Septic interpretations from a third order soil survey

by William Thomas Christner, Jr

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Soils
Montana State University

Abstract:
Demographic changes throughout the Rocky Mountain west are resulting in an increasing number of rural subdivisions away from city centers. Rural housing developments require on-site sewage disposal systems to handle household waste. Development of large tracts of formerly range and forest soils, has produced the need for septic system suitability information of these soils. Range and forest soils, typically covered by third order soil surveys, are not intended for septic interpretations. However, they may contain the data necessary for septic interpretations. The Gallatin Local Water Quality District (LWQD) in southwestern Montana contains portions of Gallatin Valley and Gallatin National Forest (GNF) soils within its boundaries. Gallatin Valley soils are lowland agricultural soils covered by a second order soil survey and have been interpreted for on-site sewage disposal systems. GNF soils are higher elevation range and forest soils covered by a third order soil survey and are not interpreted for on-site sewage disposal systems. The Gallatin LWQD provides the opportunity to determine if the third order GNF soil survey contains the data necessary for septic system interpretations. This case study also provides the opportunity to compare septic interpretations from second order GallatinValley soils to septic interpretations from corresponding third order GNF soils along the Gallatin Valley/GNF border.

Initial investigation of the third order GNF soil survey provided data regarding the septic limitations of GNF soils. Septic interpretations based on the most-limiting restriction were made for each GNF soil map unit. An ArcView™ coverage of the most limiting septic restriction for GNF soils was constructed and compared to the corresponding Gallatin Valley coverage along the Gallatin Valley/GNF border. Initial results showed poor agreement between septic interpretations of corresponding Gallatin Valley/GNF border map units based on the most-limiting restriction.

Complete septic interpretations (slight, moderate and severe) for all restrictions were compared between corresponding Gallatin Valley/GNF border map units. Results showed a high percent match (73%) between the complete septic interpretation of corresponding Gallatin Valley/GNF border map units. These results were consistent in a refined comparison that weighted each GNF map unit according to its percent match with its corresponding Gallatin Valley map unit. This method produced a 75 percent match.

Septic interpretations based on observations from twenty-four field soil pits suggested that restrictions with high percent match results were favored by a high number of map units with "slight" limitations. Comparisons based on a broad range of limitation data (slight, moderate and severe) showed higher agreement with GNF data than Gallatin Valley data ($p = 0.74$ vs. 0.65 respectively). I found that although the third order GNF soil survey was not designed for septic interpretation, it can provide preliminary septic interpretations of GNF soils within the Gallatin LWQD. Methodologies used in this study may be transferable to other areas of the Rocky Mountain West susceptible to rural expansion.

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APPROVAL

of a thesis submitted by

William Thomas Christner Jr.

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date August 19, 1999

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ABSTRACT

Demographic changes throughout the Rocky Mountain west are resulting in an increasing number of rural subdivisions away from city centers. Rural housing developments require on-site sewage disposal systems to handle household waste. Development of large tracts of formerly range and forest soils, has produced the need for septic system suitability information of these soils. Range and forest soils, typically covered by third order soil surveys, are not intended for septic interpretations. However, they may contain the data necessary for septic interpretations. The Gallatin Local Water Quality District (LWQD) in southwestern Montana contains portions of Gallatin Valley and Gallatin National Forest (GNF) soils within its boundaries. Gallatin Valley soils are lowland agricultural soils covered by a second order soil survey and have been interpreted for on-site sewage disposal systems. GNF soils are higher elevation range and forest soils covered by a third order soil survey and are not interpreted for on-site sewage disposal systems. The Gallatin LWQD provides the opportunity to determine if the third order GNF soil survey contains the data necessary for septic system interpretations. This case study also provides the opportunity to compare septic interpretations from second order Gallatin Valley soils to septic interpretations from corresponding third order GNF soils along the Gallatin Valley/GNF border.

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Complete septic interpretations (slight, moderate and severe) for all restrictions were compared between corresponding Gallatin Valley/GNF border map units. Results showed a high percent match (73%) between the complete septic interpretation of corresponding Gallatin Valley/GNF border map units. These results were consistent in a refined comparison that weighted each GNF map unit according to its percent match with its corresponding Gallatin Valley map unit. This method produced a 75 percent match.

Septic interpretations based on observations from twenty-four field soil pits suggested that restrictions with high percent match results were favored by a high number of map units with "slight" limitations. Comparisons based on a broad range of limitation data (slight, moderate and severe) showed higher agreement with GNF data than Gallatin Valley data ($p = 0.74$ vs. 0.65 respectively).

I found that although the third order GNF soil survey was not designed for septic interpretation, it can provide preliminary septic interpretations of GNF soils within the Gallatin LWQD. Methodologies used in this study may be transferrable to other areas of the Rocky Mountain West susceptible to rural expansion.

CHAPTER 1

INTRODUCTION

Demographic changes throughout the rocky mountain west are resulting in an increasing number of rural subdivisions away from city centers. Similar changes in Gallatin County have produced a shift from an economy based on agriculture and forestry to one based on recreation and land development. According to the Montana Agricultural Statistics Service, the amount of agricultural land in the state has been declining since 1978. In 1969 nearly sixty percent of Gallatin County was in agriculture. By 1992 the figure had dropped to forty-four percent (Schontzler, 1996). The loss of agricultural land has been accompanied by an increase in the population of the Gallatin Valley and in the number of rural properties subdivided. Rural housing developments in Gallatin Valley require on-site septic systems to handle household waste disposal. Rural housing developments without proper planning and site selection can threaten and, in some cases, contaminate surface and ground water resources through septic system failure (Bauder, 1993). Proper septic system location and design requires knowledge of the soil properties that affect the construction and function of septic systems (Soil Survey Staff, 1993; Montana Department of Health and Environmental Sciences, 1992). This knowledge will minimize the potential for pollution and health hazards in local and regional areas and also help minimize construction costs (Bauder, 1993; Montana Water Quality Bureau Circular WQB 6, 1992; Tinker, 1990). Soil information regarding septic system limitations can aid system design and installation and also reduce the risks to surface and ground water resources. The availability of the soil information necessary to determine the septic system limitations of an area depends on the type of soil survey conducted for the area.

There are five different levels of soil survey described by the Soil Survey Staff of the United States Department of Agriculture (Soil Survey Staff, 1993). Each level of soil survey reflects a change in scale, level of detail and uses for which the soils can be interpreted. The lower the order the more intensive and, therefore, the more detailed the soil survey.

First order soil surveys are very intensive and detailed surveys performed on small areas. Surveys of this order are used to obtain precise information for site specific planning objectives such as irrigation, drainage, specialty crops and building sites. They provide detailed information on the soils and their variability. Base map scale is 1:15,840 or larger. Second order soil surveys are intensive and detailed surveys performed on larger areas. They are more inclusive, rather than site specific, soil surveys used to plan agriculture, construction and urban development where detailed information about soils and their variability are required to assess treatment needs and suitable uses. Map scales range from 1:12,000 to 1:31,680. Third order soil surveys are extensive surveys for large areas that require less detail or precise soil information. They are typically used to identify a single land use with few subordinate uses. This level of survey is used to assist in general range, forest, recreational and community planning. Map scales range from 1:20,000 to 1:63,360. Fourth order soil surveys are extensive surveys of large areas that require more generalized soil information. They are used in regional land use planning and to select areas which require more intensive study and/or investigations. They provide broad information concerning land use potential and general land management. Map scales range from 1:63,360 to 1:250,000. Fifth order soil surveys are very extensive surveys for large areas that require very generalized soil information. They are used for planning regional land use and interpreting very generalized information and to select areas for more intensive study and/or investigation. Map scales range from 1:250,000 to 1:1,000,000.

Soil survey interpretations are keyed to a particular land use, which evolve over time and periodically require revision. When the intended use of the soils covered by a specific survey changes, additional information may be needed to interpret a soil for the new use. This requires re-evaluation of the initial soil survey, and may establish the need for a new, more detailed soil survey of the area. Alternatively, the initial survey may contain the necessary data to make the new interpretation. As rural subdivisions move further away from city centers, significant portions of range and forest soils are subdivided. Range and forest soils are generally covered by third order soil surveys which are not intended for septic system interpretations. However, the data necessary to assess septic system limitations may exist in a third order soil survey. If the data do exist, it would save the time and money required to perform a new, more detailed soil survey, providing a valuable database to facilitate rural subdivision planning. The

Gallatin Local Water Quality District (LWQD) is in need of this type of information.

The Gallatin LWQD, located in Gallatin County, Montana (Figure 1), was created in 1997 to take responsibility for the quality of the water resources within its boundaries. It encompasses land in both Gallatin Valley and the Bridger, Bangtail, and Hyalite mountains of Gallatin National Forest (GNF). At the time of its creation, Gallatin County health officials identified the need for a data base which would provide the necessary information to assess septic system location, construction and operation within the Gallatin LWQD. The second order soil survey of the Gallatin County Area[1], which covers Gallatin Valley soils, has been interpreted for septic system limitations however, the third order GNF soil survey has not. This poses a problem for the Gallatin LWQD.

Many areas of the GNF within the Gallatin LWQD contain alternate one-square mile sections in private ownership. This "checkerboard" ownership dates back to the early settlement of the West when the Federal Government granted every other section bordering a railroad corridor to the railroad companies. Today private individuals and companies own these sections. Occasionally the private owner will offer to "swap" these checkerboard sections with the Forest Service for an equal value of continuous sections in another area. Through this method, recently privatized land may become available for housing development after the timber has been harvested. When development occurs, information regarding the septic system limitations of GNF soils will be needed to help

1

Because the second order soil survey of Gallatin County Area includes only the soils in Gallatin Valley and not GNF, it is hereby referred to as the second order soil survey of Gallatin Valley.

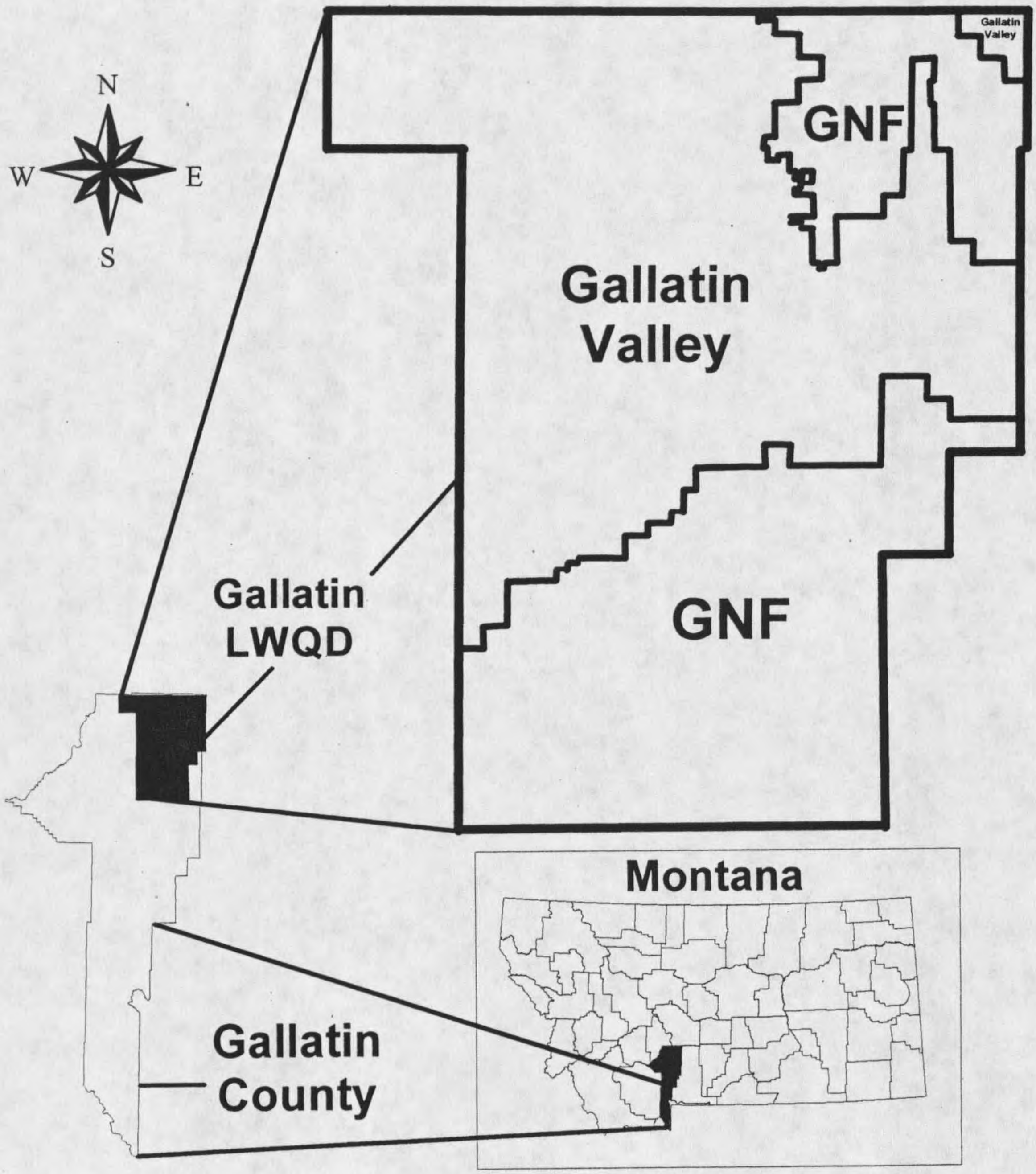

Figure 1. Location of Gallatin LWQD within Gallatin County, Montana. Gallatin LWQD contains portions of Gallatin Valley and GNF within its boundaries.

insure proper planning of septic system location, construction and operation. Since housing development is not one of the management objectives for GNF, the GNF soil survey was not interpreted for septic system limitations. However, the possible development of GNF land indicates a need for such interpretations. Although the third order GNF soil survey was not designed for septic system interpretations, the survey may contain sufficient data to assess the septic system limitations of the soils. This information would help the Gallatin LWQD attain its goals and also provide Gallatin County health officials with a valuable database. The GNF soil survey was evaluated to ascertain if adequate soil data exists to produce preliminary septic interpretations of GNF soils. The Gallatin LWQD provided the opportunity to determine if septic system interpretations can be obtained from a third order soil survey and, through comparison with the septic system interpretations from the second order Gallatin Valley soil survey, the opportunity to investigate the reliability of the third order survey interpretations. This case study provides perspective for other areas with similar trends and needs in southwestern Montana and other western regions where urban sprawl has the potential to extend from city centers into range and forest areas with checkerboard ownership.

CHAPTER 2

ASSESSING SEPTIC SYSTEM LIMITATION PARAMETERS FROM A THIRD ORDER SOIL SURVEY

Introduction

Assessing septic system limitations requires specific information concerning ten soil properties (Table 1). These properties are: USDA soil texture, frequency and duration of flooding, depth to bedrock, depth to cemented pan, frequency and duration of ponding, depth to high water table, permeability between sixty and one-hundred and fifty centimeters, percent slope, percent coarse fragments by weight, averaged to a depth of one meter and, total subsidence potential (Soil Survey Staff, 1993). Limitations are described in terms of severity; "slight", "moderate" and "severe." "Slight" limitations present minor problems for septic installation and/or operation.. "Moderate" limitations do not require exceptional risk or cost but the soil does possess certain undesirable properties or features. "Severe" limitations require unacceptable risk to use the soil if not appreciably modified. Special design will significantly increase construction costs and appreciably higher maintenance cost is required for satisfactory performance of the

Table 1. Soil properties, limitations and, restrictive features for septic tank adsorption fields (after Table 620-17, National Soil Survey Staff, 1996).

Property	Limitations			Restrictive Feature	Installation (I) and/or Effluent (E)
	Slight	Moderate	Severe		
USDA Texture	—	—	Ice	Permafrost	I
Subsidence (cm)	—	—	> 60	Subsides	I
Flooding	None	Rare	Frequent/ Occasional	Flooding	E
Depth to Bedrock (m)	> 1.8	1.0 - 1.8	< 1.0	Depth to Rock	E/I
Depth to Cemented Pan (m)	> 1.8	1.0 - 1.8	< 1.0	Cemented Pan	E/I
Ponding	(-)	(-)	(+)	Ponding	E
Depth to High Water Table (m)	> 1.8	1.2 - 1.8	< 1.2	Wetness	E
Low Permeability (0.6- 1.5 m, cm/hr)	5.0 - 15.0	1.5 - 5.0	< 1.5	Slow Perc	E
High Permeability (0.6- 1.5 m, cm/hr)	5.0 - 15.0	1.5 - 5.0	> 15.0	Poor Filter	E
Percent Slope	< 8	8 - 15	> 15	Slope	I
Large Stones > 76 mm (weighted avg. to 1 m)	< 25	25 - 50	> 50	Large Stones	I

septic system. Soil data used to determine septic system limitations can be grouped into two categories: those that affect the absorption of the effluent and those that interfere with the installation of the system (Soil Survey Staff, 1993; Montana Water Quality Bureau Circular WQB 6, 1992).

Soil properties that affect effluent absorption are flooding, bedrock, cemented pan, ponding, high water table, and permeability. Soil permeability rates indicate the amount of time septic effluent interacts with the soil. High permeability rates do not allow soil enough time to adequately filter septic effluent. Slow permeability rates may result in septic effluent bypassing the adsorption field and/or accumulating at or near the soil surface. High water tables and flooding cause saturation of the absorption field and reduce septic effluent filtering. Shallow bedrock and cemented pans reduce the total thickness of an adsorption field, therefore reducing its capacity to filter septic effluent (Soil Survey Staff, 1993).

Septic system installation is also a concern. Soil properties that affect septic system installation include soil texture, subsidence, bedrock, cemented pan, slope and coarse fragments. Shallow bedrock, cemented pan, the presence of ice, stones and boulders all interfere with excavation. Stones and boulders may damage a system during backfill operations. Subsidence interferes with septic system installation and maintenance (Soil Survey Staff, 1993). Information regarding these soil properties is required to assess the septic system limitations of GNF soils.

Data regarding soil properties that effect septic system installation and operation may exist in the third order GNF soil survey. However, because of the greater level of generalization in a third order soil survey, the reliability of the data is unknown. Since the GNF soil survey has not been interpreted for septic system limitations, and certain portions of the GNF that lie within the Gallatin LWQD are subject to development, it is necessary to determine if the information available in the third order GNF soil survey can provide reliable septic interpretations for GNF soils. The research objective is to determine if the protocol used to interpret the second order Gallatin Valley soil survey for septic system limitations may be used to establish the septic system limitations for the third order GNF soil survey, using the data available in the third order GNF soil survey.

Study Area

The study area is located in the Rocky Mountain region of southwestern Montana. The study site consists of Gallatin Valley and GNF soils within the Gallatin LWQD (Figure 1). Gallatin Valley soils are low elevation soils dominated by the accumulation of surface deposits (alluvium and loess). They are used primarily for home sites, recreation, and agriculture. GNF soils are high elevation range and forest soils located in the mountain around Gallatin Valley. They occur in landforms dominated more by bedrock and, to a lesser extent, alluvium and glacial till. They are used primarily for recreation, wildlife habitat, and timber production.

Purpose

The purpose of this part of the study is to determine if the third order GNF soil survey contains the data necessary to calculate septic system interpretations. If the data do exist, each GNF map unit will be interpreted for septic system limitations. An ArcView™ coverage based on the most limiting septic interpretation will be constructed for the GNF soils within the Gallatin LWQD. Finally, consistency of the septic system interpretation for GNF soils will be examined along the border between second order Gallatin Valley soils and third order GNF soils.

Methods

Locating the Data and Determining the Limitation

Soil data necessary to establish septic system limitations was obtained from the Soil Survey of Gallatin National Forest, Montana final report, July 1996, and the interim draft report, April 1984 (Table 2). The final report contains data on flooding potential, ponding potential, depth to high water table, permeability, percent slope and percent coarse fragments. The interim draft report contains data on depth to bedrock. The reports contain information regarding depth to cemented pan and USDA soil texture. However, cemented pans and permafrost (the only restriction for soil texture) do not occur in this region, therefore the information is not required. Information on subsidence potential does not exist for GNF soils. Subsidence potential is the potential decrease in surface elevation as a result of drainage of wet soils having organic layers or semifluid mineral layers (Soil Survey Staff, 1993). According to the soil survey leaders for Gallatin Valley and GNF, soils exhibiting this potential do not exist in the Gallatin LWQD or, exist in an areal extent smaller than the map unit scale of either soil survey (personal communication 1998; Rolfes, Resource Soil Scientist, USDA-NRCS Bozeman, MT; Shovic, Soil Scientist, USFS Interagency Spatial Analysis Center-Gallatin National Forest, Bozeman, MT).

Table 2. Source of septic system limitation information for GNF soils, (Davis and Shovic, 1984 and 1996.

Property	Source
Flooding potential	Taxonomic classification, Table 13, GNF final report Landform, Table 1, GNF final report
Depth to bedrock (in)	Table 1, GNF interim draft report
Ponding potential	Table 6, GNF final report
Depth to high water table (in)	Representative pedon description, GNF final report
Permeability, 24" - 60" (in/hr)	Representative pedon description, GNF final report
Percent slope	Table 1, GNF final report
Percent coarse fragments	Representative pedon description, GNF final report

Flooding potential information was obtained by interpreting Tables 1 and 13 in the GNF soil survey final report. Table 1 of the GNF soil survey final report provides landform information for each soil map unit. Landforms are defined by slope, shape of slope, pattern and density of low order streams, relief and other properties (Davis and Shovic, 1996). Landforms associated with flooding are stream terraces and floodplains.

Table 13 of the GNF soil survey final report lists the family, or higher, taxonomic classification of each soil within the map unit. Taxonomic classifications contain formative elements that indicate proximity to a floodplain. The formative element associated with floodplain deposits on which soils develop is *fluv*, derived from the Latin *fluvius* for river. The connotation of *fluv* is a floodplain. After the flooding potential of a map unit is determined a limitation is assigned.

Limitations are assigned based on flooding characterization of the soils and the corresponding flood frequency over a one hundred year period (Table 3). A slight limitation is assigned when there is no reasonable possibility of flooding (none). A moderate limitation is assigned when the flooding frequency is between zero to five times in one hundred years (rare). A severe limitation is assigned when the flooding frequency is greater than five times in one hundred years (occasional/frequent), (Soil Survey Staff, 1993). Flood frequency is determined by landscape position, soil morphology/stratification and, floodplain maps (personal communication 1998; Tony Rolfes, Resource Soil Scientist, USDA-NRCS Bozeman, MT). If available floodplain maps take precedence.

No floodplain maps exist for the GNF. Therefore, existing information on landform position and soil morphology/stratification from the GNF soil survey were used to determine the flooding frequency for each GNF map unit. Previous studies have documented the use of soil surveys to delineate areas subject to flooding (Cain and Beatty, 1968; McCormick, 1971). Three GNF map units within the Gallatin LWQD are described as having the potential to flood; 64-2A, 64-2C and 66-1A. Landforms in map

Table 3. Flood frequency criteria and classification used to determine septic system limitations for flooding, (after Table 3-4, Soil Survey Manual, 1993).

Classification	Frequency Criteria
None (N)	no reasonable possibility
Rare (R)	1 -5 times in 100 years
Occasional (O)	5 - 50 times in 100 years
Frequent (F)	≥ 50 times in 100 years
Common (C)	occasional and frequent can be grouped for certain purposes called common

units 64-2A and 64-2C consist of glacial outwash benches and terraces, floodplains and terraces. These soils are subject to flooding after prolonged, high intensity storms (Davis and Shovic, 1984). Landforms in map unit 66-1A consist of floodplains. These soils are frequently flooded (Davis and Shovic, 1984). Map units 66-2A and 66-2C were classified as flooding occasionally (5 - 50 times in 100 years). Map unit 66-1A was classified as flooding frequently (≥ 50 times in 100 years). All three map units received a "severe" septic system limitation for flooding based on their flooding classification.

Depth to bedrock information was obtained from Table 1 of the GNF soil survey interim draft report. Table 1 lists a depth to bedrock range for each map unit based on field observations (Davis and Shovic, 1984). The most limiting value in the range was used to calculate the septic system limitation. A "slight" limitation was assigned when depth to bedrock was greater than 1.8 meters. A "moderate" limitation was assigned when depth to a bedrock was between 1.0 to 1.8 meters. A "severe" limitation was assigned when depth to bedrock was less than 1.0 meters (Soil Survey Staff, 1993).

Ponding potential information was obtained from Tables 6 and 13 of the GNF soil survey final report. Table 6 of the GNF soil survey final report lists the frequency of wet areas as low, moderate or high for each map unit. A low rating indicates that wet areas occur infrequently and are easily avoided. A moderate rating indicates that wet areas occur commonly but can normally be avoided. A high rating indicates that wet areas are difficult to avoid entirely (Davis and Shovic, 1984). Ponding information may also be obtained from the taxonomic classification of a soil.

Formative elements associated with water in the soil are *aqu* and *hydr*. *Aqu* is derived from the Latin *aqua* which means water and connotes a characteristic associated with wetness. *Hydr* is derived from the Greek *hydro*, meaning water and connotes the presence of water , (Soil Survey Staff, 1998). Ponding limitations are determined by a binary , +/-, process. The soil either ponds or it does not. A positive value results in a "severe" septic system limitation (Soil Survey Staff, 1993). A "severe" limitation was assigned to GNF soils based on two criteria. First, the map unit must have a "high" frequency of wet areas in Table 6 of the GNF soil survey final report and second, the map unit taxonomic classification must indicate wetness.

Depth to high water table information was obtained from the representative pedon description in the GNF soil survey final report. The limitation is based on the presence of free water in the soil profile. This is accomplished through direct contact with the water table or is inferred through the presence or absence of redoximorphic features in the soil profile. Redoximorphic features, such as mottles and gleying, are soil properties associated with wetness and result from the oxidation of iron and manganese compounds in the soil after saturation with water and subsequent drainage (Roth et. al, 1997). Previous studies have documented the use of redoximorphic features to infer water table depth and soil drainage (Simonson and Boersma, 1972; Vepraskas and others, 1974; Bouma, 1983; Franzmeier and others, 1983; Vepraskas and Wilding, 1983; Pickering and Veneman, 1984; Watts and Hurt, 1991; Vepraskas, 1996). The presence of redoximorphic features in the representative pedon description was used to infer water table depth. A "slight" limitation was assigned where the water table was greater than 1.8 meters below the soil surface. A "moderate" limitation was assigned when the water table was between 1.2 to 1.8 meters below the soil surface and a "severe" limitation was assigned when the water table was less than 1.2 meters below the soil surface (Soil Survey Staff, 1993).

Permeability class for each map unit was determined through the application of the USDA-NRCS field guide for determining relative permeability (Table 4). Permeability classes are based on a combination of soil texture and structure. Corresponding permeability values were assigned according to Part 618.44b of the USDA National Soil Survey Handbook (Table 5). Acceptable permeability values range from 1.5 (cm/hr) to 15.0 (cm/hr). A "slight" limitation was assigned when permeability was between 5.0 - 15.0 (cm/hr). A "moderate" limitation was assigned when permeability was greater than or equal to 1.5 (cm/hr) and less than 5.0 (cm/hr). A "severe" limitation was assigned when permeability was greater than 15.0 (cm/hr) or less than 1.5 (cm/hr) (Soil Survey Staff, 1993). Permeability values greater than 15.0 and less than 1.5 (cm/hr) both produce "severe" septic system limitations.

Information on percent slope for each map unit was obtained from Table 1 GNF Soil Survey final report which lists a slope range for each map unit. The highest, or most limiting, value in the range, was selected to determine slope limitations. A "slight" limitation was assigned to slopes less than eight percent. A "moderate" limitation was assigned to slopes between eight and fifteen percent. A "severe" limitation was assigned to slopes greater than fifteen percent (Soil Survey Staff, 1993).

Information on the presence and amount of coarse fragments was obtained from the representative pedon description in the GNF Soil Survey final report. The value is a weighted average to a 100 centimeter depth. The contribution of each horizon was calculated with equation 1:

Eq 1. [percent coarse fragments in horizon] x [horizon thickness (cm)/100 (cm)]

Values for each horizon to a 100 centimeter depth were summed to produce the value used to determine the septic system limitation for large stones. A "slight" limitation was assigned to values less than twenty-five percent. A "moderate" limitation was assigned to values between twenty-five and fifty percent. A "severe" limitation was assigned to values greater than fifty percent.