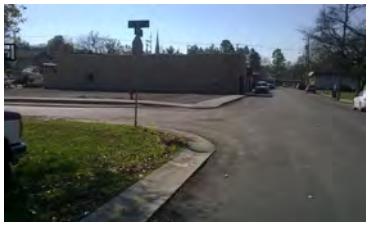
Lakewood Infrastructure Benefits Study

Single Investment, Double the Return, Triple the Benefits

METRO WATER SERVICES

wilmot inc.
sustainability services ♻ consulting



Lakewood Infrastructure Benefits Report:
Single Investment, Double the Return, Triple the Benefits

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SECTION 1 - Executive Summary

OBJECTIVE

The following case study explores multiple impacts of a large infrastructure investment in Lakewood, Tennessee, located within Metropolitan Nashville - Davidson County. The project included renovation of the water distribution system and wastewater collection system, and the addition of a stormwater collection system, within the community. Using "triple bottom line" analysis to measure how the construction project affected people, planet and profits, this report explores and identifies benefits that could also be realized through similar future investments.

BACKGROUND

Lakewood is a one-square-mile neighborhood that is comprised of of a residential area with nearly 1,000 predominantly 2- and 3-bedroom ranch homes built in the 1920s to the 1940s, and a commercial district that sits along the main corridor of Old Hickory Boulevard. The neighborhood, located near a DuPont plant, was originally established prior to 1918, with a then-modern sewage system. In 1959, the community incorporated as Dupontonia, changed to the name of Lakewood in 1961, and was annexed by the Metropolitan Government of Nashville and Davidson County in 2011. At the time of annexation, the existing water and wastewater infrastructure in Lakewood was greatly aged, and well below the standards of Metro Water Services. Further, Lakewood did not have a stormwater collection system at all. After rain events, water would pool on streets and lawns. To bring the Lakewood area up to current standards, Metro Water Services (MWS) financed a $13.9M project to improve the water and sewer systems and to install new stormwater collection infrastructure. In 2015, near the completion of the project, MWS funded this study to explore and quantify the impacts of this investment.

APPROACH

Triple bottom line analysis includes the economic, social and environmental impacts of the construction project on the Lakewood community. Economic outcomes were measured by modeling the growth in economic activity and the jobs that were created or sustained during the project. By analyzing project spending and readily available municipal data, the study team identified real and potential benefits to the community that may result in future property value increases. Social outcomes were identified via interviews with project staff and community members, as well as through data analysis. Environmental outcomes were expressed as reductions in environmental costs, such as those resulting from distribution system leakage, excess infiltration and inflow requiring sewage treatment, energy consumption related to additional water and sewer treatment, and external environmental costs of producing energy for water and wastewater treatment and conveyance.

The term "Investment" will be used interchangeably throughout the report to represent the $13.9M investment in the water, wastewater and stormwater infrastructure in Lakewood, Tennessee.

RESULTS/ CONCLUSIONS

The impacts of the Investment spent to renovate existing water and sewer systems and install a stormwater collection system in Lakewood can be measured in terms of triple-bottom-line: people, planet and profits. The social, environmental and economic benefits are quantifiable and impressive.

SOCIAL IMPACTS (PEOPLE)

- AESTHETIC IMPROVEMENTS - Lakewood had limited curbs and sidewalks before the stormwater infrastructure improvements. Affected streets and sidewalks were restored to current standards, resulting in improvements throughout the community. Valley gutters were installed to support stormwater collection.
- WATER PRESSURE IMPROVEMENTS – Tuberculation inside water supply pipes constricts the effective inner diameter of pipes, reducing water flow into buildings. Lakewood complaints of "low water pressure" to MWS have dropped 81% starting from MWS' takeover in 2011 to 2015, as the water improvements are being completed.
- IMPROVED FIRE PROTECTION – Existing tuberculated water lines were replaced with larger diameter piping, which both increased water volume and improved flow available to fire hydrants. Previously, a fire in Lakewood might have required tanker trucks from three stations to respond to a call because hydrant flow was low. The Investment added three hydrants - an 18% increase –and doubled available hydrant flow, enabling only a single truck to respond to the same fire.

- IMPROVED STORMWATER DRAINAGE – Standing water during and after rainstorms is dramatically reduced with new valley gutters and underground stormwater piping. The new system is designed to capture 98% of heavy rainfall events.
- REDUCED SEWER BLOCKAGES AND BACKUPS – More than 85% of sewer back-up complaints prior to the Investment were due to tree root intrusion into cracks in sewers. Sewer replacement and the installation of durable materials should reduce sewer back-ups and related complaints.
- REDUCED OCCUPANT DISTURBANCES FOR MAINTENANCE AND REPAIR – Water and sewer mains and service lines in Lakewood alleys required access to private property for MWS to conduct repairs and service. Installing new mains in Lakewood streets allows maintenance access without disturbing occupants.
- HELPING SMALL AND DISADVANTAGED BUSINESSES – For this project, specifically, 91% of the construction was performed by small and disadvantaged businesses. This support of diversity in hiring fosters innovation, equity, and merit-based success.

ENVIRONMENTAL IMPACTS (PLANET)

- REDUCING SEWER INFLOW AND INFILTRATION – The decades-old sewer system had numerous leaks as a result of decayed piping and loosened joints. When clean groundwater and rainwater infiltrate sewer pipes, it mixes with sewage and adds wastewater volume to the treatment plant. New pipes would reduce this infiltration by an estimated 5.5 million gallons per year, mitigating the health and environmental costs of conventional energy generation required to treat that volume. Locally, 53% of electricity is derived from burning fossil fuels contributing to these costs borne by the larger community and environment.
- $11,000 to $27,000 ANNUAL REDUCTION IN OPERATIONS AND MAINTENANCE COST – Water infiltrating the sewer system increases the volume of wastewater needing treatment. As the Investment has reduced inflow and infiltration, MWS expects treatment cost savings.

ECONOMIC IMPACTS (PROFITS)

- 159 JOBS SUPPORTED- For this project, 71 people in Davidson County were directly employed by the total design and construction effort. The selected model indicates that additionally, 38 people were indirectly employed because of business-to-business spending and 50 people were employed because of project employees spending their wages in Davidson and six adjacent counties.
- GENERATED ECONOMIC OUTPUT OF $27.1 MILLION – The model shows that for the $13.9 million that was spent directly in Davidson County (owner-to-business), an additional $5.7 million was spent indirectly (business-to-business) and $7.5 million more was recorded in induced spending (project employee-to-business) in Davidson and six adjacent counties. This output includes the multiplier effect of paying wages, overhead, and taxes, and the profit earned by businesses affected.
- $1.36 MILLION CONTRIBUTED TO PROPERTY VALUES AT SOME 300 HOMES – MWS addressed restoration of service to homes where existing mains in the alleys behind buildings lines were abandoned and replaced by new mains in the streets. This restoration would normally be the financial responsibility of the building owners, with MWS replacing service to the meters only. The new service lines, however, offer much improved conditions inside the buildings, improving the reputation of the neighborhood.
- INFRASTRUCTURE JOBS CONTRIBUTE TO LOCAL EMPLOYMENT STABILITY – According to study area data, in 2014, there were 6,587 infrastructure jobs in Davidson County, which was 2,297 more jobs than in residential construction. Infrastructure jobs are more unaffected by swings in housing supply and demand, making them a more stable source of construction employment for a community. Continued and consistent investments in maintaining and improving water infrastructure will result in multiple benefits to communities.

CHALLENGES – This study addresses challenges imposed by limitations of data and timing. Although research indicates that property values have increased in the community of Lakewood, it is not conclusive that the increases are due solely to the Investment. It is also premature to assess the extent the Investment as a catalyst for additional residential and commercial development in Lakewood.

APPLICATIONS/ RECOMMENDATIONS

The findings of this study can be used to communicate real benefits to people, planet and profits from water infrastructure investment in the Lakewood community. The vast ripple effect of the initial investment is illustrated here. These findings may be applied to consideration of investments in water infrastructure in Nashville and beyond.

SECTION 2 - Introduction and Approach

2.1 Approach of Study

This report describes the economic, social and environmental impacts of the Investment on the community. While many economic and community benefits have already been realized, at this writing, the project is still under construction, and therefore some benefits are only preliminary, estimated or expected. In many regards, this report may be treated as a baseline for future comparison.

Metro Nashville's mayor and agencies, including MWS, have embraced sustainable development in many ways. As sustainable development is often measured by its commitment to the "triple bottom line," this report will discuss the economic, social, and environmental impacts that result from the Investment.

The economic impacts discussion addresses the number and nature of jobs created, wages associated with the jobs, and the changes in economic activity that result from the Investment. Additionally, the report evaluates various local economic indicators that can be measured, such as business license applications, building permit applications, and local housing sales. The social impacts of the Investment range from the aesthetic improvements within the community to some very tangible benefits for homeowners, business owners, and community members. Finally, the environmental impacts section measures the amount of water, energy and other operational costs saved as a result of the improvements. This report includes a discussion of the benefits to the community and society that result from these reductions, as they relate to the external costs of the energy and water consumption.

2.2 Introduction

Infrastructure provides the rigid organization and well-regulated safety required in modern society for the growth of densely populated cities. Along with reliable energy and durable roads, centralized water and sewer systems are some of the most basic infrastructure in modern society. When basic needs such as clean drinking water are met by reliable infrastructure, societies are able to improve their economies, education, public health, and environmental preservation. The role of infrastructure in sustainable development is to provide for the balance of the economic, social and environmental needs and demands of society.

In 2011, the American Society of Civil Engineers released a series of economic studies under the title *Failure to Act* which detailed the numerous and overwhelming economic impacts that result from chronic underinvestment in aging infrastructure. The Water and Wastewater report estimated the cost of inaction to be $35,000 per household, and between $500,000 and $1 million per business over the next 20 years, as a result of reduced reliability of water delivery and reduced quality of wastewater treatment. [1]

Likewise, every four years, the ASCE releases *The Report Card for America's infrastructure*. In 2013, they awarded the nation's water and wastewater infrastructure with a D.[2] Also in 2013, the EPA submitted a report to Congress stating that the necessary infrastructure improvements would require investment of up to $384.2 billion over the next 20 years.[3]

As American cities develop and expand in an attempt to accommodate rapidly growing populations, the aging water and wastewater infrastructure incurs increasing stress. To meet the demands of growth and to prevent the possibly catastrophic economic, health, and environmental implications of failure of the aging system, cities must invest in preventative maintenance for their water and wastewater infrastructure. While the need for funding is enormous and the costs of investments are large, there are many added community benefits that result from capital investments in systems maintenance and improvements.

Capital investments in city infrastructure have a variety of impacts on local communities. These investments stimulate local economies by creating and supporting jobs. One review of twenty national studies noted that an estimated job creation is realized, from 9 to 22 jobs per million dollars spent in a water and wastewater capital investment. The Lakewood Investment was also found to be within this range.[4] Such investments also result in secondary spending,

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[1] American Society of Civil Engineers. (2011). Failure to act: the economic impact of current investment trends in water and wastewater treatment infrastructure. Boston, MA: Economic Development Research Group.

[2] American Society of Civil Engineers. (2013, March). 2013 Report card for Americas infrastructure. Retrieved from: http://www.infrastructurereportcard.org/grades.

[3] U.S. Environmental Protection Agency. (2013). Drinking water infrastructure needs survey and assessment (5th report). Washington, DC. U.S. EPA.

[4] Water Research Foundation & Water Environment Research Foundation. (2014). National Economic and Labor Impacts of the Water Utility Sector: Technical Report. San Francisco, CA: Quinn, Safriet, Feeney, Lauf.

which increases revenue for local businesses and boosts income for state and local governments in the form of taxes, business permits, etc., all of which raise the region's GDP.

As the foundation to modern society, infrastructure provides humans with a greater level of organization and safety; in turn promoting further development. Properly established and maintained water infrastructure is essential to the health and safety of densely populated urban environments. Suitable water infrastructure provides safety to human populations by preventing the spread of pathogens, flooding, and crop damage. Infrastructure can also protect natural habitats from erosion and soil loss as well as oversaturation of human, agricultural and industrial organic waste which can lead to eutrophication, oxygen depletion, and algal blooms. [5]

Capital infrastructure investments result in many social and environmental benefits to community residents, such as improving community aesthetics and the function of the water system for residents and businesses, attracting business investment and development, and supporting small and local businesses. Some social impacts can be quantified; for example, the increased volume of water delivered to fire hydrants. However, the benefits to the community from that impact, such as lives and property saved, are more difficult to quantify. Likewise, while social impacts such as community aesthetics, public safety, stormwater reduction, and quality of water and sewer service are certainly beneficial, they can also be difficult to assess. This report attempts to show how these social impacts might be realized in the study area.

Energy efficiency has become a recent key focus in the water industry. The water and wastewater industry is a major consumer of energy in the U.S. According to a report by the U.S. Department of Energy, the treatment and distribution of water and wastewater consumes about 4% of the energy in the U.S.[6] Water distribution and treatment is also generally the largest consumer of energy for a municipal government, making up 30-40% of all energy expenditures.[7] Water is required for many forms of conventional energy generation, including coal, nuclear and hydroelectric. Likewise, energy is required to transport and treat both wastewater and potable water. As a result of increasing demand for each of these resources, the concept of the Water-Energy Nexus has arisen to both define this relationship and to stress the need for both energy and water efficiency. [8]

Because of this relationship, inefficient management of one of these resources can also be considered inefficient management of the other. Therefore, the external costs of energy production can also be considered the external costs of inefficient water delivery and wastewater treatment systems. An external cost, or externality, is an unintended consequence of an activity that affects unrelated parties and is not reflected in the cost of the good or service provided.

A major negative externality of conventional energy production is pollution. Air pollution produced by coal-fired power plants is a significant risk factor for human disease such as respiratory infections, asthma, COPD, heart disease, stroke, and lung cancer, and can also contribute to major environmental destruction. Human society pays indirectly for these impacts through increased health costs, premature death, decreased productivity, species loss, and habitat destruction.

These costs, however, are not included in the rates paid by energy producers or consumers, making them "external" to the conventional wholesale and retail transactions. In this example, the parties that profit from the production and distribution of electricity, do not directly pay for the impacts of pollution.

The maintenance of water infrastructure plays a major role in reducing energy expenditure, and can help to mitigate the external costs of energy generation. In aging systems, water leaks are more common, resulting in water loss and energy waste. Older systems are also composed of materials prone to corrosion and have a higher break rate, leading to more water loss.[9]

In wastewater removal and treatment, the unnecessary treatment of stormwater in combined sewer systems is a major energy sink. Additionally, as a system ages, material decay; ground shifting, vegetation roots, and other forces act on the sewer pipes, connections and manholes, allowing ground water to "infiltrate" into the sewerage system. Inappropriate

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[5] Waller, P., M. Yitayew. (2016). Wastewater Contaminants and Treatment. *In Irrigation and Drainage Engineering* (412-426). Switzerland: Springer International Publishing.

[6] U.S. Department of Energy. (December, 2006). Energy Demands on Water Resources. Retrieved from:http://www.circleofblue.org/waternews/wp-content/uploads/2010/09/121-RptToCongress-EWwEIAcomments-FINAL2.pdf

[7] U.S. EPA. (May, 19 2015). State and Local Climate and Energy Program: Water/Wastewater. Available: http://www3.epa.gov/statelocalclimate/local/topics/water.html. Accessed: 10/12/12.

[8] U.S. Department of Energy. (June 2014). The Water-Energy Nexus: Challenges and Opportunities. Retrieved from: http://energy.gov/downloads/water-energy-nexus-challenges-and-opportunities

[9] Folkman,S. (April 2012). Water Main Break Rates in the US and Canada: A Comprehensive Study. Utah State University Buried Structure Laboratory. Retrieved from: http://www.watermainbreakclock.com/docs/UtahStateWaterBreakRates_FINAL_TH_Ver5lowrez.pdf

connections such as sump pumps and roof drains allow "inflow" directly into the piping. Inflow and infiltration (I/I) cause dilution of collected sewage, which results in unnecessary energy expenditure to treat rainwater or groundwater.

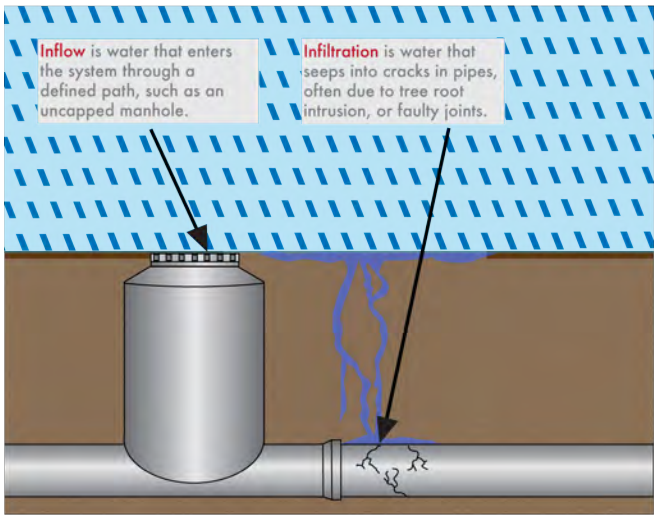

Figure 2-1 Inflow and Infiltration Sources

Maintaining and repairing aging water infrastructure helps to prevent these types of problems, and by decreasing the volume of water lost and treated increases the efficiency of transport and treatment processes. The increase in efficiency in water distribution and wastewater treatment that results from capital infrastructure investments can reduce the related energy demand and can help to attenuate the effects of pollution and other external costs of inefficiency.

SECTION 3 - Understanding the Investment

3.1 Historical Context of the Investment

In 2011, MWS began the design, rehabilitation, construction, and operation of a comprehensive water distribution and sewer and stormwater collection system within the former city limits of Lakewood, Tennessee. A brief listing of events is useful to understanding the municipal changes in scope and responsibility that led to the Investment.

1918:

- January: World War I caused U.S. government to contract with E.I. DuPont deNemours Co. to build world's largest gunpowder plant complex on 5,600 rural acres, 10 miles from downtown Nashville.
- November: Signing of armistice ending World War I drastically reduced demand for gunpowder. In the meantime, 3,800 buildings and infrastructure had been constructed for production and employee housing, including a modern sewerage system.

1920s

- Previously vacated industrial site and village of Old Hickory was sold to DuPont for production of rayon. DuPont built and operated "company town."
- Real estate developers supplemented Old Hickory housing stock by building new subdivisions, Dupontonia and Rayon City, in neighborhoods adjacent to Old Hickory.

1959-1961

- Dupontonia incorporated as a city, then changed its name to Lakewood.

1963

- Governments of Davidson County and City of Nashville merged to form a consolidated metropolitan government.
- City of Lakewood chose to remain an autonomous "satellite city" operating its city council, police department, and water and sewer network.

1960s-2000s

- Water was supplied to Lakewood via Old Hickory Utility District.
- City of Lakewood was responsible for maintaining its water distribution network.
- MWS took over maintenance of Lakewood's sewer collection network.
- Sewage was pumped to the MWS Dry Creek Wastewater Treatment Plant.
- Lakewood's stormwater was not and had never been collected.

2010-2011

- City of Lakewood voters passed a referendum to surrender their municipal charter and become part of Metro Nashville General Services District.
- MWS began planning replacement of water and sewer lines, and stormwater collection.
- Lakewood's MS4 permit compliance became MWS' responsibility.
- MWS made payments to Old Hickory Utility District to supply water to Lakewood until MWS completed design and construction of new water main to serve Lakewood.

2011-2013

- MWS held public meetings in Lakewood to discuss Investment.
- MWS designed water and sewer system upgrades.
- Hazen & Sawyer designed stormwater collection system.

January 2014-June 2016

- Water distribution and sewer and stormwater collection improvements are being constructed in sections of the area formerly known as City of Lakewood.

3.2 Scope of the Investment

The Investment intended to address deferred maintenance within Lakewood's decades-old water and sewer network and install its first stormwater collection system. The scope of construction was specified as follows.

Water and Sewerage Systems

The Lakewood Water and Sewer Replacement and Rehabilitation Project was designed to solicit the construction of replacement sewer, replacement water, new storm sewer, and rehabilitation of existing sewer, appurtenances, and surface restoration all-inclusive of erosion control, in a portion of the Lakewood community in eastern Davidson County.

- Construction of approximately 12,000 LF of 8- to 4-inch diameter water main
- Construction of approximately 10,000 LF of 8-inch diameter sewer
- Construction of approximately 10,000 LF of 15- to 45-inch diameter stormwater pipe
- Rehabilitation of approximately 9,000 LF of 8- to 12-inch diameter sewer including service renewals and manholes
- Existing water and sewer service building connection relocation/redirection from various locations to the new mains on approximately 200 properties
- Restoration of roadway surfaces with approximately 9,000 tons of asphaltic pavement materials

Stormwater Collection

The Lakewood Stormwater Improvements Project was designed to solicit the installation of over 7,600 linear feet of valley gutter and 135 catch basins along the roadways in addition to over 9,800 linear feet of stormwater pipe in order to collect the stormwater encompassing over 77 acres in a portion of the Lakewood community in eastern Davidson County.

At the completion of the project, MWS will have spent an estimated $13,915,420 on the Investment. A summary of the project's estimated expenses and allocation by system type is shown in *Table 3-1*.

Investment Cost Estimates By System Type through 2016	
System Type	Estimated Cost
Sewer	$6,477,785
Water	$4,143,274
Stormwater	$3,294,361
Total	$13,915,420

Table 3-1 Investment Cost Estimates by System Type through 2016

SECTION 4 - Study Methodology

In taking the triple bottom line approach to measure the impacts of the investment, this study investigated a number of areas. Methodologies requiring a depth of explanation are found in this section. The methodologies for more simple data acquisition can be found alongside the data in *Section 5 Research Findings*.

4.1 Economic Impacts Methodology

The purpose of economic portion of the study was to quantify the impacts of a $13.9M capital investment by MWS on the local economy. An economic impact is any change, positive or negative, in the level of economic activity in an industry or region.[10] Economic impacts can be measured in many ways, including the number of jobs created or sustained by economic activity, a positive or negative change in employee compensation, business revenue, or the development of new businesses or industries in an area. These impacts can occur as the result of a capital investment such as the one analyzed here, or of any number of other business or government economic activities that move in or out of a local economy.

4.1.1 Investigation and Classification of Spending

To estimate the economic impacts of the Investment, it was first necessary to develop a detailed breakdown of how and where the Investment was spent. To do so, the investigation team interviewed several MWS employees, members of the construction management team, and the primary contractor. The interviewers asked the following questions:

- Where did the project take place?
- What was the time frame of the project?
- What were the primary spending activities of the project?
- How much of the budget was spent on each of these activities?
- What level of employment was sustained by the project?

The figures that were collected in this portion of the process represent the direct effects of the Investment. They were further analyzed to determine the indirect and induced effects of the spending on the community.

4.1.2 Modeling the Investment

Three main types of economic impacts are defined in an Economic Impact Analysis. The first type describes the **Direct Impacts,** which are the direct effects on jobs, wages and businesses that result from the economic change being analyzed. The second, **Indirect Impacts,** are the effects on other industries that result from business to business interactions between those directly impacted industries and other supporting industries. Finally, the **Induced Impacts** are the effects on industries as a result of the household spending of those employed by the businesses that are directly or indirectly impacted by the economic change.

Direct Effect: result of the initial spending
Indirect Effect: result of business-to-business spending
Induced Effect: result of household-to-business spending

The direct, indirect, and induced effects of the MWS Investment were measured with the use of an input-output model. Input-output models are widely used tools that measure the spending between industries with the use of economic multipliers. Some of the most commonly used input-output modeling tools are RIMS, RIMS II, and IMPLAN. For this study, IMPLAN, a widely-used data and software system for modeling economic impacts for more than 20 years, was selected. IMPLAN creates regional and industry-specific multipliers using data from sources such as the Bureau of Economic Analysis (BEA), the U.S. Census Bureau and the U.S. Bureau of Labor Statistics. The three ways that the economic impacts are measured in this report are:

Employment: the measure of the total number of jobs that were created or sustained by a particular investment. This includes all full-time, part time, and seasonal employees;
Labor Income: the total of all types of labor income, which includes employee compensation (total payroll cost of employee; wage, benefits and taxes) as well as proprietor income; and

[10] Economic Development Research Group. (1997). Measuring economic impacts of projects and programs. Boston, MA: Weisbrod, and Weisbrod.

Total Output: the value of industry production, which includes gross business revenue (business expenses and labor) as well as business income (profit).[11, 12]

For the purposes of this study, the research team chose to use the measure of economic impacts of the investment in employment numbers, labor income, and total output. Total Output was chosen over Value Added because it is the more comprehensive measure of impact on an economy, including both business profit as well as the revenue that is applied to intermediate costs, taxes, and employee compensation.

IMPLAN uses regional multipliers in the Social Accounting Matrices (SAM) to account for variation in the cost of goods and services between regions. When modeling the economic impact, the local purchasing percentage (LPP) was set to regional purchasing coefficient (RPC) from the SAM. The RPC is the proportion of local demand for a commodity that is supplied locally.[13] If there are commodities that are not available in that region, or that are assumed not to have been purchased in the region because there was not enough available to meet the demand of the project, then that is considered to be leakage. Leakage is spending that is done outside of the study region, and considered a loss to the local economy. The economic impacts that are leaked from the region specified are not measured in the final economic impacts reflected in this study's findings (Section 5).

4.1.3 The Region Modeled

A form of Multi-Regional Analysis, an IMPLAN methodology, was performed to incorporate the economic effect of interaction between Nashville and the surrounding communities and minimize unwanted leakage. Because the total investment was made within Davidson County, the direct impacts were modeled within Davidson County as well. The indirect and induced impacts were modeled in both Davidson County as well as the six surrounding counties. This inclusion of the surrounding counties would capture the impacts of workers employed in Davidson County but who live and spend their wages in surrounding counties as well as materials purchased from counties surrounding Davidson County.

4.1.4 Building the Model

The economic impacts of the Investments were modeled using IMPLAN. Before the software was applied, the data had to be formatted with IMPLAN codes to be put into the IMPLAN software. The investment capital spending (IMPLAN Activities) was categorized into the three industries shown in *Table 4-1*, which correspond with IMPLAN Sectors also in *Table 4-1*. This was done to maximize the precision of the model. The "Design and Management" portion of spending included the cost of design and management within MWS (water and sewer portion) as well as that of selected contractors (stormwater portion). *Table 4-1* shows the sectors identified in the study as directly affected by the Investment.

Capital Spending	IMPLAN Activity	IMPLAN Sector
Water & Sewer Construction	Industry Spending Pattern (minus commodity 3449)	58 Construction of Other New Non-Residential Structures
Street Construction	Industry Spending Pattern (minus commodity 3449)	56 Construction of Streets and Highways
Design & Management	Industry Change	449 Architectural, Engineering and Related Services

Table 4-1 Sectors and Activities identified in the IMPLAN Model

4.1.5 Analysis-By-Parts

In order to include all three sectors, the spending patterns of each sector in *Table 4-1* were analyzed to ensure no double-counting. Double-counting would occur, for example, because within the spending pattern for IMPLAN Sector 58, "Construction of Non-Residential Structures," there is a commodity associated with the architectural, engineering and related services, which corresponds to Sector 449, "Architecture, Engineering and Related Services."

[11]IMPLAN Glossary. (2015) IMPLAN Group LLC. Retrieved from: http://implan.com/index.php?option=com_glossary&view=glossary&glossid=13&Itemid=1866

[12]Economic Development Research Group. (1997). Measuring economic impacts of projects and programs. Boston, MA: Weisbrod, and Weisbrod.

[13] IMPLAN Glossary. (2015) IMPLAN Group LLC. Retrieved from: http://implan.com/index.php?option=com_glossary&view=glossary&glossid=13&Itemid=1866

In order to prevent the double-counting that would occur by modeling an industry change for both sector 58, and sector 449, Analysis-By-Parts (ABP) was performed. Using ABP, the spending patterns for Sector 58 and 56 were altered. For information about the ABP methodology, see *Appendix A.*

4.2 Social Impacts Methodology

The social impacts of the Investment were determined through site visits, interviews, drawings analysis, service call data and other work order history. *Table 4-2* describes the variety of sources and analyses used to determine social benefits.

Social Impact	Types of Analyses Performed
5.2.1 Aesthetic Improvement	Site visits, photos, interviews with construction management staff, MWS staff, and residents
5.2.2 Improved Water Pressure	Analysis of service call history
5.2.3 Improved Fire Protection	Reviews of before and after drawings of hydrant locations and piping, interviews with Nashville Fire Department staff and insurance agents
5.2.4 Improved Stormwater Drainage	Reviews of scopes of work, design deliverables, and "as built" drawings
5.2.5 Reduced Sewer Blockages and Backups	Analysis of service call history
5.2.6 Reduced Occupant Disturbances for Maintenance and Repair	Interviews with MWS staff, analysis of service call history
5.2.7 Impacts allocated to disadvantaged businesses	Review of accepted construction bid, interview with general contractor

Table 4-2 Social Impacts and Analyses

Lakewood was used as the study group for all social data analyzed. The remaining parcels of ZIP code 37138 that occur within Davidson County were used as the "control group." *Figure 4-1* depicts these approximate locations.

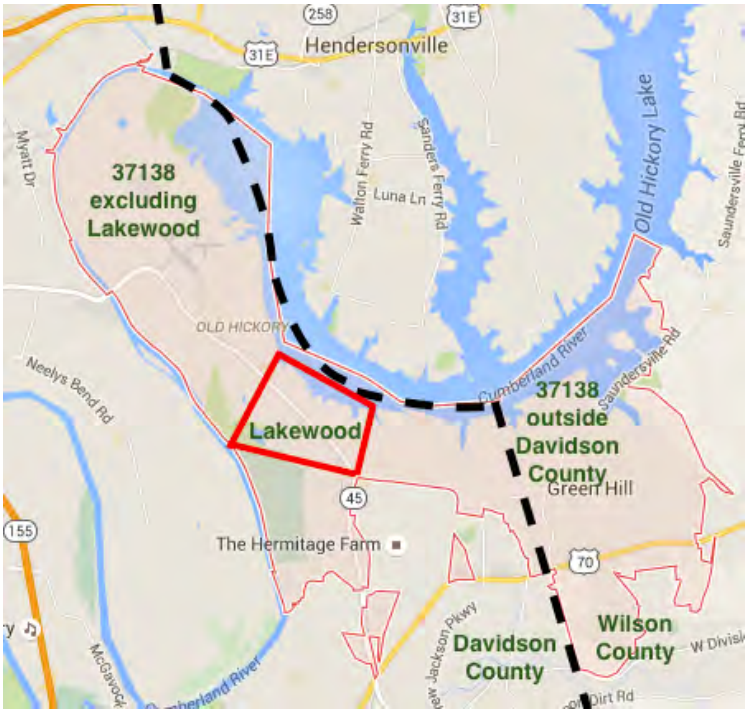

Figure 4-1 Relative Locations of Lakewood, 37138 ZIP Code, and Davidson County Line

ZIP 37138 was chosen because it includes both Rayon City and the original tracts of Old Hickory developed by DuPont in the 1920-30s, which have similarities in the age of buildings, median income, demographics, and proximity to Nashville city center.

4.3 Environmental Impacts Methodology

Environmental impacts can include any form of alteration to the earth's natural ecosystems. Detrimental impacts include any threats to human health, other species, or any of earth's natural processes. Society pays the cost of these losses, whether through the loss of the inherent good that nature provides, the loss of essential ecosystem services provided by disappearing species, or through physical harm to human populations. These costs, while very real, are often difficult to measure or quantify- this report serves as a best-attempt to represent the social costs of these impacts.

This section of the report focuses on increasing water and energy efficiency in both the water and wastewater systems, and reducing the negative external costs of energy production.

4.3.1 Increasing Efficiency

Efficient delivery and treatment of water is a major way for the Water/Wastewater Industry to reduce dependence on energy. This section describes ways in which the Investment affected distribution water loss and inflow and infiltration.

4.3.1.1 Distribution Leakage Reduction

To measure the increase in water efficiency from the improvements, data was provided by metro water services and the project management team for Metro Water Services. Water distribution loss is determined through various techniques, including sounding for leaks, and district measurements in which water flows are measured at night when demand is lowest, over a 48-hour period to get a second night of data to compare to the first night.

In the water industry, municipalities measure water loss using the infrastructure leakage index, which is a ratio of real losses to unavoidable losses. [14, 15] Although Nashville MWS does measure water loss using this system, no comprehensive data was available for the Lakewood area for any time period after the Investment. However, some reduction in leakage is projected due to replacement of the existing system with new and superior materials.

4.3.1.2 Sewerage I/I Reduction

Inflow and Infiltration reductions were measured by comparing flow data from flow meters before and after the Investment. Data for flow meter LW01, located downstream from the Investment, was gathered and analyzed by the Clean Water Nashville Overflow Abatement Program Management Team.

Flow meter LW01 is located at manhole 053-07-01. The area measured by this monitor also includes approximately 11 miles of gravity sewer not associated with the current Lakewood project. The Lakewood project only accounts for approximately one quarter of the sewer monitored at LW01.

To analyze the changes in observed flows, datasets for the following timeframes were reviewed:

- July 1 through September 30 in 2015: This period was used to assess the post-construction conditions. Although the majority of the project has been constructed, not all construction activities were completed in July 2015, and the results presented herein should be considered preliminary for that reason.
- July 1 through September 30 in 2011, 2012, and 2013. These periods were used to assess the pre-construction conditions. Several years were selected to assess the impact of rainfall events.

Selection of data from similar seasons, i.e., summer data, reduced the potential variability in groundwater levels and antecedent moisture conditions that generally occurs between seasons. There was no post-Investment wet-season data to analyze, so this report only portrays reductions in dry-season flows. Because inflow and infiltration is generally higher in the wet season, the results presented in this report are very conservative, and an additional analysis of wet-season data is suggested to ascertain the full impact.

To control for varying levels of rainfall between years, the reduction in flow was compared to another similar flow meter. Flow meter GC13, which is also in the Dry Creek WWTP service area, was also analyzed. GC13 is located in manhole 052-05-124.

4.3.2 Calculating External Costs

The external costs of energy generation are very difficult to conceptualize and compute. Each form of conventional energy generation, including coal, hydro and nuclear, have negative consequences that affect society in varying ways. In

[14] American Water Works Association. (2012). *IWA/AWWA Water Audit Method*. Retrieved from: http://www.awwa.org/portals/0/files/resources/water%20knowledge/water%20loss%20control/iwa-awwa-method-awwa-updated.pdf

[15] Delgado, D.M. (2008). Infrastructure Leakage Index (ILI) as a Regulatory and Provider Tool Retrieved from: http://wsp.arizona.edu/sites/wsp.arizona.edu/files/uawater/documents/Fellowship200708/Delgado.pdf

order to best express the external costs of energy that can be linked to inefficient water infrastructure in Nashville, this study will focus on the negative external costs of coal-fired electricity.

Coal constitutes about 40% of the fuel used for electricity generation by TVA, which supplies Nashville. Other fuel sources include nuclear at 33%, hydroelectric at 10% and 3% from renewable sources.[16] While the proportion of coal in the fuel mix has been dropping, at 55% in 2008, down to about 35% in 2015, it is still the majority fuel source in the Southern United States.[17]

The negative consequences of coal pollution are numerous. One study published in *Ecological Economics Review* investigated a list of 56 independent consequences of coal pollution, and attempted to calculate their costs, using the method of "full-cost accounting."[18] This list includes methane and ammonia emissions, coal-ash spills, stream pollution, property loss, and human illnesses including asthma, COPD, heart disease, and lung cancer. A complete list of these external costs can be found in *Appendix B*. The investigators were able to estimate the social costs for 9 of these 56 impacts. They determined that for these 9 impacts, the external costs ranged from 9.35 cents to 26.64 cents per kilowatt-hour, with a "best" cost of 17.84 cents/kilowatt-hour. A summary of the monetized externalities, as well as some assumptions and background information are presented in the text of *Appendix B.*

When accounting for the full cost of coal-generated electricity, the costs or financial savings discussed do not represent actual dollars saved or spent by MWS. Rather, a "full cost net present value" represents the value to numerous stakeholders that are impacted by the life cycle of coal-fired electricity Because externalities are all of the costs the consumer does not directly bear, this conceptual equation describes how a full cost of coal should be understood: Retail price paid + Externalities = Full cost of coal.

4.3.3 Impact from Reducing External Costs

Using the value of 17.84 cents/kWh as the full cost, external cost savings as a result of the improvements were estimated. This was done by determining the energy expenditure per gallon treated, and accounting for the reduction in gallons per year as a result of I/I reduction.

[16] Tennessee Valley Authority. (2015). Integrated Resource Plan – 2015 Final Report. Retrieved from: https://www.tva.gov/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/2015_irp.pdf
[17] U.S. Energy Information Administration. Use of coal fired generators in the Southeast has been declining. (2013, November 22). Washington, DC: M. Tyson Brown. Retrieved from: https://www.eia.gov/todayinenergy/detail.cfm?id=13911
[18] Epstein, P.R., J.J. Buonocore, K. Eckerle, M. Hendryx, B.M. Stout III, R.Heinberg, R.W. Clapp, B. May, N. L. Reinhart, M.M. Ahern, S.K. Doshi, and L. Glustrom. (2011). Full cost accounting for the life cycle of coal "Ecological Economics Reviews." Robert Costanza, Karin Limburg & Ida Kubiszewski, Eds. Ann. N.Y. Acad. Sci. 1219: 73–98.

SECTION 5 - Research Findings

5.1 Economic Impacts

5.1.1 Direct Employment

The $13.9M Investment directly impacted three IMPLAN Industry Sector categories. The value of this spending in each of these categories is shown in *Table 5-1*. This direct spending resulted in the revenue and profit for the businesses that were contracted to complete the project. Revenue includes employee wages, business overhead, taxes and intermediate costs such as materials.

In *Table 5-1*, the cost is broken down by the category in which the spending occurred. The value for spending in design and management includes the cost of design and management within MWS as well as that completed by contractors.

Industry Category	Spending
Water & Sewer Construction	$8,710,988
Street Construction	$2,584,870
Design & Management	$2,619,562
Total	$13,915,420

Table 5-1 Spending in Investment Industry Categories

Employment totals were calculated using data from MWS, hour and rate estimates provided by the primary contractor and one of the sub-contractors, and on-site employment data from Unifier (project management software) generated throughout the project.

Based on the actual employment data, the direct spending in the three industries resulted in a total employment of approximately 60 full-time equivalents. A full-time equivalent is defined as the hours worked by an employee on a full time basis, or 2,080 hours per year calculated using 40 hours per week for 52 weeks.

Table 5-2 describes the number of hours worked in each category and the number of FTEs created. It is worth noting that in construction sectors, employees often work more than 40 hours a week. Such is the case for this project, where the construction employees worked an average of 50 hours a week; accounted for in the calculations so that the FTE values in *Table 5-2* reflect a normal 40-hour workweek.

Industry Category	Total Hours	FTEs	IMPLAN Jobs
Water and Sewer Construction	78,049.68	37.52	44.69
Street Construction	21,749.55	10.46	12.46
Total Design & Management	24,382.64	13.39	14.11
MWS Design & Management	8,900.00	4.28	
Contract Design	3,182.00	1.53	
Contract Management	10,834.85	5.21	
Support	1,465.79	0.70	
Total	124,181.87	59.70	71.26

Table 5-2 Calculated FTEs by Industry Category

IMPLAN uses a different definition of "job" when calculating employment values. Instead of using FTEs, IMPLAN considers each individual job, whether it be full-time, part-time or seasonal in employment calculations. For this reason, FTEs were converted into IMPLAN first by converting from a 40 to a 35-hour workweek (which is how IMPLAN's data sources define an FTE), and then converting to IMPLAN jobs using industry-specific conversion factors provided by IMPLAN. The resulting IMPLAN Jobs values were used as inputs to the IMPLAN model.

5.1.2 Economic Output

Using IMPLAN's input-output model, it was estimated that the economic impacts of the $13.9M Investment generated a total output of approximately $27.1M. This Investment therefore resulted in an additional $13.7M in community

economic activity. The total output refers to all of the overall economic impact experienced in the community including employee compensation, business costs, taxes and business profit. *Table 5-3* shows that 71 direct jobs, and a total of 159 jobs in the community were created or sustained from this project; and a total of 11.4 jobs per million dollars in spending that resulted from the Investment.

Impact Type	Employment	Labor Income	Output
Direct Effect	71.26	$6,274,354.76	$13,915,420.00
Indirect Effect	37.69	$2,118,126.69	$5,742,911.12
Induced Effect	50.32	$2,861,497.24	$7,523,539.65
Total Effect	159.27	$11,253,978.69	$27,181,870.78

Table 5-3 Input-Output Analysis for Economic Impact in Davidson County

The Investment has had direct, indirect and induced effects on the community. These effects resulted in employment that was either created or sustained in the community. *Table 5-4* shows the top industry sectors, in descending order of employment, that were impacted either through direct, indirect, or induced effects. This table indicates the level of employment that resulted in the community from the Investment, as well as the employment compensation and the output of each sector. The three sectors that experienced the largest impacts are those that were directly affected by the Investment (IMPLAN Sectors 58, 449, 56). Notice also the impacts on real estate, retail, restaurants and other food industries, hospital, automotive, repair, etc. These impacts are attributed to industry and household spending within the community. The complete table that illustrates the impacts on all industries is included in *Appendix C*.

Sector	Description	Employment	Labor Income	Value Added	Output
58	Construction of other new nonresidential structures	44.69	$3,857,544.80	$3,932,860.47	$8,710,988.00
449	Architectural, engineering, and related services	15.29	$1,578,701.33	$1,530,493.20	$2,805,487.54
56	Construction of new highways and streets	12.46	$942,732.47	$949,016.25	$2,584,870.00
395	Wholesale trade	4.77	$399,813.22	$761,448.77	$1,165,109.17
501	Full-service restaurants	3.85	$90,608.32	$95,827.55	$175,483.05
440	Real estate	3.83	$134,883.87	$657,778.61	$865,859.23
464	Employment services	3.49	$118,633.63	$178,704.79	$219,634.51
502	Limited-service restaurants	3.23	$60,746.16	$132,681.13	$248,483.07
403	Retail - Clothing and clothing accessories stores	2.61	$66,490.95	$126,257.25	$203,914.64
407	Retail - Nonstore retailers	2.40	$50,634.22	$144,350.81	$248,616.30
482	Hospitals	2.23	$410,122.67	$379,864.65	$526,000.32
405	Retail - General merchandise stores	2.17	$62,953.28	$101,909.29	$155,443.44
406	Retail - Miscellaneous store retailers	1.96	$48,161.76	$53,077.53	$79,847.16
411	Truck transportation	1.94	$118,199.68	$141,535.89	$319,183.59
400	Retail - Food and beverage stores	1.61	$58,763.79	$81,363.83	$115,394.68
468	Services to buildings	1.56	$43,788.90	$47,256.99	$68,213.32
503	All other food and drinking places	1.52	$44,323.18	$37,142.39	$61,925.83
454	Management consulting services	1.52	$137,367.25	$142,421.84	$216,714.30
475	Offices of physicians	1.40	$177,471.00	$173,144.23	$241,396.25
401	Retail - Health and personal care stores	1.35	$65,732.82	$84,320.69	$123,627.54

Table 5-4 List of impacts of the Investment by Industry Category

5.1.3 Modeled Taxes on the Investment

The spending that was spurred by the Investment, resulted in tax income for local, state and federal governments. IMPLAN modeled that the taxes paid on Direct, Indirect and Induced spending resulted in a total of about $2M in federal

taxes and a total of about $800,000 in state and local taxes. These taxes, seen in *Table 5-5,* will go to support future investments and infrastructure improvements.

Tax Type	Direct	Indirect	Induced	Total
Federal Taxes	$975,872	$467,389	$624,786	$2,068,047
State and Local Taxes	$124,857	$281,886	$393,307	$800,050

Table 5-5 Taxes that Resulted from Direct, Indirect and Induced Spending

5.1.4 Increase in Property Values at Sale

There was speculation among the project team that an additional economic benefit of the Investment would be growth in property sales value following the Investment. Property sales data was accessed from the Metro Nashville and Davidson County Property Assessor. Data was analyzed for years between 2000 and 2015 for the relative increase in the average price per square foot paid for single-family homes compared to the previous year.

The average price per square foot for homes purchased in Lakewood was compared to two similar neighborhoods. These were Woodbine, which was built around the same time as Lakewood and has similar vintage homes, and the other neighborhoods in the 37138 ZIP that are within Davidson County. *Homes that were purchased for less than $1/sq. ft. were excluded from the dataset.

Figure 5-1 shows the average sales price per square foot relative to that of the previous year. The relative growth of property sales prices in Lakewood between 2000 and 2015 is similar to that seen in the two control neighborhoods. There is an upward trend in relative property sales price between 2014; however, this mirrors the two control neighborhoods, and can likely not be attributed to anything more than the rising value of housing in Nashville as a whole.

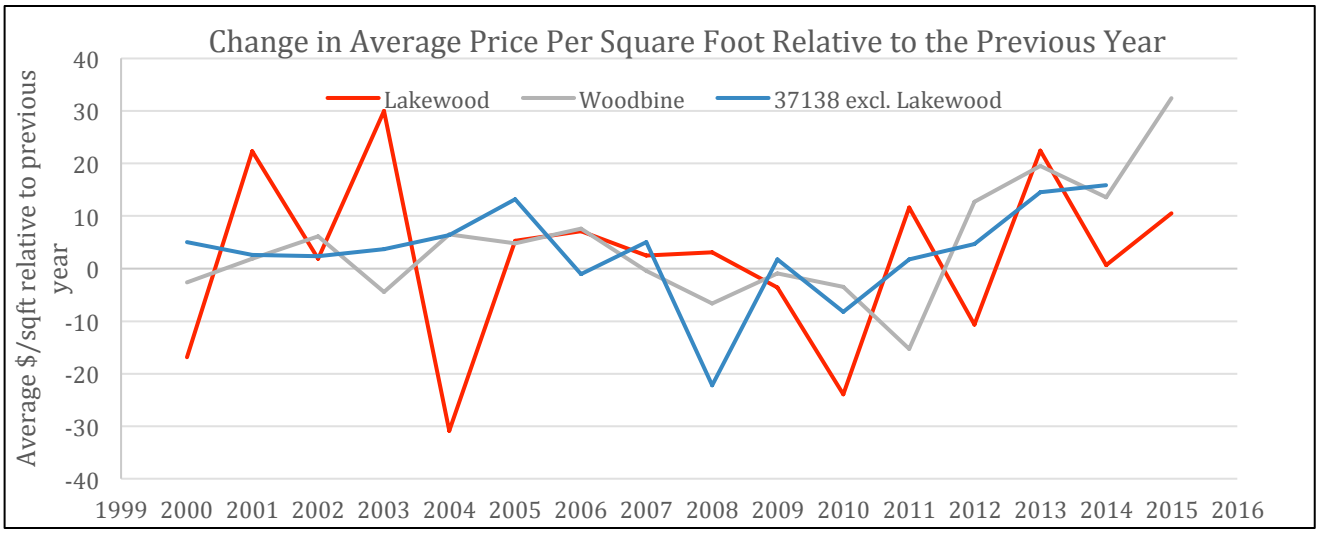

Figure 5-1 Comparison of Average Home Sales in Lakewood, 37138, and Woodbine

Once the project in Lakewood is complete, there may be a rise in the sales price of homes in the area due to the multiple positive impacts that resulted from the Investment. While the results of this study can be used as a baseline for future studies on the impact on housing prices in this area relative to similar areas in Nashville, it is not conclusive that the Investment alone has caused Lakewood's property values to increase.

5.1.5 Investment as a Catalyst for Development

The benefits of infrastructure improvements often spur further investment and development. While this study was completed prior to the completion of the project, the findings are only preliminary. However, there were some indications of ways in which the Investment could attract or has begun to attract development.

5.1.5.1 Property Disclosures

According to the Residential Property Disclosure Act, adopted by the Tennessee State Legislature in 1994,[19] a seller of residential real property is required to provide the buyer a disclosure of property conditions including known material

* the homes in the portion of 37138 outside of Davidson County were excluded from this analysis

[19] TCA Title 66, Chapter 5, Part 2

defects. The disclosure requirements include several areas where the performance of Lakewood's water, sewer, and stormwater systems and related drainage may have been known defects that a seller would have to consider disclosing. This could have impacted the value of properties in Lakewood as well as the success of sales.

Table 5.6 lists the requirements, as well as possible and likely response of residents before and after the Investment.

Disclosure	Possible Pre-Investment Response	Possible Post-Investment Response
Is City Water Supply NOT in operating condition? If Yes, then describe.	"Yes" if water pressure was very low.	"No" except for tuberculation of building plumbing.
Is City Sewage Disposal NOT in operating condition? If Yes, then describe.	"Yes" if a slow drain or backups were frequent.	"No" since sewers should be unobstructed and drain well.
Is Seller AWARE of any defects or malfunctions in any of the following: Plumbing?	"Yes" if water pressure was very low.	"No" except for tuberculation of building plumbing.
Is Seller AWARE of any defects or malfunctions in any of the following: Sewer?	"Yes" if a slow drain or backups were frequent.	"No" since sewers should be unobstructed and drain well.
Is Seller AWARE of any of contaminated soil or water on the subject property?	"Yes" if outdoor backups or stormwater ponding occurred.	"No" since sewers should be unobstructed and drain well and stormwater system is in place.
Is Seller AWARE of any flooding, drainage, or grading problems?	"Yes" if outdoor backups or stormwater ponding occurred.	"No" since sewers should be unobstructed and drain well and stormwater system is in place.
Is Seller AWARE of any past or present interior water intrusions, standing water within foundation and/or basement?	"Yes" if stormwater came into basements or crawlspaces.	"No" since stormwater system is in place.

Table 5-6 Potential Sales Disclosure Scenarios Before and After Investment

No previous disclosures from Lakewood were reviewed, however, the updates made through the Investment, did attenuate many of the issues listed in the disclosure related to water sewer and stormwater. As a result, this may ease the process for individuals who would like to sell property in Lakewood. Additionally, the absence of undesirable conditions on the disclosures may reduce psychological or financial barriers to buying Lakewood property.

5.1.5.2 Improved Building Permit Volume

Investment and development in the housing market in Lakewood was another possible form of economic impact that was analyzed. Building permit data was provided by Metro Nashville Building Codes Department. Detailed data was only available from May 2013 through October 2015; therefore 2013 and 2015 were annualized (prorated using the available data). *Figure 5-2* shows the increase in issued permits per 1,000 parcels in each area studied.

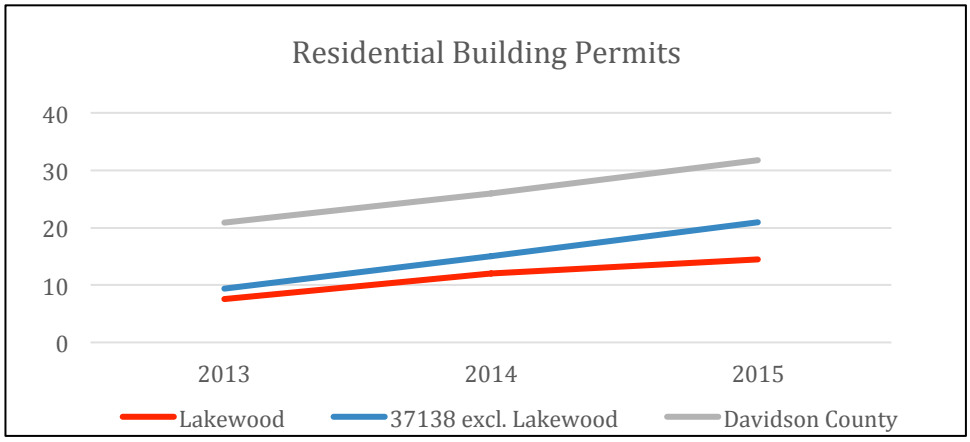

Figure 5-2 Annualized Residential Building Permits per 1,000 parcels, 2013-2015

The number of building permit applications per 1000 residents in Lakewood is growing at about the same rate as both Davidson County and the rest of 37138. Because the development in Lakewood is not growing faster than other parts of Nashville, the growth is likely due to the overall growth in Nashville.

At least one real estate investor was actively developing a few properties in Lakewood during the investigation. In October 2015, the developer was building two new houses, one in place of a demolished house and another on an adjacent empty building lot. He was also rehabilitating another house and was planning to build 12 attached townhouses after selling the three houses in progress at the time. He hopes to continue developing in Lakewood. When questioned about his motivations for developing in Lakewood, he stated that he was aware of the improvements in the water infrastructure in Lakewood, however they did not influence his decisions. He offered that although MWS improvements are a convenient coincidence, the avoided cost of the new water and sewer service lines to the house foundation were not significant enough to affect his larger cost structure for or against investing in each house or lot.

As the Investment is not yet complete, aspects that would make the neighborhood the most visually attractive such as curbs and street repaving have not yet been completed. For this reason, it may be too early to assess the Investment's possible impact on building permits as a sign of increasing interest in Lakewood.

5.1.6 Investment's Contribution to Property Values

The nature of the Investment in Lakewood was unique, in that very large portions of both the water and wastewater service lines were not only replaced, but relocated. Many lines and manholes were moved from behind and even under homes to the street where they could be more easily accessed. Additionally, when MWS designed the new system, the "as built" documentation was so deficient that it was determined to be a less expensive net investment to bring mains into the street than to repair them in their pre-Investment locations.

In cases where services were relocated, private laterals and service lines were also replaced. While private service lines are generally considered to be the responsibility of the property owner, this replacement was necessary to reconnect customers to the main. In total, 161 private sewer connections and 143 private water connections were installed.

Although this was a highly exceptional case, the new laterals that were installed provide the same performance effect in the buildings as if they had been just purchased by the building owners. For this reason, the new, high quality laterals installed effectively exhibit some value increase on each of the affected properties. This value increase is labeled here as "potential value added," being that a building is only worth what someone will pay for it. As the buildings were connected to mains both before and after the Investment, a prospective buyer of a building may not fully appreciate, nor may their offer fully value, the quality or vintage of the post-Investment lateral connections. Therefore, this estimate represents the maximum potential value added as a result of the new laterals.

To estimate the value of this portion of the Investment, the average length of copper water pipe and PVC sewer pipe installed per building was calculated. Inquiries to a few local plumbers provided an average estimate of how much the same installation would cost a building owner. *Table 5-7*shows the calculation of installation costs if the laterals had been paid for by affected Lakewood building owners.

A. Average cost of sewer and water trenches and piping:	$7,000
B. Average MWS tap fees for sewer & water connections:	$2,000
C. Average amount per connection ((B + C)/2):	$4,500
D. Total connections (sewer: 161) + (water: 143):	304
E: Total property value added (C x D):	$1,368,000

Table 5-7 Potential Value Added to Buildings -New Laterals Investment

5.1.7 Contribution of Investment to Employment Stability

The Great Recession, which began in the final years of the 2000s, massively impacted spending and employment in many sectors throughout the economy. The construction industry was particularly negatively impacted, with 682,000 job losses between December 2007 and December 2008 alone; a loss whose equal had not been seen since 1942. Residential construction spending fell by 33% in 2008 and by 44% in 2009, and spending in commercial construction did not fare much better. [20]

[20] Kelter, L. A. (March 2009) Substantial job losses in 2008: weakness broadens and deepens across industries. Monthly Labor Review: 20-33. Retrieved from: http://www.bls.gov/opub/mlr/2009/03/art2full.pdf

Despite the recent rapid increase in the number of housing units being built in Nashville, residential construction employment has not increased at the same rate, possibly due to the shift from single-family to multifamily construction during the same period. According to the National Association of Home Builders, single-family housing construction supports an average of 2.97 jobs per unit while multifamily housing construction supports only an average of 1.13 jobs per unit.[21, 22, 23]

While the residential construction sector grows with the ebb and flow of population fluctuations, the heavy construction of infrastructure construction sector remains a strong and steady employer, both nationally and regionally. Despite the massive job losses and spending cuts in the overall construction sector, there was relatively little change in employment in heavy construction during the Great Recession, which experienced its most dramatic drop in spending in 2010, with only a 2.8% reduction. [24]

The study area data for Davidson County provided by IMPLAN, found in *Table 5-8,* supports this observation. In 2014 there were about 1.5 times more heavy construction jobs in Davidson County than residential construction jobs. Research performed by the Economic Policy Institute suggests that this may be due to the maintenance aspect of infrastructure spending, which tends to be more labor-intensive than capital-intensive. [25]

IMPLAN Sector	FTEs	FTE groups compared
Construction of new highways and streets	1,701.13	6,586.78
Other infrastructure related construction	4,885.65	
Construction of new single-family residential structures	3,559.94	4,289.61
Construction of new multifamily residential structures	729.66	

Table 5-8 IMPLAN Construction Categories and FTE Groups Compared

5.2 Social Impacts

The Investment resulted in several considerable social benefits to the community. Because the case study was done prior to the completion of the project, many of these findings are preliminary, and could act a benchmark for measuring future social benefits that may arise from the Investment.

5.2.1 Aesthetic Improvement

The Investment was responsible for a massive renovation of the streetscapes in Lakewood, which led to a great improvement in the aesthetic appearance of the community. Once complete, the project will have renovated surfaces bordering more than 250 parcels in Lakewood.

The scope of surface improvements includes curbs, valley gutters, selected sidewalk improvements, new sidewalks, and street paving to cover excavated areas in roadways. At the time of this investigation, the final portion of sewer rehabilitation was being completed and the surface improvements had only begun.

At this writing, "after" photos of surface improvements were not able to be captured. The adjacent Village of Old Hickory offers examples of what Lakewood streets will likely resemble, once construction is complete. *Figures 5-3* depicts an example of "before" and potential "after" construction area streetscapes. The "before" streetscape has an absence of curbs and substantially patched asphalt roads; the "after" has street edges defined with curbs and finished street surfaces.

[21] Emrath, P. (2014, May 1). Impact of Home Building and Remodeling on the U.S. Economy. Retrieved from: http://www.nahb.org/en/research/housing-economics
[22] Harrison, D. K. Hudson. (2015, October 21). Home Construction Rebounds Amid Surge in Multifamily Units. Retrieved from: http://www.wsj.com
[23] Thompson, E. (2015, July 17). Multifamily Surge Pushes Housing Starts Up 9.8 Percent in June. Retrieved from: http://www.nahb.org/en/news-and-publications/Press-Releases
[24] Markstein, B.M. (September, 09 2011). Construction Market Data Group, LLC. Retrieved from: http://www.cmdgroup.com/market-intelligence/articles/the-impact-of-a-recession-on-the-construction-outlook/
[25] Bivens, J. (2014, July 1). The Short- and Long-Term Impacts of Infrastructure Investments on U.S. Employment and Economic Activity. Retrieved from: http://www.epi.org/publication/impact-of-infrastructure-investments/

Figure 5-3, Uncompleted Area in 2015 and Similar Improved Neighborhood (Village of Old Hickory, adjacent to Lakewood).

5.2.2 Improved Water Pressure

Over time, water distribution systems require repair or replacement to preserve optimal function. During the investigation, anecdotal accounts indicated numerous reports of low water pressure from residents of Lakewood, prior to the Investment. For clarity it is important to distinguish between supplied pressure, or the pressure supplied via the water main at regulatory and designed standards, and effective pressure, or the water pressure experienced by residents at the tap. What Lakewood residents were experiencing prior to the Investment was reduced effective pressure.

A major reason for this low effective pressure was identified to be tuberculation of galvanized and cast iron pipe. Tuberculation, a common occurrence in aging pipes, is a corrosive process that produces hard knob-like mounds on metal surfaces, reducing diameter and flow in water distribution systems. *Table 5-9* describes the existing and replacement materials used in Lakewood.

System	Existing Materials	Replacement Materials
Water	Galvanized and cast iron pipe	Copper and ductile iron pipe
Sewer	Clay and concrete pipe originally. Low quality plastic replacements	PVC pipe

Table 5-9 Existing and Replacement Materials

Table 5-10 shows the number of calls related to low water pressure between mid-2011 and October 2015 in Lakewood and the remaining parcels of 37138. The values are presented in terms of the rate of calls per area households, which was measured as the number of detached single-family homes in each area. The rate of calls in Lakewood was about five times greater than the rate in 37138 excluding Lakewood.

Study Area	#of "low pressure" calls (% of homes) Aug. 2011- Oct. 2015
Lakewood (733 homes)	18 (2.5%)
37138 excluding Lakewood (3,888 homes)	17 (0.4%)

Table 5-10 "Low Water Pressure" Service Calls in the Study Area

Tuberculation may also occur in water pipes within homes, which would also reduce the effective water pressure delivered to residents. Because corrosion is correlated with age, the ages of homes in Lakewood were compared to those in the rest of 37138. *Figure 5-4* illustrates that the homes in Lakewood and in Old Hickory were built in roughly the same time frame, with the median year of construction for both being 1960. Because the vintage of the homes is similar, water pressure in the two communities could be compared based solely on the improvements to the lines outside of the homes.

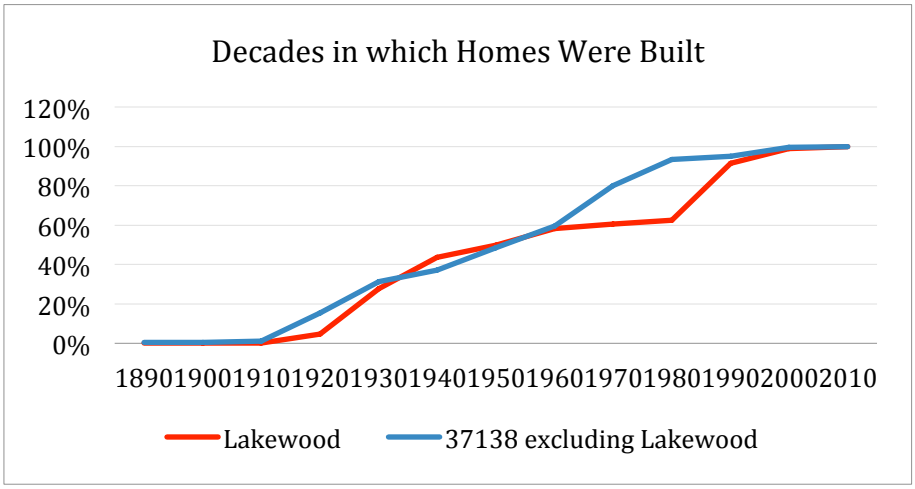

Figure 5-4 Construction of Homes in Study Area

Service call notes indicated that for some of the service calls placed to MWS, the issues with water delivery were not the fault of MWS, but were rather an indication of a problem on the private side of the meter. In these cases, the calls were excluded from the sample.

In summary, *Figure 5-5* shows the annual pattern of low pressure service calls to MWS excluding those determined to be private trouble. There is a steady reduction in annual calls in Lakewood, particularly after 2014. The annual call volume in the remainder of 37138 fluctuates greatly and does not have an apparent trend.

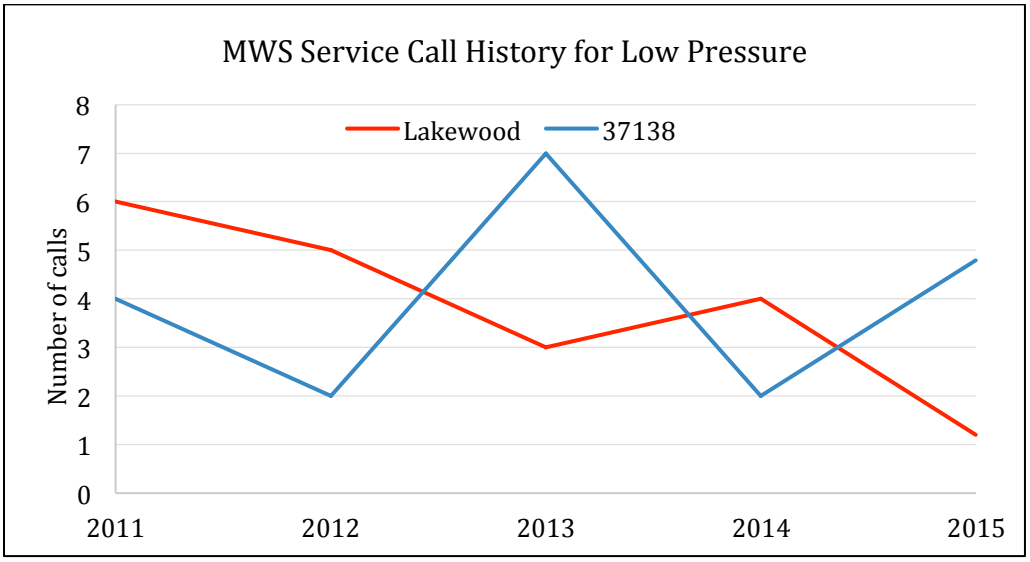

Figure 5-5 Five-Year Trend of Low Water Pressure Service Calls in Study Area

5.2.3 Improved Fire Protection

The water delivery network in Lakewood was initially developed in the 1920s. Other utilities were responsible for water delivery prior to MWS taking over in 2011. Therefore, the precise level of compliance with current fire protection is difficult to know. The parts of the Investment that improved fire protection included replacement of tuberculated water pipes, an increase in pipe diameter, replacement of selected existing hydrants, and addition of three more hydrants to the Lakewood area.

Currently, some insurers discount property insurance premiums for buildings less than 1,000 feet from a fire hydrant.[26] In an attempt to estimate the social benefit of premium costs saved by homeowners, the study team contacted various local insurance agents. Some insurers were only interested in whether the building was within five miles of a fire station and did not care whether it was within 1,000 feet of a hydrant (Protection Class 9). For insurers that did offer a discount, moving from Protection Class 9 to Protection Class 4, the discount was estimated at $350 per year for a home valued at

[26] Insurance Services Office's Protection Class 4

$150,000. *Appendix D* illustrates the original (blue) and new (yellow) hydrant density with 1,000-foot range rings around each hydrant.

The map in *Appendix D* indicates that even prior to the investment, the Lakewood parcels included in the Investment were already easily covered multiple times by existing hydrants (already Protection Class 4). Therefore, it is not expected that homeowners will experience reduced premiums as a result of the increased hydrant density from the Investment.

What is not shown in *Appendix D* is the size of the supply lines feeding the original hydrants. The supply lines feeding the hydrants had a 6" inner diameter (I.D.). However, most of the remainder of the network had 2.25" I.D. supply lines (serving most of the buildings). The 2.25" lines reduced the total volume of water available in the network and created a bottleneck prior to the 6" hydrant lines for water entering the network. The Investment upgraded the 2.25" lines to 8" I.D. lines, substantially increasing the network volume and removed the bottleneck prior to the hydrant lines.

To quantify this improvement in available hydrant fire flow MWS provided a sample of seven measurements before and two measurements after the Investment from hydrants within a few blocks of each other. The available hydrant fire flow measurements from each sample were averaged then the samples were compared. *Figure 5-6* shows that available hydrant fire flow doubled from ~950 gallons per minute (gpm) to ~1,900 gpm. The most extreme variances between the two samples showed almost a tripling of available flow. However, because the sample sizes were small, the Investment's construction still in progress, and before and after measurements of the identical hydrants were lacking, the doubling observed from the average sample approach is a reasonable estimate of flow improvement.

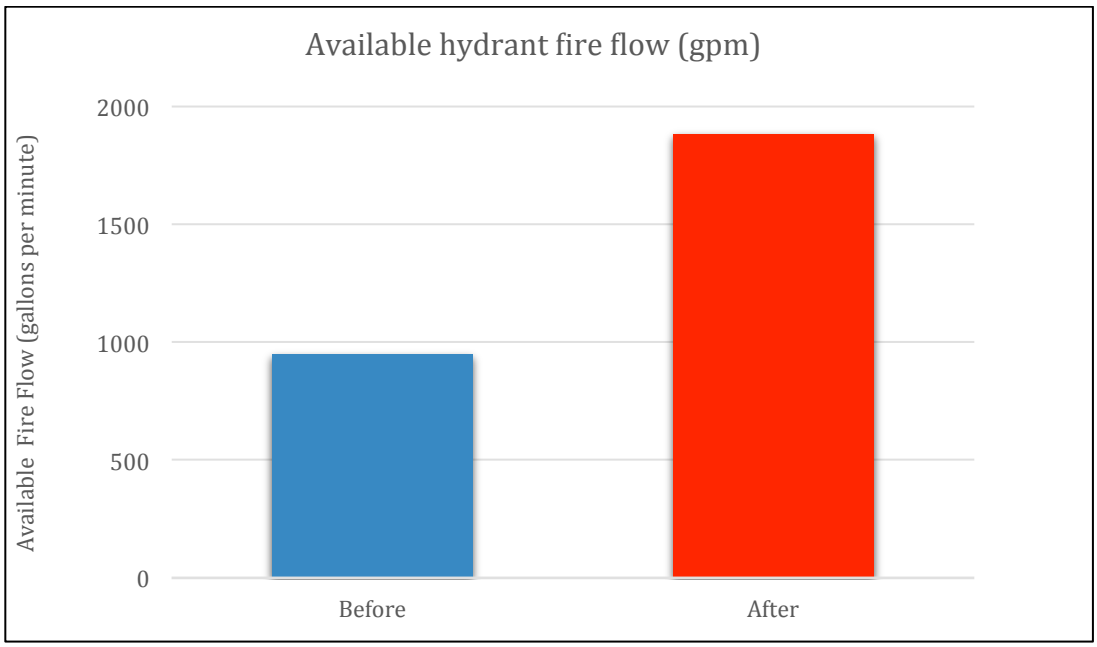

Figure 5-6 Change in Available Fire Flow Before and After the Investment

A final observation on the impact of the Investment comes from the National Fire Protection Association 2013 Public Input Report. Although hydrant density may have been adequate to meet regulations, continuing to rely on the volume of water available to fire truck pumps in Lakewood's network could have caused significant damage or contamination to the water mains. The report discusses this risk: "A primary concern should be the ability to maintain sufficient residual pressure to prevent developing a negative pressure at any point in the street mains, which could result in the collapse of the mains or other water system components or back-siphonage of polluted water from some other interconnected source." [27] Interviews with MWS staff included descriptions of discovery of the existing water system interconnections and valving in undocumented places, which could have easily led to the back-siphonage described above. Both risks are substantially reduced due to the new water system funded by the Investment.

[27] National Fire Protection Association (2009). Recommended Practice for Fire Flow Testing and Marking of Hydrants (2007 ed.). Quincy, MA.

The improvements delivered by the Investment were presented to representatives of the Nashville Fire Department to gain insight into the fire protection impacts of the Investment. *Table 5-11* shows this assessment and their comments.

Period	Investment Area Fire Hydrants	Supply Line Size	Fire Department Comments
Existing	16	6 & 2.25"	Low network water volume was not regularly able to fill fire truck fast enough to extinguish fire. Very quick response was needed for Lakewood fires, because every second they burned they would get harder to put out with limited water supply from hydrants. Standard practice for Lakewood fires required tanker trucks from multiple stations because hydrant supply was limited.
New	19	6 & 8"	At least double available hydrant fire flow is now available from new piping: • Enables simultaneous operation of multiple hoses from single tanker truck. • Enables much quicker filling of truck reserve tanks (750-1,000 gallons to fill). • Enables fire to be put out faster because the faster water that can be brought to the base of the fire the quicker the fire can be contained. • Reduces risk of injury or loss of life for firefighters and occupants. • Reduces need for backup tanker trucks. • Reduces friction in supply line. • Reduces load on truck pumps. • Reduces wear on truck pumps. • Reduces risk of fire jumping to another structure.

Table 5-11 Fire Hydrants and Water Line Capabilities from Nashville Fire Department

Even though hydrant coverage has not substantially changed and property owners may not earn premium discounts, actual property and human loss from fires have a notably enhanced chance of being reduced as a result of substantially increased hydrant fire flow.

5.2.4. Improved Stormwater Drainage

Prior to the Investment, Lakewood did not have any formal stormwater infrastructure, although there were instances in which some homeowners may have been illegally directing their storm runoff into the nearest sanitary sewer. During interviews with MWS staff who conducted the public meetings in 2011, it became clear that the residents had expressed more enthusiasm about planned stormwater mitigation than for the planned improvements in water pressure.

Improvements to the stormwater system included valley gutters in selected streets, storm inlets and catch basins, and the underground stormwater piping draining to adjacent Old Hickory Lake. In addition to meeting MS4/NPDES standards with this design and installation, the Lakewood neighborhood should experience noticeable drainage improvements during and after storms. The stormwater upgrades are designed to handle up to 95,000 gallons per minute or 98% of the heavy rainfall events in excess of 3" of rain, which is the amount expected during a 10-year storm event. This will greatly reduce roadway and property flooding in the event of a 10-year rainfall event. In other words, it will reduce the chance of noticeable flooding in the community to less than 10% in any given year.

As designed, the improvements should provide the neighborhood with much better drainage after storm events, reduce risks and damage from driving through flooded streets, and reduce stormwater ponding. The reduction of standing water also reduces habitat for vector-borne diseases such as West Nile virus and La Crosse Encephalitis, two diseases of local concern listed by the Tennessee Department of Health.

5.2.5 Reduced Sewer Blockages and Backups

Another social benefit of the Investment is a reduction in incidence of sewer blockages and backups. MWS has experienced four sanitary sewer overflows in this area since 2010, three due to blockages in the MWS-owned portion of the sewer system and one due to high flows during a rainfall event.

Analysis of MWS service call history included descriptions of sewer blockages and backups may have sent sewage to building crawlspaces, basements, or bathrooms. At most, human or animal interaction with raw sewage presents a health risk; at least, the odor, lost time, and potential property damage of a sewer backup presents a general nuisance to any party involved in it. Since the Investment includes improvements to both the MWS-owned portion of the sewer system as well as some private service connections, the study sought insight regarding how the Investment might alleviate the causes of the blockages.

MWS service call history was used to determine the frequency of sewer backups in Lakewood prior to the Investment. Calls related to backups were identified by searching for Problem Code SSSBU, "Sewerage Backing Up." Because post-project data is not yet available and to get a better cross-section of blockage causes, the sample set was to include all SSSBU calls within MWS service territory in the 37138 ZIP code.

Data from 151 MWS SSSBU service calls, representing the 37138 ZIP code were reviewed. In many cases, the cause of the backup was not evident and many causes occurred in the ratepayer's portion of the sewer piping. Where details were available, intrusion of vegetation roots were the most common natural cause, comprising 12 out of 14 instances, or, 85% of the time.

New materials, such as PVC sewer pipe, should reduce access points for roots enough to substantially delay the next round of blockages related to roots. The new sewer piping should also reduce the number of calls associated with collapsed existing piping, whether detailed in the call history or not.

5.2.6 Reduced Occupant Disturbances for Maintenance and Repair

Interviews and service calls history revealed that before the improvements, occupant permission was often required to provide access to properties for MWS personnel to accomplish repairs or maintenance. A brief review of these scenarios and how the Investment has reduced the need for disturbing occupants will reveal this benefit to the neighborhood.

Table 5-12 shows the types of maintenance and access scenarios that existed before the Investment and the post-Investment benefit. Many of these scenarios occurred because easements were either unestablished or unenforced or because of a lack of enforcement for building codes. Some, such as the location of alley access manholes behind homes, may have been suitable when buildings were constructed and only become a problem with later development in Lakewood. The improvements included moving many sewer and water lines and water meters into the street and rights-of-way. This relocation effort should substantially reduce the need for occupant permission or disturbance to gain access to and maintain the system.

Maintenance/Access Scenario	Post-Investment Remedy
Sewer system ran diagonally underneath buildings	New collection mains and manholes in streets on a grid pattern consistent with street access.
Manholes behind buildings (from alley sewer lines)	Easiest alley access locations were preserved. Other alley access was left in place and filled with concrete. New collection lines installed in streets.
Manholes under buildings	New collection mains and manholes installed in streets. New sewer laterals from mains to buildings.
Service and meter behind residential security gates	New collection mains and manholes installed in streets. New sewer laterals from mains to buildings.

Table 5-12 Various Maintenance and Access Scenarios for the Study Area

5.2.7 Impacts Allocated to Disadvantaged Businesses

Metro Nashville is committed to assisting in the development of minority, Service Disabled Veteran, small, and woman-owned businesses (SMWSDVBE) in Davidson County. The Office of Minority and Women Business Assistance (BAO) works to coordinate available public and private services in an effort to support the development and economic prosperity of small and disadvantaged businesses. This support is achieved by collaborating with Metro Nashville Government Departments and other members of the Nashville business community, thereby better ensuring SMWSDVBEs to be viable competitors for work with the City.

Spending data was provided by the construction general contractor who won the project via competitive bid. Data for the fulfillment of Metro's SMWSDVBE goals can be found in *Table 5-13*. Over 90% of the work on the project was contracted by small or women owed businesses.

Proportion of Small and Disadvantaged Businesses	
Total Bid	$10,293,365
Small or Disadvantaged Bid	$9,344,719
% Small or Disadvantaged	91%

Table 5-13 Contribution of Lakewood Investment to Metro Nashville's SMWSDVBE goals

5.3 Environmental Impacts

As part of the triple bottom line approach, this report will attempt to quantify the environmental impacts and social costs of water leakage, inflow and infiltration, and the external costs of coal-fired energy generation.

5.3.1 Reducing Water Losses from Distribution System Leaks

Interviews and site visits revealed that there had been some level of known leakage as well as common complaints of "red water" in Lakewood before the Investment. Metro Water would regularly flush the system in Lakewood to mitigate this problem, a practice whose frequency should be notably reduced following the Investment. Red water is an indication of corrosion in pipes. Corrosion is associated with a higher leakage rate, as 25% of water main breaks are associated with corrosion.[28]

Figure 5-7 "Fire Hydrant Flushing Rusty Water," Photo by Daniel Case

An analysis of data by MWS for the time period between 2011 and 2015 indicated that there was not a higher rate of leakage in the Lakewood distribution system than in other parts of Nashville. This was concluded because when the system was sounded in early 2015, only one leak was found. Additionally, data indicated that prior to Lakewood's annexation, when water was being purchased from Old Hickory Utility District by MWS to supply to Lakewood area, the usage was about 200,000 gallons per day. According to MWS this was not an unusually high rate of consumption for the area and did not indicate much leakage.

As the city of Lakewood's origins date back as far as the 1920s, and it was formally incorporated in the 1959, the infrastructure of both the water distribution system and the sewage system was composed of materials of a variety of age and vintage. Due to a lack of detailed records, specific age, vintage and material were not able to be determined. However, upon excavation of the old systems for replacement, certain qualities of the former mains and pipes were identified. According to some of the onsite engineers, the materials found in the previous water distribution system were mainly cast iron pipe and galvanized pipe. The sewer system was composed mainly of clay pipe as well as some concrete pipe. What limited stormwater infrastructure there was, was composed of mainly low-quality plastic.

The replacement materials- ductile iron and copper for distribution, PVC for sewage, and reinforced concrete pipe for stormwater- are more modern durable materials and are less prone to breaks and leaks. One study done by Utah State University found that cast iron has an average break rate of 24.4/100miles/year, and galvanized pipe has a break rate of about 21.0/100miles/year. Alternatively, PVC has an average of 2.6 breaks/100 miles/year, ductile iron has an average break rate of 4.9/100miles/year and copper has an average break rate of 21.0/100miles/year.[29] The more durable and resilient materials used in the replacement will likely last longer and be more reliable than the older ones.

Several methods were employed in an attempt to measure the value of reduction in water loss, but none were fit to create an accurate estimate. While the leakage rate in the existing system was unknown, but not very high, it is undoubtedly lower in the new system.

5.3.2 Reducing Sewer Line Inflow and Infiltration

Data provided by the Clean Water Nashville Overflow Abatement Program Management Team measured the reduction of Inflow and Infiltration in Lakewood following the Investment, relative to the surrounding area.

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[28] Folkman,S. (April 2012). Water Main Break Rates in the US and Canada: A Comprehensive Study. Utah State University Buried Structure Laboratory. Retrieved from: http://www.watermainbreakclock.com/docs/UtahStateWaterBreakRates_FINAL_TH_Ver5lowrez.pdf

[29] Folkman,S. (April 2012). Water Main Break Rates in the US and Canada: A Comprehensive Study. Utah State University Buried Structure Laboratory. Retrieved from: http://www.watermainbreakclock.com/docs/UtahStateWaterBreakRates_FINAL_TH_Ver5lowrez.pdf

The summers of 2012 and 2013 experienced considerably more rainfall than usual, based on data collected at rain gauge 2 (in proximity to GC13) and rain gauge 3 (in proximity to LW01). *Table 5-14* shows the observed rainfall in inches at both gauges. Nashville typically receives approximately 10.2 inches of rainfall during July through September.

Year	LW01 - Rain Gauge 3	GC13 - Rain Gauge 2
2011	11.86	9.29
2012	21.59	32.81
2013	22.89	23.44
2015	10.44	8.41

Table 5-14 Observed Rainfall at Selected Gauges

The observed flow data for the summers (July 1 - September 30) was summarized by averaging all flows from the datasets. The resulting flows are summarized in *Table 5-15*.

Year	Average of all July – September flows (mgd)	
	LW01	GC13
2011	0.16	0.80
2012	0.27	1.08
2013	0.38	1.14
2011-2013	0.27	1.01
2015	0.17	0.69
Difference 2011-2013 to 2015	37%	32%
Relative reduction in flow for LW01 vs GC13	5%	

Table 5-15 Flow Summary in Million Gallons per Day (mgd)

As shown in *Table 5-16*, there is a correlation between the observed flows and the observed rainfall data at both flow monitors. A comparison of all flows from the summers of 2011 through 2013 (pre-construction) relative to 2015 (post-construction) indicate a flow reduction of 37% for LW01; however, the same periods indicate a flow reduction of 32% for GC13, an area where no significant projects have been constructed between 2011 and 2015. Thus, the difference in flow between these two flow meters was determined to be a result of the Investment. A 5% reduction of the total flow at LW01 may be attributed to the Lakewood improvements.

Because the Lakewood project area represents approximately one quarter of the length of pipe monitored by LW01, and no significant changes are believed to have occurred in the other areas, a flow reduction of 20% is reasonable for the purposes of this study of the impacts of the Lakewood improvements. It is recommended that this area continue to be analyzed, as additional data is available. It is possible that a different, likely higher, value would be estimated when considering flow patterns during the winter, because of higher groundwater and antecedent moisture conditions.

With the assumption that the same 5% reduction of the annual average flow for 2011-2013 (shown in *Table 5-16*), will remain constant, there is and expected annual flow reduction of 0.015 mgd or approximately 5.5 million gallons (mg) over the full year.

Avg. 2011-2013 Full year average flow = (0.25 + 0.26 + 0.35)/3 = 0.15 mgd
x 5% x 365 days per year = 5.5M gallons

Year	Full year average flow (mgd)	Total rainfall (inches)
2011	0.25	51.09
2012	0.26	53.45
2013	0.35	67.95

Table 5-16 Average Annual Flow for Nashville: 2011, 2012, and 2013

It is important to note that project construction was not complete as of the dates of the summer 2015 flow measurements. Additionally, the season measured represents the driest part of the year for rainfall and antecedent moisture conditions. The summer months traditionally have the least amount of I/I in the greater Nashville area. For this

reason, these findings are a conservative estimate of I/I volume that might ultimately be prevented from entering the improved Lakewood sewer system. Because of the consistent presence of the LW01 and GC13 flow meters before and after the Investment, opportunity exists for further study after construction is finished, over longer observation periods, and before any other sewer improvements are made in the areas measured by these flow meters.

5.3.2.1. Externalities Reduced

The I/I in Lakewood's sewer system sends extraneous, additional flow to the Dry Creek Wastewater Treatment Plant (DCWWTP) for treatment. As wastewater treatment requires roughly twice as much electricity as pumping potable water, a renovated sewer system that reduces I/I would also reduce the cost externalities associated with coal-fired electricity.

The external costs of conventional energy generation include environmental degradation, species loss, and threats to human health and well-being. Many of these costs are innumerable. From loss and damage to property, to the development of chronic illnesses such as asthma and COPD, and heart disease, and fatal illnesses such as cancer, to the loss of essential ecosystem services provided by the species and habitats, human society is paying these costs.

Inefficiencies in both energy production and water treatment can greatly increase energy demand. The interdependency between these industries exacerbates the demand for both. Increased efficiency in water delivery helps to reduce the demand for both energy and potable water, and mitigates the negative environmental and health costs of energy generation.

While the calculation below does provide some indication of reduction in societal costs as a result of infrastructure improvements, it does not include the full costs. First, because the 5.5-million-gallon reduction is a very conservative estimate, as the flow measurements were only taken during dry-season. Secondly, the 17.84 cents used to calculate this number, only represents the cost of 9 out of the 56 external costs of coal-fired electricity. And finally, because coal-fired electricity is only one risk factor for these external costs. For this reason, these calculated cost savings are not meant to represent the total cost-savings that could be achieved, but rather a framework for how cost-savings can be realized.

5.3.2.2 Cost Externalities Reduced due to I/I Reduction Estimate

When accounting for the full cost of coal-generated electricity, the costs or financial savings discussed do not represent actual dollars saved or spent by MWS. Rather, a "full cost net present value" represents the value to numerous stakeholders that are impacted by the coal life cycle.

With I/I reduction estimates, cost externalities can be calculated. *Table 5-17* shows calculation of cost externalities reduced due to estimated I/I reductions from renovated Lakewood sewer system. As a reminder, these are not annual cash flows or savings to MWS; they are annual savings in public costs in the form of reduced health care costs, etc., (as discussed in *Appendix B*). This calculation is shown in more detail in *Appendix B*.

A. Annual expected flow reduction	5.5 million gallons
B. DCWWTP treatment electricity cost	0.0019 kWh/gallon
C. kWh consumed to treat A. (A x B)	10,377 kWh
D. Best cost (from Appendix B)	$0. 1784/kWh
E. Annual Cost Externalities Reduced (C x D)	$1,864

Table 5-17 Cost Externalities Based on Reduced I/I

5.3.2.3 Reduced MWS Operations and Maintenance Costs

An added benefit of the Investment is the projected cost savings to MWS, through reduced operations and maintenance costs, as a result of greater efficiency in the system.

A June 2014 report from the U.S. EPA Water Infrastructure Outreach Program, *Quick Guide for Estimating Infiltration and Inflow*,[30] identified a range of costs, from $2-$5 per thousand gallons, for wastewater collection and treatment costs. *Table 5-18* shows estimates of the costs MWS might avoid as a result of the Investment.

[30] U.S. Environmental Protection Agency. (June 2014). Quick Guide for Estimating Infiltration and Inflow. Retrieved from: http://www3.epa.gov/region1/sso/pdfs/QuickGuide4EstimatingInfiltrationInflow.pdf

Wastewater Treatment cost/thousand gallons	Estimated Annual Gallons of I/I Avoided	Estimated Annual Costs Avoided
$2	5,500,000	$11,000
$5	5,500,000	$27,500

Table 5-18 Estimated Annual MWS O&M savings from Investment's reduction of sewer I/I

SECTION 6 - Conclusion

This study has presented the triple bottom line impacts from the Lakewood Investment. The value of infrastructure investments improves society in both small ways and in much larger economic, social, and environmental ways. There is more that could be done to track the success of this project and to offer insight into the impacts from other projects like it. The following areas are recommended as topics for additional study.

Near-term (6 months to 1 year post-construction)

- I/I reduction analysis at LW01, et al.
- Opinion surveys of long-time residents to confirm performance expected
- Analyze expected improvements in MWS service calls and maintenance
- Confirm that all MWS assets that should have been retired actually have been retired
- Larger study of economic impact and jobs supported by MWS and other Metro infrastructure spending

Medium-term (1 to 2 years post-construction)

- I/I reduction analysis at LW01, et al. (before neighboring areas experience infrastructure improvements)
- Business license growth
- Building permit growth
- Opinion surveys of recent property buyers

Long-term (3 to 5 years post-construction)

- Property value increases from sales data
- Property tax increases from increased property values

As seen in this study, there are current and future positive impacts from infrastructure spending, many of which should be quantified and explored further. The project kept 159 neighbors employed in both direct and supporting roles with $27.1M flowing into hundreds of industries. An economy benefits from stable, working class jobs, opportunities to start new businesses and support for the growth of communities. Property owners in Lakewood will benefit from water, sewer, and stormwater performance similar to a new subdivision with new connections, functional drains, and good water pressure. Water will be available when it is needed to fight fires, and be efficiently discharged when it is not, such as after storms. Lastly, maintained infrastructure ensures the efficiency of what was originally designed. Intact water and sewer lines keep water where its intended relieving the burden on the utility to move and treat the extra water. Reducing inefficiencies such as those in Lakewood reduces the health and environmental damage that can occur when energy is wasted.

MWS' Investment in Lakewood can now support another generation of economic and community development while protecting its residents and resources at the same time.

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APPENDICES

Appendix A Analysis-By-Parts Methodology

When evaluating the spending pattern of the three industries that are represented in the Investment, is was found that commodity 3449 Architectural, Engineering and Related Services is included in the spending patterns of both of the construction sector. To do a standard industry change for all three of these sectors, would have been double counting, because of the overlap between the direct spending of sector 449, and the indirect purchase of commodity 3449.

For this reason, the model was built using the Analysis-by-parts method, which would allow each industry to be represented but would remove the possibility of double-counting. To do so, the industry spending patterns for both construction sectors were imported as two separate activities, and the commodity 3449 was removed from the spending patterns. The activity level was set to the total number of dollars spent in each industry. Next, another activity was created and set as an industry change in sector 449 having an industry spending value equal to the spending on design and management.

Because the industry spending patterns were imported, the direct impacts of sectors 56 and 58, including employee compensation, were not included in the ABP model. To adjust for this, a separate scenario was created for each of the construction sectors as industry changes. The data from the labor income column for the direct impact for each sector was then applied in the ABP scenario as a labor income change. Finally, the scenario including sector 449 industry change, sector 58 and 56 industry spending patterns, and the labor income change for sectors 58 and 56 was run.Once the model was run, the numbers were added from the direct impacts of the industry change scenarios for sector 56 and 58 to the total impacts from the ABP method.

To perform a Multi-Regional Analysis, with the direct impacts analyzed in only Davidson County, and the indirect and induced impacts measured in the seven-county region, two models were built. The first was a simple industry change in each of the three industries analyzed only in Davidson County. Because Industry Spending Patterns do not affect the direct impacts, they were selected. The second model was constructed using the above ABP methodology, and was analyzed across Davidson, Cheatham, Rutherford, Robertson, Sumner, Williamson, and Wilson County. *Table A* shows the Direct, Indirect and Induced Effects for each of the three sectors analyzed. These values, pulled from the two models were added together to create the total values seen in the final "Total" rows.

Direct Effect of Sector 449, Sector 58 and Sector 56 modeled in Davidson County only.				
Impact Type	**Sector**	**Employment**	**Labor Income**	**Output**
Direct (Davidson County)	449 Architecture, Engineering and Related Services	14.11	$1,534,555.80	$2,619,562.00
	56 Construction of Roads and Highways	12.46	$942,732.47	$2,584,870.00
	58 Construction of New Non-Residential Structure	44.69	$3,857,544.80	$8,710,988.00
Total Direct		**71.26**	**$6,274,354.76**	**$13,915,420.00**
Indirect (Davidson, Cheatham, Rutherford, Robertson, Sumner, Williamson, Wilson Counties)	449 Architecture, Engineering and Related Services	9.85	$590,556.93	$1,264,150.35
	56 Construction of Roads and Highways	6.79	$414,019.76	$1,297,351.86
	58 Construction of New Non-Residential Structure	21.06	$1,113,550.00	$3,181,408.91
Total Indirect		**37.69**	**$2,118,126.69**	**$5,742,911.12**
Induced (Davidson, Cheatham, Rutherford, Robertson, Sumner, Williamson, Wilson Counties)	449 Architecture, Engineering and Related Services	12.18	$692,280.90	$1,820,236.93
	56 Construction of Roads and Highways	8.25	$469,228.18	$1,233,698.98
	58 Construction of New Non-Residential Structure	29.89	$1,699,988.17	$4,469,603.74
Total Induced		**50.32**	**$2,861,497.24**	**$7,523,539.65**
Overall Total		**159.27**	**$11,253,978.69**	**$27,181,870.78**

Table A Cumulative Effects of All of the Scenarios Including the Direct Effects, the Indirect and Induced Effects

Appendix B Cost Externalities Assumptions and Additional Impacts

Externality	Low, ¢/kWh	High, ¢/kWh	Best, ¢/kWh
Mining Activates			
1. Land disturbance	0	0.17	0.01
2. Methane emissions	0.03	0.34	0.08
3. Public health burden	4.36	4.36	4.36
4. Abandoned mine lands	0.44	0.44	0.44
Transportation Activities			
5. Fatalities in transport	0.09	0.09	0.09
Combustion Activities			
6. Air pollutant emissions	3.23	9.31	9.31
7. Mercury emissions	0.02	1.72	0.33
8. Climate damage from CO_2 and N_2O	1.02	10.2	3.06
9. Subsidies	0.16	0.27	0.16
Totals, ¢/kWh	9.35	26.64	17.84

Table B Externalities of Coal

1. Land disturbance: An estimated 6 – 6.9 million tons of CO_2e are emitted annually from the removal of soil and plants at MTR and mining sites. The high and low costs are estimated using a cost of $10-$100/ton emitted. The best estimate is $162.9 million, using a cost of $30/ton CO_2e emitted.
2. Methane Emissions: Energy Information Agency (EIA) estimates that 71 tons CO_2e of methane were emitted in 2007. Approximately 93% of this coal was used for electricity generation, indicating not all methane emissions are due to electricity generation. With this factored in, the cost estimate ranges from $684 million to $6.84 billion (based on social cost of carbon range $10-100/ton emitted). The best estimate is $2.05 billion, based on a $30/ton cost of carbon.
3. Public health burden: This estimate includes the costs of excess mortality in coal mining regions. Studies compiled from 1979-2004 show that mortality from lung cancer, as well as heart, respiratory and kidney disease were heaviest in coal mining regions of Appalachia when compared to national death rates. There were 10,923 calculated excess deaths in the Appalachia region. This number was adjusted down to 2,347 to reflect higher smoking rates, obesity, and poverty in the region. Based on a value of a statistical life (VSL) of $7.5 million, the cost is $74.6 billion (4.36 ¢/kWh). The VSL is a commonly accepted method for estimating, so there is no high or low range for this estimate.
4. Abandoned mine lands (AML): This cost reflects the cost of reclaiming land from abandoned mines prior to 1977 (in 1977 a law was passed requiring operators to perform reclamation). There remain $8.8 billion in unfunded reclamation projects as of 2008.
5. Fatalities from transporting coal: In 2007, 246 people were killed on freight railroads directly attributable to coal transport. The NRC estimated 246 based on the total number of fatalities on railroads, prorated based on how much rail traffic is devoted to coal transport (70%). Only 5 of the fatalities were occupational, the remaining 241 were unrelated to the coal industry. Again, there is no range because the VSL of $7.5 million was used instead of high and low estimates.
6. Air pollutant emissions: The Natural Resources Council (NRC) has found that emissions of $PM_{2.5}$, PM_{10}, SO_2, and NO_x from combustion are directly attributable for damages to public health, property, visibility, farmland, and forests. The NRC estimate is probably an underestimate, and represents the low range of acceptable estimates. The high estimate, $187.5 billion, is more commonly accepted among researchers as it is based on more recent and detailed statistics. It includes excess mortality from air pollutants, as well as other negative community impacts.
7. Effects of mercury emissions: includes lost productivity from mercury (0.10 ¢/kWh), increased cases of mental retardation (0.02 ¢/kWh), and excess cardiovascular disease associated with mercury exposure (0.21 ¢/kWh).
8. Climate damage from Carbon dioxide and nitrates: The EIA estimates that 1.97 billion tons of CO_2 and 9.3 million tons of CO_2e of nitrates were emitted from coal fired power plants. Using the range of $10-100/ton, high and low estimates range from $20.6 billion to $205.6 billion. Using the best estimate of $30/ton, the cost is $61.7 billion (3.06 ¢/kWh).
9. Subsidies were calculated by the EIA and include: Direct expenditures, tax expenditures, R&D, loans and loan guarantees, and programs such as TVA that serve targeted consumers in specific regions. Full report is available on

EIA website: http://www.eia.gov/analysis/requests/subsidy/, The high estimate is from an Environmental Law Institute study on subsidies.

There are other social and environmental impacts that are not monetized in this report. Because the United States coal infrastructure is far reaching, it is impossible to capture and monetize all impacts. Some known impacts that are not assigned a cost in this report are:

Pollution

- Ammonia releases
- Methane emissions
- Stream pollution
- Stream destruction
- Groundwater contamination
- Mercury exposure
- Heavy metal release
- Carbon emissions
- Increased air particulates
- Transportation emissions
- Ash spills
- Slurry spills

Ecological Risks

- Acid rain
- Loss of marine life
- Decreased ozone
- Eutrophication
- Harmful algal blooms
- Lost carbon storage
- Deforestation
- Land disturbance
- Soil loss
- Loss of biodiversity
- Damage to farmland
- Land required for waste disposal
- Incomplete reclamation

Community Risks

- Population declines
- Community illnesses
- Community disabilities
- Mental health impacts
- Loss of views
- Blasting damage
- Increased poverty
- Decrease in jobs
- Wear on infrastructure
- High violent crime rates
- Tourism loss
- National security concerns
- Higher infant death
- Mudslides
- Flooding
- Litigation
- Lost property value
- Building degradation

Job-related Risks

- Mining injuries
- Disabilities
- Chronic illness
- Mining deaths
- Transportation injuries

Appendix C Impacts by IMPLAN Industry Sector (Sorted by Employment)

Sector	Description	Employment	Labor Income	Value Added	Output
58	Construction of other new nonresidential structures	44.69	$3,857,544.80	$3,932,860.47	$8,710,988.00
449	Architectural, engineering, and related services	15.29	$1,578,701.33	$1,530,493.20	$2,805,487.54
56	Construction of new highways and streets	12.46	$942,732.47	$949,016.25	$2,584,870.00
395	Wholesale trade	4.77	$399,813.22	$761,448.77	$1,165,109.17
501	Full-service restaurants	3.85	$90,608.32	$95,827.55	$175,483.05
440	Real estate	3.83	$134,883.87	$657,778.61	$865,859.23
464	Employment services	3.49	$118,633.63	$178,704.79	$219,634.51
502	Limited-service restaurants	3.23	$60,746.16	$132,681.13	$248,483.07
403	Retail - Clothing and clothing accessories stores	2.61	$66,490.95	$126,257.25	$203,914.64
407	Retail - Nonstore retailers	2.40	$50,634.22	$144,350.81	$248,616.30
482	Hospitals	2.23	$410,122.67	$379,864.65	$526,000.32
405	Retail - General merchandise stores	2.17	$62,953.28	$101,909.29	$155,443.44
406	Retail - Miscellaneous store retailers	1.96	$48,161.76	$53,077.53	$79,847.16
411	Truck transportation	1.94	$118,199.68	$141,535.89	$319,183.59
400	Retail - Food and beverage stores	1.61	$58,763.79	$81,363.83	$115,394.68
468	Services to buildings	1.56	$43,788.90	$47,256.99	$68,213.32
503	All other food and drinking places	1.52	$44,323.18	$37,142.39	$61,925.83
454	Management consulting services	1.52	$137,367.25	$142,421.84	$216,714.30
475	Offices of physicians	1.40	$177,471.00	$173,144.23	$241,396.25
401	Retail - Health and personal care stores	1.35	$65,732.82	$84,320.69	$123,627.54
436	Other financial investment activities	1.25	$62,910.01	$86,906.53	$214,668.96
483	Nursing and community care facilities	1.14	$55,702.99	$62,555.25	$91,445.19
504	Automotive repair and maintenance, except car washes	1.06	$65,815.72	$87,593.87	$115,795.09
460	Marketing research and all other miscellaneous professional, scientific, and technical services	1.02	$69,126.94	$67,539.20	$95,966.36
473	Junior colleges, colleges, universities, and professional schools	1.00	$61,718.75	$72,790.96	$117,745.43
399	Retail - Building material and garden equipment and supplies stores	0.99	$50,505.33	$73,789.87	$107,086.05
402	Retail - Gasoline stores	0.99	$34,431.20	$47,214.00	$73,719.54
461	Management of companies and enterprises	0.98	$121,454.03	$148,548.53	$237,626.09
433	Monetary authorities and depository credit intermediation	0.96	$84,407.45	$149,174.44	$215,611.36
396	Retail - Motor vehicle and parts dealers	0.92	$58,841.09	$93,234.53	$117,842.21
485	Individual and family services	0.91	$26,190.01	$24,334.76	$34,396.10
445	Commercial and industrial machinery and equipment rental and leasing	0.87	$66,692.44	$161,823.47	$223,843.06
438	Insurance agencies, brokerages, and related activities	0.87	$58,666.63	$87,827.60	$161,812.56
447	Legal services	0.85	$72,917.20	$111,177.63	$152,974.46
487	Child day care services	0.84	$21,748.20	$23,569.27	$35,031.06
434	Nondepository credit intermediation and related activities	0.82	$71,285.59	$76,093.27	$124,959.42
517	Private households	0.81	$10,426.30	$10,426.30	$10,453.81

509	Personal care services	0.80	$30,877.44	$29,478.55	$38,222.62
474	Other educational services	0.79	$21,116.50	$19,775.78	$32,377.83
465	Business support services	0.78	$39,727.54	$39,431.06	$55,373.98
404	Retail - Sporting goods, hobby, musical instrument and book stores	0.78	$19,145.93	$26,650.94	$41,068.32
448	Accounting, tax preparation, bookkeeping, and payroll services	0.75	$84,171.82	$107,531.60	$124,177.24
467	Investigation and security services	0.73	$22,623.45	$25,067.24	$34,850.58
512	Other personal services	0.72	$24,859.45	$21,741.80	$28,468.56
437	Insurance carriers	0.71	$74,212.27	$182,593.92	$329,574.01
469	Landscape and horticultural services	0.70	$23,308.86	$27,744.95	$40,651.95
416	Warehousing and storage	0.68	$28,003.30	$34,209.50	$65,135.35
62	Maintenance and repair construction of nonresidential structures	0.67	$43,737.28	$44,099.58	$109,575.32
462	Office administrative services	0.62	$48,577.77	$49,151.12	$58,191.36
415	Couriers and messengers	0.57	$20,946.48	$30,283.27	$57,026.72
492	Independent artists, writers, and performers	0.55	$13,953.62	$14,355.50	$23,173.17
457	Advertising, public relations, and related services	0.54	$38,949.21	$75,361.24	$124,630.46
206	Ready-mix concrete manufacturing	0.51	$30,438.68	$34,877.44	$160,744.68
427	Wired telecommunications carriers	0.51	$37,855.28	$74,512.06	$197,398.07
472	Elementary and secondary schools	0.51	$23,531.03	$24,215.35	$34,672.69
476	Offices of dentists	0.50	$46,226.71	$55,012.41	$75,235.66
516	Labor and civic organizations	0.46	$9,504.81	$26,105.57	$31,898.51
414	Scenic and sightseeing transportation and support activities for transportation	0.45	$29,411.02	$35,784.58	$71,063.11
209	Other concrete product manufacturing	0.44	$28,108.00	$32,146.78	$91,323.52
478	Outpatient care centers	0.43	$38,375.58	$49,464.74	$81,853.52
507	Commercial and industrial machinery and equipment repair and maintenance	0.42	$32,880.99	$50,170.55	$66,482.71
526	Other local government enterprises	0.42	$41,107.87	$49,081.05	$131,967.16
480	Home health care services	0.41	$52,613.95	$47,622.85	$52,706.83
497	Fitness and recreational sports centers	0.40	$4,694.32	$8,409.29	$16,978.78
30	Stone mining and quarrying	0.38	$18,052.83	$56,335.11	$98,748.97
477	Offices of other health practitioners	0.38	$51,325.17	$54,493.54	$64,924.16
496	Other amusement and recreation industries	0.37	$5,724.72	$10,230.69	$21,073.15
398	Retail - Electronics and appliance stores	0.36	$19,832.75	$16,553.83	$25,148.69
397	Retail - Furniture and home furnishings stores	0.36	$15,745.60	$24,056.73	$36,890.82
484	Residential mental retardation, mental health, substance abuse and other facilities	0.36	$16,466.06	$11,944.62	$16,260.73
508	Personal and household goods repair and maintenance	0.36	$25,800.01	$31,968.23	$38,017.52
450	Specialized design services	0.34	$22,224.10	$23,943.61	$33,803.12
63	Maintenance and repair construction of residential structures	0.32	$20,702.22	$20,701.18	$56,111.96
470	Other support services	0.30	$10,089.93	$10,138.85	$20,794.19
518	Postal service	0.30	$27,294.78	$18,914.17	$31,638.60
452	Computer systems design services	0.29	$29,808.88	$26,886.16	$39,025.64

412	Transit and ground passenger transportation	0.29	$16,134.99	$20,097.22	$29,365.06
495	Gambling industries (except casino hotels)	0.28	$10,455.50	$22,012.94	$39,438.18
455	Environmental and other technical consulting services	0.28	$23,628.33	$18,431.64	$27,128.33
439	Funds, trusts, and other financial vehicles	0.26	$20,541.56	$50,974.16	$89,276.32
486	Community food, housing, and other relief services, including rehabilitation services	0.26	$9,779.95	$11,387.69	$22,040.22
435	Securities and commodity contracts intermediation and brokerage	0.24	$36,990.40	$449.92	$17,292.07
514	Grantmaking, giving, and social advocacy organizations	0.24	$10,210.24	$29,888.82	$37,992.67
425	Radio and television broadcasting	0.24	$17,878.21	$12,751.52	$47,221.39
453	Other computer related services, including facilities management	0.23	$22,449.78	$24,808.13	$39,385.91
430	Data processing, hosting, and related services	0.22	$20,139.82	$23,603.10	$69,514.72
423	Motion picture and video industries	0.22	$13,983.31	$28,295.30	$48,587.13
471	Waste management and remediation services	0.21	$11,254.40	$16,829.41	$40,288.77
506	Electronic and precision equipment repair and maintenance	0.20	$16,267.59	$20,330.64	$29,231.32
459	Veterinary services	0.19	$8,400.94	$10,036.52	$19,427.91
443	General and consumer goods rental except video tapes and discs	0.18	$9,292.95	$10,682.86	$15,565.73
154	Printing	0.18	$9,049.60	$15,289.52	$31,293.92
515	Business and professional associations	0.17	$11,266.98	$33,285.02	$38,750.42
207	Concrete block and brick manufacturing	0.17	$11,874.63	$15,759.88	$46,537.18
442	Automotive equipment rental and leasing	0.17	$9,231.37	$29,509.71	$44,550.37
511	Dry-cleaning and laundry services	0.15	$6,031.47	$8,083.32	$11,268.60
408	Air transportation	0.15	$7,781.81	$15,585.11	$46,254.46
458	Photographic services	0.14	$7,246.92	$5,926.80	$10,099.64
505	Car washes	0.14	$7,382.25	$8,608.42	$10,888.69
237	Prefabricated metal buildings and components manufacturing	0.14	$10,465.78	$13,012.73	$37,608.74
479	Medical and diagnostic laboratories	0.14	$13,269.02	$13,769.02	$19,554.67
481	Other ambulatory health care services	0.14	$14,121.55	$14,573.05	$20,153.21
513	Religious organizations	0.14	$4,978.34	$6,552.95	$17,856.13
417	Newspaper publishers	0.14	$7,085.77	$11,798.21	$18,479.64
208	Concrete pipe manufacturing	0.13	$7,745.28	$9,743.98	$32,244.94
491	Promoters of performing arts and sports and agents for public figures	0.13	$6,299.56	$9,451.36	$18,674.48
422	Software publishers	0.12	$12,714.30	$28,582.91	$40,388.42
525	Local government electric utilities	0.12	$12,046.30	$27,631.67	$75,785.71
144	Prefabricated wood building manufacturing	0.12	$9,608.57	$12,595.06	$26,921.02
466	Travel arrangement and reservation services	0.11	$6,741.94	$11,351.04	$21,711.18
20	Extraction of natural gas and crude petroleum	0.11	$2,088.75	$1,056.16	$19,755.58
418	Periodical publishers	0.11	$6,728.80	$14,140.98	$30,138.16
493	Museums, historical sites, zoos, and parks	0.10	$3,680.11	$3,801.77	$8,161.86
10	All other crop farming	0.10	$462.71	$781.10	$1,188.73
158	Asphalt shingle and coating materials	0.10	$12,601.83	$30,876.70	$100,654.66

	manufacturing				
428	Wireless telecommunications carriers (except satellite)	0.09	$4,418.69	$35,499.43	$154,649.97
409	Rail transportation	0.09	$9,605.60	$16,337.48	$31,797.53
488	Performing arts companies	0.08	$7,676.16	$15,173.16	$21,033.32
463	Facilities support services	0.08	$3,725.32	$7,464.03	$13,415.50
11	Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	0.08	$329.99	$1,121.16	$2,291.76
499	Hotels and motels, including casino hotels	0.07	$2,474.93	$5,024.66	$8,001.44
49	Electric power transmission and distribution	0.07	$8,147.22	$39,154.68	$101,021.94
238	Fabricated structural metal manufacturing	0.07	$3,952.79	$5,215.34	$19,354.35
510	Death care services	0.07	$3,139.61	$5,825.63	$7,785.02
489	Commercial Sports Except Racing	0.06	$14,119.18	$16,510.44	$18,121.29
141	Other millwork, including flooring	0.06	$2,742.38	$3,480.92	$10,416.68
498	Bowling centers	0.05	$737.27	$1,589.01	$2,738.84
446	Lessors of nonfinancial intangible assets	0.05	$1,876.19	$30,330.72	$63,691.45
519	Federal electric utilities	0.05	$7,690.95	$14,071.62	$58,846.07
134	Sawmills	0.05	$1,983.35	$2,395.82	$12,504.74
429	Satellite, telecommunications resellers, and all other telecommunications	0.04	$1,775.86	$1,300.17	$3,343.56
139	Wood windows and door manufacturing	0.04	$2,128.80	$2,662.89	$8,525.57
242	Ornamental and architectural metal work manufacturing	0.04	$2,487.63	$2,713.47	$8,200.27
410	Water transportation	0.04	$4,234.66	$8,086.94	$30,618.78
213	Cut stone and stone product manufacturing	0.04	$1,558.70	$1,715.41	$4,699.07
94	Bread and bakery product, except frozen, manufacturing	0.04	$1,405.64	$1,821.13	$4,311.35
343	Automobile manufacturing	0.03	$3,594.63	$10,998.87	$53,762.74
419	Book publishers	0.03	$2,223.18	$12,537.04	$15,350.64
432	Internet publishing and broadcasting and web search portals	0.03	$2,218.06	$2,941.62	$17,080.01
241	Sheet metal work manufacturing	0.03	$2,325.22	$2,569.81	$6,571.56
50	Natural gas distribution	0.03	$3,584.74	$7,481.86	$20,394.91
137	Engineered wood member and truss manufacturing	0.03	$1,445.07	$1,551.74	$5,412.07
106	Bottled and canned soft drinks and water	0.03	$2,194.06	$4,600.59	$22,848.72
388	Sign manufacturing	0.03	$1,274.93	$1,323.79	$2,854.97
157	Asphalt paving mixture and block manufacturing	0.02	$5,310.78	$4,687.55	$18,151.16
80	Frozen specialties manufacturing	0.02	$1,408.72	$1,772.91	$8,394.07
195	Other plastics product manufacturing	0.02	$1,124.80	$1,492.24	$5,714.42
16	Commercial logging	0.02	$1,759.60	$1,877.06	$2,778.63
31	Sand and gravel mining	0.02	$6,422.49	$23,960.57	$27,141.43
89	Animal, except poultry, slaughtering	0.02	$919.88	$1,817.38	$12,216.60
413	Pipeline transportation	0.02	$3,517.32	$6,136.45	$9,450.61
51	Water, sewage and other systems	0.02	$879.10	$1,521.86	$4,154.10
340	Wiring device manufacturing	0.02	$919.18	$2,290.53	$6,282.52
334	Switchgear and switchboard apparatus	0.02	$2,782.54	$5,081.38	$9,826.64

	manufacturing				
201	Flat glass manufacturing	0.02	$1,266.92	$1,640.56	$6,080.16
84	Fluid milk manufacturing	0.02	$1,142.97	$2,029.21	$13,510.62
149	Paperboard container manufacturing	0.02	$1,557.91	$2,039.22	$8,124.14
494	Amusement parks and arcades	0.02	$136.81	$575.49	$991.63
90	Meat processed from carcasses	0.02	$768.13	$1,093.68	$7,793.78
14	Animal production, except cattle and poultry and eggs	0.02	$94.71	$198.26	$250.40
205	Cement manufacturing	0.01	$1,136.45	$1,804.37	$7,289.87
6	Greenhouse, nursery, and floriculture production	0.01	$367.04	$658.07	$818.63
420	Directory, mailing list, and other publishers	0.01	$344.01	$1,268.04	$2,798.74
92	Poultry processing	0.01	$496.77	$638.42	$4,001.24
18	Commercial hunting and trapping	0.01	$118.36	$265.74	$588.16
331	Other major household appliance manufacturing	0.01	$892.16	$2,730.92	$8,893.44
142	Wood container and pallet manufacturing	0.01	$542.32	$624.84	$1,776.43
424	Sound recording industries	0.01	$1,051.76	$3,805.43	$5,193.98
456	Scientific research and development services	0.01	$982.17	$1,309.69	$3,000.75
490	Racing and Track Operation	0.01	$247.08	$266.25	$358.96
368	Wood kitchen cabinet and countertop manufacturing	0.01	$503.63	$537.98	$1,564.77
431	News syndicates, libraries, archives and all other information services	0.01	$685.16	$1,595.61	$10,789.79
159	Petroleum lubricating oil and grease manufacturing	0.01	$2,300.91	$7,892.24	$18,272.87
351	Motor vehicle electrical and electronic equipment manufacturing	0.01	$914.83	$1,406.12	$4,930.95
326	Lighting fixture manufacturing	0.01	$965.34	$1,699.91	$3,833.43
19	Support activities for agriculture and forestry	0.01	$167.10	$196.37	$332.65
196	Tire manufacturing	0.01	$1,104.76	$1,749.31	$5,159.35
145	All other miscellaneous wood product manufacturing	0.01	$373.75	$533.57	$1,775.85
274	Other commercial service industry machinery manufacturing	0.01	$795.70	$1,307.31	$3,348.81
276	Heating equipment (except warm air furnaces) manufacturing	0.01	$698.41	$1,069.14	$2,848.21
249	Machine shops	0.01	$668.17	$752.49	$1,556.30
98	Tortilla manufacturing	0.01	$491.79	$773.01	$2,108.48
260	Fabricated pipe and pipe fitting manufacturing	0.01	$688.63	$974.93	$2,620.17
4	Fruit farming	0.01	$143.92	$247.53	$286.59
451	Custom computer programming services	0.01	$842.72	$1,093.43	$1,787.97
96	Cookie and cracker manufacturing	0.01	$709.22	$1,285.68	$3,497.73
108	Breweries	0.01	$403.78	$1,570.39	$6,796.03
111	Tobacco product manufacturing	0.01	$816.88	$12,399.85	$24,886.83
190	Plastics pipe and pipe fitting manufacturing	0.01	$638.48	$1,641.03	$4,648.80
198	Other rubber product manufacturing	0.01	$579.27	$975.40	$2,621.40
240	Metal window and door manufacturing	0.01	$434.30	$526.92	$1,653.52
444	Video tape and disc rental	0.01	$321.25	$1,473.72	$1,896.58

520	Other federal government enterprises	0.01	$896.71	$621.89	$1,792.26
328	Household cooking appliance manufacturing	0.01	$339.70	$764.75	$3,306.63
394	All other miscellaneous manufacturing	0.01	$435.34	$479.81	$1,237.56
182	Toilet preparation manufacturing	0.01	$372.57	$1,642.19	$4,955.99
252	Metal coating and nonprecious engraving	0.01	$382.36	$589.85	$1,551.91
253	Electroplating, anodizing, and coloring metal	0.01	$426.99	$468.13	$960.08
248	Spring and wire product manufacturing	0.01	$312.14	$434.29	$1,365.56
364	Boat building	0.01	$337.84	$350.50	$1,532.55
140	Cut stock, resawing lumber, and planing	0.01	$212.37	$304.89	$1,233.13
36	Other nonmetallic minerals	0.01	$483.46	$961.00	$1,455.90
100	Other snack food manufacturing	0.01	$324.96	$1,202.12	$3,990.55
426	Cable and other subscription programming	0.01	$436.63	$571.47	$3,999.45
356	Other motor vehicle parts manufacturing	0.01	$305.25	$536.18	$2,594.44
155	Support activities for printing	0.01	$272.23	$433.19	$709.64
38	Support activities for oil and gas operations	0.01	$129.19	$128.28	$454.40
523	Other state government enterprises	0.01	$629.70	$535.83	$986.27
250	Turned product and screw, nut, and bolt manufacturing	0.00	$345.45	$489.48	$1,103.22
219	Rolled steel shape manufacturing	0.00	$302.83	$659.09	$3,543.35
184	Explosives manufacturing	0.00	$298.15	$376.49	$1,502.57
3	Vegetable and melon farming	0.00	$121.70	$180.67	$222.46
40	Other nonmetallic minerals services	0.00	$163.93	$133.33	$331.58
105	All other food manufacturing	0.00	$177.52	$230.74	$1,081.84
188	Plastics packaging materials and unlaminated film and sheet manufacturing	0.00	$226.14	$428.45	$1,439.18
352	Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	0.00	$240.40	$408.85	$1,568.90
254	Valve and fittings, other than plumbing, manufacturing	0.00	$338.70	$521.48	$1,170.69
261	Other fabricated metal manufacturing	0.00	$300.24	$371.21	$807.42
12	Dairy cattle and milk production	0.00	$114.26	$304.32	$555.25
363	Ship building and repairing	0.00	$293.24	$300.27	$803.51
421	Greeting card publishing	0.00	$240.32	$605.58	$836.05
78	Confectionery manufacturing from purchased chocolate	0.00	$164.03	$294.64	$988.72
199	Pottery, ceramics, and plumbing fixture manufacturing	0.00	$108.91	$125.85	$365.88
177	Paint and coating manufacturing	0.00	$237.69	$553.12	$2,194.08
251	Metal heat treating	0.00	$191.18	$300.18	$854.95
390	Musical instrument manufacturing	0.00	$170.84	$162.69	$370.28
107	Manufactured ice	0.00	$199.06	$85.84	$367.46
200	Brick, tile, and other structural clay product manufacturing	0.00	$129.70	$156.11	$552.62
336	Storage battery manufacturing	0.00	$154.51	$217.61	$814.73
191	Laminated plastics plate, sheet (except packaging), and shape manufacturing	0.00	$111.19	$235.93	$652.16
333	Motor and generator manufacturing	0.00	$139.80	$238.69	$833.73

193	Urethane and other foam product (except polystyrene) manufacturing	0.00	$123.57	$213.01	$762.51
204	Glass product manufacturing made of purchased glass	0.00	$109.13	$128.66	$445.85
162	Industrial gas manufacturing	0.00	$200.69	$494.47	$1,792.38
217	Iron and steel mills and ferroalloy manufacturing	0.00	$127.30	$285.01	$2,002.12
376	Showcase, partition, shelving, and locker manufacturing	0.00	$94.63	$109.05	$355.22
215	Mineral wool manufacturing	0.00	$127.51	$185.00	$683.94
214	Ground or treated mineral and earth manufacturing	0.00	$229.20	$346.32	$1,129.47
7	Tobacco farming	0.00	$48.53	$68.46	$90.34
150	Paper bag and coated and treated paper manufacturing	0.00	$141.41	$225.80	$845.26
178	Adhesive manufacturing	0.00	$200.16	$350.23	$1,175.18
156	Petroleum refineries	0.00	$344.12	$2,553.42	$15,064.89
2	Grain farming	0.00	$8.79	$19.94	$134.90
306	Other communications equipment manufacturing	0.00	$94.83	$350.46	$743.15
239	Plate work manufacturing	0.00	$112.45	$119.75	$335.30
187	Other miscellaneous chemical product manufacturing	0.00	$128.62	$218.99	$908.83
192	Polystyrene foam product manufacturing	0.00	$68.92	$135.21	$547.36
151	Stationery product manufacturing	0.00	$91.28	$139.71	$549.08
348	Motor home manufacturing	0.00	$134.84	$166.97	$605.61
377	Mattress manufacturing	0.00	$60.87	$100.75	$524.33
231	Iron and steel forging	0.00	$102.24	$170.91	$630.13
370	Nonupholstered wood household furniture manufacturing	0.00	$39.26	$45.86	$154.91
385	Sporting and athletic goods manufacturing	0.00	$64.06	$105.86	$323.82
65	Dog and cat food manufacturing	0.00	$143.20	$672.18	$2,014.50
277	Air conditioning, refrigeration, and warm air heating equipment manufacturing	0.00	$78.01	$140.94	$503.62
174	Pharmaceutical preparation manufacturing	0.00	$112.45	$410.04	$1,649.16
185	Custom compounding of purchased resins	0.00	$88.86	$188.03	$672.59
127	Men's and boys' cut and sew apparel manufacturing	0.00	$119.22	$118.92	$210.04
180	Polish and other sanitation good manufacturing	0.00	$177.03	$307.42	$769.48
338	Fiber optic cable manufacturing	0.00	$69.09	$72.09	$415.28
95	Frozen cakes and other pastries manufacturing	0.00	$58.66	$87.59	$195.32
339	Other communication and energy wire manufacturing	0.00	$58.53	$103.24	$599.90
67	Flour milling	0.00	$122.63	$314.09	$1,716.63
346	Motor vehicle body manufacturing	0.00	$43.19	$52.43	$286.15
26	Lead and zinc ore mining	0.00	$222.05	$930.11	$1,237.35
392	Broom, brush, and mop manufacturing	0.00	$42.92	$60.40	$245.38
121	Textile bag and canvas mills	0.00	$55.46	$62.67	$136.78
202	Other pressed and blown glass and glassware manufacturing	0.00	$73.68	$83.79	$230.62
109	Wineries	0.00	$28.21	$36.72	$200.47
500	Other accommodations	0.00	$12.21	$17.46	$31.67

115	Nonwoven fabric mills	0.00	$63.23	$118.93	$383.08
197	Rubber and plastics hoses and belting manufacturing	0.00	$59.38	$100.32	$249.05
97	Dry pasta, mixes, and dough manufacturing	0.00	$41.11	$91.18	$367.43
298	Fluid power cylinder and actuator manufacturing	0.00	$30.58	$40.88	$150.43
386	Doll, toy, and game manufacturing	0.00	$14.21	$23.69	$164.83
13	Poultry and egg production	0.00	$17.12	$43.42	$107.03
327	Small electrical appliance manufacturing	0.00	$43.22	$104.61	$310.67
103	Mayonnaise, dressing, and sauce manufacturing	0.00	$32.43	$67.13	$378.65
355	Motor vehicle metal stamping	0.00	$42.55	$65.58	$227.09
15	Forestry, forest products, and timber tract production	0.00	$1.22	$2.62	$31.78
119	Carpet and rug mills	0.00	$27.00	$37.40	$202.02
316	Automatic environmental control manufacturing	0.00	$36.95	$82.19	$167.19
87	Dry, condensed, and evaporated dairy product manufacturing	0.00	$21.87	$46.58	$893.42
383	Dental laboratories	0.00	$26.06	$27.04	$48.50
389	Gasket, packing, and sealing device manufacturing	0.00	$45.34	$57.37	$138.16
186	Photographic film and chemical manufacturing	0.00	$25.99	$38.06	$279.23
175	In-vitro diagnostic substance manufacturing	0.00	$42.23	$56.08	$153.56
332	Power, distribution, and specialty transformer manufacturing	0.00	$44.86	$70.80	$177.08
153	All other converted paper product manufacturing	0.00	$23.44	$32.85	$147.90
164	Other basic inorganic chemical manufacturing	0.00	$51.98	$136.11	$437.85
179	Soap and other detergent manufacturing	0.00	$30.05	$127.32	$440.54
380	Surgical appliance and supplies manufacturing	0.00	$33.94	$64.93	$158.45
81	Canned fruits and vegetables manufacturing	0.00	$40.45	$50.91	$229.84
1	Oilseed farming	0.00	$8.94	$42.96	$57.08
301	Electronic computer manufacturing	0.00	$57.74	$320.34	$579.24
310	Capacitor, resistor, coil, transformer, and other inductor manufacturing	0.00	$19.09	$41.40	$79.74
234	Crown and closure manufacturing and metal stamping	0.00	$22.10	$27.41	$78.58
259	Small arms, ordnance, and accessories manufacturing	0.00	$31.76	$68.03	$144.87
88	Ice cream and frozen dessert manufacturing	0.00	$39.89	$60.36	$155.08
126	Cut and sew apparel contractors	0.00	$18.47	$4.96	$14.89
167	Synthetic rubber manufacturing	0.00	$27.66	$49.44	$344.56
303	Computer terminals and other computer peripheral equipment manufacturing	0.00	$16.96	$76.39	$227.76
48	Electric power generation - All other	0.00	$47.17	$105.53	$169.52
281	Machine tool manufacturing	0.00	$24.04	$40.78	$89.83
66	Other animal food manufacturing	0.00	$29.70	$63.93	$428.34
101	Coffee and tea manufacturing	0.00	$28.55	$53.91	$188.95
247	Hardware manufacturing	0.00	$17.39	$25.74	$85.89
324	Software and other prerecorded and record reproducing	0.00	$8.33	$18.93	$61.74
129	Other cut and sew apparel manufacturing	0.00	$16.57	$16.68	$33.67

243	Power boiler and heat exchanger manufacturing	0.00	$21.48	$29.89	$80.86
189	Unlaminated plastics profile shape manufacturing	0.00	$14.97	$27.70	$93.50
220	Steel wire drawing	0.00	$22.67	$34.55	$109.87
229	Ferrous metal foundries	0.00	$23.05	$36.94	$83.79
218	Iron, steel pipe and tube manufacturing from purchased steel	0.00	$15.09	$25.48	$124.78
300	Scales, balances, and miscellaneous general purpose machinery manufacturing	0.00	$16.80	$22.97	$65.09
294	Power-driven handtool manufacturing	0.00	$15.87	$52.54	$134.60
123	Other textile product mills	0.00	$13.09	$16.19	$37.36
350	Motor vehicle gasoline engine and engine parts manufacturing	0.00	$15.56	$27.35	$137.75
183	Printing ink manufacturing	0.00	$17.94	$26.26	$99.55
279	Special tool, die, jig, and fixture manufacturing	0.00	$12.90	$15.37	$33.56
359	Other aircraft parts and auxiliary equipment manufacturing	0.00	$20.27	$19.02	$56.02
77	Chocolate and confectionery manufacturing from cacao beans	0.00	$7.43	$17.74	$126.62
391	Fasteners, buttons, needles, and pins manufacturing	0.00	$4.35	$4.69	$27.03
354	Motor vehicle seating and interior trim manufacturing	0.00	$12.19	$19.07	$104.18
278	Industrial mold manufacturing	0.00	$9.20	$12.43	$29.08
264	Construction machinery manufacturing	0.00	$12.96	$25.87	$136.61
378	Blind and shade manufacturing	0.00	$5.23	$5.70	$23.21
244	Metal tank (heavy gauge) manufacturing	0.00	$11.15	$14.74	$48.51
384	Jewelry and silverware manufacturing	0.00	$2.66	$5.23	$33.65
130	Apparel accessories and other apparel manufacturing	0.00	$6.38	$6.43	$19.56
280	Cutting tool and machine tool accessory manufacturing	0.00	$10.77	$12.59	$28.25
72	Fats and oils refining and blending	0.00	$10.22	$21.73	$302.40
295	Welding and soldering equipment manufacturing	0.00	$6.53	$9.81	$41.59
166	Plastics material and resin manufacturing	0.00	$13.66	$37.02	$225.98
325	Electric lamp bulb and part manufacturing	0.00	$5.87	$7.36	$34.75
163	Synthetic dye and pigment manufacturing	0.00	$12.43	$34.10	$139.09
37	Drilling oil and gas wells	0.00	$2.28	$2.43	$24.47
379	Surgical and medical instrument manufacturing	0.00	$8.12	$15.01	$40.92
120	Curtain and linen mills	0.00	$3.19	$4.08	$15.21
349	Travel trailer and camper manufacturing	0.00	$81.16	$82.41	$102.90
309	Semiconductor and related device manufacturing	0.00	$5.09	$35.47	$95.18
315	Search, detection, and navigation instruments manufacturing	0.00	$8.82	$23.29	$47.60
288	Air and gas compressor manufacturing	0.00	$4.14	$8.08	$41.32
230	Nonferrous metal foundries	0.00	$5.30	$7.76	$21.11
114	Narrow fabric mills and schiffli machine embroidery	0.00	$4.66	$5.24	$14.88
117	Textile and fabric finishing mills	0.00	$4.03	$5.97	$21.10
317	Industrial process variable instruments manufacturing	0.00	$4.60	$11.27	$30.54

353	Motor vehicle transmission and power train parts manufacturing	0.00	$4.37	$7.53	$43.78
307	Audio and video equipment manufacturing	0.00	$4.51	$13.83	$36.52
335	Relay and industrial control manufacturing	0.00	$4.31	$7.54	$22.90
270	Printing machinery and equipment manufacturing	0.00	$4.60	$5.61	$16.48
304	Telephone apparatus manufacturing	0.00	$8.22	$29.95	$58.47
221	Alumina refining and primary aluminum production	0.00	$8.97	$18.56	$56.81
76	Nonchocolate confectionery manufacturing	0.00	$3.68	$5.64	$23.61
374	Custom architectural woodwork and millwork	0.00	$4.05	$4.46	$9.89
312	Printed circuit assembly (electronic assembly) manufacturing	0.00	$2.97	$3.65	$17.57
5	Tree nut farming	0.00	$1.08	$1.68	$1.90
387	Office supplies (except paper) manufacturing	0.00	$4.08	$6.37	$13.23
273	Photographic and photocopying equipment manufacturing	0.00	$7.89	$20.72	$34.90
128	Women's and girls' cut and sew apparel manufacturing	0.00	$3.95	$4.06	$11.00
228	Secondary processing of other nonferrous metals	0.00	$4.73	$21.06	$69.31
285	Mechanical power transmission equipment manufacturing	0.00	$2.44	$3.84	$12.30
313	Other electronic component manufacturing	0.00	$1.61	$2.73	$9.58
320	Analytical laboratory instrument manufacturing	0.00	$3.72	$8.77	$18.62
367	All other transportation equipment manufacturing	0.00	$1.97	$1.87	$21.71
371	Other household non-upholstered furniture manufacturing	0.00	$1.85	$2.03	$9.83
262	Farm machinery and equipment manufacturing	0.00	$2.90	$7.18	$25.98
8	Cotton farming	0.00	$1.08	$1.64	$2.02
305	Broadcast and wireless communications equipment manufacturing	0.00	$3.38	$6.70	$15.29
282	Rolling mill and other metalworking machinery manufacturing	0.00	$2.23	$3.09	$8.35
365	Motorcycle, bicycle, and parts manufacturing	0.00	$1.76	$1.44	$17.21
321	Irradiation apparatus manufacturing	0.00	$1.83	$6.29	$22.88
226	Copper rolling, drawing, extruding and alloying	0.00	$1.77	$4.41	$30.83
21	Extraction of natural gas liquids	0.00	$1.20	$1.13	$25.23
112	Fiber, yarn, and thread mills	0.00	$1.04	$1.33	$7.64
287	Pump and pumping equipment manufacturing	0.00	$1.12	$2.16	$8.33
173	Medicinal and botanical manufacturing	0.00	$2.90	$3.43	$11.14
271	All other industrial machinery manufacturing	0.00	$1.22	$1.58	$5.01
236	Handtool manufacturing	0.00	$1.67	$2.42	$4.64
267	Food product machinery manufacturing	0.00	$0.57	$0.74	$4.05
110	Distilleries	0.00	$1.60	$10.21	$20.05
291	Conveyor and conveying equipment manufacturing	0.00	$0.86	$1.18	$3.83
382	Ophthalmic goods manufacturing	0.00	$0.78	$1.32	$3.95
286	Other engine equipment manufacturing	0.00	$1.42	$2.87	$13.90
104	Spice and extract manufacturing	0.00	$0.15	$0.23	$5.87
314	Electromedical and electrotherapeutic apparatus manufacturing	0.00	$1.00	$4.17	$7.47

113	Broadwoven fabric mills	0.00	$0.57	$0.88	$2.91
133	Other leather and allied product manufacturing	0.00	$0.17	$0.12	$0.86
39	Metal mining services	0.00	$0.13	$0.16	$0.85
342	All other miscellaneous electrical equipment and component manufacturing	0.00	$0.34	$0.53	$1.96
323	Blank magnetic and optical recording media manufacturing	0.00	$0.62	$0.61	$1.44
373	Wood office furniture manufacturing	0.00	$0.27	$0.32	$0.93
322	Watch, clock, and other measuring and controlling device manufacturing	0.00	$0.12	$0.35	$1.00
165	Other basic organic chemical manufacturing	0.00	$0.10	$0.24	$3.80
347	Truck trailer manufacturing	0.00	$0.14	$0.15	$0.40
358	Aircraft engine and engine parts manufacturing	0.00	$0.12	$0.12	$0.32
345	Heavy duty truck manufacturing	0.00	$0.04	$0.08	$0.47
283	Turbine and turbine generator set units manufacturing	0.00	$0.01	$0.02	$0.10
319	Electricity and signal testing instruments manufacturing	0.00	$0.00	$0.01	$0.04
9	Sugarcane and sugar beet farming	0.00	$0.00	$0.00	$0.00
17	Commercial fishing	0.00	$0.00	$0.00	$0.00
22	Coal mining	0.00	$0.00	$0.00	$0.00
23	Iron ore mining	0.00	$0.00	$0.00	$0.00
24	Gold ore mining	0.00	$0.00	$0.00	$0.00
25	Silver ore mining	0.00	$0.00	$0.00	$0.00
27	Copper ore mining	0.00	$0.00	$0.00	$0.00
28	Uranium-radium-vanadium ore mining	0.00	$0.00	$0.00	$0.00
29	Other metal ore mining	0.00	$0.00	$0.00	$0.00
32	Other clay, ceramic, refractory minerals mining	0.00	$0.00	$0.00	$0.00
33	Potash, soda, and borate mineral mining	0.00	$0.00	$0.00	$0.00
34	Phosphate rock mining	0.00	$0.00	$0.00	$0.00
35	Other chemical and fertilizer mineral mining	0.00	$0.00	$0.00	$0.00
41	Electric power generation - Hydroelectric	0.00	$0.00	$0.00	$0.00
42	Electric power generation - Fossil fuel	0.00	$0.00	$0.00	$0.00
43	Electric power generation - Nuclear	0.00	$0.00	$0.00	$0.00
44	Electric power generation - Solar	0.00	$0.00	$0.00	$0.00
45	Electric power generation - Wind	0.00	$0.00	$0.00	$0.00
46	Electric power generation - Geothermal	0.00	$0.00	$0.00	$0.00
47	Electric power generation - Biomass	0.00	$0.00	$0.00	$0.00
52	Construction of new health care structures	0.00	$0.00	$0.00	$0.00
53	Construction of new manufacturing structures	0.00	$0.00	$0.00	$0.00
54	Construction of new power and communication structures	0.00	$0.00	$0.00	$0.00
55	Construction of new educational and vocational structures	0.00	$0.00	$0.00	$0.00
57	Construction of new commercial structures, including farm structures	0.00	$0.00	$0.00	$0.00
59	Construction of new single-family residential structures	0.00	$0.00	$0.00	$0.00

60	Construction of new multifamily residential structures	0.00	$0.00	$0.00	$0.00
61	Construction of other new residential structures	0.00	$0.00	$0.00	$0.00
64	Maintenance and repair construction of highways, streets, bridges, and tunnels	0.00	$0.00	$0.00	$0.00
68	Rice milling	0.00	$0.00	$0.00	$0.00
69	Malt manufacturing	0.00	$0.00	$0.00	$0.00
70	Wet corn milling	0.00	$0.00	$0.00	$0.00
71	Soybean and other oilseed processing	0.00	$0.00	$0.00	$0.00
73	Breakfast cereal manufacturing	0.00	$0.00	$0.00	$0.00
74	Beet sugar manufacturing	0.00	$0.00	$0.00	$0.00
75	Sugar cane mills and refining	0.00	$0.00	$0.00	$0.00
79	Frozen fruits, juices and vegetables manufacturing	0.00	$0.00	$0.00	$0.00
82	Canned specialties	0.00	$0.00	$0.00	$0.00
83	Dehydrated food products manufacturing	0.00	$0.00	$0.00	$0.00
85	Creamery butter manufacturing	0.00	$0.00	$0.00	$0.00
86	Cheese manufacturing	0.00	$0.00	$0.00	$0.00
91	Rendering and meat byproduct processing	0.00	$0.00	$0.00	$0.00
93	Seafood product preparation and packaging	0.00	$0.00	$0.00	$0.00
99	Roasted nuts and peanut butter manufacturing	0.00	$0.00	$0.00	$0.00
102	Flavoring syrup and concentrate manufacturing	0.00	$0.00	$0.00	$0.00
116	Knit fabric mills	0.00	$0.00	$0.00	$0.00
118	Fabric coating mills	0.00	$0.00	$0.00	$0.00
122	Rope, cordage, twine, tire cord and tire fabric mills	0.00	$0.00	$0.00	$0.00
124	Hosiery and sock mills	0.00	$0.00	$0.00	$0.00
125	Other apparel knitting mills	0.00	$0.00	$0.00	$0.00
131	Leather and hide tanning and finishing	0.00	$0.00	$0.00	$0.00
132	Footwear manufacturing	0.00	$0.00	$0.00	$0.00
135	Wood preservation	0.00	$0.00	$0.00	$0.00
136	Veneer and plywood manufacturing	0.00	$0.00	$0.00	$0.00
138	Reconstituted wood product manufacturing	0.00	$0.00	$0.00	$0.00
143	Manufactured home (mobile home) manufacturing	0.00	$0.00	$0.00	$0.00
146	Pulp mills	0.00	$0.00	$0.00	$0.00
147	Paper mills	0.00	$0.00	$0.00	$0.00
148	Paperboard mills	0.00	$0.00	$0.00	$0.00
152	Sanitary paper product manufacturing	0.00	$0.00	$0.00	$0.00
160	All other petroleum and coal products manufacturing	0.00	$0.00	$0.00	$0.00
161	Petrochemical manufacturing	0.00	$0.00	$0.00	$0.00
168	Artificial and synthetic fibers and filaments manufacturing	0.00	$0.00	$0.00	$0.00
169	Nitrogenous fertilizer manufacturing	0.00	$0.00	$0.00	$0.00
170	Phosphatic fertilizer manufacturing	0.00	$0.00	$0.00	$0.00
171	Fertilizer mixing	0.00	$0.00	$0.00	$0.00

172	Pesticide and other agricultural chemical manufacturing	0.00	$0.00	$0.00	$0.00
176	Biological product (except diagnostic) manufacturing	0.00	$0.00	$0.00	$0.00
181	Surface active agent manufacturing	0.00	$0.00	$0.00	$0.00
194	Plastics bottle manufacturing	0.00	$0.00	$0.00	$0.00
203	Glass container manufacturing	0.00	$0.00	$0.00	$0.00
210	Lime manufacturing	0.00	$0.00	$0.00	$0.00
211	Gypsum product manufacturing	0.00	$0.00	$0.00	$0.00
212	Abrasive product manufacturing	0.00	$0.00	$0.00	$0.00
216	Miscellaneous nonmetallic mineral products manufacturing	0.00	$0.00	$0.00	$0.00
222	Secondary smelting and alloying of aluminum	0.00	$0.00	$0.00	$0.00
223	Aluminum sheet, plate, and foil manufacturing	0.00	$0.00	$0.00	$0.00
224	Other aluminum rolling, drawing and extruding	0.00	$0.00	$0.00	$0.00
225	Nonferrous metal (exc aluminum) smelting and refining	0.00	$0.00	$0.00	$0.00
227	Nonferrous metal, except copper and aluminum, shaping	0.00	$0.00	$0.00	$0.00
232	Nonferrous forging	0.00	$0.00	$0.00	$0.00
233	Custom roll forming	0.00	$0.00	$0.00	$0.00
235	Cutlery, utensil, pot, and pan manufacturing	0.00	$0.00	$0.00	$0.00
245	Metal cans manufacturing	0.00	$0.00	$0.00	$0.00
246	Metal barrels, drums and pails manufacturing	0.00	$0.00	$0.00	$0.00
255	Plumbing fixture fitting and trim manufacturing	0.00	$0.00	$0.00	$0.00
256	Ball and roller bearing manufacturing	0.00	$0.00	$0.00	$0.00
257	Small arms ammunition manufacturing	0.00	$0.00	$0.00	$0.00
258	Ammunition, except for small arms, manufacturing	0.00	$0.00	$0.00	$0.00
263	Lawn and garden equipment manufacturing	0.00	$0.00	$0.00	$0.00
265	Mining machinery and equipment manufacturing	0.00	$0.00	$0.00	$0.00
266	Oil and gas field machinery and equipment manufacturing	0.00	$0.00	$0.00	$0.00
268	Semiconductor machinery manufacturing	0.00	$0.00	$0.00	$0.00
269	Sawmill, woodworking, and paper machinery	0.00	$0.00	$0.00	$0.00
272	Optical instrument and lens manufacturing	0.00	$0.00	$0.00	$0.00
275	Air purification and ventilation equipment manufacturing	0.00	$0.00	$0.00	$0.00
284	Speed changer, industrial high-speed drive, and gear manufacturing	0.00	$0.00	$0.00	$0.00
289	Measuring and dispensing pump manufacturing	0.00	$0.00	$0.00	$0.00
290	Elevator and moving stairway manufacturing	0.00	$0.00	$0.00	$0.00
292	Overhead cranes, hoists, and monorail systems manufacturing	0.00	$0.00	$0.00	$0.00
293	Industrial truck, trailer, and stacker manufacturing	0.00	$0.00	$0.00	$0.00
296	Packaging machinery manufacturing	0.00	$0.00	$0.00	$0.00
297	Industrial process furnace and oven manufacturing	0.00	$0.00	$0.00	$0.00
299	Fluid power pump and motor manufacturing	0.00	$0.00	$0.00	$0.00
302	Computer storage device manufacturing	0.00	$0.00	$0.00	$0.00

308	Bare printed circuit board manufacturing	0.00	$0.00	$0.00	$0.00
311	Electronic connector manufacturing	0.00	$0.00	$0.00	$0.00
318	Totalizing fluid meter and counting device manufacturing	0.00	$0.00	$0.00	$0.00
329	Household refrigerator and home freezer manufacturing	0.00	$0.00	$0.00	$0.00
330	Household laundry equipment manufacturing	0.00	$0.00	$0.00	$0.00
337	Primary battery manufacturing	0.00	$0.00	$0.00	$0.00
341	Carbon and graphite product manufacturing	0.00	$0.00	$0.00	$0.00
344	Light truck and utility vehicle manufacturing	0.00	$0.00	$0.00	$0.00
357	Aircraft manufacturing	0.00	$0.00	$0.00	$0.00
360	Guided missile and space vehicle manufacturing	0.00	$0.00	$0.00	$0.00
361	Propulsion units and parts for space vehicles and guided missiles manufacturing	0.00	$0.00	$0.00	$0.00
362	Railroad rolling stock manufacturing	0.00	$0.00	$0.00	$0.00
366	Military armored vehicle, tank, and tank component manufacturing	0.00	$0.00	$0.00	$0.00
369	Upholstered household furniture manufacturing	0.00	$0.00	$0.00	$0.00
372	Institutional furniture manufacturing	0.00	$0.00	$0.00	$0.00
375	Office furniture, except wood, manufacturing	0.00	$0.00	$0.00	$0.00
381	Dental equipment and supplies manufacturing	0.00	$0.00	$0.00	$0.00
393	Burial casket manufacturing	0.00	$0.00	$0.00	$0.00
441	Owner-occupied dwellings	0.00	$0.00	$549,296.68	$836,153.72
521	State government passenger transit	0.00	$0.00	$0.00	$0.00
522	State government electric utilities	0.00	$0.00	$0.00	$0.00
524	Local government passenger transit	0.00	$0.00	$0.00	$0.00
527	Used and secondhand goods	0.00	$0.00	$0.00	$0.00
528	Scrap	0.00	$0.00	$0.00	$0.00
529	Rest of the world adjustment	0.00	$0.00	$0.00	$0.00
530	Non-comparable imports	0.00	$0.00	$0.00	$0.00
531	Employment and payroll of state govt, non-education	0.00	$0.00	$0.00	$0.00
532	Employment and payroll of state govt, education	0.00	$0.00	$0.00	$0.00
533	Employment and payroll of local govt, non-education	0.00	$0.00	$0.00	$0.00
534	Employment and payroll of local govt, education	0.00	$0.00	$0.00	$0.00
535	Employment and payroll of federal govt, non-military	0.00	$0.00	$0.00	$0.00
536	Employment and payroll of federal govt, military	0.00	$0.00	$0.00	$0.00
	TOTALS	159.27	$11,253,978.69	$14,254,638.14	$27,181,870.78

Table C Impacts by IMPLAN Industry Sector (Sorted by Employment)

Appendix D Map of Fire Hydrant Density

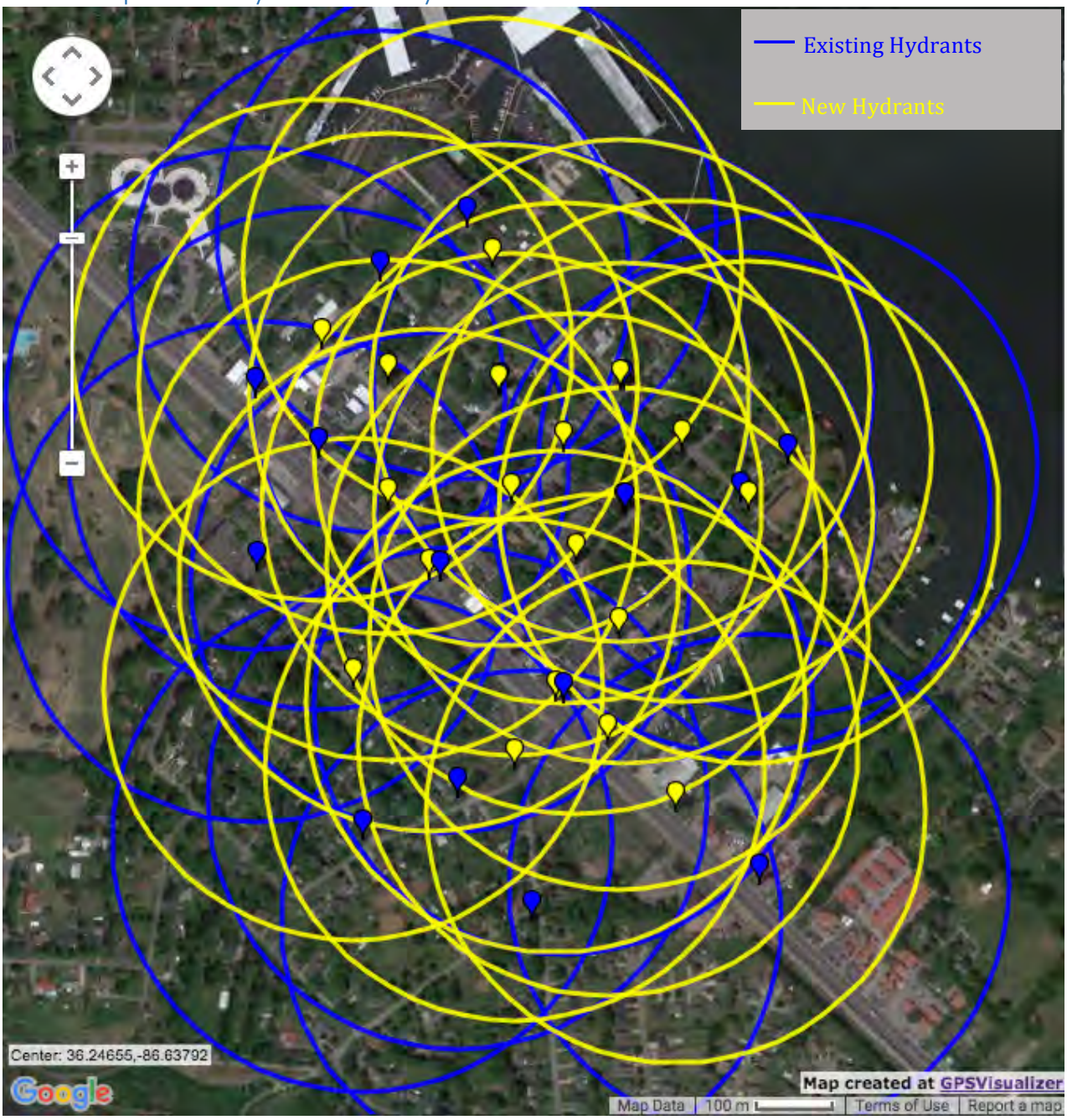


Figure D Fire Hydrant Density in Study Area

Appendix E Cost Externalities Calculations

Calculation #1: Average kilowatt-hours used to treat one gallon of wastewaster at Dry Creek WWTP			
Avg. kilowatt-hours per year (2006-2014):	**12,171,405**	**kWh**	
Avg. kilowatt-hours per month:	**1,014,284**	**kWh**	
Avg. kilowatt-hours per day:	**33,809**	**kWh**	
Avg. kilowatt-hours per hour:	**1,409**	**kWh**	
Avg. gallons wastewater treated per year (2006-2014):	**6,451,200,000**	**Gallons**	
Avg. gallons wastewater treated per month:	**537,600,000**	**Gallons**	
Avg. gallons wastewater treated per day:	**17,920,000**	**Gallons**	
Avg. gallons wastewater treated per one hour:	**746,667**	**Gallons**	
Avg. gallons wastewater per kilowatt-hour:	**530.03**	**Gallons per kilowatt-hour**	
Avg. kilowatt-hour per gallon wastewater treated:	**0.0019**	**Kilowatt-hour per gallon**	
Average watts per gallon:	**0.08**	**Watts per gallon**	
Calculation #2: Estimated Cost Externalities Reduced from I/I Reduction to Dry Creek WWTP			
			Source
A. Annual expected flow reduction	**5,500,000**	**gallons**	**LW01 vs. GC13**
B. DCWWTP treatment electricity cost	**0.0019**	**kWh/gallon**	**Calculation #1**
C. kWh consumed to treat A.	**10,450**	**kWh**	**A x B**
D. Weighted Best cost	**$0.1784**	**per kWh**	**Section 4.3**
E. Annual Cost Externalities Reduced	**$1,864**		**C x D**

Table E Cost Externalities Calculations

Appendix F City of Lakewood, Tennessee - Boundary and Zoning

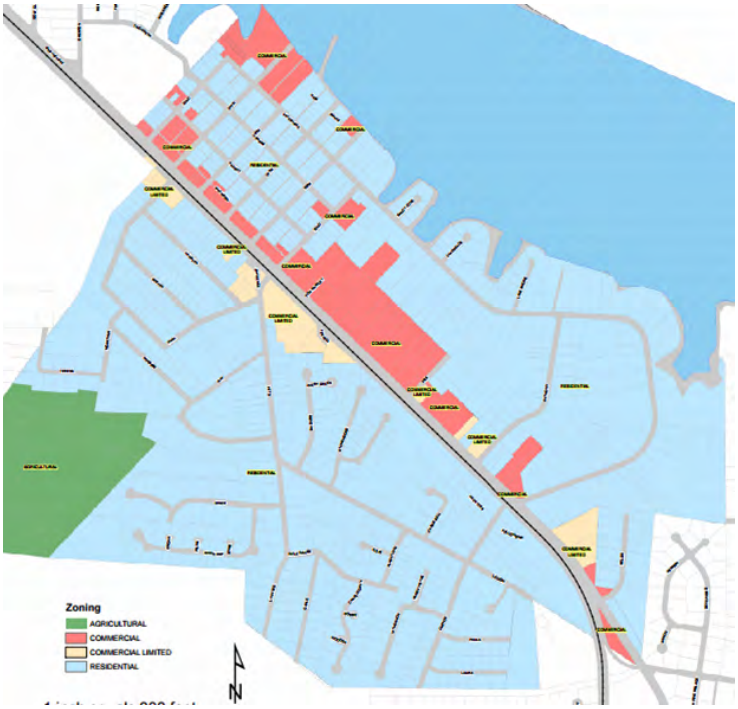


Figure F City of Lakewood, Tennessee - Boundary and Zoning

Appendix G Water system included in Investment

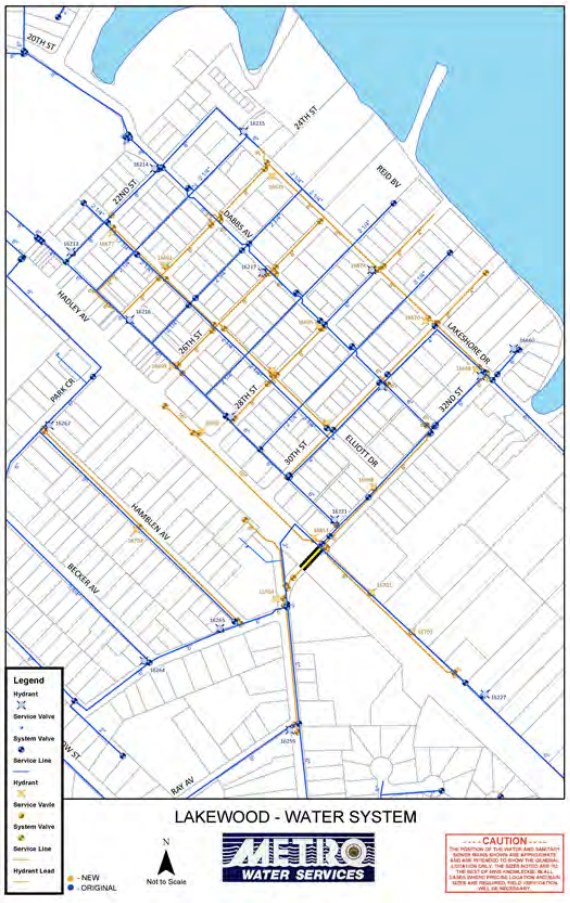


Figure G Water System Included in Investment

Metro Water Services

Lakewood Infrastructure Benefits Study - Summary of Impacts Matrix

Metric	*Study Finding*	*Notes*
ECONOMIC IMPACTS		
Employment		
Background: The investment of $13.9M to renovate existing water and sewer lines, and install a stormwater collection system in Lakewood supported employment in and around Nashville, TN.		
	71	Direct (owner to business) - Davidson only
	38	Indirect (business to business) - Davidson + 6 adjacent counties
	50	Induced (employee to business) - Davidson + 6 adjacent counties
	159	Total
Economic Output		
Background: The investment of $13.9M to renovate existing water and sewer lines, and install a stormwater collection system in Lakewood generated direct, indirect, and induced spending in and around Nashville, TN.		
	$13.9M	Direct (owner to business) - Davidson only
	$5.7M	Indirect (business to business) - Davidson + 6 adjacent counties
	$7.5M	Induced (employee to business) - Davidson + 6 adjacent counties
	$27.1M	Total
Increase in Property Values at Sale		
Background: It was speculated that these infrastructure improvements would provide greater convenience for residents, possibly increasing demand to live in the study area, thereby increasing building sales prices beyond the average price appreciation of the surrounding areas.		
	Lakewood growth <= Nashville's average growth rate	Insufficient data to project future growth rate due to Investment
Investment as catalyst for development		
Background: It was speculated that these infrastructure improvements would provide greater incentive for development of new homes and businesses in the study area.		
	Lakewood growth <= Nashville's average growth rate	Insufficient data to project future growth rate due to Investment

Metro Water Services

Lakewood Infrastructure Benefits Study - Summary of Impacts Matrix

Metric	*Study Finding*	*Notes*
Investment's contribution to property values		
Background: When water and sewer improvements were made, many mains in alleys behind buildings were abandoned and replaced by mains in the streets in front of buildings. Normally, building owners would pay a plumber to connect to new mains. MWS paid to restore the service lines of building owners that were affected.		
	$1.36M	Retail cost of water & sewer service connections
	~300 connections	# of connections affected
Infrastructure's contribution to local employment stability		
Background: Some construction activity attracts public interest while others rarely make headlines. For example, housing starts are a topic regularly reported as a sign of economic health. Meanwhile, spending on infrastructure in a community can support more jobs and less employment fluctuation than housing construction.		
	4,290	# of residential construction jobs in Davidson County (2014)
	6,587	# of infrastructure construction jobs in Davidson County (2014)
	154%	More infrastructure construction than residential construction jobs

SOCIAL IMPACTS

Aesthetic Improvements		
Background: Lakewood began as a subdivision of homes to house employees of the nearby Dupont factory and supporting employers in the 1920's. Limited curbs and sidewalks existed pre-construction.		
	Streets	Restored all affected to current Public Works standards
	Sidewalks	Restored all affected to current Public Works standards
	Valley gutters	Installed new to support stormwater collection

Metro Water Services

Lakewood Infrastructure Benefits Study - Summary of Impacts Matrix

Metric	*Study Finding*	*Notes*
Water Flow into Lakewood properties		
Background: Tuberculation inside water supply pipes constricts a pipe's effective inner diameter, reducing flow into buildings. Regardless of whether the constriction is due to a private or Metro service line, ratepayers call MWS' service center to report "low water pressure" in their buildings.		
	8	# "low water pressure" complaints to Metro Water Services, 2011
	5	# "low water pressure" complaints to Metro Water Services, 2012
	4	# "low water pressure" complaints to Metro Water Services, 2013
	4	# "low water pressure" complaints to Metro Water Services, 2014
	1	# "low water pressure" complaints to Metro Water Services, 2015
	88%	Reduction from 2011 MWS takeover to 2015
Improved Fire Protection		
Background: Renovated water supply pipes without tuberculation and with larger diameters increase water volume and improve flow available to fire hydrants. Three additional hydrants (an 18% increase in # of hydrants) also serve the community after the Investment.		
	950 gpm	Available Hydrant Fire Flow "before" Investment
	1,900 gpm	Available Hydrant Fire Flow "after" Investment
Improved Stormwater Drainage		
Background: New valley gutters and underground pipes collect stormwater to prevent ponding and standing water that occurred after rains storms prior to the investment.		
	95,000 gpm	Amount of water to be collected by new stormwater system
	<10-year storm events	Size of storm used as basis of system design
	98% of heavy rainfall events	Rainwater captured during heavy rainfall events (>3" of rain)
Reduced Sewer Blockages and Backups		
Background: Sewer lines can collapse or be infiltrated by vegetation roots. Renovated lines can eliminate both causes of potential sewer blockage.		
	85%	Expected reduction in calls based on "tree roots" as previous causes

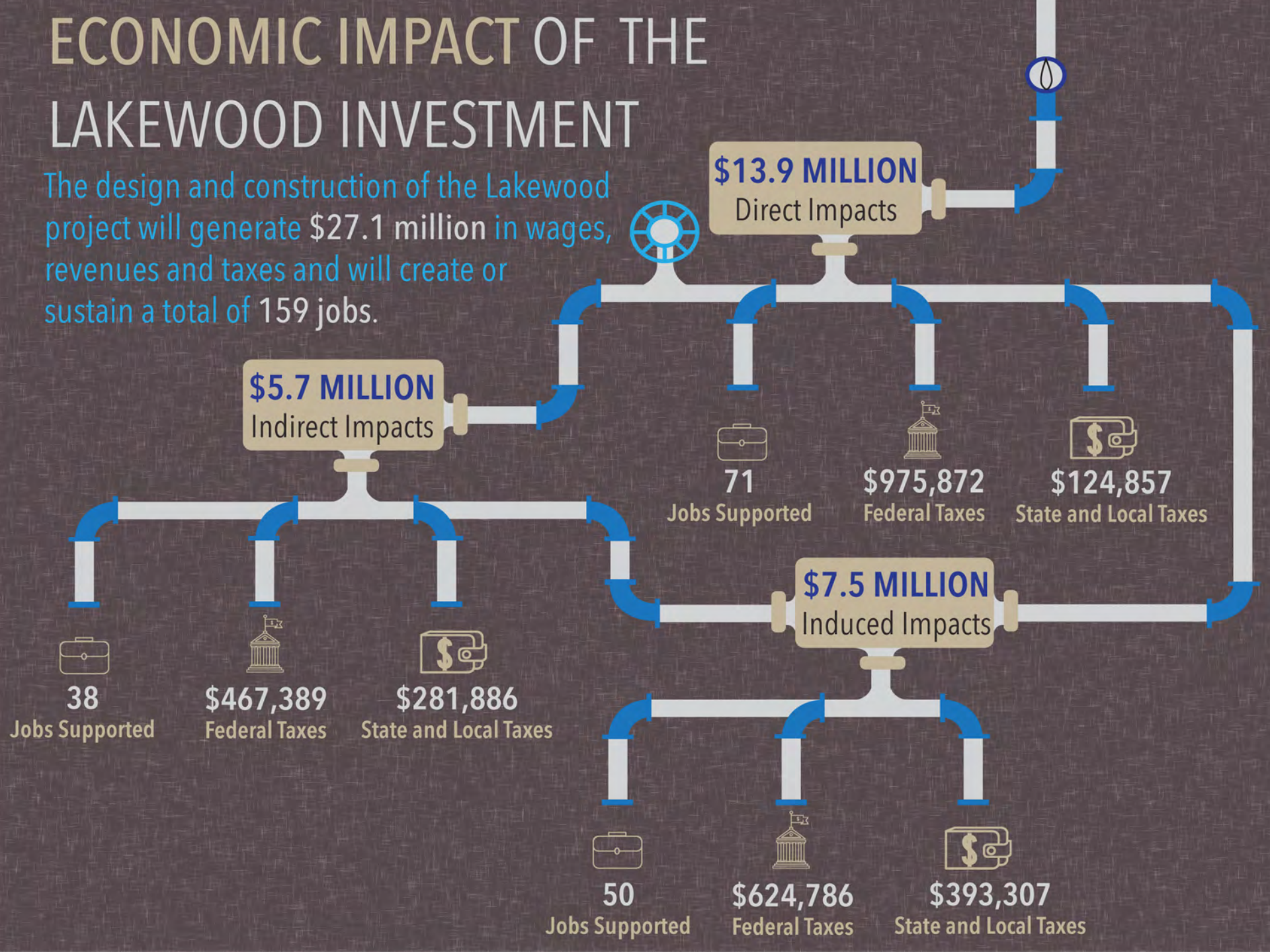
Metric	*Study Finding*	*Notes*
Reduced Occupant Disturbances for Maintenance and Repair		
Background: Prior to the Investment many water and sewer mains and service lines were in alleys behind buildings. MWS often needed access to private property (behind fences, inside homes, etc.) to perform service.		
	Mains in alleys abandoned for mains in streets.	Changes to reduce MWS need for private property access.
Impacts Allocated to Disadvantaged Businesses		
Background: Diversity is critical to an organization to foster innovation, equity, and merit-based success.		
	91%	% of work performed by Small & Disadvantaged Businesses

ENVIRONMENTAL IMPACTS

Reducing Water Losses from Distribution System Leaks		
Background: It was speculated that a decades-old water system will have numerous unknown leaks as a result of decayed piping, loosened joints, settling, and nearby activity.		
	Insufficient data	Water leakage rate from Lakewood water supply.
Reducing Sewer Inflow & Infiltration		
Background: It was speculated that a decades-old sewer system will have numerous known and unknown leaks as a result of manholes, decayed piping, loosened joints, settling, and nearby activity.		
	5,500,000 gallons annually	Reduced Inflow & Infiltration (I/I) into Lakewood sewer system
Reduced MWS Operations & Maintenance Costs		
Background: Water leaking out of and into a decades-old system cause more water to enter the treatment plant, requiring treatment. This project's reduction of inflow and infiltration are estimated to reduce treatment costs.		
	$11,000-$27,500	Estimated (low to high) annual cost reductions

ECONOMIC IMPACT OF THE LAKEWOOD INVESTMENT

The design and construction of the Lakewood project will generate $27.1 million in wages, revenues and taxes and will create or sustain a total of 159 jobs.



Total Jobs & Wages Impact