Implementing (Waste)water Treatment Alternatives: A Comparative Case Study of Small Town Decision-making

Courtney Dufford, Young-Eun (Amber) Kim, Julia Moen
Carleton College, Environmental Studies
Senior Comprehensive Project
March 12, 2014

Abstract

There is an urgent need for expanded wastewater treatment systems in small communities. In 2008, three billion gallons of untreated sewage were dumped into Minnesota's waterways. Of this total, 700 million gallons were generated by small communities. Constructed wetlands have been shown to be an effective, multi-purpose system to help address this treatment gap. However, the ways in which the local decision-making process impacts the implementation of these green infrastructure systems in small rural towns is unexplored in the literature. We thus undertake a comparative case study of the wastewater decision-making process in two most-similar towns in Southwest Minnesota: Pennock and Prinsburg. Pennock is a typical case that installed stabilization ponds, while Prinsburg is our case of interest for its implementation of a subsurface wetland system. Through an analysis of the decision-making process, we identify five major nodes of interaction that occur during this process: 1) internal organization, 2) choice of an engineering firm, 3) choice of a treatment system, 4) funding, and 5) implementation. When choosing a treatment system, we find that cost, odor, and aesthetics are the three major decision-making criteria valued by local decision-makers. We also find that the established precedent of using tried and true stabilization pond systems, as well as risk aversion in both regulatory agencies and private engineering firms constrain the choices available to local decision-makers. However, local decision-makers, to differing degrees depending on their capacity and their leaders, can explore alternatives like constructed wetlands if their objectives for the system are not being met by the traditional options. Lastly, placing wastewater treatment within the larger scope of water resource management may further facilitate innovation of sustainable alternatives to traditional management by encouraging towns to approach the problem with a more critical mindset than just resolving a compliance order.

Acknowledgements

We would like to thank the many people who have helped us throughout the comps process. We would especially like to thank our advisor Kim Smith, whose guidance kept our project moving effectively, much like that of an experienced WWTP operator. Many thanks to our interviewees for sharing their time and knowledge of wastewater treatment systems and for their accommodating responses to our many questions about poop.

Thanks to Tsegaye Nega and Constanza Ocampo-Raeder for their methodological feedback, as well as to the rest of the ENTS department for their guidance and support. Thank you to Danya Leebaw for helping us to filter the literature, much like the cattails in a constructed wetland system. Thank you to Tami Little for stabilizing this process and many thanks to our fellow ENTS majors for keeping us solidly afloat.

Special thanks to William Moen for sifting through our draft and providing edits. Finally, thanks to our family and friends for putting up with an extraordinary number of (crappy) waste puns in the past few months, we greatly appreciate your patience and support!

Table of Contents

I. Introduction 4

II. Analytic Framework 5
- Wastewater Treatment 5
- Decision-making processes 9
- Summary 15

III. Methodology 15
- Case Selection 15
- Research Structure 16

IV. Results 18
- Pennock 18
- Prinsburg 20
- Decision-making Criteria 23
- Characteristics of decision-makers 25
- Characteristics of general public 26
- Characteristics of external actors 27

V. Analysis 30
- (Un)certainty in wastewater decision-making 30
- Local organization 31
- Choosing an engineering firm 32
- Choosing a wastewater treatment system 33
- Funding 34
- Implementing the system 35
- Value-based decision-making 35

VI. Conclusion 36
- Limitations and Future Research 38

VII. Bibliography 40

VIII. Appendicies 46
- Appendix A. Stabilization Pond 46
- Appendix B. Constructed Wetland Technology 49
- Appendix C. Spatial Analysis 52
- Appendix D. Interview Protocol 53
- Appendix E. Pennock Decision-making Timeline 55
- Appendix F. Prinsburg Decision-making Timeline 56
- Appendix G. Interviewees 57

I. Introduction

Minnesota, home to the headwaters of the Mississippi River, is a major contributor of residential, agricultural, and industrial pollution to this waterway. The million acres of agricultural floodplain in the basin is a large source of agricultural contaminants such as nutrient runoff and agricultural chemicals, while urban regions like the Twin Cities are particularly heavy polluters of industrial waste (Theiling and Nestler 2010; Wiener and Sandheinrich 2010). Although more attention has been given to agricultural and industrial contributions to pollution, *fecal coliform* bacteria and other contaminants found in sewage present another major source of pollution to the Mississippi River (MPCA 2008).

In response, the State of Minnesota has been working to decrease contamination levels within state waterways, avoid drinking water contamination, and provide safe recreational opportunities for citizens, as part of the federal Clean Water Act. In 1992, spurred by Governor Arne Carlson's famous call to "clean up the Minnesota River," the Minnesota Pollution Control Agency (MPCA) was charged to focus increasingly on identifying impairments to Minnesota's surface waters through Total Maximum Daily Load (TMDL) studies (MPCA 2007). These studies revealed that over 1,000 small communities (classified as having populations of 3,000 or less) had non-compliant wastewater treatment systems, including many with "straight-pipes" dumping raw or partially settled sewage directly into waterways and county ditch systems. The collective wastewater output of these unsewered communities is about 700 million gallons of the 2.3 billion gallons of sewage produced by all small communities in Minnesota (MPCA 2008, 5). As of 2008, MPCA had worked with over 110 small communities to rectify their noncompliant wastewater treatment systems, prioritizing high polluting municipalities where the problem could be solved with comparatively low cost systems, yet many wastewater treatment concerns remain unaddressed (McCarthy and Gillingham 2008).

Properly managing wastewater is fundamentally tied to both the health of our surface waters and the maintenance of adequate groundwater supplies. As such, wastewater is an important component of water resource management, although many water resource managers still view wastewater treatment as separate from larger water cycles (Thomas and Durham 2003). Integrated water resource management is a more holistic approach that places wastewater into the broader water cycle both before and after treatment (Gooch and Stålnacke 2010; Biswas 2004). However, there is still a disconnect in many rural small towns where wastewater treatment is viewed as a burden and a compliance measure rather than a local responsibility critical to maintaining local water resources or a valuable resource for reuse.

Although national and state governments regulate the broader management of water resources, municipal governments are charged with implementing a compliant wastewater treatment system for their community. The most commonly used methods of wastewater treatment in rural Minnesota are traditional "pipe and pond" systems which are centralized, technologically dependent wastewater treatment plants (WWTPs). However, green infrastructure systems, a broad term used to describe the use of a natural system's ecological properties to perform a variety of functions, have also proven to be effective treatment methods (EPA 2013c). As one example of green infrastructure for wastewater treatment, constructed wetlands utilize the natural filtration properties of plants and organisms in the wetland and the soil to provide secondary, or biological, treatment of wastewater after solids have been separated. Since the 1950s, constructed wetlands have been gaining traction as a system that can treat wastewater as well as traditional "pipe and pond" systems under certain circumstances, while providing ecosystem services such as flood control, carbon sequestration, and habitat (Vyzmal 2010).

Despite the proven efficiency of constructed wetlands in terms of performance, cost, and ecological benefits, the use of this green infrastructure system has yet to be widely adopted in the United States. In Minnesota, there are only 26 existing and 3 proposed constructed wetlands out of a total 477 municipal WWTPs (EPA 'Permit Compliance System' 2013). Given that communities have wastewater treatment needs and the literature has identified constructed wetlands as a viable option for some small communities, the current lack of subsurface constructed wetlands in Minnesota is puzzling. Thus, we examine the question: **how does the wastewater treatment decision-making process in small communities influence the implementation of subsurface constructed wetland systems?**

In order to examine the decision-making processes behind small town wastewater treatment systems that impact the implementation of constructed wetlands, we have undertaken a comparative case study of two most-similar towns in Southwest Minnesota, Pennock and Prinsburg. Although both towns have implemented WWTPs within the last 14 years (2006 and 2000 respectively), their decision-making processes resulted in two different treatment system choices: a traditional stabilization pond in Pennock and a subsurface constructed wetland system in Prinsburg. Drawing upon varied political, aesthetic, economic, and ecological scholarly conversations, as well as pulling from logistical and design-focused texts, we seek to contribute an interdisciplinary perspective to the literature on wastewater treatment decision-making in rural America. Examining the wastewater treatment decision-making process as it relates to green infrastructure from multiple lenses not only helps us to identify the important features of wastewater decision-making, but also informs how the multi-disciplinary values of stakeholders interact throughout the process.

II. Analytic Framework

In our review of relevant literature, we first provide a brief overview of wastewater treatment in small rural towns, and look at the application of green infrastructure systems for wastewater treatment. Then we focus on subsurface constructed wetlands, which is a type of wastewater green infrastructure implemented by Prinsburg, MN. We intend to provide relevant background information about wastewater treatment options and green infrastructure, as well as highlight factors unique to green infrastructure and wastewater treatment that could influence the decision-making process. Because there is a lack of literature on the implementation of green infrastructure for wastewater treatment in small rural towns, we examine the general decision-making and environmental decision-making literature that we use to analyze the wastewater decision-making process of our case studies. We summarize the various stakeholders, challenges, along with approaches and models in decision-making.

Wastewater Treatment

Wastewater treatment is a critical pollution mitigation strategy to ensure the vitality of aquatic ecosystems and minimize waterborne illnesses in humans. Generally, wastewater in the United States is processed in a central location using wastewater treatment plants (WWTP) with high levels of sewage intake and output. The United States has used centralized WWTPs for nearly two centuries, but before that, urban and rural areas used decentralized systems of privy vaults and cesspools (Burian et al. 2000). Once centralized systems were widely implemented and money had been invested in creating centralized wastewater systems and infrastructure, these systems became the norm and funding became widely available for this technology (Burian et al. 2000, 53).

There are many types of wastewater treatment options for municipalities. There is no one “best technology” for wastewater treatment because the needs of each town vary depending on regulatory requirements, community characteristics, physical conditions, and financial factors (Olson et al. 2001; Kalbar et al. 2012). Different types of wastewater are available and these generally consist of some or all of the following processes: preliminary treatment to remove solids, secondary treatment using biological processes to filter water, disinfection to remove pathogens, tertiary treatment removing smaller solids and any nutrients left, and in some systems an additional disinfection or purification step as well (Olson et al. 2001). For large towns and cities, mechanical systems are often used. Mechanical systems can take many forms and are generally very expensive, difficult to maintain, unnecessarily rigorous treatment for small communities. For communities with populations of less than approximately 600 people, other options are available that cost less to implement and maintain than mechanical systems (Frisman Interview). These options include stabilization ponds or lagoons, sand filters, land treatment systems, and constructed wetlands (EPA Manual 2000). The two systems we focus on are stabilization ponds and constructed wetlands.

Stabilization ponds are classified as “natural” or “biological” systems, which are contrasted with mechanical systems. The stabilization pond system has been cited as the “simplest and most economical method of municipal wastewater treatment for rural areas and small communities” (Fritz et al. 1979). Widely recognized as the best system for small towns, most engineering recommendations include pond systems for towns with populations less that approximately 600 people and that have no heavy industry. Benefits of this system include low maintenance requirements, the smell is generally not too pungent, and the cost is reasonable. The system allows solids to drop to the bottom and utilizes bacteria to filter pollutants from the water. See *Appendix A.* for further information about Stabilization Ponds.

Constructed wetlands are a nontraditional alternative to stabilization ponds for small communities (Olson et al. 2001). They are a type of green infrastructure that was developed in Germany in the 1950s for wastewater treatment, and despite proven success as wastewater treatment systems are infrequently utilized (Vymazal 2011). Green infrastructure is a broad term used to describe any natural system or structure that performs a variety of functions by harnessing the system’s ecological properties (EPA 2013c). Generally, green infrastructure refers to the patchwork of natural areas that provide habitat, flood protection, cleaner air, and cleaner water. Green infrastructure can be contrasted with gray infrastructure; Dougherty (2012) describes the difference between these ideas, noting that gray infrastructure is single purposed, driven by mechanical processes, and consists of human-made materials, whereas green infrastructure is characterized as multi-purpose, driven by natural processes, and land and vegetation based.

There are many benefits to the use of green infrastructure. Studies on the cost-effectiveness of green infrastructure have found that green infrastructure is generally more cost-effective than gray infrastructure due to the lower maintenance and operational requirements as well as the positive environmental externalities that different types of green infrastructure provide, such as habitat for biodiversity and pollution absorption (Dunn 2010; Vandermeulen et al. 2011). At the municipal level, green infrastructure is often used for stormwater management by mimicking nature to soak and store rainwater runoff (EPA 2013c). Green infrastructure for wastewater treatment, however, has yet to become widespread in Minnesota. Implementing green infrastructure for wastewater treatment can provide a less energy intensive, more aesthetically pleasing, and multipurpose alternative to traditional wastewater treatment systems. We focus below on characteristics of constructed wetland systems for wastewater treatment.

Constructed wetlands

Constructed wetlands filter water by taking advantage of the natural filtration properties of plants living in these ecosystems. There are two types of wetlands--open water and subsurface (University of Minnesota, Constructed Wetlands factsheet). In cold climates, caution is necessary when constructing wetlands for wastewater treatment because the cold slows the filtration of ammonia and nitrate and can freeze the system, which can kill the plants (EPA 2002b). Subsurface wetlands are less likely than open water constructed wetlands to freeze, especially if built with a layer of mulch as insulation (Wildman 2005). Subsurface systems are unable to provide as many ecosystem services as open water systems (e.g. less extensive habitat), but the problem of mosquitoes and risk of pathogen transmission is diminished in subsurface wetlands because there is no standing water (EPA Manual 2000, 97). The passive nature of constructed wetland systems makes it easier to maintain than mechanical systems, because they do not require highly skilled operators (EPA Manual 2000, 129). Constructed wetland systems are often used in conjunction with either pre- or post-treatment options, such as septic tanks, because they are generally not built to filter the solids found in raw sewage (EPA Manual 2000). Constructed wetlands have become a cost-effective and competitive technology for wastewater treatment and have been deployed internationally. Particularly in the 2000s, constructed wetlands became touted as a reliable wastewater treatment technology; however, communities in the United States have yet to fully adopt the use of constructed wetlands for wastewater treatment (Vymazal 2011). See *Appendix B* for further information regarding the design of constructed wetlands.

Numerous studies find that constructed wetlands are more cost-efficient than traditional wastewater treatment facilities. Ko et al. (2002) found that "wetlands treat more wastewater per unit of energy and with less financial cost than conventional methods." Lahiri et al. (2013) concluded that a small urban wetland provided ten times more economic benefit than if the land was in commercial use. The cost-effectiveness of constructed wetlands has made them an appealing solution for wastewater treatment in developing countries (Kivaisi 2001). Not only do constructed wetlands tend to be cheaper, but they are also easier to operate and maintain because as functioning ecosystems, wetlands do the treatment automatically with little need for oversight versus a traditional treatment plant where all the pipes, power, computers, etc. have to be monitored (EPA subsurface flow 2002; Watson et al. 1989; Kadlec and Knight 1996; Johnson).

Studies so far have found that constructed wetland systems have been proven to be cost-effective. However, there are major funding barriers that inhibit implementation of green infrastructure, despite increasing awareness of these alternatives at the local, state, and federal levels. At the local level, some municipalities lack the taxing authority to generate revenue to pay for their system (Worstell 2013). Additionally, state and federal-level grants tend to be too limited and competitive a source to support the wide scale deployment of green infrastructure (Clean Water America Alliance 2011). These funding barriers for green infrastructure in general also may apply directly to wastewater systems that are extremely capital intensive, however this possibility has not been explored. Because “small communities simply lack the capacity to pay for capital improvements and costs associated with operation and maintenance of a wastewater system,” it is very important that funding be available for these projects (McCarthy and Gillingham 2008).

The effectiveness of all wastewater treatment options, including constructed wetlands, is limited by the unique characteristics of wastewater inputs they can treat. Wetlands can be a better alternative than mechanical WWTPs in remote locations or small residential areas with limited access to conventional sewer systems and skilled operators, but with access to relatively cheap land (Brix 1994, EPA Manual 2000). Constructed wetlands require more land than mechanical systems to filter a comparable volume (Constructed Wetlands Design Manual, EPA 1999, 12). Although there is not a limit to the amount of waste a wetland can treat, as flow increases, the area of the wetland must also increase. Therefore, constructed wetlands work best for smaller towns with flows of less than $3.8x10^3$ m^3 per day (EPA wetlands subsurface flow 2002). When larger tracts of land are prohibitively expensive to purchase or when existing facilities are unable to build outward, constructed wetlands might not be feasible. In addition, codes or current building sites might not allow for expansion using wetlands. Furthermore, anaerobic conditions make wetlands less effective at removing ammonia as well as some metals, which results in wetlands being ineffective for certain wastewater input. For example, the presence of a slaughterhouse would prohibit the implementation of a constructed wetland system (EPA wetlands subsurface flow 2002).

The feasibility of constructed wetlands can also depend on a given site's suitability, encompassing landscape, climate, and soil type and other logistical details (Clean Water America Alliance 2010, 17; Hammit 2010, 48). Because the success of constructed wetlands depends on the survival of plants that filter the water, conditions that harm this vegetation such as extreme cold or heat can harm this system if not properly maintained (Wildman Interview; Brandt Interview). Hydrological and geological conditions can also affect the feasibility of wetland placement as the effect on the watershed, elevation, flood damage potential, and more have to be considered in siting the system (EPA 2000c).

We have drawn on literature about barriers to green infrastructure, which is heavily focused on logistical, funding, and policy factors, to begin to understand why constructed wetlands might be underutilized. However, since stormwater and wastewater are treated and classified differently by municipalities, the literature on stormwater green infrastructure may not be fully applicable to wastewater green infrastructure. Another limitation of the literature is that most information about constructed wetlands and other wastewater treatment options appear in manuals and other non-academic writings, which often present the problem as just a wastewater treatment option rather than within the broader context of water resource management. Furthermore, although these logistical, funding, and policy barriers are seen as most critical from a management perspective, the literature neglects the impact cultural factors may have on the implementation of green infrastructure projects (Kiker et al. 2005; Lienert et al. 2013). Cultural factors could play an important role in shaping the values and perspectives that might discourage the implementation of constructed wetlands or influence the WWTP decision-making process.

To our knowledge there are no comparative case studies that seek to understand how the decision-making process for small rural towns can lead to either traditional or alternative wastewater treatment systems. Along with understanding the characteristics of constructed wetlands as well as the identified barriers to constructed wetland green infrastructure implementation, it is important to understand the decision-making process that lead up to these systems. The process in which towns make decisions and the specific approaches towns take can affect how these factors play into each town's decision in choosing a WWTP.

Decision-making processes

Environmental decisions are generally fraught with complexities and uncertainty where the goals, constraints, and consequences are not precisely known (Kiker et al. 2005; Bellman and Lofty 1970). Water resource management problems are exemplary of such complex and uncertain situations due to the numerous stakeholders and perspectives involved (Thomas and Bruce 2003; Corderio Netto et al. 1996). The presence of uncertainty poses a major challenge to decision-makers as uncertainty makes it more difficult to weigh trade-offs (McDaniels 1999). When faced with such multi-faceted and complex situations, decision-makers simplify the problem using an intuitive or a heuristic (experienced based) process. However, this simplifying approach can lead to the loss of key pieces of information resulting in the decision-makers simply ignoring factors that they do not know how to address (Kiker et al. 2005).

Involved Stakeholders

Decision-making of all kinds is complicated by the involvement of many stakeholders (Turban 1988). Stakeholders include the actors directly responsible for making the decision (a city council, natural resource manager, etc.), the professional experts who provide technical knowledge, and the general public who are impacted by the decision (Kiker et al. 2005). While this diversity of actors can more accurately represent the real diversity of values, these varied perspectives also make the decision-making process more difficult. Research has summarized four properties of group decision-making problems that make them difficult to address: 1) they are social problems, not mathematical ones, 2) it is difficult to satisfy all constraints and requirements, 3) they are more difficult to model than single problems, 4) there are few methodologies to address the aggregation of stakeholder preferences (Matsatsinis and Samaras 2001). Groups are also liable to become entrenched within individual positions or to prematurely adopt a cohesive perspective that then excludes contrary information. This phenomenon is known as "group think" (McDaniels et al. 1999). While group decision-making is more difficult and prone to homogeneity in the same way as individual decision-making, the inclusion of multiple stakeholders in the process can be vital for reaching a viable and acceptable solution. As reviewed below, the literature notes distinct contributions and difficulties when decision-makers, experts, and the general public are all involved in the decision-making process.

I. Decision-makers

At the local level, municipal governments are the decision-makers ultimately responsible for choosing the wastewater treatment system. In Minnesota, Dillon's Rule distributes police powers, which includes sewage management, to local governments who must then comply with regulations prescribed at the state and federal levels (Minn. Stat. § 412.221, subd. 6). The policies that localities adopt to manage wastewater are varied. Some communities appear to "race to the bottom" of environmental protections, doing the least possible in terms of cost or other resources, while others are more innovative and go beyond state/federal standards (Esty 1996; Monkkonen 1990; Fischel 2001).

In theory, municipalities are citizens' most direct connection to government and provide concrete opportunities for local residents to engage actively in deciding the issues that impact their daily lives (De Tocqueville 1835). In practice, however, citizens are often far less engaged in local policies than in national government; for example, local elections typically garner lower voter turnout rates than occur in national elections (Tajbakhsh 2013). Furthermore, local governments are often more susceptible to being taken over and controlled by a few local elites, a phenomenon known as "elite capture" (Warner and Shortall 2008). These individuals may then advance policies that do not represent the views of the general local population, yet they can control the governing body for decades. Thus, scholars have identified leadership as highly important within local government, where an individual or small cohort of administrators can make policies impacting the infrastructure of the entire community (Olson et al. 2001).

Case studies have found that a catalyzing leader can be a major factor in propelling green infrastructure into the policy sphere and legitimizing its implementation (Young 2011). Additionally, decision-makers must have good knowledge of wastewater systems in order to clearly articulate their preference and a justification for that preference (Kholgi 2001). This type of leadership is especially important considering the risk-averse nature of local governments (Hammitt 2010; Clean Water America Alliance 2011). Local governments are liable for citizen safety, responsible use of tax money, infrastructure system reliability and efficacy, and other responsibilities. Carrying out these responsibilities may lead local government to be reluctant to try new and innovative approaches if the existing systems are functional and fulfill all of these community needs, particularly in times of financial difficulties (Hammitt 2010, 36). While the importance of leadership has been well-documented in case studies of stormwater green infrastructure projects, the importance of a catalyzing leader for wastewater treatment projects is less understood.

Although wastewater treatment is a power delegated to local government, municipalities, especially small communities, lack capacity to coordinate and direct a multi-million dollar WWTP project. The capacity for local governments to successfully enact and implement environmental policies varies considerably and can influence the viability of green infrastructure initiatives (Gargan 1981; Press 1998). Capacity includes not only the financial resources available to a community, but also the human capital, knowledge, and intergroup trust that allows a policy to be successful. In his work on local environmental policy capacity, Press (1998) developed a framework that categorizes local capacity into several factors (see *Table 1*). Leadership, knowledge, and intergovernmental collaboration are particularly relevant capacity indicators impacting the installation of stormwater green infrastructure (Olson et al. 2001). Additionally, the literature on rural development in the United States identifies capacity as a particularly relevant factor for small communities in rural areas where technical and administrative expertise and funding are often inadequate (Brown 1980). While practical manuals mention the limited capacity of a town to make these decisions, the academic literature generally does not explore the importance of decision-maker capacity in wastewater treatment decisions for small rural towns in the United States.

Table 1. Local Capacity Factors and Indicators (Press 1998)

Local Policy Capacity	**Indicators**
Economic and administrative resources	Number of professional staff Per capita income Fundraising potential via state/federal/private donors
Political variables	Formal powers of politicians Ratio of elected/appointed posts Voter turnout
Social capital	Social trust Cooperation and association Non-political group membership Community expectations of collection action
Environmental attitudes and behaviors	Awareness of environmental issues Number of environmental groups

II. Experts

With their formal knowledge and experience with WWTPs, scientists and engineers are indispensable stakeholders from the wastewater decision-making process. This is especially true in countries of the Global North where the wastewater treatment process is dominated by the engineer's perspective (Lienert et al. 2013). In the decision-making literature, scholars note that the primary role of experts is to provide technical details, as requested by the decision-makers, to better inform the process (Kiker et al. 2005). These categories are not mutually exclusive; for example, experts may also take on secondary roles as members of the public or as decision-makers themselves, but their main focus is to respond to the values and criteria expressed by the decision-makers. In regard to urban water resource decision-making, Abrishamchi et al. (2005) note the intersecting relationship between decision-makers and engineers. They find that through an iterative process, decision-makers set policy goals and criteria from which engineers undertake a technical analysis, generating information that further aids the decision-makers. Additionally, scholars within the field of problem solving have noted fundamental differences between the ways novices and experts interpret and respond to problems. Being an expert in one domain does not result in global problem solving expertise. Chi et al. (2014) find that when placed in a problem-solving situation outside their domain of expertise, experts interpret the problem and devise similar strategies to address it as any other novice within that domain. This has important implications to the extent in which engineers' knowledge can translate to different systems and disciplines; but the role of expertise has not been addressed from this lens in the literature.

Within the wastewater decision-making process, state regulatory agencies enforce scientifically-based standards and provide technical advice. These public agencies are charged with preventing pollution throughout the state, yet they operate under tight budgetary constraints. Agencies' limited resources create an institutional tendency towards risk aversion where actors seek to utilize tried-and-true methods that are unlikely to result in costly failures (Rainey 2009; Feeney and DeHart-Davis 2009). Additionally, Bozeman and Kingsley (1998) find that organizations have a more risk averse culture when they have high involvement with elected officials and must navigate more institutional bureaucracy. In the literature on public administration, risk averse public agencies are a well-documented phenomenon; however the point(s) at which risk-averse state agencies intersect with local actors, who may also exhibit risk aversion behaviours, and the impact of this interaction on the decision-making process is not fully understood.

III. General public

The general public has a unique role to play in the decision-making process as they are the stakeholders most directly impacted by the outcomes in the short and long-term. However, the importance of including the public into decision-making processes has been contested within the literature and in practice. While the general public may have the greatest experience to weight value judgments and formulate success criteria, their added voices may increase the difficulty of the process and may even negatively impact the outcome. In a review of the literature, Irvin and Stansburg (2004) identify the disadvantages of citizen participation in governmental decision-making (summarized in *Table 2*). For the sake of time efficiency and cost-savings, they find there is a strong argument for top-down administration for situations when: 1) communities are complacent, 2) governments would reach the same conclusion without public input, and 3) complex technical information is required to make a decision.

Table 2. Disadvantages of Citizen Participation in Government Decision-Making (Irvin and Stansburg 2004)

	Disadvantages to citizen participants	Disadvantages to government
Decision Process	Time consuming (even dull) Pointless if decision is ignored	Time Consuming Costly May backfire, creating more hostility toward government
Outcomes	Worse policy decision if heavily influenced by opposing interest groups	Loss of decision-making control Possibility of bad decision that is politically impossible to ignore Less budget for implementation of actual projects

However, scholars and practitioners have increasingly called for public involvement in environmental decision-making processes. McDaniels et al. (1999) outline three rationales for public involvement: 1) normatively, governments should gain the consent of the people they govern, 2) substantively, scientists and engineers do not hold all relevant wisdom, and 3) instrumentally, it is easier to implement policies when they are backed by broad public support. The extent to which the public is involved in the decision-making process also varies; engagement can range from informing the public about the decision to meaningfully involving them in the process with the goal of making choices that reflect the public's values (McDaniels et al. 1999). Irvin and Stansburg (2004) find that citizen participation in decision-making is advantageous when the decision is at a point of gridlock or is at a "crisis stage" where actions need to be changed. Even when decision-makers seek public involvement, it often remains difficult to engage a representative group of the population in the process. Economic or geographic constraints may inhibit an individual's or group's ability to attend frequent meetings. Additionally, individuals may feel alienated or distrustful of government, especially when government officials do not adequately represent their diverse citizenry (McDaniels et al. 1999; Irvin and Stansburg 2004; Kiker et al. 2005). Thus, Ostrom (1990) finds that collaborative decision-making works best when the group is small and homogenous, and hypothesizes that this will most likely be found in rural communities.

In addition to the aforementioned constraints, the general public may be particularly disinclined from engaging in the wastewater decision-making process due to public conceptions of waste. The profane aspect of waste (and by extension, wastewater) may decrease involvement because sewage is socially unacceptable to discuss, hidden out of sight, out of mind (Durkheim 1912). Reviewing the history of public health in the United States, Armstrong (1993) notes that public health concerns over waste, and sewage in particular, has been a part of social discourse for the vast part of the United States' history. Today, these notions manifest themselves as the scientific disposal of waste, moving sewage from the private, personal sphere into the public realm where it is sterilized and removed into nature (Brix 1994). Throughout the waste disposal process, knowledge of the system is rarely explicitly shared unless an individual is consciously involved (for example as a municipal treatment plant operator); instead, citizens subconsciously know that toilets are connected to sewer pipelines but often have no knowledge of the treatment or disposal process of waste downstream from themselves.

Additionally, the public's aesthetic preferences may serve as barriers to the appreciation and acceptance of constructed wetlands. Particularly for green infrastructure such as rain gardens, a huge barrier is the public perception that natural prairie grasses are ugly and weed-like and that only traditional ornamental plants and lawn are beautiful (Clean Water America Alliance 2010; Hammitt 2010, 42). Wetlands, with a dense distribution of varied species, go against an aesthetic desire for tidy green space and open water, and these perceptions impact our valuation of natural and constructed wetlands (Nassauer 2004). For example, the presence of wetlands in a neighborhood is often seen as undesirable and leads to decreased home values. Yet, wetlands that have open water or a mowed area around their edges, and thus align more closely with our aesthetic preferences, have actually been shown to increase housing values (Nassauer 2004). Because outdoor green infrastructure is more visible to the public eye as compared with gray infrastructure which mostly deals with underground piping and indoor infrastructure, norms of cultural aesthetics may hinder implementation, even if on-paper policies exist to promote green infrastructure. There is a lack of scholarship that has explored how cultural ideas about waste and wetlands intersect with public involvement in wastewater decision-making processes.

Multicriteria Decision-Making

The complex nature of environmental issues and stakeholder values results in a decision-making process that must take into account many factors and interests. Multicriteria decision analysis (MCDA) provides a framework for decision-makers to address these differing value judgments (Kiker et al. 2005). This framework allows criteria to be addressed individually and weighted explicitly in terms of its relevance. This often allows for a quantitative valuation of important criteria identified by stakeholders. There are several approaches for MCDA including multiple attribute decision-making (MADM) and multiple objective decision-making (MODM). Multiple objective decision-making addresses an infinite set of alternatives constrained by specific objectives, whereas multiple attribute decision-making addresses a finite set of alternatives based on their characteristics (Hwang and Lin 1987). This means that MODM methods are helpful for design problems, when stakeholders develop a new solution to their problem based on their objectives rather than the available options. This is contrasted with MADM methods that are most useful for choice problems, where alternatives are known and available, but decision-makers must choose between them (Hwang and Lin 1987). Water resource management system problems, such as wastewater treatment facilities are described in the literature to be MADM problems because they evaluate a discrete number of different systems in order to decide on one that best fits the situation (Kalbar et al. 2012).

Multicriteria decision analysis is especially important in environmental management decisions where uncertainty, as well as factors such as ecological health, energy use, and public health and acceptance are important (Huang et al. 2011). There are various models that decision-makers can use to evaluate their criteria through the multicriteria decision-making process. These methods include Multi-Attribute Utility Theory, ELECTRE (ELimination and Choice Expressing Reality), PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation), AHP (Analytic Hierarchy Process), and TOPSIS (Technique for Order Preference by Similarity); all of these, at the most basic level, serve to quantify the relative importance of criterion to find the most appropriate alternative. Huang et al. (2011) provided a review of these models' uses and trends in environmental decision-making. Literature indicates that these models, while used for general environmental decision-making analyses, are not always implemented in more technically-focused decisions such as wastewater treatment systems (Olson et al. 2001; Kalbar et al. 2012).

Kiker et al. (2005) classifies the application uses from MCDA into five areas: 1) prioritization of site/areas for industrial/military activity, 2) environmental/remedial technology selection, 3) environmental impact assessment, 4) stakeholder involvement, and 5) natural resource planning. Of the three most relevant applications to wastewater treatment, technology selection and natural resource planning applications are more widely used than stakeholder involvement (Kiker et al. 2005). Especially for projects such as wastewater treatment facilities that so directly affect the local decision-makers and other stakeholders it is necessary to include not only technical criteria about system type, but also stakeholder criteria (Kiker et al. 2005; Abrishamchi et al. 2005). Evaluating systems on stakeholder values as well as technical aspects has been cited as especially important for developing countries where local decision-making ownership of the project is critical to economic and political success and autonomy (Murphy et al. 2009; Kalbar et al. 2012). Many examples of MCDA come from environmental decisions that are less specific than wastewater treatment facility choice. The articles that focus on MCDA for wastewater treatment overwhelmingly come from case studies in less developed countries, which, while providing insight, presents a gap in our understanding of how MCDA is utilized by small rural towns in the United States that is the focus of our project's case studies.

Summary

Through this review of the literature, we have noted that current scholarship lacks a comprehensive exploration of the wastewater treatment decision-making process in small rural communities. In these decisions, stakeholders include local decision-makers, state actors, engineers and others with technical skills, as well as the general public. Along with this variety of stakeholders, wastewater treatment also involves many disciplines including natural and physical sciences, and social sciences including politics, economics, and sociology (Kiker et al. 2005). Some technical literature addresses the implementation of green infrastructure; however, the literature does not extend to the process of choosing green infrastructure, and especially choices concerning constructed wetlands. Most recent literature describing wastewater treatment is based in developing countries, thus we are not sure how this applies to the United States (Abrishamchi et al. 2005; Kalbar et al. 2012). Given the lack of literature on decision-making in small, rural governments, exploring this gap is particularly relevant.

III. Methodology

Case Selection

In order to explore how the wastewater decision-making process influences the implementation of constructed wetlands, we have undertaken a comparative case study of two decision-making processes that resulted in different wastewater treatment systems. We chose cases that were small communities in Minnesota with municipally-owned wastewater treatment plants (WWTPs). As demonstrated in the scholarly literature, constructed wetlands are often more spatially viable in rural areas and are thus adopted more frequently by small communities rather than large urban centers. Although constructed wetlands have been successfully implemented in privately owned housing developments, given that 75% of wastewater treatment plants in the United States are publicly owned we identified two municipally-owned cases to serve as more generalizable instances for the application of constructed wetlands (EPA 2013a). Furthermore, we considered when the wastewater treatment system in each community was implemented, identifying systems that had been installed in recent years so that we could speak directly with individuals involved in the implementation process and to ensure that actors were basing their decisions on similar knowledge pools.

For our study, we will utilize a controlled comparison of two communities: one that adopted constructed wetlands (Prinsburg) and one that chose a more traditional pond treatment option (Pennock). Our cases are most-similar; both are located within Kandiyohi County in central Minnesota (Figure 1), have populations in which greater than 90% of citizens identify as white, and had similar median household incomes, $42,273 (Pennock) and $38,125 (Prinsburg) around the time period of WWTP implementation (U.S. Census Bureau 2000). As small communities with populations of 508 citizens and 497 citizens in Pennock and Prinsburg respectively, both cases have wastewater flows that could be treated by constructed wetland systems. Additionally, we conducted a GIS analysis of both treatment sites and found similar hydrological and spatial characteristics in both locations (*Appendix C*). Finally, as part of the EPA's effort to establish wastewater treatment systems in rural areas where no previous treatment existed, Prinsburg and Pennock have both adopted new treatment systems recently: Prinsburg in 2006, Pennock in 2000. For both cases, our primary focus of analysis was the recent decision-making process that resulted in each WWTP.

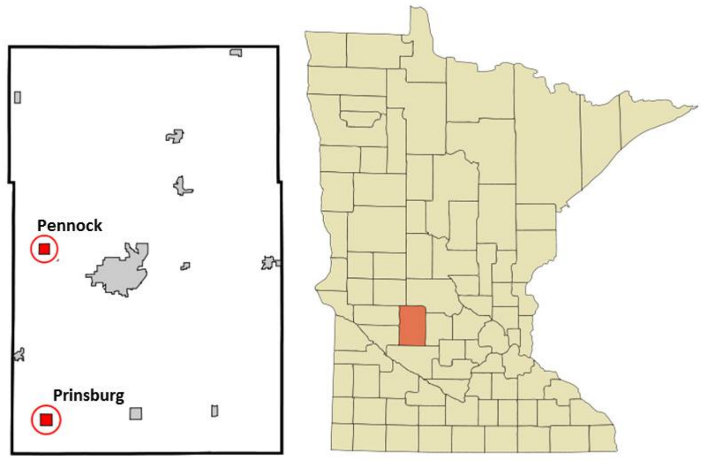

Figure 1. Map of Pennock and Prinsburg

Research Structure

Based on George and Bennett's (2005) work on case study research design, we utilized a structured, focused comparison methodology to trace the process by which small, Minnesotan communities decide upon and implement a WWTP. Analyzing this decision-making process will allow us to focus in on the specific stakeholders and points of interaction that impact the implementation of constructed wetlands for wastewater treatment. The literature on green infrastructure has identified many economic, political, and spatial barriers to its implementation for stormwater management. We will use these identified barriers to guide our research in identifying the decision-making criteria valued for WWTP implementation. The results of our study may lend insight into how other small municipalities located in Minnesota decide on a WWTP and how this process facilitates or discourages the use of constructed wetlands for wastewater treatment. Our case study methodology was guided by the following questions:

1. Who were the main actors in the decision-making process? What were the backgrounds and goals of these actors?
2. What wastewater treatment systems were proposed? What knowledge (internal and external) informed this process? Was some information valued more highly than others?
3. What local, state, and federal wastewater treatment and land-use policies governed the wastewater treatment selection process?
4. What local, state, and federal funding mechanisms enabled or constrained proposed wastewater treatment options?
5. Do the main actors have past experience with green infrastructure? How were discussions about green infrastructure incorporated into the process?
6. Where is the wastewater treatment facility located within local land and water systems? Why was that location chosen?
7. How were the citizens of the municipality incorporated into this process? How was educational outreach about sewage and the various treatment options utilized?

8. How do cultural perceptions of wetlands and waste manifest in community awareness and engagement with the wastewater treatment systems?

Archival Analysis

For both cases, city council meeting minutes, community and regional papers, and MPCA documents were searched for references to the treatment plant siting beginning with the MPCA citation and ending two to three years after the system had been installed. These documents allowed us to identify the main local actors in the decision-making process and the regulatory agencies involved, as well as to gain a better understanding of the social/geographical/political action arena. This information was then used to establish a preliminary timeline of events for each WWTP.

Interview Protocol

Semi-structured interviews were conducted with the actors identified during archival analysis, as well as through a snowball sampling method. These individuals included town wastewater treatment plant operators, mayors, members of city council during the system implementation, wastewater engineers, and MPCA staff, among others. The primary focus of each interview was to trace the process of implementing that community's WWTP from the project's inception until several years after completion. Through these interviews, we aimed to learn the backgrounds of the main actors involved and their past exposure to green infrastructure. Additionally, we sought to understand what other wastewater treatment options were considered in each case and why the actors decided to choose the system that they did. Throughout, we strove to illuminate the public's interaction and involvement in the process to understand how public acceptance of the WWTP projects may have influenced the decision-making process.

Although the interview content varied depending on whom we were speaking with, each interview included a review of that community's timeline and specific questions about that individual's role in the process (see *Appendix D* for interview protocol). Interviews with community members were conducted in person, recorded, and transcribed for later analysis. Interviews with external agencies (MPCA, Rural Development, and Rural Water Association) and engineering firms (Bolton and Menk and North American Wetland Engineering) were conducted over the phone.

Additionally, we visited both treatment facilities and were given a tour of Prinsburg's constructed wetland system by the city's wastewater operator. For both systems, maps and WWTP blueprints were utilized by city operators to explain how each system functioned.

GIS Analysis

We conducted a basic GIS analysis to check for possible geographic and spatial differences between the two towns that may have influenced the suitability of constructed wetlands in the towns. We used National Land Cover Data 2006 and the National Hydrography Dataset to check for geologic, climatic, hydrologic, and land use characteristics (see *Appendix C* for more details).

IV. Results

Utilizing interviews, archival sources, and geospatial analysis, we conducted a most-similar case-study of the wastewater decision-making processes in two small, rural Minnesotan towns. In Minnesota, the process to implement a new wastewater treatment plant is typically initiated by an MPCA citation. As two of the largest noncompliant small communities, Pennock and Prinsburg received citations from MPCA in the mid-1990s, at the beginning of MPCA's focus on small communities. We find that the decision-making process is composed of six main stages: internal organization of the town, choosing an engineering firm, determining an appropriate system, acquiring funding, implementing the system, and operating and maintaining the system. We have also identified three main factors that decision-makers considered when deciding between WWTPs: cost, odor, and aesthetics. Finally, we explore the characteristics of decision-makers, the general public, and outside actors (scientists, funding agencies, and engineers) and their roles within the wastewater decision-making process. Beginning with Pennock as the typical decision-making case, the wastewater decision-making processes for both of our cases are traced below.

Pennock

Introduction

Pennock is a small town with no major industry, with 57% of citizens commuting out of town to work, mostly to nearby Willmar a town of about 20,000 people (U.S. Census Bureau 2010). As you drive past, parallel to the railroad tracks, you notice a convenience store and gas station, The Pit Stop, where a few groceries, hot food, snacks, and "Pit Stop" mugs are sold. A right turn into town brings you past a long rectangular park with a gazebo, and to main street where the Post Office, a bank, and City Hall are located. The houses on the surrounding streets appear well used, but not untidy. With 508 people and seven parks, everyone has space to play. The town is run by Mayor Kevin Crowley; he works as the Vice-President of Heritage Bank in town, has been mayor for 15 years, and a member of Pennock's six member city council for about 15 years before that. The timeline of events leading to Pennock's wastewater treatment system is summarized in *Appendix E*.

Internal Organization

Pennock's previous wastewater management system was comprised of individual septic tanks that were released into the county ditch system. Before MPCA issued a formal citation, the agency was in communication with the city, and it was common knowledge that Pennock's system would have to change. Although their first correspondence began in 1991, MPCA did not issue a formal citation of noncompliance until 1994. Around 1997, the city sought to develop additional housing lots in town, but was denied funding by the Rural Finance Authority due to their noncompliant sewage system. This prompted the city to seriously pursue new wastewater treatment options, and in 1998, Mayor Crowley began to engage with the decision-making process.

Engineering Options

After the MPCA notice of violation, several engineering firms contacted the Pennock City Council about designing their sewer system. Three engineering firms submitted Wastewater Feasibility Studies to the City. The City Council formed a wastewater committee, which consisted of then-Council Member Crowley, the Clerk at the time, and the former mayor Joe Hamstad. Councilmember Crowley took the lead on the project and was in touch with the City of Willmar's engineer to discuss the option of combining Pennock's sewer collection with Willmar's facility. Bolton and Menk were chosen as the most appropriate engineering firm after their presentation. The main factors in this decision were cost and Bolton and Menk's willingness to take charge of the project. Because Pennock did not have a full-time city employee, it was important to the council members that the engineering firm be available and close by to work on any problems that came up. In general, the firms that bid for the job suggested pond systems with similar prices, so the determining factors in deciding the engineering firm were Bolton and Menk's customer service and the nearby location of their office (only 15 minutes away in Willmar).

System Decision

Bolton and Menk made three system recommendations to the Council: 1) Connect with Willmar's mechanical wastewater facility, 2) a stabilization pond system, or 3) an aeration pond system. The City Council was interested in the stabilization pond system because it requires little maintenance and is generally not very odorous. This system was also most cost effective (Crowley Interview). After the decision had been made, just before construction, Rural Development impeded the process by asking that Pennock look further into connecting with the City of Willmar. According to the mayor, this was a waste of time, because it halted the process and ended up not even being feasible. When Bolton and Menk looked into this plan, they found that Willmar's system was already over capacity. After this hurdle the Council decided to go ahead with the stabilization pond system. They bought land just outside of town from a farmer. Through negotiations, they eventually purchased this land at a price higher than that of average farmland, but less expensive than commercial land. This land not only sites the WWTP, but also a brush burning site for the city.

Funding

Mayor Crowley was instrumental in acquiring funding for this project. Crowley was in contact with Senator Dean Johnson who encouraged him to present at the State Capitol to seek funding for their project. In 1997, Pennock was granted a combination grant of deed money from USDA's Rural Development. Receiving a combination grant of $2 million for a $3 million project was virtually unheard of, but Pennock was able to receive these funds through the work of Crowley and interested legislators, as part of the statewide goal to clean up waterways. This funding was necessary because it decreased the costs incurred on the citizens of Pennock who make up the difference with monthly fees. The sewer bill was added onto the water bill, which was about $15 per month before the system was in place. The sewage bill of about $30 increased the residents' water bill to $45 per month (Pennock Minutes Sept. 23, 1999).

Implementation

Once the plan to build stabilization ponds was decided, Pennock held public meetings to inform citizens of the facility. These hearings were well attended, usually with about 20 people. The council was pleased with the turnout and general approval of the system (Pennock Minutes March 30, 1999). These meetings mostly focused on the cost that would be fronted to citizens of Pennock, but concerns also included questions about how the construction process would affect individual yards as the system was connected to the septic tanks. The town did not have much say in the placement of the facility; the specific site was chosen because of its proximity to the drainage tiles where the effluent would flow. However, there was not much contestation about the placement, especially because the Council had chosen a spot downwind of the town, which addressed the concern with odor. The biggest issue with construction was the fact that roads were torn up for the entire winter, but Pennock hired the construction company responsible for building the ponds to do the street upkeep, which worked well.

Maintenance

Pennock's stabilization pond system requires a Class D operator's license. Instead of paying to certify a city employee, the City hired Woody Nelson, wastewater operator in the neighboring city of Kerkoven, to oversee the system part-time. As the ponds do not require much day-to-day management, Nelson checks on the pond system twice a month and discharges the effluent from May to July and again between September and November (Nelson Interview). Day-to-day oversight is done by Terry Thole, a paid city staff member and city council member. Thole's role involves checking the automatic system monitor and being aware of changes or problems with the system (Nelson Interview). If there is a problem, Nelson comes into town at the cost of $20 each trip, according to the city clerk's records. Nelson is paid $100 per month as the consultant (Johnson Interview). The ponds serve as frequent habitat for geese and ducks because of the open water and food from surrounding corn fields. However, this can become a problem when the number of waterfowl increase the amount of fecal matter in the system above the standard for discharge (Nelson Interview). The ponds have worked well for the town, despite grease build up in the lift station. The smell is basically non-existent most of the year, except during the spring when the winter ice turns over as the system turns from anaerobic back to aerobic.

Prinsburg

Introduction

Prinsburg is a small town of 497 residents in Kandiyohi County, MN. Prinsburg is highly demographically homogeneous (97.6% white) and has a strong Dutch tradition, with town residents often referring to their Dutch ancestry. This town has a strong local government consisting of an elected mayor and city council. Harvey van Eps, the current mayor and general manager of the town's agricultural co-op, has been the mayor for the past two decades. The townspeople pride themselves on the cleanliness and well-maintained state of their city. Driving through town, the tidiness and well-put together aesthetics of the town are apparent – the houses look to be well-maintained and even the city office building looks relatively new, clean, and polished. Prinsburg is not an industrial town, but is home to several businesses including an agricultural cooperative, field tile manufacturer, construction company, bank, small cafe, and a private Christian school that draws students from the area. The timeline of events leading to Prinsburg's wastewater treatment system is summarized in *Appendix F*.

Internal Organization

Originally, Prinsburg did not have a centralized wastewater collection system; instead, individual lots had septic tanks connected to drainage tiles which discharged directly into Chetumba Creek. In 1995, Prinsburg received its first notice of wastewater violation from MPCA. Upon receiving this notice, the Prinsburg City Council met with representatives from MPCA, Minnesota Rural Water Association, and Midwest Assistance Program to discuss how to proceed (Prinsburg Meeting Minutes June 13, 1995). Following their advice, Mayor van Eps then hand-picked a wastewater committee comprised of community members with expertise in various aspects of the process such as construction, water and soils, and finance (Van Eps Interview). Assured by their city attorney that they would not be pressured by MPCA as long as they continued to make progress towards compliance, the city took their time weighing the different wastewater treatment options.

Engineering Options

Once on the MPCA list of noncompliant towns, Prinsburg was contacted by several engineering firms. Even though Prinsburg did not want to implement a traditional pond system because of the smell, they were not presented with other options by any of the engineering firms that originally contacted them. By 1998, Prinsburg, seeing no other option, almost contracted with Bolton and Menk, a major engineering firm in the region, to implement a traditional pond system (Prinsburg Meeting Minutes April 21, 1998). It was then that another engineering firm, North American Wetlands Engineering (NAWE) contacted Prinsburg. Seeing that NAWE offered alternative, non-traditional systems, and after touring some of their constructed wetland systems, Prinsburg hired NAWE.

System Decision

After conducting feasibility studies, NAWE presented Prinsburg with multiple options including a stabilization pond, mechanical treatment plant, and a subsurface constructed wetland system (Brandt Interview; Van Eps Interview; Wastewater Meeting Minutes June 10, 2003). Prinsburg's main concerns in selecting their treatment system were cost, odor, site location, maintenance, and aesthetics. In order to avoid the costs incurred by purchasing land, the City of Prinsburg wanted to install their WWTP on the 33 acres of land right next to the town. NAWE's constructed wetlands were a viable option for the site, but the proposed stabilization ponds would not have been suitable within that acreage. This land availability helped to make constructed wetlands comparably priced to a more traditional pond system. Additionally, the lack of odor associated with subsurface constructed wetlands was appealing to wastewater committee members.

The wastewater committee members were also strongly convinced of the constructed wetland system's viability through their personal observations of existing NAWE wetland systems. While touring installed NAWE subsurface wetlands, committee members noted that many of the constructed wetland systems were used in upscale housing developments and concluded that if wealthy residents liked the system, then it must be functioning well (Van Der Pol Interview; Van Eps Interview). Randy Van Der Pol expressed, "we figured if these people with half million dollar houses were happy with [the constructed wetland], then it must be working out pretty well for them because these people would not sit still if the system was causing odor problems in their nice neighborhood" (Van Der Pol Interview). Furthermore, the mayor and members of the wastewater committee were pleased about the system's aesthetics in that constructed wetlands were not an eyesore and blended in well with the surrounding landscape. In 1999, the city council finally decided to implement a subsurface constructed wetland system. However, it would not be until 2005 that the plans would be finalized and construction commenced.

Funding

NAWE played an active role in helping Prinsburg secure funding. Engineering firms are aware of the various funding sources and so NAWE was able to direct Prinsburg to them. The process to receive funding had many steps and required expertise, so Prinsburg hired Robert Williamson to aid with the grant and loan applications (WPF Service Contract 2002). A major prerequisite to receiving funding from USDA Rural Development was performing a city survey to assess how much Prinsburg is capable of paying~~.~~ The survey analysis ultimately led to a $47.65/month sewer fee for households. The exact comprehensive cost of the entire project is difficult to pinpoint but is estimated to be no more than $2.5 million (Van Eps Interview; Slagter Interview; see pg 29 for more information).

Implementation
After the approval of the constructed wetland system by the city council, public hearings were held to address concerns about funding and inconveniences from construction. Compared to other town meetings, these hearings were well-attended, with estimates of 20-50 people at the meetings. The final meeting in September 2005 about the final costs to the residents was attended by 117 members of the community (Homeowner Meeting Agenda May 11, 2005). The public expressed a variety of concerns including worries about financial burden, how construction would affect their land, the odor, and the longevity of the system. Compared to before when there was no wastewater fee, a monthly $47.65 fee caused some concern and well as other individual financial burdens such as hooking up homes to the system which could cost hundreds of dollars (Prinsburg flyer Sept 5, 2005). However, no major concerns were expressed regarding the functionality of the system -- some citizens were curious about constructed wetlands, but when explained, there were no objections to implementing a non-traditional wastewater treatment plant.

Implementation and construction of the constructed wetland was done by Dunnick Bros. and Kober Excavating. While Dunnick Bros. had a construction supervisor overseeing the project, Prinsburg hired on a member of the wastewater committee (the president of a construction company) to serve as an additional supervisor (Van Eps Interview; Prinsburg Meeting Minutes). By atypically hiring their own construction supervisor, Prinsburg demonstrated a more vested interest in ensuring the proper construction of their system. The construction process was also chronicled in the local newspaper, *The Raymond-Prinsburg News,* so the public could easily keep updated about the progress. The construction process lasted three years and included connecting each house to the new sewage line, in addition to building the constructed wetland system. There were some delays in construction but overall, the construction occurred as planned with no major issues. By 2006, half of the city was hooked-up to the plant and by 2007, the system was fully completed and running.

Maintenance
Prinsburg's constructed wetland system requires a Class C operator's license; however, because constructed wetlands were an unconventional system, few wastewater operators had the expertise to properly maintain constructed wetlands. To deal with this problem, NAWE had a partnership with EcoCheck, a company that provides constructed wetland management services, to better ensure that the constructed wetland systems it installed would be properly maintained. Prinsburg had considered hiring a new staff person to operate the system but found that it was more cost-efficient to avoid purchasing a Class C license and easier to contract with EcoCheck. The initial annual contract with EcoCheck in 2005 was $25,869/year (Prinsburg Meeting Minutes Sept. 5, 2005). EcoCheck continues to maintain the Prinsburg system and the cost is around $2,500/month according to the Clerk's records. However, Nolan Slagter, the city's maintenance

employee, also monitors the system daily. Since its completion in 2007, the wetland system has been running smoothly (Slagter Interview). Deer, pheasants, fox, song birds, and muskrats frequent the site, and Slagter must ensure that muskrats do not start burrowing into the wetlands. Additionally, in 2008, the agricultural co-op in Prinsburg began reusing the system effluent for fertilizer application instead of drawing upon their groundwater resources (Prinsburg Minutes 2008).

Decision-making Criteria

There were three main factors considered in both towns by the decision-makers to decide upon the final WWTP: cost, odor, and aesthetics. These three factors were weighed the most heavily in the towns' searches for an appropriate WWTP and became the top three criteria decided upon and communicated to the engineers. In both Pennock and Prinsburg, the local leaders and the main engineers cited the cost of the WWTP as the most important criteria (DeWolf Interview; Crowley Interview; Brandt Interview; Slagter Interview). The leaders of the towns were very concerned about cost-effectiveness because as small rural towns because they did not have the necessary finances to build and operate a WWTP. WWTPs cost millions of dollars and a portion of the costs would be borne by the town's residents through higher sewer and water fees; thus affordability was key. The cost-effectiveness of a system was dependent on factors such as financing options, operation and maintenance costs, land availability, land type, and system longevity (*Table 3*).

Table 3. List of factors that affect cost

Factors	Detail
Financing option	Interest rate, grace period, loan period, loan/grant ratio, etc.
Operation and maintenance costs (O&M)	Monthly cost of operation and maintenance including data collection, effluent discharge, monitoring, etc.
Land availability	Cost to purchase land, land owned by the city, use of land in relation to it's highest and best use
Land type	Soil composition- heavy clay, karst features, etc.
System longevity	Longer system longevity makes more expensive systems cost-efficient

Ease of operation and maintenance was a critical component of cost (Crowley Interview). Pennock had limited resources so it was important to the city that they build a facility that would not require hiring a full-time operator. This consideration influenced their engineering firm choice; they wanted to hire a local firm so that the firm could be in charge of monitoring the progress of the project. Land availability and access were also an important component of the overall project cost. Pennock did not already own land, which added the cost of purchasing land to the project. Because of the placement of drainage tiles in which the effluent drained, it made the most sense for the City to purchase land to the east of town. Soil type can also factor into costs because some soil types, like clay, are more conducive to WWTPs and can thus minimize costs. Pennock had heavy clay soil, so the stabilization pond did not need a synthetic liner, decreasing construction costs.

In Prinsburg, the overall cost of the system was also cited as an important factor, though it was not as emphasized by the decision-makers as it was in Pennock (Van Eps Interview; Slagter Interview; Van Der Pol Interview). For Prinsburg, land availability played a very large role in deciding an affordable system. Prinsburg already owned 33 acres of land adjacent to town that was suitable for a constructed wetland (Slagter Interview; Brandt Interview; Prinsburg Meeting Minutes). Land acquisition is an expensive, arduous process and since the city already owned land, it was a major cost and time saving factor. An important point to note is that the type of system suited to this parcel of land was limited. A constructed wetland could be implemented there but a stabilization pond would not have worked because the pond system needs to be further away from the town (Wilman Interview; Van Eps Interview).

Even though costs were a major concern, Prinsburg took a less common route by choosing the constructed wetland system even though it was not the most long-term cost-efficient option. The upfront capital and construction costs of a stabilization pond and a constructed wetland system were similar, but the operation and maintenance costs for constructed wetlands are significantly higher. In Pennock, monthly maintenance costs of the pond system estimated to not exceed $500 in an average month, which cover the wages of the city maintenance employee and the wastewater operator hired part-time to check the pond once a month (Johnson Interview). In contrast, Prinsburg contracts the operation out to a third party, EcoCheck, who comes twice a month to check the system. The monthly fee to EcoCheck is approximately $2,500 and another $2,500 is paid to Nolan Slagter, the city maintenance employee who oversees the constructed wetland on a daily basis (Prinsbrug Meeting Minutes; VanDyken Interview). It is important to note that the difference in operation and maintenance costs could be due to the different class categorizations of the two systems. A stabilization pond necessitates a Class D license while a subsurface constructed wetland requires a Class C license, which has more rigorous requirements than a Class D license. A Class C license requires a bachelor's degree and three years of previous experience as a licensed wastewater operator, whereas a Class D license only requires a high-school diploma and one year of previous experience. This requirement for a more qualified and experienced wastewater operator for Class C facilities may make all Class C facilities more expensive to operate (MPCA 2009). Despite the greater operation and maintenance costs, Prinsburg decision-makers made this conscious decision to implement the constructed wetland system (Van Eps Interview).

In addition to cost considerations, both towns also had odor and aesthetic concerns regarding their WWTP options, but to varying degrees. Pennock weighed aesthetics lightly and their concerns did not strongly impact their decision-making beyond cursory consideration. In Pennock, system odor was a concern and thus they requested to their engineers that the WWTP be located downwind to avoid odors. Although the pond was sited downwind of town, it was located only 750 meters away, implying that odor was not a significant concern (GIS Analysis). Aside from this request, there were no other factors that they acted upon (DeWolf Interview). The close proximity to town and the lack of objections to the location in the city council minutes suggests that the aesthetics of the pond were also not too great of a concern. Later, efforts were taken to plant trees by the pond to make it look nicer. This was a retroactive action taken when DNR funds became available to cover these costs (Pennock Meeting Minutes, Feb. 6, 2002).

Prinsburg on the other hand, had strong odor and aesthetic concerns that weighed heavily in their decisions. The mayor and other wastewater committee members had experienced the smell of neighboring pond systems and were aware of a particularly negative WWTP odor in Willmar (Van Eps Interview; Van Der Pol Interview; Slagter Interview). Prinsburg wanted to avoid this situation if possible and was strongly driven by this concern to look for alternatives. After visiting some constructed wetland sites and seeing that the constructed wetlands emitted very little odor, the wastewater committee was determined to implement this system (Prinsburg Meeting Minutes Sept. 8, 1998; Interviews).

Furthermore, the wastewater committee members were particularly impressed with the aesthetics and accessibility of a constructed wetland system. They liked that the wetland was more aesthetically pleasing since it blended in better with the landscape. The region is originally a wetland-filled region and so the residents were very much used to seeing wetlands and cattails (Van Eps Interview; Slagter Interview). At one site visit, the committee members also saw a wedding take place right next to the constructed wetland and were extremely impressed at the system's accessibility. Prinsburg's constructed wetland is currently right next to a nature trail and also located next to a new housing development. These developments show that the townspeople are very confident in the performance of the wetland and demonstrates their acceptance of the system. By implementing constructed wetlands, Prinsburg was able to benefit from the unique characteristics of the system, mainly their pleasing aesthetics and odorlessness.

Characteristics of decision-makers

In the wastewater decision-making process in both Pennock and Prinsburg, the decision-makers consisted of city councilmembers and a wastewater committee, led by a strong mayor. Both Pennock and Prinsburg have dynamic mayors who have held this role for over fifteen years, are well-respected, and hold management-level jobs. Mayor Kevin Crowley of Pennock takes responsibility for imagining and following through with various major projects in town including establishing a gas station/convenience store and expanding the number of housing lots (Crowley Interview). Similarly, in the case of the wastewater citation, Crowley headed the project, starting as a council member and continuing when he was elected mayor in 1999. Pennock established a sewer committee to work on the project, but this committee consisted only of Crowley, the clerk, and the previous mayor.

Harvey Van Eps, mayor of Prinsburg, is the general manager of a local agricultural co-op based in Prinsburg, with sites in two other towns. Similar to Mayor Crowley, Mayor Van Eps has a very long history of involvement in local government. Before becoming mayor over twenty years ago, he was also a part of the City Council (Van Eps Interview). As a respected figure in town, Harvey was able to approach the problem in the manner he desired with little resistance and enthusiastic response. Upon MPCA notification, Van Eps decided to take a comprehensive approach. He single-handedly created a wastewater committee with hand-picked members from the community. The creation of such a steering committee was very important in Prinsburg's success at implementing a constructed wetland, because these citizens were able to devote time and knowledge to the decision. Under Van Eps's direction, the wastewater committee became an extremely involved group that took charge of the project, spending many hours researching options and communicating with enforcement staff and engineers, and ultimately recommended NAWE's subsurface constructed wetland system to the city council.

Atypically, the decision-makers in Prinsburg also possessed general knowledgeable about wastewater treatment alternatives: a key factor for their persistent search for a suitable WWTP. Unless they work in the construction or wastewater treatment industry, most citizens have very little knowledge of wastewater treatment, particularly less common alternative systems. However, Mayor Van Eps, though his knowledge was anecdotal, knew that such alternatives most likely existed. Van Eps had been told by the former mayor, who was also the president of a construction company, of wastewater treatment systems in Canada that used cattails and native plants and had expressed that he saw potential in them as future wastewater treatment options (Van Eps Interview). Although Mayor Van Eps and the wastewater committee may not have known specifically about these constructed wetland systems, their general knowledge about a possible alternative provided strong motivation to keep looking rather than settling for a status quo with which they were not satisfied.

Additionally, utilizing the policy capacity framework developed by Press (1998), we note that both Pennock and Prinsburg lacked the capacity to implement a wastewater treatment system without assistance from external actors. With only one full-time staff member and a small, mostly residential tax base, both Pennock and Prinsburg have limited administrative and economic resources to devote to the project. Decision-makers also lacked awareness about the pollution concerns created by wastewater treatment systems, therefore MPCA intervention was necessary to initiate the process. However, both communities are characterized by a high degree of social capital; several extended families (i.e. Sportels, Slagters, etc.) are based in each town and many residents have lived in the community their whole lives. Decision-makers in both towns are able to draw upon an extended network of relations.

Characteristics of general public

In both cases, the role of the general public was limited in the wastewater decision-making process. Decision-makers engaged the public by informing them about the decision-making process- what options were being discussed, how much their sewer bills would increase, how private property would be impacted during construction, etc. These public hearings were held intermittently throughout the process with the intention of explaining what was going on, not asking for input. However, in Prinsburg, the community was more engaged in the decision-making process than in Pennock. Each of Prinsburg's public meetings was attended by approximately forty people, while Pennock's were less well attended with around ten to twenty people in attendance (Meeting Minutes; Slaghter Interview; Van Der Pol Interview; Van Eps Interview). Additionally, Prinsburg's decision-makers held more public meetings focused specifically on the choice of treatment systems than were organized in Pennock.

The ability for the two towns to mobilize and engage in the decision-making process may also have been impacted by differing levels of homogeneity and skills within the general public. Although both Pennock and Prinsburg have near identical population size and racial demographics according to the U.S. Census Bureau, Prinsburg is slightly more homogeneous than Pennock. There is a very strong Dutch sensibility in Prinsburg that the residents seem to hold onto and seem proud of. One interviewee noted, "we've got a town of fussy Dutchmen that keep everything pretty nice", and in almost every interview, both Prinsburg residents and external actors referred to the town's Dutch ancestry. There was no such sentiment of town cohesion that was mentioned by any of the Pennock-related interviewees. In fact, in an interview with the facility operator, he mentioned "the Hispanics" in a way that seemed otherizing (Nelson Interview). The strong Dutch sentiment in Prinsburg could make the town feel more united and close-knit.

Drawing on the workforce of the local agricultural co-op and construction company, Prinsburg has more residents with professional skills they can draw upon during the decision-making process. This sort of community composition probably made it more feasible for a Prinsburg to establish a wastewater committee with such qualified individuals that could dedicate time outside of their full-time jobs to the project. That the individuals picked for the wastewater committee all readily agreed to participate also could point back to the strong sense of community within Prinsburg and willingness to participate in the process. In Pennock, little effort was made to include citizens who were not on the city council. This could signify a lack of interest and engagement from residents, or that the council perceived there were no citizens who could provide qualified knowledge about implementing these types of systems.

Characteristics of external actors

While towns are the ultimate decision-makers in the wastewater treatment decision-making process, their interaction with outside actors is very important. These scientists and engineers comprise regulatory agencies and engineering firms, and are involved in most steps of the process to some extent. Through interviews with these actors we were able to better understand the role they played in the wastewater treatment decision process. The following sections describe the characteristics of these outside actors first focusing on regulatory agencies and then moving to engineering firms.

Regulatory Agencies

Minnesota Pollution Control Agency (MPCA), the state enforcement agency which has legal authority to issue citations and levy fines and other legal repercussions if towns are in violation of its standards is an important actor throughout the process. MPCA catalyzes the process by initiating and responding to total maximum daily load (TMDL) studies, and also approves the WWTPs chosen by the towns. Upon issuing the citation of non-compliance, MPCA communicated directly with city leaders about the next steps they needed to take and provided education about the health and environmental impacts of releasing untreated sewage into the county ditch system. The agency was then in communication with engineering firms and city administrators about the ongoing status of the project. In Pennock, George Eilertson (from the Minnesota Association of Counties) "told the City that if they dragged their feet and did nothing they would come in and take action. MPCA also told the City that if they would move ahead, they would work with them" (Pennock City Council Minutes, June 1997). It was clearly articulated to both communities that they were not being rushed into compliance; as long as the community was moving forward with the decision-making process, they would be given as much time as needed to come to the appropriate decision for their community. Although the MPCA is lenient about the length of the decision-making process, there comes a point where towns must start taking action to prove they are serious about decreasing pollution. In Prinsburg, they spent several years exploring their options and the MPCA ended up putting significant pressure on them to get the system done, threatening the city with a fine of $100/day (Prinsburg Meeting Minutes, March 13, 2003).

Although MPCA was not actively involved in the towns on a daily basis, it was still a major actor through its authority on a statewide level. Such organizations particularly play a bigger role in the beginning of the process soon after towns have received notices of violations. In Pennock, MPCA raised no concerns regarding the suitability of their proposed stabilization pond system. As several actors noted, stabilization ponds are "rubber-stamp" projects in southwestern Minnesota. However, MPCA was more involved in the decision-making process in Prinsburg. Because constructed wetlands are less common, MPCA required a more thorough review of the constructed wetland system before approval. NAWE had to submit more documentation to assure MPCA of the design's integrity and ability to comply with MPCA standards. This process took several months longer than that for a tried and true system like a stabilization pond (Brandt Interview; Van Eps Interview).

Public agencies that permit facilities and assist communities with the decision-making process to create these facilities may further constrain the options available to local government. Although, MPCA does recommend specific WWTP systems to municipalities, its established practice of quickly approving certain systems and its familiarity of these more common systems can limit the choices towns can making certain systems easier to implement; and for small communities with limited capacity whose highest priority is to be compliant with the law, the higher transaction costs of implementing a less conventional system can be a barrier. Overall, MPCA's mission as a regulatory agency makes them risk averse and more reluctant to adopt new technologies when the current ones are working well because they do not want to face possible further issues of non-compliance. If there is a tried and true system that has proven to consistently work, it is hard to put energy into new innovative alternatives (Panebianco and Pahl-Wostl 2006; Rogers 2003).

Non-governmental Organizations

In addition to regulatory agencies and private firms, there are non-profit organizations that try to help rural communities address their capacity gap. Non-profits such as Minnesota Rural Water Association provide technical expertise to small towns and also influence the decision-making process by providing recommendations and advice. In Prinsburg, the nongovernmental organizations Minnesota Rural Water Association and Midwest Assistance Program provided preliminary guidance on how to hire an engineering firm, what WWTP options are available to small communities, and questions to ask throughout the process. The Minnesota Rural Water Association representative informed the Prinsburg city council of expected engineering and consulting costs, various treatment systems like stabilization ponds, aeration ponds, and lagoons, and general cost estimates of a pond system ($1.5 to 2 million).The Midwest Assistance Program representative recommended that Prinsburg establish a wastewater committee comprised of one to two council members, one to two members of the public, and an appointed clerk that would meet monthly to investigate the issue and make recommendations (Prinsburg Meeting Minutes, June 13, 1995). These organizations aim to provide support and services for small towns that do not have vast resources.

Funding

Financing organizations, namely USDA Rural Development and Rural Finance, played a crucial role in building the financial capacity of both communities. These external actors not only provided loan and grant opportunities at rates below the market, but also assisted communities with the process of acquiring this capital. The amount of financial assistance given by these agencies is determined by the median household income of individuals utilizing the system. State financing of WWTPs is vital to their implementation because cities, especially small communities without an industry to help distribute the burden of cost, lack the tax base needed to finance a multi-million dollar project, in addition to the other services they provide.

Rural Development has its set of federal regulations to follow concerning loans and grants for wastewater treatment. Eligibility for these loans and grants (outlined in 7 CFR 1780) is highly dependent on the need priority and financial needs of the communities. Rural Development has determined that 1.7% of a household's income should be spent on sewer services; the agency then works backwards from this figure to determine how much the community can afford in loans. At the time of decision-making, both Pennock and Prinsburg were high funding priorities and also demonstrated financial need, as their household incomes at the time were below the state median household income at $42,273 and $38,125, respectively (U.S. Census Bureau 2000). Both Pennock and Prinsburg received loan funding from Rural Development. These loans have a standard 40 year payback (Friesen Interview; 7 CFR 1780). In addition to the Rural Development financing, Prinsburg received a grant from the Minnesota Department of Employment and Economic Development because it was categorized by MPCA as a high priority project (Prinsburg Meeting Minutes January 13, 2004). Pennock received a half of their grant money from the Wastewater Infrastructure grant. See *Table 4*. for details about funding and costs for both towns.

Table 4. Descriptions of cost for each town

	Pennock—Stabilization Pond	Prinsburg—Constructed Wetland
Estimated total system cost	$3,224,000	$2,500,000*
Construction bid	$2,568,751	$2,160,193
Loan funding	$1.188 million RD grant	$1,358,000 RD loan
Grant funding	$1.067 million Wastewater Infrastructure grant; $1.067 Rural Development grant; Total grants: $2.134 million	$793,000 Minnesota Department of Employment and Economic Development grant
Total funding from loans and grants	$3.122 million funding	$2.151 million funding
Monthly sewer rate	$29.30/month	$47.65/month

**Signifies the value comes from an interview, rather than City Council Meeting Minutes*

To secure financing, towns must also have their systems approved by Rural Development. In the case of Prinsburg, they initially also received some delays in the approval process because the engineers at Rural Development were unfamiliar with the constructed wetland system (Brandt Interview). Agencies like Rural Development and MPCA do not formally recommend certain systems to the communities. However, the approval process and familiarity with certain systems can lead to preferences for these systems, which can be perceived as a recommendation for these traditionally used systems. Therefore, it is easier and quicker to secure funding and approval for traditional systems such as stabilization ponds.

Engineering Firms

Engineering firms that consult towns also play a very important role in the town's decision-making process. Providing the technical knowledge and expertise that small towns lack, both Pennock and Prinsburg relied heavily on their hired engineering firms. Thus, even though the towns hired the firms, they are still heavily dependent on the capacity of the firm. In both Prinsburg and Pennock, all of these external actors worked together to create an wider framework within which the internally established decision-making bodies and leaders could work.

Engineering firm presence was critical in the system choice that each town made. Engineering firms closely monitor MPCA's database of non-compliant systems, and both communities were contacted shortly after receiving their citations by firms offering their technical services. After being contracted, firms draft the technical design of the system per MPCA regulations, attend community meetings and communicate directly with residents about the WWTP, and connect communities with funding organizations to finance the project. Cities must rely on engineering recommendations because the town residents are usually not knowledgeable about wastewater treatment systems.

Municipal choice within the wastewater decision-making process is limited by the types of wastewater treatment systems engineering firms are willing and able to design. This is especially apparent in Prinsburg, where community leadership was atypically aware of and interested in non-traditional wastewater treatment systems. However, they were originally only able to find a firm that was willing to undertake traditional treatment systems -- stabilization ponds, aeration ponds, or connection to an existing WWTP. Constrained by the treatment system offerings of the engineering firms, Prinsburg originally chose the firm Bolton and Menk to design their system, which would have been a stabilization pond. Even though Mayor Van Eps from Prinsburg knew anecdotally about constructed wetlands, it took them several years to be presented with a firm built this alternative system. Upon learning of the firm North American Wetland Engineering (NAWE) which offered constructed wetland systems in addition to more traditional options, the community switched their decision quickly. Communities are very constrained by the options given to them by engineering firms, and even more constrained if they do not know about other options in order to continue looking for a firm that could provide a better alternative than a traditional pond system for their community.

V. Analysis

(Un)certainty in wastewater decision-making

We find an interesting tension between the uncertainty found in general decision-making literature (McDaniels 1999) and the well-understood process of wastewater treatment system choice for small towns. Although uncertainty exists in the wastewater treatment decision-making process, it is more subtle than examples seen in general environmental decision-making literature (Kiker et al. 2005). The process for choosing a wastewater treatment system is well established, which lessens the uncertainty that towns face when attempting to solve sewage pollution problems. However, the process is only scripted for traditional systems, which engineers and state actors have extensive experience implementing. The lack of variation in the decision-making outcomes creates efficiency, which is necessary for small towns with limited resources. However, this can complicate the process of implementing alternative treatment options, especially underutilized systems such as constructed wetlands. It is important to further explore the uses of wastewater green infrastructure like constructed wetlands, even if the current traditional systems are working well, to be able to capitalize on the additional values that green infrastructure systems can provide for communities.

We observed a reliance on system precedent throughout the process, as the decision-making and approval process works most efficiently when towns choose traditional stabilization ponds. Engineers and the MPCA have established the precedent that stabilization ponds are best for small local towns (DeWolf Interview). Local decision-makers are also aware of the precedence of stabilization ponds, having seen this sytem used repeatedly in surrounding towns (Crowley Interview; DeWolf Interview). Not only does this make the process of choosing some alternative systems more difficult, but also prevents awareness of a wider selection of options.

When local decision-makers do become aware of alternative options, as in the case of Prinsburg, they must interact with external actors who seek to minimize uncertainty in the process- a potential point of conflicting values. Bolton and Menk engineers asserted that they strongly value the ability to give a 100% guarantee that the wastewater treatment facility they implement will work (DeWolf Interview). Stabilization ponds give a sense of security to engineers, MPCA, and local decision-makers whereas less common, alternative systems such as constructed wetlands are regarded as riskier to implement.

In the following paragraphs, we frame our analysis around the major nodes of interaction we have identified within the decision-making processes of our two case studies: local organization, choosing an engineering firm, choosing a treatment system, funding, and implementing the system. These nodes and the stakeholders involved are summarized in *Table 5* below and elaborated upon in the following paragraphs.

***Table 5*. Decision-maker interactions with stakeholders in the wastewater treatment decision-making process**

Stakeholders	**Nodes of interaction**				
	Internal organization	Engineering firm choice	Wastewater system choice	Funding	Implementation
MPCA	Moderate	Low	Moderate		Low
Engineering Firms		High	High	Low	High
Rural Development			Low	High	
Rural Water Association	High				
Pennock Public			Low		Low
Prinsburg Public			Low		Low

Table 5. At each major interaction node, the level of interaction between local decision-makers and other stakeholders is summarized. A high degree of interaction indicates that the given stakeholder has a higher influence over the outcome of that node than local decision-makers. A moderate level indicates relatively equal influence. A low level indicates that the stakeholder has less influence on the outcome than decision-makers.

Local organization

For both Pennock and Prinsburg, the wastewater treatment decision-making process began as a result of a MPCA citation of noncompliance. In both cases, the treatment of wastewater was not identified by the communities as a problem--sewage was not bubbling up into residents' yards and the noncompliant system was not causing a health scare. Thus, from the onset of the decision-making process, we see an important interaction between decision-makers and external regulators. In order to avoid MPCA fines, decision-makers organized themselves internally to create a decision-making body and maximize their capacity to address this noncompliance issue (Press 1998).

As observed in the literature on green infrastructure, we find that local leadership was an important factor for the implementation of constructed wetlands (Olson et al. 2001; Hammitt 2010; Young 2011). In large part, the wastewater treatment system outcomes for both Pennock and Prinsburg can be attributed to the two main leaders--the mayors of each town. They were the towns' primary communicators with the engineering firms, MPCA, and Rural Development. As predicted by the literature on small town governance, we find an elite capture of the local government in both towns where the mayors and a small cohort of individuals initiated and headed the WWTP implementation process (Warner and Shortall 2008). The mayors of both communities have been in power for over twenty years and there is little turnover amongst city council members. In Pennock, the sewer committee was comprised of only three people, all of whom were already involved in city administration. In Prinsburg, Mayor Van Eps hand-selected the members of the wastewater committee based on the individual's expertise to include more citizens as decision-makers. Furthermore, although public hearings were held, the main decisions in both towns were made by the mayors and the wastewater committees. The importance of leadership in decision-making can be seen clearly in Prinsburg, where Mayor Van Eps had anecdotal knowledge that alternative systems existed and seemed to catalyze the desire explore those options. Strong-willed and determined decision-makers were key in leading Prinsburg to an alternative system.

In both communities, the mayors established wastewater or sewer committees to research WWTPs and provide recommendations throughout the process. While not responsible for making official decisions during the process, we find that the dynamics within Prinsburg's wastewater committee were an important aspect of the decision-making process. With seven members on the wastewater committee, we find that a larger and more diverse wastewater committee increased Prinsburg's capacity to make decisions more independently throughout the process, as compared to Pennock where the three sewer committee members were comparatively much less involved. However, since Van Eps singlehandedly chose the members, there is probably a bias inherent in the wastewater committee. These advisory bodies may have been characterized by "group think," as found in previous research on group decision-making dynamics (McDaniels et al. 1999). "Group think" may have played a particularly strong role in Prinsburg where the wastewater committee came to a consensus early on that stabilization ponds would create too much odor in their community and thus actively sought different options. For Prinsburg, including residents with construction and ecological experience in the decision-making body increased the knowledge base of the local decision-makers and allowed them to better research alternatives and engage in dialogue with the engineers than in Pennock.

Choosing an engineering firm

The second major interaction node we identify in the wastewater treatment decision-making process is choosing an engineering firm--a necessity for small towns whose decision-makers lack the capacity and expertise to design a compliant WWTP. Because small towns are highly dependent on engineering firms, the availability of firms and the types of systems they are willing to construct constrains the decision-makers' options. For both Pennock and Prinsburg, we noted a limited pool of available engineering consulting firms from which each municipality could choose. In rural America, private for-profit firms are disadvantaged by small markets, geographic isolation, and reduced access to skilled labor and technology (Brown 1980; Acs and Malecki 2003). As a result, there are fewer available firms from which communities can choose, and often this choice is further narrowed by geographical constraints. In Pennock, city leaders noted the importance of hiring an engineering firm that was locally based; they wanted engineers who were more familiar with the area and would be able to frequently visit the site and attend community meetings. Under Pennock's criteria, only one firm, Bolton and Menk, was a possible engineering choice. Literature on rural development in the United States, finds that trust is vital to the successful implementation of infrastructural projects (Putnam 1993). Prioritizing trust built through a local connection, typical rural communities like Pennock may be further constrained in their choice of engineering firms to those actors located nearby.

Although the literature has focused considerably more attention on risk aversion in the public sector (Bozeman and Kingsley 1998), we find that the risk aversion of engineering firms further constrains the choices available to decision-makers at this node as well. For example, Bolton and Menk explicitly does not build constructed wetlands because there is a greater possibly they will fail, even though they have seen examples of systems that can be maintained effectively (DeWolf Interview). Brad DeWolf, President/CEO at Bolton and Menk, noted, "There were a number of projects that Bolton and Menk passed on from a technology standpoint and a reputation standpoint. We didn't want to get involved with constructed wetlands." If local decision-makers cannot find an engineering firm that is able and willing to design a constructed wetland system for their town, the ability for communities to implement this green infrastructure system is eliminated. Thus, we find that the interaction between decision-makers and engineering firms at this node in the decision-making process is critical for the implementation of constructed wetlands.

Choosing a wastewater treatment system

The choice of the wastewater treatment system encompasses decision-maker interactions with regulatory agencies, as well as the enactment of values held by decision-makers themselves. Consistent with the literature on risk aversion in public sector agencies, we find the MPCA to be risk averse in its approval of constructed wetlands for wastewater treatment (Rainey 2009; Feeney and DeHart-Davis 2009). During the design of Prinsburg's constructed wetlands system, MPCA engineers raised concerns to NAWE about the viability of the system, slowing the decision-making process by several months (Van Eps Interview). Currently, in response to the failure of several constructed wetland systems implemented by small towns in the early 2000s, MPCA no longer recommends constructed wetlands as a viable treatment option for communities in the southwest region, even though the reason for failure may be maintenance related (Gillingham Interview; Meyer Interview). With many small towns still lacking compliant wastewater treatment infrastructure and limited funds available to address this pollution, MPCA's risk aversion towards constructed wetlands is justifiable and unsurprising. However, the disinclination of a regulatory agency like MPCA to permit or even share information about a less tried-and-true system such as constructed wetland definitively narrows the choices available to local decision-makers who may have differing values or assessments of risk. Unlike the findings of Abrishamchi et al. (2005), we note that scientists and engineers, not decision-makers, are the ones setting the policy goals. External actors present a discrete number of "viable" systems to local decision-makers, who then choose from these options. These viable systems are grounded in the precedent of what previous towns value and leaves little opportunity for decision-makers to raise values or criteria that differ from the standard.

When choosing the wastewater treatment system that would be best for their community, we find that economic and odor concerns were the two most cited concerns within our case studies. For Pennock, the most important criteria for decision-makers were the efficient use of their time and resources, as well as overall cost of the system. Pennock's decision-makers decided to implement a traditional system because they were facing legal restrictions on town expansion and therefore they did not want to spend extra time searching for other options when the stabilization pond served their purpose (Crowley Interview). Pennock leadership also cited odor as an important factor, but it did not weigh strongly enough to justify looking for an alternative to stabilization ponds.

In contrast, Prinsburg's decision-makers decided that odor was an extremely important criteria and vocalized strong concerns about the smell from a stabilization pond. Prinsburg took a value-based approach by articulating a common value of having a minimally odiferous system (Keeny 1994). This led Prinsburg decision-makers to choose NAWE, even though the firm had never before built constructed wetlands to handle a flow comparable to size of the towns (Van Eps Interview; Slagter Interview). The Prinsburg leadership also valued cost-effectiveness as an important factor in their decision. Cost was the most important criteria for Prinsburg in that the system needed to be affordable, but Prinsburg's main goal was not to minimize costs. As long as an option is within Prinsburg's affordable range, odor was the most important criteria. Because the cost difference between a stabilization pond and a constructed wetland was within a reasonable range, cost was not a point of contention. The extent of Prinsburg's strong value on odor can be seen in terms of the trade-offs they made. Although the upfront capital costs of the constructed wetland and stabilization ponds are similar, the operation and maintenance costs are significantly higher. Thus, by choosing to install the subsurface constructed wetland system, Prinsburg made a trade-off between long-term cost savings and odor, even in the face of some lingering uncertainties the decision-makers had about the longevity of the system. This contrasts with general economic theory that assumes that actors will always go for the most cost-effective option (Tietenberg and Lewis 2009). However, this theory does not allow for the quantification of criteria such as odor, aesthetics, or ecological value because they do not have a determined market value, and thereby limits a solely economic approach to the decision.

The end result of constructed wetland implementation was not only having a low-odor system with ecological and aesthetic benefits, but the process also fostered a strong sense of ownership of system. Mayor Van Eps said, "I think we were real persistent to stay the course there because we wanted to see the end results" (Van Eps Interview). Whereas in Pennock, only Mayor Crowley expressed pride in the system, Prinsburg's pride in the system extends beyond just the Mayor to the wastewater committee and possibly the wider community because they drew upon a wider range of council members and residents. This can be seen through outside actors recognizing the effort Prinsburg put into completing the system. They have been awarded two Certificates of Commendation from MPCA (2008 and 2009) and an Achievement Award from Minnesota Rural Water Association (2010); these awards hang on the wall in City Hall for the general public as well as visitors to see. Through communicating their objective, Prinsburg's values were combined with NAWE's expertise to result in more holistic decision that satisfied Prinsburg's objectives (Kiker et al. 2005).

Funding

Although research has found that green infrastructure systems are cost-effective (Ko et al. 2002; Kivaisi 2001), the literature on green infrastructure also acknowledges that receiving funding can be difficult (Clean Water America Alliance 2011). In our case studies, we did not find funding to be a factor that influenced which system was chosen, although Prinsburg's funding was delayed due to slow MPCA approval. This departure from the literature could be the result of the unique position these towns were in. They were recognized statewide as two of the most critical noncompliant wastewater treatment systems (Crowley Interview), and thus funding may have been more readily available than is typical. However, there could be additional complexities; for both towns, cost and funding were difficult to quantify and not well documented. Construction of Prinsburg's wetlands seems to have been cheaper than Pennock's pond system, which is supported by literature about green infrastructure (Kivaisi 2001). However, operation and maintenance costs for constructed wetlands are significantly higher. This is especially important to note because funding agencies, such as Rural Development, provide grants and loans for construction related expenses, but not for operation and maintenance costs (Frisman Interview). This potential funding barrier does not appear in the literature and needs to be further explored.

Implementing the system

During the final stage of the wastewater treatment decision-making process, decision-makers had their first notable interactions with the general public. Once the wastewater treatment system had been chosen, local officials held public hearings to inform the public and answer residents' questions about the anticipated effects of the new system. We find that the wastewater treatment decision-making process in these two small towns is characterized by a lack of involvement in the process by the general public. This aligns with Irvin and Stansburg's (2004) findings that the public is less likely to be involved in environmental decisions where a technical understanding of the choices is needed, as well as the fact that communities are complacent with the status quo. We hypothesize that if sewage began flooding residents' basements, community involvement in the decision-making process would have drastically increased. However, throughout both decision-making processes, wastewater continued to remain out of sight, out of mind for the general public. Through our analysis, we were unable to determine the impact that cultural conceptions of waste had on community engagement, but hypothesize that a lack of involvement with wastewater prevented residents from being engaged with the environmental concerns and opportunities associated. Future research is needed to parse if and how the profane nature of waste informed the wastewater decision-making process.

Value-based decision-making

Decision-making literature presents the view of complicated and model-based decision-making being the norm in the process. We find that multicriteria decision-making analysis using highly technical models has limitations for the wastewater treatment decision-making process. However, we find that using MCDA principles could provide valuable insight for a wastewater decision that values local decision-makers' as well as the public's objectives (Kiker et al. 2005). In multiple attribute decision-making (MADM), decision-makers examine various alternatives and decide between them depending on the criteria they find most important (Hwang and Lin 1987). We have found that decisions are constrained in this process because outside actors approach towns within this MADM framework by presenting only two to three alternatives rather than giving communities time to discuss and weigh criteria important to them.

Unsurprisingly, neither town used any of the MADM models described in literature as useful for multicriteria environmental decision-making (Huang et al. 2011). Although these models have been used in wastewater treatment in less developed countries (Kalbar et al. 2012), it seems that highly technical approaches to making the decision is unnecessary because an informal structured decision-making process already exists for small rural towns in the United States. Resources such as the MPCA, Rural Water, and Midwest Assistance Program, as well as engineering firms guide towns through the process. However, we find that this highly structured process of decision-making can obstruct the process of choosing a system for towns like Prinsburg for which criteria such as odor, aesthetics, or others is valued equally or more than cost or efficiency. The current structured process is very efficient, but this efficiency ignores inter-town differences in decision-making criteria.

We find the idea of multiple objective decision-making (MODM) compelling as it approaches problems solely from objectives, without alternatives in mind, thereby making values and objectives of decision-makers very important. MODM decisions are reserved for problems where no alternatives exist; because there are many alternatives available for wastewater treatment, this approach is not fully applicable to wastewater treatment decision-making. However, the basic principles of this approach influenced the way that we understood decision-making in Prinsburg and Pennock. Because Prinsburg was able to focus on a specific objective--to implement a system with as little odor as possible--it opened up their field of alternatives to include constructed wetland systems beyond the limited list established by precedent. The current MADM framework for wastewater treatment decisions examines criteria only insofar as they relate to available alternatives. Although Huang and Lin's (1987) definition of MODM is not applicable to wastewater treatment decision where alternatives exist, the current approach to MADM models does not emphasize the importance of evaluating criteria and objectives for each town.

We recognize the importance of precedent in creating the least hassle for stakeholders with limited resources, but find that when values are not clearly articulated, less quantitatively-grounded values such as aesthetic considerations or odor may be undervalued. In both cases, the public was largely left out of the initial discussion of important criteria decided upon by the wastewater committee and city council. The use of a model would bring these values to light and might help decision-makers come to a more representative decision. As we saw in the case of Prinsburg, developing a clear idea about that community's decision-making criteria, and thereby informally weighing criteria, can help articulate the needs of a community and result in an alternative system that best fits community values. Because Prinsburg's leadership valued having a system with the least negative odor possible, and because they had capacity and knowledge to search for other options to be made available rather than going with the first best system presented, they were able to eventually implement an alternative system with additional ecological benefits, an added value that Prinsburg did not even consider as criteria. Evaluating public objectives and values could offer greater insight into a town's needs and make the case for looking at alternative systems. Approaching these processes through an extensive valuation of the criteria that are important for these towns could result in constructed wetlands or other feasible alternatives becoming more common-place, thereby expanding the existing treatment system precedent.

VI. Conclusion

By examining the differences in the decision-making processes in Pennock and Prinsburg, we have developed a more nuanced understanding of the conditions and constraints under which small rural towns make wastewater treatment decisions. As a typical case, Pennock accepted the most cost-effective system offered by a local engineering firm without first establishing strong value-based criteria. In contrast, Prinsburg identified odor as an extremely important decision-making criteria early in the process. Communicating with multiple engineering firms to find a system that was a best fit for them, Prinsburg's more value-based approach to the wastewater decision-making process gave them a greater sense of ownership in the project. This sense of ownership and investment in their system continued after the installation of the constructed wetland system, and even led to an innovative water reuse project. Prinsburg's successful decision to go against the precedent and pursue a nontraditional, constructed wetland system offers us insights into the significant role that small rural towns could play in the innovation of wastewater treatment management.

In our case study, we note a distinct deviation from the existing literature on wastewater treatment decision-making that finds experts are subordinate to decision-makers (Abrishamchi et al. 2005). Rather, in small rural towns, we find that the engineers had an equal if not more influential role in the decision outcome than the local decision-makers. Even if towns establish their own decision-making criteria, they may still be unable to implement a system that fulfills all of their criteria due to constraints created by risk averse regulatory agencies and engineering firms. This constraint is especially notable in rural communities where choice is already geographically limited. Most importantly, as the majority of new wastewater treatment systems are needed in small, rural communities, this constraining framework does not bode well for the increased implementation of constructed wetland systems in Minnesota.

Additionally, we find that the framing of wastewater treatment may also limit the ability of local decision-makers to envision alternative system choices. Catalyzed by MPCA's initial citation, the wastewater treatment process that follows is focused on addressing this compliance concern (Crowley Interview; Van Eps Interview). When viewed as a compliance measure, the resulting decision-making process becomes almost a linear checklist procedure confined to the options presented by engineers and local precedent with few uncertainties. This sets wastewater treatment decisions apart from most environmental decisions that are approached with many complexities and uncertainties (Kiker et al. 2005; Bellman and Lofty 1970).

The view of wastewater treatment as a compliance issue may also be tied to cultural perceptions of waste and wastewater. Currently, wastewater treatment is viewed as the disposal of waste, rather than a water management opportunity. Thus, the emphasis is on *waste*, something which has no value, rather than on *water*, a finite and valuable resource. Considering the negative public perception of waste, the association of wastewater with waste rather than with water may discourage interest and engagement with this issue. Thus, we hypothesize that cultural perceptions of wastewater may frame how stakeholders engage with the wastewater decision-making process specifically. The role that cultural perceptions of waste play in the wastewater treatment decision-making process has been markedly under-analyzed in the literature on sociology, decision-making, and green infrastructure.

The case of Prinsburg also demonstrates the potential for small towns to engage in innovation by becoming more invested in their wastewater management. Through this, they start to gain a better understanding of how wastewater fits into the water cycle and water resource management. The positive implications of this could possibly be magnified by increasing the involvement of decision-makers and the general public in the wastewater treatment decision-making process (Irvin and Stansburg 2004; McDaniels et al. 1999). Greater engagement by not only the decision-makers, but also the local residents may be critical in voicing more values and objectives, which allows towns to explore even more options beyond stabilization ponds. This could serve to increase the development and use of green infrastructure for wastewater treatment.

In Prinsburg, Mayor Van Eps' active involvement in the process led him to realize that the treated water could be reused to preserve the town's high-quality groundwater (Van Eps Interview). Since successfully implementing a reuse scheme that sells treated wastewater to the local fertilizer co-op, Van Eps has not stopped imagining more developments and expanded reuse of the wastewater -- he envisions the treated water to be reused even at the residential level (Van Eps Interview). Although Van Eps and the other decision-makers do not consider themselves to be environmentalists, their increased understanding of the role that wastewater can play in preserving Prinsburg's local water resources nevertheless has led to the adoption of very innovative water management policies, even in the face of MPCA opposition. We hypothesize that if towns consider wastewater treatment as a water resource management tool, engagement with wastewater need not end once the system has been installed. Rather, this paradigm shift could foster ongoing, long-term engagement in water resource management. The example of Prinsburg suggests that if towns approached wastewater treatment from the beginning as a water resource management issue rather than a grudgingly resolved compliance measure, there could be greater potential for the development of new and improved WWTPs and water reuse opportunities.

Local governments, small and large, are crucial actors in the implementation of many land-use and water resource management decisions. However, the dynamics within these local decision-making processes remains under explored by the literatures of multiple disciplines. By reframing the decision-making process of something as ordinary as wastewater treatment to consider multiple criteria and systems-level thinking, local governments have the potential to implement innovative and sustainable wastewater treatment systems that are integrated more broadly into local water resource management systems.

Limitations and Future Research

Data Collection

Time and resource constraints limited the amount of time we were able to spend on-site in our case study towns. Spending less than two days in each community gave us little time to build rapport with residents and gain a more nuanced understanding of each city's unique socio-cultural arena. While we were able to interview most of the major actors involved in the decision-making process (mayors, wastewater committee members, maintenance managers, etc.), we were unable to contact several key decision-makers. Furthermore, our results do not include the perspectives of less involved decision-makers on both community's city councils. Time limitations further hindered our ability to communicate with community residents impacted by, but not directly involved in the wastewater decision-making process. Future studies could build on this gap by investigating how public perceptions about sewage, waste, and wetlands impacted citizen involvement with the wastewater decision-making process.

Our data was further limited by informational gaps in town documents and the memory of decision-makers about events that occurred over ten years ago. Utilizing city council meeting minutes and newspaper articles to initially frame our understanding of the action arenas in both communities, we quickly realized that much of the decision-making process went unrecorded. The lack of comprehensive financial records of the process made it very difficult to piece together the exact costs of the system. Additionally, interviewees often noted the difficulty of remembering the order and importance of events throughout the process, especially smaller details about where and how they accumulated knowledge about wastewater treatment options. This posed a particular challenge when the interviewees' recollections conflicted with other interviews or the meeting minutes, making it difficult for us to know which accounts were the most accurate or rely on.

Funding

As interviews with town decision-makers, agency staff, and scholarly literature note, the cost comparison between constructed wetland and stabilization ponds is of primary importance. However, we find that it is nearly impossible to develop an exact comparison between systems because in our cases, cost encompassed resewering the community and other related construction costs, hiring other professionals to help with paperwork, engineering consultation fees, as well as the cost of the systems themselves. This difficulty was augmented by the lack of detailed financial records regarding costs and funding. Thus, our paper only provides a cursory analysis of the funding process. While we note the involvement of USDA Rural Development and Rural Finance Authority among others, there are a wide range of local, state, federal, and nongovernmental actors that could provide funding. Sufficiently mapping this funding network, and the concurrent 'strings attached' which constrain how and when funding can be utilized could be a complete project in itself. This analysis would be particularly relevant for organizations that seek to facilitate the implementation of constructed wetland systems.

In addition, we found a discrepancy between the literature and our case studies about system cost because of the extremely high maintenance of constructed wetlands. The literature generally concludes that the operation and maintenance costs of constructed wetlands are very low; but this was not the case in Prinsburg. Future research should investigate this inconsistency to determine if Prinsburg was just an anomaly or if the maintenance costs of constructed wetlands actually are greater than what the literature generally concludes. Furthermore, since funding is available for upfront cost of construction and not operation and maintenance, future studies should also look into into the specifics of how federal and state funds for wastewater treatment can inhibit the adoption of constructed wetlands or other wastewater green infrastructure.

VII. Bibliography

Abrishamchi, Ahmad, Ali Ebrahimian, Massoud Tajrishi, and Miguel A. Mariño. "Case study: application of multicriteria decision making to urban water supply."*Journal of Water Resources Planning and Management* 131, no. 4 (2005): 326-335.

Armstrong, David. "Public health spaces and the fabrication of identity." *Sociology* 27, no. 3 (1993): 393-410.

Bellman, Richard E., and Lotfi Asker Zadeh. "Decision-making in a fuzzy environment." *Management science* 17, no. 4 (1970): B-141.

Boland, Per and Sven Hunhammar. "Ecosystem services in urban areas." *Ecological Economics* 29 (1999): 293-301.

Boyer, Tracy, and Stephen Polasky. "Valuing urban wetlands: a review of non-market valuation studies." *Wetlands* 24, no. 4 (2004): 744-755.

Bozeman, B. and G. Kingsley. "Risk culture in public and private organizations." *Public Administration Review* no. 58 vol. 2 (1998): 109-118.

Brix, Hans. "Constructed wetlands for municipal wastewater treatment in Europe." *Mitsch, W.J. (Ed.), Global Wetlands; Old World and New.* Elsevier, Amsterdam (1994): 325–334.

Brix, Hans. "Use of constructed wetlands in water pollution control: historical development, present status, and future perspectives." *Water Science and Technology* 30, no. 8 (1994): 209-224.

Brown, Anthony. "Technical Assistance to Rural Communities: Stopgap or Capacity Building?" *Public Administration Review* 40, no 1 (Jan-Feb 1980): 18-23. http://www.jstor.org/stable/976103

Burian, Steven J., Stephen J. Nix, Robert E. PItt, and S. Rocky Durrans. "Urban Wastewater Management in the United States." *Journal of Urban Technology* 7, no. 3 (2000): 33-62.

Buss, S. "Private landowners' values for rare species and natural communities." Doctoral thesis. University of Minnesota, 1994.

Chen, Z. M., Chen, G. Q., Chen, B., Zhou, J. B., Yang, Z. F., & Zhou, Y. "Net ecosystem services value of wetland: Environmental economic account." *Communications in Nonlinear Science and Numerical Simulation* 14, no. 6 (2009): 2837–2843.

Chi, Michelene TH, Robert Glaser, and Marshall J. Farr, eds. *The nature of expertise*. Psychology Press, 2014.

Clean Water America Alliance. "Barriers and Gateways to Green Infrastructure." 2010. http://www.uswateralliance.org/pdfs/gireport.pdf

Cotting, Jennifer. "Green Infrastructure Financing." Powerpoint from the Environmental Finance Center, National Center for Smart Growth, University of Maryland. December 2012.

Daily, G.C. "Social constraints on restoration ecology." In *Nature Conservation III: Reconstruction of Fragmented Ecosystems* ed. DA Saunders, RJ Hobbs, and PR Ehrlich. Perth: Surrey Beatty & Sons, 1993.

DeTocqueveille, Alexis. Democracy in America. 1835.

Dougherty, Tara. "Wastewater Treatment Wetlands." (presentation, Technical Assistance Partnership Forum, Conestoga-Rovers and Associates, March 22, 2012). http://syracusecoe.org/EFC/images/allmedia/Presentations/TAPF_Dougherty.pdf

Doyle, Martin W. and David G. Havlick. 2009. "Infrastructure and the Environment," *Annual Review of Environment and Resources* 34: 349-373.

Dunn, A. D. "Siting Green Infrastructure: Legal and Policy Solutions to Alleviate Urban

Poverty and Promote Healthy Communities. *Boston College Environmental Affairs Law Review*, *37,* no. 1 (2010): 41–66.
Durkheim, Emile. *The elementary forms of the religious life*. 1912.
Environmental Protection Agency. *Arcata, California - A Natural System for Wastewater Reclamation and Resource Enhancement.* 1993. http://www.epa.gov/owow/wetlands/pdf/Arcata.pdf
Environmental Protection Agency. "Basic Information About Water Security." Last updated Sept. 11, 2013a. http://water.epa.gov/infrastructure/watersecurity/basicinformation.cfm
Environmental Protection Agency. "How can I overcome the barriers to green infrastructure?" Last updated Sept. 23, 2013b. http://water.epa.gov/infrastructure/greeninfrastructure/gi_barrier.cfm
Environmental Protection Agency. *Manual: Constructed Wetlands Treatment of Municipal Wastewaters.* Cincinnati, OH: Office of Research and Development, 2000.
Environmental Protection Agency. "Guiding Principles for Constructed Wetlands: Providing for Water Quality and and Wildlife Habitat." Washington D.C.: Office of Wetlands, Oceans, and Watersheds, 2000c. http://water.epa.gov/type/wetlands/constructed/upload/guiding-principles.pdf
Environmental Protection Agency. "Wastewater Technology Fact Sheet Wetlands: Subsurface Flow." Washington, D.C.: Office of Water, 2000b.
Environmental Protection Agency. "What is Green Infrastructure." Last updated Jan 11, 2013c. http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm
Environmental Protection Agency. "Permit Compliance System." http://www.epa.gov/enviro/facts/pcs-icis/search.html
Environmental Protection Agency. "Use of Green Infrastructure in NPDES Permits and Enforcement." Memorandum from Linda Bornazian, Director of Water Permits Division and Mark Pollins, 16 August 2007.
Esty, Daniel C. "Revitalizing environmental federalism." *Mich. L. Rev.* 95 (1996): 570.
Feendy, Mary K. and Leisha DeHart-Davis. "Bureaucracy and Public Employee Behavior: A Case of Local Government," *Review of Public Personnel Administration,* no. 29 vol. 4 (2009): 311-326.
Fischel, William A. "Homevoters, municipal corporate governance, and the benefit view of the property tax." *National Tax Journal* (2001): 157-173.
Fritz, Jack J., Andrew C. Middleton, and Dale D. Meredith. "Dynamic Process Modeling of Wastewater Stabilization Ponds." *Journal (Water Pollution Control Federation),* 51, no. 11 (Nov 1979): 2724-2743. http://www.jstor.org/stable/25040488?origin=JSTOR-pdf
Gargan, John J. "Consideration of local government capacity." *Public Administration Review* (1981): 649-658.
George, Alexander and Andrew Bennett. "Case Studies and Theory Development in the Social Sciences." MIT Press, 2005.
Goad, Mark E. "Introduction to Wastewater Treatment Ponds." *Water World.* http://www.waterworld.com/articles/print/volume-27/issue-10/editorial-features/introduction-to-wastewater-treatment-ponds.html
Hammit, Sarah A. "Toward Sustainable Stormwater Management: Overcoming Barriers to Green Infrastructure." Master's thesis, Massachusetts Institute of Technology, June 2010.

Huang, Ivy B., Jeffrey Keisler, and Igor Linkov. "Multi-criteria decision analysis in environmental sciences: ten years of applications and trends." *Science of the total environment* 409, no. 19 (2011): 3578-3594.

Irvin, Renee A., and John Stansbury. "Citizen participation in decision making: is it worth the effort?." *Public administration review* 64, no. 1 (2004): 55-65.

Johnson, Bill. "Constructed Wetlands Meet Environmental and Cost Requirements for Rose Acre Farms." *Land and Water.* Online feature. http://www.landandwater.com/features/vol50no1/vol50no1_2.html

Kadlec, R. H. "Decomposition in wastewater wetlands." In *Constructed Wetlands for Wastewater Treatment: Municipal, Industrial and Agricultural*, 459-468. Chelsea, Michigan: Lewis Publishers, 1989.

Kadlec, R. H. and Knight, R.L. *Treatment Wetlands.* Lewis Publishers, Boca Raton, FL: CRC Press, Inc., 1996.

Kalbar, Pradip P., Subhankar Karmakar, and Shyam R. Asolekar. "Technology assessment for wastewater treatment using multiple-attribute decision-making."*Technology in Society* 34, no. 4 (2012): 295-302.

Kaplowitz, Michael D., and John Kerr. "Michigan residents' perceptions of wetlands and mitigation." *Wetlands* 23, no. 2 (2003): 267-277.

Keeney, Ralph L. "Creativity in decision making with value-focused thinking."*Sloan Management Review* 35 (1994): 33-33.

Kholgi, M. "Multi-Criterion Decision-Making Tools for Wastewater Planning Management." *J. Agri. Sci. Technol.* 3, (2001): 281-286.

Kiker, Gregory A., Todd S. Bridges, Arun Varghese, Thomas P. Seager, and Igor Linkov. "Application of Multicriteria Decision Analysis in Environmental Decision Making." *Integrated Environmental Assessment and Management*. Vol 1. No 2 (2005): 95-108.

Kivaisi, A. K. "The potential for constructed wetlands for wastewater treatment and reuse in developing countries: a review." *Ecological Engineering*, 14, no. 4 (2001): 545–560.

Ko, J.-Y., Day, J. W., Lane, R. R., & Day, J. N. "A comparative evaluation of money-based and energy-based cost–benefit analyses of tertiary municipal wastewater treatment using forested wetlands vs. sand filtration in Louisiana." *Ecological Economics* 49, no. 3 (2004): 331–347.

Lahiri, Supriya; Latif, Saira; O'Brien, A. "The Total Economic Value of a Small Urban Wetland: Evidence from a New England City." *Interdisciplinary Journal of Economics and Business Law* 2, no. 4 (2013): 63–80.

Lienert, Judit, Florian Schnetzer, Karin Ingold. "Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure planning processes." *Journal of Environmental Management*. Volume 125 (Aug 2013): 134-148.

Lin, Ming-Jeng, and Ching-Lai Hwang. *Group decision making under multiple criteria*. Springer, 1987.

Little, Paul E. "Environments and Environmentalism in Anthropological Research: Facing a New Millennium." *Annual Review of Anthropology* 28 (1999): 253-284.

Matsatsinis, Nikolaos F., and Andreas P. Samaras. "MCDA and preference disaggregation in group decision support systems." *European Journal of Operational Research* 130, no. 2 (2001): 414-429.

McCarthy, Barb and Brad Gillingham. Minnesota Pollution Control Agency. "Small Community Wastewater Needs in Minnesota." June 2008. http://www.pca.state.mn.us/index.php/view-document.html?gid=5192
McDaniels, Timothy L., Robin S. Gregory, and Daryl Fields. "Democratizing risk management: Successful public involvement in local water management decisions." *Risk analysis* 19, no. 3 (1999): 497-510.
Minnesota Pollution Control Agency. "Progress on a Long Voyage: Decades of Effort Show Improvement In Minnesota River Water Quality." 2007. http://www.pca.state.mn.us/index.php/view-document.html?gid=9970
Minnesota Pollution Control Agency. "Wastewater Operator Exam Requirements." 2009. http://www.pca.state.mn.us/index.php/view-document.html?gid=4188
Monkkonen, Eric H. *America becomes urban: The development of US cities & towns, 1780-1980*. Univ of California Press, 1990.
Montalo, Franco et al. "Rapid assessment of the cost-effectiveness of low impact development for CSO control." *Landscape and Urban Planning* 82 no. 3 (2007): 117-131.
Murphy, Patrick J., and Susan M. Coombes. "A model of social entrepreneurial discovery." *Journal of business ethics* 87, no. 3 (2009): 325-336.
Nassauer, Joan Iverson. "Monitoring the success of metropolitan wetland restorations: Cultural sustainability and ecological function." *Wetlands* 24, no. 4 (2004): 756-765.
Nelson, Kara L. and Ashley Murray. "Sanitation for Unserved Populations: Technologies, Implementation Challenges, and Opportunities." *Annual Review of Environment and Resources* 33 (2008): 119-151.
Netto, Oscar Cordeiro, Éric Parent, and Lucien Duckstein. "Multicriterion design of long-term water supply in southern France." *Journal of Water Resources Planning and Management* 122, no. 6 (1996): 403-413.
Olson, Kenneth, Bridget I. Chard, Douglas Malchow, and Don Hickman. Minnesota Pollution Control Agency. "Small Community Wastewater Solutions: A Guide to Making Treatment, Management, and Financing Decisions." 2001. http://septic.umn.edu/prod/groups/cfans/@pub/@cfans/@ostp/documents/asset/cfans_asset_408570.pdf
Ostrom, Elinor. *Governing the commons: The evolution of institutions for collective action*. Cambridge university press, 1990.
Page, Robert W and LaJuna Wilcher. "Memorandum of Agreement between the Department of the Army and EPA." February 6, 1990. http://water.epa.gov/lawsregs/guidance/wetlands/mitigate.cfm
Panebianco, Silke and Claudia Paul-Wostl. "Modelling socio-technical transformations in wastewater treatment—A methodological proposal." *Technovation* 26 (2006): 1090–1100.
Putnam, Robert D. "The prosperous community: social capital and public life" *American Prospect*, March 1993, 35-42.
Press, Daniel. "Local environmental policy capacity: a framework for research."*Natural Resources Journal* 38 (1998): 29.
Prinsburg City Council Meeting Minutes, December 10, 2003.
Rainey, Hal G. *Understanding and Managing Public Organizations.* San Francisco: Jossey-Bass, 2009.
Rogers, Everett M. *Diffusion of innovations (5th ed.)*. New York: Free Press, 2003.

Sparks, Richard E. “Forty years of science and management on the Upper Mississippi River: an analysis of the past and a view of the future.” *Hydrobiologia* 640, no. 1 (2010): 3–15.
Stradling, David, Ed. *Conservation in the Progressive Era Classic Texts*. Seattle: University of Washington Press, 2004.
Suutari, Amanda. “USA - California (Arcata) - Constructed Wetland: A Cost-Effective Alternative for Wastewater Treatment,” 2006. *Eco-Tipping Points*. http://www.ecotippingpoints.org/our-stories/indepth/ usa-california-arcata-constructed-wetland-wastewater.html.
Tajbakhsh, Kian. *Local Government* in “Encyclopedia of Urban Studies”, Ray Hutchison ed. Sage Publication, 2013.
Theiling, C., & Nestler, J. “River stage response to alteration of Upper Mississippi Riverchannels, floodplains, and watersheds.” *Hydrobiologia* 640, no. 1 (2010): 17–47.
Thomas, Jean-Sebastien, and Bruce Durham. "Integrated Water Resource Management: looking at the whole picture." *Desalination* 156, no. 1 (2003): 21-28.
Tietenberg, Thomas H., and Lynne Lewis. *Environmental Economics and Policy*. Prentice Hall, 2009.
Turban, Daniel B., and Allan P. Jones. "Supervisor-subordinate similarity: types, effects, and mechanisms." *Journal of Applied Psychology* 73, no. 2 (1988): 228.
University of Minnesota Constructed Wetlands Factsheet
U.S. Census Bureau Population Report, 2010. https://www.census.gov/2010census/.
Vandermeulen, V., Verspecht, A., Vermeire, B., Van Huylenbroeck, G., & Gellynck, X. “The use of economic valuation to create public support for green infrastructure investments in urban areas.” *Landscape and Urban Planning*, 103*,* no. 2 (2011): 198–206.
Verhoven, Jos TA and Arthur FM Meuleman. Wetlands for wastewater treatment: Opportunities and limitations." *Ecological Engineering* 12, no. 1 (1999): 5-12.
Vymazal, J. “Constructed wetlands for wastewater treatment: five decades of experience.” *Environmental science & technology*, 45, no. 1 (2011): 61–69.
Warner, M. E. and Shortall, S. “Growth coalitions and rural development policy in the EU and the US*.” EuroChoices* 7, 3 (2008): 35–7.
Wastewater Resources Center. “Constructed Wetlands Factsheet.” University of Minnesota. October 2010. http://www.septic.umn.edu/factsheets/constructwetlands/index.htm
Water Environment Federation. “Green Infrastructure: Barriers to Implementation.” Report for the EPA, March 31, 2011.
Watson, James T., Sherwood C. Reed, Robert H. Kadlec, Robert L. Knight, and Alfred E. Whitehouse. "Performance expectations and loading rates for constructed wetlands." *Constructed Wetlands for Wastewater Treatment: Municipal, Industrial and Agricultural. (*Chelsea, Michigan: Lewis Publishers, 1989)*,* 319-351.
Wiener, J., & Sandheinrich, M. “Contaminants in the Upper Mississippi River: historic trends, responses to regulatory controls, and emerging concerns.” *Hydrobiologia* 640, no. 1 (2010): 49–70.
Wildman, Matthew. “A ‘Green’ Alternative for Wastewater Treatment.” *Civil Engineering News*. October 2005. http://www.cenews.com/article/4571/a__green__alternative_for_wastewater_treatment
Williams, Kathryn JH, and John Cary. "Landscape preferences, ecological quality, and biodiversity protection." *Environment and Behavior* 34, no. 2 (2002): 257-274.

Worstell, Carolyn. “Green Infrastructure in the State of New Jersey: Statutory and Regulatory Barriers to Green Infrastructure Implementation.” Report prepared for New Jersey Future, January 2013.

Young, Robert F. "Planting the Living City: Best Practices in Planning Green Infrastructure—Results From Major US Cities." *Journal of the American Planning Association* 77, no. 4 (2011): 368-381.

VIII. Appendicies

Appendix A. Stabilization Pond

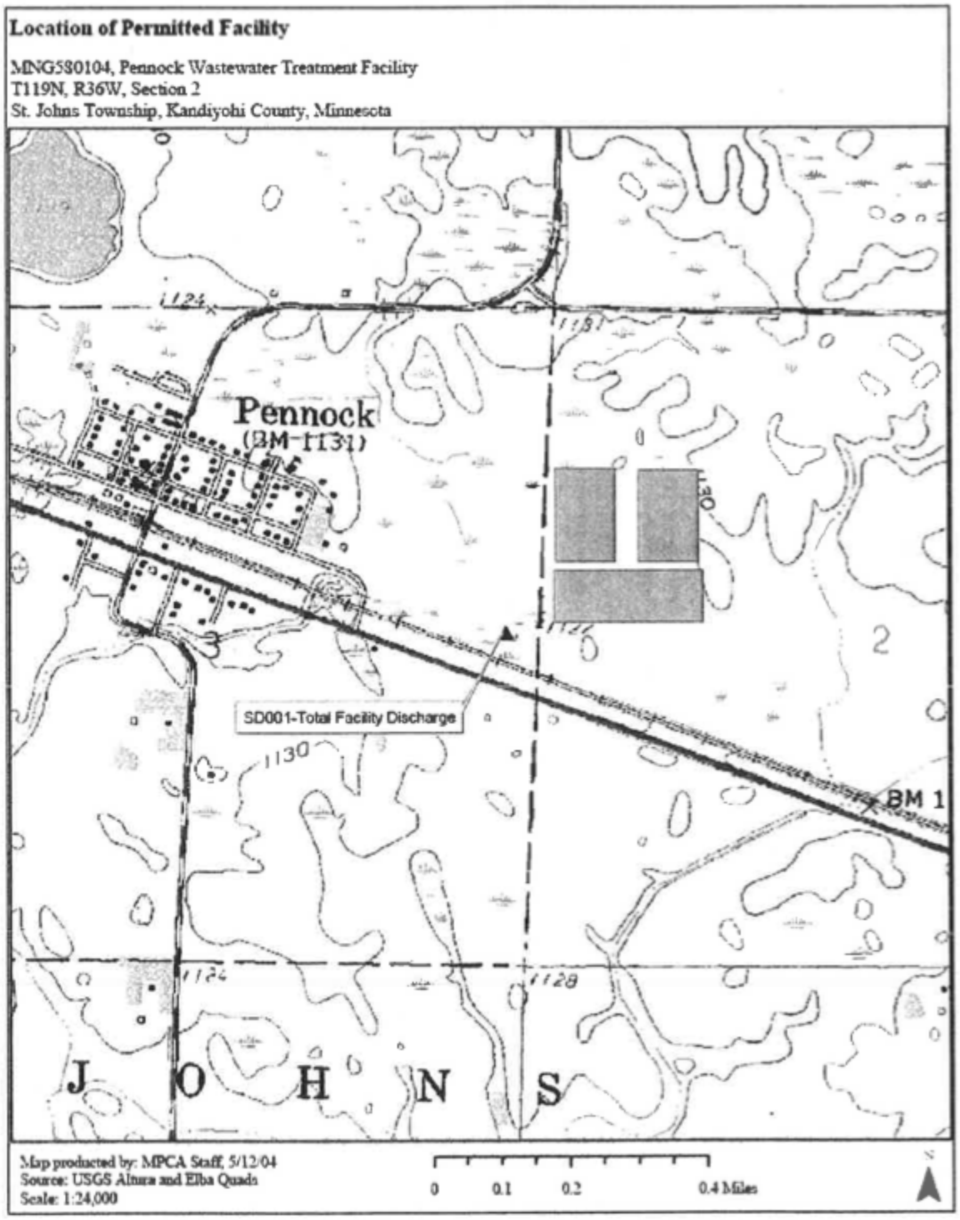

Fig 1-A. Map of Pennock, MN showing location of wastewater treatment facility. The 3-cell system discharges to a creek that runs through agricultural land surrounding the system. From MPCA letter.

Bolton and Menk recommended that Pennock implement either an aeration pond or a stabilization pond. The main difference between these two is that for aeration ponds, oxygen is supplied through a mechanical system connected to the ponds. The constant supply of oxygen allows aeration ponds to process a higher input of sewage than stabilization ponds (EPA 1983). Because Pennock implemented a 3-cell stabilization pond, this appendix will focus on providing a concise description of the design of this system.

Stabilization ponds refer to any pond where stabilization occurs naturally (EPA 1975). Stabilization refers to the process where aerobic bacteria utilize organic material for energy in the upper layer of the system (EPA 1983). Pond systems rely on this bacteria to break down organic matter including nutrients such as Nitrogen and Phosphorous, fecal matter, chemical waste from homes, and other pollutants in the wastewater. Of the three cells, there are two primary cells which consist of two layers--the upper aerobic area where stabilization occurs, and the bottom anaerobic layer where bacteria that do not need oxygen break down the solids that att the bottom of the system. After this treatment, water flows to a secondary pond leaving the solids to be decomposed in the primary ponds. Each pond has a surface area of four acres and a four-foot mean operating depth (MPCA letter).

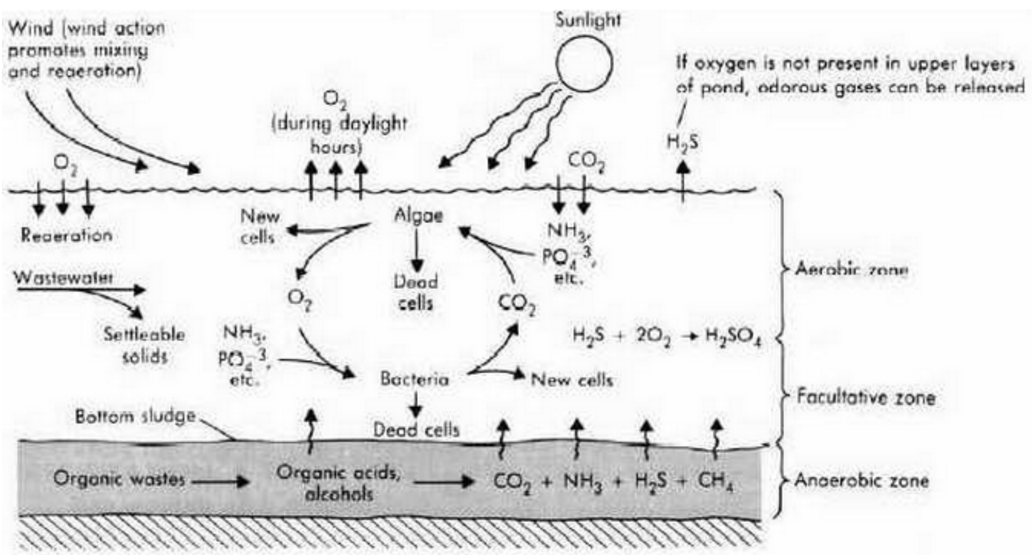

Fig 2-A. Shows the biological processes that occur in stabilization ponds. The bottom sludge layer is anaerobic bacteria decomposing organic wastes. Oxygen enters from wind rather than mechanically as in an aerated system. Algae collects on the surface; growth is facilitated by the nutrient-rich water. (Tchobanoglous and Schroeder 1987)

The only mechanical components to stabilization pond systems are flow measurement devices, sampling systems, and pumps (EPA 1983). Operation and maintenance of these systems require little effort when everything is functioning as it should be. Terry Thole works for the city of Pennock and monitors the pond system, which involves checking the flow measurement readings daily. The operator, Woody Nelson, works in a city about 15 minutes away and is on call on a day-to-day basis to visit the system if there are problems. Nelson's main job involves taking two samples per month of the flow, pH, Phosphorous, Total Suspended Solids, Dissolved Oxygen, and indicators of system treatment (Nelson Interview). The Pennock ponds are Controlled Discharge Ponds, which means that the system is designed to retain wastewater for a long time (180 day detention pond for the Pennock system) before a planned discharge (EPA 1975; MPCA letter to Pennock). The ponds discharge for a few weeks at a time when receiving water conditions are appropriate (EPA 1975). For the Pennock system, this requires that Nelson discharge the system several times a year during May-July and then September-November (Nelson Interview). During the winter, the ponds are frozen over and the whole process becomes anaerobic because the ice prevents oxygen from reaching the bacteria (Nelson Interview). In the spring, turnover of ice can cause a smell as the warmer water layer from below the ice melt resurfaces and aerobic bacteria reappear (Nelson interview, Olson et al. 2001).

The Pennock system needs to be re-permitted every 10 years and is expect to have a life of about 30 years (Nelson Interview). The ponds work with septic tanks at each house that collect wastewater and transport it through a main sewer line to the ponds east of town (Crowley). The treated water is discharged to an unnamed creek (MPCA letter to Pennock). The most common problem in the operation of Pennock's system is algal blooms that cover the surface water and grease build-up from septic tanks. The grease build-up is a problem unique to Pennock, most likely resulting from a misuse of the system from individual homes where residents are putting grease in the system (Nelson Interview; Crowley Interview).

Works Cited

Environmental Protection Agency. "Design Manual: Municipal Wastewater Stabilization Ponds." Office of Research and Development. Cincinnati, OH (October 1983).

Environmental Protection Agency. "Wastewater Treatment Ponds." Office of Water. Washington, D.C. (March 1975).

Minnesota Pollution Control Agency. "Final Issuance National Pollutant Discharge Elimination System/State Disposal System Notice of Coverage." Letter to Mayor Crowley. 4 November 2010.

Tchobanoglous, G. and Schroeder, E. (1985). *Water Quality Characteristics, Modeling, Modification*. Addison-Wesley; Reading, Massachusetts, USA.

Appendix B. Constructed Wetland Technology

Subsurface horizontal-flow constructed wetlands are a secondary treatment option that uses plants and bacteria to filter wastewater. They must be used in conjunction with some primary treatment because subsurface horizontal-flow wetlands are unable to filter solid waste. Prinsburg's system uses four septic tanks, each 15 by 20 feet with a holding volume of 20,000 gallons, as primary treatment where solids fall to the bottom.

The wetland system consists of four cells with clay-lined bottoms. Wastewater from the septic tank flows into a 1.5 foot layer of sewer rock, where aerobic bacteria filter pollutants. A mechanical aerator blows air into the gravel layer to provide oxygen for these aerobic bacteria. Nitrogen and Phosphorous is consumed by these bacteria, but also removed through uptake from plant roots that enter the gravel layer from the surface. Above the sewer gravel layer is 1 foot of peat/mulch which serves to stabilize plants and also prevents system freezing in the winter (Slagter Interview). Plants in the system mostly consist of cattails, although some other wetland plants such as bulrushes are intermixed. Diversity of species was higher when the system was first planted, but after the first winter cattails survived in greatest number (Slagter interview). After the water is filtered through the wetlands, it is lifted by pumps to sand filters for tertiary treatment. From May to October, warmer months when waterway usage is highest, the wastewater must be treated with chlorine to meet stricter MPCA standards. Finally, treated water flows in continuous discharge into the nearby Chetumba Creek.

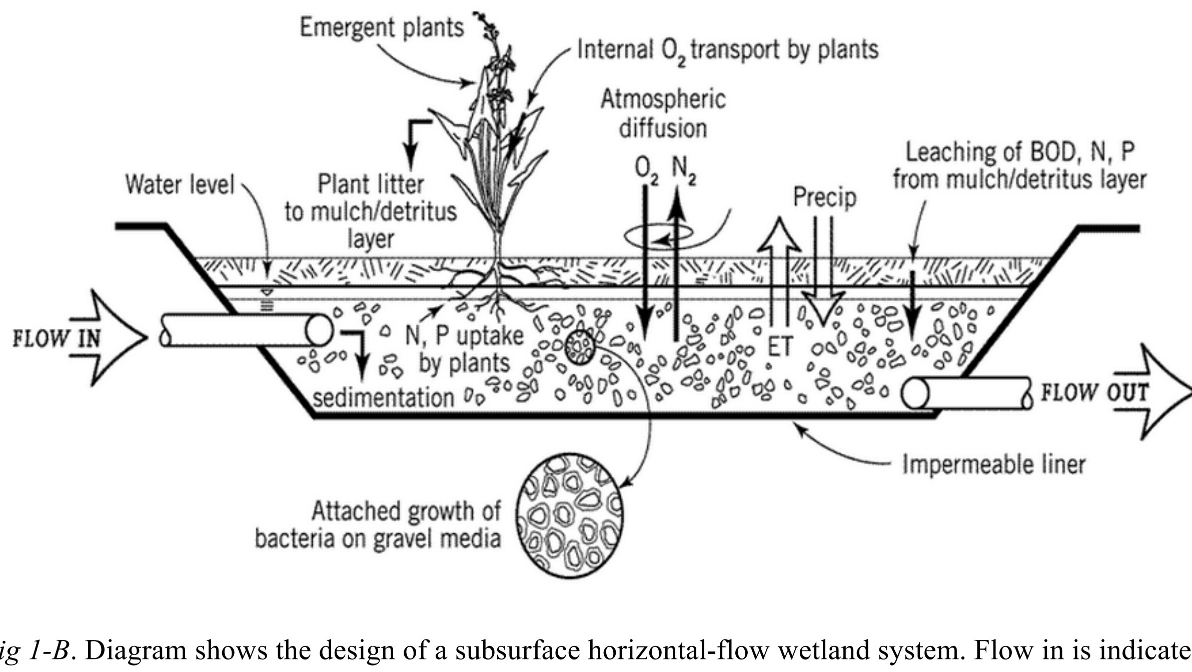

Fig 1-B. Diagram shows the design of a subsurface horizontal-flow wetland system. Flow in is indicated on the left, which in Prinsburg's case is water that has a majority of the solids removed through septic tanks. Flow out is water that has been filtered through the bacteria and plant roots in the gravel layer. Oxygen is added through a mechanical pump in Prinsburg's system as well. (Image from Triple-T sanitation company)

The constructed wetland system operator monitors flow, pH, Phosphorous, Total Suspended Solids (TSS), Dissolved Oxygen, and other indicators of system treatment. Large loads of organic material decrease dissolved oxygen levels making bacteria less efficient. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels can be tested as an indicator of water quality. Wetland systems have been found to be very reliable in the removal of BOD, COD, TSS, and organic materials (EPA 2000b). Natural wetlands facilitate denitrification, but this process is different in subsurface constructed wetlands because they are aerated. Constructed wetland technologies are generally less effective at removing Nitrogen and ongoing research about nitrification and denitrification in this system is working toward improving this process in constructed wetland systems (Austin, EPA 2000b).

In general, the Prinsburg system has very successful filtration, with 98% removal from day one (Slagter Interview). Nolan Slagter does day-to-day monitoring of the Prinsburg system, but Prinsburg also contracts out maintenance to a company called EcoCheck. They inspect the system two times per month, mostly maintaining the septic tanks that filter solids and organics. Tank filters must be cleaned about two times per year, and pumps about once per year. The actual wetland cells require careful regular observation, but not as much maintenance (Symmack Interview). Other required maintenance includes mowing and burning the area around the wetlands, which is done in the spring, checking the aeration blower system, observing wetlands for plant health and to prevent establishment of shallow-rooted invasive species, and adjusting water input levels so that the system does not freeze in the winter (Symmack Interview).

Fig 2-B. Prinsburg's constructed wetlands. Three of the four wetland cells are visible in the frame.

Fig 3-B. Prinsburg's wastewater treatment facility. In foreground is an entry to one of the septic tanks that lie belowground, behind is the sand filter with non-mowed grass on top.

Works Cited

Austin, David. "Nitrogen Removal Using Advanced Wetland Systems." Presentation. North American Wetland Engineering. Forrest Lake, Minnesota. http://www.dep.state.fl.us/water/watersheds/docs/ptpac/WetlandNitrogenRemoval_NAWE.pdf

Environmental Protection Agency. "Constructed Wetlands Treatment of Municipal Wastewaters." Manual. Office of Research and Development, Cincinnati, OH (2000).

Environmental Protection Agency. "Wetlands: Subsurface Flow." Wastewater Technology Fact Sheet. Office of Water, Washington, D.C. (2000).

Triple-T. "Sanitary Wastewater Treatment." http://www.wfigroup.net/Specialization/e_sanitarian_wetland.htm

Appendix C. Spatial Analysis

	Pennock	Prinsburg	Data
NLCD 2006 (NLCD Legend Land Cover Class Descriptions)	82 – Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled. 11 - Open Water - All areas of open water, generally with less than 25% cover or vegetation or soil	82 -Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.	NLCD 2006 (NLCD Legend Land Cover Class Descriptions)
Distance from town border	717 m	264m	Measure tool in ArcGIS
Watershed	Same watershed	Same watershed	National Hydrography Dataset
FTYPE of nearby feature	460 (river)	460 (river)	National Hydrography Dataset
Elevation	1130; relatively flat	1096; relatively flat	LiDAR 2011
Soils	Loam	Clay, Loam	USDA Natural Resource Conservation Service
CRA Site	Till Prairie	Till Prairie	USDA Natural Resource Conservation Service

Appendix D. Interview Protocol

General Interview Structure:
1) Personal History
2) Timeline of Events
3) Cultural Perception of Waste
4) Closing

Interview Note: Personal history, cultural perception, and closing questions are relevant for all interviews. Depending on an interviewee's role, we focus on their part of the timeline (ex: we focus on choosing the system and site with the engineering firm Bolton and Menk, while ignoring the questions about the initial process).

Personal history

1. In what capacity have you been involved in the wastewater treatment plant process?
2. How long?
3. What is your educational background/previous work experience?

Show timeline developed for each community… is this correct?

1. Initial process
    a. How were you notified that your community was not in compliance with MPCA regulations?
    b. What steps were taken next? Who did what? (ex: How were members of the wastewater committee chosen?)
    c. Assuming you had little prior experience with wastewater before this project, how did you learn more about this subject?
2. Consultants
    a. Did any organizations or agencies provide guidance about how the process worked? (perhaps… MPCA, Rural Development, Rural Area Water Association)
    b. How did you identify consultants? Choose consultants? (Ask to list several factors that were considered- ex: $, customer service, referred by acquaintance etc.)
3. Choosing the system
    a. Which systems were proposed for your community?
    b. What factors (financial, land availability, smell) were important to consider when choosing between systems?
    c. Was there a clear-cut solution for your community? Why/why not?
    d. Was there community input in this process? In what ways? What factors did the community identify as being important (ex: smells, utility rate increases, etc)?
4. Choosing the site
    a. How was the location of the facility chosen? Why that site? (utilize map)
5. Groups involved
    a. What were the roles and responsibilities of the various groups (city council, sewer/wastewater committees, etc.) involved in this process?
6. Funding the system

   a. What options were available to help finance this project?
   b. How did the community eventually choose to finance the project?
7. Installing and finalizing system
   a. How did the installation of the system go?
   b. How is the system functioning now? Is it functioning as expected?
   c. Do you think many community members are aware of the wastewater system? Why/why not?
   d. Does the system fit within the look of your community? Why/why not? What could be done to make it more visually appealing?
8. Is there anything else you'd like to add?

Cultural Perceptions of Waste

1. Show map of the town.
   a. All things being equal (cost, efficiency, etc.), where would you prefer your facility to be located—*in town, right outside of town, a few miles away*?
   b. Show map of town. What are the areas that you would let your kids play? Would you let your kids play in the area by the wastewater treatment system? Why?
2. Does your community manage stormwater? How? When was that system established?
3. Does your community have a recycling program?
4. Does your community have a town clean-up day (go around and pick up litter)?
5. Are there any environmental concerns within your community?

Closing

1. Is there anything else you'd like to add?
2. If we have further questions, would it be alright if we contacted you again?

Appendix E. Pennock Decision-making Timeline

Pennock Wastewater Treatment Timeline

Pre-1994: MPCA citation-lack of secondary sewage treatment

1994: Engineering feasibility study
Firms interviewed

1996: Bolton & Menk firm proposes 3 options: stabilization ponds, aeration ponds, sewer line connection with Willmar

1997-98: Bolton & Menk stabilization pond proposal accepted
Public hearings
Mayor and council member speak at State Legislature asking for special funding for a wastewater treatment system
Rural Development provides funding

1999: Public open houses- concerns expressed about sewer line location and billing rates
Quam Construction wins wastewater system construction bid
Residents' land assessed for hookup to public sewer system
MN Public Facilities Authority and Rural Development provide grants and loan funding

2000: Land purchased and annexed to city for treatment site
Stabilization pond system constructed

2001: City begins sewer billing
Wastewater consultant Woody Nelson hired part-time
MPCA requires stricter reporting on ponds

2002: Soil and Water Conservation tree planting around wastewater treatment ponds

Appendix F. Prinsburg Decision-making Timeline

Prinsburg Wastewater Treatment Timeline

1995: MPCA citation-lack of secondary sewage treatment
MN Rural Water Association advises
Wastewater Committee formed

1995-98: Engineering firms contacted
Bolton & Menk firm proposes stabilization or aeration ponds
(April '98)- Bolton & Menk pond proposal approved by City Council
(June '98)- North American Wetland Engineering (NAWE) firm hired by City Council
NAWE assists with identification of funding opportunities

1999: City Council decides on constructed wetland treatment system
MidMN Development Commission contracted for grant proposals and financing
Public hearings
NAWE communication with MPCA about constructed wetland systems

2000-02: Contract with Williamson Public Facilities for grant and loan applications
City Council and Wastewater Committee members tour other facilities

2003: MPCA issues a Notice of Violation- Prinsburg needs to accept higher billing rates and undertake an Environmental Assessment Study

2004: Rural Development and Wastewater Infrastructure Funds finalized
City Attorney Wayne Larson contracted for legal work on pending construction
Project approved by MPCA

2005: Contract with MN Rural Finance Authority for interim financing
Dunnick Bros. wins construction bid

2005-07: Construction progresses, unexpected costs arise
(2007) **Constructed wetland treatment system installed**

2008: Wastewater reuse project with Farmer's Coop

Appendix G. Interviewees

Brandt, Ryan- *EcoCheck*

Crowley, Kevin- *Mayor of Pennock*

DeWolf, Brad- *President/CEO Bolton and Menk Engineering*

Friesen, Kevin- *USDA Rural Development*

Gillingham, Brad- *MPCA Municipal Wastewater Compliance*

Hubbard, Ruth- *Executive Director Minnesota Rural Water Association*

Larson, Wayne- *Prinsburg City Attorney*

McCormick, Lisa- *MPCA Municipal Wastewater*

Meyer, Pam- *MPCA Engineer*

Nelson, Woody- *Pennock/Kerkhoven Wastewater Operator*

Schackman, Mike- *Pennock City Council*

Slagter, Nolan- *Prinsburg Maintenance Manager*

Symmank, Shane- *EcoCheck Project Manager*

Van Eps, Harvey- *Mayor of Prinsburg*

Van der Pol, Randy- *Prinsburg Wastewater Committee*

Wildman, Matt- *North American Wetland Engineering*