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SMALL SCALE WASTE MANAGEMENT PROJECT

Onsite Wastewater Disposal Alternatives Development and Use in Wisconsin

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E.J. Tyler

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On-Site Wastewater Disposal Alternatives - Development and Use in Wisconsin

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E. Jerry Tyler

The process of technical development and institutional implementation of on-site wastewater technologies is often complex and can take a long time. Technically proven on-site wastewater disposal methods that meet established economic, social and political goals are disposal alternatives. Some technically acceptable options are not used in Wisconsin because of the institutional constraints while some technically questionable techniques are still employed.

The goal of an on-site wastewater disposal system is to treat the wastewater such that it can be returned to the hydrocycle harmless to public health and the environment. Also, systems should minimize public nuisance, have low cost and require minimum maintenance. The purpose of this paper is to discuss the development and use of procedures and systems in Wisconsin to meet the on-site wastewater disposal goals. More exciting than telling the history of the development and use of systems is the thought of using the process to develop new technologies in the future. The process continues to thrive in Wisconsin. It is hoped that the discussion of the Wisconsin experience will stimulate others to develop technologies for their site conditions.

The Process for Development and Use in Wisconsin

In Wisconsin the process for development and use of on-site wastewater disposal systems and related procedures is under an umbrella of human and monetary resources as schematically illustrated in Figure 1. Citizens, homeowners, developers, contractors, sanitarians, soil scientists, engineers, educators, researchers, state and local regulators and elected officials are among those who have assisted and supported the stages of development and implementation of on-site wastewater disposal technologies. Wisconsin has benefited greatly from the perspectives offered by each.

Money has also been very important to the success of the on-site system development program in Wisconsin. Appropriations and grants created the Small Scale Waste Management Project (SSWMP) at the University of Wisconsin and gave the research team the capability and flexibility to respond to high priority research needs of the state. Money to SSWMP has come from state, federal and private sources. Also, many citizens have paid for the construction of experimental systems at their homes and businesses while county and state staff and numerous private business people have furnished many services. The total amount of money provided directly and indirectly to the development of solutions for on-site disposal problems in Wisconsin has not been calculated. However, since the public health and the environment are being affected and millions of dollars

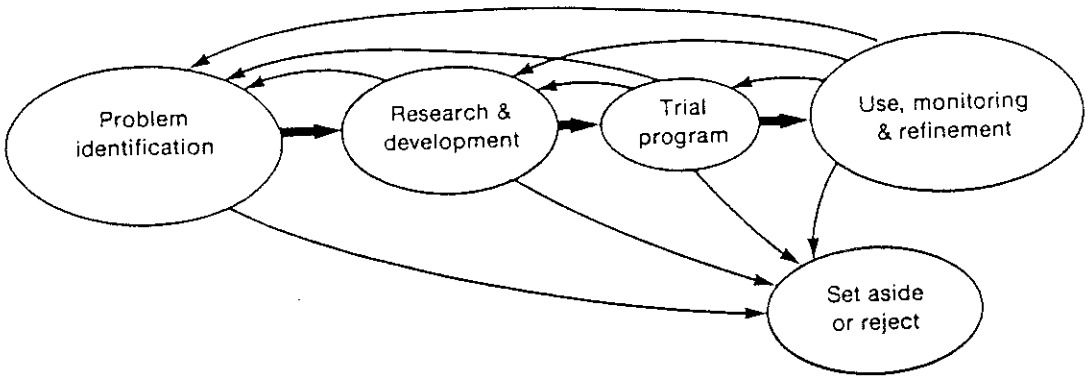

Figure 1
Human and Monetary Support

of decisions are being made based on the results of this work, the expense would seem minor. It is difficult to imagine the development process without a budget and the additional support.

Under the umbrella of the human and monetary resources is the process of development and incorporation for use of on-site wastewater disposal methods and procedures. The process is very similar to the scientific process. The stages in Wisconsin include problem identification, research and development, trial programs and use with monitoring and refinement (Figure 1). Though it may seem long, cumbersome and frustrating there have been some very successful and satisfying results because the procedures were followed.

Problem identification is the first and most important step in the development and use process in Wisconsin. Certainly without it none of the other steps would occur and no progress would be made. There is probably no place in the country using on-site wastewater disposal that is not having some problems.

The legislature of the State of Wisconsin appropriated money to the University of Wisconsin to study on-site wastewater disposal in problem soils. The appropriation was made in response to a recognized and broadly defined problem. There undoubtedly were many citizens and public officials who had recognized the problems and assisted with the decision made by the legislature. Problem recognition has been the job of many and everyone can play a role in bringing issues to the attention of others. However, problem identification must be followed with the means to address the potential solutions.

With the funded mandate of the legislature to develop means to safely dispose of wastewater in problem soil areas, researchers could intensify studies. SSWMP staff, with others, precisely defined the problems and related them to the soil and site conditions, design parameters, construction procedures and management methods. Some of the early work is reported by Bouma et al. (1972). The information was used to set priorities for the research, identify new research needs and reject or set aside some of the technologies. Arrows in Figure 1 indicate information paths.

Based on this research, and much additional work that will be discussed later, a number of disposal systems were refined and developed along with appropriate site evaluation, construction and management methods. Selected technologies were recommended to the Bureau of Plumbing of the State Department of Industry, Labor and Human Relations (formerly the Department of Health and Social Services)

for field testing. In Wisconsin, field testing for major additions or changes to current administrative code is done during a trial program which allows limited use of systems and procedures (Figure 1). During the trial program, additional problems are recognized and research needs identified, however, the major purpose of a trial program is to test the implementation of the technology by those routinely working with on-site wastewater disposal.

Successful field testing of disposal technologies during the trial programs opens the way for these technologies to be incorporated into the code for general use. Even at this point there is continued monitoring and refinement with accompanied discovery of new problems and identification of research needs. The possibility still exists that a technology could be rejected at this stage, however, it is hoped that by following the development process, rejection would be unlikely.

The sections that follow discuss in more detail how research and development and trial programs work in Wisconsin and give examples of some of the results. The process has worked in Wisconsin and may have application in other regions.

On-Site System Development in Wisconsin

On-site wastewater treatment and disposal options were objectively considered during early developmental stages by analyzing combinations of each of the possible steps of systems from the source to the discharge. The discharge of an on-site wastewater disposal system, as schematically illustrated in Figure 2, is back to the source for reuse, to the atmosphere as evapotranspiration, to the land or water surface from a point or to a plane 3 feet below a gravel filled soil absorption system. The limit of 3 feet below the soil absorption system is the depth required for a soil investigation during a site evaluation as outlined in the Wisconsin Administrative Code (DILHR, 1983). The path of water flow from the wastewater source to the point of disposal defines the on-site wastewater treatment and disposal system.

The source of wastewater could be a house, small business or other facility creating domestic wastewater. Used water enters the wastewater disposal system and passes to the treatment or pretreatment phase of the system. The level of treatment and system design depends on whether the final discharge is back into the structure, to the atmosphere, to the surface or to the

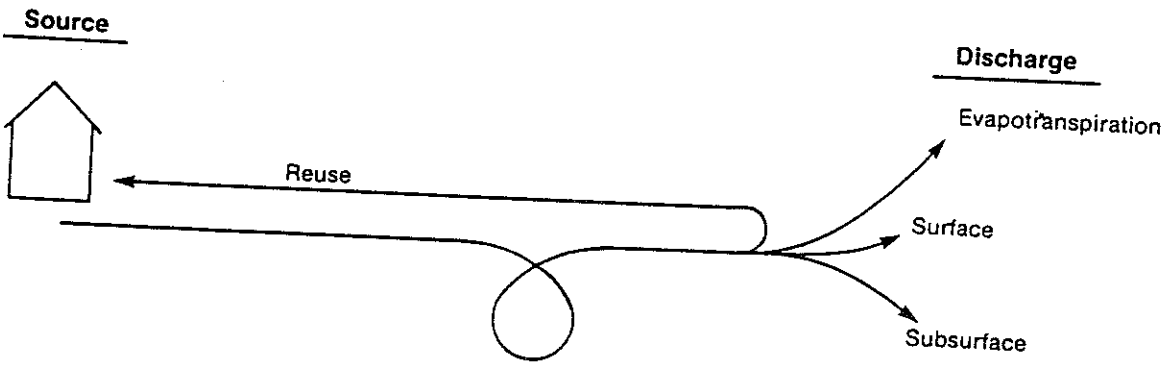

Figure 2
Treatment and Pretreatment

soil. To some extent the system design also depends on the type of domestic wastewater. Starting at each end of the system, SSWMP staff have studied all phases.

Except for complete reuse systems (Figure 2), wastewater disposal must operate within the natural environment. In Wisconsin the climate is humid with warm summers and cold winters. The soil conditions vary from sandy to clayey, shallow to deep and poorly drained to excessively drained. In many places there are deep unconsolidated glacial deposits and in other places shallow crystalline or sedimentary rocks are found. Wisconsin has numerous lakes and streams and the water table varies from shallow to deep. These environmental conditions are continually considered in relation to disposal techniques. The matching of the disposal technologies with the natural environment is essential.

Tanner and Bouma (1978) using the climatic conditions in Wisconsin and methods of predicting evapotranspiration, calculated the theoretical amount of wastewater that might be transpired by plants. They estimated that the amount of water removed by this process in some parts of the year would be near zero and only a portion of the annual wastewater volume could reasonably be disposed of by evapotranspiration. The evidence was so convincing that SSWMP stopped work with evapotranspiration systems in Wisconsin and the systems are not considered an option for wastewater disposal. In this case, only a theoretical study was required to reach a conclusion to reject the option (see Figure 1).

Reuse and surface discharge of on-site wastewaters are similar in concept, however, the level of treatment for each is different. Treatment to either level of purification is possible and SSWMP has addressed these needs. Sand filters, ion exchange procedures, precipitators, denitrification processes and disinfection units have all been studied (SSWMP, 1978). Depending on the desired level of treatment and the type of wastewater, the processes needed can be combined to make a complete treatment unit. Partial recycling of wastewater has been used on a limited basis in Wisconsin. However, state policy, which is based on a concern that technologies will not be maintained, has prohibited the general use of these techniques as well as their incorporation into a trial program (Fredrickson, 1980).

Because surface discharge and evapotranspiration are not used in Wisconsin, subsurface disposal of on-site wastewaters is the primary technique. By design, wastewater from a soil absorption system passes into the soil or into the near surface unconsolidated glacial deposits. Deep subsurface discharge of wastewaters has not been commonly used, however, in many areas, older systems may be discharging wastewater into bedrock crevices, thereby allowing the wastes to penetrate to deeper depths. Many problems with soil absorption were seen during an evaluation of existing soil absorption systems, but it was also recognized that the soil can offer a location for the safe discharge of on-site wastewaters, utilizing systems which require low maintenance. Many of the early systems studied were reported on by Bouma et al. (1972).

Site evaluation procedures, design needs, construction methods and maintenance requirements were all studied in relation to soil treatment and disposal. Hydraulic resistance due to soil clogging was defined in soil textures found in Wisconsin (Bouma, 1975). Empirical relationships of clogging to loading

rate, wastewater application method, wastewater quality and environmental conditions gave mixed results (SSWMP, 1978; Hargett et al., 1981). Treatment capabilities of the soil have been assessed in different soil materials with different hydraulic conditions (SSWMP, 1978). Some of the results of these studies are being reassessed because of recent experience. The results of some of this work have been the basis for change in the Wisconsin Administrative Code and will be discussed in latter sections. Even after all of this work, there remain many unanswered problems and plenty of room for continued research and development.

The Trial Program

The on-site wastewater disposal development process in Wisconsin has resulted in the adoption of many technically acceptable systems and subsystems as well as the rejection of some techniques that were found unacceptable. Although some technically acceptable systems are not used because of lack of institutional controls or because agency policies inhibit their use, some are field tested and later incorporated into the administrative code. In Wisconsin the adoption of new technologies or major changes in old ones has been cautious, deliberate and slow. Wisconsin now has a limited use trial program as a method of field testing and introducing new designs and technologies (Figure 1).

Trial programs are used in Wisconsin during the interim period between the research and development phase and the general use phase (see Figure 1). Based on the research and development process, researchers recommend the use of new on-site disposal technologies or the modification of existing technologies for adoption for more general use. A trial program is initiated if the recommended technology would result in a significant change. The technology must also be capable of being field tested and fine tuned without the direct influence of researchers. The ability of the site evaluators to determine site suitability, designers to put the concepts into a form that can be reviewed and used for construction, installers the ability to construct, owners the ability to maintain their systems and regulators the ability to review plans, inspect construction and help with system management are evaluated during this period. System use is often limited by the number of installations, geographical region and timetable for the trial program. The intention of the trial program is not to test the technology itself but the institutions controlling it. If problems occur, they would be discovered early and the program stopped with a minimum of influence.

Also during the trial program period, rules are developed, training and education is offered, potential land use impacts are tested and an environmental impact statement or assessment is prepared. The opportunities during this period to increase public awareness of on-site wastewater disposal and to offer education to those professionally involved are great. The response to information during a period of change in Wisconsin has been good and a noticeable improvement in site evaluation and system quality for all types of systems has been noted.

The introduction of newly developed designs and procedures for a trial program brings numerous suggestions for change. Everyone wants to incorporate their idea into the program. Many of the suggestions are made with the sincere desire to make systems less expensive. Though some of the ideas have considerable merit, they have not been through the research and development process and remain untested. These ideas should be tested using the procedures as outlined in Figure 1 before entering a trial program. Trial programs in Wisconsin are intended to test previously researched ideas and are not a place to introduce unresearched designs of individuals or committees.

Trial programs and the research and development process do not answer all of the questions related to the use of on-site technologies. System longevity is still not defined by this process since system life is hopefully longer than the development and trial programs. Therefore, it is important to continue to monitor all systems after they have been included for general use.

Use, Monitoring and Refinement

No major technological change studied by the SSWMP has been through the entire process from problem identification to use as outlined in this paper. The mound system and pressure distribution for subsurface disposal are now in the trial program phase and will most likely be incorporated into the general code with minor adjustments in the near future. In Wisconsin there is a uniform state code administered primarily by the counties.

Some changes have been made in the code that were considered minor and have therefore bypassed the trial program. The total influence of these minor changes has been considerable. A list of some changes that have occurred in Wisconsin's statutes, code or policy in the past 5 years that were a direct or indirect result of research and development are as follows:

(1) Change of slope requirements, allowing the use of steeper slopes;

(2) Improved definition of soil mottles;

(3) Inclusion of drop boxes for shallow systems on sloping land;

(4) Introduction of mounds to a trial program;

(5) Introduction of subsurface pressure distribution systems to a trial program;

(6) Modification of absorption area depth and, therefore, total soil depth;

(7) Approval of hydrogen peroxide for rejuvenating soil absorption areas; and

(8) Rescinding the aforementioned approval of hydrogen peroxide.

The list could go on, however, it can be noted that research and development has influenced every part of the code.

There are items that are not included in Wisconsin statutes, code or policy because of the research. These include evapotranspiration disposal methods and aeration units. Because of the many questions concerning unused methods, these systems are discussed during educational programs. Also, research has shown that there are existing items in the code that should be removed, such as the use of the percolation test and acceptability of soil absorption systems in very rapidly permeable soil materials.

Recently in Wisconsin, the approval for use of hydrogen peroxide as a method to rehabilitate failed wastewater soil absorption systems was rescinded. It was concluded from investigations that the procedure could have harmful effects on soil absorption systems in soil textures other than sands. No definite conclusions could be made regarding the effects of the process on sands (Hargett et al., 1983). This demonstrates that even after some period of use, techniques can be rejected.

Monitoring of on-site wastewater disposal methods in Wisconsin has not been done extensively. It is recognized that more monitoring and evaluation of generally used systems and techniques is needed. Monitoring procedures are in need of revision so that reliable statistically defined data can be gathered. Some of the more recent disposal techniques being used have been monitored and the data evaluated, but little information is available at this time.

Example of System Development and Use in Wisconsin

There have been numerous site evaluation procedures, system designs, construction techniques and monitoring methods evaluated by SSWMP. The Wisconsin mound system has been through a trial program, been the subject of an environmental impact statement and will be used here as an example of the development and use process.

Review and study of the soil resource data for the state indicated that greater than 60 percent of the land in Wisconsin has soil with shallow bedrock, shallow ground water or slowly permeable soil. For both treatment and hydraulic reasons, it was recognized that the point of infiltration of the wastewater needs to be separated from the limiting soil conditions of shallow ground water or bedrock. To accomplish this, additional material would be needed above the original ground surface. In areas with slowly permeable soil it was recognized that confining the absorption area to the most permeable part of the soil would be beneficial. This could also be accomplished by adding material above the ground surface creating a large area of infiltration into the soil A horizon or topsoil, which is usually the most permeable (see Figure 3).

Some elevated systems, already in existence, were evaluated and found to be leaking at a point where the wastewater infiltrated into the fill. Based on the need to overcome the side seepage and after considerable research about wastewater distribution techniques, a pressure, equal distribution method of wastewater application was used. This method insured that no part of the added fill material would be overloaded and research had indicated that the clogging potential might be reduced (Bouma et al., 1974). All mounds now used in Wisconsin have pressure distribution systems. Pressure distribution networks were further designed, tested and are currently in a trial program for subsurface disposal.

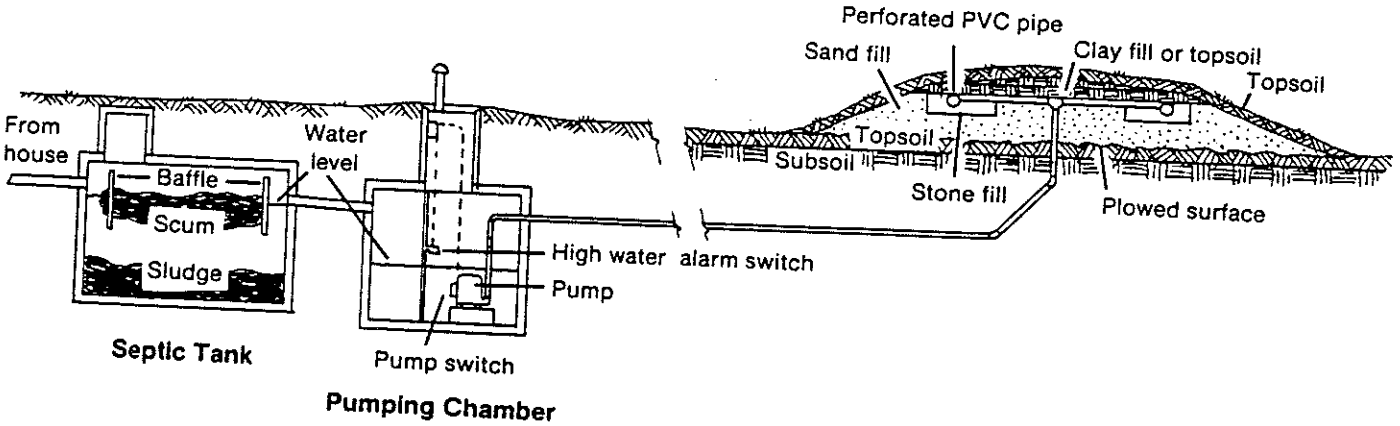

Figure 3
Cross Section of a Mound On-Site Wastewater Disposal System

An early research mound failed at the toe where the fill material contacts the natural soil surface. It was discovered that the grass at the fill soil interface created a clogging mat that restricted infiltration into the soil. To overcome this problem, plowing of the natural soil surface is now recommended to create a better infiltrative surface for the placement of a mound (Converse, 1978).

Other studies evaluated mound treatment capabilities and hydraulic conditions in great detail (Bouma et al., 1973; Magdoff et al., 1974; Green and Cliver, 1974; Bouma et al., 1975;). The site evaluation, design, construction and maintenance methods for the Wisconsin mound were developed and a mound manual was written (Converse, 1978) based on the extensive work.

In 1974, the research and development stage for the Wisconsin mound was completed and mounds were ready for a trial program. A limited number of mound systems were allowed for new construction and numerous systems were permitted as replacements for failed systems. The mound trial program was designed to observe the site evaluation, design, construction, use and regulation procedures to see if in fact this more complicated system could be installed and made to function similar to those used during research. After the first 2 years of the trial program, a second 2 year period was added. The first 2 years had been dry and it was felt that it was not a good test of the regulators and installers because they did not have to make construction decisions during periods of wet soil conditions.

A random sampling of systems was used to evaluate those mounds installed during the trial program (Harkin et al., 1979). Even though dosing volumes were sometimes found to be higher than recommended, there was no evidence of a problem. The study showed that those involved with the siting, design and installation of mounds could install satisfactorily operating systems.

Surveys of the operation of randomly selected mound systems in Wisonsin are continually being made by the SSWMP staff. The systems are functioning well, however, several minor design specification adjustments may be needed. At this time, it is still too soon to project mound system longevity.

During the trial program a number of siting, design and construction workshops were held throughout the state. County staff were eligible to conduct construction inspections of mounds only after attending one of the training programs. Also, mound technology received considerable attention by the press and public awareness of on-site wastewater disposal in general was increased.

After 4 years of the trial program and the filing of an Environmental Impact Statement, mounds were included into the code. However, they are still under the control of a trial program since mounds were the example used to initiate the concept of a trial program, and they still fit the definitions established in the statutes and codes at the time of enactment.

Since these systems might be used on lands not previously acceptable for soil absorption of on-site wastewaters, land use issues needed to be addressed. A study of the mound's potential influence on land use development in selected areas of Wisconsin resulted. The land areas that might be used for on-site wastewater systems state-wide are shown in Table 1. Even with mounds, more than half of the land area is unsuited for soil absorption systems and the influence is not uniform throughout the state (Tyler et al., 1980). To date, there has been no study to indicate the locations of actual mound use.

Table 1
Percent of Area of Wisconsin Suitable for On-Site Wastewater Systems

Study Area	Subsurface	Mound	Unsuited
	% Land Area		
44 Counties (detailed soil survey)	34.3	6.2	59.3
28 Counties (CNI+ data)	37.9	10.2	51.8
State totals	36.1	8.2	55.5

+CNI = Conservation needs inventory, 2 percent sample

Table 2
Number of Total Permits, Mound Permits and Percent of Mound Permits in Wisconsin

	1976	1977	1978	1979	1980	1981	1982
Total (no.)	22,500	23,300	23,400	18,500	14,000	12,700	11,200
Mounds (no.)	400	600	300	200	800	800	1,000
% Mounds	2	3	1	1	6	6	9

Source: Department of Industry, Labor and Human Relations, state of Wisconsin

Currently mounds are being used at an increasing rate in Wisconsin. As seen in Table 2, the percentage of permits issued for mounds versus all systems has increased from 1 to 9 percent in a short period of time. The percentage of mound permits will probably continue to increase in the future.

Many had hoped that mounds could be used in place of the undesirable holding tank. However, there have been more permits issued for holding tanks than for mounds in each of the last 2 years. Even though the mound has served well, there is still considerable development work needed to match environmental conditions and disposal options.

Summary and Conclusions

The process for development and use of on-site wastewater disposal alternatives in Wisconsin is established. Problem identification, research and development, trial programs and use implementation are under the umbrella of human and monetary support. No technologies have gone all the way through the process, but numerous less significant items have gone from research to use without a trial program. The net effect of all these changes is highly significant.

Problem identification and development is done by considering all possible options in relation to the environmental conditions in Wisconsin. Rejection or acceptance of options being considered may be done after a literature review or after considerable research. Trial programs are intended to test the institution's ability to use the technologies as defined. Even accepted technologies are monitored and refinements are made. Rejection has occurred after a technology has been adopted.

The process for development and use of on-site wastewater disposal alternatives is working in Wisconsin. Elements of the process may be of value to other regions when assessing their on-site wastewater disposal alternative needs.

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Onsite Disposal of Small Wastewater Flows

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R.J. Otis, W.C. Boyle, J.C. Converse and E.J. Tyler

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