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SMALL SCALE WASTE MANAGEMENT PROJECT

Mound Systems - The Wisconsin Experience

by

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Mound System--Wisconsin Experience (1)

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ABSTRACT

The mound on-site wastewater disposal system is used in Wisconsin to overcome several soil and site limitations of conventional subsurface soil absorption system. These limitations are slowly permeable soil, shallow zones of soil saturation and shallow depth to creviced or porous bedrock. Mounds designed and constructed for research operated as well as, or better than, properly sited and constructed conventional subsurface systems. Mounds constructed during a four year period by plumbers with inspection by county code administrators were found to operate similarly to the research mounds installed earlier.

Though mounds cost more than the conventional subsurface absorption systems, they can be used in areas with soil and site conditions unsuited for the sub-surface system. In the few cases a mound system failure recognized, correction has been easy. Life expectancy of mounds is unknown; however, there has been no indication of failure due to age of the absorption area in the mounds studied. In general, there has been good user acceptance.

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INTRODUCTION

The conventional septic tank-soil absorption on-site wastewater disposal system can function very well. However, many of these systems have failed because of poor siting, design, installation or maintenance. The need for replacement of these failing systems and the recent migration from urban to rural areas, and the limited expansion of central municipal treatment facilities has caused an increase in the use of on-site waste disposal systems.

It has been estimated that more than 60 percent of Wisconsin's land areas is unsuitable for the conventional septic tank-soil absorption on-site wastewater disposal system. Slowly permeable soils, shallow zones of soil saturation, or shallow creviced or porous bedrock are common limiting conditions. In areas of slowly permeable soil, absorption and disposal is the major concern. In other areas, treatment of the wastewater is critical. The mound system was developed to overcome these soil and site conditions that limit the use of the conventional system.

THE MOUND SYSTEM

The septic tank serves the same function as it does in a conventional system, removing both floating and settling solids (Figure 1). The septic tank effluent flows to the pumping chamber. The pump moves the wastewater into a pressurized distribution system in coarse aggregate. The wastewater moves through the fill into the soil. In slowly permeable soils, the effluent moves laterally away from the mound, while in the more permeable soils, it essentially moves downward.

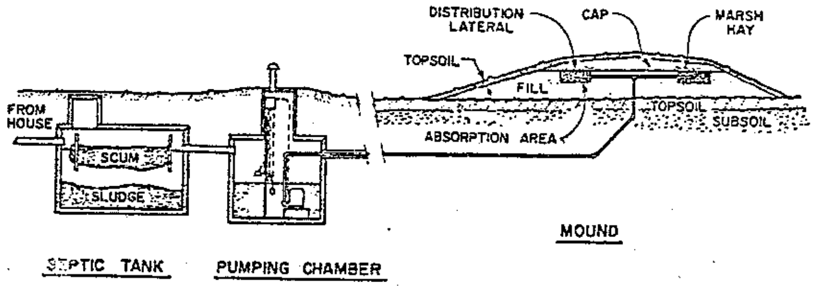

Figure 1. A cross-section of a septic tank mound system for on-site wastewater disposal.

SYSTEM CONCEPTS

Analysis of problems encountered with subsurface soil absorption systems identified specific soil and site limitations that needed to be overcome. Though often unnoticed, subsurface soil absorption systems fail because of limited travel distance or short wastewater retention time before reaching groundwater. Coarse textured soils with shallow zones of soil saturation or creviced bedrock are most susceptible to failure caused by poor purificaion. An increase in travel distance and retention time can be attained by elevating the absorption area from the limiting zone. This is done by using medium sand fill so that at least three feet of unsaturated, unconsolidated material is between the absorption area and the limiting condition. Under these conditions, treatment of the wastewaters should be adequate (Tyler et al., 1978). Flow from these types of systems is often nearly vertical (Figure 2).

Inability of the soil to accept wastewater is because of slow soil permeability, smearing and compaction from construction equipment or the

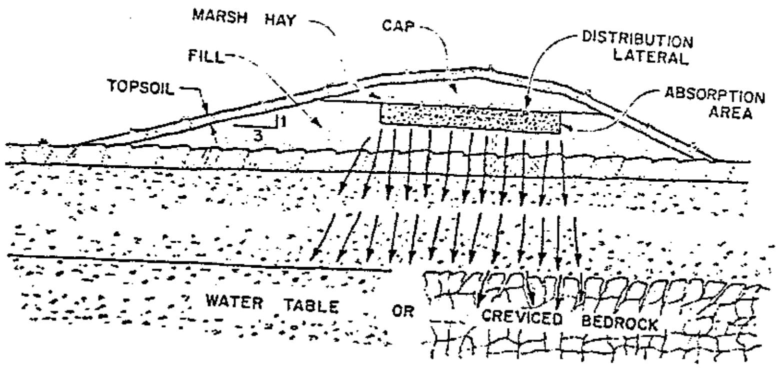

Figure 2. A cross-section of a typical mound system showing the effluent movement in permeable soil.

formation of a natural clogging mat at the soil infiltrative surface. Overcoming the limitation of slow soil permeability can often be accomplished by using the surface soil horizons, which are generally more permeable than the subsurface horizons. The contact area between the fill and the soil is the infiltrative surface for a mound. After entering the natural soil water can move horizontally over the less permeable underlying horizon. To insure that surfacing of the effluent does not occur at the toe, the infiltrative surface must be large enough so that effluent is completely absorbed before reaching the toe (Figure 3), and some permeable natural soil must be present to transmit the absorbed water beneath the toe.

On slowly permeable soils, a ground water mound may develop over the restricting horizon. The dissipation of this mound is by lateral movement in the soil. To minimize the height of rise (H) of the water table and to avoid saturation within the fill, systems should be made long and narrow, since height of rise is effected by application width (w) from the absorption bed (Bouma et al., 1975), (Figure 4). In figure 4, the bed area

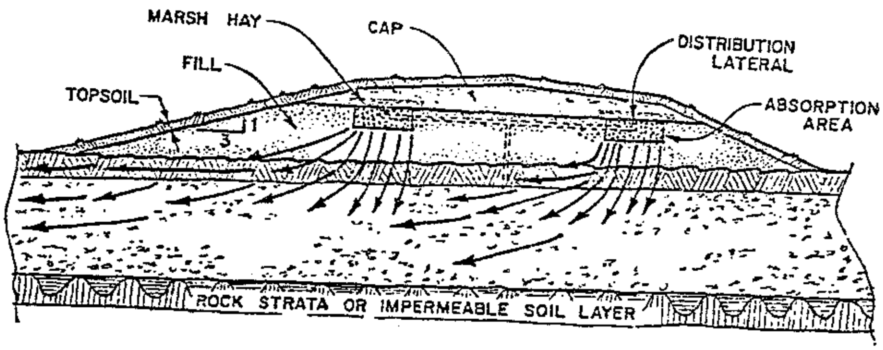

Figure 3. A cross-section of a typical mound system showing the effluent movement in a more slowly permeable soil on a sloping site.

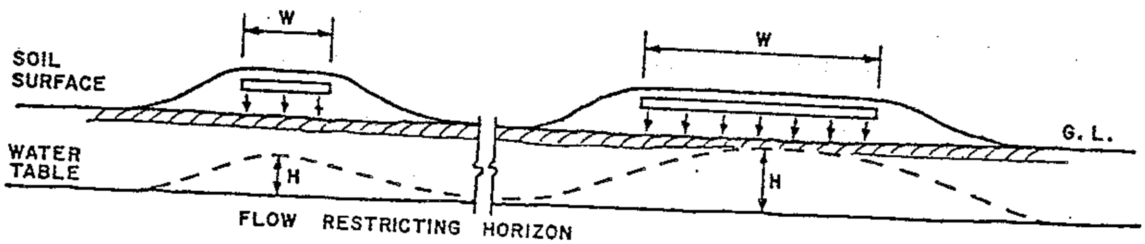

Figure 4. Influence of system width (W) on potential mounding height (H) of shallow groundwater under mounds (constant area).

area in the two mounds is constant, so that as the width decreases, length increases.

Smearing and compaction of the soil during construction is most likely in fine textured, moist soil materials (Schoenemann et al., 1979). Use of surface horizons, which are usually the coarsest in texture and more likely to be dry, reduces the potential for smearing and compaction problems. The mound system absorption area requires only plowing of the surface of the natural soil. The quality of the fill material used can significantly influence construction. Fills with too many fines such as silt and clay particles may compact or create layers of different textures during construction. The proper selection of sand used as fill minimizes these problems and maintains adequate treatment.

Clogging mats form at aggregate-soil infiltrative surfaces when septic tank effluent is trickled onto the soil. These mats develop because of a number of factors and result in restricted flow into the soil. Though mound designs use flow rates based on clogged soil conditions, the water quality at the fill-soil interface is good and appears to reduce the clogging. Use of pressure distribution reduces or eliminates clogging between the aggregate and the fill.

The design of mound on-site wastewater treatment systems is based on the concepts presented. Success of the design is a result of matching the design to given sets of site criteria.

Soil and Site Conditions

The setback distances from wells, surface waters and other features for mounds are similar to those for subsurface systems. Mounds in Wisconsin are not used in flood plains, drainageways or depressions.

In Wisconsin, two feet of soil that is not bedrock, that is unsaturated, and that will have a percolation rate of 120 min/in or faster, is required for the use of a mound (Table 1). Slope requirements vary, depending on percolation rate. For percolation rates from 0 to 29 minutes per inch, slopes up to 12 percent are permitted. For less permeable soil, slopes are limited to 6 percent. Percolation rates over

3 min/in are required on sites with shallow depth to bedrock.

Table 1. Soil and Site Conditions Used for Mound On-Site Wastewater Disposal Systems in Wisconsin

Depth to:	
Bedrock	24 inches
Soil Saturation	24 inches
Permeability	
Percolation Rate[a]	0-120[b] min/in
Slope	
Percolation Rate 0-29 min/in	0-12%
39-120 min/in	0-6%

[a] Bottom of percolation test hole is 24 inches unless there is shallow bedrock and then it is measured at 12-16 inches. If perched water, it is taken at 16 inches. If horizon of slowest permeability is at less than 24 inches, percolation test is taken in most restrictive horizon.

[b] If shallow bedrock, minimum percolation rate is 3 min/in.

Generally, sites with large trees, numerous small trees, or large boulders are unsuitable for a mound system because of difficulty in preparing the surface and the reduced infiltration area beneath the mound. The rock fragments, tree roots, stumps and boulders occupy space, thus reducing the amount of soil for proper purification. If no other site is available, then the trees must be cut at ground level, leaving the stumps. A large mound area may be necessary if many stumps and rocks are included, so that sufficient area is available to accept the effluent.

Soil and site evaluation procedures for mounds are similar to those for any other on-site soil absorption system. The only difference is in the depths to the limiting site conditions.

Design

The size and configuration of a mound system depends on the expected wastewater load and the site characteristics. (For complete design information see Converse, 1978). In Wisconsin, flow from residential homes is estimated at 150 gal/bedroom/day. The absorption area in the medium sand fill is loaded at 1.2 gal/ft^2/day, regardless of other site characteristics.

The dimensions of the mound are established by the size of the absorption area and the site characteristics. Beds or trenches within the fill are located perpendicular to the slope or along the contour so that effluent is not concentrated as it moves downslope. Particularly on slowly permeable soil it is advantageous to make the mound long and narrow. This minimizes the ground-water rise and results in minimum loading along the toe length (Figure 3).

In most cases, the basal area under the absorption area in the fill and the 3:1 side slopes is larger than the required natural soil basal area. If sufficient area is not available, the downslope side must be extended. The design loading rates for the basal area are shown in Table 2.

Table 2. Percolation Rate and Basal Area Loading Rate for Mounds.

Percolation rate min/in	Loading rate at the fill-soil contact gal/ft^2/day
3-29	1.2
30-59	0.74
60-120	0.24

Mounds on sites with porous or creviced bedrock have a minimum of two feet of sand fill between the absorption area and the natural soil. In all other cases, a minimum one foot of fill is required. Because of slope, fill depth down-slope will be greater than these minimums in much of the system. This is necessary to keep the bed or trenches level.

Pumping and Distribution System

The pumping system consists of a pump chamber, pump, controls and high water warning alarm system. The more frequent the dose, the less the chances are of saturated flow in the fill, thus the better the purification. However, dosing too frequently can lead to faster crusting. In Wisconsin, dosing a maximum of 4 times a day, with a constant volume of septic tank effluent, is required.

A pressurized distribution system spreads the effluent uniformly in the absorption area. This prevents local overloading, and maintains unsaturated flow conditions.

Based on the elevation difference between the pump and the mound, the dose volumes, the pressure desired at the end of the distribution network, and other factors, the specific distribution network is designed and a pump selected. Switching and high water level alarms systems are also selected (Converse, 1978).

Fill Material

In mounds, a medium sand fill is necessary. This material adequately treats the wastewater and can be used without danger of particle separation or compaction during construction.

Construction

Construction of the mound should not begin until the natural soil is sufficiently dry. This can be determined by rolling a piece of soil, taken at 6-8" beneath the surface, between the hands. If it forms a wire then it is too wet to prepare the surface. The surface is prepared by plowing the area. The medium sand is pushed onto the plowed area without rutting up the plowed area. The sand is placed to design depth, and bed or trenches are formed. The aggregate and the distribution system are placed. The mound is covered with topsoil and a vegetative cover started (Converse, 1978).

MAINTENANCE

Mound maintenance involves pumping the septic tank every three years or less to avoid carry-over of solids into the mound. Pump replacement will be needed occasionally. It is recommended that a water conservation plan be used and that vehicular traffic be kept away from the mound. The flow of surface water must be diverted away from the mound.

MOUND PERFORMANCE IN WISCONSIN

The technical performance of mound systems as used in Wisconsin has been excellent. The first mounds were constructed in the early 1970's for research purposes. After considerable monitoring and a few modifications, mounds were suggested for more general use since the research mounds were found to be technically successful.

Analysis for nutrients and indicator bacteria in research mounds showed these systems were operating similarly to a properly functioning subsurface system. Bacteria removal by 60 cm of fill and a short distance of natural soil was almost always greater than 99.9% (Bouma et al., 1973). Similar bacterial removal was also noted in columns simulating mounds (Magdoff et al., 1974). Virus removal was essentially complete in columns simulating mounds, with virus penetrating only 30 cm when loaded at 5 cm/day at 20^{o}C. When over-loaded at 50 cm/day and at 4^{o}C, removal was still greater than 99% through 60 cm of fill (Green and Cliver, 1974).

The movement and transformation of N and P compounds has also been evaluated in research mounds and columns simulating mounds. Compared with influent waters, the water found at the toe of the mound contained less total N (Bouma et al., 1975). Reductions of nitrogen concentrations were also noted in columns (Magdoff et al., 1974). Phosphorous was found after some time in effluents from soil columns (Magdoff et al., 1974) and has been found to be 14 and 8 mg/L in fill and underlying soil respectively (Bouma et al., 1973).

In 1974, a trial program was initiated to evaluate the ability of certified soil testers and licensed installers to properly select sites and construct mound systems under the supervision of county code administrators. The institutional systems used during the trial program included (1) acceptance by the county board, (2) training of the county code administrators, (3) state level plan review and (4) an intensive construction inspection procedure. This is a stricter program than used for normal on-site waste disposal installation in Wisconsin.

Wisconsin had a drought during the first two years of the trial program. Therefore, the ability of the code administrators and installers to decide if construction should proceed during a normal wet season was not tested. On the recommendation of the Small Scale Waste Management Project of the University of Wisconsin, the trial program was extended to test normal or wet season installation. During the total four year period, approximately 1,100 mounds were installed.

A random sampling of 33 mounds was used to evaluate mounds installed during the trial program throughout the state (Harkin et al., 1979). The mounds were of different site conditions and installed and inspected by different people. Evaluations were made on the mounds to determine if the specifications for siting, design, and construction as outlined in the manual were followed by the contractors.

Systems examined were properly designed and installed and followed the design criteria (Harkin et al., 1979). Even though dosing volumes were sometimes found to be higher than recommended, there was no evidence of a problem resulting from this discrepancy. No mound was found to have permanent ponding in the absorption bed or to have permanently saturated fill (Harkin et al., 1979).

As in research mounds, bacterial reduction from the septic tank effluent to the fill-soil interface was greater than 99% (Harkin et al., 1979). Virus was almost never found in the septic tank effluents and never found in the fill material. The amount of nitrogen in samples collected below the system was lower than for influent amounts. The bulk of the phosphorus was being removed by the fill and natural soil, and none was found in shallow groundwater around the system (Harkin et al., 1979). This study showed that certified soil testers and contractors, using the mound manual (Converse, 1978) and institutional controls, could site and install satisfactorily operating mounds.

Mound systems have successfully been accepting wastewater for nearly nine years with no sign of significant clogging or ponding. Based on these findings, it appears the life of the system could be unlimited.

Current research is under way to determine mound performance limits. Currently under investigation are mounds on soils with high water tables within 12 in. of the surface and percolation rates of up to 400 min/in.

CORRECTION OF FAILURES

Very few cases of failing mound on-site wastewater disposal systems have been reported and documented. Failures were due to poor maintenance, construction or siting, and not due to design. In all cases, correction of the failure has been successful at the same location by salvaging most of the initial system.

Fill materials with too fine a texture resulted in failure at the infiltrative surface in two mounds. Effluent surfaced on the side of these mounds. Removal of the improper fill and construction of a new mound on the same site relieved the problem.

Seepage of water at the toe of the mound has occurred in a few cases because there was insufficient basal area available to accept the effluent. Extending the fill on the downslope side increased the absorption area and solved the problem (Figure 5). Seepage at the toe may also result if groundwater enters the septic tank or pump chamber overloading the mound. In this case, the tanks need waterproofing.

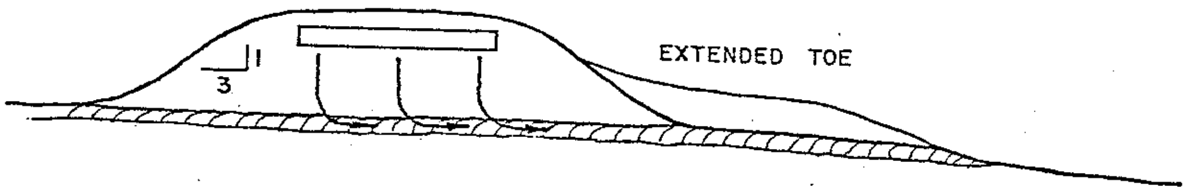

Figure 5. Extending toe of existing mound to increase the absorption area.

In one case, fibers from the household were pumped into the distribution system. Blockage in the distribution network resulted in a pump failure. Since the ends of the laterals of the distribution systems are marked, it was easy to dig out the ends, cut off the cap, blow out the fibers and recap the ends.

Undoubtedly, there were a number of pumps replaced early in the trial program because they failed due to improper selection of pump size or the use of clear water pumps instead of effluent pumps. Pump manufacturers are now developing a wider range of submersible sump pumps which are recommended for pumping septic tank effluent. Pump controls have caused considerable problems in the past. It appears that the most reliable switch is the mercury level control switch. The pressure diaphragm switch is not recommended, since it cannot be used to adjust dose volumes, and its life is very limited. Mounds have an alarm system that alerts the homeowner when the pumping system is not working. A one day storage capacity above the alarm level is required.

THE USE AND THE USER

It has been estimated that approximately 8 percent of Wisconsin's land area is suited for the mound on-site wastewater disposal system. About 36 percent is suited for conventional systems, leaving about 55 percent unsuitable for on-site disposal (Table 3).

Table 3. Percent of Area of Wisconsin Suitable for On-Site Waste Systems

Study Area	Conventional	Mound	Unsuited
	(Percent of 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

The areas of soils estimated to be suitable for mounds are not distributed uniformly throughout the state or in small areas. Some counties with detailed soil survey reports may have as high as 33 percent of the land area suitable for mounds (Figure 6). Though the mound system increases the area suited for on-site waste disposal, it does not make every parcel suitable.

After the evaluation of an Environmental Impact Statement, Wisconsin is limiting the use of mounds for new construction to a fraction of the total number of new on-site disposal systems built in the previous year. While environmental groups have raised questions about the land use impacts of this new technology, the Department of Health and Social Services is concerned over the adequacy of county regulatory programs in administering the total on-site waste disposal program. The current restriction for new construction is 3% of the total number of on-site permits issued the previous year with no more than 5% in each county. There are no restrictions on the use of mounds for replacing failing systems or existing holding tanks, provided the site meets the soil and site requirements for a mound. These requirements may change after public hearings are held in the Spring of 1980.

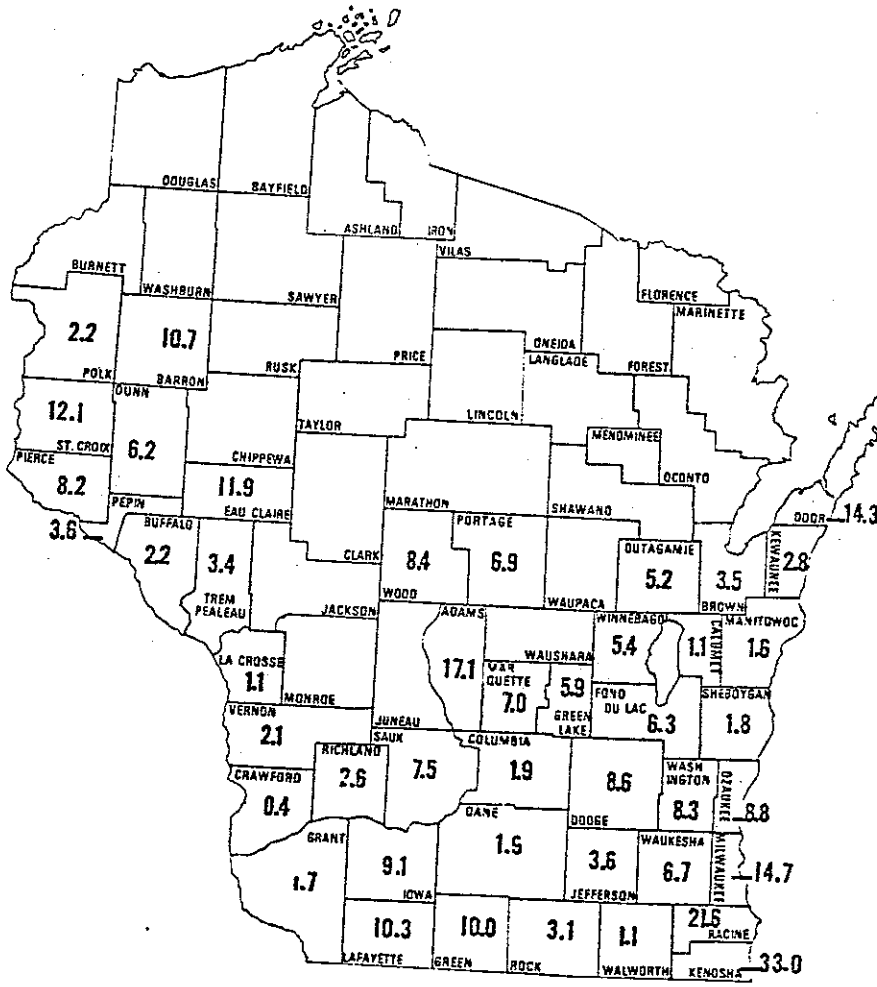

Figure 6. Estimated land suited for mound systems for various counties in Wisconsin as of March, 1980.

The introduction of the mound system in Wisconsin has had a very large impact on the total on-site wastewater disposal program. The training used in the trial program has reinforced the main principles of environmental health protection. The inspection procedures brought regulatory officials and licensed persons together in the field, which has resulted in a mutual understanding of each other's rol .

In many counties where mounds have been used (64 out of 72 counties were participating in the trial program at its conclusion), the impact of mounds has spread to users of all types of systems. Coverage in the local media of "how mounds work", and "why mounds are needed", has yielded a better public understanding of the entire regulatory program.

The owners of mound systems have reacted favorably to the new technology. User complaints have been minimal. The most common complaints are that mounds cost more and that the "pile of dir " in the yard just does not look good. The mound system does cost more, and often more than twice that of the conventional system. The fill material is one major expense and its cost can vary greatly depending on the hauling distance. With a little planning, mounds can be made a very integral part of a landscaping plan (Schutt et al., 1978). Some mounds after being constructed properly, almost vanish because of creative landscaping.

SUMMARY AND CONCLUSIONS

The mound system as used in Wisconsin has been technically proven and shown to function properly on adverse soil and site conditions when used according to design. Mounds installed by licensed installers have performed extremely well with very few failures. Failures that have occurred were easily repaired. The life expectancy of the mound on-site wastewater disposal systems is unknown, however it appears that they will have a long, usable life.

The mound system increases the total area suited for on-site waste disposal in Wisconsin but not uniformly across the state. Generally, there has been good user acceptance of mounds. High cost and visual appearance have been the most common complaints.

Mound use in Wisconsin is continuing on a controlled basis. It is expected that the new mounds will function as well as those observed in the past.

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