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Water Conservation Plan

City of Bloomington Utilities

Wittman Hydro Planning Associates

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Water Conservation Plan

City of Bloomington Utilities

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Executive Summary

Bloomington has one source of drinking water. Unlike some communities that have access to large rivers and productive aquifers, Monroe County must rely solely on reservoir storage. Consequently, the value of the water supply to our community and this region is difficult to overstate.

Conservation is part of managing Bloomington's water supply efficiently. Conservation requires participation by both City of Bloomington Utilities (CBU) and its customers, and includes increasing efficiencies and modifying behaviors. This Conservation Plan reflects CBU's commitment to manage demand and reduce losses of treated water in a way that protects our predecessors' investment and assures our community's future.

The Water System

Operation of Lake Monroe is governed by contracts between the United States of America and the State of Indiana, and the State of Indiana and the City of Bloomington. The lake has a spillway crest elevation of 556.0 feet (ft) above mean sea level (amsl). The "dry" level of the reservoir is 515.0 ft amsl. The storage in the reservoir between 538.0 ft amsl and 556.0 ft amsl, representing 259,000 acre-feet (af) of storage, is allocated to flood control. The portion of the reservoir between 515.0 ft amsl and 538.0 ft amsl, representing 160,000 af of storage, is allocated to public water supply and low-flow augmentation for the White River. The firm yield of the latter storage volume was calculated to be 122.0 million gallons per day (MGD) based on a design drought of 1940-1941. Of this volume, 75 percent is designated as the amount required to maintain minimum flows in the White River during a drought. The remaining 25 percent, equivalent to a firm yield of 30.5 MGD, is designated for withdrawals, including public water supply (Franklin Consultants, Inc., 1976). This allocation of the reservoir's total capacity is illustrated in Figure ES 1.

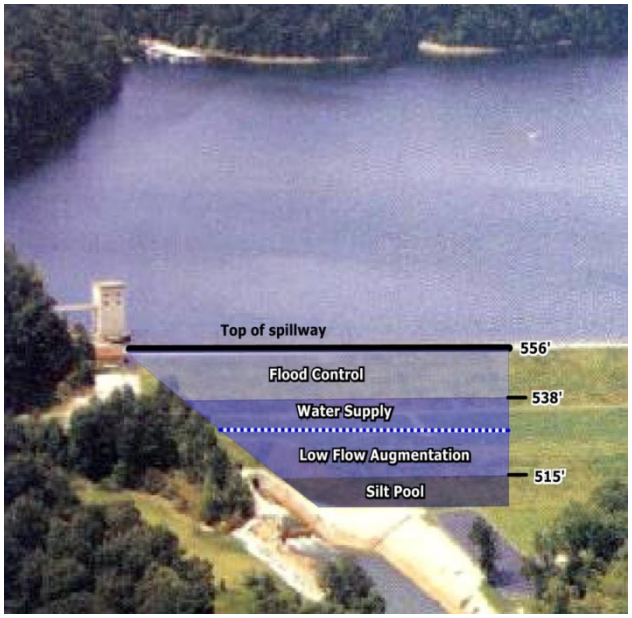

Figure ES 1. Monroe Reservoir allocations

CBU operates one water treatment plant on Lake Monroe, Monroe Water Treatment Plant, which is a conventional filtration plant. Treated water is delivered to CBU's retail service territory via a larger diameter transmission main and a network of 395 miles of water main, 6 booster pump stations, and 7 water storage tanks. CBU's retail service area is 52 square miles encompassing the incorporated City of Bloomington and surrounding unincorporated areas. CBU also supplies water to wholesale customers outside of CBU's retail service territory.

Conservation Goals

Articulating goals for CBU's conservation plan defines its intentions for conservation and provides direction for reducing water use. Also, by stating the goals of the plan, CBU is committing to reaching an objective that can relieve pressure on the water system when and where it is most needed. CBU has specified four goals that were developed through internal discussions and interested community groups.

Goal 1: Increase customer water use efficiency.

Goal 2: Develop and promote a water conservation ethic within CBU and its customers.

Goal 3: Increase the water efficiency of CBU's supply operations.

Goal 4: Establish regular monitoring and evaluation of the water conservation program.

Efficiency of Water Delivery

A utility water audit was completed for each year from 2002-2007 to evaluate water delivery efficiency. The audit accounts for water as it moves from its source to treatment to customers. The information is used to understand where water goes, where it is lost, and where efficiencies can be achieved. The main objective of the water audit is for CBU to calculate its real and apparent losses. Real losses are caused by leaks, breaks, and overflows in the water distribution system. Apparent losses are "paper losses" that represent possible errors in customer metering, meter reading, and billing data. Over the course of the study period (2002-2007) CBU's real losses ranged from 11 to 15 percent and apparent losses accounted for approximately 1 percent of the water supplied to the service area.

Reducing water loss represents an important opportunity for all utilities. For CBU, reducing water loss by one percent represents over 45 million gallons of water per year. Water loss can never be completely eliminated, but efforts to reduce it to the lowest economically justified level have significant benefits. Reductions in lost water directly reduce operating costs for water, power, and chemicals used in the production of drinking water. Revenues, however, are not reduced. Annual water audits and accounting of the cost of lost water provide the utility with the information needed to make routine decisions regarding leak repair. Some leaks will be too small or the cost of repair will be too great to justify their immediate repair. By completing an annual water audit, CBU will be able to determine the economic level of leakage for the system and track progress in reducing leakage to this level.

Water Use by CBU Customers

Selecting relevant conservation goals and measures that apply to CBU customers required analyzing customer water use. This analysis involved a detailed examination and reworking of CBU billing information in order to transform it into useable data. Once completed, the water use data was compared to weather and population data during the six year study period.

Aggregate water use by all customer classes determines the necessary facility capacity and the demands placed on the supply source. On average, from April 2002 to November 2007, the Bloomington Water Treatment plant produced 13.7 MGD; highest production occurred in the summer. The ratio of maximum to average production is an indicator of the stability of seasonal use. CBU had a maximum day (MD) to average day (AD) peaking ratio of 1.4 from 2002 to 2007. This peaking factor indicates that CBU is moderately efficient in its capital asset operation but more efficiency could be achieved.

Of the average 13.7 MGD produced by CBU, 11.8 MGD was consumed by CBU's customers. CBU service area's per capita consumption is 95 gallons per person per day (gppd), which is below the national average (175 gppd) and is to be expected given that Monroe County is located in a temperate climate zone where intense irrigation is not required for most landscaping and is limited to summer months. The weather during the six year study period was generally wetter than normal with temperatures approximately normal thus leading to less irrigation than if the study occurred during a drought or dry summer. Additionally, there is limited water-intensive industry within the service area, which keeps per capita consumption low. Peak consumption occurs during the summer with irrigation contributing to high water demands during periods of hot and dry weather. Additionally, water demand for cooling purposes is highest during the summer. Indiana University (IU), commercial, and industrial users all contribute to peak consumption through cooling water use. Finally, peak consumption often occurs in August or September, which is due, in part, to the return of IU students.

CBU divides its customers into six separate billing classes. Residential customers are classified as either residential single family (RSF) or residential multi-family (RMF). Commercial customers (COM) include government buildings and parks, retail establishments, faith-based establishments, schools, hotels, banks, offices, manufacturing establishments, service stations, and many other miscellaneous commercial services. The industrial use class (IND) in Bloomington is very limited and currently only includes two industries. The wholesale district (WD) class includes 10 customers who buy water from CBU and then distribute this water to their retail customers. Indiana University (IU) is its own customer class; however, CBU bills a portion of IU's use as commercial. The IU commercial use was extracted from the commercial class and added to the IU class for this study. The relative distribution of water use by class did not vary much from year to year for the study period. In all years, the WD class is the largest user class and IU is the single largest customer

Figure ES 2). Industrial use includes only two customers who account for approximately one percent of the total use.

Viewing water use by class reveals that all classes except the IND class use more water in the summer than in the winter (Figure ES 3). Greater summer use indicates that outdoor and cooling uses contribute to peak demand. WD and RSF use follow a similar pattern indicating that the WD are largely serving residential single family customers. RMF use closely follows IU semesters, suggesting that the majority of multi-family housing is occupied by students. IU use peaks in summer due to cooling and irrigation but also shows increases while students are on campus. Understanding individual customer class use and total use is essential to selecting conservation measures that will be effective in CBU's service area.

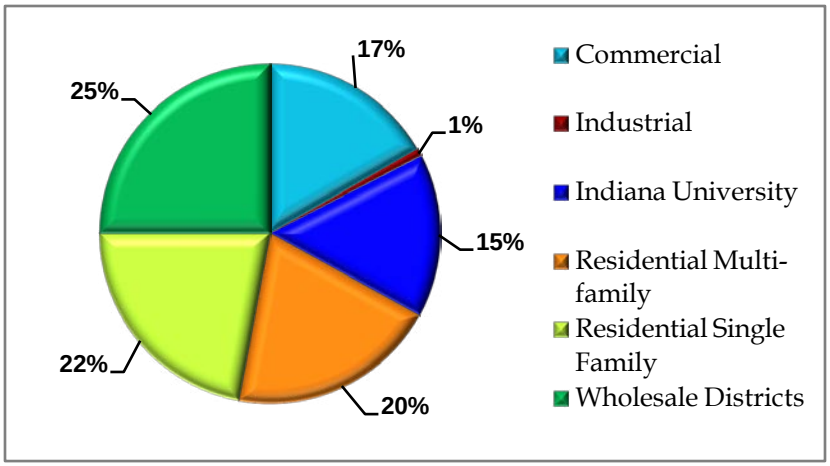

Figure ES 2. The distribution of water use by City of Bloomington Utilities' customer classes for 2006

Conservation Measures

Conservation measures are the actions taken to achieve water conservation goals. Conservation measures can broadly be classified into five different categories: economic incentives; government regulation; water management; alternative supply; and public education. Economic incentives encourage water conservation investments and behavior changes. In our commercial economy, effective incentives for conservation include conservation pricing, hardware rebates, excessive or wasteful use penalties, tradable water rights, and tax credits (Dziegielewski, 2003). Few national policies exist that focus on conservation practices, so it is important for local governments, with the support of CBU, to create water policy appropriate to the Lake Monroe water supply. The objective of a water-management program, with respect to conservation, is to reduce inefficiencies such as losses in the distribution system to the extent that is economically feasible. Using alternative water sources for appropriate uses reduces demand for potable water and helps defer future expansion of

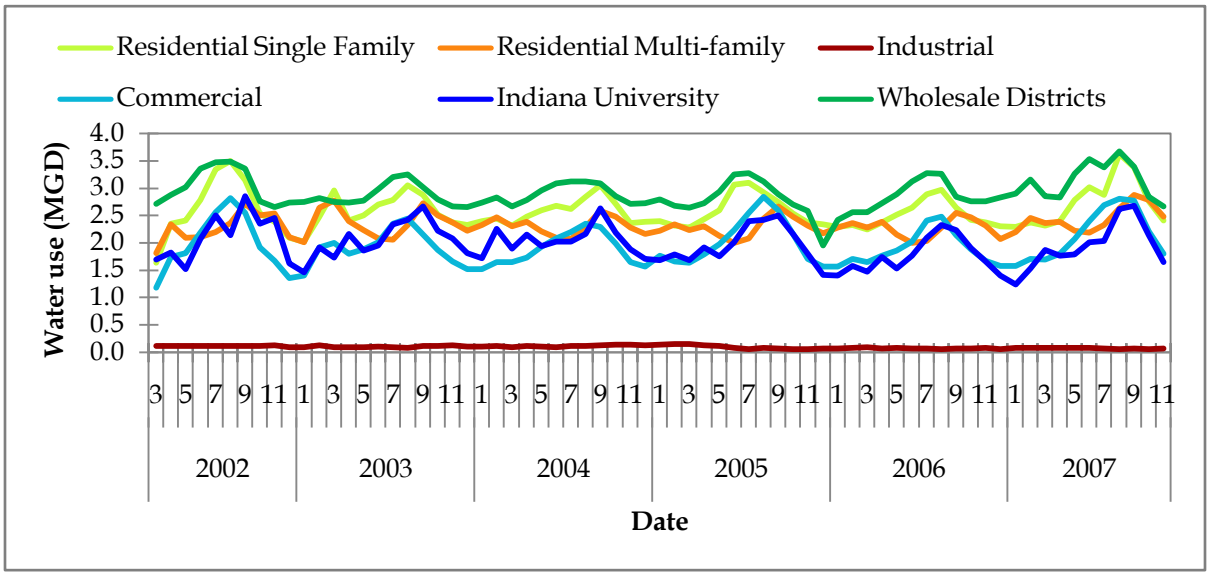

Figure ES 3. Monthly water use by City of Bloomington Utilities' customer classes for 2002-2007

treatment facility capacity. Public education is a necessary strategy for encouraging water users to integrate water saving practices into their daily activities and has been shown to be effective and less controversial than mandating behavioral changes (Dziegielewski, 2003). The recommended measures for CBU's conservation program are listed by category in Table ES 1.

Table ES 1. Measures for City of Bloomington Utilities' conservation program

RECOMMENDED MEASURES
Economic Incentives
Enact conservation pricing
Implement a leak detection and repair program for low income homes
Establish a rain sensor rebate
Policy Instruments/Government Regulation
Develop irrigation system requirements for new development
Pass a water waste ordinance
Pass a toilet retrofit on resale ordinance
Pass a submetering multi-family units ordinance
Adopt efficiency standards for new development that augment plumbing

Recommended Measures
codes
Water Management
Analyze City government water use through an audit
Conduct annual utility water audit
Hire a water conservation coordinator
Implement a leak detection and repair program
Implement a meter testing and replacement program
Alternative Supply
Develop alternative/reclaimed water supply
Public education
Notify large users of peak days
Send end-of-season notices to turn off automatic irrigation systems to all customers
Conduct a public education campaign
Post water conservation information on utility website
Develop primary and secondary school programs
Place water conservation information on bills

Future Water Use

The future water use by CBU customers was estimated using multiple regression modeling. The first step in determining future use was to understand how historical water consumption related to several different explanatory variables. Explanatory variables such as price, percent of total employment in manufacturing, and precipitation are factors that impact how water is used within a community. WHPA regressed several different explanatory variables against monthly water consumption from April, 2002 to November, 2007 resulting in 68 data points. Separate multiple regression models were developed for each customer class because their water use is influenced by different explanatory variables.

It is expected that water use will grow 25 percent if conservation are not implemented; however, if all recommended conservation measures are implemented water use will grow to 17 percent. These savings will be recognized over the course of the conservation program (2010-2030). Table ES 2 compares the estimated water use with conservation, the associated yearly savings, and the percent of savings to water use without conservation. The estimates of water savings is conservative in that the assumptions used to calculate these savings are most likely underestimates and CBU may observe greater savings. However, the savings are dependent upon CBU implementing the measures and upon participation by the community. Without cooperation between these two entities, the goal of reducing water use cannot be achieved. If cooperation is greater than anticipated, the water savings may be greater than currently shown.

Table ES 2. Impacts of water conservation on water use

Year	Use without conservation (MG/Yr)	Use with conservation (MG/Yr)	Water savings (MG/Yr)	Water savings with conservation (%)
2005	4,302	4,302	-	-
2010	4,398	4,367	31	0.7
2015	4,496	4,441	56	1.3
2020	4,677	4,587	90	2.0
2025	4,952	4,846	105	2.2
2030	5,376	5,250	125	2.4

Implementation

The measures outlined in this Plan can be implemented over the next 10 years (2010 to 2020) in 3 phases. New measures will be implemented in each phase and measures from previous phases that are ongoing will carry over into Phase II and III.

Phase I – First steps: tracking use and beginning the conservation program with the community. These measures primarily focus on community education, as the success of a conservation program depends on community awareness and involvement. In addition to education, the City of Bloomington will begin its annual water audit to lead the community in reducing use.

Phase II –Education and regulation. Community education is still a prominent component of Phase II; however, new measures targeting government regulations are implemented. These measures will ensure that new development uses water efficiently and that existing development begins to

reduce its water use as well. CBU and the City of Bloomington will work with Monroe County Government to create a CBU service area overlay district so that water conservation ordinances apply to all CBU customers, not just City of Bloomington residents.

Phase III –Alternative supply and reducing loss. Two new measures are introduced in Phase III – the alternative water supply and replacement of old meters with automatic metering reading technology. These measures are expensive and will take longer to plan and implement.

Each measure requires both financial and staff resources to be effective and to achieve the desired outcome of water reductions.

1. Introduction

Water conservation is part of an integrated approach to water resource planning that considers both supply and demand management to efficiently meet the needs of the community and environment. In the future, treatment capacity, climate change, future droughts, and potential population and economic growth will put pressure on the availability of water to City of Bloomington Utilities (CBU) and its customers. Therefore, CBU has determined that it is in the best interests of its customers to begin water conservation efforts now. This conservation plan is the first step in integrating conservation into the overall long-term goal of providing CBU customers with reliable, safe drinking water. An effective water conservation program will play an important role in CBU's pursuit of sustainable management of water resources and infrastructure, and economic development of the community.

The purpose of the City of Bloomington Utilities Water Conservation Plan (Plan) is to

- provide a brief description of the drinking water infrastructure;
- describe current water use in the system;
- estimate future demand;
- articulate the community's conservation goals;
- identify conservation measures that will achieve the City's goals; and
- provide an implementation strategy.

This document will provide direction to CBU and other City officials, but results depend on effective implementation. Additionally, the Plan will need to be reviewed and revised on a regular basis to ensure that it is effective, realistic, and that the newest technologies have been considered.

The Plan is meant to guide CBU and the Utilities Service Board (USB) in implementing water conservation efforts for the CBU and its customers. This document describes both behavioral and technological conservation measures that will help CBU and its customers achieve water conservation.

1.1. What is Water Conservation?

Historically, for many water utilities, water conservation has been a response to local drought conditions or to emergency water shortages. This is no longer the case. Water use efficiency and conservation are now considered part of a long-term strategy to meet water demands, extend the life of existing supplies, protect water quality, and reflect wise stewardship of a finite resource. There is an important link between water use and energy consumption both by the utility and in the home.

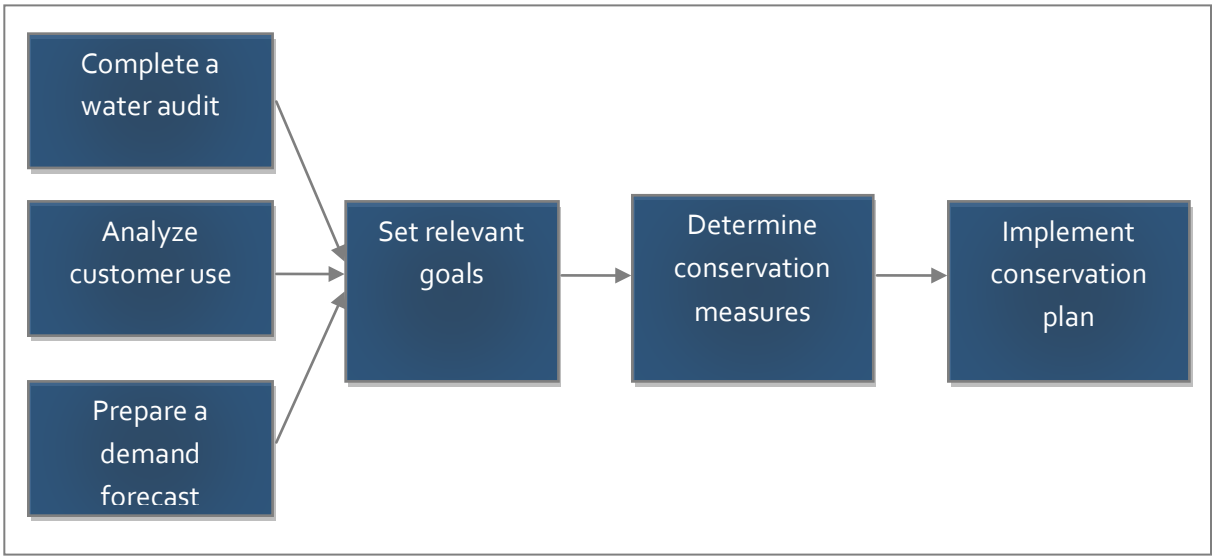

Figure 1. The steps used to develop a conservation plan

minimize waste and improve efficiency. As utilities redefine water conservation from a short-term response to a viable long-term management practice, communities and water utilities in many areas of the country are now developing and implementing water conservation plans.

1.2. Conservation Planning

Conservation planning is unique to each municipality or region. The water system, water use, future demands, climate, and culture are important for determining the goals set forth by the community, choosing appropriate conservation measures, and implementing a plan. For example, in some communities residential water use is highest during summer months and irrigation meters may be needed, while in another community industrial water use is high year round and increasing industrial efficiencies by working with each individual business is more appropriate.

A conservation plan evaluates current and projected water demands, assesses infrastructure and water supplies, and describes the actions a utility will take to reduce water loss, strategically decrease consumption, and improve the efficiency of their system. The plan should be goal oriented and practical in design and implementation. The following six components are common to both the American Water Works Association (AWWA) and U.S. EPA water conservation guidelines (U.S. EPA, 1998; AWWA, 2006) (Figure 1).

- a water audit
- analysis of customer use
- a demand forecast
- relevant goals
- conservation measures

- an implementation strategy

Each of these six components can be found in this conservation plan and will be explained in detail in the following chapters.

1.3. Why should Bloomington Conserve?

Bloomington, like most other communities in Southern Indiana, depends on surface water for its municipal supply. All surface water supplies are vulnerable to drought. Cost control and risk management are behind every effective water conservation plan. Additionally, drinking water treatment and distribution is expensive and given the need to be fiscally responsible, the community cannot waste what it produces. Beyond cost, conservation makes particular sense in a community that was historically limited by water supply options. Several factors could affect Bloomington's water supply in the future: climate change; growth; competition for resources; and increased costs. Implementing a conservation plan now allows the City to manage the resource, avoid the consequences of unwise use, provide the time required for customer behavioral changes, and allows CBU time to implement operational efficiencies.

1.3.1. Efficiency

A conservation plan can help a utility manage the supply in such a way as to reduce leaks, delay additional infrastructure, and use the existing infrastructure efficiently. CBU is presently expanding the existing water treatment facility to meet current and projected needs. Adding infrastructure is costly and conservation can help defer the need for additional upgrades in the future thus saving CBU and its customer's money. By reducing the amount of water pumped, a utility can reduce operating costs and indirect greenhouse gas emissions associated with electrical power. Active leak detection and repair programs have saved up to half of the water previously lost (U.S. EPA, n.d.). Consumer efficiencies such as new water efficient appliances and smart irrigation systems will also reduce the amount of water pumped and treated. Efficiencies alone may generate enough water savings to a utility that mandatory reductions are not required.

1.3.2. Climate change and drought

The Intergovernmental Panel on Climate Change (IPCC) has estimated that by 2100 Indiana's surface temperature will rise by 4.0-4.5°C (Intergovernmental Panel on Climate Change, 2007). While precipitation models show greater variability, temperature changes will decrease water availability and increase droughts in future years. Lake Monroe serves multiple purposes, including release of water to augment flows in the White River when it is low. During drought, when this demand is greatest, the water available for withdrawal by CBU may be limited.

In addition to decreased availability, water quality could also be impaired due to climate change. First, increased temperatures can increase algal blooms and bacterial and fungal

growth in reservoirs. Second, more extreme weather events (especially floods) can lead to increased pollutant loading into Lake Monroe and associated human health concerns. Third, more frequent low flows or an overall decrease in streamflows reduces the dilution potential of a stream (Bates, Kundzewics, Wu, & Palutikof, 2008). If water quality in Lake Monroe is reduced to the point where additional treatment is required, efficient use would minimize the impact of increased treatment costs.

1.3.3. Competition for resources

Other communities have shown interest in Lake Monroe as a potential source of water; it should be expected that this interest will continue in the future. Climate change and increased populations may cause water shortages for the Midwest, and nearby communities may look at Lake Monroe as an additional water source. Furthermore, the West is experiencing water shortages and has often viewed the Midwest as a potential new source. While the idea of shipping water from one region of the country to another may presently seem farfetched, increased need for clean water may make shipping water economically feasible in the future. By including conservation in the long-term supply options for Bloomington, the City will be better prepared for potential constraints in the future.

1.3.4. Sustainability

A water conservation program is a mechanism for promoting and developing, among CBU customers and the City of Bloomington, a modern perspective that water is a limited and valuable resource. The measures of a conservation program should encourage wise water use and instill a viewpoint of long-term sustainability. CBU and City officials understand that in order to be viable in the future, sustainable water supply and demand must be achieved. Conservation offers multiple benefits to CBU including

- decreased operating costs;
- increased reliability of supply;
- decreased infrastructure costs;
- decreased greenhouse gas emissions;
- greater ability to absorb growth; and
- long-term sustainability.

Conservation will take time and everyone must be patient as the benefits of conservation are realized. There is no easy answer or shortcut to achieving sustainable water use but conservation is an important step in support of the City's desire to be more sustainable and a leader in environmental change in Indiana.

1.4. Methods Employed in the Study

Developing CBU's conservation plan involved

- meeting with community groups to discuss the conservation plan;
- gathering and analyzing data;
- evaluating conservation measures; and
- forecasting future water use.

The general methods used to develop the plan are discussed below; more specific information is found within individual chapters and appendices.

1.4.1. Community Outreach

In order to inform the community of the planning effort and to provide an opportunity to obtain input for the development of the plan, Wittman Hydro Planning Associates (WHPA) met with 12 community groups. The groups included local government-appointed commissions, neighborhood organizations, CBU wholesale districts, and other local organizations. At the meetings, WHPA presented an overview of the conservation planning process and gathered input from community members on possible goals and conservation measures for CBU's plan. WHPA also participated in the public "Panel on Water" event, which focused on the role that conservation could play in long-term water supply planning for CBU.

1.4.2. Gathering and Analyzing Data

To understand customer water use, WHPA began with CBU's unprocessed billing and production data. While the raw production and raw billing data could not be directly used because of missing or erroneous water use data and meter inaccuracies in the production data, WHPA corrected both data sets and the data were used in analyzing CBU and its customers' water use.

The production data consisted of daily pumping rates for raw, finished, and filtered backwash water, and daily storage water levels from 1994 to 2007. Upon review of the raw data and consultation with utility operations, WHPA discovered some uncertainty in the accuracy of metering at the Monroe Water Treatment Plant. Although the issues do not impact operation of the system, addressing them was important to the analysis.

There were several issues with the raw billing data that had to be addressed in order for it to be used for analysis. The issues included missing water use data, different intervals for meter reading and production data, and data entry errors. To correct for these, WHPA developed a PYTHON® code to re-sample the billing data and better allocate billed consumption to the actual month in which it was used. Unusually large or obviously erroneous use data was flagged, and when necessary, reviewed at the individual account level to correct it. See

Appendix B for a discussion of the billing data review. CBU had previously addressed the issues by other means for purposes of monthly customer billing.

Water production and use data, once corrected, were analyzed using several different methods. All data was organized into tables and graphs to evaluate trends. Additionally, data were analyzed for averages, maximums, minimums, and compared to weather and population data to understand how and why water use changed over time.

1.4.3. Conservation Measures Evaluation

WHPA extensively researched conservation measures, drawing from experiences of other communities and from conservation planning resources such as the Alliance for Water Efficiency. The measures were screened using the following four criteria: relevance to conservation goals, anticipated water savings, cost to CBU, and cost to customers. Measures that met the four screening criteria were further evaluated to determine estimated water savings and costs associated with implementing the measures.

1.4.4. Forecasting Future Use

WHPA used multiple regression modeling to forecast baseline water use without conservation. Historical monthly consumption data was compared to explanatory variables. Explanatory variables are factors that impact how water is used by different classes of water customers within the community. Once the historical relationship of consumption and explanatory variables was established, water use was forecasted in 5 year increments from 2010 to 2030. Water savings were estimated for the recommended measures, based on conservative assumptions. The projected water use with conservation was developed from the baseline projection and estimated savings.

1.5. Organization of the Conservation Plan

This document evaluates the current and future demands by CBU and its customers, outlines conservation goals and measures, and provides an implementation plan. The organization of the report and the contents of each chapter are outlined in Table 1.

Table 1. The organization of the City of Bloomington Utilities' Conservation Plan.

Chapter	Contents
Chapter 2	Overview of CBU's water supply system
Chapter 3	Overview and evaluation of the efficiency of CBU's water delivery
Chapter 4	Factors that impact customer use and analysis of water use by CBU customers
Chapter 5	Development of conservation goals
Chapter 6	Evaluation and recommendations for conservation measures
Chapter 7	Future water demand with and without conservation
Chapter 8	Implementation plan

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2. Bloomington's Water System

Opportunities and incentives to conserve water are determined by the unique nature of each community. The water resources, infrastructure, institutions, climate and attitudes of the community help define where there is potential for progress. This chapter describes the area and population served by the City of Bloomington Utilities (CBU), and the facilities used for providing water service. The water resources the community relies upon are described, as well as the ownership and control of those resources. The governance and regulation of the utility is illustrated, including the relationships with multiple local and state agencies. The value of utility assets is presented, along with a general discussion of current rates charged for water service. Finally, the level of commitment of the community to conservation and sustainability is highlighted by identifying related efforts and initiatives already implemented.

2.1. Service Area

The City of Bloomington, established in 1818, is located in Monroe County, Indiana, approximately 50 miles south of Indianapolis (Figure 2). According to the 2007 American Community Survey, the current population of Bloomington and Monroe County is 72,254 and 128,643 respectively.

Annual precipitation in Monroe County averages 44.2 inches a year, with 19 inches of snow from November to February. January temperatures average 30.4°F, with July temperatures averaging 76.2°F. Relative humidity is generally high throughout the year.

Bloomington is the home of Indiana University (IU). Founded in 1820, IU is one of the oldest and largest state universities in America. It tops the list of the ten largest employers in the area. The others are Bloomington Hospital, Cook Inc., Monroe County Schools, Baxter, General Electric, Marsh Supermarkets, PTS, Kroger, and the City of Bloomington (Bloomington Economic Development Corporation, 2008).

Figure 2. The location of Bloomington, Indiana

CBU's retail service territory is 52 square miles encompassing the incorporated city and surrounding unincorporated areas (Figure 3). CBU also supplies water to wholesale customers outside of CBU's service territory. As shown in Figure 3, the utility supplies water directly or via wholesale customers to most of Monroe County. Some of CBU's wholesale customers provide water service to customers

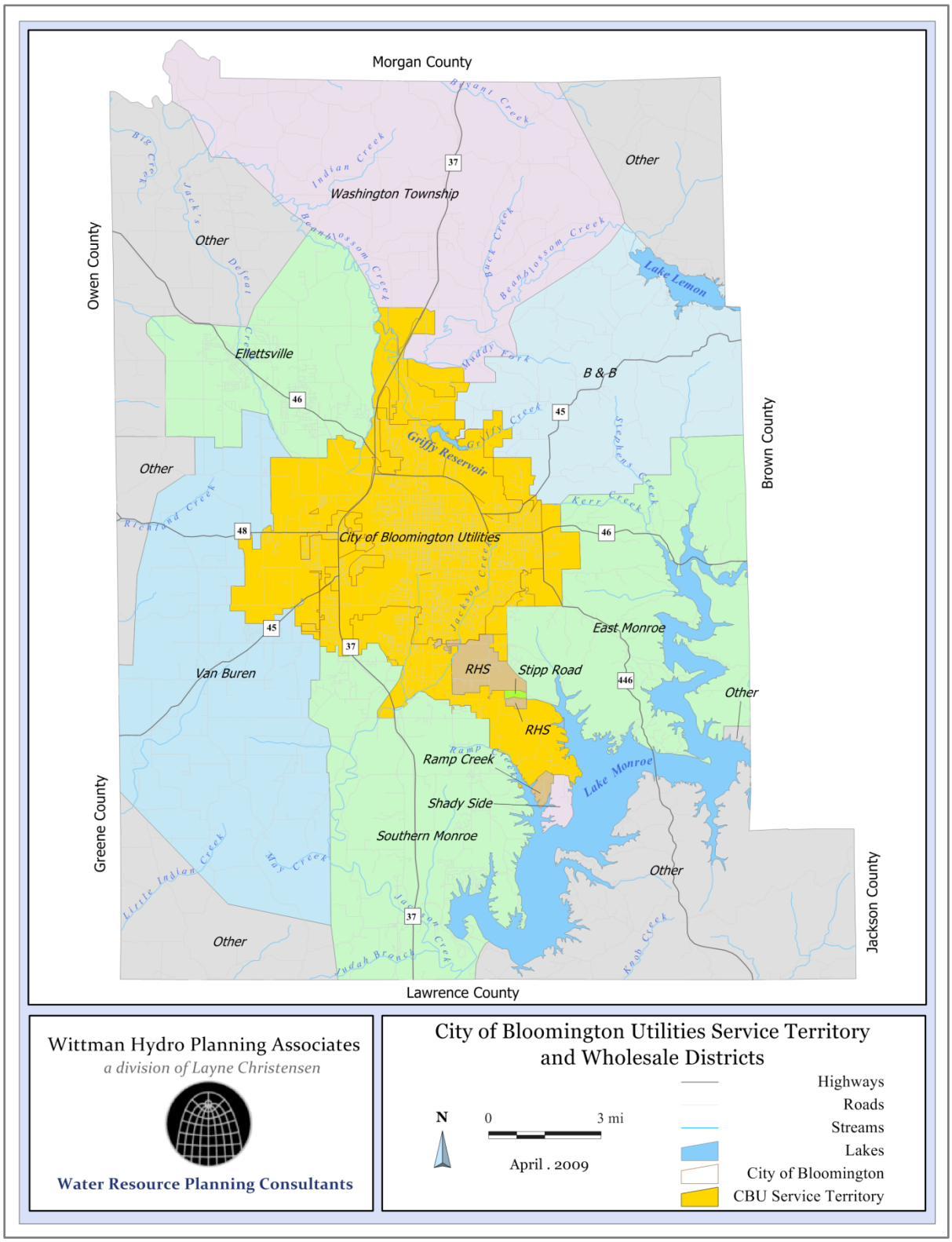

Figure 3. City of Bloomington Utilities retail and wholesale service territories

in portions of Owen, Morgan, Brown, Lawrence, and Greene Counties as well. CBU provides water service to over 22,000 residential, commercial, industrial, and wholesale customers.

2.2. Water Resources

In contrast to many communities that undertake conservation when facing immediate water shortages, Bloomington has seemingly abundant resources for the community's needs. However, Lake Monroe is not owned or operated by CBU. The reservoir serves multiple purposes, and an understanding of the amount of water available to CBU during drought is critical to conservation planning.

CBU withdraws surface water from Lake Monroe, treats it and delivers it to customers. County residents not served directly or indirectly by CBU do not receive water from Lake Monroe, while some water from the lake is delivered outside of the county through wholesale districts. Wastewater is collected and delivered to the utility's two wastewater treatment facilities, which treat and release the water to streams north and south of the city. Rainfall soaks into the ground or travels as runoff across the land surface or through storm sewers before entering streams in and around the city.

Monroe Reservoir is the sole source for the public water supply of Bloomington. With a surface area of 10,750 acres and drainage area of 441 square miles, it is the largest man made body of water in Indiana. The Lake Monroe watershed covers parts of Monroe, Brown, Lawrence, Jackson, and Bartholomew counties (City of Bloomington Utilities, 2009). The reservoir is owned by the US Army Corps of Engineers (USACE) and jointly managed by the USACE and the Indiana Department of Natural Resources (IDNR). It was originally designed to control flooding of the White River, and is still operated for that purpose. It is also operated to augment low flows in the White River. Water withdrawn from the lake for treatment at the Monroe Water Treatment Plant is purchased from the State of Indiana. In addition to providing flood control and drinking water supply, Lake Monroe is enjoyed for recreation by people from all over the state.

Operation of Lake Monroe is governed by contracts between the United States of America and the State of Indiana, and the State of Indiana and the City of Bloomington. The lake has a spillway crest elevation of 556.0 ft mean sea level (msl). The "dry" level of the reservoir is 515.0 ft msl. The storage in the reservoir between 538.0 ft msl and 556.0 ft msl, representing 259,000 acre-feet (af) of storage, is allocated to flood control. The portion of the reservoir between 515.0 ft msl and 538.0 ft msl, representing 160,000 af of storage, is allocated to public water supply and low-flow augmentation for the White River. The firm yield of the latter storage volume was calculated to be 122.0 million gallons per day (MGD) based on a design drought of 1940-1941. Of this volume, 75 percent is designated as the amount required to maintain minimum flows in the White River during a drought. The remaining 25 percent, equivalent to a firm yield of 30.5 MGD, is designated for

withdrawals, including the CBU public water supply (Franklin Consultants, Inc., 1976). This allocation of the reservoir's total capacity is illustrated in Figure 4.

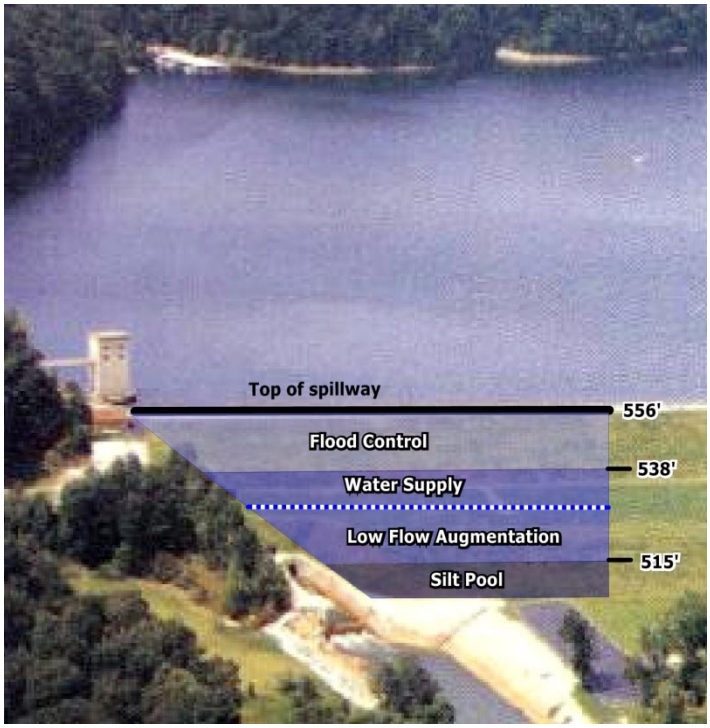

Figure 4. Monroe Reservoir allocations

Water supplied to customers in CBU's service area is generally collected and treated by CBU's two wastewater treatment plants. Water supplied to CBU's wholesale customers is delivered by those water utilities to their own customers. Wastewater from customers served by CBU's wholesale customers is collected and treated at their own wastewater treatment facilities or by individual septic systems.

As shown in Figure 5, Bloomington is divided into two drainage basins. Wastewater normally flows by gravity through underground pipes to one of Bloomington's wastewater treatment plants. Generally, people who live north of the drainage boundary are served by the Blucher Poole Wastewater Treatment Plant. Approximately 75 percent of the city's wastewater is collected from the area south of the drainage boundary and delivered to the Dillman Road Wastewater Treatment Plant.

2.3. Water Facilities

Utility infrastructure is expensive, and one of the primary incentives for conservation is to optimize the efficient use of the investments in that infrastructure. The City of Bloomington's water and

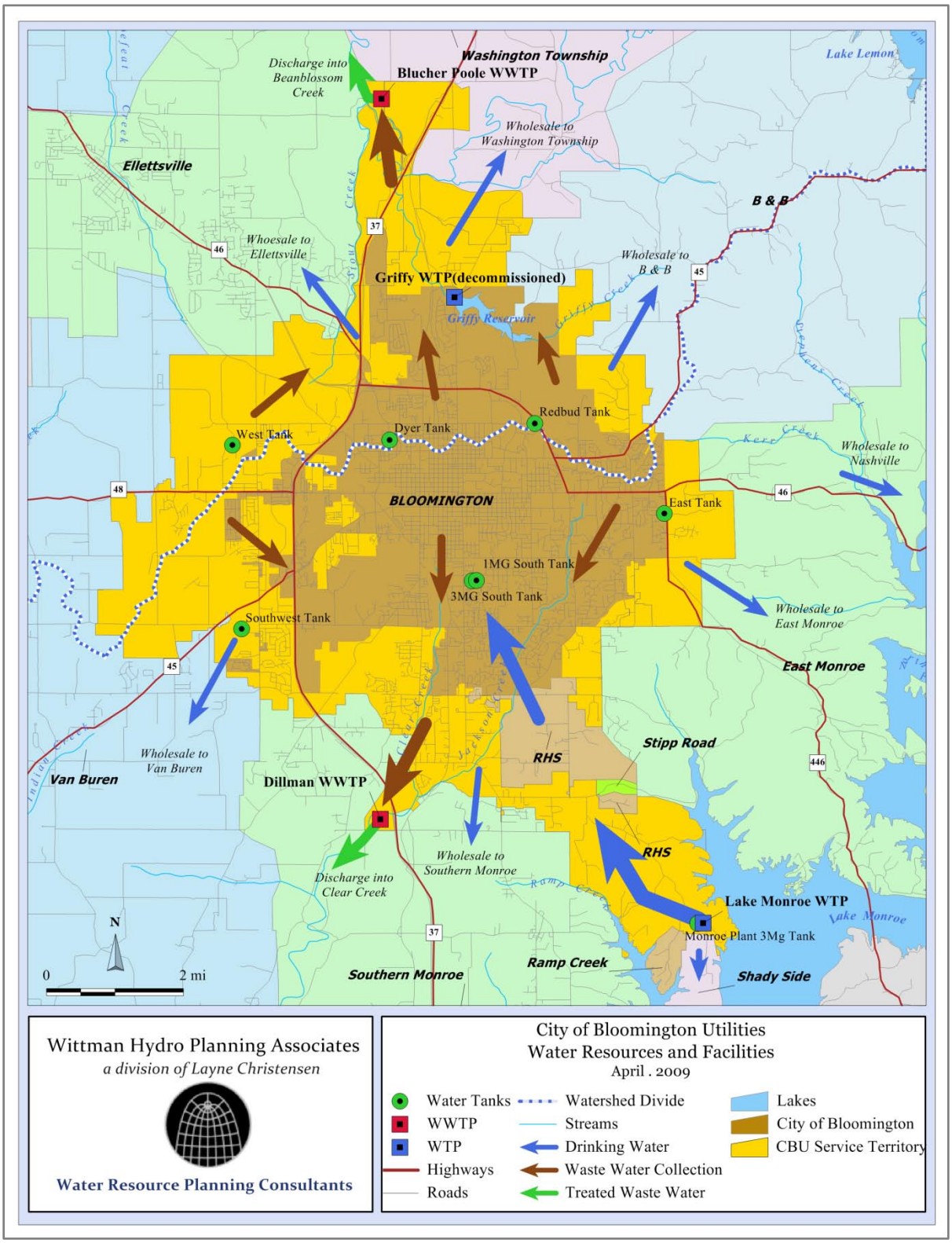

Figure 5. Generalized water flow through the City of Bloomington Utilities' distribution and collection systems

wastewater facilities are conceptually illustrated in Figure 5. The City began using Lake Monroe as its primary source of drinking water in 1967. At that time, the City also relied on Lake Griffy for a portion of its drinking water supply. The Griffy plant was constructed in 1925 and prior to the construction of Lake Monroe was the city's primary water supply. In 1996, CBU removed the Griffy plant from service and Lake Monroe became the only water supply for the city.

Drinking water is treated at the Monroe Water Treatment Plant, which is a conventional filtration plant, and supplied to the community via a large diameter transmission main. Water is distributed to CBU's approximately 22,000 retail and wholesale customers by a network consisting of 395 miles of water mains, six booster pump stations, and seven water storage tanks (City of Bloomington Utilities, 2007).

Bloomington's wastewater system consists of two wastewater treatment plants. The Dillman Road Wastewater Treatment Plant (WWTP) is located south of Bloomington. It began operation in May of 1982. It provides tertiary treatment, and discharges treated effluent to Clear Creek. The Blucher Poole Wastewater Treatment Plant is located about 5 miles north of Bloomington. The plant began operation in 1970 to serve the northern part of Bloomington. Treated water is discharged to Bean Blossom Creek. Wastewater is collected from approximately 18,100 customers and delivered to the Dillman Road and Blucher Poole WWTP's via a collection system of over 240 miles of sewer pipes and 39 lift stations (City of Bloomington Utilities, 2009).

Water system improvements are planned for completion in 2012 and 2013. A second water transmission pipeline is proposed from the Monroe Water Treatment Plant to the city to enhance water supply reliability. Additions to the Monroe Water Treatment Plant will improve the reliability and firm capacity of the plant, which has been exceeded in past years.

Water utilities are generally characterized as "asset-intensive", meaning that large investments in built infrastructure are required to provide water service. As of 2007, CBU had over $84 million in water utility infrastructure dedicated to supplying, treating and distributing water to its customers (City of Bloomington Utilities, 2007). This represents the original cost to construct the facilities, which in some cases occurred decades ago. If the same facilities were to be built today, the cost would in fact be much higher. Regular ongoing investment is required to upgrade and replace parts of the system as it ages. From 2002 to 2007, CBU's average annual investment in infrastructure was greater than $4.5 million (City of Bloomington Utilities, 2002-2007). As shown in Figure 6, approximately half of the utility's assets are in transmission and distribution infrastructure. This consists primarily of buried, "invisible" pipes, service lines and meters used to deliver water from the plant to customers. The condition of transmission and distribution infrastructure is critical to the control of water losses and the efficiency of water delivery to customers.

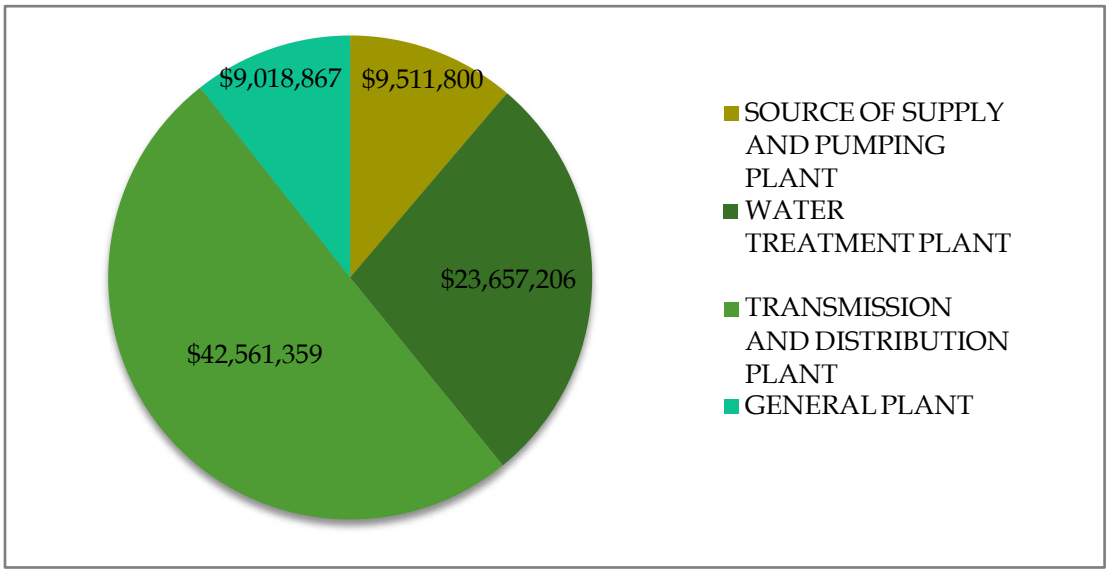

Figure 6. Cost of City of Bloomington Utilities' infrastructure in use (depreciation not included)
Note. Adapted from "Class A Municipal Water Utility Annual Report," by City of Bloomington Utilities, 2007.

2.4. Utility Management

Effective management of water resources and implementation of water conservation requires the coordination of efforts of multiple government agencies and other institutions. CBU provides three services to its customers: drinking water production and delivery, wastewater collection, treatment and disposal, and stormwater management. Each of these functions is treated as a separate and self-supporting entity for budgeting and financial planning purposes.

CBU is a municipally-owned utility and operates under the guidance and oversight of the Utilities Service Board (USB). The USB has seven members, appointed by the mayor and city council. The USB is authorized by state law to establish rules for the operation of the water and wastewater/stormwater utilities.

In Indiana, different aspects of public water supply are managed and regulated by various local, state, and federal government agencies (Figure 7). The water utility is regulated by the Indiana Utility Regulatory Commission (IURC), which has jurisdiction over water rates. The Indiana Department of Environmental Management (IDEM) enforces the provisions of the federal Clean Water and Safe Drinking Water Acts, and other rules and regulations of the State of Indiana. Lake Monroe is owned by the Indiana Department of Natural Resources (IDNR), and operated by the US Army Corps of Engineers (USACE). Ordinances enacted by the City of Bloomington and Monroe County regarding health issues, drainage, construction, and other matters also impact aspects of water supply and use by the utility's customers. The wholesale customers that in turn provide water service to their customers are also regulated by the IURC, IDEM and their own local governments.

2.5. Water Rates

The price of water can be an effective tool for achieving conservation. Water rate structures are designed to collect revenue from the utility's customers in a manner that is equitable and that provides sufficient resources for the effective management and operation of the utility. Current water rates for CBU retail customers are relatively low in comparison to other communities in Indiana.

CBU's customers are billed on a monthly basis for water service. Retail billing includes charges for both water and wastewater service. For a typical retail residential customer, approximately one-third of the bill is for water service and two-thirds for wastewater service.

Drinking water rates include a fixed charge based on the size of the meter and volumetric charge based on the amount of water used. Water use is billed in increments of one thousand gallons, which are referred to on customer bills as "units". Water rates are set for Residential, Commercial, Industrial, Outside Sales (Wholesale Districts), Indiana University, and Irrigation customer classes. The rates for each class are based on the cost of providing service to that class of customers. Water rates provide the revenue necessary to cover the cost of debt service related to infrastructure, operation and maintenance costs, customer costs, and administrative costs for all functions of the utility.

Wastewater charges include a fixed monthly service charge and a volumetric charge based on the number of water units consumed. Wastewater charges are structured the same for all customer classes. Customers located within the city limits of Bloomington also pay a monthly service charge for stormwater. All residential customers pay the same fixed monthly stormwater charge, whereas the charge for non-residential customers is calculated based on the area of impervious surfaces (roofs, driveways, decks, etc.) on the property.

Currently, the water portion of a monthly bill for a residential customer located within Bloomington's city limits and using 5,000 gallons of water is $15.20 (Indiana Utility Regulatory Commission, 2009). Figure 8 shows current monthly water rates of all non-investor owned water utilities regulated by the Indiana Utilities Regulatory Commission (IURC). Water rates in Bloomington are well below the median for this group. Wholesale districts purchase water from CBU at a lower rate than that of CBU's retail residential customers, but they incur their own distribution, operations, billing, and administrative costs for their respective utilities. These costs are included in the monthly rates charged to their customers, which are also shown in Figure 8.

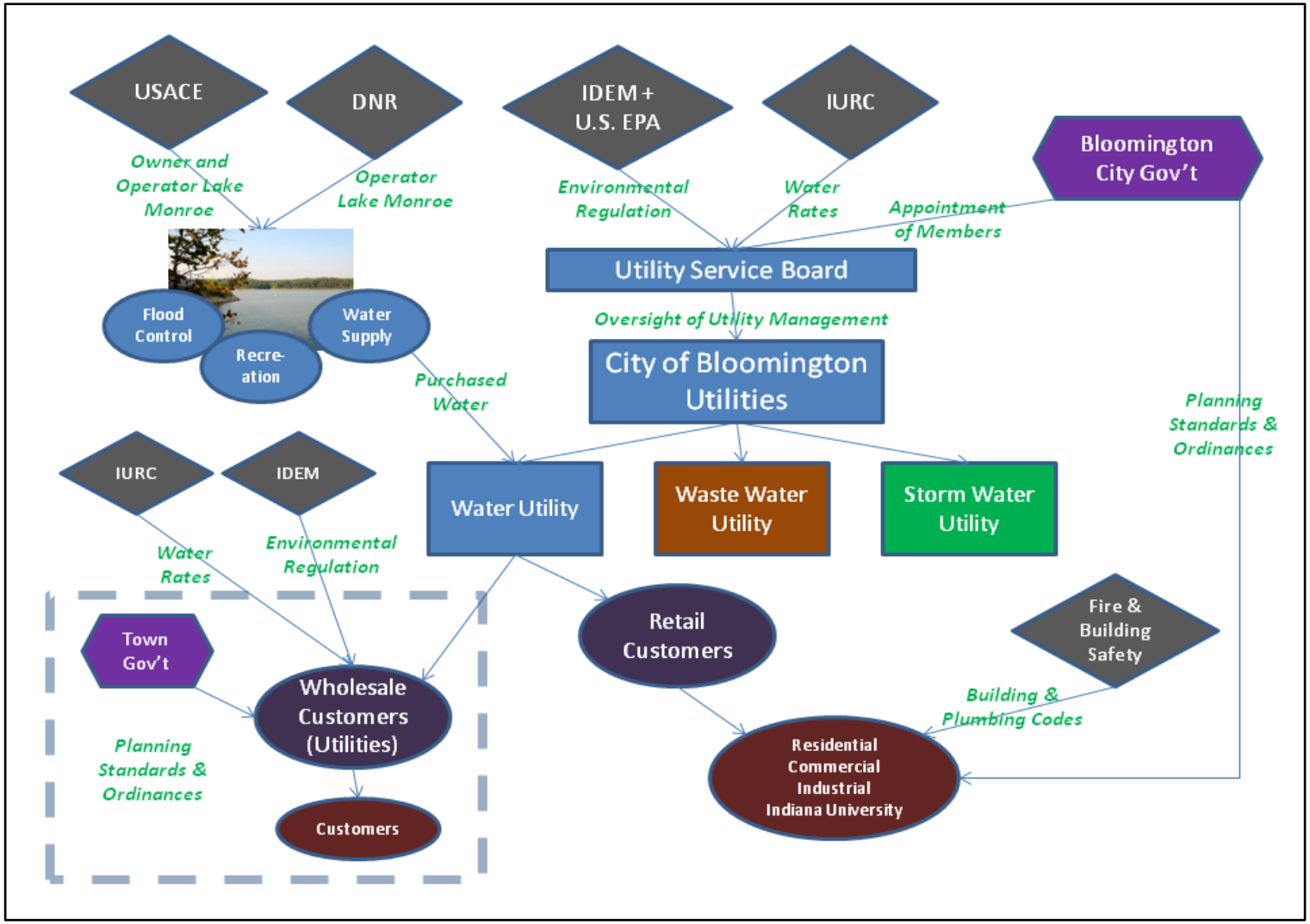

Figure 7. City of Bloomington Utilities governance and regulation

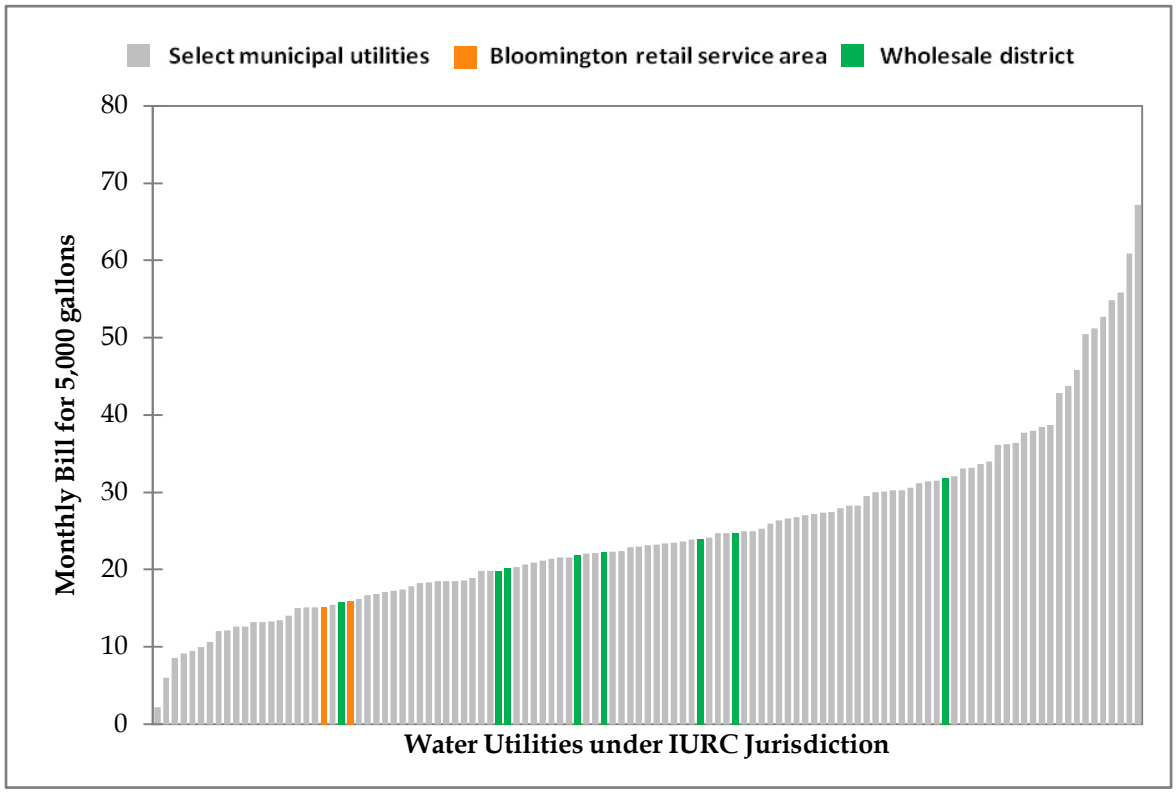

Figure 8. Comparison of average monthly customer water utility bills in Indiana
Note. Adapted from "2009 Annual Water Bill Analysis," by Indiana Utility Regulatory Commission, 2009, http://www.ai.org/iurc/files/Water_Billing_Survey_2009_Updated.pdf

2.6. Sustainability and Conservation Initiatives

Existing CBU practices contribute to the efficiency of water use. All water services are metered, which enables equitable and effective pricing structures. Also, CBU tracks its lost water and repairs leaks in the distribution system as they are discovered. Customers are notified of unusually high use so that they may locate and repair leaks.

Additionally, existing initiatives in Bloomington demonstrate the community's commitment to concepts of sustainability. The City Council passed an ordinance in March 2009 requiring the City to renovate 15 government buildings and obtain Leadership in Energy & Environmental Design (LEED) certification from the U.S. Green Building Council (USGBC) program. LEED certification for existing buildings requires water efficiency improvements to fixtures. Through the Sustainable City Initiative, Bloomington is committed to achieving environmental health, economic prosperity, and social justice. The two central vehicles for Bloomington's Sustainable City Initiative are the Department of Economic & Sustainable Development and the Bloomington Commission on Sustainability (BCOS). In 2006, Bloomington endorsed the US Mayors Climate Protection Agreement and developed an action plan for reducing the City's greenhouse gas emissions. The

local government, utility, and residents' commitment to sustainability provides a positive starting point for water conservation efforts.

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3. Efficiency of Water Delivery

The efficiency of water delivery reflects the extent to which water treated and pumped to the distribution system arrives at customer's meters. Efficiency is reduced by leakage and its measurement depends on water measurement accuracy at the plant and at the customer's services. As part of the conservation plan, WHPA completed water audits for CBU, providing an assessment of water losses within the utility and establishing a baseline for the purpose of tracking changes in non-revenue water (NRW). Adjustments to consumption and production data allowed a more accurate assessment of NRW than previously possible. As a result, NRW is higher than previously believed and opportunities exist to make gains in efficiency. The economic value of losses was determined, which provides the foundation for making economic decisions to repair or monitor leaks.

3.1. Water Audit

A water audit is a tool used to account for water as it moves from its source to customers. The purpose of the audit is to assess the movement of water through the system and identify areas where efficiencies can be achieved. WHPA used the American Water Works Association's (AWWA) auditing tools and procedures to complete a water audit for each year of the study period (2002-2007). The AWWA's method uses the International Water Association's (IWA) water balance approach to evaluate system input versus consumption and losses. Figure 9 illustrates the water balance, and the components are defined in Table 2. All of the water within CBU's system is accounted for using measured or estimated quantities of each component. The following sections discuss the components of the water balance and the audit results. Please see Appendix A for a detailed discussion of the water audits.

3.1.1. Authorized consumption

Authorized consumption is water used by retail customers, wholesale customers, CBU, and other approved entities. The water audit separates authorized consumption into the following four components:

- ***Billed Metered Consumption*** Metered consumption that is billed and produces revenue. For CBU, this component includes domestic, commercial, industrial, Indiana University, and wholesale use.

- ***Billed Unmetered Consumption*** Unmetered consumption that is billed. CBU meters all customer water use; therefore this component is currently not applicable to the utility.

- ***Unbilled Metered Consumption*** Metered consumption that is unbilled. Typically this component includes consumption by the utility or other municipal departments;

however, CBU bills itself and all government entities for the water they use therefore this component is currently not applicable to the utility.

- ***Unbilled Unmetered Consumption*** This component includes water use that is unbilled and unmetered. Examples include water used for fire fighting, main and sewer flushing, and street cleaning. This consumption must be estimated and typically the amount is small compared to the other three authorized consumption types. CBU's estimated volume is 4 MG/Yr, which represents less than 0.5 percent of authorized consumption. Figure 10 compares the City of Bloomington's authorized consumption to the volume of water supplied by CBU to the distribution system. Almost all

<table>
<tr><td rowspan="9">System input volume (corrected for known errors)</td><td rowspan="4">Authorized consumption</td><td rowspan="2">Bill authorized consumption</td><td>Billed metered consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled authorized consumption</td><td>Unbilled metered consumption</td><td rowspan="7">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="5">Water losses</td><td rowspan="3">Apparent losses</td><td>Unauthorized consumption</td></tr>
<tr><td>Customer metering inaccuracies</td></tr>
<tr><td>Data handling errors</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on transmission and distribution mains</td></tr>
<tr><td>Leakage and overflow at utility's storage tanks</td></tr>
<tr><td>Leakage on service connections up to point of customer metering</td></tr>
</table>

Figure 9. The International Water Association (IWA) and American Water Works Association (AWWA) water balance (data in volume for period of reference)

Note. Adapted from "Water Loss Control", by American Water Works Association, 2008, http://www.awwa.org/Resources/topicspecific.cfm?ItemNumber=3653&navItemNumber=32978

authorized consumption is billed metered; less than 0.5 percent is unbilled or unmetered consumption.

3.1.2. Water losses

The difference between water supplied by CBU and authorized consumption observed in Figure 10 is explained as lost water, which is further separated into real losses and apparent losses. These two categories of losses are central to calculating performance indicators.

Table 2. Components and definitions of the International Water Association (IWA) and American Water Works Association (AWWA) water balance

Water Balance Component	Definition
System input volume	The annual volume input to the water supply system
Authorized consumption	The annual volume of metered and/or unmetered water taken by registered customers, the water supplier, and others who are authorized to do so
Water losses	The difference between system input volume and authorized consumption, consisting of apparent losses plus real losses
Apparent losses	Unauthorized consumption, all types of metering inaccuracies and data handling errors
Real losses	The annual volumes lost through all types of leaks, breaks, and overflows on mains, service reservoirs, and service connections, up to the point of customer metering
Revenue water	Those components of system input volume which are billed and produce revenue
Non-revenue water	The difference between system input volume and billed authorized consumption

Note. Adapted from "Water Loss Control", by American Water Works Association, 2008, http://www.awwa.org/Resources/topicspecific.cfm?ItemNumber=3653&navItemNumber=32978

Apparent losses are "paper losses" that represent possible errors in customer metering, meter reading, and billing data. It also includes estimates of typical unauthorized consumption such as illegal connections and misuse of fire hydrants. Water lost through error and illegal use cannot accurately be accounted for and results in unrecovered revenue for CBU. Apparent losses represent water that is used without payment; it does not represent leakage. Apparent losses are valued at the retail rate charged to customers, rendering it an expensive loss for the utility.

Real losses are physical losses caused by leaks, breaks, and overflows in the water distribution system. Leaks occurring on the customer side of the system and therefore are not considered

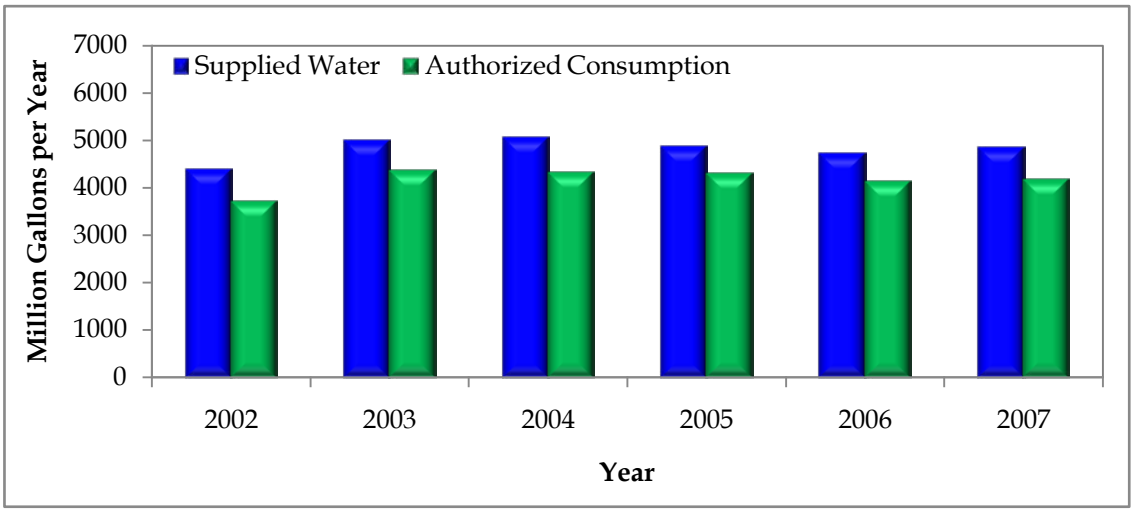

Figure 10. City of Bloomington Utilities' supplied water and authorized consumption.
Note. Consumption for 2002 is based on 10 months of data and 2007 consumption is based on 11 months of data.

part of real losses (AWWA, 2006). The cost of real losses to the supplier is valued at the marginal cost to treat and pump water.

Table 3 shows the estimated apparent and real losses for the CBU system. The volume of real losses is influenced by the amount of water supplied and used each year. From 2002 to 2007, the real loss volume ranges from 10 percent to 14 percent of supplied water. Apparent losses account for approximately one percent of water supplied to the Bloomington service areas.

It is impractical to reduce leakage to zero. The water audit calculates the unavoidable annual real losses (UARL) for the system – the theoretical lowest level of water loss achievable only by applying all of the best technology (AWWA, 2006). Although reducing losses to the UARL may be possible, it does not represent the lowest economical level of leakage (ELL). Achieving a level of leakage equivalent to the UARL would be prohibitively costly and difficult to maintain. The calculation considers CBU's length of mains, number of service connections, total length of private pipe, and average operating pressure.

Possible causes of apparent losses

- **Inaccurate customer meters**
- **Errors in billing system**
- **Errors in accounting system**
- **Illegal tampering with meters and meter reading equipment**
- **Illegal connections**
- **Unauthorized withdrawals from fire hydrants**

Possible causes of real losses

- **Leakage on transmission and/or distribution mains**
- **Losses at utility's storage tanks**

Table 3 compares CBU's current annual real losses (CARL) to its UARL. CBU's UARL ranges from 2.9 percent to 3.5 percent of water supplied to the system. The UARL increases each year as additional mains and service connections are installed.

3.1.3. Performance indicators

The AWWA's Water Audit method calculates financial and operational efficiency performance indicators that can be used by CBU for tracking water efficiency progress over time or for benchmarking. It also provides estimates of the unit cost of lost water, which is critical for making routine economic decisions to repair or continue monitoring a known leak. The performance indicators are calculated using the production, customer consumption, financial, and system data (See Appendix A for CBU's water audits). The financial indicators include non-revenue water (NRW) as percent of both volume and cost. The operational indicators include real losses and the infrastructure leakage index (ILI). These indicators reflect the current status of CBU's operations.

Financial indicators

The most basic financial indicator is NRW – water that does not provide revenue to the utility. Using the term non-revenue water replaces the term "unaccounted-for water", which has historically been defined and used inconsistently in the utility industry. NRW is the sum of apparent and real losses plus unbilled authorized consumption. Table 3 shows that CBU's percent NRW has ranged from 11.8 percent to 15.4 percent from 2002 to 2007. This level of NRW is between the 50th and 75th percentiles for utilities the same size as CBU (Lafferty & Lauer, 2005). The NRW standard set by the Indiana Department of Environmental Management is between 10-20 percent. However, the IWA and AWWA discourage using percent NRW to express and evaluate water losses because the percent value is not influenced solely by efficiency changes in managing water losses, but also by changes in consumption (Fanner, Thorton, Liemberger, & Sturm, 2006). Also, NRW is not as useful as other operation indicators because it does not quantify the volume of water lost, and does not focus on the real target of attaining the economical level of leakage.

NRW expressed as the percentage of the annual cost of running the system is a descriptive indicator of the financial efficiency of loss management activities; it should not be used for target setting. Table 3 shows CBU's NRW as a percent of the annual cost of running its system. The performance indicator ranges from 3.7 percent to 4.6 percent and it does not fluctuate overtime as does NRW percent volume.

Operation indicators

The most basic operation indicator relevant to CBU is real losses expressed in gallons per service connection per day. Real losses range from 56 gal/connection/day to 75

Table 3. The City of Bloomington Utilities' water audit performance indicators

Year	Water Supplied (MG/Yr)	Apparent Losses (MG/Yr)	Current Annual Real Losses (MG/Yr)	Unavoid-able Annual Real Losses (MG/Yr)	Percent Non-Revenue Water (NRW) (%)	NRW as percent of annual system costs (%)	Real Losses (gal/connec-tion/day)	Real Losses (gal/connec-tion/day/psi)	Infra-structure Leakage Index
2002	4392	48.5	624.1	128.9	15.4	4.1	87.39	1.19	4.84
2003	4989	56.5	570.6	156.9	12.7	3.7	65.48	0.89	3.64
2004	5057	56.4	668.3	160.5	14.4	3.8	74.83	1.02	4.16
2005	4879	55.6	517.2	164.0	11.8	3.8	56.56	0.77	3.15
2006	4718	53.6	519.9	167.2	12.2	3.9	55.77	0.76	3.11
2007	4863	54.3	629.6	155.2	14.1	4.6	72.53	0.99	4.06

Note. Consumption for 2002 is based on 10 months of data and 2007 consumption is based on 11 months of data.

gal/connection/day (Table 3). This performance indicator is useful for tracking and setting targets for leakage, but not for making comparisons between utilities (Fanner, Thorton, Liemberger, & Sturm, 2006). To compare real losses between utilities, the effect of pressure on leakage must be accounted for (Table 3). This indicator is expressed in gallons per service connection per day per psi (pressure), and is also useful for comparing regions of CBU's service area with different pressures.

According to the AWWA (2007), the best benchmarking operational performance indicator is the infrastructure leakage index (ILI) because it is non-dimensional, allowing for comparing utilities with different operating conditions. The ILI measures how well real losses are managed in a distribution network and is calculated by dividing the current annual real losses (CARL) by the UARL. The ILI is expressed as a ratio and Table 3 shows the ILI for CBU and the values of the components used to calculate it. An ILI of 1.0 (CARL = UARL) represents the lowest theoretical index possible for a utility, although the cost of achieving and maintaining this level of leakage is typically not justified. The AWWA's general guidelines for the ILI are given in Appendix A. CBU's ILI ranges from 3.11 to 4.84. CBU's scores indicate that it should continue economical repairs of leaks. Water audits provide the information required for establishing economic criteria for making decisions to repair or not repair known leaks based on the cost of water saved through leakage reduction. This is known as the economic level of leakage and it is contingent on water scarcity and expense (AWWA Water Loss Control Committee, 2003). Table 4compares CBU's average ILI with that of utilities in the United States and other countries.

3.2 Opportunities for Improved Efficiency

Reducing lost water represents an important opportunity for all utilities. For CBU, the annual cost of real losses was over $200,000 in 2007 (Appendix A). Reducing non-revenue water by one percentage point represents over 45 million gallons of water per year. Water loss can never be completely eliminated, but efforts to reduce it to the lowest economically justified level have significant benefits. Average CARL and UARL for Bloomington from 2003 to 2006 are shown in Figure 11 along with approaches to controlling real losses. Reductions in lost water directly reduce operating costs for water, power, and chemicals used in the production of drinking water previously lost to leakage. Revenue, however, is not reduced. Regular water audits and accounting of the cost of lost water provide CBU with information needed to make routine decisions regarding leak repair. Some leaks are too small or the cost of repair is too great to justify their immediate repair.

Rather than focusing on comparisons with other utilities, or general standards, CBU and its customers are best served by reducing leakage to the economic level of leakage unique to Bloomington. The ELL is not calculated; it is approached as a result of the implementation of criteria for decisions concerning the repair of leaks. Decision making criteria enable the utility to focus on attaining its unique economic level of leakage.

Table 4. Infrastructure Leakage Indexes (ILI) for utilities in the United States and other countries. (AWWA, 2007).

Location	Infrastructure Leakage Index (ILI)
Bloomington, IN	3.83
Philadelphia, PA	13.1
North America/Canada[a]	4.27
England/Wales[b]	2.44
Australia[b]	2.3
South Africa[c]	4.97

Note. Adapted from "Best Practice Performance Indicators: A Practical Approach," by IWA Task Force, 2004, *Water*, p. 43-45. [a]Average for 20 supply systems. [b]Average for 22 supply systems. [c]Average for 27 supply systems.

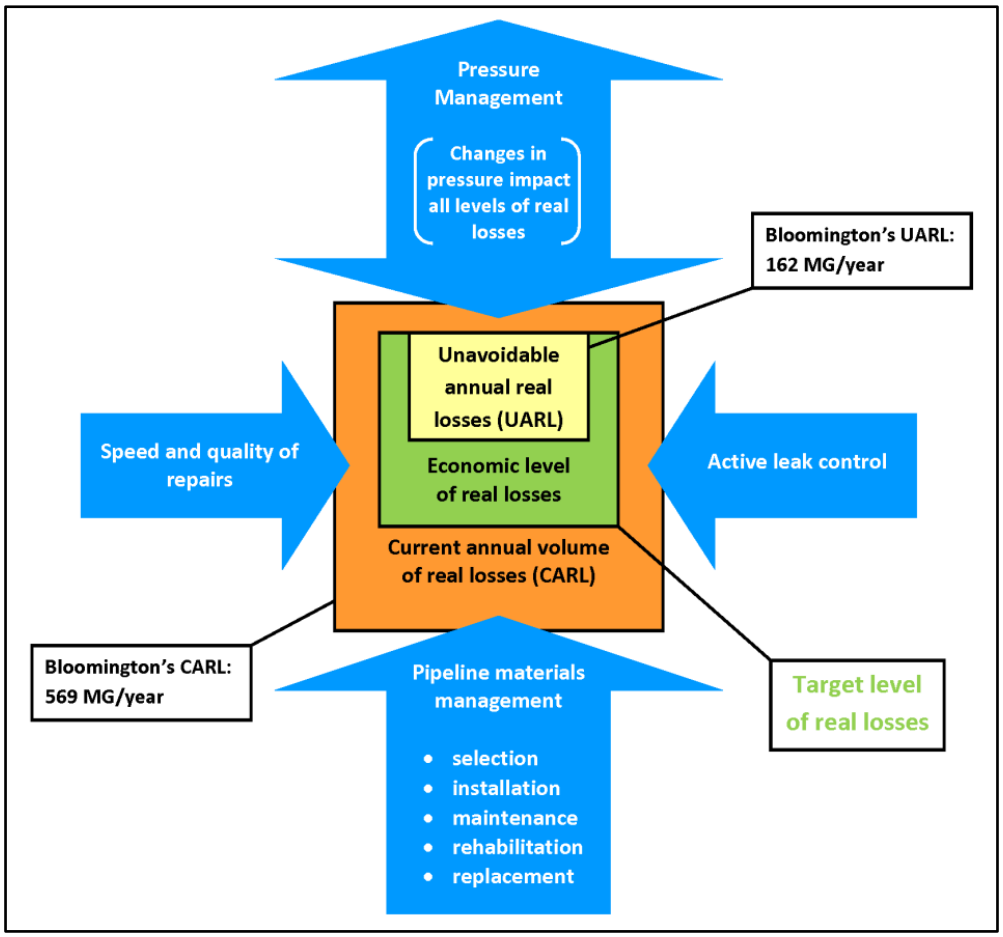

Figure 11. Four-component approach to the control of real (leakage) losses
Note. City of Bloomington Utilities' average losses from 2003 to 2006 are shown in the boxes. Adapted from "Committee Report: Applying Worldwide BMPs in Water Loss Control," by AWWA Water Loss Control Committee, 2003, *Journal AWWA*, p. 77.

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4. CBU Customer Water Use

Water use by CBU customers must be analyzed in order to establish relevant and significant goals for conservation and to select measures appropriate for the conservation opportunities that exist in the community. It is important to understand how water use changes over time and from one user class to the other. In order to build this understanding, WHPA

- obtained monthly billing and daily production records from CBU;
- screened the data for inconsistencies and errors;
- converted monthly billing records into monthly and average daily water use;
- organized and visualized the data in graphs and tables; and
- analyzed the data using numerical methods.

The following sections provide general background information regarding water use, factors that influence water use, and a detailed description of water use for the CBU service area and within individual user classes. These results provide an understanding of how water is used in the community and identify opportunities to reduce water use and increase efficiencies.

4.1. Background

Different customer classes use water for different purposes. Before discussing the findings specific to Bloomington, it is helpful to first understand the general characteristics of different classes of water users. Residential; industrial, commercial, and institutional; and wholesale classes are described below in terms of their water uses and the factors that influence their use.

4.1.1. Characteristics of Residential Use

Residential water use includes water used by single-family and multi-family dwellings for both indoor and outdoor purposes. Estimated average indoor and outdoor residential single family (RSF) water demand in the United States is 101 gallons per person per day (gppd) (Solley, Pierce, & Perlman, 1998). Of the 101 gppd, average indoor and outdoor water use is 69.3 gppd and 31.7 gppd, respectively (Mayer & Deoreo, 1999). RSF use is generally higher than residential multi-family (RMF) use due to a higher number of fixtures and appliances and greater outdoor usage. Figure 12 shows the average indoor use in a nonconserving home. The largest amount of water is used for flushing toilets (26.7 percent), followed closely by clothes washing (21.7 percent). Water use is typically greater in more affluent homes because of luxury appliances such as hot tubs, whirlpool baths, multiple-head showers, fish-tanks, and fountains (Vickers, 2001). The 31.7 gppd used outdoors is primarily for lawn and landscape irrigation; however, car washing, filling of swimming pools, sidewalk cleaning and other outdoor uses contribute to the total.

Per capita RMF demand is less than RSF, ranging from 45 to 70 gppd, because they have little to no outdoor water consumption and fewer appliances (Vickers, 2001). However, RMF use can be high in older, poorly maintained or low income multi-family buildings that have leakage problems. Additionally, outdoor RMF use can be high in affluent multi-family complexes with large irrigated landscapes, swimming pools, and fountains.

Residential water waste comes in many forms. Water is wasted by leaking devices such as appliances, faucets, toilets, and other plumbing fixtures. Although improvements in plumbing fixture efficiencies were mandated by the 1992 U.S. Energy Policy Act, new luxury shower systems that use multiple water jets and waterfalls negate the savings of the efficient plumbing fixtures (Vickers, 2001). Careless behavior wastes water, for example, leaving the water running while hand-washing dishes or brushing teeth and washing less than full loads of clothes and dishes. Inefficiencies are prevalent with outdoor watering as well. Homeowners

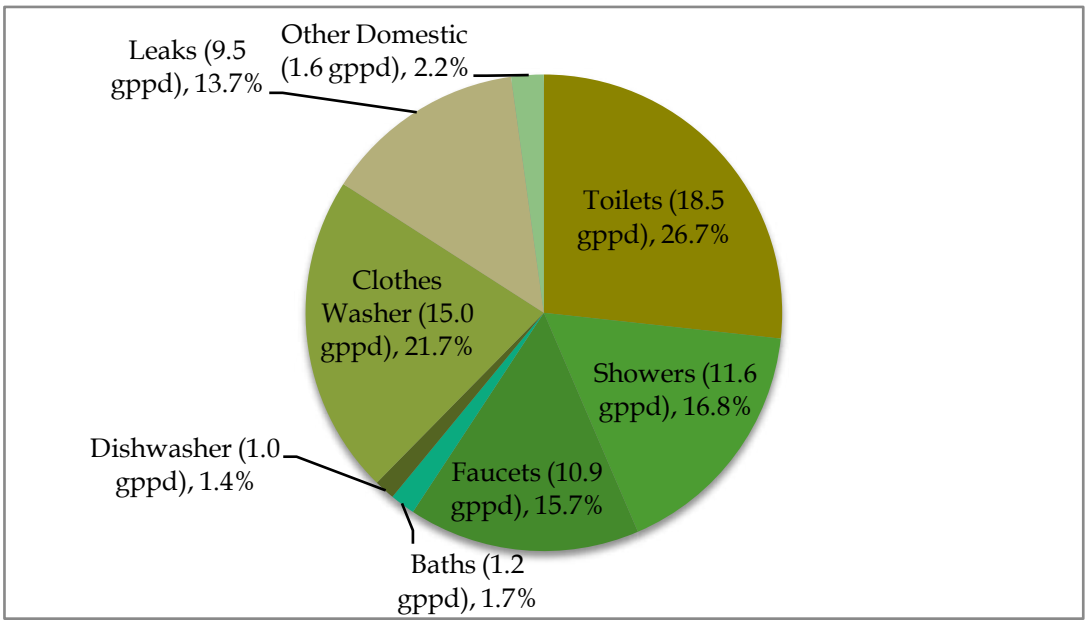

Figure 12. Average indoor water use in a nonconserving home – 69.3 gallons per person per day
Note. Adapted from "Residential End Uses of Water," by P. Mayer and W. Deoreo, 1999, Denver: American Water Works Association. Adapted from "Handbook of Water Use and Conservation," by A. Vickers, 2002, Amherst:Waterplow Press.

tend to water their lawns too often and for too long. In addition to watering grass, it is not uncommon for homeowners to water their driveways and sidewalks because of poorly positioned sprinklers or irrigation systems, which increases runoff into storm drains. Furthermore, irrigation systems contribute to water waste when factory settings are not changed to reflect the local climate and the systems are not regularly maintained.

Factors influencing residential water use

Average residential water use in the United States is 101 gppd; however, actual use varies by region and is influenced by the following factors (Vickers, 2001; Kenney, Goemans, Klein, Lowrey, & Reidy, 2008; PRI, 2005):

- Weather – Lower precipitation and higher temperatures result in greater water use.
- Water rates – When a flat rate is charged (use is not metered) or rates decrease with increased use there is no incentive to conserve water.
- Income – More affluent homes have greater number of appliances and fixtures and their use is influenced less by price.
- Efficiency of appliances and plumbing – Older appliances are less water efficient and older plumbing has more leaks than newer models. The plumbing codes adopted by local jurisdictions vary in terms of efficiency.
- Occupancy rates – The number of people occupying a residential dwelling influence the total water used in the dwelling.
- Outdoor water use – Irrigation is the primary outdoor water use; other uses include car washing, pool filling, and recreation. Outdoor use increases during summer months.
- Awareness/knowledge – People who do not know how much water they use or do not understand the need to conserve water are less likely to reduce water use.
- Total population – While most utilities have seen a decrease in per capita consumption, total consumption has increased due to population increases.

4.1.2. Characteristics of Industrial, Commercial, and Institutional Uses

Industrial, commercial and institutional (ICI) uses can account for a large portion of use within some public water supply systems and very little use in others. Total average industrial and commercial water use in the United States is estimated to be 27,100 millions of gallons per day (MGD) and 9,590 MGD, respectively (this does not include water used for mining and thermoelectric plants) (Vickers, 2001). ICI customers use water for a diverse array of processes, equipment, and products. Their general water uses are described below.

Industrial customers are typically small- and large-scale manufacturers or processors. They use water for four primary functions: heat transfer (cooling and heating), materials transfer (industrial processing), washing, and as an ingredient. In the United States, water for cooling and condensing operations represents more than 50 percent of ICI water use (Vickers, 2001). Industrial water uses vary depending on the industry (Table 5).

Commercial customers provide or distribute a retail service or product and include retail stores, restaurants, hotels, office buildings, laundromats, car washes, golf courses, and many other commercial activities. The major commercial water uses are sanitary plumbing fixtures, cooling and heating, and landscape irrigation. Water needs vary, depending on the business (Table 5).

Table 5. Industrial and commercial water uses

CUSTOMER CLASS	PRIMARY ACTIVITIES
Industrial	
Service and manufacturing	Washing and process activities
Food-processing and beverage facilities	Washing and sanitation, cooling and heating, one-pass cooling, processing
Computer and electronics manufactures	Rinsing, cooling, fume scrubbers, and water purification
Commercial/Institutional	
Hotels and motels	Cleaning and sanitation
Office buildings	Restroom use, cooling and heating, and irrigation
Hospital and medical facilities	Sanitation and cleaning
Other facilities	Restroom use

Note: Adapted from A. Vickers, 2001, *Handbook of Water Use and Conservation*, Amherst:Waterplow Press

Institutional customers include governmental and public facilities such as municipal, county, state, and federal government buildings; schools and universities; health care and medical facilities; prisons; sports arenas; and faith-based establishments. CBU classifies these customers as commercial, not institutional customers. Also, Indiana University is classified as its own customer class; however, some of its use is recorded as commercial use. The primary uses of water for institutional customers are cooling and heating, domestic purposes (restrooms), and landscape irrigation. Domestic-purpose water demand may not be as great in buildings built after 1994 because of the 1992 U.S. Energy Policy Act.

Factors influencing ICI water use

In comparison to water use in the residential class, ICI use will fluctuate more dramatically over time and in response to changes in economic conditions (Vickers, 2001). Generally,

there is a great diversity of firms and associated uses within the ICI category, making it difficult to account for all the different factors that influence water use. However, the following factors are common in ICI (Vickers, 2001; PRI, 2005):

- Weather – Lower precipitation and higher temperatures result in greater water use either because of landscape or cooling needs.
- Economics – As a whole sector, water use decreases or increases depending on how well the economy is performing (the opening or closing of businesses) and the local business atmosphere. However, economics will play a much lesser role in the water use of hospitals, schools, and government.
- Efficiency of fixtures and processes – Older businesses and facilities may be less efficient than newer facilities producing or serving the same population. The efficiency of industrial processes will also impact water use.
- Rates – Generally, the price of water decreases as use increases. The cost of water is generally a small portion of the overall ICI budget which may reduce the incentive to adopt water efficient fixtures or practices.
- Population served and building occupancy – Water use is often related to the number of people served by commercial facilities. For industrial users, water use can be related to building occupancy and number of people employed.
- Type of IC business – Some businesses use more water than others simply because of the type of business. For example, hotels, hospitals, and restaurants use more water than office buildings or retail shops. Water intensive industrial users include paper, primary metals, and chemical industries.

4.1.3. Characteristics of Wholesale Districts Use

CBU delivers water to 10 wholesale districts who in turn sell the water to residential, commercial, and industrial customers. Since the wholesale districts serve the same type of users as CBU, the factors influencing use in the wholesale districts are the same as those in CBU's direct service area.

4.2. Current Water Use in CBU's Service Area

Of the factors previously identified, weather and population are primarily responsible for the monthly and yearly fluctuations in water use. Therefore, the weather and population during the six year study period will be discussed first. A discussion of the total use is followed by water used by individual user classes.

4.2.1. Weather influence on water use

Monroe County's climate is temperate with cold winters and hot, humid summers. These hot, humid summers influence water use because temperature and precipitation are both important drivers for water use. Temperature is positively correlated with water use, while

precipitation is negatively correlated with use. When temperatures increase, more water is used for irrigation of landscaped areas and for cooling purposes. Conversely, when it rains people use less water for landscaping and other outdoor uses. Weather during the summer period (June, July, August, and September) is particularly important in Bloomington and Monroe County because water use is highest during this time.

Over the past six years the average monthly maximum summer temperatures have ranged from 82°F to 91°F (Figure 13). Comparatively, the climatic normal for average monthly maximum summer temperatures is 78°F to 86°F. Monthly precipitation was highly variable (0.16 inches to 9.35 inches per month) with precipitation amounts greater than eight inches occurring in January, March, April, May, June, July, and August throughout the six years (Figure 13). The climatic normal monthly precipitation ranges from 2.66 inches to 5.12 inches per month. During the six year study period, the average monthly summer precipitation was 4.6 inches compared to the climatic normal of 4.0 inches.

Of the six year study period, the driest and hottest summer occurred in 2007 (average maximum temperature for the four summer months was 85.8°F and average monthly precipitation was 3.3 inches). Summer 2002 was also hot (average maximum summer temperature was 85.4°F); however precipitation was higher (average monthly precipitation was 4.4 inches) than in 2007. The summers of 2003-2006 all had at least one month with precipitation greater than six inches and the average summer precipitation for these years was five inches. Total monthly precipitation could be low, but rainfall at the right time can avert landscape watering.

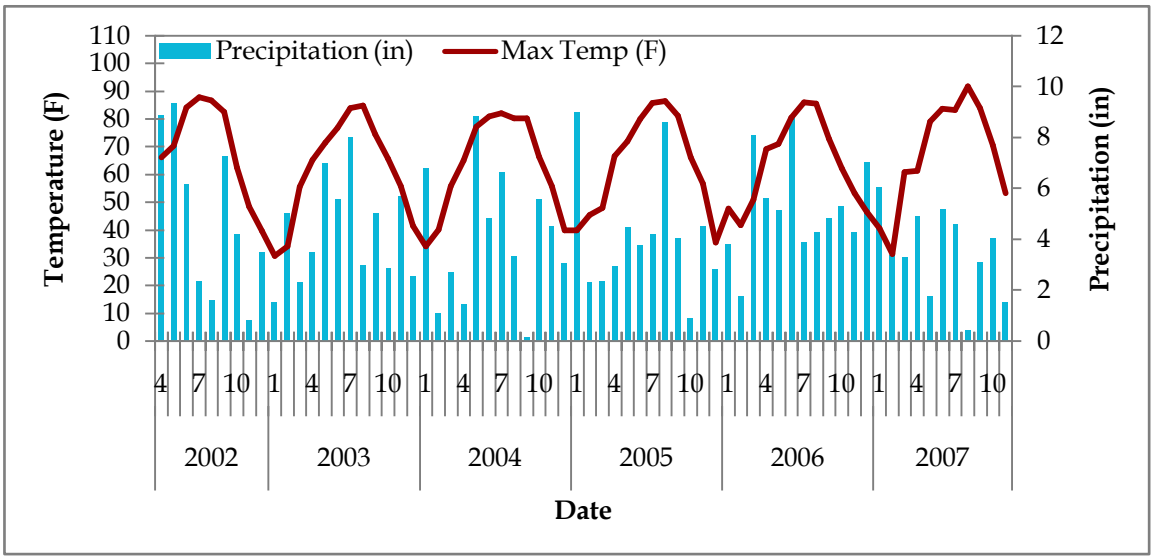

Figure 13. Precipitation and maximum temperature from 2002-2007 for Bloomington, Indiana
Note. Adapted from "Climate Data for Bloomington, Indiana," by Indiana State Climate Office, 2008, Purdue University.

4.2.2. Population

Water demand increases as a community's population increases. In Bloomington, population growth is driven by economic conditions (jobs), enrollment at Indiana University and Ivy Tech, infrastructure, and the City and County's master planning process. However, growth policies are outside of the scope of this document. Since increased population can directly affect conservation goals relating to absolute reductions, City and County growth policies should take into consideration water conservation.

Population is integral to analyzing water use on a per person basis to compare water use among different users and different locations, and for setting goals that are independent of growth. Table 6 shows the estimated populations used in calculating CBU customer per capita water use, and Appendix B provides details of how these populations were calculated. The population for each user category in Table 6 increased over the six year study period except for Indiana University On-Campus Housing, which varied.

Table 6. Population data used in calculating per capita values

Category	2002	2003	2004	2005	2006	2007
Monroe County	121,722	123,166	124,385	125,428	127,306	128,643
Wholesale Districts	39,404	40,266	40,266	40,928	41,149	41,194
CBU Service Area	*82,318*	*82,900*	*84,119*	*84,500*	*86,157*	*87,449*
Indiana University On-Campus Housing	12,012	12,001	11,641	11,247	11,540	11,981
Residential Single Family	*36,004*	*36,231*	*37,332*	*38,023*	*38,470*	*39,108*
Residential Multi-Family	*34,302*	*34,668*	*35,146*	*35,231*	*36,147*	*36,360*

Note: Italicized numbers are calculated while the non-italicized numbers are from primary sources. Appendix B includes a description of sources and how the italicized numbers were calculated.

4.2.3. Total water use

Aggregate water use by all customer classes determines the necessary facility capacity and the demands placed on the resource. The total water use by CBU customers is understood by examining four factors: total water supplied by CBU; peaking factors; total consumption; and peak consumption. The data presented in this section represents all six user classes.

Supplied water

Total water produced is the water CBU pumps from Lake Monroe and treats before delivering it to customers. However, not all produced water is consumed by customers; a portion of the treated water is used in the treatment process and some water is lost to leaks on the way to customers. On average, from April, 2002 to November, 2007, the Monroe Water Treatment plant produced 13.7 MGD. *Figure 14* shows the seasonal variation of production by month. Production is higher in the summer and the maximum production month has been August, except in 2004 when it was September. Maximum production in the summer is expected, as this is the season when demand is greatest because of increased outdoor use.

Peaking factors

The ratio of maximum to average production is an indicator of the stability of seasonal use. Lower ratios (more constant demand) indicate efficient capital asset operation. Higher ratios suggest that more capital is idle during non-peak periods. The maximum day (MD) to average day (AD) peaking ratio has historically been used to plan for utility expansion. In humid climates, average peaking factors are 1.2 to 1.7; however, some utilities have a 2.0 or higher peaking factor due to large residential outdoor use (Maddaus W. , 1999). CBU had an average MD to AD peaking factor of 1.4 from 2002 to 2007. This peaking factor indicates that CBU is moderately efficient in utilization of its capital assets but more efficiency could be achieved.

Total consumption

Of the average 13.7 MGD produced by CBU, 11.8 MGD was consumed by CBU's customers. The consumption data in *Figure 14* reveals a pattern of high consumption in the hot summer months and lower consumption in the winter months. The total consumption is less than produced water because some water is used for emergency purposes, some water is used for infrastructure maintenance, and some water is lost during distribution. The consumed water is used for residential, outdoor, commercial, and industrial uses.

In the United States, average per capita water use for public supply water is 175 gallons per person per day (gppd) and includes all users (Hutson, Barber, Kenny, Linsey, Lumia, & Maupin, 2004). The national average is high when compared to CBU customer use of 95 gppd (please note that population data was estimated using the procedure outlined in Appendix B and per capita values should be viewed as an estimate). The national average is higher than CBU's per capita usage for many different reasons. The national data includes a variety of different locations that incorporate arid areas, areas with sandy soil,

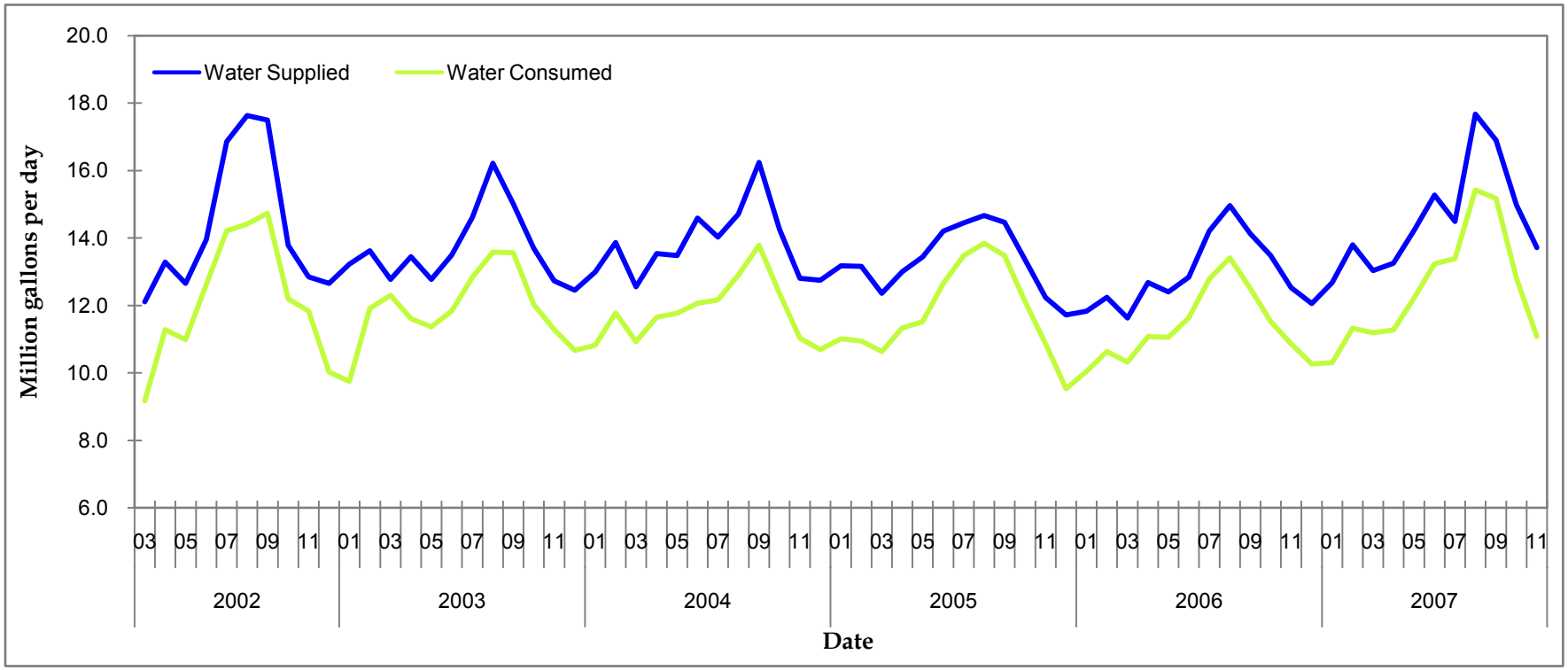

Figure 14. Water supplied by City of Bloomington Utilities and consumed by customers for 2002-2007

and areas with different socio-economic conditions than in Monroe County. All of these factors can contribute to higher usage. Additionally, there are communities throughout the U.S. that have old, leaky infrastructure (some cities have up to 70 percent leakage) which can contribute significantly to the amount of water used within a system.

CBU service area's per capita consumption is below the national average, which is to be expected given that Monroe County is located in a temperate climate zone where intense irrigation is not required for most landscaping and is limited to summer months. Weather during the six-year study period was wetter than normal, and temperatures were approximately normal. This weather pattern resulted in less irrigation use than if the study occurred during a drought or dry summer. CBU's physical losses are relatively low with an average of 13.4 percent over the course of this study. Additionally, there is limited water-intensive industry within the service area.

During the six-year study period, average per capita use exhibits a declining trend (Figure 15). This is a trend that is observed in many communities and is believed to be the result of the 1992 U.S. Energy Policy Act, which mandated that all plumbing fixtures manufactured after 1994 must meet federal standards for efficiency. As homes and buildings are renovated and more efficient fixtures are installed, per capita use will decline. This trend will eventually level off unless further efficiency improvements are mandated.

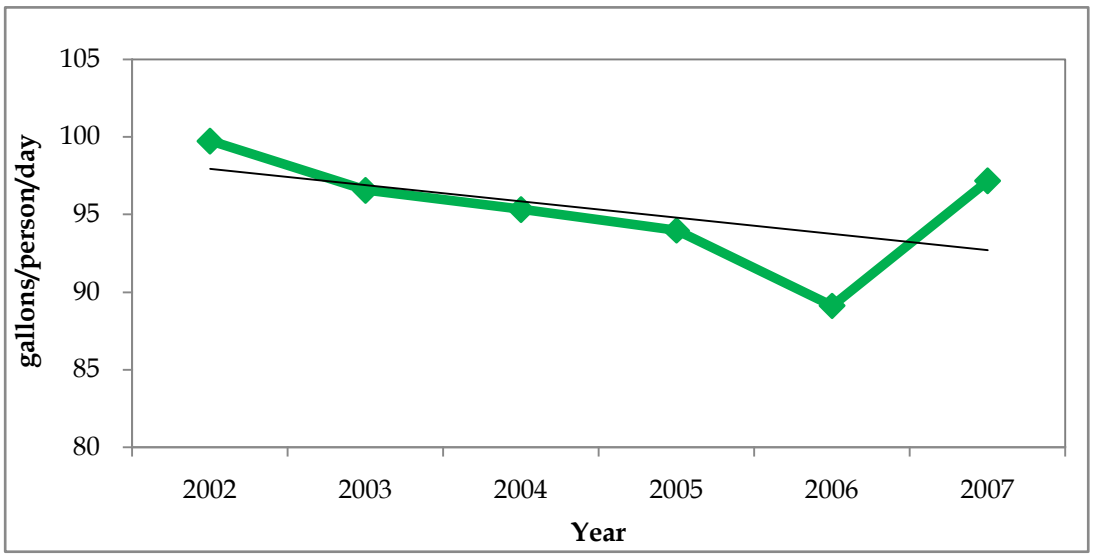

Figure 15. Per capita water use from 2002-2007 for Monroe County

Note. Consumption for 2002 is based on 10 months of data and 2007 consumption is based on 11 of months of data.

Peak consumption

As shown in *Figure 14*, consumption is highest during the summer months. There are several reasons for peak consumption occurring during the summer. Irrigation is a major cause of high water demands during periods of hot and dry weather. A portion of irrigation use is not separately metered, particularly in the residential class. Figure 16 shows that the largest amounts of metered irrigation use coincide with peaks in total use. This suggests that peaks in total water use are associated with peaks in both metered and unmetered irrigation. Additionally, water used for cooling purposes has the highest demands during the summer. IU, commercial, and industrial users all contribute to peak consumption through cooling water use. Finally, peak consumption often occurs in August or September, which is due, in part, to increased population from IU students.

4.2.4. Water use by class

CBU divides its customers into six separate billing classes. Residential customers are classified as either residential single family (RSF) or residential multi-family (RMF). Commercial customers (COM) include government buildings and parks, retail establishments, faith-based establishments, schools, hotels, banks, offices, manufacturing establishments, service stations, and many other miscellaneous commercial services. The industrial use class (IND) in Bloomington is very limited and currently only includes two industries (see Glossary for definition). In the CBU billing database, Indiana University (IU) use was billed as either IU

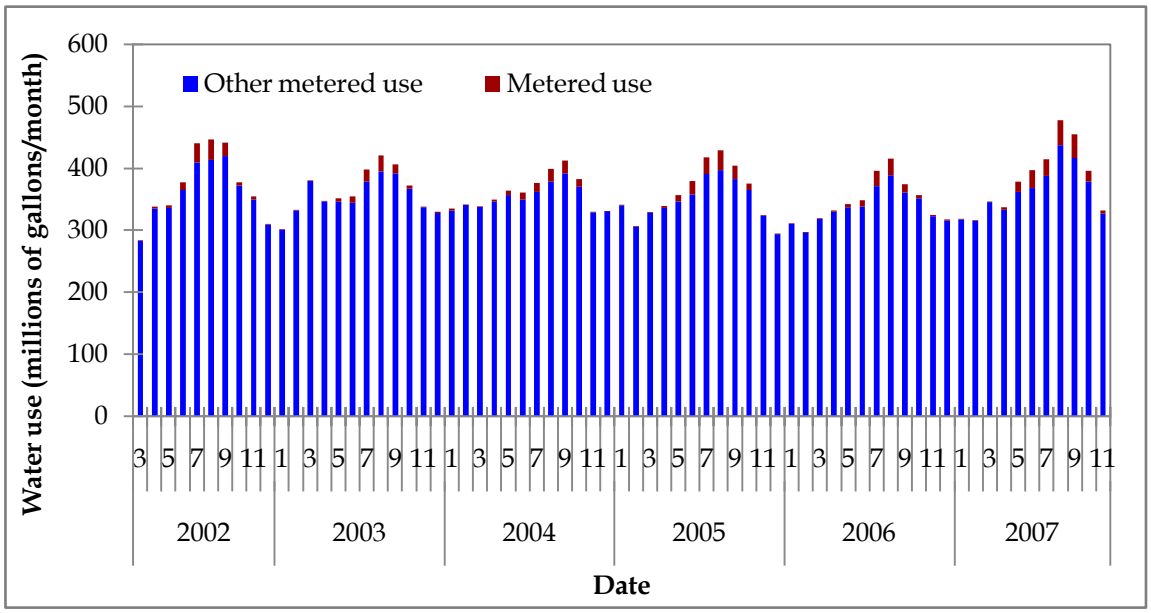

Figure 16. Metered irrigation and other metered water use for all City of Bloomington Utilities' customers from 2002-2007

Note. Not all irrigation use is separately metered in the City of Bloomington Utilities service area.

master, which was a separate class, or IU Other, which was a subclass within the commercial class. WHPA extracted the IU Other class from the commercial class and added it to the IU Master class, so that all of IU water use is accounted for in one combined IU class. These classes – RSF, RMF, COM, IND, and IU – comprise the classes of CBU retail customers. In addition, there is a wholesale district (WD) class which includes 10 customers who buy water from CBU for distribution to their own retail customers.

The relative distribution of water use by class did not change much from year to year (Table 7). In all years, the WD class is the largest user class with IU being the single largest customer. Industrial use includes only two customers who account for approximately one percent of the total use.

Similar to overall use and production, most user class' consumption varies by season, with peak use occurring in the summer months and minimum use occurring in the winter months. As shown in the example year of 2006 (Figure 17) peak consumption generally occurs during the summer for all classes, except for IND. For the most part, IU and RMF peak use occur in September due to the large number of students that return to the area at this time. RSF and WD consumption patterns are similar to one another - WD users are generally residential single family. COM use consistently peaks in August. Generally, peak production occurs during August and COM, RSF, and WD uses coincide with this peak. Production generally remains high in September because IU and RMF use peaks as COM, RSF, and WD use begins to taper off.

The peaking factor varies among user classes as expected. Peaking ratios for water use by different customer classes are developed using monthly consumption data rather than daily production data. Therefore, the user class peaking factors (which use monthly data) will always be less than the production peaking factors developed with daily data. Peak month use is reported in MGD and represents the average day of the maximum month (ADMM) of a given year. The peaking ratios developed for each class represent the ratio of ADMM to the AD for that class of customers.

The average ADMM to AD ratio for COM, RSF, IND, and IU customers was higher than CBU's production ratio (Figure 18). Customer classes with higher ratios have greater monthly variation in use. The WD and RMF have lower ratios indicating that their water use is relatively consistent throughout the year. Utility infrastructure must be built to meet peak demands; therefore customer classes with high demand and high ratios drive peak demands and the need for additional infrastructure.

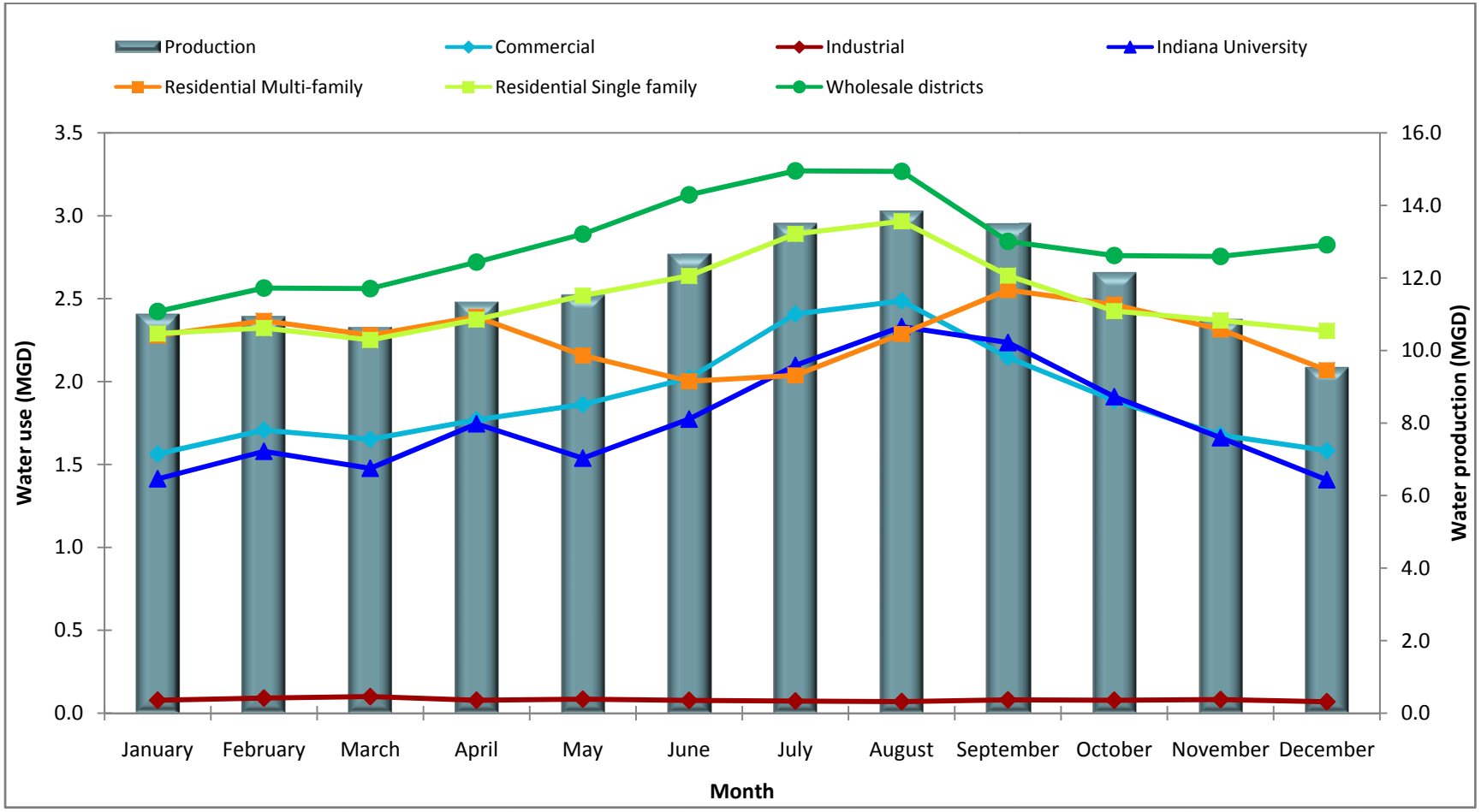

Figure 17. Monthly production and City of Bloomington Utilities' customer class water use for 2006

Table 7. Percent of total water used by each customer class for 2002-2007

Year	Single Family (%)	Multi-Family (%)	Commercial (%)	Industrial (%)	Indiana University (%)	Wholesale Districts (%)
2002	22	19	16	1	17	25
2003	22	20	16	1	17	24
2004	22	20	16	1	17	24
2005	22	19	17	1	17	24
2006	22	20	17	1	15	25
2007	22	19	17	1	16	25

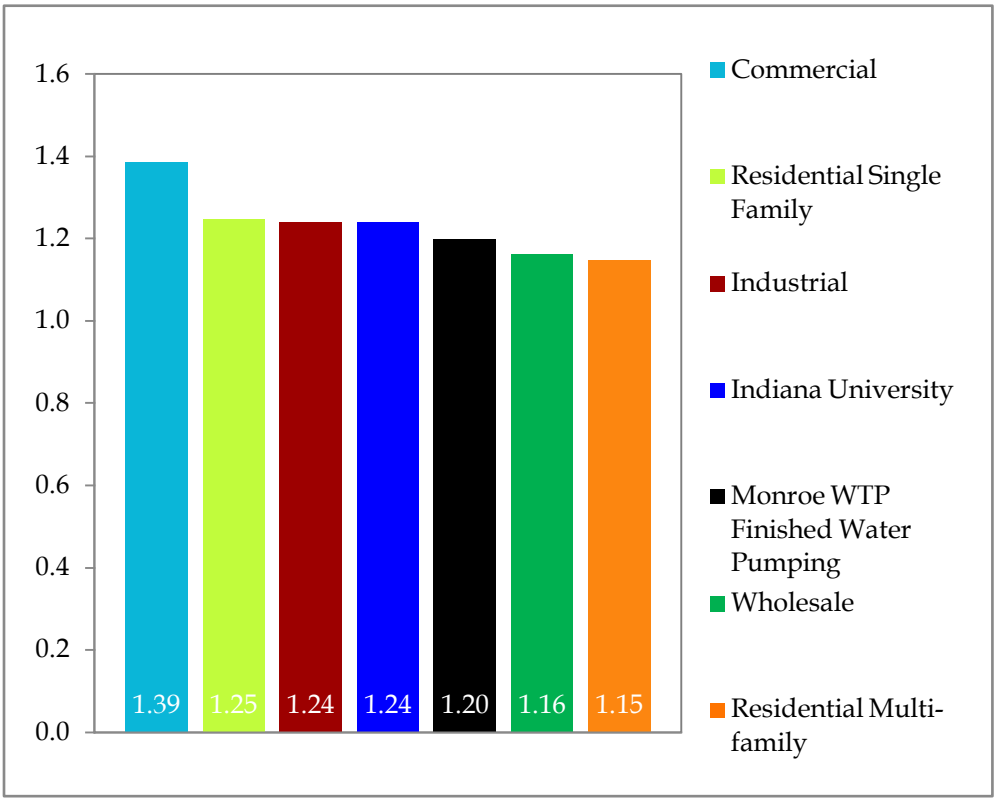

Figure 18. Ratio of maximum to average monthly water use by customer class

Note. Mean ratios for 2002-2007

Residential single family water use

Per person RSF water use has generally declined from 73 gppd in 2002 to 65 gppd in 2006 (Figure 19). In 2007, per capita water use rose again to 70 gppd. Both 2002 and 2007 had hot and dry summer weather compared to the other four study period years, driving the per capita use higher than in the intervening years. However, an underlying downward trend in RSF per person use is suggested, which is reflected in the black linear trend line in Figure 19. This is consistent with a nationwide downward trend in residential per capita use, which is thought to reflect the implementation of federal standards for plumbing fixture efficiency. The estimated values for RSF per person use are subject to errors in the billing data and in the population data. The billing data has been subject to thorough quality review and error correction, and as a result there is a relatively high degree of confidence in these data. The accuracy and precision of the population data limits the ability to correlate it to the CBU service territory; therefore the population data used in calculating per person consumption are only approximate, as are the values for per person consumption in Figure 19. These values are significantly less than the national average for residential consumption, which is 101 gppd. However, many cities have per capita uses that are near or lower than Bloomington's, such as Boston, MA, Manchester, VT, and Seattle, WA (Vickers, 2001).

Average indoor use in Bloomington is estimated to be the average use during four winter months (January, February, November, and December). Outdoor use is estimated to be the difference between the average use during four summer months (June, July, August,

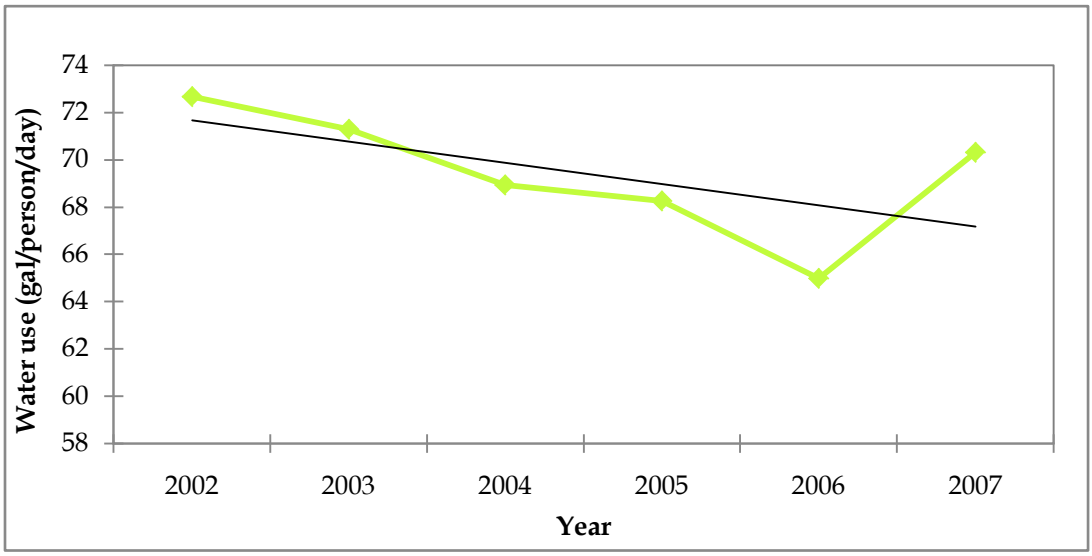

Figure 19. Residential single family per capita water use for 2002-2007
Note. Consumption for 2002 is based on 10 months of data and 2007 consumption is based on 11 months of data.

and September) and the average indoor use. Consumption data shows that summer use increased, on average, by 13 gppd when compared to winter consumption (Table 8). Both 2002 and 2007 had hot, dry summers, and higher summer consumption per person in comparison to that of other years.

Examining the winter consumption can also helps us understand indoor uses since no water would be used outdoors during winter months. Indoor use in the CBU service area is 62 gppd, which is below the national average of 69 gppd. Low indoor use could be attributed to several different factors including greater awareness regarding water use and conservation, plumbing fixture efficiencies, or lower incomes compared to other parts of the U.S. However, it is anticipated that awareness and plumbing fixture efficiencies can be further improved and additional water use reductions achieved. Reductions in per person use offset increased use due to population growth. The change in total use by RSF depends on both factors. Due to a small increase in population and a slightly declining per capita use, total RSF consumption has remained relatively unchanged over the past six years.

Table 8. Winter and summer consumption for residential single family customers

Year	Average winter consumption (gppd)	Average summer consumption (gppd)
2002	N/A	89
2003	63	79
2004	65	75
2005	62	78
2006	60	72
2007	N/A	84

Note: Winter months are January, February, November, and December; summer months are June, July, August, and September; 2002 and 2007 are missing winter month consumption data.

Residential multi-family water use

Average RMF water use has remained stable over the last six years and ranged from 2.26 to 2.44 MGD. Monthly consumption closely follows the IU semesters, which is reasonable since the majority of multi-family housing is occupied by students (Figure 20). Consumption generally peaks every year in September when most students return to town. Consumption is low during December to January and May to July when students are on winter and summer breaks. Generally, the month with the lowest consumption is June due to many students leaving town.

RMF per capita water use is typically less than RSF per capita use due to fewer appliances in the dwelling and because there is less outdoor use (Vickers, 2001). However, in Bloomington the RMF per capita water use in Bloomington is either higher or near the same levels as RSF (Figure 21). There are several possible reasons why RMF per capita use is near RSF use. First, many of the RMF units are not submetered, meaning that an entire building or complex's water use is measured by one master meter rather than each individual unit having a meter. Using master meters is cost-efficient for CBU but does not provide any financial incentive to individual customers to reduce their monthly bill by reducing use. Using master meters also decreases an individual's awareness regarding their water use because they have no way of knowing the amount of water they are actually using each month. Second, leaks within RMF units may go unreported or undetected more often or for longer periods of times than in RSF due to tenant absences, master metering where individual leaks may not be noticed, and/or lack of ownership by

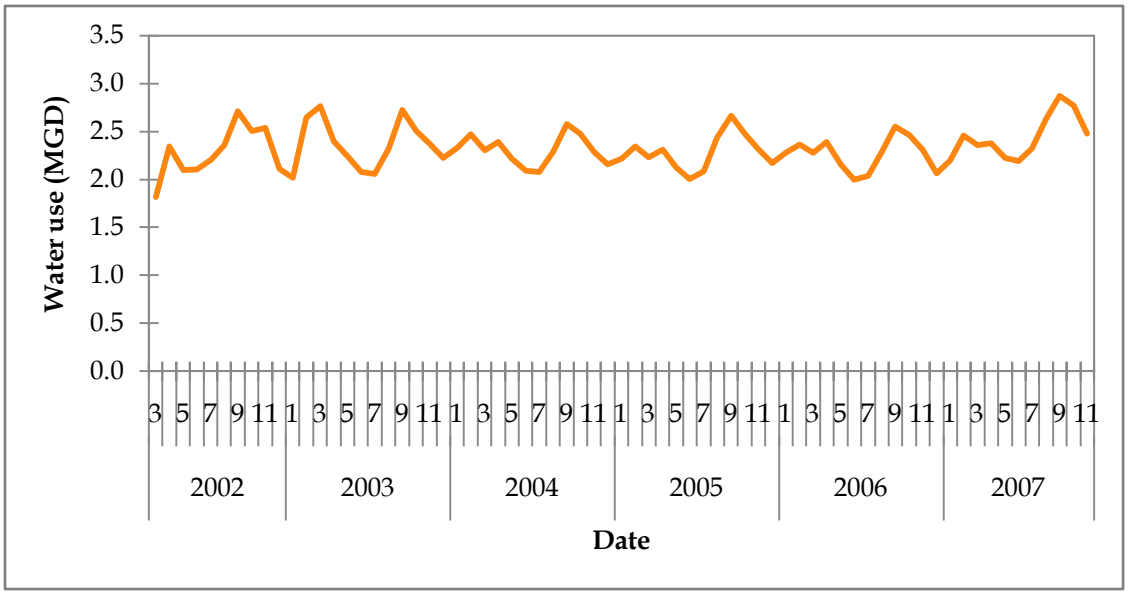

Figure 20. Monthly residential multi-family consumption for 2002-2007

individuals. Third, RMF customers in Bloomington may have more swimming pools and greater areas of landscaped surfaces compared to the national average. Finally, many of the RMF units are occupied by IU students who are often out on their own for the first time and may not be paying their utility bills. If the student is not paying their own utility bills, awareness and incentive to conserve is reduced.

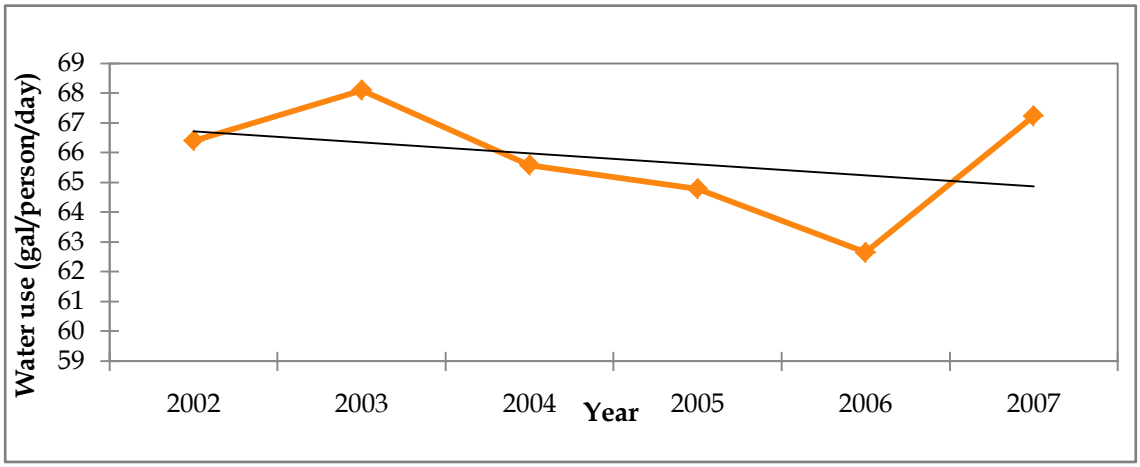

Figure 21. Residential multi-family per capita water use for 2002-2007

Note. Consumption for 2002 is based on 10 months of data and 2007 consumption is based on 11 months of data.

Table 9. Winter and summer consumption for residential multi-family customers

Year	Average winter consumption (gppd)	Average summer consumption (gppd)
2002	N/A	68
2003	67	66
2004	66	64
2005	64	65
2006	62	61
2007	N/A	67

Note. Winter months are January, February, November, and December; summer months are June, July, August, and September; 2002 and 2007 are missing winter month consumption data.

Comparing winter consumption to summer consumption, RMF use fluctuates between using more water in the summer and using more in the winter (Table 9), but there is not a large difference between the two seasons. One reason for the lack of difference is that some multi-family units typically occupied by students may be empty during the summer months reducing indoor use. Because some outdoor use is occurring, the average summer consumption does not decrease.

Industrial water use

Industrial (IND) use within CBU's overall production is very small, accounting for only approximately one percent of the total use each year and comprised of two different businesses. CBU's definition of an industrial customer is based on characteristics of their wastewater and is very specific:

> *"Any industrial user of the City's wastewater collection or treatment system whose wastewater flow exceeds (1) 25,000 gallons per day, or (2) contributes a process waste stream which makes up five percent or more of the average dry weather hydraulic or organic (BOD<TSS) capacity of a treatment plant, or (3) whose flow contains toxic or nonconventional pollutants which must be routinely sampled and tested, or (4) has a reasonable potential, in the opinion of the USB or the Director of Utility to adversely affect the wastewater treatment system treatment plant (inhibition, pass-through of pollutants, sludge contamination, or endangerment of wastewater treatment system workers.) This definition is intended to include, but not be limited to any requirement of the Federal Pretreatment Guidelines as amended and/or adopted by the US. Congress and the U.S. Environmental Protection Agency from time to time."*

The IND user class comprises only a small portion of the total use, and when examined on its own, has a very different pattern of use than the other customer classes (Figure 22). IND customers use relatively consistent amounts of water throughout the year. From 2002 to 2007, IND peak use has occurred mostly in March (2005, 2006, and 2007), but also in November (2002, 2003) and October (2004). Since IND use does not peak during the summer, it can be assumed that the water use is related predominantly to the industrial process and relatively little outdoor use is occurring. Notably, in June, 2005 water use for the IND class dropped by approximately 50,000 gallons per day and has generally stayed at this level over time. This drop in use is most likely due to a change in production or process in one or more of the businesses.

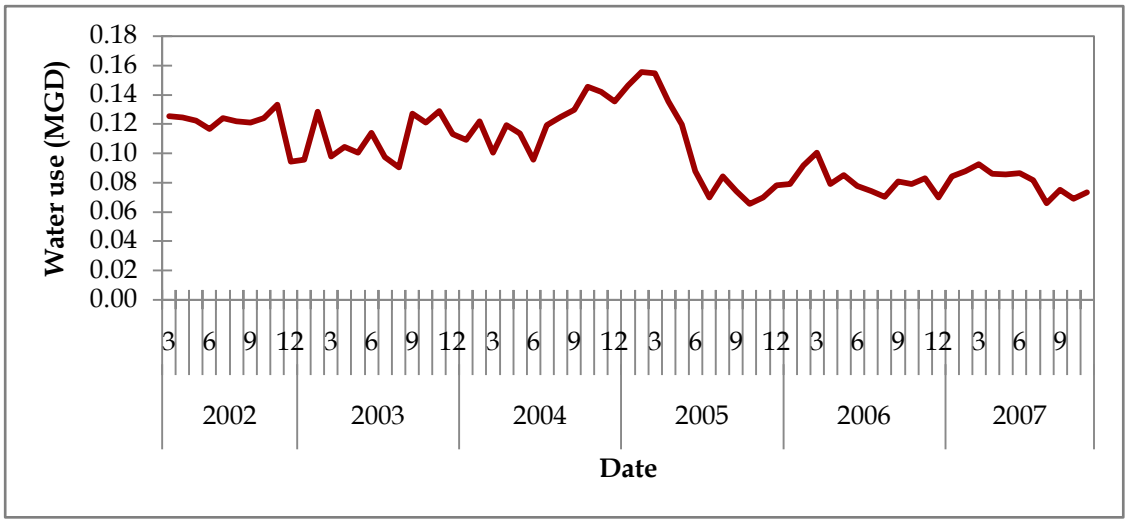

Figure 22. Monthly industrial water use for 2002-2007

Commercial water use

Commercial water use in the CBU data is defined as any business that does not fall within the industrial use and includes everything from government to manufacturing. For purposes of this analysis, the commercial subclass corresponding to non-master metered use by IU has been included with IU and is excluded from commercial. From 2002 to 2007 COM water use has generally been around 2 MGD (Figure 23). COM consumption fluctuates seasonally with peak use occurring every year from 2002-2007 in August. This peak is most likely due to outdoor use and an increase of services to student populations.

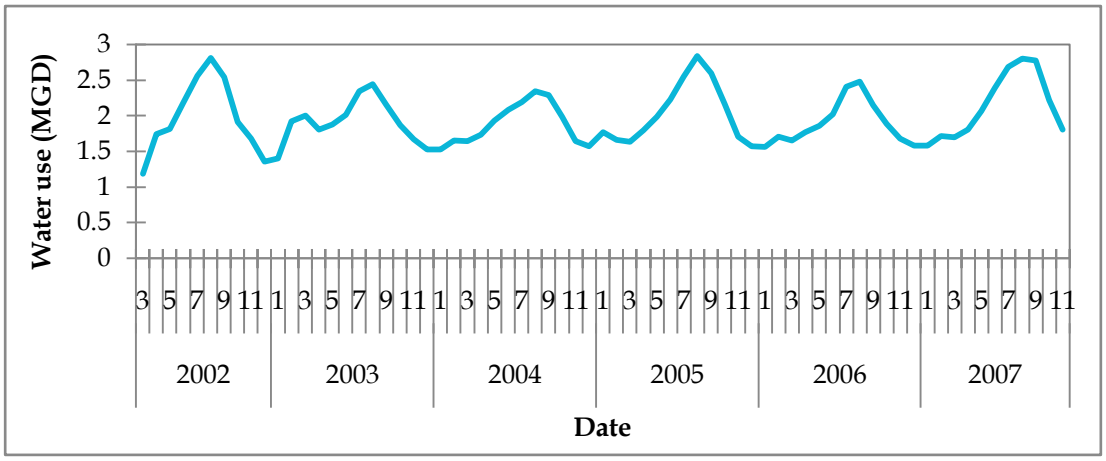

Figure 23. Monthly commercial water use for 2002-2007

When looking at the indoor (winter consumption) and outdoor (difference between summer and winter consumption) for the COM user class, it is evident that irrigation is occurring (Table 10). Additionally, when total COM use is subdivided into metered irrigation and other metered use, metered irrigation use increases to 10-25 percent of the total use during summer months (Figure 24). Actual percentage of use dedicated to irrigation during summer months is likely higher given that not all irrigation uses are separately metered. However, metered irrigation use does include golf course and local government (city and county) uses. Peaks in COM use coincide with peaks in total use seen during the summer months.

Table 10. Winter and summer consumption for commercial customers

Year	Average winter consumption (MGD)	Average summer consumption (MGD)
2002	N/A	2.5
2003	1.6	2.2
2004	1.6	2.2
2005	1.7	2.6
2006	1.6	2.3
2007	N/A	2.7

Note. Winter months are January, February, November, and December; summer months are June, July, August, and September; 2002 and 2007 are missing winter month consumption data.

Indiana University water use

Indiana University's (IU) annual water consumption has decreased over the last six years ranging from averages of 1.76 to 2.10 MGD (Figure 25). Monthly water use is lowest during the winter and highest during the summer months. IU's consumption peaks in either August (2005-2007) or September (2002-2004) when students are arriving back on campus. Even though most university students leave in May and do not return until mid-August, IU's consumption is generally highest in the summer (June through September)

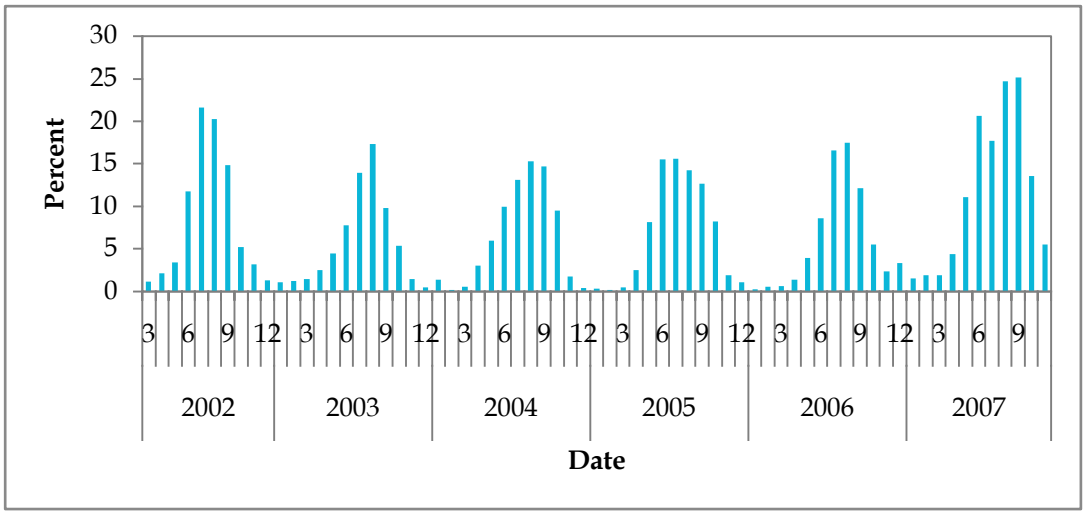

Figure 24. Percent irrigation use for commercial customers for 2002-2007

because of: irrigation and cooling demands; some students remaining on campus for summer sessions; and IU hosting several conferences.

IU's metered irrigation has increased from an average of 6 percent to an average of 11 percent of summer use over the last six years (Figure 26). This may indicate an increase in irrigation, or it may simply indicate an increase in separate metering of irrigation use. IU's irrigation needs include athletic fields, the IU Golf Course, the IU arboretum, the lawns around several campus buildings, and landscape bedding.

IU's water reductions have occurred even with increasing student enrollment and employment (Table 11). The reduction in use coincides with the university's efforts to reduce water and sewer costs and its initiation of several conservation efforts. Over the past several years, IU has implemented the following measures to save water:

- Installation of low-flow showerheads and low-use water flush valves in toilets during all dorm renovations.
- Increased the number of run cycles for all 30 on-campus cooling towers to five cycles, reducing the volume of blowdown.
- Modified its central heating system to increase condensate return from 25 - 28 percent to 60 - 70 percent.
- Electronic radio read meters have been installed on almost every building on campus.
- Initiated Leak Line, a program for students and staff to report leaks, drips, and running toilets in campus buildings.
- All new campus buildings will be LEED silver certified (certification requires reduced water use).
- Landscaping uses native plants to reduce irrigation demands.

- Educated students through an IU Energy Challenge – a dormitory energy and water conservation competition.

In 2007, IU developed a Sustainability Task Force with the objective of developing a sustainability plan for the campus. Water conservation is one of the issues addressed by the task force, which suggests that it is likely IU will continue to reduce unnecessary water use.

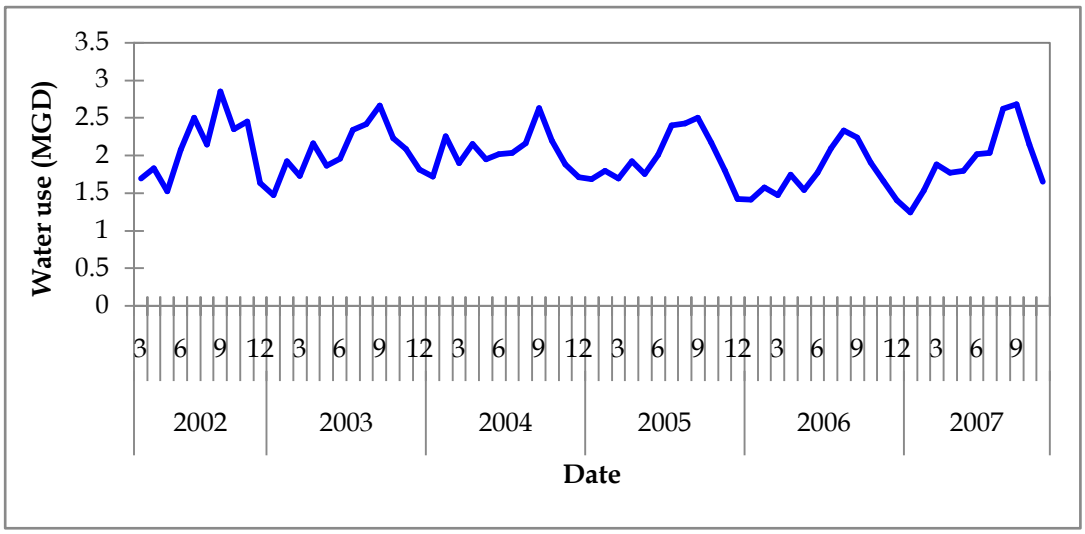

Figure 25. Monthly Indiana University water use 2002-2007

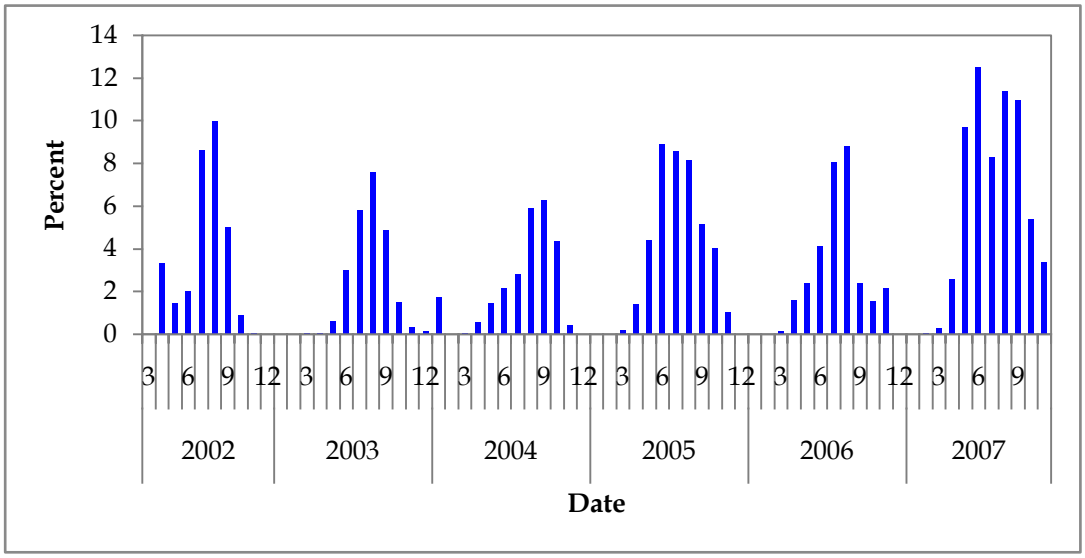

Figure 26. Percent metered irrigation use for Indiana University for 2002-2007

Table 11. Indiana University enrollment and employment for the 2002-2007 school years (Indiana University, 2009)

School Year	Enrollment	Employment
Spring 2002	35,474	6,890
Fall 2002	38,903	6,952
Spring 2003	36,281	6,952
Fall 2003	38,589	7,163
Spring 2004	36,473	7,163
Fall 2004	37,824	7,166
Spring 2005	35,694	7,166
Fall 2005	37,958	7,214
Spring 2006	36,200	7,214
Fall 2006	38,247	7,253
Spring 2007	36,698	7,253
Fall 2007	38,990	7,405

Note. Adapted from Indiana University, 2009, *IU Factbook 2002-2007*, University Planning, Institutional Research, and Accountability.

Wholesale district water use

CBU delivers water to 10 wholesale districts (WD) who in turn sell the water to their own retail customers. Like all other user classes, WD use has remained relatively unchanged over the past six years, averaging 2.9 MGD (Figure 27). The WD users account for approximately 25 percent of the total water consumption per year. All classes of users (RSF, RMF, COM, and IND) are served by the wholesale districts. However, many of the individual wholesale districts serve almost exclusively residential customers. It is likely that only Ellettsville and East Monroe, who serves Nashville, serve notable numbers of commercial or industrial customers. As with the RSF and COM classes, the peak demand

for WD occurs during the summer (either July or August for the past six years), suggesting a similar mix of uses within the WD user class.

When summer and winter consumption are evaluated, it can be seen again that summer use includes outdoor use (Table 12). Characteristics similar to RSF are expected considering that a large fraction of the WD retail customers are residential single family. However, per person consumption cannot be calculated due to the lack of data on wholesale district customers and population.

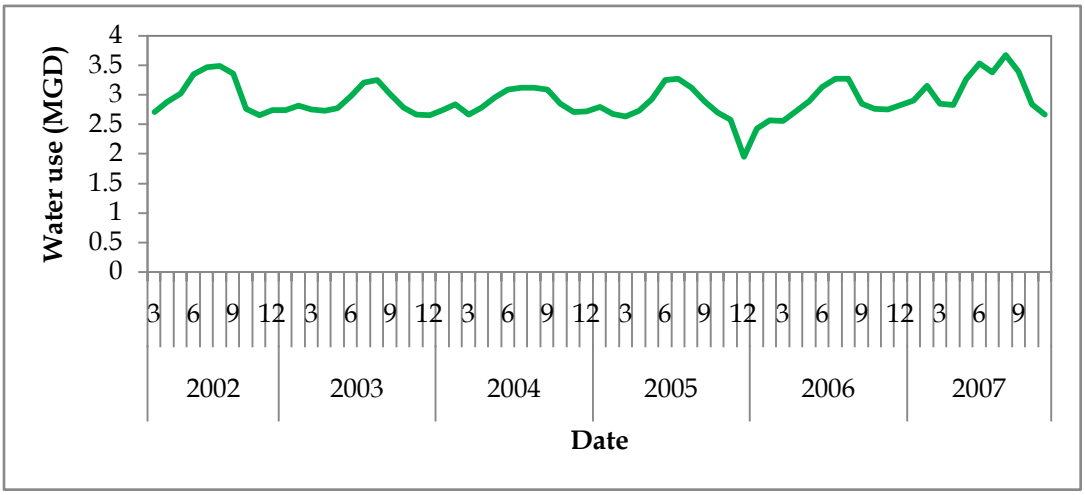

Figure 27. Monthly wholesale districts water use for 2002-2007

4.3. Opportunities for Conservation

Water use by CBU customers generally follows seasonal patterns of precipitation and temperature with greatest use occurring in summer months. The exception to this use pattern is the industrial user class, which has generally stable use throughout the year, but also only accounts for a very small portion of the overall water use. Other factors influencing water use include the presence or absence of IU students, plumbing efficiencies, and awareness of use/need to conserve.

Reductions in water use can be achieved through demand-side management that focuses on increasing individual customer efficiencies. Based upon the water use data, measures can be taken that reduce both average and peak demands and apply to every user class. Reductions in CBU peak demands can be achieved through efficiencies in outdoor use, awareness/education, and appropriate pricing structures. CBU's average use can be reduced through plumbing efficiencies, awareness/education, leak detection and repair, meter replacement, and submetering. Reducing average use will decrease overall operation costs and will help achieve sustainability. Specific

measures that will reduce use and increase efficiencies and are recommended for CBU and its customers are discussed in Chapter 6.

Table 12. Winter and summer consumption for wholesale district customers

Year	Average winter consumption (MGD)	Average summer consumption (MGD)
2002	N/A	3.4
2003	2.7	3.1
2004	2.8	3.1
2005	2.5	3.1
2006	2.6	3.1
2007	N/A	3.5

Note. Winter months are January, February, November, and December; summer months are June, July, August, and September; 2002 and 2007 are missing winter month consumption data.

5. Conservation Goals

Articulating goals for City of Bloomington Utilities' (CBU) conservation plan defines its intentions for conservation and provides direction for reducing water use. In this chapter, the goal setting process is described and each goal is explained.

5.1. Developing Goals

Before developing conservation goals, WHPA attended 12 community meetings with stakeholders identified by CBU. CBU wanted to incorporate ideas and comments from community groups into the plan. At each community meeting, WHPA gave a presentation explaining CBU's interest in conservation and the conservation planning process. After the presentation, WHPA discussed the following questions with group members.

1. What would you like to see addressed in Bloomington's conservation plan?
2. Do you have any concerns about water conservation?
3. Are you aware of existing conservation efforts?
4. Are you interested in a particular conservation measure?

Ideas and suggestions generated during the meetings shaped the development of the conservation goals and the selection of conservation measures (Appendix C).

5.2. CBU conservation goals

CBU has specified the following four goals, which are reflective of the outreach activities described above.

Goal 1: Increase customer water use efficiency.

Goal 2: Develop and promote a water conservation ethic within the community.

Goal 3: Increase the water efficiency of CBU's supply operations.

Goal 4: Establish regular monitoring and evaluation of the water conservation plan.

Conservation goals should be attainable, relevant to the local community, and measurable. When a goal is measurable, progress can be objectively evaluated. For Goals 1 and 3, CBU has developed measurable sub-goals. The sub-goals further define the goals and are listed in the individual goal descriptions. Goals 2 and 4 are not easily measurable; however, they are important for a successful conservation program and can be evaluated using qualitative methods.

Goal 1: Increase customer water use efficiency.

CBU has an abundant water source in Lake Monroe. However, Lake Monroe is dedicated to multiple purposes, which during a drought could limit the amount of water available for public

water supply. In order to ensure responsible utilization of the Lake, water lost to inefficient practices and hardware must be reduced. Accomplishing this goal requires behavioral changes on the part of customers, improvements in efficiency of CBU's water delivery operations, and upgrading of inefficient hardware with more water efficient technologies. CBU has developed two measurable sub-goals.

Sub-goal 1: Reduce average per person use by 3 percent from the 2005 baseline by 2015.
Sub-goal 2: Reduce City water use by 15 percent by 2015.

Goal 2: Develop and promote a water conservation ethic within CBU and its customers.

Promoting water conservation complements the City of Bloomington's Sustainable City Initiative, which strives to promote sustainable development, environmental health, and social development. The City of Bloomington's Sustainable City website describes sustainable development as minimizing waste and efficiently using natural resources so that they are available for future generations. Reducing unnecessary water use demonstrates the City of Bloomington's pursuit for sustainability because conserving water

- represents responsible use of Lake Monroe;
- reduces the amount of energy used by the utility and customers for treating, moving, and heating water;
- minimizes wastewater flows, and subsequently, the effluent discharged into local streams; and
- makes efficient use of existing infrastructure, allowing more customers to be served by the same facilities.

Consequently, water conservation is a natural addition to the City of Bloomington's environmental initiatives.

Goal 3: Increase the water efficiency of CBU's supply operations.

CBU can evaluate the efficiency of its water delivery operations by performing an annual water audit. The audit will allow CBU to better account for the delivery of water from Lake Monroe to its customers. Furthermore, CBU can use the audits to track changes in non-revenue water (NRW) and the cost of water losses, and then use this information to target economic levels of leakage. Also, CBU can use the water audit's performance indicators to compare its performance with other utilities. CBU has developed two measurable sub-goals.

Sub-goal 1: Complete annual water utility audits.
Sub-goal 2: Reduce NRW to 10 percent by 2020.

Goal 4: Establish regular monitoring and evaluation of the water conservation program.

CBU's conservation program is not static; it must be periodically evaluated for efficiency and cost effectiveness. Additionally, the success of the program will depend on effective participation of the community, by communicating results and soliciting input for evaluation of the program. Evaluation requires that detailed data be kept on the conservation program, such as individual program descriptions, implementation dates, and quantitative data. The data requirements for evaluating the conservation program may be slightly different than those for billing and operations. Collecting and storing the data in an appropriate manner will greatly enhance the efficiency and accuracy of future evaluation of the conservation program. Although this goal does not directly contribute to reducing water demand, it is crucial for evaluating whether or not the conservation program is achieving CBU's goals and to determine if individual measures or goals need to be revised. CBU has developed two sub-goals.

Sub-goal 1: Complete an annual report on the conservation measures implemented during the year.
Sub-goal 2: Evaluate the conservation plan five years after implementation.

These four goals along with the conservation measures will guide CBU and its customers in implementing and achieving water conservation.

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6. Bloomington's Conservation Measures

Conservation measures are the actions taken to achieve water conservation goals. Each action saves water or promotes water efficiency using hardware devices, technologies, behavior and management practices, and/or incentives. Conservation measures include demand-side and supply-side approaches. Demand-side measures target water use efficiency among water users. Supply-side measures target internal operations at the utility level and involve increasing system efficiency. Table 13 is a preview of the recommended conservation measures for City of Bloomington Utilities. The measures listed in Table 13 include a mix of demand-side and supply-side measures tailored to the City of Bloomington's community and water supply. The process used to select the measures is shown in Figure 28.

The remainder of this section describes the conservation strategies from which the measures were selected, the screening and evaluation process for selecting the measures, the estimated water savings and costs, and a description of the recommended measures.

Table 13. City of Bloomington Utilities recommended conservation measures

Conservation Measure	
Water-supply management	**Public education**
• Annual utility water audit	• Public education campaign
• Utility leak detection and repair program	• Primary and secondary school programs
• Meter testing and replacement program	• Water conservation billing information
• Water conservation coordinator	• Water conservation information on utility website
• Municipal water use audit	• End-of-season notices to turn off automatic irrigation systems to all customers
Government regulation	• Peak day notification to large users
• Water waste ordinance	**Economic incentives**
• Adopt efficiency standards for new development that augment existing plumbing codes	• Conservation pricing
• Toilet retrofit on resale ordinance	• Low income home leak detection and repair program
• Submetering multi-family units ordinance	• Rain sensor rebate
• Irrigation system requirements for new development	**Alternative water supply**

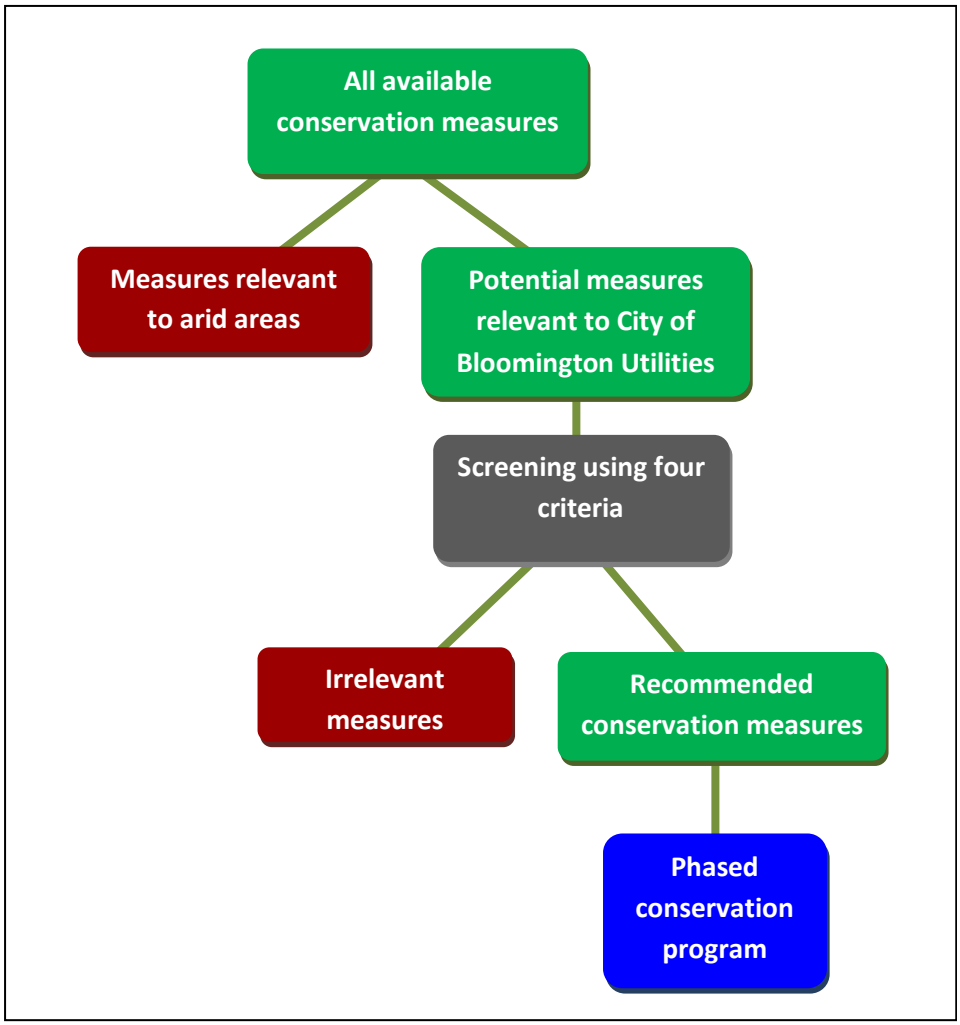

Figure 28. Screening process for selecting City of Bloomington Utilities' conservation measures

6.1. Conservation strategies

The first step in selecting CBU's conservation measures was to compile a list of potential measures that cover five broad conservation strategies: water-supply management, public education, government regulation, economic incentives, and alternative water supplies. An effective conservation plan employs a combination of conservation measures from each strategy. The following sections provide a general description of each category.

6.1.1. Water-supply management

The objective of a water-supply management program, with respect to conservation, is to reduce inefficiencies such as losses in the distribution system to the full extent that is economically feasible. Two primary goals of supply-side management are: 1) to better account for all water use; and 2) to reduce unnecessary water withdrawals and treatment.

Better accounting of water involves a water audit and controlling real and apparent losses of water. Real losses result from system leaks. Such leaks require CBU to extract, treat, and transport larger volumes of water than needed and in the process, use more energy (AWWA Water Loss Control Committee, 2003). One way to reduce real losses is to implement or increase active leak detection and repair programs. Apparent losses include meter inaccuracies, unmetered uses, data management errors, and unauthorized use. Mechanisms for reducing apparent losses are to meter all uses and test and replace aged customer meters.

6.1.2. Public education

Public education is a necessary strategy for encouraging water users, grade school students through adults, to integrate water saving practices into their daily activities. Informing all water users about the importance of water conservation has been shown to be effective and less controversial than increasing water prices and mandating behavioral changes (Dziegielewski, 2003). Also, when increasing prices or enacting watering restrictions is necessary, educated water users are better equipped to understand and accept such decisions.

The relatively low cost of carrying out public education programs makes it a widely used strategy for promoting water conservation. Educating the public can be as easy as including indoor and outdoor water conservation tips on CBU's website, disseminating information through bill inserts, or handing out information at community events. Some utilities promote water conservation in school systems by putting on programs aimed at elementary and/or high school students. In many communities, the conservation education program is also targeted at large municipal water users such as parks, golf courses, and cemeteries, or at a specific use such as lawn watering.

6.1.3. Government regulation

The role of government is to provide the regulatory environment needed for water conservation. Few national policies exist today that focus on conservation practices, so it is important for local governments, with the support of CBU, to create water policy appropriate to the Lake Monroe water supply. Ordinances are necessary for city-wide adoption of certain measures. To be effective, however, ordinances need to be enforced, and this can be politically challenging.

The extent of regulations within Bloomington will depend on the local government's level of concern with water use and supply. Generally, communities experiencing critical water shortages are more likely to enact regulations than communities with ample water. Local ordinances restricting lawn watering during the summer months or during droughts are the most common form of regulation in other areas.

6.1.4. Economic incentives

In our commercial economy, effective incentives for conservation include conservation pricing, hardware rebates, excessive or wasteful use penalties, tradable water rights, and tax credits (Dziegielewski, 2003). Economic incentives encourage water conservation investments and behavior changes. Conservation pricing indicates to customers the value and amount of water available for use. Rebates, free residential audits, and retrofit kits create opportunities to conserve water, whereas increases in water prices create a disincentive to use water.

6.1.5. Alternative water supply

An alternative water supply provides water for irrigation, cooling, or other uses that do not require potable water. Alternative water supplies may include harvested rainwater and stormwater, graywater, reclaimed water, and other lower-quality sources. Using these alternative sources for appropriate uses reduces demand for potable water and helps defer future expansion of treatment facility capacity. Water from an alternative supply must remain separated from potable supplies and is not to be used for drinking, bathing, or cooking.

6.2. Screening Conservation Measures for Applicability

A myriad of water conservation measures exist that range from simple, customer-made changes (e.g., installing water efficient showerheads) to more complex, regulatory measures (e.g., limiting a homeowner's turf acreage). Many measures are more relevant to arid areas experiencing chronic water shortages, and these measures were not considered for the City of Bloomington. The process used to select the City of Bloomington's conservation measures is illustrated in Figure 28.

This first screening is somewhat subjective. However, the objective is to broadly assess the applicability of each measure to CBU's conservation goals and to the community. Measures were eliminated because they were not relevant to the City's conservation goals or were deemed too costly to CBU or the customer. The measures that passed the screening are listed in Table 13. A description of each of these measures is provided in Section 6.4. The recommended measures will comprise CBU's conservation program and will be implemented in phases, as discussed in Chapter 8. Please see Appendix D for an explanation of the screening criteria, the list of possible conservation measures, and measures that were screened but not recommended for CBU and its customers.

6.3. Water Savings

Table 14 summarizes each recommended conservation measure's estimated water savings and cost. Please see Appendix D for the assumptions and data used in calculating water savings and costs. The water savings for some measures is unknown because the amount of savings depends on either the extent CBU implements a measure (e.g., water waste ordinance) or because it is

difficult to estimate how people will apply what they have learned (e.g., public education). However, each measure's savings will be estimated after it has been implemented.

6.4. Recommended Measures

This section provides a description of the measures recommended for the CBU conservation program. Under each conservation measure heading, the phase in which the measure is implemented, the goal(s) the measure achieves, and the target customer class are listed. Please see Appendix D for additional information on each measure, including examples of communities that have implemented similar measures, assumptions used in calculating the water savings, references for additional information, and cost information.

Table 14. Water savings and cost of recommended conservation measures

Conservation Measures	2015 Estimated Water Savings (gal/year)	Estimated Cost to CBU (Nominal values)
Water Management		
Annual utility water audit	Not applicable	Negligible
Leak detection and repair program	107.0 million	Unknown; estimated that up to $214,000 would be justified by water savings
Meter testing and replacement program	Unknown	Negligible
Conservation coordinator	Not applicable	Salary
City government water use audit	1.7 million	$1,000 + upgrade costs
Public education		
Public education campaign	Unknown	$50,000 - $70,000; varies depending on breadth of program
Primary and secondary school programs	Unknown	$5,000 to $10,000; depends on the number of classroom visits and materials provided to students
Water conservation billing information	Unknown	Negligible for initial phase
Water conservation information on utility website	Unknown	Negligible

Conservation Measures	2015 Estimated Water Savings (gal/year)	Estimated Cost to CBU (Nominal values)
End-of-season notices to turn off automatic irrigation systems to all customers	900,000	Negligible
Peak notification to large users	Unknown	Negligible
Government Regulation		
Water waste ordinance	Unknown	Negligible
Adopt efficiency standards for new development that augment existing plumbing codes	12.0 million	Negligible
Toilet retrofit on resale ordinance	3.7 million	Negligible
Ordinance requiring all new multi-family units to be sub-metered	1.4 million	Negligible
Irrigation system requirements for new development	2.7 million	Negligible
Economic Incentives		
Conservation pricing	30.1 million	Negligible if done at time of rate increase
A low income home leak detection and repair program	1.0 million	$12,000 to $15,000
Rain sensor rebate ($15)	2.2 million	$4,000
Alternative Water Supply		
Alternative water supply	15.0 million	To be determined

Note. See Appendix D for calculations.

6.4.1. Water management

Annual utility water audit

Phase 1 Goals 3, 4 Customers: CBU

The AWWA Water Loss Control Committee recommends that utilities perform an annual water audit of the distribution system. CBU will use the AWWA Water Loss Control

Committee's free water audit software to track raw, treated, and sold water throughout its system. The accuracy of raw and finished water metering at the plant should be investigated to ensure that the measurement of water delivery is as accurate as possible. The water audit will allow CBU to better account for supplied water and differentiate between real losses and apparent losses of water (please see Glossary for definitions).

Utility leak detection and repair program

Phase 1 Goal 3 Customers: CBU

Leaks in a water system are physical losses that produce needless water loss without satisfying a demand, inflate production, and raise energy costs. CBU may use the variable production cost calculated in the water audit (the total cost of purchased power, water, and chemicals divided by the total volume of produced water) to determine on a case-by-case basis the economic feasibility of repairing leaks. The variable production cost is used to calculate a leak's annual cost to the utility, which can then be used to determine if the payback of fixing the leak is economical. Based on a two-year payback, an annual program cost of $214,000 would be justified for the estimated savings.

Currently, CBU's average non-revenue water (NRW) is 13.4 percent and CBU will target a reduction to 10 percent NRW by 2020. The goal of the utility should be the economic level of leakage for the system, which may be lower than 10 percent NRW.

Meter testing and replacement program

Phase 2 Goal 3 Customers: CBU

Currently, CBU complies with the Indiana Regulatory Commission's (IURC) rule to replace aging meters every 10 years. CBU will consider integrating the following components into its replacement schedule:

- Integrate automated meter reading (AMR): this technology will allow CBU to remotely read customer meters and transfer the data to the billing system. AMR will reduce meter reading error and improve customer service. It will also allow CBU to provide better water use information to their customers.
- Test a sample of replaced meters to better estimate meter inaccuracy in the system: when CBU replaces meters, it will test a sample of them to determine the amount the meters were under-registering use. CBU will develop a data set of meter ages and accuracy which will allow them to better estimate the accuracy of customer meters for estimating apparent losses.
- Replace inappropriately sized meters: CBU will screen its consumption data for inappropriately sized customer meters. When those meters are replaced, they

will be replaced with an appropriately sized meter. Oversized meters will under-register flow, which increases apparent losses and NRW.

Testing replaced meters for inaccuracy and replacing inappropriately sized meters are the short-term components of the testing and replacement program. The long-term component is to integrate an AMR system.

Hire a water conservation coordinator

Phase 1 Goal 1,2,3,4 Customers: CBU

A conservation coordinator is recommended because a conservation program is ongoing. In addition to maintaining detailed records on each conservation measure and evaluating programs and their effectiveness, a conservation coordinator interacts with the community and is responsible for public education. The coordinator also will oversee the rebate program and work with the City of Bloomington to develop conservation ordinances. A successful conservation program is time intensive and requires a dedicated CBU staff member.

City government water use audit

Phase 1 Goals 1, 2 Customers: City government

In addition to asking the Bloomington community to increase their water use efficiency, the City of Bloomington will examine its water use by performing a water audit of all its buildings and public spaces. The purpose of the audit is to determine where the City is using the greatest amount of water and where efficiency improvements can be made. The audit will focus on indoor fixtures such as toilets, faucets, and urinals, and on outdoor use such as irrigation. The audit itself will not result in water savings. The amount of water savings depends on the changes the City makes based on the water audit results.

Recently, the City passed a green building ordinance requiring 15 City buildings to be retrofitted to meet LEED-Silver standards. The City water audit can be incorporated into the certification process because water efficiency is part of the LEED rating system. CBU bills the City of Bloomington for all of its water use, and reducing unnecessary water use, and subsequently energy, could save the City money.

6.4.2. Public education

Public education campaign

Phase 1 Goals 1, 2 Customers: RSF, RMF, COMM, IND

Public education is a critical component of a successful conservation program because it introduces the public to the importance of water conservation. Many people erroneously

believe that the Midwest is immune to long-term water shortages because it receives substantial yearly rainfall. However, long-term shortages can occur due to over use, increased populations, and long-term droughts. The primary role of a public education campaign is to change the common mentality of water being an unlimited resource to one of water being a limited and valuable resource. As the public's outlook changes, so will their behavior.

CBU's first campaign will introduce and promote its water conservation plan to the community. The campaign will explain why conservation is important for CBU and its customers, the benefits of conserving water, and actions customers can take to reduce wasteful water use. CBU will also consider a summertime educational campaign on proper irrigation practices. This campaign would inform residents on how to water for optimum plant and grass health. CBU will also consider providing conservation-themed workshops for the general public, such as building rain barrels or planting rain gardens.

The need for public education was discussed during many of the stakeholder meetings. There are many opportunities for CBU to work with existing community organizations, leveraging their resources to reach more members of the community. Organizations such as the Chamber of Commerce, Housing and Neighborhood Development, Indiana University, Bloomington Parks & Recreation Department, People's University, and the Association of Churches have existing programs and membership that would make them good partners in implementing education efforts related to water conservation.

During drought periods, CBU will post Monroe Reservoir's water level in the local newspaper, The Herald Times. Publishing the reservoir level brings awareness to the issue of drought and it becomes a regular reminder to the public of existing drought conditions and the need to use water wisely.

Primary and secondary school programs

Phase 1 Goals 1, 2 Customers: Grade school students

CBU staff will work in the Bloomington elementary schools to educate students about water conservation issues. Depending on the availability of staff, CBU will either develop a curriculum or modify a pre-packaged curriculum. In addition to in-class activities, students will receive take-home materials they can share with their family.

Education programs should not be evaluated based on cost-effectiveness because teasing out how students apply what they have learned in the classroom prevents an accurate measurement of water savings. However, most cities with a school program consider it an integral component for educating children and adults and developing a community conservation ethic.

Water conservation billing information

Phase 1 Goals 1, 2 Customers: RSF, RMF, COMM, IND

This conservation measure includes a short-term and long- term component. In the short term, CBU will include conservation messages on customer bills. These messages will remind customers to check for leaking faucets and toilets or provide tips on reducing indoor and outdoor water use. In the long term, CBU will redevelop its billing and GIS system in order to track water use by neighborhoods. By doing this, CBU will be able to provide customers with their use and compare it to the high, low, and average water use of the customer's neighbors. Comparing customers with their peers has been an effective measure for energy utilities for reducing energy use.

Water conservation information on utility website

Phase 1 Goals 1, 2 Customers: RSF, RMF, COMM, IND

CBU's website has the potential to be an important source of water conservation information for customers. CBU will expand its website to include information on indoor and outdoor water savings, water efficient fixtures, proper lawn watering, and information on building and using rain barrels. CBU may also provide links to other conservation sites (e.g., the U.S. EPA's WaterSense Program) and organizations that promote landscaping with native plants and rain gardens.

End-of-season notices to turn off automatic irrigation systems to all customers

Phase 1 Goal 1 Customers: RSF, RMF, COMM, IND

At the beginning of October, CBU will send all customers a reminder to turn off their automatic irrigation systems until next summer. By the end of October, lawn watering is no longer necessary as the first frost has typically occurred and grass begins preparing for winter dormancy. CBU may post the reminder on its website, include it as a bill message or bill insert, or send a reminder letter to users. Not all CBU customers use automatic irrigation systems; however, the notice will remind all customers who water their lawns to reduce watering in preparation for winter.

Peak day notification to large users

Phase 2 Goal 1 Customers: COMM, IND

CBU will work towards establishing triggers for sending large water users notification of upcoming dates of forecasted peak day water use. The notifications will alert large water users and prompt them to shift water intensive activities to a later time of day. The notification letters would not ask large users to forgo a specific activity on the forecasted

peak day, but rather to adjust their water use schedule for that day. Such cooperation would help CBU reduce its peak day production.

6.4.3. Government regulation

Water waste ordinance

Phase 1 Goal 1 Customers: RSF, RMF, COMM, IND

A waste water ordinance defines CBU and the City of Bloomington's position on wasting water. The ordinance may include

- prohibiting direct watering of impervious surfaces;
- prohibiting excessive lawn watering to the extent that excess water is running off into storm drains;
- prohibiting washing of hard surfaces;
- prohibiting non-recirculating fountains;
- requiring customer leaks to be fixed within a specified period of time; and
- requiring car washes to recycle water.

The purpose of the ordinance is to limit the waste of potable water. The amount of water saved by the ordinance will depend on the extent of enforcement by the City.

Adopt efficiency standards for new development that augment existing plumbing codes

Phase 2 Goal 1 Customers: RSF, RMF, COMM, IND

The Indiana 1997 Uniform Plumbing Code does not require installation of the most water efficient fixtures and appliances in new homes and buildings. It is recommended that CBU work with the City of Bloomington to adopt additional requirements based on U.S. EPA WaterSense fixture and appliance specifications. New homes built using the efficient specifications can use up to 20 percent less water than homes built using conventional standards (U.S. EPA, 2009). CBU may refer to the Green Building Council's LEED certification requirements or the Miami-Dade County Water-Use Efficiency Standards Manual for developing the new standards (Miami-Dade County, 2009). The new standards will affect all customer classes (RSF, RMF, COM, and IND) and indoor and outdoor water use.

Toilet retrofit on resale ordinance

Phase 2 Goal 1 Customers: RSF, RMF

The 1992 Energy Policy Act set uniform water efficiency standards for showerheads, faucets, urinals, and toilets manufactured after January 1994. Therefore CBU will work

with the City of Bloomington to develop an ordinance requiring RSF and RMF customers with homes or apartments built before 1994 to upgrade their toilets to high-efficiency toilets upon selling their home or rental unit(s).

Such an ordinance is relevant to CBU because approximately 76 percent of Bloomington's housing units were built prior to 1994 (2005-2007 American Community Survey). Toilets in homes built before 1994 use between 3.5 and 7 (gpf). Toilets manufactured after January 1994 use 1.6 gpf. Low-flow toilet performance has improved significantly due to innovative bowl and flushing designs, rendering them better than many of the conventional fixtures they replace (Vickers, 2001).

Submetering of a new multi-family units ordinance

Phase 2 Goal 1 Customers: RMF

It is recommended that CBU develop an ordinance requiring submetering of all new multi-family units. Many of the multi-family units in Bloomington are master metered, meaning the tenant's monthly water bill is included in the rent and he/she is not directly financially responsible for the amount of water used each month. One reason for master metering apartments is convenience; it is easier for CBU to read one master meter than numerous submeters in an apartment complex. Requiring automatic meter reading (AMR) meters on all new multi-family units will reduce the time CBU would have to invest in reading all metered units, and alert costumers of their monthly water use. In addition to tenants learning their monthly water use, they will be more cognizant of any abnormal monthly use that may be caused by a leak. Leaks in master metered units are likely to go undetected because tenants are unaware of their use.

This ordinance would directly affect new multi-family units. To evaluate expanding the program to existing units, CBU will need to work with property owners to assess the practicality of submetering. Submetering existing multi-family units would produce greater water savings and could be part of the CBU's meter testing and replacement program.

Irrigation system requirements for new development

Phase 2 Goal 1 Customers: RSF, RMF, COMM, IND

CBU will develop an ordinance that sets specific requirements for irrigation systems in new residential and non-residential development. The ordinance may include the following items:

- Require high tech irrigation controllers such as evapotranspiration controllers and soil moisture content controllers for all automatic irrigation systems installed after a certain date.
- Require irrigation systems to be installed by U.S. EPA WaterSense certified landscape irrigation professional. The U.S. EPA estimates a household could reduce water used for irrigation by 15 percent by hiring a WaterSense certified irrigation professional to install and perform regular maintenance on the irrigation system.
- Require new development to have an irrigation meter because separate meters will allow CBU to bill outdoor water use at tiered rate structure different from that used for indoor water use. Also, customers will know how much of their consumption is used indoors and outdoors.
- Require homeowners to obtain a permit and pay a fee ($250) for installing an irrigation system. The fee could be either a fixed amount or based on the size of the irrigation system.

The purpose of irrigation requirements for new development is to reduce the wasteful use of potable water for lawn watering.

6.4.4. Economic incentives

Conservation pricing

Phase 1 Goal 1 Customers: RSF, RMF, COMM, IND, WD

Currently, the CBU's water rate is a uniform rate that varies among the different customer classes. Uniform rates do not fully discourage water waste because each unit of use is priced exactly the same. Lawn watering, the largest component of outdoor water use, drives peak demand and requires utilities to invest significant amounts of capital to meet peak summer demands. Customers that do not use water for irrigation and/or do not have irrigation meters may pay for infrastructure capacity increases that are not driven by their use. CBU's irrigation rate is less than the residential rate and no wastewater charges are assessed for irrigation use.

CBU will consider changing to a conservation oriented structure such as an increasing block rate or to summer surcharges. Increasing block rates (IBR) refer to rates where with an increase in consumption, the price of water increases. IBR is an obvious conservation rate because discretionary use is charged a higher rate which may lead to decreased consumption when customers understand that higher costs are associated with increased consumption. The direct connection of price to consumption is easily understood by customers. Seasonal rates indicate to the customer that water is limited during the hot, dry period of the year. These rates are usually used to discourage inefficient outdoor use.

Seasonal rates can be justified due to seasonal demand; peak demands, not average demands, dictate the amount of infrastructure capacity required to provide safe, reliable water to customers. Seasonal rates could lead to more efficient use of existing capacity. Additionally, these rates may be more affordable for lower-income customers that generally use only the "lifeline" amount of water.

A low income home leak detection and repair program

Phase 1 Goal 1 Customers: RSF

CBU's low income leak detection and repair program will target homeowners whose annual income falls within a certain range and own a home built before 1994. A technician will locate and fix leaks within the home. For severe toilet leaks, a plumber will be made available free of cost to the homeowner. In addition to leak detection, the technician will replace inefficient hardware such as showerheads, faucet aerators, and install water displacement bags in toilets using more than 1.6 gallons per flush (gpf). The repairs and upgrades will help families reduce their annual bill by $42 per year (please see Appendix D for the cost calculation) by reducing unnecessary water use and loss.

CBU's home leak detection and repair program could become an extension of the Housing and Neighborhood Development's (HAND) Owner Occupied Rehabilitation Program. The rehabilitation program provides loans to eligible homeowners for home improvements. CBU will work with HAND to develop the program.

Rain sensor rebate

Phase 2 Goal 1 Customers: RSF, RMF, COMM, IND, WD

A rain sensor is a shut-off device that interrupts an automatic irrigation system's run cycle when a specific amount of rainfall has occurred. A properly working sensor eliminates unnecessary watering in the rain. Rain sensors are inexpensive, ranging from $20 to $30 for wired sensors and $50 to $75 for wireless sensors. They may be installed by the homeowner or a contractor. Each year, CBU will consider providing 100 customers who have an automatic irrigation system with a $10-$15 rebate. The rain sensor will save a homeowner approximately $43 per year (please see Appendix D for calculations). In addition to the rebate, CBU will include guidelines on the proper sensor settings. The rebate could be part of a public education campaign on lawn watering.

6.4.5. Alternative water supply

Alternative water supply

Phase 3 Goals 1, 3 Customers: City government, IND, COM

CBU has a unique opportunity to develop an alternative water supply for non-potable water needs, and to take a leap forward in sustainable water management. Existing infrastructure that could be reused and potential customers for non-potable water for irrigation and cooling are located in close proximity to each other. The Griffy Lake water treatment plant (WTP) was decommissioned in 1996. The pipelines previously used to deliver water from Griffy Lake WTP to the City are still in service, but are oversized for their current use. Decommissioned pipeline infrastructure exists between the Griffy WTP and Blucher Poole wastewater treatment plant (WWTP). Cascades Golf Course, and IU athletic fields and golf course are closest and would require the least infrastructure to serve. Together these initial customers have an average annual irrigation demand of 15,000,000 gallons. Their use occurs during peak demands, when loads are greatest on the Monroe WTP. During peak summer months, these demands are expected to exceed 0.5 million gallons per day (MGD). Demand will increase as additional customers are added to the system and their irrigation and cooling demands are replaced with non-potable water. The concept for the system and possible costs are described in greater detail in Appendix G.

The conservation measures described above will achieve CBU's four conservation goals by targeting CBU and its customer's water use. The most effective approach to implementing the measures is to use a three phase program. The timeline for implementation is discussed in Chapter 8.

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7. Modified Demand Forecasts

CBU's historical water use has been influenced by many factors including climate, population, economic conditions, and general efficiency improvements in customer water use. Future water use will be greatly influenced by changes in these factors. Additionally, the recommended conservation measures are projected to achieve various levels of future water savings as they are fully implemented. In order to project the relative water savings achieved through conservation, WHPA used regression modeling to estimate a baseline of future use based on the relationships of historical water use to various factors. The estimated savings achieved through conservation and other system efficiencies are then compared to baseline projections.

7.1. Future Use without Conservation

The first step in establishing a baseline of future water use was to understand how historical water consumption related to different explanatory variables. Explanatory variables are factors that impact how water is used by different classes of water customers within the community. While some of the variables are common to all classes, such as climate and price, others are specific to individual classes, such as percent of total manufacturing employment in the commercial class. The monthly historical water use data (April, 2002 to November, 2007) was obtained from CBU's billing department and the explanatory variables were obtained from various federal, state, and local agencies (see Appendix E for a complete description of variables analyzed and the multiple regression modeling). A multiple regression model was developed for each of the six user classes. Separate models were developed for each class in order to select the best explanatory variables that relate to how each class of customers uses water.

After establishing this mathematical relationship between water consumption and explanatory variables, WHPA estimated a baseline projection of future water use. Projections for the explanatory variables were obtained from official sources (i.e., U.S. Census Bureau) or developed based upon assumptions. Where projections were unavailable, historical trends for some explanatory variables were assumed to continue. Weather variables were assigned future values based are climatic normals rather than projections of weather. Future climate change and drought were not considered in the projections. The calculated future water use for each customer class represents an estimate of average use for the forecast year.

The historical data used as the basis to project future use was available only from April, 2002 to November, 2007, less than a six year time period. Since the projections are estimated out to 2030, a 20 year time period, the projections are less reliable the further into the future the estimates go because they are based on only 6 years of data. Note that use increases more rapidly from 2020 to 2030 than in 2010 or 2015; this is due, in part, to using only 6 years of data to project 20 years of use. While this is not an ideal situation, it was the data that was available for analysis. This also underscores the need to collect data that can be used in the future to both project demands and to

estimate savings from conservation. Additionally, the estimates of future use should be revised in five years using the longer dataset that will be available.

Based upon the mathematical relationships that were developed through the regression modeling, it is projected that without conservation, the total annual water consumption by CBU customers will increase by 25 percent from 2005 to 2030 (Table 15). Each individual class contributes differently to the total amount of water use in the future, and different assumptions were made to arrive at the future use of each class. The assumptions that relate to each individual user class model are included in Appendix E. The assumptions used for estimating future use do not include advances in technology or changes to efficiency standards which would increase water use efficiency in the future. The impact on water use of changes to standards has been significant in the past, and future changes could be equally significant.

Table 15. Estimates of future water use without conservation

Year	Total Consumption (MG/Yr)	Water Losses (MG/Yr)	Treatment Process Use (MG/Yr)	Total Production (MG/Yr)
2005	4,302	666	149	4,968
2010	4,398	681	152	5,079
2015	4,496	696	156	5,192
2020	4,677	724	162	5,400
2025	4,952	766	172	5,717
2030	5,376	832	186	6,208

Estimates of water that is lost to leakage (non-revenue water) and used in the water treatment process must be added to consumption to estimate the total quantity of water that must be withdrawn from Lake Monroe and produced. For the baseline projections of future water use, non-revenue water was estimated to be 13.4 percent, the average from 2002 to 2007. Treatment process use was estimated to be 3 percent, based on 2007 production data. Since these estimates are based on consumption and are held constant throughout time, the percent increase in total production remains at 25 percent while the actual amount increases.

7.2. Future Use with Conservation

To understand the impact of implementing conservation measures on future water use, WHPA adjusted the baseline forecast by the estimated annual savings for the recommended measures. The water savings for some conservation measures are difficult to quantify (i.e., education is expected to reduce use but the timing and the amount are not easily determined). As such, reductions in water use are not estimated for these measures. However, it is possible to estimate anticipated annual water savings for most of the recommended measures. The water savings calculations and associated assumptions are included in Appendix D. Water savings from each recommended measure is included in the year nearest its implementation date.

With the implementation of the recommended conservation measures, it is projected that as the population served by CBU grows, annual water use will increase by 17 percent. In comparison, annual water use is projected to increase by 25 percent without conservation. These estimated savings will be recognized over the course of the conservation program (2010-2030). Figure 29 shows the estimated water consumption and water losses with and without conservation. The

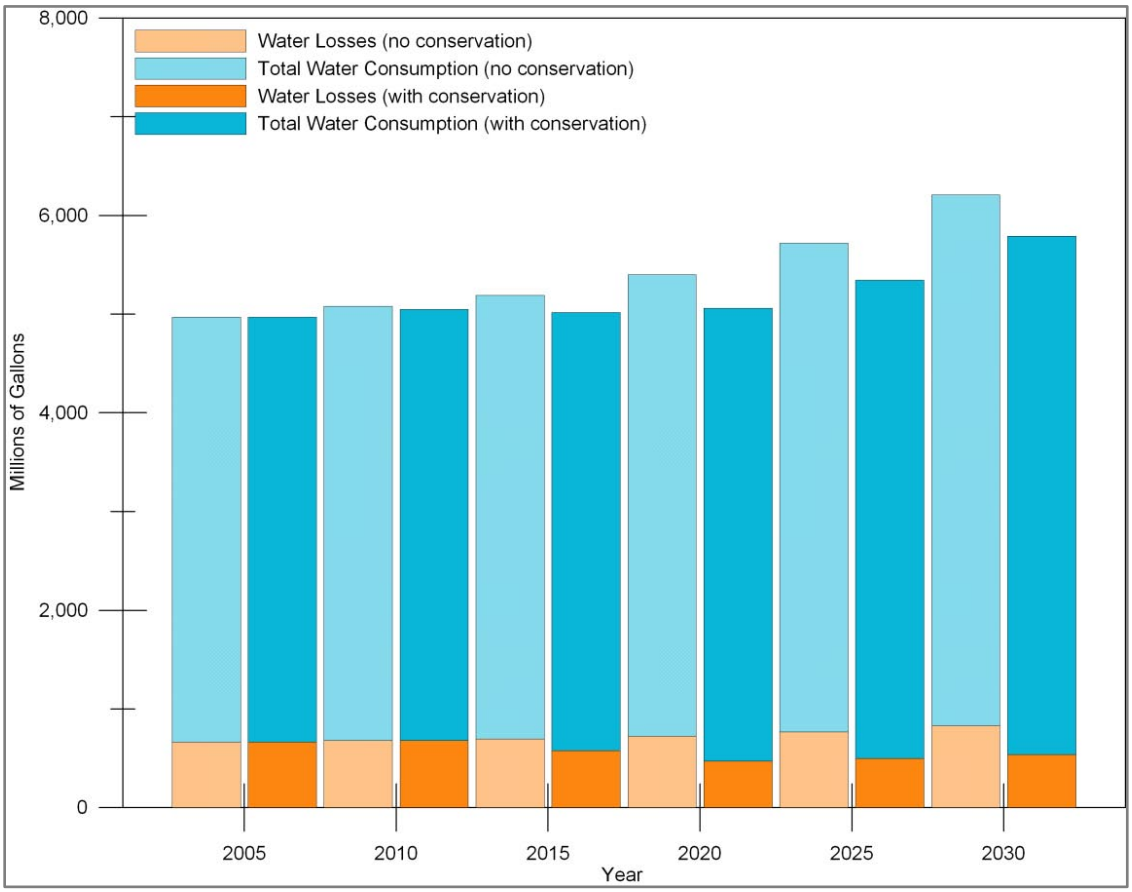

Figure 29. Estimated water consumption and water losses with and without conservation

estimates of water savings are conservative in the assumptions used for their calculation. With effective implementation, actual savings may be higher.

When considering the water savings, it is important to note that the savings are presented on an annual basis. While most of the recommended conservation measures provide savings consistently year round, the water savings for some of the measures will be realized primarily during months of peak use. For example, a conservation pricing structure will have more of an impact during months of high water use for irrigation and other outdoor uses. The bulk of the annual savings for this type of measure will occur over a period of three to four months during the summer. As a result, the water savings during these peak months will be greater than the estimated annual savings would suggest.

8. Implementation Plan

The measures outlined in this report will be implemented over the next 10 years (2010 to 2020) in 3 phases. Table 16 summarizes the three phases of the conservation program. New measures will be implemented in each phase and measures from previous phases that are ongoing will carry over into Phase II and III.

Phase I – First steps: tracking use and beginning the conservation program with the community. These measures primarily focus on community education, as the success of a conservation program depends on community awareness and involvement. In addition to education, the City of Bloomington will begin its annual water audit to lead the community in reducing use.

Phase II – Education and regulation. Community education is still a predominate component of Phase II; however, new measures targeting government regulations also will be implemented. These measures will ensure that new development uses water efficiently and that existing development begins to reduce its water use as well. CBU and the City of Bloomington will work with Monroe County Government to create a CBU service area overlay district so that water conservation ordinances apply to all CBU customers, not just City of Bloomington residents.

Phase III – Alternative supply and reducing loss. Two new measures are introduced in Phase III – the alternative water supply and replacement of old meters with automatic metering reading technology. These measures are expensive and will take longer to plan and implement.

Implementation of Phases II and III is contingent upon the performance of Phase I measures. Consequently, the remainder of this chapter focuses on Phase I measures. Implementation of Phase II and III measures will be addressed at the end of the Phase I period.

8.1. Extending Conservation to Wholesale Districts

CBU provides water to 9 wholesale districts (WD) within Monroe County, one of which serves Nashville, IN. The success of CBU's conservation plan depends not only on the efforts of CBU and its service area customers, but also on the wholesale districts and their customers. Consequently, it will be important for CBU to work collaboratively with the WD to encourage conservation. Several different methods are available for CBU to use:

- Price – WDs currently have various rate structures, including declining block rates. The WDs should consider modifications to their rate structures that would encourage water conservation.
- Contracts – As water purchase agreements come up for renewal, CBU can work with the WDs to incorporate appropriate terms consistent with water conservation and efficiency goals.

- Metering – CBU can consider upgrading wholesale customer metering equipment to better evaluate peak use.
- Education – CBU can work with individual WDs on how to use water more efficiently using demand-side or supply-side measures. The WDs would implement the supply-side measures and work with their customers to reduce customer use.
- Ordinances – CBU will work with the City of Bloomington to pass several conservation ordinances. CBU could also coordinate with the WD and Monroe County Government to develop similar ordinances in the incorporated areas and Monroe County.
- Monitoring and Evaluation – CBU and the WDs will work to share water use information for purposes of evaluating trends in per capita use and water conservation efforts.

A first step in engaging the WD in conservation efforts could be a memorandum of understanding (MOU) that acknowledges the existing conservation plan and lays out a timeline for the WD to begin conservation efforts.

8.2. Required Resources

Table 17 summarizes the time line and estimated budget for carrying out Phase I.

8.3. Monitoring and Evaluation

The City of Bloomington's conservation plan will evolve over time and must be evaluated annually and refined based on its cost-effectiveness and how well it is achieving the plan's goals. The measures and goals stated in this report are based on current information, and the specifics of this plan may change as the City of Bloomington grows and technology and customer preferences change.

The AWWA (2007) recommends collecting and monitoring four types of data for evaluating the program.

1. Water use data before, during, and after implementation of a measure.
2. Program performance and whether it is achieving its goals.
3. Program action costs in order to compare actual costs to planned costs.
4. Customer reception and feedback.

Accurate and easily attainable program data and consumption data is critical for the evaluating the impact of the conservation measures on water use. CBU's conservation coordinator will be in charge of collecting and evaluating the program data and preparing an annual report to the Utility Service Board.

8.4. Updating and Revising the Conservation Plan

CBU will revise the conservation plan five years after implementation. This revision is different from the annual evaluation of conservation measures because it will involve reassessing water use in Bloomington based on the previous five years of data and determining whether the conservation measures recommended in Phase II and III remain relevant. Also, customer water rates are scheduled to increase in the next year and the impact of the increase on water use should be evident by the time the plan is revisited.

8.5 Reliable Supply of Lake Monroe

Lake Monroe is dedicated to multiple purposes and its operation and use are subject to many contracts and agreements between the United States Government, State of Indiana, U.S Army Corps of Engineers, and multiple users in addition to CBU. At the time of the reservoir's construction, the safe yield of the reservoir was estimated based on a design drought of 1940-41. On the basis of the 1940-41 design drought and the terms of the contracts governing the allocation of the reservoir, a portion of the safe yield allocated to withdrawals for CBU and others was estimated at 30.5 mgd. The estimate of the safe yield available to CBU depends on the selection of the design drought and on the quantity and priority of withdrawals by all authorized users. The potential limits to available supply for CBU during periods of drought are in reality more severe than is apparent.

It is recommended that CBU assess the safe yield of the reservoir based on updated climate data and anticipated effects of climate change. It is also recommended that CBU assess the current allocation of the reservoir with respect to the safe yield, and take any necessary measures to clarify priority of access to water withdrawals during periods of drought.

Table 16. Recommended conservation measures for each phase of the conservation program

Phase 1
Utility water audit
Hire water conservation coordinator
Utility leak detection and repair program
End-of-season notices to turn off automatic irrigation systems
Water conservation information on utility website
Public education campaign
Basic water conservation billing information (bill messages)
Primary and secondary school programs
Low income home leak detection and repair program
Conservation pricing
City government water use audit
Water waste ordinance
Phase 2
Utility water audit
Utility leak detection and repair program
End-of-season notices to turn off automatic irrigation systems
Water conservation information on utility website
Public education campaign
Basic water conservation billing information (bill messages)
Primary and secondary school programs
Meter testing and repair program (accuracy and size testing)
Irrigation system requirements for new development
Advanced water conservation billing information (neighborhood comparisons)
Rain sensor rebate
Toilet retrofit on resale ordinance
Adopt efficiency standards for new development that augment existing plumbing codes
Ordinance requiring all new multi-family units to be submetered
Alternative water supply planning
Phase 3
Utility water audit

Phase 3 cont.
Utility leak detection and repair program
End-of-season notices to turn off automatic irrigation systems
Water conservation information on utility website
Public education campaign
Primary and secondary school programs
Advanced water conservation billing information (neighborhood comparisons)
Peak day notification letters to large users
Alternative water supply development
Meter testing and replacement (automatic meter reading)

Table 17. Phase I measures, costs, and actions

Measures	Cost ($)	Action
Annual utility water audit	-	Complete an annual system audit
Hire conservation coordinator	Salary	Develop position description and advertise for position in 2009
Utility leak detection and repair program	10,000	Use data from the water audit to asses leak repair; develop program of regular leak detection
End-of-season notices to turn off automatic irrigation systems	-	Send out reminders in October
Water conservation information on utility website	-	Develop website and collect information and resources on water conservation
Public education campaign	10,000	Develop a campaign for introducing Bloomington to conservation
Basic water conservation billing information (bill messages)	-	Include conservation messages on bills
Primary and secondary school programs	7,500	Develop classroom material and contact schools about class visits
Low income home leak detection and repair program	12,000	Work with HAND to develop and promote program
Conservation pricing	-	Assess the feasibility of conservation pricing
Municipal water audit	1,000	Work with the City to carry out audit of City water use
Water waste ordinance	-	Develop and pass ordinance

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Glossary

The following definitions were taken from AWWA and the Alliance of Water Efficiency, unless otherwise noted (the source is in parentheses after definition).

Units of Measurement

gal	Gallons, 1 gallon = 0.134 cubic feet
gppd	Gallons per person per day
gpd	Gallons per day
gpf	Gallons per flush (of toilet or urinal)
gpm	Gallons per minute
MG	Million gallons
MGD	Millions of gallons per day
MG/yr	Millions of gallons per year

Acronyms

AWC	Average winter consumption
AWWA	American Water Works Association
CBU	City of Bloomington Utilities
COM	Commercial
EPA	Environmental Protection Agency (US Government)
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IND	Industrial
IU	Indiana University – Bloomington
IURC	Indiana Utility Regulatory Commission
O&M	Operation and Maintenance.
RMF	Residential multi-family
RSF	Residential single family
USACE	U.S. Army Corps of Engineers
USB	Utility Service Board
WD	Wholesale district
WTP	Water treatment plant
WWTP	Waste water treatment plant

Definition of Words and Phrases

Account: A connection to a water system, which is billed for service.

Alliance for Water Efficiency: A non-profit organization dedicated to the efficient and sustainable use of water. It serves as a North American advocate for water efficient products and programs, and provides information and assistance on water conservation efforts.

Arid climate: A climate characterized by less than 10 inches of annual precipitation.

Average day maximum month use or demand: The maximum month consumption divided by the number of days in the month.

Average length of customer service line*:* This is entered for unmetered services and in cold or other areas where meters are installed inside homes and buildings. It is the length of customer service line either between the utility's service connection (often at the curbstop) and the meter, or to the building line (first point of customer consumption) if customers are unmetered.

Average operating pressure: The average pressure may be approximated when compiling the preliminary water audit. Once routine water auditing has been established, a more accurate assessment of average pressure should be pursued.

Average-day use or demand: A water system's average daily use based on total annual water production divided by 365.

Avoided cost: The cost of an activity or facility that could be avoided by choosing an alternative course of action.

Backwash: The use of water to clean filters. Water under high-pressure is pumped in reverse through filters, removing trapped sediment and other material.

Best management practice (BMP): A practice or combination of practices established as the most practicable means of increasing water use efficiency.

Bill stuffer: An advertisement or notice included with a utility bill.

Billed metered: All metered consumption which is billed. This includes all groups of customers such as domestic, commercial, industrial or institutional. It does NOT include water sold to neighboring utilities (water exported) which is metered and billed.

Billed unmetered: All billed consumption which is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (for example billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering. It does NOT include water sold to neighboring utilities (water exported) which is unmetered but billed.

Billing cycle: The regular interval of time when customer's meters are read and bills are issued, generally every month (monthly) or two months (bi-monthly).

Billing period: The elapsed time between two specific consecutive meter reads for billing purposes.

Billing unit: The unit of measure used to bill customers, either 100 cubic feet (abbreviated HCF or CCF) or 1000 gallons (kgals).

Capita: Latin for 'person'.

Class: Customers having similar characteristics (commercial, residential single family, etc.) grouped together for billing or program purposes.

Climatic normal: The long-term average value of a meteorological parameter (i.e., temperature, humidity, etc.) for a certain area. For example, "temperatures are normal for this time of year" means that temperatures are at or near the average climatological value for the given date. Normals are usually taken from data averaged over a 30-year period (e.g., 1971-2000 average), and are concerned with the distribution of data within limits of common occurrence (National Oceanic and Atmospheric Administration).

Commercial (COM): All businesses not considered industrial. For the purposes of water use analysis, this user class does not include any Indiana University accounts. *See Industrial.* (City of Bloomington Utilities).

Conservation rate structure: A pricing structure billed by the quantity of commodity delivered and tied to the costs associated with that delivery, designed to provide an accurate price signal to the consumer. An increasing block rate structure, if the top tier equals the utility's marginal cost of new water, is one example of a conservation rate structure.

Consumption: See water use.

Consumptive use: Water use that permanently withdraws water from its source; water that is no longer available because it has evaporated, been transpired by plants, incorporated into products or crops, consumed by people or livestock, or otherwise removed from the immediate water environment (Vickers, 2001).

Cooling tower: A mechanical device that cools a circulating stream of water by evaporating a portion of it. A cooling tower is part of a system that provides air conditioning or equipment cooling. It usually includes a heat exchanger, recirculating water system, fans, drains, and make-up water supply.

Cost-effective: When the present value of benefits exceeds the present value of costs.

Cost-effectiveness: An analysis that compares the financial benefits of water savings to the costs needed to achieve those savings.

Costs: The resources needed for a course of action.

Customer class: A group of customers (residential, commercial, industrial, wholesale, and so on) defined by similar characteristics or patterns of water usage.

Customer metering inaccuracies: Apparent water losses caused by the collective under-registration of customer water meters. Many customer water meters will wear as large cumulative volumes of water are passed through them over time. This causes the meters to under-register.

Customer retail unit cost: The Customer Retail Unit Cost represents the charge that customers pay for water service.

Declining block rate: A commodity rate whose unit price decreases with increasing water use.

Dedicated metering: Metering of water service based on a single type of use, such as metering for landscape irrigation separately from interior domestic use.

Demand management: Measures, practices or incentives deployed by utilities to change the pattern of demand for a service by its customers or slow the rate of growth for that service.

Demand-side measures: In the water industry, programs which encourage customers to modify the amount or timing of water use. These measures may include encouraging customers to implement hardware or behavior changes, or change the volume or timing of their use, depending on the time of day or time of year.

Distribution facilities: Pipes, meters, storage, pumps and other facilities used to distribute water to end users.

Drought: An extended period of below-average precipitation resulting in a reduction of water in available storage that can result in a cutback in water service to customers.

Efficiency standard: A value or criteria that establishes target levels of water use for a particular activity.

Effluent: Something that flows out, such as wastewater, treated or untreated, that flows out of a wastewater treatment plant, sewer, or industrial outfall.

End use: A fixture, appliance, or other specific object or activity that uses water.

Evapotranspiration (ET): The quantity of water evaporated from soil surfaces and transpired by plants during a specific time.

Filtration: A water treatment process that involves water passing through sand or other media, where particles and other constituents are trapped and removed from the flow.

Fixed rate: Part of a utility bill that is not affected by consumption.

Flow rate: The rate at which a volume of water flows through pipes, valves, etc. in a given period of time. Often reported as cubic feet per second (cfs) or gallons-per-minute (gpm).

Graywater: Untreated (or lightly treated) domestic effluent, not including water from toilets or the kitchen, for use on the property in subsurface landscape irrigation.

Hardscape: Landscaping that does not permit water to seep into the ground, such as concrete, brick and lumber.

Inclining block rate: A commodity rate whose unit price increases with increasing water use.

Individual metering: The installation of meters for each individual dwelling unit as well as separate common area metering with the local water utility providing customer reading, billing, and collection services.

Industrial (IND): Any user of the City's wastewater collection or treatment system whose wastewater flow exceeds (1) 25,000 gallons per day, or (2) contributes a process waste stream which makes up five percent or more of the average dry weather hydraulic or organic (BOD<TSS) capacity of a treatment plant, or (3) whose flow contains toxic or nonconventional pollutants which must be routinely sampled and tested, or (4) has a reasonable potential, in the opinion of the USB or the Director of Utility to adversely affect the wastewater treatment system treatment plant (inhibition, pass-through of pollutants, sludge contamination, or endangerment of wastewater treatment system workers.) This definition is intended to include, but not be limited to any requirement of the Federal Pretreatment Guidelines as amended and/or adopted by the U.S. Congress and the U.S. Environmental Protection Agency from time to time (City of Blooming Utilities).

Inflation: The rate of change in a price index.

In-plant use: Water that is used for treatment operations.

Irrigated area: The portion of a landscape that requires supplemental irrigation, usually expressed in square feet or acres.

Irrigation controller: A mechanical or electronic clock that can be programmed to operate remote-control valves to control watering times.

Irrigation only accounts: Accounts with a separate meter dedicated to non-sewered uses such as landscape irrigation or cooling towers.

Leak detection: The procedure of pinpointing the exact location of leaks from water pipes and fittings.

Leak survey: The systematic process of listening for leaks in a distribution system.

Length of mains: Length of all pipelines (except service connections) in the system starting from the point of system input metering (for example at the outlet of the treatment plant).

Marginal cost: The additional cost incurred by supplying one more unit of water.

Master meter error adjustment: An estimate or measure of the degree of any inaccuracy that exists in the master meters measuring the volume from own sources.

Master meter: A single meter that measures utility usage for an entire property, or an entire building, which usually includes common areas.

Meter (water): An instrument for measuring and recording water volume.

Multiple regression: Method of determining the relationship between several independent or predictor variables and a dependent variable.

NAICS (formally SIC codes): North American Industry Classification System. A consolidation of the codes for the US, Canada, and Mexico. Produced by the US Office of Management and Budget.

Native and adopted plants: Plants indigenous to an area or from a similar climate that require little or no supplemental irrigation once established.

Non-potable water: Water that does not, or may not, meet drinking water quality standards.

Non-revenue water: In a distribution system water audit, non-revenue water equals the volume of unbilled authorized consumption (water for fire fighting, system flushing and similar uses) added to real losses and apparent losses.

Number of active and inactive service connections: Number of service connections, main to curb stop. Please note that this includes the actual number of distinct piping connections whether active or inactive. This may differ substantially from the number of customers (or number of accounts).

Operating pressure: Distribution system water pressure measured in pounds-per-square-inch (psi). Municipal systems are generally maintained between 50 and 80 psi.

Peak use: The maximum demand occurring in a given period, such as hourly or daily or annually.

Per capita residential use: Average daily water use (sales) to residential customers divided by population served.

Per capita use: Water use per person.

Potable water: Water that meets federal and state water quality standards for water supplied to utility customers.

Pounds-per-square-inch (psi): A unit measure of pressure. In this case, the pressure exerted by water in a distribution system.

Produced water: Water withdrawn from the supply source and treated.

Public service announcement (PSA): An inexpensive or free advertisement or message on mass media that serves the public good.

Rain shutoff device: A device connected to an irrigation controller that overrides scheduled irrigation when significant precipitation is detected.

Raw water: Untreated water.

Reclaimed water: Municipal wastewater effluent that is given additional treatment and distributed for reuse in certain applications. Also referred to as recycled water.

Residential multi-family (RMF): More than two units in a single building (City of Blooming Utilities).

Residential single family (RSF): One or two units in a single building (City of Blooming Utilities).

Retrofit on resale: A regulation that requires plumbing fixtures to be upgraded to current code at the time property is sold.

Retrofit: 1) Replacement of existing water using fixtures or appliances with new and more efficient ones. 2) Replacement of parts for a fixture or appliance to make the device more efficient.

Reuse: Use of treated municipal wastewater effluent for specific, direct, beneficial uses. See reclaimed water. Also used to describe water that is captured on-site and utilized in a new application.

Seasonal block rate: A commodity rate that is higher in the peak irrigation season than the off-peak season.

Secondary treatment: The second step in most wastewater treatment systems, which removes most of the oxygen-demanding substances (organics) and light suspended solids. Disinfection is often the final step of secondary treatment.

Service area (territory): The geographic area(s) served by a utility.

Submetering: The practice of using meters to measure master-metered utility consumption by individual users.

Supplied water: Water the utility delivers to its customers. It does not include water used for treatment operations.

Supply-side measures: Increasing water supply by developing more raw water, generally building reservoirs and canals or drilling groundwater wells.

Surface water: Water that remains on the earth's surface, in rivers, streams, lakes, or reservoirs.

System water audit: Quantifying all uses and sources of water within a distribution system and determining the amount of non-revenue water using water production and water sales records.

Systematic data handling errors: Apparent water losses caused by systematic data handling errors in the meter reading and billing system.

Total annual cost of operating water system: This cost includes operations, maintenance, and any annually incurred costs for long-term upkeep of the system such as repayment of capital bonds for infrastructure expansion or improvement. Typical costs include employee salaries and benefits, materials, equipment, insurance, fees, administrative costs and all other costs that exist to sustain the drinking water supply. These costs should not include systems outside of drinking water.

Unauthorized consumption: Includes water illegally withdrawn from hydrants, illegal connections, bypasses to consumption meter or meter reading equipment tampering.

Unbilled metered: Metered consumption which is for any reason unbilled. This might for example include metered consumption of the utility itself or water provided to institutions free of charge. It does NOT include water sold to neighboring utilities (water exported) which is metered but unbilled.

Unbilled unmetered: Any kind of authorized consumption which is neither billed nor metered. This component typically includes items such as fire fighting, flushing of mains and sewers, street cleaning, frost protection, etc. In most water utilities it is a small component which is very often substantially overestimated. It does NOT include water sold to neighboring utilities (water exported) which is unmetered and unbilled – an unlikely case.

Uniform block rate: A commodity rate that does not vary with the amount of water use.

Unmetered water: Supplied water that is not measured for accounting and billing purposes.

UPC (uniform plumbing code): The model plumbing code, prepared by International Association of Plumbing and Mechanical Officials, which the 22 Western States use as the basis for their State plumbing codes.

User class: Customers having similar characteristics (commercial, residential single family, etc) grouped together for billing or program purposes.

Variable production cost: The cost to produce and supply the next unit of water (e.g., $/million gallons).

Volume from own source: The volume of treated water input to system from own production facilities.

Wastewater: Effluent water from residences, businesses and other water users that contains contamination.

Water audit: 1) An on-site survey of an irrigation system or other water use setting to measure hardware and management efficiency and generate recommendations to improve its efficiency. 2) For water distribution systems, a thorough examination of the accuracy of water agency records and system control equipment to identify, quantify, and verify water and revenue losses.

Water conservation: The US Water Resources Council defines water conservation as activities designed to (1) reduce the demand for water, (2) improve efficiency in use and reduce losses and waste of water, and (3) improve land management practices to conserve water.

Water exported: Bulk water sold and conveyed out of the water distribution system. Typically this is water sold to a neighboring water utility.

Water imported: Bulk water purchased to become part of the water supplied. Typically this is water purchased from a neighboring water utility or regional water authority.

Water meter size: Normally corresponds to the pipe bore, for example 1". For some models a second designation refers to the matching pipe end connections. For example, a 5/8" x 3/4" meter has a nominal 5/8" and 3/4" straight pipe threads.

Water sales: Water deliveries that are metered and billed based on the quantity of use.

Water use efficiency: A measure of the amount of water used versus the minimum amount required to perform a specific task. In irrigation, the amount of water beneficially applied divided by the total water applied.

Water use: In a restrictive sense, water that is actually used for a specific purpose (end use) or by a particular customer group, such as residential, industrial, or agricultural users; in a broader sense, water use pertains to human interaction with and influence on the hydrologic cycle and includes elements such as water withdraw and delivery, consumptive use, wastewater release, wastewater reuse, return flows, and instream uses (Vickers, 2001).

Water waste: Water use that does not fulfill a purpose or need.

Water-efficient landscape: A landscape that minimizes water requirements and consumption through proper design, installation, and management.

Wholesale district (WD): Entities who buy water from CBU for resale to retail customers (City of Blooming Utilities).

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Appendix A. Water Audits

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In this appendix, an explanation of the data used in the water audits is given, the complete water audits are provided, and the infrastructure leakage index (ILI) guidelines are provided.

Water Audit Data

Provided below is an explanation of the data for each measured or estimated component of the water audit ("AWWA WLCC Water Audit Software: Definitions", by AWWA Water Loss Control Committee, 2006).

Volume from own source: This data came from CBU's pumping data. WHPA received pumping data for 1994 to 2007.

Master meter error adjustment: A 2.3 percent adjustment was made to each month's pumping data to correct for under-registering.

Water imported: CBU does not import water.

Water exported: CBU does not separate the water it sells to the wholesale customers from the water it sells to customers within the CBU service area.

Billed metered: The total yearly volume was calculated using CBU's billing data.

Billed unmetered: CBU meters all billed consumption. This category is not relevant to the CBU system.

Unbilled metered: CBU bills all metered water use. This category is not relevant to CBU system.

Unbilled unmetered: An estimated value for unbilled unmetered of 4.0 MG/Yr was applied to all years in the water audit. This value is based upon hydrant flushing data from ME Simpson, which ranged from 937,558 gallons in 2006 to 1,107,764 gallons in 2002. Water used for fire fighting was estimated to be around 3 millions gallons per year.

Unauthorized consumption: The AWWA Water Loss Control Committee (WLCC) (2006) recommends applying the default value of 0.25 percent of the volume from own sources because the volume of unauthorized consumption is typically low for utilities. Zero unauthorized consumption is not permitted because all water utilities have some volume of unauthorized consumption according to the AWWA (2006).

Customer metering inaccuracies: The AWWA WLCC (2006) recommends entering an estimated percentage for metering inaccuracies unless meter testing has been performed and a volume is known. One percent of unbilled metered and billed metered consumption was used to estimate metering inaccuracies for CBU. The percent was determined using information provided in an article on performing economic analysis for replacing residential meters (Yee, 1999). A value of zero was not applied because all metered systems have some degree of inaccuracy (AWWA Water Loss Control Committee, 2006).

Systematic data handling errors: Errors in meter reading and the billing system were left at zero because data was not available to estimate an amount.

Length of mains: CBU provided yearly data on the length of CBU mains.

Number of active and inactive service connections: The estimated number of service connections was provided by CBU.

Average length of customer service line: Customer service line applies to unmetered services and in areas where meters are installed inside homes and buildings (AWWA Water Loss Control Committee, 2006). This category is not relevant to CBU system.

Average operating pressure: An average pressure of 73.4 psi was used. This value was determined after meeting with CBU. It is an approximate value.

Total annual cost of operating water system: The cost value came from the operation and maintenance expense CBU reported in the Municipal Water Utility Annual Report submitted to the Indiana Utility Regulatory Commission.

Customer retail unit cost: The cost was calculated by dividing the annual operating revenue by the annual volume of total water supplied. Operating revenue was obtained from CBU's Municipal Water Utility Annual Report submitted to the Indiana Utility Regulatory Commission.

Variable production cost: This cost is the sum of CBU purchased power and chemicals divided by total water supplied. Power and chemical costs were obtained from CBU's Municipal Water Utility Annual Report submitted to the Indiana Utility Regulatory Commission.

Infrastructure Leakage Index Guidelines

AWWA WLCC Water Audit Software: Determining Water Loss Standing			
Once data has been entered into the Reporting Worksheet, the performance indicators are automatically calculated. How does a water utility operator know how well his or her system is performing? The AWWA Water Loss Control Committee provided the following table to assist water utilities in gauging an approximate Infrastructure Leakage Index (ILI) that is appropriate for their water system and local conditions. The lower the amount of leakage and real losses that exist in the system, then the lower the ILI value will be. Note: this table offers an approximate guideline for leakage reduction target-setting. The best means of setting such targets include performing an economic assessment of various loss control methods. However, this table is useful if such an assessment is not possible.			
General Guidelines for Setting a Target ILI (without doing a full economic analysis of leakage control options)			
Target ILI Range	Financial Considerations	Operational Considerations	Water Resources Considerations
<1.0	If the calculated ILI value is 1.0 or less, two possibilities exist: 1) leakage is maintained at low levels in a class with the top worldwide performers in leakage control or 2) a portion of the data may be flawed, causing losses to be greatly understated. The reason 2 is likely if a low ILI is calculated but extensive leakage control practices are not employed in the operations. In such cases it is beneficial to validate the data by performing field measurements to confirm the accuracy of production and customer meters, or to identify any other potential sources of error in the data.		
1.0 – 3.0	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulation or low ratepayer affordability.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.
>3.0-5.0	Water resources can be developed or purchased at reasonable expense; periodic water rate increase can be feasibly imposed and are tolerated by the customer population.	Existing water supply infrastructure capacity is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management, water conservation) are included in the long-term planning.
>5.0 -8.0	Cost to purchase or obtain/treat water is low, as are rates charged to customers.	Superior reliability, capacity and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Water resources are plentiful, reliable, and easily extracted.
>8.0	Although operational and financial considerations may allow a long-term ILI greater than 8.0, such a level of leakage is not an effective utilization of water as a resource. Setting a target level greater than 8.0 – other than as an incremental goal to a smaller long-term target – is discouraged.		

Note. Adapted from "AWWA WLCC Water Audit Software: Definitions", by AWWA Water Loss Control Committee, 2006.

Annual Water Audits

A water audit was performed for each year of the study period (2002-2007). Water audit calculations are based on 365 days of data. January and February of 2002 and December 2007 were not included in the consumption data because of incomplete information. The water audit calculations were corrected to account for the missing days of data.

Please use the following key to understand the colored cells and abbreviations in the audit.

	Value is entered by the user
	Value may be entered by the user
	Value is calculated based on input data
	The cell contains AWWA recommended default values
M	Measured value
E	Estimated value
D	Default value

AWWA WLCC Water Audit Software: Reporting Worksheet

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? Click to access definition

Water Audit Report for: City of Bloomington Utilities
Reporting Year: 2002

Please enter data in the white cells below. Where possible, metered values should be used; if metered values are unavailable please estimate a value. Indicate this

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Volume from own sources:	?	M	4,292.811	Million gallons (US)/yr (MG/Yr)
Master meter error adjustment:	?	E	98.730	under-registered MG/Yr
Water imported:	?	-	0.000	MG/Yr
Water exported:	?	-	0.000	MG/Yr
WATER SUPPLIED:			4,391.541	MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:	Value:
Billed metered:	?	M	3,714.920	MG/Yr		
Billed unmetered:	?	-	0.000	MG/Yr		
Unbilled metered:	?	-	0.000	MG/Yr		
Unbilled unmetered:	?	E	4.000	MG/Yr		4.000
AUTHORIZED CONSUMPTION:			3,718.920	MG/Yr		

Use buttons to select percentage **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption) 672.621 MG/Yr

Apparent Losses

					Pcnt:	Value:
Unauthorized consumption:	?	D	10.979	MG/Yr	0.25%	
Customer metering inaccuracies:	?	E	37.524	MG/Yr	1.00%	
Systematic data handling errors:	?	-	0.000	MG/Yr		
Apparent Losses:			48.503	MG/Yr		

Real Losses

Real Losses = (Water Losses - Apparent Losses): 624.118 MG/Yr

WATER LOSSES: 672.621 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 676.621 MG/Yr

SYSTEM DATA

Length of mains:	?	M	413.8	miles
Number of active AND inactive service connections:	?	E	23,339	
Connection density:			56	conn./mile main
Average length of customer service line:	?	-	0.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	E	73.4	psi

COST DATA

Total annual cost of operating water system:	?	M	**$5,249,308**	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	E	**$1.84**	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	?	M	**$240.08**	$/Million gallons

DATA REVIEW - Please review the following information and make changes above if necessary:

- Input values should be indicated as either measured or estimated. You have entered:
  5 as measured values
  6 as estimated values
  1 as default values
  If using a default value (purple cells), leave 'Measured or Estimated' cell blank

- Water Supplied Data: No problems identified
- Unbilled unmetered consumption: No problems identified
- Unauthorized consumption: No problems identified
- It is important to accurately measure the master meter - you have entered the measurement type as: measured
- Cost Data: No problmes identified

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	15.4%
Non-revenue water as percent by cost:	4.6%
Annual cost of Apparent Losses:	$89,246
Annual cost of Real Losses:	$149,836

Operational Efficiency Indicators

Apparent Losses per service connection per day:	6.79	gallons/connection/day
Real Losses per service connection per day*:	87.39	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	1.19	gallons/connection/day/psi
? Unavoidable Annual Real Losses (UARL):	128.91	million gallons/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	4.84	

* only the most applicable of these two indicators will be calculated

AWWA WLCC Water Audit Software: Reporting Worksheet

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Water Audit Report for: City of Bloomington
Reporting Year: 2003

Please enter data in the white cells below. Where possible, metered values should be used; if metered values are unavailable please estimate a value. Indicate this by selecting a choice from the gray box to the left, where M = measured (or accurately known value) and E = estimated.

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Volume from own sources:	?	M	4,876.519	Million gallons (US)/yr (MG/Yr)
Master meter error adjustment:	?	E	112.160	under-registered MG/Yr
Water imported:	?	-	0.000	MG/Yr
Water exported:	?	-	0.000	MG/Yr
WATER SUPPLIED:			4,988.679	MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:	Value:
Billed metered:	?	M	4,357.580	MG/Yr		
Billed unmetered:	?	-	0.000	MG/Yr		
Unbilled metered:	?	-	0.000	MG/Yr		
Unbilled unmetered:	?	E	4.000	MG/Yr		4.000
AUTHORIZED CONSUMPTION:			4,361.580	MG/Yr		

Use buttons to select percentage **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption) 627.099 MG/Yr

Apparent Losses

					Pcnt:	Value:
Unauthorized consumption:	?	D	12.472	MG/Yr	0.25%	
Customer metering inaccuracies:	?	E	44.016	MG/Yr	1.00%	
Systematic data handling errors:	?	-	0.000	MG/Yr		
Apparent Losses:			56.488	MG/Yr		

Real Losses

Real Losses = (Water Losses - Apparent Losses):			570.612	MG/Yr
WATER LOSSES:			627.099	MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 631.099 MG/Yr

SYSTEM DATA

Length of mains:	?	M	420.9	miles
Number of active AND inactive service connections:	?	E	23,874	
Connection density:			57	conn./mile main
Average length of customer service line:	?	-	0.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	E	73.4	psi

COST DATA

Total annual cost of operating water system:	?	M	$5,419,446	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	E	$1.92	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	?	M	$189.10	$/Million gallons

DATA REVIEW - Please review the following information and make changes above if necessary:

- Input values should be indicated as either measured or estimated. You have entered:
  - **5 as measured values**
  - **6 as estimated values**
  - **1 as default values**
  - **If using a default value (purple cells), leave 'Measured or Estimated' cell blank**
- Water Supplied Data: No problems identified
- Unbilled unmetered consumption: No problems identified
- Unauthorized consumption: No problems identified
- It is important to accurately measure the master meter - you have entered the measurement type as: measured
- Cost Data: No problems identified

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	12.7%
Non-revenue water as percent by cost:	4.0%
Annual cost of Apparent Losses:	$108,456
Annual cost of Real Losses:	$107,904

Operational Efficiency Indicators

Apparent Losses per service connection per day:	6.48	gallons/connection/day
Real Losses per service connection per day*:	65.48	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	0.89	gallons/connection/day/psi
? Unavoidable Annual Real Losses (UARL):	156.94	million gallons/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	3.64	

* only the most applicable of these two indicators will be calculated

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Water Audit Report for: City of Bloomington
Reporting Year: 2004

Please enter data in the white cells below. Where possible, metered values should be used; if metered values are unavailable please estimate a value. Indicate this by selecting a choice from the gray box to the left, where M = measured (or accurately known value) and E = estimated.

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Volume from own sources:	?	M	4,942.840	Million gallons (US)/yr (MG/Yr)
Master meter error adjustment:	?	E	113.685	under-registered MG/Yr
Water imported:	?	-	0.000	MG/Yr
Water exported:	?	-		MG/Yr
WATER SUPPLIED:			5,056.525	MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:	Value:
Billed metered:	?	M	4,327.902	MG/Yr		
Billed unmetered:	?	-	0.000	MG/Yr		
Unbilled metered:	?	-	0.000	MG/Yr		
Unbilled unmetered:	?	E	4.000	MG/Yr		4.000
AUTHORIZED CONSUMPTION:			4,331.902	MG/Yr		

Use buttons to select percentage **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption)

724.623 MG/Yr

Apparent Losses

					Pcnt:	Value:
Unauthorized consumption:	?	D	12.641	MG/Yr	0.25%	
Customer metering inaccuracies:	?	E	43.716	MG/Yr	1.00%	
Systematic data handling errors:	?	-	0.000	MG/Yr		
Apparent Losses:			56.357	MG/Yr		

Real Losses

Real Losses = (Water Losses - Apparent Losses):	668.266	MG/Yr
WATER LOSSES:	724.623	MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER:	728.623	MG/Yr

SYSTEM DATA

Length of mains:	?	M	428.6	miles
Number of active AND inactive service connections:	?	E	24,467	
Connection density:			57	conn./mile main
Average length of customer service line:	?	-	0.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	E	73.4	psi

COST DATA

Total annual cost of operating water system:	?	M	**$5,681,183**	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	E	**$1.79**	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	?	M	**$206.83**	$/Million gallons

DATA REVIEW - Please review the following information and make changes above if necessary:

- Input values should be indicated as either measured or estimated. You have entered:
  - **5 as measured values**
  - **6 as estimated values**
  - **1 as default values**
  - **If using a default value (purple cells), leave 'Measured or Estimated' cell blank**
- Water Supplied Data: No problems identified
- Unbilled unmetered consumption: No problems identified
- Unauthorized consumption: No problems identified
- It is important to accurately measure the master meter - you have entered the measurement type as: measured
- Cost Data: No problems identified

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	14.4%
Non-revenue water as percent by cost:	4.2%
Annual cost of Apparent Losses:	$100,880
Annual cost of Real Losses:	$138,217

Operational Efficiency Indicators

Apparent Losses per service connection per day:	6.31	gallons/connection/day
Real Losses per service connection per day*:	74.83	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	1.02	gallons/connection/day/psi
? Unavoidable Annual Real Losses (UARL):	160.45	million gallons/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	4.16	

* only the most applicable of these two indicators will be calculated

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Water Audit Report for: City of Bloomington
Reporting Year: 2005

Please enter data in the white cells below. Where possible, metered values should be used; if metered values are unavailable please estimate a value. Indicate this by selecting a choice from the gray box to the left, where M = measured (or accurately known value) and E = estimated.

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Volume from own sources:	?	M	4,769.309	Million gallons (US)/yr (MG/Yr)
Master meter error adjustment:	?	E	109.694	under-registered MG/Yr
Water imported:	?	-	0.000	MG/Yr
Water exported:	?	-	0.000	MG/Yr
WATER SUPPLIED:			4,879.003	MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:	Value:
Billed metered:	?	M	4,302.170	MG/Yr		
Billed unmetered:	?	-	0.000	MG/Yr		
Unbilled metered:	?	-	0.000	MG/Yr		
Unbilled unmetered:	?	E	4.000	MG/Yr		4.000
AUTHORIZED CONSUMPTION:			4,306.170	MG/Yr		

Use buttons to select percentage **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption) 572.833 MG/Yr

Apparent Losses

					Pcnt:	Value:
Unauthorized consumption:	?	D	12.198	MG/Yr	0.25%	
Customer metering inaccuracies:	?	E	43.456	MG/Yr	1.00%	
Systematic data handling errors:	?	-	0.000	MG/Yr		
Apparent Losses:			55.654	MG/Yr		

Real Losses

Real Losses = (Water Losses - Apparent Losses):			517.179	MG/Yr
WATER LOSSES:			572.833	MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 576.833 MG/Yr

SYSTEM DATA

Length of mains:	?	M	436.9	miles
Number of active AND inactive service connections:	?	E	25,051	
Connection density:			57	conn./mile main
Average length of customer service line:	?	-	0.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	E	73.4	psi

COST DATA

Total annual cost of operating water system:	?	M	$5,454,855	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	E	$1.92	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	?	M	$229.35	$/Million gallons

DATA REVIEW - Please review the following information and make changes above if necessary:

- Input values should be indicated as either measured or estimated. You have entered:
  - **5 as measured values**
  - **6 as estimated values**
  - **1 as default values**
  - **If using a default value (purple cells), leave 'Measured or Estimated' cell blank**
- Water Supplied Data: No problems identified
- Unbilled unmetered consumption: No problems identified
- Unauthorized consumption: No problems identified
- It is important to accurately measure the master meter - you have entered the measurement type as: measured
- Cost Data: No problems identified

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	11.8%
Non-revenue water as percent by cost:	4.2%
Annual cost of Apparent Losses:	$106,855
Annual cost of Real Losses:	$118,614

Operational Efficiency Indicators

Apparent Losses per service connection per day:	6.09	gallons/connection/day
Real Losses per service connection per day*:	56.56	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	0.77	gallons/connection/day/psi
? Unavoidable Annual Real Losses (UARL):	164.00	million gallons/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	3.15	

* only the most applicable of these two indicators will be calculated

AWWA WLCC Water Audit Software: Reporting Worksheet

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Water Audit Report for: City of Bloomington Utilities
Reporting Year: 2006

Please enter data in the white cells below. Where possible, metered values should be used; if metered values are unavailable please estimate a value. Indicate this by selecting a choice from the gray box to the left, where M = measured (or accurately known value) and E = estimated.

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Volume from own sources:	?	M	4,612.201	Million gallons (US)/yr (MG/Yr)
Master meter error adjustment:	?	E	106.081	under-registered MG/Yr
Water imported:	?	-	0.000	MG/Yr
Water exported:	?	-	0.000	MG/Yr
WATER SUPPLIED:			4,718.282	MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:	Value:
Billed metered:	?	M	4,140.810	MG/Yr		
Billed unmetered:	?	-	0.000	MG/Yr		
Unbilled metered:	?	-	0.000	MG/Yr		
Unbilled unmetered:	?	E	4.000	MG/Yr		4.000
AUTHORIZED CONSUMPTION:			4,144.810	MG/Yr		

Use buttons to select percentage **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption) 573.472 MG/Yr

Apparent Losses

					Pcnt:	Value:
Unauthorized consumption:	?	D	11.796	MG/Yr	0.25%	
Customer metering inaccuracies:	?	E	41.826	MG/Yr	1.00%	
Systematic data handling errors:	?	-	0.000	MG/Yr		
Apparent Losses:			53.622	MG/Yr		

Real Losses

Real Losses = (Water Losses - Apparent Losses): 519.850 MG/Yr

WATER LOSSES: 573.472 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 577.472 MG/Yr

SYSTEM DATA

Length of mains:	?	M	445.2	miles
Number of active AND inactive service connections:	?	E	25,538	
Connection density:			57	conn./mile main
Average length of customer service line:	?	-	0.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	E	73.4	psi

COST DATA

Total annual cost of operating water system:	?	M	$6,293,428	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	E	$2.10	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	?	M	$291.38	$/Million gallons

DATA REVIEW - Please review the following information and make changes above if necessary:

- Input values should be indicated as either measured or estimated. You have entered:
  - **5 as measured values**
  - **6 as estimated values**
  - **1 as default values**
  - **If using a default value (purple cells), leave 'Measured or Estimated' cell blank**
- Water Supplied Data: No problems identified
- Unbilled unmetered consumption: No problems identified
- Unauthorized consumption: No problems identified
- It is important to accurately measure the master meter - you have entered the measurement type as: measured
- Cost Data: No problems identified

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	12.2%
Non-revenue water as percent by cost:	4.2%
Annual cost of Apparent Losses:	$112,606
Annual cost of Real Losses:	$151,473

Operational Efficiency Indicators

Apparent Losses per service connection per day:	5.75	gallons/connection/day
Real Losses per service connection per day*:	55.77	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	0.76	gallons/connection/day/psi
? Unavoidable Annual Real Losses (UARL):	167.16	million gallons/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	3.11	

* only the most applicable of these two indicators will be calculated

AWWA WLCC Water Audit Software: Reporting Worksheet

Back to Instructions

WASv3.0

? Click to access definition

Water Audit Report for: City of Bloomington Utilities
Reporting Year: 2007

Please enter data in the white cells below. Where possible, metered values should be used; if metered values are unavailable please estimate a value. Indicate this

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

WATER SUPPLIED

Volume from own sources:	?	M	4,753.695	Million gallons (US)/yr (MG/Yr)
Master meter error adjustment:	?	E	109.335	under-registered MG/Yr
Water imported:	?	-	0.000	MG/Yr
Water exported:	?	-	0.000	MG/Yr
WATER SUPPLIED:			4,863.030	MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:	Value:
Billed metered:	?	M	4,175.120	MG/Yr		
Billed unmetered:	?	-	0.000	MG/Yr		
Unbilled metered:	?	-	0.000	MG/Yr		
Unbilled unmetered:	?	E	4.000	MG/Yr		4.000
AUTHORIZED CONSUMPTION:			4,179.120	MG/Yr		

Use buttons to select percentage **OR** value

WATER LOSSES (Water Supplied - Authorized Consumption) 683.910 MG/Yr

Apparent Losses

					Pcnt:	Value:
Unauthorized consumption:	?	D	12.158	MG/Yr	0.25%	
Customer metering inaccuracies:	?	E	42.173	MG/Yr	1.00%	
Systematic data handling errors:	?	-	0.000	MG/Yr		
Apparent Losses:			54.331	MG/Yr		

Real Losses

Real Losses = (Water Losses - Apparent Losses): 629.579 MG/Yr

WATER LOSSES: 683.910 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 687.910 MG/Yr

SYSTEM DATA

Length of mains:	?	M	449.6	miles
Number of active AND inactive service connections:	?	E	25,990	
Connection density:			58	conn./mile main
Average length of customer service line:	?	-	0.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	?	E	73.4	psi

COST DATA

Total annual cost of operating water system:	?	M	**$6,401,508**	$/Year
Customer retail unit cost (applied to Apparent Losses):	?	E	**$2.15**	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	?	M	**$325.18**	$/Million gallons

DATA REVIEW - Please review the following information and make changes above if necessary:

- Input values should be indicated as either measured or estimated. You have entered:
  - **5 as measured values**
  - **6 as estimated values**
  - **1 as default values**
  - **If using a default value (purple cells), leave 'Measured or Estimated' cell blank**
- Water Supplied Data: No problems identified
- Unbilled unmetered consumption: No problems identified
- Unauthorized consumption: No problems identified
- It is important to accurately measure the master meter - you have entered the measurement type as: measured
- Cost Data: No problmes identified

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	14.1%
Non-revenue water as percent by cost:	5.0%
Annual cost of Apparent Losses:	$116,811
Annual cost of Real Losses:	$204,725

Operational Efficiency Indicators

Apparent Losses per service connection per day:	5.73	gallons/connection/day
Real Losses per service connection per day*:	66.37	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	0.90	gallons/connection/day/psi
? Unavoidable Annual Real Losses (UARL):	169.61	million gallons/year
? Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	3.71	

* only the most applicable of these two indicators will be calculated

Appendix B. Detailed Demand Analysis

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Billing data quality control

The City of Bloomington Utilities (CBU) provided WHPA with non-aggregated monthly billing data from 2000-2001 and 2002-2007. The 2000-2001 data was retrieved from an older database no longer used by CBU. The 2002-2007 data was retrieved from CBU's current database. Routine quality control inspections involved plotting the data, analyzing the data distributions, inspecting for outliers, and comparison of monthly billing data with monthly production data.

Errors in the unprocessed billing data do not affect the finished billing data CBU uses to prepare monthly customer bills. However, idiosyncrasies in the unprocessed billing data prevented direct use of billing data. These idiosyncrasies were related to periods of missing data, periods when the meters were not read, and the need to omit certain special use meters called deduct meters. Deduct meters were either sewer deducts, water deducts, or both. An example of a deduct meter for both sewer and water would be the case where water passes through a customer's line to reach another customer. In this case the water and sewer charges for the water that passes through is deducted from the bill. Water only deduct meters are for water that originates from a different water source but is discharged to CBU's sewers. A sewer only deduct applies to water, such as irrigation water that is used by the customer but does not return to the sewer. Adjustments for deduct meters that are both water and sewer deducts, or water only deducts had been accounted for by CBU.

Because the water use meters are not read on a strict schedule, the time between meter readings varies. Also the actual water use associated with monthly billing is often not the water use for that month, or even the month before. Since the period of peak water use is of primary importance in determining the capacity needs for water treatment, it is desirable to match the billed water use as closely as possible to the actual period of use. Since meters are not read daily, the best approximation was found by re-sampling the billing data, assigning a portion of the total use for the billing period equally to each day of the billing period and then aggregating to a monthly use by class and subclass.

A set of computer codes were designed and implemented in the PYTHON® programming language to re-sample records of the unprocessed 2002-2007 billing data. The design of the computer code for re-sampling presented a number of obstacles. Some of the meters were read at regular intervals, with only an occasional missing reading. Other meters were read at regular intervals and were not read for long periods of time when out of use. The data structure was analyzed to determine a breakpoint between these two data types. Based on this analysis, WHPA implemented a rule which specified that if the period between two meter readings was less than or equal to 70 days, the water use would be spread out equally for the entire period between the two readings. If the period between the two meter readings was greater than 70 days, the water use was attributed to the 30 day period preceding the current meter reading. By implementing this rule, WHPA hoped to distinguish between the following two types of meters

- meters that were not read because of vacancies, such as summertime absence of students in single and multi-family residential housing, changes in restaurant ownership, etc; and

- meters that were not read but were in constant use, such as some Indiana University (IU) meters.

Before re-sampling, there was very poor correlation between monthly production data and billing data (Figure 1). After re-sampling, the correlation was greatly improved and certain months in which there were especially large or small gaps between production and billing were explored in detail, leading to additional detection and correction of erroneous values for water use as described previously (Figure 2).

Close collaboration with CBU's information manager was necessary to confirm these errors. Additional consultation with IU provided insight into erratic high values for some of its meters. The months of January and February 2002 and December 2007 were incomplete for all classes and so were not used in the analysis. Most errors that were detected were related to exceptionally large single family residential use (greater than 5 million gallons per month). These errors were attributed to errors in data entry and meter readings and errors related to meter turnover. In these cases the use for that month was omitted from the aggregated data. Since average single family monthly use is small relative to the total single family monthly use, WHPA chose not to substitute a hypothetical use for the omitted use for these 16 cases. These corrections represented a deduction of 9.8 million gallons from June 2003 single family consumption, 10 million gallons from June 2007 consumption, 109 million gallons from July 2007 consumption, and 30 million gallons from August 2007 consumption. Other errors in the billing data were related to negative use due to miscalculation of the meter reading differences. These negative values had been replaced with positive values in the data files by CBU, but not removed. Therefore WHPA removed these negative values from the billing data.

The data structure for 2000-2001 billing data differed from the 2002-2007 data and therefore required a different set of PYTHON® utilities and quality assurance measures. Because the data of the prior reading was not provided in the record of the current reading, it was necessary to sort the data by account number and meter and then by date, checking that the current meter reading for the previous record was the same as the previous meter reading for the current record. This check revealed more than 4000 records of this type, many occurring as a result of missing data for residential meters in February 2000. Because these missing data would skew the demand analysis and forecast, WHPA designed a PYTHON code to detect these missing values and calculate the use for the missing period based on the readings for the months before and after the missing records. Similar to the 20002-2007 billing data, the 2000-2001 billing data was screened to eliminate negative use and single family residential use greater than 5 million gallons.

Once the problems with missing readings were corrected, additional problems surfaced with idiosyncratic readings that did not resemble other readings from the same yoke and meter. This was particularly the case with readings on IU master meters during the month of December. The consumption for these readings was eliminated, since they were inconsistent with the rest of the readings for the meter.

Plots of monthly use by class were made for both the 2000-2001 billing data and the 2002-2007 billing data. In spite of efforts to clean and repair the 2000-2001 data, it was evident from inspection that the

two datasets were not comparable. This was particularly evident in comparing the IU master meter data and the multi-family residential data for the two time frames. In the 2000-2001 data, the IU master meter monthly consumption was between 20 and 60 million gallons per month, while the 2002-2007 IU master monthly consumption was between 40 and 80 million gallons per month. The multi-family consumption for the 2000-2001 data ranged between 5 and 10 million gallons per month, while the 2002-2007 multi-family consumption was mostly between 60 and 80 million gallons per month.

It is likely that these discrepancies are the result of a shift in the classification scheme. This shift is possibly a result of classifying some IU housing meters as part of the IU master class in the earlier years and classifying these meters as multi-family meters in the later years. Ultimately the numerous idiosyncrasies in the 2000-2001 data, coupled with the lack of detail in the 2000-2001 data, caused WHPA to drop these years from the analysis.

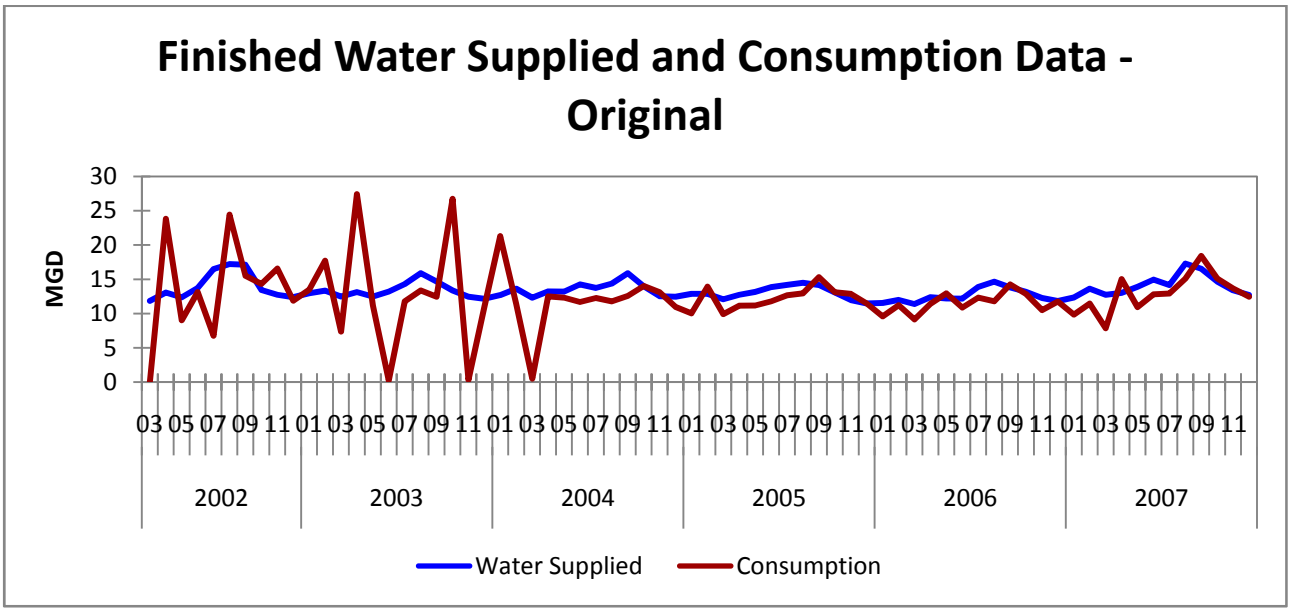

Figure 2. Comparison of original water supplied and consumption data obtained from City of Bloomington Utilities.

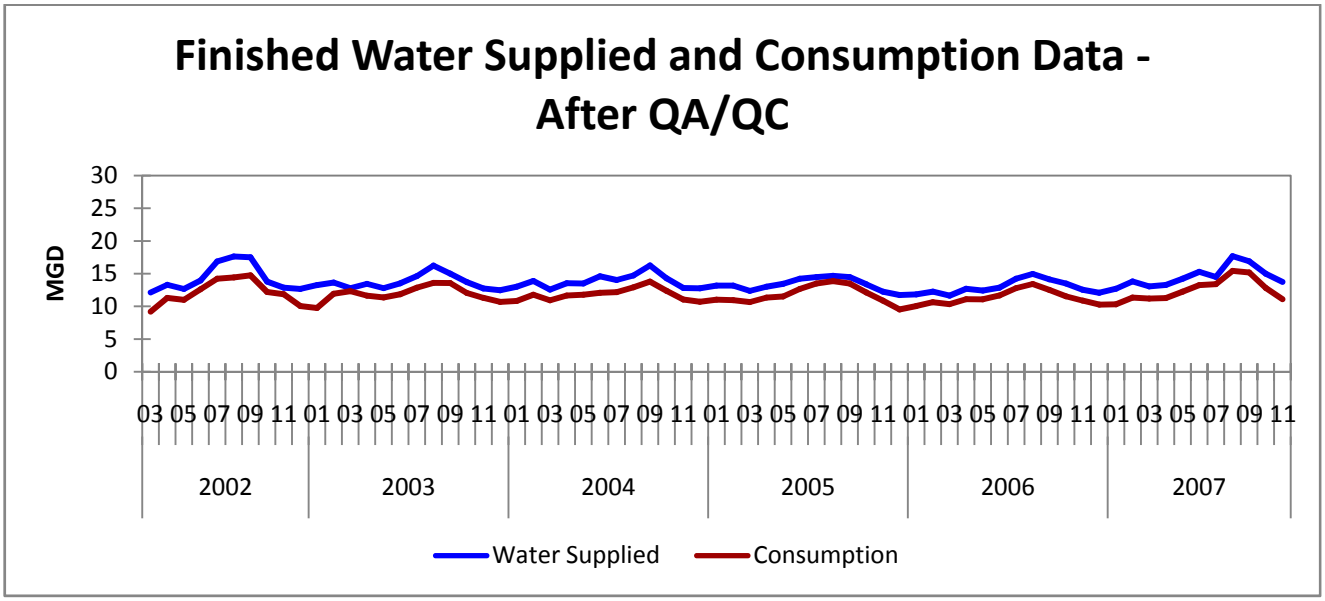

Figure 1. Comparison of finished water delivered and smoothed and corrected billed water data obtained from CBU.

Calculating Population Served by CBU

CBU sells water directly to all City of Bloomington residents and a portion of Monroe County residents, which is referred to as the CBU retail service area. Analyzing water use required estimating the CBU retail service area population and single family and multi-family populations from 2002 to 2007. Census data was unusable because of the mix of both city and county residents within the CBU retail service area. CBU serves approximately 22,000 customers; however, the number of customers is not the same as population because a customer refers to one account and not the number of people being served by that one account.

Several different approaches to calculating population exist. WHPA used known populations to calculate the unknown population (Table 1). To estimate the CBU retail service area and multi-family populations, WHPA used Monroe County population data from the American Community Survey 2005-2007 population data, and wholesale district's estimated population from the Indiana Department of Environmental Management's Public Water Supply database. While there are some areas in Monroe County that are not served either by CBU or the wholesale districts, these areas are not heavily populated and most likely the number of residents represent less than one percent of the population. Therefore, WHAP assumed that CBU provides water to all of Monroe County, either through direct service or through wholesalers.

Table 1 summarizes the data used for calculating the different populations. The CBU retail service area population was calculated by subtracting the Wholesale Districts' (WD) population from the Monroe County Population.

$P_{CBU} = P_{MC} - P_{WD.}$

Wholesale District customers live primarily in Monroe County, except for the Nashville Water Department, which serves Brown County residents. Adjustments were made to the wholesale population to reflect just Monroe County residents.

Table 1. Population data used in calculating per capita water use.

Population	Symbol	Description
Known Population		
Monroe County	P_{MC}	Data retrieved from 2002-2007 American Community Survey.
Wholesale Districts	P_{WD}	Data retrieved from the Indiana Department of Environmental Management's (IDEM) Public Water Supply Database.
Indiana University On-Campus Housing	P_{IU}	Data was provided by Indiana University.
Unknown Population		
Single Family	P_{SF}	Calculated using CBU account information and 2002-2007 American Community Survey persons per household data.
Multi-Family	P_{MF}	Calculated
CBU Service Area	P_{CBU}	Calculated

Single family population was estimated by multiplying the average number of active single family accounts (determined using CBU billing information) by 2.27 persons per household (American Community Survey). Once the single family population was estimated, multi-family population was calculated as:

$P_{MF} = P_{CBU} - P_{SF} - P_{IU.}$

Table 2 shows the calculated populations used in assessing customer water use.

Table 2. Calculated populations of City of Bloomington Utilities' customers

Category	2002	2003	2004	2005	2006	2007
Monroe County	121,722	123,166	124,385	125,428	127,306	128,643
Wholesale Districts	39,404	40,266	40,266	40,928	41,149	41,194
Indiana University On-Campus Housing	12,012	12,001	11,641	11,247	11,540	11,981
Single Family	36,004	36,231	37,332	38,023	38,470	39,108
Multi-Family	34,302	34,668	35,146	35,231	36,147	36,360
CBU Service Area	82,318	82,900	84,119	84,500	86,157	87,449

Appendix C. Stakeholder Process

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Summary of Stakeholder Process & Meetings

WHPA staff met with stakeholder groups to explain the water conservation planning process and to gather input for setting water conservation goals. WHPA staff explained that the conservation plan would include: 1) a water audit; 2) analysis of current use; 3) conservation goals; 4) conservation measures; 5) future demand; and 6) an implementation plan. The group was then asked to provide information regarding known current conservation practices, their ideas about conservation measures, and recommendations for conservation goals. Summarized below are the meetings attended by WHPA staff and the input provided by each group.

Environmental Commission (6/19/2008 and 7/17/2008)

Attendees:

Kelly Boatman - member
Phaedra Pezzulla - member
Laura Trout - member
Heather Reynolds - member
Kriste Lindberg - member
Tom McGlasson - member
Don Moore - member
Regina DiLavore - member
Linda Thompson - member
Mark Lemon – intern
Mike Litwin - member
Jacob Mazer - intern

Members of the Environmental Commission expressed an interest in protecting the water supply. At the meeting, the issue of more water storage was discussed. Two concerns related to increasing storage were lower water quality, and that storage offers too few benefits to be considered cost effective. Members also suggested bringing to the attention of the Indiana Utility Regulatory Commission the idea of a two-tier price rate structure for wholesalers and residential customers.

Water Panel at Monroe County Public Library (7/17/2008)

Attendees:

Jeff Ehman – Bloomington Utility Service Board
Pat Murphy – Director of Utilities, CBU
Jack Wittman – WHPA
Jim Allison – Retired IU professor
General public, approximately 25 members in attendance

The televised panel discussion was sponsored by the Center for Sustainable Living, Women's International League for Peace and Freedom, and Caldwell Center for Culture and Ecology, and was led by a panel consisting of Jeff Ehman, Pat Murphy, Jack Wittman, and Jim Allison. Panel members

initiated the discussion by speaking about water regulations in Bloomington, the plant expansion project, water conservation, and water rates.

Below is a list of discussion points and comments:

- A panel member explained that the purpose of a cost of service study is to help determine equitable rate structures for different consumer classes.
- In order to change water rates, the Bloomington Common Council develops an ordinance to set rates, which it then petitions to the IURC for approval.
- A comment was made regarding the necessity of considering the fixed income population when water rates increase due to the plant expansion.
- There was a request for equality of rate burden on CBU and Wholesale customers. This was followed by a comment that by implementing conservation pricing, rate-based reductions could buy time instead of undergoing plant expansion.
- A comment was made regarding the need for communication between the Utility Service Board and the mayor related to the plant expansion project.
- A panel member made a comment that conservation efforts are better late than never. They agreed that if we had started serious efforts 5 years ago on conservation, it might have deferred the need for a plant expansion.
- The question of if expanding the plant contributes to a diversified supply was raised by an attendee, and panel members responded that no, it does not.
- A panel member explained the benefit of expanding the plant would allow Bloomington to expand contract for withdrawals from Lake Monroe with DNR.
- A study conducted in 2007 suggested that Lake Monroe has the ability to meet the City's demand.
- One of the panel members commented that 85 gallons per customer per day is a reasonable consumption rate.
- A reference was made to the conservation efforts in Aurora, Colorado which produced a savings of 8% after the first year, and 26% during the second year.
- A comment was made by an attendee regarding apathy of community members and that only when it hits their pocket books do they show an interest in conservation efforts.
- An audience member made a request for increased public education on conservation measures.
- Mandatory water restriction was suggested as a possible conservation measure. A panel member reported that at the time of the meeting, it had not been brought before public.

Indiana University (8/19/2008)

Attendees:

Paul Sullivan – Co-Chair of Task Force on Sustainability
Hank Hewetson – Director, Physical Plant (Assistant Vice President for Facility Operations)
Mia Williams – Director of Landscape Architecture
Bill Haines – Physical plant assistant director for Building Maintenance
Jeff Kaden – University Engineer/Director of Engineering Services (formerly with CBU)
Lee Walters – Manager of Utility Information
Mark Menefee- Assistant Director Utilities

While Indiana University (IU) does not have a formal water conservation plan, IU has implemented many conservation measures, including the following:

- Installation of water saving shower heads and low use water flush valves in some dorms, and replacing fixtures as dorms are renovated.
- Central heating – condensate return has increased from 25-28% to 60-70%, significant water savings.
- Over the past 3 years, electronic radio read meters have been installed on almost every campus building, totaling almost 350.
- For the past 5 summers, a student intern focused on water conservation has worked with the Manager of Utility Information.
- A campus "Leak line" has been developed. Stickers have been placed around campus with a phone number linked to an answering machine for reporting of leaks, drips, and running toilets. After a call is placed, a work order to fix it is triggered.
- The IU Sustainability Task Force formed approximately 1.5 years ago, concerned with water, energy, building design (LEED), transportation, education/awareness activities, and carbon footprints. They have made an effort to conserve water and energy through informal campus initiatives, including inter-university competitions to reduce environmental impact.
- All new buildings will be designed for LEED silver certification.
- In order to reduce irrigation demand and runoff, IU uses pervious pavement, native landscaping, and plans to convert to synthetic turf.

In the past, billing was pro-rated by square footage for each building. In addition, the golf course has not always had an irrigation meter and university representatives believe that not all meters were consistently read, often resulting in under-estimates of water consumption. Currently, IU approximates that 22 percent of water use is by the heating plant, 40 percent is used in research buildings, and the rest is divided between housing and irrigation, while square footage of campus buildings is split evenly between academic and auxiliary. A comment was made regarding the potential for water savings in research buildings due to excess water use. However, persuading a change in behavior of those working in labs may be difficult. A database containing three years of water use data is available. Attendees also expressed concerns of the utility raising usage rates in an effort to compensate for lost revenue as a result of decreased water use from conservation. WHPA requested data from IU in order to help with their analysis of water use.

Housing and Neighborhood Development (HAND)/Neighborhood Associations (9/16/2008)

Attendees:

Vickie Provine - HAND
Molly O'Donnell - neighborhood association president
Cynthia Bretheim - neighborhood association president

Overall, the attendees stressed the importance of educating the public about the water supply process (including infrastructure, associated costs, etc.), in order to further stress the benefits of water conservation efforts. Below is a list of additional suggestions/recommendations.

- Provide public access to informational websites containing conservation information.
- Increase public education by doing the following actions:
    - Residential leak detection and repair, as well as the importance of timely repairs.
    - Incorporating Association of Churches as a source of information to the public by way of speakers and demonstrations. In addition, information regarding "greening of churches" could be shared within association.
    - Public workshops and seminars through the City's Parks and Recreation Department on various conservation topics such as lawn watering tips, rain barrels, etc.
- Providing proper training to applicable employees, such as city workers responsible for lawn and garden watering.
- Encouraging the City to set an example for its citizens by demonstrating water conservation practices. For example, using captured rain water from the Showers building roof for the fountain in front of City Hall.
- Alteration of codes and city ordinances to encourage water conservation, such as storm water infiltration.

The meeting also included a discussion about formulating goals and the financial benefits of the conservation plan. Representatives from WHPA explained that goals for the Bloomington study would be based on local climate and other features of the community, while using existing studies from similar communities as an example. As part of the study and conservation plan, a cost of service study may be conducted. As a result of the cost of service study, water rates may change in order to implement conservation pricing.

Council of Neighborhood Associations (9/17/2008)

Attendees: 8 individuals

At the meeting with the Council, attendees discussed issues related to the importance of water conservation and ways to make a difference. Attendees asked why there is a need for conservation measures at the present time and how the installation of a second water pipeline relates to conservation. Representatives of WHPA explained that the necessity of a second pipeline is for redundancy is to help ensure a reliable source of water to the City. WHPA also explained that conservation is vital for long term planning and can delay the need for future construction.

Attendees also had several ideas about ways to implement water conservation in Bloomington. One of the topics of discussion was educating the public about the water supply process and lawn watering (when to water, based on type of grass, etc.). A comment was made relating single family housing and peak demands. The idea of creating a City ordinance based on evapotranspiration rates and comparing neighborhood water consumption averages were also discussed.

Bloomington Board of Realtors (10/2/2008)

Attendees: 100 – 150 members

At a regular meeting of the Board of Realtors, WHPA presented an overview of the conservation planning process and CBU's desire to inform and engage the community in the effort. Possible conservation measures and goals were presented. Few questions were asked. One important question

was related to the need for conservation, given the apparent abundance of water available to the community in Lake Monroe, highlighting the importance of education regarding the actual availability of water in Lake Monroe and the other benefits of conservation – efficiency and cost control.

Sustainability Commission (10/14/2008)

Attendees:

Dave Rollo - Sustainability Commission
Christine Glaser - Sustainability Commission
John Hamilton - Sustainability Commission
Paul Schneller - Sustainability Commission
Bob Bent - Sustainability Commission
George Huntington - Sustainability Commission
Ken Berglund - Sustainability Commission
Laura Kamp - Sustainability Commission
Cynthia Schulz - Sustainability Commission
Jim Sherman - Sustainability Commission
Adam Wason - staff
Michael Leahey - staff

During the meeting, several concerns and issues were discussed related to potential conservation efforts while meeting the needs of a growing population. As part of the water conservation measures, attendees suggested utilizing alternative energy sources for water supply practices, encouraging customers to re-use gray-water, and using equitable cost structure, including one that offers discounts to customers using less than the base value. Among the concerns related to population growth and conservation planning, attendees suggested finishing the plan prior to plant expansion due to the fear that plant expansion will encourage population growth and therefore increased water demands.

Utility Service Board (11/24/2008)

Meeting minutes provided by Utilities Service Board.
http://bloomington.in.gov/documents/viewDocument.php?document_id=2367;

Attendees:

Tom Swafford – Board member
Sam Frank – Board member
Jeff Ehman – Board member
John Whikehart – Board member
Julie Roberts – Board member
Jason Banach – Board member
Tom Micuda – Board member
Patrick Murphy – CBU staff
John Langley - CBU staff
Tom Staley - CBU staff
Missy Waldon - CBU staff
Michael Horstman - CBU staff

Jon Callahan - CBU staff
Jane Fleig - CBU staff
Mike Hicks - CBU staff
Mike Bengtson - CBU staff
Jaysan Watt – ms consultants
Jim Trachtman – ms consultants
Jack Wittman –WHPA
Dan Haddock – WHPA
Sherry Mitchel-Bruker - WHPA

Jack Wittman of WHPA gave an update on the Water Conservation Plan. He presented graphs showing statistics about water pumping and consumption data.

Board member Banach asked Mr. Wittman if the data used in creating these graphs had been acquired by going through customer's bills and records. He wanted to know if it is empirical data and not guess work. Mr. Wittman said they are the actual numbers that came out of Utilities' records.

Mr. Wittman said they had been interviewing and meeting with community interest groups to get their input for this plan. It will be necessary to have a work session with the USB to get input from them as well. It will also allow the USB to see what other people have been saying.

Eventually there will be an entire report based on the data that has been gathered.

Board member Ehman said he has been interested in short term conservation measures. He has been frustrated that no one has proved, or shown to him, that short term conservation measures would not be able to address the supply problem by reducing demand. He hopes the report will discuss this. Mr. Wittman said the report will make estimates of what they believe short term and long term measures will be able to achieve. Mr. Ehman said he wants someone to show him that building a new plant is something that must be done. No one has shown him, on paper, that it would not be possible to just use conservation measures.

Utilities Director Murphy said it has been beneficial for Utilities to look at data in this way. It allows for planning on how to record data in a way that provides useful information.

Bloomington Chamber of Commerce (2/12/2009)

Attendees:

Christy Gillenwater, President & CEO Greater Bloomington Chamber of Commerce
Stephen Smith, Smith Neubecker & Associates
Brent Conner, Cook Group
Joseph Zoghbi, Baxter BioPharma
Mark Crain, Bloomington Hospital

The Chamber members expressed a general interest in participating in water conservation efforts. Attendees made several water conservation recommendations including adopting a conservation rate structure (for example, increasing consumption rates when a consumer exceeds 125% of normal usage).

To help decrease peak demands, attendees mentioned better advertisement of peak days, such as holding a summer campaign. The Chamber offered to notify major consumers using their email network to help with peak day advertising. Attendees brought to attention that Bloomington Transit plans to capture rainwater for the washing buses as a future conservation measure.

One participant noted that the Chamber's review of the proposed plant improvements had questioned the need to expand the plant for a relatively small number of peak days. WHPA explained that since conservation planning was just beginning, that the focus of the plan is to ensure that through water efficiency the existing and planned infrastructure will serve the community's needs for longer than would be possible without conservation.

Baxter, Cook and Bloomington Hospital all indicated that they have implemented water efficiency projects at their facilities.

To further assist with the water conservation efforts, potential contributions by the Chamber may include posting an environmental section on the City's website with water conservation information and better unification in developing ordinances to ensure that there are no contradictions. An additional consideration would include offering incentives for zoning in building codes, such as trade offs for impervious surfaces and capturing rainwater. The question of how to implement requirements for increased water-efficiency fixtures was discussed, noting that the State has jurisdiction over plumbing codes.

Wholesale Districts (2/12/2009)

Attendees:

Ellettsville Water
RHS Water
Southern Monroe Water
East Monroe Water
B&B Water
Washington Township
Van Buren Water
Rachel Atz – CBU staff
Sarah Goen – CBU staff
Dan Haddock – WHPA
Erica Amt - WHPA

The importance of water conservation to keep rates low and finding conservation measures that will work for the wholesale districts was discussed. Attendees suggested that decreasing water losses by better detecting and repairing leaks is a key component to water conservation efforts. The average rate of water loss for CBU since 2002 has been 13.5 percent. An additional measure to help decrease demand may include providing economic incentives to customers (such as increasing water rates, implementing conservation price structure, or offering rebates), however, attendees were concerned that customers would eventually become accustomed to higher rates and stop conserving. Other measures mentioned included educating residents about proper lawn watering techniques, installing

separate irrigation meters, providing a link to AWWA and water saving tips on publicly accessible websites, and updating to higher efficiency household fixtures.

The benefits of conservation include ensuring the most efficient use of existing and planned infrastructure. WHPA explained that by improving efficiency, the time before an additional expansion of capacity is required can be extended. This relates to replacing and updating infrastructure as a result of increasing demand due to population growth. This, however, does not prevent making necessary improvements and repairs.

Attendees also brought up several concerns related to water conservation. One of the major concerns dealt with reductions in utility revenue due to reduced water use by customers. The solution involves implementing an appropriate price structure. Additional concerns included implementing the plan, meeting peak demands with population growth (especially in rural areas), and effects of conservation efforts may not be noticeable for some time.

Bloomington Economic Development Corporation (April 2009)

Attendees:

Ron Walker – Executive Director, BEDC
Dan Haddock – WHPA

In a telephone discussion, WHPA provided an overview of the conservation planning effort by CBU. The conservation planning initiative is part of an integrated approach to water supply management. Conservation enables the utility to make more efficient use of the existing and planned infrastructure and reduce energy & chemical costs for production and delivery of water. The program focuses on end use and on the efficiency of the utility's delivery of water. The planning process has involved meetings with community stakeholder groups to obtain input on goals and measures, water use analysis, and recommendations on water conservation measures and implementation. Measures recommended are appropriate to Bloomington's climate, community and opportunities for water savings.

BEDC asked about the driver for conservation, given that there are abundant resources. WHPA explained that during drought, the resources are more limited than they appear to be due to other commitments for the water in the reservoir. The primary driver for conservation is to make efficient use of expensive infrastructure and to manage costs for production and delivery of water.

BEDC asked if there were any measures that would be of concern to the business community, or for economic development. The BEDC's concern is typically whether there is enough water to supply a potential new customer. WHPA explained that none of the proposed measures would negatively impact proposed economic development, and that the conservation efforts in conjunction with other planning efforts and capital improvements is best framed as proactive management of the water supply by the utility to ensure that there are adequate supplies and efficient use of those supplies.

WHPA explained that CBU was considering the implementation of water rates that would encourage conservation. Implementing conservation rates for residential customers is more straightforward than

with commercial and industrial customers because commercial and industrial uses vary significantly from customer to customer. Rate design for those customer classes would necessarily take this into account. The actual design of rates will be done by the City with the assistance of Crowe Horwath.

WHPA described the concept for an alternative water supply for non-potable needs. The system is proposed as a future phase for consideration by CBU. The purpose is to reduce peak irrigation and cooling demands by replacing the potable supply for these purposes with an alternative supply. The relative location of existing infrastructure and potential users in Bloomington provide a unique opportunity for this type of system. The benefits include avoided future investment in potable water supply, marketability to corporations with sustainability goals (LEED certification), and reliability of supply (drought proof). BEDC acknowledged the potential attraction and commented that rates for the alternative supply would logically need to be lower than those of the potable water system.

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Appendix D. Conservation Measures

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Screening Process

A list of possible relevant measures was developed (table below) and the applicable customer classes and water use type (indoor or outdoor) were identified. Each measure was screened using the following four criteria:

1. Relevance to conservation goals

Does the conservation measure fulfill the City of Bloomington's conservation goals? The conservation measure should contribute to achieving CBU's conservation goals; consequently, any measure that does not meet this criterion was removed from the list (received an x).

2. Anticipated Water Savings

How much water will the measure save? Some conservation measures produce greater water savings than others, whereas the water savings for some measures are unquantifiable. Each measure's estimated water savings was assigned a value using a scale of 1 to 3.

- 1 – Savings are unquantifiable
- 2 – Savings are expected, however it many not be evident for several years
- 3 – Significant savings, CBU will perceive an immediate reduction in water use

3. Cost to CBU

What is the measure's estimated cost to CBU? The cost of implementation varies among conservation measures. Each measure was assigned an estimated cost range using the following scale.

- $ = less than $10,000
- $$ = $10,000 to $25,000
- $$$ = $25,001 to $50,000
- $$$$ = greater than $50,000

4. Customer Cost

How much will the measure cost the customer? For some measures, the customer will share part of a measure's implementation cost. Each measure was assigned an estimated cost range using the following scale.

- $ = less than $50
- $$ = $50 to $250
- $$$ = $251 to $500
- $$$$ = greater than $500

Anticipated Water Savings 1 = unquantifiable 2 = savings expected, but not realized for several years 3 = significant savings	Cost to CBU $ = less than $10,000 $$ = $10,000 to $25,000 $$$ = $25,001 to $50,000 $$$$ = greater than $50,000	Customer Cost $ = less than $50 $$ = $50 to $250 $$$ = $251 to $500 $$$$ = greater than $500

	Customer Class						Target		Criteria			
Conservation Measures	SFR	MFR	COM	IND	IU	CBU	Indoor	Outdoor	Relevant to Goals	Anticipated Water Savings	Cost to CBU	Customer Cost
Public Education												
Seminars and demonstrations	•	•					•	•	-	1	$	$
Water bills with conservation information	•	•	•	•	•		•	•	•	1	$	-
Water conservation information on CBU's website	•	•	•	•			•	•	•	1	$	-
Native plant demonstration	•	•	•	•				•	-	1	$$	-
Public education campaign	•	•	•	•			•	•	•	1	$$	-
Homeowner irrigation classes	•							•	-	1	$	$
End of season notices to turn off time clocks on automatic irrigation systems	•	•	•	•	•			•	•	1	$	-
Primary and secondary school programs	•						•	•	•	1	$$	-
Peak day notification to large water users			•	•			•	•	•	1	$	-
Economic Incentives												
High efficiency washing machine rebate	•						•		x	2	$$	$$$$[a]
High efficiency dishwasher rebate	•						•		x	2	$$	$$$$[a]
High efficiency toilet rebate	•						•		x	2	$$	$$[a]
High efficiency toilet rebate plus free installation	•						•		x	2	$$	$$[a]

Anticipated Water Savings 1 = unquantifiable 2 = savings expected, but not realized for several years 3 = significant savings	Cost to CBU $ = less than $10,000 $$ = $10,000 to $25,000 $$$ = $25,001 to $50,000 $$$$ = greater than $50,000	Customer Cost $ = less than $50 $$ = $50 to $250 $$$ = $251 to $500 $$$$ = greater than $500

	Customer Class						Target		Criteria			
Conservation Measures	SFR	MFR	COM	IND	IU	CBU	Indoor	Outdoor	Relevant to Goals	Anticipated Water Savings	Cost to CBU	Customer Cost
High efficiency showerhead rebate	•	•					•		x	2	$	$ [a]
Dual flush toilet rebate			•	•			•		x	2	$$	$$ [a]
Waterless urinal rebate			•	•			•		x	2	$$	$$$ [a]
Cooling tower meter rebate			•	•			•		x	2	$$	$$$$ [a]
Rain sensor rebate	•	•	•	•				•	•	2	$	$$ [a]
Smart irrigation controller rebate	•	•	•	•				•	•	2	$$	$$ [a]
Conservation pricing	•	•	•	•			•	•	•	2	-	$-$$
Government Regulation												
Efficient plumbing code for new development	•	•	•	•			•		•	2	-	-
Toilet retrofit on resale ordinance	•	•	•	•			•		•	2	-	$$ - $$$
Irrigation system requirements	•	•	•	•	•			•	•	2	-	-
Require restaurants to serve water upon request			•				•		•	1	-	-
Prohibit non-recirculating fountains		•	•	•	•			•	x	1	-	-
Require new car washes to recycle water			•					•	x	1	-	-
Lawn watering restrictions	•	•	•	•	•			•	x	1	-	-
Landscaping code changes			•	•	•			•	x	1	-	-
Submetering multi-family units ordinance		•					•		•	2	-	-

Anticipated Water Savings 1 = unquantifiable 2 = savings expected, but not realized for several years 3 = significant savings	Cost to CBU $ = less than $10,000 $$ = $10,000 to $25,000 $$$ = $25,001 to $50,000 $$$$ = greater than $50,000	Customer Cost $ = less than $50 $$ = $50 to $250 $$$ = $251 to $500 $$$$ = greater than $500

	Customer Class						Target		Criteria			
Conservation Measures	SFR	MFR	COM	IND	IU	CBU	Indoor	Outdoor	Relevant to Goals	Anticipated Water Savings	Cost to CBU	Customer Cost
Water waste ordinance	•	•	•	•	•			•	•	1	-	-
Require efficient process equipment for selected businesses (restaurants, hotels/motels, coin operated washing machines)			•				•		x	2	-	$$-$$$
Require irrigation meters for new development	•	•	•	•				•	x	2	$	$$
Water Management												
City government water use audit			•[b]						•	2		-
Annual utility water audit						•			•	1		-
Water conservation administrator						•			•	-	$$$	-
Leak detection and repair program						•			•	3	$$$$	-
Meter testing and replacement program						•			•	-	$$$	-
Alternative Water Supply												
Rainwater harvesting	•	•	•	•				•	x	1 / 2	$	$$-$$$
Alternative/reclaimed water supply						•		•	•	3	$$$$	-

[a] Assumes this is a cost the customer is willing to incur. [b]Applies only to city government, which CBU assigns as a commercial user

Removed Conservation Measures

REMOVED MEASURES	RATIONALE FOR REMOVAL
Public Education	
Seminars and demonstrations	Anticipated low attendance; to reach more of the community, seminar topics are better incorporated into a public education campaign
Native plant demonstration	CBU has native plant landscaping on utility property, and city code promotes native species
Economic Incentives	
High efficiency washing machine rebate	High cost to CBU
High efficiency dishwasher rebate	High cost to CBU
High efficiency toilet rebate	High cost to CBU and the intent is better addressed by another measure
High efficiency toilet rebate plus free installation	High cost to CBU
High efficiency showerhead rebate	High cost to CBU and the intent is better addressed by another measure
Dual flush toilet rebate	High cost to CBU
Waterless urinal rebate	High cost to CBU
Cooling tower meter rebate	High cost to CBU
Smart irrigation controller rebate	High cost to CBU and the intent is better addressed by another measure
Government Regulation	
Lawn watering restrictions	Effectiveness is uncertain and the intent is better addressed by more efficient irrigation systems
Require efficient process equipment for selected businesses (restaurants, hotels/motels, and coin operated washing machines)	High cost to customer; not relevant at this time
Require restaurants to serve water upon request	Not easily monitored and limited savings
Prohibit non-recirculating fountains	Can be incorporated into the Water Waste Ordinance
Require new car washes to recycle water	Can be incorporated into the Water Waste Ordinance

Removed measures	Rationale for removal
Landscaping code changes	Better addressed by changes to irrigation system requirements for new development; not relevant at this time
Require dual meters for irrigation for new development	The intent of the measure is better addressed by changes to irrigation requirements
Alternative Water Supply	
Rainwater harvesting	Can be addressed in a public education campaign

Description

Conservation measure: Alternative Water Supply

Strategy: Water supply management

Target: Indoor/Outdoor Use

Applicable customer class: All customers

Description: Many of the uses of water in the community do not require the same level of quality found in drinking water. Lawn watering, landscape impoundments, heating plant and industrial cooling processes are among the most common of these. Alternative water supplies may provide an opportunity to meet these demands with lower quality source waters, preserving higher quality sources, and/or with less chemicals and energy required for treatment and delivery. In many communities, sustainable water resource management is enhanced by using treated wastewater for these purposes. Bloomington has multiple water resources available for phased development of an alternative water supply, including Lake Griffy and treated water from the Blucher Poole and Dillman wastewater treatment plants (WWTP's).

Irrigation and many cooling demands occur during hot, dry weather and coincide with peak demands on the system. As a result, they drive the need for additional infrastructure. If these demands can be economically met with other supplies, more efficient use of the drinking water plant can be achieved. In 2007, irrigation-only demands for Indiana University (IU) athletic fields and the City's Cascades Golf Course were 20,000,000 gallons/year and 5,700,000 gallons in the peak month. IU estimates that 22% of annual use is in heating plant (L. Walters, personal communication, August 19, 2008).

In Bloomington, existing abandoned or underused infrastructure and potential alternative water supply customers are located in close proximity to each other. The Griffy WTP was decommissioned in 1996. Preservation of historic portions of the building was recommended in the 2008 Griffy Lake Nature Preserve Master Plan. An existing 20-inch main that formerly served as the primary transmission main from the plant currently creates water quality problems due to low flows. The safe yield of Monroe Reservoir available to Bloomington during periods of drought is limited by the contracts governing allocation of the reservoir.

This measure requires careful planning and phased implementation.

Economic Considerations

Water savings: Phase 1 Only: 15,000,000 gallons (year), 500,000 gallons (peak day)

Cost: Unknown, subject to study

Assumptions: Initial customers include IU athletic fields and the Cascades Golf Course. Assumed 15,000,000 gallons of use per year (20,000,000 in 2007). Assumed that peak day use for lawn

watering is approximately 3 times the average day of the month = 550,000 gallons/day, based on 5,700,000 gallons in peak month (2007).

Implementation

The first step in implementation of this measure is to perform a feasibility study. The economic viability of an alternative water supply will depend on the feasibility of developing and operating the system with water rates that provide an incentive for its use. The study will include the identification of potential customers and an assessment of their requirements; technical assessment of the feasibility and cost of improving and re-commissioning existing infrastructure; master planning of the phased development of the system; rate design; and legal issues surrounding the development, permitting and operation of the system.

The first phase of the system might include the following components: rehabilitation of the Griffy WTP facilities to restore basic treatment and pumping capacity for the anticipated demands; installation of water mains to re-commission the existing 20-inch main to alternative water supply service and to extend service to the IU athletic fields and Cascades golf course. The opportunity exists to develop facilities for the nature preserve and water education in conjunction with the rehabilitation of the Griffy facilities.

Later phases of the system might include the following: expansion of pumping facilities to meet additional demand (IU, etc.); augmentation of alternative water supply with treated wastewater from the Blucher Poole or Dillman WWTP's, as demands require; extension of the distribution system by the utility or by developers.

Example Communities

The Town of Cary, North Carolina, developed an alternative water supply. It was the first city in the state to pump treated wastewater to homes and businesses for irrigation and cooling, beginning with several hundred customers in June 2001. The total project included two major phases of construction at a cost of approximately $11 million. Pipes are separate from those carrying water for drinking and uses such as bathing or washing clothes. The reclaimed water system lessens the amount of drinking water that winds up on lawns and other landscaping. It cuts the amount of wastewater that is discharged into creeks from the Town's two treatment plants. Uses include irrigation, manufacturing processes, industrial cooling, street washing and dust control at construction sites. Current demands are 20 mgd in peak months, and 1 mgd on peak days.

References

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USEPA. (2004). *Guidelines for Water Reuse.* Washington, DC: US Environmental Protection Agency.

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Conservation Coordinator

Description

Conservation measure: Conservation Coordinator

Strategy: Water supply management

Target: Indoor/Outdoor Use

Applicable customer class: Utilities

Description: A water conservation coordinator is an important component of an active conservation program. The person(s) oversee(s) all conservation related activities, and collects and maintains data on the conservation program for evaluation purposes.

Implementation

The water conservation administrator may be an individual or a group of people. This position is in charge of implementing the conservation programs such as creating bill stuffers, answering customer questions, tracking retrofit kits and rebates, organizing residential and commercial audits, and overseeing customer compliance with conservation related ordinances. The water conservation coordinator also collects information on the number of rebates handed out, monitors the number of watering restriction violations, and tracks program participation in order to periodically evaluate the conservation program. For utilities with extensive programs, having a person specialized in water conservation is more useful than burdening staff busy with other demands and responsibilities. The cost of a coordinator or team is the salaries of the individual(s).

Example Communities

The Town of Cary, North Carolina, has six positions dedicated to water conservation – one conservation coordinator, two conservation education specialists, and three technicians.

The City of Waukesha, partnered with Waukesha County to create the Waukesha County Water Conservation Council. It is in charge of building public awareness of water conservation issues within the county and city.

Denver Water started a Conservation Hotline. Customers may call the hotline with questions regarding water conservation activities in the community.

References

City of Waukesha. (2009). *Water Utility*. Retrieved from http://www.ci.waukesha.wi.us/web/guest/waterhome

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Conservation Pricing

Description

Conservation measure: Conservation Pricing

Strategy: Demand management - government regulation

Target: Indoor/Outdoor Use

Applicable customer class: All customers

Description: Conservation rate structures are generally defined as rates that discourage waste, encourage efficient use of water, and demonstrate the full cost of providing water to customers (Raftelis, 1993; Chestnut and Beecher, 1998; Stallworth, 2000; Dziegielewski, 2003; Smith and Wang, 2008). While there are several conservation-oriented rate structures, they must be designed correctly in order to achieve conservation – no rate structure is inherently a conservation rate.

As the US faces water shortages, climate change, rising costs to provide safe, reliable drinking water, and increased populations, conservation-oriented rate structures are being looked to as one conservation measure that can reduce consumption. Price alone will not achieve the reduction in demand that will be required to meet future drinking water demands but should be considered as one mechanism to achieve overall conservation goals.

Economic Considerations

Water savings (per unit): 30,104,379 gal/yr (2015)–water savings varies depending on rate

Assumptions: To calculate the water savings, the following assumptions were made.

- Used a 2-tier increasing block rate with a 50 percent increase from tier 1 to tier 2
- Conservation pricing would achieve a 1.1 percent reduction in single family consumption
- Conservation pricing would achieve a 0.55 percent reduction in all non-single family consumption

Implementation

Education is an important component no matter what rate structure is used. Customers must be made aware of the changes, the reasons for the changes, and even the rate itself. While customers may have little interest in the process, education will provide the most effective way to gain acceptance of conservation rates. It also allows customers to view conservation as a water resource rather than an imposition of restrictions.

Price elasticity is the change in use due to the change in price. For example, if the price elasticity is -0.5, a 1.0 percent increase in price would lead to 0.5 percent decrease in water use. Low-use customers have lower elasticities than high-use customers (Kenney et al, 2008; Smith and Wang, 2008). This difference is seen as the difference between essential and discretionary use. Since price is relatively inelastic (elasticities are generally less than -1.0), a strong economic signal

should be sent to customers to encourage conservation. During drought, prices have been very effective at reducing use (Dziegielewski, 2003).

Monitoring and Evaluation

To monitor and evaluate conservation rates, utilities should assess what consumption would have been without the change to conservation pricing using historical data compared to actual consumption with conservation pricing.

Example Communities

Rate	***Definition***	***Locations***
Increasing block	with increased consumption, an increase in price occurs	Joliet, IL; Boston, MA; Cleveland, OH
Drought demand	rates are increased during drought to reduce consumption	Santa Barbara, CA; El Dorado, TX
Seasonal	rates vary throughout the year (increasing during the peak period of use)	Omaha, NE; Miami, FL; Tucson, AZ
Marginal cost	rates are based upon cost of providing next incremental volume	Los Angeles, CA
Water-budget based	an increasing block rate where the blocks are defined by customer characteristics	Cary, NC; Morrisville, NC; Los Angeles, CA; Albuquerque, NM
Excess use	an increased rate is charged when the customer exceeds their predetermined "acceptable" water use	El Paso, TX; Corpus Christi, TX
Time of use	different rates are used depending the time of day the water is used (this is the same peak and off-peak concept used by electric companies)	
Uniform	the same price is charged to all customer classes, at all levels of consumption.	Nashville, TN; Bloomington, IN; Ann Arbor, MI

References

Chesnutt, T. W., & Beecher, J. A. (1998). Conservation rates in the real world. *Journal of the American Water Works Association* , *90* (2), 60-70.

Dziegielewski, B. (2003). Strategies for managing water demand. *Water Resources Update* (126), 29-39.

Kenney, D. S., Goemans, C., Klein, R., Lowrey, J., & Reidy, K. (2008). Residential water demand management: lessons from Aurora, Colorado. *Journal of the American Water Works Association , 44* (1), 192-207.

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Smith, W. J., & Wang, Y. (2008). Conservation rates: the best 'new' source of urban water during drought. *Water and Environment Journal , 22*, 100-116.

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End-of-Season Notices

Description

Conservation measure: End-of-Season Notices to Turn off Automatic Irrigation Systems

Strategy: Demand management - public education

Target: Outdoor Use

Applicable customer class: All customers

Description: End-of-season notices are a reminder to customer to turn off their automatic irrigation systems until next summer. This measure is most applicable in temperate climates where year-round watering is not possible. The notices should be sent around the time of the first frost as lawn watering is typically no longer necessary.

Economic Considerations

Unit cost: Negligible

Water savings (per unit): 900,000 gallons (2015)

Assumptions: Assumed notices would result in a 25 percent decrease in November water use. Used November 2007 single family, multi-family, and commercial irrigation use data to calculate the savings. Assumed all customers with an irrigation meter have an automatic irrigation system.

Additional Considerations

Distribution method: The notices should be sent out in October. The notice could be posted on City of Bloomington Utilities' website, included as a bill insert or bill message, or sent as a letter to all customers or only those with irrigation meters.

Monitoring and Evaluation

The utility should compare November water use to use when no reminders were sent, taking into consideration weather differences.

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Irrigation System Requirements

Description

Conservation measure: Irrigation System Requirements for New Development

Strategy: Demand management - government regulation

Target: Outdoor Use

Applicable customer class: All customers

Description: The purpose of irrigation requirements is to reduce wasteful use of potable water for lawn watering. This measure is best accomplished by creating an ordinance requiring specific system requirements.

Economic Considerations

Water savings (per unit): 2.7 million gallons (2015)

Assumptions: Assumed a 9,000 gal/yr water savings per single family household and a 15 percent reduction in water use for multi-family and commercial customers (U.S. EPA, 2009). Calculated the percent of single family, multi-family, and commercial customers with irrigation meters in 2007 and applied that percent to the forecasted number of new accounts for each customer class. Assumed 20 percent of single family, 5 percent of multi-family, and 10 percent of commercial new accounts would install irrigation systems. Calculated a per meter water use value for multi-family and commercial customers using 2007 irrigation water use data.

Implementation

The U.S. EPA's WaterSense program provides information on efficient irrigation systems. One way to ensure efficient irrigation systems is to require all new systems be installed by a WaterSense certified landscape irrigation professional. The irrigation professional is certified in system design, installation and maintenance, and system auditing.

Also, an ordinance could require that all new irrigation systems include efficient equipment such as smart irrigation controllers, rain shutoff devices, or soil moisture sensors. Smart controllers adjust the watering schedule based on actual weather and soil conditions. The rain shutoff device interrupts an automatic irrigation system cycle when a specific amount of rain has fallen. A soil moisture sensor system measures the level of moisture in the soil and prevents watering if the soil is wet (Alliance for Water Efficiency, 2009).

Monitoring and Evaluation

A utility should work with irrigation professionals to track the number of irrigation systems installed and the type. Requiring that all systems be connected to an outdoor water use meter will make it easier to track customer water use and compare it to the use of customers with irrigation systems installed before the ordinance.

Example Communities

The Town of Cary, North Carolina, requires all automatic irrigation systems be fitted with a rain sensor, the system must have a separate meter, and its installation must comply with the North Carolina State Plumbing Code and Town of Cary Standard Specifications and Details (Town of Cary, 2009) .

References

Alliance for Water Efficiency. (2009). *Landscape, Irrigation, and Outdoor Water Use*. Retrieved from http://www.allianceforwaterefficiency.org/Landscape_and_Irrigation_Library_Content_Listing.aspx

Town of Cary. (2009). *Town of Cary Homepage*. Retrieved from http://www.townofcary.org/

U.S. EPA. (2009). *Landscape Irrigation Services*. Retrieved from http://www.epa.gov/watersense/pp/irrprof.htm

Description

Conservation measure: Leak Detection and Repair Program

Strategy: Water supply management

Type: Real loss

Applicable customer class: Water utility

Description: Leaks in a water system are physical losses that produce needless water loss without satisfying a demand. Furthermore, leaks inflate production and raise energy costs. Lost revenue from system leaks can be measured in terms of production and treatment costs (USEPA, 1998). Leakage control involves efficient identification of leaks and timely, lasting repairs (AWWA Water Loss Control Committee, 2003), especially small leaks at joints and fittings. Typically small leaks go undetected yet are responsible for a large volume of non-revenue water (unaccounted-for water). A successful leak detection and repair program saves on up front costs of lost water and can defer infrastructure maintenance and expansion.

Economic Considerations

Water savings (per unit): 107,000,000 gal/yr (2105)

Assumptions: To calculate the water savings, the following assumptions were made.

- CBU's current non-revenue water is 13.4 percent
- Future non-revenue water will drop to 10 percent by 2020
- The payback period is two years

Year	Consumption	Savings (MG/Yr)	Cost ($)
2005	4,302	0	0
2010	4,368	0	10,000
2015	4,446	107	214,000
2020	4,604	212	424,000
2025	4,869	225	450,000
2030	5,281	245	490,000

Monitoring and Evaluation

It is never economical for a utility to target eliminating all leaks from a system because the cost of reducing losses increases as lower levels of losses are achieved. A utility should target an economic level of leakage, which is specific to the utility and defines the target level of leakage for efficiently managing real losses (Fanner, Thorton, Liemberger, & Sturm, 2006). The ELL changes over time due to infrastructure and leakage control technology improvements, supply and demand changes, and changes in system operating pressure. Consequently, the ELL must regularly be evaluated. The ELL can be calculated using several different approaches discussed in the Awwa Research Foundation's publication *Evaluating Water Loss and Planning Loss Reduction*

Strategies. The annual volume of water lost to leaks can be tracked by completing a water audit. Water audits compare the volume of pumped and treated water to the amount consumed by customers.

Example Communities

Currently no national laws regulating water loss exist. Depending on the utility's location, initiatives for water audits, leak detection, and leak repairs are left to the utility. States including Texas, New Mexico, and Washington have adopted regulations related to water loss control, which include mandating regular water audits and setting leakage limits.

The Massachusetts Water Resources Authority (MWRA) began an aggressive leak detection and repair program after surface water withdrawals exceeded safe yield levels. The program coincided with other conservation measures; however, water withdrawal levels dropped 20 percent within five years, which would not have been possible without leak repair. The MWRA now requires that all 6,000 miles of pipes are inspected for leaks every 2 years (MWRA, 2009).

The Gallitzin Water Authority, PA water system was experiencing over 70 percent of unaccounted for water losses in the mid-1990s. The authority partnered with the Pennsylvania Department of Environmental Protection Small Water Systems Outreach Program for assistance in repairing leaks, replacing meters, and improving customer billing. Within four years, water loss dropped to 9 percent and average water use per day dropped 58 percent (USEPA, 2002).

References

Alliance for Water Efficiency. (2009). *Water Loss Control*. Retrieved from http://www.allianceforwaterefficiency.org/Water_Loss_Control_Library_Content_Listing.aspx

AWWA Water Loss Control Committee. (2003). Applying Worldwide BMPs in Water Loss Control. *Journal AWWA , 95* (8), 65-79.

Brandes, O. B., Maas, T., & Reynolds, E. (2006). *Thinking beyond pipes and pumps: top 10 ways communities can save water and money.* Retrieved from http://www.polisproject.org/node/175

Fanner, P., Thorton, J., Liemberger, R., & Sturm, R. (2006). *Evaluating Water Loss and Planning Loss Reduction Strategies.* Denver: Awwa Research Foundation.

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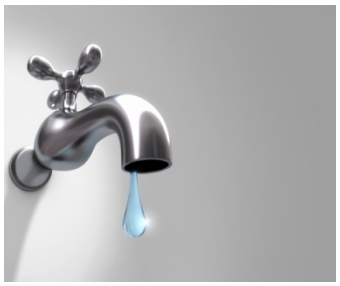
Low Income Home Leak Detection

Description



Conservation measure: Low Income Home Leak Detection and Repair Program

Strategy: Demand management - economic incentive

Target: Indoor Use

Applicable customer class: Single family

Description: A utility sponsored low income home leak detection and repair program assists homeowners with upgrading inefficient fixtures and repairing leaks. The homeowners must have an annual income less than a specific amount and must live in a home built before 1994. In 1992, the Energy Policy Act set uniform water efficiency standards for showerheads, faucets, urinals, and toilets manufactured after January 1994. Homes built with pre-1994 hardware are not as water efficient as post-1994. Retrofitting older hardware is inexpensive for the utility and saves the homeowner water and money. In addition to the retrofit, a utility technician would check all the toilets in the home for leaks and replace deteriorating toilet parts. Also, the utility may provide a plumber free of cost to the homeowner for severe leaks that it cannot fix.

Economic Considerations

Unit cost: $1,835 to $4,737. This cost assumes that 50 homes per year will require replacement of the entire items listed in the table below.

Needed Items	Range of costs per item
Toilet displacement device (0.5 to 1.5 gpf)	$0.59 to $1.50
Faucet aerator replacement	$3.00 to $10.00
Showerhead replacement	$15.00 to $30.00
Leak dye tablets	$0.10 to $0.25
Flapper valve	$2.00 to $10.00
Ballcock assembly	$5.00 to $18.00
Overflow pipe and refill tube	$8.00 to $20.00
Handle rod	$3.00 to $5.00

(Vickers, 2001)

Additional implementation costs: Cost of technician performing the repairs. The total estimated contractor cost is $10,000 per year.

Water savings (per unit): 981,832 gal/year

Assumptions: To calculate the water savings, the following assumptions were made.

- Flow rate is 80 pounds per square inch (psi)
- 2.27 persons per household[a]
- 50 homes built before 1994 are visited

Showerheads – assume 2.27 people per household shower everyday

Old unit water usage	New unit water usage	Usage difference (gpm)	Average number of minutes per shower	Average number of people per household	Savings (gal/home/ day)	Total Savings (gpd)	Annual Savings (gpy)
3	2.5	.5	8.2[b]	2.27	9.307	465.35	169,853

Toilet Displacement– assume displacement results in a 0.5 gpf savings (range - 0.5 to 1.5 gpf)

Usage without device	Usage with device	Usage difference (gpf)	Flushes per person per day	Total number of flushes per household	Savings (gal/home/ day)	Total Savings (gpd)	Annual savings (gpy)
3.5	3	.5	4[b]	9.08	4.54	227	82,855

Faucet Aerators

Old unit water usage	New unit water usage	Usage difference (gpm)	Faucet frequency per person (min/day)	Household water use (gpd)	Total Savings (gpd)	Annual Savings (gpy)
3	2.5[d]	0.5	4.05[b,c]	4.596	689.512	83,891
3	1.5[e]	1.5	4.05	13.790	689.5125	251,672

Toilet Leaks

Average leak volume (gpcd)	Per household per day	Total savings (gpd)	Annual savings
9.5[b]	21.565	1078.28	393,561

[a]2005-2007 American Community Survey. [b] (Vickers, 2001).
[c]Average faucet use frequency is 8.1 min/day.
[d]Appropriate for bathrooms.
[e]Appropirate for kitchens.

Monitoring and Evaluation

After upgrades and repairs have been made, the utility can track the homeowner's water savings by comparing their past use with their use after the repairs. Also, the utility should record what hardware was replaced and its flow rate, and what was installed and its flow rate. Also, the toilet leakage rate should be estimated.

Example Communities

Houston, Texas initiated a pilot program at a 60-unit low income housing development that involved replacing 5 gpf toilets with 1.6 gpf toilets, fixed leaks, and installed low-volume aerators. The program cost $22,000, reduced water consumption by 72 percent (1 million gallons per month), and water and wastewater bills dropped from $8,644 to $1,810 per month (U.S. EPA, 2002).

References

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Description

Conservation measure: Meter Testing and Replacement Program

Strategy: Water supply management

Target: Apparent losses

Applicable customer class: Water utility

Description: Updating and repairing customer water meters is an important supply-side management practice that reduces apparent water losses. A meter's accuracy degrades overtime because of meter wear, malfunction, or because the meter is inappropriately sized (AWWA Water Loss Control Committee, 2003). Inaccurate readings result in lost revenue for the utility and incorrect data on water usage. Accurately registering meters ensures that customers are charged appropriately for the water they use, which provides them with an incentive to conserve water. Addressing metering issues will not result in immediate reductions in withdrawal as does repairing leaks. However, accurate metering and a subsequent reduction in apparent losses results in increased revenue for the utility and allows for distinguishing between water consumption and real loss volumes (AWWA Water Loss Control Committee, 2003).

Economic Considerations

Unit cost: $40 (residential size) to $2,000+ (industrial size) (Alliance for Water Efficiency, 2008)

Service life: According to an American Water Works Association (AWWA) study, plastic meters maintain accuracy for 12-15 years and brass meters for 30-34 years (Yee, 1999).

Monitoring and Evaluation

All system meters should be tested at regular intervals. The AWWA recommends that meters 5/8 to 1 in. meters be tested every 10 years, 1 to 4 in. meters be tested every 5 years, and meters 4 in. and larger be tested every year. It is also important to check that meters are appropriately sized; a meter too large for a customer will typically under-register water use. The AWWA provides guidelines for establishing a meter-testing program in *Water Meters-Selection, Installation, Testing, and Maintenance* (M6).

Example Communities

The City of Wichita, Kansas, requires that all raw water intakes have meters installed and that malfunctioning meters be repaired or replaced within two weeks of discovery. Also, meters are tested for accuracy every three years. The utility requires that meters are installed at all service connections whose annual water use exceeds 300,000 gallons. Individual meters are required for municipally operated irrigation systems that irrigate more than one acre of turf.

References

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Multi-family Submetering Ordinance

Description

Conservation measure: Multi-family Submetering Ordinance

Strategy: Demand management - government regulation

Target: Indoor Use

Applicable customer class: Multi-family residential

Description: Many multi-family housing complexes use master meters for measuring water consumption. The tenant's water usage is included in the monthly rent and they are not aware of their monthly usage. Consequently, they have little incentive to use water more efficiently. The Alliance for Water Efficiency (2009) estimates that master metered customers use approximately 15 to 20 percent more water than tenants billed individually. Also, submetering provides greater opportunity for leak detection because a customer that receives an unusually high water bill is more likely to report a problem to apartment maintenance.

Economic Considerations

Unit cost: Submetering can be costly because each apartment or multi-family unit must be supplied by a single pipe source of water. As a result, retrofitting the plumbing may be necessary. The cost of the meter ranges from $50 to $100.

Service life: A plastic meter maintains accuracy for 12-15 years and a brass meter maintains accuracy for 30-34 years (Yee, 1999).

Water savings (per unit): According to a study on national submetering, water savings average 21.8 gal/day/unit and range from 5,550 to 17,500 gal/dwelling unit/year (Mayer et al., 2004).

Assumptions: The 21.8/gal/day/unit savings (a 15.3 percent savings compared with traditional mastered metered properties) controls for year of construction, average number of bedrooms per unit, presence of play areas, presence of cooling towers, utility's average commodity charge for water and wastewater, and whether the property was a rental or individually owned or classified as retirement community (Mayer et al., 2004).

Also, for savings to be achieved, multi-family residents will modify their behavior upon receiving monthly water bills. Additionally, monthly bills will alert tenants to leaks, which they will report to apartment maintenance.

Implementation

The alteration of existing buildings for submetering can be done by private contractors. If submetering is not mandated, the utility should work with new construction projects and existing multi-family complexes to encourage the adoption of submetering. According to the 2004 study on submetering, submetering technology has improved and the cost for submetering new construction and existing properties is reasonable (Mayer et al., 2004).

An alternative method for tracking per unit consumption when submetering is not possible involves using flow sensors or meters attached to large water consuming appliances (faucets, showers, toilets, and water heaters). Each unit's water use is estimated and then adjusted to the master meter consumption regards (Alliance for Water Efficiency, 2009).

Monitoring and Evaluation

In order to monitor and evaluate sub metering as a water conservation measure, the utility should track how total water usage changes after submeters are installed.

Example Communities

Denver City Council now requires all newly constructed multi-family housing units to use submetering in each dwelling. Denver Water offers rebates to multi-family customers, including existing buildings, for installing sub meters.

The Metropolitan North Georgia Water Planning District requires local governments to adopt one of two methods for individualized billing for residents of newly constructed multi-family units. Individual meters can either be (a) managed by the utility or (b) by the property owner in addition to a master meter monitored by the utility.

References

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Metropolitan North Georgia Water Planning District. (2006). *Multi-family Sub-unit Meters*. Retrieved from http://www.northgeorgiawater.com

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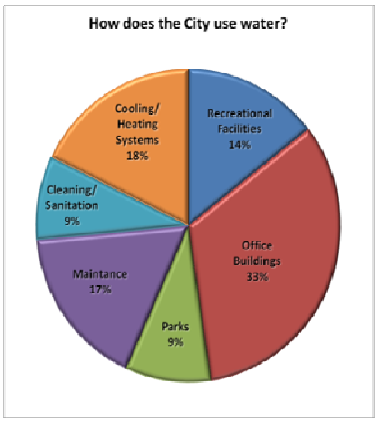
Municipal Water Use Audit

Description



Conservation measure: Municipal Water Use Audit

Strategy: Water supply management

Target: Indoor/Outdoor Use

Applicable customer class: City Government

Description: A city water audit demonstrates to residents the city's interest in conserving limited water resources. An audit identifies excess water usage, prompting the city to reduce usage by implementing appropriate measures. Measures may address irrigation methods for parks and sport fields, retrofitting older (pre-1992) municipal buildings, and redesigning city plantings to include more native, drought tolerant plants. The objective of the audit is to track the municipality's water use for better future resource management development.

Economic Considerations

Unit cost: $1,000 – estimated cost of auditor to carry out complete audit

Water savings (per unit): 1.7 million gal/yr in 2015

Assumptions: Assumed a 15 percent water savings using 2006 City Government water use data. The savings apply only to indoor water use. Assumed all City Government outdoor water use is on separate irrigation meters.

Implementation

The utility should work with the city to audit buildings and public spaces. The indoor portion of the audit should include testing and repairing toilet leaks, and when possible, retrofitting inefficient showerhead faucet aerators with new, water-efficient devices. The auditor should also make note of the number of toilets that use more than 1.6 gallons per flush (gpf). The water use for any water using item should be estimated and recorded in the audit.

The public spaces (parks, green areas, sports fields) audit should evaluate the efficiency of outdoor water-use features such as irrigation systems, pools, and fountains. The auditor may also suggest making design modifications to planters and landscaping in order minimize water use. The audit should include checking the settings on all automatic irrigation systems to confirm that they are appropriate to the local climate. Also, city water meters should be tested and calibrated, or if necessary, replaced.

At the end of the audit, the auditor will recommend efficiency measures based on the results of the audit.

Monitoring and Evaluation

The city taking an active role in water conservation sets an example to residents and demonstrates the City's willingness to make changes to save water. At the same time, an audit identifies wasteful use and, in the long run, saves the city unnecessary expense. A city-wide water audit should be performed regularly to track how the city's use changes over time and as changes are made to increase water efficiency.

Example Communities

The Salem Department of Planning and Community Development of Salem, Massachusetts completed its first city audit in 2007 as part of a conservation plan and will continue auditing city use every three years. The objective of the audit is to track the municipality's water use for better future resource management development.

The City of Waukesha, WI, will complete an audit of water use in city buildings and the City of Chanhassen, Minnesota will be auditing irrigation practices of sports fields and parks within the city limits.

A goal of the local government in Denver, CO is to be a role model for water conservation. All urinals and toilets in high-use areas will be retrofitted with high efficiency hardware and the city will work towards improving irrigation efficiency. Additionally, Denver Water, the local water supplier, is auditing more than just their water system; they are auditing their buildings, grounds, and maintenance practices for water efficiency.

References

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City of Waukesha. (2009). *City of Waukesha Homepage*. Retrieved from http://www.ci.waukesha.wi.us/WaterUtility/index.html

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Primary and Secondary School Programs

Description

Conservation measure: Primary and Secondary School Programs

Strategy: Demand management - public education

Type: Indoor

Applicable customer class: Kindergarten through 12th grade students.

Description: School programs teach students of all ages about the importance of water conservation. These programs are hands-on and engage students to track their and their families' water usage. The Alliance for Water Efficiency (2009) cites three potential benefits of school programs:

1. children learn methods to conserve water in their daily routines;
2. children bring this knowledge home and influence water conservation behavior in their family;
3. Water awareness leaves a lasting impression on the child into adulthood and improves the water using behavior of the next generation.

Economic Considerations

Unit cost: Varies, depending on the number of classroom visits and materials provided to students. The Town of Cary, North Carolina's school-based conservation education program cost $5.80 per student, and 1,300 students received take home materials.

Service life: Lifetime of students.

Water savings (per unit): Unquantifiable

Assumptions: Students comprehend the material presented to them and apply what they learn to their daily lives. This includes educating household members and encouraging them to adopt water conservation habits in their daily lives and around the house.

Additional Considerations

Outreach: In class activities include

- presentations on drinking water or the hydrologic cycle;
- water essay contests;
- constructing models of the city water system;
- home water consumption surveys; and
- distributing water conservation kits (shower heads, faucet aerators, toilet tummies, etc.).

Several districts provide ongoing lessons, with a variety of activities directed at different age groups. Water conservation principles are continually reinforced as the student ages and progresses through school.

Customer acceptance: Grade school students typically enjoy class visitors and participating in hands-on activities.

Distribution method: Utility employees work with teachers to incorporate water conservation into classroom curriculum. The utility may create its own education materials for different grade levels or use a pre-packaged curriculum and tailor it to the local conditions. Materials presented to the students include coloring books, guidebooks, homework assignments, games, and posters. The utility may also give tours of the water distribution and water treatment facilities.

Monitoring and Evaluation

The effectiveness of school programs is difficult to measure because of the complexity of measuring how students apply the information they learn in class to their every day water use habits. However, educating children when they are young and continuing water conservation programs throughout their primary and secondary education can be important for instilling a conservation ethic. Some children may never be exposed to water conservation if it were not taught in school.

Example Communities

Project WET (Water Education for Teachers) is a nonprofit water education program. Its mission is to promote awareness and stewardship of water resources through the dissemination of classroom-ready teaching aids.

Cary Public Works and Utilities (PWU) offer three programs to students of various ages. Save Lots of Water, or SLOW, is an education game directed at lower elementary age students in which they are taught how to use rain gauges, shower timers and toilet dye. For a week, students record water savings, and class rooms that achieve their water conservation goal by the end are rewarded. The Pipes program targets middle school students by asking them to construct models of the water distribution and collection facility. The third program provides high school students with a guided tour of facilities.

References

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Town of Cary, North Carolina. (2007). *Education Overview*. Retrieved from http://www.townofcary.org/depts/pwdept/water/waterconservation/education.htm

Description

Conservation measure: Public Education Campaign

Strategy: Demand management - public education

Target: Indoor/Outdoor Use

Applicable customer class: All customers

Description: A public education campaign is an important component of a comprehensive conservation plan. A successful campaign should address

- why water conservation is important to the community;
- the benefits of conserving water;
- the consequences of not using water efficiently; and
- the ways customers can conserve water.

Public education campaigns are common during water shortages with the goal to produce immediate customer behavioral changes. However, a campaigns objective with regard to water conservation is to educate customers so that they make wise decisions regarding their water use. Also, customers who are aware of the importance of conservation are better equipped to understand and accept decisions concerning increasing water rates and enacting water use restrictions.

Economic Considerations

Unit cost: Varies depending on the size and scope of the campaign. The Town of Cary, NC spent approximately $1.00 per account on promotional items for a successful summer campaign designed to reduce peak demand.

Service life: 1 year

Water savings (per unit): Unquantifiable; however, Maddaus (1987) estimates a 1-5 percent reduction.

Assumptions: For a campaign to be successful it must be a community-wide effort to reach the majority of customers in the community and customers must modify their behavior.

Additional Considerations

Outreach: A utility should use multiple media outlets such as radio, TV, public service announcements, local events, bill stuffers, and the utility's website to promote the campaign.

Customer acceptance: In the short term, customer response is positive; however, their behavioral changes eventually taper off.

Monitoring and Evaluation

The effectiveness of public education campaign is short term. Behavioral changes made in response to the campaign typically do not last longer than a year, even if the campaign continues.

Consequently, public education campaigns are not an effective long term water conservation strategy (Alliance for Water Efficiency, 2009).

Example Campaigns

National campaigns

Water Use It Wisely aims to promote consumer awareness of water use and efficient indoor and outdoor technology. The campaign's website provides visitors with water conservation tips, information on water supply technology, a month by month calendar on good water use, games, and links to other conservation resources.

WaterSense is a U.S. Environmental Protection Agency sponsored labeling program similar to Energy Star but focused on water efficient products. The program's website provides fact sheets on water-efficient products and programs along with facts about water efficiency and links to other resources.

WaterWise is an education and incentive program through which residents receive irrigation audits, learn about Energy Star and landscape rebates, and participate in conservation contests.

Utility developed campaigns

The Town of Cary has created its own campaigns, *Beat the Peak* and the *Block Leader* program. *Beat the Peak* is a summer campaign designed to reduce summer peak demand. Each residence receives a promotional item and the city launches a mass media campaign and hosts workshops. The *Block Leader* program utilizes volunteer citizens who interact with neighbors increasing awareness of the town's water conservation efforts and other environmental programs.

The City of Waukesha has started three campaigns: *20 by 2020*, which aims to reduce per capita water use in the city 20% by 2020; *Don't Flush Dollar$ Down the Drain*, which shows how much money a family of four can save by replacing old toilets; and *Don't Get $oaked by Overwatering Your Lawn*, which promotes the City's lawn watering restrictions.

Denver Water started a campaign called *Use Only What You Need*. The campaign's objective is to reduce residential water use using humor and flashy advertising. The campaign's interactive website offers conservation tips, promotional videos, and free items such as t-shirts, lawn signs, stickers, and iron-on t-shirt graphics, reminders on watering restrictions, and Xeriscape landscaping advice.

References

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Rain Sensor Rebate

Description

Conservation measure: Rain Sensor Rebate

Strategy: Demand management - economic incentive

Target: Outdoor Use

Applicable customer class: All customers

WGL & Associates

Description: A rain sensor is a shutoff device for automatic irrigation systems. It is wired to the irrigation system controller and mounted in an open area where it is exposed to rainfall (Dukes & Haman, 2002). If an irrigation system is running during a rain event, the rain sensor will turn off the cycle after a specific amount of rain has fallen. The advantages of a rain sensor include: reduces needless water use, saves money on utility because of decreased water consumption, and decreases runoff that could carry pollutants to surface waters.

Rain sensors operate by two methods: those that use water sensitive materials and those that collect water. Rain sensors containing water sensitive materials, such as cork disks, are controlled by the expansion and increased pressure that occurs when the material absorbs water. Devices that collect water in a small dish may either weigh collected rain water or use electrical conductivity to determine the amount of rainfall received. A disadvantage of the dish is greater maintenance because debris and excess water that could accumulate interferes with the accuracy and function of the sensor. Both types of devices may be adjusted to customer specified rain levels.

Economic Considerations

Unit cost: Rain sensor cost $15 to $45. An appropriate rebate amount is $15. Total program cost estimated at $4,000 for 100 rebates. This cost includes a $20 administrative cost per rebate.

Water savings (per unit): 2.2 million gal/year assuming 100 rebates are provided and the rain sensor results in a 5 percent water savings (Vickers, 2001).

Assumptions: 2007 water use data for all customers, excluding Indiana University, with a separate irrigation meter was used to estimate water savings. Approximately 320 customers in the CBU service area, 180 of which are single family accounts, have a separate irrigation meter.

Additional Considerations

Outreach: The utility should advertise rain sensors and available rebates using bill inserts or its websites. Once the customer applies for the rebate, the utility may provide information related to calibrating, testing, and maintaining devices as well as names of local contractors who can install the rain sensor.

Distribution method: To receive the rebate, customers should be required to provide proof that they own an automatic irrigation system. The utility should follow up with the customer to insure that the rain sensor was installed. If the home owner decides to install the device

themselves, the utility would inspect the property, ensuring accuracy and proper location. If the customer hires a professional to install the system, the customer may provide the utility with documentation of the provided service.

Monitoring and Evaluation

To monitor the use of rain sensors, the utility could identify and track water consumption over time for properties with rain sensors. Comparison of pre- and post-installation water use amounts during peak irrigation time periods would help to evaluate the effectiveness of rain sensors as a conservation measure.

Example Communities

As part of the "Let's be Water Smart" program, James City Service Authority of Virginia offers up to a $50 rebate for the purchase of a rain sensor. The rebate program targets older irrigation systems installed prior to March 2005, without a rain sensor already present. The program website provides information including: eligibility restrictions, rain sensor benefits, purchasing locations, and a list of private contractors capable of installation.

Denver Water offers rebates for residential and commercial customers that purchase and install rain sensors, including wireless devices. Rebates are restricted to new construction, with an account activated by a specified date, and within 90 days of purchasing the rain sensor.

The State of Florida requires rain sensors installed on new irrigation systems. Pasco County Utilities offers a $40 rebate for installing rain sensors on existing irrigation systems in the form of a credit on the customer's water bill. Installation must be completed by a utility approved contractor.

References

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Toilet Retrofit on Resale Ordinance

Description

Conservation measure: Toilet Retrofit on Resale Ordinance

Strategy: Demand management - government regulation

Target: Indoor Use

Applicable customer class: All customers

Description: The U.S. Energy Policy Act of 1992 established maximum water-use levels for toilets, urinals, showerheads, and faucets. The Act set maximum water use for toilets at 1.6 gallons per flush (gpf) and 1.0 gpf for urinals. The efficient standards applied to fixtures in residential and non-residential homes built or renovated after 1994. Prior to 1994, toilets were using approximately 3.5 gpf to 7.0 gpf. With toilets as the largest source of indoor water use (26.7%), retrofitting homes and buildings built before 1994 provides great potential for water savings (Vickers, 2001).

Economic Considerations

Unit cost: The cost for ultra-low flush toilets (ULFT) and high efficiency toilets ranges from $120 to $600, depending on brand and type of low-flow toilet. Waterless urinals range from $300 to $450. The home or business seller may include the cost of retrofitting the toilets in the property's selling price, therefore minimizing the cost of retrofitting.

Additional implementation costs: A professionally installed toilet can cost between $50 and $125. The cost includes replacing the wax ring on the floor at the base of the bowl and disposal of the old toilet (Vickers, 2001).

Service life: The service life of a toilet depends on the frequency and type of use, quality of mechanical parts, and water quality. A porcelain gravity flush toilet can last 25 to 50 years with regular maintenance (Vickers, 2001).

Water savings (per unit): 3,683,433 gal/yr (2015)

Assumptions: To calculate the water savings, the following assumptions were made.

- Persons per household – 2.27
- GPF of old toilets – 3.5 gpf
- GPF of new toilets – 1.6 gpf
- Flushes per person per day – 4
- A 1 percent growth rate was used to calculate the number of pre-1994 homes sold from 2008 to 2012
- A negative 1 percent growth rate was used to calculate the number of pre-1994 homes sold from 2013 to 2030
- Data on the number of homes in Bloomington sold from 2000 to 2007 was obtained from the Bloomington Board of Realtors
- Data on the age of Bloomington homes was obtained from the 2005-2007 American Community Survey 3 Year Estimates

Implementation

A toilet retrofit on resale ordinance requires the homeowner to upgrade any pre-1994 toilets with more efficient toilets. The city will need to validate the upgrade at the time of sale or prior to new water service to the property.
The utility should provide information on toilets that meet the specification of the ordinance on its website. One source of information is the U.S. EPA's WaterSense Program. WaterSense is a labeling program similar to Energy Star but focused on water efficient products. The website provides factsheets on water-efficient products and programs along with facts about water efficiency and links to other resources.

Monitoring and Evaluation

To evaluate the ordinance's water savings, the utility should keep track of the number of retrofits performed and gpf of the replaced toilets and new toilets.

Example Communities

The City of Santa Cruz, California, requires all residential, commercial, and industrial buildings to be retrofitted with low water use plumbing fixtures at the time of sale. Toilets must meet a standard of 1.6 gpf and 1.0 gpf for urinals. Sellers are responsible for having their home inspected by qualified individuals and obtaining a Water Conservation Certificate. However, upon mutual agreement of the buyer and seller, a transfer of responsibility of the retrofit is available, in which case the buyer would have 90 days from the sale to complete the retrofit. The Water Department offers up to a $150 rebate for replacing older toilets.

The Marin Municipal Water District in California requires that within 6 months of applying for water service at a property, residential customers must submit a "Low Flow Toilet Certificate" to ensure all toilets meet a 1.6 gpf standard. Included on the Water District's website is a copy of the certificate, and instructions of how to determine the water use of a toilet. The utility offers $250 rebates for low-volume toilets to single family homeowners and businesses and multi-family customers are eligible for free high efficiency toilets and installation. Commercial and industrial customers may also receive rebates for high efficiency urinals including up to $200 for 1.0 gpf, $350 for 1/8 gpf, and $400 for no-water urinals.

References

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Description

Conservation measure: Utility Water Audit

Strategy: Water supply management

Target: Apparent losses/Real losses

Applicable customer class: Utility

Description: A water audit is an accounting procedure that tracks raw, treated, and sold water throughout a system. The purpose of the audit is to understand the overall water system and to identify areas where efficiencies can be achieved. As part of a conservation plan, a water audit provides an assessment of water use and losses within the operation, establishes a baseline measurement of water use, and can be used to track progress made towards meeting conservation goals to reduce non-revenue water. Non-revenue water is comprised of apparent losses and real losses. Apparent losses are "paper losses" that represent errors in customer metering and billing data, and real losses are physical losses caused by leaks and overflows.

Implementation

When conducting water supply system audits, potential sources of revenue loss may originate from accounting errors, illegal connections or theft, evaporation, reservoir seepage, leakage, or overflow, distribution-system malfunction (Chesnutt et al., 2007) or leaks. A utility should target an economic level of leakage. The economic level of leakage is the level at which the cost of repairing leaks is equal to the cost of water saved through leakage reduction. This economic level is contingent on water scarcity and expense (AWWA Water Loss Control Committee, 2006). Apparent losses are valued at the retail rate the water supplier charges its customer and real losses are valued at the marginal cost to treat and pump water.

An annual water audit is useful for utilities that have implemented a leak detection program and/or a meter testing and replacement program. The audit assists the utility in tracking the progress of the programs.

The AWWA provides a free downloadable program to help conduct the audit; therefore the only other cost associated with auditing is compensation for a worker's time, depending on the quality of the utility's records.

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AWWA Water Loss Control Committee. (2006). AWWA WLCC Water Audit Software: Definitions. *AWWA Water Loss Control Committee Water Audit Software v3.0* .

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Water Conservation Billing Information

Description

Conservation measure: Water Conservation Billing Information

Strategy: Demand management - public education

Target: Indoor/Outdoor Use

Applicable customer class: All customers

Description: An informative and understandable water bill encourages consumers to incorporate water saving practices into their daily activities. Currently, the monthly water bill is the only way customers learn their households' or businesses' water use. As a result, it is important to make the bill as informative as possible. A basic water bill identifies usage volume, the water rate, fixed charges, and possibly a message from the utility. An informative water bill includes information beyond that of the basic bill such as annual average use, previous month's usage, and a comparison of the customers use to average use in their neighborhood.

Economic Considerations

Unit cost: Varies depending on extent of information included on the bill. The cost may be negligible if only water conservation messages are printed on the bill; however, changes to the billing system and bill format will result in a sizeable investment.

Additional implementation costs: In addition to changing the format of the water bill, a utility could create online accounts so that customers can get more detailed information on their usage. Online accounts are an alternative to lengthy bills. This service does not have to include online payments, but rather just give detailed account information. Such accounts are common among energy companies.

Bill inserts explaining how to read the new water bill will be necessary for the first few billing cycles.

Water savings (per unit): Unquantifiable

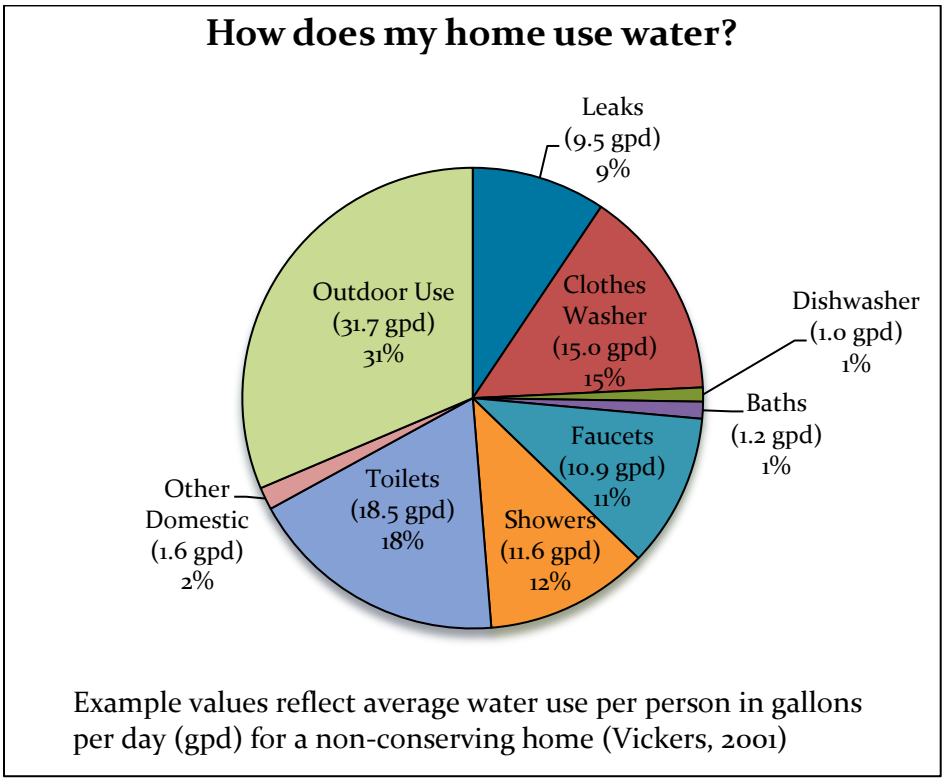
Example Information

The water bill or online account could include the following information:

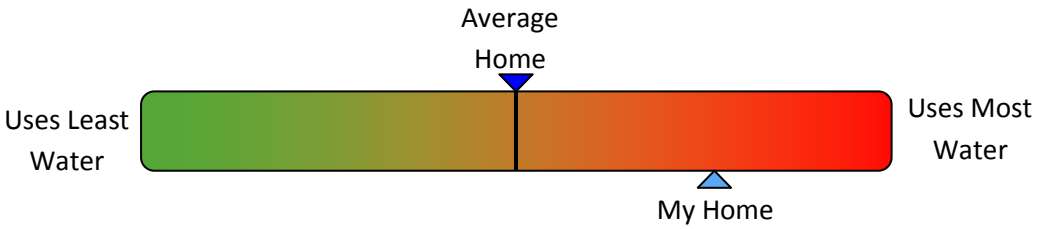
How does my home use water? – The pie chart *(on following page)* shows water use by category. If included on a utility's website, customers should have the option to fill out a water survey to help estimate how they use water. The survey may include: property details (year built, size of home, size of yard, renovations, updated fixtures, etc.); property features (type of heating and cooling systems); household details (number of occupants, homeowner or renter); utility details (specific to renters - which utilities landlord pays for); equipment and amenities (appliance information, outdoor watering practices such as automatic irrigation systems or manual watering, etc.). Customers would receive information on how to save water based on their profiles and the categories with the highest usage (Duke Energy, 2009).

How does my home compare? – The graphic below that shows a spectrum of water usage from *Uses Least Water* to *Uses Most Water* and depicts how much water a customer uses compared to their neighbors or customers with similar home-use profiles (Duke Energy, 2009).

Bill Highlights – This section would explain why the current month's water use increased or decreased from the previous month's use (Duke Energy, 2009).



How does my home compare?



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Description

Conservation measure: Adopt Water Efficient Plumbing Codes

Strategy: Demand management - government regulation

Target: Indoor Use

Applicable customer class: All customers

Description: Plumbing codes were originally adopted to ensure proper measures were taken to protect public health and safety. In order to reflect the need for more sustainable water supply practices, it is important for plumbing codes to include more water efficient standards, as it pertains to protecting future generations' public health and safety. Indiana's plumbing code was last updated in 1999, and uses the 1997 Uniform Plumbing Codes (UPC) developed by the International Association of Plumbing and Mechanical Officials (IAPMO). Despite an update in the UPC in 2006, the State of Indiana still refers to the older, less efficient, 1997 version. Utilities are encouraged to develop ordinances requiring more stringent standards within their service territory to help promote water conservation. In addition to the UPC, other examples of standards and practices aimed at higher water efficiency include the International Plumbing Code (IPC) developed by the International Code Council, and the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED).

Economic Considerations

Water savings (per unit): 12,000,000 gallons (2015)

Assumptions: Used the average commercial non-summer consumption for 2006 and multiplied by the number of forecasted new commercial accounts in 2015. Used the yearly fixture savings listed below to calculate single family savings. Multiplied the savings by the forecasted number of new single family accounts.

Device	Savings (gal/min)	Savings per house per day (gallons)	Savings per year per household (gallons)
1.28 gpf toilets	0.32	2.91	1061
1.5 gpm showerheads	0.7	8.42	3074
1.5 gpm faucets	0.7	12.87	4698
8 gal/cycle clothes washers	31	26.04	9503
6 gal/cycle dishwasher	4.5	1.02	373
Total	-	-	18,709

Residential Assumptions
person per household: 2.27
toilet - number of uses per person: 4
showers - time per person (min/day): 5.3
faucet frequency (min/day) per person: 8.1
Dishwasher use (loads/day) per person: 0.1
Clothes washer (loads/day) per person: 0.37
(Vickers, 2001)

Additional Considerations

Besides increasingly efficient fixture flow rates, building design should also be considered to further improve water savings, in particular those related to showerheads and meeting hot water demands. An increasing trend in modern showers is the use of multiple showerheads. To minimize water consumption, plumbing codes could limit the number of showerheads within a specified area, require minimum space between shower heads, or set a maximum flow rate per unit area from all combined showerheads. To prevent water waste due to waiting for hot water delivery, plumbing codes could limit hot water pipe diameter, require insulation of hot water pipes, include hot water recirculation systems, or utilize more centralized water heating systems to decrease the length hot water must travel within a building.

Example Communities

Miami-Dade County, Florida, in southern Florida developed a Water-Use Efficiency Standards Manual to take effect in January of 2009. The County Water and Sewer Department's Water-Use Efficiency Section established its own standards to use with the local plumbing code; it is applicable for all new development and substantial remodeling projects. The manual mandates the installation of the most water efficient fixtures currently available, often referencing the U.S. Environmental Protection Agency's Water Sense. The document also identifies standards for maximum flow rates in bath and kitchen fixtures. The standards include the use of no flush urinals and a more specific definition for showerheads to include any "rain system, waterfall body spray, body spa, and jet" fixtures. Additional recommendations target non-residential customers and outdoor water-users in order to help them to achieve higher water-use efficiency.

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Water Waste Ordinance

Description

Conservation measure: Water Waste Ordinance

Strategy: Demand management - government regulation

Target: Outdoor Use

Applicable customer class: All customers

Description: A water waste ordinance prevents wasteful use of potable water. Typically, the ordinance prohibits direct watering of impervious surfaces and excessive lawn watering to the extent that excess water is running off into storm drains. Some ordinances also address leaks and breaks that are not fixed within a specified amount of time, fountains that do not recycle water, washing hard surfaces with hoses, and refilling swimming pools.

Implementation

Information regarding the ordinance's restrictions should be available on the utility's or city's website. Throughout the watering season, reminders can be sent to customers through bill inserts and radio and newspaper announcements. The ordinance is enforced by either the utility or some other city department. Violations can also be reported by fellow citizens, with follow up inspection done by the utility. Violation fines typically range from $50 to $400 depending on the number of offenses.

Monitoring and Evaluation

The water savings of a water waste ordinance is not easily teased apart from other irrigation ordinances or conservation measures. Monitoring the impact of the ordinances requires keeping a record of the number of violations issued.

Example Communities

The City of Rio Rancho, New Mexico, does not allow any water, other than naturally occurring precipitation, to enter storm drains, public right-of-ways, or nearby properties. Citizens may report a violation using an online form or telephone hotline, which is followed up by an inspection by the utility. The first violation results in a notice; however, if the infraction continues fines may reach up to $150 or $300, depending on the size of the meter used on the property. After the sixth infraction, in addition to paying a fine, a flow restriction device is placed on the property.

The following communities have a waste water ordinance.

- Rohnert Park, California
- Cary, North Carolina
- Tucson, Arizona
- Santa Monica, California
- Santa Rosa, California
- Albuquerque, New Mexico
- Dallas, Texas
- Salem, Oregon

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City of Santa Rosa. (2009). *Water Utilities*. Retrieved from http://ci.santa-rosa.ca.us/departments/utilities/h20/Pages/default.aspx

Town of Cary. (2006). *Town of Cary Water Conservation Program*. Retrieved from http://www.townofcary.org/depts/pwdept/water/beat.htm

Tucson Water. (2009). *Tucson Water Homepage*. Retrieved from http://www.ci.tucson.az.us/water/

Website Water Conservation Information

Description

Conservation measure: Website Water Conservation Information

Strategy: Demand management - public education

Type: Indoor/Outdoor Use

Applicable customer class: All customers

Description: As paying for water bills online becomes more common, a utility's website becomes an important source for water conservation information. Links to indoor and outdoor conservation tips, lawn watering restriction reminders and upcoming conservation programming can be posted on the website. This method is inexpensive for the utility, provides general awareness, and practical tips for every day users to conserve water.

Economic Considerations

Cost: Negligible

Water savings (per unit): Unquantifiable

Assumptions: Customers visit the site, read through the conservation information, and make relevant changes to their behavior and/or indoor and outdoor water fixtures.

Monitoring and Evaluation

Evaluating the usefulness of a utility's online water conservation information can be accomplished by randomly surveying site visitors on whether they have applied any of the information to their everyday activities and water use, and if so, what changes they have made or plan to make. Also, the utility should keep track of the number of visitors to the site.

The effectiveness of using websites to promote water conservation is unknown. However, this method is inexpensive for the utility and provides general awareness and practical tips for conserving.

Example Information

Website information can include:

- access to water savings calculator,
- a link to city water conservation plan,
- rebate opportunities,
- best management practices for homeowners, commercial business, and industry,
- upcoming education programs,
- watering restrictions and other regulatory programs, and
- conservation tips (please see other side of sheet for example water conservation tips)

Website Water Conservation Information

The information below was obtained from U.S. EPA WaterSense program's brochure on Simple Steps to Save Water (2007).

Indoor Conservation Tips

Toilets

- Consider replacing your older toilet with a WaterSense labeled high-efficiency model that uses 20 percent less water and performs as well as or better than standard models. Compared to a 3.5 gallons per flush toilet, a WaterSense labeled toilet could save a family of four more than $90 annually on their water, and $2,000 over the lifetime of the toilet.
- Check for toilet leaks by adding food coloring to the tank. If the toilet is leaking, color will appear in the bowl within 15 minutes. Make sure to flush as soon as the test is done because food coloring may stain the tank.

Faucets

- Installing a simple aerator is one of the most cost-effective ways to save water – you can double the faucet's efficiency without sacrificing performance.
- Repair dripping faucets and showerheads. A drip rate of one drip per second can waste more than 3,000 gallons per year.

Around the House

- A full bathtub can require up to 70 gallons of water, while taking a 5-minute shower uses only 10 to 25 gallons.
- Savings from turning off the tap while brushing teeth or shaving can really add up.
- Wash only full loads of dishes and clothes or lower the water settings for smaller loads.
- Replace your old washing machine with a high-efficiency, ENERGY STAR® labeled model, which uses up to 50 percent less water and electricity.

Outdoor Conservation Tips

Lawn Watering

- Water your lawn or garden during the cool morning hours to reduce evaporation.
- Look for sprinklers that produce droplets – not mist- or use soaker hoses or trickle irrigation for trees and shrubs.
- Set sprinklers to water lawns and gardens only – check that you're not watering the street or sidewalk.
- Try not to overwater your landscaping – learn plant's water needs and water different types appropriately.
- Don't over fertilize. You will increase the grass's need for water.
- Raise your lawn mower blade to at least 3 inches. Taller grass promotes deeper roots, shades the root system, and holds soil moisture better than a closely cropped lawn.
- Plant climate-appropriate species. Try native plants, which do not require as much water, and group plants together by water requirements.
- Use mulch around trees and plants to help reduce evaporation and control water-stealing weeds.

Appendix E. Demand Forecasts

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WATER USE DATA AND MODELS FOR BLOOMINGTON

DATA

Data Sources

Data on water use within the study area were obtained from Bloomington Municipal Water Utility (BMWU). Data used to specify explanatory variables and their historical values came from several sources. Information on major drivers of water demand including population, housing and employment were obtained from the Statistics Indiana. Data were also obtained from state and federal agencies, most often from routinely collected statistics available from libraries or in electronic format on agency websites. The main source of these data was the U.S. Census. Other agencies included the Bureau of Economic Analysis and the National Oceanic and Atmospheric Administration (NOAA). The accuracy of these data reflect the data quality standards of the governmental agencies involved in data collection and reporting.

Several procedures were used to identify, correct and/or discard data with apparent errors caused by mistakes in data collection or input. The data checking procedures included: (1) arranging data in spreadsheets and visually inspecting for apparent anomalies; (2) calculating and examining standard ratios (i.e., per capita or per customer water quantity); (3) graphing time-series data to identify outliers and large shifts in values over time; and (4) comparing data values against other available data sources.

While the overall accuracy of the data used in this project is not ideal, the available data and their quality are considered to be adequate for the purpose of developing water-demand relationships for the purpose of forecasting future water use.

Historical Data on Monthly Water Use

Billing and production records were used to derive estimates of monthly water use in the BMWU water service area. Table A-1 shows the monthly data by sector for the period from April 2002 to November 2007.

The data on water use include 68 monthly observations from April 2002 to November 2007. The six major sectors of users include: single-family residential, multifamily residential, commercial, industrial, Indiana University and wholesale.

The last three columns of Table A-1 compare total sectoral sales to total production of finished water. The average percent on non-revenue water is 13.3 percent.

Table A-1. Historical Data on Monthly Water Sales and Production in Bloomington (in 1000 Gallons per Month)

Year	Month	SF	MF	Comm.	Industrial	IU	Wholesale	Total Sales	Total Prod.	UA%
2002	Apr	70,695	70,364	52,310	3,728	54,949	86,376	338,423	398,580	15.1
2002	May	74,640	64,977	56,288	3,787	47,247	93,599	340,538	392,441	13.2
2002	Jun	83,377	63,177	65,576	3,495	62,298	100,554	378,477	418,572	9.6
2002	Jul	103,602	68,368	79,549	3,843	77,678	107,641	440,681	522,605	15.7
2002	Aug	108,191	73,149	87,310	3,775	66,376	108,100	446,901	546,371	18.2
2002	Sep	94,349	81,278	76,500	3,622	85,573	100,795	442,116	524,823	15.8
2002	Oct	78,553	77,706	59,439	3,843	72,745	85,532	377,818	427,199	11.6
2002	Nov	71,487	76,213	50,247	3,998	73,552	79,568	355,065	385,540	7.9
2002	Dec	64,882	65,475	41,942	2,916	50,661	84,851	310,726	392,261	20.8
2003	Jan	62,721	62,585	43,397	2,957	45,614	84,991	302,265	410,076	26.3
2003	Feb	69,373	74,060	53,912	3,595	53,763	78,873	333,576	381,448	12.6
2003	Mar	91,512	85,756	62,161	3,028	53,611	85,307	381,375	395,915	3.7
2003	Apr	72,411	71,877	54,073	3,131	64,829	82,067	348,388	403,355	13.6
2003	May	77,700	69,324	58,277	3,107	57,874	86,006	352,289	396,036	11.0
2003	Jun	80,916	62,452	60,439	3,416	58,608	89,297	355,128	404,929	12.3
2003	Jul	86,321	63,927	72,773	3,016	72,582	99,499	398,118	453,043	12.1
2003	Aug	94,413	72,151	75,824	2,798	74,924	100,740	420,851	502,796	16.3
2003	Sep	86,246	81,792	64,774	3,805	79,867	90,448	406,932	450,248	9.6
2003	Oct	77,922	77,721	58,063	3,745	69,045	86,438	372,934	424,823	12.2
2003	Nov	71,258	71,191	49,984	3,862	62,434	79,899	338,627	381,862	11.3
2003	Dec	72,138	68,934	47,322	3,499	56,222	82,436	330,551	386,197	14.4
2004	Jan	74,199	72,210	47,258	3,383	53,296	84,963	335,310	402,795	16.8
2004	Feb	70,842	71,605	47,906	3,528	65,488	82,209	341,577	402,146	15.1
2004	Mar	71,756	71,407	51,062	3,114	58,734	82,663	338,735	389,284	13.0
2004	Apr	74,293	71,709	52,075	3,571	64,575	83,394	349,616	406,159	13.9
2004	May	80,646	68,752	59,990	3,518	60,365	91,684	364,955	417,917	12.7
2004	Jun	80,299	62,848	62,679	2,862	60,641	92,506	361,835	437,633	17.3
2004	Jul	81,373	64,377	68,067	3,696	62,944	96,774	377,231	434,779	13.2
2004	Aug	88,233	71,043	72,886	3,864	67,009	96,725	399,761	455,875	12.3
2004	Sep	91,610	77,391	68,910	3,888	78,891	92,709	413,399	487,160	15.1
2004	Oct	83,930	76,813	61,530	4,513	67,950	88,400	383,136	442,138	13.3
2004	Nov	70,830	68,564	49,379	4,255	56,490	81,415	330,933	384,238	13.9
2004	Dec	74,060	66,996	48,702	4,200	52,985	84,471	331,413	395,095	16.1
2005	Jan	74,249	68,872	54,899	4,539	52,160	86,616	341,337	408,529	16.4
2005	Feb	64,996	65,588	46,460	4,354	50,187	74,888	306,471	368,575	16.8
2005	Mar	70,866	69,262	50,619	4,793	52,391	81,748	329,679	383,252	14.0
2005	Apr	73,121	69,312	53,866	4,062	57,801	81,762	339,924	390,139	12.9
2005	May	80,577	65,918	61,452	3,711	54,473	90,807	356,939	416,654	14.3
2005	Jun	92,040	60,211	66,915	2,626	60,289	97,439	379,521	426,259	11.0
2005	Jul	95,978	64,579	79,255	2,165	74,493	101,382	417,852	448,030	6.7
2005	Aug	90,616	75,667	88,184	2,605	75,239	96,789	429,101	454,591	5.6
2005	Sep	82,519	79,878	77,928	2,222	75,022	86,738	404,307	433,884	6.8
2005	Oct	78,725	76,932	67,073	2,023	67,221	83,804	375,779	414,233	9.3
2005	Nov	71,322	69,625	51,292	2,093	54,015	77,462	325,809	367,197	11.3
2005	Dec	72,378	67,382	48,759	2,422	44,043	60,463	295,447	363,532	18.7
2006	Jan	70,972	70,611	48,474	2,440	43,822	75,109	311,427	366,709	15.1
2006	Feb	65,038	66,250	47,813	2,559	44,213	71,801	297,675	342,833	13.2
2006	Mar	69,774	70,671	51,217	3,111	45,785	79,380	319,938	360,534	11.3
2006	Apr	71,203	71,713	53,066	2,361	52,351	81,616	332,309	380,341	12.6

Year	Month	SF	MF	Comm.	Industrial	IU	Wholesale	Total Sales	Total Prod.	UA%
2006	May	78,058	66,877	57,725	2,631	47,681	89,580	342,552	384,562	10.9
2006	Jun	79,109	60,050	60,638	2,329	53,213	93,789	349,128	385,162	9.4
2006	Jul	89,600	63,164	74,620	2,291	65,020	101,400	396,096	440,461	10.1
2006	Aug	91,972	70,899	77,084	2,178	72,262	101,304	415,698	463,788	10.4
2006	Sep	79,158	76,560	64,381	2,424	67,061	85,374	374,958	423,752	11.5
2006	Oct	75,169	76,384	58,481	2,438	59,161	85,566	357,198	417,876	14.5
2006	Nov	71,050	69,410	50,335	2,481	49,845	82,652	325,773	375,789	13.3
2006	Dec	71,465	64,116	49,102	2,153	43,638	87,584	318,057	373,823	14.9
2007	Jan	71,096	68,088	49,034	2,613	38,619	89,852	319,303	393,012	18.8
2007	Feb	66,522	68,898	47,952	2,459	42,984	88,306	317,121	386,489	17.9
2007	Mar	71,611	73,224	52,671	2,869	58,195	88,363	346,932	404,098	14.1
2007	Apr	71,806	71,434	54,144	2,576	53,150	84,968	338,079	397,686	15.0
2007	May	86,379	68,916	64,163	2,643	55,742	101,186	379,029	441,014	14.1
2007	Jun	90,399	65,732	71,856	2,586	60,534	105,997	397,103	458,095	13.3
2007	Jul	88,977	72,124	83,342	2,524	63,122	104,872	414,962	449,107	7.6
2007	Aug	112,318	81,616	87,101	2,033	81,219	113,863	478,151	547,802	12.7
2007	Sep	101,514	86,172	83,363	2,253	80,312	101,641	455,255	506,876	10.2
2007	Oct	85,552	86,011	68,717	2,137	66,426	88,048	396,891	464,236	14.5
2007	Nov	72,175	74,372	54,227	2,192	49,505	79,822	332,294	411,589	19.3
Ave.	--	79,604	70,922	60,541	3,107	60,309	89,013	363,497	419,189	13.3
% Prod	--	19.0	16.9	14.4	0.7	14.4	21.2	86.7	100.0	13.3

UA% = percent of nonrevenue water obtained by comparing total metered use to total production

WATER-USE RELATIONSHIPS

Representing Water Demand

The analytical techniques for estimating water use were dictated by the type of data on actual water quantities and the corresponding data on explanatory variables that were available for each sector of water users. The general approach to representing water demand is to describe it as a product of the number of users (i.e., demand driver) and unit quantity of water usage:

$$Q_{cit} = N_{cit} \cdot q_{cit} \qquad (1)$$

where
Q_{cit} = water use (or demand) in user sector c during month i in year t;
N_{cit}= number of users (or demand driver) such as accounts, or housing units; and
q_{cit} = average rate of water requirement (or water usage) in gallons per account-day, gallons per housing unit-day, or other measure of the number water users.

Where appropriate measures of the number of users were not available, no separation of the number of users and usage rates was employed. For this reason, total monthly billed water deliveries were used as the dependent variable in IU, industrial, and wholesale sectors.

Regression Models

Modeling of water demand usually concerns the future changes in average rate of water usage, q_{cit} , in response to changing future conditions. Water-demand relationships which quantify historical changes in q_{cit} (or Q_{cit}) can be expressed in the form of equations, where the average rate of water usage is expressed as a function of one or more independent (also called explanatory) variables. A multivariate context best relates to actual water usage behaviors, and multiple regression analysis can be used to determine the relationship between water quantities and each explanatory variable. The functional form (e.g., linear, multiplicative, exponential) and the selection of the independent variables depend on the category of water demand. For example, water use by single-family sector can be estimated using the following linear model:

$$q_{SFit} = a + \sum_j b_j X_{jit} + \varepsilon_{it} \qquad (2)$$

where q_{SFit} represents water use per single-family account in month i during year t, X_j is a set of explanatory variables (e.g., air temperature, precipitation, price of water, percent of new accounts and others), which are expected to explain the variability in water use per account, and ε_{it} is random error term. The coefficients a and b_j can be estimated by fitting a multiple regression model to historical water-use data.

The actual models used in this study were specified as double-log (i.e., log-linear models) with additional variables which served to fit the model to the data and also isolate observations which were likely to be outliers:

$$\ln q_{SFit} = \alpha_o + \sum_j \beta_j \ln X_{jit} + \sum_k \gamma_k \ln R_{kit} + \sum_l \delta_l D_{lit} + \sum_m \rho_m S_{mit} + \varepsilon_{it} \qquad (3)$$

where: q_{SFit} represents per account water use in month i during year t (in gallons per account per day), $X_j^{'s}$ are a set of explanatory variables, R_k are ratio (percentage) variables such as percent of new houses, D_l are indicator (or binary) variables designating specific calendar months which assume the value of 1 for observations for a given month and zero otherwise, S_m are indicator spike variables designating individual observations in the data, ε_{it} is the random error, and $\alpha, \beta^{'s}, \gamma^{'s}, \delta^{'s}$ and $\rho^{'s}$ are the parameters to be estimated.

A large number of econometric studies of water demand have been conducted during the last 50 years. Useful summaries of econometric studies of water demand can be found in Boland et al. (1984). Also, Dziegielewski et al. (2002) reviewed a number of studies of aggregated sectoral and regional demand.

Model Estimation and Validation Procedures

Several procedures were used to specify and select the water demand models. The main criteria for regression model selection were: (1) the model included variables that had

been identified as important predictors by previous research, and their estimated regression coefficients were statistically significant and within a reasonable range of *a priori* values, and with expected signs; (2) the explanatory power of the model was reasonable, as measured by the coefficient of multiple determination (R^2); and (3) the absolute percent error of model residuals was not excessive.

The modeling approach and estimation procedure were originally developed and tested in a study conducted by Dziegielewski et al. (2002a). The development of the water use equation for preparing estimates of future water use represented a significant challenge because of the aggregate nature of the data and the limited number of observations on historical water use. The total number of available time series monthly observations was 68. The procedure for estimating the predictive water-use equations consisted of three steps: (1) derivation of a "structural model", (2) compensating for fixed effects of individual calendar months, and (3) examination of the effect outliers on the estimated model coefficients.

The first step was to identify the relevant explanatory variables, which would explain the variability of monthly water use in each sector during the 2002-2007 study period. The key explanatory variables were selected based on information from previous studies of water use. Several combinations of explanatory variables were examined prior to selecting the best "structural" model which explained the variability of historical water quantities in the data in terms of known determinants of water demand. The criteria for developing a good forecasting model are somewhat different from criteria in typical econometric applications where the researcher wishes to know which variables are statistically significant. A useful forecasting model requires not only an appropriate model specification but also accurate estimates of the regression coefficient (or elasticity) for each of the explanatory variables.

The next step in model development was to extend the structural model by including the binary variables designating individual calendar months. A regression of the key structural variables along with the calendar month binary variables to compete for a significant share of the remaining model variance was estimated. This was accomplished by using a stepwise regression procedure through which a binary variable is added to the structural model to account for the "uniqueness" of each calendar month. The binary calendar month variables with statistically significant regression coefficients were kept in the model. The coefficients of the binary month variables can be considered as representing "intercept adjustors" because they increase or decrease the main intercept of the regression equation for specific calendar months.

In the last step, the estimated regression model was examined further for the effects of possible outliers on the magnitude and statistical significance of the estimated coefficients. A special procedure was used to examine the effects of outliers on the estimated model without removing any "suspect" observation from the data or changing the observations in the original data by using a statistical "smoothing" procedure, or other methods. Accordingly, each of the 68 observations in the data set was assigned a binary indicator variable (i.e. a spike dummy) which assumes the value of 1 for a given data point and a value of zero elsewhere. For example, a binary

variable designated as January-2005 assumes the value of 1 for the January 2005 data point and zero for all other monthly observations.

These binary variables are referred to as "outlier variables" and their estimated coefficients would reveal "outlier effects." The advantage of this procedure is that all observations can be assessed with respect to the prediction surface of any model being estimated. It is important to note that the term "outlier" as used in this analysis or any other analysis is not necessarily a data error. It is only an observation that is far away from the regression surface (or the prediction surface) in a multivariate model. This distance depends on the model, and different outliers are identified for different models. In this sense, these data points could be called "model outliers" as opposed to "data outliers."

The regressions were estimated using ordinary least squares (OLS) and general linear model (GLM) procedures. The latter were used in order to correct for serial correlations in the monthly time series data.

Explanatory Variables by Sector

Table A-2 shows a list of variables which were included in the analysis of water use in the six user sectors in Bloomington. The variables are grouped into several categories including number of users, housing, prices, irrigation, income, weather, employment and IU enrollment.

Table A-2. A List of Explanatory Variables Used in Developing Water-Use Equations

Variables	Source
Number of Billed Accounts	CBU billing database
Number of Housing Units	Bloomington Board of Realtors
Cumulative Building Permits for Swimming Pools	Monroe County Building Department
Cumulative Building Permits (New Units)	Monroe County Building Department
Cumulative Building Permits as Percent of All Units	Monroe County Building Department
Cumulative Housing Units	Monroe County Building Department
Percent of New Housing Units	City of Bloomington I.T.S
Wastewater Marginal Price	CBU rate history
Water Marginal Price	CBU rate history
Total Marginal Price (Water + Wastewater)	CBU rate history
Fixed Monthly Charges ($)	CBU rate history
Average Price	Calculated
Percent Out of city consumption	CBU billing database
Percent In City Consumption	CBU billing database
Percent Irrigation (In and Out)	CBU billing database

Irrigation per Account (or Unit)	CBU billing database
Per Capita Income (Bloomington) 2007$	STATS Indiana
Per Capita income (Bloomington) 2006$	STATS Indiana
Per Capita Income (Monroe Co) 2007$	STATS Indiana
Bloomington MSA Wages 2007$	STATS Indiana
Precipitation (in)	Indiana Climate Office
Precipitation 1-month Lag	Indiana Climate Office
Normal Precipitation	Indiana Climate Office
Maximum Temperature	Indiana Climate Office
Maximum Temperature 1-month Lag	Indiana Climate Office
Normal Maximum Temperature	Indiana Climate Office
Minimum Temperature	Indiana Climate Office
Mean Temperature	Indiana Climate Office
Cooling Degree-Days	Indiana Climate Office
Normal CDD	Indiana Climate Office
Average 28 day net ET	Calculated
Average 28 day net ET 1 month Lag	Calculated
Minimum 28 day net ET	Calculated
Minimum 28 day net ET 1 month Lag	Calculated
Percent of employment in construction	US Census
Percent of employment in manufacturing	US Census
Percent of employment in retail trade	US Census
Percent of employment in health care & social assistance	US Census
Percent of employment in accommodation & food services	US Census
Indiana University Student Enrollment	Indiana University Fact Book
Number of Students in Dorms	Indiana University Fact Book
IU Full-time Equivalency Employees	Indiana University Fact Book

All of the variables in Table A-2 were examined in selecting the best regression models for predicting water use. The best predictors were included in final regression models.

Estimated Final Regression Models

Table A-3 compares the coefficients of the estimated regression models for the six user sectors. All models used logarithmic transformations of the dependent and some independent variables.

Table A-3. Estimated Final Log-Linear Regression Coefficients of Sectoral Water-Use Equations.

Variables	SF	MF	COMM	IND	IU	Wholesale
Dependent variably:	Ln GPAD	Ln GPUD	Ln GPAD	Ln MQ	Ln MQ	Ln MQ
Intercept	4.6428	4.8166	10.7474	9.2211	8.4281	10.8419
Weather/climate variables:						
Ln Precipitation (in.)	-0.0155	--	-0.0172	--	-0.0246	-0.0144
Ln Precipitation 1-mo lag (in.)				-0.0566	--	--
Ln Normal precipitation (in.)	-0.3283	--	-0.2265	--	-0.2782	--
Ln Maximum temperature (F)	0.0892	0.1238	--	--	0.3660	0.1356
Ln Normal Max Temperature (F)	0.3020	--	--	--	0.4387	--
Ln Cooling degree-days	--	--	0.0271	--	--	--
Ln Normal (CDD + 1)	--	--	0.0316	--	--	--
Explanatory variables:						
Ln Total marginal price (water + wastewater)	-0.2685	-0.1430	-0.2367	-0.5006	-0.4891	--
Cumulative SF Permits as % SF accounts	-0.0229	--	--	--	--	--
Ln IU Enrollment	--	0.1044	--	--	0.0567	--
Percent new MF units	--	-0.1678	--	--	--	--
% of employment in construction	--	--	14.1957	--	--	--
% of employment in manufacturing	--	--	2.5781	--	--	--
% of employment in retail trade	--	--	-27.4743	--	--	--
Time trend variable:						
Trend	0.0049	0.0013	--	-0.0080	-0.0020	0.0005
Binaries for calendar months:						
Jan	--	--	--	--	--	0.0486
Feb	--	0.1284	--	--	--	--
Mar	-0.0615	--	--	--	--	-0.0513
Apr	-0.0512	--	--	--	-0.0668	-0.0737
May	--	0.0481	--	0.0649	-0.1041	0.0476
Jun	--	--		--	-0.1461	0.0930
Jul	--	--	0.1156	--	--	0.0905
Aug	--	0.1201	0.1494	--	--	--
Sep	--	0.0956	0.1036	--	--	--
Oct	-0.1117	0.0481	--	--	--	-0.0443
Nov	--	--	0.0694	0.1297	--	-0.0939
Dec		-0.0425			0.0747	
Spike "outlier" variables:						
2002-May	--	--	--	--	--	--
2002-Nov	--	0.1089	--	--	0.2675	--
2002-July	0.1593	--	--	--	--	--
2002-Aug	0.1668	--	--	--	--	--
2002-Sep	--	--	--	--	--	0.1060
2003-Jan	--	--	--	--	--	--
2003-Feb	--	--	0.1914	--	--	--
2003-Mar	0.2334	0.1782	0.2275	--	--	--
2003-Sep	--	--	--	--	--	--
2003-Dec					--	
2005-Jan	--	--	--	0.4087	--	--
2004-Jan					0.2009	

Variables	SF	MF	COMM	IND	IU	Wholesale
2004-Feb					0.2449	
2005-Feb	--	-0.0887	--	0.4331	--	-0.1407
2005-Mar	--	--	--	0.4559	--	--
2005-Nov	--	--	--	-0.5021	--	--
2005-Dec	--	--	--	--	--	-0.3228
2006-Jan	--	--	--	--	--	-0.1910
2006-Feb	--	--	--	--	--	-0.1812
2007-Jul		0.1123				
2007-Aug	0.1404	0.1027	--	--	--	--
2007-Oct		0.0790				
Percent of explained variance (R^2):	88.5	92.2	92.5	66.8	86.5	89.8
Mean absolute percentage error:	2.97	2.06	3.60	10.60	5.51	2.66

GPAD = gallons per account per day, GPUD = gallons per housing unit per day, MQ = monthly gallons

The regression models in Table A-3 were applied to estimate future water use (either total and per unit usage) based on the future values of the explanatory variables.

SECTORAL DATA AND REGRESSION MODELS

This section presents the initial (structural) and final models of water demand for each sector. It also presents the data, model statistics, assumptions used to project the future explanatory variables, and assumptions regarding growth in each sector.

Single-Family Sector

Table A-4 shows the data on single-family (SF) water use and explanatory variables which were used in the estimation of water demand equations. Total monthly quantity of water billed to all SF accounts was divided by the number of billed accounts and by the number of days during each month to obtain average monthly water use per account in gallons per account per day (GPAD). The logarithm of GPAD value was used as dependent variable. Price, weather, income and percent of new housing units were used as independent variables.

Table A-4 Single Family Sector Data in Bloomington

Year	Mo.	MQ	Billed Acc.	GPAD	MP	FC	P	NP	TMx	NTMx	CBP%	Income	%Irrig.
2002	4	70,695	15,720	149.9	6.072	12.802	8.88	4.29	66.3	64.0	8.50	26,903	0.22
2002	5	74,640	15,833	152.1	6.072	12.794	9.35	5.12	70.3	73.9	8.79	26,903	0.68
2002	6	83,377	15,843	175.4	6.583	12.719	6.17	4.07	84.2	82.0	9.18	26,888	2.52
2002	7	103,602	15,920	209.9	6.576	12.711	2.36	4.32	88.0	86.0	9.60	26,858	4.38
2002	8	108,191	16,089	216.9	6.554	12.681	1.60	3.99	86.8	84.5	9.86	26,769	5.20
2002	9	94,349	16,091	195.4	6.543	12.659	7.29	3.62	82.7	78.1	10.12	26,724	4.69
2002	10	78,553	16,066	157.7	6.532	12.628	4.20	3.14	62.5	66.8	10.58	26,680	1.53
2002	11	71,487	15,997	149.0	6.532	12.615	0.84	3.95	48.5	53.5	10.88	26,680	0.25
2002	12	64,882	15,790	132.5	6.569	12.639	3.51	3.38	39.6	41.3	11.21	26,739	0.01
2003	1	62,721	13,418	150.8	6.540	12.643	1.54	2.66	30.8	36.5	13.42	28,114	0.09

Year	Mo.	MQ	Billed Acc.	GPAD	MP	FC	P	NP	TMx	NTMx	CBP%	Income	%Irrig.
2003	2	69,373	15,825	156.6	6.490	12.494	5.02	2.71	34.2	42.0	11.55	27,899	0.03
2003	3	91,512	15,994	184.6	6.451	12.413	2.34	3.66	55.6	52.4	11.76	27,732	0.01
2003	4	72,411	16,058	150.3	6.465	12.432	3.51	4.29	65.4	64.0	12.14	27,793	0.22
2003	5	77,700	16,196	154.8	6.476	12.460	7.02	5.12	71.6	73.9	12.36	27,838	1.59
2003	6	80,916	16,227	166.2	6.468	12.451	5.60	4.07	76.9	82.0	12.77	27,808	2.72
2003	7	86,321	16,179	172.1	6.461	12.436	8.03	4.32	84.1	86.0	13.21	27,778	3.81
2003	8	94,413	16,367	186.1	6.437	12.384	2.99	3.99	85.0	84.5	13.42	27,672	4.19
2003	9	86,246	16,422	175.1	6.416	12.747	5.04	3.62	74.5	78.1	13.79	27,583	3.42
2003	10	77,922	16,378	153.5	6.423	12.755	2.88	3.14	65.8	66.8	14.13	27,613	1.29
2003	11	71,258	16,275	145.9	6.440	12.790	5.71	3.95	55.8	53.5	14.46	27,687	0.16
2003	12	72,138	16,200	143.6	6.447	12.798	2.57	3.38	41.5	41.3	14.71	27,717	0.01
2004	1	74,199	16,184	147.9	6.416	12.935	6.78	2.66	34.1	36.5	14.84	28,506	0.01
2004	2	70,842	16,110	157.0	6.382	12.868	1.09	2.71	40.2	42.0	15.12	28,353	0.01
2004	3	71,756	16,186	143.0	6.341	12.790	2.74	3.66	55.9	52.4	15.39	28,171	0.06
2004	4	74,293	16,411	150.9	6.321	12.750	1.44	4.29	65.0	64.0	15.62	28,082	0.66
2004	5	80,646	16,512	157.6	6.284	12.681	8.84	5.12	77.3	73.9	15.95	27,918	1.73
2004	6	80,299	16,483	162.4	6.264	12.648	4.84	4.07	81.1	82.0	16.31	27,830	2.78
2004	7	81,373	16,527	158.8	6.274	12.661	6.65	4.32	82.2	86.0	16.69	27,874	3.21
2004	8	88,233	16,705	170.4	6.271	12.654	3.37	3.99	80.4	84.5	16.83	27,859	3.75
2004	9	91,610	16,642	183.5	6.257	12.635	0.16	3.62	80.3	78.1	17.29	27,801	3.99
2004	10	83,930	16,651	162.6	6.225	12.592	5.57	3.14	66.4	66.8	17.63	27,655	2.30
2004	11	70,830	16,515	143.0	6.221	12.582	4.53	3.95	55.9	53.5	18.11	27,641	0.21
2004	12	74,060	16,423	145.5	6.244	12.612	3.07	3.38	39.9	41.3	18.38	27,742	0.02
2005	1	74,249	16,452	145.6	6.231	12.586	9.03	2.66	39.9	36.5	18.46	28,567	0.00
2005	2	64,996	16,320	142.2	6.195	12.514	2.30	2.71	45.5	42.0	19.01	28,403	0.01
2005	3	70,866	16,469	138.8	6.147	12.411	2.35	3.66	47.9	52.4	19.15	28,182	0.02
2005	4	73,121	16,652	146.4	6.106	12.336	2.94	4.29	66.8	64.0	19.37	27,994	0.37
2005	5	80,577	16,839	154.4	6.112	12.345	4.47	5.12	72.0	73.9	19.40	28,023	1.59
2005	6	92,040	16,835	182.2	6.109	12.343	3.76	4.07	80.1	82.0	19.77	28,008	3.68
2005	7	95,978	16,904	183.2	6.081	12.299	4.22	4.32	85.8	86.0	19.92	27,879	4.37
2005	8	90,616	17,045	171.5	6.050	12.249	8.63	3.99	86.5	84.5	20.09	27,737	4.35
2005	9	82,519	16,980	162.0	5.977	12.117	4.05	3.62	81.2	78.1	20.51	27,403	3.36
2005	10	78,725	16,946	149.9	5.965	12.092	0.91	3.14	66.3	66.8	20.80	27,348	1.97
2005	11	71,322	16,829	141.3	6.013	12.155	4.52	3.95	56.8	53.5	21.20	27,569	0.22
2005	12	72,378	16,726	139.6	6.038	12.192	2.83	3.38	35.5	41.3	21.48	27,681	0.21
2006	1	70,972	16,658	137.4	6.753	13.291	3.82	2.66	47.8	36.5	21.79	28,614	0.03
2006	2	65,038	16,592	140.0	6.739	13.258	1.76	2.71	41.9	42.0	22.03	28,556	0.01
2006	3	69,774	16,723	134.6	6.702	13.186	8.10	3.66	51.1	52.4	22.20	28,399	0.02
2006	4	71,203	16,851	140.8	6.645	13.085	5.63	4.29	69.3	64.0	22.24	28,159	0.25
2006	5	78,058	17,006	148.1	6.612	13.030	5.15	5.12	71.1	73.9	22.28	28,020	1.33
2006	6	79,109	17,027	154.9	6.599	13.007	8.81	4.07	80.5	82.0	22.52	27,965	2.65
2006	7	89,600	17,124	168.8	6.580	12.967	3.90	4.32	86.0	86.0	22.62	27,882	4.29
2006	8	91,972	17,252	172.0	6.567	12.946	4.29	3.99	85.6	84.5	22.77	27,828	4.89
2006	9	79,158	17,163	153.7	6.599	13.010	4.86	3.62	73.0	78.1	23.08	27,965	2.84
2006	10	75,169	17,067	142.1	6.635	13.075	5.29	3.14	62.2	66.8	23.40	28,117	0.80
2006	11	71,050	16,992	139.4	6.645	13.085	4.27	3.95	53.3	53.5	23.70	28,159	0.08
2006	12	71,465	16,904	136.4	6.635	13.064	7.04	3.38	46.7	41.3	23.92	28,117	0.03

Year	Mo.	MQ	Billed Acc.	GPAD	MP	FC	P	NP	TMx	NTMx	CBP%	Income	%Irrig.
2007	1	71,096	16,952	135.3	6.615	13.024	6.06	2.66	40.6	36.5	24.02	28,636	0.02
2007	2	66,522	16,846	141.0	6.580	12.953	3.38	2.71	31.4	42.0	24.28	28,483	0.07
2007	3	71,611	16,991	136.0	6.521	12.835	3.29	3.66	61.0	52.4	24.31	28,226	0.02
2007	4	71,806	17,111	139.9	6.500	12.780	4.93	4.29	61.3	64.0	24.48	28,044	0.29
2007	5	86,379	17,251	161.5	6.461	12.708	1.75	5.12	79.2	73.9	24.47	27,874	2.80
2007	6	90,399	17,243	174.8	6.448	12.687	5.19	4.07	83.8	82.0	24.79	27,820	4.48
2007	7	88,977	17,342	165.5	6.450	12.691	4.59	4.32	83.3	86.0	24.82	27,827	4.59
2007	8	112,318	17,494	207.1	6.462	12.716	0.42	3.99	91.9	84.5	24.81	27,878	5.36
2007	9	101,514	17,479	193.6	6.444	12.684	3.11	3.62	84.0	78.1	25.00	27,802	4.72
2007	10	85,552	17,455	158.1	6.430	12.652	4.05	3.14	70.6	66.8	25.21	27,742	3.21
2007	11	72,175	17,345	138.7	6.392	12.573	1.52	3.95	53.3	53.5	25.52	27,578	0.51

Note. MQ = monthly deliveries in 1000s gal. Billed Acc. = number of accounts billed. GPAD = gallons per account per day. MP = marginal price. FC = fixed charge. P = precipitation. NP = normal precipitation. TMax = maximum temperature. NTMax = normal maximum temperature. CBP% = cumulative new building permits as percent of total SF accounts. Income = median household income. %Irrig. = percent of water used for irrigation.

Table A-5 shows the initial model of SF use. The price and income variables in the model have correct signs but are not statistically significant. The use of both the actual and normal precipitation and actual and normal values of maximum temperature allow the model to capture both the weather effect and the seasonality of water use. The two monthly binaries which had significant coefficients capture the "uniqueness" of these two calendar months in the annual pattern of monthly water use.

Table A-5. Initial Structural Model of Single-Family Water Use

Term	Estimate	Std Error	t Ratio	Prob.>|t|
Intercept	-0.6549	6.5602	-0.10	0.9208
Ln Tot MP	-0.1547	0.2486	-0.62	0.5364
Ln I Bloom	0.5052	0.6520	0.77	0.4416
Ln Prcp	-0.0333	0.0101	-3.31	0.0016
Normal Precipitation	-0.0853	0.0177	-4.83	<.0001
Ln Tmax	0.1530	0.0912	1.68	0.0989
Ln Normal Max Temp (F)	0.2550	0.0989	2.58	0.0125
Cumulative SF Permits to SF Accounts (%)	-0.0451	0.0159	-2.84	0.0063
Trend	0.0098	0.0040	2.46	0.0171
Apr	-0.0673	0.0265	-2.54	0.0139
Oct	-0.1139	0.0298	-3.83	0.0003

N= 68; R2= 0.7871; Mean Y= 5.0551; Root MSE= 0.0582

The final model of SF use per account is shown in Table A-6. The model includes three binary variables designation calendar month and four outlier binaries. The income variable remained statistically insignificant and was removed from the final equation.

Table A-6 Final Regression Model of Single-Family Water Use

Term	Estimate	Std Error	Chi-Square	Prob.> Chi-Square
Intercept	4.6428	0.4282	--	--
Ln Tot MP	-0.2685	0.1677	2.52	0.1127
Ln Prcp	-0.0155	0.0074	4.23	0.0398
Ln Normal Precipitation	-0.3283	0.0630	1.97	0.1601
Ln Tmax	0.0892	0.0685	17.09	<.0001
Ln Normal Max Temp (F)	0.3020	0.0099	5.18	0.0228
Cumulative SF Permits to SF Accounts (%)	-0.0229	0.0026	3.54	0.0601
Trend	0.0049	0.0180	7.60	0.0058
Apr	-0.0512	0.0197	26.30	<.0001
Oct	-0.1117	0.0210	8.09	0.0045
Mar	-0.0615	0.0421	12.98	0.0003
2002-July	0.1593	0.0426	13.85	0.0002
2002-Aug	0.1668	0.0455	22.26	<.0001
2003-Mar	0.2334	0.0457	8.83	0.003
2007-Aug	0.1404	0.0465	37.44	<.0001

N= 68; R2= 0.885; Mean Y= 5.055; Root MSE= 0.044

The estimated regression coefficients in Table A-6 show the elasticity of the marginal price variable of -0.2685 thus indicating that a 10 percent increase in marginal price was associated with a 2.685 decrease in water demand. The variable of percent of new SF units has a negative coefficient of -0.0229 indicating the effect of lower than average usage rates in new SF housing. Finally, the trend variable shows that after accounting for the effects of price, weather and new housing units, there was a positive trend in the data of 0.49 percent per month.

In order to estimate future use each of the explanatory variables needed to be projected to 2030 in 5-year increments. Below is a detailed description of the assumptions used for each of the explanatory variables used in the single-family regression model.

Total Marginal Price

Due to the plant expansion, CBU will be implementing a rate increase sometime in 2010. Therefore, WHPA worked with Crowe Horwath to determine the approximate increase and the following assumptions were made:

- 2010 rate increase is due to the 45% general rate increase for the water utility, plus 3.9% annual inflation in sewer rates.
- Total water and wastewater marginal price is approximately 1/3 marginal price water and 2/3 marginal price wastewater.
- Annual inflation rate for water and sewer is estimated at 3.9% annually (Beecher, 2008).

Precipitation

Monthly precipitation is the climatic normal precipitation value and was obtained from NOAA.

Maximum Temperature
The monthly maximum temperature is the climatic normal and was obtained from NOAA.

Cumulative single-family building permits to single-family accounts
It was assumed that the ratio of cumulative single family building permits to single family accounts would grow at an annual rate of 1%.

Multifamily Sector

Table A-7 shows the data used in developing MF models of water use. The weather variables were the same as those used in the SF sector.

Table A-7 Multifamily Sector Data for Bloomington

year	month	MQ	Bill Acc.	MF Units	GPUD	MP	FC	New MF	Income	%Irrig.
2002	4	70,364	3,533	15,622	150.14	6.072	31.632	846	27,474	0.001
2002	5	64,977	3,537	15,622	134.17	6.072	32.223	846	27,474	0.005
2002	6	63,177	3,469	15,622	134.80	6.583	31.968	846	27,459	0.023
2002	7	68,368	3,470	15,815	139.45	6.576	32.856	1,039	27,428	0.035
2002	8	73,149	3,600	15,824	149.12	6.554	33.982	1,048	27,337	0.038
2002	9	81,278	3,578	15,824	171.21	6.543	32.802	1,048	27,292	0.022
2002	10	77,706	3,555	15,866	157.99	6.532	33.076	1,090	27,247	0.005
2002	11	76,213	3,565	15,878	160.00	6.532	33.688	1,102	27,247	0.039
2002	12	65,475	3,497	15,881	132.99	6.569	34.410	1,105	27,307	0.003
2003	1	62,585	3,015	15,885	127.09	6.540	35.298	1,109	28,755	0.001
2003	2	74,060	3,514	15,885	166.51	6.490	33.231	1,109	28,535	0.001
2003	3	85,756	3,534	15,885	174.15	6.451	32.577	1,109	28,365	0.001
2003	4	71,877	3,555	15,885	150.83	6.465	32.472	1,109	28,426	0.003
2003	5	69,324	3,570	15,885	140.78	6.476	31.693	1,109	28,473	0.011
2003	6	62,452	3,473	15,885	131.05	6.468	31.278	1,109	28,442	0.024
2003	7	63,927	3,400	15,885	129.82	6.461	30.970	1,109	28,411	0.029
2003	8	72,151	3,627	15,885	146.52	6.437	30.683	1,109	28,303	0.029
2003	9	81,792	3,652	15,885	171.63	6.416	30.602	1,109	28,211	0.021
2003	10	77,721	3,669	15,885	157.83	6.423	30.947	1,109	28,242	0.008
2003	11	71,191	3,652	15,885	149.39	6.440	31.008	1,109	28,319	0.002
2003	12	68,934	3,620	15,885	139.99	6.447	31.729	1,109	28,349	0.028
2004	1	72,210	3,617	15,885	146.64	6.416	31.763	1,109	29,142	0.018
2004	2	71,605	3,602	15,889	160.95	6.382	31.745	1,113	28,985	0.001
2004	3	71,407	3,614	15,923	144.66	6.341	31.712	1,147	28,800	0.002
2004	4	71,709	3,649	16,354	146.16	6.321	31.229	1,578	28,708	0.010
2004	5	68,752	3,681	16,390	135.32	6.284	30.964	1,614	28,541	0.020
2004	6	62,848	3,540	16,444	127.40	6.264	30.204	1,668	28,450	0.026
2004	7	64,377	3,561	16,450	126.24	6.274	30.311	1,674	28,495	0.029

year	month	MQ	Bill Acc.	MF Units	GPUD	MP	FC	New MF	Income	%Irrig.
2004	8	71,043	3,735	16,510	138.81	6.271	30.263	1,734	28,480	0.027
2004	9	77,391	3,677	16,510	156.25	6.257	30.166	1,734	28,420	0.026
2004	10	76,813	3,673	16,510	150.08	6.225	30.081	1,734	28,271	0.021
2004	11	68,564	3,683	16,510	138.43	6.221	30.134	1,734	28,257	0.004
2004	12	66,996	3,658	16,510	130.90	6.244	30.555	1,734	28,361	0.001
2005	1	68,872	3,653	16,510	134.57	6.231	30.396	1,734	29,257	0.001
2005	2	65,588	3,628	16,510	141.88	6.195	30.077	1,734	29,089	0.001
2005	3	69,262	3,664	16,510	135.33	6.147	29.789	1,734	28,863	0.001
2005	4	69,312	3,693	16,510	139.94	6.106	29.530	1,734	28,671	0.006
2005	5	65,918	3,711	16,519	128.72	6.112	29.650	1,743	28,700	0.016
2005	6	60,211	3,611	16,890	118.83	6.109	29.764	2,114	28,685	0.034
2005	7	64,579	3,632	16,973	122.74	6.081	29.771	2,197	28,553	0.051
2005	8	75,667	3,795	16,985	143.71	6.050	29.579	2,209	28,408	0.112
2005	9	79,878	3,764	16,985	156.76	5.977	29.239	2,209	28,065	0.060
2005	10	76,932	3,753	16,985	146.11	5.965	29.218	2,209	28,008	0.012
2005	11	69,625	3,742	17,047	136.14	6.013	29.564	2,271	28,235	0.002
2005	12	67,382	3,734	17,047	127.51	6.038	29.821	2,271	28,350	0.001
2006	1	70,611	3,711	17,050	133.59	6.753	32.418	2,274	29,344	0.001
2006	2	66,250	3,705	17,054	138.74	6.739	32.393	2,278	29,285	0.001
2006	3	70,671	3,733	17,060	133.63	6.702	32.128	2,284	29,123	0.001
2006	4	71,713	3,760	17,064	140.09	6.645	31.799	2,288	28,878	0.003
2006	5	66,877	3,773	17,066	126.41	6.612	31.574	2,290	28,735	0.009
2006	6	60,050	3,654	17,082	117.18	6.599	31.607	2,306	28,678	0.022
2006	7	63,164	3,686	17,109	119.09	6.580	31.538	2,333	28,594	0.037
2006	8	70,899	3,846	17,112	133.65	6.567	31.351	2,336	28,538	0.031
2006	9	76,560	3,833	17,119	149.07	6.599	31.538	2,343	28,678	0.018
2006	10	76,384	3,830	17,139	143.76	6.635	31.795	2,363	28,835	0.005
2006	11	69,410	3,803	17,155	134.87	6.645	31.964	2,379	28,878	0.000
2006	12	64,116	3,798	17,175	120.42	6.635	31.961	2,399	28,835	0.000
2007	1	68,088	3,805	17,213	127.60	6.615	31.916	2,437	29,287	0.000
2007	2	68,898	3,778	17,229	142.82	6.580	31.781	2,453	29,131	0.000
2007	3	73,224	3,810	17,247	136.95	6.521	31.363	2,471	28,868	0.000
2007	4	71,434	3,828	17,275	137.84	6.500	31.059	2,499	28,682	0.004
2007	5	68,916	3,837	17,295	128.54	6.461	30.782	2,519	28,508	0.020
2007	6	65,732	3,696	17,329	126.44	6.448	30.816	2,553	28,453	0.036
2007	7	72,124	3,730	17,395	133.75	6.450	30.867	2,619	28,460	0.038
2007	8	81,616	3,928	17,407	151.25	6.462	30.750	2,631	28,512	0.047
2007	9	86,172	3,913	17,407	165.01	6.444	30.632	2,631	28,434	0.043
2007	10	86,011	3,885	17,427	159.21	6.430	30.582	2,651	28,373	0.024
2007	11	74,372	3,875	17,427	142.26	6.392	30.533	2,651	28,206	0.004

Note. MQ = monthly deliveries in 1000s gal. Billed Acc. = number of accounts billed. GPUD = gallons per MF housing unit per day. MP = marginal price. FC = fixed charge. New MF = cumulative new MF housing units. Income = median household income. %Irrig. = percent of water used for irrigation.

Table A-8 shows the initial model of MF use. The price, fixed charge and income variables in the model are not statistically significant and only price coefficient shows the correct sign. The coefficient of maximum temperature variable is also insignificant.

Table A-8 Initial Structural Model of Multifamily Water Use

Term	Estimate	Std Error	t Ratio	Prob.>|t|
Intercept	5.013431	1.151692	4.35	<.0001
Ln IU Enrollment	0.097593	0.015721	6.21	<.0001
LN MF MP W+Ww	-0.159075	0.500331	-0.32	0.7517
Multi-family Fixed Charges (Master Meter) $	0.004519	0.014584	0.31	0.7578
PC Income Adjusted 2007-07 (Bloomington) $	-0.000002	0.000025	-0.09	0.9320
Ln Precip	-0.022379	0.010328	-2.17	0.0344
Ln Normal Precipitation	-0.162429	0.060944	-2.67	0.0100
Ln Max Temp	0.050680	0.095838	0.53	0.5990
Ln Normal Max Temp (F)	0.205495	0.104294	1.97	0.0537
Ln Cumulative new MF units -Erica	-0.234782	0.079746	-2.94	0.0047
Trend	0.002747	0.001586	1.73	0.0886

N = 68; R2= 0.653; Mean Y= 4.945; Root MSE= 0.060

The final model of multifamily use per housing unit is shown in Table A-9. The model includes six binary variables designation calendar month and six outlier binaries. The income variable remained statistically insignificant and was removed from the final equation.

Table A-9 Final Model of Multifamily Water Use

Term	Estimate	Std Error	Chi-Square	Prob.> Chi-Square
Intercept	4.81658	0.43329	70.43	<.0001
Ln IU Enrollment	0.10437	0.01010	64.18	<.0001
LN MF MP W+Ww	-0.14298	0.10986	1.67	0.1959
Ln Max Temp	0.12377	0.02449	21.68	<.0001
Ln Cumulative new MF units -Erica	-0.16784	0.03650	18.41	<.0001
Trend	0.00128	0.00070	3.22	0.0730
Feb	0.12842	0.01683	42.08	<.0001
May	0.04812	0.01351	11.63	0.0006
Aug	0.12006	0.01412	49.24	<.0001
Sep	0.09558	0.01595	28.82	<.0001
Oct	0.04808	0.01422	10.56	0.0012
Dec	-0.04246	0.01443	8.15	0.0043
2002-Nov	0.10890	0.02757	14.05	0.0002
2003-Mar	0.17819	0.02698	33.69	<.0001
2005-Feb	-0.08874	0.02988	8.29	0.0040
2007-July	0.11225	0.02840	14.06	0.0002
2007-Aug	0.10273	0.02969	11.03	0.0009
2007-Oct	0.07900	0.02971	6.73	0.0095

N = 68; R2= 0.921; Mean Y= 4.945; Root MSE= 0.030

The estimated regression coefficients in Table A-9 show the elasticity of the marginal price variable of -0.1430 thus indicating that a 10 percent increase in marginal price was associated with a 1.43 percent decrease in water demand. The variable of cumulative new MF units has a negative coefficient of -0.1678 indicating the effect of lower than average usage rates in new MF housing. The trend variable shows that after accounting for the effects of price, weather and new housing units, there was a positive (increasing) trend in the data of 0.13 percent per month (or approximately 1.5 percent per year). Finally, the student enrollment counts at Indiana University are associated with monthly MF water use.

In order to estimate future use each of the explanatory variables needed to be projected to 2030 in 5-year increments. Below is a detailed description of the assumptions used for each of the explanatory variables used in the multi-family regression model.

IU Enrollment
IU enrollment projections were obtained from IU from 2009 to 2019. It was then assumed that IU enrollment remained unchanged from 2019 to 2030 because IU is expecting enrollment to decrease slightly every year. Since decreasing enrollment is not likely to continue indefinitely, it was held at the 2019 level for the remainder of the forecasting period.

Total Marginal Price
Due to the plant expansion, CBU will implement a rate increase sometime in 2010. Therefore, WHPA worked with Crowe Horwath to determine the approximate increase and the following assumptions were made:

- 2010 rate increase is due to the 45% general rate increase for the water utility, plus 3.9% annual inflation in sewer rates.
- Total water and wastewater marginal price is approximately 1/3 marginal price water and 2/3 marginal price wastewater.
- Annual inflation rate for water and sewer is estimated at 3.9% annually (Beecher, 2008).

Maximum Temperature
The monthly maximum temperature is the climatic normal and was obtained from NOAA.

Cumulative new multi-family units
It was assumed that the cumulative mulit-family units would grow at an annual rate of 0.4% which corresponds to the annual population growth rate for as projected by Indiana STATS.

Commercial Sector

Table A-10 shows the data used in developing MF models of water use. The weather variables were the same as those used in the SF sector.

Table A-10 Commercial Sector Data for Bloomington

Year	Month	MQ	Billed Acc.	GPAD	MP	FC	Constr.	Manuf.	Retail	Health	Hotels& Restaur.	%Irrig.
2002	4	52,310	1,819	958.6	5.768	41.794	0.0522	0.1589	0.1594	0.1503	0.1490	2.11
2002	5	56,288	1,839	987.4	5.768	38.699	0.0522	0.1589	0.1594	0.1503	0.1490	3.41
2002	6	65,576	1,862	1173.9	6.218	42.782	0.0522	0.1589	0.1594	0.1503	0.1490	11.73
2002	7	79,549	1,862	1378.1	6.211	35.810	0.0522	0.1589	0.1594	0.1503	0.1490	21.65
2002	8	87,310	1,890	1490.2	6.191	37.932	0.0522	0.1589	0.1594	0.1503	0.1490	20.30
2002	9	76,500	1,886	1352.1	6.180	46.940	0.0522	0.1589	0.1594	0.1503	0.1490	14.88
2002	10	59,439	1,862	1029.7	6.170	51.411	0.0522	0.1589	0.1594	0.1503	0.1490	5.18
2002	11	50,247	1,786	937.8	6.170	56.060	0.0522	0.1589	0.1594	0.1503	0.1490	3.14
2002	12	41,942	1,658	816.0	6.202	53.509	0.0522	0.1589	0.1594	0.1503	0.1490	1.29
2003	1	43,397	1,406	995.7	6.175	50.983	0.0434	0.1550	0.1559	0.1459	0.1460	1.07
2003	2	53,912	1,776	1084.1	6.128	50.348	0.0434	0.1550	0.1559	0.1459	0.1460	1.18
2003	3	62,161	1,818	1103.0	6.091	49.836	0.0434	0.1550	0.1559	0.1459	0.1460	1.42
2003	4	54,073	1,825	987.6	6.105	46.856	0.0434	0.1550	0.1559	0.1459	0.1460	2.50
2003	5	58,277	1,839	1022.2	6.115	42.568	0.0434	0.1550	0.1559	0.1459	0.1460	4.44
2003	6	60,439	1,869	1077.9	6.108	41.973	0.0434	0.1550	0.1559	0.1459	0.1460	7.77
2003	7	72,773	1,873	1253.3	6.101	41.318	0.0434	0.1550	0.1559	0.1459	0.1460	13.92
2003	8	75,824	1,877	1303.1	6.078	41.166	0.0434	0.1550	0.1559	0.1459	0.1460	17.31
2003	9	64,774	1,872	1153.4	6.058	41.326	0.0434	0.1550	0.1559	0.1459	0.1460	9.77
2003	10	58,063	1,865	1004.3	6.065	42.716	0.0434	0.1550	0.1559	0.1459	0.1460	5.32
2003	11	49,984	1,815	918.0	6.081	43.170	0.0434	0.1550	0.1559	0.1459	0.1460	1.41
2003	12	47,322	1,787	854.2	6.088	43.665	0.0434	0.1550	0.1559	0.1459	0.1460	0.49
2004	1	47,258	1,783	855.0	6.058	44.019	0.0489	0.1462	0.1586	0.1599	0.1399	1.39
2004	2	47,906	1,792	954.8	6.026	44.655	0.0489	0.1462	0.1586	0.1599	0.1399	0.15
2004	3	51,062	1,817	906.5	5.987	44.509	0.0489	0.1462	0.1586	0.1599	0.1399	0.57
2004	4	52,075	1,862	932.2	5.968	44.447	0.0489	0.1462	0.1586	0.1599	0.1399	3.05
2004	5	59,990	1,893	1022.3	5.933	44.155	0.0489	0.1462	0.1586	0.1599	0.1399	5.96
2004	6	62,679	1,897	1101.4	5.915	44.030	0.0489	0.1462	0.1586	0.1599	0.1399	9.93
2004	7	68,067	1,898	1156.8	5.924	43.862	0.0489	0.1462	0.1586	0.1599	0.1399	13.15
2004	8	72,886	1,908	1232.3	5.921	44.437	0.0489	0.1462	0.1586	0.1599	0.1399	15.31
2004	9	68,910	1,902	1207.7	5.908	43.733	0.0489	0.1462	0.1586	0.1599	0.1399	14.68
2004	10	61,530	1,897	1046.3	5.878	43.530	0.0489	0.1462	0.1586	0.1599	0.1399	9.47
2004	11	49,379	1,839	895.0	5.874	43.637	0.0489	0.1462	0.1586	0.1599	0.1399	1.71
2004	12	48,702	1,796	874.7	5.896	43.465	0.0489	0.1462	0.1586	0.1599	0.1399	0.37
2005	1	54,899	1,799	984.4	5.884	43.540	0.0526	0.1515	0.1589	0.1602	0.1413	0.33
2005	2	46,460	1,779	932.7	5.850	43.369	0.0526	0.1515	0.1589	0.1602	0.1413	0.13
2005	3	50,619	1,834	890.3	5.805	40.091	0.0526	0.1515	0.1589	0.1602	0.1413	0.48
2005	4	53,866	1,874	958.1	5.766	40.100	0.0526	0.1515	0.1589	0.1602	0.1413	2.46
2005	5	61,452	1,888	1050.0	5.772	40.296	0.0526	0.1515	0.1589	0.1602	0.1413	8.15
2005	6	66,915	1,899	1174.6	5.769	39.982	0.0526	0.1515	0.1589	0.1602	0.1413	15.54

Year	Month	MQ	Billed Acc.	GPAD	MP	FC	Constr.	Manuf.	Retail	Health	Hotels& Restaur.	%Irrig.
2005	7	79,255	1,901	1344.9	5.742	39.968	0.0526	0.1515	0.1589	0.1602	0.1413	15.60
2005	8	88,184	1,906	1492.5	5.713	39.840	0.0526	0.1515	0.1589	0.1602	0.1413	14.22
2005	9	77,928	1,906	1362.9	5.644	39.332	0.0526	0.1515	0.1589	0.1602	0.1413	12.64
2005	10	67,073	1,909	1133.4	5.633	39.217	0.0526	0.1515	0.1589	0.1602	0.1413	8.19
2005	11	51,292	1,855	921.7	5.678	39.458	0.0526	0.1515	0.1589	0.1602	0.1413	1.87
2005	12	48,759	1,799	874.3	5.701	39.539	0.0526	0.1515	0.1589	0.1602	0.1413	1.09
2006	1	48,474	1,760	888.4	6.385	41.372	0.0601	0.1278	0.1610	0.1625	0.1425	0.23
2006	2	47,813	1,779	959.9	6.372	41.155	0.0601	0.1278	0.1610	0.1625	0.1425	0.49
2006	3	51,217	1,824	905.8	6.337	41.182	0.0601	0.1278	0.1610	0.1625	0.1425	0.63
2006	4	53,066	1,850	956.1	6.284	40.816	0.0601	0.1278	0.1610	0.1625	0.1425	1.39
2006	5	57,725	1,883	988.9	6.253	40.505	0.0601	0.1278	0.1610	0.1625	0.1425	3.92
2006	6	60,638	1,898	1064.9	6.240	40.537	0.0601	0.1278	0.1610	0.1625	0.1425	8.62
2006	7	74,620	1,908	1261.6	6.222	40.288	0.0601	0.1278	0.1610	0.1625	0.1425	16.59
2006	8	77,084	1,928	1289.7	6.210	40.243	0.0601	0.1278	0.1610	0.1625	0.1425	17.52
2006	9	64,381	1,907	1125.3	6.240	40.567	0.0601	0.1278	0.1610	0.1625	0.1425	12.14
2006	10	58,481	1,879	1004.0	6.274	40.879	0.0601	0.1278	0.1610	0.1625	0.1425	5.48
2006	11	50,335	1,830	916.8	6.284	41.211	0.0601	0.1278	0.1610	0.1625	0.1425	2.36
2006	12	49,102	1,795	882.4	6.274	41.088	0.0601	0.1278	0.1610	0.1625	0.1425	3.29
2007	1	49,034	1,815	871.5	6.255	40.876	0.0644	0.1266	0.1624	0.1694	0.1402	1.54
2007	2	47,952	1,804	949.3	6.222	41.225	0.0644	0.1266	0.1624	0.1694	0.1402	1.90
2007	3	52,671	1,844	921.4	6.166	40.509	0.0644	0.1266	0.1624	0.1694	0.1402	1.85
2007	4	54,144	1,861	969.8	6.144	40.289	0.0644	0.1266	0.1624	0.1694	0.1402	4.39
2007	5	64,163	1,897	1091.1	6.107	40.086	0.0644	0.1266	0.1624	0.1694	0.1402	11.06
2007	6	71,856	1,899	1261.3	6.095	40.180	0.0644	0.1266	0.1624	0.1694	0.1402	20.65
2007	7	83,342	1,912	1406.1	6.097	40.031	0.0644	0.1266	0.1624	0.1694	0.1402	17.73
2007	8	87,101	1,913	1468.8	6.108	40.090	0.0644	0.1266	0.1624	0.1694	0.1402	24.75
2007	9	83,363	1,915	1451.1	6.091	39.888	0.0644	0.1266	0.1624	0.1694	0.1402	25.15
2007	10	68,717	1,906	1163.0	6.078	39.766	0.0644	0.1266	0.1624	0.1694	0.1402	13.55
2007	11	54,227	1,854	974.9	6.042	39.726	0.0644	0.1266	0.1624	0.1694	0.1402	5.48

Note. MQ = monthly deliveries in 1000s gal. Billed Acc. = number of accounts billed. GPUD = gallons per commercial account per day. MP = marginal price. FC = fixed charge. Constr.= fraction of employment in construction. Manuf.= fraction of employment in manufacturing. Retail= fraction of employment in retail sales. Health= fraction of employment in health services. Hotels= fraction of employment in hotels and restaurants. %Irrig. = percent of water used for irrigation.

Table A-11 shows the initial regression model of commercial water use per account. The price and fixed charge variables in the model are not statistically significant and both have coefficients with incorrect signs. The coefficient of the employment share variables and trend are also insignificant.

Table A-11 Initial Structural Model of Commercial Water Use

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept		10.6094	6.0639	1.75	0.0856
Ln Comm W+Ww		0.2231	0.7010	0.32	0.7515
Ln Precipitation (in)		-0.0321	0.0133	-2.42	0.0189
Ln Normal Precipitation		-0.2379	0.0650	-3.66	0.0006

Term		Estimate	Std Error	t Ratio	Prob>|t|
Ln Cooling Deg Days		0.0243	0.0123	1.98	0.0522
Ln Normal (CDD + 1)		0.0476	0.0124	3.83	0.0003
Ln Fixed Charges $		0.0723	0.1614	0.45	0.6558
% of employment in construction		14.6784	11.8391	1.24	0.2201
% of employment in manufacturing		4.8636	3.5640	1.36	0.1777
% of employment in retail trade		-35.8061	34.4024	-1.04	0.3024
Trend		0.0016	0.0024	0.69	0.4914

N = 68; R2= 0.813; Mean Y= 6.965; Root MSE= 0.075

The final model of commercial use per account is shown in Table A-12. The model includes four binary variables which designate calendar months and two outlier binaries. The inclusion of the binary variables resulted in correct signs and improved significance of four structural variables (i.e., price and employment shares). However, the coefficient of the trend variable remained highly insignificant and was excluded from the equation.

Table A-12 Final Regression Model of Commercial Water Use

Term	Estimate	Std Error	Chi-Square	Prob.> Chi-Square
Intercept	10.7474	2.0694	22.72	<.0001
Ln Comm W+Ww	-0.2367	0.1957	1.45	0.2289
Ln Precipitation (in)	-0.0172	0.0079	4.61	0.0318
Ln Normal Precipitation	-0.2265	0.0447	21.75	<.0001
Ln Cooling Deg Days	0.0271	0.0073	12.42	0.0004
Ln Normal (CDD + 1)	0.0316	0.0079	14.31	0.0002
% of employment in construction	14.1957	4.6167	8.85	0.0029
% of employment in manufacturing	2.5781	0.9115	7.56	0.006
% of employment in retail trade	-27.4743	14.1882	3.65	0.0561
Jul	0.1156	0.0231	21.33	<.0001
Aug	0.1494	0.0241	30.52	<.0001
Sep	0.1036	0.0228	18.01	<.0001
Nov	0.0694	0.0229	8.61	0.0033
2003-Feb	0.1914	0.0467	15.01	0.0001
2003-Mar	0.2275	0.0474	19.86	<.0001

N = 68; R2= 0.925; Mean Y= 6.965; Root MSE= 0.049

The estimated regression coefficients in Table A-11 show the elasticity of the marginal price variable (not highly significant) is -0.2367 which is close to the expected value and indicates that on average a 10% increase in marginal price was associated with a 2.367 percent decrease in water demand. No statistically significant coefficient of the trend variable was obtained.

In order to estimate future use each of the explanatory variables needed to be projected to 2030 in 5-year increments. Below is a detailed description of the assumptions used for each of the explanatory variables used in the commercial regression model.

Total Marginal Price
Due to the plant expansion, CBU will implement a rate increase sometime in 2010. Therefore, WHPA worked with Crowe Horwath to determine the approximate increase and the following assumptions were made:

- 2010 rate increase is due to the 45% general rate increase for the water utility, plus 3.9% annual inflation in sewer rates.
- Total water and wastewater marginal price is approximately 1/3 marginal price water and 2/3 marginal price wastewater.
- Annual inflation rate for water and sewer is estimated at 3.9% annually (Beecher, 2008).

Precipitation
The monthly precipitation is the climatic normal and was obtained from NOAA.

Cooling degree days
The cooling degree days parameter is the climatic normal and was obtained from NOAA.

Percent of employment in construction
Projections for employment in construction were obtained from Indiana Workforce Development Agency from 2006 to 2016. This projected annual growth rate was held constant for the entire study period.

Percent of employment in manufacturing
Projections for employment in construction were obtained from Indiana Workforce Development Agency from 2006 to 2016. This projected annual growth rate was held constant for the entire study period.

Percent of employment in retail trade
Projections for employment in construction were obtained from Indiana Workforce Development Agency from 2006 to 2016. This projected annual growth rate was held constant for the entire study period.

Industrial Sector

There are only two customer accounts in Bloomington which are designated as "industrial." Table A-13 shows the data on industrial water use which were used in estimating the industrial water use regressions.

Table A-13 Industrial Sector Data for Bloomington

Year	Mo.	MQ	MP	FC	Year	Mo.	MQ	MP	FC
2002	4	3,728.25	5.63	166.76	2005	2	4,353.74	5.71	170.66
2002	5	3,787.20	5.63	166.76	2005	3	4,793.45	5.67	169.33
2002	6	3,494.93	6.07	180.09	2005	4	4,061.97	5.63	168.20
2002	7	3,843.16	6.07	179.89	2005	5	3,710.83	5.64	168.38
2002	8	3,774.74	6.05	179.30	2005	6	2,626.11	5.63	168.29
2002	9	3,621.79	6.04	179.00	2005	7	2,165.17	5.61	167.51
2002	10	3,843.27	6.03	178.70	2005	8	2,604.79	5.58	166.66
2002	11	3,998.23	6.03	178.70	2005	9	2,221.95	5.51	164.65
2002	12	2,916.05	6.06	180.78	2005	10	2,023.49	5.50	164.32
2003	1	2,957.22	6.03	179.98	2005	11	2,093.37	5.54	165.65
2003	2	3,595.06	5.98	178.61	2005	12	2,422.44	5.57	166.32
2003	3	3,027.50	5.95	177.54	2006	1	2,440.26	6.23	196.02
2003	4	3,131.11	5.96	177.93	2006	2	2,559.41	6.22	195.63
2003	5	3,107.37	5.97	178.22	2006	3	3,111.49	6.18	194.55
2003	6	3,415.85	5.96	178.02	2006	4	2,361.41	6.13	192.91
2003	7	3,016.24	5.96	177.83	2006	5	2,630.69	6.10	191.96
2003	8	2,797.97	5.93	177.16	2006	6	2,328.65	6.09	191.58
2003	9	3,804.90	5.92	176.74	2006	7	2,290.62	6.07	191.01
2003	10	3,745.50	5.92	176.93	2006	8	2,177.55	6.06	190.64
2003	11	3,861.58	5.94	177.41	2006	9	2,423.90	6.09	191.58
2003	12	3,498.91	5.94	177.60	2006	10	2,438.13	6.12	192.62
2004	1	3,383.44	5.92	176.74	2006	11	2,480.54	6.13	192.91
2004	2	3,527.72	5.88	175.79	2006	12	2,153.12	6.12	192.62
2004	3	3,113.59	5.85	174.67	2007	1	2,613.32	6.10	192.03
2004	4	3,570.82	5.83	174.11	2007	2	2,459.07	6.07	191.01
2004	5	3,517.83	5.79	173.09	2007	3	2,868.87	6.02	189.29
2004	6	2,862.17	5.78	172.55	2007	4	2,575.72	5.99	189.82
2004	7	3,695.81	5.78	172.82	2007	5	2,642.64	5.96	188.66
2004	8	3,864.29	5.78	172.73	2007	6	2,585.68	5.95	188.30
2004	9	3,888.16	5.77	172.37	2007	7	2,524.40	5.95	188.35
2004	10	4,512.51	5.74	171.46	2007	8	2,033.03	5.96	188.69
2004	11	4,254.92	5.74	171.37	2007	9	2,253.08	5.94	188.17
2004	12	4,200.39	5.76	172.00	2007	10	2,137.11	5.93	187.77
2005	1	4,539.32	5.74	171.64	2007	11	2,191.92	5.89	186.66

Legend: MQ = monthly deliveries in 1000s gal. MP = marginal price. FC = fixed charge.

Table A-14 shows the initial regression of industrial water use. All of the variables except the intercept are not statistically significant. Also marginal price, precipitation and actual cooling degree-days have the wrong sign.

Table A-14 Initial Structural Model of Industrial Water Use

Term	Estimate	Std Error	t Ratio	Prob.>|t|
Intercept	25.7068	10.6011	2.42	0.0183
Ln Industrial W+Ww MP	7.2239	5.5935	1.29	0.2015
Ln Precipitation (in)	0.0050	0.0298	0.17	0.8681
Ln Normal Precipitation	0.1316	0.1531	0.86	0.3934
Ln Cooling Deg Days	-0.0318	0.0279	-1.14	0.2590
Ln Normal (CDD + 1)	0.0114	0.0282	0.4	0.6878
Ln Industrial Fixed Charges $	-5.8935	3.9677	-1.49	0.1427
Trend	-0.0014	0.0045	-0.3	0.7624

N = 68; R2= 0.523; Mean Y= 8.014; Root MSE= 0.174

The final model was obtained after adding two binary variables designating calendar months and four outlier variables and removing insignificant weather variables. The final model is shown in Table A-15.

Table A-15 Final Regression Model of Commercial Water Use

Term	Estimate	Std Error	Chi-Square	Prob.> Chi-Square
Intercept	9.2211	0.9990	55.23	<.0001
Ln Industrial W+Ww MP	-0.5006	0.5637	0.78	0.3759
Ln Precip Lag 1 mo	-0.0566	0.0240	5.34	0.0208
Trend	-0.0080	0.0009	56.19	<.0001
May	0.0649	0.0591	1.20	0.2741
Nov	0.1297	0.0639	4.00	0.0454
2005-Jan	0.4087	0.1385	8.19	0.0042
2005-Feb	0.4331	0.1406	8.88	0.0029
2005-Mar	0.4559	0.1400	9.85	0.0017
2005-Nov	-0.5021	0.1587	9.33	0.0022

N = 68; R2= 0.668; Mean Y= 8.014; Root MSE= 0.147

The coefficients in Table A-14 show that the strongest explanatory variable in industrial water use is the trend variable which has a negative coefficient indicating a decline in water use of 0.8 percent per month. The price variable is not statistically significant but it shows the expected sign and size of the regression coefficient (-0.5006).
In order to estimate future use each of the explanatory variables needed to be projected to 2030 in 5-year increments. Below is a detailed description of the assumptions used for each of the explanatory variables used in the industrial regression model.

Total Marginal Price
Due to the plant expansion, CBU will implement a rate increase sometime in 2010. Therefore, WHPA worked with Crowe Horwath to determine the approximate increase and the following assumptions were made:

- 2010 rate increase is due to the 45% general rate increase for the water utility, plus 3.9% annual inflation in sewer rates.
- Total water and wastewater marginal price is approximately 1/3 marginal price water and 2/3 marginal price wastewater.
- Annual inflation rate for water and sewer is estimated at 3.9% annually (Beecher, 2008).

Precipitation lagged one month
The monthly precipitation is the climatic normal and was obtained from NOAA.

Indiana University

Table A-16 shows the data on historical water use by Indiana University and explanatory variables. These data were used in estimating the water use regressions.

Table A-16 Indiana University Data in Bloomington

Year	Month	MQ	MP	%Irrig.	Students in Dorms	Enroll-ment	Empl. FTE
2002	4	54,949.24	5.35	3.36	11,688	35,474	6,890
2002	5	47,246.65	5.35	1.46	465	9,091	6,890
2002	6	62,298.23	5.72	2.02	8,327	9,091	6,890
2002	7	77,677.56	5.71	8.65	15,998	8,418	6,890
2002	8	66,376.03	5.69	10.01	9,092	8,418	6,890
2002	9	85,572.77	5.69	5.03	12,335	38,903	6,952
2002	10	72,744.95	5.68	0.92	12,335	38,903	6,952
2002	11	73,552.31	5.68	0.06	12,335	38,903	6,952
2002	12	50,661.32	5.69	0.00	12,335	38,903	6,952
2003	1	45,613.72	5.66	0.00	11,912	36,281	6,952
2003	2	53,762.87	5.62	0.00	11,912	36,281	6,952
2003	3	53,611.48	5.59	0.04	11,912	36,281	6,952
2003	4	64,829.04	5.60	0.09	11,912	36,281	6,952
2003	5	57,874.39	5.61	0.62	726	9,031	6,952
2003	6	58,607.63	5.60	3.01	7,905	9,031	6,952
2003	7	72,581.57	5.60	5.85	7,411	8,317	6,952
2003	8	74,924.25	5.57	7.61	2,036	8,317	6,952
2003	9	79,866.65	5.56	4.90	12,090	38,589	7,163
2003	10	69,044.57	5.56	1.51	12,090	38,589	7,163
2003	11	62,433.59	5.58	0.34	12,090	38,589	7,163
2003	12	56,221.93	5.58	0.17	12,090	38,589	7,163
2004	1	53,296.28	5.56	1.73	11,581	36,473	7,163
2004	2	65,487.58	5.53	0.01	11,581	36,473	7,163
2004	3	58,733.65	5.49	0.08	11,581	36,473	7,163
2004	4	64,574.55	5.47	0.55	11,581	36,473	7,163
2004	5	60,364.76	5.44	1.46	507	8,659	7,163
2004	6	60,641.38	5.42	2.14	7,248	8,659	7,163
2004	7	62,944.09	5.43	2.82	7,473	7,982	7,163

Year	Month	MQ	MP	%Irrig.	Students in Dorms	Enroll-ment	Empl. FTE
2004	8	67,008.90	5.43	5.88	1,180	7,982	7,163
2004	9	78,890.83	5.42	6.27	11,700	37,824	7,166
2004	10	67,950.37	5.39	4.35	11,700	37,824	7,166
2004	11	56,490.02	5.39	0.44	11,700	37,824	7,166
2004	12	52,984.51	5.41	0.02	11,700	37,824	7,166
2005	1	52,160.16	5.40	0.01	11,117	35,694	7,166
2005	2	50,186.80	5.36	0.02	11,117	35,694	7,166
2005	3	52,391.38	5.32	0.20	11,117	35,694	7,166
2005	4	57,801.25	5.29	1.42	11,117	35,694	7,166
2005	5	54,473.47	5.29	4.40	532	8,483	7,166
2005	6	60,289.05	5.29	8.90	5,808	8,483	7,166
2005	7	74,492.76	5.27	8.58	8,061	7,581	7,166
2005	8	75,239.36	5.24	8.18	993	7,581	7,166
2005	9	75,022.47	5.18	5.18	11,376	37,958	7,214
2005	10	67,220.88	5.17	4.04	11,376	37,958	7,214
2005	11	54,014.93	5.21	1.04	11,376	37,958	7,214
2005	12	44,043.02	5.23	0.03	11,376	37,958	7,214
2006	1	43,821.69	5.86	0.02	11,376	36,200	7,214
2006	2	44,212.61	5.85	0.03	11,376	36,200	7,214
2006	3	45,784.95	5.81	0.17	11,376	36,200	7,214
2006	4	52,350.56	5.77	1.61	11,376	36,200	7,214
2006	5	47,681.12	5.74	2.42	2,305	8,249	7,214
2006	6	53,212.81	5.73	4.16	5,954	8,249	7,214
2006	7	65,020.43	5.71	8.09	10,031	7,428	7,214
2006	8	72,261.56	5.70	8.81	2,882	7,428	7,214
2006	9	67,060.68	5.73	2.42	11,704	38,247	7,253
2006	10	59,160.73	5.76	1.54	11,704	38,247	7,253
2006	11	49,844.76	5.77	2.17	11,704	38,247	7,253
2006	12	43,637.54	5.76	0.01	11,704	38,247	7,253
2007	1	38,618.68	5.74	0.02	11,704	36,698	7,253
2007	2	42,984.37	5.71	0.04	11,704	36,698	7,253
2007	3	58,194.82	5.66	0.28	11,704	36,698	7,253
2007	4	53,150.41	5.62	2.60	11,704	36,698	7,253
2007	5	55,742.38	5.59	9.73	371	8,645	7,253
2007	6	60,533.55	5.58	12.53	7,082	8,645	7,253
2007	7	63,121.73	5.58	8.31	9,838	7,107	7,253
2007	8	81,218.91	5.59	11.39	2,797	7,107	7,253
2007	9	80,311.53	5.57	10.96	12,258	38,990	7,405
2007	10	66,426.32	5.56	5.37	12,258	38,990	7,405
2007	11	49,505.49	5.53	3.39	12,258	38,990	7,405

Note. MQ = monthly deliveries in 1000s gal. MP = marginal price. FC = fixed charge.

Table A-17 shows the initial regression of water use by the Indiana University campus. Two variables, marginal price and students in dorms have correct coefficients but are

not statistically significant. All weather variables have significant coefficients with correct signs.

Table A-17 Initial Structural Model of Water Use by Indiana University

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-19.0602	15.7498	-1.21	0.2311
IU Master W+Ww	-0.0360	0.0747	-0.48	0.6315
Ln Precipitation (in)	-0.0518	0.0164	-3.16	0.0025
Ln Normal Precipitation	-0.3625	0.1035	-3.5	0.0009
Ln Max Temp (F)	0.2660	0.1497	1.78	0.0809
Ln Normal Max Temp (F)	0.4593	0.1644	2.79	0.0070
Ln Students in dorms	0.0017	0.0186	0.09	0.9272
Ln Enrollment	0.0534	0.0294	1.82	0.0741
Ln Full-time Equivalency Employees	3.0903	1.7724	1.74	0.0865
Trend	-0.0050	0.0016	-3.06	0.0033

N = 68; R2= 0.767; Mean Y= 10.991; Root MSE= 0.095

Table A-18 shows the final regression model which contains only variables which are statistically significant at least at the probability level of 0.10.

Table A-18 Final Regression Model for Indiana University

Term	Estimate	Std Error	Chi-Square	Prob.> Chi-Square
Intercept	8.4281	0.6229	88.82	<.0001
Ln IU Master W+Ww	-0.4891	0.2682	3.25	0.0715
Ln Precipitation (in)	-0.0246	0.0126	3.73	0.0536
Ln Normal Precipitation	-0.2872	0.1061	6.96	0.0084
Ln Max Temp (F)	0.3659	0.1079	10.63	0.0011
Ln Normal Max Temp (F)	0.4387	0.1176	12.66	0.0004
Ln Enrollment	0.0567	0.0200	7.57	0.0059
Trend	-0.0020	0.0004	18.15	<.0001
Apr	-0.0668	0.0376	3.08	0.0795
May	-0.1041	0.0435	5.50	0.0191
Jun	-0.1461	0.0334	16.86	<.0001
Dec	0.0747	0.0380	3.75	0.0528
2002-Nov	0.2675	0.0771	11.10	0.0009
2004-Jan	0.2009	0.0725	7.26	0.0070
2004-Feb	0.2449	0.0722	10.63	0.0011

N = 68; R2= 0.865; Mean Y= 10.991; Root MSE= 0.076

The regression in Table A-18 shows a negative coefficient of the trend variable indicating a historical (2002 to 2007) decline in IU water use of 0.20 percent per month (or approximately 2.4 percent per year).

In order to estimate future use each of the explanatory variables needed to be projected to 2030 in 5-year increments. Below is a detailed description of the assumptions used for each of the explanatory variables used in the Indiana University regression model.

Total Marginal Price
Due to the plant expansion, CBU will implement a rate increase sometime in 2010. Therefore, WHPA worked with Crowe Horwath to determine the approximate increase and the following assumptions were made:

- 2010 rate increase is due to the 45% general rate increase for the water utility, plus 3.9% annual inflation in sewer rates.
- Total water and wastewater marginal price is approximately 1/3 marginal price water and 2/3 marginal price wastewater.
- Annual inflation rate for water and sewer is estimated at 3.9% annually (Beecher, 2008).

Precipitation
The monthly precipitation is the climatic normal and was obtained from NOAA.

Maximum Temperature
The monthly maximum temperature is the climatic normal and was obtained from NOAA.

IU Enrollment
IU enrollment projections were obtained from IU from 2009 to 2019. It was then assumed that IU enrollment remained unchanged from 2019 to 2030 because IU is expecting enrollment to decrease slightly every year. Since decreasing enrollment is not likely to continue indefinitely, it was held at the 2019 level for the remainder of the forecasting period.

Wholesale Sector

Table A-19 shows the values for monthly wholesale water deliveries together with population served by wholesale customers.

Table A-19 Wholesale Sector Data for Bloomington

Year	Mo.	MQ	Nash-ville	B&B	East Monroe	Ellets-ville	Southern Monroe	Van Buren	Shady Side	RHS	Monroe Co	Total Wh. Pop	Washing-ton Twp
2002	4	86,376.16	3,153	2,900	3,224	9,000	4,330	5,781	95	600	32,283	43,110	3,200
2002	5	93,598.93	3,153	2,900	3,224	9,000	4,330	5,781	95	600	32,283	43,110	3,200
2002	6	100,554.03	3,153	2,900	3,224	9,000	4,330	5,781	95	600	32,283	43,110	3,200
2002	7	107,641.46	3,153	2,900	3,224	9,000	4,330	5,781	95	600	32,283	43,110	3,200
2002	8	108,100.04	3,153	2,900	3,224	9,000	4,330	5,781	95	600	32,283	43,110	3,200
2002	9	100,794.75	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,110	3,625
2002	10	85,532.01	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,110	3,625
2002	11	79,567.91	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,110	3,625
2002	12	84,850.67	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,110	3,625
2003	1	84,991.37	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	2	78,872.79	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	3	85,307.30	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	4	82,066.96	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	5	86,005.92	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	6	89,296.56	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	7	99,499.04	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	8	100,740.41	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	9	90,447.91	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	10	86,437.87	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	11	79,899.44	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2003	12	82,436.24	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	1	84,963.27	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	2	82,208.58	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	3	82,663.42	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	4	83,394.26	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	5	91,684.43	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	6	92,506.09	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	7	96,774.16	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	8	96,725.29	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	9	92,708.72	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	10	88,400.37	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	11	81,414.81	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2004	12	84,470.55	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	43,972	3,625
2005	1	86,616.41	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	44,634	3,625
2005	2	74,887.59	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	44,634	3,625
2005	3	81,747.92	3,706	5,075	3,611	11,600	8,990	6,670	95	600	43,972	44,634	3,625
2005	4	81,761.88	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	5	90,807.49	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	6	97,439.45	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	7	101,381.58	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	8	96,789.41	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	9	86,738.13	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	10	83,804.28	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	11	77,461.93	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625
2005	12	60,462.73	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,634	3,625

Year	Mo.	MQ	Nash-ville	B&B	East Monroe	Ellets-ville	Southern Monroe	Van Buren	Shady Side	RHS	Monroe Co	Total Wh. Pop	Washing-ton Twp
2006	1	75,108.82	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	2	71,801.15	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	3	79,380.27	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	4	81,615.63	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	5	89,580.13	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	6	93,788.66	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	7	101,399.95	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	8	101,304.37	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	9	85,374.40	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	10	85,566.15	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	11	82,652.36	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2006	12	87,584.49	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,855	3,625
2007	1	89,852.35	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,900	3,625
2007	2	88,306.01	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,900	3,625
2007	3	88,362.51	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,900	3,625
2007	4	84,968.35	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,900	3,625
2007	5	101,186.06	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,900	3,625
2007	6	105,997.06	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,900	3,625
2007	7	104,872.07	3,706	5,075	4,494	11,600	8,990	6,670	95	600	44,855	44,900	3,625
2007	8	113,863.12	3,706	5,075	4,602	11,600	8,990	6,670	95	600	44,963	44,900	3,625
2007	9	101,641.12	3,706	5,075	4,602	11,600	8,990	6,670	95	600	44,963	44,900	3,625
2007	10	88,047.64	3,706	5,075	4,602	11,600	8,990	6,670	95	600	44,963	44,900	3,625
2007	11	79,822.17	3,706	5,075	4,602	11,600	8,990	6,670	95	600	44,963	44,900	3,625

Note. MQ = monthly deliveries in 1000s gal. Total Wh Pop = total wholesale customer population.

The initial model of wholesale water deliveries is shown in Table A-20. The model shows that only the intercept, wholesale population and trend are statistically significant. However, the wholesale population variable has a negative coefficient which is inconsistent with the expectations.

Table A-20 Initial Structural Model of Wholesale Water Deliveries

Term	Estimate	Std Error	t Ratio	Prob.>|t|
Intercept	54.1844	19.5712	2.77	0.0074
Ln Precipitation	0.0055	0.0128	0.43	0.6693
Ln Normal Precipitation	-0.1176	0.0717	-1.64	0.1061
Ln Max Temp (F)	0.1521	0.1165	1.31	0.1968
Ln Normal Max Temp (F)	0.1562	0.1230	1.27	0.2091
Ln Wholesale Population	-4.1137	1.8309	-2.25	0.0283
Trend	0.0026	0.0013	2.07	0.0432

N = 68; R2= 0.574; Mean Y= 11.391; Root MSE= 0.075

Table A-21 shows the model of wholesale water deliveries which includes eight monthly binaries and five outlier variables. Both precipitation and maximum temperature

variables have statistically significant coefficients. Also, the trend coefficient is significant and indicates the historical growth in wholesale deliveries of 0.05 percent per month (or approximately 0.6 percent per year).

In order to estimate future use each of the explanatory variables needed to be projected to 2030 in 5-year increments. Below is a detailed description of the assumptions used for each of the explanatory variables used in the wholesale districts regression model.

Precipitation
The monthly precipitation is the climatic normal and was obtained from NOAA.

Maximum Temperature
The monthly maximum temperature is the climatic normal and was obtained from NOAA.

Table A-21 Final Regression Model for Wholesale Deliveries

Term	Estimate	Std Error	Chi-Square	Prob.> Chi-Square
Intercept	10.8419	0.0959	356.40	<.0001
Ln Precipitation	-0.0144	0.0062	5.30	0.0214
Ln Max Temp (F)	0.1356	0.0237	26.73	<.0001
Trend	0.00048	0.0002	4.49	0.0340
Jan	0.0486	0.0224	4.57	0.0326
Mar	-0.0513	0.0176	8.00	0.0047
Apr	-0.0737	0.0166	17.30	<.0001
Jun	0.0476	0.0183	6.44	0.0112
Jul	0.0930	0.0187	21.17	<.0001
Aug	0.0905	0.0188	19.90	<.0001
Oct	-0.0443	0.0166	6.81	0.0091
Nov	-0.0939	0.0165	26.51	<.0001
2002-Sep	0.1060	0.0376	7.53	0.0061
2005-Feb	-0.1407	0.0361	13.68	0.0002
2005-Dec	-0.3228	0.0377	49.76	<.0001
2006-Feb	-0.1812	0.0369	20.69	<.0001
2006-Jan	-0.1910	0.0394	20.21	<.0001

N = 68; R2= 0.898; Mean Y= 11.391; Root MSE= 0.040

INDIVIDUAL WATER USE

Table A-22 Forecasted Individual Customer Class Water Use

Year	Residential Single Family	Residential Multi-family	Commercial	Industrial	Indiana University	Wholesale District
2005	947	833	747	38	717	1,020
2010	950	895	781	37	687	1,049
2015	966	957	811	34	648	1,080
2020	1,022	1,041	843	33	627	1,111
2025	1,107	1,137	926	31	606	1,144
2030	1,230	1,249	1,104	30	586	1,177

Note. All values are shown in million gallons per year (MG/Yr).

Appendix F. Cost of Service Study

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Dan Haddock

From: Dan Haddock
Sent: Sunday, November 23, 2008 10:15 PM
To: 'John R. Skomp'; 'Angela M. Steeno'; 'Michael J. Amore'
Cc: Jack Wittman
Subject: RE: Bloomington COSS Support - Max to Avg Month Ratios by Customer Class
Attachments: CBU mean monthly peak ratios - all classes.pdf; CBU 2002-07 data chart of monthly peak ratios - all classes.pdf; CBU 2002-07 monthly peak ratio commercial class.pdf; CBU 2002-07 monthly peak ratio industrial class.pdf; CBU 2002-07 monthly peak ratio IU class.pdf; CBU 2002-07 monthly peak ratio MF residential class.pdf; CBU 2002-07 monthly peak ratio SF residential class.pdf; CBU 2002-07 monthly peak ratio wholesale class.pdf

After our meeting on Thursday, we completed a final run of the code we developed to allocate the demand to calendar months, and produced our final billing data set. There were some minor changes when our final corrections to the billing data were included. The mean peaking ratios that we provided to you Thursday did not change, but some of the ratios for individual years did. Attached are the final graphs and data table for your use. Please use these instead of the graphs that I sent to you in the email below.

Thanks,

Dan Haddock
WHPA, Inc.
812.333.9399

From: Dan Haddock
Sent: Wednesday, November 19, 2008 10:03 PM
To: John R. Skomp; Angela M. Steeno; Michael J. Amore
Cc: Jack Wittman
Subject: Bloomington COSS Support - Max to Avg Month Ratios by Customer Class

John Skomp
Crowe Horwath

John:

As requested, we are providing the following data in support of the Cost of Service Study for the City of Bloomington Utilities (CBU):

1. Ratios of maximum month to average month water use by customer class for the years 2002-2007.
2. Review of test year (July 1, 2007 to June 30, 2008) peak day and peak hour finished water pumping data provided by CBU; and adjustment of finished water pumping data to compensate for inaccuracy of finished water metering, per investigation, testing and recommendation of WHPA.

Ratios of Maximum Month to Average Month Water Use by Class

Bloomington City Utilities Ratio of Maximum to Average Monthly Water Use by Customer Class							
	Commercial	Industrial	IU Master	Multifamily Residential	Single Family Residential	Wholesale	Production
2002	1.42	1.08	1.34	1.17	1.35	1.16	1.27
2003	1.33	1.16	1.26	1.19	1.20	1.16	1.21
2004	1.29	1.22	1.18	1.10	1.17	1.10	1.16
2005	1.40	1.53	1.16	1.15	1.22	1.19	1.12
2006	1.42	1.27	1.22	1.11	1.21	1.18	1.18
2007	1.46	1.17	1.27	1.16	1.35	1.20	1.25
Mean - 2002 to 2007	1.39	1.24	1.24	1.15	1.25	1.16	1.20

Note: Ratios for customer classes are derived from billing / water consumption data, ratios for production are derived from finished water pumping data.

Review and Adjustment of Test Year Peak Day and Peak Hour Finished Water Pumping Data

On 11/19/08, I met with John Trotter, Monroe WTP Superintendent, to review the peak day and peak hour data provided by CBU to Crowe Horwath, and subsequently provided by Crowe to WHPA. We reviewed the plant operation records, and determined the following:

- Peak Day Finished Water pumping occurred on 9/4/07, recorded as 20.1 million gallons that day.
- Peak Hour Finished Water pumping occurred at 10 PM on 9/3/07, recorded as a rate 24.8 million gallons per day (mgd) during that hour.

Through WHPA's analysis of production data for the conservation planning study, it was determined that a discrepancy exists between the raw water and finished water metering. Volumetric testing of the finished water meter using the ground storage tank at the plant resulted in a determination by WHPA to adjust all finished water pumping data by 2.3% to correct for under-registering of the meter. Applying the adjustment to the test year peak day and peak hour production data, provides the peak day and peak hour values recommended for use in the Cost of Service Study.

- **Peak Day Finished Water Pumping (9/4/07) = 20.6 mgd**
- **Peak Hour Finished Water Pumping (9/3/07 @ 10 PM) = 25.4 mgd**

Please advise if you have any questions about the data we have provided.

Regards,

Dan Haddock, P.E.
Senior Project Manager
Wittman Hydro, a division of Layne
320 W. 8th St., Suite 201
Bloomington, IN 47404
812.333.9399 (office)
812.333.3080 (fax)
317.696.6980 (cell)
www.wittmanhydro.com

Dan Haddock

From: Dan Haddock
Sent: Monday, December 08, 2008 10:50 AM
To: 'Michael J. Amore'
Subject: RE: Bloomington COSS Support - Max to Avg Month Ratios by Customer Class

Michael –

As requested, here is the average day high service pumping in gallons/day for the test year period.

Maximum	20,571,891
Average	14,558,375
Minimum	9,693,309

Dan Haddock
WHPA, Inc.
812.333.9399

-----Original Message-----
From: Michael J. Amore [mailto:michael.amore@crowehorwath.com]
Sent: Monday, December 08, 2008 9:21 AM
To: Dan Haddock
Subject: RE: Bloomington COSS Support - Max to Avg Month Ratios by Customer Class

Dan,

I was wondering if you could also provide me with the average daily flow for our test year.

Regards,

Michael J. Amore
Crowe Horwath LLP
10 West Market Street, Suite 2000
Indianapolis, Indiana 46204
d: 317-269-2385
f: 317-635-6127

"Dan Haddock" <dan@wittmanhydro.com>
11/23/2008 10:15 PM

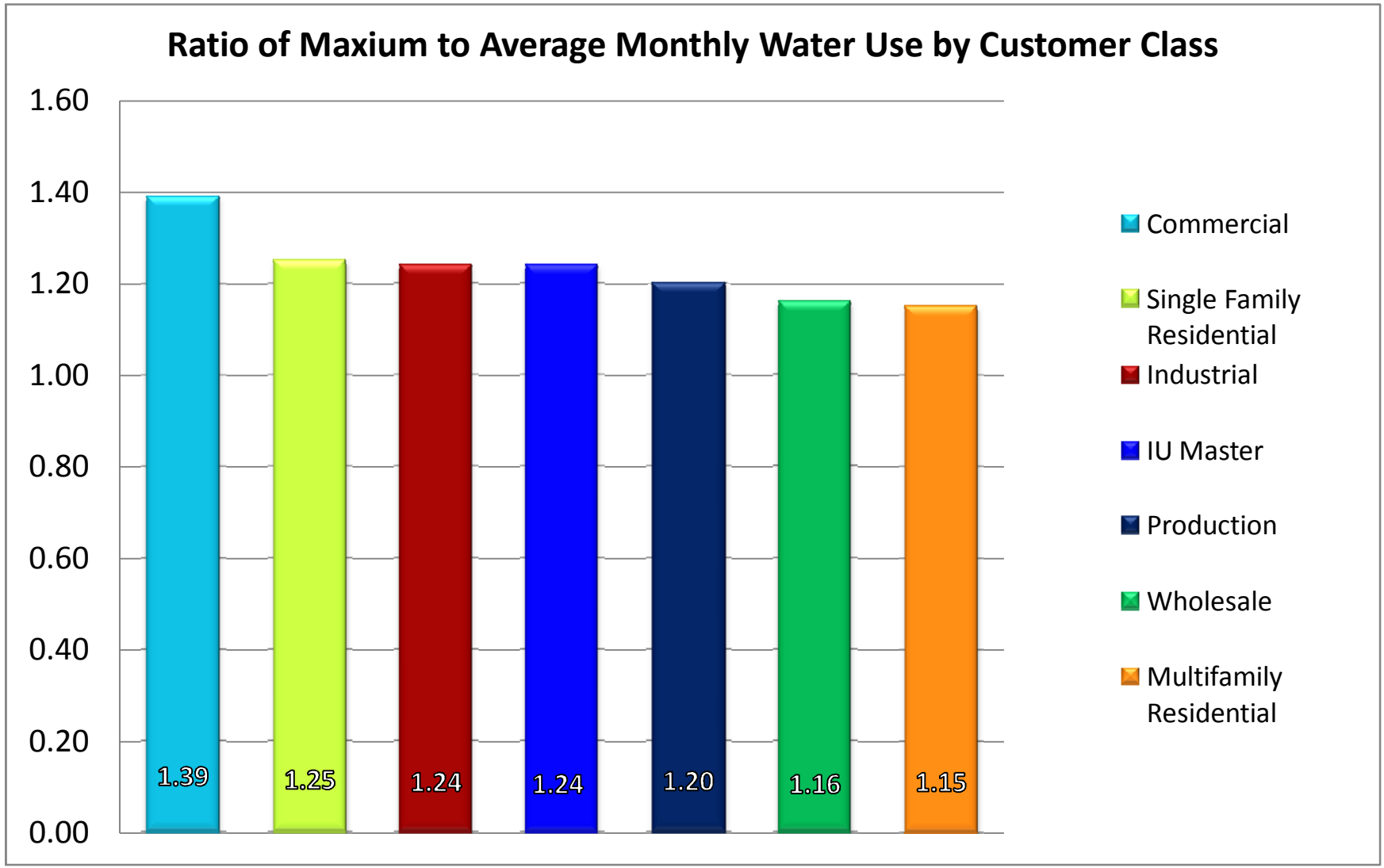
To
"John R. Skomp" <john.skomp@crowehorwath.com>, "Angela M. Steeno" <angie.steeno@crowehorwath.com>, "Michael J. Amore" <michael.amore@crowehorwath.com>

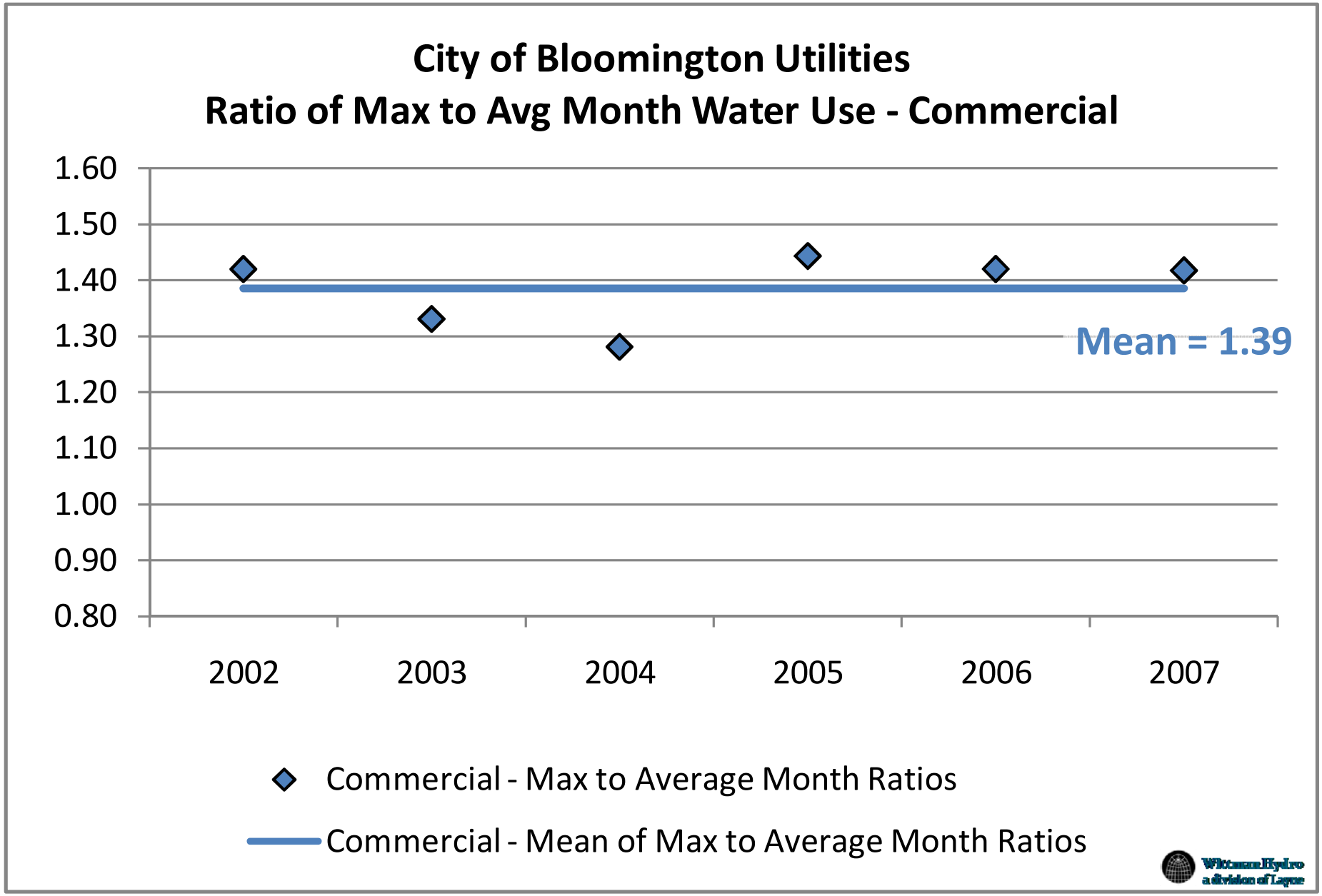
cc
"Jack Wittman" <jack@wittmanhydro.com>

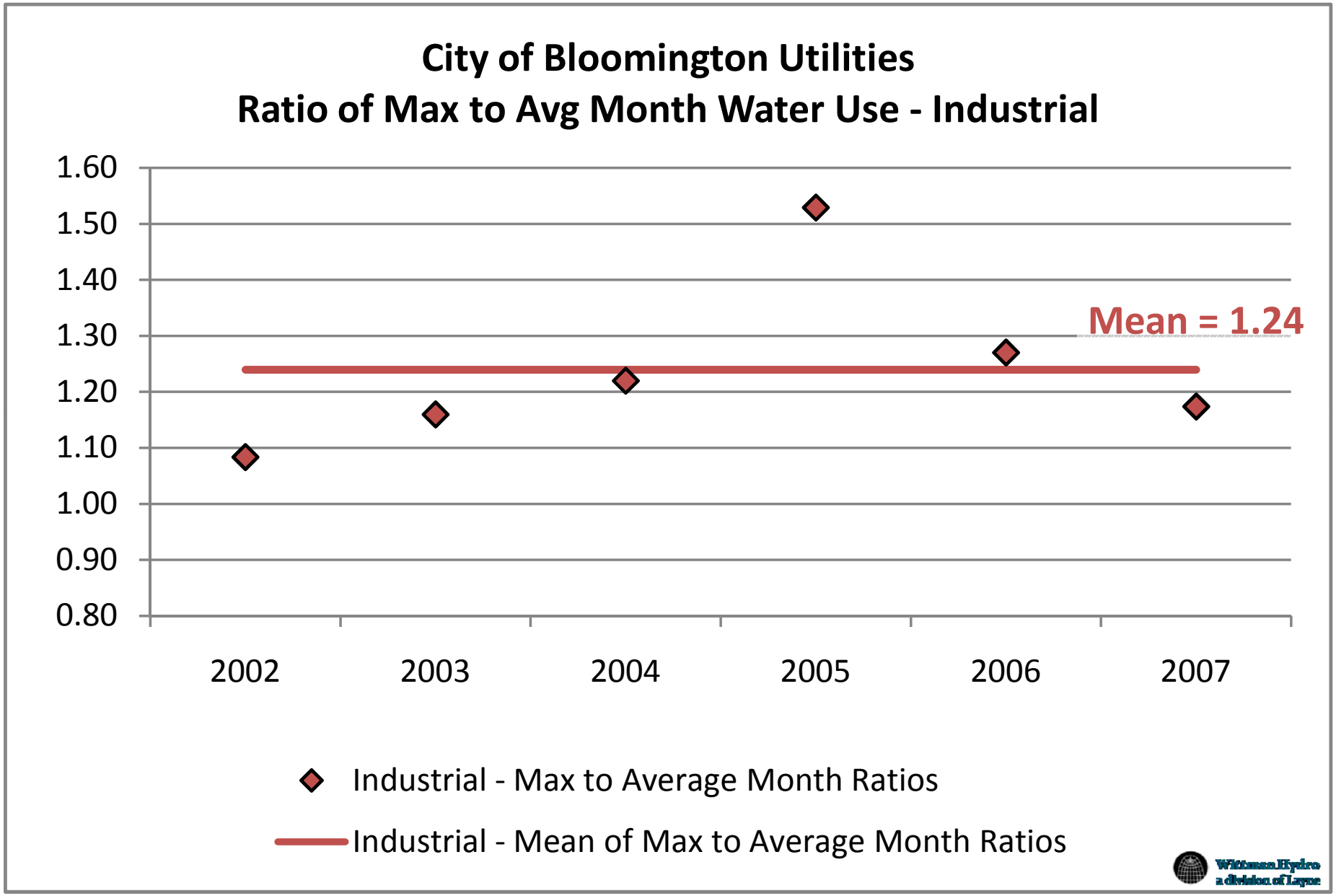
Bloomington City Utilities
Ratio of Maximum to Average Monthly Water Use by Customer Class

	Commercial	Industrial	IU Master	Multifamily Residential	Single Family Residential	Wholesale	Production
2002	1.42	1.08	1.34	1.17	1.35	1.16	1.27
2003	1.33	1.16	1.26	1.19	1.20	1.16	1.21
2004	1.28	1.22	1.18	1.10	1.17	1.10	1.16
2005	1.44	1.53	1.16	1.15	1.22	1.19	1.12
2006	1.42	1.27	1.22	1.11	1.21	1.18	1.18
2007	1.42	1.17	1.27	1.16	1.35	1.20	1.25
Mean - 2002 to 2007	1.39	1.24	1.24	1.15	1.25	1.16	1.20

Note: Ratios for customer classes are derived from billing / water consumption data, ratios for production are derived from finished water pumping data.


Ratio of Maxium to Average Monthly Water Use by Customer Class
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1.39
1.25
1.24
1.24
1.20
1.16
1.15
Commercial
Single Family Residential
Industrial
IU Master
Production
Wholesale
Multifamily Residential


City of Bloomington Utilities
Ratio of Max to Avg Month Water Use - Commercial
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
2002
2003
2004
2005
2006
2007
Mean = 1.39
Commercial - Max to Average Month Ratios
Commercial - Mean of Max to Average Month Ratios
Wittman Hydro
a division of Layne


City of Bloomington Utilities
Ratio of Max to Avg Month Water Use - Industrial
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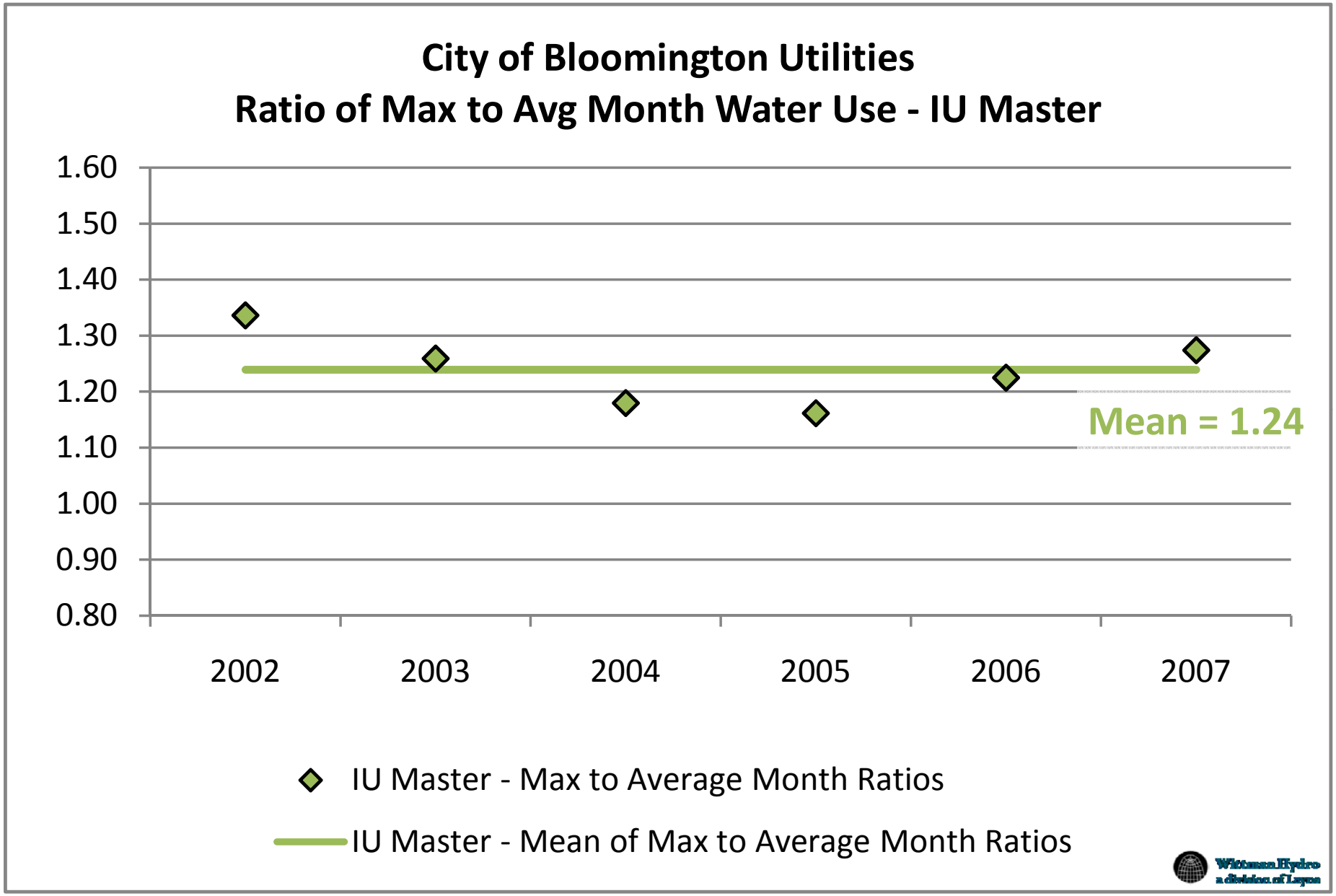
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
Mean = 1.24
2002
2003
2004
2005
2006
2007
Industrial - Max to Average Month Ratios
Industrial - Mean of Max to Average Month Ratios
Wittman Hydro
a division of Layne


City of Bloomington Utilities
Ratio of Max to Avg Month Water Use - IU Master
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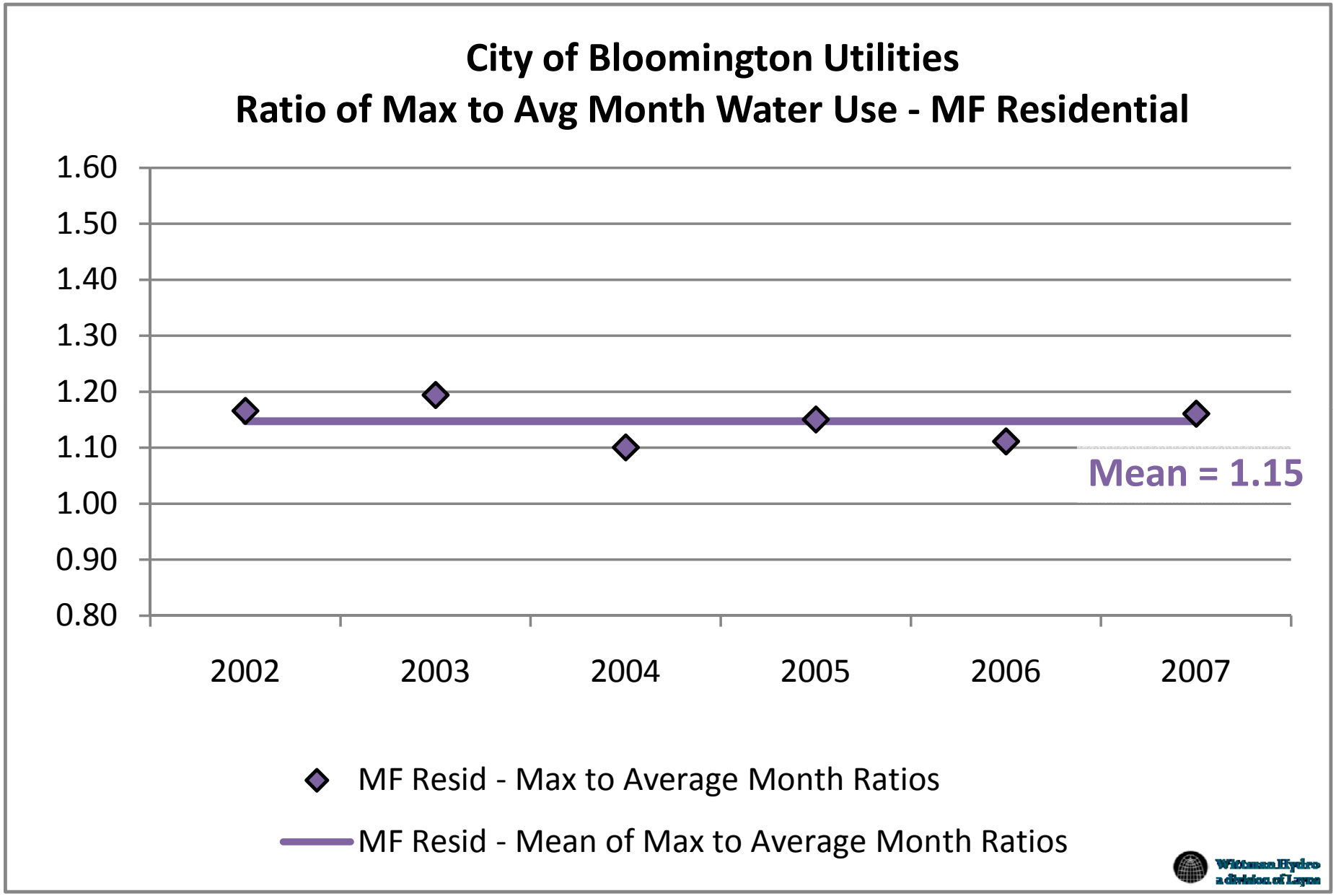
1.40
1.30
1.20
1.10
1.00
0.90
0.80
2002
2003
2004
2005
2006
2007
Mean = 1.24
IU Master - Max to Average Month Ratios
IU Master - Mean of Max to Average Month Ratios
Wittman Hydro
a division of Layne


City of Bloomington Utilities
Ratio of Max to Avg Month Water Use - MF Residential
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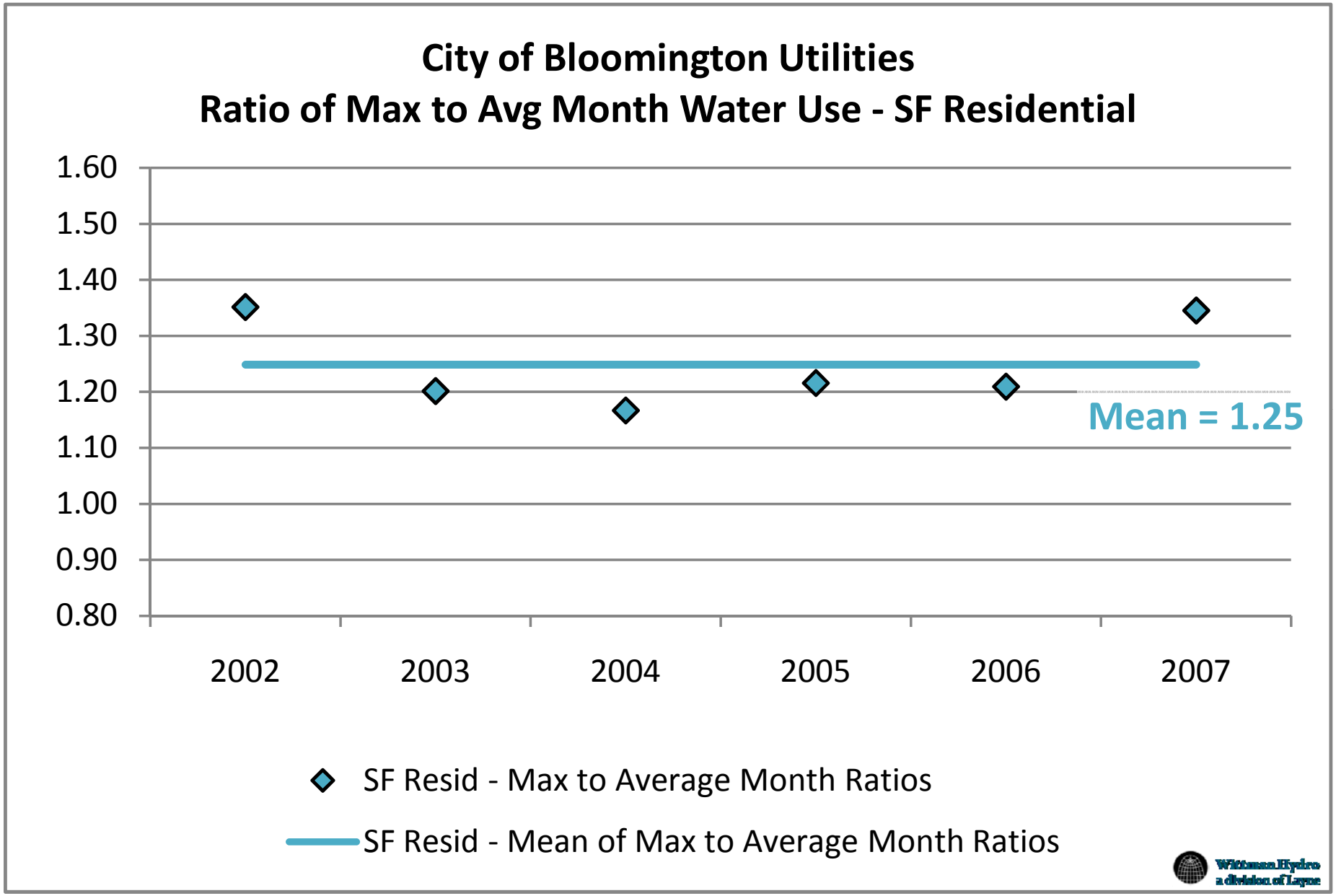
1.40
1.30
1.20
1.10
1.00
0.90
0.80
2002
2003
2004
2005
2006
2007
Mean = 1.15
MF Resid - Max to Average Month Ratios
MF Resid - Mean of Max to Average Month Ratios
Wittman Hydro
a division of Layne


City of Bloomington Utilities
Ratio of Max to Avg Month Water Use - SF Residential
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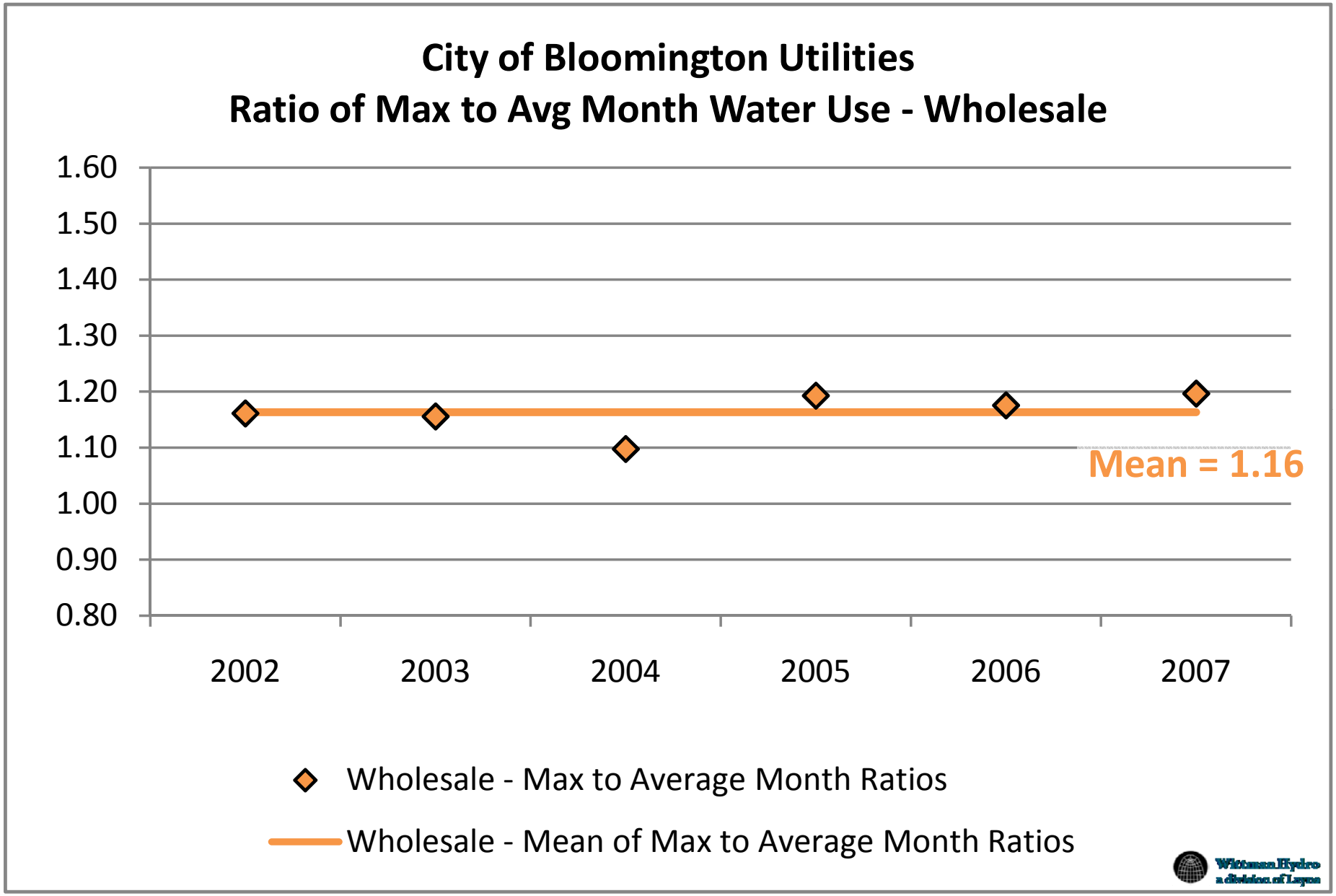
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
2002
2003
2004
2005
2006
2007
Mean = 1.25
SF Resid - Max to Average Month Ratios
SF Resid - Mean of Max to Average Month Ratios
Wittman Hydro
a division of Layne


City of Bloomington Utilities
Ratio of Max to Avg Month Water Use - Wholesale
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1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
2002
2003
2004
2005
2006
2007
Mean = 1.16
Wholesale - Max to Average Month Ratios
Wholesale - Mean of Max to Average Month Ratios
Wittman Hydro
a division of Layne

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Appendix G. Alternative Water Supply

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Concept for Alternative Water Supply

The City of Bloomington (City) has a very unique opportunity to develop an alternative (non-potable) water supply to complement its drinking water infrastructure. Infrastructure previously utilized for drinking water supply from the de-commissioned Griffy Water Treatment Plant can be improved and re-purposed to provide supply for irrigation and other non-potable demands. The development of an alternative water supply would reduce peak demands on the drinking water supply produced by the Monroe Water Treatment Plant.

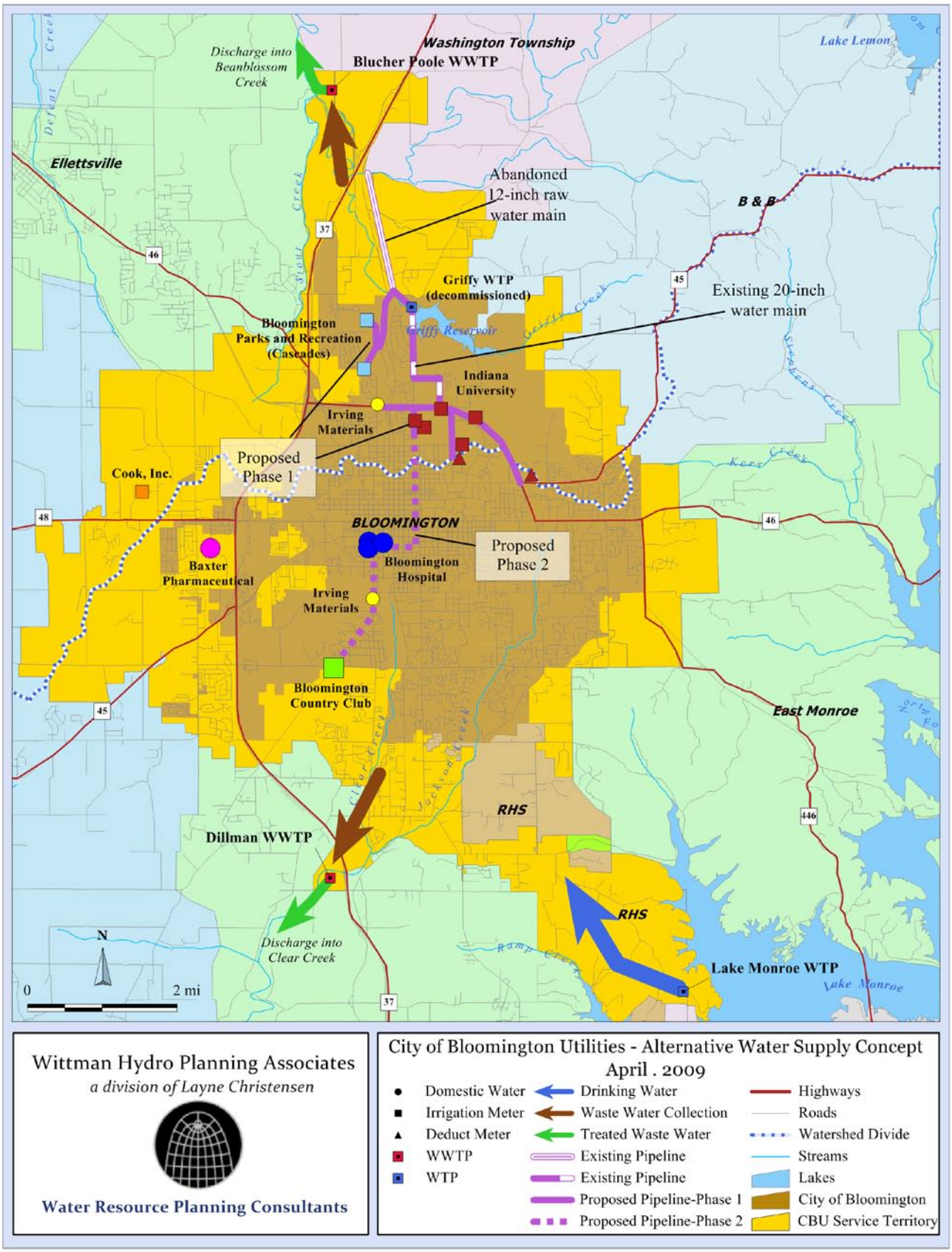
Components

The proposed alternative water supply would be developed in phases. The components and layout of a conceptual two-phase system are shown in the figure below. The proposed system would include the following components.

- Raw water intake from Griffy Lake reservoir - re-commissioned
- Griffy Water Treatment Plant - partially re-commissioned and improved to provide pumping and minimal treatment required for non-potable supply
- Transmission main – existing 20-inch main isolated from drinking water distribution system and converted to non-potable water service
- Distribution mains – constructed as necessary to connect customers to on-potable supply from transmission main
- Future supplemental supply from Blucher Poole Wastewater Treatment Plant – an abandoned 12-inch raw water main could be re-commissioned and extended to connect the Blucher Poole WWTP to the alternative water system, supplementing supply capacity with treated WWTP effluent

Potential Customers & Uses

Customers that could potentially be served by the initial phases of the system are shown in the figure below. The first phase of the system could supply irrigation water to the Cascades golf course and Indiana University (IU) athletic fields. Based on current metered irrigation water use, we estimate that the peak demand for these initial customers would exceed 0.5 million gallons per day (mgd). Future customers would likely include those that currently utilize high peak volumes of water for cooling or irrigation when overall system demands are highest.


Washington Township
Lake Lemon
Discharge into Beanblossom Creek
Blucher Poole WWTP
Ellettsville
Abandoned 12-inch raw water main
B & B
Griffy WTP (decommissioned)
Existing 20-inch water main
Bloomington Parks and Recreation (Cascades)
Griffy Reservoir
Indiana University
Irving Materials
Proposed Phase 1
Cook, Inc.
BLOOMINGTON
Proposed Phase 2
Baxter Pharmaceutical
Bloomington Hospital
Irving Materials
Bloomington Country Club
East Monroe
RHS
Dillman WWTP
RHS
Discharge into Clear Creek
Lake Monroe WTP
Lake Monroe
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Wittman Hydro Planning Associates
a division of Layne Christensen
Water Resource Planning Consultants
City of Bloomington Utilities - Alternative Water Supply Concept
April . 2009
Domestic Water
Irrigation Meter
Deduct Meter
WWTP
WTP
Drinking Water
Waste Water Collection
Treated Waste Water
Existing Pipeline
Existing Pipeline
Proposed Pipeline-Phase 1
Proposed Pipeline-Phase 2
Highways
Roads
Watershed Divide
Streams
Lakes
City of Bloomington
CBU Service Territory

Benefits

We believe that the development of an alternative water supply could result in multiple economic and other benefits for the City.

Sustainable Water Management

Water is a renewable, but finite resource. Water resources are subject to multiple and often conflicting quality and quantity demands. In many communities, water is a growth-limiting factor for development. The development of alternative water supply infrastructure will provide Bloomington with the long-term means to preserve high-quality supplies for appropriate uses. An alternative supply will provide the City with greater flexibility to manage supplies during periods of extended drought.

Economic Development

Industries and the banks that finance the construction and expansion of their facilities are increasingly concerned with water security. Communities with reliable water supplies that are not subject to curtailment during drought are considered water secure. The U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) certification program now includes mandatory requirements for water efficiency. The availability of an alternative water supply for irrigation, cooling and process needs provides an advantage for those businesses seeking LEED certification of their facilities. Certification programs for water sustainability <http://allianceforwaterstewardship.org> are now emerging, similar to those of the well-established Forestry Stewardship Council <http://www.fsc.org>. Industries that wish to obtain certification of their products will place value on the availability of alternative water supplies. The availability of an alternative water supply will provide a unique advantage to Bloomington when competing for economic development opportunities.

Defer Future Drinking Water Investments

Many of the water demands that would be met with an alternative supply are greatest when the demands on the entire system are also at their highest. By "shaving" the peak demands from the drinking water system, treatment plant infrastructure operates more efficiently and the need to further expand capacity is deferred.

Convert Water Quality Problem to an Asset

An existing 20-inch main in the northern part of the distribution system was previously used to deliver large volumes of water from the Griffy Water Treatment Plant (WTP) south to the City. Since the de-commissioning of the Griffy WTP, the movement of water through these large pipes has slowed dramatically. Water quality has deteriorated as the average age of water has increased. Converting the 20-inch transmission main from drinking water to non-potable water service would alleviate water quality problems, while simultaneously reducing the cost to implement the alternative water system.

Community Awareness

Improvements to all or part of the Griffy WTP is necessary for the operation of the system. Renovation of this facility also provides an opportunity to develop multi-purpose educational facilities for the Utility

and the Nature Preserve. Important educational activities related to water resources and water treatment could be held at this facility without the security concerns related to holding similar activities at the Monroe WTP. The preservation of this historical building was recommended in the Griffy Lake Nature Preserve Master Plan (2008). Reuse of the existing facility provides a good opportunity to obtain LEED certification for the building, further highlighting the City's commitment to sustainability.

Recommendations

Additional study is required to confirm the feasibility of an alternative water supply, and to determine the costs of constructing and operating such a system. The following areas of further study are recommended:

- Market Study – identification of potential customers, assessment of current and future demand
- Evaluation of Existing Facilities – assessment of the condition of existing facilities and the feasibility of reuse in an alternative water supply
- Preliminary design, cost estimates and options for phasing development
- Management and rate structures