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Septic Systems - Purpose in Modern Life

A septic system is usually a two-part mechanism consisting of a septic tank and drain field. The septic tank is responsible for transforming human waste into a manageable effluent, which is then transported into the drain field. Wastewater from kitchen drains, toilets, and laundry flow into one main pipe transporting the wastewater into the septic tank. Wastewater delivered to the septic tank is held inside the tank long enough to digest the organic matter (around 24-36 hours), allowing solids to fall to the bottom of the tank, forming the sludge layer, while floatable matter collects at the top, forming the scum layer. The middle layer consists of wastewater that has been processed, which is then released into the drain field for further treatment.[1] Figure 1 provides an internal view of a single compartment septic tank.[3] Sometimes septic tanks are built with multiple compartments, when there is either a high volume of waste or the waste needs to sit in the tank longer to process and break down into a more treatable product. To ensure a watertight structure, the material used in tank construction is usually concrete, fiberglass, or polyethylene. The size of the structure is dependent upon the number of bedrooms and bathrooms within a household, and is meant to withstand the busiest points (i.e. a family taking their morning showers).[2] Also, garbage disposals can add a significant amount of solids into the septic system so that is factored in when determining the appropriate sized system.

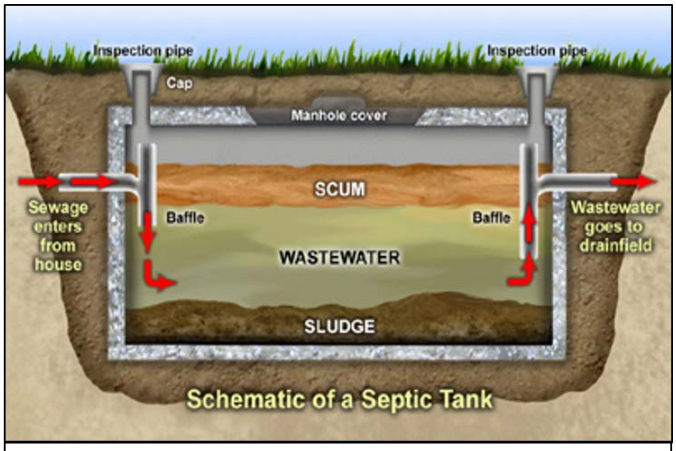

Figure 1. An interior view of a septic tank. [3]

The pretreated effluent is then moved out of the septic tank and into the drain field. A drain field is a multilayer underground network of perforated pipes made in unsaturated soil. Directly underneath these pipes is a gravel layer which allows the effluent to filter through to the soil. Soil acts as a natural filter as the wastewater moves downward towards groundwater, and soil microbes further treat the effluent before it permeates into ground or surface water.[4] This process is applicable to conventional leach field systems only—an alternative system is discussed in the following section. The entire septic system is illustrated in

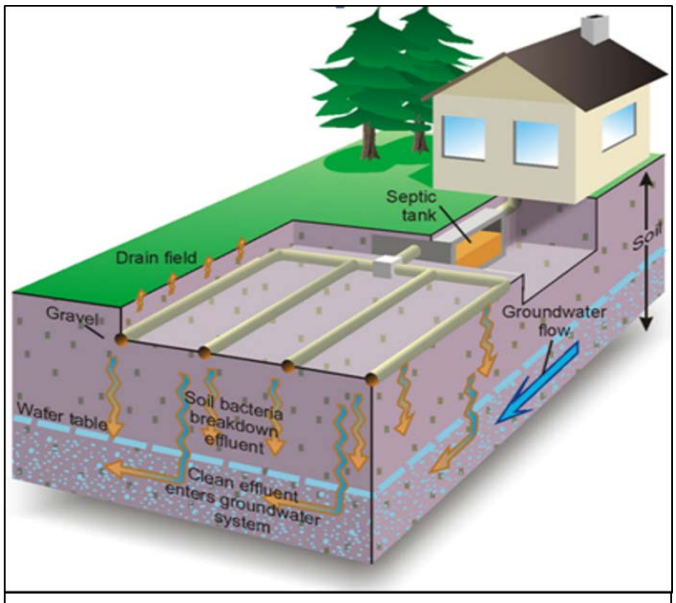

Figure 2. An internal perspective on a septic system. [5]

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Figure 2, although the drain field design and the final stages of wastewater treatment are the focus.[5] The size and type of drain field utilized depends on the estimated daily wastewater flow and soil conditions.[4]

Sand Filters

A sand filter has a network of small perforated pipes which hang above a sand/gravel bed. It is constructed so that it is watertight, and is usually made out of plastic fabric or concrete that has a specific sand fill material.[26] Effluent is pumped in small controlled doses so that it can remain in contact with air long enough to treat the sewage. If there was no pump, the wastewater would rush through the system without the necessary treatment time.

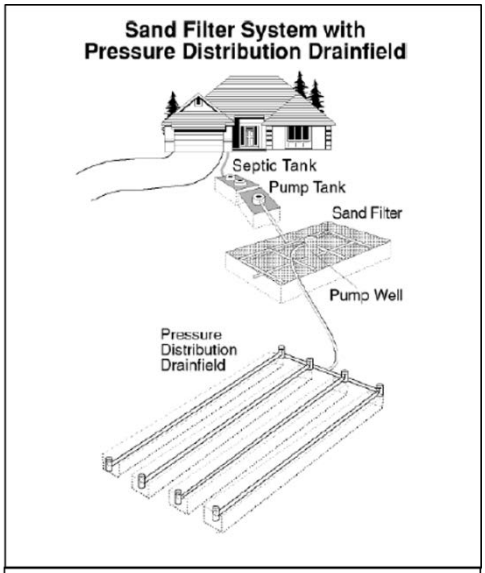

Figure 7. Septic system that includes the sand filter as an intermediary step. [26]

A sand filter isn't really a filter, but rather a way to imitate the natural biological processes that conventional septic systems facilitate. These systems are used when the soil is not compatible to transport water directly to a drain field after being treated by the septic tank. Typically, the surrounding soil lacks essential microbes or is too compact that is cannot properly breakdown and treat wastewater.

Depending upon the type of sand filter utilized in the system, wastewater has a few options once leaving the septic: either it can be pumped into the sand filter and then a drain field for further treatment for a single-pass sand filter; it can be transported into a recirculating tank and then into an open sand filter; or the treated sewage can be released into drainage ways, gutters, or a lake or creek.[28]

After effluent leaves the septic tank in a single-pass sand filter, it is then pumped into the sand filter in a controlled and uniform manner to ensure that all pipes receive an equal amount of wastewater.[26] The perforations in the pipes are small in diameter so that effluent can slowly seep into the sand below, providing the effluent enough time to be treated by microbes that function in the presence of oxygen.[26] Now that the wastewater has been mostly treated, it moves to the drain field for final processing. The pump ensures that the wastewater is pumped slowly enough to ensure that the effluent has enough time to be treated.

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A recirculating sand filter system has three basic components—a pretreated unit, a recirculation tank, and an open sand filter.[28] Once the effluent leaves the pretreated unit (which is almost always a septic tank), it enters the recirculation tank. In the recirculation tank, raw effluent from the septic tank and the sand filter filtrate are mixed and pumped back to the sand filter bed. This is illustrated in Figure 8.[28] Part of the effluent is taken to the drain field, while the rest of it is put back into the system for further treatment. Wastewater in the pump chamber is controlled by timed float switches. When the liquid level rises, the timer float turns on and begins to pump effluent out of the system. If the liquid level gets too high, an alert timer turns on and the pump pumps quickly until the high water alarm shuts off. Infrequent high water alarms will not harm the system, like if there are extra guests or parties at the household, but if the alarm comes on frequently it may indicate an issue with the system.[28]

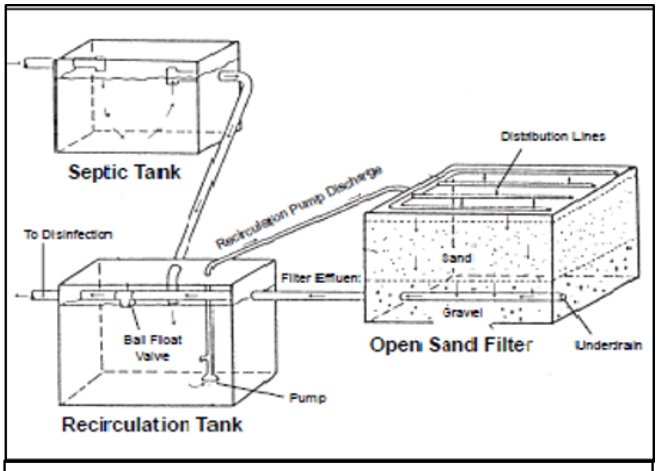

Figure 8. A typical Recirculating Sand Filter System. [28]

Surface discharge systems that release treated wastewater directly into a drainage way, gutter, or lake/creek are especially important to maintain, since it may affect aquatic ecosystems and sources of drinking water.[30] These systems often utilize chlorinator tablets to reduce the amount of bacteria being put into the environment. Homeowners that possess these types of systems need to be mindful to check the chlorine tablet and replace the tablet when it has dissolved.

The sand media used in these types of systems can be very expensive if it is not available locally, consequently increasing the cost of maintaining the system. In some systems chlorine tablets are necessary to further treat the wastewater because they are not designed to reduce pathogen levels below a specific limit.[28] Pool chlorine is never to be used as a disinfectant due to its long lasting nature and slower breakdown in sunlight.

It is recommended that sand filters should be inspected annually by a licensed professional, and a newly installed filter should be checked six months after installation.[26] In order for the sand filter to treat the wastewater, the wastewater must be able to move through it and pass into the underdrain. Therefore the sand grains should be as uniform as possible to prevent clumping. Continuous ponding seen through the inspection ports; abnormal settling or erosion; laterals not flowing evenly amongst them all; and an incorrect pump run time per dose are some signs that the sand filter or other components of the system are not working properly.[26] It is imperative that the system owner is meticulous about maintaining an alternative system, since many times these systems are working against its natural environment, thus increasing the stress to an already sensitive instrument.

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History

The septic tank was patented in America in 1881 and within a few years these tanks began to appear throughout the U.S. The economic boom following WWII increased the demand for housing, but centralized wastewater treatments were expensive and developers were not willing to wait for these systems to be built. Thus, septic systems were a cheaper and relatively quick alternative.[6] Previously, septic systems were usually reserved for rural communities, where it would not be economically practical to implement a centralized waste treatment system.

There was minimal regulation before the 1970s; the guiding standard was to not site the drain field near a drinking water well. There was even less knowledge about the importance of maintenance, with most people believing that these systems could be left alone without any care for a lifetime and beyond.[6] That mindset has now proved to be extremely problematic, since faulty septic systems directly contribute to the increase in water pollution and outbreaks of viruses and diseases.

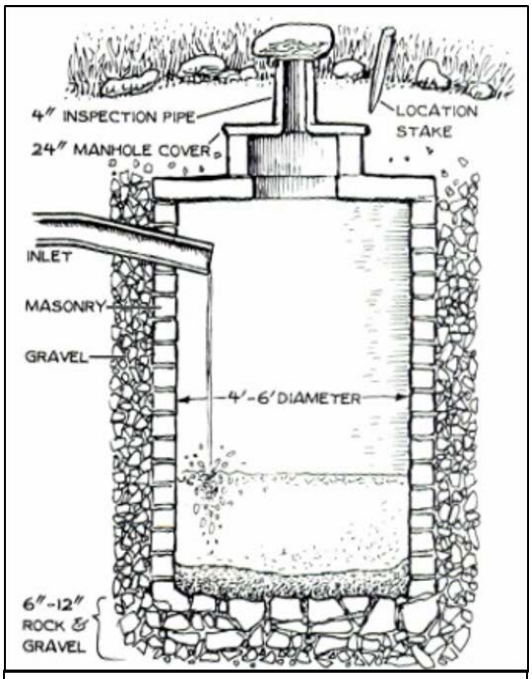

Figure 3. Internal view of a seepage pit. The effluent within the pit permeates through the surrounding gravel and makes its way directly into the groundwater. [7]

Until the latter half of the century, the septic system design had changed minimally from the beginning of its implementation in the mid-1800s, consisting of a cesspool, seepage pit, or septic tank which most often flowed via gravity into a drain field.[6] Cesspools and seepage pits are mostly prohibited now due to an increase in concern for groundwater protection and historical experiences of overuse and failure. A seepage pit would deliver effluent directly to groundwater without any treatment, and a cesspool is both a tank and drain field, having the effluent drain into the soil surrounding the cesspool.[7] The environmental movement in the 1960s and 70s pushed the Federal government to establish more regulations intended to preserve and protect America's water and aquatic ecosystems.

Regulations

Federal Regulations

- **Clean Water Act (CWA) of 1972.** Growing awareness of environmental degradation pressed Congress to amend the Federal Water Pollution Control Act of 1948, thus the Clean Water Amendments were enacted into law. The 1972 amendments aimed to restore the nation's water resources—lakes, streams, rivers, wetlands, and coastal waters—which

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had become seriously polluted.[6] The act also included billions in Federal funding for public centralized wastewater treatment systems, and cities and towns applied for funding to build, expand, or upgrade its municipal sewage treatment plants. The focus on centralized treatment plants left decentralized systems, septic systems, neglected. In 1977, amendments to the Clean Water Act included funding for decentralized wastewater treatment facilities and rural communities were able to upgrade their on-site facilities.[24] Many of these large-scale grants for cities have dried up, and in its place are low interest loans like the EPA's Clean Water State Revolving Fund Program.[25] Lake Bloomington is considered an impacted water under the CWA and subject to Total Maximum Daily Load limits for total nitrogen and total phosphorous levels to help improve the water quality.

- **National Pollutant Discharge Elimination System (NPDES) Permit.** The National Pollutant Discharge Elimination System Permit Program controls water pollution by regulating point sources that discharge pollutants into waters of the U.S. and is authorized by the Clean Water Act.[27] Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.[27] The U.S. EPA or the IL EPA are authorized to administer this permit. The goal of this permit is to reduce or eliminate pollutants, mainly nitrogen and phosphorous, and prevent them from entering into protected bodies of water. Any homeowners pursuing a replacement to their septic system must obtain this permit if their system will discharge into any protected waters.

State Regulations

- **(225 ILCS 225/) Private Sewage Disposal Licensing Act.** The Illinois Department of Public Health (IL DOPH) has the authority to set minimum design and septic tank professional licensing standards, however if a local unit of government establishes a system for the regulation and inspection of private sewage disposal contractors and minimum code of standards that is at least equal to or greater than the State's minimum standards, then the local government's ordinance will prevail.[11] The local ordinance must be submitted to the IL DOPH for approval. Not less than once each year the Department will evaluate the program to determine if it is being operated in accordance with this Act.[11]
- **77 Ill Administrative Code Part 905.40 Septic Tanks.** The Illinois Department of Public Health is responsible for setting the minimum design standards for septic tanks which includes: engineering specifications, materials, depth of the tank, inlet and outlet connections, baffles, access, capacity, multiple tanks or compartments, and septic tank installation.[12] The minimum liquid depth of the tank is 42 inches and the maximum liquid depth is 72 inches, but all other components of the septic tank design are tailored to the needs of the individual household and property.[12] The IL DOPH has put in place the following procedure for abandoned septic treatment units: "septic tanks, cesspools, pit privies, aerobic treatment plants and seepage pits that are no longer in use shall be

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completely pumped. The floor and walls shall be cracked or crumbled so that the tank will not hold water, and the tank shall be filled with sand or soil. If the tank is removed from the ground, the excavation shall be filled with soil."[12]

- **77 Ill Administrative Code Part 905.20 General Requirements.** Any new or renovated private sewage disposal systems will not be permitted when there is a sanitary sewer available for connection. For residential properties, a sewer is considered available for connection when it is within 300 feet with a sewage flow of less than 1500 gallons per day, and for non-residential properties it is when a sewer is within 1000 feet with a sewage flow of greater than or equal to 1500 gallons a day.[29] This is consistent with Illinois Plumbing Code.

Local Regulations

- **Chapter 310. Sewage Disposal Systems, Water Wells and Geothermal Exchange Systems.** This ordinance gives McLean County the authority to inspect any property or building for health and sanitation purposes and perform the necessary tests to ensure that the private sewage disposal system is in compliance.[9] Only those licensed by McLean County are permitted to perform any inspections/evaluations, and the forms utilized are provided by the McLean County Health Department. Sewage that enters the groundwater, used or abandoned wells, aquifers, field drain tiles, or other underground areas accessible to humans is strictly prohibited. Any person(s) interested in installing, altering, or repairing any private sewage disposal system is required to obtain a permit from the McLean County Board of Health and provide a plan for the sewage system.[9] The plan shall include the location of all wells, lakes, ponds, or streams on the applicant's property and on the neighboring property, if they are within 100 feet of any part of the proposed private sewage disposal system. If the proposed system is to serve new or remodeled residential construction, a floor plan must be provided. Existing structures, septic tanks, subsurface seepage systems, grease traps, cesspools, privies, sewers, and drainage tiles must be included in the plan.[9] The County charges a $103 septic tank fee, a $153 subsurface seepage field fee, and a $153 seepage bed fee.[10] In addition, for those seeking to be licensed by the County and Installer and Pumper license carries a $293 fee and a first time applicant is charged an additional 40% on top of the $293 annual fee.[10] If the septic system does not pass the first test, then the property owner is charged a $50 retest fee.[10]

<u>Operation and Maintenance</u>

The EPA has issued general guidelines for homeowners on how to properly maintain a septic system, breaking it down to four key elements: inspect and pump frequently, use water efficiently, properly dispose of waste, and maintain your drainfield.[13] The baffles on a septic tank should be inspected annually to ensure that scum is not leaving the tank and entering the absorption field. Baffles are typically located at the inlet and outlet of the tank, and Figure 1 calls them "inspection pipes". This inspection can and should be done by the homeowner, and they

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need to understand their system well enough to conduct these inspections.[14] However, a septic service professional should inspect the septic system at least every three years, and household septic tanks are typically pumped every three to five years.[13] On average, it costs $100-$300 to have a septic system routinely pumped and inspected.[15]

Each alternative septic systems, including surface discharge systems, entail a varying degree of maintenance so consult with McLean County Health Department for instructions specific for the system. A conventional septic system is one that utilizes gravity to facilitate the movement of wastewater, and alternative systems use a combination of pressure and gravity or pressure alone. Much like an automobile, all maintenance records should be kept and the homeowner needs to keep track of when the tank needs to be pumped out, and the sludge and scum levels found by the septic professional.[13]

There are four major factors that influence the frequency of septic pumping: household size, total wastewater generated, volume of solids in wastewater, and the septic tank size.[13] If a household has a garbage disposal then septic tank pumping has to occur more frequently because a garbage disposal increases the amount of solids being released into the tank.[14]

Efficient water use minimizes the use of the septic system and reduces the risk of system failure. Utilizing high-efficiency toilets, faucet aerators and high-efficiency showerheads, and energy saving washing machines can help preserve the life of the system.[13]

Proper waste disposal is essential to a well-functioning septic system, and understand what a septic tank can and cannot process is crucial. Much like centralized wastewater systems, septic systems should not have anything but human waste and toilet paper flushed into them. Although, persons living in a household with a septic system have to be particularly careful about the types of household products and toilet paper used. Septic systems will not remove or treat many water-soluble pollutants such as solvents, drain cleaners, and many household chemicals.[14] Low phosphorus detergents and cleaning products should be used whenever possible because phosphorus is the nutrient most likely to cause damage to a lake after leaving the septic system.[14] Liquid fabric softeners can contribute to excessive scum in the septic tank, so this produce should be used minimally.[14] One-ply or septic “safe” toilet paper is necessary for a well-functioning system.[14]

Drain field maintenance includes never parking or driving on the drain field, planting trees and shrubs far enough away that their roots do not infiltrate the septic system, and placing roof drains, sump pumps, and other rainwater drainage systems away from the drain field area.[13] Driveways, patios, aboveground pools, and other structures should never be built over the drain field.

For systems that require a chlorinator, it is imperative that the instrument is inspected regularly to ensure that there is still some of the chlorine tab left. This allows the wastewater to be treated further before being released into the environment and decreases the bacterial load that the environment would have to treat in the absence of the tab.

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The Signs and Cost of Septic System Failure

There are many indicators that should persuade a septic system owner to seek professional expertise. Signs of a problem include, but are not limited to: slow draining toilets, showers or sinks, sewage backing up in the basement or drains, ponded water or wet areas over the absorption field or your lawn, bright green grass over the absorption field, a dense stand of aquatic plants or algae along only your shoreline (if the property is on a lakeside/waterside), sewage odors, bacteria or nitrates show up in tests of a nearby drinking water well, or if biodegradable dye flushed through your system is detectable in nearby waters.[14] Some of these occurrences are illustrated in Figures 4, 5 and 6.[16,17,18] Even if it appears that the system is functioning properly, failure to pump routinely can allow sludge to build up to the point where waste water is released without sufficient time in the tank for treatment and the settling of solid particles.[20] Also, the sludge layer may have built up so high due to a lack of regular pumping, that it has now infiltrated the wastewater allowing for untreated solids to be released into the environment.[20] A homeowner that fails to pump their tank may believe that their system is functioning properly, but their system may be contributing to environmental degradation and contaminating the ground/surface water.

Figure 4. Ponded water over the absorption field is a sign of septic system failure. [16]

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Figure 5. Bright green grass can indicate that effluent is coming to the surface, which suggests septic system failure. [17]

A failing septic tank is usually a preventable occurrence if the owner property inspects and maintains the system regularly, but contrary to popular belief, these systems will not last infinitely. The National Environmental Services Center at West Virginia University states that it typically costs between $3,000-$10,000 to replace a faulty septic system.[15] Although other sources assert that the average cost of septic replacement is upwards of $26,000.[19] Due to the subjective nature of each septic system and the numerous variables that can affect the design, it is not possible to provide an exact average cost of replacing the system. No matter the cost of replacing the system, it is substantially less expensive to maintain a system than ignore the system until problems occur. McLean County Health Department asserts that the average lifespan of a septic system is 25-30 years.

Figure 6. Biodegradable dye has been detected in nearby water, indicating septic system failure. [18]

If issues with the drain field begin to occur such as supersaturation or bright green grass over the field, there is little remedy other than replacing the drain field.[21] Oversaturated pipes in the drain field will form a slimy bacterial mat. This bacterial mat will not allow water to permeate into the gravel pit below and therefore the trenches will no longer be able to handle the wastewater.[21] This causes water to backup into the house and drains to gurgle and drain slowly. Once this problem occurs, the trench has to be completely dried out and replaced.[21] Depending on the size of the drain field and the type of soil on the property, this can cost between $7,200-$20,000.[22] It is important to note that there are two facets that comprise a septic system—the septic tank and the drain field. One piece of this system could be replaced without replacing the other which can greatly affect cost estimates.

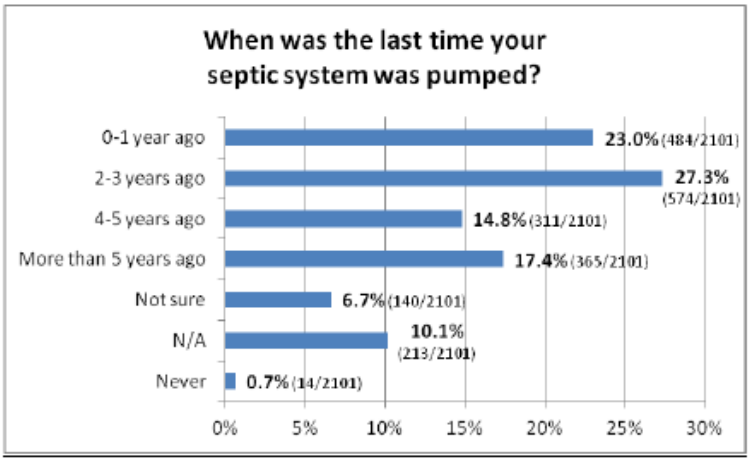
Public Understanding of Septic Systems

Much of the burden of septic system maintenance is put on the homeowner, whether it's using the correct products and not overworking the system or performing regular inspection, there is much to understand and administer. However, there is a grave misconception that septic systems

require little to no maintenance and that these systems last forever. Clallam County Environmental Health Services (CCEH) in Clallam County, WA, surveyed its residents who rented or owned properties with a septic system to assess homeowner's knowledge, beliefs, and behaviors associated with their septic systems.[23] The survey had a response rate of 13.5% and a total of 2,138 surveys were received for analysis.[23] The survey was administered mostly by mail, but respondents were also encouraged to fill out an online survey via Survey Monkey, or email/fax it into the county office.[23] One of the main objectives of the survey was to understand why 83% of septic system owners were not in compliance with the county inspection requirements.[23] CCEH found that almost 99% of the respondents knew where their septic system was located.

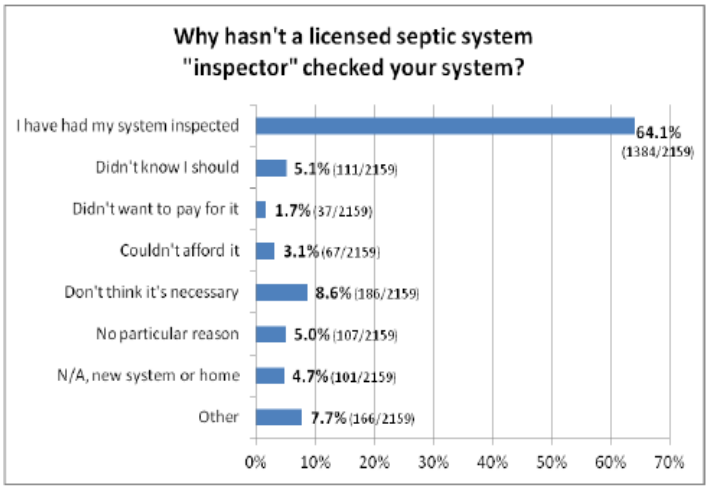
Sixty-five percent of respondents claimed that their septic tank had been pumped in the last five years. The remaining 35% had their tank pumped either more than five years ago or were not sure when or never had the tank pumped.[23] When asked about why a homeowner had not had a licensed septic system inspector check their system, 64% of respondents said that they had had their septic system inspected by someone licensed. However, according to Clallam County records only approximately 17% of homeowners with septic systems were current with their inspection.[23] This may be attributed to the survey question's wording because it does not ask when the last time a septic inspection was carried out, just whether or not an

5. When was the last time your septic tank was pumped?
(2101 responses; 37 with no response)



6. A septic system inspection involves looking at the septic tank and drainfield and all components to ensure that the system is functioning properly. Has a licensed septic system "inspector" checked your system? If no, why not? Please check all that apply.

There were 2159 responses on 2101 separate surveys. Since respondents were asked to check all the answers that apply, there were multiple responses per survey. There was no response on 37 surveys.



inspection has occurred. Also, respondents that have had their tank inspected may be more likely to respond to the survey, therefore increasing the number of responses. Lastly, those that have had their system inspected may have failed to report the inspection to the county, so the rate of compliance may be higher than 17%.

It is important to note that 18.7% of respondents have not had their system inspected because they were not aware that they should, didn't think it was necessary, or were not able to a provide a reason.[23] One faulty septic system can cause irreparable environmental damage, so it is very important that all septic system owners understand the importance of regular inspection and maintenance.

Best Management Practices

Due to the sensitive nature of septic systems and its surrounding environment, it is most beneficial for local health jurisdictions to take the lead in regulating and enforcing septic system operation and maintenance. Puget County, WA created a Best Management Practices Reference Manual for systems located in Puget County, and Washington has been a leader in septic system regulations. There will be much difficulty in changing the public's perception that septic systems require little maintenance and increasing knowledge about the way the system functions. This manual asserts that the success of a management program depends on the following: authority, expectations, accountability, and enforcement.[6]

Illinois and McLean County regulations mandate that a septic system's design must adhere to minimum standards and receive approval from the appropriate governing body. However, there is no ordinance mandating system inspection or pumping and that is left to the owner's discretion. An effective management program must clearly state and communicate to all stakeholders *who* requires the management program and *who* has the authority to enforce it.[6]

If the management program requires a certain level of maintenance from the system owner, then those expectations need to be clearly conveyed. It is crucial that each stakeholder understands what part of the operation and maintenance of the system is their responsibility.[6] This includes how service providers will do their work; how local health will provide septic system education; how regulators will enforce the rules; and how decision makers will help ensure protection of public health and safety and provide program funding.[6]

Procedures to monitor and maintain accountability must be built into the management program to ensure that all parties are doing their fair share. Accountability can be guaranteed if there are enforcement mechanisms in place and consequences for inaction need to be implemented.[6]

In addition, data collection is important in tracking progress and confirming that the management program has been effective in minimizing problems associated with faulty septic systems.

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City of Bloomington

Currently, the City of Bloomington has about 600 septic systems permitted and within city limits, although there may be systems that the City is unaware of. About 360 of these are an alternative system that contain a sand filter located at Lake Bloomington.

Lake Bloomington

Lake Bloomington is a primary source of drinking water for Bloomington residents. Almost all of the houses surrounding the lake are served by septic systems and several of them utilize an alternative design such as a sand filter. Many systems discharge into the Lake and employ a chlorinator tablet, and about half of the existing private sewage systems are beyond the typical life expectancy of 20-25 years. Soil conditions have degraded and some systems are in soil that will not effectively treat the wastewater. Some of the systems are leaking effluent, which directly contribute to the increase in nitrogen and phosphorous in the Lake. That being so, it is essential that all residents living in this area inspect and maintain their system so they do not pollute this source of water. An ongoing study has been undertaken to assess septic systems at Lake Bloomington in more detail.

There is an ongoing study that assess the septic systems at Lake Bloomington in detail. This study will provide on-site options and transport to Bloomington-Normal Water Reclamation District (BNWRD).

Other Permitted Septic Systems within City Limits

There around about 220 septic systems within the City's corporate limits. For homes that are within the City's limits and utilize an on-site wastewater treatment system, IL Admin. Code Part 905.20 will apply. This code states that if there is an available sewer connection within 300 feet of the residence then the homeowner is not permitted to replace their septic system and must connect to the available sewer. If there is an available sewer for connection, then the property owner must connect to the system and all cost is borne by the homeowner.

Conclusion

Septic systems are an effective and suitable way to treat wastewater; it is a great example of biomimicry and a natural way to restore wastewater back into the groundwater. In order for these systems to function well all parts of the septic system—design, construction, maintenance, and inspections—need to be properly managed and implemented. Just one faulty system can cause an array of environmental and public health issues. However, these systems are not permanent. The life expectancy of a system is long, but it will fail eventually. Centralized sewers should be installed wherever possible, and homeowners should tap on to them. This would lessen the burden on the McLean County Health Department and the City of Bloomington regarding oversight and enforcement of private sewage disposal regulations.

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