Chapter 7—Utilities Plan

Introduction

The availability of utilities (water, wastewater, storm water, and electricity) continues to be a key component in determining locations for new development. As such, it is important for future utility expansions to align with future land use and development plans.

Water Supply System

Madison's water supply system includes:

- 11 wells in and around the city
- A water treatment plant with a design capacity of 4M gallons per day
- Water storage in one underground and two elevated facilities with total capacity of 1.95M gallons
- Distribution system comprised of approximately 245,000 feet of pipe

Wells. Madison obtains its water supply from 11 wells located in and around the City. Eight wells draw their water from the Northern Skunk Creek Management Unit of the Big Sioux Aquifer and the remaining three draw water from the Howard Aquifer. The depth of the wells ranges from 34-257 feet and the wells have a total combined capacity of 4,050 gallons per minute and a total operating capacity of 2,800 gallons per minute (4MGD).

Treatment Facilities. Madison's existing water treatment plant was updated and expanded in 1997 to provide a current design capacity of 4M gallons per day. The plant clarifies and filters water using a lime softening process to reduce iron, manganese, and total water hardness. A 1M gallon underground storage reservoir located at the plant stores the treated water until it is delivered via three high lift booster pumps to the distribution system (Banner Associates 2008).

Water Storage Facilities. Two elevated storage reservoirs provide distribution pressure and fire protection reserve supply for the Madison water supply system. One water tower is located at 4^{th} and Union, and the second is located in the NE portion of the City. The towers can store 450,000 and 500,000 gallons, respectively. The older, northwestern tower is not used during the winter because demand does not justify it.

Existing Distribution System. The treated water is transferred from the underground clearwell located at the treatment plant to the distribution system via three high lift booster pumps. The rated capacities of the each pump is 1200-1300 gallons per minute at a total dynamic head of 260 feet. The pumps are equipped with soft start control valves on the discharge designed to minimize surges and water hammer (Banner Associates 1977). The sizes and locations of the pipes comprising the distribution system are shown in Figure 7.1. The 12, 10, and 8 inch pipes are considered to be the primary transmission lines. The City currently provides an average of 1,036,800 gallons of water per day through a single city-wide pressure zone.

Systemic Limitations and Capacities. Madison's water supply system has the following systemic limitations:

- Existing treatment plant does not effectively treat and remove sulfates
- There are frequent water main breaks suggesting age and condition of pipe warrant replacement

FIGURE 7.1

WATER INFRASTRUCTURE

Madison Comprehensive Plan

The existing system provides water service to approximately 2,031 residential users and 323 commercial/industrial users. Water demand has continually increased since operation of the water treatment plant began in 1967. Excluding the summer months, Madison's water distribution system generally has the capability to adequately provide water service to its residents. High demands during the summers of 1989-91 lead to the City instituting water restrictions. In recent the years the City has established year-round water restrictions. Table 7.1 displays population and water demand projections provided by a City consultant. Recent improvements to the treatment plant have increased capacity to 4M gallons per day. Currently, the City has twice the required water treatment plant capacity needed. It may be beneficial to evaluate and update the current water restriction policy.

Table 7.1. Projected water demands, million gallons per day (Banner Associates 1993)

Year	Population	Residential Usage	Commercial Usage	Industrial Usage	Unaccounted	Annual Average Flow	Maximum Month Flow	Maximum Day Flow	Required Plant Capacity
1990	6257	0.385	0.099	0.148	0.145	0.778	1.05	1.575	1.890
2000	6595	0.406	0.104	0.156	0.153	0.820	1.107	1.660	1.992
2010	6932	0.427	0.110	0.164	0.161	0.862	1.163	1.745	2.094

The City has also projected connection to the Lewis & Clark Rural Water System by 2019 if Federal Funding is sufficiently allocated. The City has already prepaid its local cost-share for the project. When completed, the system will provide safe, reliable drinking water to over 300,000 people in South Dakota, Iowa, and Minnesota and will replace or supplement existing sources of supply. In addition to a traditional lime softening treatment facility, the non-looped system will also include a series of pump stations and reservoirs. The water treatment plant will be located three miles north of Vermillion. The maximum capacity from the completed system will be 45 million gallons per day (Lewis & Clark Rural Water System 2004). The City of Madison will be allocated one million gallons per day once the project is completed. The Lewis and Clark water will be the City's main water source and the existing wells will be used to supplement the supply.

In addition to the systemic issues noted above, it is important to recognize how water supply fits into the overall future development pattern for the City of Madison. While the short term growth can likely be served by extension of existing water mains, future development areas need to be planned for in a more systematic way. Therefore a Water Distribution Master Plan should be completed. Such a study should include a dynamically calibrated hydraulic model. This model would provide the most effective way to evaluate the entire existing water supply system and to make decisions about future improvements. It would evaluate the system for limitations in water pressure, water lines, and water storage; evaluate alternative approaches to alleviating identified deficiencies; and provide a prioritized strategy of improvements to the system.

It will be important for the City to solidify details pertaining to the Lewis and Clark water supply the time for connection approaches. Some of the details which should be determined include the future level of well and treatment plan operations, how the water will be incorporated into the City's system, and how changes in water quality will be addressed.

Sanitary Sewer System

The Madison Sanitary Sewer System consists of:

- Approximately 230,000 feet of collection pipe
- A wastewater treatment facility located in the far southeast part of Madison and adjacent to Park Creek, as illustrated in Figure 7.2
- An infiltration-percolation (I/P) system located approximately one mile southeast of the wastewater treatment plant (Banner Associates, Inc 2007).

Collection System. The existing sanitary sewer collection and treatment system serves both domestic and industrial users. The collection lines of the sewer system terminate into two outfall lines that transport sewage to the treatment facility (Banner Associates 1993). The current collection system has no lift stations and is all gravity feed to the treatment facility.

Treatment Facility. The overall sewage treatment system includes a mechanical treatment plant followed by a infiltration percolation system. Wastewater is conveyed from the outfall lines to the treatment plant via a single 24 inch interceptor line discharging to a channel within the pretreatment building. The mechanical treatment facility provides preliminary, primary, and secondary treatment of influent wastewater prior to discharging to the I/P cells. The solids removed from the treatment process are land applied to city property or sold to farmers (Banner Associates 1993).

Infiltration/Percolation System. Tertiary treatment is provided by the I/P system which includes a storage lagoon, a pump station, and four individual I/P cells.

Sanitary Sewer System Limitations and Capacities. Madison's sanitary sewer system has the following systemic limitations:

- The collection system has very significant infiltration and inflow problems
- There may be capacity limitations within the existing collection system as continued development occurs north of the City

A large storm event in May of 2007 led to sewage backups in some homes. The heavy rain and the City's existing I/I issues overwhelmed the sanitary system resulting in some sewage backing up. This may be due to sump pumps connected to sanitary sewer lines. The influx of stormwater into the system also exceeded the treatment plant's capacity. The noted I/I problems were identified in the 2007 Wastewater Treatment Facility Plan which analyzed wastewater flows. Table 7.2 displays the variation in winter flows versus peak day influent. The findings illustrate that I/I is a major component of the treatment facilities influent flow and account for approximately 87% of the flow during peak flow events. The actual peak day I/I is much worse and unknown since portions of the influent may be diverted to a storage pond during periods of heavy influent flow (Banner Associates 2007).

**The reported flow is measured by the facilities influent meter. The actual influent flow is unknown since portions of the influent may be diverted to a storage pond during periods of heavy influent flow.*

The 2007 Wastewater Treatment Facility Plan provides recommended plant improvements to handle the 20 year projected flows and loads from the City of Madison based on the study's population projections. The study recommends significant improvements to replace mechanical treatment equipment which has reached the end of its useful life. These improvements will be made within the next year.

FIGURE 7.2

SANITARY SEWER INFRASTRUCTURE

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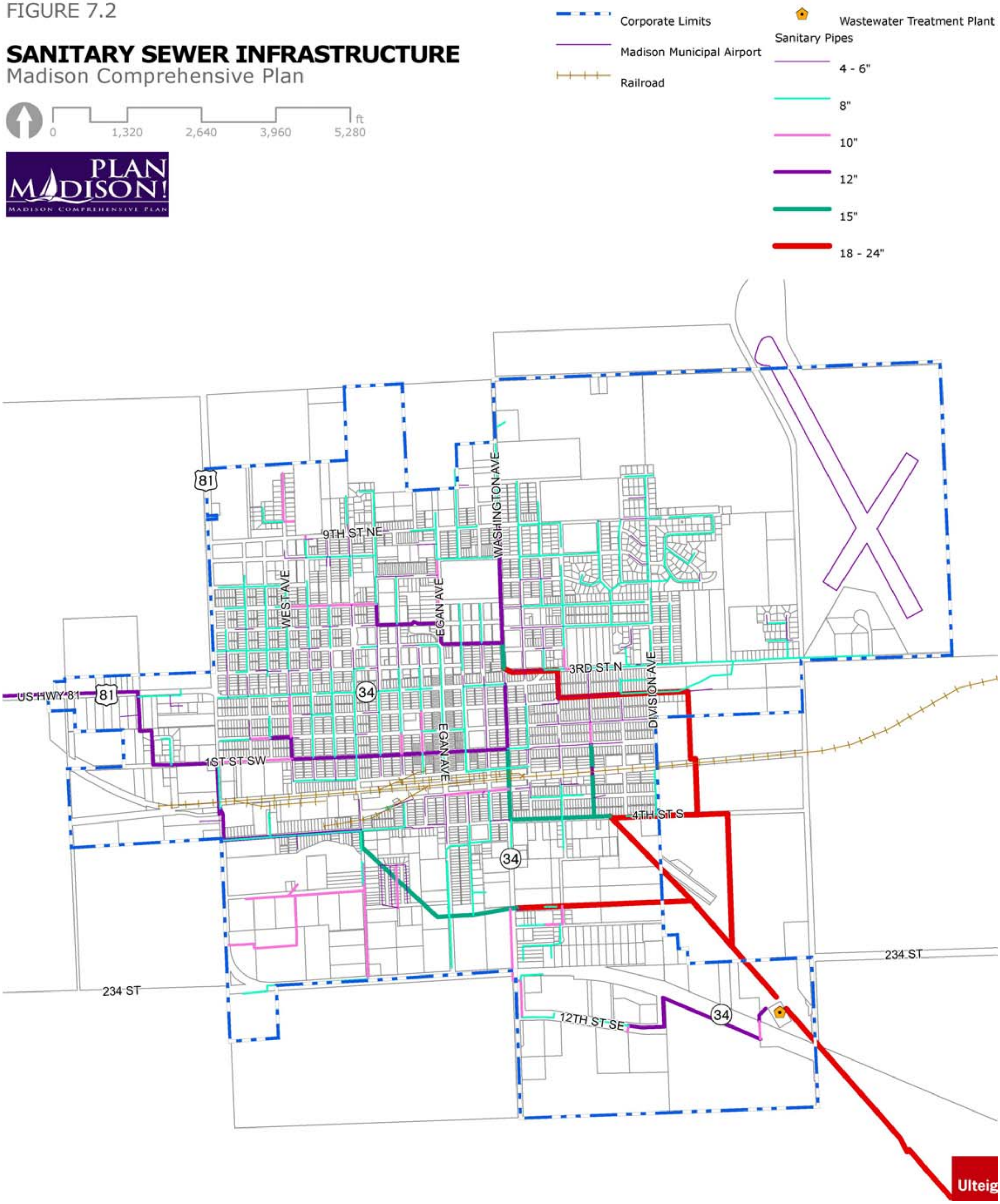


Table 7.2. Water sales versus wastewater flows (Banner Associates 2007)

Year	Winter Influent (MGD)	Winter Sales (MGD)	Winter I/I (MGD)	Peak Day* Influent (MGD)	Peak day I/I (MGD)
2004-2005	0.673	0.518	0.155	4.04	3.53
2005-2006	0.875	0.554	0.321	1.63	1.08
Average	0.774	0.536	0.238	2.84	2.31

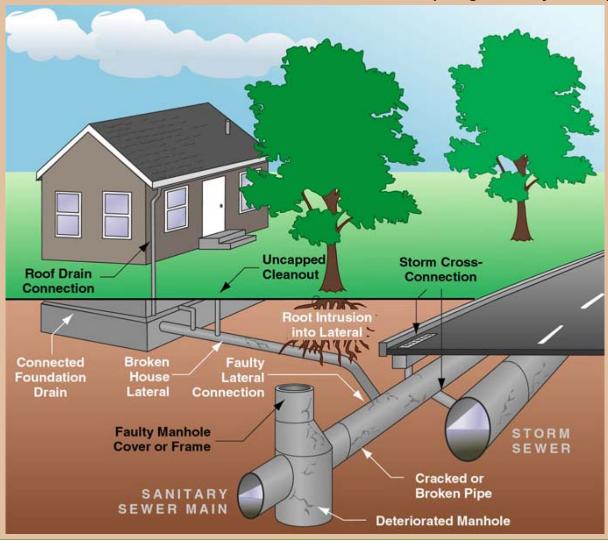
The following observations are provided for consideration as the City prepares for future growth:

- The unique population characteristics of Madison's population and the impacts of the aging baby boomer generation may cause typical population projections to under– or over project the future growth of the community. Additionally, if the Forward Madison goals are achieved, recent utility demand projections may be exceeded much sooner than the typical 20 year planning horizons.
- Since the true extent of peak day I/I flows is unknown, but already is quantified as a very high number, it seems likely that plant capacity would be capable of handling significant additional population growth if the I/I sources were eliminated. These I/I issues should be addressed through a Sanitary Sewer Evaluation Study which includes such activities as CCTV inspection, smoke testing, dye testing and sewer flow measurement in order to determine what part of the I/I is economically feasible to eliminate.
- It is likely that the largest sanitary sewer system bottleneck for future growth is in the collection system and not the treatment system. A study evaluating the collection system to determine where maintenance is needed, where increased capacity is needed to serve future growth areas, and the most efficient approach to serve future growth areas would be beneficial.
- Continued municipal development will require future trunk line extensions and may eventually require sanitary lift stations. It would be prudent for the City to develop policies establishing the way the City will prepare for and respond to these costs.

Infiltration and Inflow

Infiltration and inflow (I/I) is clean storm and/or groundwater that enters the sanitary sewer system through cracked pipes, leaky manholes, or improperly connected storm drains, down spouts and sump pumps (Figure 6.2). Most inflow comes from stormwater and most infiltration comes from groundwater. I/I affects the size of conveyance and treatment systems and, ultimately, the rate businesses and residents pay to operate and maintain them (King County 2004).

Table 7.3. Illustration of infiltration and inflow (King County 2004)



Stormwater System

The City of Madison is situated in a bowl that concentrates the stormwater runoff from three drainage basins represented by the Park Creek, Park Creek Tributary, and Silver Creek drainageways as illustrated in Figure 7.4. The Madison Stormwater System consists of surface and subsurface improvements to channel runoff into these creeks which eventually drain into Lake Madison.

Systemic Limitations and Capacities. A 1993 summer flood provided valuable insight into the capacity limitations of the Madison Stormwater System. Madison has several areas which have historically experienced drainage and flooding problems. These problems occur in:

- Sections of the Park Creek and Silver Creek drainage channels
- Identified floodplains
- Where capacity of storm water drainage system is inhibited by the age, size or lack of existing storm pipe (Banner Associates 1995).

A study was completed in 1995 to investigate the 1993 flood and develop a set of alternatives to address the drainage and flooding issues. This study evaluated the following flood control alternatives:

- Channel Improvements – cleaning and widening
- Realignment of Channels
- Diverting all or part of the peak flows
- Replacing structures at specific problems areas
- Constructing detention dams
- Wetland Restoration
- Establish Floodway
- Site specific alternatives including floodwalls, berms, or floodproofing
- Bank Stabilization and Erosion Control
- Lake Outlet Evaluation

Based on these evaluated alternatives, two different strategies for floodplain management were formulated (Banner Associates 1995). The first, and recommended, strategy involved constructing one or two detention dams upstream of Madison, and upsizing or modifying several drainage structures. The second strategy involved making improvements to the existing channel, replacing selected drainage structures, and not constructing any detention dams. Since the completion of this 1995 study, the City has completed and/or implemented some of the evaluated projects including channel and structure cleaning, and replacing several of the structures identified as restricting the channel flow. While not all part of the 1995 study recommendations, all of the following structures have been reconstructed or improved:

Park Creek

- 4th Street SE box culvert
- Grant Avenue Bridge
- Lee Avenue
- Egan Avenue
- 7th Street
- 9th Street
- Lincoln Avenue
- Harth Avenue
- 1st Street NE
- Washington & 3rd Street NE

Park Creek Tributary

- Josephine Avenue

Silver Creek

- Washington Avenue box culvert (owned and upgraded by SD DOT)

FIGURE 7.4

DRAINAGE BASIN MAP

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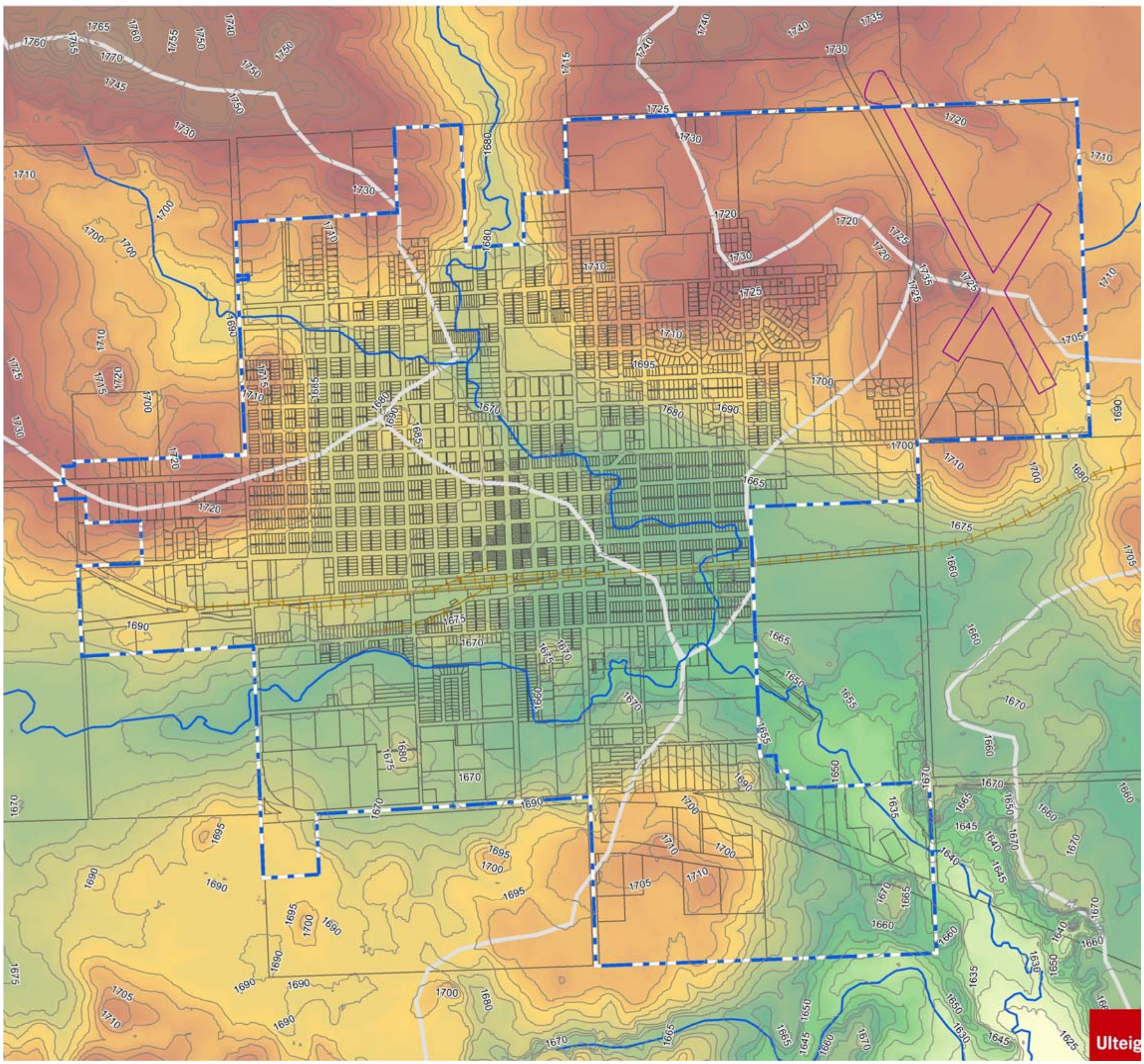
0 1,320 2,640 3,960 5,280 ft

PLAN MADISON!
MADISON COMPREHENSIVE PLAN

Corporate Limits
Madison Municipal Airport
Railroad
Hydrology
Sub-Basins
Elevation Gradient
High : 1877.42
Low : 1546.2



One significant structure which has not been replaced is the railroad. BNSF has agreed to the reconstruction of the bridge, however the City would be 100% responsible for these costs.

In addition, the City used FEMA assistance to purchase 67 homes that were flooded in 1993. These homes have since been moved and this City owned land is now public open space.

The City also initiated steps to construct a detention pond dam north of the City. The land area was identified and buyout figures were established by the City. The impacted landowner disputed the original land appraisal and after litigation the City and landowner reached a mutual agreement for the price of the land. However, the project has since stalled following a failed referendum for the project by the citizens of the City.

While the City has completed a portion of the recommendations outlined in the 1995 study, such as structure improvements and channel cleaning, it is still quite prone to the future flooding. The existing stream channels can only contain a 5 to 7 year storm event and any event greater will overtop the banks. FEMA is currently in the process of updating the City's Flood Insurance Rate Map (FIRM) with a digital flood insurance rate map (DFIRM). The new DFIRM will delineate those areas subject to a 1% chance of flooding in any year (100-year flood).

The new DFIRM will likely become effective during some time in 2008 or 2009. The construction of detention and/or retention areas upstream of the floodplain areas within the City of Madison would have the effect of modifying the area, flows and elevation of 100 year flood events in Madison. Therefore the future detention areas could reduce the impact of the new DFIRM on the local community. It should be noted that FEMA is becoming more careful about the level of development considered appropriate downstream of levees and flood control structures.

Recommended Stormwater Management Activities. In summary, the following projects from the recommended flood control strategy of the 1995 Study could be pursued:

- Replacing railroad bridge
- Constructing detention dams
- Site specific alternatives

In view of the recommended future land use plan, the recommended near term development in the vicinity of the Park Creek, and the recent draft findings of the Lake County DFIRM, the following activities are recommended:

1. In response to the new DFIRM, continue efforts to reduce flooding impacts in the developed part of the City. This should include a substantial community education program on community impacts and alternatives to address these impacts.
2. Complete a stormwater management master plan which provides strategies to manage stormwater in each of the drainage sub-basins that are part of the city or its future development areas. This master plan should incorporate actions and projects which will reduce flooding impacts in the developed part of the City. It should identify any additional regional future stormwater retention and/or detention areas which were not identified in the 1995 Banner Study, as well as identifying areas where it is more appropriate to continue the City's current practice of requiring subdivision level stormwater management at the time of development.

3. Coordinate the stormwater and floodplain management strategies of the stormwater management master plan with the recommended greenway development plan noted in the Parks, Recreation and Public Facilities Chapter.
4. Complete site specific flood protection alternatives to protect property where determined consistent with the stormwater management master plan and the greenway development plan.

Electrical Distribution System

The Madison Electrical Distribution System consists of:

- Power sources
- Transmission system
- Substation
- Distribution system
- A 10MW generation plant

Power Sources. Madison currently purchases the majority of its power and energy through its allocation from the Western Area Power Administration (WAPA) and purchases supplemental energy from Heartland Consumers Power District (HCPD). The power is delivered to the City from WAPA substations via the East River Electric Power Cooperative (East River) 69 kV transmission system (DeWild Grant Reckert and Associates Company 2002).

Transmission. The City is currently served by East River at 69 kV via three radial transmission taps from the East River transmission system. The East River line is looped to the points of the City's taps, but is operated radially, which requires a manual operation to restore service when East River line outages occur. The transmission lines in the area appear to be in good condition and the service reliability is currently adequate. However, the radial transmission line exposure is a reliability concern as is the exposure to disturbances on the East River line between the City and the source (DeWild Grant Reckert and Associates Company 2002).

Substations. The City takes delivery of power at 69 kV at three substations. The Power Plant Substation is located in the southwest portion of the City and was the City's original substation. There are four power transformers located at the substation. The Green Substation is located on the northern edge of the City and has one transformer (DeWild Grant Reckert and Associates Company 2002). The Southeast Substation was recently built and is located north of State Highway 34 in the southeast portion of the City.

Distribution. The existing distribution system consists of twelve 13.8 kV circuits, five fed from the Power Plant Substation, three from the Greene Substation (DeWild Grant Reckert and Associates Company 2002), and four from the Southeast Substation. The distribution has both overhead and underground sections, with the new construction having been built underground. The physical condition of the distribution system is very good. The overhead lines are well constructed and maintained and the underground system constructed since 1995 is all in excellent condition. The physical condition of the 4.16 system is not as good as the 13.8 kV, most notably in the downtown area. The system is considerably older and is need of eventual replacement. A recent report recommended the continued conversion of the 4.16 kV areas to 13.8 kV, instead of repairing the existing system (DeWild Grant Reckert and Associates Company 2002).

Generation. The City owns a 10 MW diesel fired generation plant which is located adjacent to the Southeast Substation. The output capacity of the plant is leased to Basin Electric, so it cannot be used by the City for peak shaving. It can, however, be used to supply power to the City's electrical system during emergencies such as power outages.

Systemic Limitations and Capacities. The City of Madison has made good progress on completion of the municipal electric system upgrades listed in the October, 2002 long range plan. The fact that summer load growth has been less than forecasted means that overall, the distribution system is improved today relative to its condition at the time of the 2002 study. The 2002 study pointed out that the major system deficiencies identified in the 1995 study had been addressed.

The primary exception to these improvements is the recommendation to rebuild the downtown Armory and Dairy Queen 4.16kV distribution circuits. These circuits were noted to be in poor physical condition in the 2002 study and were planned to be rebuilt in the 2006-2007 time frame. All the other recommended phase 2 improvements have been, or are currently being completed. The rebuild of these circuits needs to be scheduled and completed in a timely fashion.

Summer peak and winter peak demands have lagged below projections done in 2002 while energy growth has increased, although also below projections. The winter peak has increased from 16,005kW in 2001 to 18,647kW in 2007, an increase of 16.51% or approximately 2.6% per year.

The previous annual load factors ranged from approximately 57% to 62% in the 1990's. From 2002 to 2007 annual load factor has ranged from 59% to 62%.

Purchased energy has increased steadily every year and has increased approximately 11% since 2001. What is troubling is the fact that losses have remained relatively high at the 5 to 8% level. After the capital improvements that were completed based on the 1995 plan it was very encouraging to see the system losses at 3.8% in 2001. Since that time they have ranged from 4.9 to 8.2%. As a point of reference, an efficient distribution system will have losses generally in the 3 to 4% range.

2007 total dollars billed were $5,999,615 with 2007 system losses of 6.41%. The total dollars billed therefore represent 93.59% possible billings. If system losses were reduced to 4.0% an additional $154,495 would have been billed with no attendant increase in power supply costs, or billing costs. This amount would be available to fund capital improvements on the system annually.

As part of the long range planning process, capital improvements that convert the 4.16kV system to operation at 13.8kV should be investigated and pursued. The reduced cost of annual losses will help the profitability and reliability of the system. The effect will be to make the system less complex and easier to back up under on and off peak contingency conditions.

Since the utility now has a power factor correction penalty, it should provide technical aid and advice to customers who desire to correct the power factor of their loads. The electric utility should also perform a var study in order to increase the overall system power factor to the level required by wholesale power contracts. Any feeder capacity that is not carrying vars will then be available to carry real power that can be turned into revenues.

The Electric Utility has completed and adhered to comprehensive utility capital improvement plans designed to remediate or correct system deficiencies. This type of periodic high quality investigation and planning should be continued in the manner it has been in the past. Phase 3 and other possible system challenges should be reviewed, and appropriate improvements should be pursued, as recommended in the 2002 Study. Additionally, since it has been over 15 years since last done, the City should proceed with a rate study. Finally, it may be beneficial for the City to investigate the effects of splitting the costs of new transformers requested by existing or new customers to help manage costs.

Comprehensive Street Lighting Plan. A comprehensive street lighting plan including standards provides benefits to all aspects of a city. Public safety is enhanced by sufficient illumination levels of high quality lighting. With uniform street lighting standards it may be possible to ultimately reduce inventory while having sufficient stock on hand to quickly replace or repair fixtures and bulbs. The recommended process for developing a comprehensive street lighting plan would include the following steps.

Get involvement from the City departments dealing with streets, traffic signals and transportation as well as the police and fire departments. Recommended standards for illumination levels would be developed based on the involvement of this core users group. National ANSI/IES standards for roadways, alleys and bikeways exist and have proven effective. Surveying other municipalities to see what standards and practices they employ may enhance the result and provide additional items for consideration. The standards are valuable since illumination at levels above the standards can cause problems that result in decreased safety or increased maintenance.

These illumination standards can be satisfied by the use of standard equipment with standard heights for fixtures and therefore standard heights for mounting poles and assemblies. With the many new types of lighting available today, a life cycle economic cost analysis of the fixtures and lamps in use on the existing system needs to be completed in order to make valid decisions regarding the nature and speed of the replacement of existing fixtures and lamps on the system.

Depending on the age and condition of the existing system, the number of different lamps and fixtures in use, and the number of, or lack of, complaints from the populace regarding the existing lighting system, replacement plans can be part of the street lighting policies and standards. Generally residential standards and commercial standards include mounting heights, spacing standards, overhand standards, and specific fixture wattage and types.