GEOLOGICAL REPORT

FORBES LAKE OF THE OZARKS PARK

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REPORT FOR THE UTILIZATION
OF
INDIVIDUAL WASTEWATER FACILITIES
FOR THE FORBES
LAKE OF THE OZARKS PARK
BENTON & CAMDEN COUNTIES, MO.

Report For The Utilization
Of
Individual Wastewater Facilities
For The Forbes
Lake Of The Ozarks Park
Located In
Benton & Camden Counties, Missouri

Prepared By

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I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer in the State of Missouri.

STATE OF MISSOURI
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NUMBER
E-12862
REGISTERED PROFESSIONAL ENGINEER

Bill R. Crockett E-12862

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INTRODUCTION

The Forbes Lake of the Ozarks Park consists of approximately 12,600 acres located in T40N; R19, 20 and 21W of Benton and Camden Counties. The tract lies entirely south of the Lake of the Ozarks (Osage River). The subdivision is physically divided into two parcels separated by a distance of about one mile. The geographic center of the subdivision is about 10 miles east of Warsaw, Missouri. The site is served by State Routes M, V, and DD of Benton County and State Route FF of Camden County.

The east most area contains approximately 2700 acres and has some three and one half miles of shoreline along the Lake of the Ozarks. Approximately two-thirds of this area overlooks the Lake. The remaining portion is in drainage areas tributary to the Lake. The remaining parcel, or the west most parcel, contains some 9,900 acres. This parcel has a combined shoreline of some two miles divided between three separate locations. Only about one-half mile of this shoreline is on the lake proper with the remaining being on minor arms of the Lake. Deer Creek, bisects this parcel from north to south.

The terrain of the entire tract is hilly. The eastern parcel is extremely hilly with numerous bluffs or near bluffs along the Lake of the Ozarks and with numerous deep ravines penetrating the hillsides from the Lake. The elevation of this area ranges from slightly above normal lake elevation at 659 to about 920. Geologically, this difference, places this parcel in three different formations with the Roubidoux being the predominant formation sandwiched between the Upper Gasconade underneath and the Jefferson City-Cotter on top. The ravines eroded by ancient flows draining to the Osage River have side slopes, in numerous cases, exceeding 25% while the flow line gradient often exceeds 5%.

The west parcel has only a few low bluffs and very few slopes exceeding 20%. The ravines have eroded less radically. The elevations range from lake level to nearly 980 with numerous points being over elevation 900.

It is the intent of this document to provide the necessary information for the technical acceptance of the proposed subdivision site for individual waste treatment facilities by the Missouri Department of Natural Resources (DNR). While this the the primary purpose, it in not the only purpose. Secondary to DNR approval, but quite important is the direct guidance to the owner in subdivision planning and lot layout. In some cases the criteria and recommendations contained in this document are more important to the owner than necessary for the DNR.

Miller/Williams & Works, Inc. was retained to investigate the possible use of individual waste treatment facilities and/or to recommend what types of treatment would be most appropriate. In order to accomplish this task, extensive field investigation was conducted throughout the proposed subdivision. This is to be described in greater detail in a later section.

ECONOMIC JUSTIFICATION

Lots in the Forbes Lake of the Ozarks Park will have a minimum size of one acre. The average lot size (considering total land area divided by total lots) is expected to exceed 3 acres in size with an average road frontage of 200 feet.

The road network in the subdivision will remain private. Roads will be constructed in accordance with good engineering practices dictated by projected traffic volumes. The roads will be carefully considered and constructed to preserve as much of the natural beauty of the area as possible. Each lot will have access to this road network. This network will consist of about 125 miles of roadways.

A conventional sewage system is not technically feasible due to the terrain and the desire to preserve the natural aspects of the area. Individual pretreatment devices, followed by small diameter gravity systems followed by numerous pumping stations, are not a technically sound proposal from an engineering aspect. Individual pretreatment devices followed by individual pumps and small diameter force mains are not economically feasible even when considering only the initial capital investment. The individual pretreatment device followed by on-site ultimate disposal is the most economically feasible alternative by a factor of nearly 2 to 1.

With the above determination, provisions were made to proceed with the necessary field documentation to justify the usage of individual on-site facilities. Since the soils of this portion of Benton and Camden Counties had not been classified by the Soil Conservation Service, it was necessary to field determine the acceptability of the soils for the proposed facilities. Forty-eight percolation tests were performed on randomly selected locations throughout the proposed subdivision. These results rendered a basis for proposing the following systems: (1) a pretreatment device to be followed by a tile absorption field, and (2) a pretreatment device to be followed by an evapotranspiration-mound system. These systems will be discussed in detail in a later section of this document.

AREA DESCRIPTIONS

Geologically, the entire area originates from the Ordovician System, Canadian Series. The Canadian Series consists of principally arenaceous and cherty dolomite with some sandstone units present. Formations on the site from this series are the Gasconade, Roubidoux, Jefferson City and Cotter. For purposes of evaluation of this particular site, the Jefferson City and Cotter formations will be considered as one interrelated formation.

For the purposes of this report, the tract will be split into three areas based on geology and topography:

Area 1 is the entire tract located basically east of Knobby Creek, being all or part of Sections 18 and 19, T40N, R19W and Sections 12, 13, 23, 24, 25, and 26 of T40N, R20W.

Area 2 encompasses the central part of the properties and basically is the area tributary to Deer Creek and directly to the Lake of the Ozarks. This area includes all or parts of Sections 7, 8, 17, 18, 19, 20, 21, 28, 29, 30, 32, 33, and 34 of T40N, R20W and parts of Sections 13, 24, and 25 of T40N, R21W.

Area 3 includes basically the drainage area discharging to Spring Branch and Mossy Creek and includes all or parts of Sections 13, 14, 15, 21, 22, 23, 24, 25, 26, 27, and 36 of T40N, R21W and part of Section 7 of T40N, R20W.

AREA I: All three geologic formations previously mentioned make up the bedrock and influence the topography in this area. At, or just above, the level of the Lake of the Ozarks, to the north, the upper part of the Upper Gasconade formation is present. The Upper Gasconade forms the bluffs along the lake and represents that unit containing numerous caves and other solution openings that are visible at several locations. The topographical position of the Gasconade formation is such that it is mostly represented as exposed rock at low elevations on the north and northwest part of this area.

In this relatively rugged topography, the hill slopes and much of the ridge areas are made up of the Roubidoux formation. This bedrock formation composed of dolomite, chert beds and sandstone beds controls the topography and is the predominant rock unit at the surface. At higher elevations, normally at or above elevation 900, dolomite is present representing the third and uppermost bedrock formation called the Jefferson City-Cotter formation. This rock unit represents only a very small percentage of the area and is noted for its ability to outcrop readily wherever it is present. Very little soil has developed on the domolite. An outcropping of this Jefferson City-Cotter formation is represented as a glade or natural open field in a wooded area. These are present at some locations on or near the hilltops (near elevation 900). A similar formation, from the Roubidoux, does present a similar open field area effect but at somewhat lower elevations.

The Roubidoux formation predominates the landscape in this area. This formation generally exhibits a relatively high permability due to fracturing of the dolomite and sandstone beds. In addition to the fracturing, the chert beds within the bedrock can act as conduits for rapid flow of water. For this reason most of the steep gradient headwater valleys or gullys are loosing streams in that surface flow is not maintained and rapid infiltration of the water takes place.

The soils developed directly from the Roubidoux bedrock take on the same character as the parent material. The relatively high degree of permability is present in the residual soils due to the fact that the soil is similar to the underlying rock. In most instances, residual soils from the Roubidoux will be capable of absorbing relatively large quantities of effluent from individual home waste treatment systems.

Where very steep slopes are involved (exceeding 20%), surfacing of effluent or other liquids can occur because water impeding zones are present in a residual soil that will redirect percolating water in a horizontal direction to the surface. Overall, however, movement of effluent off of a lot in this setting should not be a problem.

An outcropping of heavy ledge rock (several feet thick) does exist in Sections 13 and 24 (see shaded area on Figure 1), which can present considerable difficulty during development. This geologic formation is often referred to as "Nature's Concrete". This formation is cherty remnants from the above formations which have been recemented into a conglomerate creating an extremely hard material. Percolation tests in this area indicate that the soils on top of this conglomerate are extremely tight. This particular area should be considered for large lots, "green area" and roadways. Care must be taken in locating the waste treatment facilities in this area. An area will be available on each lot to provide an adequate treatment facility site.

Twelve percolation tests were conducted in Area I. In addition, several soil probes were conducted to help further determine the soil characteristics of the area. Basically, the soil is a clay containing varying amounts of sand, chert and gravel. Only one site was classified as a silt.

Due to the percolation results, this area was divided into to sub-areas (see Figure 1). Sub-area A being that area draining directly to the Lake of the Ozarks as well as that portion of the tract in Sections 25 and 26. Sub-area B is basically Section 19, T40N, R19W. The natural slope of the land in Sub-area B is much less steep than that of Sub-area A. This terrain lends itself much better for development.

The percolation tests conducted in Sub-area A indicate that 200 square feet of trench bottom area will be required for each 100 gallons of flow per day for an absorption field disposal system. For Sub-area B, an area of up to 330 square feet for each 100 gallons of daily flow could be required. At some locations within these sub-areas, the percolation rates may be less, thus allowing lesser amounts of trench bottom area for each 100 gallons of flow. These locations are believed to be the exceptions rather than the rule.

Each lot owner shall have at least two percolation tests performed in the immediate vicinity of his proposed wastewater treatment site. The absorption field will then be sized on the actual results of these tests. All percolation tests shall be performed in accordance with the requirements of the Missouri Department of Natural Resources (see Appendix 8).

For the initial investigation percolation tests were conducted in accordance with the criteria published by the Missouri DNR and were conducted by a registered professional engineer. The percolation holes were drilled with 9 inch power auger and hand cleaned. The depth ranged from a minimum of 30 inches to a maximum of 42 inches. Refusal was encountered at some locations but the refusal was on boulders and other rock and not bedrock conditions. A site a few feet away would yield a good hole.

Undoubtably the total soil depth does exceed 4 feet at all test locations. There are locations in Area I where ledgerock and bedrock are exposed to the surface. These areas must be avoided when considering the placement of waste treatment facilities. The exposed rock areas are not of sufficient size to creat problems.

The overall average geologic rating for individual home waste treatment systems in this area is slight if individual water wells are properly constructed. The rating could be severe where proper construction of water wells is not provided. Covenants will be imposed upon all lots within the subdivision to insure proper construction of wells and to eliminate the "severe" rating. The surface water rating is slight. These ratings of "slight" and "severe" are the ratings provided by the Missouri Geologic Survey.

AREA II: This area, being bisected by Deer Creek (see Figure 2), is in a similar geologic but a different topographic setting than is Area I to the east. Between 10 and 20 feet of Upper Gasconade dolomite is exposed along Deer Creek. The Roubidoux formation is again the controlling influence from just above the floodplain elevation of Deer Creek to the highest points within of this particular area. The overall topography is less rugged in this central area than in Area I previously discussed. It appears that the chert content of the bedrock in this area is less than that of the previous area and that the sandstone represented as massive beds increases. This phenomenon probably accounts for the less rugged topographic development of this area.

In addition, more of the high areas are controlled by the dolomite of the Jefferson City-Cotter formation. These areas are basically above elevation 850. Numerous small glade areas are present with very little soil cover. Within a very short horizontal distance from the glade area and rock outcropping, the soil thickens considerable.

The water table in this area is strongly influenced by Deer Creek flowing through the center of this particular area and the Osage arm of the Lake of the Ozarks to the north. Deep penetration of effluents or other fluids would not be expected to recharge the groundwater. However, these effluents might recharge the local seeps or springs and resurface appreciable distance from their origination without effecting the groundwater supply. Geologic records indicate that widespread surface karst or other natural conditions conducive to deep vertical water movement are not present. With the dipping of the formations in the westward direction, a thicker Jefferson City-Cotter formation exists on much of this area than in Area I. This formation depth increases as one progresses westward. Also, in all likelyhood, the formations dip slightly toward the Lake of the Ozarks.

Twenty percolation tests were conducted in Area II. In addition, at least 45 soil probes were conducted to investigate the soil characteristics. The soil is basically a clay ranging from a quite uniform clay material to a cherty gravelly clay. The cherty pebbles and gravel ranged in size from a few millimeters to several inches in diameter.

The percolation results indicate this area to be the most uniform in the development. The tests indicate that an area of 200 square feet of trench bottom per 100 gallons of flow per day will be required for an absorption field. The percolation tests for this area were conducted in the same manner as the previous area. Design will be based on the on-site results of the percolation tests required of the lot owner.

Here, as with Area I, rock is exposed in isolated locations. These locations must be avoided when considering the placement of the waste treatment facilities. Normally the exposed rock areas are not of significant magnitude to create undue hardships. These areas should simply be identified and designed around. The geologic rating for individual home waste treatment systems for groundwater insertion in this area is severe where water wells are not constructed with the grouted casing. Here, as previously discussed in Area I, restrictions will be imposed on all lots to insure proper construction of water wells and to eliminate the possibility of the "severe" rating. The rating is slight where the water wells are properly constructed. The rating for surface water contamination is slight.

AREA III: Because of the bedrock dip and some isolated faulting, dolomite of the Jefferson City-Cotter formation is the predominant bedrock in this area. Portions of the northern end of Mossy Creek and Spring Branch valleys have Roubidoux bedrock exposed. But the bedrock, the soil and surface stream flow conditions suggest that the thin bedded flaggy dolomite of the Jefferson City-Cotter formation predominates.

The dolomite of the Jefferson City-Cotter formation controls the relatively general topography in most of this area. Bedrock outcrops are numerous in that soils apparently develop very slowly from this dolomitic material. Immediately up the slope or down the slope, the soils have developed to a greater depth. The bedrock has an overall low vertical permability as evidenced by most of the valleys and very small tributaries maintaining surface flow for extended periods after rainfall ceases.

Much of this soil has a low to moderate permability in this natural state. When remolded or otherwise disturbed, the soils become relatively impermeable and do not accept or transmit water rapidly. In this geologic setting, the possibility of treated effluent moving laterally and surfacing downstream of the individual home treatment systems is somewhat more likely to occur than in the previous areas. The frequency of the treated effluent movement off of an individual lot as surface flow might be higher than with the other areas. This will be prevented with properly designed and constructed systems.

Where the soils are of sufficient depth and have the ability to accept flows as evidenced by percolation tests, properly designed absorption fields will be acceptable. In some areas, on this portion of the property, very little surface soil is present. Alternative methods of individual home waste treatment will need to be considered. This is the area where the mound or evapotranspiration systems will need to be considered and utilized where appropriate.

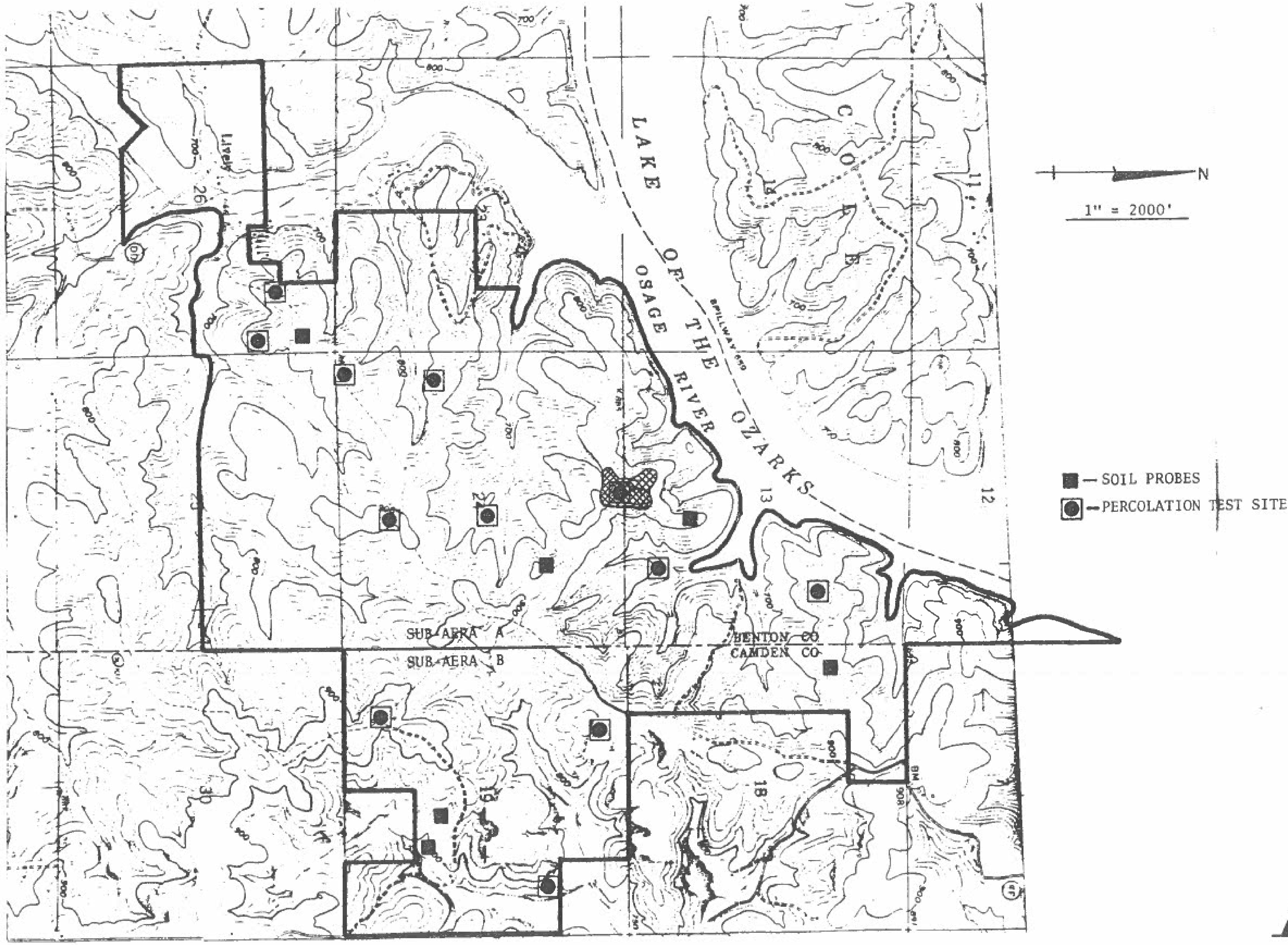
Sixteen percolation tests were performed in Area III (see Figure 3). In addition, at least 27 soil probes were conducted to help identify the soil characteristics of the area. Basically the soil is a clay with varying amounts of chert and gravel. Several of the holes near or adjacent to the glade areas contain a silty characteristic ranging from sandy silt to a silty clay. Even with the high silt content, the percolation rate did not greatly increase.

In general, the percolation rates of this area were not of significant magnitude to warrant the use of absorption fields exclusively as the final treatment method. The mound system is being proposed to offer alternative method of waste treatment to the absorption field. This system will provide an equivalent degree of treatment. Further discussion of this system will be made in later sections of this document. Here, as with the first two areas, two percolation tests will be required if absorption fields are to be used. An average area of over 300 square feet of trench bottom per 100 gallon daily flow can be expected.

Geologic groundwater rating for individual home waste treatment systems in this area with ungrouted water well casings is moderate. With individual water wells constructed with grouted casings, the rating is very slight. Surface water rating is moderate to severe. It is anticipated that on most slopes, the rating would be moderate and on the ridge where there is little to no soil, the rating could be severe. Proper design of the subdivision and sufficient land use restrictions will reduce this possible "severe" rating to a very minimum.

FIGURE 1

AREA I



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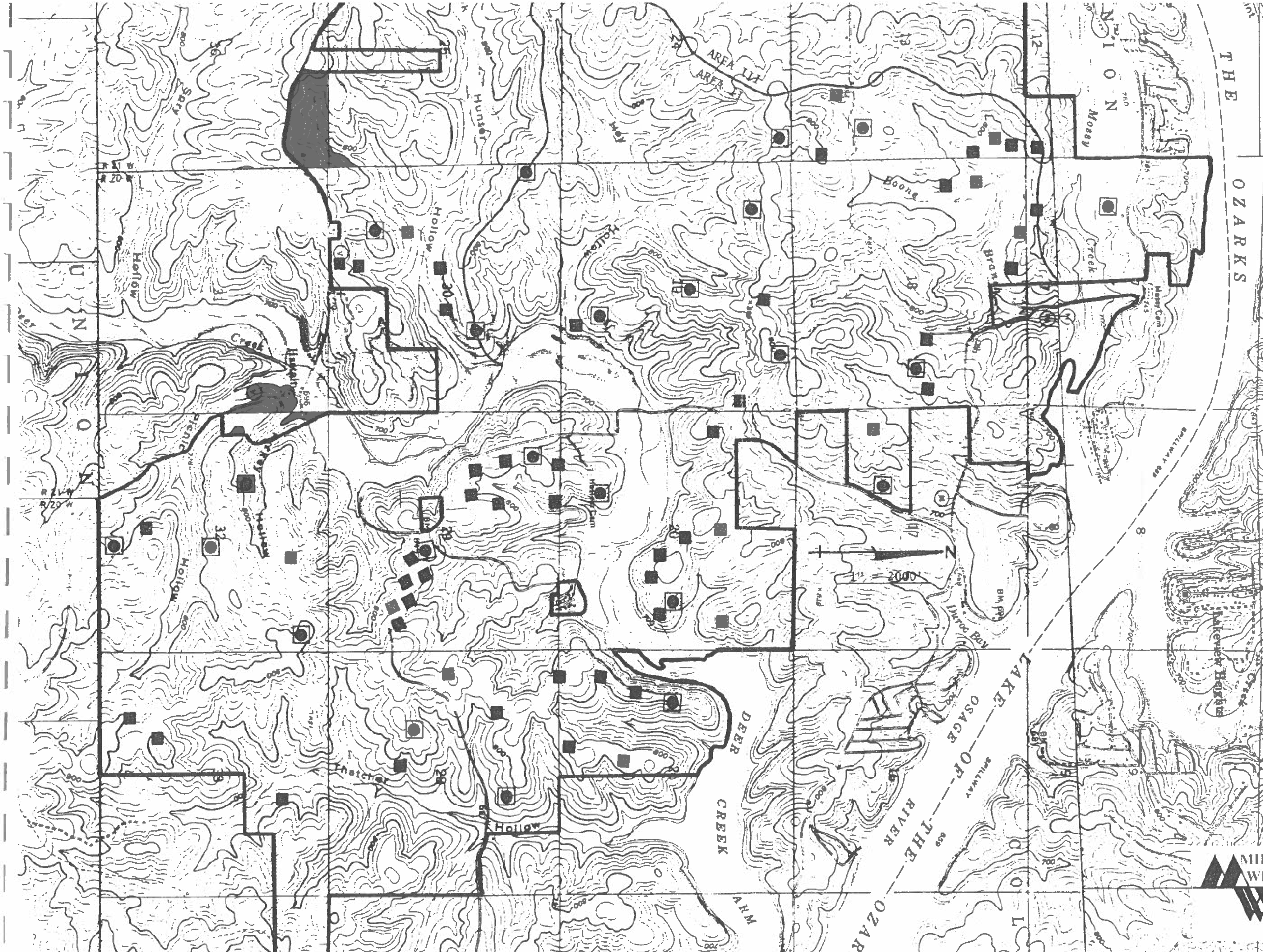

FIGURE 2

AREA II

■ — SOIL PROBES

● — PERCOLATION TEST SITES

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DESIGN CRITERIA

Protective covenants and restrictions will be placed on all lots by the developer before any lots are offered for sale. A copy of typical "Protective Covenants" is enclosed in the appendix. These covenants are not being offered as the document for the Forbes Lake of the Ozarks Park but merely as a sample of the documents which have been used previously at another location. All covenants will apply directly to Missouri statutes and regulations.

The developer also has preferred criteria by which the subdivision has been designed. Each lot shall have a minimum area of 1.0 acre. The average lot size will be 3.0 acres for the total development. The typical frontage width for an average lot will be 200 feet.

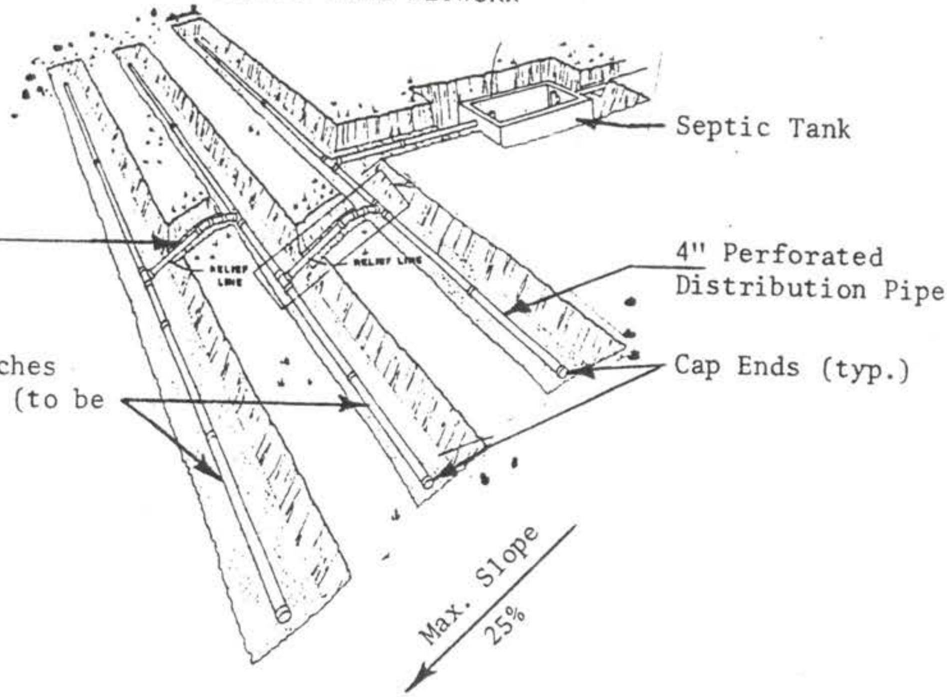
In addition, engineering criteria was considered. Numerous considerations were given to appropriate criteria for this development. Considerations include, but are not necessarily limited too: (1) slopes in excess of 25% should not be used as treatment facility sites; (2) wastewater treatment facilities, such as absorption fields and evapotranspiration mounds, and water supply wells shall not be located closer than 50 feet to a lot line nor shall these facilities be located closer than 100 feet to each other; (3) all waste flow is to be discharged to the sewage facility; (4) there is to be no extraneous water (downspouts, footing drains, etc.) discharged to the sewage facility; (5) minimum septic tank size for 3 bedroom home is 1000 gallons - 4 bedroom home a minimum tank size to be 1,200 gallons; (6) the anticipated average daily flow to be 100 gallons for first bedroom and 75 gallons for each additional bedroom; (7) absorption fields are to be used where soil percolation rates are sufficient to allow; (8) an alternate system, such as evapotranspiration and percolation mounds, are to be considered where soil percolation rates are not sufficient for absorption fields; and (9) any system shall be designed and constructed in compliance with established criteria of the Missouri DNR and/or the Missouri Division of Health. When the percolation rate is less than 18 minutes per inch drop, 200 square feet of trench bottom per 100 gallons of flow is recommended for an absorption field. With a percolation rate between 18 and 40 minutes per inch drop, 330 square feet of trench bottom is recommended. Where percolation rates exceed 40 minutes per inch drop, an alternate system, utilizing a mound system, must be considered. Any system deviating from the criteria established within this document shall be recommended by a duly registered engineer in the State of Missouri, shall be approved by the Land Owners' Association and shall be in compliance with DNR criteria and regulations.

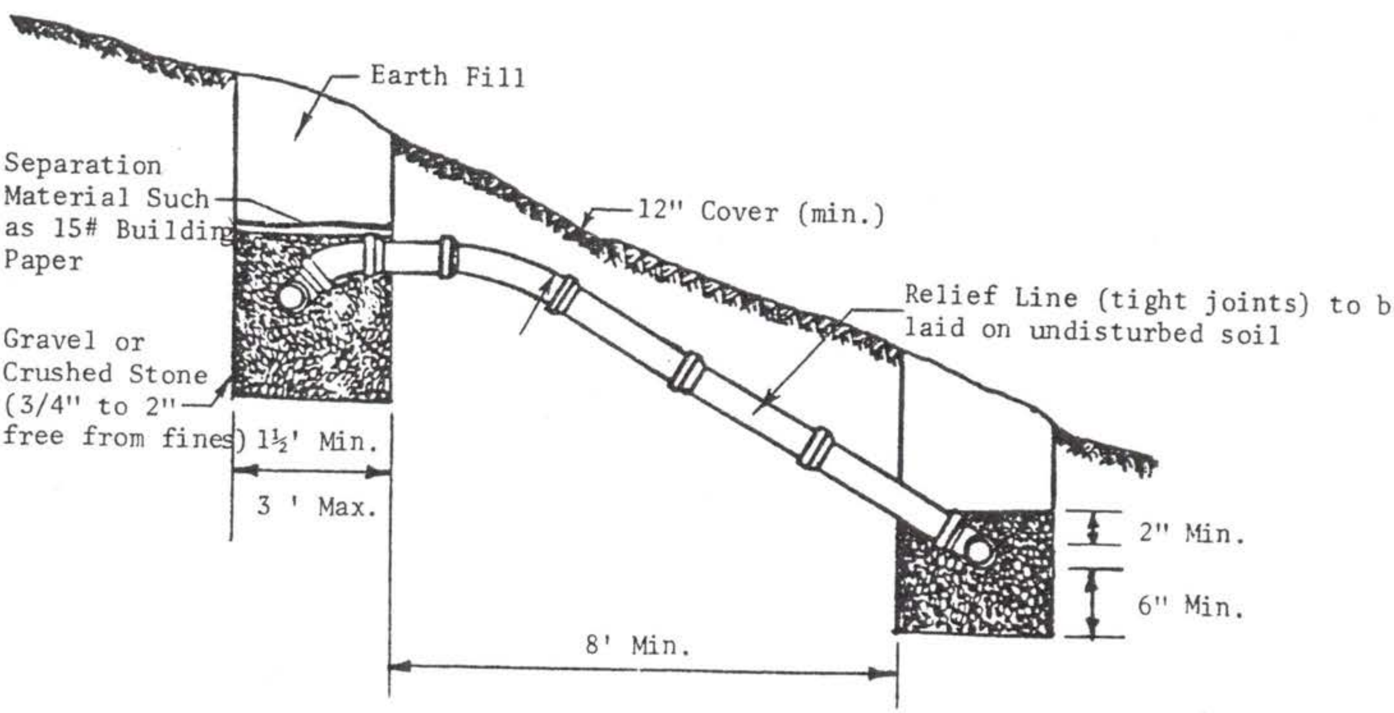
Relief line distribution networks are to be used as continuously ponded multi-trench systems for absorption fields. This network provides distribution as shown by Figure 4. This design does offer the ease of add-on construction for additional distribution field if necessary. This network does not permit the home owner to manually rest the upper trenches while using the lower trenches.

The network uses overflow or relief lines between trenches. The invert of the overflow section should be located near the top of the porous media to use the maximum capacity of the trench, but it must be lower than the septic tank outlet invert. The invert of the overflow from the first absorption trench should be at least 6 inches lower than the invert of the pretreatment unit outlet. Relief lines may be located anywhere along the length of the trench, but successive trenches should be separated 5 to 10 feet to prevent short-circuiting. Additional criteria is presented on Figure 4.

FIGURE 4

RELIEF LINE NETWORK





Typical Section

TABLE 1

SUBSURFACE ABSORPTION FIELD CONSTRUCTION DETAILS

Items	Unit	Max.	Min.
Number of lateral trenches.........			2
Length of trenches.................	Feet	100	40
Width of trenches..................	Inches	36	18
Depth of tile lines (bottom).......	Inches	48	18
Slope of tile lines................	In./100 ft.	6(2)	0(1)
Depth of coarse material:			
Under pipe....................	Inches		6(3)
Over pipe.....................	Inches		2
Size of coarse material.......	Inches	2	3/4
Depth of backfill over coarse material....................	Inches		12

(1) Level (0% preferred)

(2) Negative grade from relief line to lateral end

(3) 12" recommended

Figure 5 presents a typical cross section of a septic tank. A septic tank is merely a sedimentation unit through which sewage is allowed to flow and solids allowed to settle and digest anaerobically.

Prefabricated septic tanks may be constructed from precast concrete, steel, fibreglass or polyethelene. Most site constructed tanks are made from reinforced poured concrete. A minimum cover of 12 inches is recommended.

FIGURE 5

CROSS SECTION OF A TYPICAL SEPTIC TANK

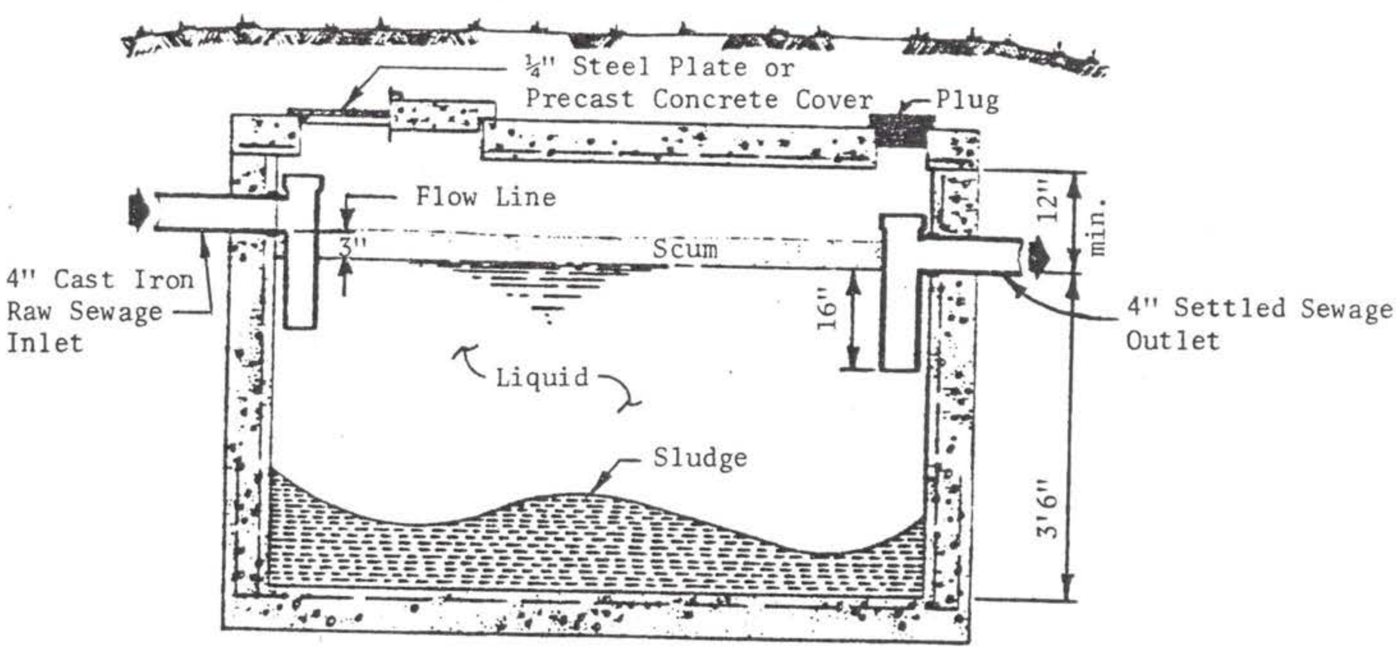


TABLE 2

SEPTIC TANK VOLUME REQUIREMENTS

Home Size	Tank Capacity
3 Bedroom or less	1,000 gallons
4 Bedroom	1,200 gallons
Each Additional Bedroom	250 gallons additional

Note: Septic tank size to be the same regardless of type of secondary unit.

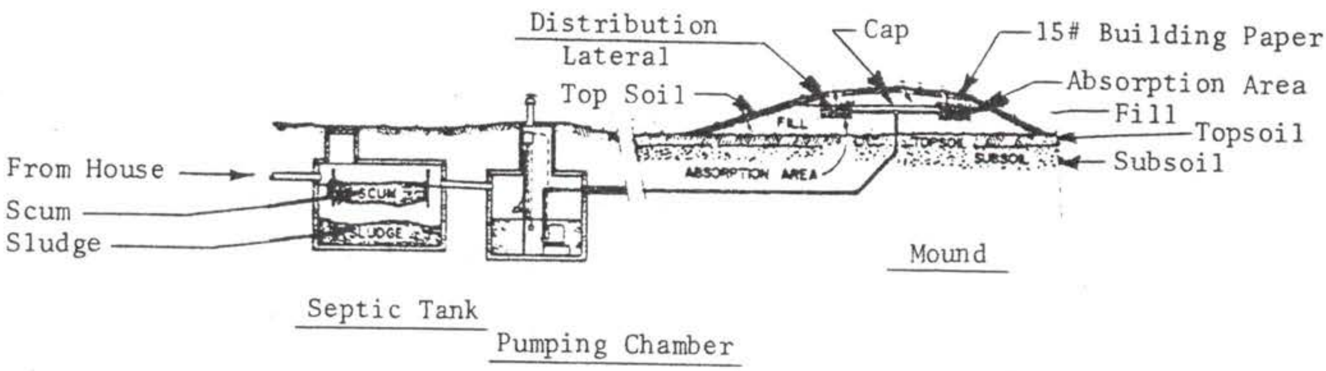
In areas where the conventional soil absorption fields are not suited because of site limitations such as low permeability of soils or shallow soils, alternate methods of disposal were investigated. A selected alternative is a mound system.

The purpose of the mound system is to provide final disposal of waste flows from the individual homes. This system basically provides treatment zones above the natural soils. Therefore, an adequately treated waste flow is subjected to the natural soils for absorption at quite low rates. Also some of the effluent can and/or will be evaporated directly to the atmosphere or by transpiration through plants which have been planted on the mound's surface.

This proposed alternative consists of the septic tank, a pumping chamber, and the mound. The septic tank is sized in the same manner as for the conventional septic tank-soil absorption system. The pump transports the effluent to the mound and pressurizes the distribution within the mound. A siphon can be used in place of the pump if the mound is located down slope of the septic tank sufficiently to induce adequate head. The mound consists of a fill material, an absorption area, a distribution system, and a cap of top soil. The effluent is pumped into the absorption area through the distribution system. It flows through the fill material where it is purified and then it passes into the natural soil. The cap, usually consisting of a topsoil provides frost protection, provides barrier to infiltration, retains moisture for evapotranspiration and promotes runoff of precipitation. The topsoil aids in establishing and maintaining a good vegetative cover.

FIGURE 6

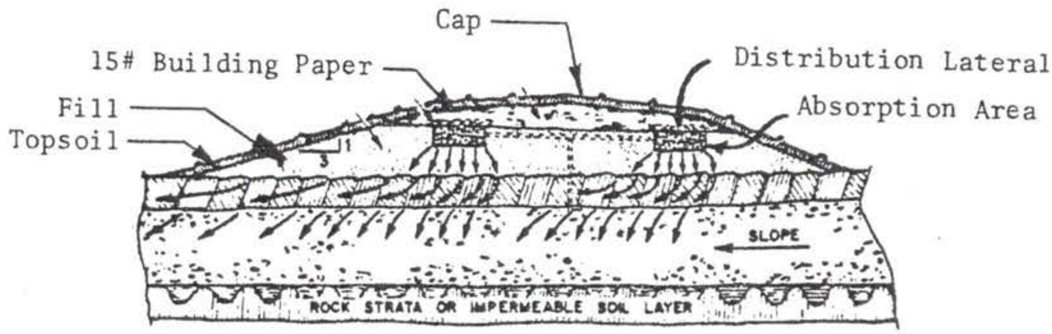
A CROSS SECTION OF THE SEPTIC TANK-MOUND SYSTEM FOR ON-SITE DISPOSAL



The mound serves several functions, depending upon the type of soil and site situation. For the slowly permeable soils, the primary function is absorption of the effluent into the natural soil. Sufficient purification will result as the effluent moves through the fill and natural soil. The absorption area is raised above the natural soil, using a suitable fill material. This places the absorption area in a more permeable fill material and removes it from the slowly permeable subsoil. The advantages are that: a) the effluent enters the more permeable natural topsoil over a larger area where it can move laterally until absorbed by the less permeable subsoil; b) the slimes that develop in the bottom of the absorption area will not clog the fill as readily as they do the less permeable natural soil; c) construction is eliminated in the shallow subsoil; d) the absorption area within the mound is much smaller than it would be if placed in the more slowly permeable subsoil but the mound is probably larger than would be a conventional system if one could be used.

FIGURE 7

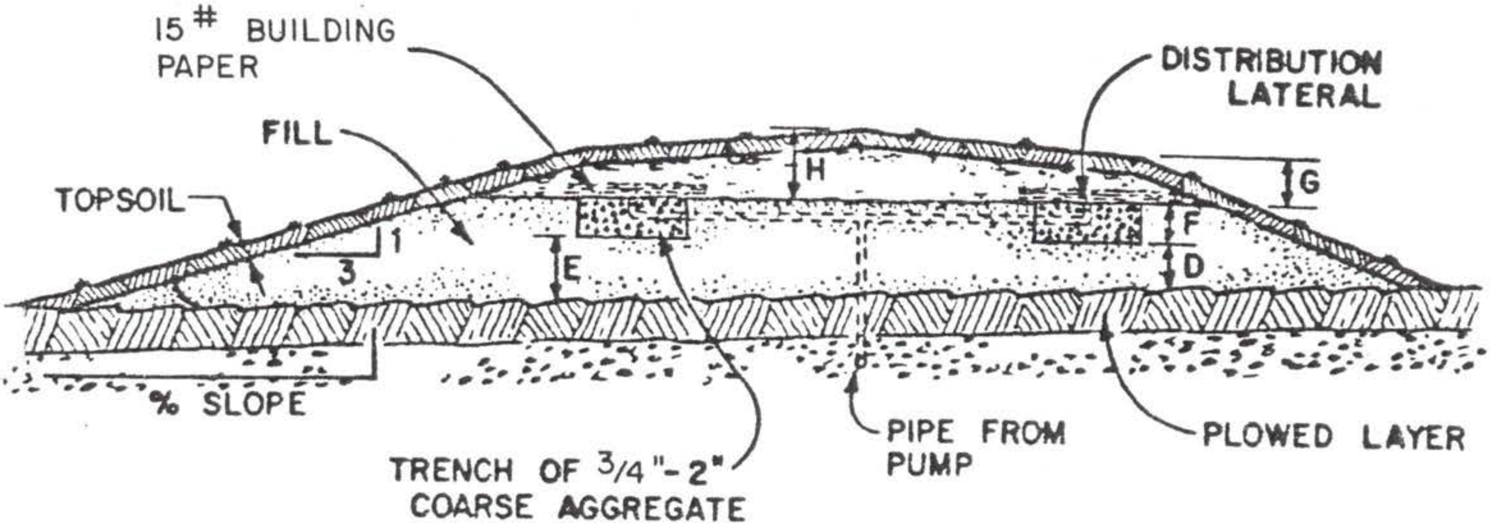
A CROSS SECTION OF A TYPICAL MOUND SYSTEM SHOWING EFFLUENT MOVEMENT IN A SLOWLY PERMEABLE SOIL

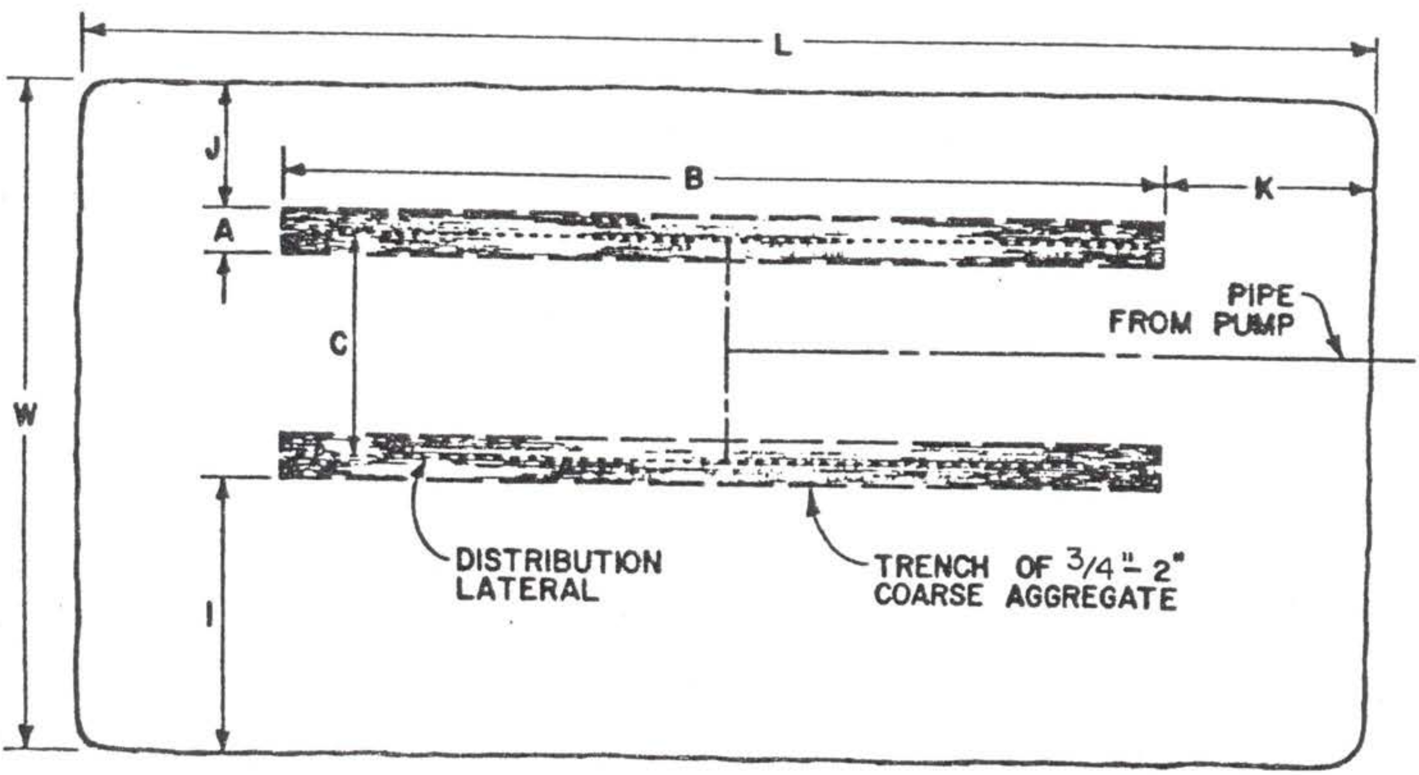


The alternate system described above is explained in complete detail by a design manual published by Agricultural Engineering Department of University of Wisconsin-Madison entitled "Design And Construction Manual For Wisconsin Mounds". This manual, with revisions, is contained in the appendix of this document.

FIGURE 8

CROSS SECTION OF MOUND SYSTEM UTILIZING TRENCHES
AND PLAN VIEW OF ABSORPTION AREA





Earlier in this document, the subdivision was divided into three separate areas referred to Area I (Sub-area A & B), Area II, and Area III. With reliance on the percolation tests performed in the field and general field observations of the geologic conditions of the terrain, Table 3 presents the design criteria for final disposal of individual effluents.

TABLE 3

ABSORPTION TRENCH REQUIREMENTS

Percolation Rates (inch/min.)	Trench Bottom Area ($feet^2$)
1 or less	60
1 to 2	75
2 to 5	108
5 to 10	144
10 to 15	180
15 to 30	285
30 to 45	390
45 to 60	495

For designing absorption trenches in Area I, Sub-area A and Area II, a trench bottom area of 200 square feet per 100 gallons of flow per day should be sufficient to provide the final disposal. With the somewhat tighter soils located in Sub-area B of Area I, the trench bottom area will likely need to be increased up to 330 square feet per 100 gallons of daily flow. As the capability of the soils to accept water decreases below 40 minutes per inch drop, the use of absorption trenches becomes more cost prohibitive. Consideration should be given to the alternative system, such as the mound system, as previously discussed.

It is certain that each soil condition and its capability of receiving water have not been determined. Consequently, the specific condition identified for each area could appear in any or all of the other areas. For example, at any specific location in Area III, a percolation rate could exist which would only require 100 square feet of trench bottom per 100 gallons of daily flow. The trench areas given in the preceding paragraph reflects the representative data collected. These represent the rule rather than the exception.

Based on estimated water usage of 100 gallons per day for the first bedroom and 75 gallons per day for each additional bedroom thereafter, the estimated daily usage is 250 gallons per day for a 3 bedroom home. For presentation purposes a 3 bedroom home will be considered.

Assuming an average trench width of 2 feet, the trench length for Area I, Sub-area A is 250 feet. This is 5 trenches 50 feet long or the equivalent. Same calculations hold true for any other area.

Due to the geologic setting of Area I and II, and in part to the topographic setting, rapid vertical migration of fluids, including effluent, would not penetrate to sufficient depths to recharge groundwater. Manmade openings, such as water wells, are the only known avenue for deep recharged penetration potential. Proper construction techniques will eliminate this potential source for groundwater recharge.

Wells shall be cased to a minimum depth of 100 feet or to 20 feet into clean, unstained rock with 6 inch diameter steel or wrought iron casing having a minimum weight of 13 pounds per foot. The drill hole to the casing depth shall be a minimum of 8 inches (preferably 10 inches) in diameter. At least 3 spacer guides shall be provided in the lower 30 feet of the casing. The annular space between the casing and the drill hole shall be sealed with neat cement grout. The water-cement ratio shall be approximately one bag of cement per six gallons of water. The remaining depth of the well shall be drilled to provide a 6 inch hole. The total depth of the well should be between 300 and 350 feet. The geologist from the Division of Geology, Missouri DNR has discussed this extensively in his letter dated April 5, 1982 (see Appendix 5). This recommendation along with the requirement of grouting the well casing will be incorporated into the "Protective Covenants."

In Area III, the dolomites of the Jefferson City-Cotter formation are very tight vertically so that recharge from effluents or other water vertically into the underlying aquifier would not be expected. Water wells again will be the only known avenue for recharge to the underlying aquifiers. Surface weathering of the rock has promoted a high horizontal permeability in the upper few feet of the exposed formation, particularly in a valley bottom where water is present much of the time.

RECOMMENDATIONS AND CONCLUSIONS

Based on the results of the percolation tests and the geological investigation of the area, the conclusions varied appreciable from site to site. In order to better identify the areas being discussed, the total tract was divided into three areas. These areas (including sub-area splits) have been delineated on Figures 1, 2, and 3.

Geologically, Areas I and II are very similar. Topographically, considerable variation exists. Actually there is considerable difference within the topography of Area I. This leads to appreciable difference in the rate of percolation from one side of the hill to the other side. Consequently, Area I was divided into two sub-areas A and B. Sub-area A being the rough terrain facing the Osage River and having the more porous soils. Sub-area B is the relatively rolling terrain away from the river and having a somewhat deeper, tighter, more homogeneous clay soil. The average percolation rate for Sub-area A, was about 15 minutes per inch of water level drop. This resulted in a recommended trench bottom area for tile absorption field of 200 square feet per 100 gallons flow. The percolation rate for the heavier clay soils of Sub-area B resulted in an average water level drop of about 1 inch every 35 minutes. This resulted in a required trench bottom area of 330 square feet per 100 gallons flow being recommended for absorption fields.

As stated previously, Area II is quite similar to Area I geologically. As would be expected, the percolation rate determined by the field test is quite similar. Here, as with Sub-area A of Area I, the recommended trench bottom area of 200 square feet per 100 gallons flow will be used for absorption fields.

Due to the westward dipping of the bedrock in Area III, the predominant formation ceases to be the Roubidoux and becomes the Jefferson City-Cotter as one moves westward on the site. This Jefferson City-Cotter formation controls the relatively gentle topography of Area III. Bedrock outcropping is more noticeable, thus it is apparent that the soils develop more slowly from this dolomitic material. The bedrock has a low vertical permeability as evidenced by the stream flow in most of the valleys. Since the residual soils retain the characteristics of their parent materials, a low to moderate permeability would be expected. This is confirmed by the percolation tests conducted on the area. The median time required for the water level to drop one inch exceeded 45 minutes. In some cases as much as 90 minutes per inch drop was observed over a four hour period. This inability of the soil to accept water lead to a thorough investigation of alternative systems. The alternative system chosen was the mound system utilizing both percolation and evapotranspiration to control the waste flow. For example, a mound 46' x 62' in these soils is designed to accept the waste flow of 300 gallons per day. This will be sufficient for a three bedroom house.

For design purposes, the total waste flow was estimated at 100 gallons per day for the first bedroom and 75 gallons per day for each bedroom thereafter. This yeilds a waste flow of 250 per day for a three bedroom home.

The septic tank for either installation shall have 1000 gallon capacity with a 1200 gallon tank to be used for a 4 bedroom house. For each bedroom after a total of four, 250 gallons of additional capacity will be required. It must be understood, that the above recommendations reflect the average condition at particular sites. Any site ranging from a few feet away to several hundred feet could vary appreciably. However, the above recommendations should satisfy the needs for waste treatment.

All water supply wells shall be constructed in such a manner to assure that surface or near surface flows do not move vertically into the water supply aquifier. This can be accomplished by proper grouting of the well casing. The casing depth will be 100 feet or 20 feet into unstained rock formation.

In order to maintain adequate separation of water supply and wastewater facilities, a minimum of 50 feet from the adjoining property line shall be maintained. This would insure a miminum distance of 100 feet between facilities as recommended by the DNR.

A Land Owners' Association has been incorporated to control and enforce provisions of the "Protective Convneants" of the subdivision. All documents relating to the Land Owners' Association, "Protective Covenants", and other restrictive requirements have been submitted to the DNR regional office and become a part of the documentation related to this report.

In conclusion, individual sewage treatment facilities and water supply wells can be utilized as utilities in the Forbes Lake of the Ozarks Park in Benton and Camden Counties provided design criteria and design requirements, as previously outlined, be incorporated into final construction planning.

APPENDICES

APPENDIX 1

Engineering Geological Report on Liquid Waste Treatment, Individual Waste Treatment Systems, for the Forbes Project

ENGINEERING GEOLOGIC REPORT ON LIQUID WASTE TREATMENT, INDIVIDUAL WASTE TREATMENT SYSTEMS, FOR THE FORBES PROJECT

CAMDEN AND BENTON COUNTIES

LOCATION: Principally T. 40 N, R. 20, 21 W., Benton County, south of Osage River.

This large land tract will be broken down into three areas based on geology and topography.

Area 1 is the tract including parts or all of Sec. 13, 23, 24, 25 and 26, T. 40 N. R. 20 W., Benton County and parts of Sec. 18, 19, T. 40 N., R. 19 W., Camden County.

Area 2 pertains to the central part of the property including parts or all of Sec. 7, 17, 18, 19, 20, 21, 28, 29, 30, 32 and 33, T. 40 N., R. 20 W., Benton County.

Area 3 includes the area of Spring Branch and Mossy Creek including parts or all of Sec. 13, 22, 23, 24, 25, 26, and 27, T. 40 N., R. 21 W., Benton County.

Information requested by Mr. Bill Crockett, P.E., Williams and Works.

Area 1

General Geology

Three geologic formations make up the bedrock and influence the topography in Area 1. At and just above lake level to the north, the upper part of the Upper Gasconade formation is present. The Gasconade forms the bluffs along the river and represents that rock unit containing numerous caves and other solution openings that are visible at many locations. The topographic position of the Gasconade formation is such that it is only represented as exposed rock at low elevations on the north-northwest part of the property.

In this relatively rugged topography, the hillslopes and much of the ridge areas are made up of bedrock of the next formation, the Roubidoux. This bedrock formation composed of dolomite, chert beds and sandstone beds control the topography and is the predominating rock unit at the surface.

At high elevations, normally at elevation 900 or above, dolomite is present representing the third or uppermost bedrock formation called the Jefferson City formation. This rock unit only represents a very small percentage of the area and is noted for its ability to outcrop readily wherever it is present. Very little soil is developed on the dolomite and it is represented as a glade or natural open field area.

As mentioned above, the Roubidoux formation predominates the landscape in Area 1. The Roubidoux formation generally exhibits a relatively high permeability due to fracturing of the dolomite and sandstone beds. In addition to the fracturing, the chert beds within the bedrock act as conduits for rapid flow of water. For this reason, most of the steep gradient headwater valleys or gulleys are losing streams in that surface flow is not maintained for any extended period after rainfall. Rapid infiltration of water takes place. This feature in part is responsible for development of the extensive solution work in the form of caves and springs at low elevations in the upper Gasconade dolomite.

The soils developed directly from the Roubidous bedrock take on the same character as the parent rock. The relatively high degree of permeability is present in the residual soils due to the presence of excessively large amounts of chert and sandstone and a soil fabric similar to the underlying rock.

In most instances, soils on the Roubidoux will be capable of absorbing very large quantities of effluent in individual home waste treatment systems. On large lots (averaging 3 acres or greater) runoff of effluent from individual lots would not be expected during the average rainfall period. Where very steep slopes are involved, surfacing of effluent or other liquids can occur as thin water impeding zones are present in the residual soil that will redirect percolating water to the surface. Overall, however, movement of effluent off a lot in this setting would not be expected. The phenomenon of surfacing water is present in the southeast part of Sec. 19, Benton County and as seeps and small springs and at lower elevations as stream flow.

Several small sinkholes are present in the Roubidoux that represent solution work in the dolomite. This area is not considered karstified at the surface but much solution work is present at depth particularly in the upper part of the Gasconade formation.

Due to the geologic setting and in part to the topographic setting, rapid vertical migration of fluids including effluent would not penetrate to sufficient depths to recharge groundwater. Manmade openings such as individual water wells are the only known avenue of deep recharge penetration potential. Proper construction techniques including grouting of casing would eliminate this potential source for groundwater recharge.

The overall average geologic rating for individual home waste treatment systems in Area 1 is slight if individual water wells are properly constructed. The rating is severe where proper construction of water wells is not followed. The surface water rating is slight.

Area 2

General Geology

Area 2, dissected by Deer Creek, is in a similar geologic but different topographic setting than Area 1 to the east. Ten to twenty feet of upper Gasconade dolomite is exposed along Deer Creek with solution work noted in several of the exposures. The Roubidoux formation is again the controlling influence from just above the floodplain elevation of Deer Creek to near the highest peaks. The overall topography is less rugged in this central area than in Area 1. It appears that the chert content of the bedrock in Area 2 is less than in Area 1 and the sandstone, represented as massive beds, increases in Area 2 from Area 1. This phenomenon may account for the less rugged topographic development.

In addition, more of the high areas, again principally above elevation 850 to 920 are controlled by dolomite of the Jefferson City formation. Glade areas are present with very little soil. Within very short horizontal distances from the glade area rock outcrops, soil thickens considerably.

Deer Creek running through the center of this area and the Osage Arm of Lake of the Ozarks to the north, both are presenting a water table in that area. Deep penetration of effluent or other fluids would not be expected to recharge to groundwater except as recharge to seeps and springs. No widespread surface karst or other natural conditions conducive to deep vertical water movement are noted. Individual wells on each lot would appear to be the only potential avenue of recharge of surface water.

Geologic rating or individual home waste treatment systems for groundwater recharge in Area 2 is severe with water wells not constructed to state standards. The rating is slight where water wells are constructed to state standards. The rating for surface water contamination is slight.

Area 3

General Geology

From the Benton - Camden County line to the east, the bedrock apparently dips in a slightly westerly direction. Because of the bedrock dip and some faulting, dolomite of the Jefferson City formation is the predominant bedrock in Area 3. Portions of the northern end of Mossy Creek valley and Spring Branch have Roubidoux bedrock exposed but bedrock, soil and surface stream flow conditions suggest that the thin bedded flaggy dolomite of the Jefferson City formation predominates.

The dolomite of the Jefferson City formation which is only represented on the high peaks in Area 1 and 2 controls the relatively gentle topography in most of Area 3. Bedrock outcrops are numerous in that soils apparently develop very slowly on this dolomite bedrock. Numerous glades are present where very little to no soil masks the bedrock. The bedrock has an overall low vertical permeability evidenced by most of the valleys and very small tributaries maintaining surface flow for extended periods after rainfall ceases.

The soil, where present in Area 1, had a moderate permeability in its natural state. When remolded or otherwise disturbed, the soils become relatively impermeable and do not accept or transmit water rapidly. In this geologic setting, surfacing of effluent or other fluids downslope of individual home waste treatment systems more readily occurs than in Area 1 or Area 2. The frequency of effluent movement off of an individual lot as surface flow will be higher than in Area 1 or 2. Large lot sizes (averaging 3 acres or more) however, would be expected to help nullify surface water effect.

In many areas of this portion of the property, very little to no soil is present. Alternative methods of individual home waste treatment may need to be considered.

As mentioned above, the bedrock is very tight vertically so recharge of effluents or other water vertically into underlying an aquifer would not be expected. Water wells again would be the only known avenue of recharge to underlying aquifers.

Geologic groundwater rating for individual home waste treatment systems in Area 3 with water wells constructed not following state standards is moderate. With individual water wells constructed according to state standards, the rating is slight. Surface water rating is moderate to severe. It is anticipated that on most slopes the rating would be moderate and on the ridge areas where very little to no soil is present, the rating would be severe.

It should be noted that the reference to water wells in the geologic rating scheme is mentioned frequently. This is because it is the only variable that can be altered. Other variables in the rating scheme are natural conditions and cannot be as readily altered. The groundwater rating criteria is based on 9 factors and the surface water rating criteria is based on 5.

Thomas J. Dean, Geologist
Engineering Geology Section
Geology & Land Survey
May 4, 1982

orig: Bill Crockett
Williams & Works
cc: DEQ, Jeff City

APPENDIX 2

Typical "Protective Covenants"

ARTICLE VIII
PROTECTIVE COVENANTS

The following restrictions, conditions and covenants, collectively called "Protective Covenants," are imposed upon all the Lots and Common Areas, without limiting or altering the provisions of Article VII, except that items (h) through (k) and item (s) shall not apply to the existing structures on the lots described in Exhibit C, attached hereto and made a part hereof:

(a) All refuse, rubbish, trash, garbage or waste shall be kept, disposed of or removed in a sanitary manner. All household refuse and rubbish, trash, garbage or waste shall be kept in closed containers inside a building or other approved enclosure until taken to a disposal place operated or licensed by the proper public authority for such disposal. Nonhousehold refuse, rubbish, trash, garbage or waste, other than dead leaves and fallen limbs, shall not be permitted to remain exposed on a Lot.

(b) Noxious, obnoxious, noisy, unsightly or otherwise offensive objects or activities, specifically including vehicle repairs and littering, shall not be permitted nor shall anything be permitted that may be an unreasonable annoyance or nuisance to other Owners.

(c) Any vehicle, whether self-propelled or not, permitted to remain on any Lot or Common Area shall be kept in a licensed and operable condition. Any vehicle, whether self-propelled or not, shall be parked in such a manner that it is not a nuisance, aesthetically or otherwise, to other Members. A truck larger than three-quarter (3/4) ton rating shall only be kept on a Lot inside an approved building except during any period of authorized construction. A vehicle shall not be parked on that part of any road normally used by vehicles being driven on such road. The provisions of this paragraph shall not apply to Declarant during time of construction of roads.

(d) Any vehicle requiring its operator to have an operator's license under the laws of the State of Missouri shall be operated only by a person having a valid operator's license.

(e) Excessively noisy vehicles of any kind, all-terrain vehicles, trail-bikes, helicopters, aircraft or motorcycles shall not be used anywhere in Forbes Lake of the Ozarks Park.

(f) No structure of a temporary or mobile nature, motor home, mobile home, camper truck, travel trailer, camping trailer, other vehicles used or designed for camping, or tent, shall be placed on a Lot prior to construction of the residential building.

(g) No camping is allowed on a Lot. Camping is permitted only in areas designated by the Environmental Control Committee and only under the conditions set by said Committee.

(h) Lots shall be used for residential purposes only, and no residential building shall be permitted which shall house more than one (1) family. No building shall be erected nearer than thirty (30) feet to any boundary line of any Lot. For the purpose of this covenant, eaves, steps and open porches shall be considered as a part of the building.

(i) No single-family residence, exclusive of open porches, garages, carports and appropriate ancillary buildings, shall be less than one thousand (1,000) square feet in main floor area. No commune, cooperative or similar type of living arrangement shall be permitted anywhere in Forbes Lake of the Ozarks Park.

(j) Building materials shall not be placed on a Lot nor shall foundation work be started for any Improvement unless such Improvement has previously been approved by the Committee. No mobile homes or previously erected homes shall be allowed. Once approval is obtained, such Improvement must be completed within twelve (12 months) after building materials are first placed on such Lot or foundation work is begun, whichever occurs first.

(k) Any tank for the storage of gas or liquid shall be hidden from view of other Lots and the Common Areas.

(l) All Improvements shall be maintained in such a manner that they do not become unsightly, in disrepair, unsanitary or a fire hazard.

(m) No kennel or other facility for raising or boarding dogs or other animals for commercial purposes shall be kept in Forbes Lake of the Ozarks Park. No animals of any kind shall be raised, bred or kept in Forbes Lake of the Ozarks Park except horses and reasonable numbers of dogs, cats or other ordinary household pets. No poultry may be kept in Forbes Lake of the Ozarks Park. No dog shall be allowed to run loose except when accompanied by a person capable of keeping such dog under surveillance and control. Horses will be allowed only with the approval of the Environmental Control Committee, but then only on Lots larger than four (4) acres that have suitable terrain, vegetation and fencing.

(n) No guest house, garage, carport, boat house, dock or other outbuilding shall be constructed on any Lot until after commencement of construction of the dwelling house on the same Lot.

(o) Existing tree lines on all Lots shall not be disturbed or altered, and wherever practicable, all Improvements shall be placed a reasonable distance behind such tree lines as determined by the Committee.

(p) No tree having a diameter at breast height greater than six (6) inches shall be cut down without prior approval of the Committee.

(q) No Lot shall be subdivided or partially leased.

(r) Any outdoor fire shall be made in a receptacle having a properly operating spark screen. No campfires built on the ground will be allowed. All fireplaces, whether inside a building or outdoors, shall have an operationally approved spark screen covering the top of the chimney. No condition which creates a fire hazard shall be permitted on a Lot.

(s) No commercial enterprise shall be operated.

(t) No hunting shall be permitted.

(u) No firearms, explosives, fireworks or arrows shall be used, shot or discharged except in such areas as may be designated by the Assocation for such use, shooting or discharge.

(v) No explosives shall be used for construction purposes unless such use has been approved by the Committee.

(w) One professional quality sign of not more than one (1) square foot in area shall be allowed to be displayed for advertising such Lot or Improvement thereon for sale, lease or rent.

(x) All wells must be drilled in accordance with the standards required by the State of Missouri for this development.

(y) All septic systems must be constructed according to the standards required by the State of Missouri for this development.

(z) Only wind, electric and hand-powered craft will be allowed on lakes forty (40) acres or smaller within the development.

APPENDIX 3

Design & Construction Manual for Mound Systems

DESIGN EXAMPLE for MOUND on SLOWLY PERMEABLE SOIL

An example is used to illustrate the design procedure. The method outlined in the text is followed step by step for a situation commonly found in practice. Example plans have also been prepared for most site conditions encountered and are included following the design example. These prepared plans may be used where similar site conditions exist. In cases where these plans cannot be adapted to the site, a mound may be designed as illustrated below.

Design a mound system for a 3 bedroom home with the following site conditions. Several small trees are on the site. Rock fragments, impermeable layer, and bedrock are a factor.

Slope	6%
Percolation Rate	120 min/in. at 24 inches
Groundwater	Several feet deep

Step 1. Select the Site

The mound site should be selected prior to house location and road building. Consider all criteria listed in Table 1 and the discussion under the "Soil and Site Requirement" section for all possible locations on the lot. Consider the difficulties in constructon of the mound at the various locations. Evaluate all criteria, weigh one site against the other, then pick the best site.

Step 2. Wastewater Load

Design loading is 100 gal/day for first bedroom, then 75 gal/day for each remaining bedroom, so with 3 bedrooms the design loading is 250* gal/day.

Step 3. Select the Fill Material

Select a medium sand texture. Sometimes it is necessary to make a judgement on the quality of sand versus the transportation costs, but there are sands which are too coarse or too fine that are not acceptable. A medium sand texture will have a design infiltration rate of 1.0 gal/ft^2/day.

Step 4. Size the Absorption Area

Since the medium textured sand is being used, the infiltration rate is 1.0 gal/ft^2/day.

* Flow in excess of design recommendation contained in report. For purposes of this example and field construction use table amounts.

Absorption area required - 250 gal/day ÷ 1.0 gal/ft^2/day = 250 ft^2

Since this is a slowly permeable soil a trench system must be used. This will spread the liquid out along the slope. Trench width of 2-4 ft is permissible.

Use a trench width of 3 ft. (A) then:

Trench length = 250 ft^2 ÷ 3 ft. = 83.3 ft. say 84 ft.

This is too long for a single trench system. Use 2 or 3 parallel trenches of equal length, preferably 2 trenches. More than 3 trenches may concentrate the liquid into a small area and also result in higher mounds on sloping sites.

For a 2 trench system:

Trench length = 84 ft. ÷ 2 ft. = 42 ft. (B)

Trench spacing is determined by the design loading rate of the natural soil. For a soil with percolation rate of 120 min/in., the design infiltration rate is 0.24 ft^2/day. All of the effluent from the upslope trench must be absorbed by the natural soil before it reaches the downslope trench through lateral movement. Assume one-half of effluent in each trench.

Trench spacing = 125 gal/day ÷ 0.24 gal/ft^2/day ÷ 42 ft. = 12.5 ft. (C) from center to center

Step 5. Mound Height

Fill depth (D) = 1 ft. (min. fill depth beneath absorption area)

Fill depth (E) = D + slope (C+A)
= 1 ft. + .06 (12.5 + 3) ft.
= 1 ft. + 0.93
= 1.93 ft. (this is approximate as trenches must be at same elevation)

Trench depth (F) = 0.75 ft. minimum depth with a min. of 0.5 ft. of aggregate below distribution system.

Cap and top soil depth (H) = 1.5 ft. which include 1 ft. of subsoil and 0.5 ft. of top soil.

Cap and top soil depth (G) = 1.0 ft. which include 0.5 ft. of subsoil and 0.5 ft. of top soil.

Step 6. Mound Length and Width

End Slopes (K) = mound depth at center x 3:1 slope.

$$= \left[\frac{(D+E)}{(2)} + F+H \right] \times 3$$

= 3.7 ft. x 3
= 11.1 ft.

Upslope Width (J) = mound depth at upslope edge x 3:1 slope x slope correction
= (D+F+G) x 3 x 0.85
= 2.75 ft. x 3 x 0.85
= 7.0 ft.

Downslope Width (I) = mound depth at downslope edge x 3:1 slope x slope correction
(E+F+G) x 3 x 1.22
= 3.68 ft. x 3 x 1.22
= 13.4 ft.

Mound Length (L) = B + 2K
= 42.0 ft. + 2 x 11.1 ft.
= 64 ft.

Mound Width (W) = J + A/2 + C + A/2 + I
= 7 ft. + 1.5 ft. + 12.5 ft. + 1.5 ft. + 13.4 ft.
(C is center to center of trenches)
= 36 ft.

Step 7. Basal Area

On sloping sites the basal area is that area under and downslope of the trenches (B x (C+A+I). On level sites it is the total area under the mound (BxW) except for end areas. The design loading rate of the soil with percolation rate of 120 min/in. is 0.24 gal/ft^2/day.

Basal Area Required = daily flow ÷ infiltrative capacity of soil
= 250 gal/day ÷ 0.24 gal.ft^2/day
= 1,040 ft^2

Basal Area Available = B x (C+A+I)
= 42 ft. x (12.5 ft. + 3 ft. + 13 ft.)
= 1,214 ft^2

Sufficient area is available. If it were not, then the downslope width (I) would be increased until sufficient area is available.

Step 8. Distribution System

Figure A-5 of this Appendix shows typical examples of a distribution system. Design requires selection of hole spacing and diameter, lateral diameter and spacing, manifold length and diameter. Lateral length is defined as the distance from manifold (supply end) to far (distal) end. Tee to tee construction is preferred.

Hole spacing = 30 in.
Hole diameter = 1/4 in.

Lateral length

Lateral lengths (p) normally are about 0.5 feet shorter than one-half the length of trench. In this example, lateral length would be 20.5 ft. [(42 ft ÷ 2) -.5 ft.].

Hole Spacing

Holes are spaced 30 in. apart.

The following are hole spacing distances in inches from the manifold to distal end of lateral. There are 9 holes per lateral.

15, 45, 75, 105, 135, 165, 195, 225*, and hole in end.

*If the last hole, based on 30 in. spacing, is equal to or greater than 15 in. from the end of the lateral, put another hole in the end cap of the pipe or close to it.

Lateral Diameter

Lateral diameters are dependent upon lateral length, hole size and spacing. Table A-4 gives the maximum allowable length for various hole diameters and hole spacing. For the 30 in. spacing and 1/4 in. hole, allowable lateral lengths for 1 in. diameter is 25 ft. and for 1 1/4 in. diameter is 38 feet. Since lateral lengths required is 20.5 ft., the lateral diameter must be 1 in.

Lateral Spacing

For trench systems, lateral spacing is from center to center of trenches. For this example, it is 12.5 ft.

Manifold Length

Manifold length is distance between the outside laterals or summation of all lateral spacings. For this example, it would be 12.5 ft.

For these mound systems, the manifold diameter is normally 2 or 3-in., depending on the size of the pipe from the pumping chamber to the mound and the inlet location. The inlet can be in the side of the manifold between the laterals (Fig. A.5), or it can be in the end of the manifold, preferably on the upslope edge. In either case, the manifold must slope toward the inlet so it will drain. For either inlet location, the manifold can be 2-in. diameter if the pipe is 2-in. diameter. If the pipe from the pump is 3-in. diameter, and the inlet is in the end, then the manifold must be 3-in. If the inlet is in the side, then the manifold can be 2-in. diameter.

Step 9. Pumping Chamber Size

Table A-5 gives the recommended pumping chamber size which is 500-750 gal. capacity. The features shown in Fig. A-6 should be incorporated into it.

Step 10. Pump Size

Assume the pumping chamber is located 75 ft. from the mound center and the elevation difference is 9 ft. from the pump to the lateral invert.

Pump Capacity

Using the recommended pressure of 2 ft. at the distal end of the lateral, Table A-6 gives the pump capacity of 36 gpm for 1/4-in. diameter holes for a 3 bedroom sized mound. Figure A-7 can be used to determine flow rate for other pressures.

Pump Head

The total head consists of (1) elevation difference, (2) friction loss, and (3) desired pressure at end of laterals.

(1) elevation head = 9 ft.

(2) friction loss -

Friction loss is dependent upon flow rate and pipe diameter.

Table A-7 gives the friction loss/100 ft. of pipe for various diameter pipes and flow rates. For flow rate of 36 gpm, the friction loss for:

(a) 2-in. diameter is 2.05 ft/$_{100\ ft.}$ x 75 ft. = 1.54 ft.

(b) 3-in. diameter is 0.30 ft/$_{100\ ft.}$ x 75 ft. = 0.23 ft.

Either pipe can be used. Ignore friction losses for fittings. Manifold friction loss can be estimated by adding its length to the pipe length when figuring friction loss.

(3) Pressure at distal end of lateral

Fig. A-7 can be used to determine pressure at supply end of lateral. For a 2 ft. pressure at distal end for 1/4-in. diameter holes, the pressure at supply end is 2.5 ft.

Total Head = 9 ft. + 1.5 ft. + 2.5 ft. = 13.0 ft. for 2-in. diameter pipe.
= 9 ft. + 0.2 ft. + 2.5 ft. = 11.7 ft. for 3-in. diameter pipe.

Pump size

Select a pump which would pump at least 36 gpm at 13.0 ft. of head. This given head loss is based on using a 2 in. pipe. The pump opening will be smaller.

or

Select a pump which would pump at least 36 gpm at 12 ft. of head. This given head loss is based on using a 3 in. pipe. The pump opening will be smaller.

Step 11. Dosing Quantity

From Table A-8, the net recommended dosing quantity is 115 gal/dose. The void volume of the laterals needs to be checked to see if the dosing quantity is 10 times the void volume. From Table A-9, the void volume of 1 in. diameter pipe is .041 gal/ft. For 122-feet of lateral, the void volume is 5.0 gal. which, when multiplied by 10, is less quantity given in in Table A-8. Therefore, the volume is 115 gal./dose. Adjustments need to be made for flow back so 115 gal. is actually dosed. For a 5-ft. diameter pumping chamber, the net liquid level differential per dose cycle is 9.4 in.

Step 12. Select the controls which will give the flexibility necessary for the proper quantity per dose.

TABLE A-1. DESIGN CRITERIA FOR A MOUND FOR A 3 BEDROOM HOME ON 4 TO 12% SLOPE WITH LOADING RATES TO 250 GAL/DAY FOR SLOWLY PERMEABLE SOIL
Fig. A-1 and A-2

PARAMETER	SYMBOL	UNITS	SLOPE % 4	6	8	10	12
Trench Width	A	Ft	3	3	3	3	3
Trench Length	B	Ft	42	42	52	42	42
No. of Trenches	–	--	2	2	2	2	2
Trench Spacing	C	Ft	12.5	12.5	12.5	12.5	12.5
Mound Height	D	Ft	1	1	1	1	1
	E	Ft	1.6	1.9	2.2	2.6	2.9
	F	Ft	0.75	0.75	0.75	0.75	0.75
	G	Ft	1	1	1	1	1
	H	Ft	1.5	1.5	1.5	1.5	1.5
Mound Width	J	Ft	7	7	7	7	7
	I*	Ft	13	14	15	16	17
	W	Ft	35	36	37	38	39
Mound Length	K	Ft	10.7	11.1	11.6	12.2	12.6
	L	Ft	64	65	66	67	68
Lateral Length	P	Ft	20.5	20.5	20.5	20.5	20.5
Lateral Diameter	–	In	1	1	1	1	1
No. of Holes per Lateral**	–	--	9	9	9	9	9
Hole Spacing**	–	In	30	30	30	30	30
Hole Diameter	–	In	¼	¼	¼	¼	¼
Manifold Length	R	Ft	12.5	12.5	12.5	12.5	12.5
Manifold Dia.***	–	In	2	2	2	2	2

* Additional Width to obtain required basal area

** Last hole is located at end of lateral

*** Diameter dependent upon size of pipe from pump and inlet position

TABLE A-2. DESIGN CRITERIA FOR A MOUND FOR A 4 BEDROOM HOME ON 4 TO 12% SLOPE WITH LOADING RATES TO 325 GAL/DAY FOR SLOWLY PERMEABLE SOIL
Fig. A-1 and A-2

PARAMETER	SYMBOL	UNITS	SLOPE %				
			4	6	8	10	12
Trench Width	A	Ft	3	3	3	3	3
Trench Length	B	Ft	59	59	59	59	59
No. of Trenches	-	--	2	2	2	2	2
Trench Spacing	C	Ft	12.5	12.5	12.5	12.5	12.5
Mound Height	D	Ft	1	1	1	1	1
	E	Ft	1.6	1.9	2.2	2.6	2.9
	F	Ft	0.75	0.75	0.75	0.75	0.75
	G	Ft	1	1	1	1	1
	H	Ft	1.5	1.5	1.5	1.5	1.5
Mound Width	J	Ft	7	7	7	7	7
	I*	Ft	13	14	15	16	17
	W	Ft	36	37	38	39	40
Mound Length	K	Ft	10.7	11.1	11.6	12.2	12.6
	L	Ft	81	81	82	83	84
Lateral Length	P	Ft	29	29	29	29	29
Lateral Diameter	-	In	1¼	1¼	1¼	1¼	1¼
No. of Holes per Lateral**	-	--	11	11	11	11	11
Hole Spacing**	-	In	30	30	30	30	30
Hole Diameter	-	In	¼	¼	¼	¼	¼
Manifold Length	R	Ft	12.5	12.5	12.5	12.5	12.5
Manifold Dia.***	-	In	2	2	2	2	2

* Additional Width to obtain required basal area
** Last hole is located 8" from end of lateral
*** Diameter dependent upon size of pipe from pump and inlet position

TABLE A-3. DESIGN CRITERIA FOR A MOUND FOR LARGER HOME ON 4 TO 12% SLOPE WITH LOADING RATES TO 450 GAL/DAY FOR SLOWLY PERMEABLE SOIL Fig. A-3 and A-4

PARAMETER	SYMBOL	UNITS	SLOPE %				
			4	6	8	10	12
Trench Width	A	Ft	3	3	3	3	3
Trench Length	B	Ft	50	50	50	50	50
No. of Trenches	-	--	3	3	3	3	3
Trench Spacing	C	Ft	12.5	12.5	12.5	12.5	12.5
Mound Height	D	Ft	1	1	1	1	1
	E	Ft	1.6	1.9	2.2	2.6	2.9
	F	Ft	0.75	0.75	0.75	0.75	0.75
	G	Ft	1	1	1	1	1
	H	Ft	2	2	2	2	2
Mound Width	J	Ft	7	7	7	7	7
	I*	Ft	12	14	15	16	17
	W	Ft	57	61	61	61	62
Mound Length	K	Ft	12	13	13	14	14
	L	Ft	74	76	76	78	78
Lateral Length	P	Ft	24.5	24.5	24.5	24.5	24.5
Lateral Diameter	-	In	1¼	1¼	1¼	1¼	1¼
No. of Holes per Lateral**	-	--	10	10	10	10	10
Hole Spacing**	-	In	30	30	30	30	30
Hole Diameter	-	In	¼	¼	¼	¼	¼
Manifold Length	R	Ft	25	25	25	25	25
Manifold Dia.***	-	In	2	2	2	2	2

* Additional Width to obtain required basal area

** Last hole is located at end of lateral

*** Diameter dependent upon size of pipe from pump and inlet position

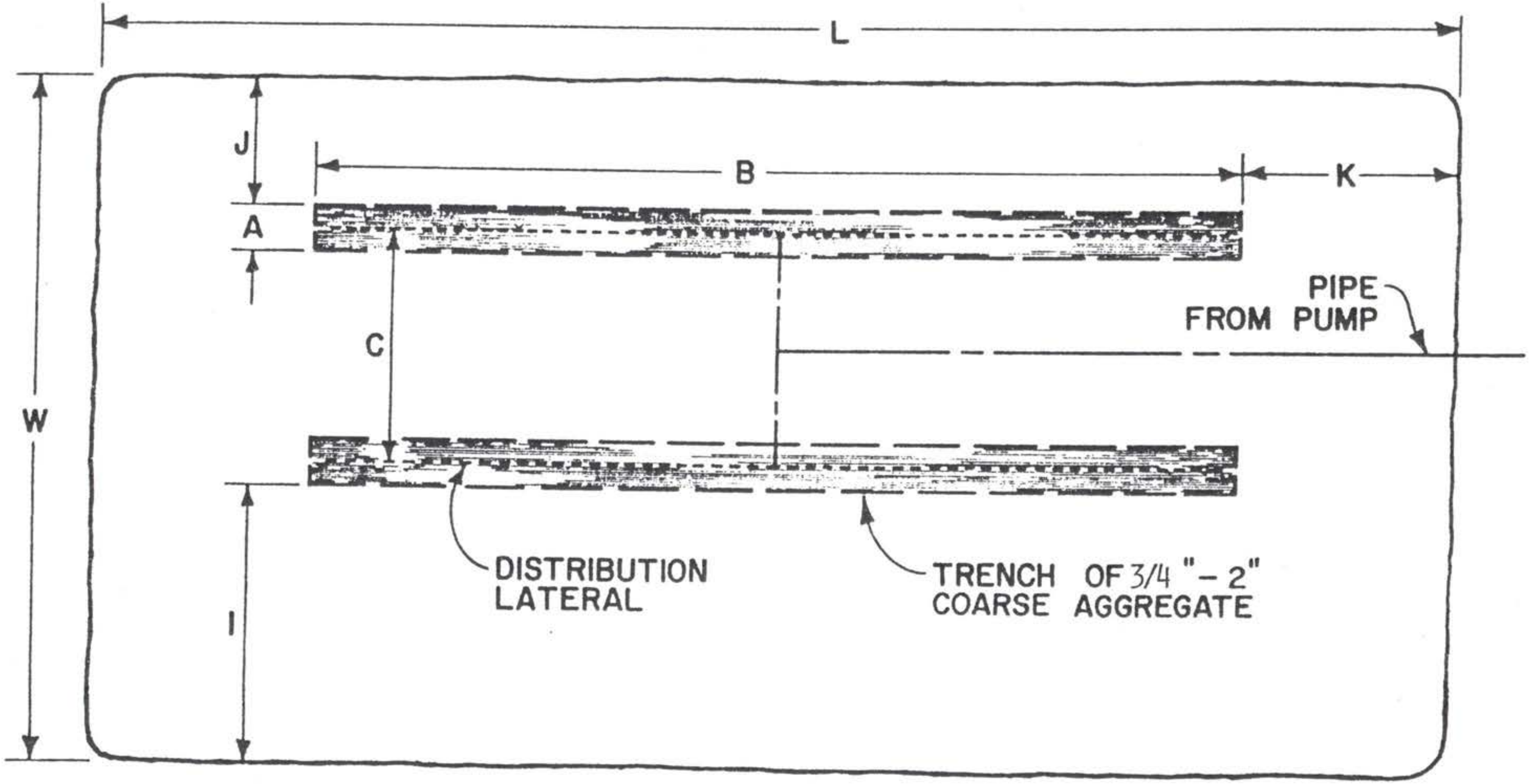


Fig. A-1 Plan view of a mound system using 2 trenches for the absorption area.

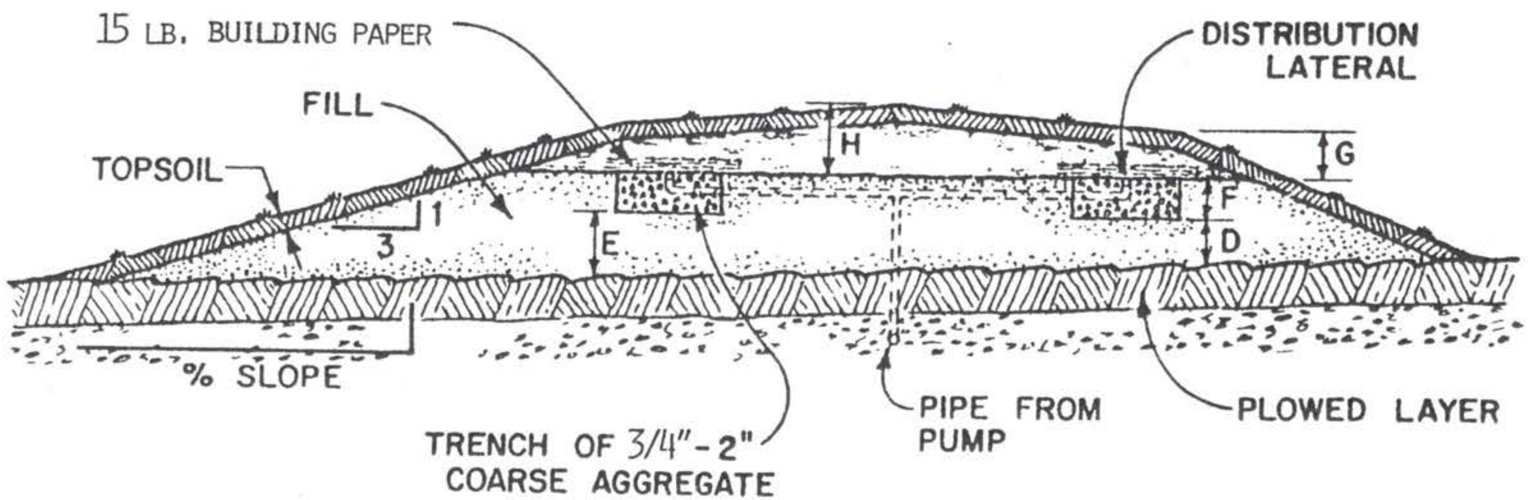


Fig. A - 2 Cross section of a mound system using 2 trenches for the absorption area.

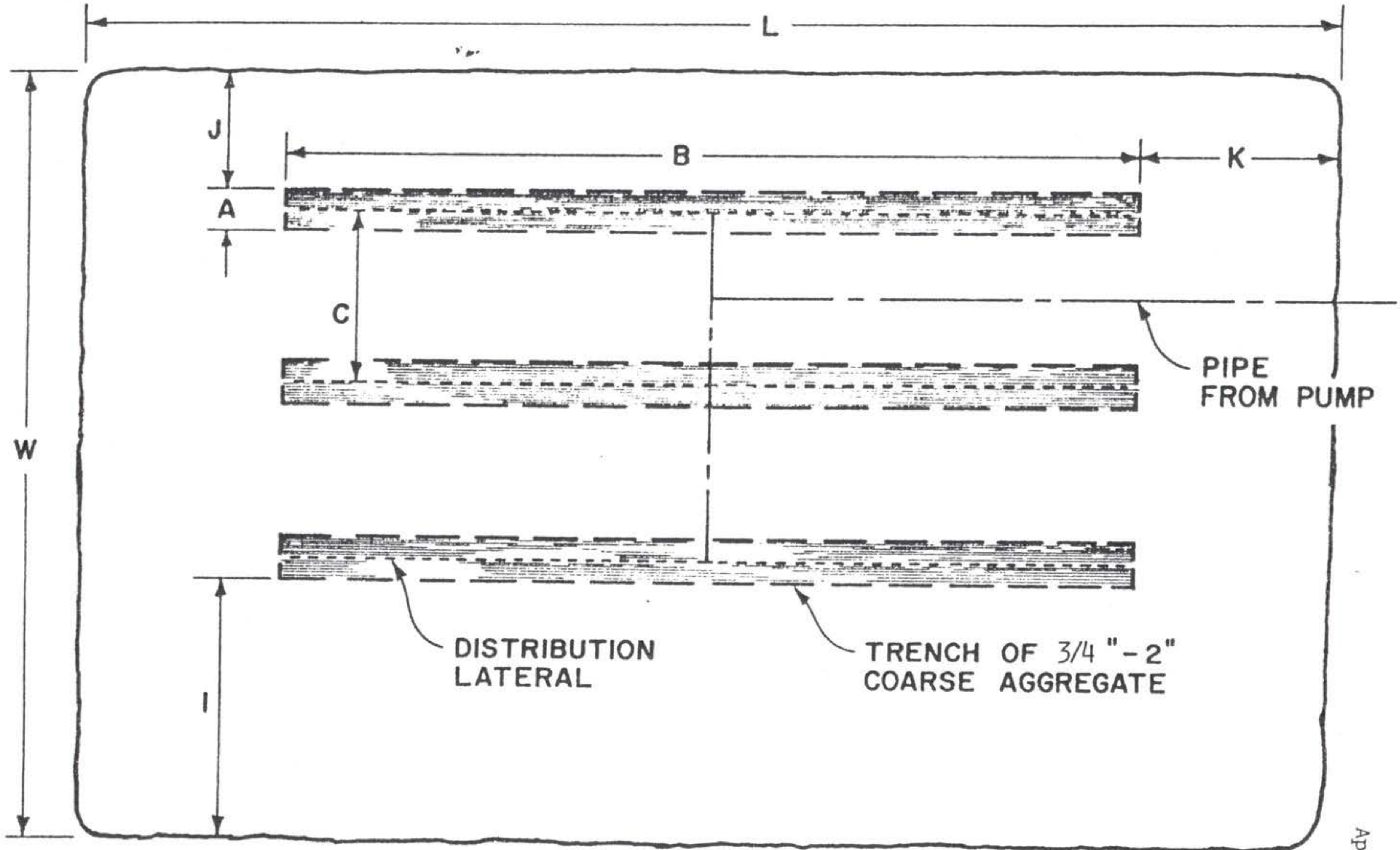


Fig. A -3 Plan view of a mound system using 3 trenches for the absorption area.

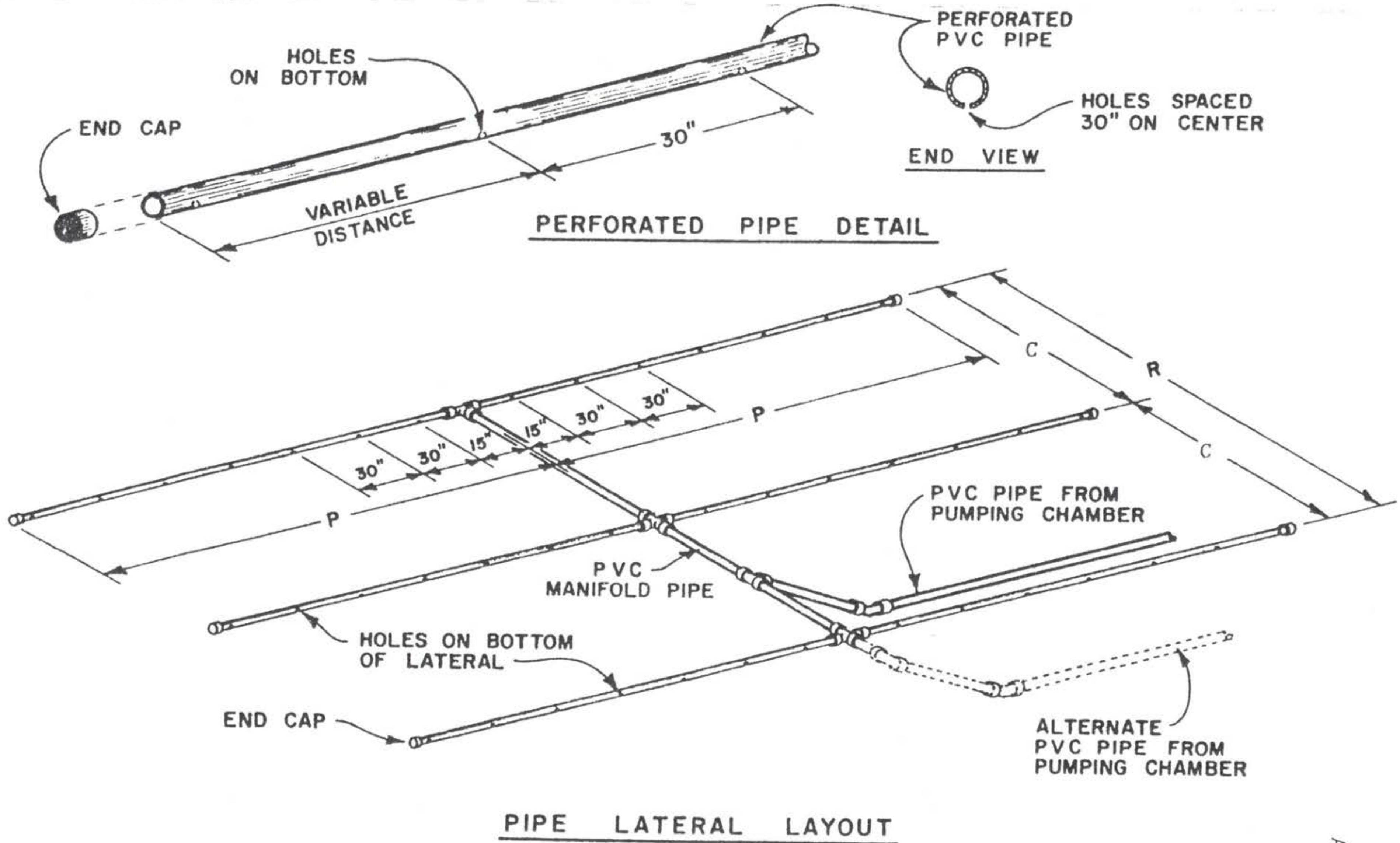


Fig. A -5 The distribution system for a mound. One lateral is placed down the center of each trench as shown on plan views. Note alternate inlet positions. The variable distance between the last hole and the next to last hole will range between 15 and 30 in., depending upon the length of trench. Distribution system must be arranged so manifold and laterals drain after each dose.

TABLE A-4 **Allowable Lateral Lengths (Feet) for Three Pipe Diameters, Three Perforation Sizes, and Two Perforation Spacings (Machmeier 1975)**

Perforation spacing (in)	Perforation Diameter (in)	Pipe Diameter		
		(1 in)	(1-1/4 in)	(1-1/2 in)
30	3/16	34	52	70
	7/32	30	45	57
	1/4	25	38	50
36	3/16	36	60	75
	7/32	33	51	63
	1/4	27	42	54

TABLE A-5 Recommended Pumping Chamber Sizes for Various Sized Homes

Home Size No. Bedrooms	Minimum Pumping Chamber Size Gallons
1	250-500
2	250-500
3	500-750
4	500-750
5	750-1000

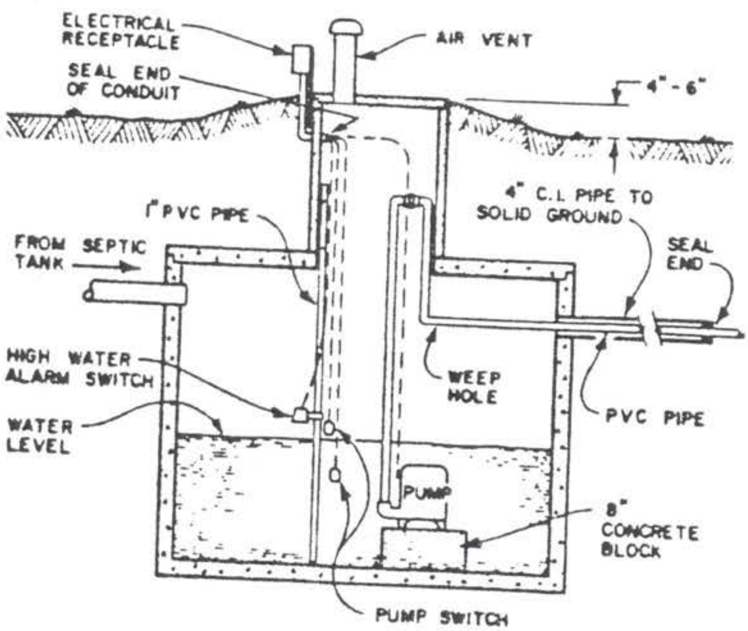


Fig. A-6

A detailed cross-section view of a typical pumping chamber

TABLE A-6. Pump Flow for Various Sized Mounds Using a 7/32 in. and 1/4 in. Dia. Perforations for a Pressure of 2.5 ft. at the Supply End of the Lateral. Laterals are Spaced 3 ft. Apart with Perforations Spaced 30 in. Apart. (Based on Curves in Fig. A.7).

Home Size No. Bedrooms	Absorption Area For Distribution System ft^2	Pumping Capacity[a] 7/32 in. orifice dia. gpm	Pumping Capacity[a] 1/4 in. orifice dia. gpm
2	175	21	26
3	250	28	36
4	325	36	47
5	400	44	57

[a] pump capacity required for the total pressure head which includes elevation difference, friction loss and desired pressure is lateral.

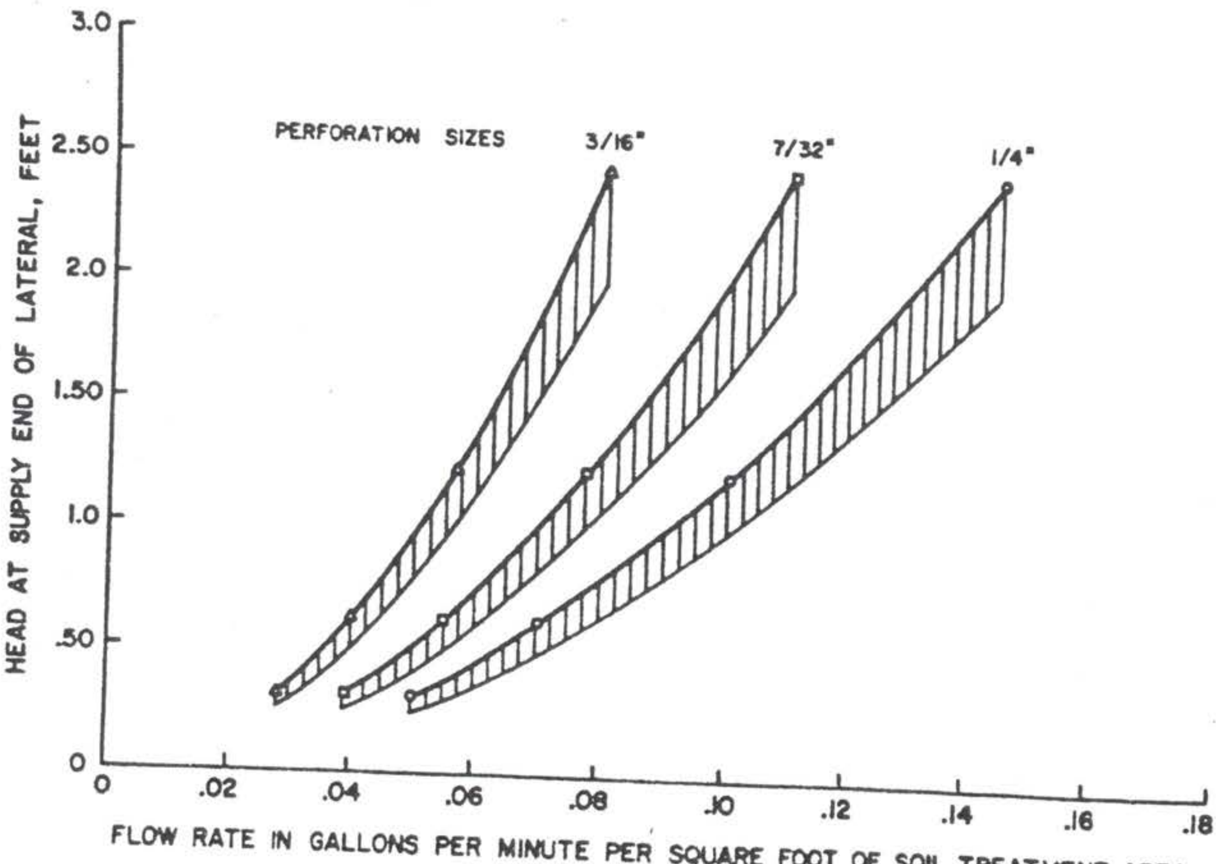


Fig. A-7 Flow rate vs. head for perforation spacing of 30 in. and lateral spacing of 3 ft. The lower curve for each perforation represents the head at the distal end of lateral (Machmeier 1975).

TABLE A-7 **Friction Loss in Schedule 40 Plastic Pipe (C = 150)**

Flow	Pipe Diameter (in)								
	1	1 1/4	1 1/2	2	3	4	6	8	10
gpm	ft/100 ft								
1	0.07								
2	0.28	0.07							
3	0.60	0.16	0.07						
4	1.01	0.25	0.12						
5	1.52	0.39	0.18						
6	2.14	0.55	0.25	0.07					
7	2.89	0.76	0.36	0.10					
8	3.63	0.97	0.46	0.14					
9	4.57	1.21	0.58	0.17					
10	5.50	1.46	0.70	0.21					
11		1.77	0.84	0.25					
12		2.09	1.01	0.30					
13		2.42	1.17	0.35					
14		2.74	1.33	0.39					
15		3.06	1.45	0.44	0.07				
16		3.49	1.65	0.50	0.08				
17		3.93	1.86	0.56	0.09				
18		4.37	2.07	0.62	0.10				
19		4.81	2.28	0.68	0.11				
20		5.23	2.46	0.74	0.12				
25			3.75	1.10	0.16				
30			5.22	1.54	0.23				
35				2.05	0.30	0.07			
40				2.62	0.39	0.09			
45				3.27	0.48	0.12			
50				3.98	0.58	0.16			
60					0.81	0.21			
70					1.08	0.28			
80					1.38	0.37			
90					1.73	0.46			
100					2.09	0.55	0.07		
125						0.85	0.12		
150						1.17	0.16		
175						1.56	0.21		
200							0.28	0.07	
250							0.41	0.11	
300							0.58	0.16	
350							0.78	0.20	0.07
400							0.99	0.26	0.09
450							1.22	0.32	0.11
500								0.38	0.14
600								0.54	0.18
700								0.72	0.24
800									0.32
900									0.38
1000									0.46

Velocities in this area become to great for the various flow rates and pipe diameter.

TABLE A-8. Recommended Dosing Quantity for Various Sized Homes

Home Size No. Bedrooms	Dosing Quantity* Gal/Dose
1	50
2	75
3	115
4	150
5	200

* Each system needs to be checked to see if this is at least 10 times the lateral void volume.

TABLE A-9. Void Volume for Various Diameter Pipes

Diameter inch	Volume gal/ft. length
1	.041
1¼	.064
1½	.092
2	.164
3	.368
4	.655
6	1.47

APPENDIX 4

Mound Construction Techniques

MOUND CONSTRUCTION TECHNIQUES

Mound construction procedures are just as important as the mound design. Good design with poor construction will result in mound operating poorly and may result in failure. Proper equipment is essential. Small track type tractors work best. Wheel type tractors are too difficult to maneuver in the fill. The following is a step by step procedure for mound construction which has been tried and proven. Other techniques could be used as long as the basic principles of mound design, operation and construction are not violated.

- Select a site which meets the criteria

- Stake out the mound on this site so that the trenches or bed runs perpendicular to the direction of the slope. Reference stakes are recommended in case corner stakes are disturbed.

- Measure the average ground elevation along the upslope edge of bed or upper trench. This is necessary to determine the bottom elevation of the trenches or bed.

- Determine where the pipe from the pumping chamber connects to the distribution system in the mound.

- Trench and lay the effluent pipe from pumping chamber to mound. Cut and cap the pipe one ft. beneath the ground surface. Lay pipe below frost line or sloping uniformly back to the pumping chamber so that it drains after dosing. Backfill and compact soil around pipe to prevent back seepage of effluent along pipe. This step must be done before plowing to avoid compacting and disturbance of surface.

- Check the moisture content of the soil at 7-8 in. deep. If it is too wet, smearing and compaction will result, thus reducing the infiltration capacity of the soil. Soil moisture can be determined by rolling a soil sample between the hands. If it rolls into a ribbon, the site is too wet to prepare. If it crumbles, soil preparation can proceed.

- Cut trees to ground level, remove excess vegetation by mowing. Prepare the site using a moldboard plow by plowing perpendicular to the slope. Chisel plowing may be used if a moldboard plow is not available. Rototilling must not be done on heavy soils but can be used on non-structural soils such as sands. Immediate construction after plowing is desirable. Avoid rutting of plowed area with vehicular traffic.

- Extend the effluent pipe to several feet above the ground surface.

- Place the fill material which has been properly selected around the edge of the plowed area. Keep wheels of truck off plowed areas. Minimize traffic on the downslope side of mound. Work from the end and upslope side.

- Move the fill material into place using a small track type tractor with a blade. Always keep a minimum of 6 in. of sand beneath tracks to prevent compaction of the natural soil.

- Place the fill material to the required depth which is the top of the trenches or bed. Shape sides to the desired slope.

- With the blade of the tractor form the bed or trenches. Hand level the bottom of the trenches and beds. Make sure bottoms are at the same ele-vation and level.

- Place the coarse aggregate in the trenches or bed. It should be 3/4-2 in. non-deteriorating aggregate. This is the same aggregate as recommended for the conventional system. Level aggregate to the design depth.

- Place the distribution system on the aggregate. Connect the manifold to the pipe from pumping chamber. Slope manifold to effluent pipe. Lay laterals fairly level, removing large rises and dips.

- Place 2 in. of aggregate over the distribution pipe.

- Place untreated building paper or a synthetic fabric, such as Typar, Mirafi or the equivalent over aggregate.

- Place soil on top of the bed or trench to a depth of 1 ft. in center and 6 in. at outer edge of bed or trenches. This may be subsoil or top soil.

- Place 6 in. of good quality top soil over the entire mound surface. This will raise the elevation at the center of the mound to a minimum of 1.5 ft. (H) and the outside edges of bed or trenches to 1 ft. (G).

- Landscape the mound by planting grass, using the best vegetation adaptable to the area. A mixture of 60% bluegrass, 30% creeping red fescue and 10% annual rye grass may be the desired vegetative cover. Shrubs can be planted around the base and up the sideslopes. They should be somewhat moisture tolerant since the toe of the mound may be somewhat moist during various times of the year. Evergreen shrubs often are used as plantings.

- Mound maintenance involves pumping the septic tank every 3 years to avoid carryover of solids into the mound. A good water conservation plan within the house assures mound will not be overloaded. Avoid excess traffic in mound area. Winter traffic on mound should be avoided to minimize frost penetration.

APPENDIX 5

Letter From Division of Geology - Recommendation for Private Well Construction

MISSOURI DEPARTMENT OF NATURAL RESOURCES
P.O. Box 250 Rolla, Missouri 65401 (314) 364-1752

April 5, 1982

Mr. Bill R. Crockett, P.E.
Williams & Works
409 Vandiver Drive
Building 5, Suite 100
Columbia, MO 65202

Dear Bill:

Our File: Benton - Camden Counties
T. 40 N., R. 20 & 21 W.
Forbes Project

This is in reply to your letter of March 30 requesting information on the recommended construction of private wells for the Forbes site.

I think it would be wise to plan on a minimum casing depth of 100 feet. This amount is probably more than enough for most drill sites and since it will be designated as the minimum amount which is acceptable, problems which are encountered below that depth can be dealth with by setting more casing. We are not trying to case the wells to any particular stratigraphic interval. We are however, interested in casing to a point which is below any actively weathered zone which has connection with the surface. In the eastern part of the area, 100 feet will place the bottom of the casing just above or just below the contact between the Roubidoux Formation and the Upper Gasconade Dolomite. In the western part of the area, the bottom of the casing will be near the contact between the Jefferson City Dolomite and the Roubidoux Formation.

It would be extremely difficult for the driller or engineer to determine stratigraphic intervals from the drill cuttings. It will however, be possible to determine casing intervals using the premise that the casing be set a minimum of 100 or 20 feet into clean, unstained rock.

Total depths will range from approximately 300 feet in the eastern part of the area (middle of the Lower Gasconade Dolomite) to approximately 350 feet in the western part of the area (upper part of the Lower Gasconade Dolomite). At these depths, yields could range from 15 to 30 gallons a minute.

Christopher S. Bond Governor
Fred A. Lafser Director

Division of Geology and Land Survey
Wallace B. Howe Director

When I may be of further assistance, please feel free to contact me.

Yours sincerely,

Don E. Miller, Chief
Water Resources Data & Research
Geology and Land Survey

DEM:djh

APPENDIX 6

Checklist for Approval of Plan of Operation for Subdivision in Unincorporated Area

CHECKLIST FOR APPROVAL OF PLAN OF OPERATION FOR SUBDIVISION IN UNINCORPORATED AREA

The following items have been determined to be the procedure for approval of plans of operation for subdivision:

1. Approval of the plan for operation is required before the Engineering Report will be approved by the agency.

2. Unless a municipality or public sewer district is proposed as the operating authority, a Home Owners' Association must be created. The association is required as a back-up authority where a PSC-regulated sewer company is proposed, because the sewer company could always go out of business.

3. The Home Owners' Association must be incorporated. It will usually be a not-for-profit corporation. The powers of the association, provisions for regular and special assessments, liens, etc., must be contained in restrictive covenants running with the land.

4. Guaranty contracts from the developer and the Home Owners' Association are required. These contracts basically constitute promises from the developer and the association to enforce and live by the terms of the restrictive covenants. These contracts are enforceable by DNR.

5. If interim use of on-lot disposal is proposed for the development, the Engineering Report must include a calculation of the amount of money which must be escrowed from each lot sale to provide a fund for construction of the sewer system in the future. An escrow agreement between the developer and a financial institution must be drafted, and the restrictions must refer to the escrow arrangement.

6. The developer's attorney must submit the restrictions, guaranty contracts, and escrow agreement (if appropriate) to DNR in draft. The contents of these documents will be finalized through discussion with the developer's attorney.

7. By letter, with copy to the regional office, inform the developer's attorney that the form of the documents constituting the plan for operation to be acceptable. That letter will inform the developer's attorney that he must submit to the regional office the following:

   A. As-filed copy of the plat;
   B. As-filed copy of the restrictions;
   C. Proof that the Home Owners' Association has been incorporated;
   D. The executed originals of the guaranty contracts from the developer and association.

8. Upon receipt of all of the above documents, in proper form, the regional office will be in a position to approve the Engineering Report and plan for operation. On each guaranty contract there will be a space at the bottom of the contract for signature by the appropriate person in the regional office signifying acceptance of the guaranty contract. The acceptance line should be signed and dated, and copies of the accepted contracts should be returned to the developer with the approval letter.

A letter will be sent to the developer's engineer, copy to the developer and regional office, indicating approval of the technical aspects of the Engineering Report once all of those aspects are approvable. That letter lets the developer and engineer know that no further work is needed on the Engineering Report, even through it may take further work on the plan for operation documents. That letter always warns the developer that the Engineering Report is not being approved, and that lot sales prior to such approval are unlawful. DNR's letter to the developer's attorney approving the form of the plan for operation documents will contain a similar warning about premature sales.

APPENDIX 7

Descriptions of Subdivision Tract

DESCRIPTION

A) T40N, R19W (Camden County)

1) The W½ of the SW¼, the W½ of the NW¼, and the NE¼ of the NW¼ of Section 18 and;

2) The SE¼ and the W½ of the NE¼, the E½ and the NW¼ of the SE¼, and the W½ of Section 19.

B) T40N, R20W (Benton County)

1) That portion of Section 12 lying easterly of the Lake of the Ozarks;

2) That portion of Section 13 lying southerly and easterly of the Lake of the Ozarks.

3) All of the NE¼ except that portion of the SW¼ of the NE¼ lying south of the Lake of the Ozarks, and the SE¼ of Section 23.

4) All of Section 24.

5) The NE¼ and the NW¼ of Section 25.

6) The NE¼ of the NE¼, the SE¼ of the NE¼, the SW¼ of the NE¼ excepting that portion lying south of the County Road and except ------------ Subdivision, the N½ of thw SW¼, and the S½ of the NW¼ of Section 26.

7) The NW¼ of the NW¼ of Section 34.

8) The NE¼, the N½ of the SW¼, and the NW¼ of the NE¼, the SW¼, and the NW¼ of Section 34.

9) The NE¼, the SE¼, that portion of the SW¼ lying east of State Route V, and NW¼ excepting 45 acres more or less lying along the westerly side of said ¼ section of Section 32.

10) That portion of the NW¼ of NW¼ of Section 31 lying north of State Route M.

11) The NE¼, the NW¼ of SE¼, the SW¼, and the NW¼ of Section 30.

12) All of Section 29 except 5 acre sportsman club.

13) That portion of the E½ of the NE¼ lying south of the County Road, the W½ of NE¼, the SE¼, the SW¼ and the NW¼ of Section 28.

14) The SW¼ and that portion of the NW¼ lying south of the Deer Creek arm of Section 21.

DESCRIPTION (CONT)

15) The NE¼, the SE¼ excepting 7.5 acres more or less in the south ½ of SE¼ and the Hastain Cemetery of Section 20.

16) All of Section 19.

17) All of Section 18 except that portion of the N½ of the NW¼ of NE¼ lying west of State Route M.

18) That portion of the SE¼ lying east of State Route M and south of County Road, the SW¼, and that porton of the NW¼ lying south of the Lake of the Ozarks except 7.5 acres more or less of the SE¼ of the NW¼ lying adjacent to State Route M and the Mossy Cemetery all in Section 7.

C) T40N, R21W

1) The SE¼ of the SE¼ of Section 12.

2) All of Section 13.

3) That portion of the S½ of the SE¼ lying east of State Route M except a 4 acre± tract lying on the east side of the SE¼, the W¼ of the SW¼, and a triangular tract being the SW¼ part of the W¼ of NW¼ of Section 14.

4) The S½ of SE¼, the SW¼ except the SW¼ of SW¼, the S½ of the NW¼ and miscellaneous lots of existing subdivision all in Section 15.

5) The SE¼ of the SE¼ lying east of County Road of Section 21.

6) All of Section 22.

7) All of Section 23 except that portion of the NW¼ of NE¼ lying west of State Route M and the E½ of NE¼ of NW¼.

8) All of Section 24.

9) The NE¼, the SE¼ except west 200 feet thereof, all of the SW¼ lying north of State Route V and the NW¼ of Section 25.

10) The N½ of the N½ of NE¼, the SE¼ of NE¼ of NE¼, E½ of SE¼ of NE¼, NE¼ of SE¼, that portion of SE¼ of SE¼ lying north of State Route V, that portion of SW¼ of SE¼ lying north of State Route V except 7± acre tract lying in NE corner of intersection of State Routes M and V, that portion of the SW¼ lying west of State Route M and north of County Road, and NW¼ of Section 26.

DESCRIPTION (CONT)

11) The NE¼, that portion of the SE¼ lying north of County Road, the NE¼ of SW¼, that portion of SE¼ of SW¼ lying north of County Road, NE¼ of NW¼, SE¼ of NW¼, NW¼ of NW¼ of Section 27.

12) That portion of the NE¼ of NE¼ lying east of County Road of Section 28.

13) That portion of NE¼ of NE¼ lying north of County Road of Section 34.

14) That portion of NW¼ of NW¼ lying north of County Road of Section 35.

APPENDIX 8

Percolation Tests Procedure

PERCOLATION TESTS PROCEDURE

Percolation tests shall be conducted by or under the supervision of an architect or engineer registered in the State of Missouri or by an employee of a local health department. Certification of test results and recommendation for the amount of absorption area required shall be prepared.

All percolation tests required shall be performed in accordance with the following:

a. Dig or bore the holes with horizontal dimensions of from 4 to 12 inches and vertical sides to the depth of the bottom of the proposed absorption device. Holes can be bored with 4 inch diameter post-hole type auger.

b. Roughen or scratch the bottom and sides of the holes to provide a natural surface. Remove all loose materials from the hole. Place about 2 inches of coarse sand or fine gravel in the hole to prevent bottom scouring.

c. Fill the hole with clear water to a minimum depth of 12 inches over the gravel. By refilling, if necessary, or by supplying a surplus reservoir of water (automatic siphon), keep water in hole for at least four hours, and preferably overnight. In sandy soils, i.e., GW, GP, SW, or SP classified according to the "Unified Soils Classification System," the above saturation procedure is not necessary and the test can be made after the water from one filling has seeped away.

d. Percolation rate measurements should be made on the day following the saturation process, except in sandy soils.

e. If water remains in the test hole after overnight saturation, adjust the depth to 6 inches over the gravel. From a fixed reference point, measure the drop in water level at approximately 30-minute intervals over a 4-hour period. The drop which occurs during the final 30-minute period is used to calculate the percolation rate.

NOTE: The engineer should determine if the water in the test hole is due to a high groundwater condition or the permeability of the soil.

f. If no water remains in the hole after overnight saturation then pour in clear water to a depth of about six inches over the gravel. From a fixed reference point, measure the height of the water surface at approximately 30-minute intervals over a 4-hour period, refilling the hole to a depth of 6 inches when the percolation rate indicates the hole will run dry before the next reading is made. The drop which occurs during the final 30-minute period is used to calculate the percolation rate.

If a hole must be refilled to obtain a final 30-minute reading, determine from the previous reading the water level drop during the interval. Add water until the level above the bottom equals this figure plus one-half inch. Measure drop during the final 30-minute period.

g. In sandy soils, or other soils in which the first 6 inches of water seeps away in less than 30 minutes, after the overnight saturation period, the time interval between measurements can be taken at 10 minutes and the test run over a period of one hour. The drop which occurs in the final 10 minute period is used to calculate the percolation rate.