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Pool Safety and Technology

An Interactive Qualifying Project

Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In Partial fulfillment of the requirements for the Degree of Bachelor of Science

Sponsoring Agency: U.S. Consumer Product Safety Commission

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Abstract

Much has been much done to prevent unintentional drownings in swimming pools, especially for children. However it still remains a significant problem today. Working in coordination with the Consumer Product Safety Commission (CPSC), we researched aspects of the problem, focusing primarily on the contribution of technology and then developed concepts to help alleviate the problem. We made recommendations to the CPSC on how to further develop the Submersion Prevention Effectiveness Rating system and the Submersion Prevention System concepts we created.

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Executive Summary

After 30 years of work, child unintentional drownings is still a major concern. The many characteristics of the problem make it a difficult one to solve. Every category distinguished so far, education and awareness, legislation and enforcement, and technology has made headway in developing a solution. However, even with this progress, there are many drawbacks and problems that need addressing in each of the categories.

As the availability of swimming pools increases, the risk of a pool-related accident is amplified. Many pool owners are unaware that the lack of proper pool safety technology is putting the lives of their children as well as others at risk. In spite of government and private companies' efforts to produce and market a failure-free pool safety technology, children are still succumbing to accidental drowning deaths in unsupervised swimming areas. Drowning today is still the second-leading cause of unintentional deaths for children between the ages of 1 and 19 (Brenner, Trumble, Smith, Kessler, & Overpeck, 2001b).

The goal of this project was to assess current pool alarm technologies for safety purposes and to make recommendations to the CPSC regarding potential future pool alarm technologies and the feasibility of the development of such a technology into a consumer product. We identified current pool alarm technologies and their effectiveness, identified human factors related to use and acceptance of pool alarms, and developed specifications for an ideal future pool alarm system for the CPSC. In doing this, we discovered the consumer has no easy way of determining the reliability of the safety technologies on the market today. We also made final recommendations to the CPSC regarding the agency's interaction with the development of a system complying with our specifications, as well as the feasibility of development into a consumer product.

After thorough literature review and web research, we decided that all the alarm systems that exist up to this date are not effective or reliable enough to properly prevent a person from drowning in a swimming pool. In order to tackle this problem, we came up with a better system for drowning prevention. The system uses sensor technology, wireless networks and embedded system design as well as future pool immersion prevention technologies. The system uses many sensors to help increase the reliability and effectiveness of identifying an intruder in the swimming pool area. Digital and wireless technology is used to alert the user of any intrusion to the pool. The immersion prevention is used to secure the swimming pool, preventing intruders from entering the swimming pool.

From our analysis of the information gathered through literature review and web research, we found a large gap in submersion prevention. Pool alarm devices have been around for decades and are now being incorporated into local laws and ordinances in an attempt to lower the rate of accidental pool drowning deaths. However, many people believe these to be unnecessary, unreliable, or give people a false sense of security beyond the device's capabilities. This gap is what a Submersion Prevention Effectiveness Rating (SPER) System would fill. Our evaluation of current technologies for pool safety and the trends in sensor systems, wireless networking and embedded system design, has allowed us to compile a framework for a future model of a Submersion Prevention System (SPS) to protect from immersion incidents.

All the devices incorporated into the SPS would be rated using the SPER system. This would make it easy for the consumer to decide which devices to purchase for his/her personal application. Most would not be able to have all these devices because of the cost, nor would it be necessary to have all the devices. The SPER System would facilitate the construction of a SPS. An SPS provides many customizable options for the consumer. With the convenience and

reliability gained by an integrated system, we believe this system idea to be reasonably marketable to the consumer in the not-too distant future.

1.0 Introduction

A main source for entertainment and enjoyment, pools or other private swimming areas serve as a backyard gathering place for friends and family, but when left unattended they can become a deadly attraction for an unsupervised child. Pools and swimming areas can be divided into two categories, residential pools which are used by only one dwelling, and municipal pools, which are connected to multiple dwellings or provided by a local municipality. The difference between the two is public pools and swimming areas require lifeguard supervision during active operational hours, and proper barriers during closed hours. Conversely, residential pools do not have lifeguards on duty and are normally left unsupervised when not in use, although there is minimal legislation that requires barriers. Residential pools rarely have lifeguards overseeing swimmers, including children. Parents are the primary, and sometimes the only source of supervision for most children in residential pools and swimming areas.

As the technology for swimming pool design advances, especially with the new designs for inflatable and collapsible pools, the more readily available such products are to the general public. This decreases the price of these products, increasing the ease of purchase for many middle and lower income homeowners. Owning a pool in the backyard has become more commonplace, and with the number of pools in residential homes increasing, so does the risk for drowning incidents. Many pool owners are unaware that the lack of proper pool safety technology is putting the life of their children and the lives of many others at risk. In spite of government and private companies' efforts to produce and market a simple and effective pool safety technology, children are still drowning in unsupervised pools and swimming areas. Drowning today is the second leading cause of unintentional deaths among children from 1 to 19

years old (Brenner, Trumble, Smith, Kessler, & Overpeck, 2001a). Most of these drowning deaths are directly related to lack of adult supervision. Awareness about pool safety within the American public and a better technology to prevent unattended children from accidental drowning are necessary in today's society.

Even though pool safety technology has advanced over the years from fences to sensors, and there has been a reduction of unintentional drowning deaths, there is still no technology being marketed that uses a systems approach for drowning prevention. As a result, four-sided fencing still remains one of the best ways to keep unattended children out of harm's way. Many alarms on the market today may seem overly sensitive to many users or even intrusive in daily living, especially alarms that warn the homeowner whenever anything enters the pool. This causes some people to de-activate alarms when they should be kept activated, essentially negating the system's protection altogether. Also, the technology available today is not integrated. Every unit works individually to protect the pool or the user. A system that communicates and coordinates from various devices could have a higher effectiveness and less of a chance of false alarming because it would have more information from the property on the events taking place. With the coordination of the devices, the system could determine whether a child was entering the pool, or if it was some other event naturally occurring that disrupted a sensor.

This brings up another short-coming of pool alarms in today's market. Immersion alarms activate after something enters the water of the pool. Therefore, an unattended child would already be in the water when the alarm activates. In the ideal situation, a homeowner would be warned when a child is in the vicinity of the pool or private swimming area, not already in the water. Additionally, the alarms take time away from rescuers. Time is of the essence when

dealing with a drowning, a child only needs to be in the water for two minutes, and he or she will probably suffer from brain damage due to the lack of oxygen. Therefore, rescue time is imperative.

The goal of our project was to make recommendations to the Consumer Product Safety Commission (CPSC) concerning the future of pool safety technology. We first familiarized ourselves with the technology available to consumers today, as well as legislation that has been put in place to make pool areas safer. We spoke with many people from the pool safety industry and organizations concerned with children's safety, such as Safe Kids. Other objectives of our project were completed using interviews with CPSC staff. We discussed many topics including objectives concerning Economics, Human Factors, and Engineering. By reviewing reports that extracted data from the CPSC databases, we were able to determine what the primary hazard patterns are in the accidental drowning deaths of children. We also researched pool safety guidelines and legislation from France and Australia to obtain a global perspective on how this problem was approached. With our recommendations, the CPSC can move forward with research, establish new standards, promote the development of a Submersion Prevention System, and increase public awareness of the risks involved with swimming pools. In doing so, the CPSC will be able to make pool areas safer by preventing avoidable drowning deaths incidents of children.

2.0 Background

In order to fully understand the necessity for an effective pool alarm, it is essential to be familiar with the complexities of pool safety. We begin by discussing general information regarding the extent of drowning as a problem in the past and today. Additionally, we discussed existing legislation pertaining to pool safety and defined pool categories. We also reviewed pool safety technology, ranging from simple barriers to complex sensors.

2.1 Incidents in Swimming Pools

There are many drowning and near drowning accidents each year in the United States with the majority of these victims being children. In 2005, there were 694 unintentional drowning deaths of children under the age of ten from a population of 43,873,783 in the United States (National Center for Injury Prevention and Control, 1999 to 2005). This number is lower than that for the year 2000 in which there were 801 deaths for a population of 43,999,359. Even though there was a significant decrease in the number of unintentional drowning deaths, drowning is still the second leading cause of unintentional death among children ages 1 to 19 years (Brenner, Trumble, Smith, Kessler, & Overpeck, 2001b).

There are many factors that could have caused this decrease in the death rates of unintentional drowning of children. One major factor could be the public awareness of the dangers of pools. Most drownings are caused by the lack of pool owners' awareness of proper safety issues for pools. With the advance of the internet and computer technology, it has become faster and easier for pool owners and the general public to gain reliable information regarding pool safety. Articles and requirements for proper pool fencing and designs can be easily acquired with a basic search on the internet or a visit to the governing authority in the local area. Even though this information is readily available, we perceive that many people are not taking full

advantage of this available information, and applying the guidelines available to their swimming pool area.

Another factor that might have helped decrease the drowning rates of children is the improvement in pool alarm technology in recent years. Pool alarm technology has advanced from simple motion sensors that detect anything entering the pool area, to water wave and sound sensors that discriminate between objects and people that fall in the water by the wave or sound they create.

Figure 2-1 Pool Submersion Deaths to Children under 5

Pool Submersion Deaths to Children under 5 2001-2003		
Year	Deaths ⁴	Deaths per 100,000 Population ⁵
Average	280	1.4
2003	287	1.4
2002	282	1.4
2001	269	1.4

Source: CPSC databases including NEISS (See Table 1 above), IPII (Injury and Potential Injury Incidents), DTHS (Deaths) and INDP (In Depth Investigations). IPII is a mixture of various types of information including newspaper clippings, consumer complaints and reports from other government agencies such as medical examiners/coroners. Information is voluntarily submitted to IPII, so that staff cannot be sure that information on all the deaths has been received. Source documents were checked to eliminate duplicate incident reports.

(Greene & McDonald, 2006)

According to Figure 2-1, these data show that over time the number of drowning deaths has increased despite the fact that the deaths per 100,000 population has remained stagnant. These data were extracted from the National Electronic Injury Surveillance System (NEISS), a database provided by the CPSC. These data also show the great importance for drowning prevention in the United States, because even with the decrease of deaths from 2001 to 2003, there are still too many children drowning in the United States.

Unattended children can drown in almost any place. The sites for drowning include artificial pools such as swimming pools, Jacuzzis, hot tubs, whirlpools, spas, domestic bathtubs, buckets, outdoor lakes, ponds, pits, quarries, rivers, creeks, canals, and salt water areas. (Brenner, Trumble, Smith, Kessler, & Overpeck, 2001b). Yet most of the drownings occurred in swimming pools. There were a total of 435 unintentional drownings in swimming pools in the United States in 1995.

Swimming pools can also be divided into two sub-categories, municipal and residential. New government regulations have become stricter with municipal pools, requiring them to comply to set standards and lifeguards at all times. This has resulted in a reduction in unintentional drowning deaths, yet there have not been many similar laws passed that affect residential pools. This explains the high number of unintentional drowning deaths that still occur today.

2.2 Non-Governmental Organization Perspective on Pool and Spa Drowning

In an interview with Alan Korn (Personal Communication - Director of Public Policy and General Council of SafeKids, 2008), Director of public policy and general counsel of Safe Kids



Figure 2-2 Safe Kids "Water Watcher" Card

(Safe Kids Worldwide, 2004b) that the pool is a dangerous place where their children can drown. In order to promote active supervision, Safe Kids has implemented a "Water Watcher" program, which helps parents to actively supervise their children by wearing a card on the neck of the responsible parent that

USA, a Non Governmental Organization (NGO) based in Washington, D.C. Safe Kids feels that the most important thing for a parent to know about drowning is pool safety. It is vitally important to engage in active supervision. The majority of parents are not aware

states that they are solely responsible for watching everyone in the pool for the designated time. If that parent does not want to perform this task anymore, he/she can pass the card and the responsibility to another parent. This way, the pool has an adult who will constantly supervise the children in the pool. He also expressed that another way to prevent drowning is by passively preventing, or implementing isolation fencing around the perimeter of the pool.

Alan Korn (Personal Communication Alan Korn, November 17, 2008) believes the most effective way to ensure pool safety of children would be to focus on all areas which include Education, Engineering/Environment, Enforcement, and Evaluation. As mentioned above, it is imperative to educate parents about pool safety, entrapment, and drowning risks, so they will know how to actively supervise their children. In environmental changes, Safe Kids looks at how pools are built and maintained. Safety devices such as alarms, fences, and emergency phones are key components in pool safety. For enforcement, Korn felt it would be helpful to inspect pools and see if proper safety precautions are being followed. Finally, with evaluation, the full “big picture” is looked at to see if it has effectiveness.

We also asked if he felt there was anything that manufacturers could do in order to prevent accidental drowning. He expressed that engineers should test the product more before they bring it to the market so they can see if it is truly effective. There should be something similar to the rule when buying a bicycle, with inflatable pools: the “if you buy a bike, buy a helmet” rule. In this case, fences should be linked to inflatable pools for child drowning prevention. He suggests that the manufacturers could work with the CPSC or Safe Kids to give resources of responsibility. Manufacturers could help in spreading education on pool safety.

Since the federal government just introduced a pool safety law, for the first time in 230 years of our nation's history (Virginia Graeme Baker Swimming Pool Safety Act), Alan Korn has stated that the government should try to actively create more laws regarding this issue and police them.

Safe Kids has made many an effort to promote pool safety and drowning awareness. During their National Safe Kids Week, the organization addressed swimming pool and spa drowning publicly. With regards to future efforts, Safe Kids plans to monitor compliance with the Virginia Graeme Baker Swimming Pool Safety Act according to Alan Korn, and then if the CPSC is provided with funding to give grants to states that adopt this act, which the law mentions, Safe Kids will use its local and national offices to help encourage individual state legislators to create laws regarding pool safety. Safe Kids will also actively recommend parents to use the Water Watchers program.

2.3 Current Pool Safety Technologies

There are many consumer products available today that may improve the prevention of child pool-related accidents and unintentional drownings (Morgenstern, Bingham, & Reza, 2000). These products help to combat the problem from many different aspects. They include



simple barriers, such as fences and pool covers, and more advanced sensor and alarm technology. All the products offer a certain layer of protection; however simple barriers are still the best method to keep pools the safest.

Research completed by many public health advocates and researchers has shown that the surest way of preventing

Figure 2-3 Isolation Fencing around In-ground Pool

childhood drowning is to have four-sided or isolation fencing around the swimming pool (Morgenstern, Bingham, & Reza, 2000). With self-latching gates, the fence restricts access to the pool from surrounding areas and also from the house on the same property. Statistics show that 34% to 67% of child drownings and near drownings can be attributed to unfenced or incompletely fenced swimming pools. The most significant problem facing fencing is that the public often perceives it as costly, ugly, inconvenient and unnecessary. Legislation has been passed to make it a requirement by law, but the ordinance is often neglected and unenforced.

Another layer of protection in use today is the rigid pool cover (Brenner, 2003). These pool covers need to be taken off and put back on every time the pool is used, which may be seen as very inconvenient by the owners and provide no protection when the pool is in use. These covers do provide some additional protection, but they should never be used in place of four-sided fencing. Some pool covers, especially the non-rigid type like solar or plastic covers, increase risk. Some children have been known to drown by apparently trying to walk on these non rigid covers. If a child does fall into a pool with one of these covers, rescue would be delayed because the cover hides the child as well as wraps around the child's body.

There are many technologies that exist today that go above and beyond fencing (Brenner, 2003). However, these new technologies at the forefront of the industry, do not replace the protection provided by simple fencing. Often times pool alarms are used inconsistently and inappropriately by the owner.

Some of the pool alarm technologies available today include surface and subsurface disturbance alarms, personal immersion alarms, perimeter alarms, gate alarms, and video monitoring alarms (Whitfield, 2000).

The surface wave sensor floats on the water's surface. It contains an electrical circuit that has two contacts, one which rests in the water, and one which rests above the surface (Whitfield, 2000). When an object disturbs the water and the water makes contact with the above surface contact, it completes the electrical circuit, sounding the alarm. Sensitivity can be elevated by increasing, or lowered by decreasing the distance between the surface of the water and the above surface contact.

There are a few different types of subsurface disturbance alarms (Whitfield, 2000). These types of sensors mount under the surface of the water between half an inch and 12 inches below the water on the side of the pool. The technologies used in these devices employ pressure change detectors, magnetic motion detectors, and acoustic sound detectors. One sensor incorporates a switch located at the top of a sensing throat that is sensitive to pressure changes. As a wave makes contact and travels into the throat of the sensor, a change in pressure is created. This pressure change activates a switch which activates the alarm. Another subsurface alarm relies on a magnetic float below a magnetic sensor. If this float comes in contact with a disturbance that creates enough motion in the float to create a signal in the magnetic sensor, it sounds the alarm. Both of these subsurface alarm types use an electrical adjustment to control the way the circuit responds to the disturbance stimulating the sensors. One alarm also incorporates a mechanical adjustment for the depth of the sensor, which would change the sensitivity according to the depth of the sensor.

A new kind of subsurface alarm, called passive sonar, uses a hydrophone, an underwater microphone, as a sensor that detects a sound disturbance created by a falling person. The hydrophone constantly monitors the acoustic sounds present in the swimming pool (AquaSonus, 2007). A microprocessor in the poolside unit digitizes these acoustic signals so that it can be

analyzed digitally. The unit then uses the built-in program in order to analyze these sounds and distinguish between items falling into the pool such as a pump, toys, rain, debris and an actual intrusion event. This system uses advanced software codes in order to discriminate between objects and persons that fall into the pool which decreases the likelihood of false alarms. After detecting the sound of a child, adult, or pet falling in the pool, the alarm sounds (Dumas, 2006). The benefit of using a subsurface alarm compared with a surface alarm is that they can be used in conjunction with pool covers and solar blankets.

The personal immersion alarm approaches the issue of children falling into pools from the opposite side of the water disturbance alarms (Whitfield, 2000). Instead of alarming the owner of a disturbance in the water, the wristband is worn by a child and notifies the child's parent or guardian when it comes into contact with water. The wristband is secured to the child using a locking key that prevents its removal. When the wristband becomes wet, it warns the parent or guardian that it has been exposed to water. There are some aspects of the wristband that may be seen as shortcomings. First of all, the wristband is a sealed, battery operated unit. This means that once the battery is depleted, the whole wristband sensor must be replaced. Therefore, the user needs to be aware of the wristband indicator to make sure that the unit is in proper operational condition. Besides the fact that the wristband has to be replaced when the battery runs out, the wristband also alarms whether it was being submerged in a pool or exposed to any other water source, including being placed under a running tap. This could cause the parent or guardian to remove the wristband if it becomes a nuisance.

The CPSC has tested various types of pool alarms (Whitfield, 2000). From the data gathered in these tests, CPSC staff concluded that the subsurface pool alarms, in general, are the best performer out of the devices tested. Not only were they more consistent in alarming when

they needed to, they also were less likely to create a false alarm. When the object simulating the weight of a small child was pushed into a pool, the subsurface alarm sensors were the most reliable in detecting the disturbance. The surface alarms were close in performance to the subsurface alarm sensors.

A new personal immersion alarm system covers false alarms by using ultrasonic signals in order to activate an alarm (Dolphin Alarms, 2008). This system has three key components. One component is the wristband. Upon contact with water it sends an underwater ultrasonic signal. Another key component is the receiver float that is placed anywhere on the surface of the pool. It receives and identifies the signal sent from the wristband. It then activates a sound alarm and sends a signal to the last component, the remote receiver, through an air signal. The remote receiver that is placed anywhere in the house receives the air signal and then sounds a sound alarm. Since the signal from the wristband is transmitted through the water of the pool to the receiver, the alarm will not sound if the wristband is activated while outside of the pool.

There are two technologies currently in use for perimeter alarms. One commonly used alarm is the passive infrared (PIR) motion detector (SmartPool INC., 2001). A PIR sensor is used to detect any temperature difference caused by human body movement against a cold background. This technology is used in many home alarm systems. It is also used on the perimeter of the pool in order to monitor the pool entrance or other area a person might pass before they enter the pool. One of the many pool alarm companies that produce this alarm uses this technology combined with the sub-surface submersion alarm technology in order to create a system that warns the user when a person is near the pool, and also when someone enters the pool. The advantage of combining both of these sensors is that the user will be alerted before and after a person goes into the water, increasing the time the rescuer has to perform a rescue.

Another less commonly used type of perimeter alarm is the LASER perimeter alarm. It makes use of the LASER's reflective properties by using mirrors and reflectors (Dumas, 2006). The mirrors are used to change the direction of the LASER beam path, and the reflectors are used to reflect the LASER beam back to the receiver (Prevent Laser Perimeter Alarm Operation Manual, 2008). By using these two components, the user can cover the entire surrounding of the pool using only one LASER beam. When the LASER beam is obstructed by any object, the alarm sounds. Some of the LASER perimeter alarms have software built into them so that they can change modes. One example is the swim mode which allows the user to break the LASER beam, enter, and leave the pool area for a 30 minute period without sounding the alarm. This alarm can be unreliable because any object that passes through the LASER beam can set it off. Another disadvantage of this type of alarm is that it has to be plugged in, which makes it vulnerable to power outages.

Gate alarms use a combination of magnet and magnetic sensors to detect a change in the magnetic field created by the magnet when the sensor is broken (Swimming Pools Etc, 2008). Gate alarms are mounted directly on a pool's gate with two magnetic switches. When the gate opens, the magnet will be separated from the sensor, therefore sounding the alarm. The disadvantage of this sensor is that the user has to deactivate the alarm each time he or she wants to enter the pool and then reactivate it after leaving. This type of alarm does not guard against intrusions from other places in the gate or fence.

An innovative technology has been developed in order to help lifeguards on duty to supervise pools. This technology relies on video surveillance recognition software to detect a motionless person under the water. This system uses a network of digital cameras that are mounted above the surface of the water or in the pool walls and linked to a central processor unit

to monitor the trajectories of swimmers in the pool and to analyze, in real time, their activity (MG International, 2008). The system then can automatically identify a person who is motionless underwater. Shortly after detection, it alerts the lifeguard on duty via a LED panel that is located around the pool and at the supervision workstation located on another lifeguard's desk to the exact location of the swimmer in danger. This pool alarm is targeted towards municipal pools due to the high cost of installation. The downfall of this system is that it does not work with decreased visibility such as at night with no light, or if all the cameras are blocked.

With this said, the CPSC stated that, "A pool alarm can be a good additional safeguard in that it provides an additional layer of protection against child drownings in swimming pools" (Whitfield, 2000, p. 14). However, CPSC recommends that pool alarms should not be used as a primary device to prevent incidents in place of supervision or barriers completely surrounding the pool areas because the alarms need re-activation at each use. Also some alarms require the separate purchase of a remote feature for the alarm to sound inside the house. The personal immersion alarm would also provide another layer of protection. The downfalls with the personal immersion alarm include the fact that someone needs to place it on the child, and the child would need to wear it all the time. The negative aspects of these alarms may deter consumers from purchasing or using this new technology effectively, but many of these products do reduce the likelihood of what could be a fatal accident.

Increasing risk of Inflatable Pools

Another pool technology that is quickly raising the awareness of pool safety advocates is the inflatable/portable pool. The convenience and price that inflatable pools offer attract consumers into this dangerous play "toy". Inflatable swimming pools become even more popular during the summer when everyone wants to have fun in the pool, but cannot afford to construct

one. A 15 to 16 foot diameter inflatable pool costs between \$200 to \$330 and it takes less than one hour for the set up (Shin, Mui, & Trejos, 2006). It is convenient and easy to have an inflatable pool in your backyard since there is no digging needed and consumers do not need to worry about building codes requirements. Although inflatable pools may seem attractive to consumers, CPSC Chairman Hal Stratton warns about the dangers they bring with them, “Consider the danger of water before investing in an inflatable pool. Parents need to understand any [water], poses a drowning risk” (Shin, Mui, & Trejos, p. 1). Organizations, such as CPSC, Good Housekeeping and Insurance Information Institute, have been involved with this issue.

However, in several places, there is still no legislation regarding inflatable pools and this increases the risk of drowning in one of them. The CPSC saw an increase in drowning deaths in these kinds of pools from 2004 (9 deaths) and 2005 (17 deaths) period (Shin, Mui, & Trejos, 2006). Some factors that account for the increase in deaths in inflatable pools include not draining the water from the pool when people are done using it and entrapment in the pool’s filter. This makes inflatable pools unsafe without the supervision of an adult, since a child can easily climb into it and drown. An inflatable pool can hold up to 4,400 gallons of water and although it is important to drain it after each use, consumers find it inconvenient to drain such a large pool.

2.4 Municipal Pools vs. Residential Pools

In the United States, municipal pools differ from residential pools in many different ways (Center for Disease Control and Prevention, 2008). One major difference is the presence of certified lifeguards on duty at all times. Municipal pools also have certain standards that need to be followed according to town ordinances. Residential pools rely solely on the homeowner, and

the safety precautions he/she chooses to take. Unlike municipal pools, residential pools also do not have a staff to ensure the cleanliness and safety of all those who utilize the pool features.

Installing a pool in a backyard is a significant responsibility. Because there is no official national legislation regarding safety regulations for residential pools, the CPSC (2003) provided a handbook giving, “Safety Barrier Guidelines for Home Pools.” It clearly states that these guidelines are not a CPSC standard, and therefore homeowners should contact their local authorities to see whether these provided guidelines are included in their area’s building codes or in other regulations.

Each municipality has its own building codes associated with installing a residential pool. Therefore, this lack of uniform legislation allows for discrepancies regarding safety guidelines. If each state has a different standard for pool safety, and then each local authority has its own standards, there is room left for inconsistent information. according to Mike Scerbo (Personal Communication Mike Scerbo, October 1, 2008), athletic director of St. Joseph of the Palisades High School in Northern New Jersey and a CPO (Certified Pool Operator). Many homeowners don’t realize the responsibility associated with installing a pool on their property. Legally, the homeowner is responsible for any accident that occurs within the pool, near the pool, or on the homeowner’s property in relation to the pool.

Each homeowner is required to apply for specific construction permits if they are installing an “in-ground” pool (Personal Communication Mike Scerbo, October 1, 2008). They are required to have a minimum 3.5ft locking fence around the perimeter of their property, and concrete around the perimeter of the pool. With regards to the actual safety of the pool, each homeowner is responsible for creating personal safety standards. If there are small children

(under the age of 10) involved, each homeowner is required to take responsibility for those children. If the children do not know how to swim, the homeowner needs to take certain precautions to ensure safety of the child. Additionally, since there is no life-guard on duty, the homeowner is accountable for all emergencies that may occur in or around the pool. It would be in the best interest of the homeowner, to have someone who is CPR certified or has had basic water rescue training on the premises when the pool is in use. This, of course, is not a mandated law, but it could help reduce the amount of pool related incidents that occur on a daily basis.

Municipal pools are only responsible for all state laws regarding the water chemical standards for the pool (Personal Communication Mike Scerbo, October 1, 2008). They must follow their own local construction and safety precautions. We were fortunate enough to have a contact in New Jersey that has experience in swimming pools and swimming pool safety. Scerbo stated that in the state of New Jersey, the municipal pools can meet minimum standards, but they don't have to exceed them. There is no motion detector or alarm while the pool is locked up, just the fence to ensure safety. However, these safety precautions are not compelled by state legislation. Within Hudson County, New Jersey, some municipal pools installed motion detectors, but quickly uninstalled them when the detectors were picking up the motion of geese more often than those of children.

However, in accordance with the new Pool and Spa Safety Act that was passed by Congress in December of 2007, all municipal pools now have to comply with the Virginia Graeme Baker Pool and Spa Safety Act (Virginia Graeme Baker Pool and Spa Safety Act, 2007). According to this law, beginning 1 year after the date of enactment of this act,

[E]ach public pool and spa in the United States shall be equipped with anti-entrapment devices or systems that comply with the ASME/ANSI A112.19.8 performance standard, or any successor standard; and each public pool and spa in the U.S. with a single main drain other than an unblockable drain shall be equipped, at minimum, with 1 or more of the following devices or systems designed to prevent entrapment by pool or spa drains such as a safety vacuum release system, a suction-limiting vent system, a gravity drainage system, an automatic pump shut-off system, a drain disablement, or any other systems that are equally effective (pp. 2-3).

Overall, the general safety precautions of municipal pools include four sided fencing of some sort, and constant lifeguard duty. Motion detectors and alarms are not necessary due to lack of operation during the evening. If an event were to occur in the evening, such as a swim meet, only the competitive lanes would be open, and all other areas of the pool would be closed to the public, under the watchful eye of pool managers (Personal Communication Mike Scerbo, October 1, 2008).

The CDC also gives other suggestions for home-owned pools (Center for Disease Control and Prevention, 2008). They state that a home-owner should,

Install a four-sided, isolation pool fence that completely separates the house and play area of the yard from the pool area. The fence should be at least 4 feet high. Use self-closing and self-latching gates that open outward with latches that are out of reach of children. Also, consider additional barriers such as automatic door locks or alarms to prevent access or notify you if someone enters the pool area

(Water-Related Injuries Facts - NCIPC, 2008)

They also say to remove all toys, balls, and water related toys from the water after use of the pool to prevent small children from curiously entering the pool. If there is nothing in the pool to create curiosity, it may lower the chance of a child wandering into the pool unattended.

Given these comparisons between residential and municipal pools, it is apparent that fencing is mandatory and strongly encouraged (United States Consumer Product Safety Commission, 2003). Other guidance includes water safety classes, and CPR training, especially for homeowners. Even in other parts of the world, such as Australia, legislation has been passed to maintain the safety of toddlers and children. Even though the United States puts a bare minimum on safety regulations for pools, they have “precautions” that are strongly encouraged. Manuals like the one the CPSC published for homeowners are a good tool to use if unsure of proper safety standards. With regard to municipal pools, it is up to the local authorities to determine if the pool is safe or not, and ultimately, the responsibility of the pool manager has a great effect on the well being of municipal pool attendees.

2.5 Pool Safety Regulations and Standards

Regulations have been put in place at a state and federal level in order to assist the public in protecting their children from this dangerous environment, where, if not well protected, they may become easy victims of incidents.

Florida

In Florida, a residential swimming pool must be equipped with a four feet high or taller barrier around the perimeter of the pool (2008 Florida Statutes Residential Pool Safety Act, 2008). Similar to New Jersey’s building codes to ensure that children will not be able to access

the pool without the supervision of an adult, the barriers should not have any ornaments that would allow a child to climb on it or be placed near a permanent structure. An above ground swimming pool should also be constructed with a ladder that can be removed to ensure that a child will not be able to gain access to the pool. Ladders should be removed while the pool is not in use or it should be locked and gates should be opened outwards from the pool.

Arizona

Arizona shares some similar laws regarding pool safety requirements with Florida. In Arizona, the gates should also operate in the same manner as in Florida (Pool Guard, 2007). Although this law does not specify whether it applies to an in-ground or above-ground pool, the law has requirements for gates. The gate must be self-closing and specific dimensions (54 inches) must be set to prevent a child from opening the gate, considering that a child is below this established height. It is also required that no openings or decorations greater than four inches become part of protection boundaries. In an indoor pool, one must remember to place a pool cover that is operated by a key switch. Arizona has been trying to make recommendations and enact laws affecting pool safety since many cities in the area are not stressing the importance of such prevention.

In some cities, fences are not required to enclose the pool apart from the house; instead, they enclose the whole property (Arizona Pool Fence, 2004). Other cities, such as Gilbert, do not even have barrier code laws. In order to make pool safety effective among all cities, the State of Arizona passed a law which gives the state the absolute power to supervise and provide maintenance to public and semi-public pools. Fire departments have the right to make any changes to these barriers, if they do not follow the specific standards for pool safety, once or twice a year. In addition to this, they can also close pools that do not adhere to safety standards

required by the state and mandate evacuation of the area. This law only applies to public and semi-public pools such as the ones found in hotels, clubs and apartment building complexes. The state does not have the power to supervise private pools.

California

The California Department of Public Health (CDPH) enacted a series of acts to help its residents. According to the California Swimming Pool Safety Act, beginning in 2007, home owners who wish to construct a swimming pool on their property should follow at least one out of the seven safety requirements suggested in the act (Pool Guard, 2007). These seven requirements include having a pool cover, not building the pool very close to the house, having a self-closing gate and doors that connect the house to the pool (in the case of an indoor pool), the use of swimming pool alarms (does not include wristband alarms) that detect unauthorized entrance to the pool, alarms on doors in the house that give access to the pool, a removable mesh pool fencing with a self-closing and self-latching gate, and any other forms of protection approved by the American Society for Testing and Materials (ASTM) standards (Pool Guard, 2007). All of these devices need to follow ASTM standards.

New York

In 2006, New York amended its Uniform Fire Prevention and Building Codes regarding residential codes (NY Department of State Division of Code Enforcement and Administration, 2006). The code now states that, “any residential or commercial swimming pool constructed or substantially modified after December 14, 2006, shall be equipped with an acceptable pool alarm capable of detecting a child entering the water and of giving an audible alarm” (p. 1). These codes also state that the pool alarm must be capable of the following:

- 1) Detecting a child entering the water and giving an audible alarm when it detects a child entering the water;
- 2) Making an audible sound poolside and at another location on the premises where the swimming pool is located;
- 3) Being installed, used and maintained in accordance with the manufacturer's instructions;
- 4) Meeting the standards of ASTM F2208, "Standard Specification for Pool Alarms,"
- 5) Being an alarm device which is not located on persons(s) or which is dependent on device(s) located on person(s) for its proper operation

(NY Department of State Division of Code Enforcement and Administration, 2006, p. 1).

Connecticut

The 1999 Connecticut building code requires that all pools, even temporary use or storable pools require a building permit. It also defines what a pool actually is: "A man-made body of water is considered a pool if it meets the following conditions: If the water level is more than 24" deep, if the surface area is greater than 250 square feet, if it has a permanent water recirculating system, and if it involves structural materials" (Town of Watertown, Connecticut, 2007, p. 1). With regard to barriers, these building codes require that all gating be installed prior to filling the pool with water. By order of "Public Act No.99-140 by the CT General Assembly, a 'pool alarm' must be installed in all new or renovated pools. This device shall emit a sound of at least 50 decibels when a person or object weighing fifteen pounds or more enters the water in a swimming pool" (Town of Watertown, Connecticut, 2007, p. 9).

New Jersey

Currently, the state of New Jersey is in the process of enacting a law pertaining to pool safety (New Jersey State Legislature, 2006). The law proposes requirements for barriers, especially isolation fencing, surrounding the pool area. It also specifies that a gate within the fence shall be self-closing and self-latching. The bill then describes that if the residence or living area, “constitutes part of the wall, fence, or barrier outlined in this bill, the owner may elect one of the following in lieu of meeting all the specifications...an isolation fence...a motorized safety pool cover that meets ASTM standards” (New Jersey State Legislature, 2006). Even though New Jersey doesn’t have specific legislation that is in place regarding pool safety, each municipality has their own distinct building codes regarding constructing in-ground pools (Personal Communication Mike Scerbo, October 1, 2008). Each homeowner is required to have a minimum 3.5ft fence around the perimeter of his/her property. They are also required to have cement around the perimeter of the pool. There is no requirement regarding additional pool safety technology such as a pool alarm or gate alarm, which is left to the discretion of the homeowner.

Federal Legislation

Presently, there is only one federal law that is concerned with pool and spa safety. The “Virginia Graeme Baker Pool and Spa Safety Act”, addresses the prevention of accidents caused by drain covers and pool suction systems. It became federal pool safety legislation on December 19th, 2007 (Virginia Graeme Baker Pool and Spa Safety Act, 2007). The reason behind the creation of this act came from an incident with a 7-year old girl (Graeme) trapped by a pool drain suction system. The purpose of this law is to prevent children from being entrapped by requiring public pools make use of approved drain covers and suction devices that prevent entrapment, to

ensure that accidents like that of Graeme does not happen, and also mandates the construction of barriers to keep children from going into the pool when there is no one watching (Stark, 2008)

The law incentivizes states by granting money to those that adopt the Graeme Act (Robledo, 2008, p. 1). The author of the bill and Congresswoman for the state of Florida, Rep. Debbie Wasserman Schultz expressed her opinions on the effectiveness of this legislation, “The passage of this legislation means fewer children will die from drowning in swimming pools or spas. Three hundred thirty-five children died in the United States in 2004, and basic pool safety legislation would have dramatically reduced those fatalities” (Robledo, 2008, p. 1). This law also encompasses residential pools by requiring the use of approved drain covers under the ASME/ANSI standard in home-owned pools. The president of the Association of Pool & Spa Professionals, Bill Weber, explains the objectives of the implementation of this law:

Our objective was to be sure the language in the bill that called for anti-entrapment laws was consistent with our standard. That would enable us to take the standards to any state that wants to participate and say, ‘If you want to comply and participate in this program, here’s the answer.’ That’s precisely what happened (Robledo, 2008, p. 1).

Regulations have been trying to improve the pool safety standards and reduce the number of incidents. However, there are some challenges to enforcement of these regulations since they vary from state to state. Although there are several regulations that are similar among states, each state has its own way of enforcing these laws.

International Pool Safety Legislation

Child drowning is still one of the main causes of deaths in several parts of the world, leading to the implementation of various pool safety laws. Some countries, such as France and Australia have implemented laws on swimming pool safety in order to assist the public on precautions and recommendations on ways to decrease drowning in the country.

France

France has been facing serious problems with drowning, especially with children, thus raising its concern with pool safety. A study conducted by the French Health Watch Institute (Ministre de la Santé, de la Jeunesse, des Sports et de la Vie associative., 2008) from June 1st to September 30th 2008 shows this situation:

Children under age 6 accounted for 15% of drowning incidents (173 children, 43 of whom died as a result), though they account for only 7% of the population. In children under age 13, being left unattended (42% of drowning incidents), not knowing how to swim (34%) or a fall (30%) were the most frequently reported circumstances in drowning (p. 1).

In order to decrease the number of deaths related to drowning, France enacted the Swimming Pool Safety law on January 3rd, 2003 (Commission de la Sécurité des Consommateurs (CSC), 2007). This law focuses mainly on outdoor in-ground and semi-in-ground residential pools. According to it, newly constructed pool needs to be equipped with at least one of the four permissible safety facilities no later than 2004 and by 2006 all swimming pools need to have some type of safety device. These devices include fences/barriers, safety covers, shelters and alarm systems. All of these devices must obey the AFNOR (Association

Française de Normalisation) standard, and failure to do so may result in fines that can exceed up to 45,000 EUR (58,131 USD) (Angloinfo French Riviera, 2008). According to the CSC, “France is the only European country with a legislative and regulatory system on pool safety”. The necessity to have multiple layers of protection is expressed by a worker in a pool company, Du Toit, in France (Britten, 2008):

I would just like to advice people of the dangers of swimming pools and to ensure that they ensure their pool have adequate security systems in place, especially for children under 5. In France in 2006, there were 119 accidental drownings in private pools, which resulted in 50 deaths in private pools, even after a new law was passed to ensure all pools had a security system. The only system that works 100% effective is a fence, combined with surveillance by an adult (p. 1).

Since the law was implemented in 2004, the number of swimming pools equipped with safety devices increased. In 2007, there were a total of 800,000 in ground swimming pools in France and out of these 800,000 pools, more than 620,000 had safety devices (Commission de la Sécurité des Consommateurs (CSC), 2007). In 2006, when the law reached the deadline for all swimming pools to have some type of safety device, there was an increase of 70% of pools equipped with a safety device.

A survey conducted by the Swimming Pool Trade Association showed preferences on pool safety devices among consumers. Most people, 45%, prefer immersion detection alarms and in second place, was safety covers with 35.3% (Commission de la Sécurité des Consommateurs (CSC), 2007). The other 19.7 % prefer other types of safety devices.

France's Minister of Housing, Youth, Sports, and public and private organizations have also been promoting drowning prevention campaigns each year in order to stress public awareness on pool safety (Ministre de la Santé, de la Jeunesse, des Sports et de la Vie associative., 2008). The 2005 prevention campaign, supported by the National Institute for Prevention and Health education (INPES), launched two brochures indicating special attention to be taken before, during and after bathing, and how to better protect your pool. These brochures were distributed to the public and placed on the web.

A study shows that the number of children drowning in swimming pools is decreasing after the Swimming Pool Safety Act was implemented (AquaSensor, 2008). The table below, (Table 2-1) shows that there was an increase of number of private pools in France since the year 2000 and a decrease in deaths of children in this type of pool. In 2003, when the law was created, there were 25 deaths of children. In 2004, when the law was implemented, there were 17 deaths and in the subsequent year the number of deaths decreased to 10. However, since this law is still recent, these numbers are not representative of a statistically significant sample size to determine the effectiveness of the law.

Table 2-1 Drowning Deaths in France before and after Swimming Pool Safety Act implemented

Year	Deaths of children in private pools	Number of private pools
2000	32	708 000
2001	23	773 000
2002	14	854 000
2003 (heat wave)	25	928 000
2004 (application of the Act)	17	1 056 000
2005	10	1 154 000

(AquaSensor, 2008)

Australia

In other parts of the world, such as Western Australia, studies have been done over the past 20 years to determine the most common reason for childhood drowning. In a study conducted during the observed years of 1988-2000, almost two-thirds of the swimming pools in which children drowned had only 3-sided fencing (Stevenson, Rimajova, Edgecombe, & Vickery, 2003):

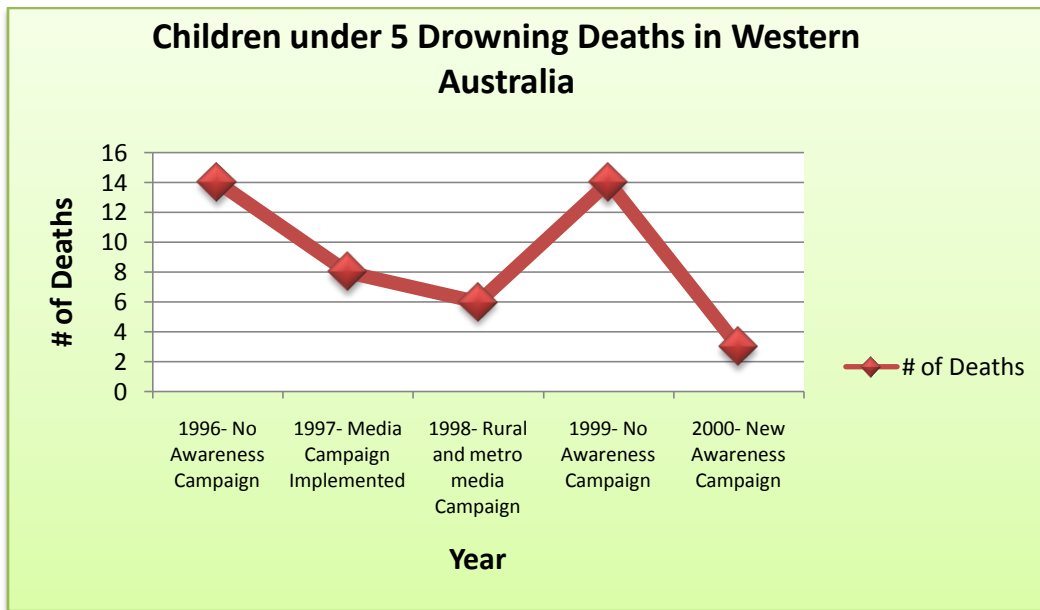
The proportion of Western Australian children drowning in private swimming pools is the same as Australia as a whole; between 1987 and 1996, 81 children younger than 5 years drowned in Western Australia, with 54% of the drowning occurring in private swimming pools. This is lower than in the United States, where between 60% and 90% of child drowning (younger than 5 years) occurs in private swimming pools (p. e115).

In comparison to the United States, Australia has a significantly lower rate of toddler drowning in private swimming pools (Stevenson, Rimajova, Edgecombe, & Vickery, 2003). This could be due to the fact that Western Australia introduced new legislation in 1992. Australian legislation states, “if a swimming pool was installed before July 1992, then its enclosure may include a wall that contains a door or window permitting direct access between the enclosed area and the residence (before July 1992, 3-sided fencing)” (Stevenson, Rimajova, Edgecombe, & Vickery, 2003, p. e115). This is similar to what the United States has adopted as their “standard” for swimming pool barrier safety. With regard to education on this topic, the Australians felt that other preventative approaches were necessary. In order to accomplish this, all Australian states offer water safety education and the teaching of resuscitation techniques. This also includes the

use of media campaigns and educating parents and caregivers on the crucial need for supervision around a pool.

A study that was conducted in Western Australia shows that public awareness reduces the number of child drowning (Tate, 2000). Over the last decade, the Health Department of Western Australia has strived to improve the awareness level among residents. In 1996, when there was no media campaign to raise awareness on toddler drowning, there were 14 toddler drowning deaths. When a media campaign was implemented the following year, the number of deaths decreased to eight. The decrease continued through 1998 with the implementation of more media campaigns. In 1999 there was no awareness campaign and the number of drowning deaths increased to fourteen. The following year, a new awareness campaign was introduced and the number of toddler drowning deaths decreased to three. The figure below (Figure 2-4) represents the trends in drowning deaths over this time span, showing the effectiveness of the media campaigns in Western Australia. Although this research does not specify whether these drownings are strictly related to swimming pools, it clearly shows that an intense awareness campaign has a very positive effect on its residents. An implementation like this could help the United States with its current issue.

Figure 2-4 Toddler Drownings in Western Australia after Media Campaign Implemented



(Tate, 2000)

Northern Australia also adopted new legislation, the Swimming Pool Safety Act 2004, where modified Australian standards concerned with the safety of children in the pool are required (Government N. T., 2004). According to the new law, swimming pools need to be surrounded by barriers that separate them from the house or any other buildings in the property. Barriers should follow the standards specified by the government. The modified standards target children by ensuring that new barriers will keep them away from the pool area. New pool owners have seven days to make new arrangements to their pool area so that it obeys the standards set by the government (Government N. T., 2008). If the pool owner uses a shared fence with their neighbor as part of a pool barrier, they should let their neighbors know that they are constructing a pool next door. Swimming pools constructed after 2003 must follow the Modified Australian Standard. Pools constructed before 2003 must choose between complying with the Modified Australian Standard or the Community Safety Standard (Government N. T., 2008). The

government is also attempting to spread the information to the public by distributing copies of the new standards along with diagrams which show how barriers should be set up.

New South Wales (NSW) in southeastern Australia also shares some common regulations in its NSW Swimming Pool Act 1992 with Northern Australia. This law applies to swimming pools constructed from 1990 and requires that they have a child proof fence surrounding the pool (City of Canturbury, 2008). According to the act, fences should isolate the pool from the house and should be constructed following the standards specified by the government. In addition to these requirements, a safety warning notice also needs to be placed near the pool area. In the City of Canterbury, the government has the right to inspect pools in order to ensure that they comply with the law and if people are following the correct standards for fences. Failure to comply with the law results in fines up to \$220. The importance of this act is expressed by the Local Government Association of NSW, “Drowning is the fourth most common accidental form of death in Australia, and the sixth most common in NSW. Over 300 people drown each year in Australia, with one-third of these in NSW” (Local Government of NSW, 2005).

ASTM Pool Alarm Standards

American Society for Testing and Materials (ASTM) created standard specifications for Pool Alarms in order to provide performance requirements for pool alarms for residential swimming pools and spas (ASTM International, 2002). They define a pool alarm as, “a device designed to provide a rapid detection and automatic alarm in incidents of accidental, unintentional or unsupervised entry of a child one year of age or older into the water of a swimming pool or spa” (p. 1). They categorize pool alarms into four types, as discussed in previous sections and then lay out the performance requirements. ASTM states that:

- 1) Alarms shall sound both at poolside and inside any adjacent residence... via remote receiver within 20 seconds or less.
- 2) The condition of a swimming pool alarm, either on or off, shall be indicated with an energized lamp... visible from a distance of 10ft at $\pm 45^\circ$ perpendicular to the unit, to indicate the operability of the product.
- 3) Pool Alarms are to automatically reset (p. 1).

The standards then address each specific type of pool alarm (categorized A-D) and how they should operate in accordance with previous sections of the standards (ASTM International, 2002). They also state that the consumer product must be, “equipped with proper instructions that describe proper installation, size and shape limitations, troubleshooting instructions, name and contact information of manufacturer, and power requirements, (i.e. batteries)” (p. 3). The standards also specifically state that each device should clearly state that, “[t]his device is not intended to replace any other safety consideration; that is, adult supervision, lifeguards, fences, gates, pool covers, locks, and so forth, and some devices may not detect gradual entry” (p. 3).

2.6 The Human Element

A swimming pool provides a backyard haven in the hot summer months, or even longer depending on the region, for families across the country. It serves as a central theme to a yard’s landscape, as well as for some, a status symbol of wealth. Pools can be the focal point of a neighborhood barbeque, family gathering, or party. However, these places of fun and relaxation are still bringing tragedy to many families with the event of an accidental drowning or near-drowning of a child. Although governmental and non-governmental organizations, such as the CPSC and Safe Kids, have tried to raise awareness of the issue through standards and media

campaigns, roughly 300 children under five years of age are still drowning accidentally in pools annually according to the CPSC (Gipson, 2008).

In order to develop a solution to the problem of unintentional child drowning deaths, safety officials and regulations must understand how people, both children and adults, interact with swimming pools. Studying about how people are acting, risks people perceive, and how incidents accidents happen around swimming pools may help draw a clearer picture of what occurs around an incident. This, along with the public's perception of pool alarms, will go a long way in discovering a solution to the problem of child drowning incidents.

From October 26 to November 12, 2005, Safe Kids conducted a Harris Interactive Survey of 4,495 adults 18 years and older with children 14 years of age and younger (Cody, Morton, Quraishi, & Wilcox, 2006). In the nation-wide cross-section, figures for age, sex, ethnicity, income, and propensity to use the internet were all weighted to make the proportions equal to that of the actual population. The results were broken down into age groups of the children for a better picture of what was happening. Respondents' included 1,301 parents with children younger than 5 years. Children 5-9 years old were represented by 1,386 parents, and there were 1,801 parents with children in the 10 to 14 year old range. It should also be noted that out of the 4,495 parents, less than half (2,166) of the parents owned in-ground, above-ground, or inflatable pools or spas.

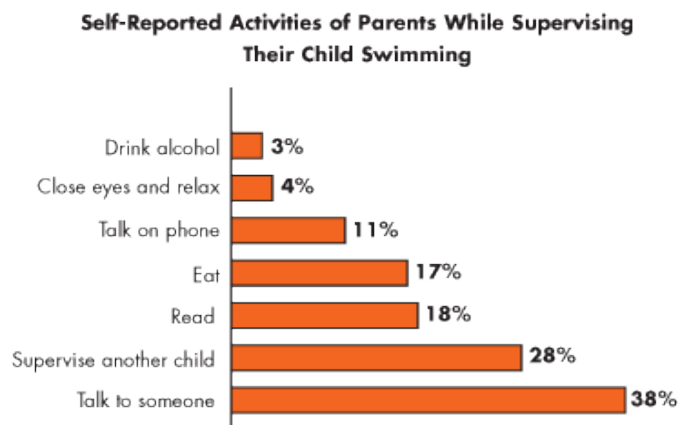
The survey found that 90% of children 14 years old and younger swim, of which 6 out of 10 swim at least once a week during the swimming season (Cody, Morton, Quraishi, & Wilcox, 2006). However, the survey concluded that parents are only somewhat aware of the risk of their

children drowning. Only 34% of parents recognized drowning as the second leading cause of accidental death for children 14 years old and younger.

Active supervision of a child while swimming is one of the main strategies of general drowning prevention promoted by Safe Kids (Cody, Morton, Quraishi, & Wilcox, 2006). They made a point of saying that the supervision should be made by an adult with undivided attention. According to the survey results, parents are in the majority if they actively watch their preschool child. However, as the child grows older, attentive adult supervision diminishes. The rate falls from 93% of parents believing it necessary to stay in visual contact with a 2-year-old and 80% of parents for a 6-year-old to 42% of parents for a 10-year-old. Another finding of the survey was the number of parents engaged in distracting activities while the child was swimming. This included 6% of parents with a child under 5 years old, 23% of parents with children between 5 and 9 years old, and 40% of parents with children between 10 and 14 years old. Only 6% of parents reported doing nothing else while supervising a swimming child.

Figure 2-5 Self-Reported Activities of parents while Supervising Kids - Safe Kids

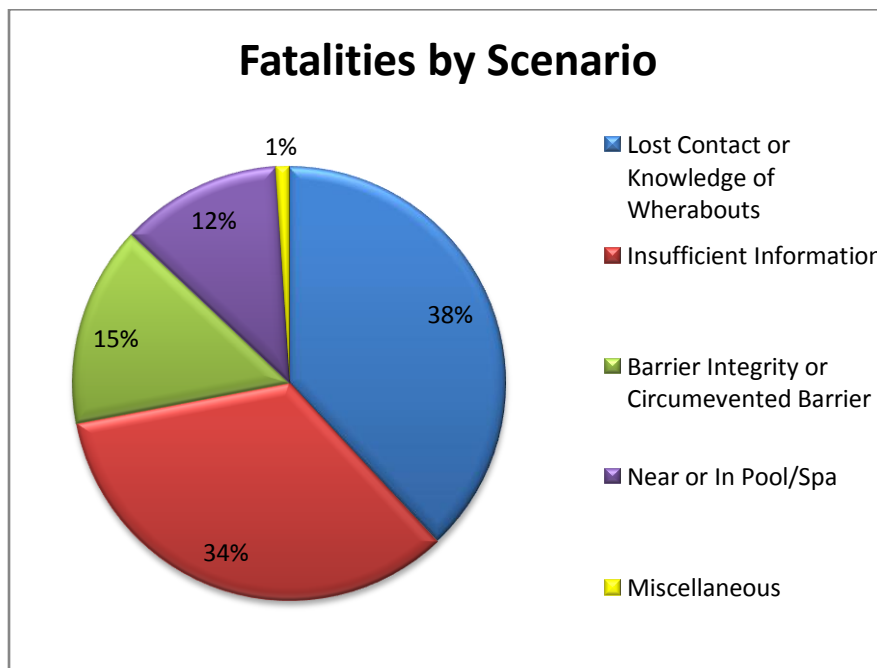
These are activities commonly participated in by adult supervisors of children swimming.



(Safe Kids Worldwide, 2004a)

A report completed by the CPSC shows the percentage of children younger than 5 years old who drowned categorized by scenario (Gipson, Pool and Spa Submersion: Estimated Injuries and Reported Fatalities 2008 Report, 2008). This gives a good picture of how these accidents occurred from the years 2003 to 2005 (See Figure 2-6). The largest portion, 38%, of unintentional drowning deaths occurred because the person watching the child lost contact or knowledge of the whereabouts of the child, occurring 38% of the time. The next known scenario was 15% of the total incidents which were blamed on barrier integrity or a barrier being circumvented. This was followed by 12% of total incidents where the child was in or near a pool or spa area. Unfortunately, for 34% of the incidents the cause could not be determined from the information obtained.

Figure 2-6 Fatalities by Scenario



(Safe Kids Worldwide, 2004a)

This pie chart shows the breakdown of the total fatalities by scenario between 2003 and 2005.

When it comes to protecting against drowning, pool alarm technology is one of the newest methods of protection (Personal Communication Mary Ann Downing, November 5, 2008). Most consumers buy for convenience, conviction, or because a crisis has occurred. Code compliance can be grouped with conviction in the case of pool alarms. Downing has found that people seek better pool safety when one of three events occurs. First, the consumer has bought a new pool; second, the consumer has bought a house with a pool; and third, the consumer has a new baby or toddler in the family.

Many consumers, however, purchase safety devices in order to comply with codes (Personal Communication Mary Ann Downing, November 5, 2008). In this case the search is immediate, and often the cheapest alarm that passes code is purchased. Downing believes more and more people use the internet instead of retail stores to do some research before purchasing. Still, the cheapest category of surface alarms may be the most popular. With a price tag of around \$100, most consumers are unwilling to pay for a better device, even if they do want to prevent drowning. When weighing options most consumers will sacrifice performance and drowning prevention for price.

An employee of a pool alarm manufacturer, Bob Lyons (Personal Communication Bob Lyons, November 8, 2008), has found that buyers and sellers subject to laws have been found to buy or sell the cheapest compliant product before buying a product with higher performance, and therefore higher cost. Lyons has also found that consumers who are required by law to buy a pool alarm often remove or deactivate the device within weeks or even sooner after the inspection was passed. Going beyond this, Lyons has noted that where legislation has mandated the use of pool alarms, the public acceptance has actually diminished.

Another type of alarm purchased by consumers is gate alarms because they are cheap and they also will pass codes (Personal Communication Maureen Williams, November 4, 2008). Unfortunately, Williams has found that most people will deactivate these types of alarms because they are often accidentally set off. Examples of ways in which they are set off include an adult forgetting to push the bypass button or a careless older child goes through the gate. In some extreme cases, building contractors have actually been known to have one alarm that they install on a door or gate to pass inspection, which they then remove and bring to the next job site and install there. Some also install a new alarm and tell the consumer to return it to the store after passing inspection.

When consumers are looking for safety for their family, higher end alarms are often purchased (Personal Communication Mary Ann Downing, November 5, 2008). However, the search may not be immediate. Downing has found that often there needs to be a crisis in the news or within a consumer's immediate social circle to initiate a search for a pool safety technology. Lyons believes that for children 1 to 4 years old, high risk children 5 to 10 years old, such as children with autism, and pets, parents and grandparents will buy pool alarms to break the deadly silence of a drowning incident (Personal Communication Bob Lyons, November 8, 2008). They also may buy them for travelling use. Unlike barrier devices, most pool alarms do have some portability, which is a key feature for consumers looking for protection in a public, condo or residential pool away from home. Lyons states that personal immersion (Type D) pool alarms are the best pool alarm for this situation.

One reason certain pool alarms may not be purchased by consumers, is their bad track records, which affects the opinions of consumers about pool alarms in general (Personal Communication Merle Stoner, November 10, 2008). Organizations such as Good Housekeeping,

Consumer Reports, CPSC, and others have done tests with certain pool alarm devices. Those that did not meet ASTM standards and were found unreliable would not be recommended to consumers.

Currently, according to Downing (November 5, 2008), the public perception of pool alarms is that they do not work because of the poor quality of surface alarms. Consumers believe that all pool alarms false alarm too often. Downing believes that an improved public awareness of the quality and relative low cost of subsurface alarms could greatly improve the current drowning death rate. Lyons (November 8, 2008) believes that consumers are becoming familiar with the value of the pool alarm technology that has advanced recently. Consumers are recognizing that pool alarms can “break the silence” of an immersion accident. Publications, such as the 2008 Good Housekeeping Report on pool alarms, have increased acceptance of alarms that perform well, while diminishing the acceptance of those that do not. Legislation in New York and Connecticut, while enlarging local markets, has not improved public feelings towards pool alarms. Lyons (November 8, 2008) anticipates the California legislation to be more effective due to the fact that it is more considerate to consumers.

According to Bob Hoenig and Bill Roberts (Hoenig & Roberts, November 28, 2008), two pool alarm manufacturers, it is not in the best interest of pool manufacturers and pool retailers to make consumers aware that pools are dangerous and cause injury and even death. Telling any consumer interested in pools this information may deter them from making a purchase. Many consumers, after purchasing a pool, do not want a fence, which would decrease the chances of accidental immersion, around the pool because it is too expensive or is not aesthetically pleasing (Personal Communication Mary Ann Downing, November 5, 2008).

Pool alarms have been available to the consumer for many years now, and some of the technology has not changed for 20 years (Hoenig & Roberts, November 28, 2008). In the case of wave detectors, the technology remains essentially unchanged since its inception. Limitations to these types of devices include the speed in which it takes to sound an alarm is very slow (around 12 seconds in a 16 foot by 32 foot pool) and wind can set them off. Other technologies used by pool alarms include active sonar, which is expensive priced at roughly \$5,000, and passive sonar, or a hydrophone.

Although awareness of new pool alarm devices is on the rise, consumers still associate the term pool alarm with older surface wave detectors that have a propensity for false alarms or “going off whenever the wind blows” (Personal Communication Mary Ann Downing, November 5, 2008). Consumers, who are trying to make their pools safer, not just trying to pass code, are looking for reliability when purchasing a pool alarm. There is little confidence in pool alarms today among consumers and retailers according to Hoenig and Roberts. Immersion detecting pool alarms cannot prevent immersion; it can alarm a pool owner of the incident. According to Hoenig and Roberts, if consumers wish to not put up fences because of aesthetics or price, pool alarms can help fill that gap.

2.7 CPSC Prototype

The CPSC has developed a pool alarm prototype that discriminates children from adults. By using height, foot length and literacy, the alarm prototype has the ability to distinguish a child from an adult. For this technology device, engineers used sonar technology to measure a person’s height. The acoustic sensor is set up on top of a passageway so that the people who pass under it can be measured. To measure foot length the engineers designed a sensor mat with closely separated individual contact switch elements. The mat can be set up under the height sensor. For

the third discriminating category literacy, they used software technology to build a computer program that asks the user/intruder questions which have to be answered within a time limit. This computer can be located before or after the other two alarms. The entire alarm prototype system would need two sensors with a central processing unit, a display, and a keyboard. The data acquired by the three different sensors and input are sent to the CPU, which then compares and analyzes the data. It then decides if the person entering the pool is a child or an adult. When a child enters the pool area, the alarm is activated. When an adult enters the pool area the alarm does not activate.

One of the benefits of this system is that it relies on multiple sensor technologies, decreasing the chances of false alarms. Another benefit is that the alarm guards against children entering the pool area. A disadvantage of this type of alarm is that it only guards against children entering the pool area, leaving them unprotected after they are already in the pool area. Further information can be found in Appendix C.

Summary

After 30 years of work, child unintentional drowning death is still a major concern. The many characteristics of the problem make it a difficult one to solve. Every category distinguished so far, education and awareness, legislation and enforcement, and technology, has made headway in developing a solution. However, even with this progress, there are many drawbacks and problems that need addressing in each of the categories. Also, as these categories increase their effectiveness, there are new technologies that provide other avenues of risk to the consumer that have not been addressed, like the inflatable pool.

3.0 Methodology

The goal of this project was to assess current pool alarm technologies for safety purposes and to make recommendations to the CPSC regarding potential future pool alarm technologies and the feasibility of development of such a technology into a consumer product. The following objectives were used to carry out the project. We identified current pool alarm technologies and their effectiveness, identified human factors related to use and acceptance of pool alarms, and developed specifications for a future pool alarm system for the CPSC. In doing this, we discovered the consumer has no easy way of determining the reliability of the safety technologies on the market today. We also made final recommendations to the CPSC regarding the agency's interaction with the development of a system complying with our specifications, as well as the feasibility of development into a consumer product. This chapter focuses on how we achieved our objectives.

3.1 Identifying Current Pool Alarm Technologies

This section addresses the current pool alarm technologies that have already been developed by manufacturers and are in use around the world today. We observed some devices technically to determine technologies used in the device. By grouping these devices into their respective categories (surface, subsurface, perimeter, gate, and immersion alarms) we were able to examine their capabilities more successfully. This grouping aided us in determining the positive and negative aspects of each category. The information provided by the CPSC, as well as those from interviews with key individuals internal and external to the CPSC, gave us an overview of the technologies' capabilities. We also studied pool alarm use in France and Australia by carefully reviewing information from the French Commission de la Sécurité des

Consommateurs (CSC), and Australian Pool Safety websites by carefully looking over their available material concerning pool alarms and their implementation.

3.3 Human Factors Related to Swimming Pool and Pool Alarm Use

This section addresses topics involved with determining how children and adults interact with pools and pool alarms, as well as the risks perceived by children and adults surrounding pools and pool alarm technologies. We interviewed key personnel within the CPSC, especially in the Directorate of Human Factors. We also spoke with individuals outside of the CPSC, including employees of nonprofit organizations such as Safe Kids Worldwide and various pool alarm manufacturers. These correspondences and interviews allowed us to determine these perceived risks. This research helped us understand how children and adults interact with pools and react to pool alarms, as well as what people look for when purchasing a pool alarm. These interviews were another key step towards developing recommendations for the CPSC on the feasibility of developing a Submersion Prevention Effectiveness Rating system, as well as a Submersion Prevention System that could be transitioned into a consumer product. For a complete list of interview protocol, please see Appendix B.

3.3 Identify Pool Safety Standards and Legislation

Since its inception, the CPSC has been investigating the safety issues surrounding pools, some of which are reviewed briefly in Chapter Two. To completely understand the CPSC's influence on safety surrounding pools and pool alarm technologies, we spoke with key individuals within the organization. From these interviews we learned about the Federal government's authority to ensure safety in these areas, as well as the state and local governments' legislative rules and regulations. By determining the limits of the Federal, state, and local governments with regards to mandating swimming pool standards, we also explored

the capabilities of different government agencies working together to make pools safer and pool alarm technology better.

3.4 Potential Future Pool Alarm Device

By using the information gathered in achieving our previously mentioned objectives, we found a direction for the study of potential future pool alarm devices. We took a more in-depth look at the prototype child discrimination device designed by the CPSC briefly described in Chapter two. In our research, we explored sensor technologies available today, as well as possible shortcomings of these sensor devices. We also identified possible additions or modifications that would make an alarm a more effective tool in keeping children safe around pools. We then created design specifications for a potential future pool alarm system. This was accomplished by following a few simple steps that design engineers use in developing a prototype. We brainstormed functional requirements of such a device. We researched sensor technologies available today in all different technological aspects to determine what technologies would be useful in such a device. The potential pool alarm system used data gathered in the completion of the first three objectives as well as information gathered in the review of the device created by the CPSC.

4.0 Results & Analysis

In this section we discuss results of our research about problems and gaps in today's pool safety awareness, legislation, and technology related to pool safety. Then we present concepts that were developed at a basic level to show ways in which these problems and gaps may be alleviated in the future. As a result of these problems and gaps, we conceptualized a rating system for the consumer to be able to evaluate the pool safety of his or her home. We also provided a framework for a Submersion Prevention System, which uses all of today's pool safety technologies integrated as a system to add layers of protection to the average homeowner's backyard.

4.1 Pool Alarm Technologies

We have evaluated a number of existing pool safety technologies through literature review and web search as well as interviews with manufacturers and experts in the pool safety awareness field. Table 4-1 shows a comparative evaluation of these technologies. Details of each technology are provided in the Chapter 2.

Inflatable Pools

Inflatable pools have become a very popular way for consumers to enjoy the luxury of a pool in their backyard. Because this product is so cheap, it is appealing to the average American consumer. This product is easy to install, and is a simpler, and more portable version of a stationary above ground pool, but when used just for convenience, it can be a deadly attraction for toddlers. Most consumers who use this product do not take the proper safety precautions, which increase the risk of an unintentional drowning incident in the home. In a study done by the CPSC, a total of 283 drowning incidents occurred, with nine percent of those incidents attributed to portable pools (Gipson, Pool and Spa Submersion: Estimated Injuries and reported Fatalities,

2008 Report, 2008). One aspect that needs to be taken into consideration is the price of these inflatable pools. Since the average cost of a pool alarm is more than the inflatable pool itself, further research needs to be done so that consumers, who buy this product, will want to make their swimming area safer. Considerations relating to design and safety of the product also need to be taken into account, so that the inflatable pools really do function as an above ground pool, and can use all the safety benefits that the above ground pool provides. This further research can be carried out potentially by another student group, such as one from WPI, or a Capstone project at a different university.

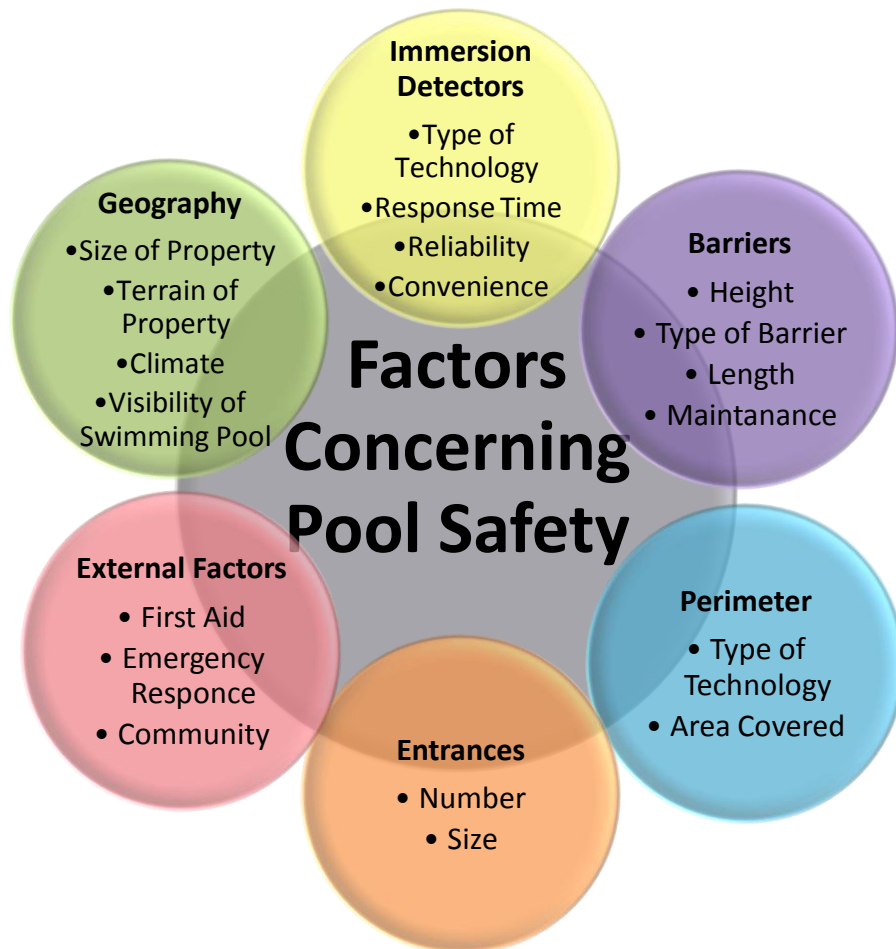
Table 4-1 Existing Pool Safety Technologies

Device Type	Price Range	Function
Surface Wave Detectors	\$60.00 - \$200.00	Unreliable, Detects wave on surface after submersion
Subsurface Wave Detectors	\$100.00 - 300.00	Better reliability, still slow; Detects waves underwater after submersion
Active Sonar	\$4,500.00 - \$6,500.00	Good Reliability; Sends sounds wave, maps entire area
Passive Sonar (Hydrophone)	\$500.00	Good Reliability; listens to the pool for any disturbances, and sends out an alarm
Video Surveillance Recognition	\$130,000.00	Designed for Municipal Pools with Lifeguard on Duty
Gate Alarm	\$1.99 - \$30.00	Announces when someone goes through the gate
Infrared Alarm	\$15.00 - \$150.00	Reads temperature Difference between objects
Personal Immersion Alarm	\$50.00 - \$190.00	Guards the user, not the pool
Perimeter Alarm	\$20.00 - \$600.00	Detects someone moving towards the pool

4.2 Submersion Prevention Effectiveness Rating (SPER) System

Rating systems can be seen everywhere, from movie and television rating systems to Green building rating systems. These rating systems can help industry determine how well they are producing, gamers determine their ability level, or consumers purchase the best product. From our research we have found that the pool safety and alarm technology sector lacks a rating system. Good Housekeeping and the CPSC have evaluated many different types of pool alarms, but there has been no system developed to directly help a consumer purchase the right safety and alarm technology for his/her backyard swimming pool or spa area.

Figure 4-1 Factors Concerning Pool Safety - A Complex Problem



Our proposed solution is to define a Submersion Prevention Effectiveness Rating (SPER) system. Incorporating every aspect of a pool or spa area, we feel a comprehensive function can be constructed to represent the ability of a property to prevent accidental drowning deaths in a scalar manner. This scale can be applied to a five star system that many consumers are familiar with seeing throughout different product areas, such as the automobile five star safety rating. Although the actual function would be created by statisticians and requires more research, we have represented the function in the following way:

$$f_{SPER} = f\{I, B, P, E, X, G\}$$

Equation 4-1 General SPER Function

Incorporated in this function are six sub functions representative of the areas in which effectiveness of a submersion prevention system can be attributed. The sub function *I* represents immersion detectors, a last line of defense against drowning. Barriers are represented by the sub function *B*. Perimeter sensors or sensors detecting activity in the vicinity of the pool or spa are represented by the sub function *P*. The sub function *E* represents any type of entrance providing access to the pool area from public areas or the dwelling on the property. All external factors, such as those imposed by a community, are incorporated into the sub function *X*. The last area covered by the general function is geography of the property represented by the sub function *G*. With these areas incorporated into the function, everything contributing to the effectiveness of a property's submersion prevention system is incorporated into a scalar quantity that can be quickly compared by a consumer to standards that would be determined to help the consumer be aware of the danger surrounding a pool or spa area. Figure 4-1 shows the relationship between the factors concerning pool safety.

Immersion Detectors

The following function represents the sub function for immersion alarms:

$$I = f\{T_T, t, r, c\}$$

Equation 4-2 Immersion Alarm Sub Function

Immersion detectors include surface, and subsurface alarms. When evaluating these alarms, we thought of a couple of aspects that could assign positive or negative values to these devices. One factor of immersion alarms is the type of technology (T_T) used. If the immersion detector is a surface alarm, it may receive a lower rating than a subsurface alarm, because traditionally, a subsurface alarm is more reliable. The reaction to a wave and the amount of time (t) it takes for the alarm to sound also needs to be taken into account. If the alarm takes too long to react, this will earn a negative number. Another factor is reliability (r). If the alarm has the tendency to false alarm, this may generate a negative number. If the alarm is hard to deactivate, this may also have a negative effect because it can become bothersome and inconvenient to the homeowner, which may cause them to stop using the device all together. Therefore, convenience (c) is another factor.

All of these considerations must be thought of because some of these alarms give homeowners a false sense of security, especially the surface alarms. Most of those are prone to false alarms and are sometimes difficult to deactivate, so the homeowner may choose not to use them, although the original intention to address pool safety was there.

Barriers

The following function represents the sub function for immersion alarms:

$$B = f\{h, t_b, l, M\}$$

Equation 4-3 Barrier Sub Function

When evaluating all of the variables involved with pool safety, barriers are usually the ones that first come to mind. An example of a barrier may be a perimeter fence around a property, an isolation fence, a gate, or a door. In order for the Barrier variable to be taken into full account, there are several pieces that contribute to the function. This includes height (h), type of barrier (t_b), length of barrier (l) and how much maintenance is required (M). Each of these aspects would be assigned a numerical value, some weighted more than others, and some having a negative value, depending on the circumstance.

Several factors to consider with height include how tall the fence is. If the fence isn't tall enough, a child may be able to climb over it, causing a negative effect, and therefore a negative value. The type of barrier also needs to be considered. Is the barrier a chain link, wooden or PVC plastic fence? Does it have a self-closing, self-locking gate attached to it? Does the fence follow CPSC recommendations? Another factor to think about is the length of the barrier. If the barrier is a fence, does it cover the entire perimeter of the property? How much of the property is enclosed by the fence? If the fence encloses the entire property, a positive value would be assigned, but if it does not, then a negative value would be assigned. Maintenance is another very important factor. Homeowners want something that is simple and easy to maintain. If this barrier is a lot of work to maintain, it might be awarded a negative value. How often does the barrier need to be replaced? This may pertain to a lock on the gate, or if the fence is not very durable.

Therefore, with consideration of all these factors, the value assigned to Barriers would be a sub function of the main SPER function, and would take into account height, type of barrier, length of barrier, and maintenance required.

Perimeter

Perimeter sensors would be represented by the following function:

$$P = f\{T_P, A_C\}$$

Equation 4-4 Perimeter Sensor Sub Function

Perimeter alarms come in many kinds. They range from passive infrared motion detectors to laser sensors. In this sub-function, the type of perimeter alarm will be evaluated, and then given a grade number based on its effectiveness. The effectiveness evaluation will be made based on the following:

The type of technology (T_P) used is one variable include in the perimeter sensor sub function. For example a laser alarm with build in software that prevents false alarming will rank higher than a normal laser alarm.

Another variable considered by the sub function is the area they covered (A_C). For example, laser alarms cover a greater range in length therefore ranking higher than an infrared alarm when covering the outside perimeter of the pool. Yet infrared alarm covers more area than the laser alarm, which would rank higher than the laser alarm when used to guard the perimeter of the pool gate or door. Also, more sensors are required for larger property sizes.

There are weaknesses and advantages that each alarm has over other alarms. For example, laser alarms do not function well under poor visibility or rain, and infrared sensors do

not work well when the ambient temperature is the same as a person's body temperature. These disadvantages would be considered when developing the rating system.

Entrances

The following function represents the sub function for entrances:

$$E = f\{n, s\}$$

Equation 4-5 Entrances Sub Function

This sub function is based on the number (n) and sizes (s) of entrances to the pool area. The more entrances to the pool area there are, the harder it is to guard against intrusions, therefore the house would receive a lower ranking depending on the amount of entrances to the pool area that it has. Gates play a big role in this function. Gates that are properly maintained and have self closing and self locking latches will gain positive points, gates that are hard to maintain and do not have any safety devices on them will receive fewer points or even negative points since they can give a false sense of security. The same reasoning applies to doors. Windows that are placed at adult eye level, out of a child's reach, and with appropriate security devices would be a positive according to the rating system since they are not easily accessed by children, and the sensors can help in locating and identifying an intrusion into the pool area.

External Factors

The following function represents the sub function for external factors:

$$X = f\{A, R, C\}$$

Equation 4-6 External Factors Sub Function

External factors account for items to consider outside of pool safety technologies. These include first aid (*A*), emergency response (*R*) and community (*C*).

In emergency response, forms of emergency rescue are taken into account. Unlimited forms of emergency response can be considered. One example of a good emergency response is having a CPR certified person in the house. A house with a CPR certified person may receive a higher value in the rating system compared to a house without anyone who knows how to perform proper CPR. Other factors that may bring a high value in the emergency response category include an Automated External Defibrillator (AED) in the house and the time it takes for an EMS ambulance to come to the house in case of an emergency. A possible scenario for how these items can be implemented into the SPER concept is when a parent rescues a child from drowning, and this child is unconscious. The parent does not know how to perform CPR and calls EMS to give the proper emergency rescue to the child. However, the EMS in this neighborhood takes a very long time to get to the house. The EMS delay to respond to the emergency may give a negative number to the emergency category and consequently a low number on this house's SPER system. These items are just some suggestions on how one might receive a high value for the emergency response category, but they are not limited to other forms of emergency responses.

For first aid, emergency supplies are given a certain value in the SPER system. The lack of certain vital emergency aid may result in a negative number or a low number in the rating system. For first aid, some components to consider consist of a simple first aid kit for non-drowning related accidents, an emergency phone close to the pool with emergency numbers attached to it, a poster illustrating the proper steps in CPR and an AED in the house. A house that contains all of these items may be given a high value for its first aid category, which may

contribute to a high SPER value. All of these simple supplies may assist and make a difference on how much time it takes to rescue someone who is drowning.

In the community category, we give credits to communities where they have some type of a neighborhood watch drowning prevention program. In this case, the prevention program will just work as the neighborhood crime watch program, where neighbors will help each other to report if there are children coming to someone else's property. A house that participates in such a program may receive a high value on its community category in the external factors of the SPER system.

Geography

The sub function for geography would be represented by the following:

$$G = f\{A_p, T, w, v\}$$

Equation 4-7 Geography Sub Function

The sub function G includes anything affecting the safety of the pool or spa area pertaining to geographic factors. This would include items like size of property. The size of a property (A_p) is a determining factor, because a large property is harder to protect. The terrain, (T), affects the safety of the pool because certain sensors may be blocked by geographical features or vegetation on the property. Climate (w) comes into play in that weather, especially in the winter, may make some sensors inoperable in certain areas. Also the visibility of the pool (v) can affect the safety. If the pool is hidden behind the house it is not as attractive a nuisance to the public as a pool located in the front yard.

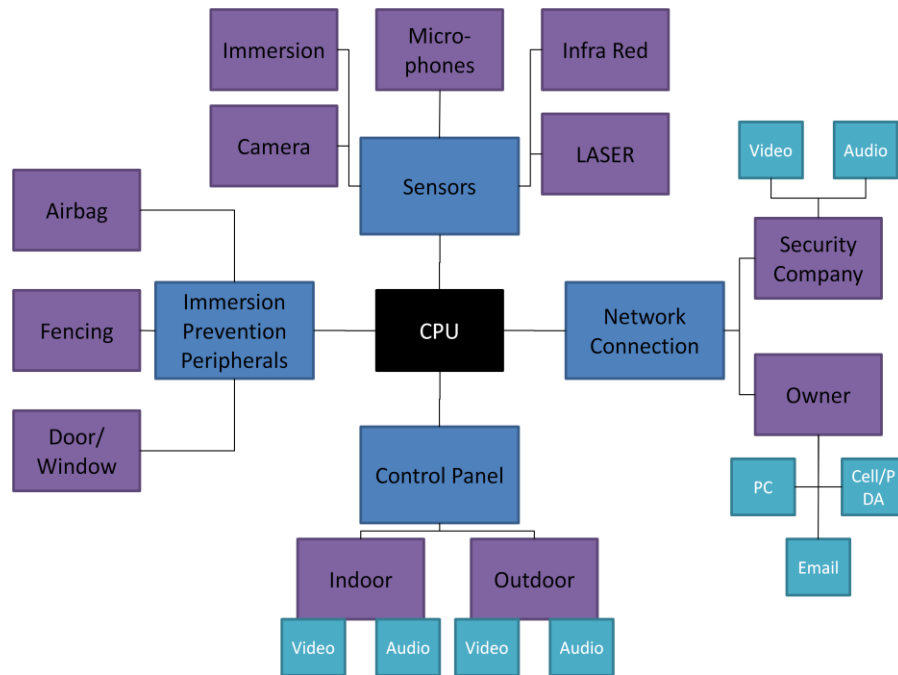
Summary of SPER System

The SPER System would be able to make it easier for consumers to recognize the reliability or safety of pool safety devices and their individual pool properties. Based on a scale, such as the five star system, consumers could easily see where their property falls. Further development of this proposed idea is necessary to achieve a satisfactory reliable rating system. However, a rating system that works in this way could lead to greater awareness and safer devices, which may result in a decrease of unintentional drowning deaths.

4.3 The Submersion Prevention System

Based on our evaluation of current technologies for pool safety and the trends in the sensor systems, wireless networking, and embedded system design, we propose a “Utopia” for future pool safety systems. Isolated technologies in today’s layers of protection scheme do not provide enough reliability or convenience for consumers to use them effectively. In order to tackle this problem, we used a systems approach to develop a system for drowning prevention. The system uses sensor, digital and wireless network technology and future pool immersion prevention technologies under one central processing unit. The system can uses sensor technology to help increase the reliability and effectiveness of identifying an intruder in the swimming pool area. Digital and wireless technology is used to alert the user of any intrusion into the pool itself. The immersion prevention used to secure the swimming pool, not letting intruders into the swimming pool. With an integrated system, customizability is the key to the consumer being able to pick and choose devices for the system that will be triggered by qualitatively different scenarios. Figure 4-2 shows the general block diagram of the Submersion Prevention System.

Figure 4-2 Submersion Prevention System



Sensor Technology

As discussed in Chapter 2, many different sensor technologies exist today. Without these different sensor technologies, many pool alarms would not be on the market today. The Submersion Prevention System would incorporate many of these different sensor technologies, including those already in use by pool alarms, as well as those in use by other devices. With a diverse selection of sensor devices available to the SPS, flexibility and convenience would be readily available to the consumer.

Starting from the water in the pool, immersion detection sensors would include devices like the passive sonar (hydrophone) devices available today, as well as the personal immersion sensors that are worn by a child or pet. Both of these devices could be developed to communicate wirelessly with the Central Processing Unit of the SPS, shown in Figure 4-2. According to a personal communication with Mary Ann Downing on November 5, 2008, surface wave detection

devices are being bought by consumers less today than in the past. A trend may be seen with subsurface wave detection devices in the future with the debut of passive sonar devices on the consumer market, with a cost nearly a tenth (\$500) of active sonar systems (\$4500-\$6500).

Moving in an outward direction from the water's edge, the system would have sensors on the pool cover, if the pool has one, to tell the consumer if the pool cover is open or closed, functioning properly, or malfunctioning. Although this may not directly save a child's life, it would add to the convenience for the consumer and make it much more likely that the entire system is functioning at its peak performance. Outside of the pool, a consumer's individualized SPS could include an array of devices to ensure protection.

Perimeter LASER-based detection devices could be used around the pool area to alert the home owner of someone in the area of the pool. Often false alarming because of something breaking the beam, such as leaves blown by the wind, this device could still be useful in the SPS because the system would use algorithms to determine if an alarm needs to sound depending on what sensors are detecting. If just the perimeter sensor detects something, and all the sensors leading to this point, as well as after this point, do not detect anything, the system may just make the consumer aware that specific device was tripped in a non-intrusive manner because the likelihood of someone being in the area is minimal.

Additional sensors around the perimeter sensors, depending on the consumer's preferences and property needs, could include motion detectors and video surveillance. Infrared motion sensors are commonly used in devices such as outdoor lighting. In the event of a body with a different temperature than the background moving in front of the sensor, the infrared motion sensor turns on the outdoor flood lights. This has been applied to intrusion alarm

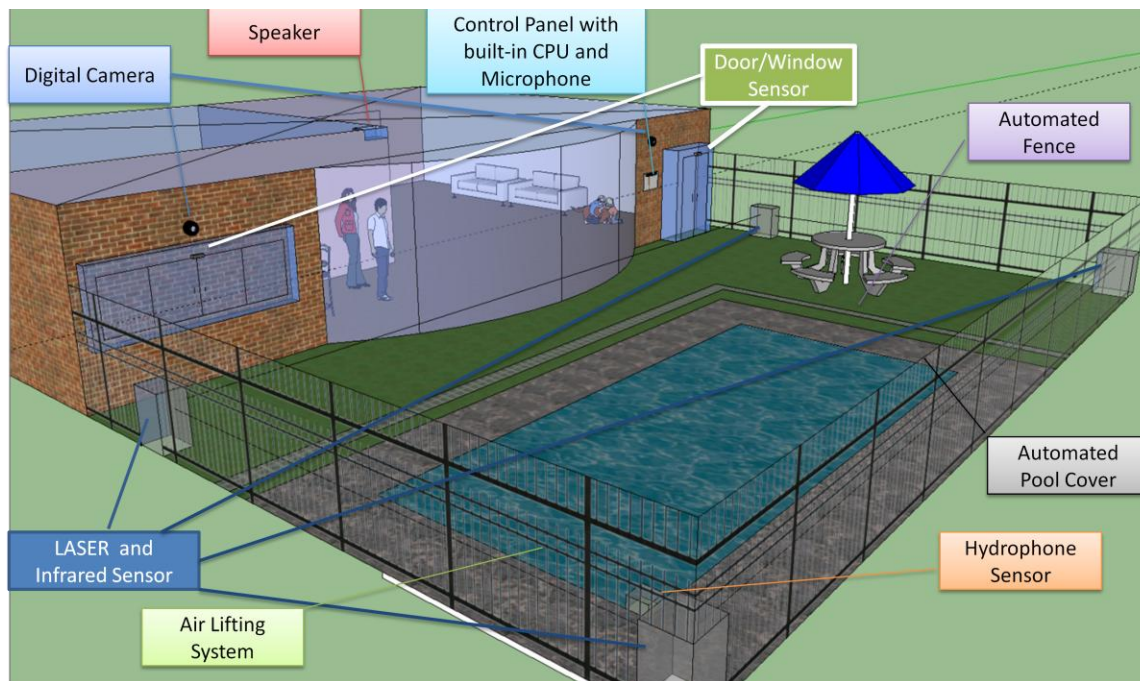
technology and could be utilized to make a consumer aware of someone moving on the consumer's property. Advances in video surveillance and recognition software in the future could lead to a video surveillance system that can discriminate between children and adults, as well as the owners of the property and strangers. With this possibility, the video surveillance system could alert the consumer to strangers on the property or the consumer's young child in the area of the pool.

Today consumers can purchase gate, door, and window alarms. The sensors used in these devices could be incorporated into the SPS to protect the entrances to the pool area. The CPU of the system could also determine if the gate, for example, is propped open, unlatched, or even malfunctioning. This would help to ensure the entire SPS is performing properly, and help strengthen the weakest link in barrier devices.

More for convenience than safety, the SPS could have microphones throughout the house and pool area. With these, and voice recognition software, the consumer could activate and deactivate various sensor systems and corresponding alarms throughout the property. This would eliminate the necessity of the consumer having to go to the control panel every time someone wishes to use the pool area or access other places on the property. Also, in coordination with the video surveillance system mentioned above, the SPS could better determine who is on the property, and whether or not that person should be on the property, through voice and video recognition, thereby making false alarms less likely in the event of an adult being in the area of the pool. With the convenience of being able to deactivate sensors and corresponding alarms from the control panel located in the most convenient place(s) in the house, the consumer will be more likely to utilize the system than an array of unconnected devices that have to be deactivated one at a time.

The multitude of applications sensor technology could bring to this future model of a SPS is only touched upon in this section, as a starting point for future development. Through the system integration of these devices, convenience and safety of the consumer are increased. All of these interchangeable devices could be sold individually, or in packages, to help a consumer build a personalized Submersion Prevention System, depending on the consumer's needs and the Submersion Effectiveness Rating (SPER) system.

Figure 4-3 House with Proposed SPS System



Immersion Prevention Peripherals

The Immersion Prevention Peripherals subsystem concentrates on a combination of technologies and ideas proposed by inventors, manufacturers and our team. These peripherals focus on technologies such as pool airbag, fencing, door and window security system, and automated covers.

Pool Airbag

A technology currently being developed in Germany uses a combination of a pool alarm and airbag to prevent children from drowning in the swimming pool (Poolsolarm, 2008). The pool airbag is placed at the bottom of the pool, and a plastic cover in the pool's shape lies on top of it. When a child falls into the pool, the alarm detects this fall and the airbag fills up. This pressure lifts the plastic cover, consequently lifting the child to the surface. After the child is lifted to the surface of the pool and is not inside the pool, the air inside the airbag is released and the plastic cover is brought back to the bottom of the pool. The use of this type of technology would solve the problem of someone having to be in the pool when the alarm goes off in order to save a child from drowning.

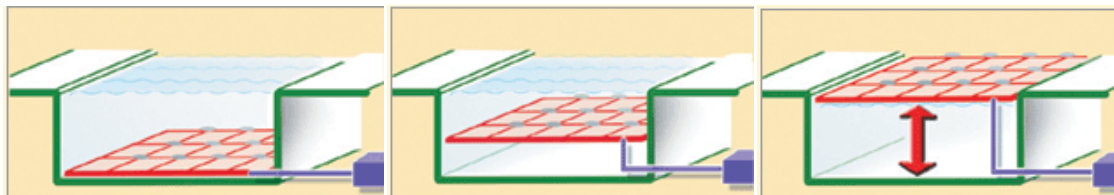
Figure 4-4 Airbag Lifting System



Before



After



(Poolsolarm, 2008)

Pop-up Fencing System

In the process of researching the different forms of pool safety devices used by consumers and proposed by manufacturers, we discovered that fencing is still considered by many as the most effective safety device for keeping the children away from the pool. Based on this idea, we suggest that manufacturers think about designing a pop-up fencing system where fences would pop up from the ground of the area surrounding the pool's perimeter. It combines the technology used in perimeter alarms and fences. Sensors outside the area being protected would sense a person coming to the area of the pool by motion and by the proximity to the sensors surrounding the fence. An alarm will sound, and fences will automatically pop up from the ground at a regulated speed to a particular height. The pop-up fencing system will help homeowners who are aesthetically concerned with the view of the pool in their backyard. By adopting the pop-up fencing system, the concept of isolation fencing is still kept, as well as the view of the pool, but this pop up fencing apparatus will still be able to prevent children from entering the pool area. Future research on practicality and cost of such a system is needed in the future.

Door/Window System

An automated door and window system will help keep doors and windows that are accessible to the pool area closed and locked at all times. Sensors in this system will be able to detect children from adults. If the sensor in the door or the window senses that a child is coming closer, it will automatically close and lock. Doors and windows will unlock when adults come close to them. Once doors and windows are unlocked, there will be a limited time for them to remain open. With this system put into practice, it will be easier for parents to keep their children

away from the pool area. Doors and windows locking and unlocking automatically just adds to the convenience of the system, thereby being more likely to be used by the consumer.

Automated Covers

Automated covers will be used to keep the pool covered when a child comes close to the pool. There will be sensors that will detect when a person comes close to the pool area and the pool cover will automatically cover the pool, thus preventing the child from getting into the pool.

Control Panel

In order for the Submersion Prevention System to have full functionality, the user interface needs to be easy to use and easy to maintain. We think it would be a good idea to install a control panel in the system so the consumer would be able to turn off multiple alarms at once, and check safety status reports. The control panel would also have an audio feature, where the consumer could use it to talk into the panel to activate or de-activate specific devices. This would be advantageous to the system because right now, each alarm that a consumer would buy to install in or around their pool is separate from each other. If the consumer wanted to turn off the alarms because he or she was having a party or some event where there would be a lot of people around, they would have to walk around their property and turn off each alarm individually. With a control panel, the consumer could easily turn off a gate alarm, a pool alarm, perimeter alarm, etc., from one location.

The control panel would also have a unit both inside and outside the house, preferably one near the pool area. The control panel might also have some first aid information and guidelines stored in it as an application, as well as a phone in the unit so the consumer would be able to call 911 in an emergency.

The control panel could use a touch screen as the interface, or one with buttons, whichever the consumer prefers. The status reports about the functionality of the safety devices could be sent in an email to the consumer's personal email, or straight to the control panel so when the consumer checks which devices are on, he or she can receive an alert. Using this feature, for example, they can check which devices have batteries that are running low and which gate door is ajar. This addition to the system is a very important one because it allows for ease of use by the consumer, which is what we aim to achieve by designing this entire system.

The control panel can also be incorporated into an entertainment system. The consumer may want to hook up an mp3 player, or stereo system to the control panel to play music during a gathering. With a control panel, the consumer can be in charge of the music right from the screen, instead of having an external system set up for entertainment.

Consumers want minimalism and effortlessness so they don't have to be bothered with maintaining products, or replacing and keeping track of which devices work and which ones are malfunctioning. The control panel addresses all of those problems by having everything controlled by one unit.

Network Connections

The CPU will be connected to a wireless network. This network allows the CPU to communicate and interact with outside personnel.

Many home alarm systems already have a network connection to their security company that responds when any alarm goes off in the house. These security companies offer a series of services such as 24-hour monitoring with a full network of interconnected customer monitoring centers throughout the country. This monitoring can notify both the police and the house to keep the house protected. They also already offer multi-layer protection such as monitoring houses for fire/smoke, carbon monoxide and other home emergencies (Security Choice, 2008). Our proposed system takes advantage of this already available service by combining both the system of the pool alarm with the home alarm security company. When the CPU activates alert mode, it contacts the security company streaming both live audio and video of the pool perimeter to the customer monitoring centers. If the company deems the situation an emergency, the company immediately calls the emergency contact numbers for the house, and local authorities. If they see that it was a false alarm, the company sends a signal to the system to shut down the alarm.

This system will also address a downfall that alarm technologies have today: lack of proper maintenance reports. The system will be able to perform maintenance inspections for any faulty functionality and generate a report based on the results from the inspection. The CPU will then e-mail these reports monthly to the user via email, or directly to the control panel. If the user does not take action to safely maintain the devices, the CPU sends a report to the security company for further actions.

To make this system attractive for consumers in the market and competitive with other available products, this system will be able to use the network connection in order to perform entertainment downloads to the system such as movies and songs to satisfy the growing demand of digital entertainment of society.

The costs of the sensor devices would be equivalent with the costs of corresponding sensor devices that work in isolation today. Although we cannot estimate a proposed price for this system, we do expect it to be more expensive than the available technologies today when it first comes on the market. In spite of increased cost, we expect the system's gains over today's technologies would make it appealing to many consumers. We also expect the increased research is done in the field of sensor technology to help reduce the cost of various parts of the system. Costly barriers are incorporated into this system, but legislation in many states includes barriers, and we foresee this trend continuing to other states as well.

This system would require the use of certain peripherals from each category. However, it provides many customizability options for the consumer. Along with the convenience and reliability gained by an integrated user, and the entertainment options it could provide, we believe this system idea to be more marketable to the consumer. The consumer would find it safer, and easier to use making the owner more likely to keep using the product and keeping the pool area safe.

5.0 Conclusions

After much research, we decided that all the alarm systems that exist up to this date are not effective or reliable enough to properly prevent a person from drowning in a swimming pool. In order to tackle this problem, we came up with a better system for drowning prevention. The system uses sensor, digital and wireless network technology and also future pool immersion prevention technologies under one central processing unit. The system can use many sensors to help increase the reliability and effectiveness of identifying an intruder in the swimming pool area. Digital and wireless technology is used to alert the user of any intrusion to the pool. The immersion prevention is used to secure the swimming pool, not letting intruders into the swimming pool.

From our analysis of the information gathered, we found a large gap in submersion prevention. Pool alarm devices have been around for decades and are now being incorporated into local laws and ordinances in an attempt to lower the rate of accidental pool drowning deaths. However, many people believe these alarms to be unnecessary or unreliable, while research shows that people develop a false sense of security based on the devices capabilities. This gap is what a Submersion Prevention Effectiveness Rating (SPER) System would fill. Based on this rating system, a future model of a Submersion Prevention System (SPS) to protect from immersion incidents is possible.

The SPER System would involve every aspect of submersion prevention surrounding any given pool in a to-be-determined function. The outcome of this function would be a value on a scale that would be applied to a five star rating scale. Five star rating scales are used in many rating systems in use today, including hotels and consumer products. Because of this, the system

would be easily recognizable and most consumers would have a basic understanding of a given rating.

Based on the SPER system, the rating of a pool area would filter down to the individual devices sold in stores and on the internet. Every tested device would have a label on it telling the consumer the value it would add to the consumer's pool's SPER. This way a consumer, or designer, could easily pick and choose the devices that the pool property needs to be as safe as needed based on the label on the packaging of the devices.

Also, with the implementation of this rating device, it would make it easier for pool alarm manufactures to come up with new models for their devices. Our team devised a model of a future Submersion Prevention System (SPS) using a systems approach. In discussions (noted in chapter 2) with pool alarm manufacturers and sales representatives, consumers buy products for convenience, conviction, or a crisis. Since conviction is controlled by legislation, and because crises are to be avoided in the world of pools and pool alarms, then the final aspect that we decided to improve upon is convenience. The framework that we have provided for a comprehensive systems approach to a pool technology system would allow the users to fully customize their unit, making it more appealing to the average consumer.

All the devices incorporated into the SPS would be rated using the SPER system. This would make it easy for the consumer to decide which devices to purchase for his/her personal application. Most would not be able to have all these devices because of the cost, nor would it be necessary to have all the devices. The SPER System would facilitate the construction of a SPS. The SPS could also be expanded to provide entertainment, through devices that would allow

iPods to be plugged in for music in the pool area, to streaming music and videos from the Internet.

6.0 Recommendations to the CPSC

Based on our evaluation of current technologies for pool safety and the trends in sensor systems, wireless networking, and embedded system design, we proposed a “Utopia” for future pool safety system. After carefully reviewing the problem, we also came up with related recommendations for the CPSC to carry out in order to help decrease the number of drownings that occur annually, nationwide. In this section we discuss our specific recommendations to the CPSC.

6.1 SPER Implementation

In order for the CPSC to carry out these recommendations we have made for them, there needs to be an appropriate amount of staff who can accomplish these tasks. We recommend that the CPSC turn these tasks into a Senior Capstone project for senior engineers, or an MQP [Major Qualifying Project] for WPI students. The means by which to do so would include contacting an interested university and describe to them what the project entails. Any university that has senior engineers that need to fulfill a capstone project could be the target, including WPI students who need to fulfill their MQP, since the CPSC already has established good relations with WPI. This project would be open to students from several majors, for example, Mechanical Engineering, Electrical Engineering, and Mathematics.

6.2 SPS Design

Based on our evaluation of current technologies for pool safety and the trends in the sensor systems, wireless networking, and embedded system design, we propose a “Utopia” for future pool safety systems. We recommend that the CPSC take our framework for a future system into consideration to use a “systems approach” to solving the unintentional drowning problem in the U.S. today.

6.3 Government Research on Pool Sensors

We recommend that the Government sponsor more research on sensor technology applied to pool safety, and take some of the current technology used by the military and adapt these technologies for swimming pool safety. We need better sensor technologies, so that pool alarm manufacturers will be able to produce pool alarms with faster response time to pool incidents and fewer false alarms.

With further research and development in sensor technology, a decrease in the cost of the sensors, will decrease the cost of production of pool alarms. Based on the economic law of supply and demand if the price of sensors related to pool technology decreases, the demand for pool alarms will increase. With more pool alarms in the market, there should be a fall in the price of pool alarms, leading to greater interest in pool alarms and its overall sales.

6.4 Expanded Research on Inflatable Pools

Based on the research we have reviewed about pool safety and drowning incidents, we have found that limited research has been done with regard to inflatable pools. There are many drownings occurring annually due to the increase in sales of this product, because such pools are affordable to the average American consumer. With that, we recommend that the CPSC does more research be on inflatable pools, especially with regard to design and safety. These pools are a simple way for families to enjoy the summer months, but they are truly a deadly body of water when left unattended due to the instability of the product.

6.5 Pool Safety Awareness

Education is an essential part of drowning prevention. It is only through education that manufacturers and adults can communicate to children about the dangers of an unsupervised

swimming pool. With education, parents will become more familiar with the safety precautions and will help them in learning how to provide the appropriate emergency response to a drowning child. For parents to become aware of how it is important for them to supervise their children while they are in the pool, a better drowning prevention program is needed. Although there are some Non Governmental Organizations that work on drowning prevention, there is a need for more organizations and the government to increase their involvement with this issue. One way to enforce the importance of safety precautions in the swimming pool is to establish a national drowning prevention week and to have T.V. commercials that show steps to improve safety in the pools. Handouts discussing these basic precautions can also be distributed to homeowners when they buy a swimming pool. This will help the homeowner in realizing that pool supervision, while in use, is extremely important since he/she is responsible for anything that happens in the pool.

The CPSC could also update their website, on the section specifically designed for kids, so that it is more “user friendly” for children and parents. The current CPSC website, on the “Kids” section does not have any information regarding drowning prevention, which should not be left out since drowning is the second leading cause of death for children under the age of 19. This way, children who use the internet to play games, get homework assignments, etc., can update their parents on any pool safety issues that they may have learned about on this new interactive website.

Appendix A: U.S. Consumer Product Safety Commission

Located in Bethesda, Maryland, the U.S. Consumer Product Safety Commission (U.S. Consumer Product Safety Commission, 2008) is “committed to protecting consumers and families from products that pose a fire, electrical, chemical, or mechanical hazard or can injure children” (U.S. Consumer Product Safety Commission). The CPSC, which was created in 1972, is an independent agency responsible for protecting the public from risks of serious injury or death from more than 15,000 types of consumer products under the agency’s jurisdiction. Deaths, injuries and property damage from consumer product incidents cost the nation more than \$800 billion annually. Since its foundation, the CPSC has contributed significantly to the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years. Structured hierarchically, the CPSC is headed by three presidential-nominated commissioners, with many important groups reporting to these commissioners including Congressional Relations, Inspector General, General Counsel, Equal Employment, Minority Enterprise, the Secretary, and the Executive Director (U.S. Consumer Product Safety Commission).

With a small employee base of only 400 persons, the CPSC works to fulfill the service it provides to the American public (Nord & Moore, 2007). Despite its relatively small size, throughout its 33-year history the U.S. Consumer Product Safety Commission has been highly effective at reducing product-related injuries and deaths. Although there has been a significant increase in the country’s population over that time, product-related deaths and injuries in many categories have been reduced by as much as half or more.

The requested budget comes from a report submitted to Congress every year. In 2007, the 2008 requested budget was \$63,250,000. The Commission's request for 2008 of \$63,250,000 represents an increase of \$880,000 from 2007 (Nord & Moore, 2007)

The CPSC is continuously dealing with problems concerning consumer products. In order to keep their information as current as possible, and to lighten the load of the employees, the CPSC recruits students of Worcester Polytechnic Institute. For over 15 years, the CPSC has sponsored Interactive Qualifying Projects (IQP) from their office in Maryland.

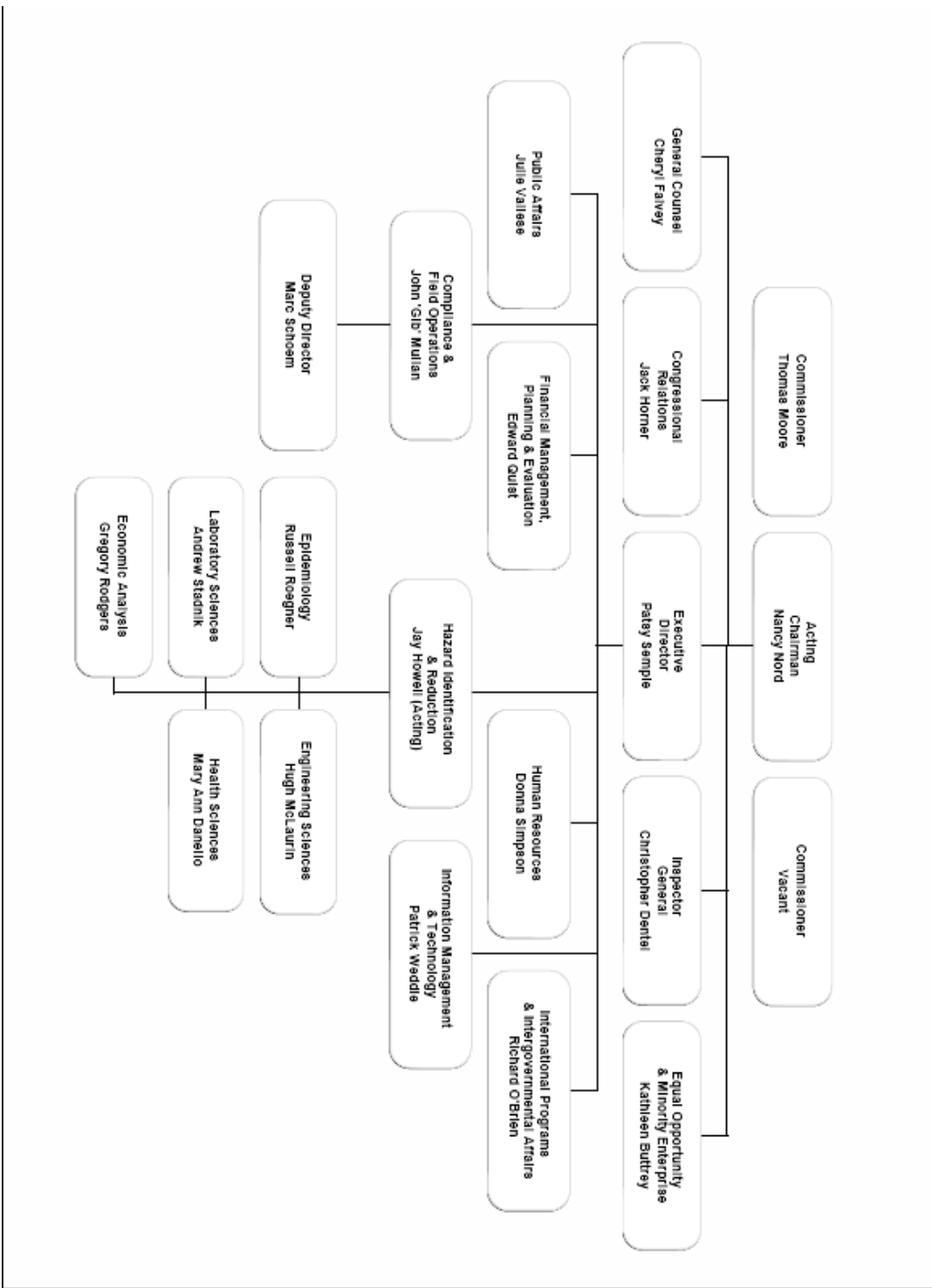


Figure A-1 Consumer Product Safety Commission Organizational Chart (U.S. Consumer Product Safety Commission, 2008)

Appendix B: Interview Protocols

Protocol for Interview with Individual with Professional Experience in Pool Safety

I.e. Swim Coach, Municipal Pool Manager, Athletic Director

Is it ok for us to record our conversation with you?

Name:

Length of experience regarding swimming pools:

Occupation:

1. How long have you had experience with swimming pools?
 - a. Can you talk a little about what you do in your job?
2. How many children do you see in the pool in an average per day?
 - a. Could you describe what they normally do in the pool?
 - b. What are the things that you watch for while they are in the pool?
3. How old are the children?
4. Could you describe the safety standards for the pool?
 - a. Are there specific standards designed for children?
 - i. Could you tell us more about it?
5. What are the most common accidents in the pool?
 - a. Are any of them related to children?
6. How is the pool guarded at night (during non-operating hours)?
 - a. Do you use any form of technology for the security of the pool?
 - i. Can you give us specifics?
7. Are you aware of any governmental regulations regarding the safety of swimming pools?
 - a. If yes, please tell us more about it.
8. What existing pool alarms have you heard of, if any?
9. Do you believe that a pool alarm that discriminates children from adults will help in improving the safety of the pool? Why?
10. If you had a pool, would you want to install a pool alarm?
 - a. If yes, would you prefer one that discriminates children from adults? Why?

Protocol for Interview with Home-Owner with In-Ground Pool

Is it ok for us to record our conversation with you?

Name:

1. How many children use the pool on average per day?
 - a. Could you describe what they normally do in the pool?
 - b. What are the things that you watch for while they are in the pool?
2. How old are the children?
3. Could you describe the safety standards for the pool?
 - a. Are any specifically designed for children?
 - i. Could you tell us more about it?
4. What process did you have to go through with your town in order to install the pool?
 - a. Are there any specific safety regulations that you needed to follow?
5. What are the most common accidents in the pool?
 - a. Are any of them specifically related to children?
6. How is the pool guarded at night (during non-operating hours)?
 - a. Do you use any form of technology for the security of the pool?
 - i. Can you give us specifics?
7. Do you have a fence around your property?
 - a. Can you describe the type of fence?
 - b. How tall is the fence?
8. Are you aware of any governmental regulations regarding the safety of swimming pools?
 - a. If yes, please tell us more about it.
9. Do you know of any existing pool alarms?
10. Do you believe that a pool alarm that discriminates children from adults will help in improving the safety of the pool? Why?
11. Would you want to install a pool alarm?
 - a. If yes, would you prefer one that discriminates children from adults? Why?

Protocol for Interview with an Organization Concerned with Pool Safety

Date:

Name:

Occupation:

1. What do you feel is the most important thing for parents to know about Pool Safety?
2. What do you think the most effective way to ensure pool safety would be? Safety Education? Technology? Legislation?
 - a. Why?
 - b. How would it be implemented?
3. If Safe Kids had all the resources they needed, including man power and funding, what actions would they take to help alleviate this problem?
4. Do you feel there is anything the manufacturers of pools can do to prevent accidental drowning?
5. Should the government get more involved with regards to drowning accidents?
6. With regards to drowning prevention, what does Safe Kids plan to do in the future?

Appendix C: CPSC Field Test Study Report

In an excerpt from the CPSC's Field Test Study Report, it states:

“Every home contains areas or items that can pose hazards to children 5 years old and younger (United States Consumer Product Safety Commission, 2004). Despite the existence of both passive and active safety systems, thousands of children die or are treated in emergency rooms each year for injuries associated with window falls, swimming pool submersions, and exposure to hazardous substances.

A reduction in the number of incidents may be possible with additional systems that identify unaccompanied young children in areas with potential hazards and sound an alarm. Fewer nuisance alarms may be possible if the system identifies and classifies persons as children or adults. Such a safety system could be designed to be always on, non-intrusive, sensitive, and flexible. These features would help alleviate problems associated with common consumer behaviors such as forgetting to arm the system or ignoring alarms from systems with a high false alarm rate.

This report describes some characteristics of a system that discriminates between children and adults. An anthropometric analysis identifies factors amenable to adult/child identification. Differences in height, foot length, and cognition (literacy in this study) were evaluated as means of determining whether a person entering an area is an adult or a child. The testing showed that simple sensor systems are capable of acquiring data adequate for such discrimination (United States Consumer Product Safety Commission, 2004, p. i).

Appendix D: Glossary of Acronyms

- AED**- Automated external defibrillator
- AFNOR** -Association Française de Normalisation
- ANSI**- American National Standards Institute
- ASME** – American Society of Mechanical Engineers
- ASTM**- American Society for Testing and Materials
- CDC**- Center for Disease Control and Prevention
- CDPH**- California Department of Public Health
- CPR** – Cardiopulmonary Resuscitation
- CPSC** – Consumer Product Safety Commission
- CSC** - Commission de la Sécurité des Consommateurs
- EMS**- Emergency Medical Service
- ICM**- Injury Cost Model
- IR**- Infrared
- LASER**- Light Amplification by Stimulated Emission of Radiation
- LED**- Light Emitting Diode
- NEISS**- National Electronic Injury Surveillance System
- NGO** – Nongovernmental Organization
- NSW**- New South Wales
- PIR**- Passive Infrared
- PVC** – Polyvinyl chloride
- SPER** – Submersion Prevention Effectiveness Rating
- SPS**- Submersion Prevention System

Appendix E: Pricing of Current Pool Safety Technologies

Device Type	Price Range	Source	URL
Surface Wave Detectors	\$60.00 - \$200.00	Amazon.com	http://www.amazon.com/s/ref=nb_ss_gw?url=search-alias%3Daps&field-keywords=pool+alarm&x=9&y=24
Subsurface Wave Detectors	\$100.00 - 300.00	Amazon.com	http://www.amazon.com/s/ref=nb_ss_gw?url=search-alias%3Daps&field-keywords=pool+alarm&x=9&y=24
Active Sonar	\$4,500.00 - \$6,500.00	(Bailey, 2006)	
Passive Sonar (Hydrophone)	\$500.00	(Bailey, 2006)	
Airbag System	Unknown	Currently being developed in Germany	http://www.pool-airbag.com/
Video Surveillance Recognition	\$130,000.00	Personal e-mail correspondence with Jon Damaska, sales director from MG International	
Gate Alarm	\$1.99 - \$30.00	google.com	http://www.google.com/products?q=gate+alarm&show=dd&safe=on&sa=N&start=0
Infrared Alarm	\$15.00 - \$150.00	google.com	http://www.google.com/products?q=infrared+alarm&show=dd
Personal Immersion Alarm	\$50.00 - \$190.00	Amazon.com	http://www.amazon.com/s/ref=nb_ss_gw?url=search-alias%3Daps&field-keywords=pool+alarm&x=9&y=24

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