Running head: HAZARD ASSESSMENT FOR WATER RETENTION AND DETENTION PONDS

Hazard Assessment for Water Retention and Detention Ponds

Jeremy J. Hansen

Fox Valley Technical College, Appleton, Wisconsin

Town of Grand Chute Fire Department, Grand Chute, Wisconsin

Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expression, or writings of others.

Signed: ____

Abstract

The problem was the Town of Grand Chute had not implemented risk reduction measures to reduce injuries and deaths related to the increasing number of water retention and detention ponds. The purpose of the research is to determine the hazards and identify prevention methods to reduce the potential for injuries and deaths related to water retention and detention ponds. Descriptive Research was selected to answer the following four research questions: (a) what are the legal requirements for the water retention ponds, (b) what is the statistical population at risk within the community, (c) what access obstacles would be the most effective to reduce potential injuries and deaths, and (d) who would be responsible for pond-related injuries and deaths. The procedures used by the author included a literature review, personal interviews, and observational analysis. The research revealed ponds are constructed based on standards set by the Environmental Protection Agency's Clean Water Act. Standards are written primarily for improving water quality and not for the safety of the civilian population. Research suggested 77.8% of all exposed occupancies were residential. Most often, natural barriers are used to persuade people from entering the ponds. Legal liability begins with the design. To claim damages for negligence, the plaintiff must prove the proximate cause of injuries was due to the pond and a fail to act. Recommendations included developing pond specific water rescue training, publishing an article discussing pond safety and distributing to all occupancies, developing a curriculum for use in the elementary schools.

Table of Contents

Introduction

In 1997, the Town of Grand Chute created a sanitary district to address the issue of storm water management. One objective of the sanitary district was to construct storm water retention ponds for the purpose of slowing the influx of water produced during a storm event. While these retention ponds are successful at their designed purpose, the ponds create a new hazard for those who live in the community.

The problem is the Town of Grand Chute has not implemented risk-reduction measures to reduce injuries and deaths related to the increased number of water retention ponds.

The purpose of the research is to determine the hazards and identify prevention methods to reduce the potential for injuries and deaths related to water retention ponds.

Descriptive Research was selected to answer the following four research questions: (a) what are the legal requirements for the water retention ponds, (b) what is the statistical population at risk within the community, (c) what access obstacles would be the most effective to reduce potential injuries and deaths, and (d) who would be responsible for pond-related injuries and deaths.

Background and Significance

The Town of Grand Chute is located in the Fox River Valley region of Wisconsin, one of the largest and fastest growing urban centers in the state, supporting many nationally and internationally known corporations and businesses. The Fox Cities are located in eastern Wisconsin, approximately 100 miles north of Milwaukee and 30 miles south of Green Bay. The Town of Grand Chute is around 15,000 acres in size or 25 square miles. Of the 10,000 plus acres that fall within four major zoning categories, approximately 42% of the land is residential, 29% is agricultural, 23% is commercial, and 6% is industrial. The Town of Grand Chute's aggregate assessed value is just over $2.3 billion. According to the United States Census Bureau (2011) the population for the Town of Grand Chute was 14,490 in 1990, 18,392 in 2000, and estimated to be 20,917 in 2009. The growth indicates a 22% increase in population from 1990-2000 and a 31% increase from 1990-2009 as shown in Table 1.

Table 1

Town of Grand Chute Population Increase

Year	Population	Increase from Previous year	Increase from 1990
1990	14,490	0%	0%
2000	18,392	21%	21%
2009	20,917	12%	31%

The total housing in the Town of Grand Chute in 2000 was 7,965. The total housing units had an occupancy rate of 95%, and a 5% vacancy rate (United States Census Bureau, 2011). Owner-occupied housing accounted for 54% while renter-occupied housing accounted for 46% of the units. Between 2000 and 2004, 527 single-family homes were constructed. Another 324 single-family homes were constructed between 2005 and 2009 (United States Census Bureau, 2011). During the ten year period, 851 new single-family homes were built. This constitutes an increase of 11% in the total housing units and a 21% increase in the owner-occupied housing units.

The population characteristics in The Town of Grand Chute is comprised of 93% Caucasian, 3.5% Hispanic or Latino, 1.5% Asian, 0.8% African American, 0.4% American Indian and Alaska Native (United States Census Bureau, 2011). Other races, or a combination of several races, fill out the remainder of the population. According to the United States Census Bureau (2009), 5.8% to the population was under 5 years old, 15.6% of the population was 14 years old and younger, and 21.2% of the population was 19 years old and younger.

According to Conner, Cryer, and Langley (2007) drowning was estimated to be the second leading cause of injury death after road traffic injuries. In 2007, there were 3,443 fatal unintentional drownings in the United States, averaging ten deaths per day (Center for Disease Control and Prevention, 2010). Approximately 20% of the fatal drowning victims were children who were 14 years or younger. While that statistic is startling, for each fatality there are an additional four children that receive medical attention for a nonfatal water-related injury (Center for Disease Control and Prevention, 2010). The Center of Disease Control and Prevention (2010) reported that fatal drowning remains the second leading cause of unintentional injury-related death for children ages 1-14 years. Drowning is a leading cause of injury death among children between age 1 and 19. Children younger than 15 years old account for 25% of all drowning (Center for Disease Control and Prevention, 2003). In a publication produced by the Center of Disease Control and Prevention (2010) titled *Unintentional Drowning*, nearly 30% of all the fatalities of children 1 to 4 years old were due to drowning. The fatal drowning rates of African Americans children ages 5 to 14 is 3.1 times that of white children in the same age range. Among Americans Indians and Alaskan Native children, the fatal drowning rate is 2.2 times higher than white children (Center for Disease Control and Prevention, 2010).

This research relates directly to the Executive Analysis of Community Risk Reduction (EACRR) course. The course teaches community leaders to be proactive, to seek out problems before they become critical. Community risk reduction begins with analyzing the community and identifying potential hazards. The identified hazards are categorized based on the variables of frequency with which the event may occur, severity of the event, duration of the event, and the capacity for the community to respond to and manage the event (Federal Emergency Management Agency, 2009). Once a hazard is identified, risk reduction strategies must be put in place to mitigate the hazard. The EACRR course teaches the Concept of the Five E's (education, engineering, enforcement, economic incentives, and emergency response) to develop realistic, comprehensive, and effective solutions to the identified hazard (Federal Emergency Management Agency, 2009).

This research ultimately relates to the United States Fire Administration's Operational Goals and Objectives. Goal number one states "reduce risk at the local level through prevention and mitigation," goal number four states "improve the fire and emergency services' professional status," and goal number five states, "Lead the Nation's fire and emergency services by establishing and sustaining USFA as a dynamic organization" (United States Fire Administration, 2009, p. 14). The goals are further supported by objective 1.1 "encourage the State, local, and tribal adoption of risk reduction, prevention, mitigation, and safety strategies" (United States Fire Administration, 2009, p. 18), objective 4.1 "enhance the professionalism of the nation's fire and emergency service leaders" (United States Fire Administration, 2009, p. 21), and objective 5.1, "maintain a positive work environment to ensure the organization's well-being and productivity, and 5.2 "continuously improve our business systems and processes" (United States Fire Administration, 2009, p. 22).

Literature Review

Water retention and detention ponds have been widely used throughout the United States for many years (United States Environmental Protection Agency, 1999). Retention and detention ponds can be found throughout the United States, with the exception of arid climates. In arid regions, detention ponds are typically constructed to reduce flooding downstream (United States Environmental Protection Agency, 2006). Over the last several years there has been a significant increase in the number of water retention ponds dotting the urban landscape. A majority of the ponds have been constructed to satisfy local government regulations for storm water detention in new residential sub-divisions ("Storm water detention," 1998).

A properly located and well-constructed retention or detention pond can be an eye pleasing addition to landscaping ("Pond building," 1998). Good landscaping design technique must consideration of size of the pond, site visibility, relationship to the surrounding environment, and shoreline configuration. A pond that can be viewed from the home or road increases the beauty of the landscape and often increases the property value ("Pond building," 1998).

The difference between a retention pond and a detention pond is simple. The retention pond always has water in it and a detention pond only detains the water during rainy periods. Both retention and detention ponds are designed to help control the runoff and limit flooding during high water times. A detention pond will hold the water for a short time and then slowly release it, normally within 72-hours (State of Hawaii, 2009).

From a functional perspective, retention ponds have several advantages. The retention ponds are simple to operate; they have a low maintenance cost and high performance (National Aeronautics and Space Administration, 2007). Depending on the design, the retention pond normally serves three main purposes: to capture storm water to prevent flooding in low lying areas and around creeks and streams, to detain and slow the rate of runoff to reduce erosion and degradation of wildlife habitat, and to capture and hold sediment and other pollutants contained in runoff (“Implementing the phase II,” 2003).

According to the Nonpoint Source News-Notes (“Implementing the phase II,” 2003), the Nation’s leading source of water quality degradation is from runoff. Capturing and holding the runoff during a storm event, the detention ponds control both the storm water quantity and quality (United States Environmental Protection Agency, 1999). Most detention ponds function to trap pollutants in the runoff, such as nutrients, metals, and sediments (“Storm water detention,” 1998).

A retention pond is a permanent pool of water that is designed to improve water quality by treating storm water runoff. Retention ponds are designed to hold rain water that has runoff from the surrounding lawns, roads, parking lots, and roof tops (“Storm water detention,” 1998). A water retention pond is a shallow basin that protects water resources from storm water runoff. Retention ponds are often fairly small in total acreage, typically less than an acre. One function of the pond is to control the release of pollutants from this runoff into the environment. Retention ponds have no outlets or streams; water collects in the pond and is released through atmospheric phenomenon such as evaporation or infiltration (National Aeronautics and Space Administration, 2007). A retention pond allows sediment to settle out of the storm water. It allows for pollutants to be filtered out of the runoff through natural biological activity in the pond (Lexington-

Fayette Urban County Government, 2009). The United States Environmental Protection Agency (2006) stated incoming storm water in a retention pond is treated by allowing particles to settle out and the pond's algae to process nutrients.

Wet detention ponds are storm water control structures providing both retention and treatment of contaminated storm water runoff. The pond consists of a permanent pool of water into which storm water runoff is directed (Wisconsin Department of Natural Resources, 2010). Runoff from each rain even is detained and treated in the pool until it displaced by runoff from the next storm. By catching and detaining runoff during storm events, detention ponds control both storm water quantity and quality. The excess water held in the pond is slowly released to the nearby waterway. In this way, the detention pond reduces the speed in which the runoff enters the natural waterways. This protects areas downstream from flooding and erosion ("Storm water detention," 1998). The pond's natural physical, biological, and chemical processes work to remove pollutants. Sedimentation processes remove particulates, organic matter, and metals, while dissolved metals and nutrients are removed through biological uptake.

According the article *Other sources of information about west nile virus and detention ponds*, published by the Wisconsin Department of Natural Resources (2010), a higher level of nutrient removal and better storm water quantity control can be achieved in wet detention ponds than can be achieved with dry ponds, infiltration trenches, or sand filters. Some benefits of a detention pond include a decreased potential for downstream flooding and stream bank erosion and improved water quality due to the removal of suspended solids, metals, and dissolved nutrients (United States Environmental Protection Agency, 1999).

The process for choosing a pond site is as important, if not more important, than the actual construction process ("Pond building," 1998). Pond construction should begin with assessing the safety of the location, the water-holding capacity of the soil, the geological makeup and topography of the pond site, and the characteristics of the drainage area ("Pond building, 1998). Proper construction of the pond must be preceded by proper planning and design. Major consideration must be paid to the size, shape, and water control structure requirements. The topography is the single most important factor of the pond construction since the amount of earthmoving that is required will ultimately determine the construction cost. Other costs such as clearing, site preparation, pipe, concrete, other construction materials, and landscaping are often minor when compared to the excavating and earthmoving cost ("Pond building," 1998).

Generally, ponds should be deep enough to maintain open water areas and limit the resuspension of sediment by wind or waves. According to the article *Storm water detention ponds*, published by the Illinois Environmental Protection Agency (1998) the average depth should be at least 4 to 5 feet and a maximum depth of eight feet. In concert with the depth, the United States Environmental Protection Agency (2006), recommends that ponds are always designed with a length-to-width ratio of at least 1.5:1. Often times retention and detention ponds are built near each other in a row. The water is held up in the detention pond to help eliminate flooding and slowly drains in the retention pond. The use of multiple ponds in a series as part of a "treatment train" approach can slow the rate of flow through the system (United States Environmental Protection Agency, 2006).

Shoreline is one of the most important aspects of erosion control. Pond shorelines should have a very gradual slope, ideally 5:1 ("Storm water detention," 1998). The gradual slope allows for an easier establishment of vegetation and provides some safety, allowing those who enter the pond an easy way out. Guo et al. (2006) agree the slope inside the basin should not exceed a 3:1 vertical slope. This slope minimizes erosion and allows heavy equipment access to periodic sediment removal with minimal submerged cleanout.

Reducing erosion by establishing stabilizing vegetation is difficult if pond shorelines are too steep. Stabilizing the shoreline can be accomplished by a combination of a properly sloped pond and by planting native wetland plants along the shoreline. Deep-rooted prairie grasses on the pond side slopes should, in most cases, are adequate to stabilize eroding detention pond shorelines ("Storm water detention," 1998). Plant species native to the region have evolved and adapted to local conditions over thousands of years and are usually much more tolerant of the prevailing weather extremes in a given location ("Implementing the phase II," 2003). Once established, most native species usually require no irrigation beyond normal rainfall, and, because they typically grow more slowly, require less maintenance and generate less yard waste.

The height and density of the vegetation can be increased progressively from the water's edge to the undistributed vegetation. The shape of the pond should complement its surroundings. Irregular shapes with smooth, flowing shorelines are generally more compatible with natural landscaping ("Pond building," 1998). Erosion and signs of degradation can contribute to a decline in the pond's visual appeal ("Storm water detention," 1998). However, proper landscaping can make the ponds an asset to the community and can also enhance the pollutant removal. A vegetative buffer should be preserved around the pond to protect the banks from erosion and provide some pollutant removal before the runoff enters the pond (United States Environmental Protection Agency, 2006).

All retention and detention ponds need maintenance. The responsibility for long-term inspection and maintenance depends on the local ordinance ("Storm water detention," 1998). The local municipality or parks district may have the responsibility of planting and maintaining the ponds structure. However, the surrounding homeowners' association or property owners may be responsible for trash pickup and mowing.

Retention and detention ponds are the drainage basin for an area, and tend to be a magnet for items like garbage. Trash and debris are washed into other areas after heavy rain and wind events. Trash and debris should be removed routinely to maintain an attractive appearance and to prevent the outlet from becoming clogged. According to the United States Environmental Protection Agency (1999), retention and detention ponds should be inspected after each rain event.

The Outagamie County, Wisconsin, Subdivision Ordinance (1997) states the maintenance, including mowing any grass or clearing the drains of debris, is the responsibility of the property owners of the land division (Chapter 37, Section 18.35(2)(j)). The Lexington-Fayette Urban County Government (2009) identifies the property owner as responsible for non-structural maintenance such as mowing, litter removal, algae removal, tree limbs removal, and landscaping. In addition, maintenance may also include control of algae growth and insects, and odors (United States Environmental Protection Agency, 1999).

The County and/or Town of Grand Chute retain the rights to perform the maintenance and repairs if the property owners fail to comply with the local ordinance (Outagamie County, Wisconsin, Subdivision Ordinance, 1997). The costs associated with the maintenance can be assessed among the property owners of the land. If a specific cause can be identified, then the payment shall be assessed to a specific property (Outagamie County, Wisconsin, Subdivision Ordinance, 1997).

The governing body is responsible for structural maintenance such as repairing erosion, removing excess silt, and removing large debris (Lexington-Fayette Urban County Government, 2009). Occasionally, sediment accumulated in the bottom of the pond needs to be removed. The frequency depends on how well soil erosion and sedimentation controls are working at the site (“Storm water detention,” 1998). The United States Environmental Protection Agency (1999) estimates the sediments in the bottom of a permanent pool should be removed about every 2 to 5 years. This data is contradicted by the article *Storm water detention ponds* (1998) where it states sedimentation removal may not be needed more often then 10 to 20 years, depending on how much sediment the pond was designed to store.

Regardless of who performs it, maintenance of a retention or detention pond must be completed to ensure the proper operation, acceptable aesthetics, and water quality effectiveness of the detention pond. The Illinois Environmental Protection Agency (“Storm water detention,” 1998) recommends several simple maintenance activities that should be performed.

- Inspect the discharge point periodically and after storms, and remove any debris that may be blocking water from escaping.

- Inspect the pond shoreline for erosion, and stabilize as needed.
- Inspect for and remove trash and debris.
- Monitor the shoreline and side slopes for vegetation and conduct supplemental planting as needed for the first three years. Then, inspecting once a year should be adequate.
- Remove nuisance plants. Native plants may require mowing or prescribed burning.

The State of Hawaii (2009) recommends that each pond is inspected annually to verify that the person responsible for the ongoing maintenance of the retention or detention pond is completing the task.

Ponds, like any body of water, tend to attract people of all ages (“Pond building,” 1998). For this reason, there is always a chance of injuries or drowning. Whether it is a detention pond, retention pond, or a swimming pool, it is difficult to predict what a young child passing by may do. Water retention and detention ponds do not have desirable water quality. The water may appear to be green, muddy, or cloudy. This is caused by sediment, algae, and other particles suspended in the water (“Storm water detention,” 1998). If the pond is large enough and contains fish, bottom-feeding fish, specifically the carp species, can cause a lot of turbulence in the water while they search for food.

Retention ponds can remove 30 to 80% of certain pollutants from the water before they enter nearby streams (National Aeronautics and Space Administration, 2007). According to the Illinois Environmental Protection Agency (“Storm water detention,” 1998) and National Aeronautics and Space Administration (2007) the removed pollutants include sediments, bacterias, greases, oils, chemicals, and metals. These sediments and contaminants can settle out of the water and become trapped in the soil and accumulate. These pollutants can bioaccumulate and have a negative effect on the overall water quality, subsequently affecting plants, animals, and human life (National Aeronautics and Space Administration, 2007). Therefore, swimming in a retention or detention pond is highly discouraged.

The water may contain a mixture of chemical and biological waste. This may be the result of saturated ground, over-taxed sewage and septic systems, or commercial or industrial runoff. People and first responders who are exposed to water from a retention or detention ponds could expect to contract an illness. In the Emergency Operations Manual, *Book 8: Inland water rescue and emergencies*, the Fire and Rescue Departments of Northern Virginia (2009) list several common illnesses associated with exposure to contaminated water:

- Gastrointestinal illnesses following ingestion of the contaminated water.
- Infectious hepatitis or aseptic meningitis from viruses in sewage-contaminated water.
- Leptospirosis following exposure to waters contaminated by animal urine.
- Intestinal bacteria such as E. Coli, Salmonella, Shigella, Hepatitis A Virus, and agents of typhoid, paratyphoid, and tetanus.

The United States Environmental Protection Agency (2006) believes regions with a cold climate pose another challenge. The spring snow melt may have large pollutant loads which can rapidly overwhelm the pond. In addition, high concentrations of road salt and road sanding may impact pond vegetation as well as reduce the storage and treatment capacity of the pond.

Both retention and detention ponds have received a lot of press regarding their potential as breeding grounds for mosquitoes. Concerned parties are raising questions about whether the benefits of these ponds are worth the potential risks associated with mosquitoes that rely on water for hatching grounds (“Implementing the phase II,” 2003). In the article *Mosquitoes associated with storm water detention/retention areas,* published by the University of Florida IFAS Extension (2003) adds validity to the concern by stating, the widespread use of storm water systems may lead to the increase of the mosquito population, unless adequate precautions are taken. Mosquito proliferation in stormwater ponds is a concern, especially when so many wet and dry ponds are in place and continue to be installed across the country. In general, the concern surrounds the potential for creating a mosquito breeding habitat due to the shallow and stagnant standing water, thus increasing the potential risk to adjacent community of exposure to the West Nile virus (“Implementing the phase II,” 2003).

Overall, abundant populations of mosquitoes are more frequently associated with retention systems than they are with detention systems. Since the retention ponds are constructed to have water in them at all times, it would be difficult to completely eliminate the mosquito habitat. For this reason, it is especially important to conduct effective mosquito prevention programs by applying pesticides to control the early life stages of the mosquito (“Implementing the phase II,” 2003).

Properly designed, operated, and maintained ponds are not conducive to standing water and as such should not be fertile breeding grounds for mosquitoes (“Implementing the phase II,” 2003). Regulations relating to the design and construction of detention ponds stipulate that storm water inflow must be dissipated within 72 hours so to accommodate a new volume of incoming storm water ("Mosquitoes associated with storm," 2003). Guo et al. (2006) believe it is important to design the pond to drain the water in less than 72 hours to eliminate or reduce the potential of maintaining a mosquito breeding ground.

Safety and legal liability begin with the design of the pond. Engineers who fail to account for public safety when designing water retention or detention ponds put themselves, their clients, and their employers at considerable risk (Guo et al., 2006). According to the article *Pond building: A guide to planning, construction, and maintaining recreational pond* (1998) the owner of the pond may be liable in a case of injury or death resulting from use of the pond whether or not use of the pond was authorized. In addition to the property owner, failure to properly address pond-related risks could leave all parties involved with the design, construction, and maintenance subject to legal liability in the event of an injury or death (Guo et al., 2006).

Retention and detention ponds can be a successful method for managing storm water. However, the ponds can be dangerous and pose a risk to public health, safety, and the welfare of people. Urban storm drainage system planners, designers, facility owners, maintenance staff, and municipalities, including their elected officials and governing bodies, must be aware of such risks and insist on the use of recommended techniques to minimize them (Guo et al., 2006). The Center for Disease Control and Prevention (2003) suggests one intervention to prevent drowning deaths includes the removal of the hazard; creations of barriers and protection of those at risk. Commonly employed strategies are water safety education, fencing of water hazards, and wide-spread teaching of the resuscitation techniques (Conner, Cryer & Langley, 2007).

Guo et al., (2006) believe there is a lack of public education relating to the hazards associated with water retention and detention ponds. Community education can be a valuable tool. Guo et al., (2006) suggest educational activities should focus on those children who are most at risk. Prevention efforts need to utilize local radio and television stations to broadcast short public service announcements that emphasize what hazards accompany storm drainage facilities. Informational flyers that explain the risks related to the ponds should be distributed to home owners' and the home owner's association.

The Center for Disease Control and Prevention (2010) states formal swimming lessons can help protect young children from drowning. Bernard, Paulozzi, and Wallace (2007) agree and recommend providing swimming lessons to children aged four years or older. However, Guo et al., (2006) suggest there is no substantial research to confirm swimming lessons lessen the risk of drowning. It seems obvious that for an individual, swimming ability would be protective in a drowning situation. However, it is likely that the ability to swim also reduces one's fear of the water, reduces that likelihood of adaptive supervision, and affects the choice of activities undertaken (Guo et al., 2006).

One thing that can be agreed upon is the supervision of those at risk. Drowning prevention measures should include carefully supervising children around any water source (Bernard, Paulozzi, & Wallace, 2007). Supervisors of children should provide "touch supervision," meaning they should be close enough to reach the child at all times. Adults should not be involved in any distracting activities, such as reading, playing cards, talking on the phone, or mowing the lawn, while supervising children (Center for Disease Control and Prevention, 2010). The Center for Disease Control and Prevention (2010) reported most children who drown were last seen in the home, had been out of sight for less than five minutes, and were in the care of one or both parents at the time.

Depending on their size, water retention and detention ponds could be mistaken for recreational bodies of water. The ponds should be clearly marked with warning signs that prohibit swimming (State of Hawaii, 2009). The warning signs should inform people that the ponds may fill suddenly with deep water, and should include educational interpretative signs that explain how the retention pond works (Guo et al., 2006).

Unsafe conditions may be present in and around the ponds during dry and wet weather. Most ponds have items such as inlet and outlet/overflow pipes that are unprotected (Guo et al., 2006). Due to normal curiosity, children may enter an unprotected pipe or they may be drawn in due to the water's current. Preventing this hazard can be accomplished by installing a guard over the pipe's opening ("Pond building," 1998). Bars on the face of an inlet or outlet pipe should provide an opening between them of 4-5 inches (Guo et al., 2006). When possible, integrate the pipes into an outlet structure that has multiple small openings and a sloping trash rack at the pipe entrance. The rack should have a surface area that is many times larger than the surface area of the outlet pipe. Guo et al. (2006) argue a larger rack can reduce the velocity of the water flowing into it and minimize the risk of a person being pinned against the rack. The larger rack allows some water to pass through if some of the surface area is covered with trash or debris.

Even with constant supervision and children who have completed swimming lessons, barriers such as a fence are necessary to protect people (Center for Disease Control and Prevention, 2010). In some cases, the construction of retention and detention ponds occurs where there are limitations on space. Typically, these ponds are built with a steep slope on one or more sides. A fence should be used to create a barrier and deter adults and children from wandering too close (Guo et al., 2006). The Center for Disease Control and Prevention (2010) suggests the pond be surrounded by a fence that is a minimum of four feet tall. The State of Hawaii’s Injury Prevention Panel recommends that retention ponds have enclosures similar to those that are required for residential swimming pools, with a four-sided fence at least four feet high that allows access through one or more locked gates (State of Hawaii, 2009).

The Indiana Builders Association does not believe fencing is an adequate means of protection (Associated Press, 2011). It believes fencing could even endanger children who might find a way into a fence-lined pond. The Indiana Builders Association believes the barrier fence, built to keep children out, may become a barrier to the firefighter attempting to perform a rescue (Associated Press, 2011). Guo et al. (2006) state if a situation does occur where public safety agencies are needed; these rescue agencies may be impeded by a fence. Additionally, the barrier may also limit the children’s ability to self-rescue from the pond.

Aesthetically pleasing fencing or railing can be useful in the attempt to keep people out of harm’s way. However, the cost for some of the fencing may prohibit the use of it. Most homeowners do not want cheap looking fencing visible from their window. This can lower property values and ruin the view. In place of using fencing, some have chosen to plant thick shrubs (Guo et al., 2006). Planting of vegetative barriers, from the top of the bank to the water's edge around the perimeter of wet-bottom ponds without a security fence, is highly recommended (State of Hawaii, 2009). Guo et al. (2006) and the

State of Hawaii (2009) states a zone of vegetative barriers serve as potential obstacles to persons or animals who may consider entering the water. The vegetation shall preferably be planted in a manner that does not disguise the pond's edge. The approach can create a wildlife habitat and provide an attractive natural shoreline (Guo et al., 2006).

Water retention and detention ponds that are in public areas must be designed for safety. The ponds need to have shallow, slow slopping sides of 8:1 to 12:1 to enhance safety and allow for easy egress if people happen to fall in (Guo et al., 2006). In their article, Guo et al. (2006) explain slopes that are too steep can be hazardous to people who are performing general maintenance, including removing accumulated trash or mowing the lawn. Where the slopes need to be more aggressive, safety rails need to be installed (Guo et al., 2006).

Retention and detention ponds are often integrated into spaces that are frequented by the public. Examples of places where one might find a pond would be parks, bike and walking trails, playgrounds, apartment building complexes, and residential sub-divisions (Guo et al., 2006). Guo et al. (2006) recommend modifying the location of the ponds to reduce the risks to the public. There should be a reasonable attempt to separate certain lands, such as schools and daycares, from the area where ponds are constructed. The State of Hawaii (2009) requires ponds to have a one-hundred-foot-wide buffer in the design surrounding the pond to separate it from schools, childcare facilities, homes, parks, athletic fields, or housing projects. In addition, trails and sidewalks need to be separated from all storm water detention facilities by not less than 25-feet, measured from the one hundred year storm water line (State of Hawaii, 2009).

Water retention and detention ponds have been widely used across the United States (United States Environmental Protection Agency, 1999). According to the National Aeronautics and Space Administration (2007) the ponds are simple to operate; have low maintenance costs; reduce or prevent pollution from entering the rivers, streams, lakes, and ground water; and reduce flooding. When designing the ponds, engineers must pay special attention to size and shape and not forget about safety ("Pond building," 1998). Maintenance of the ponds is normally handled by both the property owner and local government ("Storm water detention," 1998). There are many hazards associated with water retention and detention ponds. Guo et al. (2006) state the ponds can be dangerous and pose a risk to public health, safety, and the welfare of people. The risks from the ponds can be reduced using a multi-system approach, including pond design, maintenance, barriers, and education.

Procedures

The procedures used to meet the goals of this research were built on the APIE (Analysis, Planning, Implementation, and Evaluation) change model. An executive analysis of potential hazards within the Town of Grand Chute determined there was a potential risk of the population interacting with water retention and detention ponds. The problem statement, "the problem was the Town of Grand Chute had not implemented risk reduction measures to reduce injuries and deaths related to the increasing number of water retention ponds," was created to drive the research.

During the planning process to mitigate the identified problem, a vision or purpose statement of change was developed. The purpose statement, "the purpose of the research was to determine the hazards and identify prevention methods to reduce the potential for injuries and deaths related to water retention and detention ponds.," was developed to answer the question of what was expected to be accomplished during the research. More specifically, four questions were developed to identify particular areas to be addressed: (a) what are the legal requirements for the water retention ponds, (b) what is the statistical population at risk within the community, (c) what access obstacles would be the most effective to reduce potential injuries and deaths, and (d) who would be responsible for pond-related injuries or deaths. Descriptive Research was selected to answer the questions.

Interviews were implemented as a method of gathering information about water retention and detention ponds, specifically codes, standards, and regulations that govern the ponds. An in-depth analysis of the problem statement, purpose statement, and research questions was performed to develop the interview questions.

A personal interview was conducted with Thomas Marquardt, Director of Public Works, Town of Grand Chute, Grand Chute, Wisconsin on May 11, 2011 (Appendix A). Mr. Marquardt and the Town of Grand Chute were selected for several reasons. First, the focus of the applied research project centers around the Town of Grand Chute and its statistics. Within the Town of Grand Chute, the Director of Public Works is responsible for the construction and maintenance of the ponds. Mr. Marquardt is an educated individual whose fourteen plus years of prior experience as the Director of Public Works for a total of two municipalities within Wisconsin allows him to be able to share his experience from both communities.

A personal interview was conducted with Nick A. Vande Hey, Senior Project Engineer, McMahon and Associates, Neenah, Wisconsin on May 19, 2011 (Appendix B).

Mr. Vande Hey was selected based on information found during the literature review. An internet search produced a PowerPoint presentation from March 5, 2008 that was prepared by Mr. Vande Hey and presented to the Town of Menasha. McMahon and Associates has been used by the Town of Grand Chute and other local municipalities to design water retention or detention pond systems. Mr. Vande Hey has worked for McMahon and Associates for 15 years and in a similar position for two years in Washington D.C. He is a council member for the Northeast Wisconsin Stormwater Consortium and the Fox Wolf Watershed Alliance.

To determine the population at risk, the author performed an in-depth analysis of the census data for the Town of Grand Chute. The author used the United States Census Bureau website to gather information related to the population of the Town of Grand Chute. The data was stratified into specific age categories, populations of each age group, and percentages that each age group accounted for within the total population (Appendix C). The author searched the Center of Disease Control and Prevention website for statistical date related to drowning. The data collected from the United States Census Bureau was collated with information gathered from the Center of Disease Control and Prevention to determine the population at risk.

The procedure for determining if the statistical population at risk would interact with a water retention or detention pond began with performing an exposure analysis. Data for the analysis was obtained from Thomas Marquardt, Director of Public Works and Richard Trilling, Assistant Chief of Prevention, both from the Town of Grand Chute. Assistant Chief Trilling and Director Marquardt worked with additional Town of Grand Chute staff to gather maps for the research. Additional contacts were made with individuals from Outagamie County, Wisconsin, Planning and Zoning Departments. In both cases they referred the author back the Town of Grand Chute.

The location of the water retention and detention ponds was determined by observing their locations as plotted on the Town of Grand Chute's 2011 Stormwater Management Plan. The map was provided to the author by Assistant Chief Trilling. The map measured 14.5 inches by 10.5 inches (Appendix D). It contained all of the roads, highways, lot boundaries, and ponds for the Town of Grand Chute.

The Stormwater Management Plan map was used in conjunction with the map index. The map index pages are used by the Grand Chute Fire Department to respond to emergency incidents. The fire department map index lists all of the streets in the Town of Grand Chute alphabetically, and in some cases for longer streets, by address block numbers. Each map page represented a small area of the Town of Grand Chute. The map pages showed address numbers, street names, and lot boundaries. The legend on the map indicated that one inch was equivalent to 450 feet. The maps measured 8.2 inches (3,690 feet) by 7.5 inches (3,375 feet). The pages have a one-inch (450-foot) overlap around all four edges of each map page with the adjoining map page. An example of one of the map pages can be viewed in Appendix E. A total of 128 map pages were reviewed. The map index was last updated and printed on February 15, 2011.

The fire department map index broke the Town of Grand Chute into 128 pages, or sections, which created a grid system for observing pond locations. Taking one map index page at a time, and starting from the southeastern most corner of the Town of Grand Chute, the author observed the location of the ponds on the Stormwater Management Plan map and plotted the pond on the fire department map index pages.

The location of the pond was based on its represented position on the Stormwater Management Plan map in relationship to road curves and lot boundaries. It was then transferred to the fire department index map. Verification of the pond location was performed by utilizing the Town of Grand Chute's Geographic Information System (GIS) webpage. The GIS was last updated with aerial photographs in the summer of 2010. The author attempted to visually identify the pond to more accurately place it on the fire department map index.

Ponds used within this research were randomly selected. The process started by taking one page from the fire department map index, starting with the highest page number, and plotting it onto the Stormwater Management Plan map containing the pond locations. Ponds were selected by working from the southeastern corner of the map index and working to the northwest. When multiple ponds existed on a single map index page, the first pond was selected and then every third. The total amount of water retention or detention ponds within the Town of Grand Chute was 349 (Appendix D). The total number of ponds studied was 104 or 29.8%.

The name given to the location of each pond was based on the closest street address. A circle was drawn from the approximate center of the pond using a locking compass. Research was not able to determine what a "safe" distance from a pond was. For that reason, the author personally chose to use a 500-foot radius from approximate center as the measuring distance. This produced a measuring area that contained a 1,000-foot-diameter circle. This process was repeated for all 128 pages of the fire department map index. The locking compass was recalibrated to the 500-foot radius (1,000-foot diameter) every five map index pages. A map index page with the 500-foot exposure circles drawn on it can be viewed in Appendix E.

The buildings that had fallen within the circle were identified and counted. The structures were broken into several categories including:

- One and Two Family
- Multi-Family
- Hotels/Motels
- Commercial
- Places of Assembly, also broken down into:
    - Educational
    - Daycares
    - Other (including restaurants, pub, churches, etc.)
- High-rises

The GIS was used to verify the existence of the structure. In a few cases, there was an address assigned to a lot but the GIS did not show a structure. The open lot was not counted. GIS, and the author's personal knowledge of the Town of Grand Chute, was used to verify the category of the structure. In some instances, the distances between the ponds meant the measured circles of two or more ponds would overlap. A structure that fell in multiple measured circles was counted in each circle. The information was accumulated in a Microsoft Excel spreadsheet (Appendix F).

The author contacted the Town of Grand Chute's attorney, three law firms in the region, two others within the State of Wisconsin, University of Wisconsin – Marquette law professors, Wisconsin League of Municipalities, and Wisconsin Towns' Association in an unsuccessful attempt to obtain a legal opinion of liability related to water retention and detention ponds. Liability-related opinions listed in the results sections are based on tort law cases for water retention and detention ponds found during an internet search.

The evaluation step of the APIE change model will be used in the future to measure the results of this research. An evaluation tool would be developed based on the recommendations.

Limitations

There are possible limitations to the research. The information listed in this research is based on the opinions of the individuals interviewed. Information gathered during the interviews assumed the individuals had the requisite knowledge to accurately respond to each question. It was assumed the individuals interviewed gave the necessary time to fully answer the interview questions and provided an accurate account of what their organization believes is accurate and current techniques and procedures.

The research focused only on the Town of Grande Chute and is an accurate representation of the Town of Grand Chute. The data may not be representative of other municipalities. The pond exposure data was obtained by using the most current aerial views of the Town of Grand Chute. The GIS webpage showed the aerial photos were taken in 2010. The age of the aerial photos means the statistical data may not be completely accurate for 2011 structural construction.

The pond locations were taken from the Stormwater Management Plan. The author made a significant effort to place the pond in the correct location. The pond was located onto the fire department map index by carefully observing lot lines and lot configurations. It is possible the pond was not placed in the exact location as it was on the Stormwater Management Plan map. A variance of just a few feet could skew the number of exposed structures.

Only structures inside the Town of Grand Chute borders were counted. In a few instances, ponds near the borders had structures within the 500-foot boundary that were not counted because they did not fall within the Town. The research did not take into account the size of the land parcels. Commercial lots are often larger than residential lots, thus creating more exposures for a land area zoned residential as compared to commercial land. Each structure was counted only once. Whether it was a multi-family structure with four units or thirty, the structure was only counted once within the 500-foot circle. This also holds true for a commercial building. Whether it was one company or a strip mall with multiple shops under one roof, it was counted only once.

Results

The purpose of the research was to identify hazards and prevention methods to reduce the potential of injuries and deaths related to water retention and detention ponds. The research was driven by four questions.

The research revealed that water retention and detention ponds are constructed based on standards set by the Environmental Protection Agency's Clean Water Act and the recommendations from the Wisconsin Department of Natural Resources (T. Marquardt, personal communication, May 11, 2011). N. Vande Hey (personal communication, May 19, 2011), stated Wisconsin is regulated by the federal requirements of the EPA's Clean Water Act. The main purpose of the standards is to protect property from water runoff. Essentially, the ponds are a flood-control measure meant to improve water quality by removing suspended solids, including the pollutants from water runoff. Wet Detention Code 1001 provides guidance for pond construction (N. Vande Hey, personal communication, May 19, 2011). The Town of Grand Chute follows the stormwater utility regulation section of the Town's ordinance. The ordinance references the regulations put in place by the Wisconsin Department of Natural Resources, specifically NR 151 and 216 (T. Marquardt, personal communication, May 11, 2011 and N. Vande Hey, personal communication, May 19, 2011).

A review of the standards and regulations found they were written with the primary purpose of improving water quality and providing a method for reducing the total suspended solids during peak flows for post-construction sites (Wisconsin Department of Natural Resources, 2007). The standards lack any reference to safety measures or obstacles to protect the civilian population.

The research focused on the potential interaction between the water retention and detention ponds and the civilian population. In the Town of Grand Chute, 5.8% of the population is under of the age of 5 years, 5.1% of the population is between the ages of 5 and 9 years, 4.7% of the population is between the ages of 10 and 14 years, and 5.6% is between 15 and 19 years. A total of 21.2% of the population is age 19 and under.

An exposure analysis observed 104 ponds or 29.8% of the total water retention and detention ponds within the Town of Grand Chute. Only ponds within the Town of Grand Chute were included in this research. Information obtained for the research was placed into a Microsoft Excel spreadsheet.

Results for the Stormwater Management Map (Appendix D), the Grand Chute Fire Department's map index (Appendix E), and the data available from the Town of Grand Chute GIS shows the civilian population does have the potential to interact with the water retention and detention ponds. The research looked at the type of occupancy and if there was an exposure to a water retention or detention pond. The total number of exposed structures and the percent of the overall sample can be viewed in Table 2.

Table 2

Pond Exposure by Occupancy Type as a Percentage

Occupancy	Exposures	Percent
1-2 Family	944	61.9
Multi-family	243	15.9
Hotel/Motel	5	0.3
Commercial	316	20.7
Place of Assembly	16	1.0
High-rise	1	0.1

The exposure sample of 104 ponds was used to determine the rate of exposure. As long as one structure of a specific type was found to be within the exposure circle, the occupancy type was considered to have an exposure to that particular pond. One-two family occupancy had 57 exposure incidents for a rate of 54.8%. Multi-family occupancies had 30 exposure incidents for a rate of 28.8%. Hotel/Motels had three exposures for a rate of 4.8%. Commercial occupancies had 43 exposure incidents for a rate of 41.3%. Places of Assembly had nine exposure incidents for a rate of 8.6%. Places of Assembly were broken down into three sub-categories that included educational facilities, daycares, and other. Educations facilities had one exposure incidents for a rate of 0.9%. Daycares had three exposure incidents for a rate of 2.8%. Other occupancies, that included restaurants, pubs, or churches, had 11 exposure incidents for a rate of 4.9%. High-rise occupancies had one exposure incident for a rate of 0.9%. The aforementioned data can be viewed in Table 3.

Table 3

Rate of Exposure as a Percentage of the Total Sample Listed by Occupancy Type

Occupancy	Exposures	Percent
1-2 Family	57	54.8
Multi-family	30	28.8
Hotel/Motel	3	4.8
Commercial	43	41.3
Place of Assembly	9	8.6
High-rise	1	0.9

In many cases, the occupancy type had multiple buildings exposed to a single pond. Table 4 illustrates the average number of buildings exposed to each pond. It should be noted, the size of each building not taken into consideration. A multi-family structure may contain four or forty families. The true number of persons exposed it still unknown.

Table 4

Average Number of Exposed Structures per Incident Listed by Occupancy Type

Occupancy	Incidents	Structures	Average
1-2 Family	57	944	16.56
Multi-family	30	243	8.1
Hotel/Motel	3	5	1.7
Commercial	43	316	7.35
Place of Assembly	9	16	1.8
High-rise	1	1	1

According to T. Marquardt (personal communication, May 11, 2011) the pond must be constructed with a 3:1 (horizontal:vertical) slope above the water line. There must be a 10:1 slope below the water line and the 3:1 slope after the ten-foot-depth mark is reached. This data is confirmed in the Wet Pond 1001 standard. It recommends the side slopes below the safety shelf shall be 2:1 or flatter and the interior side slope above the safety shelf shall be 3:1 or flatter (Wisconsin Department of Natural Resources, 2007).

Most often, natural barriers are used to dissuade people from wading into the ponds (T. Marquardt, personal communication, May 11, 2011). N. Vande Hey (personal communication, May 19, 2011) believes access obstacles should be made of natural materials. For one, there are no fences around pond, lakes, or rivers. The ponds, lakes, and rivers are much larger and deeper than a water retention or detention pond (N. Vande Hay, personal communication, May 19, 2011). Access obstacles, such as tall grasses and barberry or other thorny bushes can be used. It is up to the authority having jurisdiction to decide what cost they are willing to incur in order to secure the pond (T. Marquardt, personal communication, May 11, 2011).

T. Marquardt and N. Vande Hey agree (personal communication May 11, 2001 and personal communication May 19, 2011) fences or other permanent obstacles may hinder first responders from performing a quick rescue if someone needs help. Both agree that fences may need to be installed if there is an uncommon situation that could potentially add danger. N. Vande Hey (personal communication May, 2011) gave an example of a business that is discharging warm water that in colder climates could make ice conditions unpredictable. If there is an exposure to a large number of children, like a daycare, schools, or playground, a fence may be considered (T. Marquardt, personal communication, May 11, 2011). N. Vande Hey (personal communication, May 19, 2011) would give more consideration to fences if they are retrofit ponds that are going into an existing area. The Wet Pond 1001 standard recommends additional safety features beyond the safety shelf where conditions warrant them (Wisconsin Department of Natural Resources, 2007).

N. Vande Hey (personal communication, May 19, 2011) believes top soil can be used as an obstacle. This opinion is reinforced in the Wet Pond 1001 standard; it states top soil must be spread on all distribution areas above the safety shelf to a minimum depth of four inches (Wisconsin Department of Natural Resources, 2007). Incorporating 12 inches of top soil on top of the safety shelf will produce a mucky situation for anyone who decided to enter the pond. This hostile condition may persuade an individual to reconsider before entering into the deepest parts of the pond. While the top soil does not restrict access it does make it quite unpleasant (N. Vande Hey, personal communication, May 19, 2011). The addition of thorny brush and tall grasses can increase its effectiveness (N. Vande Hey, personal communication, May 19, 2011).

Kozlowski (1985) cites from the case of *Cope v. Doe* (1984), where the court ruled the owner of a land parcel had no duty to remedy a condition that presents an obvious hazard. The court believed there are many dangers encountered during normal daily activities that are fully understood and can be appreciated by any age. The rationale for this ruling is that, since individuals are expected to avoid obvious dangers there is no reasonable risk of harm (Kozlowski, 1985). The law then is there are no damages awarded for injuries caused by a danger found to be obvious.

Under Illinois law, owners of land generally do not owe a duty to protect individuals from falling into bodies of water and drowning or potentially drowning (*Ahmed v. Pickwick Place Owners' Association and Vista Property Management, Inc.*, 2008). The potential of drowning in a body of water is normally considered an open and obvious risk that individuals should appreciate and avoid. The law does not require persons to warn or protect against possible injuries and death from open and obvious conditions. An opinion from *Bucheleres v. Chicago Park District* (1996) the condition itself would carry its own warning of potential harm (*Ahmed v. Pickwick Place Owners' Association and Vista Property Management, Inc.*, 2008). In the case of *Cope v. Doe* (1984), Kozlowski (1985) cites, the danger presented by drowning in the retention pond was open and obvious and that the plaintiff and the victim should appreciate the danger given their inability to swim.

There is no liability for drowning in a pond or reservoir under the attractive nuisance doctrine (*Wilford v. Little*, 1956). A pond, although artificial, is no different from those natural ponds and streams that exist everywhere. A pond cannot be rendered inaccessible to people by any ordinary means any more than a river or lake. Therefore, to render it safe, it must be filled, drained, or essentially destroyed (*Wilford v. Little*, 1956). As with other common dangers that exist in nature, it is the duty of parents to supervise and warn their children. The court found in *Wilford v. Little* (1956) that failing to do so; the guardian should not expect to hold others responsible.

In order to recover damages for negligence, the court cited the case of *Marshall v. Burger King Corp.* (2006), where the plaintiff must prove the defendant owed a duty to act, the defendant breached that duty, and that the breach was the proximate cause of the plaintiff's injuries (*Ahmed v. Pickwick Place Owners' Association and Vista Property Management, Inc.*, 2008). Failing to prove a wet pond is a dangerous condition, as needed to prove negligent liability, but rather an open and obvious hazard, would result in there being no liability to the property owner for an injury or death related to the pond

(Kozlowski, 1985). In the case of *Sanchez v. East Contra Costa Irrigation Co.* (1928) negligence was proven. A victim's body was found in a siphon that transported water under a cross-stream. The court ruled the defendant had created a concealed danger in the nature of a trap (siphon) to those who lived close by, and one that could easily be guarded (*Wilford v. Little*, 1956).

Discussion

Water retention and detention ponds have been widely used throughout the United States for many years (United States Environmental Protection Agency, 1999). In 1997, the Town of Grand Chute created a sanitary district to address the issue of storm water management. The objective was to construct stormwater retention and detention ponds for the purpose of reducing the total suspended solids within the water and controlling water runoff from a storm event (Wisconsin Department of Natural Resources, 2007). Retention ponds are designed to hold rain water that has runoff from the surrounding lawns, roads, parking lots, and roof tops ("Storm water detention," 1998). While the retention and detention ponds were successful at their designed purpose, the ponds created a new hazard for those who live in the community.

The research suggests that water retention and detention ponds are constructed based on standards set by the EPA's Clean Water Act and the recommendations from the Wisconsin Department of Natural Resources (T. Marquardt, personal communication, May 11, 2011). N. Vande Hey (personal communication, May 19, 2011), stated Wisconsin is regulated by the federal requirements of the EPA's Clean Water Act.

According to the article *Storm water detention ponds,* published by the Illinois Environmental Protection Agency (1998) the average depth should be 4-5 feet with a maximum depth of 8 feet. The United States Environmental Protection Agency (2006), recommends that ponds are always designed with a length-to-width ratio of at least 1.5:1. Pond shorelines should have a very gradual slope, ideally 5:1. A shoreline that is designed too steep makes it difficult to reduce erosion by establishing stabilizing vegetation ("Storm water detention," 1998). Guo et al., (2006) agree the slope inside the basin should not exceed a 3:1 vertical slope. The sediments in the bottom of a permanent pool should be removed about every 2 to 5 years (United States Environmental Protection Agency, 1999).

In the State of Wisconsin, Wet Detention Code 1001 provides guidance for pond construction (N. Vande Hey, personal communication, May 19, 2011). Town of Grand Chute follows the stormwater utility regulation section of the Town's ordinance. The ordinance references the regulations put in place by the Wisconsin Department of Natural Resources, specifically NR 151 and 216 (T. Marquardt, personal communication, May 11, 2011 and N. Vande Hey, personal communication, May 19, 2011). A review of the standards and regulations found they were written with for the purpose of improving water quality by reducing the total suspended solids during peak flows (Wisconsin Department of Natural Resources, 2007). The standards lack specific references to safety measures for the civilian population.

The Outagamie County, Wisconsin, Subdivision Ordinance (1997) states the maintenance is the responsibility of the property owners of the land parcel (Chapter 37, Section 18.35(2)(j)). The Lexington-Fayette Urban County Government (2009) identifies the property owner as responsible for non-structural maintenance such as mowing, litter removal, algae removal, tree limbs removal, and landscaping. The United States

Environmental Protection Agency (1999) states maintenance may also include control of algae growth, insects, and odor . The County and/or Town of Grand Chute retain the rights to perform maintenance if the property owner(s) fail to comply with the ordinance (Outagamie County, Wisconsin, Subdivision Ordinance, 1997). Any costs associated with the maintenance can be assessed among the property owners of the land. If a specific cause can be identified then the payment shall be assessed to a specific property (Outagamie County, Wisconsin, Subdivision Ordinance, 1997).

The research focused on the potential for interaction between the water retention or detention ponds and the civilian population. Ponds, like any body of water, tend to attract people of all ages (“Pond building,” 1998). For this reason, there is always a chance of injuries or drowning.

According to the United States Census Bureau the total population of the Town of Grand Chute was 20,465. The Center for Disease Control and Prevention (2010) reported fatal drowning remains the second leading cause of unintentional injury-related death for children ages 1-14 years. Approximately 20% of the fatal drowning victims is a child who is 14 years or younger. In the Town of Grand Chute the population at risk within the 1-14 age group is 15.6% or 3,193. Drowning is a leading cause of injury death among children between age 1 and 19. The Town of Grand Chute population at risk within this age group is 4,339 or 21.2%. In a publication produced by the Center of Disease Control and Prevention (2010) titled *Unintentional Drowning*, nearly 30% of all the fatalities of children 1-4 years old were due to drowning. The Town of Grand Chute population at risk within the 1-4 age group is 1,187 or 5.8%.

An exposure analysis suggested what occupancy types had the greatest exposure to the ponds. A total of 104 or 29.8% of the water retention and detention ponds in the Town of Grand Chute were observed. The research suggested the most threatened occupancy types are one- and two-family and multi-family structures. Of the 1524 observed exposures, 61.9% were one- and two-family occupancies. Another 15.9% of observed exposures were multi-family occupancy. Between the two occupancy types, the research suggested 77.8% of all exposure occupancies were residential in nature.

The exposure sample of 104 ponds was used to determine the rate of exposure. The research revealed one- and two-family occupancies had 57 exposure incidents for a rate of 54.8%. Commercial occupancies had second highest with 43 exposure incidents for a rate of 41.3%. Multi-family occupancies had 30 exposure incidents for a rate of 28.8%. Next, the number of structures exposed per exposure incident was determined. Here again, one- and two-family occupancies lead with an average of 16.56 structures exposed per pond. Multi-family occupancies moved back into the second place with 8.1 structures exposed per pond.

It needs to be said, the size of the multi-family building has not been taken into consideration. A multi-family structure may contain four or more families. The true number of persons exposed it still an unknown. However, based on the above data, it can be concluded the population of the Town of Grand Chute has the opportunity to interact with water retention and detention ponds.

Water retention and detention ponds that are in public areas must be designed for safety. The State of Hawaii (2009) require ponds to have a one hundred-foot-wide buffer surrounding the pond to separate it from schools, child care facilities, homes, parks, athletic fields, or housing projects. Guo et al., (2006) recommend modifying the location of the ponds to reduce the risks to the public. In areas where the ponds and people will interact, the ponds need to have shallow, slow-sloping sides of 8:1 to 12:1 to allow for easy egress if people happen to fall in (Guo et al., 2006). T. Marquardt (personal communication, May 11, 2011) believes the pond must be constructed with a 3:1 slope above the water line, a 10:1 slope below the water line, and the 3:1 slope after the ten-foot-depth mark is reached. The Wet Pond 1001 standard recommends the side slopes below the safety shelf shall be 2:1 or flatter and the interior side slope above the safety shelf shall be 3:1 or flatter (Wisconsin Department of Natural Resources, 2007). Guo et al., (2006) explain slopes that are too steep can be hazardous to people who are performing general maintenance.

The Wet Pond 1001 standard recommends additional safety features beyond the safety shelf where conditions warrant them (Wisconsin Department of Natural Resources, 2007). Fences may be considered if there is an exposure to a large number of children, like a daycare, schools, or playground (T. Marquardt, personal communication, May 11, 2011). N. Vande Hey (personal communication, May 19, 2011) would give more consideration to fences if they are retrofit ponds that are going into an existing area.

The Indian Builders Association believes a fence, built to keep people out, may become a barrier to the firefighter attempting to perform a rescue (Associated Press, 2011). T. Marquardt and N. Vande Hey agree (personal communication May 11, 2001 and personal communication May 19, 2011) fences or other permanent obstacles may hinder first responders from performing a quick rescue if someone needs help. Both agree that fences may need to be installed if there is an uncommon situation that potentially adds danger. Additionally, the barrier may also limit a child's ability to self-rescue from the pond (Guo et al., 2006).

N. Vande Hey (personal communication, May 19, 2011) believes access obstacles should be made of natural materials. Most often, natural barriers are used to persuade people from wading into the ponds (T. Marquardt, personal communication, May 11, 2011). Guo et al., (2006) recommends planting thick shrubs rather than using fencing. The State of Hawaii (2009) recommends planting vegetative barriers from the top of the bank to the water's edge around the perimeter of wet-bottom ponds without a security fence. Guo et al., (2006) and the State of Hawaii (2009) states a zone of vegetative barriers serve as potential obstacles to persons or animals who may consider entering the water. Access obstacles, such as tall grasses and barberry or other thorny bushes can be used. It is up the authority having jurisdiction to decide what cost they are willing to incur in order to secure the pond (T. Marquardt, personal communication, May 11, 2011).

N. Vande Hey (personal communication, May 19, 2011) believes top soil can be used as an obstacle. The Wet Pond 1001 Standard states top soils must be spread on all distribution areas above the safety shelf to a minimum depth of four inches (Wisconsin Department of Natural Resources, 2007). N. Vande Hey (personal communication, May 19, 2011) believes incorporating 12 inches of top soil on top of the safety shelf will produce a mucky situation. This condition may help deter an individual entering into the deepest parts of the pond. The addition of thorny brush and tall grasses can increase its effectiveness (N. Vande Hey, personal communication, May 19, 2011).

Guo et al., (2006) state most ponds have inlet and outlet/overflow pipes that are unprotected. Children may enter the unprotected pipes due to their normal curiosity or they may be pulled in due to the water's current. This hazard can be eliminated by installing a guard over the pipe opening ("Pond building," 1998). Guarding on the face of an inlet or outlet pipe should provide an opening between them of no more than 4 to5 inches (Guo et al., 2006). Outlet pipe structures need to be constructed with multiple small openings. A surface area that is many times larger than the surface area of the outlet pipe can reduce the velocity of the water flowing into it and minimize the risk of a person being pinned against the rack (Guo et al., 2006).

The research suggested public education relating to the hazards associated with water retention and detention ponds can help reduce the risk (Guo et al., 2006; Cryer & Langley, 2007). The educational activities should focus on those children who are most at risk. Prevention efforts need to utilize radio and television stations to broadcast public service announcements that emphasize the hazards that are associated with water retention or detention ponds. Informational flyers should be distributed to home owners and the home owners' association notifying them of the risks related to the ponds (Guo et al., 2006).

Legal liability begins with the design. Engineers who fail to account for safety when designing a water retention or detention pond put themselves and others at considerable risk (Guo et al., 2006). In order to receive damages for negligence, the plaintiff must prove the defendant owed a duty to act, the defendant breached that duty, and that the breach was the proximate cause of the plaintiff's injuries (*Ahmed v. Pickwick Place Owners' Association and Vista Property Management, Inc.*, 2008). Kozlowski (1985) stated failing to prove the wet pond was a dangerous condition would result in there being no liability to the property owner for an injury or death related to the pond.

The research suggested there is no liability for drowning in a pond or reservoir under the attractive nuisance doctrine (*Wilford v. Little,* 1956). Kozlowski (1985) cites from the case of *Cope v. Doe* (1984), where the court ruled the owner of a land parcel had no duty to remedy a condition that presents an obvious hazard. Under Illinois law, owners of land do not owe a duty to protect individuals from falling into bodies of water and drowning or potentially drowning (*Ahmed v. Pickwick Place Owners' Association and Vista Property Management, Inc.*, 2008). In the case of *Cope v. Doe* (1984), Kozlowski (1985) cites the danger presented by drowning in a body of water is normally considered an open and obvious risk. The law does not require persons to warn or protect against possible injuries and death from open and obvious conditions. The condition itself would carry its own warning of potential harm (*Ahmed v. Pickwick Place Owners' Association and Vista Property Management, Inc.*, 2008). The research suggested a pond, although man-made, is no different from those natural ponds, rivers, or lakes that exist everywhere. Since individuals are expected to avoid dangers that are open and obvious, there is no reasonable risk of harm (Kozlowski, 1985). There are no damages awarded for injuries caused by a danger found to be obvious.

Recommendations

The following recommendations resulted from the research conducted to determine the hazards and identify prevention methods to reduce the potential for injuries and deaths related to water retention ponds. While this research looked into the legal requirements for the water retention ponds, the statistical population at risk within the community, access obstacles that would be the most effective to reduce potential injuries and deaths, and who would be responsible for pond related injuries and deaths, the research indicates the following recommendations:

1. By the end of this fiscal year, the Town of Grand Chute's Battalion Chief of Safety and Training will develop water rescue training that is specific to the hazards associated with water retention and detention ponds and all members of the fire department will receive the training.
2. By next spring, the Town of Grand Chute's Fire Prevention Specialist will develop an article that will be published in the Town's news letter and will send an informational brochure discussing pond safety to all occupancies in the Town of Grand Chute.
3. By the end of the next school year, the Town of Grand Chute's Fire Protection Specialist will develop a water retention and detention pond curriculum for use in the Town of Grand Chute elementary schools.

The research led to the recommendation of the development of a training and education program for fire department members and elementary schools children. Future readers could assist with the development of an evaluation tool that could be used to determine if the training and education program is effective. Future readers could assist with the development of a local ordinance requiring a fence to be included for ponds constructed near places where children congregate. This may include schools, daycares, or playgrounds. Research is needed to determine what would be considered an acceptable safe distance to construct an unprotected pond or the appropriate height the fence would need to be.

References

Ahmed v. Pickwick Place Owners' Association and Vista Property Management, Inc., No. 10-07-2047 (3d. Ill. 2008).

Associated Press (2011, January 11). Lawmakers want homeowners to pay for pond safety. *WANE-TV*. Retrieved from http://www.wane.com/dpp/news/homeowners-to-pay-for-pond-safety

Bernard, S., Paulozzi, L., & Wallace, L. (2007, May). Fatal Injuries Among Children by Race and Ethnicity – United States, 1999-2002. *Morbidity and Mortality Weekly Report, 56(SS05).* Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5605a1.htm

Center for Disease Control and Prevention, National Center for Injury Prevention and Control. (2003). *Injury research agenda: Preventing injuries in sports, recreation, and exercise.* Retrieved from http://www.cdc.gov/ncipc/pubres/research_agenda/Research%20Agenda.pdf

Center for Disease Control and Prevention, National Center for Injury Prevention and Control. (2010). *Unintentional drowning: Fact sheet.* Retrieved from http://www.cdc.gov/HomeandRecreationalSafety/Water-Safety/waterinjuries-factsheet.html

Conner, J., Cryer, C., & Langley, J. (2007). *International comparison of injury deaths: Drowning.* Retrieved from University of Otago, Department of Preventive and Social Medicine website: http://www.cdc.gov/nchs/data/ice/Int_comp_Combined_9_07_2_%20w.pdf

Federal Emergency Management Agency. (2009). Executive Analysis of Community Risk Reduction Student Manual 1st Edition. Washington D.C.: Federal Emergency Management Agency.

Fire and Rescue Departments of Northern Virginia, Emergency Operations Manual. (2009). *Book 8: Inland water rescue and emergencies.* Retrieved from http://docs.google.com/viewer?a=v&q=cache:84lEUzkLrDoJ:www.loudoun.gov/controls/speerio/resources/RenderContent.aspx%3Fdata%3D8d280fdc56f94af4877a01b2ee657597%26tabid%3D286%26fmpath%3D%252Ffire%2Band%2Brescue%2Bcommission%252F2009%2Bcommission%2Bmeeting%252Fseptember%2B2009%252Fmeeting%2Bpacket+water+rention+pond+hazards&hl=en&gl=us&pid=bl&srcid=ADGEESgEq5UU7lSN9YUHMaDHnqNIjOBg2aW04dJdIf_ssYstsq6Pukkw217e8C2GWvyITXSftBfzci5yVls5k1TxK6cmjJIi7-y1uKe_H31G91NhC3W7jvuKTvPVKAHiuAZDpOwY5rfZ&sig=AHIEtbQkh2AlKtWTK4bW2o9oWCCSK3rPhA

Guo, J., Jones, J., Pittinger, R., & Urbonas, P. (2006, January/February). Safety at urban stormwater ponds. *Storwater.* Retrieved from http://www.udfcd.org/resources/pdf/conferences/conf2006/5-1%20Jones%20Safety%20Considerations.pdf

Implementing the phase II stormwater rule – One city's experience. (2003, May). *Nonpoint Source News-Notes.* Retrieved from http://www.epa.gov/owow/info/NewsNotes/pdf/71issue.pdf

Kozlowski, J. (1985) *Retention pond drowning case studies*. Retrieved from University of George Mason, Law Review website: http://classweb.gmu.edu/jkozlows/lawarts/03MAR85.pdf

Lexington-Fayette Urban County Government, Storm Water. (2009). *Detention basins & retention ponds*. Retrieved from http://www.lexingtonky.gov/index.aspx?page=1773

Mosquitoes associated with storm water detention/retention areas. (2003, May). *University of Florida IFAS Extension.* Retrieved from http://edis.ifas.ufl.edu/mg338

National Aeronautics and Space Administration. (2007). *NASA's potentials contributions for remediation of retention ponds using ultraviolet radiation and photocatalysis.* Retrieved from http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080008856_2008008507.pdf

Outagamie County, Wisconsin, Subdivision Ordinance. (1997). *Required improvements: Surface water drainage restriction.* Retrieved from http://www.co.outagamie.wi.us /zoning/codes/subdivisionordinance.htm#REQUIRED IMPROVEMENTS

Pond building: A guide to planning, construction, and maintaining recreational ponds. (1998, August) *Alabama Cooperative Extension System*. Retrieved from http://www.aces.edu/pubs/docs/A/ANR-1114/ANR-1114.pdf

State of Hawaii, The Senate Twenty-Fifth Legislative. (2009). *A bill for an act relating to detention and retention ponds* (S.B. No. 1057). Retrieved fromhttp://www.capitol.49utaga.gov/session2009/bills/SB1057_.HTM

Storm water detention ponds. (1998, June). *Illinois Environmental Protection Agency.* Retrieved from http://www.epa.state.il.us/water/conservation/lake-notes/stormwater –detention-ponds.pdf

United States Census Bureau, American Fact Finder. (2009). *American Community Survey 2005-2009.* Retrieved from http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=06000US5508730075&-qr_name=ACS_2009_5YR_G00_DP5YR5&-ds_name=ACS_2009_5YR_G00_&-_lang=en&-redoLog=false&-_sse=on

United States Census Bureau, American Fact Finder. (2011). *Fact sheet: Grand chute, Outagamie county, Wisconsin.* Retrieved from http://factfinder.census.gov/servlet/SAFFFacts?_event=&geo_id=06000US5508730075&_geoContext=01000US%7C04000US55%7C05000US55087%7C06000US5508730075&_street=&_county=Grand+Chute&_cityTown=Grand+Chute&_state=04000US55&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=060&_submenuId=factsheet_1&ds_name=ACS_2009_5YR_SAFF&_ci_nbr=null&qr_name=null&reg=&_keyword=&_industry

United States Census Bureau, American Fact Finder. (2011). *Population estimates.* Retrieved from http://factfinder.census.gov/servlet/DTTable?_bm=y&-geo_id=06000US5508730075&-ds_name=PEP_2009_EST&-mt_name=PEP_2009_EST_G2009_T001

United States Environmental Protection Agency. (1999). *Stormwater technology fact sheet: Wet detention ponds.* Retrieved fromhttp://www.epa.gov/owm/mtb/wetdtnpn.pdf

United States Environmental Protection Agency, National Pollutant Discharge Elimination System. (2006). *Wet ponds.* Retrieved from http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=68

United States Fire Administration. (2009). *America's Fire and Emergency Service Leaders Strategic Plan Fiscal Years 2009-2014*. Retrieved from http://www.usfa.dhs.gov/downloads/pdf/strategic_plan.pdf

Wilford v. Little, Civ. No. 21469 (2d. Cal. 1956).

Wisconsin Department of Natural Resources, Conservation Practice Standard, Storm Water Management Technical Standards. (2007). *Wet Detention Pond 1001*. Retrieved from http://www.dnr.state.wi.us/runoff/stormwater/techstds.htm

Wisconsin Department of Natural Resources, Runoff Management. (2010). *Other sources of information about west nile virus and detention ponds.* Retrieved from http://dnr.wi.gov/run off/stormwater/wnvlinks.htm

Appendix A
Personal interview with Thomas J. Marquardt

Name: Mr. Thomas J. Marquardt

Position: Director of Public Works

Organization: Town of Grand Chute, WI

Date: May 11, 2011

Time: 0800 hours

1. **How long have you been in your current position?**

   Mr. Marquardt has worked in his current position with the Town of Grand Chute for the past four years. Prior to this job, Mr. Marquardt worked as the Director of Public Works for the City of Cedarburg, Wisconsin for ten years.

2. **What is your level of education?**

   Mr. Marquardt received a Bachelor's degree in Civil Engineering from the University of Wisconsin – Madison and a Master's degree in Business from the University of Wisconsin Madison – Edgewood.

3. **What is the most current population for the Town of Grand Chute?**

   The unofficial results from the 2010 census have the population of the Town of Grand Chute at 20,956. The official census data should be arriving soon.

4. **Who is responsible for the ponds during the construction phase and when they are completed?**

   During the construction phase of a retention or detention pond, the site developer would be responsible for the ponds. This may be a general contractor or a specific excavating company depending on how and why the pond is being constructed. Upon completion of the pond the responsibility, or liability, related to the pond could fall on the hands of two different entities. First, if there is a subdivision association that manages the area, they would be responsible for the upkeep, maintenance, and liability. The other option would be for the developer to do a deed transfer to the Town of Grand Chute in which case the Town of Grand Chute would take over the maintenance, upkeep, and liability. When this occurs, the occupant of the subdivision would receive a bill or tax assessment for any cost incurred by the Town of Grand Chute.

After the pond is complete the party responsible for the pond must complete any maintenance related to the pond. This would include treatment of the water, if needed, and the removal of settled solids by dredging. For most ponds dredging would occur every 10-15 years. Some ponds may have to be dredged more often depending on the size, use, and contamination of the runoff.

5. What codes and standards apply to the ponds and what conditions do they impose?

The Town of Grand Chute follows the regulations set by the stormwater utility section of the Town's ordinances and the regulations put in place by the Wisconsin Department of Natural Resources (DNR). Specifically, NR 151 and 216 that relate to stormwater management. Both of these regulations follow the standards set by the EPA's Clean Water Act.

6. What laws govern the construction of the pond?

The contractors follow the recommendations of the Wisconsin Department of Natural Resources.

7. Have there been any incidents of injuries or deaths due to, or related to, the retention pond?

None that I am aware of.

8. How are the water retention or detention sites chosen?

The primary way a site is selected is based on determining the water shed, or how the water will drain throughout the community. Ponds which are constructed after the surrounding area has been developed are based on the watershed, what properties are available, and the cost to acquire the properties. All new developments incorporate the ponds as part of the planning process when developing a site plan. The newer ponds are figured into the cost of construction.

9. Who is responsible for injuries or deaths related to the ponds?

I am not an attorney, but I would believe whoever the contractor would be during the construction of a pond and whoever is the property owner after construction is complete.

10. Who pays for the cost of constructing the ponds?

In new construction the developer adds the cost of the pond(s) into the cost of the development. Retrofitting ponds into an existing area is covered by the sanitary district. Sanitary district funding comes from a portion of the water bill for that occupancy. Additional funding may come in the form of grants from the [Wisconsin] Department of Natural Recourses.

11. How is the size of the pond determined?

The size of the pond is based on a couple of factors. First, studies are done to determine the watershed for the 100-year storm. The categories of how they determine the 100-year storm are currently in limbo. It appears that we are having the 100-year storm every few years. So they are looking at whether the flow needs to be reevaluated. Another consideration is the amount of pavement that is in the vicinity. More pavement would mean the pond would fill up quicker due less water being absorbed because of the lack of porous soil. We also have to look at the availability of land. We may have to create several smaller ponds to meet the regulations

12. What is the size range of ponds constructed in the Town of Grand Chute?

The pond sizes are based largely on the available land. The smallest pond in the Town of Grand Chute is the size of a residential lot; about one-quarter of an acre. The largest pond is around seven acres in size.

13. Is there a specified distance the ponds need to be from certain occupancy types (i.e. daycare, residential homes, etc.)?

None, but we will try to fence those ponds that will be constructed near places where kids would frequent. In the city of Cedarburg there were restrictions on how close a pond could be constructed in relation to schools, daycares, and playgrounds.

14. How many ponds were in the Town of Grand Chute during year 2001, 2006, and 2011?

I'm not sure. I'll have to get back to you with that data.

15. Are there more plans to construct more ponds?

Yes, both in new subdivisions and in established areas of the Town of Grand Chute. Established areas of the Town of Grand Chute have requirements to meet the removal of 40% of suspended solids that are found in the water. New constructions developments must meet the 80% of the removal of suspended solids.

16. What access obstacles are required to be installed during construction and who requires them?

None, there are no requirements. The pond itself must be constructed with a 3:1 slope above the water line. It must have a 10:1 slope below the water line and the 3:1 slope after the ten-foot depth mark is reached. As far as access obstacles, natural barriers like tall grasses and barberry bushes are used. It is up to the authority having jurisdiction to decide what cost they are willing to incur in order to secure the pond. A few years ago, one of the planning commissioners pushed for an ordinance to have fencing a requirement on all ponds. She had a grandchild in Arizona or Florida that drowned in a retention pond. However, that did not pass.

17. Does appearance figure into the design and selection of the obstacles?

Absolutely, it's a consideration. Depending on where the pond is going to be placed, it may be designed to look like nothing more than a hole or a depression in the ground. One property owner in a commercial area on the west side of the Town of Grand Chute built a large decorative rock wall, installed a water fountain and water fall, and added the company's sign on the wall. The business essentially incorporated the pond into the landscaping of the property. Really, you can do anything that you want with the pond as long as it meets the requirements of the intended purpose. It all depends on what you're willing to spend.

18. In your experience, what are other organizations using for obstacles?

I don't know of anyone using anything other than natural barriers. There may be an occasional fence installed due to its proximity to children, but those are very rare instances.

19. Research related to pool safety suggests fencing, gates, and/or signage may reduce the chance of injury or deaths. Have those types of obstacles even been considered for retention ponds?

Yes, we have considered those types of obstacles. Some of the ponds do have one some, or all of the ones you mentioned. However, the costs associated with them make it cost prohibitive to install them on all ponds. Secondly, we have a concern that if someone would fall into a pond and need to be rescued, the fences and gates may actually prevent the fire department from making a quick rescue.

Appendix B
Personal interview with Nick A. Vande Hey

Name: Mr. Nick A. Vande Hey

Position: Senior Project Engineer

Organization: McMahon and Associates

Date: May 19, 2011

Time: 1500 hours

1. **How long have you been in your current position?**

   Mr. Vande Hey has worked in his current position with McMahon and Associates since 1996. Prior to his current employment, Mr. Vande Hey worked in a similar position in Washington D.C. for two years. Mr. Vande Hey is a council member for the Northeast Wisconsin Stormwater Consortium and the Fox Wolf Watershed Alliance.

2. **What is your level of education?**

   Mr. Vande Hey received a Bachelor's degree in Civil and Environmental Engineering from the University of Wisconsin – Madison.

3. **What codes and standards apply to the ponds and what conditions do they impose?**

   Wisconsin is regulated by the federal requirements of the EPA's Clean Water Act. Specifically in Wisconsin, we are regulated under Administrative Rule NR 151 which is published and enforced by the Wisconsin Department of Natural Resources. The conditions the rules enforce are aimed at protecting property from water runoff. It is essentially a flood control measure. The rule is also meant to improve water quality but removing suspended solids, including pollutants, from the water runoff.

4. **Are there any local ordinances that govern the ponds?**

   None that I am aware of. The Town of Menasha does not have any. [The Town of] Grand Chute does not have any, but they do occasionally require a fence similar to a swimming pool. Occasionally communities may have something relating to how close a pond can be to a well. That is less for safety then it is for water quality concerns.

5. What laws govern the construction of the ponds?

The Standards Oversight Council (SOC) oversees the development, maintenance, and distribution of technical standards that support water conservation programs. SOC does not write standards, but only oversees the process. Essentially, the SOC provides guidance and input into the development of standards. Wet Detention code 1001 provides the framework to contractors during pond construction.

6. How are the water retention or detention sites chosen?

During a new development the pond site is figured into the overall site plan. The selection process gets more difficult when attempting to place a pond in an existing development. The easiest method is to look for open land within the existing development. If there is land, a determination must be made if it is a wet land, has a creek or stream, or if it has hazardous materials on it. One must look at the water shed and determine how much runoff will need to be captured. Next, who owns the property? If the local government does, that makes it all the easier. If not, how much does the property owner want for the land? The local government does have the right to use eminent domain, but that is not often looked upon favorably by the community so it is not the first choice. The concepts will be presented to the public for their feedback. After all of the information on all of the potential properties are compiled we [McMahon and Associates] will rank the properties according to what would be the best choice. We [McMahon and Associates] would base our ranking on a combination of categories including location, cost of the land, cost of construction, availability, and public input. Ultimately, the governing body will make the final decision on where the ponds are built.

The size of the pond is determined by the land use. Commercial and industrial areas will have more pavement surrounding them. The pavement will cause more water to runoff and will require a larger pond to be constructed. Residential areas have more green space to absorb the rain and runoff needing less of a pond to be constructed.

7. Is there any need to obtain a permit?

Yes, several permits may be needed. Including site/project dependent, erosion control, pond permit, wetland permits, shoreline permits, and depending on the size of the pond dam permits may be needed. Again, if a dam permit is needed, the size of the pond, will determine what category of dam permit is needed.

8. Is there a specified distance the ponds need to be from certain things (daycare, residential home, etc.)?

None. However, in one case a pond was going to be constructed near an existing daycare. Due to the open water hazard the pond would create, the daycare staff to child ratio would change. Ironically, the daycare moved to their current location because a pond was constructed next to their old site. After input from the business, the Town of Grand Chute decided to also install a fence around the entire pond. The fence would eliminate the open water hazard for the daycare. The Town of Grand Chute did not have to do this but chose to so the business would not be negatively impacted.

9. What access obstacles are required to be installed during construction?

No access obstacles are required during construction. Contractors will normally install an orange safety fence, but nothing is required.

10. Who requires access obstacles?

The 1001 code requires a safety shelf eight foot wide. The larger the pond the larger or longer the safety shelf will be. One of the design features that I [Mr. Vande Hey] like to incorporate into the pond is 12 inches of top soil on top of the safety shelf. The top soil will produce a mucky situation for anyone who chooses to wade in the water. The purpose of the top soil is to develop an unfavorable condition where the individual who is trying to access the water would think twice before wading in to the deepest parts of the pond. The top soil does not restrict access but does make it quite unpleasant. Planting of tall grasses around the pond could add further difficulty when wading into the water. Not only would someone have to deal with the muck, they would have to brush away tall grasses too. The grasses can also deter wildlife from occupying the pond because they would not be able to see possible predators. The tall grasses or fences can hide trash and other debris.

My [Mr. Vande Hey] professional opinion relating to access obstacles are they should be made of natural materials. I [Mr. Vande Hey] do not recommend fences. For one, there are no fences around ponds, lakes, or rivers. They are much larger and deeper than a wet pond. A fence can hide trash. If the wet pond is out of sight the likelihood of it [trash] being picked up is decreased. A fence can hinder the first responders from quickly rescuing someone who may need help. I [Mr. Vande Hey] would give more consideration to fences if they are retrofit ponds which are going into an existing area. Essentially asking the question, what was here first? I [Mr. Vande Hey] would also be inclined to have fences installed if there is an uncommon situation that could add danger, like an industrial complex that is constantly discharging warmer water into a pond. This could make winter ice unpredictable which may warrant more precautions.

11. What are other organizations using for obstacles?

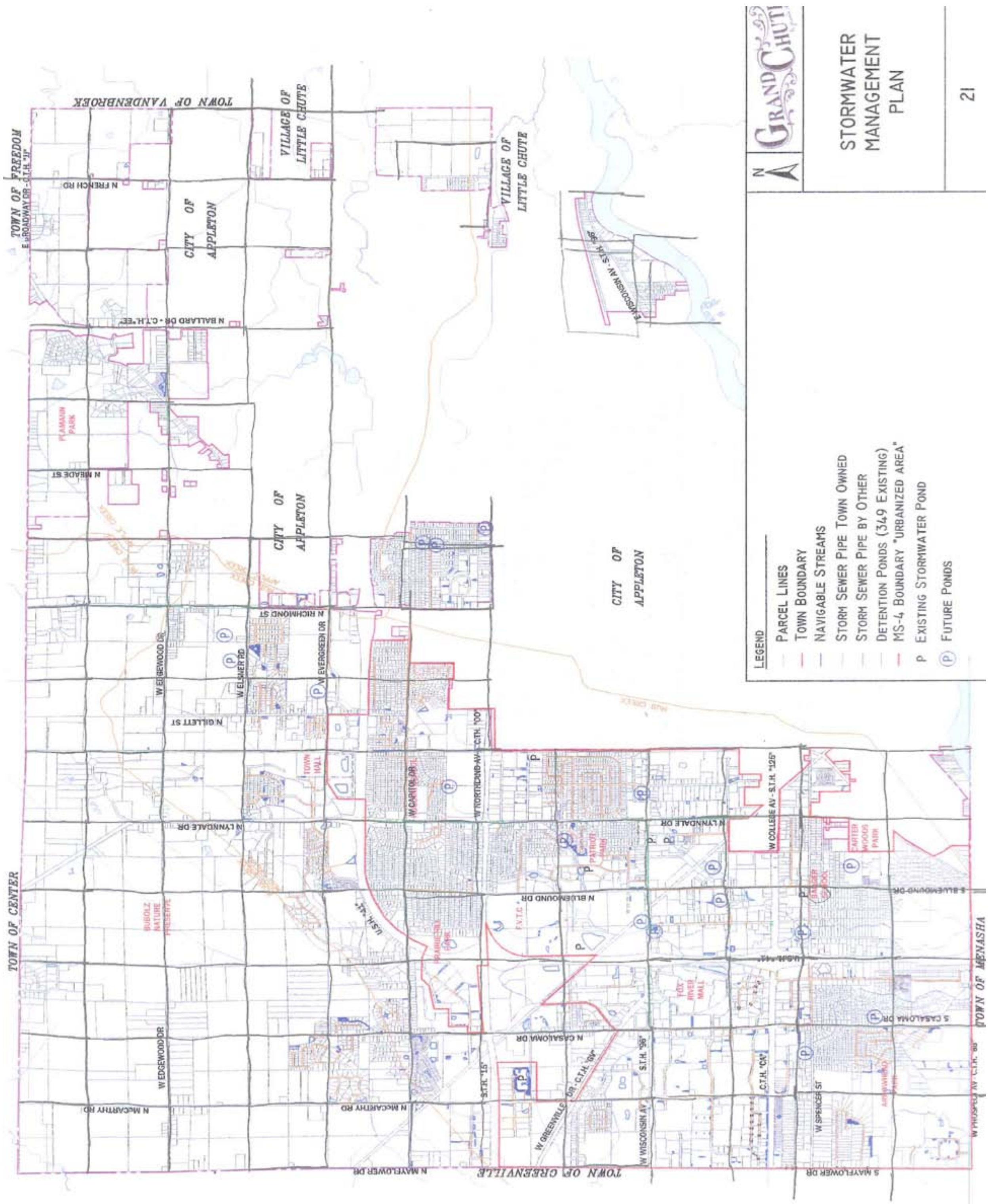
The only obstacles that I [Mr. Vande Hey] know that have been used by others are fences with some limited signage and thorny landscaping. In one case, a business put the retention pond underground. This was more for space issues and not for safety.

Appendix C
United States Census Bureau Data

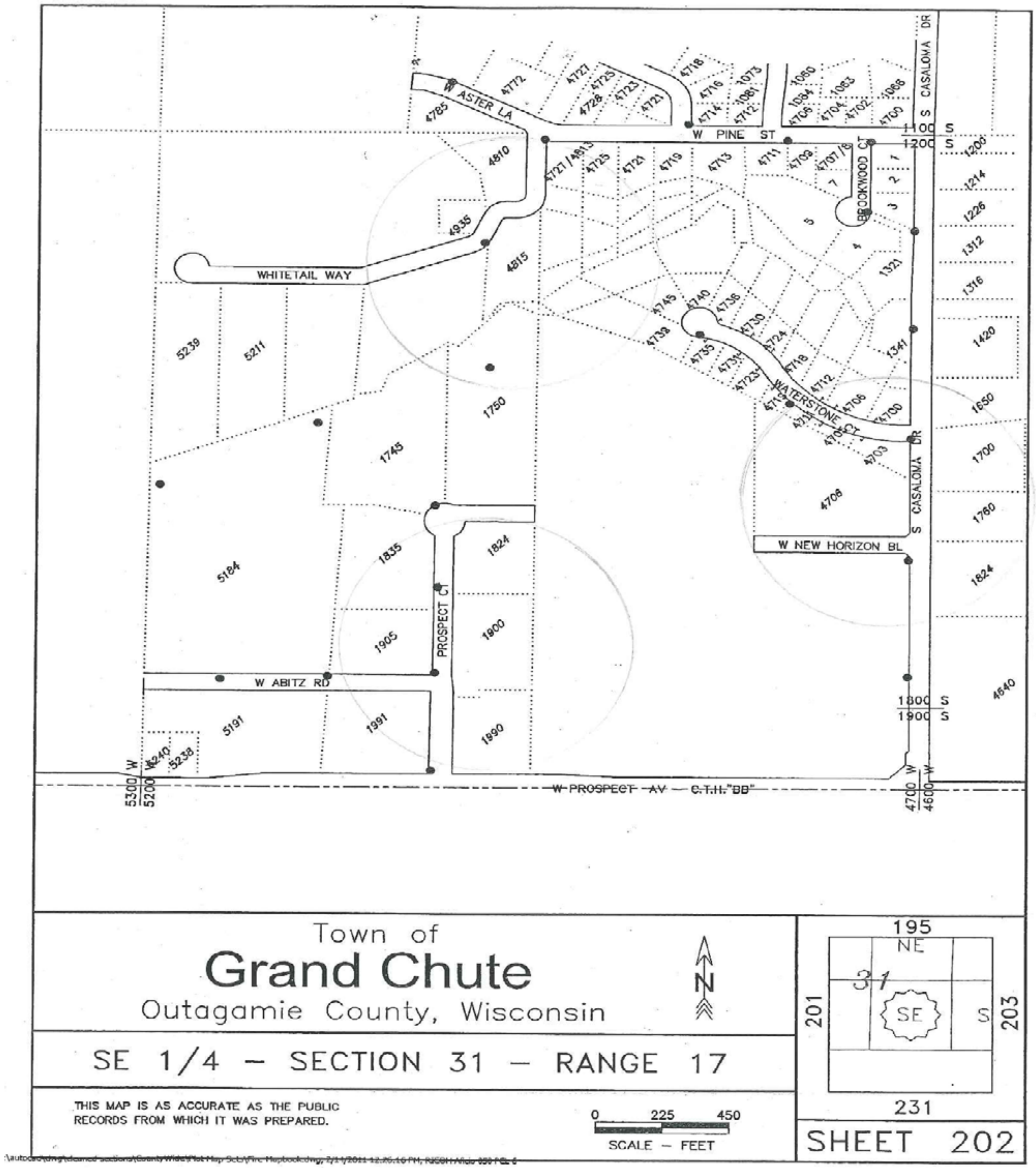
Town Of Grand Chute Population						
Total Population	Town		Male		Female	
	20,465		10,110		10,356	
Age	Percent	Population	Percent	Population	Percent	Population
Under 5 years	5.80	1,187	5.40	546	6.10	632
5 to 9 years	5.10	1,044	5.00	505	5.10	528
10 to 14 years	4.70	962	5.10	516	4.40	456
15 to 19 years	5.60	1,146	5.70	576	5.60	580
20 to 24 years	10.50	2,149	10.10	1,021	10.90	1,129
25 to 29 years	9.40	1,924	10.60	1,072	8.20	849
30 to 34 years	5.80	1,187	5.10	516	6.40	663
35 to 39 years	6.20	1,269	7.30	738	5.10	528
40 to 44 years	5.80	1,187	5.60	566	5.90	611
45 to 49 years	7.90	1,617	6.80	687	8.90	922
50 to 54 years	7.30	1,494	7.70	778	6.80	704
55 to 59 years	6.10	1,248	7.30	738	4.90	507
60 to 64 years	4.80	982	4.30	435	5.20	538
65 to 69 years	4.00	819	3.50	354	4.50	466
70 to 74 years	3.90	798	3.40	344	4.30	445
75 to 79 years	3.10	634	4.30	435	1.90	197
80 to 84 years	2.50	512	1.80	182	3.10	321
85 years and over	1.70	348	1.00	101	2.50	259

Age Categories						
5 to 14 years	9.80	2,005	10.10	1,021	9.50	984
15 to 17 years	3.50	716	3.70	374	3.40	352
18 to 24 years	12.60	2,578	12.10	1,223	13.10	1,357
15 to 44 years	43.30	8,861	44.40	4,488	42.20	4,370
16 years and over	83.20	17,026	82.80	8,370	83.60	8,657
18 years and over	80.90	16,555	80.80	8,168	81.00	8,388
60 years and over	19.90	4,072	18.30	1,850	21.50	2,226
62 years and over	17.80	3,643	16.50	1,668	19.00	1,967
65 years and over	15.10	3,090	14.00	1,415	16.30	1,688
75 years and over	7.30	1,494	7.10	718	7.40	766

Appendix D
Grand Chute Stormwater Management Plan



Appendix E
Town of Grand Chute map index page



Appendix F

WATER RETENTION OR DETENTION PONDS EXPOSURES WITHIN 500 FEET

Map Book	Location	1 and 2 Family	Multi-family	Hotel/Motel	Commercial	Place of Assembly			High-rise
						Education	Daycares	Other	
p. 202	1900 Prospect Court				6				
	4815 Whitetail Way	6	2						
	4706 South Casoloma Drive	9			1				
p. 201	5696 Technology Circle				7				
	5789 Technology Drive				8				
p. 196	5517 West Natures Lane	33							
p. 195	1066 Crocus Lane	28							
p. 194	4141 Boardwalk Circle	6	1		12				
p. 193	1112 South Westland Drive	8			3				
p. 191	2324 West Spencer		2		10				
p. 170	415 North Perkins Street				8				
p. 168	415 North Bluemound Drive	6	7		3				
p. 167	234 West Hanskimmel Drive			2	11				
	425 West Lawrence Street			1	8				1
p. 166	134 South Maplehill Drive	6			2				
	225 North Casoloma Drive				12				
p. 165	5463 Pennsylvania Avenue	10	6		4				
	5800 Pennsylvania Avenue	8	4		5				
p. 160	4714 West Integrity Way				7		1		
	720 North Mayflower Drive	2	24		2				
	5320 West Michaels Drive		5		4				
p. 159	900 North McCarthy Road				3				
	4803 West Michaels Drive				5				
	1000 North Mutual Way				7			3	
p. 158	4301 Frontage Road			2	1				
	706 North Casaloma Drive				4			1	
p. 157	3600 West Woodman Drive	3	3		7				
	1000 Westhill Boulevard				3			3	
p. 156	3255 West Highview Drive				10				
	1120 North Hickory Farm Lane				18				
p. 155	707 North Perkins Street				9				
	2142 North Hard Drive				17				

p. 134	2300	West Russet Court	11	1	3			
p. 133	3005	West Brewster Street	5	5	6			
	2	Systems Drive			6			
	1998	North Rexford Street	41					
	2776	West Commonwealth Court	38					
p. 132	3800	West Wisconsin Avenue						
p. 131	4350	Frontage Road			5			3
	1565	North Federation Drive			5			
p. 130	1694	West Schroth Lane			4			
	5054	West Anita Street	10	9	2			
	1400	North Silverspring Drive		21				
p. 129	1395	North McCarthy Road		22				
	1900	North McCarthy Road	16	12				
p. 124	5365	West Clairemount Drive	2		4			
p. 123	5036	West Clairemount Drive			3			
p. 122	2025	West Parkway Boulevard	9		4			
	2228	Olde Casoloma Drive	7		1			
p. 121	1825	North Bluemound Drive				1	1	
p. 120	10	Tri-Park Way	6	4	2			
p. 119	2350	West Pershing Street		14	8		1	
	2155	West Nordale Drive			9			
	2400	West Nordale Drive			10			1
	2219	North Perkins Street	30	9	2			
p. 102	102	East First Avenue	31	2	3			
p. 101	475	West Ridgeview Circle		10	5			
	590	West Highland Park Avenue	7	4	2			
	235	West Florida Avenue	36	6				
p. 99	1493	Westchester Court	20					
	1784	Sanctuary Court	3	7				
p. 98	2229	West Twin Willows Drive	25					
p. 97	3113	Selma Court	31		1			
p. 96	2901	West First Avenue	7					
p. 95	2915	North Victory Lane			6			
	4400	West Grand Chute Boulevard			3			
p. 94	2605	West Converters Drive			2			
	3305	North Casoloma Drive		9				
	4943	West Woods Creek Lane	16	4				
	5027	West Capital Drive	6					
p. 93	2910	North Tempest Court						
	5483	West Neubert Road			4			
	5305	West Capital Drive			3			
p. 87	5211	West Century Farm Boulevard	2					
	3403	North Thornberry Drive	26					

	3904	Cobble Creek Drive	19		
p. 86	3820	North Maple Edge Court	11		
	4513	West Amberwood Lane	32		
	3536	Russelwood Drive	18		
p. 84	2691	West Grand Chute Boulevard			
	3964	North Crosscreek Circle	7	29	
p. 83	4030	Town Lakes Circle		4	
	4033	Town Lakes Circle		2	
p.82	1618	West Evergreen Drive	9	8	4
	1429	West Roselawn Drive	35	7	1
	1800	West Capital Drive	40		
p. 81	1150	West Evergreen Drive			
p. 80	37	Apache Court	34		1
p. 65	4160	Richmond Street	3		1
p. 64	4580	North Orion Lane	16		
	4357	North Moon Glow Court	28		
p. 63	1633	Little Ranch Road	30		
	4358	North Skyway Lane	20		
	4507	North Gillett Street	24		
p. 62	4450	North Bull Rush Drive	31		
	4411	White Hawk Drive	36		
p. 58	4824	West Jack Pine Court	9		
p. 47	4927	Wren Court			3
p. 35	5400	North French Road			
p. 32	1355	North Lake Road	26		
p. 29	428	County Road JJ	2		1
p. 27	1810	North Gillett Street	1		
p. 14	4100	West Harmony Lane	3		
p. 8	4838	Richmond Street			5