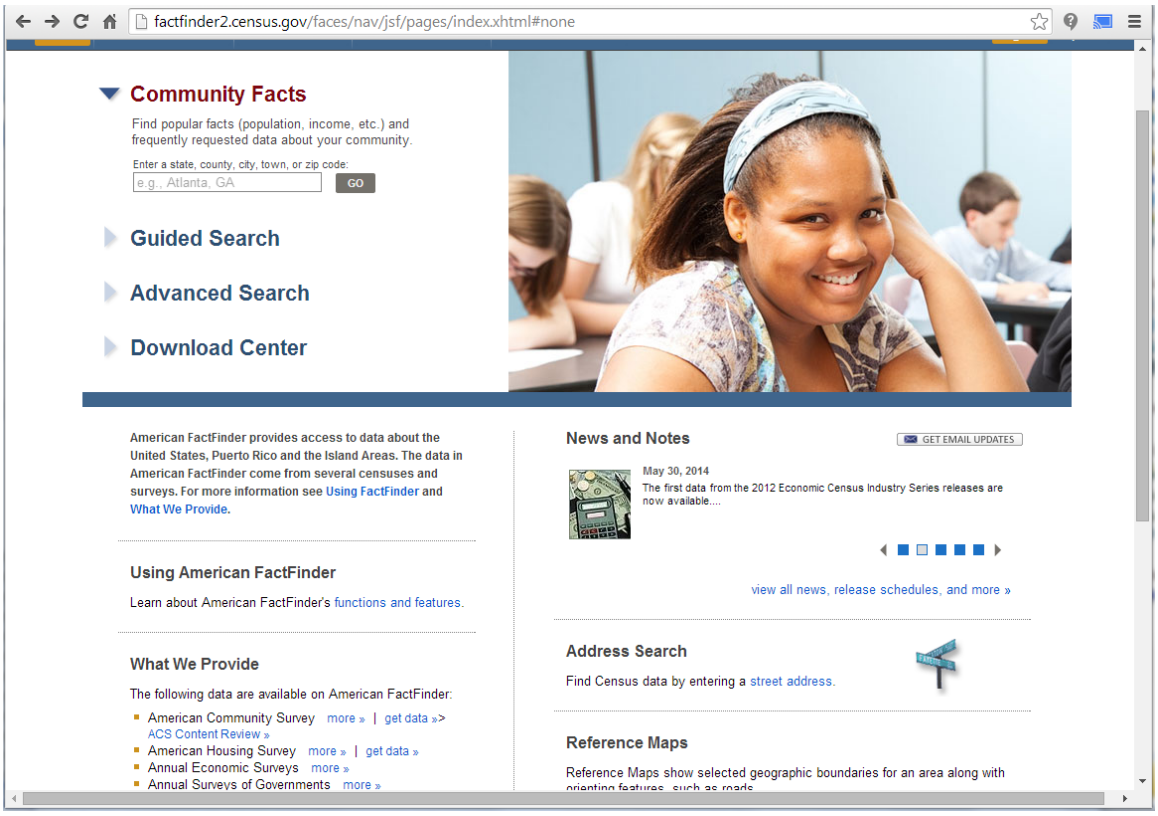


Figure 13. American FactFinder main page.

From the main page, clicking on advanced search will bring a drop down tab similar to the one seen in Figure 14; click on the text box area that says show me all.

After clicking on the show me all text box, it will bring you to a new page where data can be searched for and parameters can be set. The web site should now look like Figure 15.

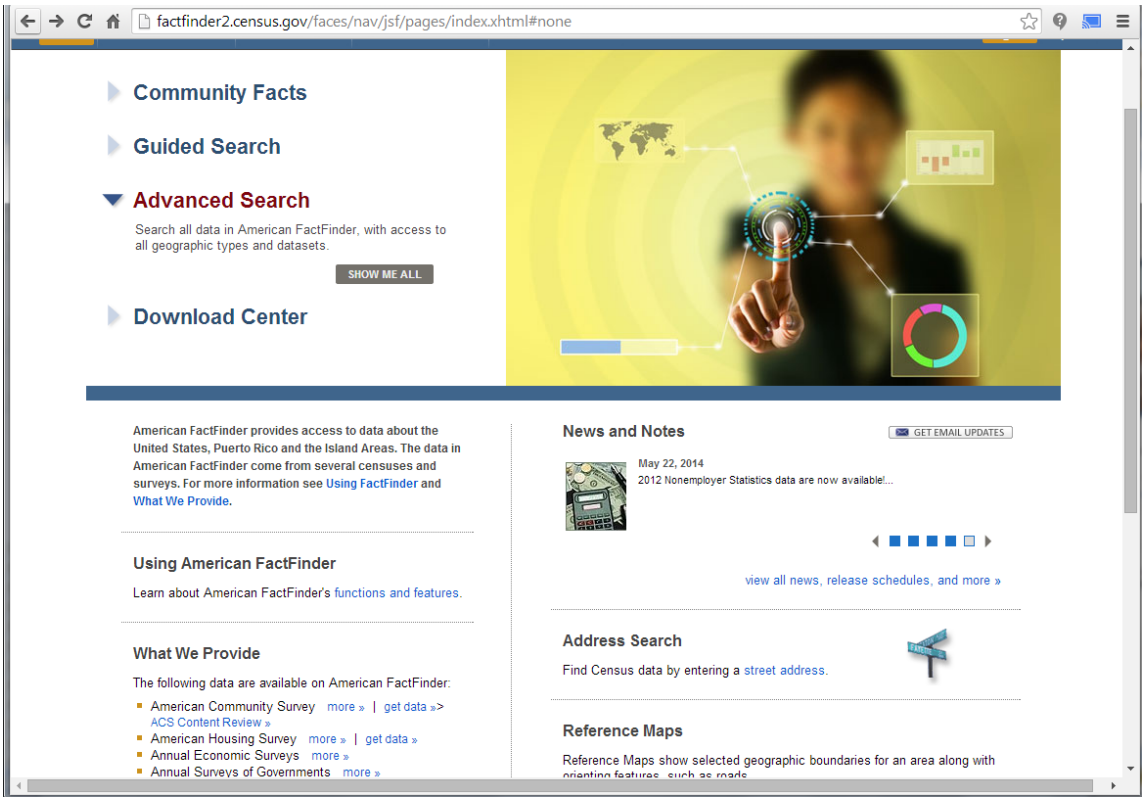


Figure 14. American FactFinder advanced search option.

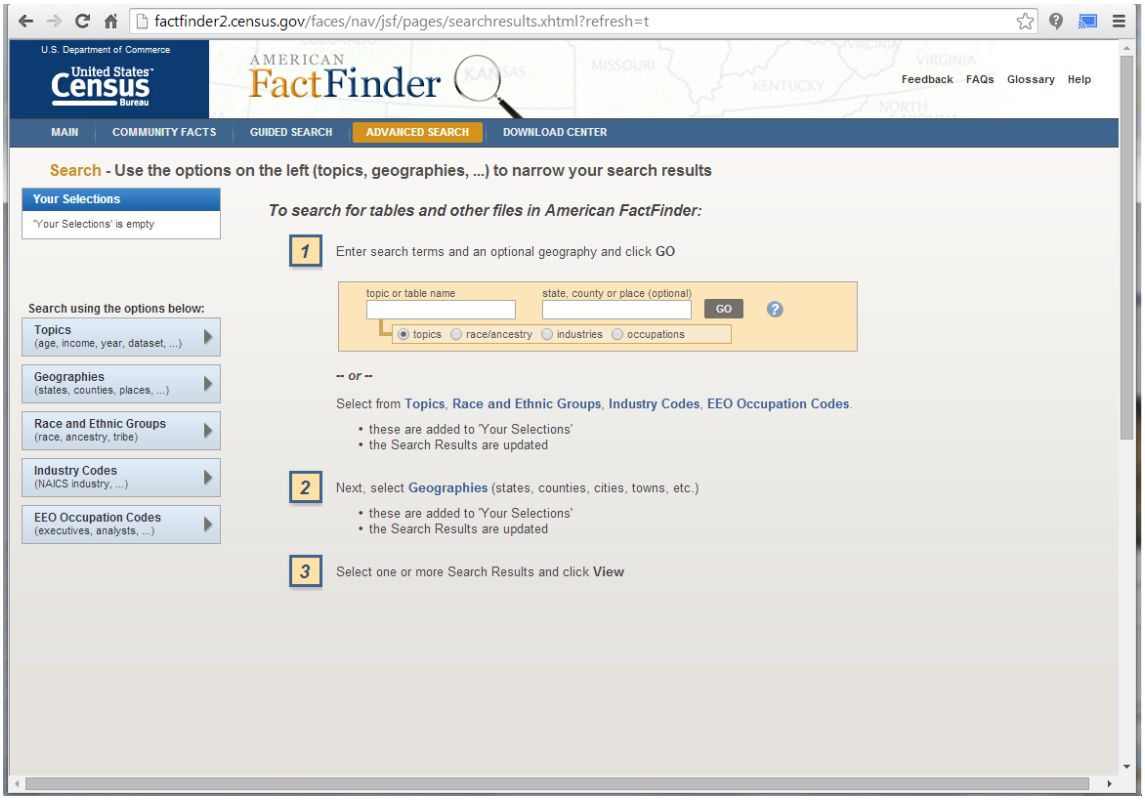


Figure 15. American FactFinder selection area.

To start selecting the data that will be used, the first step is to click on the box titled topics. This box can be found on the right side of the web side under the search using the options below menus. Clicking on this box will open a new window with several different areas of data. At the bottom of the list is one topic called Dataset. Click on Dataset and scroll down till 2007 Economic Census (790) is visible. It should look something like Figure 16.

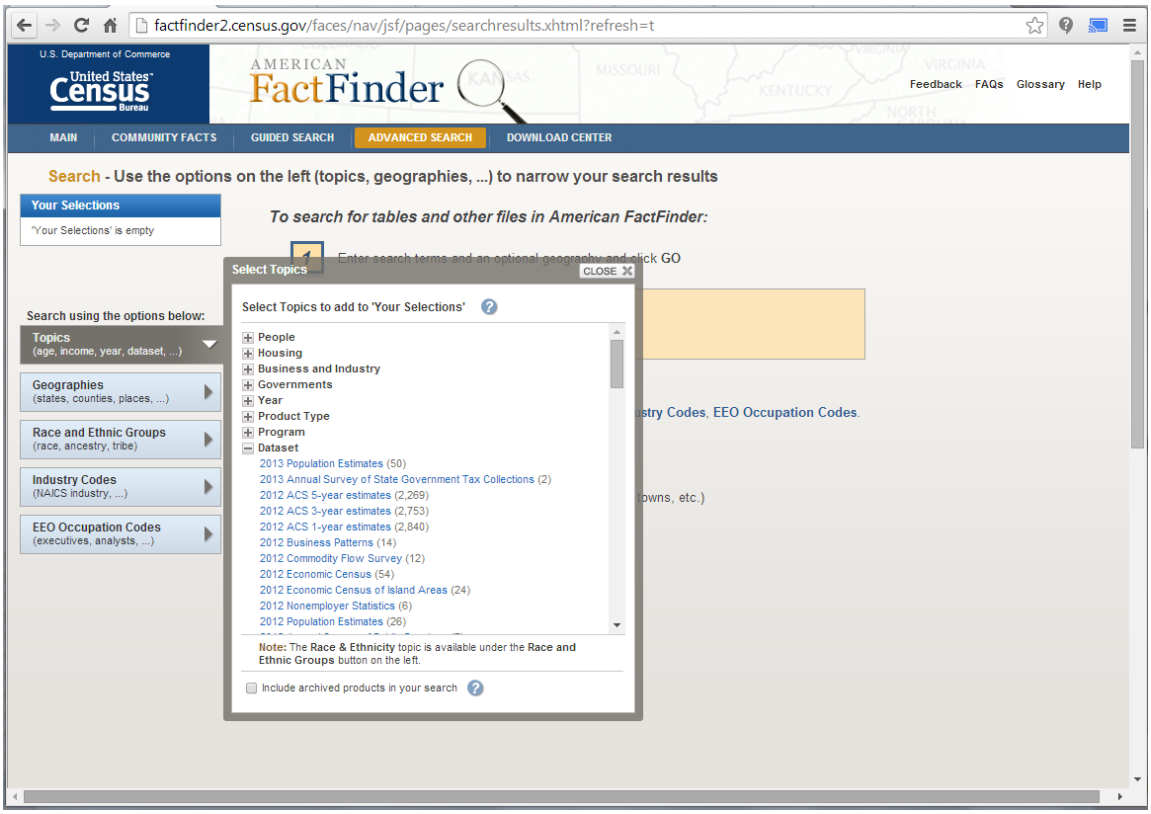


Figure 16. Selection of 2007 economic census.

Once 2007 Economic Census (790) is located, click on the name to have the dataset applied to your sections. This area can be located in the top right hand corner of the website. Figure 17 shows what your page should look like at this point.

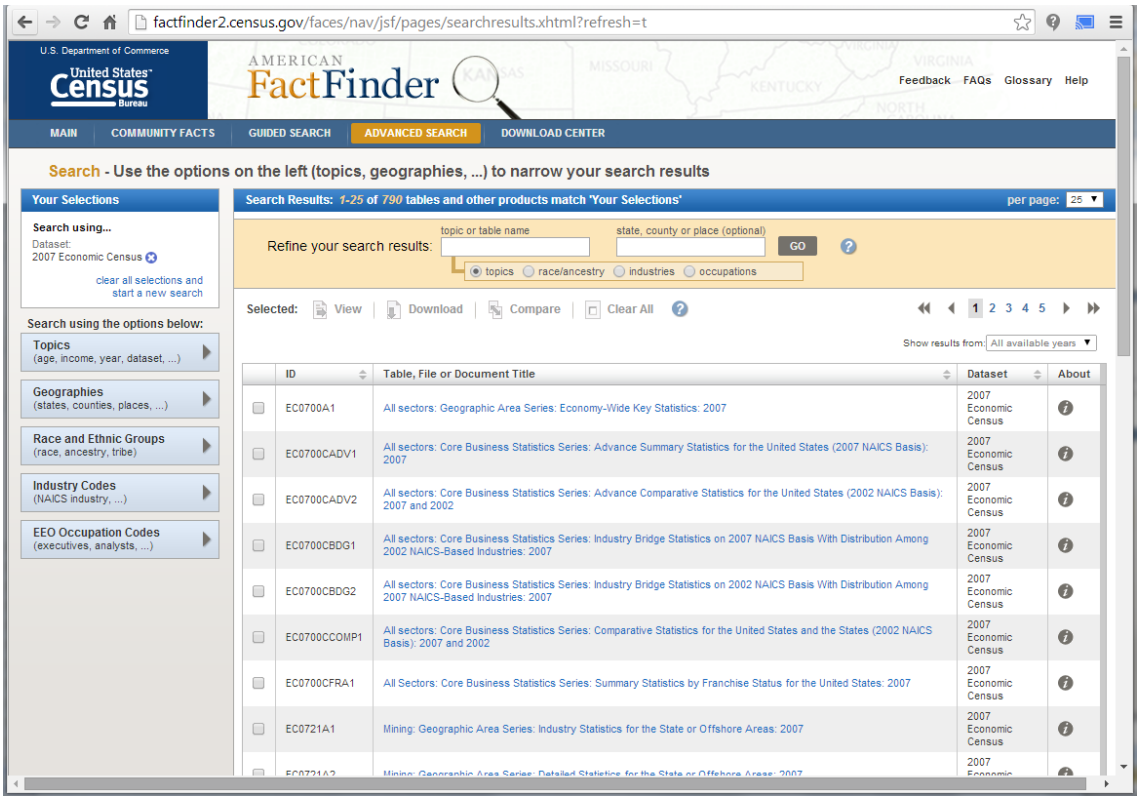


Figure 17. 2007 Economic census applied to search selections.

The next step is to choose the type of data that is needed from the 2007 Economic Census. To further refine the data, the next step is to click on Geographics, which can be found on the left hand side of the website right below Topics. After clicking on this box a new window will appear and the website should look like Figure 18.

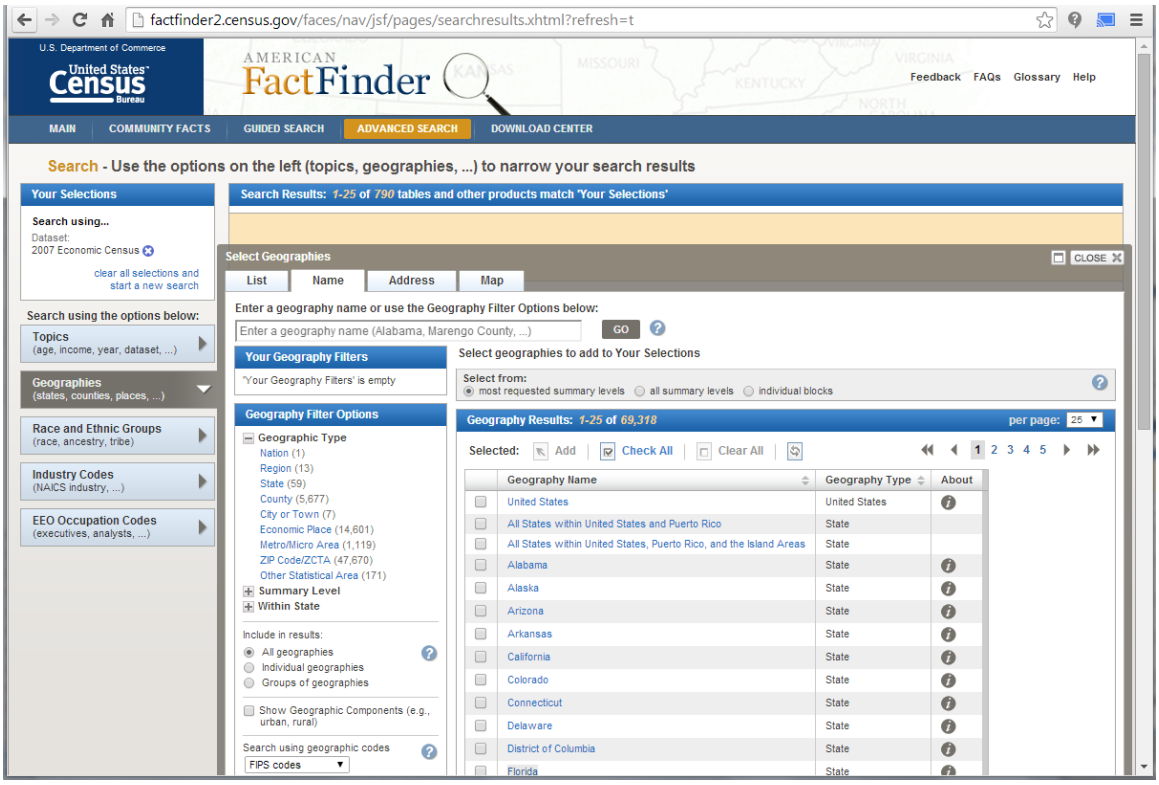


Figure 18. American FactFinder geographic's selection.

This new window that has opened is used to select the geographical area that is need. In this case, it would be easier to search by the name, which can be found from the GIS maps covered in section **Error! Reference source not found.**. Using ArcGIS, open the attribute table from the desired shapefile, in this case Broward County was used as an example, and use the names of the cities to look up the economic activity. Once a cities name is searched for the web site will change to look similar to Figure 19.

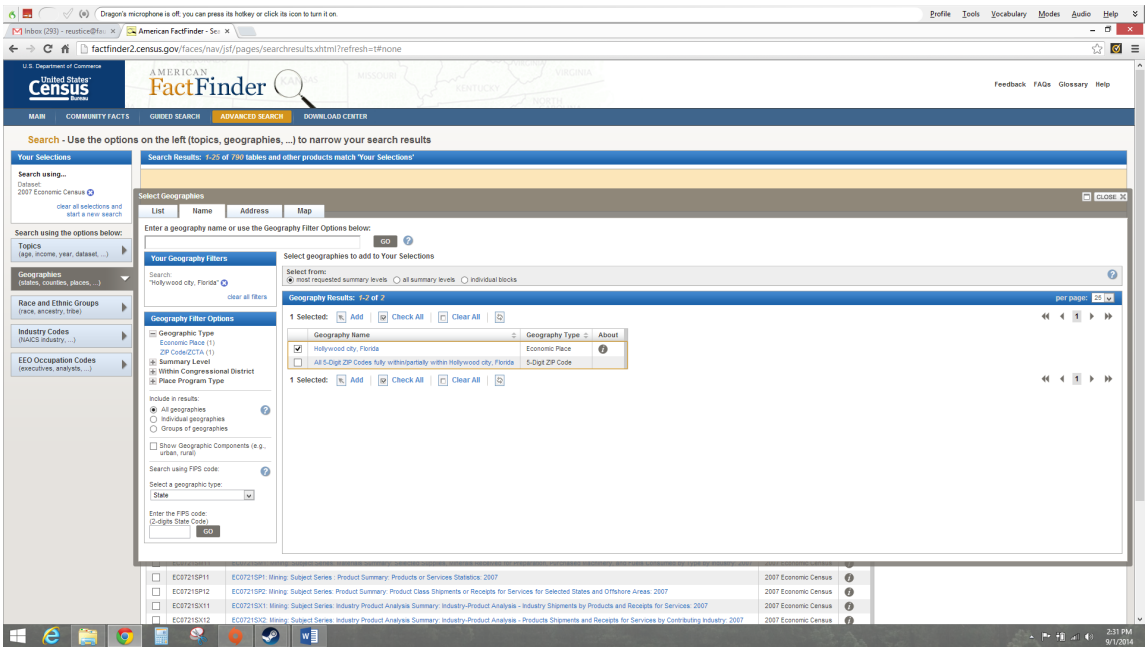


Figure 19. American FactFinder geographic name search.

After hitting go, search box will display new geographic based upon name entered. In this example, while searching for Hollywood city Florida, the returned results gave two available selections. Selection that was used was Hollywood city Florida with the geographic type of economic place. Check the box next to the correct item and hit the add button, which can be found below the returns searched items. The add button will add what you have selected to the "your selections" box found in the top left-hand corner. Repeat the city name search for all cities that are located in the County. After all desired cities are found close out the select geographies window. The website should now currently look similar to Figure 20. As a recommendation, the selection of economic activity should be done per County.

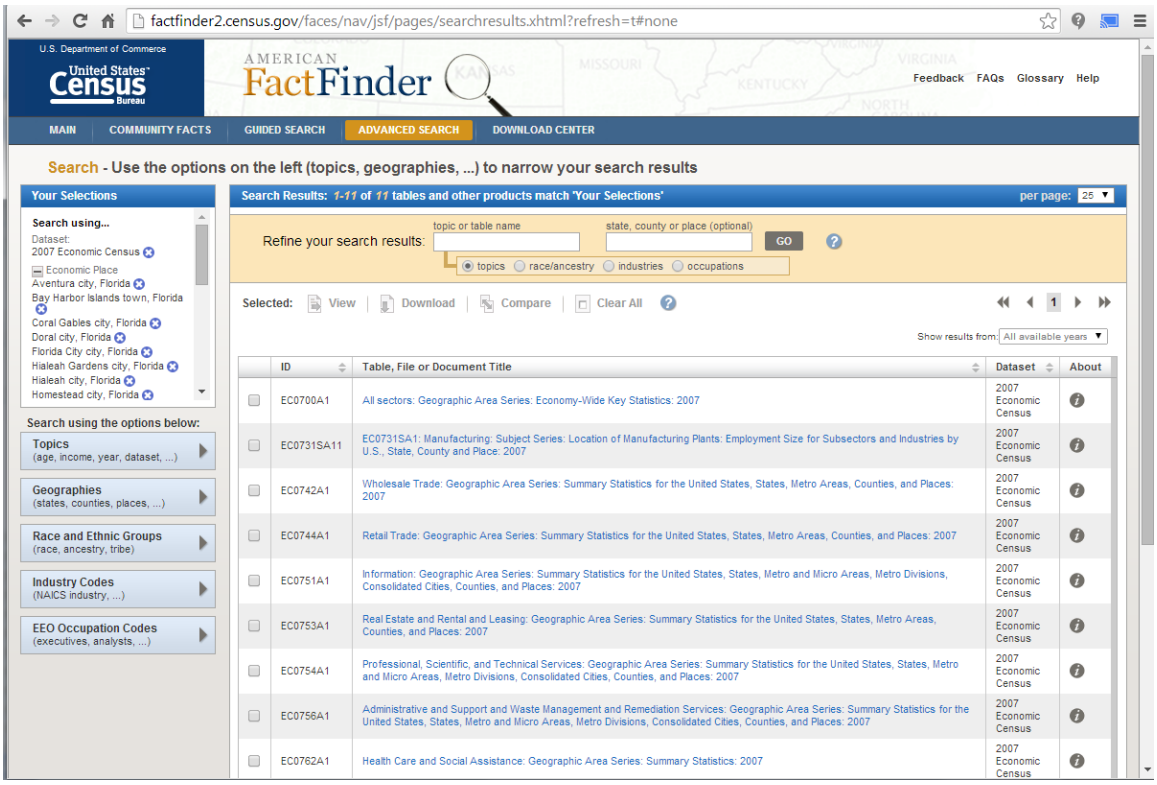


Figure 20. American FactFinder completed search selection.

Now that all the economic data has been located for a given County, the American Factfinder website will display all the data that matches the selected items from before. The first item that appears in the search results section of the website is titled “All sectors: Geographic Area Series Economy-Wide Key Statistics: 2007” is the data as needed for this research. The ID number is also unique to the type of data that is needed; it will always have an ID number of EC0700A1. Now that the desired information has been found, click on the title of the data set. Once this has been done it will bring you to a new window, which should now look like Figure 21. The title and ID Number will be the same or when other counties are searched for. It is important that when going on to search for data from other counties that the current selection of data it is cleared in the process is restarted.

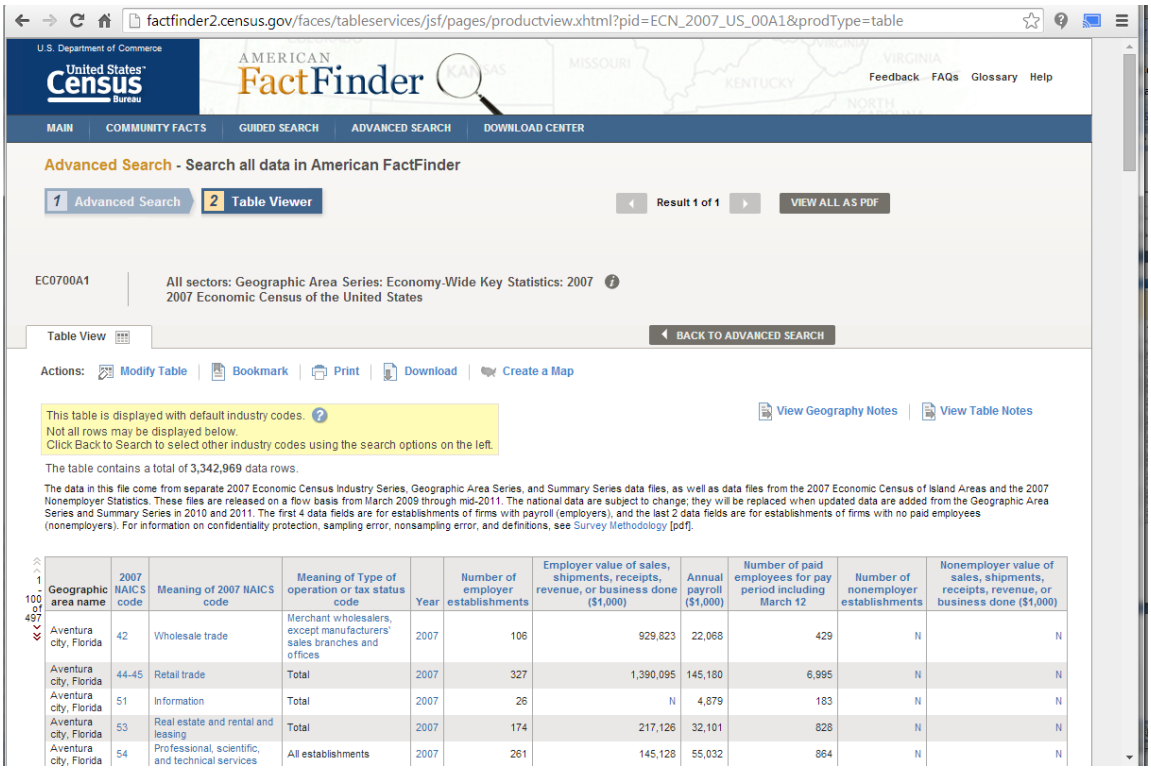


Figure 21. American FactFinder data selection for county economic activity.

Now that the data has been found is important to download this information to Excel for more comprehensive data analysis. To do so at the top of the page there is a download button clicking this will open a new window, which will look like Figure 22. This data is also broken up into different economic areas. There are 13 in total, and range from wholesale trade, retail trade, real estate, etc.

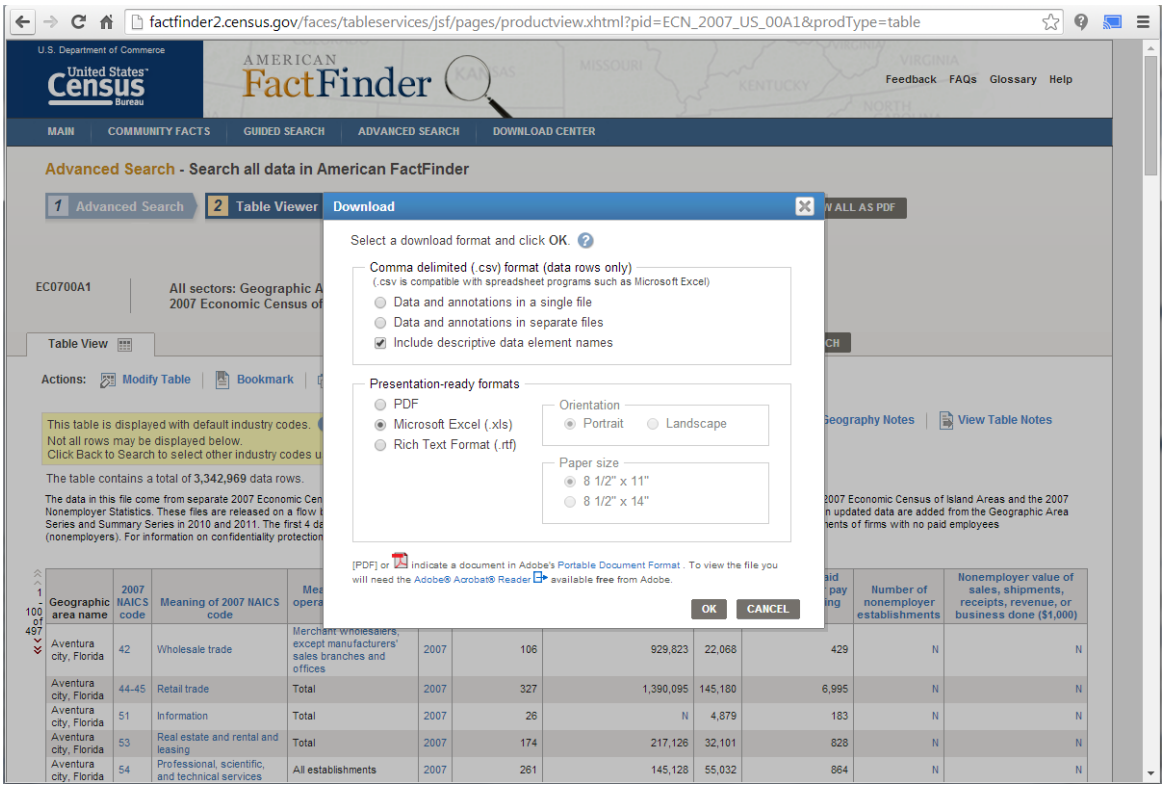


Figure 22. American FactFinder saving data.

Now that the download window has opened up, make sure at under presentation ready formats, that Microsoft Excel is chosen. The data will download as a zipped file. It is important to save all is related to this research in one area. Doing so will help make arc GIS in the data sorting phase runs smoother.

Data Sorting

At this point in the research the total finished water data was located from South Florida Water Management District and the economic data was gather from the American FactFinder website. The next step was taken in this research was to combine both of these data sets in order to make a clear conclusion. These steps can be seen in the Combining Data section of this report.

Combining Data

To combine the data, open the South Florida Water Management's District's total finished water Excel sheet that was found in the Water Use Data section of this report. To make things easier, hide columns C through I. This can be done by clicking on the column letter and dragging the cursor over to I and releasing the mouse button. Now right-click on the selected columns, and select "hide." Another way to make things easier is by color coding each County found in column A with a different color. Color coding will become very important in this section. Color coding allows information to be more easily sorted and helps reduce confusion. In order to find out which city is serviced by which municipality arc GIS was used. Take the shape file provided by South Florida Water Management District and overlaying it with the County shape files. Then go into the attributes table of each shape file, and with the selector tool, click on one of the cities name. Now look at that map view. The city that was selected will now be highlighted in the map view. Use the identification tool to find out which utility that city lies within. Once this information has been identified, create a new row underneath the utilities name that has been found. In the letter V column of Excel write down the cities name. Repeat this process for all cities within all three counties. When dealing with Broward County and some portions of Miami-Dade County it was found at some cities had multiple utilities that serviced that municipality. To sort out these issues, please refer to the Future land use section. At this point the Excel sheet should look similar to Figure 23.

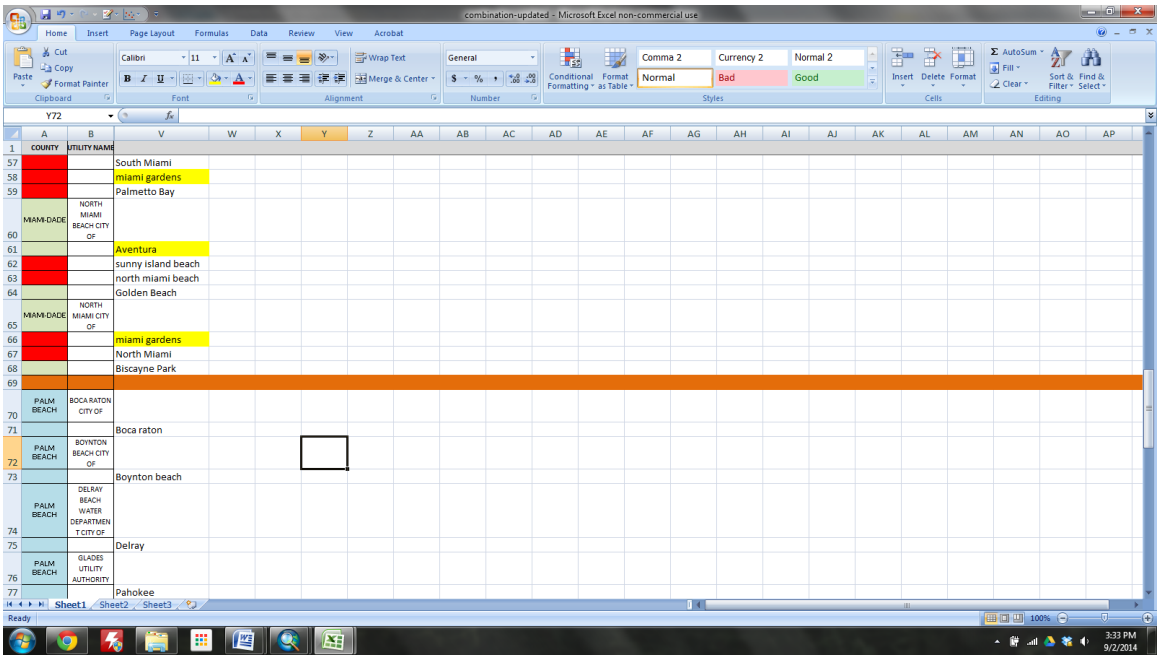


Figure 23. Sorting city utility provider.

The data that was obtained in the Economic Data section of this report should be unzipped from its compressed file format and opened. This data will look like Figure 24. The data found within this Excel sheet from American FactFinder will need to be copied into the master spreadsheet. Copy only the data from row five down to when the table ends. Paste this data into a new tab in the master spreadsheet which has formally been known as Excel spreadsheet from South Florida Water Management District. Label the new tab when the data has been pasted with the correct County at data originated from. Repeat this step for all three counties.

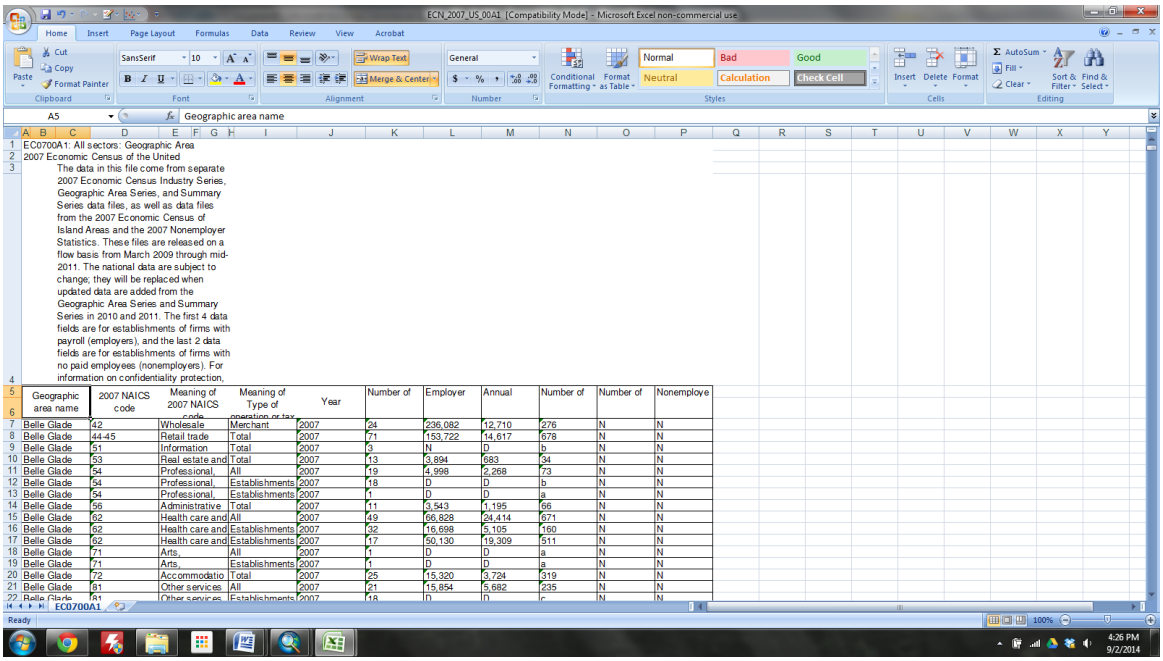


Figure 24. American FactFinder unzipped economic data.

Once all data has been pasted into its correct location, it will be now time to color code various items. Color and entire cities data with one color, in the city that comes after it with another. Repeat this process so that there is an oscillating color change. Next right-click on the letter L column and create a new column. This new column needs to be created to allow the data in column L to be cleaned up for use. In column M, row three type the following formula.

$$= \text{VALUE}(\text{TRIM}(\text{CLEAN}(\text{L3})))$$

The data in column L has unique characters which prevents Excel from accepting them within formulas. The formula applied in column M basically removes spaces while also removing nonprintable characters. This formula should also be applied to the entirety of column M, and after that is finished excel should currently look like Figure 25.

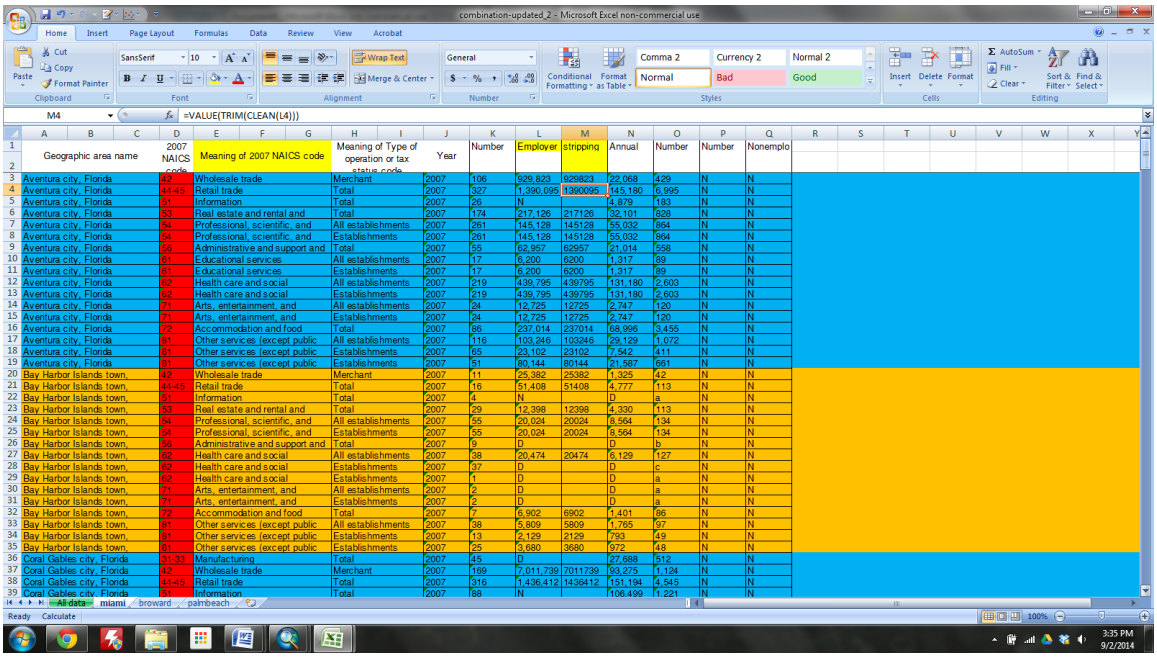


Figure 25. Adding economic data to master excel sheet.

On the main page of the master Excel file, the sheet with data from South Florida Water Management District will from henceforth be referred to as the All Data Sheet. On the All Data sheet, create labels for the types of Economic data that was found. The categories are:

- Manufacturing
- Wholesale trade
- Retail trade
- Information
- Real estate & rentals
- Professional, scientific, and technical services
- Administrative and support and waste management and remediation services
- Educational services

- Health care and social assistance
- Arts, entertainment, and recreation
- Accommodation and food services
- Other services (except public administration)
- Total

These categories come from the data found from American FactFinder, but the names can be changed or shorted for personal preference. Start the adding the categories in cell X2. Now going back to the cities names that where added under it's correspond utility that served the municipality; the SUMIF formula was used to bring the economic data from the county sheets to the All Data sheet. An example of how the formula was setup can be seen below.

$$= SUMIF(palmbeach!\$E\$20{:}\$G\$41, x2, palmbeach!\$M\$20{:}\$M\$41)$$

Use the SUMIF function to capture and bring the appropriate data to the All Data page and if all is done correctly should look similar to Figure 26.

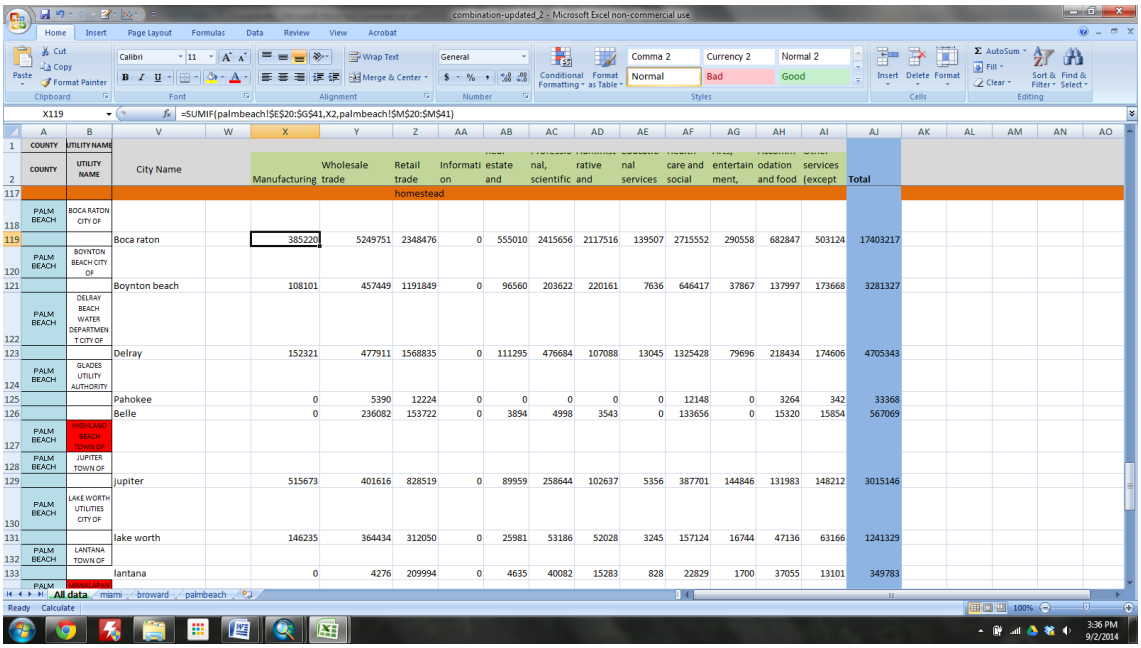


Figure 26. Main data sheet with SUMIF formula applied.

The overlaps that are in Broward County and Miami-Data County will be solved by using Future Land use and requiring the shape files to be split up. Any overlaps where highlighted in yellow to insure these issues would be addressed. At this point, the All Data sheet should look like Figure 27.

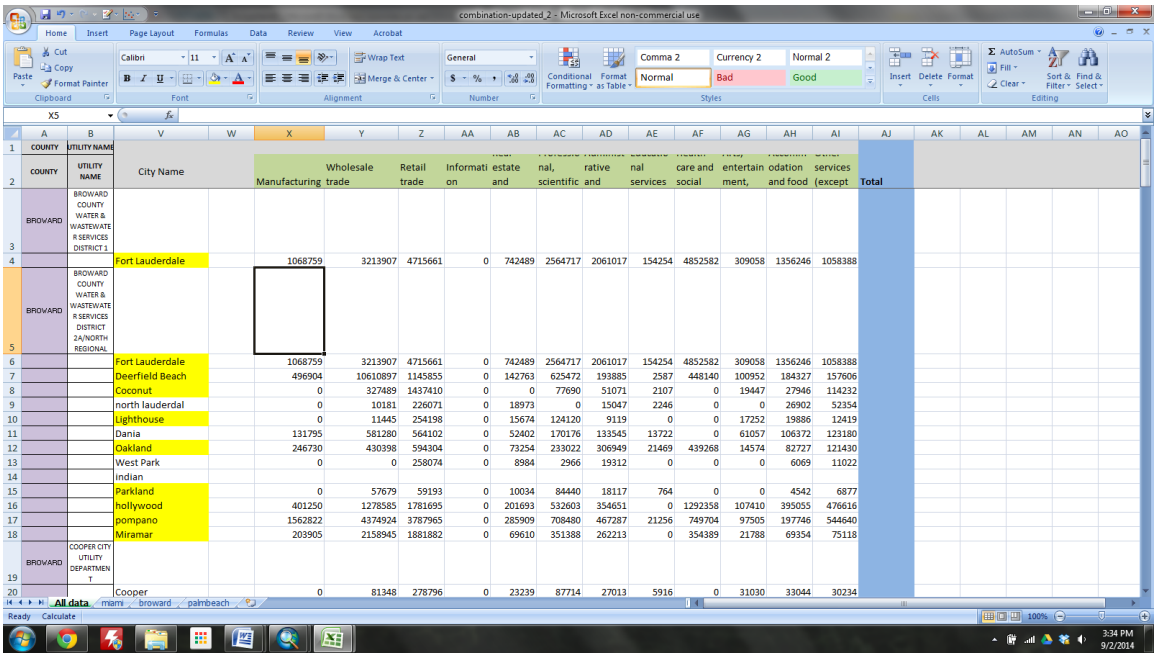


Figure 27. All data sheet highlighted overlaps.

Future Land Use

Future land use files are needed in this portion of the research for Broward County. The way the water service areas are laid out are in a way that some utilities provide water across multiple cities. So the way that was chosen to separate out each cities portion is to use the land use files; and identify the amount of businesses within each service area and use GIS to split these into ratios of water per city.

The necessary data can be found from Broward County Planning Councils website. Following the following link will take you to the page where this data was taken from: http://www.broward.org/PLANNINGCOUNCIL/Pages/gisdata.aspx

Once on this page, download the Future Land Use Plans zip file. Extract the data and add it to GIS. Open the attributes table. At this point it should look like Figure 28.

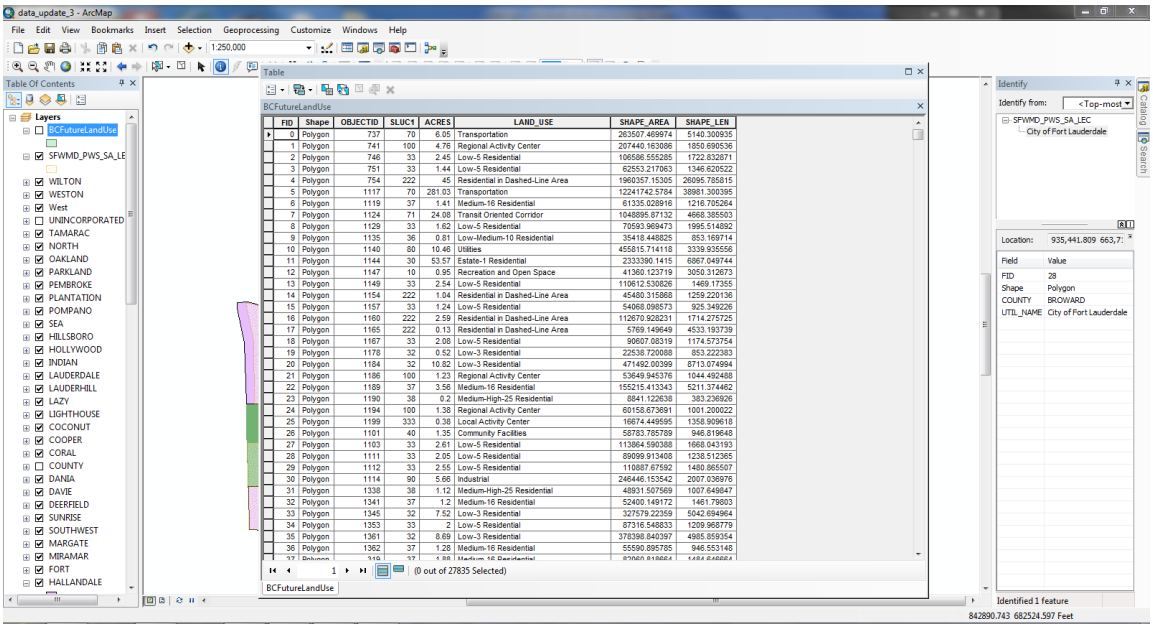


Figure 28. Future land use attributes table.

Open the select by attributes box. This tool is needed because the future land use file downloaded has a wide range of land use types and needs to be narrowed down to only what is needed. At this point the program should look like Figure 29.

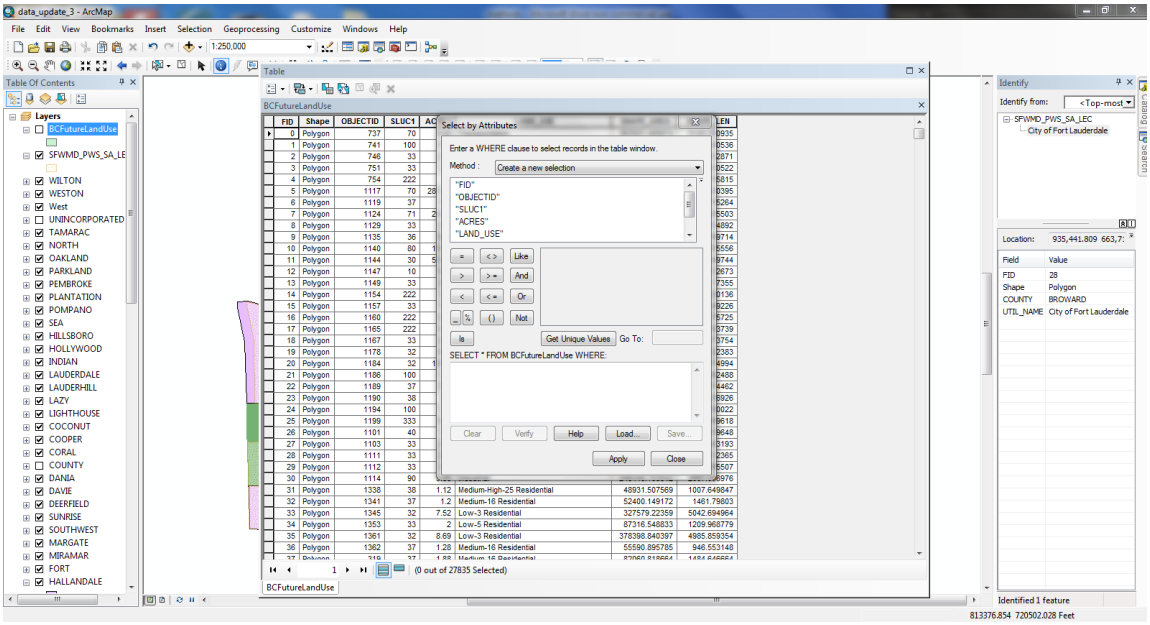


Figure 29. Future land use attributes selector.

In the method section of the window click on “LAND_USE”, this will be the area in the attributes table the search will be narrowed too. Click on the “equal” symbol. Now click on get unique values, and click on “Commercial.” Repeat this processes for the following, and be sure to include the OR symbol in between each entry.

- Commercial Recreation
- Employment Center-High
- Employment Center-Low
- Industrial
- Office Park

When finished the selection box should look like Figure 30.

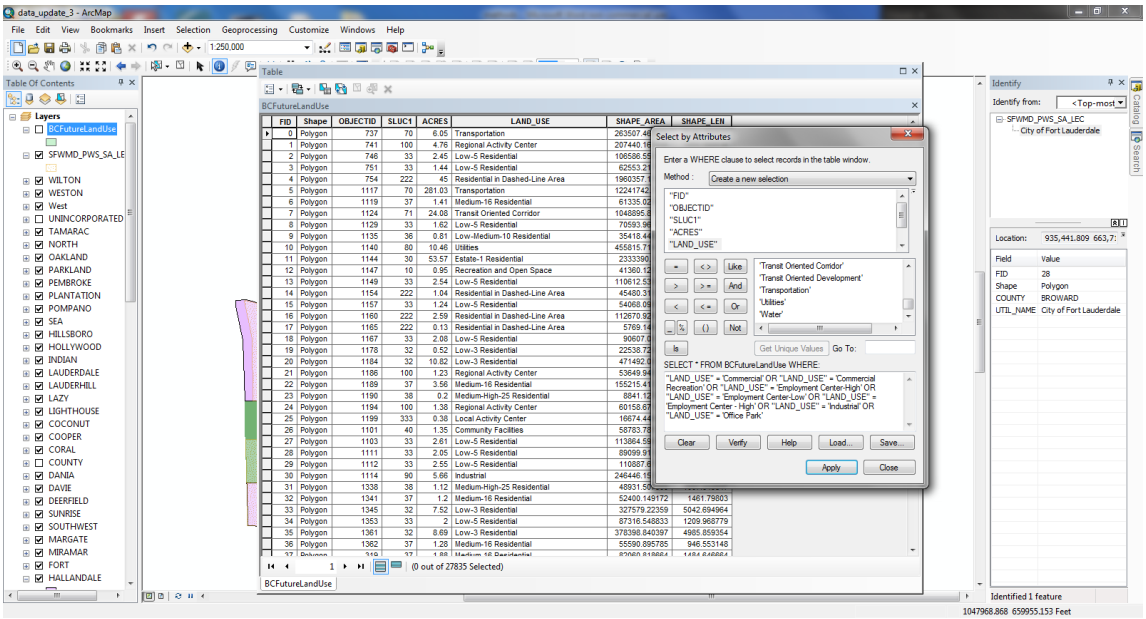


Figure 30. Attributes table formula string.

After the formula has been entered, hit the apply button at the bottom of the select by attributes window. The ArcGIS will now look like Figure 31.

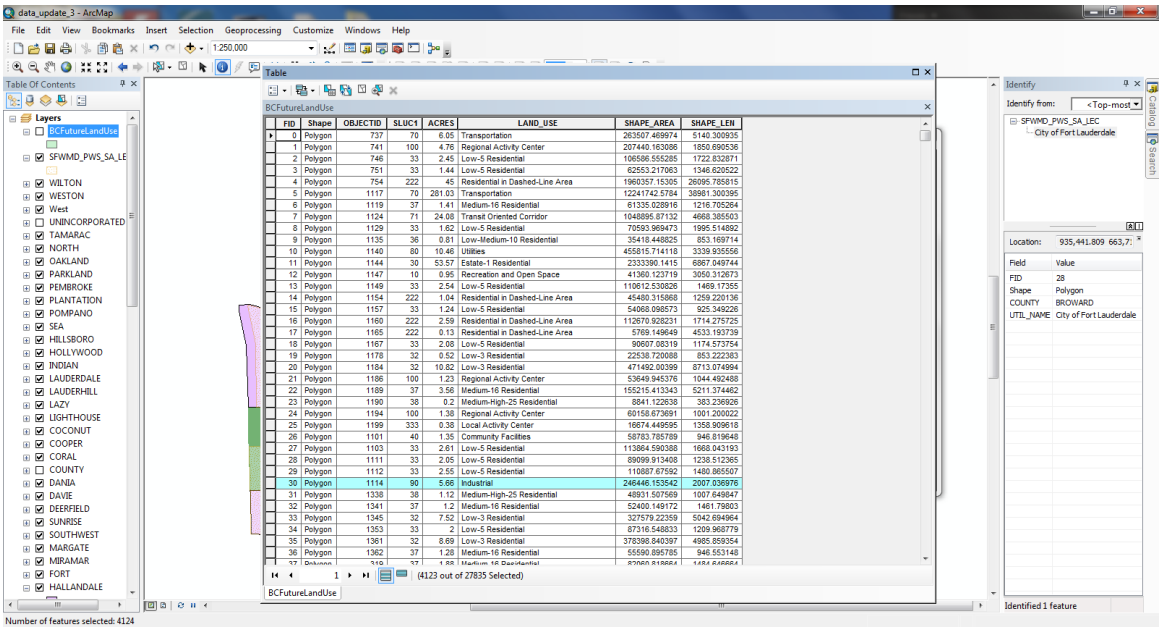


Figure 31. Attributes table selection with highlights.

To condense the highlighted search selections, click on Show selected records. This can be found at the bottom on the table, next to the displaced number of selected records. At this point the program will look like Figure 32.

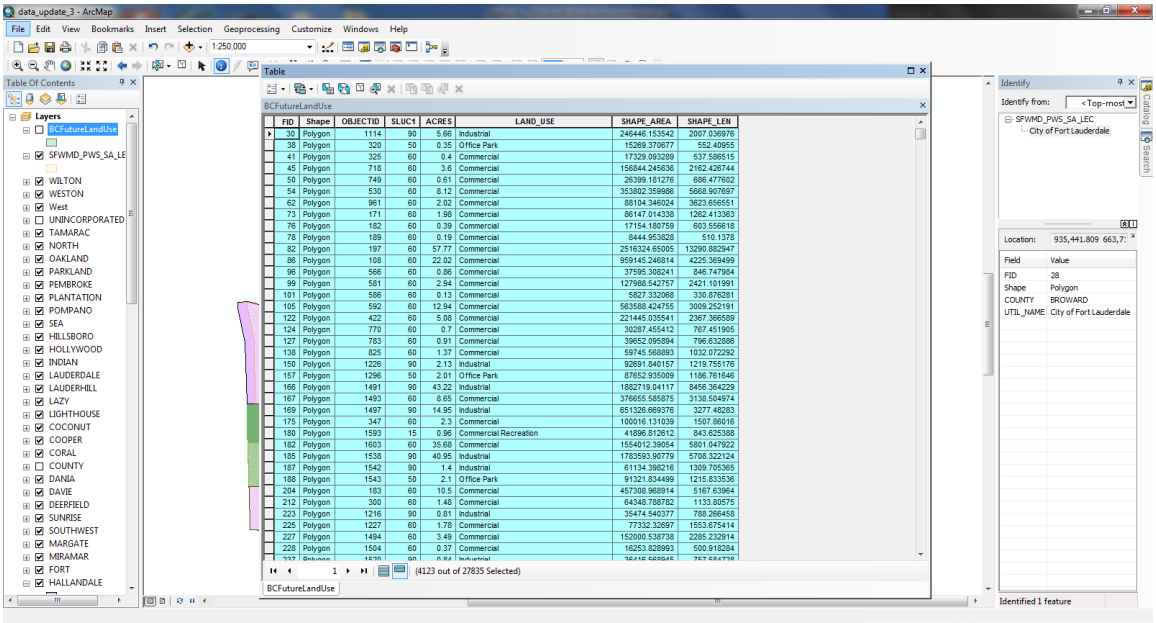


Figure 32. Condensed selected attribute table records.

A new shape file needs to be created from the selected records found in the future land use file. To do this, right click on the file in the layers management area in the table of contents window. Go down to selection and then over to create layer from selected features. Figure 33 shows a more visual path to get to this option in ArcGIS.

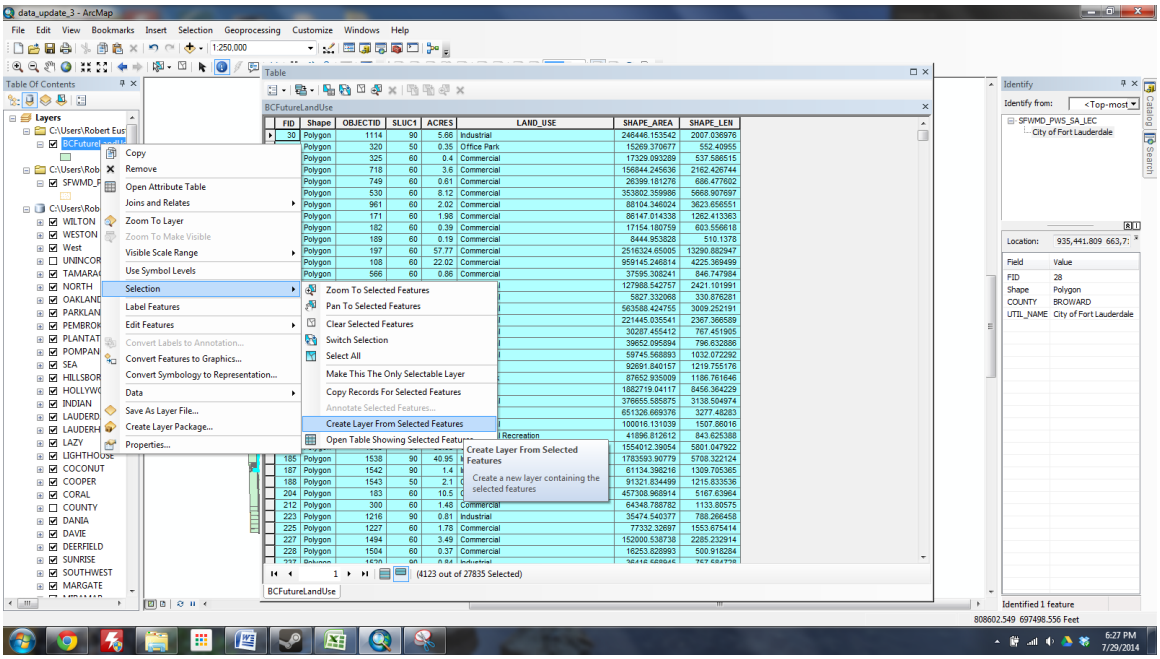


Figure 33. Creating new layer from selected features.

Split Up The Data Now

After the records have been exported into a new feature class from the highlighted records; the data needs to be cleaned up some more to only include Browed County data. Using ArcGIS, the Broward County shapefile will have the cities separated and used to create a new feature class of each individual city. First use the original Broward County shapefile to Clip the South Florida Water Management Districts Utility shapefile. This

will create a new layer with only the utilities that are within Broward County. Figure 34 shows the tools setup before being applied.

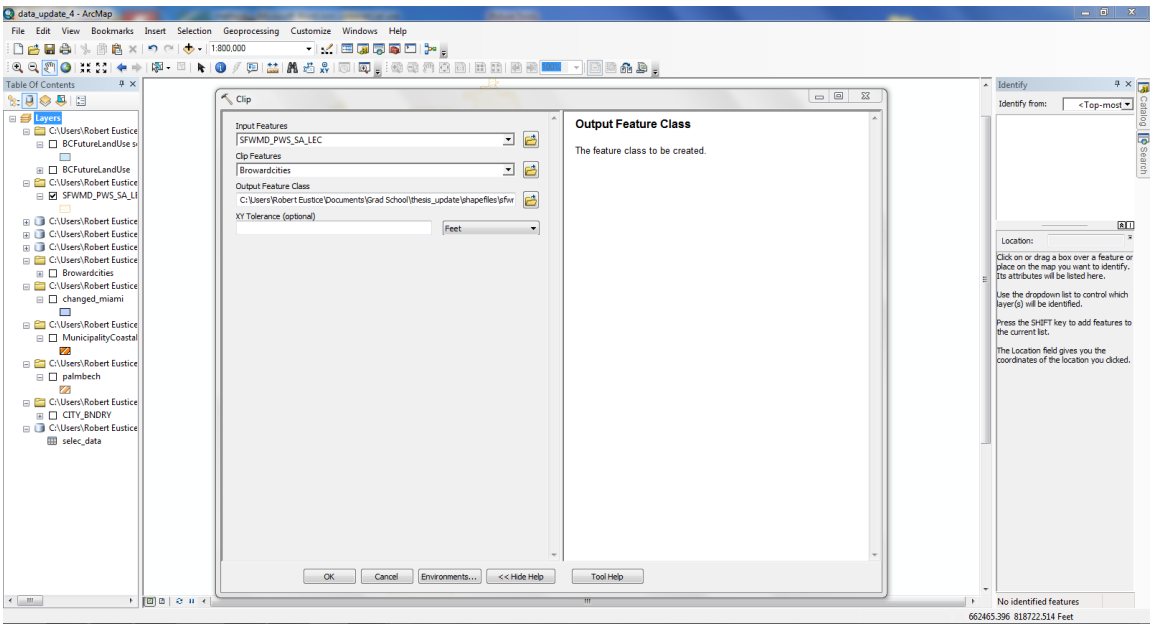


Figure 34. Clipping utilizes to Broward County.

Going back to the master list that is in excel, look for where cities appear to be serviced by more than one utility. If any are found mark them in anther color, in this case yellow, so that further data refinement can be done for these areas. An example of this process can be seen in Figure 35.

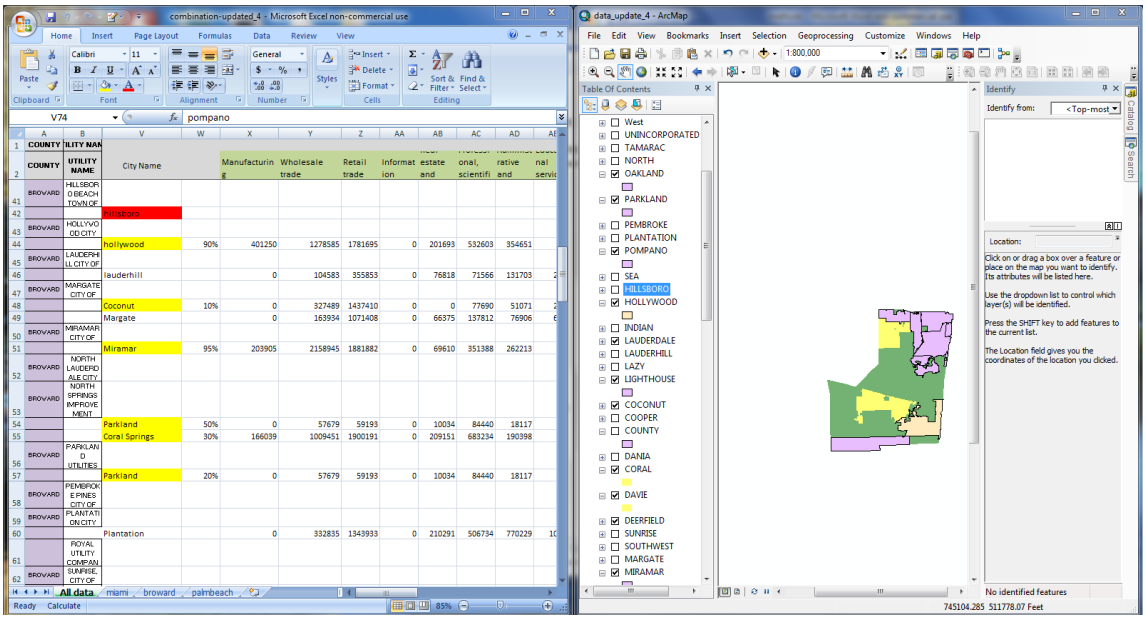


Figure 35. Finding duplicates in master list.

Then use the Clip took to clip just the SFWMD file to the browed county shape file. This tool can be found under geo-processing. Changed the color to gray to be distinguishable from the other layers and stand out more.

Once the clipping is done, apply the layer and have the cities overlaid on top. Delete the cities that are not need by using the start edit feature. This can be done by right clicking on the layer and going to edit features then start editing. A visual of how to get to this tool can be seen in Figure 36.

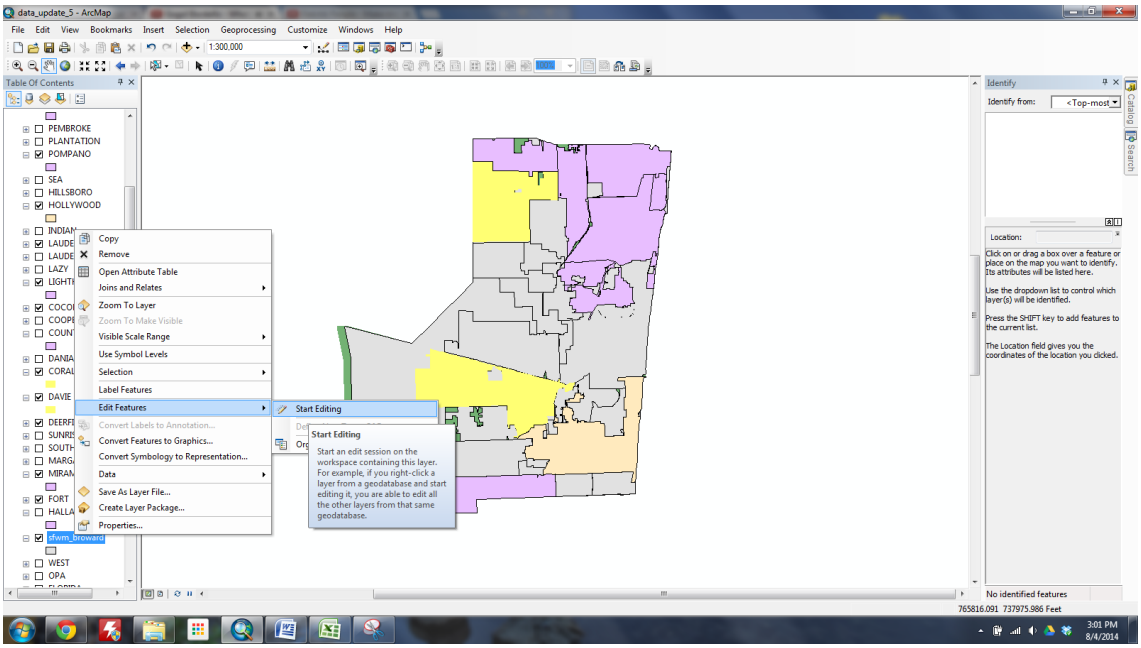


Figure 36. Modifying layer with editing tool.

A new window will open up, click continue. The window will look something like Figure 37.

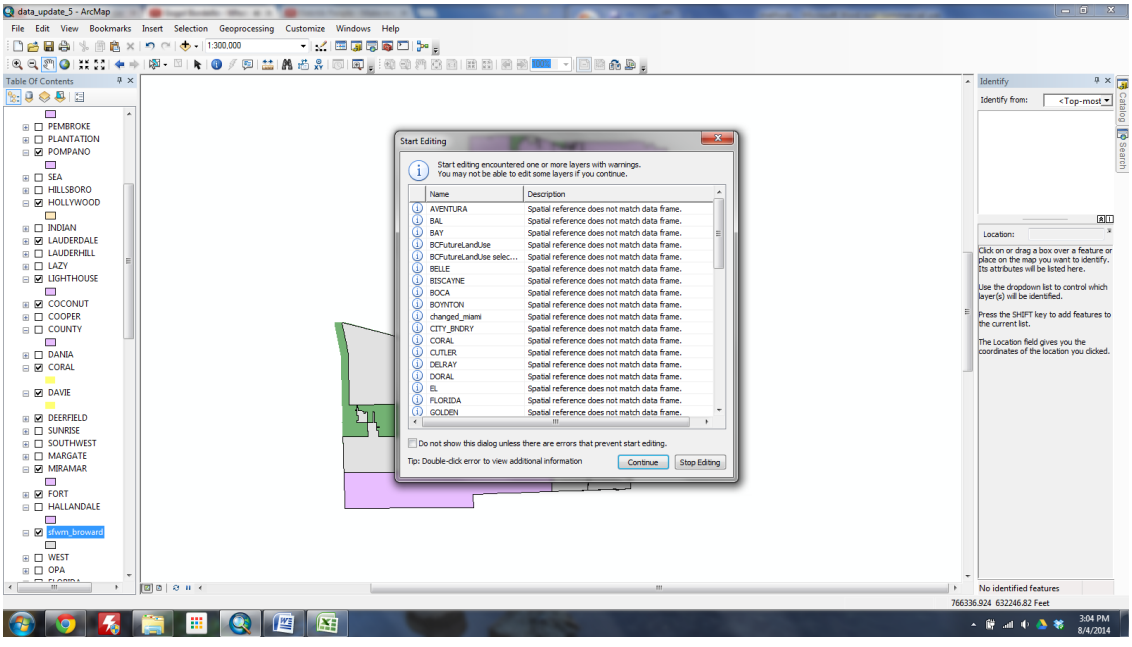


Figure 37. Start editing window.

Now to start editing the layer, click on the areas that are in gray. The gray area will light up with a teal color border around the utility. In some cases, the gray areas went into areas that where colored from other layers. If there is no overlay from another layer, the delete key on the keyboard will remove this utility from the shape file and attributes table. But when they do overlay do not delete them, instead keep them for further processing. An example of a utility with overlay can be seen in Figure 38.

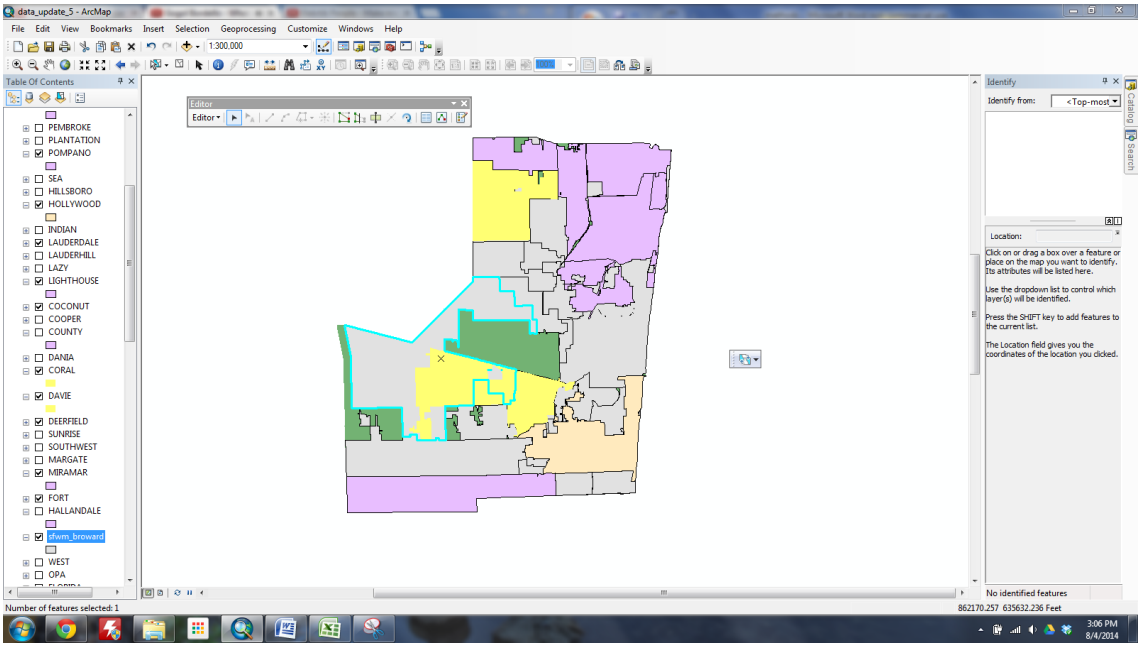


Figure 38. ArcGIS utility overlapping city boundaries.

After getting all the ones that could be easily seen, a check was done with the attributes table to insure all known duplicated utilities where removed. Any ones that are found in this stage can be deleted still. To do this click on the row of the table containing the utility and again use the delete key found on the keyboard. An example of this process can be seen in Figure 39.

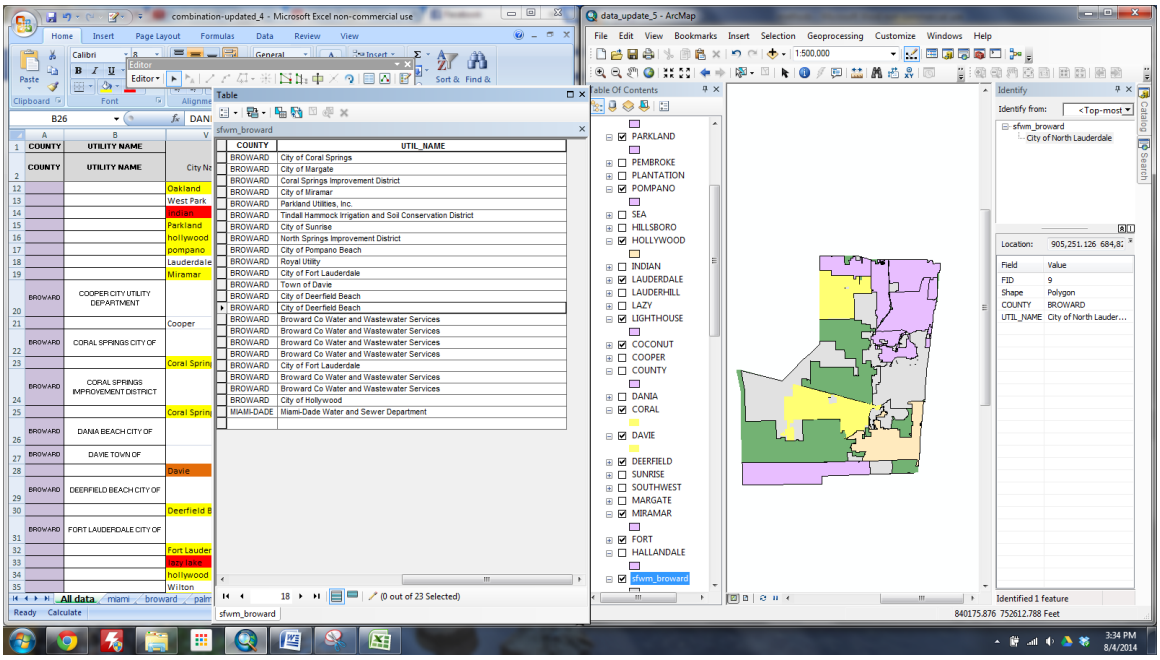


Figure 39. Double checking attributes table for known utility duplicate.

Next, clip the land use files with the cities that had overlapping water use boundaries. This was done by going to geo-processing then clipping. This will help separate out just the number of commercial factors per city. The clipping tool was set up as seen in Figure 40.

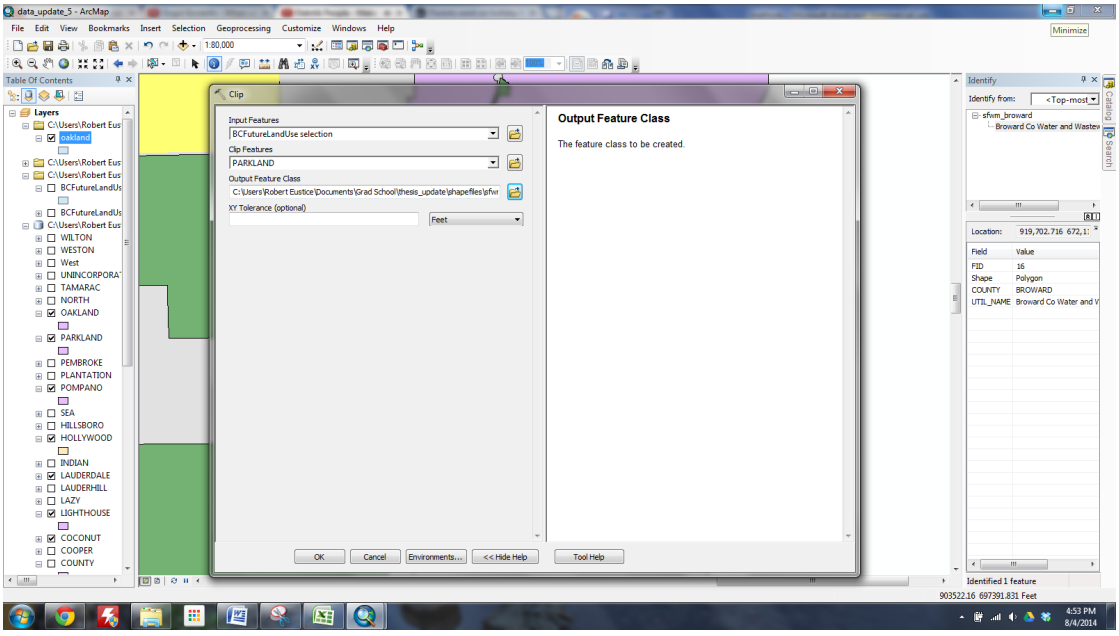


Figure 40. Land use clipped with city.

This process was repeated for the rest of the cities that had overlaying water service areas.

The cities that where clipped are as follows:

- Fort Lauderdale
- Miramar
- Deerfield
- Davie
- Coral Springs
- Coconut Creek
- Lighthouse Point
- Lauderdale-by-the-Sea
- Pompano Beach
- Parkland
- Oakland

Once the clipping of city boundaries from the land use file was completed, go to each attribute table for the above cities. Write down in the master spread sheet the number of companies that where in each city. The Broward County shape file will need to be split up so each utility is its own separate shapefile. This needs to be done to manually check for overlapping areas with the land use file. Splitting up the shapefile can be done using the Split tool, but before using this tool make sure that the names of the utilities that are within the Broward County attributes table have no spaces in the name. The split tool is not able to read spaces so it will only read the first word and often this can mean there are overlapping names, which will cause problems and won't displace the

information correctly. To find the Split tool, go to the right side of ArcGIS and use the search tab. Once the tool is found, enter the Broward County shape file for both the Input Featuers and Split Features box. Select Util_Names for the Split Field. The window before clicking ok should look like Figure 41.

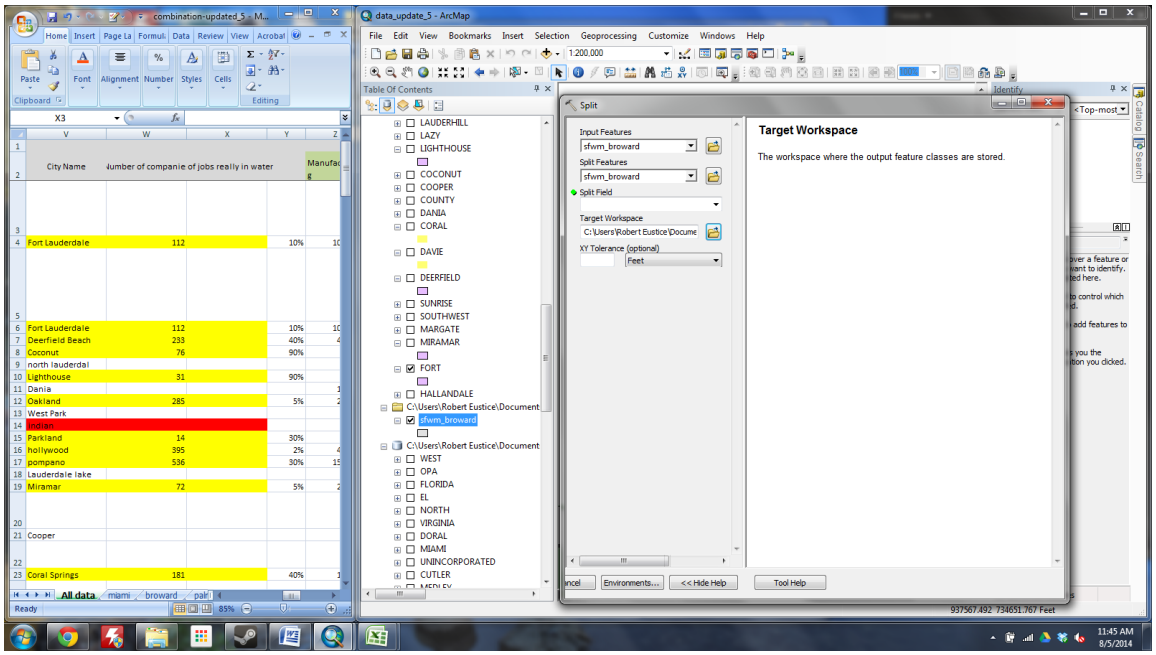


Figure 41. Splitting up SFWMD utility file.

Now use the intersect tool found under geo-processing to create new feature classes from the intersection area of two layers. The idea is the city file which has land use data will be intersected by the utilities to create a new feature class. The intersect tool is set up similar to Figure 42.

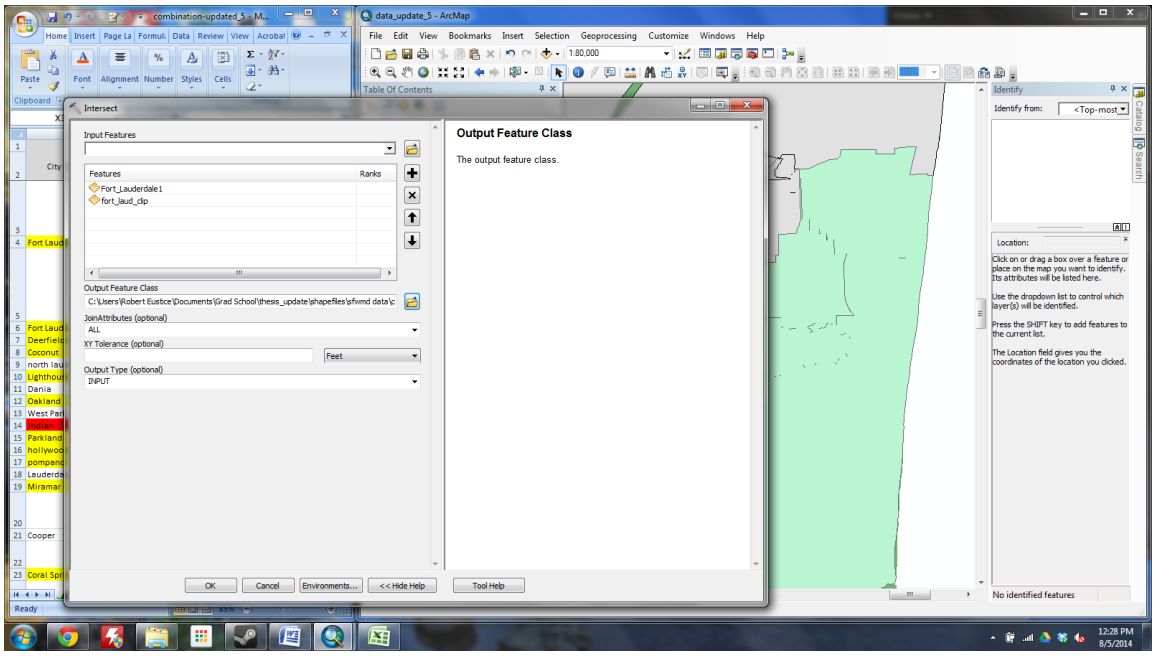


Figure 42. Intersect tool.

The new shape file that was created was added to GIS. Opening the attribute table reviled how many companies where in that service area. The number was added to the excel spread sheet and calculated the percent from the total number in the city. This will then be multiplied by the total to find how much economic activity is associated to each area.

Final Data Sorting

To continue with Combining Data section of this report, the master spread sheet should look like Figure 43. The rows with the utilities name where colored black to them stand out, and to be a place for the finished data. The next thing that needs to be done is to adjust each utility's economic activity based on the percentage the utility services.

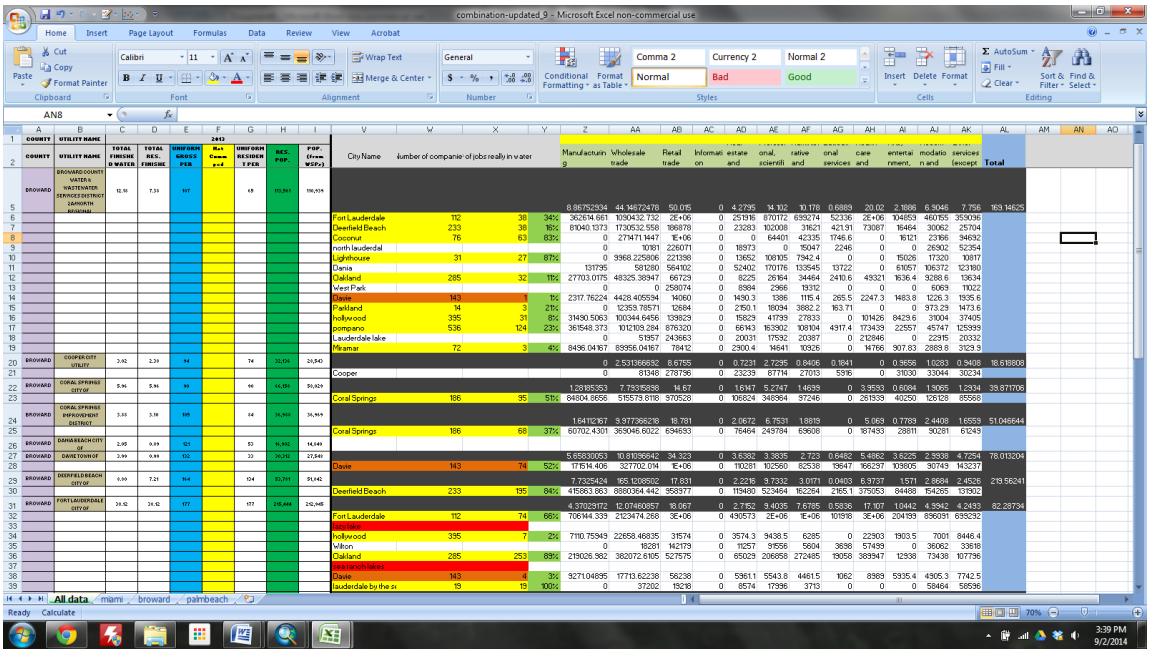


Figure 43. Master spreadsheet before adjusting for multiple utilities.

To make the adjustments the formula originally applied to pull the economic data from the county sheets to the main All data sheet needs to be modified. The percentage found needs to be multiplied at the end of the formula. The formula should now look like:

$$= SUMIF(broward!\$E\$104{:}\$G\$123, Z2, broward!\$M\$104{:}\$M\$123) * \$Y\$7$$

The formula when applied should look like Figure 44.

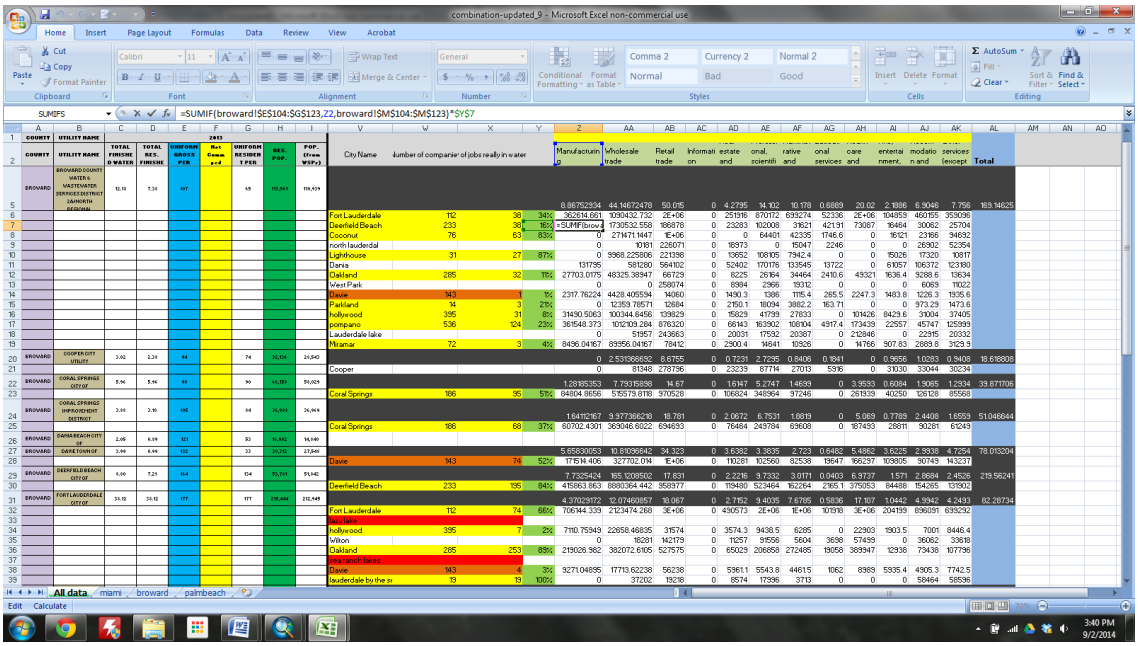


Figure 44. Master spreadsheet formula modification.

All of the utilities need to have their city data added up into the black rows now. But the data also needs to be adjusted for residential population. Doing so will result in dollar amount per population. This needs to be done in order to compare the data with water use, which is in total finished water per population. An example of the formula used is:

$$= SUM(Z6{:}Z19)/\$H\$5$$

The master spreadsheet should look like Figure 45.

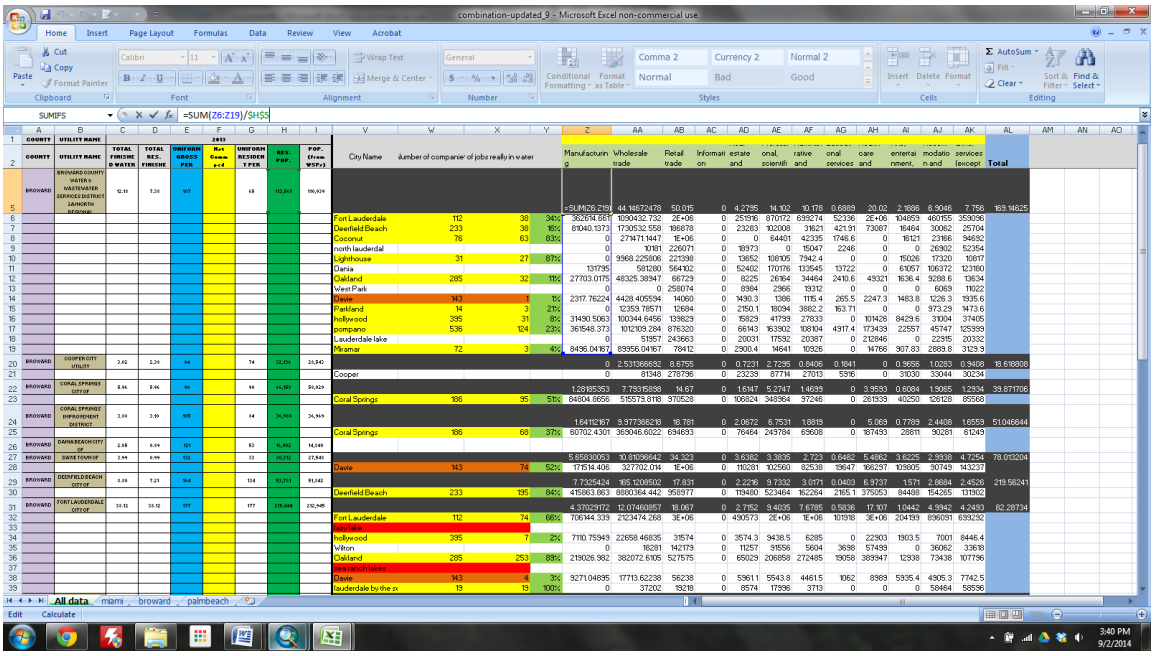


Figure 45. Master spreadsheet adjusting economic activity for population.

The economic sectors need to be summed up for each utility. An example of the formula used is:

$$= SUM(Z5{:}AK5)$$

The formula can be seen in use in Figure 46.

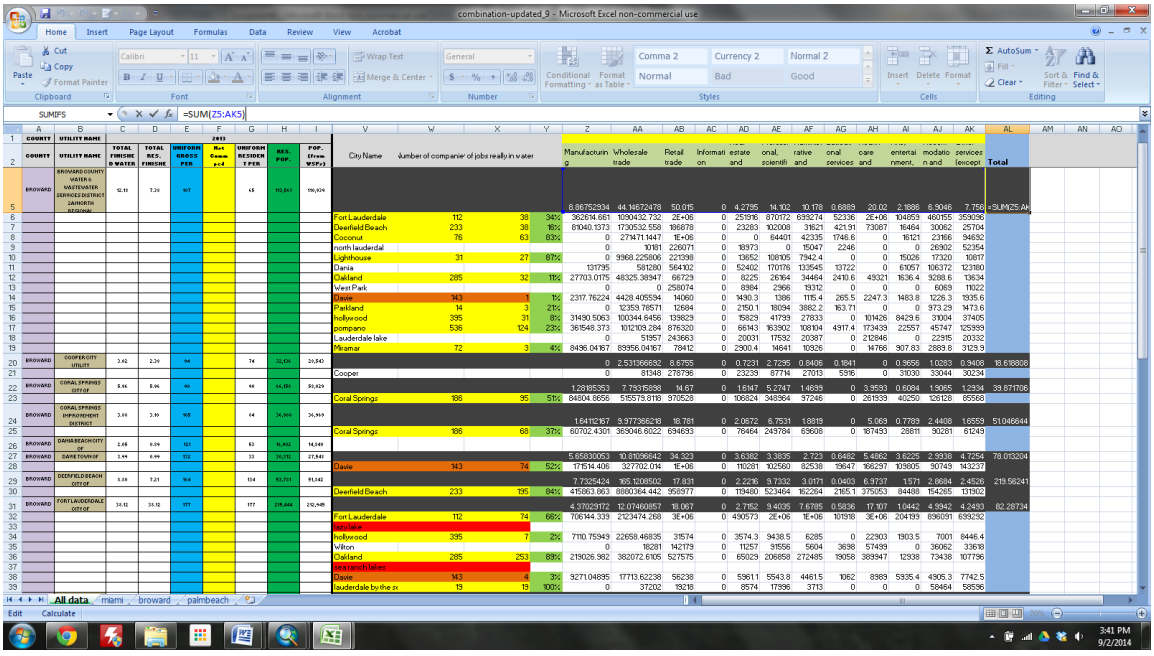


Figure 46. Master spreadsheet utility totaling.

Finally to make things easier to read hide un-needed rows and columns. The master spreadsheet when finished should look like Figure 47.

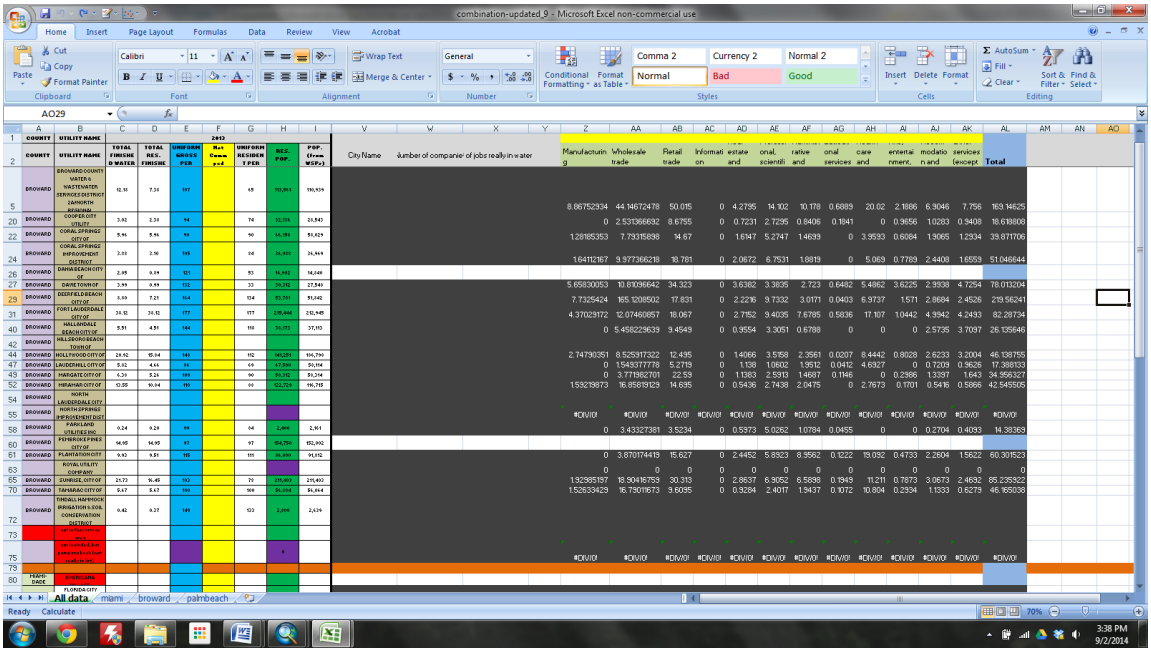


Figure 47. Final master spreadsheet.

Statistical Analysis

To analyze the results from the master spreadsheet statistical analysis will be done using Excel. Excel was chosen for its wide acceptance among professionals in scientific scholars first for its flexibility and accuracy in performing statistical analysis.

GIS Analysis

An initial analysis was done on the data. The purpose of this part was to find visually if there was a trend. This step was done by using the supplied utility boundary shp file provided by South Florida Water Management District and the future land use files found in Broward County geodatabase files. The next step is to add all of the

cleaned up economic activity and water use data to the utility boundaries attribute table. This can be done by right clicking on the boundaries file and go to edit features, then start editing. Right click once more on the file and click on open attributes table. Begin adding the data similarly to the file like one would to an excel sheet.

After the information has been added to the attributes table, right click on the file and go to properties. Then go to the symbology tab. Click on the Value Field tab and select the option for water use. Then at the bottom click add all values. The final step is to pick a desired Color Ramp. Once everything is done click ok. Repeat this step for economic activity.

To create the desired map for identifying pockets of large commercial activity, the future land use files where used. Using the already created commercial activity only land use information used in the separating data stage of this paper import the County shp file. Over lay the commercial activity file on top of the Broward County shp file to make the desired effect.

Descriptive Statistics

Descriptive statistics was performed first on the final data from the master spreadsheet. This form of statistics was chosen for its ability to help describe and summarize data in a meaningful way. What is meant by that is this method can be used to help find patterns and indicate if the data is normally distributed.

Before descriptive statistics can be applied to the data, it first must be modified so that there are no zeros within the data set. Any zeros left in the data set will cause some statistical test to either not run or give it incorrect outcomes. The information and manufacturing economic sectors were removed first from the master spreadsheet. These

are sectors were removed first because of the lack of data found by the census. The next step in cleaning up the data was to remove any utility that presented a zero in any economic sector. The justification behind this was that the utility that would be removed was not a complete picture of an ideal utility. To further explain this, this research is looking at developing an equation that could be used to predict water use a son economic activity. By including utilities with zero economic activity in certain sectors it will alter the baseline equation.

Once all the zeros have been removed from the data set, the remaining data set should look like Figure 48.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	COUNTY	UTILITY NAME												
2	COUNTY	UTILITY NAME	UNIFORM GROSS REC	Wholesale trade	Retail trade	Real estate and	Professional, scientifi	Administrative and	Educational services	Health care and social	Arts, entertainment,	Accommodation and food	Other services (except	Total
3	BROWARD	BROWARD COUNTY WATER & WASTEWATER SERVICES DISTRICT 2A/NORTH	107	44.14672478	50.01465	4.279451	14.10173	10.17768	0.68888	20.02047	2.188617	6.904573	7.755958	169.1462546
4	BROWARD	DAVIE TOWN OF	132	10.81096642	34.32322	3.638186	3.383491	2.722963	0.648168	5.486182	3.62248	2.993826	4.725425	78.01320394
5	BROWARD	DEERFIELD BEACH CITY OF	164	165.1208502	17.83116	2.221598	9.733246	3.01713	0.040257	6.973704	1.570959	2.868394	2.452577	219.5624123
6	BROWARD	FORT LAUDERDALE	177	12.07460857	18.06729	2.715177	9.403546	7.678522	0.583615	17.10657	1.044241	4.99416	4.249321	82.28733985
7	BROWARD	HOLLYWOOD CITY OF	148	8.525917322	12.49511	1.406593	3.515803	2.356103	0.020676	8.444186	0.80282	2.623269	3.200376	46.13875481
8	BROWARD	PLANTATION CITY OF	115	3.870174419	15.62713	2.445244	5.892256	8.956151	0.122198	19.09249	0.473302	2.260419	1.562163	60.30152326
9	BROWARD	SUNRISE, CITY OF	103	18.90416759	30.31314	2.863692	6.905158	6.589814	0.194915	11.21132	0.787338	3.067338	2.469188	85.23592192
10	BROWARD	TAMARAC CITY OF	100	16.79011673	9.609504	0.928433	2.401695	1.943657	0.107236	10.80353	0.293369	1.133254	0.627909	46.16503762
11	MIAMI-DADE	MIAMI-DADE WATER & SEWER DEPARTMENT (aka MIAMI-DADE CONSOLIDATED PWS)	136	19.63964847	8.465399	1.53739	5.660006	0.628185	0.195885	7.880491	0.700704	1.880166	1.986229	50.31092807
12	MIAMI-DADE	NORTH MIAMI BEACH CITY OF	117	3.12006	8.487653	1.184249	1.547091	0.534381	0.066094	3.758571	0.259765	2.045904	1.208511	22.21227765
13	PALM BEACH	BOCA RATON CITY OF	235	40.3827	18.0652	4.269308	18.58197	16.28858	1.073131	20.88886	2.235062	5.252669	3.870185	133.8709
14	PALM BEACH	BOYNTON BEACH CITY OF	127	4.462394646	11.62643	0.941939	1.986324	2.147661	0.074489	6.305769	0.369391	1.346155	1.694124	32.00919892
15	PALM BEACH	DELRAY BEACH WATER DEPARTMENT	231	7.352476923	24.13592	1.712231	7.3336	1.647508	0.200692	20.3912	1.226092	3.360523	2.686246	72.38989231
16	PALM BEACH	JUPITER TOWN OF	168	4.561910231	9.411053	1.021834	2.937908	1.165842	0.060838	4.403851	1.645289	1.49918	1.683523	34.24869872
17	PALM BEACH	LAKE WORTH UTILITIES CITY OF	102	9.733814103	8.334669	0.693937	1.420566	1.389637	0.086672	4.196688	0.447222	1.258974	1.687126	33.15515491
18	PALM BEACH	LANTANA TOWN OF	184	0.454708816	22.33071	0.492885	4.26231	1.625191	0.088049	2.42763	0.180778	3.94042	1.393157	37.19584045
19	PALM BEACH	PALM BEACH COUNTY WATER UTILITIES DEPARTMENT	117	0.079226667	2.196474	0.081318	0.279005	0.08381	0.017669	1.286965	0.029877	0.211617	0.152733	4.41869449
20	PALM BEACH	RIVIERA BEACH CITY OF SPECIAL	63	34.584025	11.87013	1.5162	2.3835	1.0013	0.0314	1.7742	2.6534	1.121325	3.33635	90.264475
21	PALM BEACH	SEACOAST UTILITIES	176	3.237844532	22.42284	1.579465	7.131831	3.830901	0.075447	13.30398	0.976193	3.478827	3.200033	60.72896145
22	PALM BEACH	WELLINGTON PUBLIC UTILITIES DEPARTMENT	108	3.702784091	10.58032	1.441742	4.163068	0.916875	0.192936	4.832254	0.687689	1.752102	1.733409	30.00318182
23	PALM BEACH	WEST PALM BEACH PUBLIC UTILITIES CITY OF	212	9.099504146	28.20914	3.120257	23.63229	3.546098	0.291253	27.67157	3.923053	5.09522	7.158934	115.5974313
24														

Figure 48. Remaining dataset after zeros have been removed.

The data set can now have descriptive statistical analysis applied at this time. This can be done by going to File, then Options in the drop down window. Click on Add-Ins and go to Analysis ToolPak. Make sure this tool is turned on and if it is not click to add it the list of tools. After that has been completed, go to the Data ribbon in Excel and choose Data Analysis. Choose Descriptive Statistics from the new window that appears and hit ok. In Figure 49, the figure shows the data used to perform the analysis and how the test should be set up.

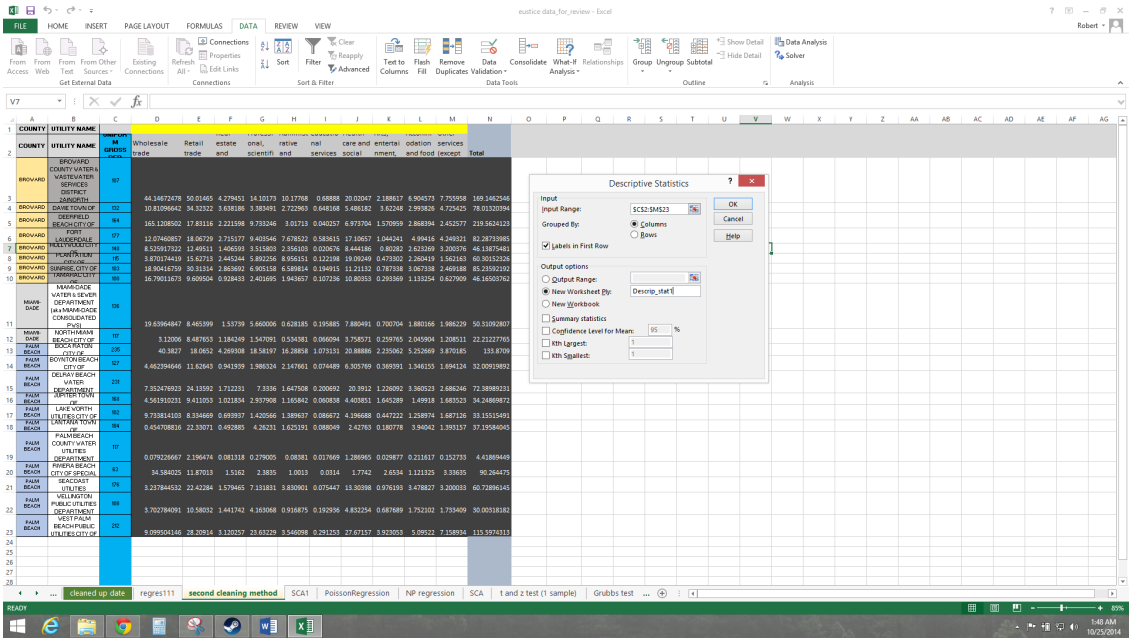


Figure 49. Descriptive statistics analysis selected data.

After clicking ok, a new Tab will be created with the given name specified of the user's choice. This information will be used to determine the data set is normally distributed. From this section going forth, the research will go under the assumption that the data is normally distributed with the standard deviation having 2 degrees of freedom

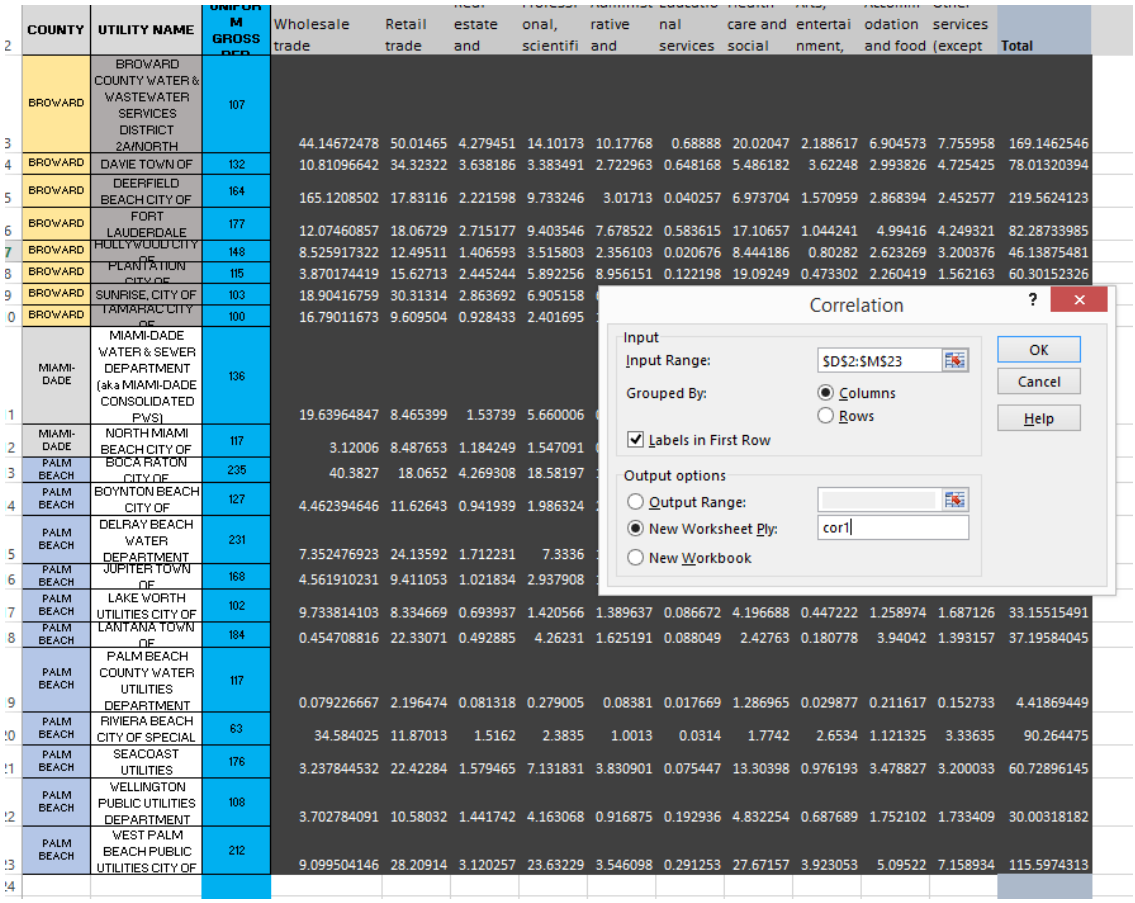
from the mean. In addition, it will also be assumed there is a linear relationship between economic activity and the water use.

In addition, an additional outside toolpak was use as well called XLStat. This toolpak is a plugin for excel and preforms descriptive statistics in the same manner. This tool was used to preform deactivate statics in order to create P-value graphs and normal distribution graphs which can be found in the data ribbon at the top.

Correlation Matrix

A correlation matrix will be used to test dependency among economic activity variables. This test aims to provide insight as to which variables will have the largest impact in be the best contributors in formulating an equation to predict water use based upon economic activity. R values gathered from this past will help determine which sectors are good predictors. Preform correlation matrix Excel will be used once again; but the same plug-ins used as described in the Descriptive Statistics section. Go to the data ribbon at the top of Excel, and click on data analysis. A new window will open, from the list select correlation. The final input selection should look similar to Figure 50.

Once all input selections have been made click okay to finish the process.



COUNTY	UTILITY NAME	UNIFORM GROSS REC	Wholesale trade	Retail trade	Real estate and	Professional, scientifi	Administrative and	Educational services	Health care and social	Arts, entertainment,	Accommodation and food	Other services (except	Total
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BROWARD	DAVIE TOWN OF	132	10.81096642	34.32322	3.638186	3.383491	2.722963	0.648168	5.486182	3.62248	2.993826	4.725425	78.01320394
BROWARD	DEERFIELD BEACH CITY OF	164	165.1208502	17.83116	2.221598	9.733246	3.01713	0.040257	6.973704	1.570959	2.868394	2.452577	219.5624123
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BROWARD	PLANTATION CITY OF	115	3.870174419	15.62713	2.445244	5.892256	8.956151	0.122198	19.09249	0.473302	2.260419	1.562163	60.30152326
BROWARD	SUNRISE, CITY OF	103	18.90416759	30.31314	2.863692	6.905158							
BROWARD	TAMARAC CITY OF	100	16.79011673	9.609504	0.928433	2.401695							
MIAMI-DADE	MIAMI-DADE WATER & SEWER DEPARTMENT (aka MIAMI-DADE CONSOLIDATED PWS)	136	19.63964847	8.465399	1.53739	5.660006							
MIAMI-DADE	NORTH MIAMI BEACH CITY OF	117	3.12006	8.487653	1.184249	1.547091							
PALM BEACH	BOCA RATON CITY OF	235	40.3827	18.0652	4.269308	18.58197							
PALM BEACH	BOYNTON BEACH CITY OF	127	4.462394646	11.62643	0.941939	1.986324							
PALM BEACH	DELRAY BEACH WATER DEPARTMENT	231	7.352476923	24.13592	1.712231	7.3336							
PALM BEACH	JUPITER TOWN OF	168	4.561910231	9.411053	1.021834	2.937908							
PALM BEACH	LAKE WORTH UTILITIES CITY OF	102	9.733814103	8.334669	0.693937	1.420566	1.389637	0.086672	4.196688	0.447222	1.258974	1.687126	33.15515491
PALM BEACH	LANTANA TOWN OF	184	0.454708816	22.33071	0.492885	4.26231	1.625191	0.088049	2.42763	0.180778	3.94042	1.393157	37.19584045
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PALM BEACH	SEACOAST UTILITIES	176	3.237844532	22.42284	1.579465	7.131831	3.830901	0.075447	13.30398	0.976193	3.478827	3.200033	60.72896145
PALM BEACH	WELLINGTON PUBLIC UTILITIES DEPARTMENT	108	3.702784091	10.58032	1.441742	4.163068	0.916875	0.192936	4.832254	0.687689	1.752102	1.733409	30.00318182
PALM BEACH	WEST PALM BEACH PUBLIC UTILITIES CITY OF	212	9.099504146	28.20914	3.120257	23.63229	3.546098	0.291253	27.67157	3.923053	5.09522	7.158934	115.5974313

Figure 50. Creating correlation matrix in Excel.

Graphs

The graphs created for this research were done by the use of Excel.

Regression Model

The regression model was performed in order to estimate the relationship among variables. This technique is used for modeling equal Asians and analyzing several variables at once, when the focus is on a relationship between a dependent variable and multiple independent variables. In this case the dependent variable is the total water use and the independent variables are the economic activity. It will be assumed that the data

is normally distributed and is linear. This must be first understood before performing a linear regression model.

To perform a regression model, first go to the Excel ribbon labeled as the data. As before and click on data analysis. When the new window opens up, go to Regression and click ok. Fill out the new box so that it is similar to Figure 51.

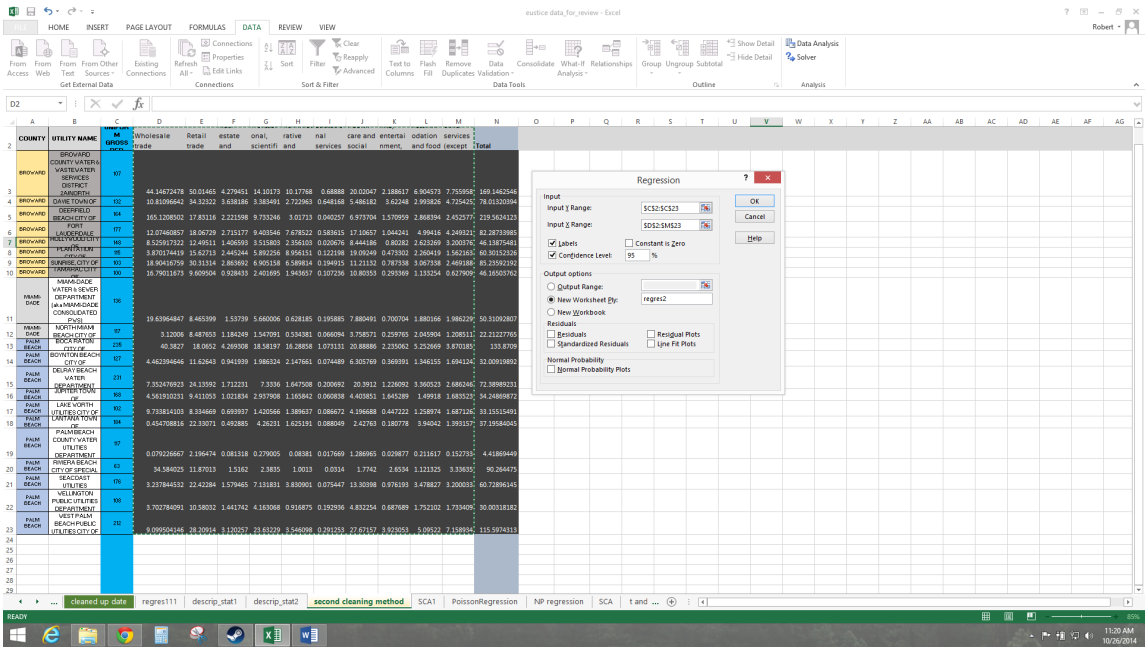


Figure 51. Regression model inputs.

RESULTS

The results for the GIS analysis, this descripted statistics, correlation matrix, and regression model can be found below.

GIS Analysis

The results for the water intensity per utility map created by GIS can be found in Figure 52. You can see in the figure that the highest intensity is located in Boca Raton, Delray, and West Palm Beach. This could be an early sign that the utilities had high per capita water use and that conservation efforts should be taken into consideration.

When looking at Figure 53, which was created using GIS, we can see that the Broward and Boca Raton area received a lot of economic activity per utility. If recalled, the previous figure it seems as though Boca Raton and West Palm Beach are good candidates to predict water use based upon economic activity.

A closer look was taken into the commercial activity in Broward County as seen in Figure 54. This was done as a result in the data sorting process, and to see where the highest density of commercial activity would be located at. As can be seen from the figure, the highest density is located in Fort Lauderdale. This coincides with Figures 52 and 53, which predict that a strong correlation between economic activity and water use will be found in Broward County along these highly dense commercial centers.

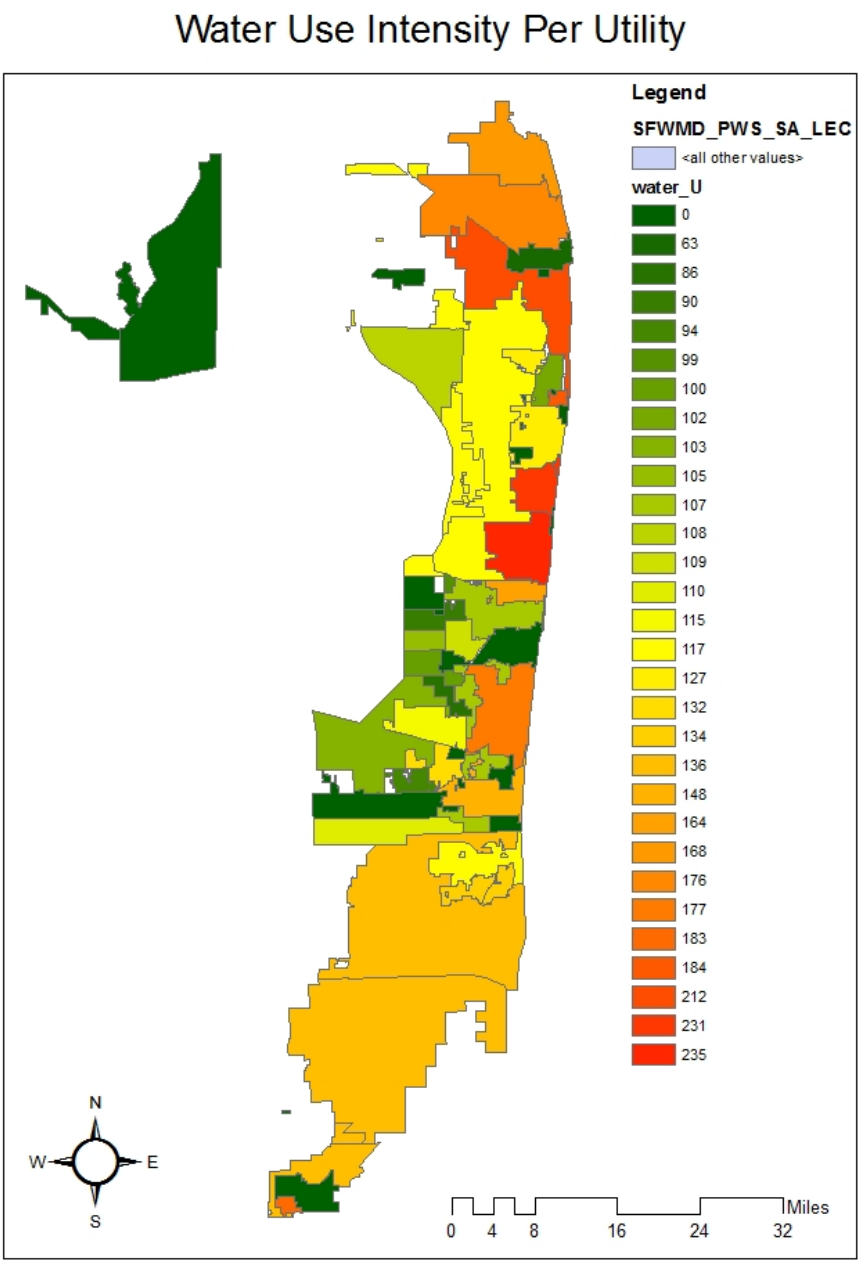


Figure 52. GIS water use intensity per utility map.

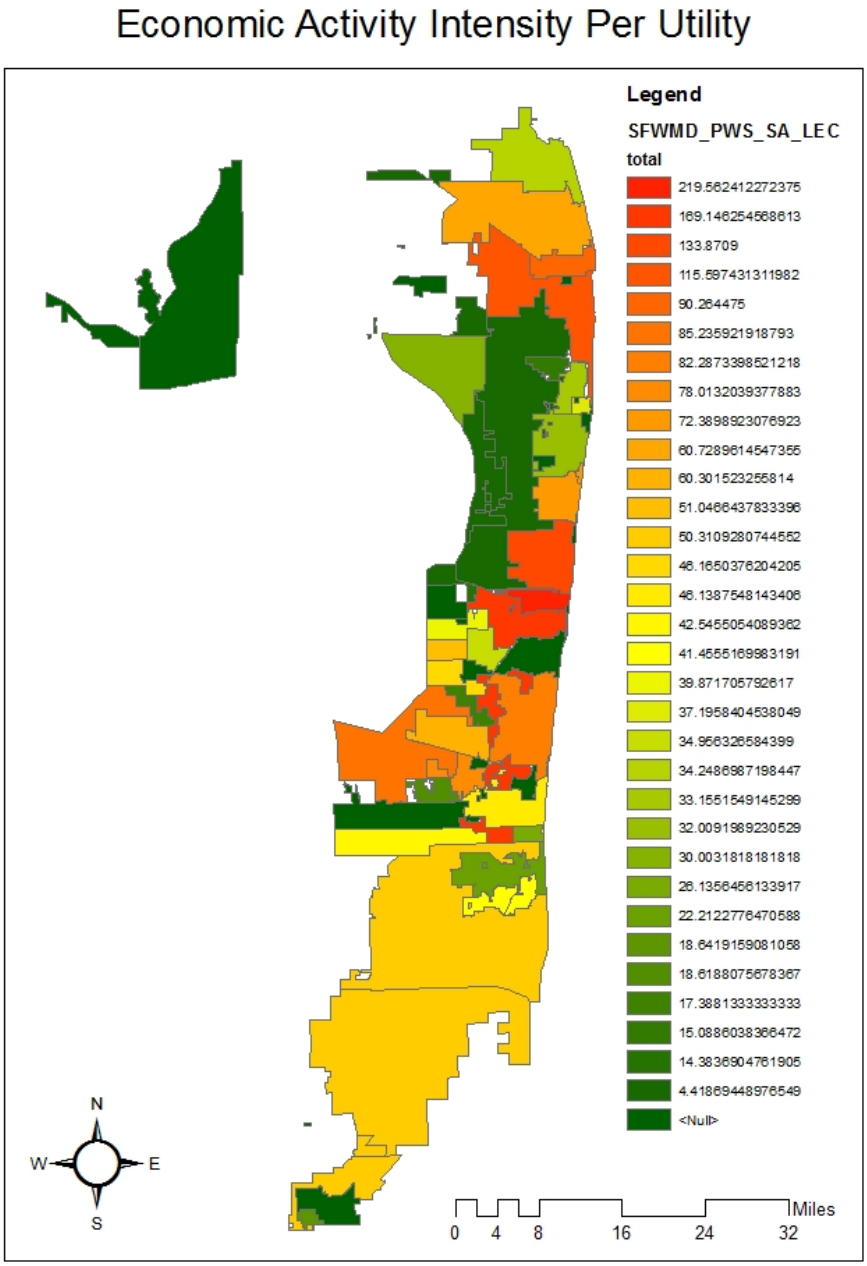


Figure 53. GIS economic activity intensity per utility.

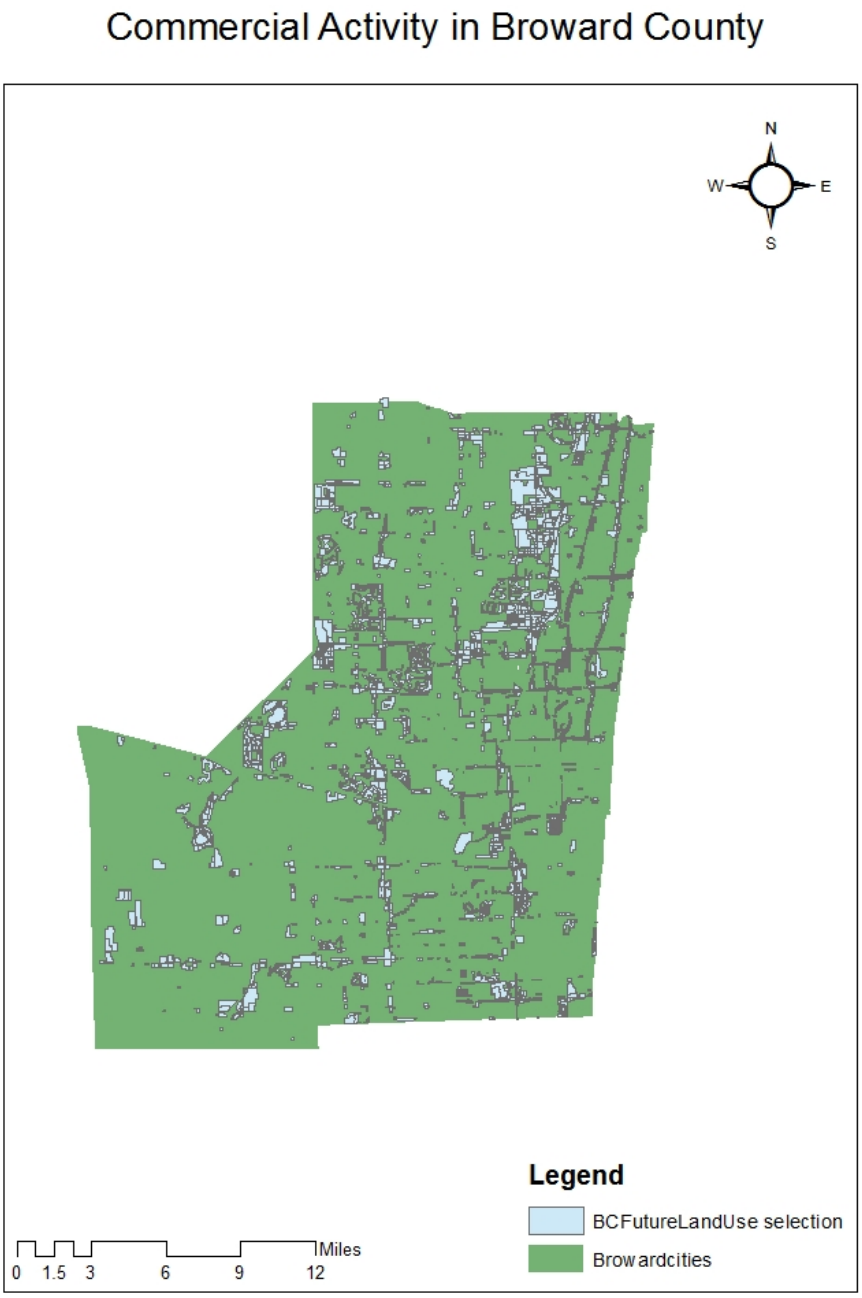


Figure 54. GIS commercial activity in Broward County.

Descriptive Statistics

The output from the standard descriptive statistics analysis can be seen in Table 3.

Table 3

Basic Statistics

Statistic	UNIFORM GROSS PER CAPITA 2013
No. of observations	41
Minimum	0.000
Maximum	234.540
1st Quartile	96.610
Median	115.430
3rd Quartile	148.110
Mean	113.906
Variance (n-1)	3729.435
Standard deviation (n-1)	61.069

Table 3 shows that the model has a standard deviation of 61, and a max range of 234 with a minimum of zero. Moving on to the P-P Plots. A closer examination of the output files from the XL-Stat that analysis can be seen in Figure 55 and Figure 56.

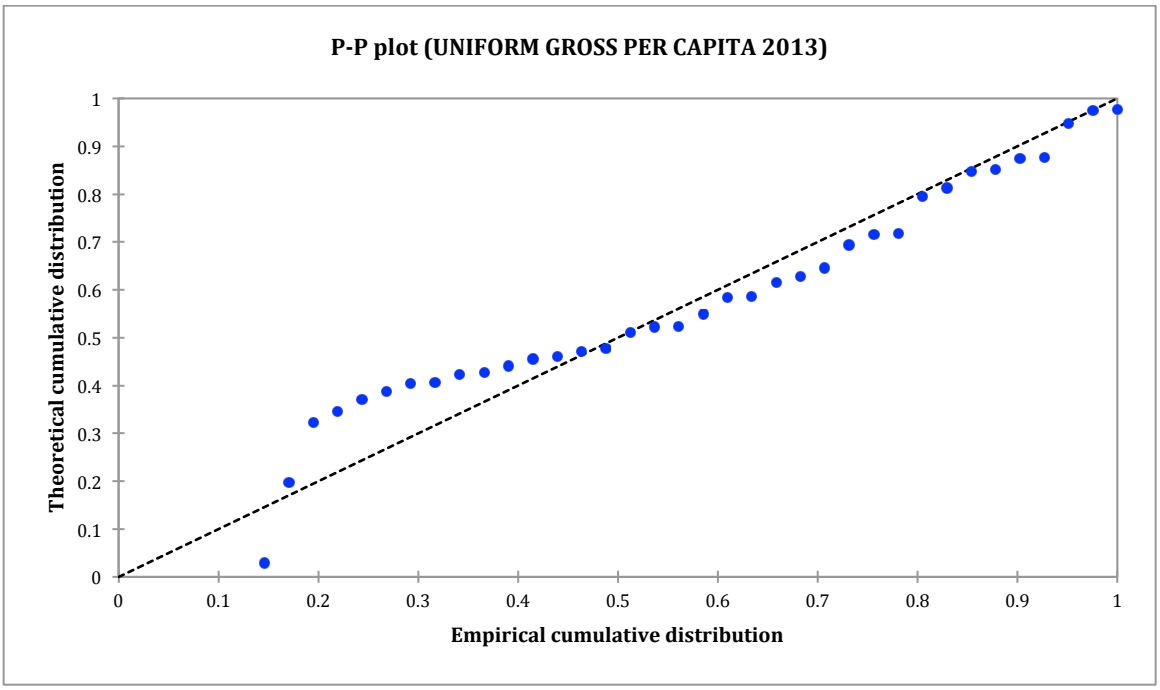


Figure 55. Over all P-P plot.

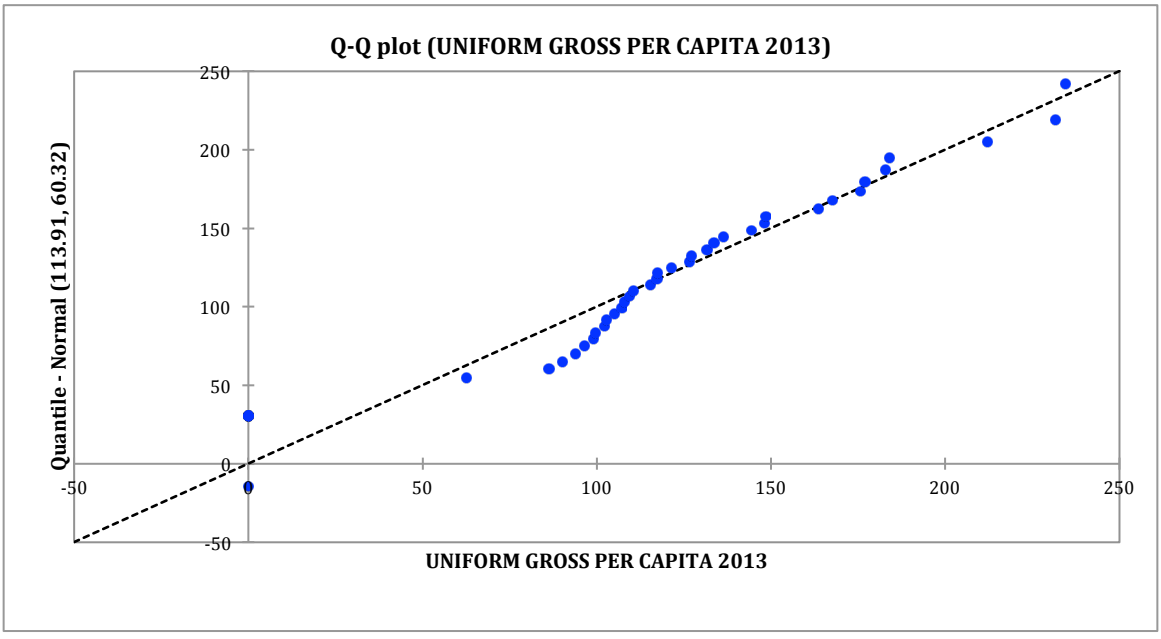


Figure 56. Over all Q-Q plot.

From examining both the Q and P plot, it can be inferred that the data is normally distributed but with a small sample size. For further examination the Q – Q plot for each economic sector can be found in Figures 57-66.

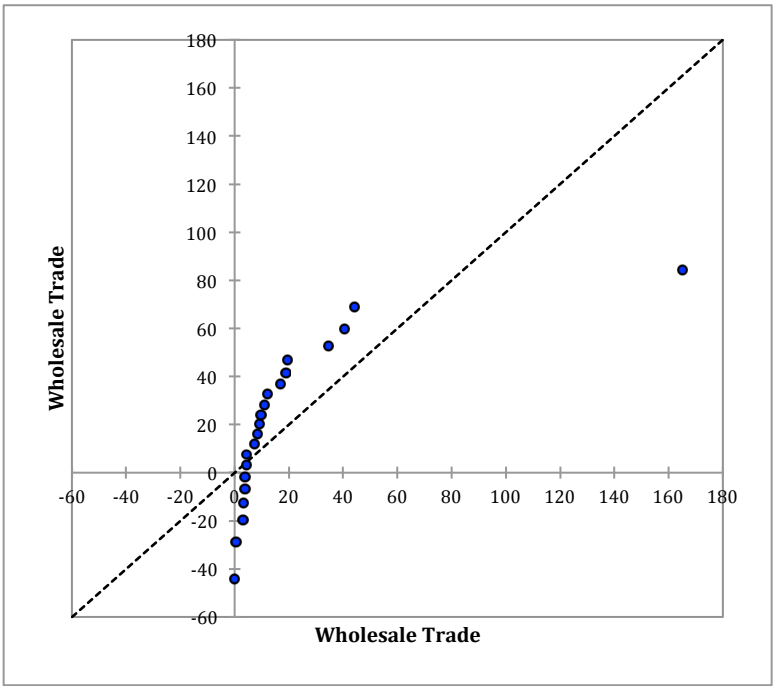


Figure 57. Q-Q plot wholesale.

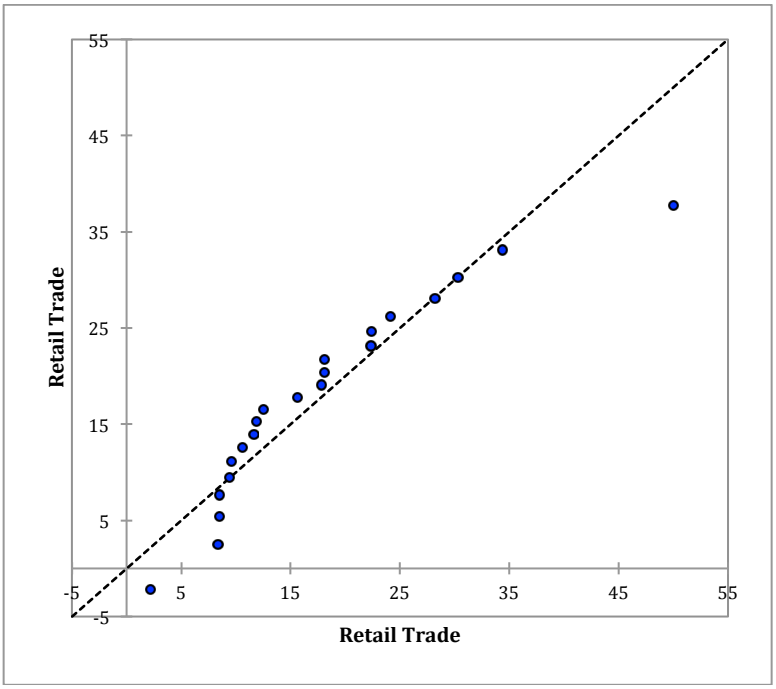


Figure 58. Q-Q plot retail trade.

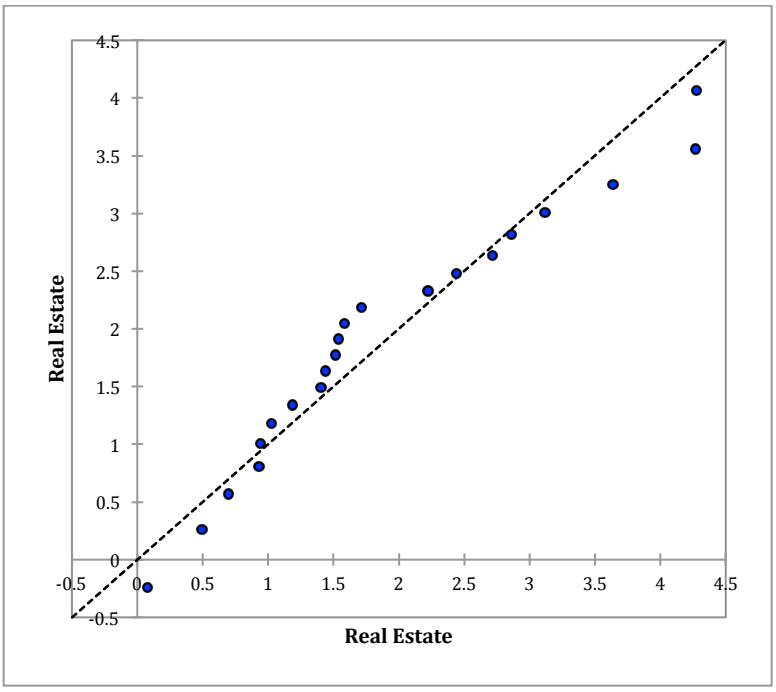


Figure 59. Q-Q plot real estate.

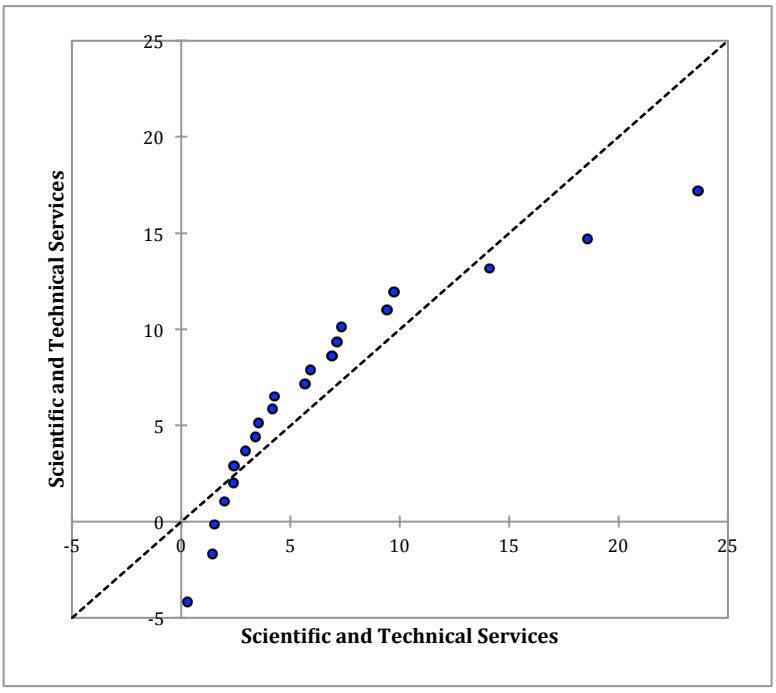


Figure 60. Q-Q plot scientific and technical services.

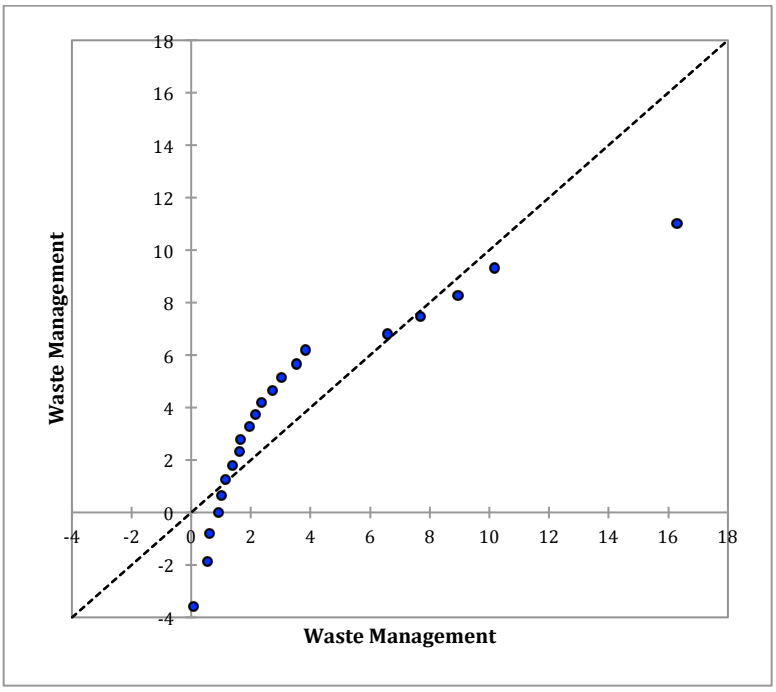


Figure 61. Q-Q plot waste management.

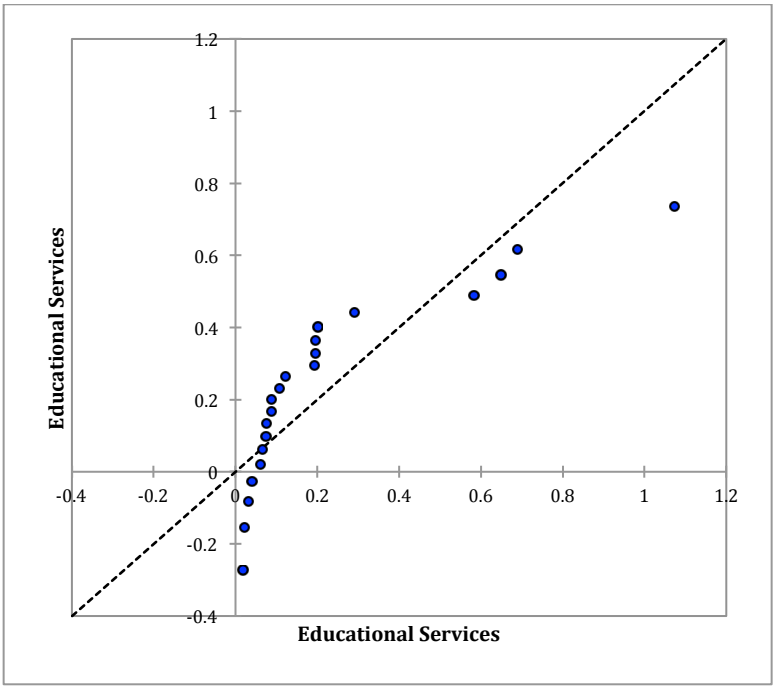


Figure 62. Educational services.

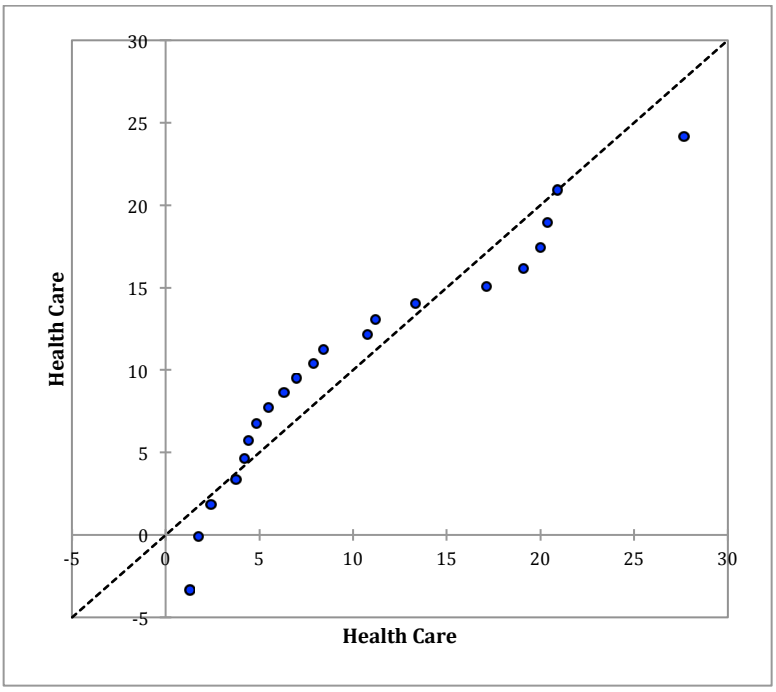


Figure 63. Q-Q plot health care.

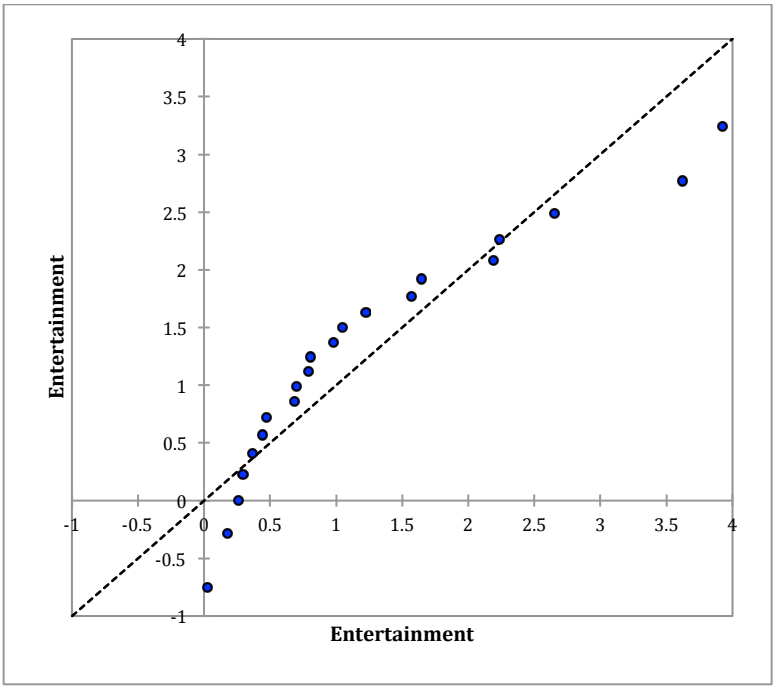


Figure 64. Q-Q plot entertainment.

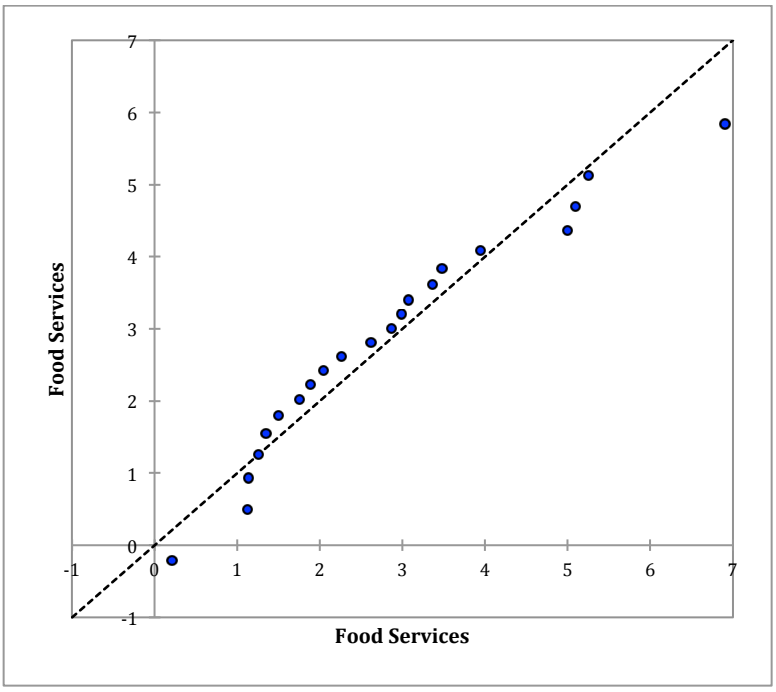


Figure 65. Q-Q plot food services.

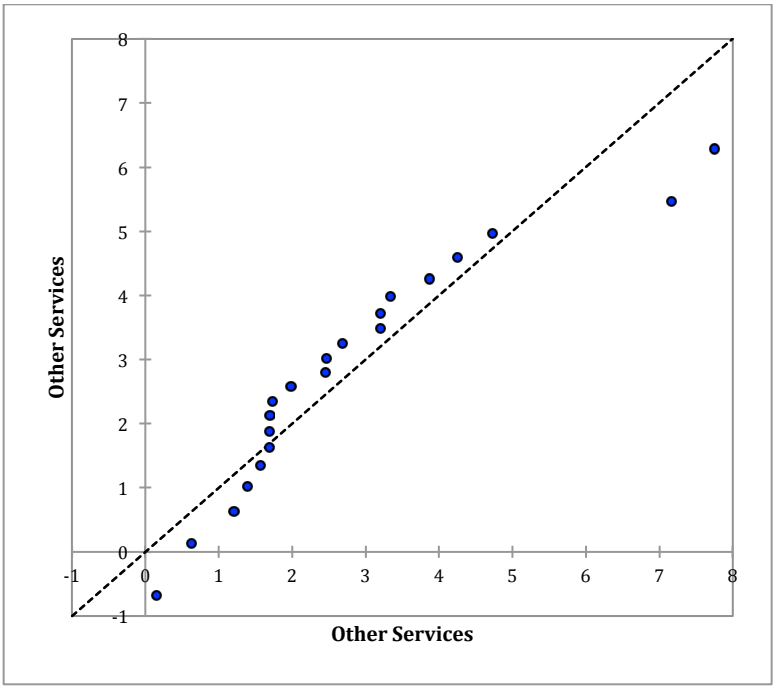


Figure 66. Q-Q plot other services.

As with the total Q – Q plot all economic sectors showed to be normally distributed, but seem to have a small sample sizes which could pose a problem in further analysis.

Correlation Matrix

The results of the performed correlation matrix can be found in Table 4. The table displays R values, which are in indicators of how good a variable is at predicting. Within Table 4 a conditional formatting function was applied in Excel show that any values at above 0.7 would be marked in red. This was done to help indicate anything with a 70% prediction rate would be easily identifiable.

Table 4

Correlation Matrix

	Wholesale Trade	*Retail Trade*	*Real Estate*	*Scientific and Technical Services*	*Waste Management*	*Educational Services*	*Health Care*	*Entertainment*	*Food Services*	*Other Services*	*Total*
Wholesale Trade	1										
Retail Trade	0.153	1									
Real Estate	0.285	0.755	1								
Scientific and Technical Services	0.275	0.553	0.743	1							
Waste Management	0.177	0.470	0.789	0.643	1						
Educational Services	0.075	0.537	0.835	0.612	0.789	1					
Health Care	0.017	0.535	0.680	0.838	0.660	0.530	1				
Entertainment	0.220	0.554	0.683	0.614	0.256	0.509	0.406	1			
Food Services	0.172	0.804	0.782	0.809	0.693	0.711	0.728	0.474	1		
Other Services	0.153	0.797	0.797	0.759	0.471	0.611	0.646	0.793	0.817	1	
Total	0.818	0.606	0.726	0.707	0.558	0.474	0.513	0.522	0.661	0.618	1

As would be expected the category food services holds the highest R-value within the correlation matrix; with the exception of the one-to-one values. It does not come with any surprise that food services would hold such a high R squared value, because in all aspects of cooking water would be needed at some point. On the other hand real estate

has shown to be a significant contributor as well within the correlation matrix. The buying and selling of homes does not seem like something that would require high water use or correlate to any of the other economic sectors, except in the case that in Florida housing market drives other economic sectors.

The lowest performing economic sector within the correlation matrix is by far wholesale trade. This doesn't come as much of a surprise, because South Florida is not a large producer of wholesale goods. However South Florida is a destination or large distributors who sell retail items, and because of this the results for retail trade are somewhat disappointing. But either way, wholesale trade and retail trade are low water use economic sectors. Nothing can be definitively concluded though from these findings, and so at regression model will be needed to further analyze the results.

Plot Everything

Miami-Dade County is a very full of culture and attracts millions of people to its cities every year. What is so unique about Miami-Dade County from a water resource point of view is that there are only a few utilities that serve the entire County. After the data has been cleaned up which was covered in the methodology section, there are only two utilities that did not have zeros in their economic sectors. This results in Miami-Dade County no longer being able to produce any meaningful graphs from its data set. Because there are only two utilities all economic sectors have an R squared value of one indicating a perfect relationship because there are only two point’s data. Miami-Dade County's data however can still be used only when it is combined with the other utilities. An example of this can be seen in Figure 67.

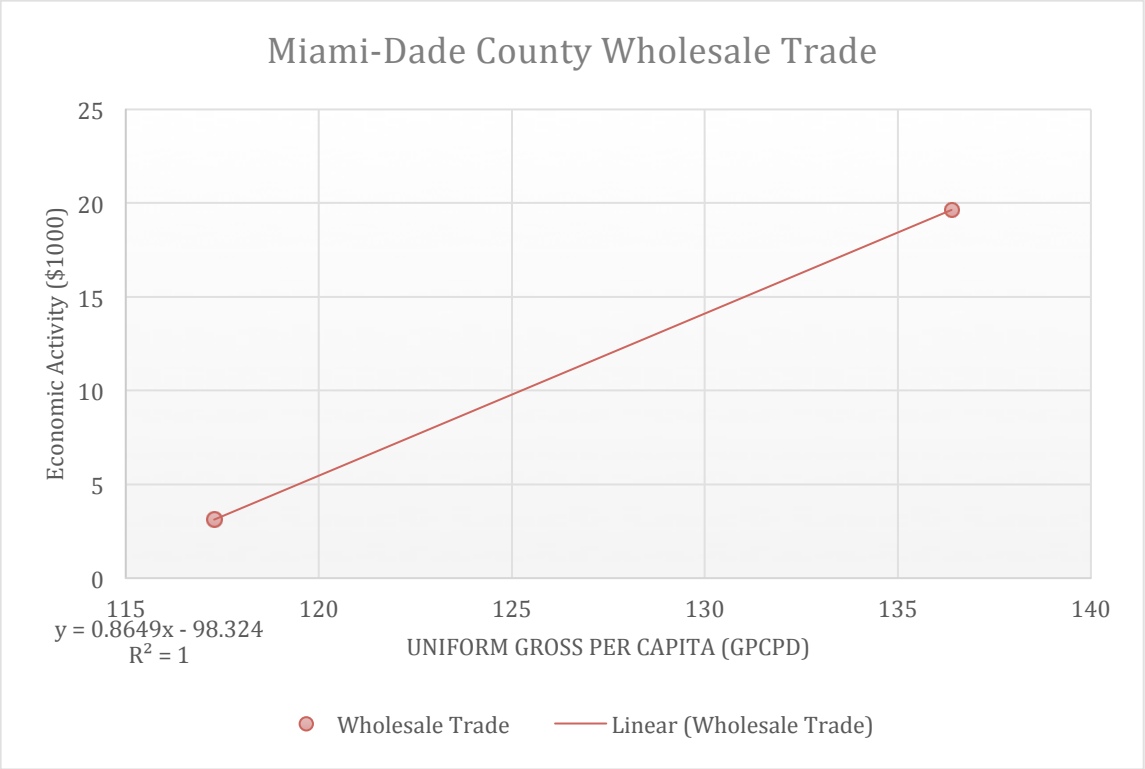


Figure 67. Miami-Dade County wholesale trade.

The second interesting thing is found from the graphs was how poorly food services R squared value was; see Figure 68.

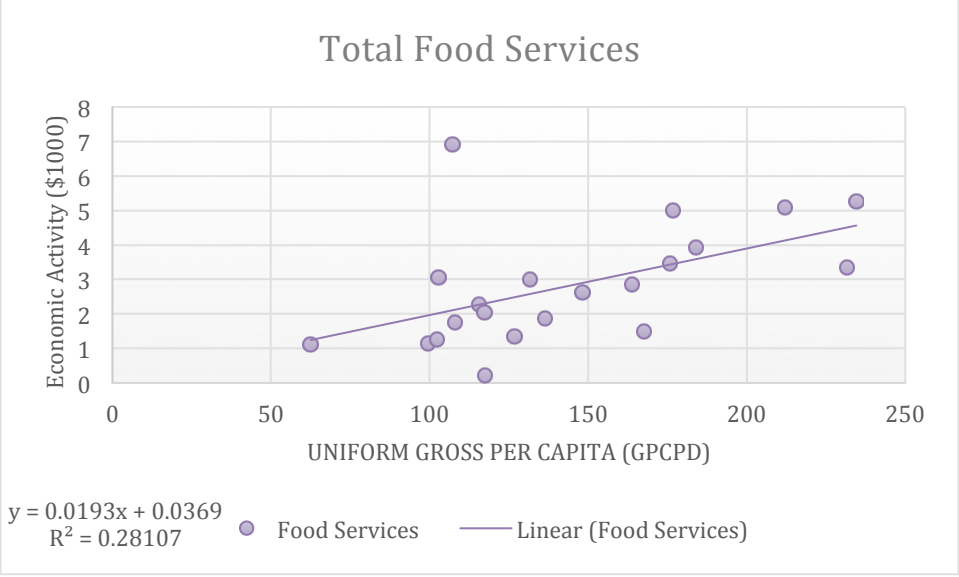


Figure 68. Total food services example.

It was postulated that food services would had a strong goodness of fit within the graph, but instead it shows that there are many outliers within the data. The preparation of food inherently uses water in all aspects. Whether it is cleaning items that will be used or the addition of potable water within the cooking itself, there was less of a relationship between economic activity and water use than expected. A cause for this might be from Miami-Dade and Broward County not using potable water for Irrigation. A closer look was then taken into Palm Beach and Broward County Food Services results.

Palm Beach County does use potable water for irrigation, because of this there could be data points within Broward and Miami-Dade County that are muted by Palm Beach counties larger water use. As can be seen in Figure 69, there is a very strong correlation between economic activity and water use.

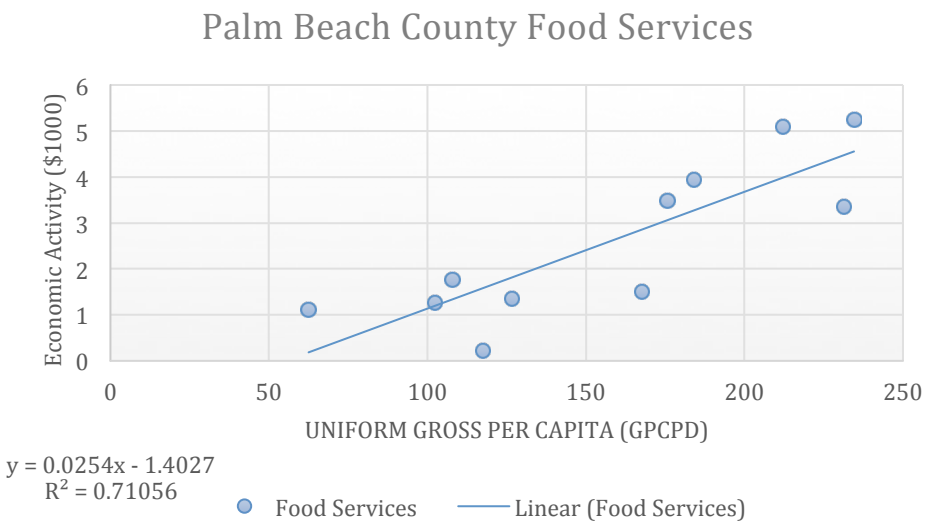


Figure 69. Palm Beach County food services.

Broward County, however, as seen in Figure 70, has a very weak R squared value. This mean the data is not a good fit, and as a result could be the reason that the overall food services appears to not be a good indicator for water use.

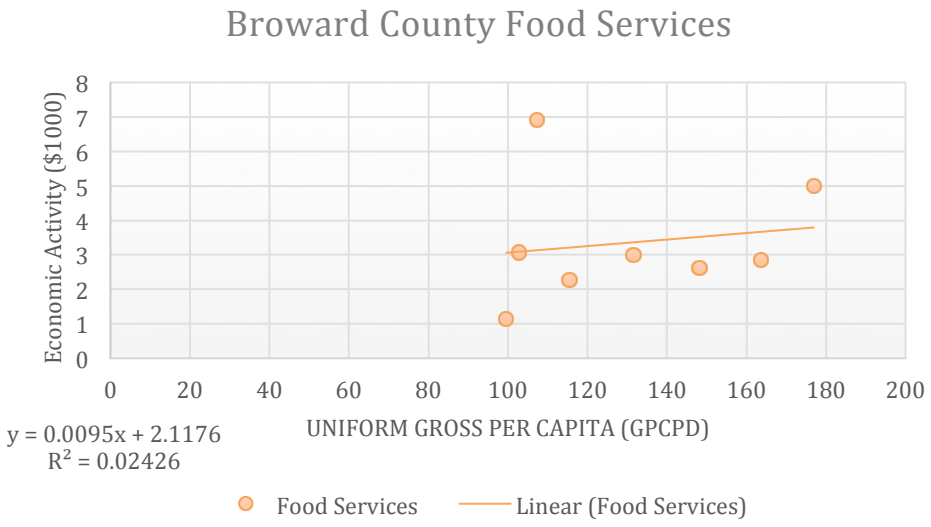


Figure 70. Broward County food services.

The last graph that stood out was healthcare, which can be seen in Figure 71.

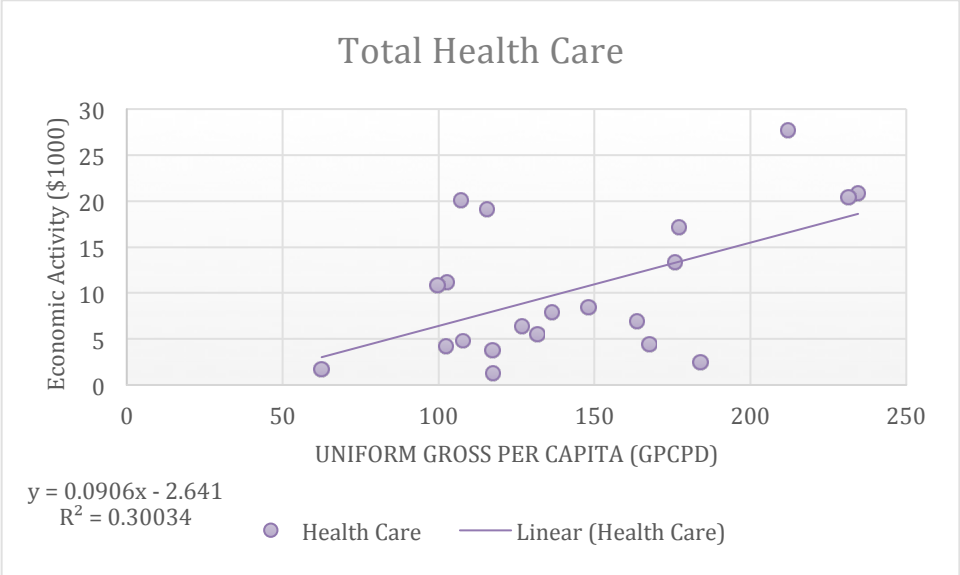


Figure 71. Total health care example.

Healthcare at the highest R squared value among all other graphs. It was not expected at healthcare would seem like such a good indicator. Hospitals tend to be in larger communities and act as economic centers. A small community like North Lauderdale is less likely to have a hospital than Fort Lauderdale. Hence per capita would be impacted in Fort Lauderdale by health services.

A summarized results for all of the created graphs can be seen in Table 5, or by checking Appendix A.

Table 5

Summarized Graphs Results

	Palm Beach County		Broward County		Miami-Dade County		Total	
Economic Sectors	X	R^2	X	R^2	X	R^2	X	R^2
Wholesale Trade	0.0071	0.009	0.6638	0.1309	0.8649	1	0.0425	0.003
Retail Trade	0.1047	0.5454	-0.1452	0.0979	-0.0012	1	0.0447	0.0347
Real Estate	0.0125	0.3504	-0.0032	0.0074	0.0185	1	0.0068	0.0687
Scientific and Technical Services	0.0927	0.4962	0.022	0.0264	0.2153	1	0.0771	0.3599
Waste Management	0.0442	0.3104	-0.0199	0.0314	0.0049	1	0.0271	0.095
Educational Services	0.0031	0.3339	0.0004	0.0018	0.0068	1	0.0022	0.1349
Health Care	0.1287	0.6312	-0.0386	0.0407	0.2158	1	0.0906	0.3003
Entertainment	0.0063	0.0891	0.0046	0.0151	0.0231	1	0.0062	0.0657
Food Services	0.0254	0.7106	0.0095	0.0243	-0.0087	1	0.0193	0.2811
Other Services	0.0145	0.2014	0.0073	0.0093	0.0407	1	0.0112	0.0711
Total	0.4391	0.4279	0.5006	0.0601	1.3802	1	0.3277	0.0913

Regression Model

Excels regression model first output data was the statistics, which describes the fit of the data to the model. These results can be seen in Table 6.

Table 6

Regression Statistics

Statistical Analysis	Results
Multiple R	0.898279
R Square	0.806905
Adjusted R Square	0.61381
Standard Error	28.67787
Observations	21

The first and main thing to note from the statistics is the R Square value. The R Square value tells how good of a fit the variables are with one another within the model. The value observed, 0.806, shows that this is a good model and is a reliable prediction model.

The main analysis of the regression model can be found in Table 7.

Table 7

Regression Model

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	101.1028	17.95	5.63	0.0002	61.1	141.1	61.1	141.1
Wholesale trade	0.0794	0.25	0.32	0.7546	-0.5	0.6	-0.5	0.6
Retail Trade	-1.4377	1.53	-0.94	0.3696	-4.8	2.0	-4.8	2.0
Real Estate	-23.9936	22.77	-1.05	0.3168	-74.7	26.7	-74.7	26.7
Scientific and technical services	-0.5286	3.57	-0.15	0.8853	-8.5	7.4	-8.5	7.4
Waste Management	-3.8725	4.15	-0.93	0.3729	-13.1	5.4	-13.1	5.4
Educational Services	42.9581	60.15	0.71	0.4914	-91.1	177.0	-91.1	177.0
Health Care	3.8836	2.05	1.90	0.0873	-0.7	8.4	-0.7	8.4
Entertainment	39.3834	15.34	2.57	0.0280	5.2	73.6	5.2	73.6
Food Services	44.7613	14.94	3.00	0.0134	11.5	78.1	11.5	78.1
Other Services	-33.8167	10.85	-3.12	0.0109	-58.0	-9.6	-58.0	-9.6

It will be assumed that any P-value with a value less than 0.05 will be considered statistically significant to its contribution to the model. This means that these sectors are good indicators and predictors of water use. However the values that do not meet this threshold can't be ignored; it just means that based upon the given input variables and geographical location the sectors that fail this test are not significant.

With all of the variables taken into consideration an overall prediction model was able to be created Equation 1, and it has shown to be a reliable model.

Equation 1 Predictive Water Use Equation

$$Y = 101.1028 + x_1(0.0794) + x_2(-1.4377) + x_3(-23.9936) + x_4(-0.5286) + x_5(-3.8725) + x_6(42.9581) + x_7(3.834) + x_8(39.3834) + x_9(44.7613) + x_{10}(-33.8167)$$

Where:

x_1 Wholesale trade

x_2 Retail trade

x_3 Real estate and rental and leasing

x_4 Professional, scientific, and technical services

x_5 Administrative and support and waste management and remediation services

x_6 Educational services

x_7 Health care and social assistance

x_8 Arts, entertainment, and recreation

x_9 Accommodation and food services

x_{10} Other services (except public administration)

Y Predicted water use in gross per capita

As can be seen in the equation, the strongest economic indicators are Educational Services, Entertainment, and Food Services. The model was tested against the input data used in order to see how reliable the equations was. The average margin of error was ±2.77%, with extremes of +52% and -45%. In Figure 72 the tested equation displaces the graphical results for the tested model. The results show that the equation is producing normally distributed data, but because of the small sample size it's not a smooth continuous curve.

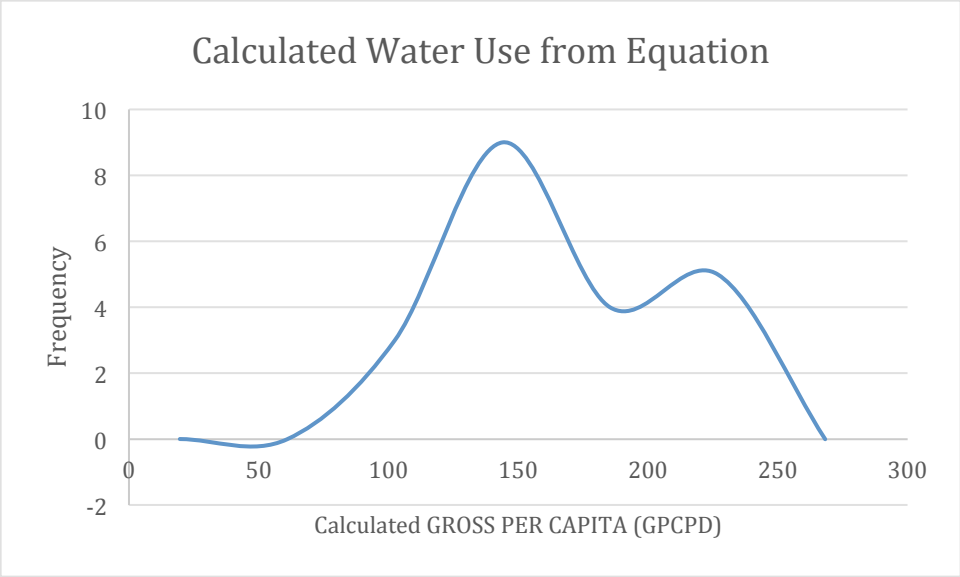


Figure 72. Tested equation.

To adjust for the small sample size that is being test, the equation is tested using randomly generated data that is based on the standard deviation and mean from the original data set. Figure 73 shows the results of the rest. As can be seen the result is a smooth continuous graph that is normally distributed.

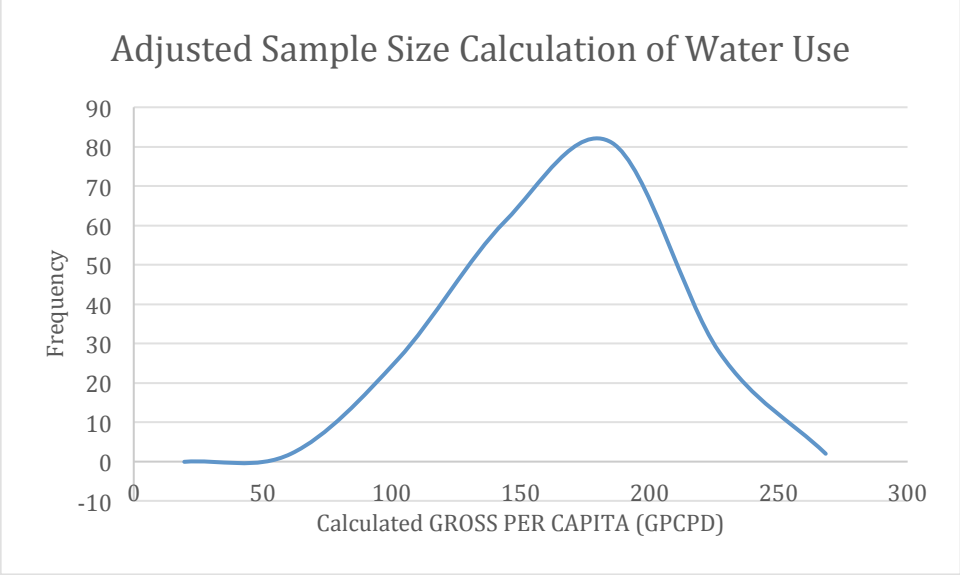


Figure 73. Adjusted equation test.

CONCLUSION

The current methods that are being utilized by utilities to predict water use are based on prediction through population, while penalizing economic activity. The data indicates that economic activity can make a significant difference on per capita water use. The southeast Florida case studies were useful in than few have large irrigation components. In fact, most of the Broward utilities have no irrigation component as residents have historically relied on individual irrigation wells. However the per capita water use rates vary widely. It was found that commercial/economic activity affects per capita use and to regulate base don per capita use is an economic barrier to a community. Since jobs are important, water use should not be a limiting factors.

This project identified a series of components that affect water use, although these factors were neither uniform nor sole predictors on their own. As a result, a model was developed for southeast Florida based on census data on economic activity and water use patterns. This new method allows utilities to understand water demand based on economic growth and make smarter planning decision not just on a utility level but also on an overall city or even county development. This method is currently limited by the availability of economic data, but with the availably data the regression models show that water use can be predicted within a 2.7% margin of error.

FUTURE WORK

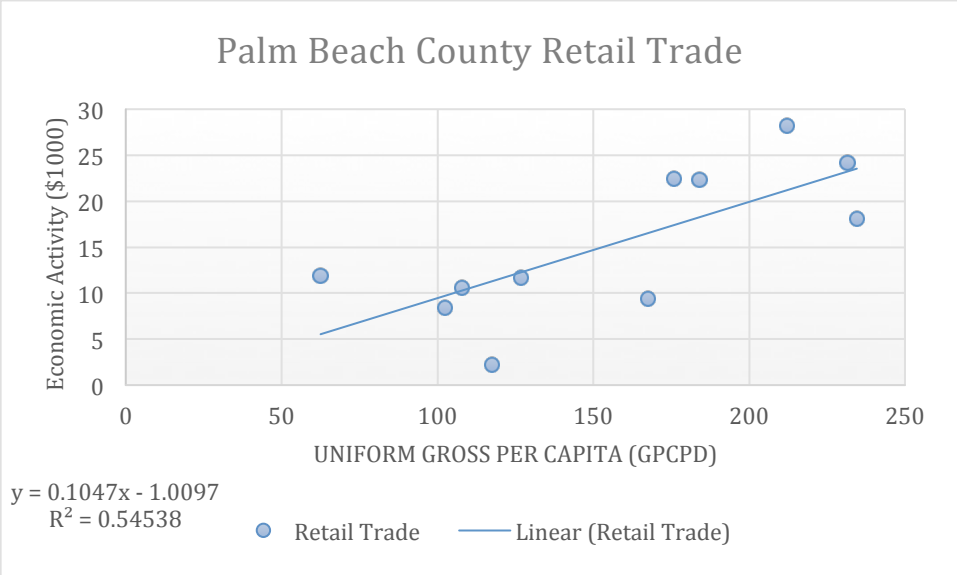
There are a few ways that this research can be expanded for future work, the first being a look into gathering more data on residents of the utilities. It would be interesting to see if there is a correlation between average household income and water use as well as to see if there is a correlation between water use and diversity of the community. The second way this research can be expanded for future work would be to analyze the P values in the regression model further. Extracting the economic sectors with P-values less than 0.5 and running the regression model again would make for some interesting results. Removing these values might help show if the strong economic sectors influence within the formula might mask the influence of the lower economic sectors. And finally I looked into the use of other statistical analysis methods be beneficial. A dreary look into the use of non-normally distributed as well as more normally distributed models might help yield different results with the same data.

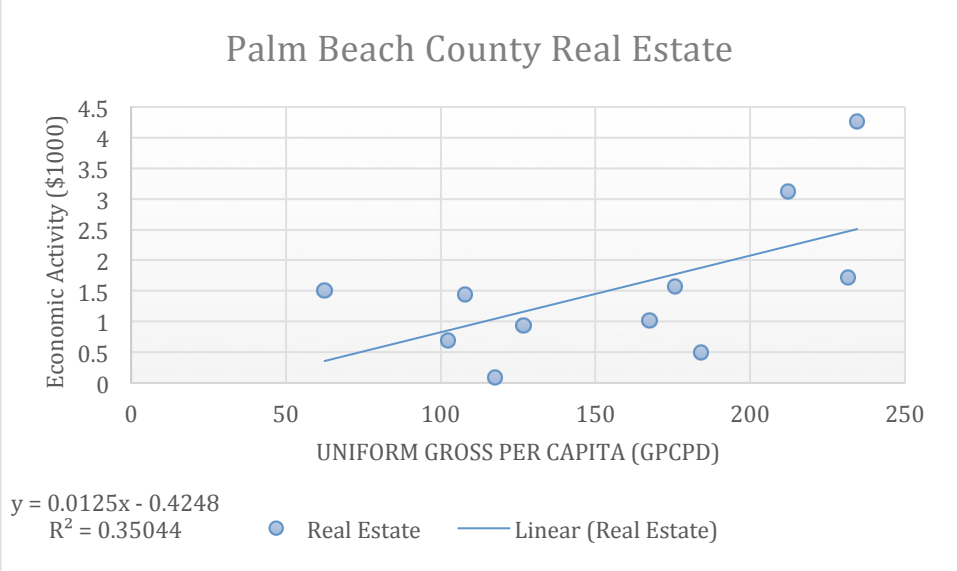
APPENDICES

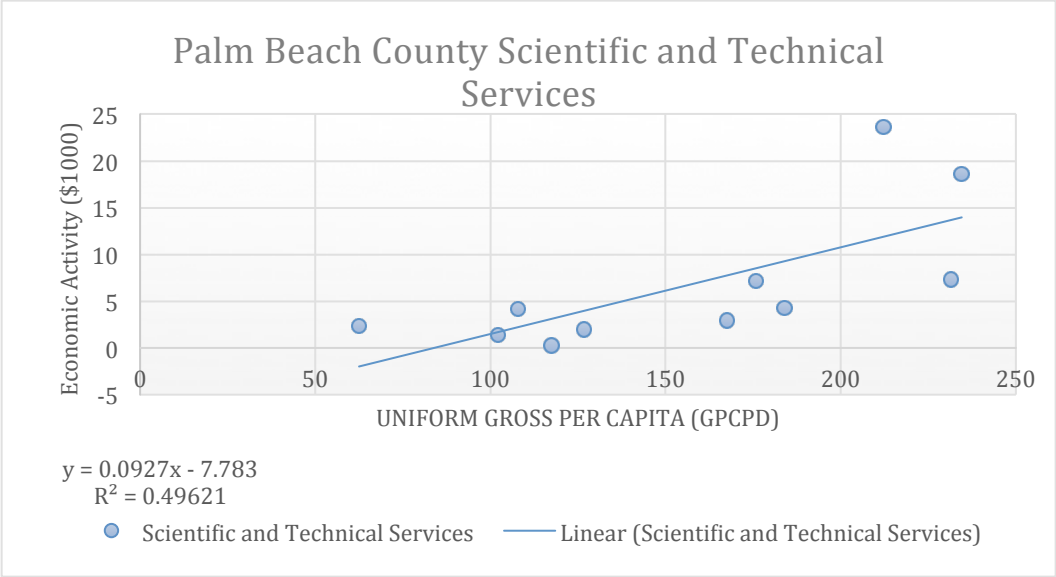
Appendix A

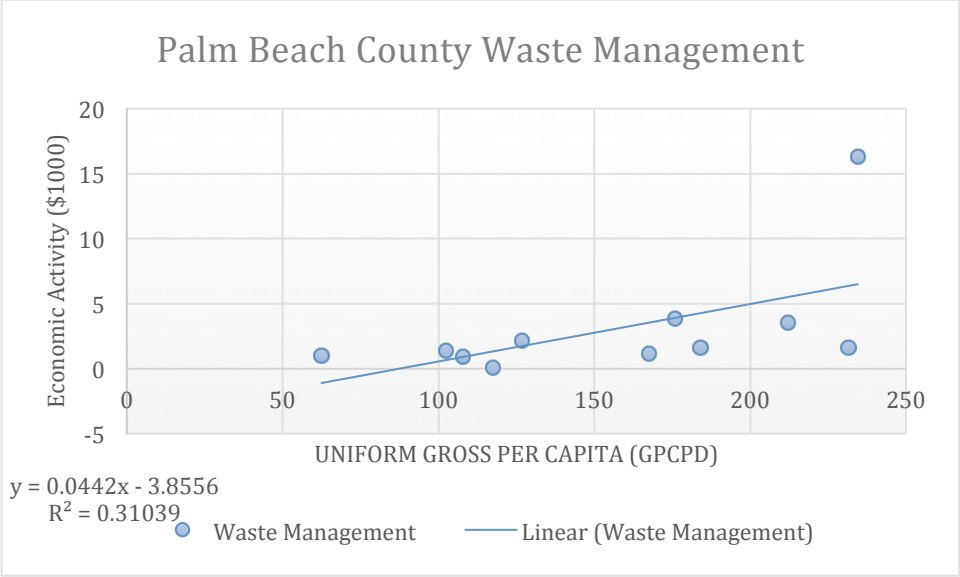
Economic Activity Per Gross Per Capita Water Use

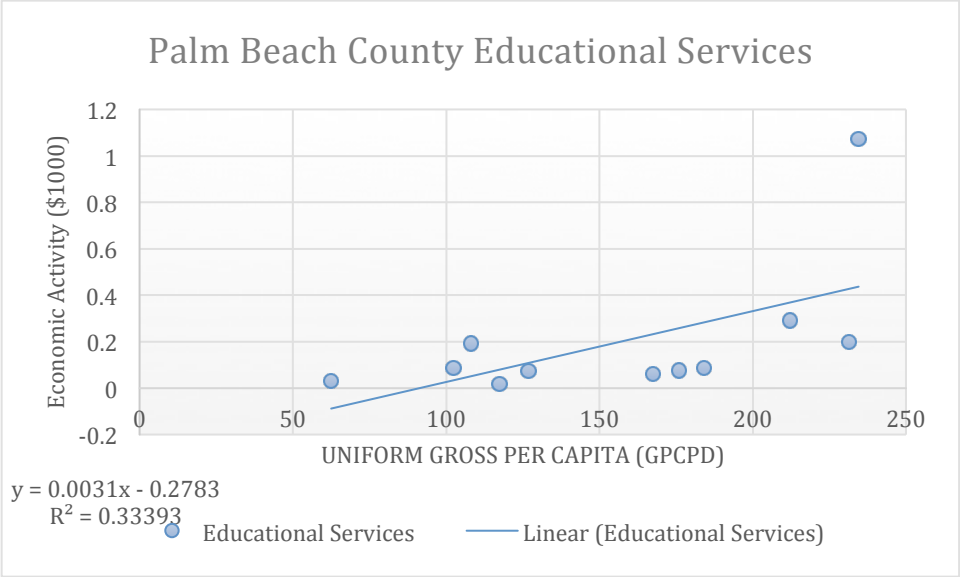
Palm Beach County

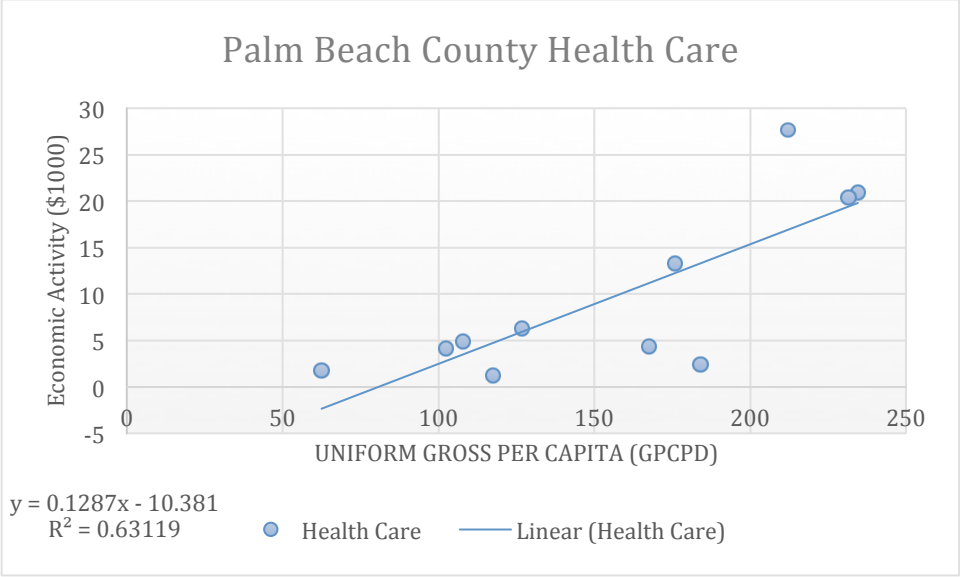


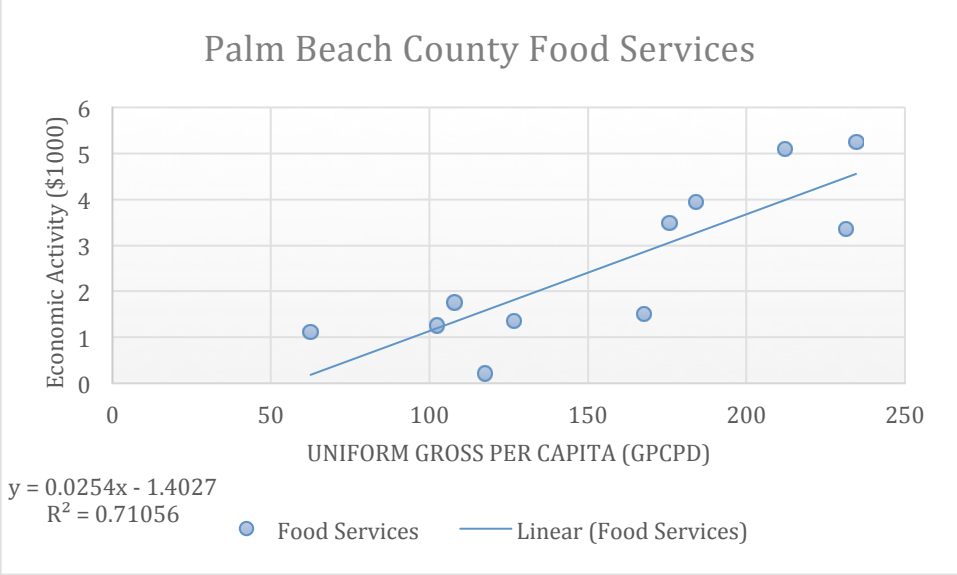


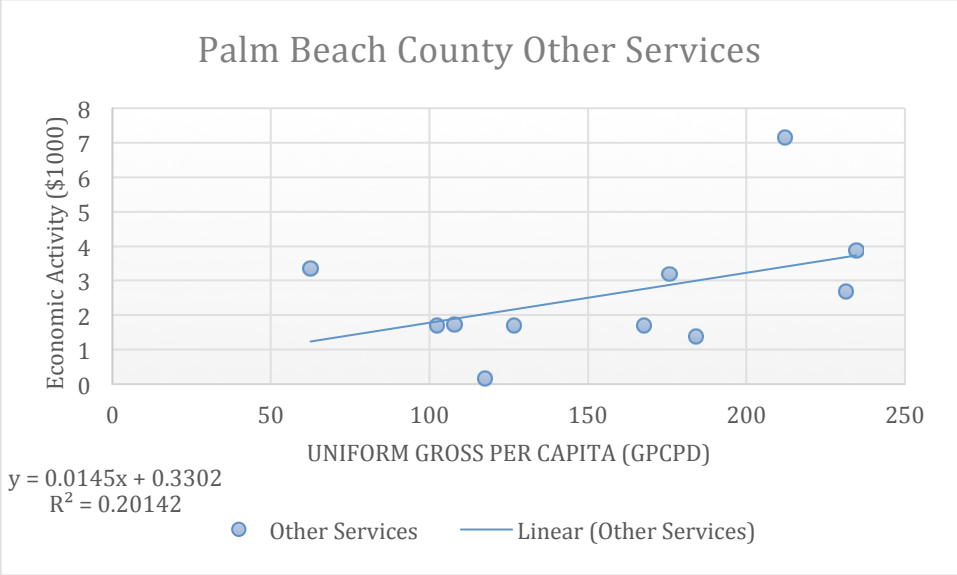

Palm Beach County Scientific and Technical Services
Economic Activity ($1000)
25
20
15
10
5
0
-5
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0927x - 7.783
R² = 0.49621
Scientific and Technical Services
Linear (Scientific and Technical Services)

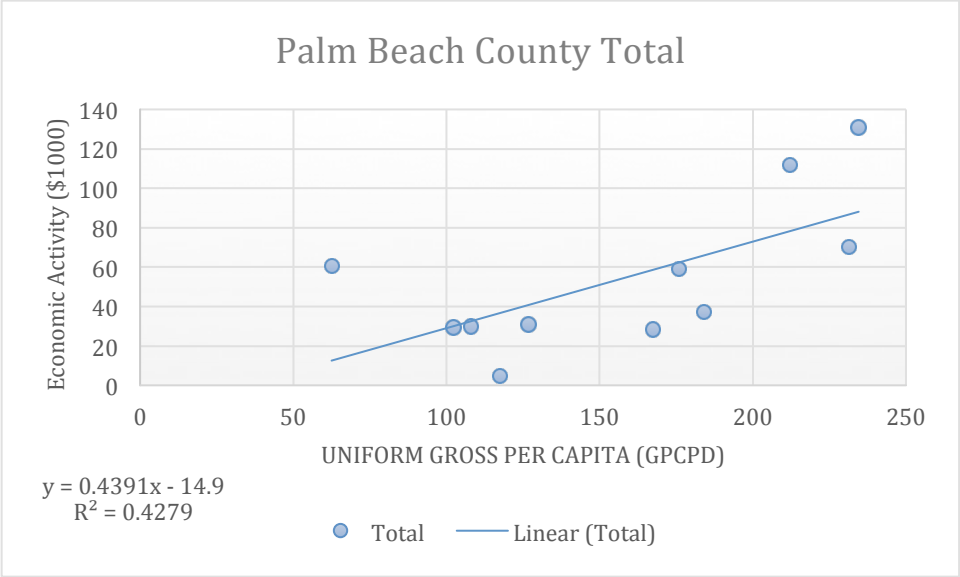

Palm Beach County Waste Management
Economic Activity ($1000)
20
15
10
5
0
-5
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0442x - 3.8556
R² = 0.31039
Waste Management
Linear (Waste Management)

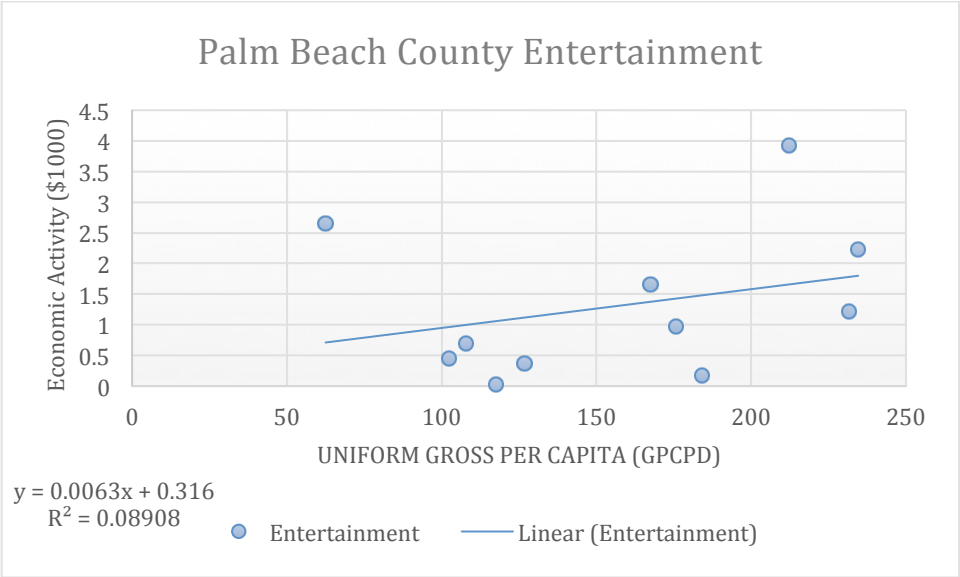

Palm Beach County Educational Services
Economic Activity ($1000)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0031x - 0.2783
R² = 0.33393
Educational Services
Linear (Educational Services)

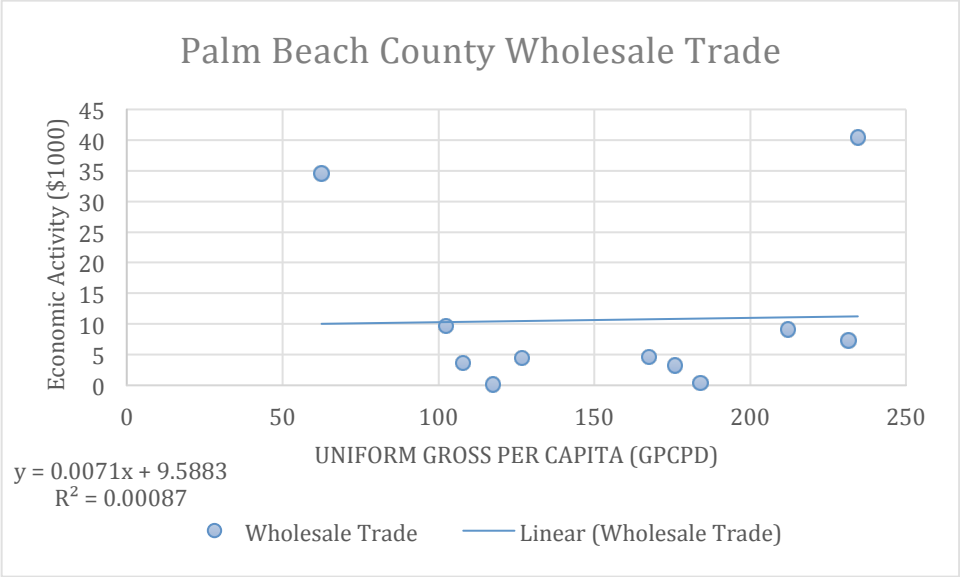

Palm Beach County Health Care
Economic Activity ($1000)
30
25
20
15
10
5
0
-5
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.1287x - 10.381
R² = 0.63119
Health Care
Linear (Health Care)


Palm Beach County Food Services
Economic Activity ($1000)
0
1
2
3
4
5
6
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0254x - 1.4027
R² = 0.71056
Food Services
Linear (Food Services)

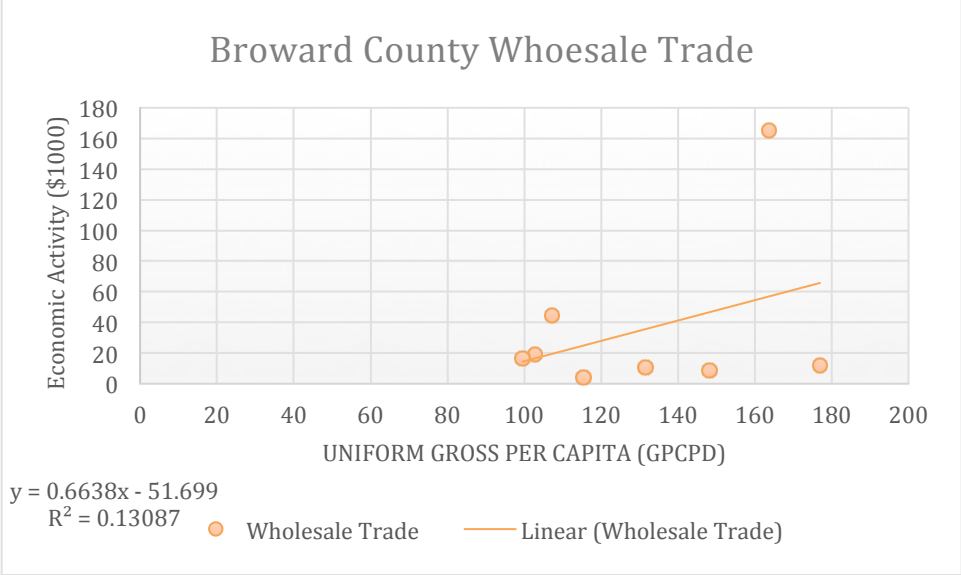

Palm Beach County Other Services
Economic Activity ($1000)
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0145x + 0.3302
R² = 0.20142
Other Services
Linear (Other Services)

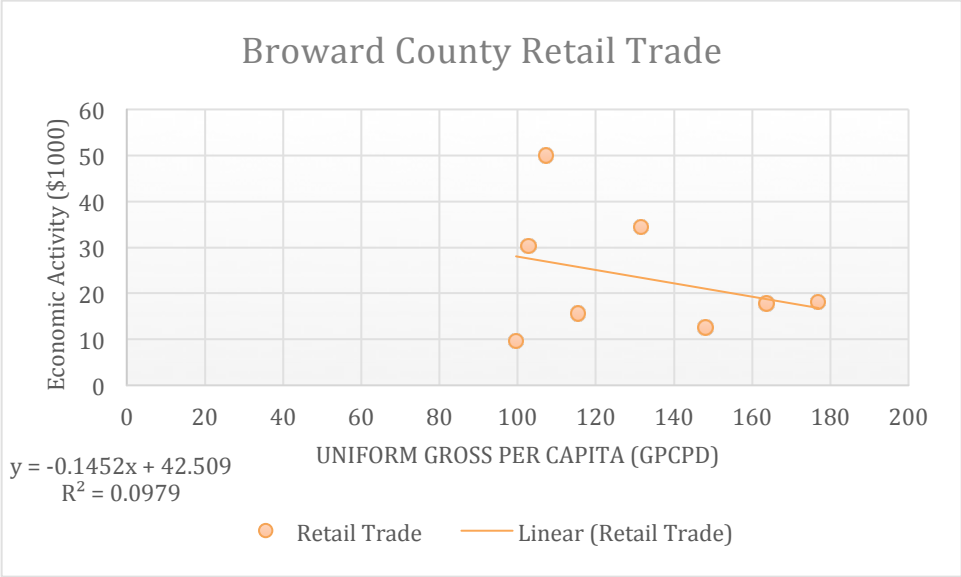

Palm Beach County Total
Economic Activity ($1000)
140
120
100
80
60
40
20
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.4391x - 14.9
R² = 0.4279
Total
Linear (Total)

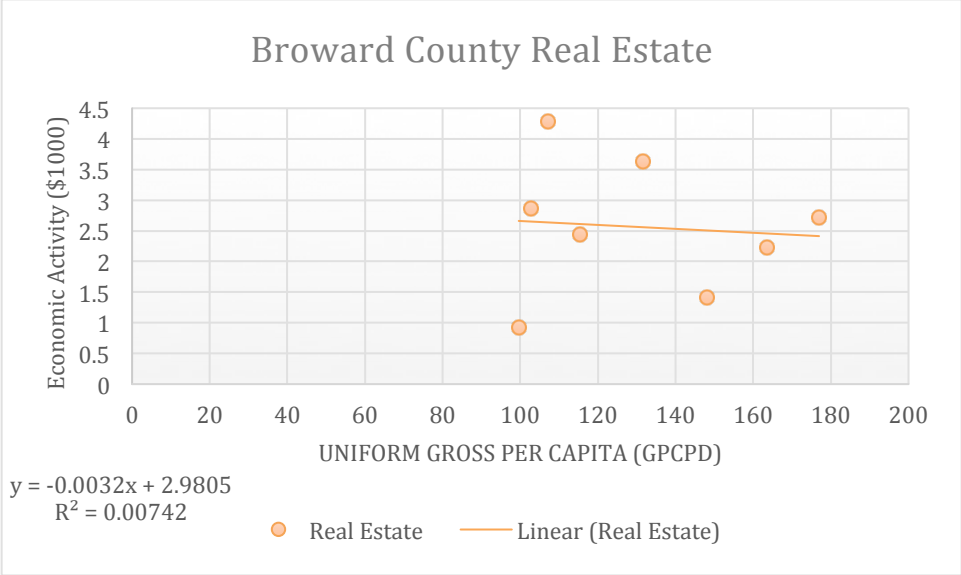

Palm Beach County Entertainment
Economic Activity ($1000)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0063x + 0.316
R² = 0.08908
Entertainment
Linear (Entertainment)

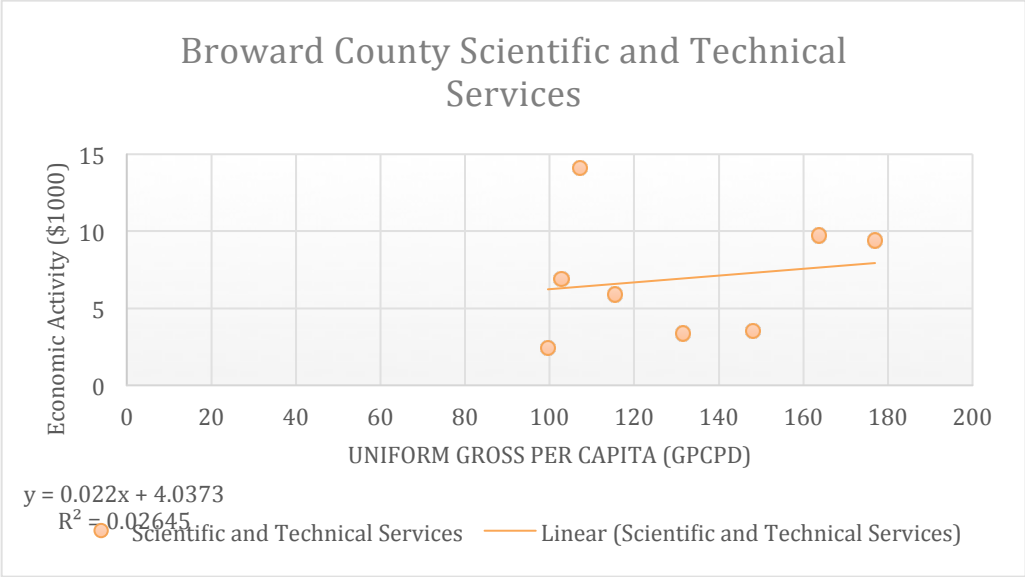


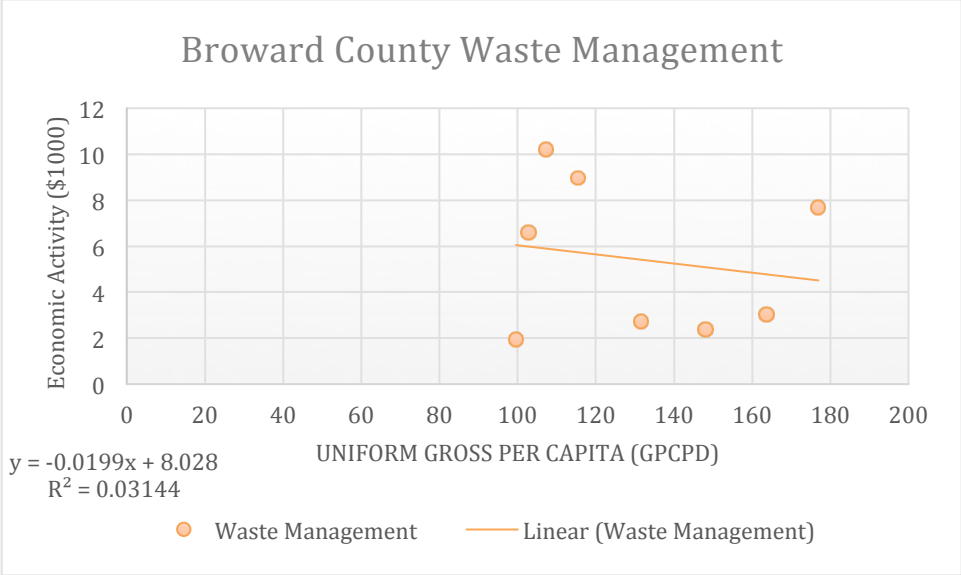
Broward County

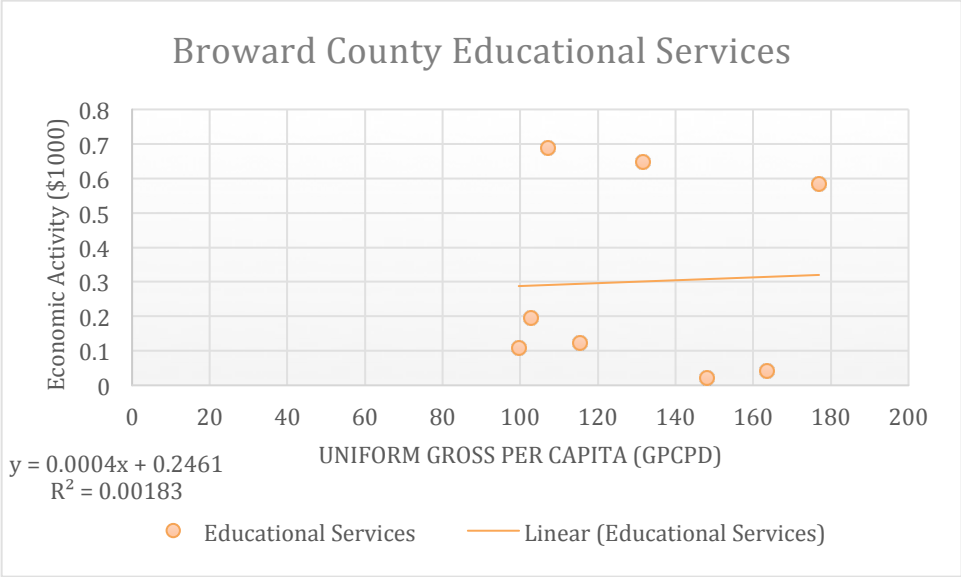


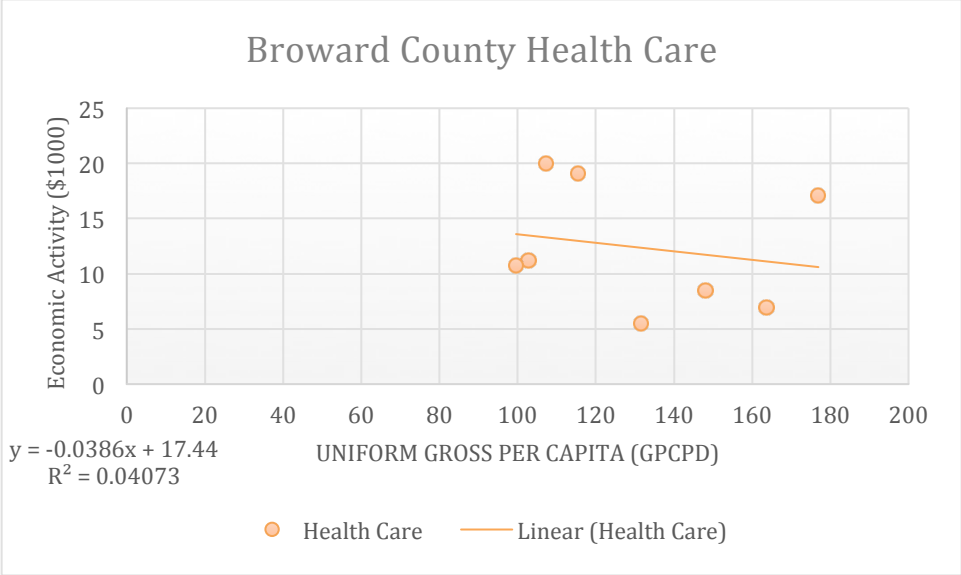

Broward County Retail Trade
Economic Activity ($1000)
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = -0.1452x + 42.509
R² = 0.0979
Retail Trade
Linear (Retail Trade)

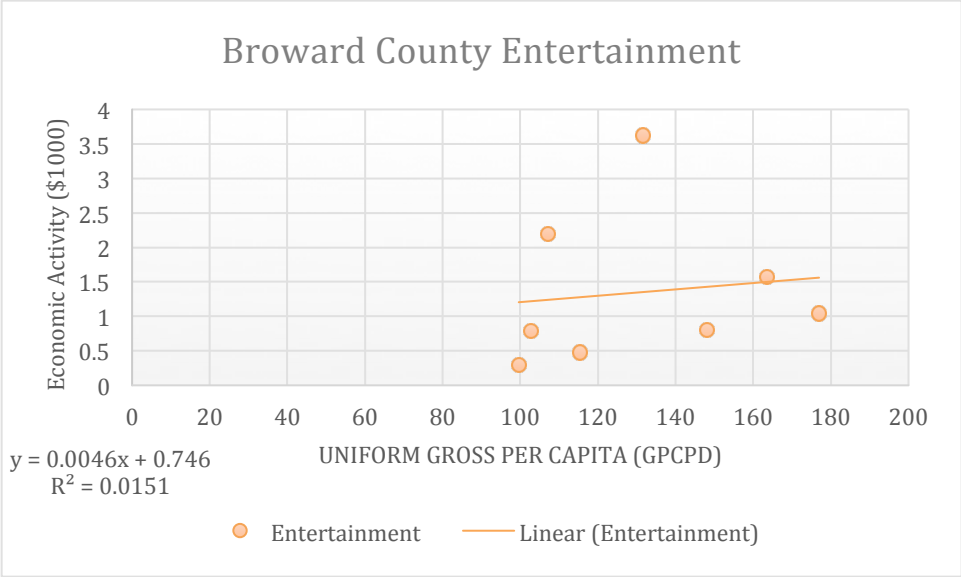

Broward County Real Estate
Economic Activity ($1000)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = -0.0032x + 2.9805
R² = 0.00742
Real Estate
Linear (Real Estate)

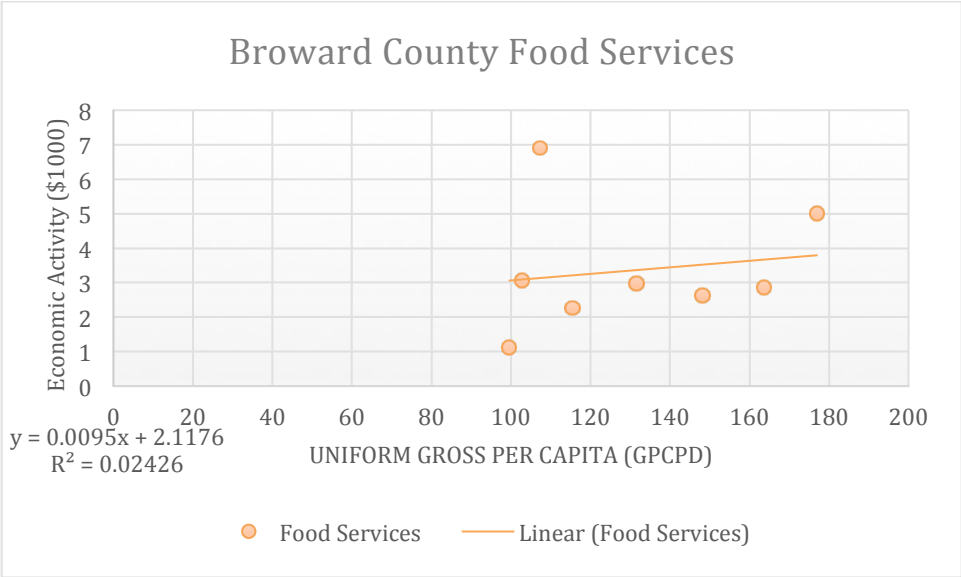

Broward County Scientific and Technical Services
Economic Activity ($1000)
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.022x + 4.0373
R² = 0.02645
Scientific and Technical Services
Linear (Scientific and Technical Services)

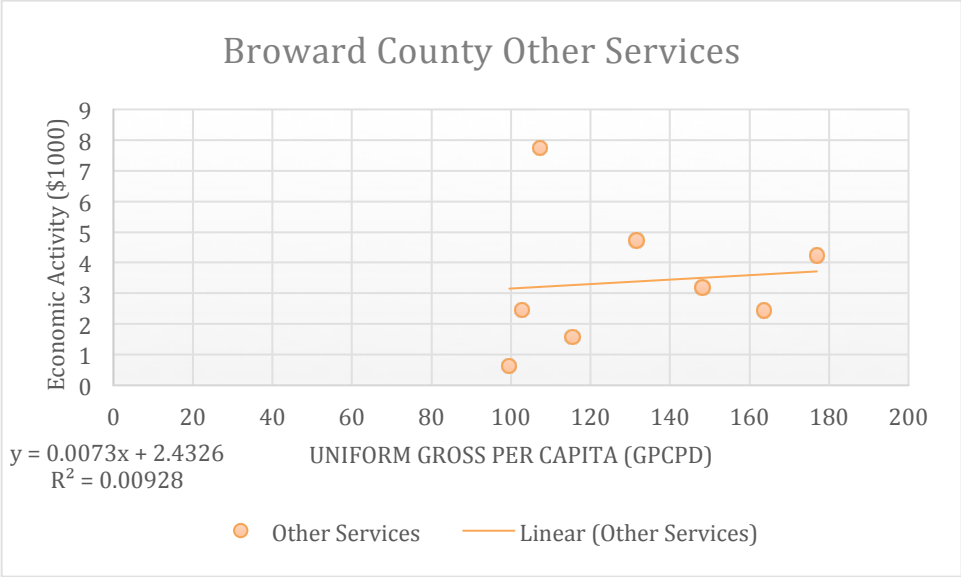

Broward County Waste Management
Economic Activity ($1000)
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = -0.0199x + 8.028
R² = 0.03144
Waste Management
Linear (Waste Management)

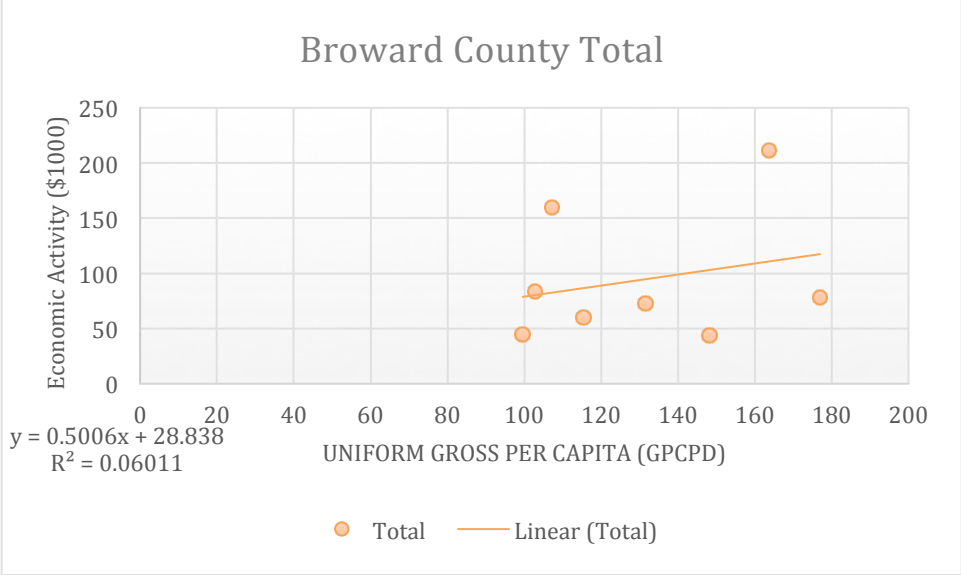

Broward County Educational Services
Economic Activity ($1000)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0004x + 0.2461
R² = 0.00183
Educational Services
Linear (Educational Services)


Broward County Health Care
Economic Activity ($1000)
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = -0.0386x + 17.44
R² = 0.04073
Health Care
Linear (Health Care)

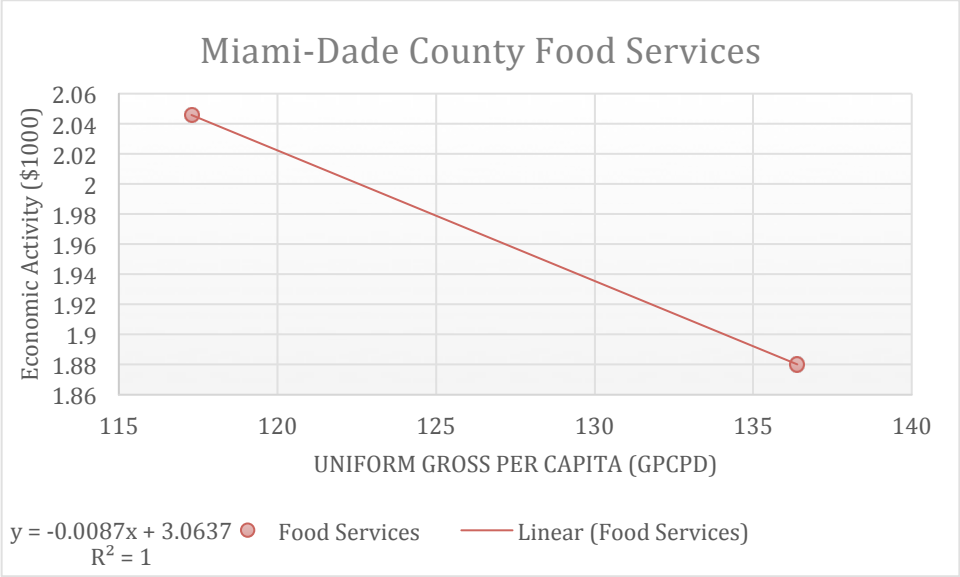

Broward County Entertainment
Economic Activity ($1000)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0046x + 0.746
R² = 0.0151
Entertainment
Linear (Entertainment)

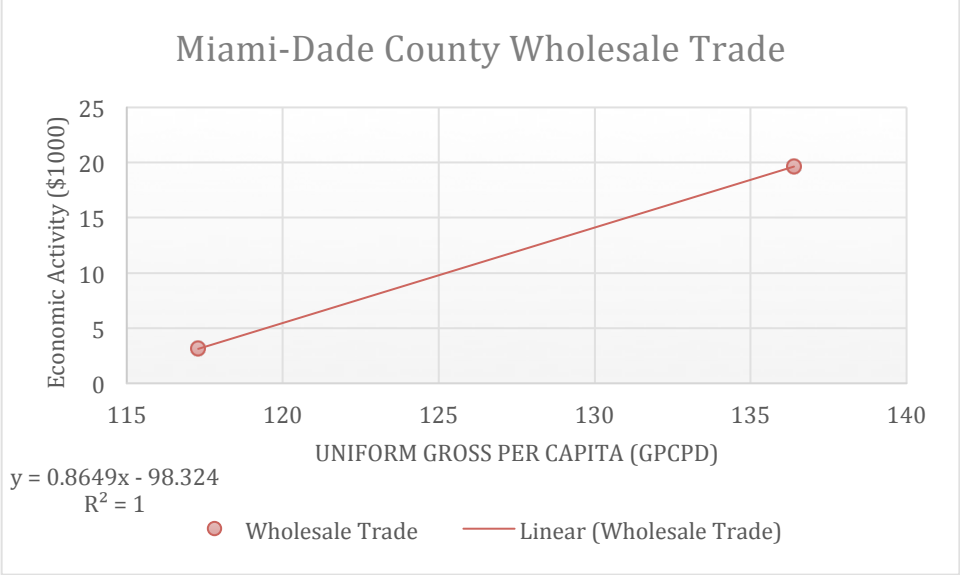

Broward County Food Services
Economic Activity ($1000)
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0095x + 2.1176
R² = 0.02426
Food Services
Linear (Food Services)

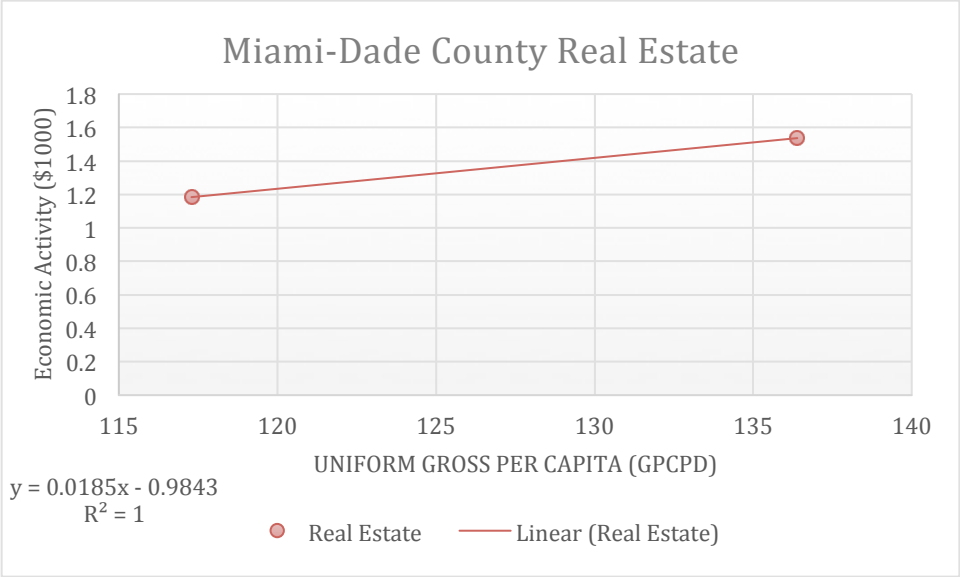

Broward County Other Services
Economic Activity ($1000)
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
y = 0.0073x + 2.4326
R² = 0.00928
UNIFORM GROSS PER CAPITA (GPCPD)
Other Services
Linear (Other Services)

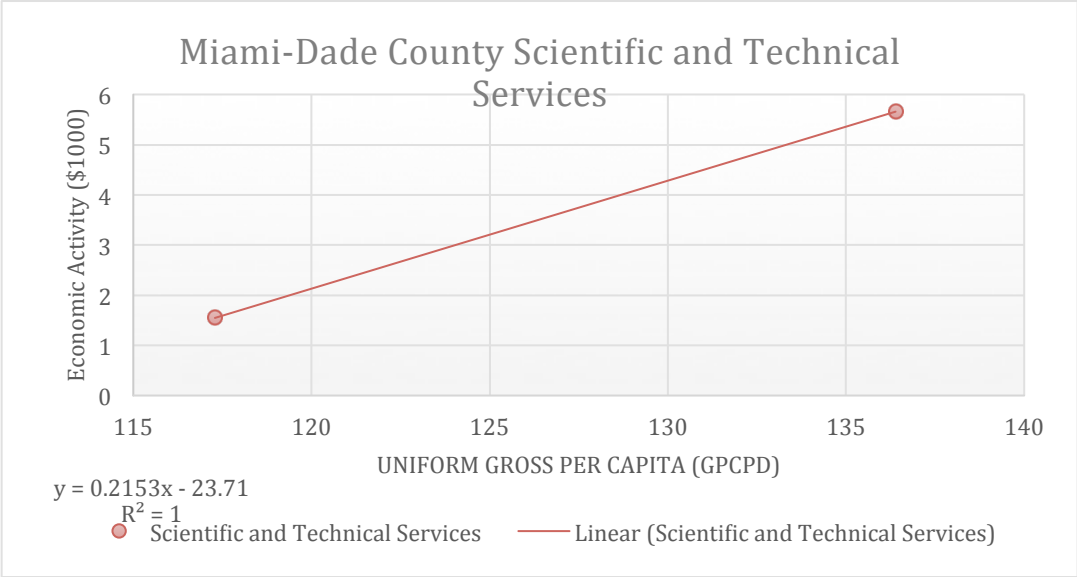

Broward County Total
Economic Activity ($1000)
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
180
200
y = 0.5006x + 28.838
R² = 0.06011
UNIFORM GROSS PER CAPITA (GPCPD)
Total
Linear (Total)

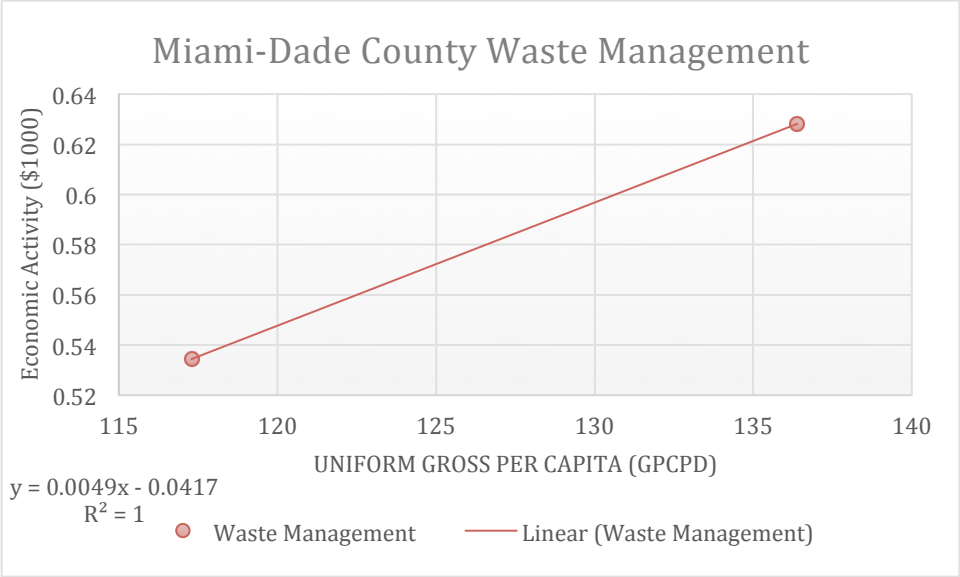
Miami-Dade County

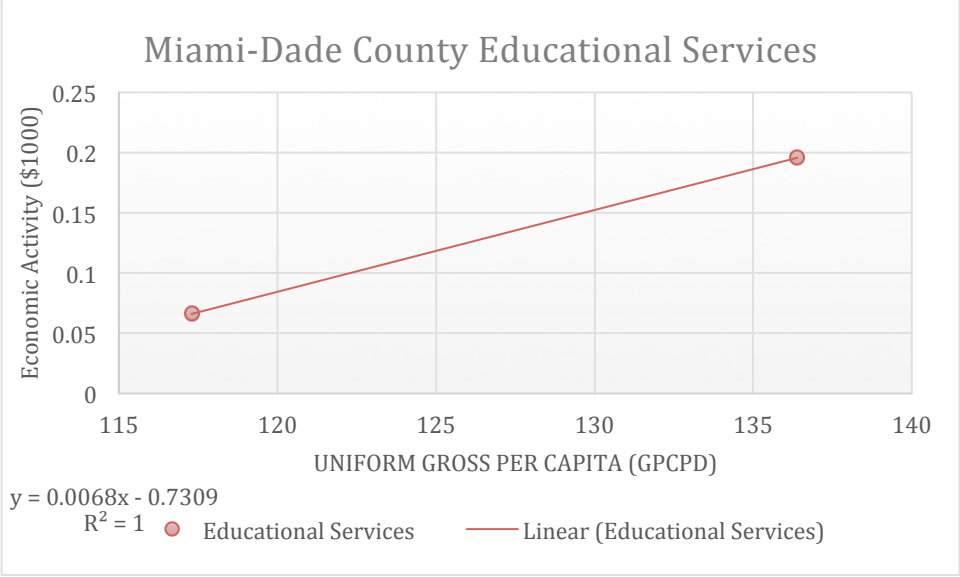


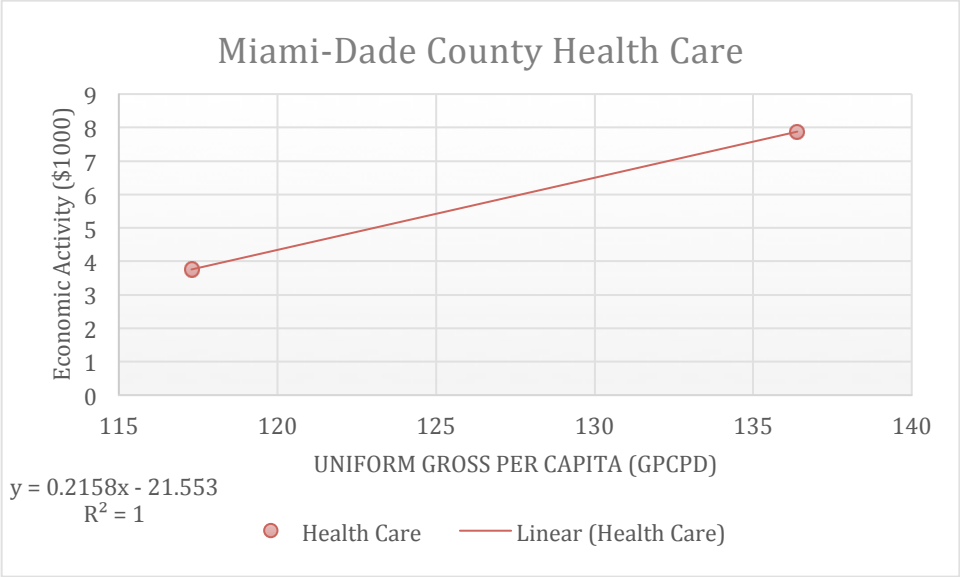


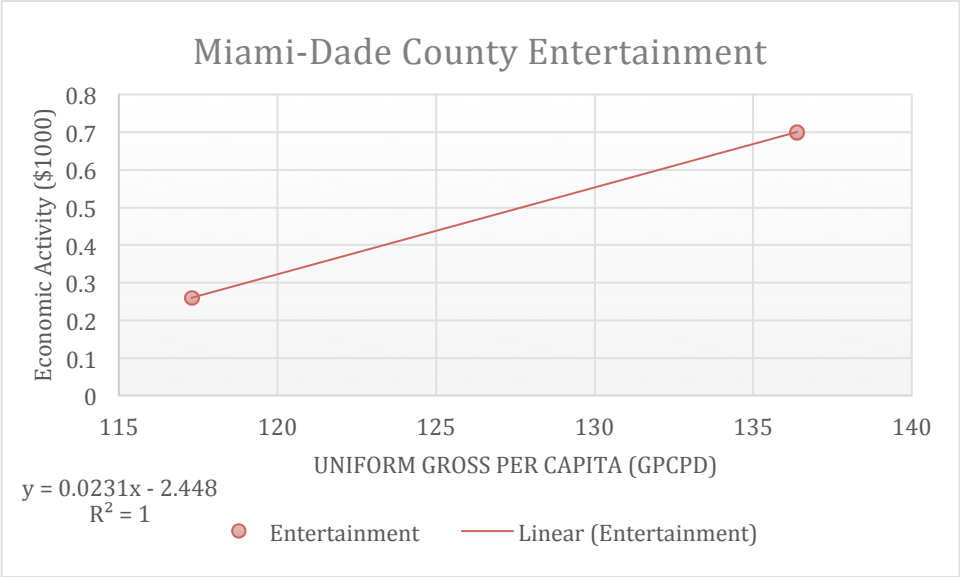

Miami-Dade County Real Estate
Economic Activity ($1000)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0185x - 0.9843
R² = 1
Real Estate
Linear (Real Estate)

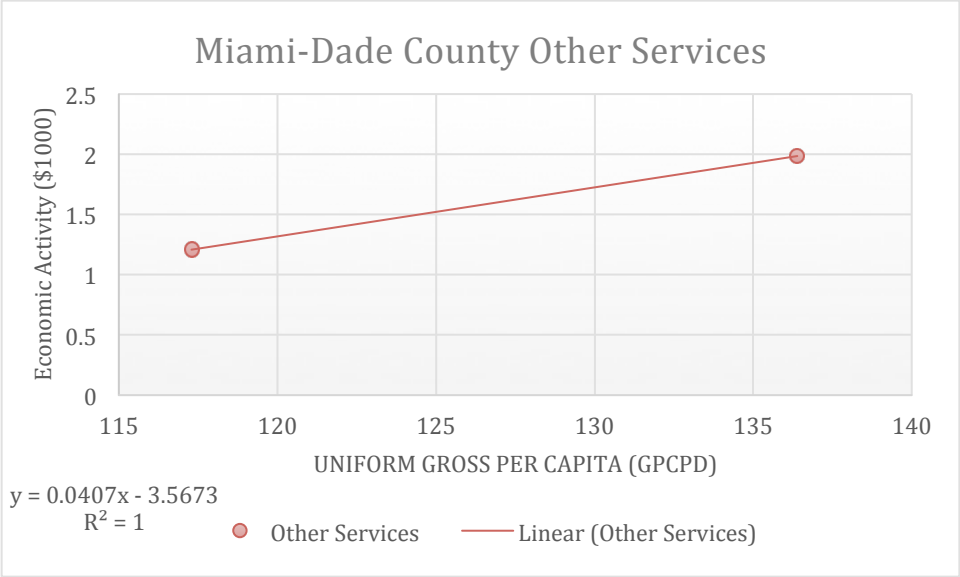

Miami-Dade County Scientific and Technical Services
Economic Activity ($1000)
6
5
4
3
2
1
0
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.2153x - 23.71
R² = 1
Scientific and Technical Services
Linear (Scientific and Technical Services)

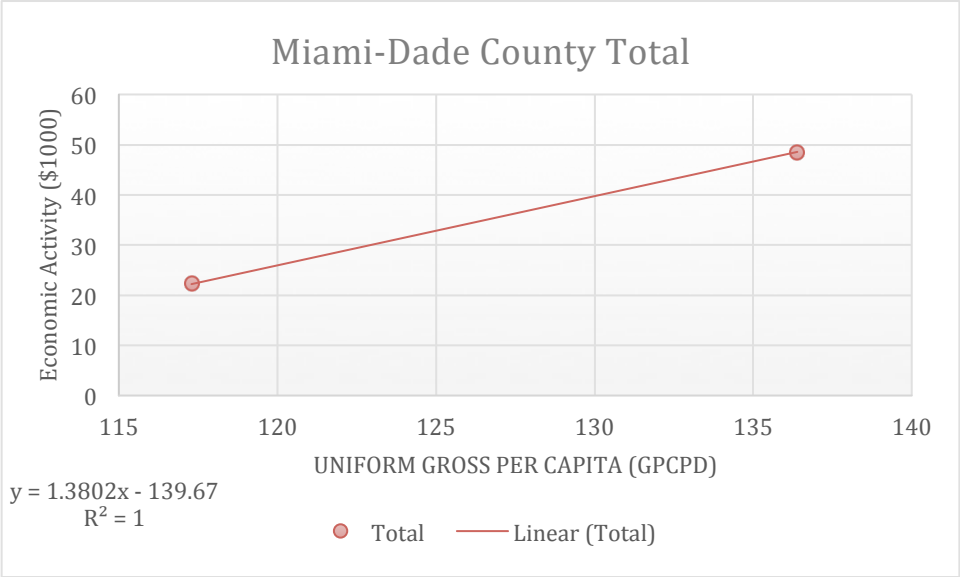

Miami-Dade County Waste Management
Economic Activity ($1000)
0.64
0.62
0.6
0.58
0.56
0.54
0.52
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0049x - 0.0417
R² = 1
Waste Management
Linear (Waste Management)


Miami-Dade County Educational Services
Economic Activity ($1000)
0.25
0.2
0.15
0.1
0.05
0
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0068x - 0.7309
R² = 1
Educational Services
Linear (Educational Services)

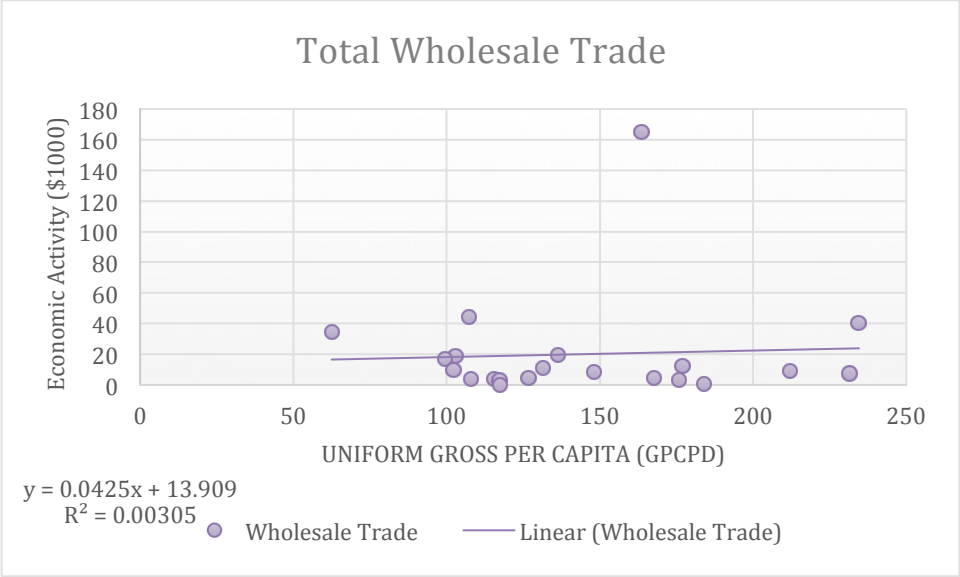

Miami-Dade County Health Care
Economic Activity ($1000)
9
8
7
6
5
4
3
2
1
0
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.2158x - 21.553
R² = 1
Health Care
Linear (Health Care)

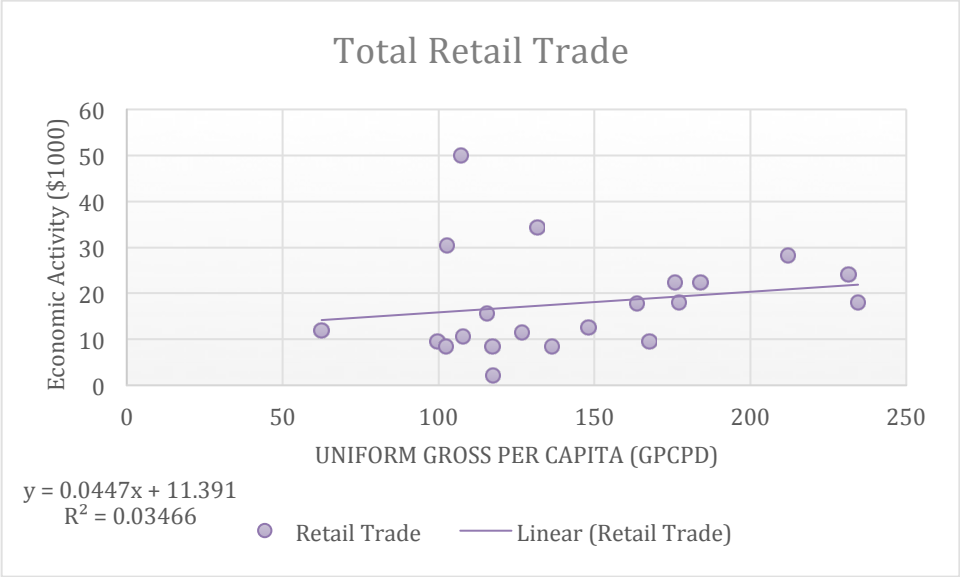

Miami-Dade County Entertainment
Economic Activity ($1000)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0231x - 2.448
R² = 1
Entertainment
Linear (Entertainment)

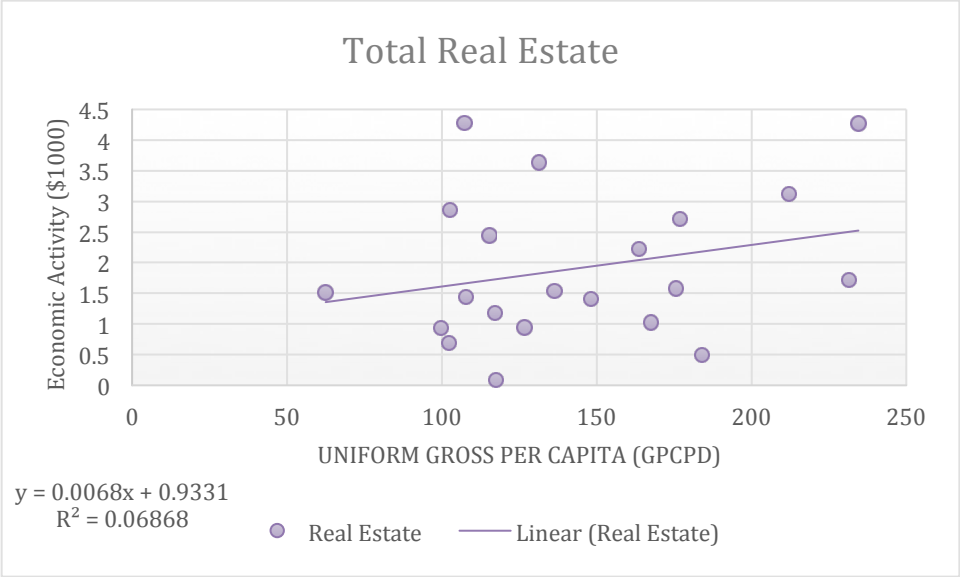

Miami-Dade County Other Services
Economic Activity ($1000)
2.5
2
1.5
1
0.5
0
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0407x - 3.5673
R² = 1
Other Services
Linear (Other Services)

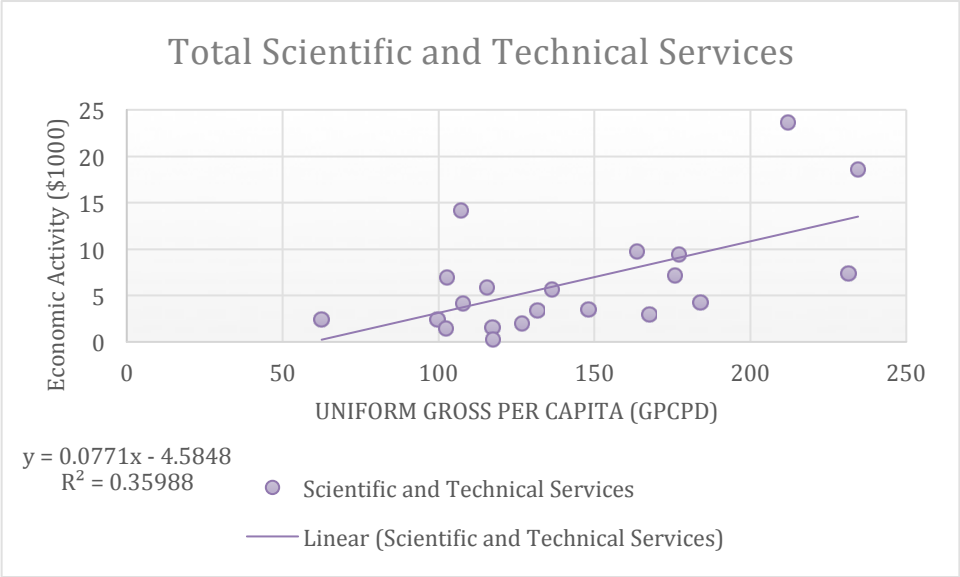

Miami-Dade County Total
Economic Activity ($1000)
60
50
40
30
20
10
0
115
120
125
130
135
140
UNIFORM GROSS PER CAPITA (GPCPD)
y = 1.3802x - 139.67
R² = 1
Total
Linear (Total)

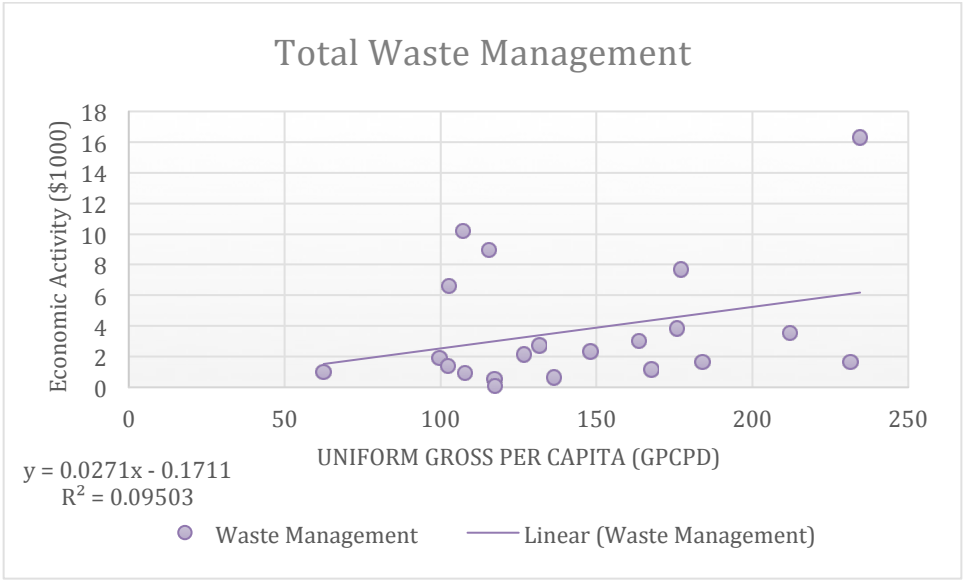
All Three Counties

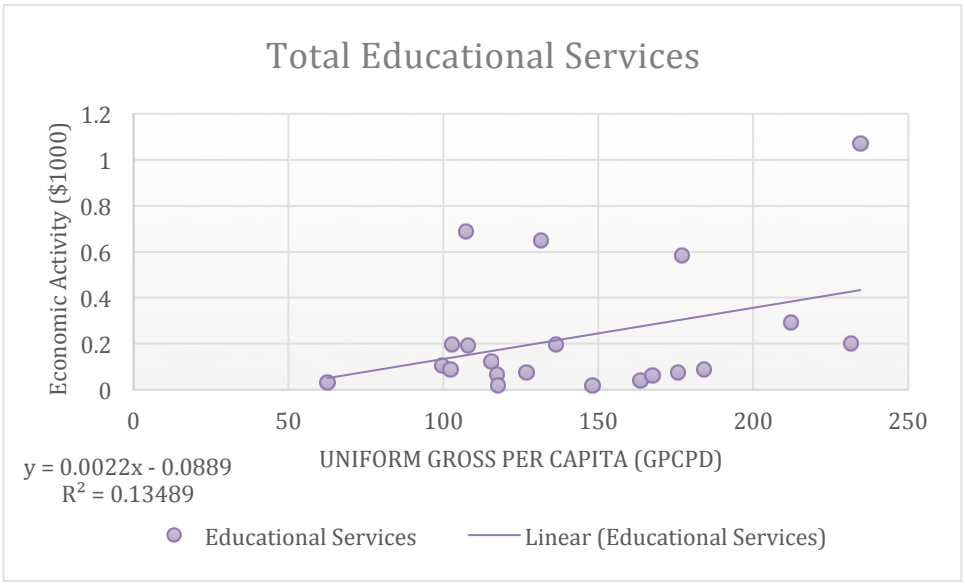


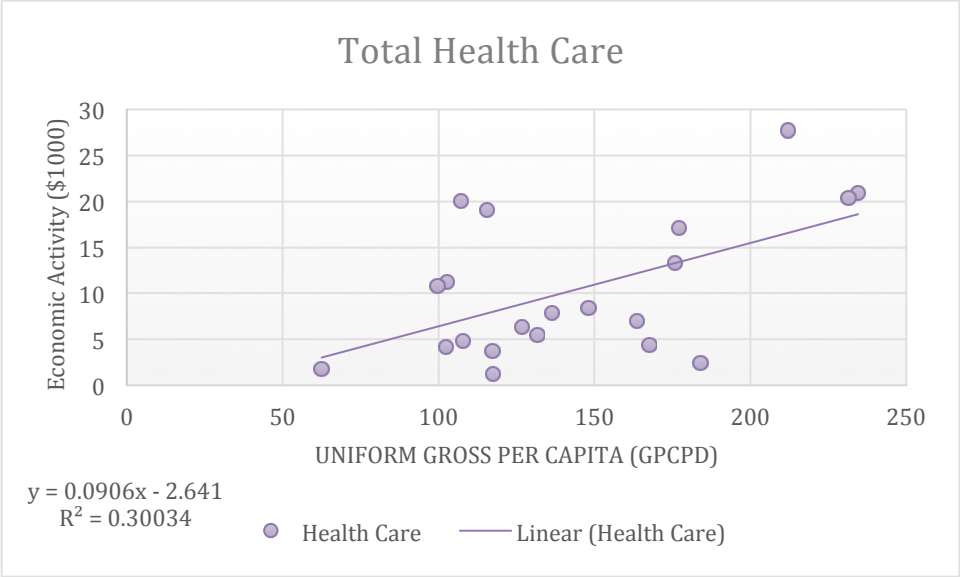


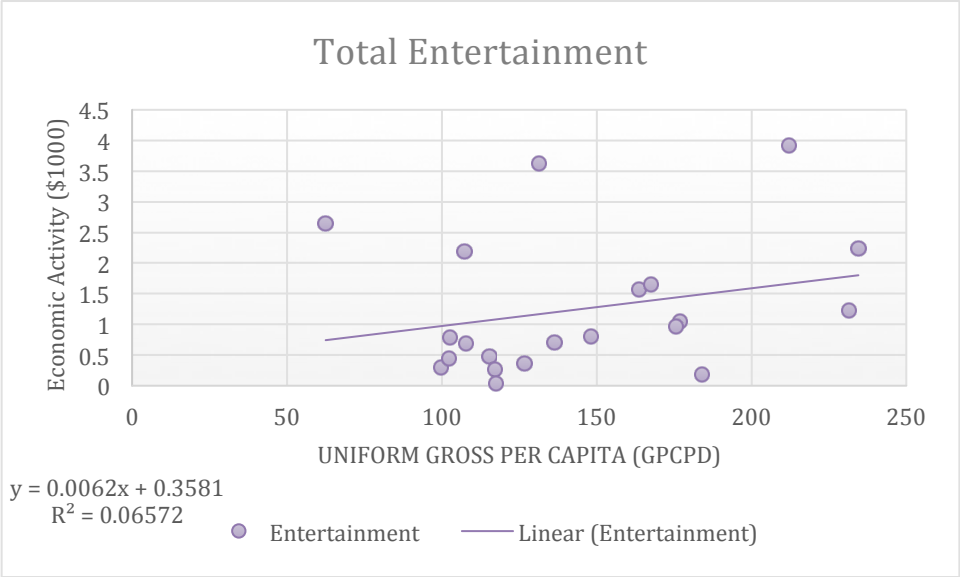

Total Real Estate
Economic Activity ($1000)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0068x + 0.9331
R² = 0.06868
Real Estate
Linear (Real Estate)

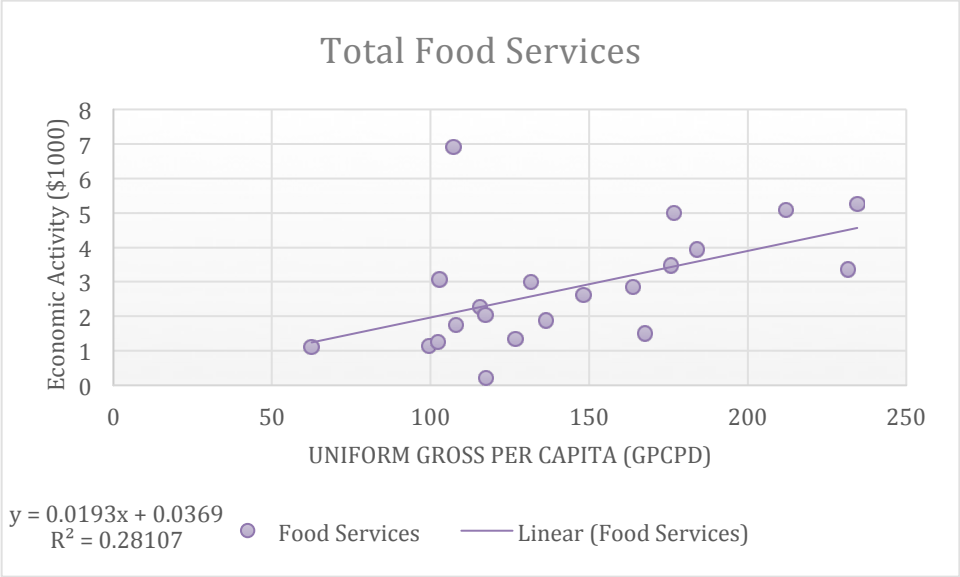

Total Scientific and Technical Services
Economic Activity ($1000)
25
20
15
10
5
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0771x - 4.5848
R² = 0.35988
Scientific and Technical Services
Linear (Scientific and Technical Services)

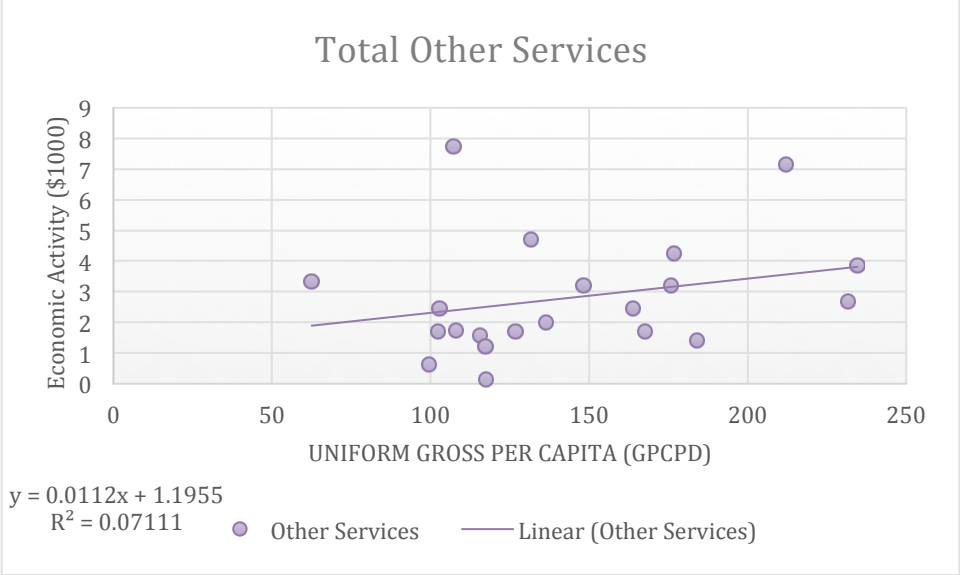

Total Waste Management
Economic Activity ($1000)
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0271x - 0.1711
R² = 0.09503
Waste Management
Linear (Waste Management)

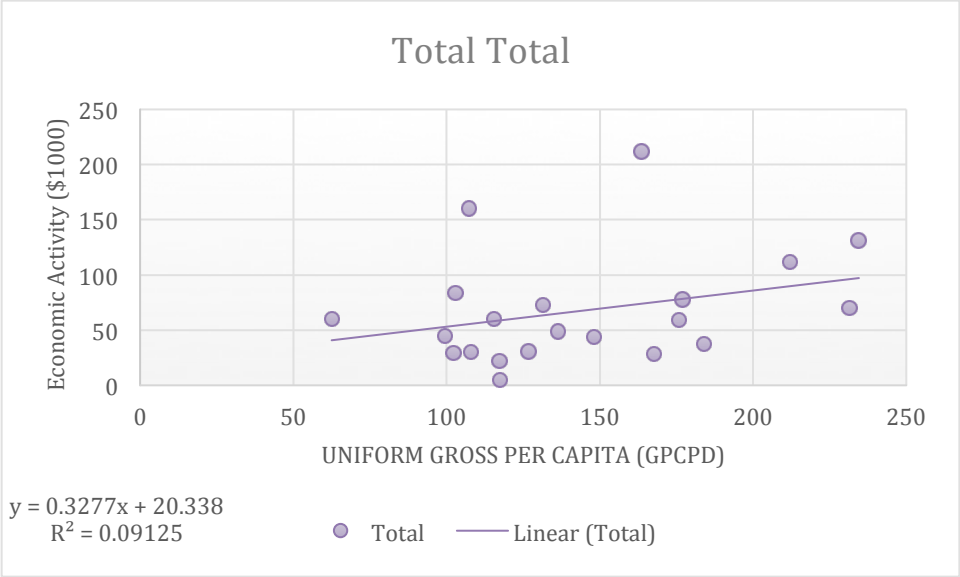

Total Educational Services
Economic Activity ($1000)
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0022x - 0.0889
R² = 0.13489
Educational Services
Linear (Educational Services)


Total Health Care
Economic Activity ($1000)
30
25
20
15
10
5
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0906x - 2.641
R² = 0.30034
Health Care
Linear (Health Care)


Total Entertainment
Economic Activity ($1000)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0062x + 0.3581
R² = 0.06572
Entertainment
Linear (Entertainment)


Total Food Services
Economic Activity ($1000)
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0193x + 0.0369
R² = 0.28107
Food Services
Linear (Food Services)


Total Other Services
Economic Activity ($1000)
0
1
2
3
4
5
6
7
8
9
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.0112x + 1.1955
R² = 0.07111
Other Services
Linear (Other Services)


Total Total
Economic Activity ($1000)
250
200
150
100
50
0
0
50
100
150
200
250
UNIFORM GROSS PER CAPITA (GPCPD)
y = 0.3277x + 20.338
R² = 0.09125
Total
Linear (Total)

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