ASSESSMENT OF CURRENT WASTEWATER TREATMENT AND DISPOSAL IN GALLATIN COUNTY

Prepared
For
Gallatin County Planning Board

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"Civilized people should be able to dispose of sewage in a better way than by putting it in the drinking water."
Theodore Roosevelt 1910

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INTRODUCTION

Purpose
This report was commissioned by the Gallatin County Planning Board. The purpose is to provide an accurate inventory of current domestic wastewater treatment and disposal practices in Gallatin County. Inventories of septic systems, septic system density, septage land application sites, public sewage systems, biosolids land application sites, sewer and water districts, and designated ground water mixing zones were completed.

Background
All treated wastewater in Gallatin County is disposed of by discharging it to surface water, discharging it to ground water, or applying it on the land surface. At the same time, residents in Gallatin County, with the exception of City of Bozeman residents, rely on ground water for their drinking water supply. Between 1990 and 2009 the population of Gallatin County increased by about 79%, resulting in a similar increase in the amount of wastewater generated in the County. The increased need for wastewater treatment occurred throughout urban, suburban, and rural areas of the County. Significant investments have been made by municipalities and sewer and water districts to expand and improve centralized wastewater treatment infrastructure in the urban and suburban areas. A parallel increase in the number of septic systems installed in suburban and rural areas of the County has occurred.

SEPTIC SYSTEMS

Septic System Regulations
***Overview*:** Individual, shared, and multiple-user septic systems that serve less than 25 people and have less than 14 service connections are regulated as *non-public* systems. Numerous statutes, rules, and regulations govern the use of septic systems. Montana Code Annotated (MCA) provides state law governing septic systems. The MCA enabling statutes provide for adoption of the Administrative Rules of Montana (ARM) and local regulations. Together, the MCA, ARM, and local regulations provide the general laws regulating the use of septic systems. Local regulations consist of the Gallatin City-County Health Code-Chapter 3, the Gallatin County Subdivision Regulations, and subdivision regulations adopted by municipalities (Bozeman, Belgrade, Manhattan, and Three Forks). Federal laws promulgated under the Clean Water Act, and the Safe Drinking Water Act, provide additional regulation of septic systems. Under the Clean Water Act, non-point source pollution to surface water bodies, including septic systems, could ultimately be regulated by establishment of Total Maximum Daily Load (TMDL) limits for pollutants in surface water. Under the Safe Drinking Water Act, the use of septic systems that receive wastes from servicing of motor vehicles and equipment are regulated by the U.S. EPA Underground Injection Control Program (UIC).

Minimum Standards: Unless public water is provided, a minimum lot size of 1-acre is required for installation of a septic system. Septic tanks must be made out of concrete or other corrosion resistant material, and must have a capacity of at least 1,000 gallons for homes with up to 3 bedrooms and at least 1,500 gallons for 4 or more bedrooms. Drainfields or other subsurface disposal structures must be at least 4-feet above high ground water, and systems serving homes with 4 or more bedrooms must use a pressure-dosed subsurface disposal system. A designated replacement area for the subsurface disposal system must be provided.

Standard separation distances for septic systems include the following: drainfields or other subsurface disposal systems must be located at least 100-feet away from drinking water wells, springs, surface water bodies, and designated 100-year floodplains; sealed components, including the septic tank and sewer lines, must be located at least 50-feet away from surface water bodies, private drinking water wells, and private drinking water springs; and sealed components must also be at least 100-feet from public water supplies.

Local Regulations: The Gallatin City-County Health Code-Chapter 3, provides for local regulation of septic systems. These regulations were first adopted in January 1966, and have been revised nine times since then. Current regulations were adopted in June 2004, and are administered by the Health Department through the Environmental Health Services Division (EHS). Outhouses, cesspools, seepage pits, septic systems with metal septic tanks, and any system installed prior to the adoption of local regulations for septic systems are classified as o*bsolete septic systems*, under the County Health Code, and can't be legally used without a variance.

Review, Approval, and Permitting of Septic Systems: If individual septic systems are proposed for wastewater treatment in a subdivision, they are reviewed and approved by DEQ as part of the subdivision approval process. The Gallatin City-County Health Department (EHS) also reviews and approves the proposed septic systems, acting as a reviewing agent for DEQ, and under local authority. If the subdivision is approved, DEQ issues a Certificate of Subdivision Approval (COSA). Once issued, a COSA does not have an expiration date. DEQ can't finalize approval of a subdivision unless the Health Department also approves it. As the subdivision is built out, each lot owner is required to obtain a permit from EHS for the septic system. This helps assure that lot owners are aware of the septic system requirements for the subdivision, including specifications, required location on the lot, and location of the designated replacement area. An EHS permit to construct a septic system becomes a permit to operate the system once completed. The permit expires in 2-years if the septic system is not built. Once installed, there is no expiration date for a septic system permit.

Inspection and Monitoring of Septic Systems: There is no routine inspection or monitoring requirement for most septic systems in the County. It is up to the owner to inspect and maintain the septic system. Inspections may be completed if EHS receives a complaint regarding an existing septic system. Current regulations also don't require septic tanks to be pumped out on a periodic basis, and don't require that an access port for inspecting and pumping the tank be extended to the ground surface.

Federal Regulation of Motor Vehicle Waste Disposal Wells: Any subsurface disposal structure, including a septic system, that receives waste fluids associated with the servicing of motor vehicles or other equipment that includes internal combustion engines are classified by EPA as *motor vehicle waste disposal wells*. New installations of motor vehicle waste disposal wells were banned nationwide, as of April 5, 2000. Existing motor vehicle waste disposal wells constructed prior to April 5, 2000 were required to be closed, or obtain a discharge permit from EPA. Although these new rules have been in place for almost 10-years, many structures that would be classified as motor vehicle waste disposal wells are probably still in use in Gallatin County.

Inventory and Mapping of Septic Systems in Gallatin County

Review of Environmental Health Services Septic System Permit Database: EHS maintains records of septic systems in a database using Tyler Technologies ® software. Commonly referred to as the Tyler® database, it contains records for all of the septic system permits issued by EHS since 1966. The database is not a spatial database, but it does allow for the scanning of septic system permits for digital storage and retrieval. As of August 3, 2010 the database contained records for 15,787 non-public septic systems, including records for 628 voided permits and 2,200 replacement permits. Accounting for the voided and replacement permits, the database contains records for 12,959 active, non-public septic system permits in Gallatin County.

The true number of active septic system permits in the County would be less, due to issuance of replacement permits that could not be cross-referenced, permits for abandoned structures, and permits for structures now connected to a public sewage system. Currently the Tyler® database does not contain enough information to determine how many of the active, non-public permits are for shared and multiple-user systems. The Tyler ® database also does not contain enough information to correctly query it to determine the number of permits issued for nitrogen-reducing septic systems in Gallatin County. Since these systems require routine maintenance, it would be useful to be able to track them with the Tyler® database.

Construction of County-Wide Individual Septic System GIS Database:

A spatial septic system database was constructed by GLWQD using Geographic Information System (GIS) software. The database contains information on known and probable locations of all septic systems in Gallatin County. It was constructed by copying and modifying the Gallatin County Structures database maintained by the GIS Department. Currently other data associated with the septic system points in the database is limited. It is hoped that the GLWQD and EHS can work together to increase the accuracy of the database and associate other information with the mapped septic systems. The database currently contains location information for 13,350 septic systems in the County. This includes accurate GPS locations for 1,017 septic systems that have been located by EHS during site inspections, and 4,163 septic systems located by Custer *et al.* (2000). A total of 8,090 septic system locations are based on point locations from the Gallatin County Structures database. The septic system locations are shown on Map A-1, entitled Septic Systems, Septage and Biosolids Disposal Sites in Gallatin County, Montana, included in Appendix A of the report.

Estimated Wastewater Discharge from Septic Systems in Gallatin County

DEQ specifies a design flow rate of 300 gallons per day (gpd) for a three-bedroom house. Using this design flow as an average, the estimated cumulative daily discharge of wastewater into the subsurface within the County from the 13,350 septic systems mapped would be about 4 million gpd (4,005,000 gpd). On an annual basis this discharge is equal to about 1.46 billion gallons. The discharge would be about 6.7 times the daily discharge of Belgrade, but less than the daily discharge of Bozeman (5.5 mgpd). The estimated discharge from septic systems based on the GIS mapping assumes that each system serves a single family or structure. It was not possible to determine how many shared and multiple-user systems there are in the County. The GIS database would show two systems for two homes on a shared system. This would accurately reflect discharge from two homes. Multiple-user systems serving a structure like a multiplex would be mapped as a single septic system, and the discharge would be underestimated.

PUBLIC SEWAGE SYSTEMS

Public Sewage System Regulations

Overview: The term *public sewage system* has specific regulatory meaning and is defined by the state of Montana under the Administrative Rules of Montana (ARM) as a system that provides collection, transportation, treatment, and disposal of sewage for 15 or more families (or connections) or 25 or more persons daily for 60 or more days in a calendar year. There is significant overlap in the statutes, rules, and regulations that govern individual septic systems and those that govern public sewage systems. The primary factors that dictate how public sewage systems are regulated are 1) the volume of wastewater treated, and 2) the method of disposal of the treated wastewater.

Large public sewage systems that discharge treated wastewater to a surface water body, and are not associated with specific subdivisions or developments are only regulated under rules promulgated from the Montana Water Quality Act, and the Federal Clean Water Act. In Gallatin County the City of Bozeman, Town of Manhattan, City of Three Forks, and Town of Willow Creek fall into this category. The Montana Subdivision and Platting Act and the Montana Sanitation in Subdivisions Act both apply to construction of public sewage systems if they are proposed as part of a subdivision. Numerous statutes under the Water Quality Act also apply to public sewage systems.

Review, Approval, and Permitting of Public Sewage Systems: The review and approval of public sewage systems is generally the responsibility of DEQ. The process for review and approval depends on when the system was built, the system design flow, the proposed method of discharge (surface water or ground water), and if the system is associated with a subdivision proposal. If a public sewage system is proposed as part of a subdivision, it's reviewed by the DEQ Subdivision Section, including an engineering review. This review process includes a non-degradation analysis. The DEQ Public Water Supply Section reviews and approves public sewage systems not associated with a subdivision. Regardless of the association with subdivision, if the proposed sewage system has a design flow of more than 5,000 gpd, the DEQ Water Protection Bureau also reviews the system and issues any required discharge permits. If a public sewage system is approved by DEQ, EHS issues a local permit to operate the system. The local permits are only issued if the proposed system discharges to ground water.

Inspection and Monitoring of Public Sewage Systems: DEQ is responsible for operational oversight and inspection of public wastewater systems once they are approved. The GLWQD could not find any information showing that DEQ has any kind of structured process for routine inspection and monitoring of public sewage systems in Gallatin County. It is not even clear who at DEQ is responsible for inspection of public systems. Most inspections of public sewage systems in Gallatin County have been completed by DEQ staff from the State Revolving Fund (SRF) Program, of systems that have received SRF funding or technical support. It also appears that DEQ does not work with or inform the Health Department of inspections in Gallatin County. DEQ can enter into agreements with local governments for inspection of wastewater treatment facilities and delegate review of small public sewage systems to local governments, but has not done so with Gallatin County.

Ground Water Discharge Permits and Spray Irrigation: Public sewage systems approved by DEQ after May 1998, with a design flow of more than 5,000 gpd, are required to obtain a ground water discharge permit if they discharge to the subsurface. The permit requirements include establishment of a designated ground water mixing zone. DEQ has the discretion in the permit process to require monitoring wells within, or and at the end of mixing zone. Not all public sewage systems in Gallatin County that have ground-water discharge permits have ground-water monitoring wells.

If systems use spray irrigation as the sole means of disposal of treated wastewater, they are not required to obtain a ground water discharge permit. It is assumed that there is no recharge of ground water from the irrigation system(s). In reality there most likely is some infiltration of the treated wastewater into the ground, and recharge of ground water below the spray irrigation areas.

Surface Water Discharge Permits: If a public sewage system discharges to a surface-water body, the DEQ Water Protection Bureau issues a discharge permit. The practice of discharging treated wastewater directly to surface water was much more common in the past. The City of Bozeman, the City of Three Forks, the Town of Manhattan, Town of Willow Creek, and the Holcim Inc. cement plant north of Three Forks all have active surface water discharge permit. The last new discharge permit issued in Gallatin County was for the Big Sky Water and Sewer District. Issuance of this permit was very controversial, and while it is still valid, the District has never used it.

Inventory and Mapping of Public Sewage Systems in Gallatin County

Compilation of Information on Public Sewage Systems: Information on public sewage systems was compiled by EHS and GLWQD. EHS reviewed hard copy files on public sewage systems that are maintained by DEQ in Helena, updated hard copy files for public sewage systems, and constructed a GIS database for public sewage systems. GLWQD contacted several public systems and visited several of the larger centralized systems to obtain additional information. One problem noted was that information on public sewage systems at DEQ is not readily accessible to the public. System information is often contained in multiple files maintained by different sections and bureaus of DEQ. DEQ does not maintain a public access database of public sewage system information, and overall, there is a poorly structured system for public access to hard copy files on public sewage systems.

Construction of County-Wide Public Sewage System GIS Database: The GLWQD created a GIS database for public sewage systems by modifying the GIS database constructed by EHS. The GLWQD public sewage systems GIS database currently contains records for 147 systems. Vaulted toilets at campgrounds, fishing access sites, and other locations, were not counted as public systems. Appendix A, Map A2, entitled Locations of Public Sewage Systems in Gallatin County, Montana shows locations of all of the public systems in the GIS database. A summary of the inventory information is provided in the table below, including the cumulative estimated discharge.

Inventory Summary for Public Sewage Systems in Gallatin County

Type of Treatment System	Secondary Treatment+	# of Systems	Estimated/Reported Discharge (gpd)	Permitted Discharge
Holding Tank	N/A	2	930	1,100
Septic Tank w/ Seepage Pits	Very Limited	2	1500	1,500
Septic Tank w/Gravity-Feed Drainfield	Limited	31	60,242	60,242
Septic Tank w/Pressure-Dosed Drainfield	Limited	51	216,519	216,519
Septic Tank w/Elevated Sand Mound	Limited	10	21,580	32,804
Septic Tank w/ Open Bottom Sand Filter	Limited	1	9,745	9,745
Septic Tank w/Intermittent Sand Filter	Yes	2	5,290	5,290
Septic Tank w/Recirculating Sand Filter*	Yes	15	146,785	177,705
Septic Tank w/Recirculating Trickling Filter	Yes	9	42,575	62,575
Lagoon Systems	Yes-limited	13	1,816,575	2,990,925
Sequenced Batch Reactor Plants	Yes	7	497,271	918,138
Activated Sludge (mechanical) Plants	Yes	4	5,705,348	6,792,537
TOTALS		**147**	**8,524,360**	**11,269,090**

+All systems provide primary treatment *1 system discharges to an elevated sand mound, others to pressure dosed drainfield

Basic Septic Systems: Of the 147 public sewage systems in the County, 86 (59%) are basic septic system designs. These systems provide the same basic level of treatment as individual septic systems, but on a larger scale. Collectively the 86 basic septic systems discharge an estimated 279,191 gpd. While they represent 59% of the public systems in Gallatin County, they only treat about 3% of the total wastewater generated by all public systems.

Lagoon Systems: Thirteen public sewage systems, including several centralized systems, use lagoons for wastewater treatment. Most lagoons are aerated and discharge to ground water. Facultative anaerobic lagoons include the Amsterdam/Churchill, Willow Creek, Rider Trailer Court, and Bridger Pines lagoons. The quality of the effluent produced by lagoon systems is highly variable, and several of the lagoon systems in Gallatin County are known to have problems. The Amsterdam/Churchill lagoon system appears to have a substantial leakage problem. The Bridger Pines Subdivision lagoon system is currently under a moratorium by DEQ, and the Forest Park lagoon system has been under investigation by the DEQ Enforcement Division. The River Rock lagoon system was recently under a DEQ enforcement order due to elevated levels of nitrate detected in ground water monitoring wells. A small lagoon system serving the Rider Trailer Court in Manhattan is currently being evaluated by EHS and DEQ. It is not clear what this lagoon system was approved for, and there is a possibility that it has a substantial leakage problem.

Centralized Public Sewage Systems: A summary of the systems classified as centralized public sewage systems is provided in the following table. Collectively the large centralized systems in Gallatin County have invested about $60,150,000 on wastewater treatment plant infrastructure improvements in the last 10 years. In addition, the City of Bozeman has started a major expansion and plant upgrade project, with an estimated cost of about $54,000,000.

Summary of Centralized Public Sewage Systems in Gallatin County

Facility	Type of Plant	Method of Disposal	Average gpd January	Average gpd July	Maximum Plant Capacity	DEQ Permitted Treatment Capacity
City of Bozeman	Modified Activated Sludge	Discharge to East Gallatin River	5,500,000	5,500,000	5,800,000	5,800,000
City of Belgrade	Aerated Lagoons	Spray Irrigation and Infiltration Beds	600,000	600,000	Unknown	903,000
Town of Manhattan	Biowheel	Discharge to Dita Ditch	140,000	140,000	Unknown	250,000
City of Three Forks	Facultative Lagoons	Surface Water via shallow GW	172,800	172,800	Unknown	453,000
Town of West Yellowstone	Aerated Lagoon	Ground Water	282,000	550,000	Unknown	1,000,000
Four Corners (UtilitySolutions)	Oxidation Ditch System	Drainfields	55,000	55,000	100,000	100,000
Big Sky W & S District	Sequenced Batch Reactor	Spray Irrigation	450,000	300,000	600,000	650,000
RAE W & S District	Sequenced Batch Reactor	Rapid Infiltration Beds	60,000	100,000	200,000	200,000
Town of Willow Ck.	Facultative Lagoons	Discharge to Madison River	19,000	19,000	Unknown	34,000
Amsterdam/Churchill	Aerated Lagoon	Ground Water	84,100	84,100	Unknown	76,250
TOTALS (gpd)			**7,362,900**	**7,520,900**		**9,466,250**

Methods of Disposal for Treated Wastewater: About 69% of all treated wastewater currently being disposed of in Gallatin County is discharged to surface water, 22% is discharged to ground water, and about 9% is land applied (spray irrigation). The estimated discharge for systems that use spray irrigation may be high, because information on these discharges was limited. Total discharge of treated wastewater to ground water in the County, from all public systems, is about 1.9 million gpd. Lagoons account for most of this discharge, with an estimated discharge to ground water of 1.2 million gpd. The only mechanical treatment plant that discharges to ground water is Utility Solutions, with a reported discharge of about 58,000 gpd. The remainder of the ground water discharge is from the various types of septic systems, and sequenced batch reactor plants. These other systems discharge about 0.6 million gpd, to ground water.

***Permitted Public Sewage Systems*:** Most public sewage systems that discharge to ground water do not have discharge permits. Of the 147 public sewage systems in Gallatin County, 140 of them discharge to ground water or use spray irrigation for disposal of treated wastewater. Of these, only 16 systems have ground water discharge permits (11%). There are 6 systems that discharge to surface water, and all of them have surface water discharge permits, or have permits pending. Public sewage systems in Gallatin County that discharge to surface water include the City of Bozeman, the City of Three Forks, the Town of Manhattan, the Town of Willow Creek, and the Holcim Inc. Cement Plant at Trident.

SEWER AND WATER DISTRICTS

Background

County sewer and water districts are created to facilitate construction, management and operation of public sewer and/or water systems. The most common purpose for creating a sewer and water district is to allow non-governmental entities and unincorporated areas in need of sewer and/or water services to apply for grant and loan funds and construct water and sewer infrastructure.

Sewer and Water District Regulations

Regulatory Overview*:* Montana Code provides the statutes governing creation and operation of sewer and water districts. To create a sewer and water district, a petition with the signatures of at least 10% of the registered voters in the proposed District must be submitted to the County Commission. The Commission then holds a hearing after giving public notice and reviewing the proposed district. If the Commission decides to move forward with creation of the district an election is required unless all of the registered owners of properties within the proposed district sign the petition. Once a sewer and water district is created, an election is required to appoint a Board of Directors.

Management and Oversight of County Water and Sewer District: During the process of approval of sewer and water districts, the County Commission has some authority to modify the proposed district boundary. Once the district is created the Commission has no authority to regulate or manage the district. The Board of Directors holds all of the authority to modify the District's programs, change district boundaries, set fees for services, and other actions. There is often confusion among the public as to who operates and regulates these districts. Although 'county' is in the name, these districts are not operated as County agencies. If the district constructs water and or sewer infrastructure, these systems may be classified as public systems by DEQ, but this does not mean the systems are owned by the public. Districts can also contract for these services, as the Four Corners Water and Sewer District has done with Utility Solutions.

Inventory and Mapping of Approved Sewer and Water Districts in Gallatin County
There are currently 17 Sewer and Water Districts in Gallatin County. Boundaries of all of the approved sewer and water districts are shown on all the maps in Appendix A. All of the districts but two provide public sewer, public water, or both. The Spain Bridge Meadows and Mount Ellis Meadows districts were approved by the Gallatin County Commission with plans to use individual wells and individual septic systems on each lot. It is unclear what the benefits of creating these sewer and water districts are.

SEPTAGE AND BIOSOLIDS

Background
All wastewater treatment systems produce solids, often referred to as sludge, during the treatment process. In addition to disposal of treated wastewater, these solids must be disposed of. When a septic tank is pumped out, all of the contents are removed, including settled solids, floating solids, oils, grease, and raw wastewater present in the tank. This combined mixture is referred to as septage. If the solids are produced in a mechanized wastewater treatment plant, and they undergo additional treatment, they are referred to as biosolids. The physical and chemical characteristics of septage and biosolids are very different. Disposal methods for septage and biosolids in Gallatin County vary, but most of them are land applied, either directly on the land surface, or injected into the soil just below the land surface.

Septage Regulations
Overview: Handling and disposal of septage is regulated by DEQ under the statutory authority provided in Montana Code. DEQ has adopted rules governing both septage haulers, and the disposal of septage and other related wastes. The Waste and Underground Tank Management Bureau of DEQ, Solid Waste Section, administers the septage haulers rules. The Gallatin County EHS Division works as an agent of DEQ to inspect hauling equipment, proposed land application sites, active land applications sites, and to respond to complaints. Both DEQ and EHS maintain files on all of the approved septage application sites in Gallatin County.

Land Application of Septage: Land owners or septage haulers must apply for a land application license. Haulers are required to keep records of septage disposed of, including dates, volumes of septage, sources of septage, application sites and application areas. The information is supposed to be submitted to DEQ semi-annually. There are specified setbacks and other conditions specified in the rules for land application of septage. Septage must be applied at least 500-feet from occupied or inhabitable building, 150-feet from surface waters, including ephemeral or intermittent drainages and wetlands, 100-feet from federal, state, county or city maintained highways or roads, and 100-feet from drinking water supply sources. Septage can’t be surface applied on slopes greater than six percent, or injected on slopes greater than twelve percent. Seasonal high ground water must be at least 6-feet below land surface.

Inventory and Mapping of Septage Disposal Sites
The majority of septage appears to be disposed of via land application. The West Yellowstone treatment plant reportedly takes septage from the West Yellowstone area. The Big Sky Water and Sewer District treatment plant also is reported to take septage. Operators of other wastewater treatment plants are not obligated to take the waste, and therefore operators in the Gallatin Valley have been hesitant to, citing examples of problems experienced by those that do. The Bozeman treatment plant is the best suited system for accepting septage because of the large treatment flows. However, the policy of the City of Bozeman is to not take septage. While the plant is being upgraded and expanded, a change in this policy should be pursued, and the City of Bozeman should be encouraged to add a septage dumping station.

The GLWQD compiled available information on the locations of septage land application sites in Gallatin County. Permit files maintained by EHS were reviewed. Using maps and other information in these files, a GIS database layer was constructed and the approved land disposal areas were mapped. There are 10 licensed septage haulers approved to dispose of septage on about 819 acres in Gallatin County. The approved land application sites are owned by five different land owners. The inventoried septage land application sites are shown on Map A-1 in Appendix A, entitled Locations of Septic Systems, Septage and Biosolids Disposal Sites in Gallatin County, Montana.

Biosolids Regulations

Overview: The U.S. EPA regulates disposal of biosolids directly in Montana. Rules for handling biosolids are provided in the Code of Federal Regulations (40 CFR, Part 503). Under the EPA rules biosolids are classified and regulated based on pathogen concentrations and levels of pollutants in the biosolids. Class A biosolids have pathogen levels below detection limits and they have no site application or use restrictions. Class B biosolids contain low levels of pathogens and have some use restrictions.

Inventory and Mapping of Biosolids Disposal Sites

All mechanical treatment plants, sequenced batch reactor plants, and lagoon systems produce biosolids. Methods used to dispose of biosolids in Gallatin County include on-site disposal, disposal at a licensed landfill, composting and selling the product, or direct land application for soil amendment. Treatment plants within Gallatin County have chosen different disposal methods based on the amount of biosolids produced, treatment plant location, and costs. In lagoon systems the biosolids slowly accumulate in the bottom of the lagoons. Very little information was found on disposal of biosolids from lagoon systems in Gallatin County. When the Belgrade system was reconstructed in 2004, biosolids from the old lagoons were spread on the land surface near the lagoons.

The Town of Manhattan is the only system known to dispose of biosolids at the Logan landfill. They have a specially designed truck that collects and transports their biosolids. The Big Sky Sewer and Water District composts and sells its biosolids for private use. The RAE Water and Sewer District disposes of their biosolids in an on-site reed bed. The City of Bozeman has a well structured biosolids program. They are by far the largest producer of biosolids, in direct proportion to the amount of wastewater they treat.

The only records found documenting volumes of biosolids produced were those of the City of Bozeman. They keep detailed records on where and how much biosolids they land apply. For 2008 the City of Bozeman reported that they produced 9.4 million gallons/year of Class B biosolids. The City has approval to land apply biosolids on 36 fields, covering about 1,900 acres. The fields are owned by six different land owners, and all of the sites are within 4 miles of the treatment plant. The approved biosolids injection sites used by the City are shown on Map A-1 in Appendix A, entitled Locations of Septic Systems, Septage and Biosolids Disposal Sites in Gallatin County, Montana

GROUND WATER MIXING ZONES AND CUMULATIVE IMPACTS

Ground Water Mixing Zones and Septic System Plumes

Discharge from a septic system results in a plume of contaminated ground water that can be delineated and tracked, based on contaminants in the treated wastewater. There is no specific end to the plume, rather it simply fades away. While related to the concept of contaminant plumes, mixing zones consist of a specified portion of an aquifer, defined by length, width, and thickness, where ground water pollutants are allowed to exceed applicable water quality standards. Public sewage systems approved after May 1998, with a design flow of more than 5,000 gpd are required to obtain a ground water discharge permit, which includes establishment of a designated mixing zone.

Discussion of Cumulative Impacts and Carrying Capacity

The concept of cumulative impacts is easy to visualize for point-source discharges to a river or stream. You can measure the flow of the stream, measure the flow and concentrations of pollutants in the point-source discharges, and make reasonable calculations of the concentrations of pollutants in the stream. You can also easily measure pollutant concentrations in the stream to see what the actual cumulative impacts are. Evaluating cumulative impacts in ground water, especially a large aquifer system like the one in the Gallatin Valley, is much more difficult. The sources of pollution are widely dispersed. It is very difficult to accurately measure the volume of ground water flowing through an area. Ground water flow directions vary locally and regionally, and include vertical movement of the ground water. The pollutants that enter ground water are continually being diluted and diffused, and in many cases reacting and interacting with aquifer materials. For all of these reasons, and others, predicting cumulative impacts to ground water from the disposal of treated wastewater is very difficult.

The concept of carrying capacity is often discussed when looking at potential impacts from sources of pollution like septic systems. One way to think about the concept of carrying capacity is that it combines the concept of cumulative impacts with some regulatory pollutant limit. In a stream or river, the concept of Total Maximum Daily Load (TMDL), used to manage surface water pollutants, is basically a surface water carrying capacity determination. Again, the concept is much harder to translate to an aquifer system. A ground water carrying capacity analysis could look at the total amount of pollution sources, such as septic systems, that an aquifer could handle without causing problems. In order to begin to evaluate carrying capacity, some threshold pollutant concentration, such as nitrate must be established. This concentration could be set based on a trigger value that is less than the drinking water standard, allowing a safe margin of error.

Inventory and Mapping of Designated Mixing Zones for Public Systems

The GLWQD reviewed available files for information on locations of designated mixing zones for public sewage systems that have been issued a Ground Water Pollution Control System (GWPCS) permit. Since the requirement has only been in place since May 1998, and only applies to sewage systems with design flows over 5,000 gpd, there are not that many designated mixing zones. Out of 147 inventoried public sewage systems, MGWPCS permits have only been issued for 18 systems. Public sewage systems installed prior to May 1998 can be required to obtain a GWPCS permit if they are found to be violating water quality standards. One issue noted is that under current regulations mixing zones are allowed to extend across property boundaries, regardless of the consent of adjoining property owners.

Lot Size and Septic System Density

The most common practice for limiting public health risks and ground water contamination from individual septic systems is to regulate the minimum lot size required. This provides a means of controlling septic system density, but does not address cumulative impacts or carrying capacity. In Montana the minimum lot size for use of individual septic systems is 1-acre. There are a number of exemptions from this rule, which are spelled out in ARM 17.36.340. The most common exemption used allows for septic systems on ½-acre lots if the water supply is a public system. The GLWQD researched the basis for the 1-acre lot size in the ARM, and could not find any reference to how this lot size was determined. The individual septic system database (point layer) and the Gallatin County parcel layer were used to analyze the current distribution of septic systems relative to lot sizes in Gallatin County. About 48% of the septic systems inventoried are on lots of 2-acres or less, 24% are on lots of 1-acre or less, and about 9% are on 1/2 –acre lots.

Individual Septic System Density Mapping

Using the septic system GIS database, and the public land survey system grid (township, range, and section), septic system density analysis was completed by the GIS Department. Density analysis was done utilizing ArcGIS 9.2 software, and was performed on the septic system point map to try and quantify septic density per unit area across the county. The resulting GIS layer shows septic systems density in units of systems/acre, for 10-acre grid cells. A map showing the results in units of septic systems per acre was created, and is provided in Appendix A, Map A-2. The septic system density mapping highlights relatively high septic system densities west of Belgrade, southeast of Belgrade (Valley Center area), and south of Bozeman. The map also highlights numerous smaller high density areas such as Gallatin Gateway, the Mountain View subdivisions along Interstate 90 between Bozeman and Belgrade, and the Mount View subdivision southwest of Belgrade.

Nondegradation Analysis for Subdivisions with Individual Septic Systems

When subdivisions are proposed with individual septic systems, DEQ requires that a nondegradation analysis be performed to estimate the impacts of the septic systems on ground water quality (see section 3.2 for regulatory background on nondegradation). Nondegradation analysis focuses on phosphorous and nitrate as the contaminants of concern. The analysis includes both a phosphorous breakthrough analysis and a nitrate sensitivity analysis, because the two contaminants behave very differently in ground water. Phosphorous is primarily evaluated because of the potential impacts it has on surface water bodies. Phosphorous is usually the limited nutrient in area surface water bodies, and even small amounts discharged via contaminated ground water, can have significant impacts. Nitrate is evaluated because it is a significant pollutant in septic system effluent, is persistent in the environment, poses a human health risk above concentrations of 10 mg/l, and is a surface water nutrient. In most cases the focus of nondegradation analysis is nitrate contamination in ground water.

There are a number of technical issues that can influence the predicted nitrate levels in ground water from septic systems. The nitrate sensitivity analysis is highly dependent on the aquifer properties used to complete the dilution calculations. On-site aquifer testing using a test well is the preferred method to obtain a value for hydraulic conductivity, but this is not always required, or practical. Non-degradation analysis is also highly sensitive to the direction of ground water flow, which is used to predict the orientation of the mixing zone and avoid contamination of down-gradient water wells. Given all of the potential factors that can influence the outcome of a nitrate sensitivity analysis, the key factors are proper use of the highest quality data available to complete the analysis, and good regulatory review of nondegradation analysis reports prepared for proposed subdivisions.

ACKNOWLEDGMENTS

This project was funded by the Gallatin County Planning Board, with matching funds provided by the Gallatin Local Water Quality District (GLWQD). The GLWQD met several times with the Environmental Health Services (EHS) Division of the Gallatin City-County Health Department (GCCHD), and reviewed files on public sewage systems maintained by EHS. Denise Moldroski, with EHS, compiled extensive information on public sewage systems, which is incorporated into this report. The Gallatin County GIS Department assisted by providing several GIS (Geographic Information System) data layers, and processing septic system location information to create a septic system density map. Several public sewage system operators also assisted by providing information on their wastewater treatment systems.

REPORT ORGANIZATION

This report is organized into eight chapters which cover the following topics:

- **Chapter 1:** Purpose, scope of work, environmental concerns, and wastewater treatment trends.
- **Chapter 2**: Past efforts to examine wastewater disposal issues in Gallatin County.
- **Chapter 3**: Information on septic systems, including classification, regulations, types of septic systems, and, inventory and mapping of septic systems in Gallatin County.
- **Chapter 4**: Information on public sewage systems, including classification, regulations, treatment methods, inventory and mapping, and description of system in Gallatin County.
- **Chapter 5**: Information on county sewer and water districts in Gallatin County.
- **Chapter 6**: Information on solids produced during wastewater treatment, including characteristics, regulations, and disposal in Gallatin County.
- **Chapter 7**: Discussion of ground water mixing zones and cumulative impacts.
- **Chapter 8**: Conclusions and recommendations.

References, a glossary of terms, and a list of acronyms used in the report, are provided at the end of the report. Additional information is provided in appendices to the report. Three maps are included as attachments to the report. Map A1 shows the locations of individual septic systems, and areas where septage and biosolids are land applied. Map A2 shows the locations of pubic sewage systems in Gallatin County, and County Sewer and Water Districts. Map A3 shows the density of septic systems (systems/acre) in the County on a 10-acre grid spacing.

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 Purpose and Scope of Work

This report was commissioned by the Gallatin County Planning Board. The purpose is to provide an accurate summary of the current status of wastewater treatment and disposal in Gallatin County to aid the Planning Board, County Commission, Gallatin City-County Board of Health, and others in making informed decisions regarding future management of wastewater. The report is focused on inventorying current wastewater treatment and disposal practices in the County. An anticipated future step is to use this report to identify study areas and strategies for assessing impacts to water resources from disposal of wastewater. The goals of the report are as follows:

I. **Examine and summarize the current status of domestic wastewater treatment and disposal in Gallatin County, and;**

II. **Summarize important topics related to wastewater treatment and disposal for the benefit of decision makers and community members charged with making decisions on future wastewater treatment and disposal in Gallatin County.**

Objectives for the project, as approved by the Planning Board-Wastewater and Water Subcommittee are listed in Table 1. The scope of this project included compiling information on domestic, commercial, and industrial wastewater treatment and disposal practices in Gallatin County. Individual septic systems, public sewage systems, sewer and water districts, septage land applications sites, and biosolids land application sites, were all inventoried and mapped. Septic system density was also mapped. The scope of the project also included reviewing existing information on wastewater treatment systems, reviewing past reports related to wastewater disposal in Gallatin County, reviewing rules and regulations governing wastewater treatment and disposal, providing a basic summary of the fate of wastewater contaminants in ground water, and reviewing the basic hydrogeology of selected areas of Gallatin County as it relates to disposal of wastewater. It is important to note that concentrated animal feeding operations (i.e. feed lots, dairies) also produce significant quantities of sewage, which generally receives very little treatment. Assessment of this waste stream is beyond the scope of this report.

Table 1
Project Objectives Specified in Planning Subcommittee Work Plan

Objective	Title	Location
1	Inventory & map public sewage systems in Gallatin County[a]	Chapter 4
2	Inventory and map individual septic systems in Gallatin County	Chapter 3
3	Research the 1-acre standard lot size requirements for septic systems in MT	Chapter 7
4	Inventory and map land application sites for biosolids and septage	Chapter 6
5	Provide an overview of the hydrogeology of selected areas in the County	Appendix E
6	Provide a summary of the fate and transport of contaminants in treated wastewater after disposal into surface water or above ground water	Appendix D
7	Prepare a final report for the Planning Board	N/A

(a) *Primary mapping of Public Wastewater Systems was completed by the Environmental Health Services Division of the Gallatin County Health Department. This task was intended to expand on that mapping effort and include additional information on the systems.*

1.2 Environmental Concerns

All treated wastewater in Gallatin County is eventually disposed of by discharging it to surface water, ground water, or the land surface (aka spray irrigation or land application). Potential impacts to ground water and surface water resources from disposal of treated wastewater vary depending on the chemical and biological characteristics of the treated wastewater, the volume of wastewater disposed of, the method of disposal, and the hydrogeologic setting of the disposal area.

Along with treated wastewater, residual solids are produced in the treatment process. Solids gradually build up in septic tanks and must be periodically pumped out to maintain the septic system. These solids, along with all of the other contents of the septic tank, are referred to as septage. Solids are also generated by public sewage systems. If the solids are produced in mechanical treatment plants, and undergone additional treatment, they are referred to as biosolids. Most of the septage and biosolids produced in the County are disposed of by land application, to take advantage of the nutrient value of the solids. The characteristics of the two types of solids, and the methods used to land apply them, are very different. Like disposal of treated wastewater, disposal of solids also has the potential to impact water resources, depending on the characteristics of the solids, the amount of solids disposed of, the methods used to dispose of them, and the hydrogeologic setting of disposal sites.

1.3 Growth Patterns and Wastewater Treatment Trends

During the last two decades Gallatin County has experienced significant population growth. The population of Gallatin County was 50,463 in 1990, increased to 67,831 by 2000, and was 90,347 in 2009 (U.S Census Bureau, 2010). This represents a population increase just under 40,000 people, and an increase of 79% in the last 20 years. Ironically, as more people move to Gallatin County to enjoy the area's natural amenities and quality of life, the increasing population threatens to degrade the area's water resources, which is one of the amenities that attracts people. Since all homes, commercial buildings, and industrial facilities, produce wastewater, it is likely that Gallatin County has experienced an increase in the quantity of wastewater requiring treatment and disposal between 1990 and 2009, roughly parallel to the 79% increase in population.

Population growth has occurred within urban, suburban, and rural areas of the County. However, over the last two decades, growth patterns have changed from more traditional growth focused in urban areas, toward greater suburban and rural development. For example, Gallatin County's population increased by 29% between 2000 and 2007 while the land area used for this development increased at a rate four times that (US Census 2008, Smart Growth Montana). The increase in suburban and rural development in the County has resulted in a significant increase in the number of septic systems being used to treat and dispose of wastewater. During the 20-year period between 1989 and 2008 the Health Department issued 9,460 septic systems permits in Gallatin County. These additional septic systems not only serve residential development, but also commercial developments outside of areas serviced by public sewage systems. Given that septic systems rely in part on the old adage that 'dilution is the solution to pollution', population growth, and a commensurate increase in the number of septic systems, holds the potential to degrade the quality of the County's ground water and surface water resources.

Population growth in the urban areas of Gallatin County has resulted in the need to expand and improve existing centralized wastewater collection, treatment, and disposal systems. For example the population of Belgrade nearly doubled between 1998 and 2008 (MT CEIC, 2009). In 2004-2005 the City of Belgrade, which utilizes a lagoon system for wastewater treatment, significantly modified and expanded their wastewater treatment system to cope with the increasing demands. The Town of Manhattan recently completed construction of a new mechanical wastewater treatment plant that replaced an older lagoon system. Both the Big Sky and RAE water and sewer districts have replaced old lagoon systems with advanced sequenced batch reactor plants in the last 10 years. During this same period the City of Bozeman made several upgrades to its wastewater treatment plant. In addition, the City of Bozeman is currently undertaking a major construction project that includes a number of upgrades to the wastewater treatment plant. The improvements will ultimately more than double the plant's treatment capacity and significantly improve the quality of the treated wastewater produced.

There has also been a recent increase in the creation of county sewer and water districts in Gallatin County. Formation of these special districts is governed by Montana statute and they must be approved by the Gallatin County Commission. The first district created was the Willow Creek Sewer and Water District, in 1973. In the 26 year period between 1973 and 2009 a total of 17 sewer and water districts have been approved in Gallatin County. Of the 17 approved districts, 5 (29%) have been created in the last 4 years.

CHAPTER 2
PAST WORK RELATED TO WASTEWATER TREATMENT AND DISPOSAL IN GALLATIN COUNTY

A significant amount of work has been completed to look at issues associated with wastewater treatment and disposal in Gallatin County, much of which focused on potential impacts to water resources. The following subsections highlight the more significant efforts to examine wastewater treatment and disposal issues in Gallatin County since 2000. A detailed review of previous work that relates to wastewater treatment and disposal in the County is beyond the scope of this report.

2.1 Magnitude, Extent, and Potential Sources of Nitrate in Ground Water in the Gallatin Local Water Quality District (Kendy 2001)

The U.S. Geological Survey, in cooperation with the GLWQD, measured ground-water levels and collected water-quality samples from wells at 96 sites within the GLWQD (Kendy 2001). The study concluded that the primary source of recharge to the Gallatin Valley aquifer system is the West Gallatin River and irrigation diversions in the valley. Chlorofluorocarbons (CFCs) were used to estimate the age of ground water at 27 sites. It was concluded that most recharge to ground water at these sites occurred between the 1960s and 1990s, suggesting fairly rapid movement of ground water through the Gallatin Valley aquifer system. Nitrate levels in ground water from the 96 sites sampled showed relatively low concentrations, generally less than 3 milligrams per liter (mg/l), compared to a drinking water standard of 10 mg/l set by the U.S. Environmental Protection Agency (EPA). Only two sites had nitrate concentrations above the standard. Potential sources of nitrate considered were runoff from timber harvest areas, atmospheric deposition, livestock waste, fertilizer, soil organic nitrogen, and domestic septic systems. The study concluded that most nitrate in the ground water was from fertilizer and soil organic nitrogen.

2.2 Spatial Data for Septic System Assessment (Custer *et al.* 2000)

Custer *et al.* (2000) compiled numerous sources of data and constructed a Geographic Information System (GIS) database to evaluate the suitability of land within the GLWQD for the use of septic systems. The data compiled included soil types, areas of bedrock, slope, depth to ground water, and other hydrogeologic information. An important outcome of this project was a data layer (map) showing the relative suitability of land areas within the GLWQD for installation of septic systems (Figure 1). Land areas were assigned an index value based on the number of limiting factors for installation of septic systems. The higher the index value, the more limiting factors the land area has. This project also included creating a GIS database of many septic system locations within the GLWQD, by matching Department of Revenue parcel records with septic system permit records maintained by EHS.

The entire project was Web based, and all of the information compiled was made available to the public via the Geographic Information and Analysis Center (GIAC) Web site at MSU. A final report for the project was not prepared. The project was removed from the GIAC site in 2007. Dr. Custer then provided the project data to the Gallatin County GIS Department in hopes the project would be hosted on the Gallatin County Web site. To date this has not happened, and in a recent conversation with Dr. Custer, he stated that he was working on hosting the information on the MSU Earth Sciences Department website (personal communication Jan. 2009). Placing the project data on the Gallatin County website or the GLWQD website is still a long-term goal.

2.3 The Effects of Septic Systems on Surface Water and Groundwater Quality in Two Subdivisions in the Gallatin County Local Water Quality District, Montana (Fleming 2003)
Fleming (2003) evaluated the impacts to ground water from septic systems in two subdivisions in the Bozeman area. Both subdivisions were mature residential subdivisions noted for shallow ground water and proximity to water-quality impaired streams. The subdivisions studied were the Middle Creek subdivision and the Gardener Park subdivision. The Middle Creek subdivision, situated between Bozeman and Four Corners, is underlain by a sandy, silty, fine-gravel aquifer. The Gardener Park subdivision is located south of Bozeman, and is underlain by a fine to medium-gravel aquifer.

Shallow monitoring wells installed in both subdivisions, and existing deeper domestic wells, were sampled for coliform bacteria, chloride, ammonia, nitrate, and phosphorous. Water quality field measurements were also taken to document pH, specific conductivity, temperature, and dissolved oxygen. Water quality impaired streams in the area of the two subdivisions were also sampled for the same parameters, above, within, and below the subdivisions. Results of the study showed that nitrate levels remained relatively low in both subdivisions, with most results below 2 mg/l nitrate. Some wells tested positive for total coliform, and one shallow monitoring well tested positive for fecal coliform bacteria.

2.4 Spatial Analysis of Nitrate and Coliform Bacteria Data within the GLWQD (Greenup 2003)
Greenup (2003) performed spatial analysis of ground water nitrate and coliform bacteria data from water samples collected from wells within the Gallatin Local Water Quality District. Water quality data from several previously completed studies were combined with a large database of sampling results provided by Montana Microbiological Services. Using GIS software, Greenup plotted the locations of 1,907 wells, which had 970 nitrate sampling results and 4,074 coliform-bacteria sampling results. The data were statistically compared with other existing GIS data layers, including the Septic System Limitations Index map (2.2 above), housing density, locations of septage and biosolids land application sites, well depth, and hydrogeology.

Less than 1% of the 970 well samples for nitrate exceeded the 10 mg/l drinking water standard. Areas along the western flank of the Bridger Range and the northern front of the Gallatin Range showed nitrate levels higher than background levels. Spatially, nitrate concentrations in ground water were found to correlate best with hydrogeology (aquifer properties). Areas with higher rates of ground-water movement generally had lower nitrate concentrations, attributed to higher dilution potential. For coliform-bacteria, the sampling data showed that 13% of the 4,074 coliform-bacteria samples were positive. However, no correlation between positive coliform-bacteria samples and other factors could be demonstrated. It was concluded that site specific factors such as well depth and well construction were probably responsible for most positive coliform-bacteria samples.

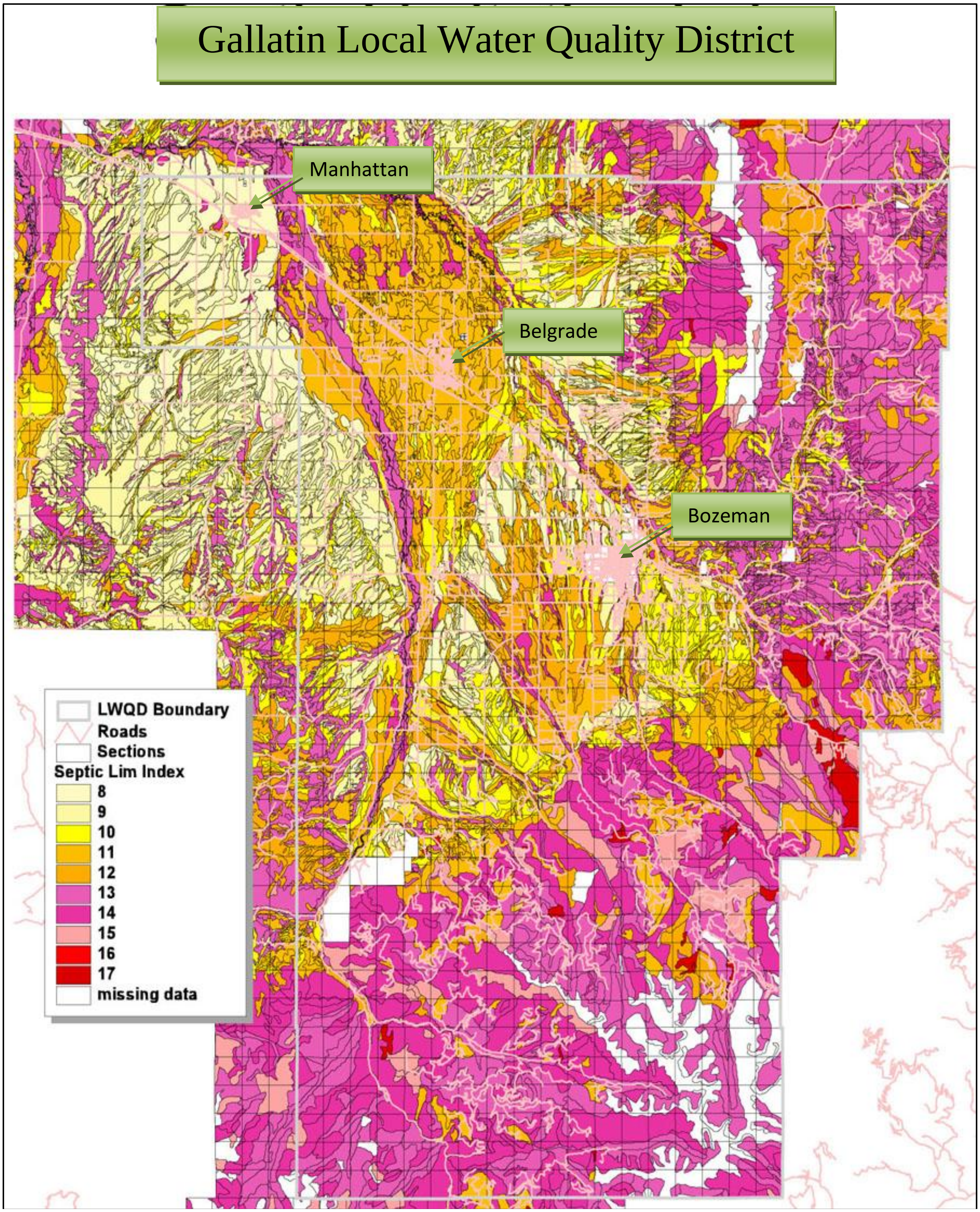

Figure 1. Septic System Limitation Index Map (Custer *et al*. 2000): *This map shows relative limitations for use of septic systems within the Gallatin Local Water Quality District, based on a number of factors. The lowest index number of 8, shown as light tan, has the least limitations, and the highest index value of 17, shown in red has the most severe limitations.*

2.5 Gallatin Water Resources Task Force (English 2005)

The Gallatin Water Resources Task Force was formed at the request of the County Commission in December 2003 to identify water resource issues and possible solutions. The GLWQD facilitated eleven Task Force meetings between December 2003 and June 2004. A final report summarized the efforts of the Task Force (English 2005). While most of the issues the Task Force addressed were associated with water wells, ditches, and floodplains, the Task Force also discussed the following issues associated with wastewater treatment and disposal:

Task Force Issue #3 Statement

Small wells may be drilled in areas that are part of a mixing zone for a community wastewater system that crosses property boundaries. These mixing zones are approved by DEQ prior to the well being drilled, and typically without the adjoining property owner's knowledge.

Task Force Issue #4 Statement

There are problems with regulating the separation between small wells and septic systems. While there is an effective process to make sure that new septic systems are not permitted within 100 feet of an existing well, there is not an effective process for making sure that new wells are not drilled within 100 feet of an existing septic system.

The Task Force also recommended data needs, stating "*an accurate GIS database of potential sources of water pollution is needed for things such as individual and community sewer systems…*" The Task Force did not suggest specific solutions to each of the issues discussed. It was felt that giving the Commission a number of different potential solutions to each issue, along with some of the pros and cons of each potential solution would be more useful. The only specific recommendation that the Task Force agreed on was the idea of creating some type of technical advisory council to assist the Commission and others with water resource issues. While the technical advisory committee was never created, the idea is still valid, and could be resurrected and expanded to include wastewater issues.

2.6 Gallatin County Regional Wastewater Study (Great West 2007)

Great West Engineering (2007) was commissioned by Gallatin County to conduct a reconnaissance level engineering study to evaluate the feasibility of providing regional wastewater collection and treatment services to the area generally referred to as the growth triangle (Bozeman-Belgrade-Four Corners/Gallatin Gateway). The study was based on U.S. Census tract data (2000-2005), existing development patterns, and a projected annual growth rate of 5%. Ten different regional wastewater management alternatives were evaluated. The work was focused on the municipalities of Bozeman and Belgrade, and the four non-municipal population centers of Four Corners, Gallatin Gateway, Valley Center, and the West Belgrade area. Based on growth projections, it was predicted that the Bozeman, Belgrade, and Four Corners area would remain as separated population centers thorough 2025. Belgrade, Valley Center, and the area west of Belgrade were projected to merge into a single population center.

Of the 10 regional management alternatives evaluated, two full regionalization strategies were ruled out as being too costly for the projected population in 2025. Four partial regionalization alternatives were evaluated, and several of these were recommended for further evaluation. Four population center alternatives, that would rely on existing infrastructure for Belgrade and Bozeman, and use a separate treatment system to serve the non-municipal population centers (Four Corners, Gallatin Gateway, Valley Center, and West Belgrade), were also considered. A hydropower alternative, that would utilize the gravity flow of wastewater to generate power, was considered but deemed to not be practical. A copy of the executive summary for this report is provided as Appendix A.

2.7 Local Regulation of Wastewater Systems Prospective Review (Greenbaum 2008)
The Gallatin County Attorney's Office completed a review of the various laws that provide legal authority to Gallatin County to regulate wastewater treatment systems (Greenbaum 2008). A copy of the report, prepared for the Wastewater and Water Subcommittee of the Planning Board, is provided as Appendix B.

2.8 Public Water and Wastewater Systems in Gallatin County (GCCHD 2009)
EHS summarized current information on public water and wastewater systems in Gallatin County (GCCHD 2009). This report contains a wealth of information on public wastewater treatment systems, current activities of the EHS, and applicable rules and regulations dealing with wastewater treatment and disposal. Since the report was originally released, EHS and the GLWQD have worked to further update information on public sewage systems. A revised report, dated September 29, 2009 is included as Appendix C. Of special note, this report contains a table of all the known public sewage systems in the County.

2.9 River Rock Subdivision Area Ground Water Resource Assessment
In the fall of 2007 the GLWQD began evaluating ground-water quality and ground-water flow patterns in the River Rock area, located southwest of Belgrade. This area has a history of problems with elevated nitrate levels in ground water. In 1998, when the High-K subdivision was approved along Amsterdam road, concerns were raised that installation of septic systems in the coarse sand and gravel soils in the area, which had historically been used for disposal of dairy waste, would result in flushing of nitrate into ground water. In 1999 the GLWQD collected water quality samples from wells in the Royal Arabian subdivision area, located just north of the High-K subdivision area. Elevated levels of nitrate, and a higher than normal occurrence of coliform-bacteria, were documented in private wells in the Royal Arabian subdivision area. Finally, in 2007 elevated levels of nitrate in ground water monitoring wells installed below the River Rock wastewater treatment plant, and in private wells down-gradient from the plant, raised additional concerns in the area.

The GLWQD completed extensive sampling of ground-water wells in the River Rock area in 2008 and 2009. The study area, and the locations of wells sampled, are shown in Figure 2. Over 100 water-quality samples were collected from 71 domestic wells. All of the wells were sampled for nitrate, chloride, and coliform bacteria. Selected wells were also sampled for other constituents, including dissolved salts, metals, nitrogen and oxygen isotopes, personal care products, and pharmaceutical compounds. Prior to collecting samples, wells were purged by pumping them for 30-45 minutes. Static and pumping water levels, pumping rates, and water quality field parameters (temperature, dissolved oxygen content, specific conductivity, pH, and oxidation-reduction potential) were recorded. The locations and elevations of selected wells in the study area were surveyed to determine ground water flow directions. The GLWQD is currently working on a final report for this project.

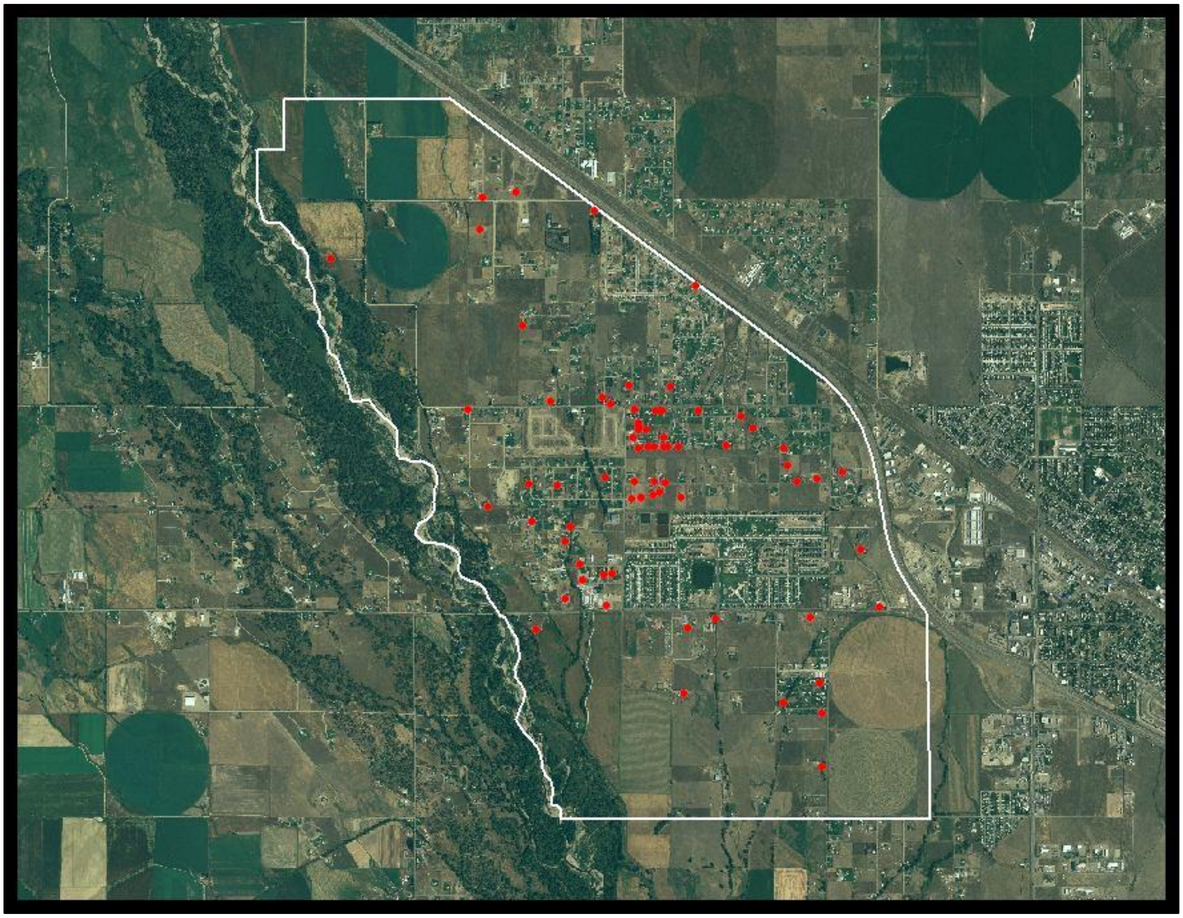

Figure 2. **Study Area for River Rock Area Ground Water Assessment.** *The locations of 71 wells that were used to collect over 100 water quality samples are shown with red dots. Water samples were analyzed for a broad range of contaminants, including nitrate, chloride, coliform bacteria, metals, nitrogen and oxygen isotopes, personal care products, and pharmaceuticals.*

2.10 Assessment and Distribution of Pharmaceuticals and Endocrine Disrupters in Wastewater, Ground Water and Surface Waters of the Gallatin Valley, Gallatin County, Montana

This project was a joint project between the GLWQD and the Montana Bureau of Mines and Geology (MBMG). Ground water, surface water, and wastewater samples were collected from 60 sites within Gallatin County. Sampling sites for this project are shown in Figure 3. The samples were analyzed for 32 different compounds that are classified as pharmaceuticals and personal care products (PPCP), including several compounds that are also considered to be endocrine system disrupters (Table 2).

Wastewater sampling included collection of raw wastewater (influent) and treated wastewater (effluent) from 8 different public wastewater treatment systems to evaluate how well the systems do at removing these compounds during the treatment process. Pharmaceutical compounds that persist through the treatment process ultimately end up being discharged to ground water or surface water. Ten surface water sites, and forty-two ground water sites were sampled to see which if any of the compounds persist in water resources. A final report on this project is currently being prepared by MBMG with assistance from the GLWQD.

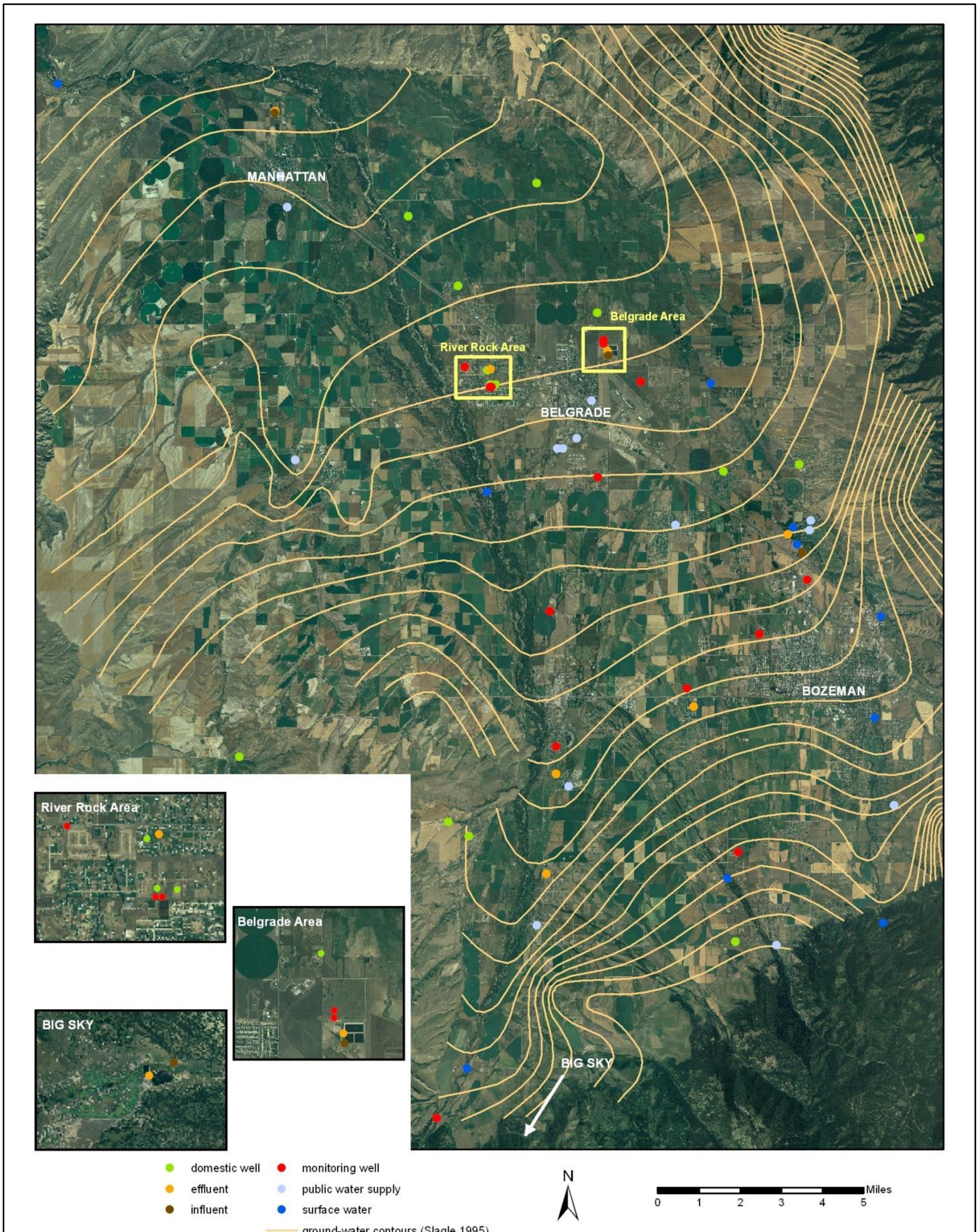

Figure 3. Sampling Sites for Pharmaceuticals and Personal Care Products in Gallatin County. *Ground water, surface water, and wastewater samples were collected from 60 sites in Gallatin County to assess the distribution and concentration of pharmaceuticals. The samples were collected by the Gallatin Local Water Quality District and the Montana Bureau of Mines and Geology.*

Table 2
Analysis List for Pharmaceutical Assessment Project (GLWQD-MBMG 2010)

COMPOUND	USE	COMPOUND	USE
17-α-estradiol	estrogenic hormone	Fluoxetine	Antidepressant
17-β-estradiol	estrogenic hormone	Gemfibrozil	Lipid-regulator, high cholesterol
17α-ethinyl estradiol	oral contraceptives	Hydrocodone	pain reliever
Acetaminophen	pain reliever, fever reducer	Ibuprofen	pain and inflammation reliever
Androstenedione	steroid hormone	Iopromide	radiology contrast agent
Atrazine	Herbicide	Meprobamate	anti-anxiety
Bisphenol A	Plastsizer	Methadone	pain reliever, addiction,detox.
Caffeine	stimulant, mild diuretic	Naproxen	pain & inflammation reliever
Carbamazepine	anticonvulsant, mood stabilizer	Oxybenzone	active ingredient in sunscreen
Phenytoin	anti-epileptic, anti-convulsant	Pentoxifylline	Increases blood flow, circulation
DEET	bug repellant, insecticide	Progesetrone	birth control, menopause therapy
Diazepam	anti-anxiety	Salicylic Acid	acne, corn, wart, dandruff treatment
Diclofenac	non-steroidal anti-inflammatory	Sulfamethoxazole	Antibiotic
Diethylstilbestrol	synthetic nonsteroidal estrogen	Testosterone	steroid hormone
Estriol	estrogenic hormone	Triclosan	antibacterial, agent in soaps
Estrone	estrogenic hormone	Trimethoprim	antibiotic/urinary tract infections

2.11 Gallatin County Regional Wastewater Management System Feasibility Study-Phase II

As a follow-up to the 2007 Regional Wastewater Study completed by Great West Engineering, Gallatin County contracted with Stahly Engineering & Associates to complete additional work to evaluate potential options for future management of wastewater. A report for this project is currently in draft form, and the following summary is based on the July 2010 Preliminary Draft (Stahly Engineering 2010). The study area for this project is shown on the maps provided in Attachment A. The Phase II study considered an overall 3% growth rate over a 20-year period ending in 2030. The projected population growth was distributed based on current zoning densities. This method of distributing future population growth recognizes that areas zoned for growth will grow at a faster rate than more mature existing high density areas. For example the rate of population growth within the City of Bozeman will be less than in the more sparsely populated areas surrounding Bozeman, that are zoned for high density development.

Based on the projected distribution of future population growth, spreadsheet models were used to estimate wastewater collection, treatment, and disposal system costs for various scenarios. The scenarios considered constraints on future wastewater management, including water rights, non-degradation requirements, depth to ground water, soil types, and physical limitations. An economic comparison of the real costs of development using on-site treatment systems vs. centralized treatment systems was also completed. Preliminary results suggest that a centralized wastewater treatment system serving the area west of Belgrade and the Valley Center area is feasible, with possible expansion to adjacent high density areas, and to the south along the Jack Rabbit Lane corridor.

The possibility of conveying treated wastewater from regional collection and treatment systems to the Missouri River for hydropower generation and surface water disposal was determined to not be a feasible alternative. The most likely options for future wastewater disposal are ground water discharge and spray irrigation. Numerous constraints limit available land areas for these methods of future disposal, and the report recommends that certain lands should be identified and considered for preservation as future wastewater treatment and disposal areas. It is also recommended the subdivision review process be enhanced to consider preservation of future regional sewer trunk line routes.

CHAPTER 3
ON-SITE WASTEWATER TREATMENT SYSTEMS (SEPTIC SYSTEMS)

3.1 Classification of Septic Systems

Wastewater treatment systems that serve a single-family home, several closely spaced homes, or structures with multiple living units, are commonly referred to as on-site wastewater treatment systems. In most cases these on-site systems consist of a septic tank and some type of subsurface wastewater disposal structure, typically a drainfield. In this report the term 'septic system' is used to describe all types of on-site wastewater treatment systems in Gallatin County that serve a single structure, several closely spaced structures, or multi-unit structures, and are not considered 'public sewage systems' by the State of Montana. Public sewage systems are defined and described in detail in Chapter 4.

While septic systems are mainly used to treat and dispose of household (domestic) wastewater, they are also used to treat and dispose of wastewater from commercial and industrial facilities. Wastewater from commercial and industrial processes can vary widely in quality and quantity. If wastewater constituents are concentrated, the wastewater is referred to as high-strength wastewater, and the septic system must be specifically designed to treat the extra wastewater load. It is reasonable to assume that any commercial or industrial structure in Gallatin County that is not served by a public sewage system is using a septic system for wastewater disposal. Septic systems or other structures such, as dry wells, used by commercial or industrial facilities to dispose of non-sanitary wastewater may be classified by the U.S. Environmental Protection Agency (EPA) as Class V injection wells. These systems pose additional risks to ground water quality because of the potential for disposal of wastewater containing a wide variety of chemicals.

3.1.1 Individual Septic Systems

Most septic systems in Gallatin County serve a single household or structure. Types of septic systems used in Gallatin County range from the cesspool, which is the crudest type of system, to engineered nitrogen-reducing treatment systems. The most common type of septic system used in Gallatin County is a septic tank that discharges to a drainfield. Discharge to the drainfield is by gravity flow, or by periodic pumping (pressure dosing). While most individual septic systems probably serve 2 to 6 people, they can serve up to 24 people and still be considered individual systems. The regulatory definition of an individual septic system is provided in the Administrative Rules of Montana (ARM 17.36.101) as follows:

> ***Individual Wastewater System*** {*a wastewater system that serves one living unit or commercial structure. The total number of people served may not exceed 24*}

3.1.2 Shared and Multiple-User Septic Systems

Septic systems that treat wastewater from two homes or commercial structures are called shared septic systems. Septic systems that serve more than two living units or commercial structures, but not more than 14 units are referred to as multiple-user septic systems. While these systems serve multiple families and/or multiple structures, they are not large enough to be classified as public sewage systems. Information is not readily available on how many shared or multiple-user septic systems are currently in use in Gallatin County. While the hard copy septic system permit records on file with EHS accurately indicate how many structures or connections are allowed to be served by permitted septic systems, the EHS septic system permit database often does not include this information, and the database can't currently be queried to determine the number of permitted shared and multiple-user septic systems in Gallatin County.

The regulatory definitions of shared and multiple-user septic systems are provided in the Administrative Rules of Montana (ARM 17.36.101) as follows:

> ***Shared Wastewater System*** {*A wastewater system that serves or is intended to serve 2 living units or commercial structures. The total number of people served may not exceed 24*}
>
> ***Multiple-User Wastewater System*** {*A nonpublic wastewater system that serves or is intended to serve 3 through 14 living units or 3 through 14 commercial structures. The total number of people served may not exceed 24*}

3.1.3 Septic Systems for Commercial and Industrial Wastewaters

Septic systems that treat and dispose of commercial or industrial wastewater pose a greater risk to ground-water quality than septic systems used solely for disposal of domestic wastewater. The increased risk is due to the potential for a wide range of different types of chemical waste to be disposed of into these septic systems. Traditional septic systems are designed to breakdown and treat human waste and the associated grey water (domestic wastewater). They are not designed to treat many types of other chemical waste. Examples of chemicals that have the potential to pass through a septic system untreated or only partially treated include heavy metals, salts, solvents, fuels, oils, pesticides, and pharmaceuticals. Commercial or industrial facilities in Gallatin County that use septic systems include restaurants, laundromats, car washes, taxidermy shops, meat processors, photography studios, automotive repair facilities, autobody shops, print shops, art studios, veterinary hospitals, and manufacturing facilities.

Septic systems used by commercial establishments that generate wastewater containing other wastes besides normal sanitary waste need to be specially designed to function properly, and may require some type of pretreatment system. The flow rates into these types of septic systems may be very sporadic, with large peak flows, or high volume flows (i.e. restaurants, carwash). If the septic system is not properly designed to treat the peak flows, poorly treated wastewater may discharge to ground water during peak flow periods, and the septic system may fail prematurely due to clogging of the drainfield. These types of septic systems may also receive high-strength wastewater, and if not properly designed this may result in system failure, poor treatment, or both. High-strength wastewater may contain large amounts of fats, oils, grease (FOG), suspended solids, salts, or organic matter. Restaurants are a common example of a commercial operation that generates high strength wastewater. In this case large amounts of FOG may clog the septic system if not properly designed. To address the large amounts of oil and grease in restaurant waste, a grease trap is often installed prior to the septic tank to pre-treat the wastewater. In some cases an aerobic treatment component is added to help remove FOG.

There is no better example in Gallatin County of the potential for a septic system used by a commercial facility to contaminate ground water than the Bozeman Solvent Site. This Montana Superfund site was discovered in 1989. It was determined that a dry cleaning business disposed of used dry cleaning solvent (perchloroethylene, aka PCE) into the sewer system in a local shopping mall. The sewer system was connected to a septic system and the PCE passed through the septic system untreated, contaminating ground water. A plume of contaminated ground water now extends from Main Street, several miles northward, to the East Gallatin River. Millions of dollars have been spent trying to remediate this problem, and while much progress has been made, soil and ground water contamination persists over 20-years later.

3.2 Overview of Regulations Governing Septic Systems

There are numerous statutes, rules, and regulations governing the use of septic systems in Montana and Gallatin County. Montana Code Annotated (MCA) provides state law governing septic systems. The MCA enabling statutes provide for adoption of the Administrative Rules of Montana (ARM) and local regulations. Together, the MCA, ARM, and local regulations provide the general laws regulating the use of septic systems. Local regulations consist of the Gallatin City-County Health Code-Chapter 3, the Gallatin County Subdivision Regulations, and subdivision regulations adopted by municipalities (Bozeman, Belgrade, Manhattan, and Three Forks).

Federal laws promulgated under the Clean Water Act, and the Safe Drinking Water Act, provide additional potential regulation of septic systems. Under the Clean Water Act, non-point source pollution to surface water bodies, which includes septic systems, could ultimately be regulated by establishment of Total Maximum Daily Load (TMDL) limits for pollutants in surface water. Under the Safe Drinking Water Act, the use of septic systems that receive wastes from servicing of motor vehicles and equipment are regulated by the U.S. EPA Underground Injection Control Program (UIC).

The rules and regulations that apply to the use of septic systems depend on if, and how, the land has been subdivided. If septic systems are proposed for use in a subdivision application, they are reviewed and approved by the Montana Department of Environmental Quality (DEQ) under the Montana Subdivision and Platting Act, the Montana Sanitation in Subdivisions Act, the Montana Water Quality Act, and by the local planning departments under the authority of the Gallatin County Subdivision Regulations, and other municipal planning regulations. In these cases the Health Department (EHS) reviews the proposed septic system use as an agent of the DEQ, and under local authority. If the parcel the septic system is being installed on is not part of a subdivision, review, permitting, and installation, of the septic system is regulated by the Health Department under the Gallatin City-County Health Code.

3.2.1 Montana Codes Applicable to Septic Systems

Montana statutes governing individual septic systems, are summarized in Table 3, and described below.

Table 3
Montana Statutes Governing Septic Systems

TITLE	CHAPTER	MCA Reference
(50) Health and Safety	(2) Local Boards of Health	50.2-Part 1 General provisions
(75) Environmental Protection	(5) Water Quality	75.5.301(4) Mixing Zones
(75) Environmental Protection	(5) Water Quality	75.5.303 Non-degradation
(76) Land Resources and Use	(3) Local Regulation of Subdivisions	76.3-Part 1 and Part 5 Montana Subdivision and Platting Act
(76) Land Resources and Use	(4) State Regulation of Subdivisions	76.4-Part 1 Montana Sanitation in Subdivisions Act

Local Boards of Health**:** The powers and duties assigned to Local Boards of Health, related to the regulation of septic systems, are provided under MCA 50-2-116 (1)(k) as follows: "*subject to the provisions of 50.2.130,* (local boards of health) *shall adopt necessary regulations that are not less stringent than state standards for the control and disposal of sewage from private and public buildings and facilities that are not regulated by Title 75, chapter 6, or Title 76, chapter 4. The regulations must describe standards for granting variances from the minimum requirements that are identical to standards promulgated by the board of environmental review and must provide for appeal of variance decisions to the department as required by 75.5.305.*"

In simple terms this language states that the Board of Health must adopt regulations governing wastewater disposal for facilities not regulated by the state under Public Water Supply rules (MCA 75-6) or the Sanitation in Subdivision Act (MCA 76-4). The regulations developed under this authority can't be more stringent than the applicable state statues, unless additional conditions can be meet.

The Board of Health can adopt regulations more stringent than the State if they satisfy the conditions of MCA 50-2-130 (2) and (3), which states the following: "*2) The local board may adopt a rule to implement 50-2-116(1)(k), (2)(c)(iii), or (2)(c)(iv) that is more stringent than comparable state regulations or guidelines only if the local board makes a written finding, after a public hearing and public comment and based on evidence in the record, that: (a) the proposed local standard or requirement protects public health or the environment; and (b) the local board standard or requirement to be imposed can mitigate harm to the public health or environment and is achievable under current technology. (3) The written finding must reference information and peer-reviewed scientific studies contained in the record that forms the basis for the local board's conclusion. The written finding must also include information from the hearing record regarding the costs to the regulated community that are directly attributable to the proposed local standard or requirement*."

Mixing Zones and Non-degradation (MCA 75-5-3)**:** The Montana Water Quality Act (MCA 75-5) is a broad ranging act dealing with many aspects of water quality in Montana. Specific to regulation of individual septic systems, the act contains language dealing with the designation of mixing zones for wastewater disposal, and non-degradation of state waters. For mixing zones the act directs the Montana Board of Environmental Review to adopt rules under MCA75-5-301(4), which states that the Board must *"adopt rules governing the granting of mixing zones, requiring that mixing zones granted by the department be specifically identified and requiring that mixing zones have: (a) the smallest practicable size; (b) a minimum practicable effect on water uses; and (c) definable boundaries."*. Non-degradation of state waters is addressed in the act under MCA 75-5-303. This statute consists of a one page policy statement. MCA 75-5-303(1) states that "*Existing uses of state waters and the level of water quality necessary to protect those uses must be maintained and protected*." However, the statute goes on to state that exceptions are allowed based on cost, economics, and social considerations.

Montana Subdivision and Platting Act (MCA 76-3-1 and 76-3-5): This act governs the subdivision of land in Montana into parcels of less than 160 acres. A subdivision is defined as: "*a division of land or land so divided that it creates one or more parcels containing less than 160 acres that cannot be described as a one-quarter aliquot part of a United States government section, exclusive of public roads*…" The act includes requirements for local regulation of subdivision, including wastewater disposal in subdivisions. Specifically, 76-3-501 states the following: "*The governing body of every county, city, and town shall adopt and provide for the enforcement and administration of subdivision regulations reasonably providing for: (7) subject to the provisions of 76-3-511, the regulation of sanitary facilities;"*

The provisions of MCA 76-3-511 have broad implication for local regulation of wastewater disposal. It states that local regulation can't be more stringent than state regulations or guidelines unless the local regulations are designed to protect public health or the environment, can mitigate harm to the public health or environment, is achievable under current technology, and is backed up with referenced information and peer-reviewed scientific studies. Under this section of the Subdivision and Platting Act, Gallatin County can adopt more stringent regulations for the treatment and disposal of wastewater, but a high standard is set for backing up the regulations with scientific information. It is important to note that the act does not provide a specific definition of what is considered peer-reviewed scientific information.

Montana Sanitation in Subdivisions Act (MCA76-4-1): Like the Subdivision and Platting Act, this act also governs the subdivision of land in Montana, but it governs subdivision of parcels less than 20 acres in size. The following definition of a subdivision applies to the Sanitation and Subdivision Act: *"Subdivision" means a division of land or land so divided that* (it) *creates one or more parcels containing less than 20 acres, exclusive of public roadways, in order that the title to or possession of the parcels may be sold, rented, leased, or otherwise conveyed and includes any resubdivision and any condominium or area, regardless of size, that provides permanent multiple space for recreational camping vehicles or mobile homes.".*

The other distinction between this act and the Subdivision and Platting Act is that it specifies the Montana Department of Environmental Quality adopt rules governing wastewater disposal rather than local government. Specifically MCA 76-4-104 reads as follows: *"(1) The department shall, subject to the provisions of 76-4-135, adopt reasonable rules, including adoption of sanitary standards, necessary for administration and enforcement of this part. (2) The rules and standards must provide the basis for approving subdivisions for various types of public and private water supplies, sewage disposal facilities, storm water drainage ways, and solid waste disposal. The rules and standards must be related to: (a) size of lots; (b) contour of land; (c) porosity of soil; (d) ground water level; (e) distance from lakes, streams, and wells; (f) type and construction of private water and sewage facilities; and (g) other factors affecting public health and the quality of water for uses relating to agriculture, industry, recreation, and wildlife.".*

An interesting aspect of the Sanitation in Subdivisions Act is the public policy statement it contains (MCA 76-4-101), which depending on how it is interpreted, could have broad implications for regulation of wastewater treatment systems and water supply wells. The policy statement reads as follows: *"It is the public policy of this state to extend present laws controlling water supply, sewage disposal, and solid waste disposal to include individual wells affected by adjoining sewage disposal and individual sewage systems to protect the quality and potability of water for public water supplies and domestic uses and to protect the quality of water for other beneficial uses, including uses relating to agriculture, industry, recreation, and wildlife."* An example in Gallatin County where this policy may have implications is the River Rock area, where the River Rock subdivision public sewage system may be impacting individual wells in the adjoining Wildhorse Trails subdivision.

3.2.2 Administrative Rules of Montana Applicable to Septic Systems

The Administrative Rules of Montana governing wastewater disposal, including septic systems are summarized in Table 4, and described below.

Table 4
Administrative Rules of Montana Governing Individual Septic Systems

TITLE	CHAPTER	ARM Reference
(17) Environmental Quality	(30) Water Quality	17.30.501 through 518 Mixing Zones in GW and SW
(17) Environmental Quality	(30) Water Quality	17.30.701 through 717 Nondegradation
(17) Environmental Quality	(36) Subdivisions/On-site subsurface wastewater treatment	17.36.911 through 17.36.924 On-site subsurface Treatment Systems

Ground Water Mixing Zones: Rules governing the designation of ground water mixing zones for disposal of wastewater are provided in ARM 17.30.501 through 518. A dual definition of a mixing zone is provided in 17.30.502 (6), which also references MCA 75-5-103 (18). The MCA definition states that a mixing zone "*means an area established in a permit or final decision on nondegradation issued by the department where water quality standards may be exceeded, subject to conditions that are imposed by the department and that are consistent with the rules adopted by the board.*". Additionally the ARM defines a mixing zone as "*a limited area of a surface water body or a portion of an aquifer, where initial dilution of a discharge takes place and where water quality changes may occur and where certain water quality standards may be exceeded*." ARM 17.30.508 (2) states "*No mixing zone for ground water will be allowed if the zone of influence of an existing drinking water supply well will intercept the mixing zone*." The zone of influence for a well is the land surface area overlying the cone of depression for a pumping well. For large public water supply wells, the zone of influence/cone of depression may be documented based on a pumping test, but for individual wells it is generally small and undocumented. The rules specify standard mixing zones for individual septic systems, which vary depending on the size of the lot, and the use of the septic system. Standard mixing zones are discussed in more detail in Chapter 7.

Non-degradation of Water Quality: The non-degradation rules for septic systems are tied to the State classification of ground water and focus on nitrate and phosphorous as pollutants of concern. The rules apply to Class I and Class II ground waters which are defined in MCA 17-30-1006, based on the *specific conductance* (aka conductivity) of the ground water. Class I ground waters are those ground waters with a natural specific conductance less than or equal to 1,000 micro-Siemens/cm at 25ºC. Class II ground waters are those ground waters with a natural specific conductance that is greater than 1,000 and less than or equal to 2,500 micro-Siemens/cm at 25ºC. Most shallow ground water in Gallatin County is Class I ground water. Methods of conducting non-degradation analysis for subdivisions with individual septic systems are discussed more detail in Chapter 7.

On-Site Subsurface Wastewater Treatment Systems: The Administrative Rules of Montana (ARMs) implementing the statutory requirements of the Sanitation in Subdivisions Act (MCA 76-4-1) are found in ARM 17.36.101 through 1107. Rules for septic systems are found in ARM 17.36 Sub-Chapter 9 (aka Minimum Onsite Rules). The rules specify the types of septic systems allowed and design standards. Most notably, MCA 17-36-914 (Wastewater Treatment Systems-Technical Requirements) adopts by reference Circular DEQ-4. Circular DEQ-4 is a primary reference for design and installation of septic systems, with detailed requirements for design, location, and installation of septic systems. An updated 2009 version includes new standards for systems used to dispose of grey water.

3.2.3 Gallatin City-County Health Code (Chapter 3)

Local regulations for septic systems were first adopted January 1, 1966. The regulations have been revised nine times since, in 1970, 1973, 1978, 1992, 1993, 1994, 1997, 2001, and 2004. Current regulations, in **Gallatin City-County Health Code-Chapter 3 (*Regulations for Wastewater Treatment Systems*)**, were adopted June 27, 2004, under the authority in MCA 50-2-116. The regulations are administered by EHS, and adopt by reference Circular DEQ-4. The City-County Board of Health is currently considering revisions to Chapter 3. One significant change being considered is a requirement that all new septic systems use pressure distribution (pressure dosed drainfield or other subsurface disposal system). New rules governing disposal of grey water have been adopted by DEQ and apply to the Chapter 3. The regulations adopt by reference the Administrative Rules of Montana (ARM) shown in Table 5.

Table 5
Applicable ARM Adopted by Reference in Chapter 3, Gallatin City-County Health Code

Title	ARM Reference	Purpose
Subdivision Application and Review	17.36.101	Definitions
Subdivision Requirements	17.36.320	System Design
“	17.36.322	System Siting
“	17.36.324	Floodplains
“	17.36.325	Site Evaluation
“	17.36.326(1)	Agreements and Easements
“	17.36.326(3)	“
“	17.36.326(4)	“
“	17.36.327	Existing Systems
Subsurface Wastewater Treatment Systems	17.36.911 to 17.36.914(5)	Multiple Subjects
“	17.36.914(7) to 17.36.924	Multiple Subjects

Minimum Septic System Design Standards in Gallatin County: Several requirements apply to most septic systems. The lot must be at least 1-acre if the water supply is a private well, and ½-acre if served by a public water system. Septic tanks must be made out of concrete, or other corrosion resistant material. The tank must have a capacity of at least 1,000 gallons for homes with up to 3 bedrooms, and 1,500 gallons for systems serving homes with 4 or more bedrooms. Pressure-distribution is required if over 1,000 square feet of drainfield is required, which typically occurs with homes with 4 or more bedrooms. Pressure distribution can also be required if the soils are coarse grained. Drainfields or other subsurface disposal structures must have a separation of at least 4-feet from seasonal high ground water. A designated replacement area for the subsurface disposal system is also required.

Drainfields or other subsurface disposal systems must be located at least 100-feet away from drinking water wells, springs, surface water bodies, and designated 100-year floodplains. The separation required between subsurface disposal structures and a well can be even higher if the designated mixing zone for the septic system overlaps the standard 100-foot radius of a well. Sealed components, including the septic tank and sewer lines, must be at least 50-feet away from surface water, private wells, and private springs, and at least 100-feet from public water supplies.

Review, Approval, and Permitting of Individual, Shared, and Multiple-User Septic Systems: If individual septic systems are proposed for wastewater treatment in a subdivision, they are reviewed and approved by DEQ as part of the subdivision approval process. The Gallatin City-County Health Department (EHS) also reviews and approves the proposed septic systems, acting as a reviewing agent for DEQ, and under local authority. If the subdivision is approved, DEQ issues a Certificate of Subdivision Approval (COSA). Once issued, a COSA does not have an expiration date. DEQ can’t finalize approval of a subdivision unless the Health Department also approves it. As the subdivision is built out, each lot owner is required to obtain a permit from EHS for the septic system. This helps assure that lot owners are aware of the septic system requirements for the subdivision, including specifications, required location on the lot, and location of the designated replacement area. An EHS permit to construct a septic system becomes a permit to operate the system once completed. The permit expires in 2-years if the septic system is not built. Once installed, there is no expiration date for a septic system permit.

If an individual septic system is proposed for a parcel that is not part of a subdivision, such as a parcel created by an exempted Certificate of Survey (COS), EHS reviews, approves, and permits the septic system. A Site Evaluation, completed by a Professional Engineer (PE) or Registered Site Evaluator, is required if the sanitary restrictions have not been lifted on the parcel. Currently EHS has 47 registered PE and Site Evaluators. The site evaluation typically includes digging a test pit to evaluate soil and shallow subsurface conditions, conducting percolation field tests to determine infiltration rates, and documenting other site conditions, such as slope, distances to surface water features, distances to nearby water wells, and depth to ground water. The Health Code also regulates septic system installers, who are required to pass an exam to obtain a registration of competency. This registration must be renewed every two years. Currently 117 installers are registered with EHS. These requirements help assure that septic system Site Evaluators and Installers are aware of current regulations.

Permitting of Commercial and Industrial Septic Systems: Since May 31, 1997 the Health Department (EHS) has required that applicants for a non-public septic system permit complete a Wastewater Treatment System Commercial Addendum form if the septic system will receive commercial wastewater. The form includes questions on the types of waste that will be disposed of, the type of business, and if any floor drains will be connected to the septic system. If a septic system applicant proposes to dispose of industrial waste into a septic system DEQ approval is required prior to EHS issuing a permit.

One problem noted by EHS is that the definition of industrial waste used by DEQ is vague. MCA 75-5-103(12) states *"Industrial waste" means a waste substance from the process of business or industry or from the development of any natural resource, together with any sewage that may be present.'* The vagueness recently came to light when EHS reviewed a septic system permit application for a local cheese company. The wastewater produced by the proposed operation was considered industrial waste by DEQ, requiring their review and approval. This type of operation may not have been considered industrial in the past.

Inspection and Monitoring of Individual, Shared, and Multiple-User Septic Systems: There is no routine inspection or monitoring requirement for most septic systems in the County. It is up to the owner to inspect and maintain the septic system. Inspections may be completed if EHS receives a complaint regarding an existing septic system. Chapter 3, Section 8, of the Health Code allows EHS to require record keeping and inspect septic systems. Specifically, subsection 8.2 states "*EHS has the authority to require the owner of a WWTS to maintain and submit records of system inspection, maintenance, cleaning, monitoring, and testing.*" Subsection 8.4 gives EHS the authority to inspect septic systems. It states "*EHS is authorized to enter private property during reasonable hours to inspect a WWTS or with due cause, to determine compliance with these regulations*."

Current regulations don't require septic tanks to be inspected and pumped out on a periodic basis. They also do not require that a septic tank access port for inspecting and pumping the tank be extended to the ground surface. Circular DEQ-4 only requires that access ports for inspection of each compartment of the septic tank be extended to within 12-inches of finished ground surface. Access ports for septic tanks with effluent filters are required to be extended to ground surface so the filter can be cleaned and maintained. It would be easier, and less expensive for septic system owners to inspect and maintain their septic tanks if all access ports for inspection, pumping, and effluent filters, were required to be extended to the surface. Gallatin County should consider adding this requirement to local regulations, with due consideration of design to address potential safety issues.

Obsolete Septic Systems: Under the current Health Code it is unlawful to operate an obsolete septic system in Gallatin County. A septic system can be considered obsolete based on construction, extreme age, or inability to meet other requirements of the Health Code. Obsolete systems include outhouses, cesspools, seepage pits, septic systems with metal septic tanks, and any system installed prior to the adoption of local regulations on January 1, 1966. There are probably a significant number of septic systems in the County that are obsolete under the current Health Code, and strict enforcement would be unreasonable. For this reason, enforcement of this provision of the Health Code is done on a discretionary basis by EHS.

A septic system can also be considered obsolete if there is a change in usage that exceeds the original permitted treatment capacity of the system either in terms of wastewater volume or wastewater strength. A common scenario is a septic system permitted for a 3-bedroom home that is later remodeled into a 4-bedroom home. If the homeowner does not obtain a new septic system permit and make any required improvements to the septic system to account for the increased treatment capacity required, the system could be considered obsolete. Review of numerous septic system permits for homes for sale in the Bozeman area suggests this is a common problem. A septic system can also be considered obsolete if there is a change of use of the system that increases wastewater strength, or changes the type of wastewater being disposed of, without the owner obtaining a permit and making any required improvements. An example of this would be a septic system permit issued for a retail sales business that is later converted into a restaurant. In this case the change to a restaurant would result in production of high-strength wastewater that would exceed the original permitted design. Another example would be a residential structure that is converted into a commercial business.

3.2.4 Levels of Treatment for Nitrogen-Reducing Septic Systems

The processes used to treat wastewater are generally divided into **treatment stages** referred to as **primary, secondary, and tertiary treatment**. Treatment stages include various physical, chemical, and biological processes used to treat wastewater. Stages of treatment apply to all types of treatment systems from septic systems to large municipal treatment plants. Treatment stages are described in more detail in section 4.3 (Stages of Wastewater Treatment). When evaluating the potential impacts to ground-water quality from septic systems, the most commonly evaluated contaminants are nitrogen compounds. Treated effluent from standard septic systems contains high levels of nitrogen, usually in the form of nitrate. Nitrate is the most oxidized end product of the breakdown of ammonia and organic nitrogen compounds in wastewater. While standard septic systems are effective at converting ammonia and organic nitrogen to nitrate, they do not remove much total nitrogen from the wastewater. Total nitrogen concentrations in effluent from a standard septic system range from 40-80 mg/l and average 50 mg/l (Circular DEQ-4). Additional information on the fate of nitrogen and other wastewater contaminants is provided in Appendix D.

To reduce contamination of ground water with nitrate from septic systems, several septic systems have been developed that remove some of the nitrogen from wastewater during the treatment process. This is accomplished by converting the nitrate to nitrogen gas using anaerobic bacteria. The nitrogen gas escapes into the atmosphere, effectively removing nitrogen from the wastewater and reducing the concentration of nitrate in the final effluent. For these types of septic systems DEQ designates **nitrogen-reduction treatment levels** based on the amount of nitrogen the systems remove.

DEQ has established designations for nitrogen-reducing treatment systems as adopted in ARM 17.30.702(9)(10)&(11). To achieve designation as a nitrogen-reducing system, treatment systems must be reviewed and approved by DEQ in accordance with ARM 17.30.718. Testing data is required to prove the systems achieve the nitrogen reduction claimed. The designated treatment levels don't apply to systems treating industrial wastewaters. There are three nitrogen-reduction levels designated by DEQ as levels 1a, 1b, and 2, which are summarized in Table 6. Descriptions of nitrogen-reducing treatment systems approved for use as individual septic systems are provided in subsection 3.4.

Table 6
Montana DEQ Designated Nitrogen-Reducing Treatment Levels

Treatment Level	% Total Nitrogen Reduction (total nitrogen in influent vs. effluent)	Allowed effluent concentration (measured as nitrate-nitrogen)
1b	More than 34% but less than 50%	>30 mg/l but no higher than 40 mg/l
1a	More than 50% but less than 60%	>24 mg/l but no higher than 30 mg/l
2	At least 60%	24 mg/l or less

ARM 17.30.702(9)(10) and (11), define the three levels of nitrogen-reducing systems is as follows:

> *(9) "**Level 1a treatment**" means a subsurface wastewater treatment system (SWTS) that:(a) removes at least 50%, but less than 60%, of total nitrogen as measured from the raw sewage load to the system; or (b) discharges a total nitrogen effluent concentration of greater than 24 mg/L, but not greater than 30 mg/L. The term does not include treatment systems for industrial waste. A level 1a designation allows the use of 30 mg/L nitrate (as N) as the nitrate effluent concentration for mixing zone calculations."*
>
> *(10) "**Level 1b treatment**" means a SWTS that: (a) removes at least 34%, but less than 50%, of total nitrogen as measured from the raw sewage load to the system; or (b) discharges a total nitrogen effluent concentration of greater than 30 mg/L, but not greater than 40 mg/L. The term does not include treatment systems for industrial waste. A level 1b designation allows the use of 40 mg/L nitrate (as N) as the nitrate effluent concentration for mixing zone calculations."*
>
> *(11) "**Level 2 treatment**" means a SWTS that: (a) removes at least 60% of total nitrogen as measured from the raw sewage load to the system; or (b) discharges a total nitrogen effluent concentration of 24 mg/L or less. The term does not include treatment systems for industrial waste."*

3.2.5 Federal Regulation of Motor Vehicle Waste Disposal Wells

The EPA Underground Injection Control (UIC) program regulates Class V injection wells under the authority of the Safe Water Act. In December 1999 EPA adopted new regulations for certain types of Class V injection wells, which are defined as injection wells that dispose of non-hazardous waste into or above an aquifer. Most Class V injection wells in Gallatin County are dry wells used for stormwater disposal. Septic systems that receive waste fluids associated with the servicing of motor vehicles or other equipment with internal combustion engines are regulated by EPA as 'motor vehicle waste disposal wells'. In the past it was common practice to connect floor drains in automotive repair facilities to a dry well or septic system. Motor vehicle waste disposal wells are a concern because they may discharge solvents, fuels, antifreeze, motor oil, battery acid, heavy metals, or other pollutants into ground water. Usually these fluids are discharged in small quantities via shop floor drains. Over time the small amounts add up to significant amounts of pollution in the subsurface. Figure 4 shows a photograph of a motor vehicle waste disposal well being excavated in Missoula, Montana. The floor drains in the automotive repair shop discharged directly to the disposal well, along with a single bay car wash. During excavation a thick, oily waste was found surrounding the entire area of the dry well.

Motor vehicle waste disposal wells were banned nationwide by EPA in April 2000. Motor vehicle waste disposal wells constructed prior to April 2000 were required to be closed, or obtain a discharge permit from EPA if they are determined to be in delineated source water protection areas for public water supply wells, or other delineated sensitive ground water areas. However, EPA Region 8, which includes Montana, has banned them statewide in Montana, regardless of location. An inventory and inspection program in Missoula County in the early 1990's documented over 100 motor vehicle waste disposal wells (English 1993). It is reasonable to assume that there are numerous similar disposal systems still in use in Gallatin County. The GLWQD contacted EPA Region 8, who reported that about 30 facilities had been inspected in Gallatin County, and several motor vehicle waste disposal wells were closed (Cheung 2009). Because of the potential for motor vehicle waste disposal wells to contaminate ground water, an effort should be made to locate them in Gallatin County, and work with EPA to close them.

Figure 4. Photograph of a motor vehicle waste disposal well being excavated. *Over 100 of these disposal wells were located in Missoula, and closed by EPA. Many of them required extensive remediation. In this photo soils around the dry well (top-center) are heavily contaminated with motor oil and solvents. Photograph courtesy of the Missoula Valley Water Quality District.*

3.3 Descriptions of Common Septic Systems Used in Gallatin County

While rare now, there are still a few locations in the County where raw sewage is piped directly to a river, creek, ditch, or storm sewer. EHS reports that they still find a few of these types of disposal systems each year. With the exception of these direct discharges of raw sewage, most septic systems consist of a septic tank and some type of subsurface disposal system. Brief descriptions of the most common types of septic systems used in Gallatin County are provided in the following subsections. The systems are generally described in order of increasing complexity and increasing level of treatment.

3.3.1 Cesspools

A cesspool is simply an excavated hole or pit in the ground used to dispose of raw sewage. It is distinguished from an outhouse because it also receives gray water from plumbing in a structure. A septic tank is not included, so there is no pretreatment of the wastewater prior to discharge into the ground. The cesspool is the crudest form of septic system. Cesspools are outdated systems which tend to plug easily due to the amount of solids disposed of directly into the system. Older cesspools often were constructed with hand-rocked pits 3 to 6 feet in diameter, and up to 10-feet deep. Cesspools provide very little treatment of wastewater because the raw sewage is discharged below the organic soil horizon, the contact area with surrounding sediments is limited, the separation between ground water and the wastewater is reduced due to the depth of burial, and the environment inside the cesspool tends to remain anaerobic. Cesspools are considered obsolete, and are not permitted under current Gallatin County regulations. Because cesspools tend to clog easily they have a limited life. For this reason, there are probably not many cesspools still in use in the more urbanized areas of Gallatin County or for structures that are continuously occupied. There may still be numerous cesspools in Gallatin County that are associated with cabins and other seasonal dwellings.

3.3.2 Septic Tanks

With the exception of cesspools, all other common septic systems include a septic tank as part of the treatment system. The septic tank provides partial primary and secondary treatment of domestic wastewater prior to discharge into some type of subsurface disposal structure. The tank slows the velocity of the incoming raw sewage, which allows for the physical separation of liquids and solids. Inside the tank raw sewage undergoes physical and biochemical transformations. Facultative anaerobic bacteria break down organic material, consuming most available oxygen and creating an anaerobic environment.

Four distinct layers form in a properly functioning septic tank as shown in Figure 5. Heavy solids settle to the bottom of the tank forming a sludge layer. Fats, oils, and grease (FOG) float to the top of the liquid layer forming a scum layer. The remaining liquid layer in between the sludge and scum layers is referred to as black water, and it discharges to the subsurface disposal structure. Above the scum layer gases, including carbon dioxide, hydrogen sulfide, and methane collect to form the fourth layer. These gases are vented to the atmosphere through the plumbing system.

Solid organic matter that accumulates on the bottom of the tank is converted, by facultative anaerobic bacteria, into liquid organic matter, water, ammonia, methane, carbon dioxide, hydrogen sulfide, and residual solids. The residual solids must be periodically pumped out. Gases produced during decomposition dissolve into the wastewater and rise to the top of the tank. Anaerobic degradation in the septic tank is incomplete, and wastewater leaving the septic tank contains suspended solids, dissolved solids, liquid organic matter, and dissolved gases. The effluent leaving the tank still has a high biochemical oxygen demand (BOD), with typical septic tank BOD removal efficiencies of 30-50%. Septic tanks also remove about 60-80% of the settleable solids, oils, greases, and floating debris, but do not provide for good removal of nitrogen, chlorides, viruses, and toxic organic compounds (EPA/625/R-00/008 Feb 2002).

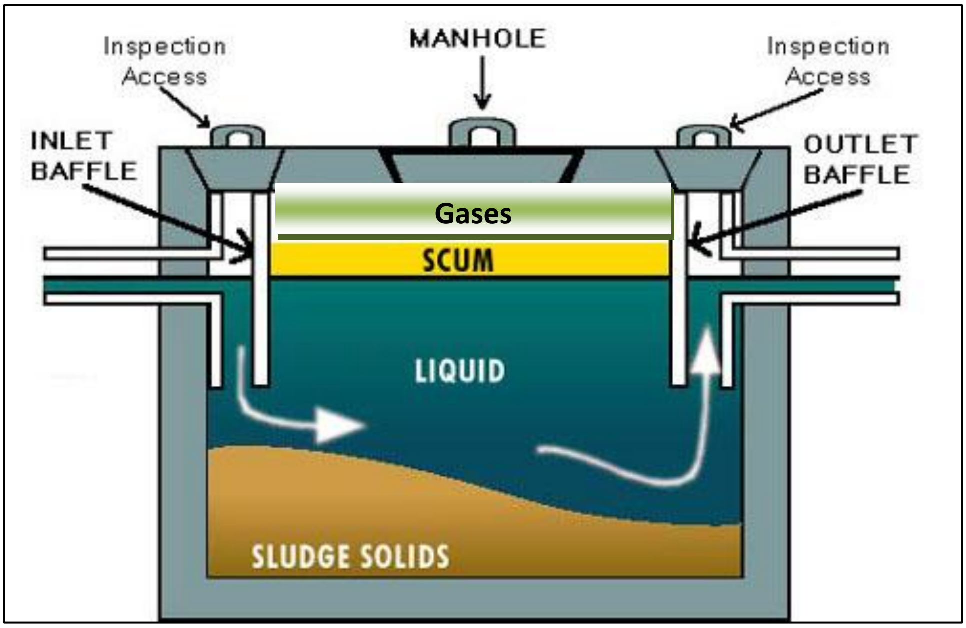

Figure 5. Standard Septic Tank Diagram. *Raw wastewater entering a septic tank encounters quiescent conditions that allow solids to separate from the liquid waste. Heavy solids settle to the bottom to form sludge, floating solids form a scum layer, and the remaining partially treated wastewater, called black water, flows out of the tank to the disposal structure.*

Solids that accumulate in the septic tank must be removed periodically to prevent buildup to the point that solids pass through the tank and clog the soils around the disposal structure. The frequency of pumping required depends on tank size, volume of wastewater disposed of, and the strength of the wastewater. Table 7 provides a good reference for septic tank pumping frequency based on the size of the tank and the number of residents being served. Using this reference, a pumping frequency of 1.5 to 6 years is suggested for the typical range of 3-6 people using the most common 1,000-1,500 gallon size tanks. Many references recommend a pumping frequency of 3 to 5 years for septic systems serving individual homes, which falls within the range shown in Table 7.

Table 7
Recommended Septic Tank Pumping Frequency in Years

Tank Size (gallons)	Number of Residents									
	1	2	3	4	5	6	7	8	9	10
500	5.8	2.6	1.5	1.0	0.7	0.4	0.3	0.2	0.1	
750	5.1	4.2	2.6	1.8	1.3	1.0	0.7	0.6	0.4	0.3
900	11	5.2	3.3	2.3	1.7	1.3	1.0	0.8	0.7	0.5
1000	12.4	5.9	3.7	2.6	2.0	1.5	1.2	1.0	0.8	0.7
1250	15.6	7.5	4.8	3.4	2.6	2.0	1.7	1.4	1.2	1.0
1500	18.9	9.1	5.9	4.2	3.3	2.6	2.1	1.8	1.5	1.3
1750	22.1	10.7	6.9	5.0	3.9	3.1	2.6	2.2	1.9	1.6
2000	25.4	12.4	8.0	5.9	4.5	3.7	3.1	2.6	2.2	2.0
2250	28.6	14.0	9.1	6.7	5.2	4.2	3.5	3.0	2.6	2.3
2500	31.9	15.6	10.2	7.5	5.9	4.8	4.0	3.5	3.0	2.6

Source: Modified from Pennsylvania State University Cooperative Extension Service
Highlighted values represent the most common range of residents and septic tanks sizes

3.3.3 Seepage Pits

A seepage pit system is basically a cesspool type structure with a septic tank installed to provide treatment of the wastewater prior to disposal. Seepage pits provide better treatment than cesspools due to the partial primary and secondary treatment provided in the septic tank. Once black water from the septic tank enters the seepage pit, treatment is limited by the same factors that limit treatment in cesspools. The disposal structure is typically constructed of concrete seepage rings that are 4 to 6 feet in diameter, and about 3 feet tall. The rings are stacked to obtain the desired depth of the seepage pit, typically 6 to 9 feet below ground surface. The concrete walls have large open holes in the sides and the bottom is open. The area around the seepage rings may be backfilled with coarse rock to increase wastewater storage capacity and surface area available for infiltration. Figure 6 shows a photo of a seepage pit being installed. Under current Gallatin County regulations seepage pits are obsolete, and are not permitted. For replacement systems, where space is limited and the original septic system used a seepage pit, a replacement permit may be obtained to install a new seepage pit with a variance.

Figure 6. Photograph Showing Installation of a Seepage Pit. *The top concrete ring of a seepage pit structure is shown during installation. In this case coarse rock is being backfilled around the outside of the seepage rings. The pipe in lower center is the discharge line from the septic tank.*

3.3.4 Gravity-Feed Septic Tank-Drainfield Systems

The most common type of septic system in Gallatin County is probably the gravity-feed septic tank and drainfield system. For many years this type of system has been the standard in Montana. It is still allowed for use in homes in the County that have up to three bedrooms and don't have special site restrictions. The septic tank provides partial treatment prior to gravity flow out of the tank and into a set of perforated pipes buried in the soil zone. Figure 7 shows a diagram of a typical gravity-feed drainfield system. The drainfield system provides better treatment of wastewater than a seepage pit because the effluent from the septic tank is distributed over a large area (typically 400-1000 square feet), and is discharged into the soil zone where it receives aerobic treatment prior to migrating downward to the water table.

Gravity-feed drainfield systems are simple to construct, and do not require electricity to operate. A common problem with a gravity-feed drainfield is that the flow rate is highly variable into the drainfield since it must match the flow coming from the home. This can sometimes result in overloading and saturation of the soils. Another common problem is that effluent from the septic tank often only flows to a small portion of the drainfield if the distribution pipes are not precisely leveled. This problem is even more common in gravity-drainfield designs where a header pipe connects all the lateral lines together, and there is no distribution box. This problem was observed in a septic system permitted in Gallatin County in 1999. The drainfield was sized for a 3-bedroom home and was only serving three residents. It failed within 12 months of installation. Excavation and inspection of the header pipe revealed that it had over 1-foot of elevation difference from one end to the other. This resulted in all of the septic tank effluent flowing to only one lateral drain line. The single drain line was overwhelmed and sewage began surfacing. This problem was resolved by removing the header and installing a distribution box with separate outlet pipes running to each drainfield lateral. Installation of a distribution box for gravity-feed drainfields is recommended because even with careful construction a header pipe might not be perfectly level, and may shift as backfill material settles.

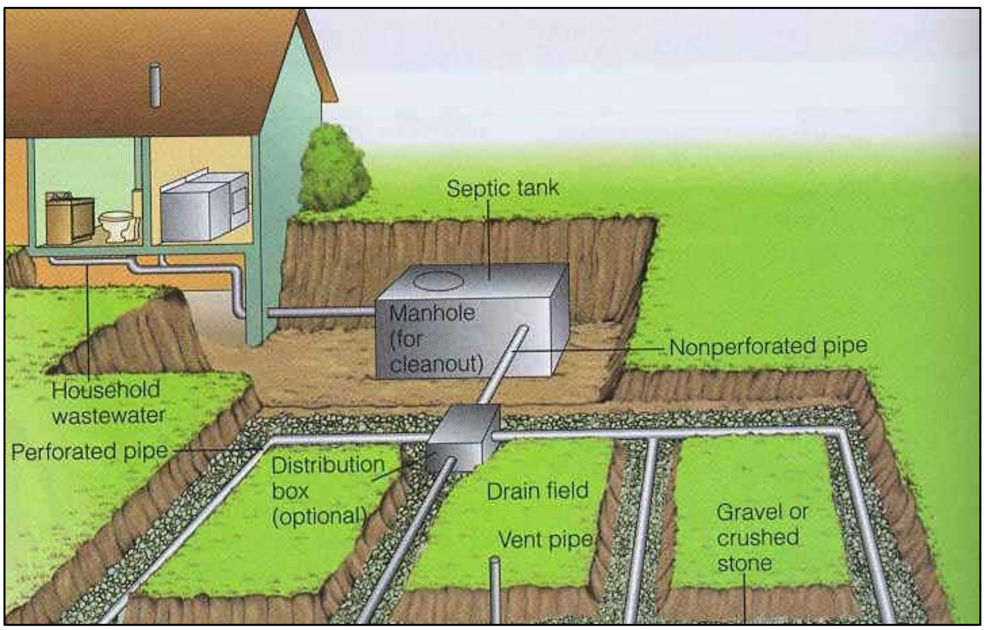

Figure 7. **Diagram of a Conventional Septic Tank and Gravity Drainfield with Distribution Box.** *This is probably the most common type of septic system in use in Gallatin County. In this diagram a distribution box is installed to evenly split the gravity flow from the tank into each of the drainfield lines.*

3.3.5 Pressure Dosed Septic Tank-Drainfield Systems

The common problems associated with gravity-feed drainfields are eliminated with a pressured-dosed septic tank-drainfield system. These systems use either a single tank with a separate pumping chamber, or a standard septic tank connected to a separate dosing tank. A timer, or float control switch, periodically turns on the pump. Effluent is pumped to the drainfield under pressure, resulting in uniform distribution throughout the drainfield. Better treatment is obtained because the effluent is discharged over a larger area, and the soils do not remain saturated. Installation of a septic tank and separate dosing tank for a pressure dosed septic system is shown in Figure 8.

Current County regulations require pressure distribution systems for homes with more than three bedrooms, and for commercial systems with more than 1,000 square-feet of drainfield. Section 16.1 of the Health Code-Chapter 3 gives EHS the option to require pressure distribution in areas where soils or other site conditions are marginal. The regulations also require pressure distribution if soils in the drainfield area are coarser than medium sand or sandy loam soils (Section 16.2). Many of the soils in the Gallatin Valley, including the Belgrade area and West Gallatin River area, from Belgrade to the mouth of Gallatin Canyon are coarser than medium sand/sandy loam.

Figure 8. **Photograph Showing Installation of a Septic Tank and Dosing Tank**. *A timer or float controlled pump in the dosing tank periodically pumps effluent to the drainfield under pressure, resulting in even distribution and improved wastewater treatment in the drainfield area.*

3.3.6 Elevated Sand Mounds

Elevated sand mounds (ESM) consist of a septic tank that pumps into an engineered sand bed constructed above grade. The sand bed is constructed using a specified grade of uniform sand. Design standards for ESM are found in Circular DEQ-4, and are adopted by reference in the Gallatin County Health Code. Elevated sand mounds are often used where there are restrictive site conditions such as shallow bedrock, high ground water, or very coarse soils. Prior to January 2005, ESM were approved as Level 2 nitrogen-reducing systems by DEQ. As such, they were approved for use in areas where elevated levels of nitrate in ground water limited additional septic system usage. Effective in January 2005, DEQ declassified ESM as Level 2 systems. Based on results of four studies that DEQ reviewed, the average reduction in total nitrogen in ESM was only 5%, when the total nitrogen concentration entering the ESM was compared with the concentration in the effluent from the ESM (DEQ, 2005). The DEQ review also reported that the average total nitrogen concentration in the effluent from elevated sand mounds averaged 51.5 mg/l. For purposes of completing non-degradation analysis of proposed ESM systems DEQ now requires that 50 mg/l be used for dilution calculations, which is the same concentration required for dilution calculations using conventional drainfields.

3.4 Descriptions of DEQ Approved Nitrogen-Reducing Septic Systems

DEQ maintains a list of approved nitrogen-reducing septic systems, which is updated periodically. The list, and other information on nitrogen-reducing septic systems is available on the Internet at www.deq.mt.gov/wqinfo/nondeg. As of June 2010 there are no systems approved for Level 1a treatment, one system approved for Level 1b treatment, and eleven systems approved for Level 2 treatment. Of the eleven approved Level 2 systems, only three are approved for non-public systems (individual, shared, and multiple-user). Other Level 2 systems are only approved for public systems.

3.4.1 Level 1b Nitrogen-Reducing Systems-Intermittent Sand Filters

The only approved Level 1b nitrogen-reducing system is the Intermittent Sand Filter (ISF). An ISF typically consists of a septic tank with a pumping chamber, that doses a below grade sand-filter bed. Design standards for ISF are found in Circular DEQ-4, and are adopted by reference in the Gallatin County Health Code. Well sorted sand is required in the sand filter to promote slow even migration of the wastewater through the sand bed. Microbes colonize the surfaces of the sand grains, treating the wastewater as it infiltrates through the sand. Aerobic conditions are maintained in the sand bed by intermittently dosing it to avoid saturation. Microscopic anaerobic conditions probably form on the sand grain surfaces, allowing for some denitrification. Wastewater passes through the sand bed once, and is then collected and pumped to a subsurface disposal structure. A diagram of a ISF is shown in Figure 9.

Properly constructed ISF are reported to achieve BOD and TSS removal rates of 90% or better and total nitrogen remove rates of 18 to 33% (EPA 2002). EPA reports that ISF can produce treated effluent with less than 10 mg/L BOD, less than 20 mg/L TSS, and almost complete conversion of ammonia to nitrate. Along with ESM, DEQ re-evaluated the designation of ISF as Level-2 nitrogen reducing systems and reclassified them as Level-1b systems in January 2005. In this case, DEQ reviewed 17 studies of ISF and concluded that the average reduction in total nitrogen for ISF was 30% (DEQ 2005). They also report that the average total nitrogen concentration in the treated effluent was 32.7 mg/l. For purposes of non-degradation analysis, DEQ requires that 40 mg/l nitrate be used for ISF.

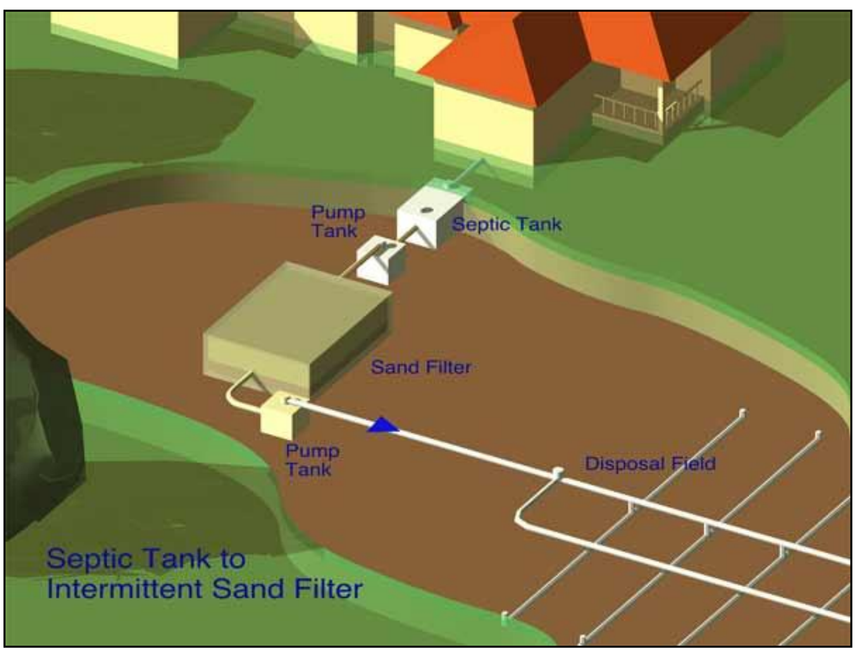

Figure 9. **Drawing of an Intermittent Sand Filter System**. *Effluent from the septic tank flows into a dosing tank. From the dosing tank effluent is evenly distributed under pressure to a below-grade sand bed. Treated effluent from the sand bed is collected and pumped to a drainfield.*

3.4.2 Level 2 Nitrogen-Reducing Systems-Recirculating Trickling Filters

The three Level 2 systems approved for use as individual septic systems are the AdvanTex®, Eliminite®, and Quanics® systems. All three are patented treatment systems that use a proprietary treatment media (filter). They are classified as recirculating trickling filters (RTF). Wastewater from a dosing/recirculation tank is periodically pumped to the top of the proprietary filter media, evenly applied, and allowed to trickle through the filter media. Effluent collected at the bottom of the filter bed flows back to a dosing/recirculation tank, where about 20% is split off and discharged to a final disposal structure, and the remainder is again passed over the filter media. This recirculation design allows the wastewater to be passed over the filter media multiple times.

The environment inside the filter media unit is generally aerobic, but microscopic anaerobic environments on the filter media also probably develop. As the wastewater repeatedly encounters aerobic and anaerobic conditions ammonia and organic nitrogen compounds are aerobically oxidized to nitrate (nitrification), and then reduced to nitrogen gas by anaerobic bacteria (denitrification). Nitrogen reduction is accomplished by venting the nitrogen gas to the atmosphere. To meet DEQ Level-2 standards these units are required to remove at least 60% of the total nitrogen load present in the raw wastewater, and produce a final effluent with a total nitrogen concentration of 24 mg/l or less.

***AdvanTex® Treatment Systems*:** The Orenco Systems Inc. Advantex® septic system was approved by DEQ as a Level 2 nitrogen-reducing system in August 2004. A typical system consists of a processing tank, which functions like a standard septic tank, a filter pod containing a patented synthetic textile filter, pumping chambers, and a final disposal structure. Final disposal is usually via a pressure dosed drainfield. Raw wastewater enters the processing tank, where solids and liquids are separated. Clarified liquid is then periodically pumped to the top of the filter pod and allowed to trickle through the filter. After the wastewater trickles through the filter, it flows to a recirculation chamber, where a small portion (about 20%) is diverted to the disposal structure and the remainder is recirculated through the system. Figure 10 shows a drawing of a packaged AdvanTex® treatment unit for individual household use.

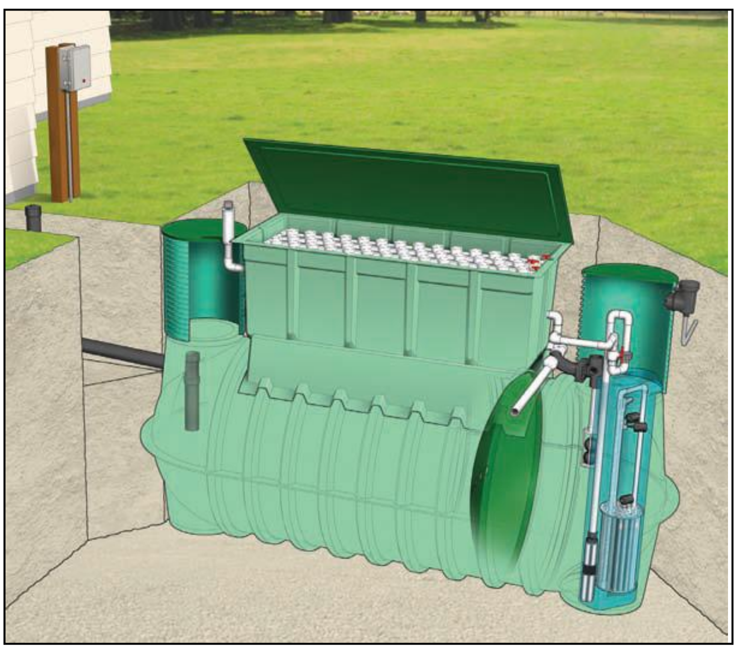

Figure 10. **Drawing of an Orenco-AdvanTex® Recirculating Trickling Filter System**. *AdvanTex® makes a packaged treatment unit for household use, that combines the processing tank, filter pod, and recirculating pump chamber all into a single unit. Drawing courtesy of Orenco Systems Inc.*

***Eliminite® Treatment Systems*:** Fluidyne, Inc**.** manufactures the Eliminite® system. This treatment system was also approved by DEQ as a Level 2 nitrogen-reducing system in August 2004. The system is based on a patented treatment media called MetaRocks®, which are cobble-size pieces of synthetic foam with a coarse surface texture. The MetaRocks® provide a substrate for microbes to grow on, and have a much larger surface area than natural cobbles. The MetaRocks® also provide open pore spaces for circulation of air inside the treatment unit. The Eliminite® system also uses a dosing/recirculation tank design. Clarified effluent from the dosing tank is repeatedly applied to the top of the MetaRocks® and allowed to trickle through the filter. Figure 11 shows an Eliminite® system being installed.

Figure 11. **Photograph of Fluidyne-Eliminite® Recirculating Trickling Filter System Installation**. *This system uses patented MetaRocks® as a treatment media. They provide a large surface area over which clarified wastewater is repeatedly applied. The wastewater trickles through the MetaRocks®, and back to a dosing/recirculation tank. Photo courtesy of Fluidyne Inc.*

***Quanics® Treatment Systems*:** Quanics Inc. manufactures Level 2 systems which use the same basic recirculating trickling filter design as the AdvanTex® and Eliminite® systems, but Quanics® offers a choice of two different filter media. Their AeroCell® systems use a patented synthetic open cell foam media in the trickling filter tank. The foam is in the form of cubes that fill trickling filter tank, similar to the design of the MetaRocks® used by the Eliminite® systems. The other Quanics® filter media is a patent-pending fiber material called Bio-COIR®. Coir fibers are fibers derived from the husk of coconuts, and the Bio-COIR® filter media is marketed as a natural, renewable resource material. The Quanics® systems were just approved by DEQ as Level 2 nitrogen-reducing systems in June 2010.

3.5 Evaluation of Monitoring Data for DEQ Approved Nitrogen-Reducing Systems

A review of wastewater monitoring data collected from operating nitrogen-reducing septic systems in Montana was recently completed by DEQ. While DEQ has not issued a report summarizing the monitoring data collected, they did provide the monitoring data to the GLWQD for review. The monitoring data includes influent and effluent water quality from several counties in the State, and includes a mixture of commercial systems, multiple-user systems, and individual systems serving both year-round residents, and seasonal/vacation homes. The monitoring data is from AdvanTex® and

Eliminite® Level 2 systems, and several Level 1b intermittent sand filter systems. Since the Quanics® Level 2 systems were just approved for use in June, 2010, no monitoring data is available for these systems. The following subsections summarize the monitoring data obtained from DEQ for nitrogen-reducing systems in Gallatin County.

3.5.1 Monitoring Data for Commercial AdvanTex® Systems in Gallatin County

Monitoring data for 5 commercial AdvanTex® systems in Gallatin County were obtained from DEQ. These systems include the Barner Assisted Living Facility, Cottonwood Fire Station, Everett's Rest, RAE/Sourdough Fire Station, and Yellowstone Mountain Club Phase I. Three of the 5 systems had reports showing effluent concentrations for total nitrogen close to or below the required 24 mg/l. The other 2 systems have exceeded the final effluent limits. One of these systems also had higher than expected total nitrogen concentrations coming into the treatment system (influent). For the 5 commercial systems there were monitoring results for 22 influent samples. The average influent total-nitrogen concentration was 63.4 mg/l, with a range between 16 and 124 mg/l. Monitoring results for 20 effluent samples showed an average total-nitrogen concentration in effluent of 29.4 mg/l, with a range of 4.7 to 60.8 mg/l.

3.5.2 Monitoring Data for ISF and AdvanTex® Systems in Gallatin County

The DEQ monitoring data included records for 8 ISF systems in Gallatin County that serve individual structures. Seven effluent sampling results were available for the 8 systems in the County. One system had no sampling results and may not be in operation yet. For ISF the average effluent total-nitrogen concentration was 33.7, which is well within the limit of 40 mg/l set for Level-1b nitrogen-reducing systems. The range of total-nitrogen concentrations in the effluent monitoring samples was 3.4 to 117 mg/l. Only one sample, at 117 mg/l was above the 40 mg/l limit. The reason for this anomaly is unknown.

The DEQ records contain monitoring data for 15 AdvanTex™ systems serving individual structures in Gallatin County. Influent water quality sampling data was too limited to evaluate. Monitoring results for 27 effluent samples collected from these systems showed an average total-nitrogen concentration of 26.9 mg/l, which is slightly higher than the 24 mg/l limit set for Level-2 systems. The effluent total-nitrogen concentrations for the 27 samples ranged from 4.9 mg/l to 99.8 mg/l. Of the 27 effluent samples, 12 (44%) exceeded the 24 mg/l Level-2 limit for total nitrogen.

3.6 Inventory and Mapping of Individual Septic Systems in Gallatin County

Existing information on the number and locations of individual septic systems in Gallatin County was available from several sources. However, none of these sources was sufficient to determine both the total number of septic systems in use and the locations of these septic systems in the County. To resolve this, a spatial database of individual septic system in Gallatin County was constructed by the GLWQD using Geographic Information System (GIS) software and several existing septic system data sources. For purposes of constructing the spatial database, individual septic systems include shared and multiple-user systems that are not classified as public sewage systems by DEQ (see subsections 3.1.1 and 3.1.2). Additional inventory information on individual septic systems was obtained by reviewing the septic system permit database maintained by EHS.

3.6.1 Review of Environmental Health Services Septic System Permit Database

The permitting requirements for individual septic systems in Gallatin County began January 1, 1966. It is reasonable to assume that for several years after the septic system permitting requirements became effective that numerous systems were still installed without a permit. This would have been primarily due to the lack of knowledge of the new regulations by property owners and/or the septic system installers. It is also likely that a few septic systems have knowingly been installed or replaced without a permit after 1966, under the belief that no one will ever know.

The EHS office maintains records of septic system permits. For many years these records consisted of hard copies of septic system permits and associated documents. Starting in about 1991 EHS began constructing an electronic database of septic system permits. This database has evolved through time using several different software programs. The current database software being used is produced by Tyler Technologies®, and is the same software that the County Clerk and Recorder is using for records management. The EHS Tyler® database was started in 2005 and it contains all of the septic system permits issued by EHS. This database is not a spatial database, but it allows for the scanning of the septic permit documents for digital storage and retrieval. EHS began scanning septic permits in about 2007, and is still working on scanning old permit documents. This process is expected to be completed in 2010.

Figure 12 shows the permitting trends along with population growth in Gallatin County between 1966 and 2008. Table 8 shows the number of septic system permits issued each year between 1966 and 2009. Over this time a total of 15,813 permits have been issued according to annual statistics provided by EHS. The EHS Tyler® database currently contains records for 15,787 non-pubic septic system permits, issued between January 1, 1966 and August 3, 2010. Of these, 628 records are for voided permits, and 2,200 records are for replacement permits (Moldroski 2010). Removing these, the database shows 12,959 active, non-public (individual, shared and multiple user) permits. The actual number of permitted septic systems physically in use can't be determined but it is most likely less than 12,959. This is due to issuance of replacement permits where an original permit could not be matched, issuance of permits for structures that have been abandoned, and issuance of permits for structures later connected to a public sewage system

Currently the Tyler® database does not contain enough information to determine how many of the active, non-public permits are for shared and multiple-user systems. The Tyler ® database also does not contain enough information to correctly query it to determine the number of permits issued for nitrogen-reducing septic systems in Gallatin County. Since these systems require routine maintenance, it would be useful to be able to track them with the Tyler® database.

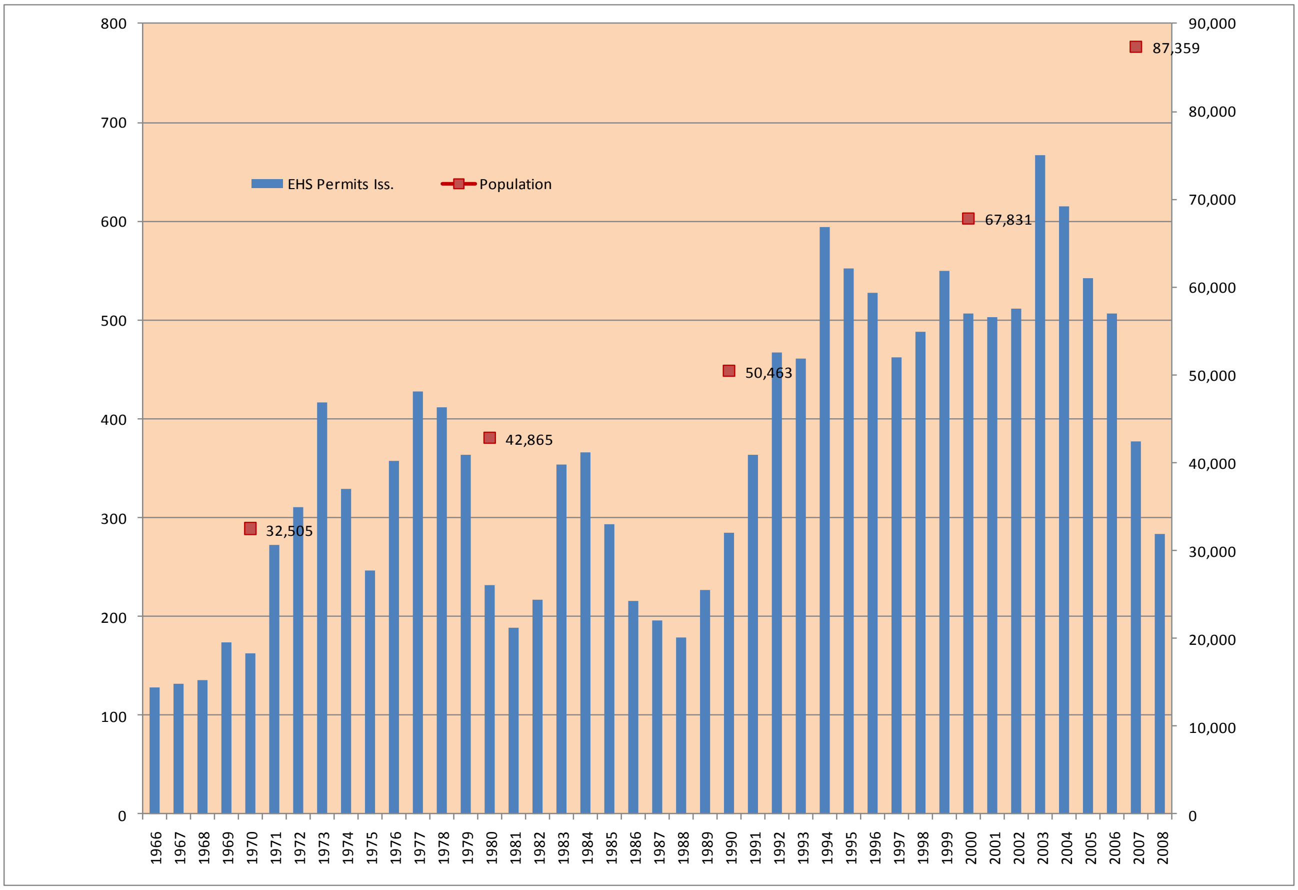

Figure 12. Septic System Permits Issued by Year, and Population Trends in Gallatin County. *Between 1966 and 2008, EHS records show that 15,593 septic system permits were issued. The building booms in the 1970s and 1990s in Gallatin County are reflected in the annual permit data. Population growth in the County during the same period went from about 30,000 in 1966 to almost 90,000 in 2008.*

Table 8
Septic System Permits Issued by EHS-1966 through 2009

Year	# Permit	Year	# Permit	Year	# Permit	Year	# Permit
1966	128	*1977*	428	*1988*	178	*1999*	550
1967	132	*1978*	411	*1989*	227	*2000*	506
1968	135	*1979*	363	*1990*	285	*2001*	503
1969	174	*1980*	231	*1991*	364	*2002*	511
1970	163	*1981*	188	*1992*	467	*2003*	667
1971	272	*1982*	217	*1993*	461	*2004*	615
1972	310	*1983*	354	*1994*	594	*2005*	542
1973	416	*1984*	366	*1995*	522	*2006*	507
1974	329	*1985*	293	*1996*	528	*2007*	377
1975	247	*1986*	215	*1997*	462	*2008*	284
1976	357	*1987*	196	*1998*	488	*2009*	220

3.6.2 Construction of County-Wide Individual Septic System GIS Database

A County-wide spatial database was constructed to show known and probable locations of individual septic systems in Gallatin County. GIS software and existing spatial databases were used. The Structures GIS database was used as a starting point based on the assumption that all residential and commercial buildings (structures) in the County are either served by an individual septic system, a public sewage system, or do not have a sewer system. The database was first copied, and then modified to create the septic system database. Table 9 shows the databases and other information used to construct the septic system database.

Table 9
Information Used to Construct County-Wide Septic System GIS Database

Information Reference	Type	Information Source
Gallatin County Structures Database	GIS Spatial Database	GIS Department
GPS Locations for Inspected Septic Systems	GIS Spatial Database	EHS Division of Health Dept.
Septic Systems within the GLWQD	GIS Spatial Database	Custer et *al* (2000)
Boundaries of Incorporated Cities/Towns	GIS Spatial Database	GIS Department
Boundaries of Approved Sewer/Water Dist.	GIS Spatial Database	County Clerk and Record
Pubic Sewage System Files	Hard Copy Files	EHS Division of Health Dept

Gallatin County GIS Department Structures Database: The GIS Department maintains the Structures database, which shows the locations of residential, commercial, and other structures in Gallatin County for purposes of addressing, and locating structures for 911 emergency response personnel. This database is the most complete, accurate, and updated GIS point layer available for structures in the county. The basis for using the structures database as a starting point was that if structures served by public sewage systems could be identified and removed, the remaining structures in the County would have to be on an individual septic system, if the structure had a sewer system at all. To eliminate structures that would not have a septic system, the Structures database was filtered using an attribute field for 'structure type'. Structures such as transformer stations, communications towers, sewer lift stations, water pumping stations, ski lifts, and restrictive access gates, were removed from the database.

EHS Database of GPS Located Septic Systems: In 2000 EHS began using GPS units to record locations of septic systems during site inspections. The GPS locations are differentially corrected and are accurate to within a few meters. EHS maintains a GIS spatial database with the GPS located septic systems. This is the most accurate location data available for septic systems in the County. However, EHS does not inspect all septic systems installed, so the database is a subset of systems permitted since 2000, or older systems that have been inspected since 2000. The modified structures layer was edited to replace structure points on parcels with the more accurate GPS locations when available. A total of 1,017 structure points were replaced with GPS located septic system points from the EHS database.

Septic Systems Within the GLWQD: Custer *et al.* (2000) constructed a GIS database of septic system locations in the GLWQD (see subsection 2.1). Montana Department of Revenue parcel records, with owner name, address, and sewer type, were cross-referenced with the EHS septic system permit records. If the location of a septic system in the EHS database was matched with a DOR record, a point representing a septic system was mapped on the parcel. Many septic system permit records did not have sufficient information to make a match with the DOR parcel records, so this GIS database also contains a subset of septic systems within the GLWQD as of 2000. The database contained 4,163 septic system points which were used to replace points in the modified Structures database.

***Boundaries of Incorporated Cities and Towns*:** A GIS layer that showed the boundaries of incorporated cities and towns was used to remove structures points inside of areas served by municipal public sewage systems. It was assumed that there are no active septic systems within the incorporated areas. This assumption is not 100% valid, but the number of active septic systems in these areas is probably very small. The GLWQD did attempt to contact municipalities to verify there were no septic systems. The City of Bozeman reported that there are probably only a few active septic systems within the city limits (Alston 2010). Efforts to obtain this information from the other municipalities were unsuccessful. Research to locate septic systems within these areas was beyond the scope of this project

Boundaries of Approved County Sewer and Water Districts: A GIS data layer showing the locations of approved sewer and water districts in Gallatin County was used to identify parcels served by public sewage systems. Structures points were removed from the database if they were within an area served by a public sewage system within a Sewer and Water District. The Four Corners Sewer and Water District was the hardest one to edit because they are served under contract by Utility Solutions, which has a larger service area. GLWQD staff met with Utility Solutions to try and identify properties that are hooked to the treatment plant within their service area (Campbell 2009). The Big Sky Sewer and Water District was also contacted to determine which structures they served (Edwards 2009).

3.6.3 Septic System Inventory Results

Appendix A, Map A1 entitled Septic Systems, Septage Disposal Sites, and Biosolids Disposal Sites in Gallatin County, Montana, shows the locations of septic systems in Gallatin County based on the GIS mapping. The database currently contains records and locations for 13,350 known or probable septic systems. This compares to 12,959 active, non-public septic systems contained in the EHS Tyler® database. The EHS Tyler® database probably contains some duplicate permit records for properties that have had replacement permits that were not linked to an original permit record. The number of duplicate permits can't be determined. If the methods used to create the septic system GIS layer are reasonable, and the 13,350 systems mapped is close to the actual number of active septic systems in the County, then comparison of the two datasets provides some indication of the number of unpermitted septic systems in the County. Using this information, there are probably at least 400 unpermitted septic systems in use in Gallatin County.

Overall, the County-wide septic system GIS database provides a reasonably accurate count of the number of active septic systems in Gallatin County, and reasonably accurate septic system point locations. Of the 13,350 septic systems mapped, those with EHS GPS locations are accurate to within a few meters, and for those located using the other data sources, most points are probably located within 200-feet of the actual location. A total of 8,170 of the septic system locations are based on the locations of structures, and the remaining 5,180 locations are based on more accurate information. When the GIS Department collects GPS positions for structures, they normally get close to the structure but can't reasonably be at or on the structure when recording the position. Often they may add an off-set to the recorded GPS position to make it more accurate. For this reason, most structure points plot near the actual structure location, but not directly on it. At the scale of the County, the location errors are insignificant. At the scale of a subdivision or similar sized area, most points fall within the correct parcel. The database should be accurate enough to use with other spatial databases, such as land use maps, soils maps, hydrogeology maps, and subdivision maps.

Figure 13 shows a clip of the septic system database plotted on an aerial photograph, within a high-density development area. The area includes subdivisions with individual septic systems, and a subdivision on a public sewage system. Parcels with structures that are known to be served by a septic system have a septic system point plotted within the parcel. None of the septic system points plot on roads, or open space lots, so the accuracy looks reasonable. Structures in a subdivision known to be served by a public sewage system don't have points associated with them.

Figure 14 shows another clip of the septic system point layer, showing a more rural setting with lower septic system density. In this case the primary structures appear to have an associated septic system point. In several cases you can see multiple buildings around a mapped point. In these cases it was determined, based on looking at the structures, that they are barns, storage units, or other structures that most likely do not have a septic system. One point located in the upper center of the figure does not have a structure located with it, possibly because the structure was built when the base photo was taken.

The process used to create the septic system database assumes that each structure that was not edited out has an individual septic system. Some septic systems in the County are shared or multiuser systems. There is currently no easy way to identify locations of shared and multiuser septic systems. If two structures are connected to a shared septic system, the point layer would show two septic systems for the two structures. This likely has led to a small over-count of septic systems. For purposes of estimating quantities of wastewater flow, the mapped points would correctly account for two families worth of sewage being disposed of using septic systems. For multiuser septic systems, such as a four-plex serving 4 families, the septic system point layer correctly shows only one septic system point. In this case, using the point layer to estimate quantities of wastewater being disposed of into septic systems would underestimate the flow.

3.6.4 Estimated Wastewater Discharge from Individual, Shared, and Multiple-user Septic Systems

DEQ specifies a design flow rate of 300 gallons per day (gpd) for a three-bedroom house. Using this design flow, the estimated cumulative daily discharge of wastewater into the subsurface within the County from the 13,350 septic systems mapped would be about 4 million gpd (4,005,000 gpd). On an annual basis this discharge is equal to about 1.46 billion gallons. The discharge would be about 6.7 times the daily discharge of Belgrade, but less than the daily discharge of Bozeman (5.5 mgpd). The estimated discharge from septic systems based on the GIS mapping assumes that each system serves a single family or structure. It was not possible to determine how many shared and multiple-user systems there are in the County. The GIS database would show two systems for two homes on a shared system. This would accurately reflect discharge from two homes. Multiple-user systems serving a structure like a multiplex would be mapped as a single septic system, and the discharge would be underestimated.

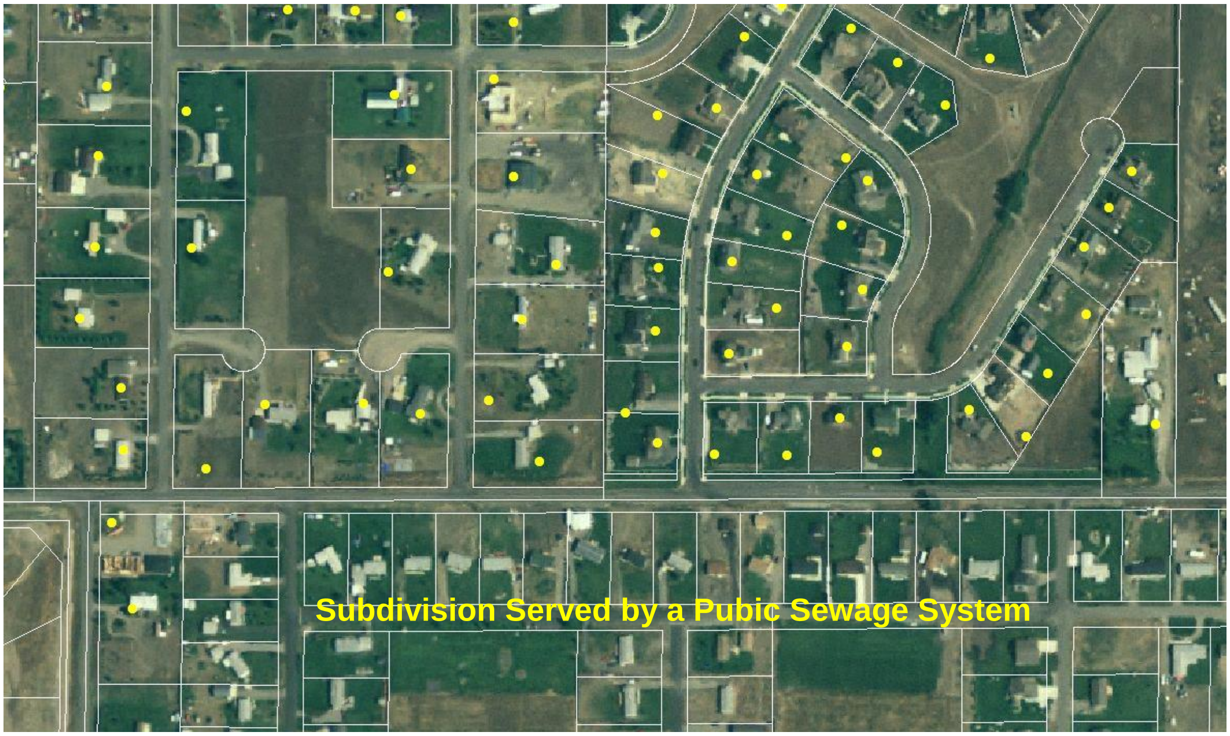

Figure 13. **Large Scale View of the Septic System Point Layer in an Urban Residential Area**. *Yellow dots represent septic systems in the county-wide septic system database. Most points fall reasonably close to structures on the aerial photo base map. The view also shows an area served by a public wastewater system (bottom center and right) that has no septic system points assigned.*

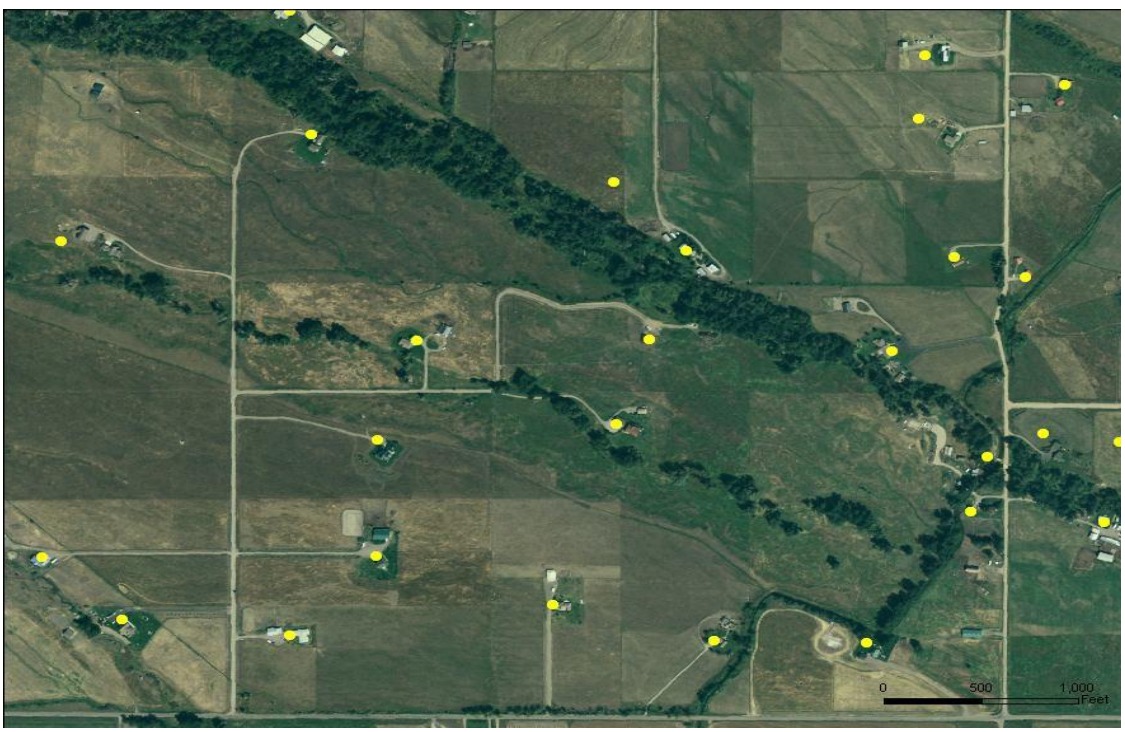

Figure 14. Large Scale View of the Septic System Point Layer in a Rural Residential Area. *Yellow dots represent septic systems in the county-wide septic system database. This view shows that most points fall reasonably close to what visually appears to be the primary residential structure lot.*

CHAPTER 4
PUBLIC SEWAGE SYSTEMS

4.1 Classification of Public Sewage Systems

Various terms are used to describe wastewater treatment systems that are considered public systems. These include municipal treatment plant, centralized wastewater treatment system, community sewer system, public wastewater system, and water reclamation facility. The term '**public sewage system**' has specific regulatory meaning and is defined by the state of Montana under the Administrative Rules of Montana (ARM). Definitions for both regulatory and commonly used terms for wastewater treatment systems are provided in the Glossary of Terms at the end of the report. It is important to note that the term 'public' does not refer to ownership of treatment systems, which can be owned by public or private entities, but rather the number of people served, or the number of service connections.

The primary differences between the various public sewage systems in Gallatin County has to do with how much wastewater is being treated, the complexity of the treatment system design, and how extensive the collection sewer network is for the treatment system. For purposes of this report the definitions below are used to separate public sewage systems into smaller systems that generally serve small clusters of homes or single subdivisions, and large systems serving urbanized areas.

4.1.1 Public Sewage System

A *public sewage system* provides collection, transportation, treatment, and disposal of sewage for 15 or more families (or connections) or 25 or more persons daily for 60 or more days in a calendar year. Public sewage systems are further categorized as follows: (i) "***Community sewage system***" means a public sewage system that serves at least 15 service connections used by year-round residents or that regularly serves at least 25 year-round residents; or (ii) "***Non-community sewage system***" means any public sewage system which is not a community sewage system (modified from ARM 17.38.101).

4.1.2 Centralized Public Sewage System

A *centralized public sewage system* is a wastewater collection and treatment system that consists of extensive collection sewers and a centralized treatment facility. These systems serve an urbanized community that may or may not be incorporated. They typically have well over 100 service connections and serve residential, commercial, and possibly industrial users (modified from U.S. EPA 2002). Centralized wastewater treatment systems are classified as *Community Public Sewage System*s within the Administrative Rules of Montana.

4.2 Regulation of Public Sewage Systems

There is significant overlap in the statutes, rules, and regulations that govern individual septic systems as described in subsection 3.2, and those that govern public sewage systems. Public sewage systems that are proposed as part of the development of one or more subdivisions are generally regulated under the same statutes (MCA), rules (ARM), and regulations (Gallatin County Health Code-Chapter 3), as individual septic systems. The primary factors that dictate how public sewage systems are regulated are the volume of wastewater treated, and the method of disposal of the treated wastewater.

Large public sewage systems that discharge treated wastewater to a surface water body, and are not associated with specific subdivisions or developments are only regulated under rules promulgated from the Montana Water Quality Act, and the Federal Clean Water Act. These systems must operate under a Montana Pollution Discharge Elimination System (MPDES) permit issued by DEQ. In Gallatin County the City of Bozeman, Town of Manhattan, City of Three Forks, and Town of Willow Creek fall into this class, and all have surface water discharge permits.

4.2.1 Montana Codes Applicable to Public Sewage Systems

The Montana Subdivision and Platting Act and the Montana Sanitation in Subdivisions Act both apply to construction of public sewage systems if they are proposed as part of a subdivision. Numerous statutes under the Water Quality Act also apply to public sewage systems, including statutes for mixing zones, non-degradation, permitting of discharges, and the State Revolving Fund (SRF) Program. Table 10 shows the titles and references for MCA that apply to public sewage systems.

Table 10
Montana Statutes Governing Public Sewage Systems

TITLE	CHAPTER	MCA Reference
(37) Professions and Occupations	(42) Water Treatment Plant Operators	37-42-Parts 1,2,3.
(50) Health and Safety	(2) Local Boards of Health	50-2-Part 1 (General Provisions)
(75) Environmental Protection	(5) Water Quality	75-5 Part 3 (Classification and Standards)
(75) Environmental Protection	(5) Water Quality	75-5 Part 4 (Permits)
(75) Environmental Protection	(5) Water Quality	75-5-Part 11 (Water Pollution Control State Revolving Fund)
(75) Environmental Protection	(6) Public Water Supplies, Distribution, and Treatment	75-6-Part 1 (Public Water Supply)
(75) Environmental Protection	(6) Public Water Supplies, Distribution, and Treatment	75-6-Part 30(Regional Water and Wastewater Authority)
(76) Land Resources and Use	(3) Local Regulation of Subdivisions	76-3-Part 1 and Part 5 (Montana Subdivision and Platting Act)
(76) Land Resources and Use	(4) State Regulation of Subdivisions	76-4-Part 1 (Montana Sanitation in Subdivisions Act)

Water Treatment Plant Operators**:** MCA 37-42-104 requires that DEQ establish a classification system for wastewater treatment plants based on size, physical conditions, and wastewater quality. This chapter also requires DEQ to establish procedures for certification and licensing of wastewater treatment plant operators, and establish an advisory council for certified operators (MCA 37-42-Part 2). MCA 37-42-301 requires DEQ to *"certify persons as to their qualifications to supervise successfully the operation of such water and wastewater treatment plants and water distribution systems."*

Local Boards of Health**:** MCA Title 50 (Health and Safety) contains numerous chapters that either require, or allow DEQ to establish rules governing wastewater disposal at public places, including schools, campgrounds, motels, swimming pools, and retail stores. MCA 50-2 Part 1 (Local Boards of Health) contains the statutes governing creation and operation of these boards. The powers and duties assigned to Local Boards of Health include adoption of regulations governing public sewage systems. MCA 50-2-116 (1)(k) as follows:

"*subject to the provisions of 50-2-130, adopt necessary regulations that are not less stringent than state standards for the control and disposal of sewage from private and public buildings and facilities that are not regulated by Title 75, chapter 6, or Title 76, chapter 4. The regulations must describe standards for granting variances from the minimum requirements that are identical to standards promulgated by the board of environmental review and must provide for appeal of variance decisions to the department as required by 75-5-305.*"

MCA 50-2-130 restricts the Board of Health from adopting rules more stringent than State rules. However, MCA 50-2-130 does allow the Board of Health to adopt more stringent requirements governing sewage disposal if the following conditions are satisfied: *"(2)(a) the proposed local standard or requirement protects public health or the environment; and (b) the local board standard or requirement to be imposed can mitigate harm to the public health or environment and is achievable under current technology. (3) The written finding must reference information and peer-reviewed scientific studies contained in the record that forms the basis for the local board's conclusion. The written finding must also include information from the hearing record regarding the costs to the regulated community that are directly attributable to the proposed local standard or requirement.*"

***Montana Water Quality Act*:** Numerous statutes relating to wastewater treatment and disposal are included in MCA 75-5, generally known as the Montana Water Quality Act. MCA 75-5 Part 3 (Classification and Standards) requires the Montana Board of Environmental Review to adopt rules governing mixing zones and nondegradation of state waters, and to adopt a classification system for state waters, and water quality standards. For mixing zones, the act directs the Montana Board of Environmental Review to adopt rules under MCA75-5-301(4), which states that the Board must *"adopt rules governing the granting of mixing zones, requiring that mixing zones granted by the department be specifically identified and requiring that mixing zones have: (a) the smallest practicable size; (b) a minimum practicable effect on water uses; and (c) definable boundaries."*

Nondegradation of State Waters: MCA 75-5-303 addresses nondegradation. This statute consists of a one page policy statement. MCA 75-5-303(1) stating that "*Existing uses of state waters and the level of water quality necessary to protect those uses must be maintained and protected*." However, the statute goes on to state that exceptions are allowed based on cost, economics, and social considerations.

Permits: MCA 75-5 Part 4 requires the Montana Board of Environmental Review to establish rules for discharge of treated wastewater to ground water and surface water. MCA 75-5-401 is listed as a temporary statute, which states *"(1) Except as provided in subsection (5), the board shall adopt rules: (a) governing application for permits to discharge sewage, industrial wastes, or other wastes into state waters, including rules requiring the filing of plans and specifications relating to the construction, modification, or operation of disposal systems*;"

Finally, the Water Quality Act includes statutes providing for creation of the State Revolving Fund program. Known as the, ***Water Pollution Control State Revolving Fund Act***, MCA 75-5-11 has statutory language allowing DEQ, in partnership with DNRC to develop and implement a program that provides technical assistance and loan funds to public sewage systems.

Public Water Supplies, Distribution, and Treatment: Part 1 (Public Water Supply) of MCA 75-6 contains language that requires DEQ to establish experiment stations and conduct experiments on wastewater treatment methods. Specifically, MCA 75-6-104 (7) states the Department (DEQ) shall "*establish and maintain experiment stations and conduct experiments to study the best methods of treating water, drainage, wastewater, and sewage to prevent pollution, including investigation of methods used in other states*;" The GLWQD is not aware of how this statute is being satisfied.

MCA 75-6-104(12) allows DEQ to enter into agreements with local governments for inspection of wastewater treatment facilities. DEQ may also delegate review of small public sewage systems to local governments. MCA 75-6-121 states that the department may "*enter into agreements with local boards of health whenever appropriate for the performance of surveys and inspections under the provisions of this part."* DEQ has not entered into an agreement with Gallatin County for these services.

Regional Water and Wastewater Authority Act: MCA 75 Part 3 provides the governing statutes for formation of a regional wastewater treatment authority. The purpose of the act is "*to permit certain public agencies to make the most efficient use of their powers relating to public water supplies and the transportation and treatment of wastewater by enabling them to cooperate with other public agencies on a basis of mutual advantage and to provide services and facilities to participating public agencies. It is also the purpose of this part to provide for the establishment of a public body, corporate and politic, that is known as a regional water authority or, when appropriate, a regional wastewater authority or regional water and wastewater authority*." The act also states "*The function of the regional wastewater authority is to enable public agencies to join together to provide the most economical method of transportation and treatment of wastewater and to provide the transportation and treatment services to public service districts, municipalities, publicly and privately owned wastewater utilities, and others*."

Both the Montana Subdivision and Platting Act MCA 76-3, and the Montana Sanitation in Subdivisions Act MCA 76-4, include language governing public sewage systems as part of the subdivision review and approval process. These two acts are described in more detail in subsection 3.2.1.

4.2.2 Montana Administrative Rules Applicable to Public Sewage Systems

The Administrative Rules of Montana (ARM) created to administer the MCA associated with public sewage systems are summarized in Table 11. Circular DEQ 2, entitled Design Standards for Wastewater Facilities, is a primary reference for construction of public sewage systems. The circular is adopted by the Montana Board of Environmental Review under the authority of MCA 75-6-103(2)(f). If the public sewage system proposed is a subsurface system (septic system), DEQ Circular 4 applies.

Table 11
Administrative Rules of Montana Governing Public Sewage Systems

TITLE	CHAPTER	ARM Reference
(17) Environmental Quality	(30) Water Quality	17.30.501-518 (Mixing Zones in Surface Water and Ground Water)
(17) Environmental Quality	(30) Water Quality	17.30.701 through 717 (Nondegradation of Water Quality)
(17) Environmental Quality	(30) Water Quality	17.30.10 through 17.30.14 Discharge Permits
(17) Environmental Quality	(40) Water Treatment Systems and Operators	17.40.201 et seq. Water and Wastewater Systems and Operators
(17) Environmental Quality	(40) Water Treatment Systems and Operators	17.40.301 et seq. Wastewater Treatment Works Revolving Fund

Ground Water Mixing Zones: Rules governing the designation of ground water mixing zones for public sewage systems are provided in ARM 17.30.501 through 518. A duel definition of a mixing zone is provided in 17.30.502 (6), which also references MCA 75-5-103 (18). The MCA definition states that a mixing zone "*means an area established in a permit or final decision on nondegradation issued by the department where water quality standards may be exceeded, subject to conditions that are imposed by the department and that are consistent with the rules adopted by the board.*"

Additionally the ARM defines a mixing zone as "*a limited area of a surface water body or a portion of an aquifer, where initial dilution of a discharge takes place and where water quality changes may occur and where certain water quality standards may be exceeded*." ARM 17.30.508 (2) states "*No mixing zone for ground water will be allowed if the zone of influence of an existing drinking water supply well will intercept the mixing zone*."

The rules specify that the standard mixing zones for public sewage systems are 500 feet long. The thickness of a standard mixing zone in an unconfined aquifer is 15 feet, starting at the top of the water table. The rules designating mixing zones do not require the use of monitoring wells for compliance purposes. Instead, the rules give DEQ the discretion to require them, with ARM 17.30.517 stating "*Monitoring may be required at the down-gradient boundary of the mixing zone to measure compliance for a ground water mixing zone established for other than a single family septic system drainfield, if there is an overriding site-specific impact-related reason to require monitoring and the mixing zone is within 500 feet of surface water, another ground water mixing zone, or a drinking water well, or if there is some other overriding site-specific, impact-related reason to require monitoring.*" The rules also allow mixing zones to extend across property boundaries, regardless of adjoining landowner consent.

Non-degradation of Water Quality: In terms of public sewage systems the non-degradation rules are tied to the State classification of ground water and to nitrate and phosphorous as the pollutants of concern. The rules apply to Class I and Class II ground waters which are defined in MCA 17.30.1106 as follows: Class I ground waters are those ground waters with a natural specific conductance less than or equal to 1,000 micro-Siemens/cm at 25ºC. Class II ground waters are those ground waters with a natural specific conductance that is greater than 1,000 and less than or equal to 2,500 micro-Siemens/cm at 25ºC. The rules, and methods for conducting non-degradation analysis are discussed in Chapter 7.

Discharge Permits: Montana has primacy for compliance with the federal Clean Water Act, and issues permits for point-source discharges to ground water and surface water. ARM 17.30.10 (Montana Ground Water Pollution Control) provides rules for issuing discharge permits for discharge of treated wastewater to ground water. Public sewage systems that discharge to surface water must obtain a Montana Pollution Discharge Elimination System (MPDES) permit from DEQ. ARM 17.30.12 provides water quality standards for MPDES permitted discharges, and ARM 17.30.13 contains the rules for MPDES permits to discharge to surface waters.

Water and Wastewater Systems and Operators**:** ARM 17.40.202 provides a classification of wastewater treatment systems as required by MCA 37-42-104. The following classes of wastewater treatment systems have been adopted by DEQ: Class 1--conventional, high rate, or biological nutrient removal activated sludge systems or any treatment system with mechanical tertiary (advanced) treatment processes; Class 2--treatment such as extended aeration, oxidation ditches, trickling filters, package plants, sequencing batch reactors, or bio-disc treatment systems; Class 3--aerated lagoons; and Class 4--lagoons not utilizing artificial aeration. ARM 17.40.203 contains the rules governing the certification of wastewater treatment plant operators.

State Revolving Fund Program: ARM 17.40, Subchapter 3 contains the rules for administration of this program, which creates a perpetual financing mechanism for eligible water pollution control projects through use of low interest loans and other financial incentives. The program loans typically have up to a 20-year repayment schedule, but can be extended to up to 30-years if the project applicant has documented hardships. This program has been used for most, if not all of the large wastewater treatment plant upgrades in Gallatin County.

4.2.3 Review, Approval, and Permitting of Public Sewage Systems

Review and approval of public sewage systems is generally the responsibility of DEQ. The process for review and approval depends on when the system was built, the system design flow, the proposed method of discharge (surface water or ground water), and if the system is associated with a subdivision proposal. A flow chart, showing the public sewage system review process, is shown in Figure 15.

If a public sewage system is proposed as part of a subdivision, it's reviewed by the DEQ Subdivision Section, including an engineering review for compliance with Circular DEQ 2 and 4. The review process includes a non-degradation analysis. The DEQ Public Water Supply Section reviews and approves public sewage systems not associated with a subdivision. Regardless of the association with subdivision, if the proposed sewage system has a design flow of more than 5,000 gpd, the DEQ Water Protection Bureau also reviews the system and issues any required discharge permits.

If a public sewage system is approved by DEQ, EHS issues a local permit to operate the system. This has not always been the case. Prior to the early 1990's EHS was issuing local permits for these systems, but they stopped doing it at the direction of DEQ (GCCHD 2009). Starting in July 2001 EHS again started issuing permits for public sewage systems. The local permits are only issued if the proposed system discharges to ground water. After EHS issues a permit for a public sewage system they may also inspect the system during installation. No information was obtained on how many public sewage systems EHS has inspected during installation.

4.2.4 Inspection and Monitoring of Public Sewage Systems

DEQ is responsible for operational oversight and inspection of public wastewater systems once they are approved. The GLWQD could not find any information showing that DEQ has any kind of structured process for routine inspection and monitoring of public sewage systems in Gallatin County. It is not clear, based on review of the applicable MCA and ARM governing public sewage systems, what Section or Bureau of DEQ is responsible for inspection of public sewage systems. Most inspections of public sewage systems in Gallatin County have been completed by DEQ staff from the State Revolving Fund (SRF) Program, primarily for systems that have received SRF funding support or technical support.

Numerous requests to DEQ for a list of systems in Gallatin County that have been inspected have been made by EHS, but to date, DEQ has not provided the information (Moldroski 2010). For inspections that may have been done in the recent past, it also appears that DEQ does not work with or inform the Health Department of the inspections. MCA 75-6-104(12) allows DEQ to enter into agreements with local governments for inspection of wastewater treatment facilities. DEQ may also delegate review of small public sewage systems to local governments. DEQ has not entered into an agreement with Gallatin County for these services.

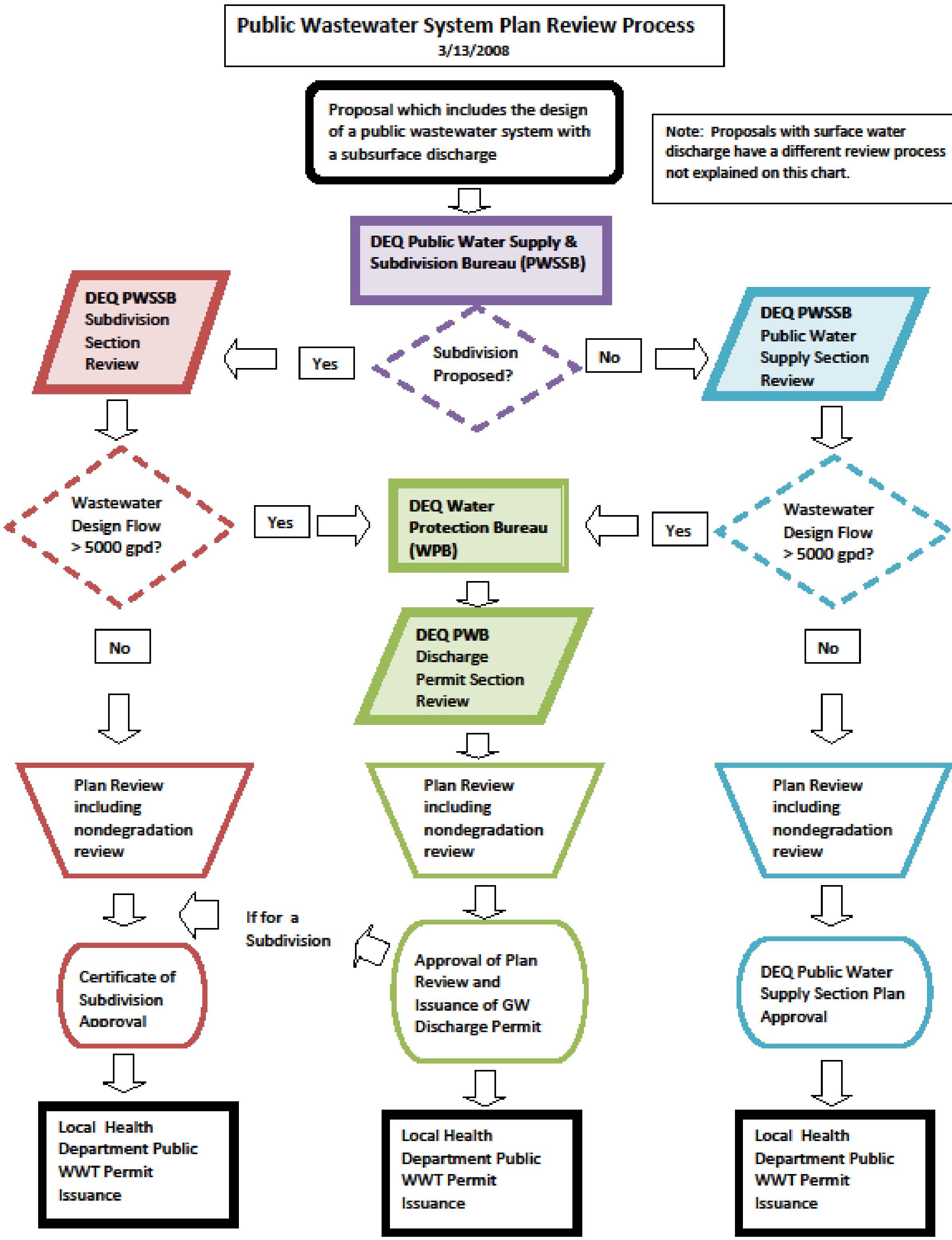

Figure 15. Flow Chart for Approval of Public Sewage Systems with Ground Water Discharge
Three different divisions of DEQ are involved in review and approval of public sewage systems. In all cases, once approved, EHS now issues a local permit. From (GCCHD 2009), Appendix C.

4.2.5 Ground Water Discharge Permits and Spray Irrigation

Starting in May 1998, new public sewage systems with a design flow of more than 5,000 gpd were required to obtain a Montana Ground Water Pollution Control System (MGWPCS) permit if the treated wastewater was going to be disposed of in the subsurface (ARM 17.30.10). Older treatment systems, and those approved after May 1998 with design flows less than 5,000 gpd are not required to obtain a ground water discharge permit. A notable exception is that systems constructed prior to May 1998 that are found to be contaminating ground water above drinking water standards may be required to obtain a permit. A local example of this exception is the River Rock Sewer and Water District, which operates a lagoon system constructed prior to 1998. Based on monitoring well data for this system, DEQ has required them to obtain a ground water discharge permit. MGWPC permits are issued by the Water Protection Bureau of DEQ, and must be renewed on a periodic basis. Recently DEQ issued permits for the River Rock Sewer and Water District, the City of Belgrade, and Utility Solutions in Four Corners.

The MGWPC permit process includes establishment of a designated ground water mixing zone. DEQ has the discretion in the permit process to require ground water monitoring wells within the mixing zone and at the end of the mixing zone. Because of this discretion not all public sewage systems in Gallatin County that have ground-water discharge permits have ground water monitoring wells. Without the monitoring wells, it is difficult to monitor ground-water quality down-gradient of disposal areas and verify compliance with discharge permit requirements. Permitted systems are also required to submit quarterly monitoring reports to DEQ for any required monitoring. The GLWQD requested copies of these monitoring reports for the 2nd quarter of 2009 (April-June), and reviewed the reports to see what information was available. Monitoring reports were obtained for 8 systems that had approved ground water discharge permits. One problem noted is that DEQ does not appear to provide copies of quarterly monitoring reports to EHS for systems in Gallatin County.

If systems use spray irrigation as the sole means of disposal of treated wastewater, they are not required to obtain a ground water discharge permit. It is assumed that there is no recharge of ground water from the irrigation system(s). In reality there most likely is some infiltration of the treated wastewater into the ground, and recharge of ground water below the spray irrigation area. The amount of recharge is dependent on the method of irrigation. In agricultural practices, pivot irrigation systems have about a 10% recharge rate, and wheel lines have about a 20% recharge rate.

4.2.6 Surface Water Discharge Permits

If a public sewage system discharges to a surface-water body, the Water Protection Bureau issues a Montana Pollution Discharge Elimination System (MPDES) permit, following the rules in ARM 17.30.13. The MPDES permit process mirrors the requirements of national pollutant discharge elimination system (NPDES) program, established and administered by EPA under the federal Clean Water Act. These discharge permits have been issued for many years, and the May 1998 start date for ground water discharge permitting does not apply. Based on the records compiled by EHS, there are 6 pubic sewage systems with MPDES permits for surface water discharge.

The practice of discharging treated wastewater directly to surface water was much more common in the past, and many of the large municipal treatment systems in the State use this practice, including the City of Bozeman, the City of Three Forks, the Town of Manhattan, and the Town of Willow Creek. The Holcim Inc. cement plant north of Three Forks also has a surface water discharge permit. The last new discharge permit issued in Gallatin County was for the Big Sky Water and Sewer District.

Issuance of the Big Sky surface water discharge permit was very controversial, and while it is still valid, the District has never used it. Surface water discharge permits (MPDES) must also be periodically renewed, and like with the MGWPCS permits, there is a significant backlog of expired permits. The City of Bozeman recently renewed their MPDES permit after operating for several years without one. The Town of Manhattan still has not been granted a permit for their new treatment plant.

4.3 Stages of Wastewater Treatment

The design processes used by public sewage systems to treat wastewater vary significantly depending on the type of system. Large centralized wastewater treatment systems such as the City of Bozeman plant are complex and highly mechanized, while some public systems are basically large versions of a standard septic tank and drainfield system. Despite all the variations in design of wastewater treatment systems, the basic physical, chemical, and biological processes used to treat wastewater are similar. The differences in the level of wastewater treatment depend on which processes a treatment system uses and the sequence of the wastewater processing.

Physical processes are used to remove solids, oils, and fats, from the wastewater. Biological treatment processes are then used to breakdown suspended and dissolved organic material in the wastewater, using indigenous bacteria and protozoa. Most of the biological treatment relies on promoting growth of bacteria that require oxygen to proliferate (aerobic bacteria), and protozoa, using some type of aeration process. The microbes breakdown organic waste into basic chemical compounds including transformation of ammonia and organic nitrogen compounds to nitrate (see Appendix B for more detail).

The aerobic biological treatment process is very effective at transforming organic nitrogen compounds to nitrate, but they do not remove nitrogen from the wastewater. Once the organic nitrogen compounds are transformed to nitrate, wastewater treatment systems rely on processes that create anaerobic conditions and promote the growth of facultative anaerobic bacteria (bacteria that do not need oxygen to survive). The anaerobic bacteria can convert the nitrate created by the aerobic bacteria into nitrogen gas, which escapes to the atmosphere, effectively removing nitrogen from the wastewater.

Overall, the conventional processes used to treat wastewater are traditionally divided into the three stages of primary, secondary, and tertiary treatment. A fourth stage of pre-treatment is often incorporated into municipal plants or plants that handle special wastes from commercial or industrial facilities. The following subsections describe the basic stages of wastewater treatment:

4.3.1 Pre-Treatment. Treatment plants that receive “special wastes”, such as wastewater from restaurants, carwashes, automotive repair facilities, and other commercial and industrial facilities often require pretreatment of the special wastewater to avoid upsets and problems at the treatment plant, clogging of sewer mains, and contamination of the final effluent and biosolids that are produced during treatment. Examples of pre-treatment systems would be grease traps for restaurants, sand traps for car washes, and oil/water separators for automotive repair facilities. If a facility produces wastewater that is very acidic or basic, the wastewater may need to be neutralized. Wastewater containing high levels of heavy metals may need to be pretreated to remove the metals prior to discharge to the treatment system. Because of these concerns, most large municipal plants, including the City of Bozeman Plant have Pre-treatment Programs with a Pre-treatment Coordinator that inspects and permits special waste facilities.

4.3.2 Primary Treatment: Primary treatment is the first stage in the treatment of wastewater after any pre-treatment. This is the most basic level of treatment, relying primarily on physical processes to separate solids, oils, and fats from the wastewater. For non-mechanical treatment systems such as a septic tank-drainfield system, all of the primary treatment occurs in the septic tank. Fats, oils, and greases float to the top of the tank forming what is commonly referred to as a scum layer. Inorganic and organic solids that are heavier than water settle to the bottom of the septic tank.

In mechanical treatment plants the incoming wastewater usually passes through some type of structure, often called the head works, which contains screens to remove large solids such as cloth, plastics, and wood. The screen structure usually also has a grit chamber that reduces flow velocities and allows coarse particles (grit) to settle out. The grit includes non-degradable heavy solids such as stones, coarse sand and bottle caps. The screens and grit chamber remove materials that can clog equipment and damage pumps. After the wastewater has passed through the screen and grit chamber, it usually flows to some type of primary sedimentation tank where water velocities are low. These tanks, usually referred to as primary clarifiers, allow for finer organic and inorganic solids to settle out of the wastewater. Oils and grease are also separated and skimmed off of the wastewater. The remaining wastewater, a more homogenous liquid mixture, is then decanted from the primary clarifier. Figure 16 shows a photograph of a primary clarifier at the City of Bozeman Wastewater Treatment Plant.

4.3.3 Secondary Treatment: The secondary treatment stage is mainly based on biological treatment of the wastewater, although some additional physical settling of inorganic and organic solids also occurs. During this stage of treatment the goal is to significantly reduce the amount of *total suspended solids* in the wastewater and the *biochemical oxygen demand* (BOD), typically by at least 85%. Bacteria and protozoa consume biodegradable, soluble, organics such as sugars, fats, and other organic compounds. Most of the biological treatment in this stage is completed by aerobic bacteria, and protozoa, which requires large amounts of oxygen. For this reason, all systems use some method of aeration to provide large amounts of oxygen to support the bacteria and protozoa. This is most commonly accomplished using blowers with diffusion bubblers, or mixers to rapidly stir the wastewater.

Among all of the different types of treatment plants, there are two basic methods used to achieve secondary treatment. These two methods are referred to as “suspended growth” and “fixed film” processes, depending on where the bacteria and protozoa are colonized. The type of method employed is often what is used to classify the treatment plant. For example, the Bozeman treatment plant is classified as an “activated sludge” plant, which is a suspended growth process. Here the bacteria and protozoa are mixed with and suspended within the wastewater during treatment. The Bozeman plant uses large blowers with diffusion bubblers to provide aeration of the wastewater. The other secondary treatment method is referred to as a “fixed film” process. In this type of treatment system the bacteria and protozoa are colonized on a fixed substrate and the wastewater is passed over the substrate. The newly constructed Manhattan treatment plant is unique in that it employs both an activated sludge process and a fixed film process. The plant uses “biowheels” as a substrate for microbes to live on. The biowheels are partially submerged in the wastewater and slowly rotates in it. A biofilm grows on the surface of the wheels and interacts with the wastewater. The rotating biowheels also mix air into the wastewater to provide aeration (Figure 17).

4.3.4 Tertiary Treatment: Tertiary treatment, also sometimes referred to as advanced treatment, can consist of any type of additional treatment required prior to discharging treated wastewater to the environment. More than one tertiary treatment process may be used at a treatment plant. The two most common types of tertiary treatment are nutrient reduction, and disinfection. Tertiary treatment for nutrient reduction is designed to reduce the levels of nitrogen and/or phosphorous in the final treated wastewater. This type of treatment is usually incorporated if the treated wastewater is discharged to a surface water body, to avoid excessive growth of algae in the receiving surface water. While a certain level of nutrient reduction is accomplished during secondary treatment, tertiary treatment steps for nutrient remove are designed to significantly decrease nutrient concentrations in the wastewater beyond what can be achieved during secondary treatment.

Figure 16. Primary Clarifier Tank at the Bozeman Wastewater Treatment Plant. *Incoming wastewater flow is slowed, allowing heavy solids to settle and lighter solids, oils and grease to float to the surface. Scum is scraped off the top and sludge is pumped from the bottom. The remaining water is decanted for continued treatment. (Photo courtesy of Tom Adams)*

Figure 17. Biowheels at the New Manhattan Wastewater Treatment Plant. *The biowheels provide a substrate for bacteria and protozoa that treat the wastewater to colonize on. The biowheels slowly rotate in the wastewater providing contact with the bacteria and protozoa, and aeration of the wastewater.*

Currently none of the large treatment plants in Gallatin County incorporate tertiary treatment for nutrient removal. However, the new Manhattan plant is considered a biological nutrient reduction plant, where increased nutrient removal is accomplished during advanced secondary treatment. The Bozeman plant will also be a full biological nutrient reduction plant when current upgrades are completed. Again, this biological nutrient reduction is being accomplished during advanced secondary treatment. If disinfection is practiced, it is always the final process. This method of tertiary treatment is also most commonly applied if the treated wastewater will be discharged to a surface water body where human contact may occur. It is also applied if the treated wastewater is used for spray irrigation and human contact may occur. The two most common forms of disinfection are addition of chlorine, and use of ultraviolet light. Several of the treatment plants in Gallatin County incorporate disinfection in their treatment process, including the Bozeman, Manhattan, and Big Sky treatment plants.

4.4 Inventory and Mapping of Public Sewage Systems

Inventory and mapping of all the known public sewage systems in Gallatin County has been completed by EHS and the GLWQD. This work included compiling historic information, locations of treatment systems, types of treatment systems, current discharge volumes, approved discharge volumes, permitted ground water and surface water discharges, and when available, effluent water quality. The following subsections describe the information compiled.

4.4.1 Compilation of Information on Public Sewage Systems

EHS completed extensive work to compile information on all of the known public sewage systems in Gallatin County. They reviewed files maintained by DEQ in Helena, including archived files for older systems. Information on system design, approved treatment capacity, system plans, as-built drawings, and discharge permits issued by DEQ for ground water and surface water discharges, was obtained if available.

To obtain this information, EHS staff made multiple trips to Helena to review files. For some systems DEQ appears to have good records. For other systems, primarily older ones, DEQ has limited information. EHS combined the public sewage system information obtained from DEQ with existing information they have on file, to establish updated files for each of the known public sewage systems in Gallatin County. EHS also entered information for all of the public sewage systems into their Tyler® database, which has in the past been mainly used to track individual septic systems. The GLWQD accessed these files multiple times to obtain information for this report. In addition the GLWQD contacted some system operators by phone, and completed site visits of some of the systems in the County, to obtain additional information.

A significant problem noted was that information on public sewage systems contained in DEQ files is not readily accessible to the public. System information is often contained in multiple files maintained by different sections and bureaus of DEQ. For example, files for a system might be found in the Subdivision Review Section of DEQ if the system was reviewed and approved as part of a subdivision application. If the system was required to obtain a ground water or surface water discharge permit, information might be found in files maintained by the Water Protection Bureau of DEQ, and if there have been problems with the system, the DEQ Enforcement Division may also have a file for the system. Several systems have also received funding or technical assistance from the State Revolving Fund Program, which also maintains files for public sewage systems.

While DEQ may have a reasonable internal system for organizing and keeping track of the multiple files for public sewage systems, it is difficult for the general public and local government agencies to obtain the information. In most cases travel to Helena is required to review the files and obtain information, and an advanced call is required to make sure the files will be available. DEQ does not maintain a public access database of public sewage system information, and overall, there is no structured system for public access to hard copy files on public sewage systems that are maintained by DEQ.

4.4.2 Construction of County-Wide Public Sewage System GIS Databases

Using information from public sewage system files, and GPS data collected during field inspections, EHS constructed a spatial database of public sewage systems using GIS software. The database includes a point layer showing the locations of public sewage systems in Gallatin County. For systems that have been GPS located, there are sometimes multiple points recorded to show the locations of specific components of the system. Information in the database associated with each location is currently limited, but is being added by EHS on a routine basis. The GLWQD copied and modified the EHS public sewage systems database to create a point layer that just shows the locations of disposal sites for treated wastewater. Information on some systems was updated, and an effort was made to find actual, estimated, or permitted discharge flows for each system. For small systems with no flow information, a default discharge of 750 gpd was assigned.

4.4.3 Results of County-Wide Public Sewage System Inventory and Mapping

The GLWQD public sewage systems GIS database currently contains records for 147 systems. Vaulted toilets at campgrounds, fishing access sites, and other locations, were not counted as public systems. Cumulative discharge of treated wastewater from all of the systems in the database is about 8.54 mgpd using measured or estimated discharge. If permitted or design flows are used the cumulative discharge is about 11.28 mgpd. Appendix A, Map A2, entitled <u>Public Sewage Systems and Sewer and Water Districts in Gallatin County</u> shows locations of all of the public systems in the GIS database. Attachment B (GCCHD 2009) includes a table of all of the known public systems.

Types of Public Sewage Systems: Public sewage systems in Gallatin County range from rudimentary holding tanks and seepage pits, to complex mechanical treatment plants that provide primary, secondary and tertiary treatment. A summary of public sewage systems by type is provided in Table 12.

Table 12
Inventory Summary for Public Sewage Systems in Gallatin County

Type of Treatment System	Secondary Treatment+	# of Systems	Estimated/Reported Discharge (gpd)	Permitted Discharge
Holding Tank	N/A	2	930	1,100
Septic Tank w/ Seepage Pits	Very Limited	2	1500	1,500
Septic Tank w/Gravity-Feed Drainfield	Limited	31	60,242	60,242
Septic Tank w/Pressure-Dosed Drainfield	Limited	51	216,519	216,519
Septic Tank w/Elevated Sand Mound	Limited	10	21,580	32,804
Septic Tank w/ Open Bottom Sand Filter	Limited	1	9,745	9,745
Septic Tank w/Intermittent Sand Filter	Yes	2	5,290	5,290
Septic Tank w/Recirculating Sand Filter*	Yes	15	146,785	177,705
Septic Tank w/Recirculating Trickling Filter	Yes	9	42,575	62,575
Lagoon Systems	Yes-limited	13	1,816,575	2,990,925
Sequenced Batch Reactor Plants	Yes	7	497,271	918,138
Activated Sludge (mechanical) Plants	Yes	4	5,705,348	6,792,537
TOTALS		**147**	**8,524,360**	**11,269,090**

+All systems assumed to provide basic primary treatment
*One system discharges to an elevated sand mound, all others to pressure dosed drainfield

Basic Septic Systems: Of the 147 public sewage systems in the County, 86 (59%) are basic septic system designs. The Stockyard Café in Bozeman, and Stacy's Bar and Restaurant in Gallatin Gateway, use holding tanks. The Lionshead Resort in West Yellowstone, and the Happy Hour Bar, use seepage pits. According to EHS, the Happy Hour Bar is under new ownership, and may be upgraded. Of the remaining systems, there are 31 gravity-feed drainfield systems and 51 pressure-dosed drainfield systems. These systems provide the same basic level of treatment as individual septic systems, but on a larger scale. Collectively the 86 basic septic systems discharge an estimated 279,191 gpd. While they represent 59% of the public systems in Gallatin County, they only treat about 3% of the total wastewater generated by all public systems.

Lagoon Systems: Thirteen public sewage systems, including several centralized systems, use lagoons for wastewater treatment. Table 13 summarizes the inventory results for lagoon systems. Most lagoons are aerated and discharge to ground water. Facultative anaerobic lagoons include the Amsterdam/Churchill, Willow Creek, Rider Trailer Court, and Bridger Pines lagoons. The quality of the effluent produced by lagoon systems is highly variable, and several of the lagoon systems in Gallatin County are known to have problems. The Amsterdam/Churchill lagoon system appears to have a substantial leakage problem. The Bridger Pines Subdivision lagoon system is currently under a moratorium by DEQ, and the Forest Park lagoon system has been under investigation by the DEQ Enforcement Division. The River Rock lagoon system was recently under a DEQ enforcement order due to elevated levels of nitrate detected in ground water monitoring wells. A small lagoon system serving the Rider Trailer Court in Manhattan is currently being evaluated by EHS and DEQ. It is not clear what this lagoon system was approved for, and there is a possibility that it has a substantial leakage problem.

Table 13
Inventory Summary for Lagoon Systems in Gallatin County

Facility Name	Lagoon Type	Disposal Method	Estimated or Measured Discharge (gpd)	Permitted/Approved Discharge (gpd)
Belgrade City, + IP Cells	Aerated	Ground Water/Irrigation	600,000	903,000
Bucks T4-Best Western	Aerated	Ground Water	17,300	17,300
River Rock	Aerated	Ground Water	374,000	374,000
Riverside W&S District	Aerated	Ground Water	30,000	30,000
Three Forks	Aerated	Surface Water	172,800	453,000
Bridger Pines Subdivision	Facultative	Evapotranspiration	17,100	17100
Forest Park	Aerated	Ground Water	32,725	32,725
West Yellowstone	Aerated	Ground Water	416,000	1,000,000
West Yellowstone KOA	Aerated?	Ground Water	22,750	22,750
Hebgen Lake Estates	Aerated	Ground Water	39,100	39,100
Amsterdam-Churchill	Facultative	Ground Water	84,100	76,250
Rider Trailer Court	Facultative ?	Ground Water	9,000	9,000
Willow Creek	Facultative	Surface Water	19,000	34,000
TOTALS			**1,833,875**	**3,008,225**

Methods of Disposal for Treated Wastewater: About 69% of all treated wastewater currently being disposed of in Gallatin County is discharged to surface water, 22% is discharged to ground water, and about 9% is land applied (spray irrigation). The estimated discharge for systems that use spray irrigation may be high, because information on these discharges was limited. Both the River Side Water and Sewer District (30,000 gpd) and Buck's T-4 in Big Sky (17,300 gpd) are reported to rely on spray irrigation, but this could not be verified. The City of Belgrade uses both spray irrigation and rapid infiltration beds to treat about 600,000 gpd. No records were obtained to show how this disposal is distributed, so an estimate of 60% spray irrigation (360,000 gpd) and 40% ground water discharge (240,000 gpd) was used. Cumulative discharge by method of disposal is summarized in Figure 18.

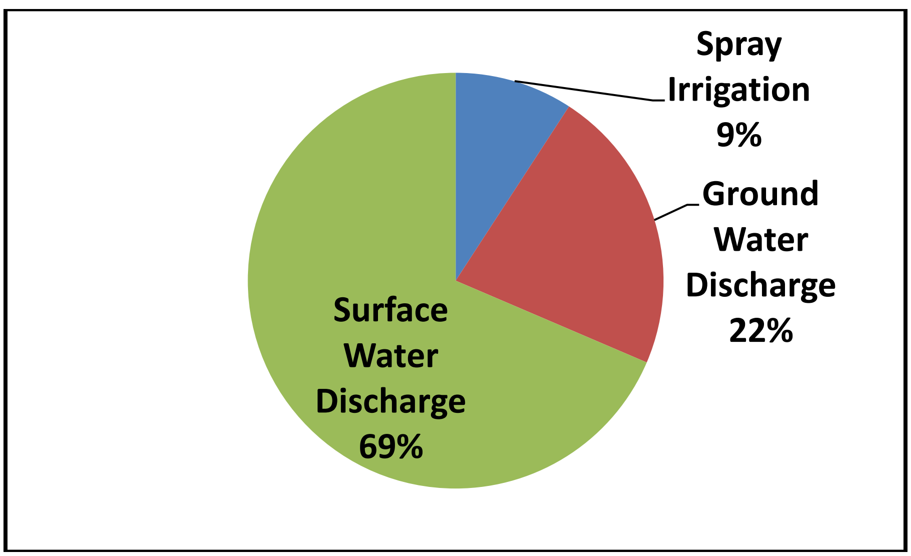

Figure 18. Cumulative Public Sewage System Discharge by Disposal Method. *An estimated 8.52 mgpd is discharged by public sewage systems in Gallatin County. The majority (69%) is discharged to surface water by large centralized systems. Estimates for spray irrigation discharge may be high due to lack of accurate records.*

Discharge of Treated Wastewater to Ground Water: Total discharge of treated wastewater to ground water in the County, from all public systems, is about 1.9 million gpd. Lagoons account for most of this discharge, with an estimated discharge to ground water of 1.2 million gpd. The only mechanical treatment plant that discharges to ground water is Utility Solutions, with a reported discharge of about 58,000 gpd. The remainder of the ground water discharge is from the various types of septic systems, and sequenced batch reactor plants. These other systems discharge about 0.6 million gpd, to ground water. A summary of ground water discharge by system type, excluding lagoons and mechanical systems discharge is summarized in Figure 19.

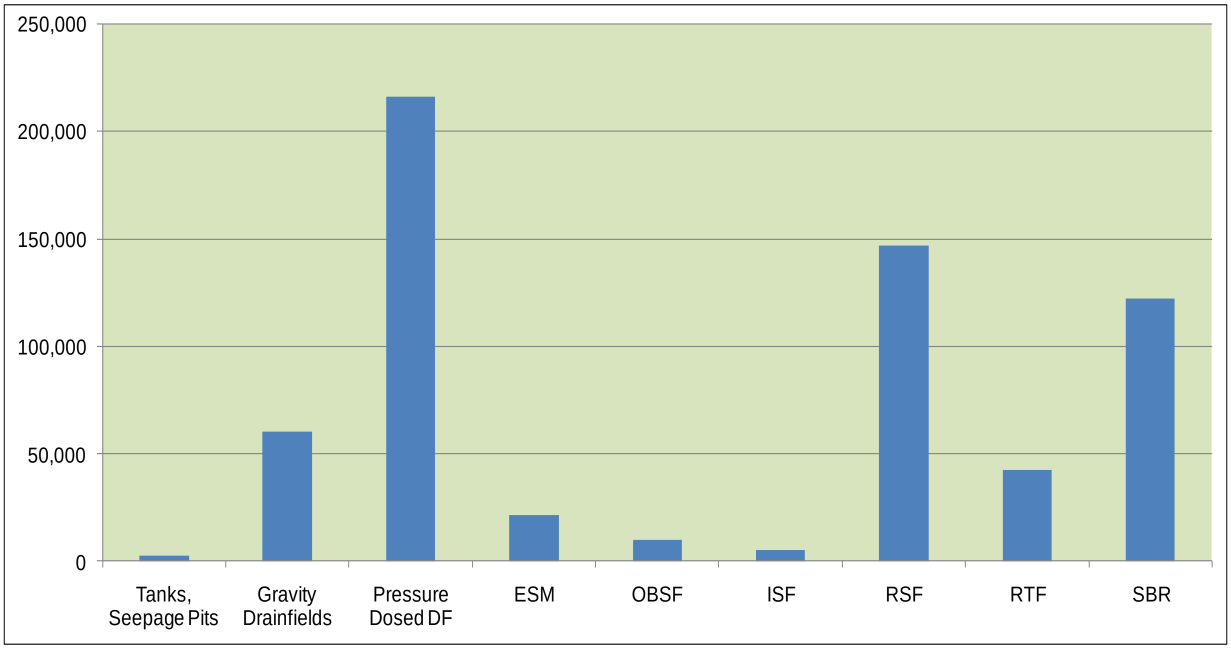

Figure 19. Discharge to Ground Water by System Type, Excluding Lagoons. *Most discharge of treated wastewater by systems that discharge to ground water, excluding lagoons, is from pressure dosed drainfield systems, recirculating sand filters (RSF), and sequence batch reactors (SBR).*

Permitted Public Sewage Systems**:** Most public sewage systems that discharge to ground water do not have discharge permits. Of the 147 public sewage systems in Gallatin County, 140 of them discharge to ground water or use spray irrigation for disposal of treated wastewater. Of these, only 16 systems have ground water discharge permits (11%). There are 6 systems that discharge to surface water, and all of them have surface water discharge permits, or have permits pending. Public sewage systems in Gallatin County that discharge to surface water include the City of Bozeman, the City of Three Forks, the Town of Manhattan, the Town of Willow Creek, and the Holcim Inc. Cement Plant at Trident. One of the surface water discharge permits is the permit issued to the Big Sky Sewer and Water District for discharge to the Gallatin River. This permit has never been exercised. Public sewage systems with ground water discharge permits are discussed in more detail in Chapter 7 (section7.3.3). Table 14 shows permitted systems, and which ones have monitoring wells and submit monitoring reports to DEQ.

Table 14
Summary of Ground Water Discharge Permits for Public Sewage Systems

System Name	MPDES Permit #	Disposal Method	Monitoring Reports	Monitoring Wells
4 Dot Meadows	MTX000108	Pressure Dosed Drainfield	Yes	1 well
Belgrade Gardens	MTX000136	Pressure Dosed Drainfield	No	Unknown
Bozeman KOA	MTX000126	Pressure Dosed Drainfield	No	Unknown
Bridger Bowl Base Area	MTX000144	Pressure Dosed Drainfield	No	Unknown
City of Belgrade	MTX000116	Rapid Infiltration Beds	Yes	Multiple Wells
Countryside Estates	MTX000177	Pressure Dosed Drainfield	Yes	2 Wells
East Gallatin Commercial	MTX000165	Pressure Dosed Drainfield	No	Unknown
Firelight Meadows A,B,C	MTX000129	Pressure Dosed Drainfield	No	Unknown
Greenhills Ranch	MTX000150	Pressure Dosed Drainfield	No (Not Active)	Unknown
Lazy J South	MTX000172	Pressure Dosed Drainfield	Yes(Not Active)	1 Well
Manley Meadows	MTX000153	Elevated Sand Mound	Yes	4 Wells
RAE Water&Sewer Dist.	MTX000117	Rapid Infiltration Beds	Yes	4 Wells
Ramshorn View Est.	MTX000103	Pressure Dosed Drainfield	No	Unknown
River Rock	?	Rapid Infiltration Beds	No	3 Wells
Red Creek Ranch	MTX000119	Pressure Dosed Drainfield	No	Unknown
Utility Solutions	MTX000110	Rapid Infiltration Beds+DF	Yes	None Reported
Valley Grove IV Sub	MTX000112	Pressure Dosed Drainfield	Yes	1 Well

4.4.4 Recent Infrastructure Investments to Centralized Public Sewage Systems

In August 2009 the GLWQD conducted a phone survey of centralized public sewage systems to obtain general information on the systems, and information on recent work completed by the systems to upgrade or expand their treatment systems. Most of the municipalities or urbanized areas that operate centralized public sewage systems in the County have made significant investments in wastewater collection and treatment infrastructure in the last 10 years (2000 to 2009).

Utility Solutions in Four Corners made the largest investment, with significant expansion of wastewater collection and wastewater disposal infrastructure in the Four Corners area. The cost of this expansion was about $22,500,000 (Barb Campbell 2009). The City of Bozeman has made several upgrades to their collection system and treatment plant over the last 10 years costing, at a cost of about $6,000,000 (Tom Adams 2009). In addition, the City is currently working on a major upgrade and expansion of the treatment plant, with work being completed in several phases. When all of the phases are completed the projected cost of the upgrades is about $54,000,000.

Other centralized systems that have made significant infrastructure investments in the last 10-years include the City of Belgrade, the City of Three Forks, the Town of Manhattan, the Town of Willow Creek, the RAE Water and Sewer District, and the Big Sky Water and Sewer District. The Town of West Yellowstone is the only centralized public sewage system that did not report any significant upgrades during the last 10 years, although several future upgrades are in the planning phase. Collectively the large centralized systems in Gallatin County invested about $60,150,000 on wastewater collection and treatment infrastructure improvements between 2000 and 2009. A summary of the investments and upgrades is shown in Table 15. With the addition of the current upgrades being made by the City of Bozeman, total infrastructure investments by centralized public sewage systems in Gallatin County since 2000 will total about $114,500,000.

Table 15
Centralized Public Sewage System Infrastructure Investments in Gallatin County 2000-2009[(a)]

Treatment System	Investment	Improvements Made	Future Improvements
City of Bozeman	**$6,000,000**	upgrades to collection sewers, digester, other equipment	expansion, conversion to biological nutrient reduction
City of Belgrade	**$7,000,000**	increased capacity, aerated lagoons and storage basin, spray irrigation	commission new Wastewater Facilities Plan
City of Three Forks	**$1,000,000**	slip lining of sewer mains, flow meters	unknown, possible new plant
Town of Manhattan	**$6,500,000**	new biowheel biological nutrient reduction plant	
Town of Willow Creek	**650,000**	new lagoon system, lift stations, UV disinfection	
Town of West Yellowstone	None Reported		pressure main, lift stations
Utility Solutions (Four Corners)	**$22,500,000**	various new collection sewers, lift stations, subsurface disposal structure	plant expansion as needed
RAE Water and Sewer Dist.	**$1,500,000**	new sequenced batch reactor plant	preliminary engineering for plant upgrade
Big Sky Water and Sewer Dist.	**$15,000,000**	new sequenced batch reactor plant	
TOTAL INVESTMENT	**$60,150,000**		

(a) Based on a phone survey completed by the GLWQD in August 2009, and other information collected by the GLWQD.

4.5 Descriptions of Centralized Public Sewage Systems in Gallatin County

A summary of the systems classified as centralized public sewage systems is provided in Table 16. A brief description of each type of system is provided in the following subsections.

4.5.1 City of Bozeman Treatment Plant

The Bozeman wastewater treatment plant, officially called the Bozeman Water Reclamation Facility, currently serves about 35,000 people, or about 30% of the County's population. The sewage collection system consists of over 150-miles of gravity sewer mains, 3,300 manholes, and 6 lift stations to pump sewage to the plant (GreatWest 2007). It is the largest centralized treatment plant in Gallatin County. The plant currently treats about 5.5 million gallons per day (mgpd) and has a design capacity of 5.8 mgpd. Due to ground water infiltration into sewer mains, illicit stormwater connections, and illicit connections of sump pumps, flows have been as high as 11 mgpd during the rainy season.

Originally constructed in 1970, the facility has been expanded and upgraded several times. The plant is classified as an activated sludge treatment plant, which is a type of suspended growth plant where the microbes are suspended in the water through mixing and aeration. Solids settle from the waste water in clarifiers which are then recirculated to maintain microbial activity. Waste solids are reduced in volume and toxicity in an *anaerobic digester* which generates methane. Some of the methane is used to heat the plant. Biosolids (digested solids) from the plant are land applied to agricultural fields in the valley. Specially designed trucks are used to inject the biosolids into the soil profile for use as fertilizer (see Chapter 6 for more on biosolids). The final treated effluent, shown in Figure 20, is chlorinated and then discharged to the East Gallatin River.

Table 16
Summary of Centralized Public Sewage Systems in Gallatin County

Facility	Type of Plant	Method of Disposal	Average gpd January	Average gpd July	Maximum Plant Capacity	DEQ Permitted Treatment Capacity
City of Bozeman	Modified Activated Sludge	Discharge to East Gallatin River	5,500,000	5,500,000	5,800,000	5,800,000
City of Belgrade	Aerated Lagoons	Spray Irrigation and Infiltration Beds	600,000	600,000	Unknown	903,000
Town of Manhattan	Biowheel	Discharge to Dita Ditch	140,000	140,000	Unknown	250,000
City of Three Forks	Facultative Lagoons	Surface Water via shallow GW	172,800	172,800	Unknown	453,000
Town of West Yellowstone	Aerated Lagoon	Ground Water	282,000	550,000	Unknown	1,000,000
Four Corners (UtilitySolutions)	Oxidation Ditch System	Drainfields	55,000	55,000	100,000	100,000
Big Sky W & S District	Sequenced Batch Reactor	Spray Irrigation	450,000	300,000	600,000	650,000
RAE W & S District	Sequenced Batch Reactor	Rapid Infiltration Beds	60,000	100,000	200,000	200,000
Town of Willow Ck.	Facultative Lagoons	Discharge to Madison River	19,000	19,000	Unknown	34,000
Amsterdam/Churchill	Aerated Lagoon	Ground Water	84,100	84,100	Unknown	76,250
TOTALS (gpd)			**7,362,900**	**7,520,900**		**9,466,250**

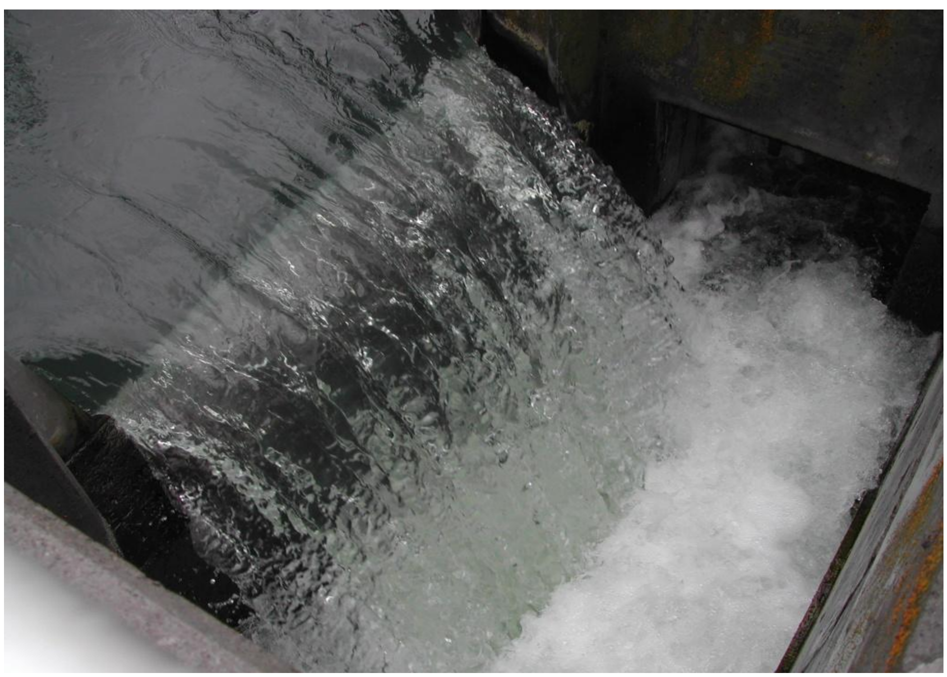

Figure 20. Photograph of Final Treated Effluent Leaving the City of Bozeman Plant. *Treated wastewater is disinfected prior to discharge to the East Gallatin River. The structure in the photograph is about 4-feet across, and the discharge is about 5.5 million gpd. Photo by GLWQD*

As currently configured, the Bozeman plant provides advanced secondary treatment of wastewater. The City is currently operating the plant as a modified activated sludge plant using a process referred to as the *Bardepho process*. This process includes alternating aerobic and anaerobic cycles during treatment to induce both aerobic microbes and facultative anaerobic microbes to treat the wastewater. With this process change, the plant reports about a 40% increase in total nitrogen removal as compared to previous operation of the plant (Adams 2009).

To accommodate anticipated future demands and increased regulation of the treated discharge, the City of Bozeman recently began work on a major plant upgrade and expansion estimated to cost approximately 54 million dollars. When all phases of the project are completed the plant capacity will be about 13 million gpd. Over the next 3 years the plant will be expanded and upgraded to provide tertiary treatment. The tertiary treatment will remove nitrogen and phosphorus from the wastewater using Biological Nutrient Removal (BNR) technology to further enhance treatment. The use of chlorine for final disinfection, which produces chlorinated byproducts, will be replaced with ultraviolet disinfection.

4.5.2 City of Belgrade

The Belgrade wastewater treatment plant is located within the Gallatin Field Airport property. The original treatment facility was constructed in 1973 and consisted of a four-cell facultative lagoon system. Facultative lagoons are generally shallow, and do not include any type of aeration. Instead, they rely on populations of facultative anaerobic bacteria that can live in both aerobic and anaerobic environments. The original facultative lagoons were unlined, had significant seepage losses, and the quality of the treated effluent was poor. Belgrade spent about $7,000,000 to upgrade and expand the plant, which was completed in 2004 (GreatWest, 2007). Two of the facultative lagoons were reconstructed, lined, and converted to mechanically aerated lagoons. The other two original facultative lagoon cells were converted to a single, lined storage basin for treated wastewater.

Treated wastewater from the storage basin is disposed of via spray irrigation at various locations within and near the Belgrade airport, and via 15 rapid infiltration basins. Ten infiltration basins are located adjacent to the lagoon system, and 5 additional basins are located southeast of the lagoons on airport property. The City of Belgrade has a discharge permit for disposal into the rapid infiltration basins, with a limit of 903,000 gpd. The percentage of treated effluent that is disposed of via spray irrigation vs. rapid infiltration could not be determined, but it is believed that as much as possible is disposed of using the irrigation system, to reduce nitrate loading to ground water. The spray irrigation system is computer controlled and cycles from location to location on a constant basis. An aerial view of the current Belgrade treatment plant area is shown in Figure 21.

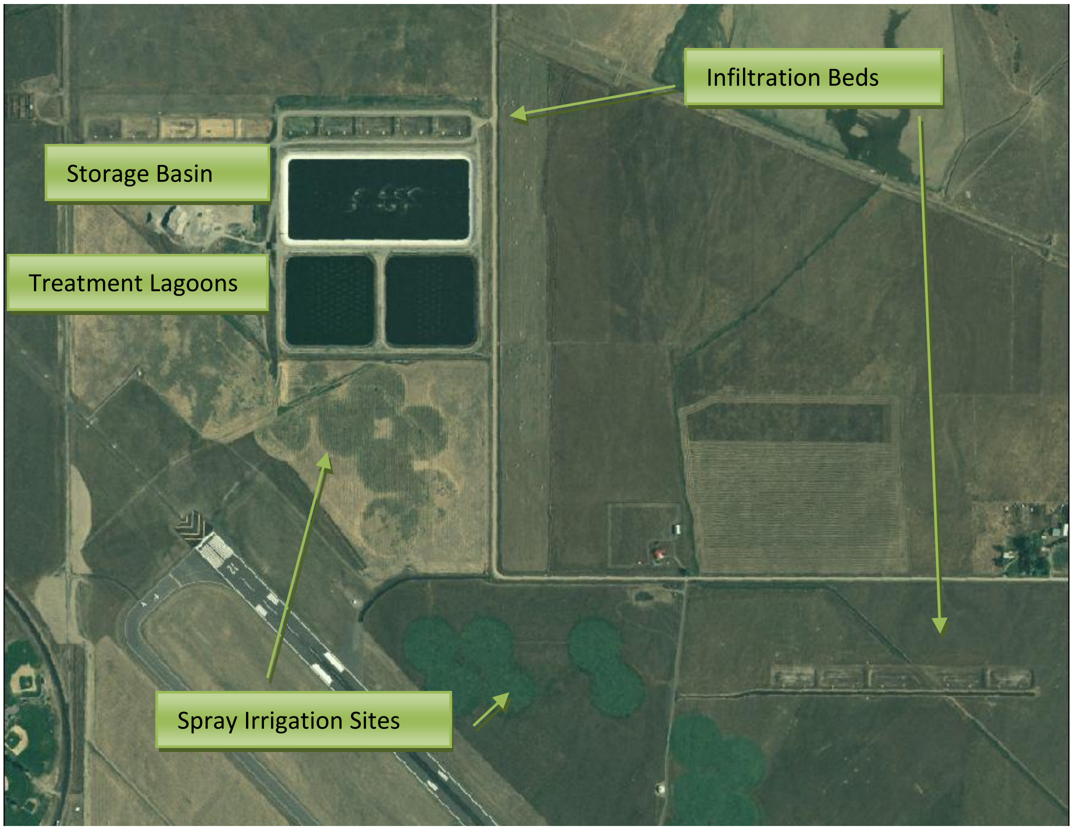

Figure 21. Aerial Photograph of the Belgrade Wastewater Treatment System. *The two aerated treatment lagoons, the storage basin for treated wastewater, rapid infiltration beds, and spray irrigation areas are easily visible on this aerial photograph taken in 2005.*

4.5.3 Town of Manhattan

The Town of Manhattan built an entirely new mechanical treatment plant in 2007, which uses an innovative biowheel treatment system. This plant replaced an old lagoon system, and is the newest centralized wastewater treatment system in Gallatin County. The system cost about $6,500,000 to build. The new plant became operational in the summer of 2008 and is currently treating about 140,000 gpd. The plant has a permitted treatment capacity of 370,000 gpd and is designed to be easily expanded. The system currently serves about 1,360 people, but could serve up to 2,700 people at full capacity (Johnson, 2009). It is classified as a biological nutrient removal plant, meaning it can remove a significant percentage of the total nitrogen and phosphorous from the influent

The biowheel technology used at the new plant is unique for the area. The plant design incorporates both activated sludge and fixed-film biological treatment processes. Incoming wastewater first flows into large equalization tanks where it is continuously mixed. The equalization basins allow for stabilization of flows and function basically as an activated sludge (suspended growth) treatment process, similar to the City of Bozeman plant. From the equalization basins the mixed wastewater enters large tanks containing the biowheels, which slowly rotate, partially submerged in the wastewater. The biowheels providing a surface for microbes to grow on that treat the wastewater, and slowly mix air into the wastewater (see Figure 17). After the biowheel tanks, the effluent flows into a final clarifier tank and then into a disinfection building. The final effluent is disinfected using ultraviolet (UV) light, and discharged to the Dita Ditch, which flows into the Gallatin River.

4.5.4 City of Three Forks

The City of Three Forks operates a facultative lagoon system that was built in about 1984. The system consists of two passively aerated 7.5-acre shallow lagoons. In the facultative lagoons, wastewater is treated in the upper, shallow zone by aerobic bacteria and algae, with passive oxygenation due to contact with the atmosphere. Sunlight supports the growth of algae, which also produce oxygen during respiration. In the deeper portions of the lagoons, oxygen is depleted and facultative anaerobic bacteria thrive, providing treatment of the wastewater. Facultative lagoons can be cost effective for smaller wastewater flows if you can rely on gravity flow to the plant and passive aeration. Because facultative lagoons include a mix of aerobic and anaerobic treatment environments, they can be effective at removing nitrogen. However, the treatment environment is hard to control, and often treatment can be significantly reduced.

After treatment in the facultative lagoons, wastewater is stored in a 15-acre bentonite-lined holding pond. From the holding pond treated water is discharged to rapid infiltration beds which are underlain by a drain system that discharges to the Madison River. The system is designed to treat wastewater from up to 2,400 residents, but is currently serving about 1,728 residents. The system is permitted for 453,000 gpd, but is currently treating about 172,000 gpd. In the past, the volume treated was poorly known, but Three Forks just spent about $150,000 installing four flow meters. They also recently spent about $850,000 to slip line sewer mains in the system to reduce ground water infiltration into the mains.

The surface water discharge permit was recently renewed by DEQ. They currently have a discharge requirement for 85% removal of BOD and TSS, but reportedly are having some problems achieving those limits (Johnson, 2009). The Three Forks system may not be able to meet increasingly stringent discharge limits for surface water discharge. For this reason, and because of the age of the system, it is likely that Three Forks will have to either modify their existing plant or build a new mechanical treatment plant in the next 5-10 years.

4.5.5 Town of West Yellowstone

West Yellowstone's wastewater treatment system is the second largest system in Gallatin County, in terms of permitted treatment capacity. The system is permitted for a discharge of up to 1,000,000 gpd, which is slightly more than the City of Belgrade (903,000 gpd). The treatment plant is an aerobic lagoon system. The treated wastewater is discharged to rapid infiltration beds. One of the challenges faced by the system is that the flow rate varies significantly during the year. During the summer months the system must handle the load from millions of visitors, but in the winter time the load is greatly reduced. Currently the system is treating about 550,000 gpd in the summer and 282,000 gpd in the winter

4.5.6 Four Corners-Utility Solutions LLC

This treatment plant was originally constructed in 2001 to serve the Elk Grove subdivision, and subsequently purchased by Utility Solutions LLC. Utility Solutions LLC is a private company that contracts to provide centralized wastewater treatment services to the Four Corners Water and Sewer District, and also separately provides services to some surrounding subdivisions. Since the purchase, Utility Solutions LLC has constructed an extensive sewer collection system, and a new subsurface disposal system to service the Four Corners area, at a cost of $22,500,000. The Sewer and Water District was recently in negotiations to purchase the treatment plant and wastewater collection system from Utility Solutions LLC, but these negotiations appear to have failed.

The Utility Solutions plant is classified as an oxidation-ditch type treatment system, with extended aeration and an aerobic digester. The oxidation ditch design is a type of activated sludge process, with wastewater circulating in a round ditch. Aeration occurs while the wastewater circulates in the ditch, via rotating paddles. Currently the design capacity of the plant is about 150,000 gpd and it is treating about 85,000 gpd. The treatment plant was designed to be easily expanded as demand increases.

A MGWPCS permit issued in 2005 shows a total combined discharge allowance of up to 735,537 gpd using four discharge locations. The discharge locations include a rapid infiltration gallery at Elk Grove, a rapid infiltration gallery northwest of Bozeman Hot Springs, an existing disposal system at Bozeman Hot Springs, and a spray irrigation area. An aerial view of the treatment plant is shown in Figure 22. Biosolids generated by the plant are disposed of by land application under an EPA 503 permit.

Figure 22. Aerial Photograph of the Utility Solutions LLC Wastewater Treatment Plant. *Located at the Elk Grove subdivision, this treatment plant currently serves portions of the Four Corners area. Photo taken in 2005 (Alan English).*

4.5.7 Big Sky Water and Sewer District

The current Big Sky Water and Sewer District treatment plant was built in 2004 at a cost of about $15,000,000. Prior to 2000, Big Sky also invested about $5,300,000 to construct a wastewater filtration plant in 1997. The treatment plant is a Sequenced Batch Reactor (SBR) type plant, which replaced an old lagoon system. Sequencing batch reactor plants are activated sludge plants, similar to more traditional activated sludge treatment plants such as the Bozeman treatment plant. The physical and biological treatment processes are similar, with the primary difference being that SBR plants collect influent wastewater in a reactor tank until the tank is full. The wastewater then undergoes all phases of treatment as a "batch", in one tank.

Incoming wastewater is equalized (evenly mixed) while the tank is filling. Then the wastewater undergoes aeration and clarification prior to discharge of the treated wastewater (effluent). SBR plants have two or more reactor tanks and while one batch of wastewater is being treated, the other tank is being filled. This type of treatment system is ideally suited to wastewater discharges that have low flows, variable flows, or intermittent flows. Because the treatment process occurs within a single tank, they also typically require less land area to build. For these reasons they are ideal for areas like Big Sky.

Wastewater flows at Big Sky vary seasonally, like the flows in West Yellowstone. However, the peak season in Big Sky is in the winter rather than the summer. The Big Sky plant is currently treating about 300,000 gpd during the summer season, and 450,000 gpd during the height of the winter ski season (Edwards 2009). Treated wastewater from the SBR batch tanks is discharged to large holding tank, which then discharges water to a final treatment building where the treated wastewater is filtered, chlorinated, and discharged to a large storage basin. The final treated wastewater in the storage basin is used for landscape and golf course irrigation during the growing season. The Big Sky Water and Sewer District does have a valid permit to discharge the treated wastewater to the West Fork of the Gallatin River, but this permit was very controversial when it was issued and the District has never exercised it. The use of treated wastewater for snowmaking is currently being studied. As part of the facility upgrades, Big Sky also constructed a composting facility to convert biosolids from the plant to compost for local use in landscaping.

4.5.8 RAE Water and Sewer District

The RAE Water and Sewer District is also a SBR system. It was constructed in 2002 and replaced an existing lagoon system. The SBR tanks are housed in greenhouse style buildings. The system currently serves about 350 connections with and estimated population of 770. Even though the resident population is year-round, the plant does experience seasonal variation in wastewater flows. In the summer time the system treats about 100,000 gpd, and in the winter this drops to 60,000 gpd (King 2009). This variation is attributed to infiltration of shallow ground water during the wet season. The system is permitted for up to 200,000 gpd. Treated wastewater from the SBR tanks is discharged to an equalization tank and then is pressure dosed (pumped) into a drainfield for final disposal after ultraviolet disinfection. Biosolids are pumped to a reed bed for additional treatment and final disposal.

4.5.9 Town of Willow Creek

The Willow Creek treatment plant is a facultative lagoon system that was built in 2005. It consists of two main facultative lagoon cells and a final polishing pond. The main treatment cells have a capacity of about 2.4 million gallons, and are lined with an HDPE synthetic liner. The final polishing pond has a capacity of about 1.4 million gallons and is also lined. The lagoon system is designed to operate in a continuous-flow mode, or in a controlled-discharge mode. In the continuous-flow mode, flow of treated wastewater from the plant matches incoming wastewater flow rates. In the controlled-discharge mode, lagoon levels are allowed to fluctuate, and treated effluent is stored during periods when the receiving water (Madison River) flow is low. When river levels increase, treated wastewater is discharged.

The treated effluent is discharged to the Madison River via a force-main that dumps into a ditch north of town, that connects to the river. The effluent is disinfected using ultraviolet light prior to discharge. A new MPDES discharge permit was issued in 2007, which allows an average daily discharge of 34,000 gpd, and a peak discharge of 136,000gpd. Currently the plant is treating about 19,000 gpd (Novak 2009). The permit requires monitoring of flow, BOD, TSS, temperature, pH, fecal coliform bacteria, ammonia, nitrate, and phosphorous. A review of EHS files shows the system has a history of complaints between 2005 and 2009, with several notices of violation issued by DEQ.

4.6 Descriptions of Other Public Sewage Systems in Gallatin County by Design Type
With 146 public systems in Gallatin County, it is not practical to describe most of the smaller systems. There are two holding tank systems and two septic tank-seepage pit systems which have already been discussed. The following subsections describe the remaining public systems by design type, and highlight some of the more interesting systems. They are described in increasing order of complexity, expense, and treatment capability.

4.6.1 Gravity-Drainfield Systems
There are 32 known public sewage systems that use the basic septic tank and gravity-drainfield design. Collectively the 32 systems discharge about 60,000 gpd of treated wastewater to ground water. None of these systems have ground water discharge permits, due to the age of most of the systems, or the size of the systems (less than 5,000 gpd). The largest system is the Mount Ellis Academy, with a permitted discharge of 15,000 gpd. Other notable gravity-drainfield systems are the Hidden Valley Trailer Court (9,100 gpd), and the Country Court Mobile Home Park (4,725 gpd). A portion of the Star Mobile Home Park consisting of about 30 mobile homes is also served by a gravity-feed drainfield (7,500 gpd).

These systems are among the older systems in the County, and of the 32 systems, 6 have no information on current or permitted treatment volumes. For these systems a flow of 750 gpd was used as an estimate. The level of treatment from gravity-drainfield systems is more limited than other more advanced systems. The primary problems are that the drainfield receives highly variable flows, matching system demand. This can result in slug flows of partially treated wastewater entering the drainfield, and long periods of saturated conditions in the soils of the drainfield. Another common problem is that effluent is not evenly distributed, and often only a portion of the drainfield receives all of the effluent. For these reasons, new public sewage systems are not permitted with this design. A diagram of a standard gravity-drainfield system is shown in Figure 7 (subsection3.3.4).

4.6.2 Pressure-Dosed Drainfield Systems
These systems are the most common in Gallatin County, with 50 of the total of 145 systems (34%) using the basic septic tank and pressure dosed drainfield design. The pressure-dosed drainfield design is an improvement over the gravity system because it solves the two problems noted above. Effluent from the septic tank discharges to a separate dosing tank. A pump in the dosing tank is typically controlled by a float switch, and when the tank is full, a ‘dose’ of effluent is pumped to the drainfield. The drainfield lines are pressurized, resulting in uniform distribution throughout the drainfield. The periodic dosing also allows for controlled alternation of saturated and unsaturated conditions in the soil.

Collectively, 50 pressure-dosed systems in the County discharge about 216,546 gpd. Four of these systems have ground water discharge permits (MGWPCS). The Gallatin Valley Homesteads subdivisions have the largest system of this type, with a permitted capacity of 34,000 gpd. This system serves a high density development southwest of Belgrade. Other larger systems include Belgrade Gardens, with a capacity of 24,300 gpd, Stonegate at Riverside (15,360 gpd), Green Hills Ranch (12,950 gpd), and the Bozeman KOA (12,250 gpd). A newer portion of the Star Mobile Home Park is also served by a recirculating sand filter that discharges to a pressure-dosed drainfield (11,500gpd).

4.6.3 Elevated Sand Mounds
These systems are typically used in areas with high ground water. Effluent from a septic tank typically flows into a dosing tank, and is then pumped into a network of pipes installed in an elevated sand mound. The wastewater filters through the sand mound and discharges to ground water. Elevated sand mounds were previously thought to be effective at removing nitrogen, and were listed as Level-2

nitrogen-reducing systems by DEQ. Based on review of several studies, DEQ determined that these systems don't provide significantly better treatment than a pressure-dosed drainfield system. There are currently 9 public sewage systems using this design, discharging about 32,279 gpd. The largest of these serves the Manley Meadows subdivision, and is permitted for 14,700 gpd. This system is also the only elevated sand mound that has a ground water discharge permit. Other large systems include the All West Business Park (4,995 gpd), Baker Springs (4,950 gpd), and Heritage Christian School (3,500 gpd).

4.6.4 Open Bottom and Intermittent Sand Filter Systems
These systems are not very common, and there are only two public sewage systems in Gallatin County using the designs, with one of each permitted in the County. The Holiday Inn Express and Country Kitchen, located south of Belgrade is the only permitted septic-tank and open bottom sand filter system. It is permitted for 9,745 gpd. This type of system is basically the same as an elevated sand mound system, but because the depth to ground water is not a limiting factor, the sand bed is installed below grade. Treatment quality is expected to be the same as elevated sand mounds and pressure-dosed drainfield systems. The City of Belgrade has a sewer main installed adjacent to the Holiday Inn Express, but efforts to try and get them to hook to the system have been resisted.

The only permitted intermittent sand filter system serves the Gallatin Gateway School. This system is permitted for 3,750 gpd. This type of system is more advanced. Effluent from the septic tank first flows into a dosing tank, and is then pumped into a sand filter (bed) that is lined. Wastewater passes through the sand bed one time, and then into another dosing tank. The final dosing tank pumps effluent to a pressure-dosed drainfield. So the basic system is a pressure-dosed drainfield with a sand filter installed between the septic tank and the drainfield.

Intermittent sand filter systems do provide better nitrogen removal than the more conventional systems described above. When DEQ reviewed elevated sand mounds and removed them from the list of approved Level-2 nitrogen-reducing systems, they also reassessed intermittent sand filters. Based on this review they reclassified them as Level-1b nitrogen-reducing systems. A diagram of one of these systems for a single family home is shown in Figure 9 (subsection 3.4.1).

4.6.5 Recirculating Sand Filter Systems
There are 15 public sewage systems in Gallatin County that use this design, with some variation in the final disposal method. These 15 systems collectively discharge an estimated 178,000 gpd, with several notably large systems. Four of these systems have ground water discharge permits. The largest approved system of this type is the Four Dot Meadows subdivision, with a permitted treatment capacity of 39,550 gpd. Other large systems include the Countryside Estates subdivision (30,920 gpd), the Antler Ridge subdivision (22,750 gpd), and Ramshorn View Estates (14,800 gpd). Firelight Meadows (systems A and B) also currently uses this type of system, but according to EHS records, they are currently switching to a recirculating trickling filter system (described below).

Continuing to increase in complexity and treatment capability, recirculating sand filter systems are classified as Level-2 nitrogen-reducing systems. The big difference between these systems and the ones previously discussed is that wastewater passes through the sand filter numerous times before final disposal. Effluent from a septic tank flows into a dosing tank, and is then applied under pressure to the top of a sand filter which is lined. After passing through the sand filter most of the effluent is returned to the dosing tank, while a small portion is routed to the final disposal structure. In this way, the wastewater is treated several times through the sand filter. Once wastewater leaves the sand filter recirculation system, it is discharged to the subsurface.

There are some variations on how the treated effluent is discharged to the subsurface from recirculating sand filter systems. Thirteen of the approved systems use a gravity drainfield system. Four Dot Meadows subdivision is the only recirculating sand filter system that uses a pressure dosed drainfield. Due to high ground water conditions, it is installed in fill above grade. The Big Horn Center in Big Sky, uses an elevated sand mound for final disposal, possibly also due to high ground water conditions.

4.6.6 Recirculating Trickling Filter Systems

These systems are similar to recirculating sand filter systems, except that the wastewater is repeatedly passed over a patented filter media. Only seven public systems in Gallatin County are using these systems. The collective flow from these public systems is about 60,000 gpd. Two of these systems have ground water discharge permits. The largest, the Lazy J South subdivision, and has a permitted capacity of 20,000 gpd. Firelight Meadows system C has a capacity of 13,160 gpd, and the Garden Center Commercial Subdivision has a capacity of 15,000 gpd . With the exception of the Garden Center Commerical Subdivision, which uses a natural gravel filter media, all of these systems use either the AdvanTex® and Eliminite® treatment systems (subsection 3.4). Figure 23 shows an AdvanTex® system installed at Gravel Hollow along highway 191, south of Four Corners.

Figure 23. AdvanTex® Level-2 Nitrogen-Reducing Treatment System Installed as Public System. *One of seven public sewage systems using recirculating trickling filters. The system is approved for up to 5,100 gallons per day.*

4.6.7 Sequencing Batch Reactors

In addition to the two centralized public sewage systems that use SBR technology (RAE and Big Sky), there are also five smaller systems that use SBR. Collectively, these five smaller systems are permitted to discharge 68,138 gpd. If RAE and Big Sky are added, the total discharge from SBR systems in Gallatin County is estimated to be 523,000 gpd, with the Big Sky system by far the largest with a seasonal average of 375,000 gpd. The other public systems that use SBR are Valley Grove IV subdivision (43,000 gpd), East Gallatin Commercial Center (12,000 gpd), Big Sky Comfort Inn (4,288 gpd), Springhill Park Subdivision (7,350 gpd), and Everybody's Gym (former name), with a discharge of 1,500 gpd.

4.6.8 Lagoon Systems

There are 13 lagoon systems in Gallatin County that are currently treating a combined volume of about 1.8 billion gpd of wastewater. Of this amount, 1.3 billion gpd (72%) is discharged by the four large centralized systems described in subsection 4.5 above (Belgrade, West Yellowstone, Three Forks, and Willow Creek). The other nine lagoon systems in Gallatin County, which discharge a total of about 500,000 gpd, include the Bridger Pines subdivision, the Forest Park Mobile Home Park, Hebgen Lake Estates, River Rock subdivisions, the Riverside Sewer and Water District, and Buck's T-4 Best Western.

Each lagoon system design is unique. Overall, the quality of wastewater treatment provided by lagoon systems is highly variable. Reviewing EHS files, and other information, it is clear that these systems generate more citizen complaints than any other type of system. Complaints about odors are the most common problem. Several of the lagoon systems in Gallatin County are either known to have problems, or are suspected of having problems. The Bridger Pines lagoon system is currently under a DEQ moratorium, precluding any additions to the system until existing problems are solved. The Amsterdam-Churchill lagoon system is believed to have substantial leakage into the subsurface from the treatment cell(s). The River Rock Sewer and Water District, is currently in litigation with nearby homeowners. Monitoring wells for this lagoon system have repeatedly detected high nitrate concentrations in ground water down-gradient of rapid infiltration beds used to dispose of the treated wastewater..

The Forest Park trailer court wastewater treatment system is shown in Figure 24 It consists of two lagoons and three percolation beds. The system is located very close to the West Gallatin River. It was recently reviewed by the DEQ Enforcement Division and the State Revolving Fund, but to date no actions have been taken. Information in DEQ files on this system is limited. Questions have also been raised about the Riverside lagoon, which is adjacent to the East Gallatin River. However, no documented problems are known. The Hebgen Lake system has been under DEQ review for some time.

Figure 24. The Forest Park Lagoon System Situated Along the West Gallatin River. *Due to the proximity of this system to the river, and shallow ground water, concerns have been raised about potential contamination of the West Gallatin River.*

CHAPTER 5
GALLATIN COUNTY SEWER AND WATER DISTRICTS

County sewer and water districts are normally created to facilitate construction, management and operation of public sewer and/or water systems. The most common purpose for creating a district is to allow non-governmental entities and unincorporated areas in need of sewer and/or water services to apply for grant and loan funds and construct water and sewer infrastructure. Creation of a district also provides a structure for operation and management. The Spain Bridge Meadows and Mount Ellis Meadows districts were approved by the County with plans to use individual wells and individual septic systems on each lot. It is unclear what the benefits of creating these districts are.

5.1 Regulatory Overview

Statutes governing sewer and water districts are provided in MCA 7-13-22. Authorization to create districts is provided in MCA 7-13-2203, which states "(1) *A county water and/or sewer district may be organized and incorporated and managed as herein expressly provided and may exercise the powers herein expressly granted or necessarily implied. (2) The people of any county or counties or portion of a city or a county or city and county or any combination of these political divisions, whether such portion includes unincorporated territory or not, in the state of Montana, may organize a county water and/or sewer district under the provisions of this part and part 23 by proceeding as therein provided."*

To create a Sewer and Water District a petition, with the signatures of at least 10% of the registered voters in the proposed District, must be submitted to the County Commission. The Commission then holds a hearing after giving public notice and reviewing the proposed district. If the Commission decides to move forward with creation of the district an election is required unless all of the registered owners of properties within the proposed district sign the petition.

The powers and duties of county sewer and water districts are provided in MCA 7-13-2217, which reads as follows: *"(1) Any district incorporated as provided in this part and part 23 shall have power to: (a) have perpetual succession; (b) sue and be sued, except as otherwise provided herein or by law, in all actions and proceedings in all courts and tribunals of competent jurisdiction; (c) adopt a seal and alter it at pleasure; (d) take by grant, purchase, gift, devise, or lease and to hold, use, enjoy, and to lease or dispose of real and personal property of every kind, within or without the district, necessary to the full exercise of its powers; (e) make contracts, employ labor, and do all acts necessary for the full exercise of the foregoing powers."*

Once a sewer and water district is created, an election is required to appoint a Board of Directors. MCA 7-13-2232 spells out the requirements of composition of the Board. If there are no municipalities within the boundaries of the district, the board of directors must have 5 members, with the exception that if there are 10 or less qualified electors in the district, only 3 Board members are required. If the district includes an incorporated municipality 1 additional director for each of municipality must be appointed.

5.2 Approved Sewer and Water Districts in Gallatin County

There are currently 17 Sewer and Water Districts in Gallatin County. They include a mix of districts that provide just public water, just public sewer, both pubic water and sewer, and no public sewer or water. The oldest district in Gallatin County is the Willow Creek Sewer District, created in 1973. The most recently approved district is the Gallatin Gateway Sewer and Water District, approved in 2009. Table 17 provides a summary of the sewer and water districts approved in Gallatin County. Boundaries of all of the approved sewer and water districts are shown on the maps included in Appendix A.

Table 17
Approved Sewer and Water Districts in Gallatin County

District Name	Year	Public Water	Public Sewer	Sewer Type
Willow Creek Sewer District No. 306	1973	No	Yes	Aerated Lagoons
Amsterdam Churchill Sewer District No. 307	1993	Yes	Yes	Lagoon
Riverside Water and Sewer District No. 310	1976	Yes	Yes	Lagoon
Bridger Pines Water and Sewer District	1977	Yes	Yes	Lagoon
Rae Water and Sewer District No. 313	1977	Yes	Yes	Sequenced Batch Reactor, Infiltration bed
Yellowstone Holiday Water and Sewer District No. 348	1989		Yes	Septic Tank and Pressure Dosed Drainfield
Big Sky Water and Sewer District No. 363	1993	Yes	Yes	Sequenced Batch Reactor, Spray Irrigation
Gallatin Valley Homesteads Sewer District	1997	No	Yes	Septic Tank Pressure Dose Drainfield
Valley Grove Water and Sewer District No. 373	1998	yes	Yes	Sequenced Batched Reactor Pressure Dosed Drainfield
4 Dot Meadows Sewer District No. 374	1999	No	Yes	STEP Tanks, Recirculating Sand Filter Pressure Dosed Drainfield
River Rock Water and Sewer District No. 377	2001	Yes	Yes	Aerated Lagoons, Infiltration Beds
Four Corners Water and Sewer District No. 385	2003	Yes	Yes	Oxidation Ditch, Pressure Dosed Drainfields
Spain Bridge Meadows Water and Sewer District	2006	No	No	Individual Septic Systems
Mount Ellis Meadows Water and Sewer District	2006	No	No	Final plat approval in 2006, but not built out.
Hebgen Lake Estates Water and Sewer District	2007	Yes	Yes	Lagoon
Countryside Estates Water and Sewer District	2007		Yes	Septic Tank, Recirculating Sand Filter
Gallatin Gateway Water and Sewer District	2009	No	No	In Planning Stage

5.3 Management and Oversight of County Water and Sewer District

During the process of County Commission approval of sewer and water districts, the Commission has some authority to modify the proposed district boundary. Once the district is created the Commission has no authority to regulate or manage the district. The Board of Directors holds all of the authority to modify the District’s programs, change district boundaries, set fees for services, and other actions. There is often confusion among the public as to who operates and regulates these districts. Although ‘county’ is in the name, these districts are not operated as County agencies. If the district constructs water and or sewer infrastructure, these systems may be classified as public systems by DEQ, but this does not mean the systems are owned by the public. All facilities are owned by the sewer and water district. Districts can also contract for these services, as the Four Corners Water and Sewer District has done with Utility Solutions.

CHAPTER 6
SEPTAGE AND BIOSOLIDS

All wastewater treatment systems produce solids, often referred to as sludge, during the treatment process. In addition to disposal of treated wastewater, these solids must be disposed of. When a septic tank is pumped out, all of the contents are removed, including settled solids, floating solids, oils, grease, and raw wastewater present in the tank. This combined mixture is referred to as septage. If the solids are produced in a mechanized wastewater treatment plant, and they undergo additional treatment, they are referred to as biosolids. The physical and chemical characteristics of septage and biosolids are very different. Disposal methods for septage and biosolids in Gallatin County vary, but most of them are land applied, either directly on the land surface, or injected into the soil just below the land surface.

6.1 Septage

In a septic system the septic tank provides primary treatment by trapping solids, oils, grease, and non-biodegradable trash, limiting them from exiting the tank and potentially clogging the drainfield or other disposal structure. A septic tank typically retains 60-70% of the solids, oil and grease that enters the tank (U.S. EPA 1999). These materials, collectively referred to as septage, must periodically be pumped from the septic tank to prevent system failure (Figure 25). Most septage is generated by individual septic systems serving residential properties, but it also includes waste pumped from vaulted toilets, holding tanks, porta-potties, grease traps, car wash sumps, commercial/industrial septic systems, and public sewage systems that use septic tanks.

Most of the septage disposed of in Gallatin County is land applied for use as a soil amendment. This practice can be safe and effective if done properly, but it also poses potential risks to both human health and the environment. Septage contains high concentrations of pathogens, which when disposed of on the ground surface can be a public health risk. Septage also typically contains high concentrations of nitrogen and phosphorus, both of which are nutrients, and can cause degradation of surface water if runoff from an application area occurs. If disposed of in areas of shallow ground water, there is also a risk of causing ground water contamination.

6.1.1 Characteristics of Septage

Septage generally has a strong, objectionable odor due to gases produced by bacteria under the anaerobic conditions in the tank. It typically contains grease, grit, hair, and plastics, paper, and other large solids. Because the septage has only undergone partial primary treatment in the septic tank, it contains high concentrations of BOD, organic nitrogen compounds, pathogenic and non-pathogenic organisms (bacteria, viruses, and protozoa), and ammonia. Table 18 shows average chemical and physical characteristics for septage.

Septage may contain organic chemicals, compounds used in personal care products, and pharmaceuticals. It is difficult to get representative samples of septage for these types of contaminants since it is highly dependent on what products are being used and disposed of in any particular household. The concentrations of these contaminants in septage may be higher than in biosolids because the septage has only undergone partial primary treatment. As previously mentioned in subsection 3.1.3, the dry cleaning solvent perchloroethylene was dumped into a septic system in Bozeman in the late 1980s, resulting in a major ground water contamination problem and creation of the Bozeman Solvent Site. When the septic tank was removed, the septage in the tank was highly contaminated with perchloroehtylene and had to be disposed of as hazardous waste.

Figure 25. Photograph of a Septic Tank being Pumped. *When a septic tank is pumped all of the contents are removed. The combined mixture is called* septage, *and it includes settled solids (sludge), fats, oils, grease and other floating solids (scum), partially treated wastewater (black water), and any other non-biodegradable trash that has entered the tank (photo courtesy of Alan English).*

Table 18
Typical Physical and Chemical Properties of Septage

Parameter	Average Concentration in Septage (mg/l)[(a)]
Total Solids	34.1
Total Volatile Solids	23.1
Total Suspended Solids	12.9
Volatile Suspended Solids	9.0
Biochemical Oxygen Demand (BOD)	6,480
Chemical Oxygen Demand (COD)	31,900
Total Kjeldahl Nitrogen	588
Ammonia Nitrogen	97
Total Phosphorus	210
Alkalinity	970
Grease	5,600
pH	Variable 1.5-12.6 SU

Source: U.S. EPA (1994)

A recent screening study in Missoula Montana found detectable levels of pharmaceuticals and personal care products in samples collected from septic tanks (Godfrey and Woessner 2004). In this study, thirty-two single-family septic systems and ten community (public) septic systems were sampled for 19 different pharmaceuticals and 3 pharmaceutical metabolites. It was noted in the report that there were several analytical problems, but that these problems probably resulted in under reporting the concentrations of detected compounds in the septic tanks. In the individual septic tanks and the community septic tanks acetaminophen, caffeine, cotinine, paraxanthine, and warfarin were detected in more than 60% of the samples.

6.1.2 Regulation of Septage Disposal

Montana Code Annotated: The handling and disposal of septage is regulated by DEQ under the statutory authority of MCA 75-10-12 (Septage Disposal-Licensure). These statutes specify what must be addressed in the rules adopted by DEQ. Of note, the statutes require licensure of septage haulers, with the exception that the owner or lessee of private property may pump their own septic tank and dispose of the septage on their own land. They may also hire a licensed hauler to pump their tank and dispose of the septage on their own land (MCA 74-10-1210).

Land application of septage is allowed under the Montana Water Quality Act, as a nonsignificant Activity. MCA 75-5-317 states that *"(h) land application of animal waste, domestic* septage, *or waste from public sewage treatment systems containing nutrients when the wastes are applied to the land in a beneficial manner, application rates are based on agronomic uptake of applied nutrients, and other parameters will not cause degradation;"*

Administrative Rules of Montana: DEQ has adopted rules governing both septage haulers, and the disposal of septage and other related wastes. These rules are provided in ARM 17.50 Subchapter 8 (Cesspool, Septic Tank, and Privy Cleaners). Under the rules no one, unless exempted under MCA 75-10-1210, can handle or haul septage without a license. To obtain a license, haulers must submit an application to DEQ. Information required in the license application includes a listing of the counties the hauler will work in, a list of the land application sites the hauler will use, and the estimated volume of septage and other wastes the hauler will dispose of at each site.

The Waste and Underground Tank Management Bureau of DEQ, Solid Waste Section, administers the septage haulers rules. The Gallatin County EHS Division works as an agent of DEQ to inspect hauling equipment, proposed land application sites, active land applications sites, and to respond to complaints. Both DEQ and EHS maintain files on all of the approved septage application sites in Gallatin County. The authority to inspect proposed and active septage disposal sites is provided under ARM 17.50.812 states *"(1) The department and local health officers or local designated health representatives may conduct inspections of proposed disposal facilities for* septage *and other wastes regulated under this subchapter. Upon request, an inspector shall present credentials. (2) The department and local health officer or the local health officer's designated representative may inspect disposal sites and appropriate records to determine if a violation of Title 75, chapter 10, part 12, MCA, or this subchapter is occurring or has occurred. (3) Applicants, licensees and owners of disposal sites shall allow inspections conducted under this rule*."

Licensing Septage Haulers and Land Application Sites: Land owners or septage haulers must apply for a land application license. The application must include their estimated volume of pumping of septage, portable toilets, grease traps, or sumps. Additionally, each pumper must specify either a land application site or a waste water treatment facility with signed owner/operator permission. For land application sites, additional information on soils, crops, nitrogen requirements, high groundwater level, setbacks to surface water, slope, vector control (fencing), acreage and maps must be included to ensure the dispersal of human waste on the site will not pose a threat to human health or to water quality. Each pumper must annually apply for licensure to the state regulatory program, which works with the assistance of local county sanitarians to review the application.

Septage haulers are required to keep records of septage disposed of, including dates, volumes of septage, sources of septage, application sites and application areas. The information is supposed to be submitted to DEQ semi-annually. There are specified setbacks and other conditions specified in the rules for land application of septage. Septage must be applied at least 500-feet from occupied or inhabitable building, 150-feet from surface waters, including ephemeral or intermittent drainages and wetlands, 100-feet from federal, state, county or city maintained highways or roads, and 100-feet from drinking water supply sources. Septage can't be surface applied on slopes greater than six percent, or injected on slopes greater than twelve percent. Seasonal high ground water must be at least 6-feet below land surface.

The rules for approving the land application sites require submission of an application, which must contain information on the land ownership, site location, soil properties, vegetation, depth to ground water, surface slope, the distance to nearby surface waters, and the volume of septage that will be disposed of at the site. The rules also require a disposal operation and maintenance plan for each land application site including provisions for access control, if necessary, and the types and sources of wastes to be managed on the site. The operation and maintenance plan must include a description of the vector attraction reduction and pathogen reduction methods proposed for use on the site and a listing of equipment available for managing each type of waste.

The DEQ rules do allow for routine and emergency application of septage onto frozen or snow covered ground. ARM 17.50.810 (2) (Special Conditions) states that "*A person may apply routine maintenance pumpings or emergency pumpings including, but not limited to, pumpings required due to septic system freeze-ups, overflows, flooding, or failures, to frozen or snow covered ground, only if no other reasonable treatment method is available. Reasonable treatment method options include hauling the waste to a waste water treatment plant or a* septage *storage, treatment, or dewatering facility that will accept the waste and that is within 25 miles of the point of generation…*" This rule also requires that the sites or fields used have a slope of less than or equal to 3% and are not within a 100-year floodplain.

6.1.3 Inventory and Mapping of Septage Disposal

The GLWQD compiled available information on the locations of both septage and biosolids land application sites in Gallatin County. For mapping septage land application sites the GLWQD reviewed permit files maintained by EHS. These files contain information on each approved septage application site in the county. Using maps and other information in these files, a GIS database layer was constructed and the approved land disposal areas were mapped. The results show that there are 10 licensed septage haulers that are approved to dispose of septage in Gallatin County. Based on the GIS map layer, there are at least 819 acres of land approved for land application of septage. Some of the maps in the license files are of poor quality, and the exact acreage could not be determined. The approved land application sites are owned by five different land owners.

A map showing the locations of all the mapped septage and biosolids land application sites in Gallatin County is provided in Appendix-A, Map A-1, entitled Locations of Septic Systems, Septage and Biosolids Disposal Sites in Gallatin County, Montana. An example of the septage land application site GIS layer is shown in Figure 26 for approved sites west of Amsterdam. One land owner in the Amsterdam area, has the majority of the acreage approved for land application of septage in Gallatin County, with about 620 acres available. The GLWQD met with this land owner, reviewed his operation for disposing of septage, and inspected one of the land disposal sites. This land owner has assembled a honey wagon with an injector system, and has used the equipment to inject septage into the soil, although not on a consistent basis. This equipment is shown in Figure.27. This landowner has also experimented with storing septage in a 50,000 gallon bladder tank and then filling the honey wagon from the tank. A photo of the bladder tank is shown in Figure 28.

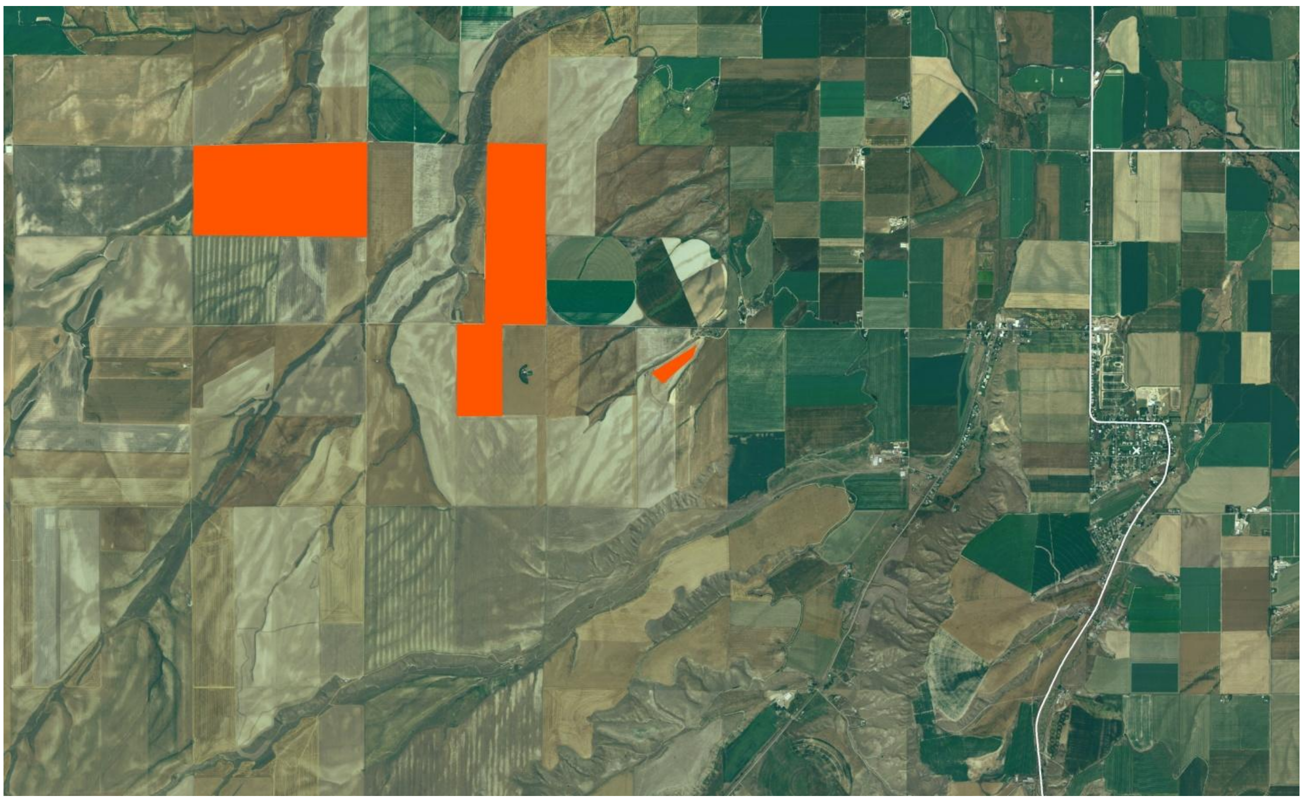

Figure 26. Clip from Map A-1 Showing Septage Land Application Sites West of Amsterdam*. A total of 620 acres on several sites west of Amsterdam are approved for land application of* septage. *The sites, all owned by one landowner are shown in red.*

Figure 27. Septage Injection System Designed by a Landowner in the Amsterdam Area. *This is the only septage injection system known in the area.*

Figure 28. Bladder Tank Used by Owner of Land Application Site for Storing Septage. *The owner of this system has experimented with storing* septage *for later land application.*

The majority of septage appears to be disposed of via land application. Information on how much septage is land applied vs. other disposal methods was not available. The West Yellowstone treatment plant reportedly takes septage from the West Yellowstone area. The Big Sky Water and Sewer District treatment plant also is reported to take septage. Operators of other wastewater treatment plants are not obligated to take the waste, and therefore operators in the Gallatin Valley have been hesitant to, citing examples of problems experienced by those that do. The Town of Manhattan's former lagoon underwent expensive dredging because of illicit septage discharge into a sewer main by a septage hauler.

Due to the high percentage of solids and the high BOD present in the septage, operators must carefully, and slowly add this high strength waste to dilute it and avoid upset of the plant biology. The Bozeman treatment plant is the best suited system for accepting septage because of the large treatment flows. The higher flows minimize the potential for plant upset. However, the policy of the City of Bozeman is to not take septage. While the plant is being upgraded and expanded, a change in this policy should be pursued, and the City of Bozeman should be encouraged to add a septage dumping station.

Information on the haulers and the waste handling they reported is provided in Table 19. Based on reports filed by 10 licensed septage haulers in Gallatin County, 3.6 million gallons of septage and other related wastes were pumped and disposed of in 2008. This includes septage from individual septic systems and septage from septic tanks associated with public sewage systems. About 360,000 gallons were reportedly pumped from vault toilets and portable outhouses. While similar to septage pumped from a septic tank, waste from vaults and portable outhouses is much more concentrated, and often contains disinfectant and deodorant additives. Most of the other waste pumped by the haulers was from grease traps.

As an independent check on the reported volume of septage handled by haulers, the number of individual septic systems inventoried in Gallatin County was used to estimate the amount of septage produced in the county. A total of 13,350 septic systems were mapped as part of the individual septic system inventory. If it is assumed that on average, most people have their septic system pumped every five years, then about 2,670 tanks would need to be pumped annually. The majority of systems probably use a 1,000 gallon septic tank, so the annual amount pumped would be about 2.7 million gallons. Excluding vault pumping, the septic system pumpers reported hauling about 400,000 gallons more septage than estimated based on the number of septic systems in the county.

6.2 Biosolids

The term biosolids is used to describe sewage sludge that has been processed to make it safe for beneficial use as an agricultural soil amendment (fertilizer) or as an ingredient in compost. Biosolids, previously known as 'sewer sludge,' underwent a name change and rebranding in the 1970's as they became recognized not solely as a waste product, but one with a valuable beneficial use as a fertilizer. Approximately fifty-percent of the biosolids produced in the US are land applied, however this fertilizes less than one-percent of all agricultural acreage (EPA 2009). Biosolids differ from septage in that they have undergone a higher level of treatment.

Table 19
2008 Gallatin Valley Septic Tank Pumper Volumes (Gallons)

License	Name	Septage	Vault	Grease	Sumps	Other
S-1008	Big Johns Portable Restrooms and Septic Service		331,245			
S-1020	Grayling Enterprises dba Howell Septic & Excavating	23,750				1,800
S-1011	GWWS, Inc dba Hegar's Septic Service	604,700		75	2,500	7,000
S-978	Little Stinkers	700,950		23,700		
S-903 *and* S-980	Potty Princess Portable Rentals aka Gallatin Valley Septic Service *and* Robbins Septic Service	438,300	27,900			
9-937	Scenic City Enterprises	1,048,193		110,450		
S-977	Sewer Master	196,900		10,250	7,450	
S-966	TLC Landscape and Excavation				450	750
S-794	Yellowstone Drain *and* Surfs Up Septic	65,930				
S-899	Yellowstone Rental and Sports		0			
	Total	**3,078,723**	**359,145**	**144,475**	**10,400**	**9,550**

6.2.1 Characteristics of Biosolids

Biosolids consist of a mixture of solid, semi-solid, and liquid residue generated during the treatment of domestic sewage in a treatment works (EPA 1994). The chemical, physical, and biological characteristics of biosolids vary depending on the how they are processed in the treatment plant, and on the quality of the incoming wastewater. Generally, biosolids have low levels of BOD, organic nitrogen compounds, and pathogens. The solids content of biosolids is typically 2-12% if they are not dewatered, 12-30% if dewatered, and up to 50% if they are dried (Evanylo 2009). Biosolids generally do not have a strong odor due to the treatment received. They also do not contain grit or non-biodegradable trash, which is removed at the beginning of the treatment process.

Treatment of sewage sludge to produce biosolids typically consists of some combination of thickening (gravity separation of solids), aerobic or anaerobic digestion (bacterial decomposition), mechanical dewatering, addition of lime to increase the sludge pH, and heat drying. These processes break down organic compounds and tend to destroy pathogenic organisms. Lime is usually only added if the biosolids are not injected, as a means of reducing odors and attraction of vectors. Treatment processes used to produce biosolids generally do not remove heavy metals. As a result biosolids may have varying levels of heavy metals which are primarily related to the concentrations of heavy metals in the sewage influent to the treatment plant. If the treatment plant receives primarily domestic sewage, heavy metals concentrations in the biosolids will be low. If the plant receives significant volumes of commercial or industrial wastewater, heavy metals concentrations in the biosolids could be elevated. Table 20 shows average concentrations of heavy metals in biosolids from a national survey (EPA 1993), along with established regulatory limits for biosolids, and typical concentrations in septage.

Table 20
Average Heavy Metals Concentrations in Biosolids, EPA Regulatory Limits for Biosolids, and Average Heavy Metals Concentrations in Septage (mg/kg, dry weight basis)

Heavy Metal	Mean Biosolids[(a)]	Biosolids Limits[(b)]	Mean Septage[(c)]
Arsenic (As)	10	41	4
Cadmium (Cd)	7	39	3
Chromium (Cr)			14
Copper (Cu)	741	1500	140
Lead (Pb)	134	300	35
Mercury (Hg)	5	17	0.15
Molybdenum (Mo)	9		
Nickel (Ni)	43	420	15
Selenium (Se)	5	100	2
Zinc (Zn)	1202	2800	290

(a) National Sewage Sludge Survey (U.S. EPA 1990), (b) 40CFR Part 503, (c) U..S. EPA (1993)

Biosolids may also contain organic chemicals, compounds used in personal care products, and pharmaceuticals. These compounds are found in low concentrations in biosolids, and the potential public health risks and environmental risks are unknown. One concern is that if these compounds are present in biosolids that are land applied, they may become bio-available in the soils. Laboratory analysis of biosolids for pharmaceuticals and personal care products is relatively new and research is ongoing. Due to laboratory complications in analyzing biosolids for these types of contaminants, at very low levels, some of the data being reported may be suspect. In general if the compounds have an affinity for adsorbing onto the solids (are hydrophobic), and are resistant to biodegradation, they are more likely to persist through the treatment processes and end up in biosolids.

In a recent study, 9 different commercially available biosolids products were tested for 87 different organic wastewater compounds (OWC), including compounds used in cleaners, personal care products, and pharmaceuticals (Kinney *et al*. 2006). They found that 55 of the 87 OWCs were detected in at least one of the nine biosolids products, and 25 of the OWC tested for were found in all 9 of the biosolids products, including some of the pharmaceutical compounds. A summary of the results from this study are shown in Table 21.

6.2.2 Regulation of Biosolids

The U.S. EPA regulates disposal of biosolids directly in Montana. Rules for handling biosolids are provided in the Code of Federal Regulations (40 CFR, Part 503). The EPA regulations for biosolids are focused on rules for beneficial reuse of the biosolids for manufacture of compost, or land application as fertilizer. Under the EPA rules biosolids are classified and regulated based on pathogen concentrations and levels of pollutants in the biosolids. There are two pathogen classes for biosolids. Class A biosolids have pathogen levels below detection limits and they have no site application or use restrictions. Class B biosolids contain low levels of pathogens and have some use restrictions. These restrictions include restrictions on crop harvesting, animal grazing, and public access for a period of time after application. Class B biosolids cannot be sold or given away in a bag or other container for land application at public contact sites (e.g., parks, golf courses, lawns, and home gardens). Pollutant levels in biosolids are also regulated. Limits for heavy metals in biosolids are shown in Table 20 above.

Table 21
25 Organic Wastewater Compounds found in 9 of 9 Biosolids Products Tested[a]

Organic Compound	Type of Compound	Median Conc. (ug/kg OC)[b]
carbamazapine	Antiepileptic drug	68
Diphenhydramine	Antihistamine drug	340
Fluoxetine	Antidepressant drug	370
d-limonene	Fragrance, solvent	630
Tonalide (AHTN)	Fragrance	11600
Galaxolide	Fragrance	3900
indole	Fragrance	19,600
4-tert-octylphenol	Detergent metabolite	4030
Para-nonylphenol-total	Detergent metabolite	261,000
Nonylphenol, monoethoxy-total	Detergent metabolite	21600
Nonylphenol, dithoxy-total	Detergent metabolite	7010
Bisphenol A	Plasticizer, fire retardant	4690
3-beta-coprostanol	Steroid	126,000
Cholesterol	Steroid	209,000
Beta-sitosterol	Steroid	131,000
Stigmastanol	Steroid	17,400
Phenanthrene	Polycyclic aromatic hydrocarbon	342
Anthracene	Polycyclic aromatic hydrocarbon	139
Fluoranthene	Polycyclic aromatic hydrocarbon	1,090
Pyrene	Polycyclic aromatic hydrocarbon	1,110
Phenol	Disinfectant chemical	2,180
Triclosan	Disinfectant chemical	10,200
Diethylhexyl phthalate	Plasticizer	10,500
Para-cresol	Preservative	4,400
Skatol	Fecal indicator	2,510

a) Modified from Kinney et. al. (2006)

b) Note that concentrations are reported in units of ug/kg of the organic carbon fraction (OC) of the biosolids, rather than in units of ug/kg of the bulk dry product. This results in higher concentrations as compared to the overall concentration of these compounds in biosolids.

6.2.3 Inventory and Mapping of Biosolids Disposal

All mechanical treatment plants, sequenced batch reactor plants, and lagoon systems produce biosolids. Methods used to dispose of biosolids in Gallatin County include on-site disposal, disposal at a licensed landfill, composting and selling the product, or direct land application for soil amendment. Treatment plants within Gallatin County have chosen different disposal methods based on the amount of biosolids produced, treatment plant location, and costs. In lagoon systems the biosolids slowly accumulate in the bottom of the lagoons. Very little information was found on disposal of biosolids from lagoon systems in Gallatin County. When the Belgrade system was reconstructed in 2004, biosolids from the old lagoons were spread on the land surface near the lagoons.

The Town of Manhattan is the only system known to dispose of biosolids at the Logan landfill. They have a specially designed truck that collects and transports their biosolids. The Big Sky Sewer and Water District composts and sells its biosolids for private use. The RAE Water and Sewer District disposes of their biosolids in an on-site reed bed. The City of Bozeman has a well structured biosolids program. They are by far the largest producer of biosolids, in direct proportion to the amount of wastewater they treat.

The only records found documenting volumes of biosolids produced were those of the City of Bozeman. They keep detailed records on where and how much biosolids they land apply. For 2008 the City of Bozeman reported that they produced 9.4 million gallons/year of Class B biosolids. The City has approval to land apply biosolids on 36 fields, covering about 1,900 acres. The fields are owned by six different land owners, and all of the sites are within 4 miles of the treatment plant. The approved biosolids injection sites used by the City are shown in Figure 29. The City injects biosolids at a depth of 9-12" below ground, in a rotation of fields. A specially designed injector truck is used by the City to dispose of biosolids. There biosolids injection truck is shown in Figure 30. The City can only land apply biosolids during the growing season, so they also maintain a 5.5 million gallon storage lagoon for winter biosolids storage (Layton 2009). Following completion of the current plant upgrade and expansion, the City plans to begin de-watering their biosolids with a screw press to produce cake like product. This will greatly reduce the volume of biosolids to be transported to nearby fields.

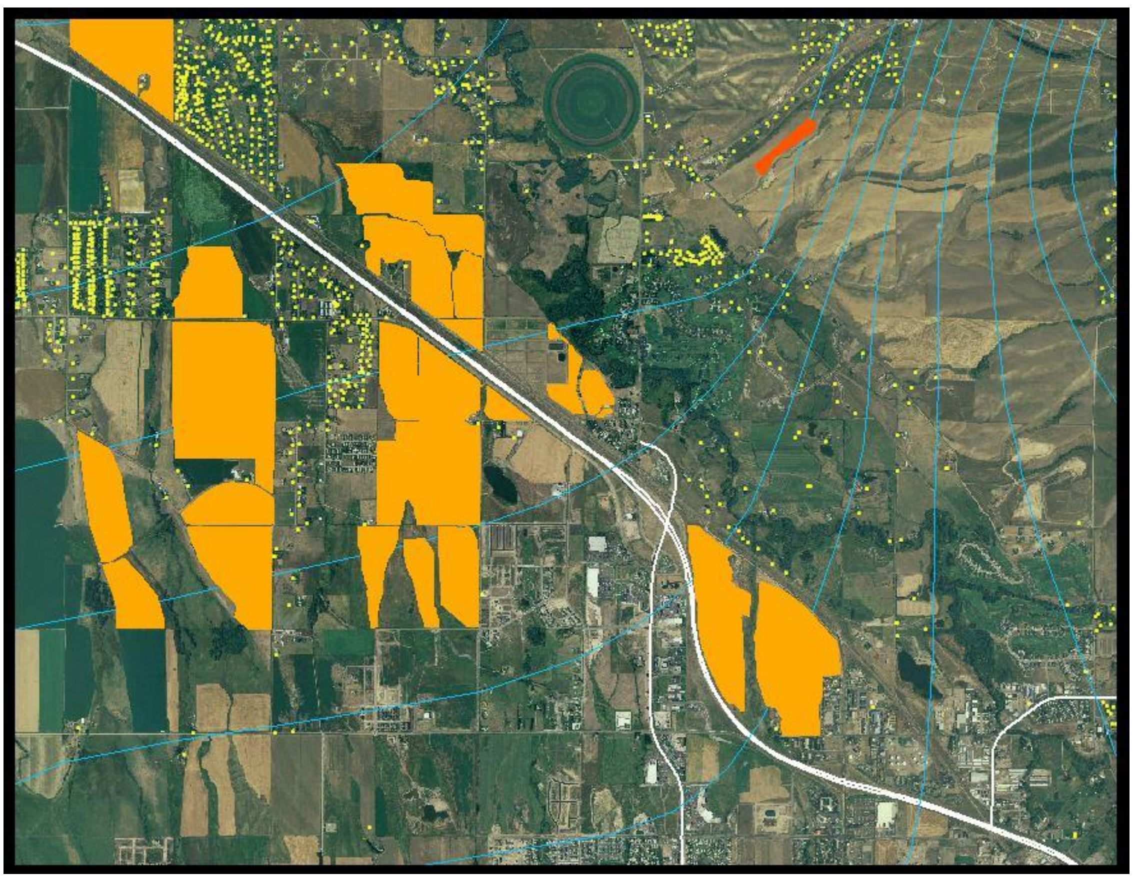

Figure 29. Approved Biosolids Injection Sites for the Bozeman Treatment Plant. Biosolids *disposal areas are shown in orange. The City has approval to land apply* biosolids *on 36 fields, covering about 1,900 acres. The fields are owned by six different land owners, and all of the sites are within 4 miles of the treatment plant. There is one registered* septage *application site shown in red.*

Figure 30. Biosolids Injector Truck used by the City of Bozeman Wastewater Treatment Plant. *The Bozeman has the largest, and the most structured program for handling and disposing of* biosolids. *Specialized trucks inject the* biosolids *into the soil.*

CHAPTER 7
GROUND WATER MIXING ZONES AND CUMULATIVE IMPACTS

7.1 Discussion of Cumulative Impacts and Carrying Capacity

A detailed analysis of cumulative impacts and carrying capacity is beyond the scope of this report. Both of these terms represent broad concepts that are very hard to quantify. However, much of the information compiled on disposal of wastewater in Gallatin County is relevant to evaluation of cumulative impacts and carrying capacity.

The concept of cumulative impacts is easy to visualize for point-source discharges to a river or stream. You can measure the flow of the stream, measure the flow and concentrations of pollutants in the point-source discharges, and make reasonable calculations of the concentrations of pollutants in the stream. You can also easily measure pollutant concentrations in the stream to see what the actual cumulative impacts are. Evaluating cumulative impacts in ground water, especially a large aquifer system like the one in the Gallatin Valley, is much more difficult. The sources of pollution are widely dispersed. It is very difficult to accurately measure the volume of ground water flowing through an area. Ground water flow directions vary locally and regionally, and include vertical movement of the ground water. The pollutants that enter ground water are continually being diluted and diffused, and in many cases reacting and interacting with aquifer materials. For all of these reasons, and others, predicting cumulative impacts to ground water from the disposal of treated wastewater is very difficult.

The concept of carrying capacity is often discussed when looking at potential impacts from sources of pollution like septic systems. One way to think about the concept of carrying capacity is that it combines the concept of cumulative impacts with some regulatory pollutant limit. In a stream or river, the concept of Total Maximum Daily Load (TMDL), used to manage surface water pollutants, is basically a surface water carrying capacity determination. Again, the concept is much harder to translate to an aquifer system. A ground water carrying capacity analysis could look at the total amount of pollution sources, such as septic systems, that an aquifer could handle without causing problems. In order to begin to evaluate carrying capacity, some threshold pollutant concentration, such as nitrate must be established. This concentration could be set based on a trigger value that is less than the drinking water standard, allowing a safe margin of error. While this report does not directly evaluate cumulative impacts or carrying capacity, a lot of the information provided is relevant. The following sections provide information that could be used to start the process of evaluating these two concepts.

7.2 Ground Water Flow Patterns in the Gallatin Valley

Analysis of ground water flow patterns is scale dependent. It is useful to see the big picture, and understand the regional patterns of ground water flow in the Gallatin Valley. When looking at specific sites and sources of pollution, including subsurface disposal of wastewater, the regional flow patterns provide good background information, but often the local flow patterns are either different, or more complex. Regardless of the scale of view, it is important to remember that ground water flow patterns are normally shown in map view, which leads to the impression that the flow is generally horizontal. In reality ground water flows in three dimensions, and vertical ground water movement is common.

7.2.1 Regional Ground Water Flow Patterns

The U.S. Geological Survey (USGS) mapped regional ground water flow in the Gallatin Valley during the water years 1952-1953 (Hackett 1960), and again during water year 1994 (Slagle 1995). These are the only regional ground water flow maps available for the Gallatin Valley. Both sources are often sites by engineers and others that are evaluating subdivisions and wastewater disposal, including non-degradation analysis. Figure 31 shows the regional ground water flow patterns as mapped by Slagle. In general, ground water flows from higher elevation towards lower elevation at right-angels to the ground-water contour lines shown on the image. The base map is a color infrared aerial photograph that highlights wet areas in red. Maps A1 and A2 in Appendix A also show the regional ground-water contours. In general, ground water flows from southeast to northwest across the Gallatin Valley. The primary sources of recharge are stream flows entering the valley from the Gallatin and Bridger Ranges, and the West Gallatin River entering the valley at the mouth of Gallatin Canyon. The West Gallatin River has a significant influence on regional ground water flow patterns. Ground water flow patterns in the Gallatin Valley are also significantly altered by widespread distribution of surface water around the valley for irrigation.

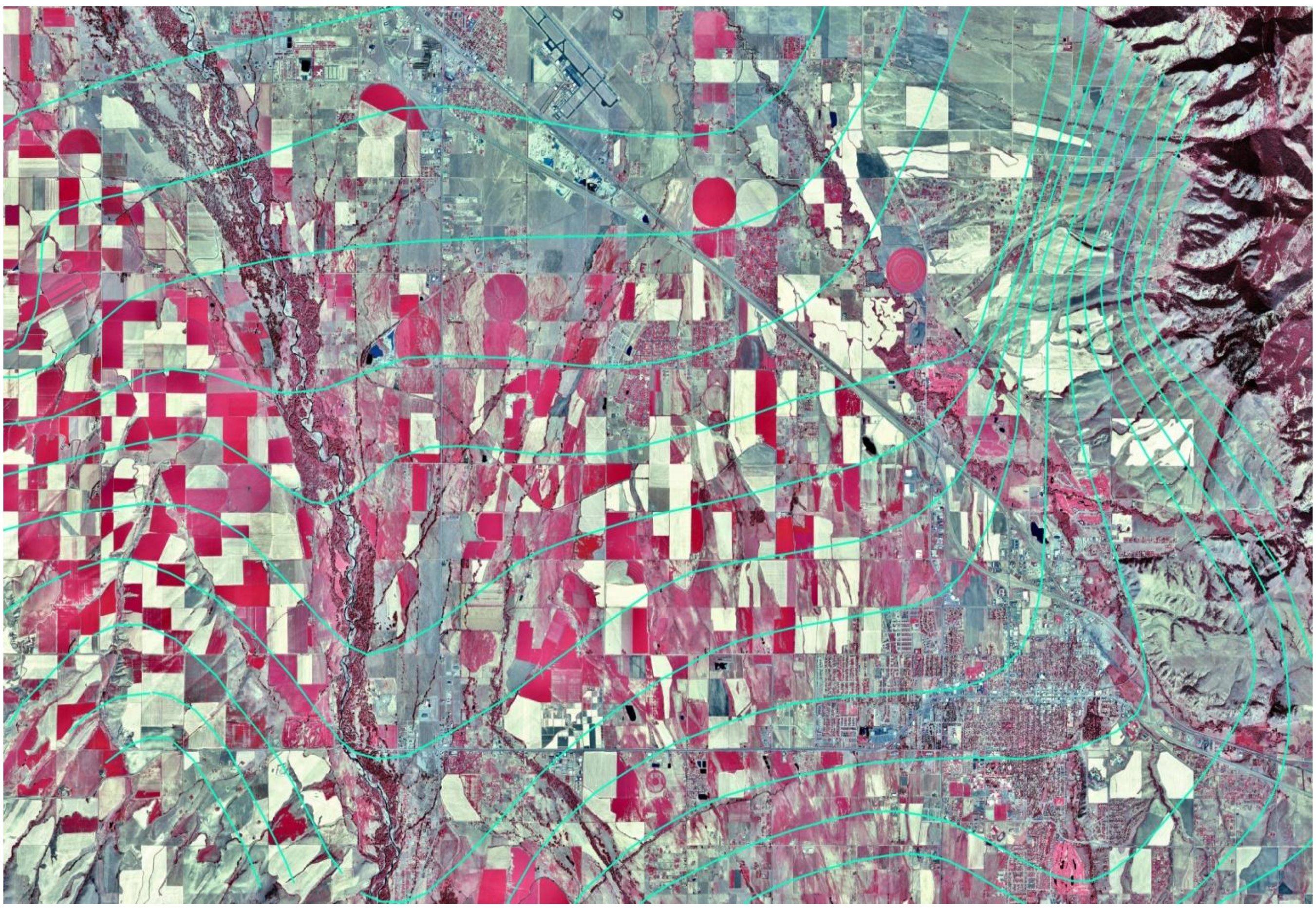

Figure 31. Example of Regional Ground-Water Flow Patterns in the Gallatin Valley. *Light blue lines show elevation contours for ground water in a portion of the Gallatin Valley. Dark blue arrows show the directions of regional ground water flow. Ground-water contours modified from Slagel (1995).*

7.2.2 The Need for Accurate Local Ground Water Flow Information

The regional ground water flow mapping by Hackett (1960) and Slagle (1995) do not agree in some areas. They are both based on widely spaced measurements, approximate elevations of wells, and interpretation of the data by the authors. While useful for understanding general ground water flow in the Gallatin Valley, they should not be used to conduct detailed evaluations of potential impacts to ground water from subsurface disposal of wastewater, especially for completion of nondegradation analysis. A good example of the need to obtain accurate local ground water flow information was documented by the GLWQD in the River Rock area.

To assess ground-water quality in the River Rock area (see subsection 2.8), select wells were surveyed and static water levels were measured seasonally to see if the ground water flow direction changed throughout the year. The locally measured directions of ground water flow were compared with the regional flow directions mapped by Hackett (1960) and Slagle (1995). It was found that neither regional map accurately showed ground water flow direction in the center of the study area, the Hackett map was reasonably accurate for the north part of the study area, and the Slagle map was representative for the southeast part of the study area. Figure 32 shows how the regional flow directions and local flow directions compare for the River Rock study area. It was also documented during this study that there was significant downward vertical movement of ground water in the area of the River Rock lagoons. This is significant since pollutants that reach ground water will travel vertically downward too, and may be missed by shallow monitoring wells installed down-gradient from the source of pollution.

7.3 Ground Water Mixing Zones and Septic System Plumes

Excluding a few rare exceptions, all septic systems ultimately discharge to ground water. Discharge from a septic system results in a plume of contaminated ground water that can be delineated and tracked, based on contaminants in the treated wastewater, such as nitrate, chloride, or dissolved solids (conductivity). Contaminant plumes gradually become un-traceable as the pollutants are dispersed and diluted in the aquifer. There is no specific end to the plume, rather they simply fade away. An arbitrary plume edge is usually based on some measured contaminant concentration, typically a regulatory standard. Aquifer properties, principally hydraulic conductivity and ground water flow velocity, the volume of wastewater discharge, and the concentrations of contaminants in the wastewater discharge, all affect the size and shape of the contamination plume emanating from a septic system.

While related to the concept of contaminant plumes, mixing zones are regulatory in nature. A mixing zone is a specified portion of an aquifer, projected to the land surface, where a ground water pollutant is allowed to exceed applicable water quality standards. The down-gradient edge of the mixing zone is the point of compliance, where the ground water pollutant concentration must be below the applicable water quality standard. Mixing zones have defined boundaries that may or may not fully contain the actual ground water contamination plume. Designated mixing zones for individual septic systems for residential use, on lots less than 2-acres, are 100-feet long. For other non-public septic systems the designated length varies depending on use, lot size, and subdivision size. For public sewage systems the standard length is 500-feet. Table 22 shows standard ground water mixing zones for septic systems. The thickness of a mixing zone in an unconfined aquifer is 15 feet, starting at the top of the water table.

Some public sewage systems may have monitoring wells located at the down-gradient edge of a designated mixing zone for compliance monitoring. Public sewage systems approved after May 1998, with a design flow of more than 5,000 gpd are required to obtain a ground water discharge permit. These systems may have monitoring wells, depending on the permit conditions, at the discretion of DEQ (see subsection 4.2.5).

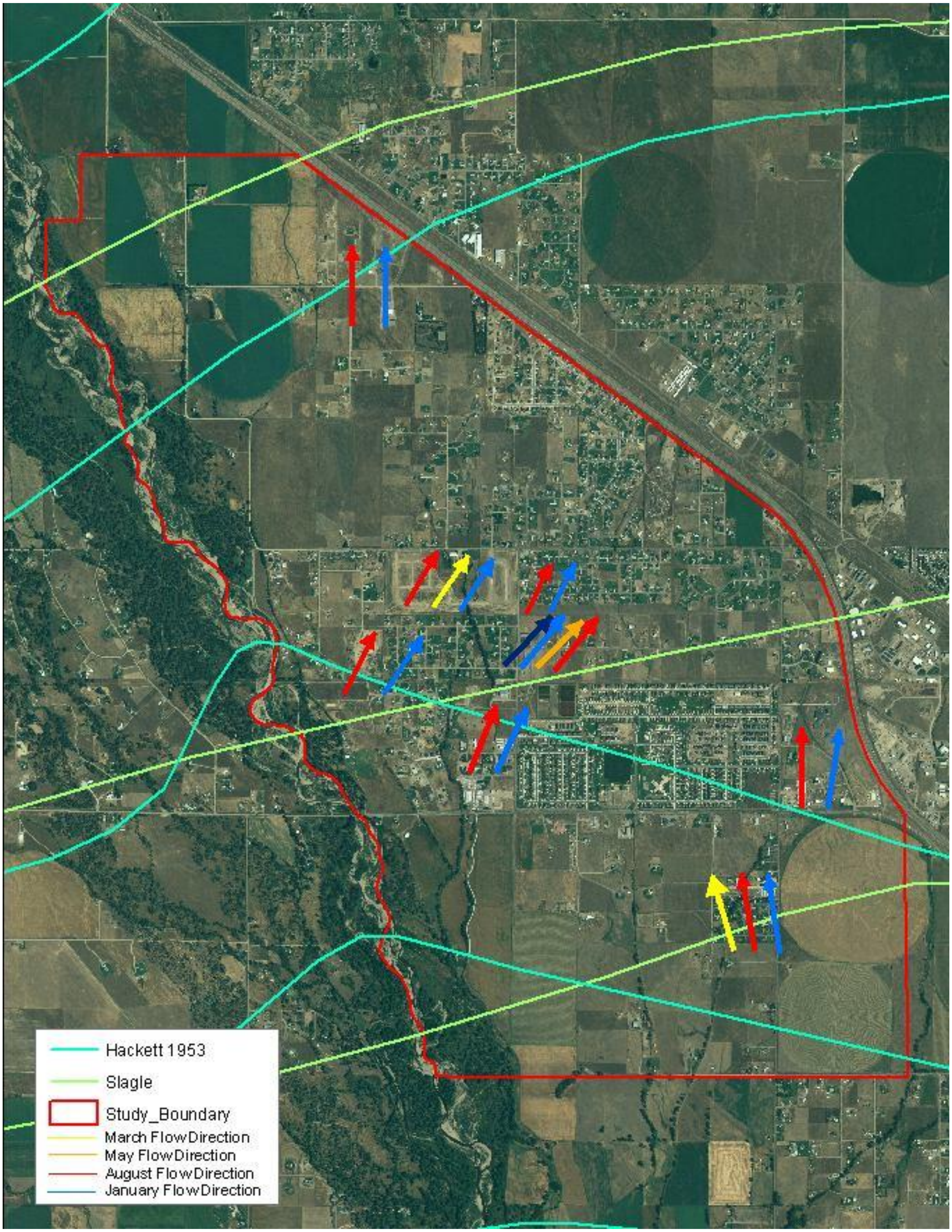

Figure 32. Regional and Local Ground Water Flow Patterns in the River Rock Area. *A comparison of two sources of regional ground water patterns with local flow data shows the danger of using the regional information for evaluating potential impacts from subsurface disposal of wastewater.*

Table 22
Standard Ground Water Mixing Zones for Septic Systems*

Type of Systems	Lot Size (acres)	Subdivision Size (acres)	Standard Mixing Zone Length (feet)
Single-family	< 2	NA	100
Single-family	≥ 2	5 to 10	200
Single-family	≥ 2	<5 or >10	500
Duplex	NA	NA	500
Multi-user	NA	NA	500
Commercial	NA	NA	500
Public	NA	NA	500

*See ARM 17.30.517(1)(d)(viii) for complete rule requirements

7.3.1 Mixing Zones and Plumes for Individual Septic Systems

Figure 33 shows the shape of an actual plume of contaminated ground water emanating from an individual septic system, based on measured chloride concentrations. This figure illustrates the point that all septic systems have ground water contamination plumes associated with them. It also shows how the plume diminishes with distance based on defined pollutant concentrations. The plume eventually fades away as the contaminant is dispersed and diluted. The plume is not really getting thinner, but rather as the contamination is diluted, the concentration lines shrink.

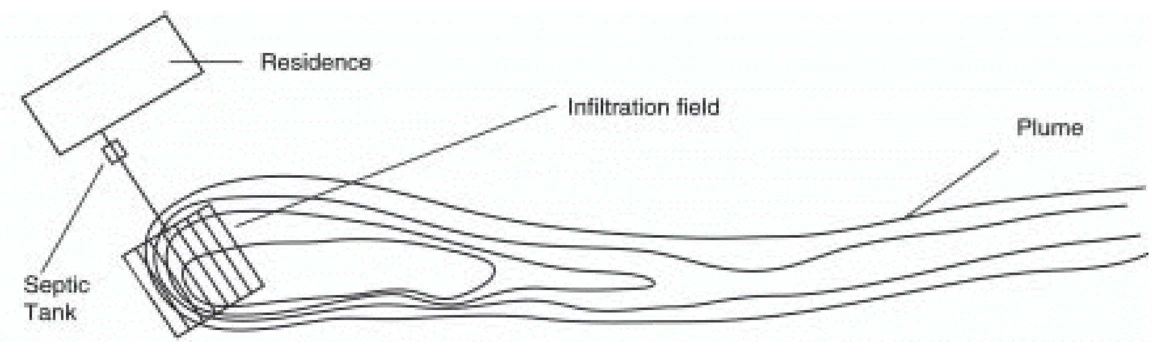

Figure 33. Measured Plume Emanating from an Individual Septic System. *A septic system in a shallow, sandy aquifer in Canada was intensely monitored to document the size and shape of the plume of contaminated ground water created by the septic system.*

Ground water mixing zones for large public sewage systems often receive public attention, but most people don't visualize mixing zones for individual septic systems. Standard mixing zones for individual septic systems are defined in ARM 17.30.517 as "*100 feet for a single family septic system drainfield in towns or subdivisions where individual lots are less than two acres in size*". A 100-foot separation between drinking water wells and septic systems is also a statutory requirement. This separation requirement has been in place longer than the rules governing mixing zones, and is probably the basis for the 100-foot standard mixing zone for individual septic systems. Standard mixing zones also have a defined depth, which extends from the top of the water table beneath the source, to 15 feet below the water table. Figure 34 shows an area of individual septic systems in the Gallatin Valley, with standard mixing zones depicted. Viewed from this perspective, the need to properly place water wells and septic systems on lots based on accurate ground-water flow direction information is easier to appreciate.

Figure 34. **Visualization of Mixing Zones for Individual Septic Systems in a High Density Area**. *The yellow rectangles are the surface areas of the mixing zones, oriented with ground water flow.*

7.3.2 Mixing Zones and Plumes for Public Sewage Systems

Like individual septic systems, public sewage systems that discharge treated wastewater to the subsurface, and ultimately to ground water, create plumes of contaminated ground water that can also be defined and tracked, based on contaminants in the treated wastewater, such as nitrate, chloride, or dissolved solids (conductivity). The only difference between a contamination plume from an individual septic tank and from a large public sewage system is size. Preliminary results from the GLWQD's study of ground water quality in the River Rock area indicate that the plume of contamination from the River Rock Sewer and Water District treatment system can be tracked up to a quarter mile using field measurements of dissolved oxygen and specific conductivity.

For public sewage systems built after 1998, with discharge flows over 5,000 gpd, a ground water discharge permit is required. These permits are issued by the DEQ Water Protection Bureau. A mixing zone is defined for the permit. Mixing zones can be site specific in shape and length, or a standard mixing zone can be designated as specified in ARM17.30.517, which states "*A specific depth and width are necessary to determine the aquifer cross-section area (A) for a standard mixing zone. The aquifer cross-section area prescribed by the following lengths is used as the area (A) in the equation: (A) The depth of a standard ground water mixing zone extends from the top of the water table beneath the source down to 15 feet below the water table. (B) The width of a standard mixing zone is equal to the width of the source plus the distance determined by the tangent of 5º times the length of the mixing zone on both sides of the source.*" The length of a standard mixing zone for a public sewage system is 500. Figure 35 shows how a standard mixing zone for a public sewage system would look in comparison to surrounding mixing zones for individual septic systems.

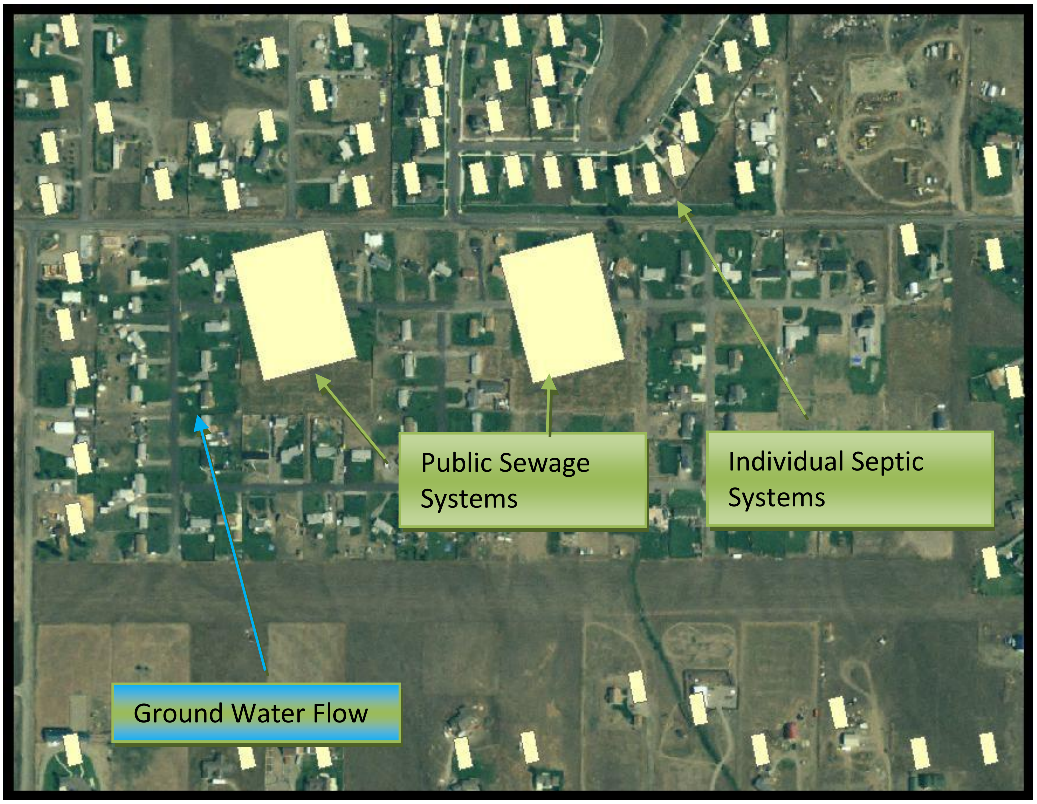

Figure 35. Standard Mixing Zones for Public Systems and Individual Septic Systems. *While the shape of these mixing zones are simplified, they provide a good visual comparison of the size of standard mixing zones for individual septic systems and public sewage systems.*

7.3.3 Inventory and Mapping of Designated Mixing Zones for Public Systems

The GLWQD reviewed available files for information on locations of designated mixing zones for public sewage systems that have been issued a Ground Water Pollution Control System (GWPCS) permit. Table 23 shows all of the known public sewage systems in Gallatin County that have ground water discharge permits. Since the requirement has only been in place since May 1998, and only applies to sewage systems with design flows over 5,000 gpd, there are not that many designated mixing zones. Out of 147 inventoried public sewage systems, GWPCS permits have only been issued for 18 systems. Public sewage systems installed prior to May 1998 can be required to obtain a GWPCS permit if they are found to be violating water quality standards. An example of this is the River Rock system, which was recently required to obtain a permit even though the system was approved prior to 1998.

The GLWQD used site maps found in the system files of EHS to digitize the locations and shapes of all of the known designated mixing zones for public sewage systems. A GIS data layer was created to plot the mixing zone locations. The mapped mixing zones are not shown on the public sewage systems map included in Appendix A, Map A-3 due to the scale of the map. One problem that was noted was that the descriptions of the designated mixing zones were sometimes vague, and the quality of the maps provided with the permit information was generally poor. None of the designated mixing zones are based on surveyed locations. An example of one of the mapped mixing zones is shown in Figure 36.

Table 23
Public Sewage Systems in Gallatin County with Ground Water Discharge Permits

System Name	System Type	GWPCS Permit #	Permitted Discharge (gpd)
Belgrade Gardens	Pressure Dosed Drainfield	MTX000136	24,300
Bozeman KOA	Pressure Dosed Drainfield	MTX000126	12,250
Green Hills Ranch	Pressure Dosed Drainfield	MTX000150	12,950
Red Creek Ranch	Pressure Dosed Drainfield	MTX000119	9,400
Manley Meadows	Pressure Dosed Drainfield	MTX000153	14,700
Bridger Bowl Base Area	Recirculating Sand Filter	MTX000144	10,210
Country Side Estates	Recirculating Sand Filter	MTX000177	30,920
Firelight Meadows A&B	Recirculating Sand Filter	MTX000129	19,890
Ramshorn View Estates	Recirculating Sand Filter	MTX000103	14,800
4Dot Meadows	Recirculating Sand Filter	MTX000108	39,550
Firelight Meadows C	Recirculating Trickling Filter	MTX000129	13,160
Lazy J South	Recirculating Trickling Filter	MTX000172	20,000
E. Gallatin Comm.Center	Sequencing Batch Reactor	MTX000165	12,000
Valley Grove IV	Sequencing Batch Reactor	MTX000112	43,000
RAE Water & Sewer	Sequencing Batch Reactor	MTX000117	200,000
River Rock	Aerated Lagoon	?	374,000
Utility Solutions (spray)	Mechanical Treatment Plant	MTX000110	100,000
Utility Solutions (other)	Mechanical Treatment Plant	MTX000110	635,537
City of Belgrade	Aerated Lagoon	MTX000116	903,000

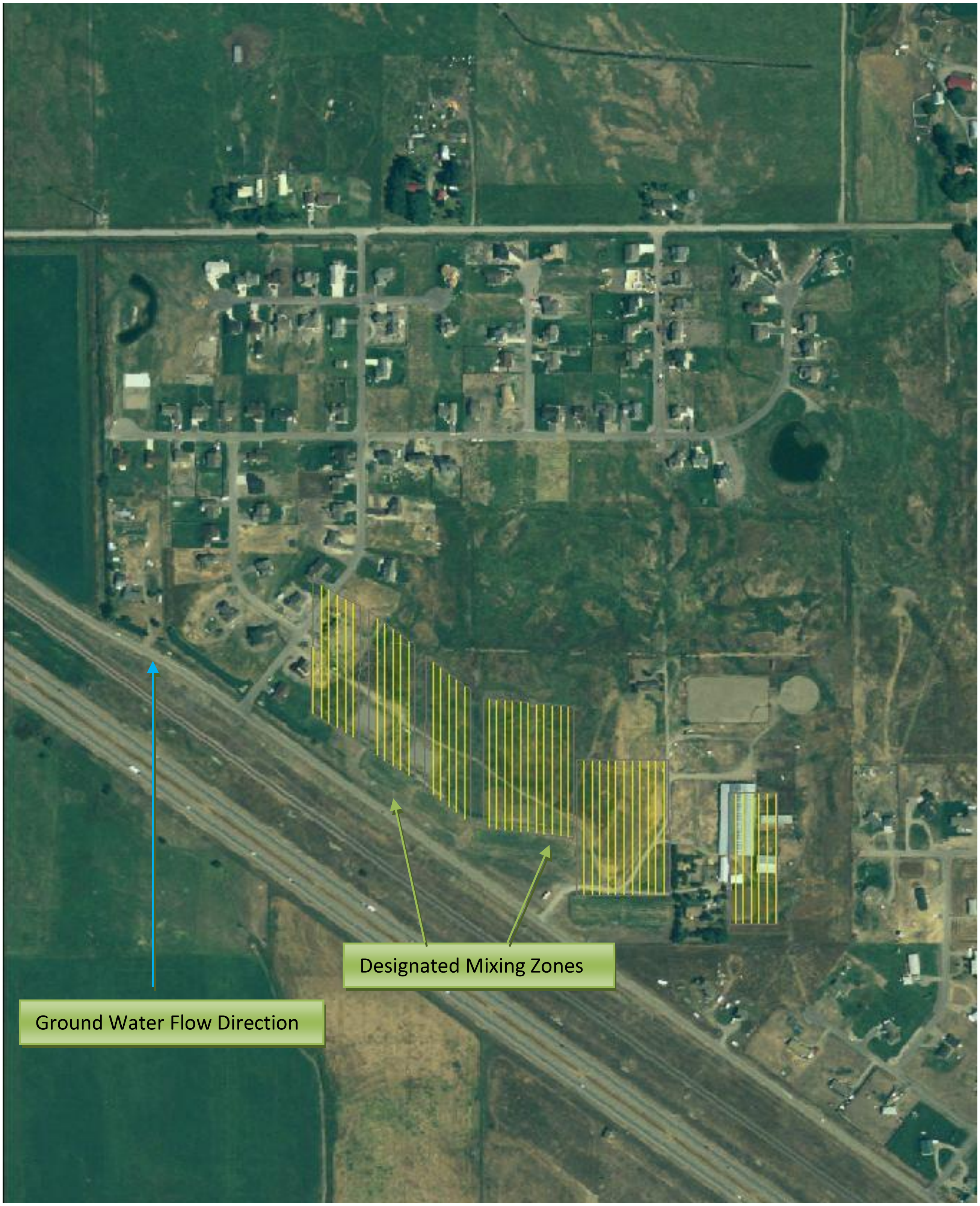

Figure 36. Example of Designated Mixing Zone for a Public Sewage System. *This example of a GIS layer for designated mixing zones shows several designated areas for the 4 Dot Meadows Subdivision. Homes in this subdivision are on individual wells, with lots less than 1-acre in size.*

7.4 Lot Size and Septic System Density

The most common practice for limiting public health risks and ground water contamination from individual septic systems is to regulate the minimum lot size required. This provides a means of controlling septic system density, but does not address cumulative impacts or carrying capacity.

7.4.1 Individual Septic System Lot Size Requirements

In Montana the minimum lot size for use of individual septic systems is 1-acre in most cases. There are a number of exemptions from this rule, which are spelled out in ARM 17.36.340. The most common exemption used allows for septic systems on ½-acre lots if the water supply is a public system. An example of the use of this exemption is the Cobblestone subdivision located west of Belgrade. This subdivision is served by the River Rock public water supply, and consists of ½ acre lots with septic systems.

The individual septic system database (point layer) and the Gallatin County parcel layer were used to analyze the current distribution of septic systems relative to lot sizes in Gallatin County. Using the GIS software, parcels that had a septic system on them were identified. Then the frequency distribution of the septic systems on those parcels was determined based on lot size. The results are shown in Figure 37. About 48% of the septic systems inventoried are on lots of 2-acres or less, and 24% are on lots of 1-acre or less, and about 9% are on 1/2 –acre lots.

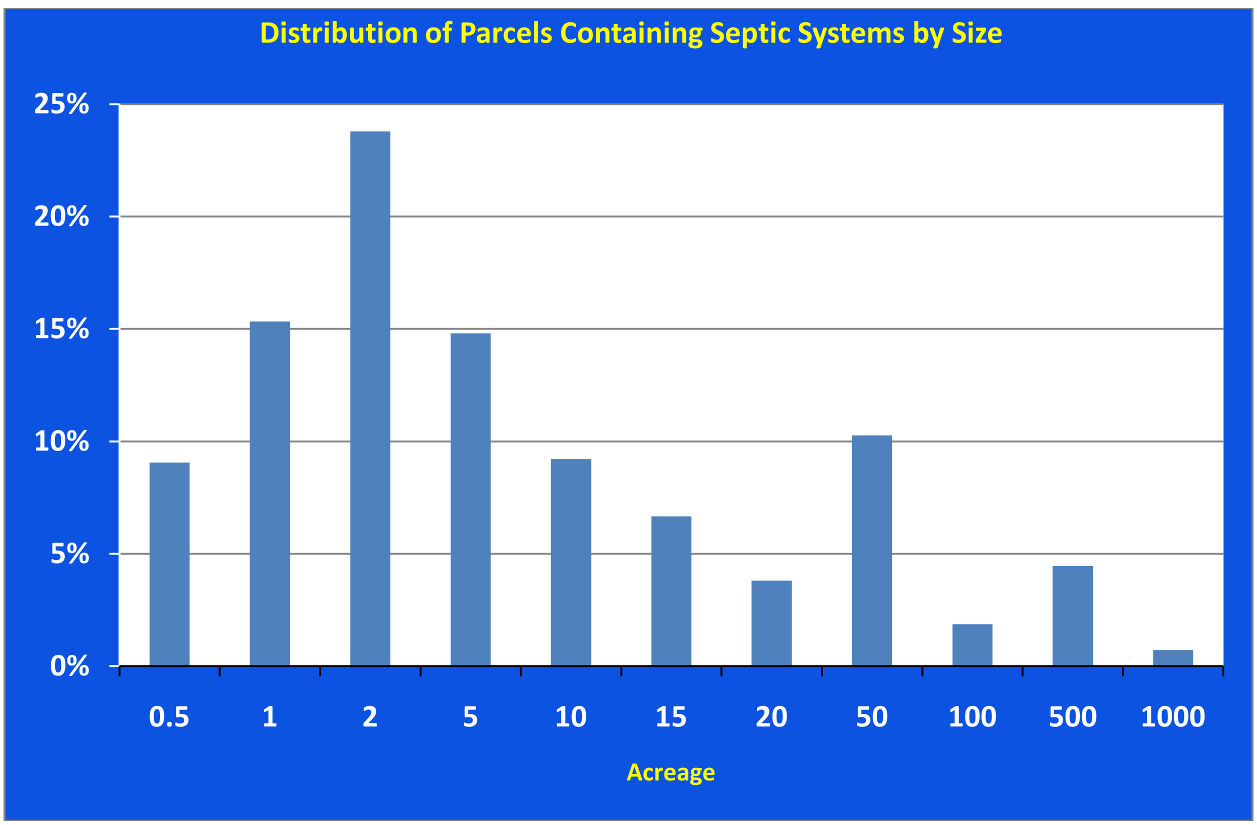

Figure 37. **Frequency Distribution of Individual Septic Systems vs. Lot Size**. *About 48% of all individual septic systems in Gallatin County are on lots of 2 acres or less in size, and 24% are on lots of one acre or less. Nine percent of all septic systems in the County are on lots of ½ acre or less.*

The GLWQD researched available scientific information on the relationship between septic system density and water quality impacts to determine if Montana's minimum lot size requirements for septic systems were scientifically supported. As part of this effort, numerous attempts to try and document the scientific basis for developing the 1-acre minimum lot size requirement for septic systems in Montana were made. No documentation of basis could be verified. Rule makers in Montana probably looked at the minimum lot size requirements in other states and developed the Montana regulations based on that information, but no reference to scientific basis could be documented.

There are several studies that have been done in other states, that have attempted to scientifically determine a safe minimum lot size for use of septic systems. Using mathematical models, Perkins (1984) reported that ½-acre to 1-acre lot sizes provided minimum reasonable protection of water quality. Brown and Bicki (1987) reviewed several studies and concluded that the minimum lot size necessary to ensure protection of ground water quality was ½-acre to 1-acre. However, they also noted that some studies reviewed suggested that larger minimum lot sizes were needed in some settings. While more literature review is possible in this subject area, it is beyond the scope of this project.

The DEQ Subdivision Review Section has been considering making changes to the rules governing subsurface wastewater disposal systems. Recommended changes considered include a requirement that all wastewater treatment systems, mixing zones, water supplies, and well isolation zones must be contained solely within the parcel. This contrasts with the current possibility that allows mixing zone and well isolation zones to cross property boundaries. These changes could necessitate the need for a minimum lot size in excess of one acre.

7.4.2 Individual Septic System Density Mapping

Using the individual septic system point layer (see subsection 3.5), and the public land survey system grid (township, range, and section), septic system density analysis was completed by the GIS Department. Density analysis was done utilizing ArcGIS 9.2 software, and was performed on the septic system point map to try and quantify septic density per unit area across the county. The resulting GIS layer shows septic systems density in units of systems/acre, for 10-acre grid cells. A map showing the results in units of septic systems per acre was created, and is provided in Appendix A, Map A-3, entitled Septic System Density in Gallatin County, Montana. An example of the septic system density layer is shown in Figure 38. This is a large scale view of the septic system density map in the River Rock area, southwest of Belgrade.

The septic system density map is useful for showing areas with the highest septic system density in a quantitative way. Map A-3 shows relatively high septic system densities west of Belgrade, southeast of Belgrade (Valley Center area), and south of Bozeman. The map also highlights numerous smaller high density areas such as Gallatin Gateway, the Mountain View subdivisions along Interstate 90 between Bozeman and Belgrade, and the Mount View subdivision southwest of Belgrade. Undeveloped areas, agricultural lands, and areas served by pubic sewage systems show up as windows on the density map.

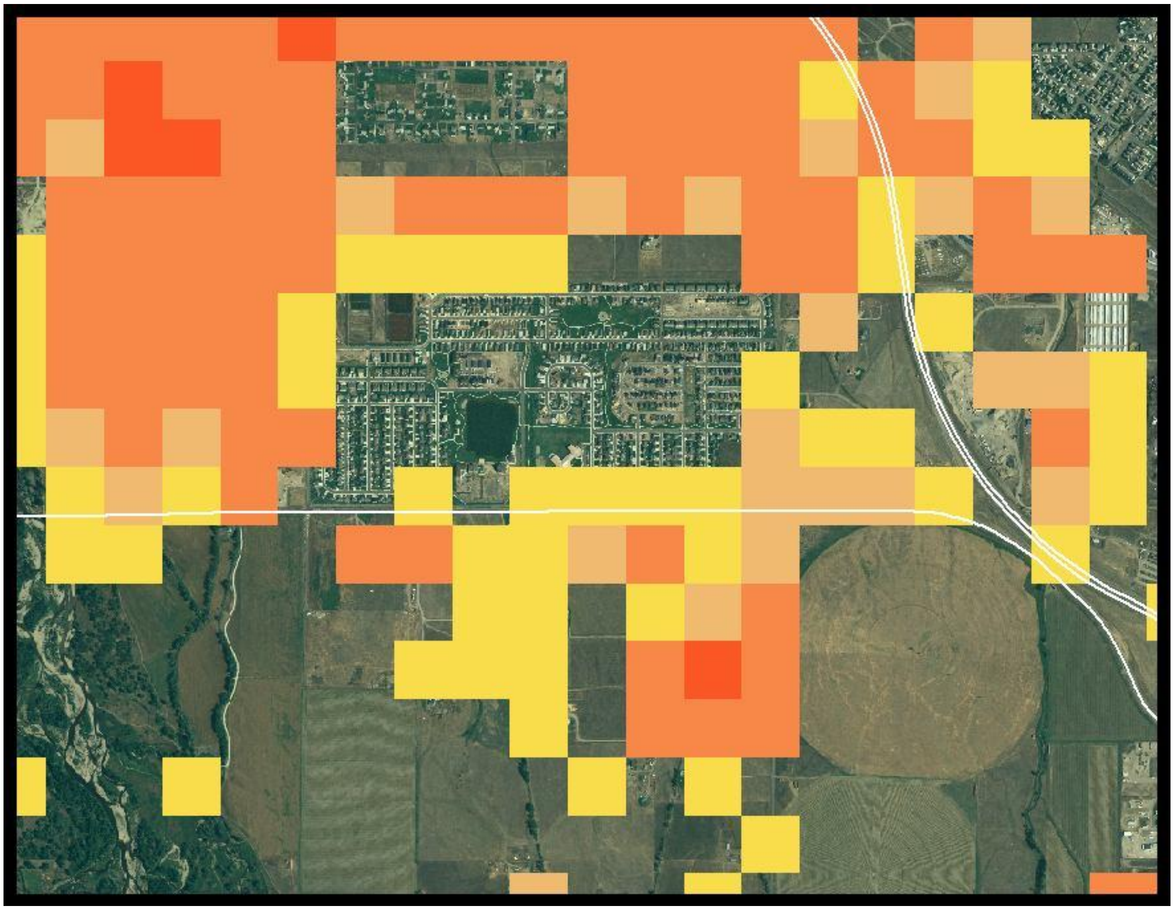

Figure 38. **Individual Septic System Density in the River Rock Area**. *The individual septic system point layer was analyzed using a grid with a 10-acre cell size. The resulting septic system density map highlights areas with higher septic system density. Yellow areas have lower septic system density while dark orange cells highlight higher density areas.*

The GIS Department also completed additional analysis of the septic system point layer using a smoothing technique. This method counts the number of septic system points within a fixed radius of each grid cell, and then averages that density over the area of the circle. The method tends to highlight the highest density areas. The septic system point map was processed to represent density at two scales. Initially the septic system point layer was smoothed using a ½-mile search radius. This provides a large scale, valley-wide view of development and septic system use patterns. This analysis is more generalized, and appears smoothed by the search radius the program utilized to highlight areas of greatest density, and muting lower-density rural septic use. A second mapping using a 100-meter search radius, resulted in smaller raster size, with greater precision and specificity allowing more subdivisions to be identified. A clip of the GIS analysis for the ½-mile search radius smoothed density data is shown in Figure 39.

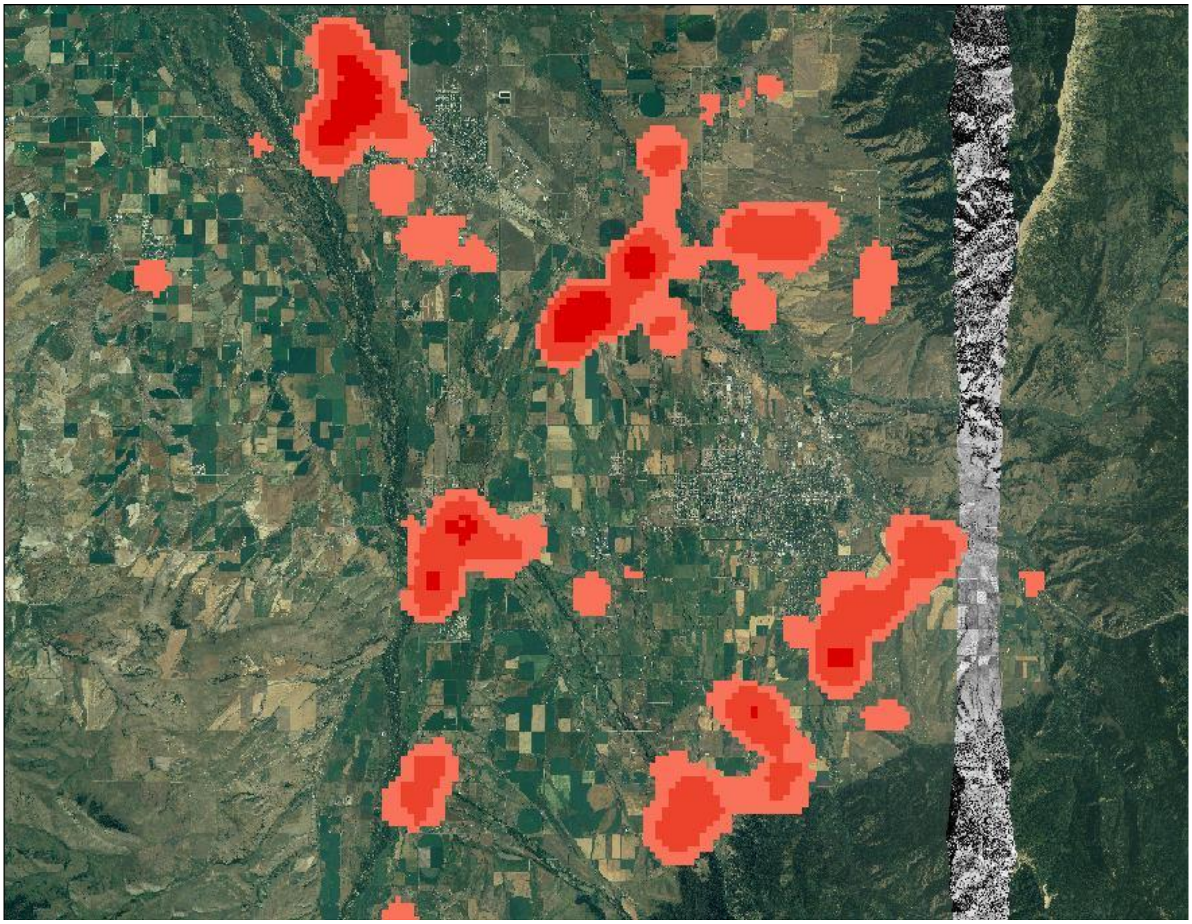

Figure 39. Smoothed Septic System Density Map of the Gallatin Valley. *A septic system point layer was evaluated using a smoothing technique that counted the number of septic system points within a ½ mile radius of each grid cell. The results highlight the highest density areas.*

7.5 Nondegradation Analysis for Subdivisions with Individual Septic Systems

When subdivisions are proposed with individual septic systems, DEQ requires that a nondegradation analysis be performed to estimate the impacts of the septic systems on ground water quality (see section 3.2 for regulatory background on nondegradation). Nondegradation analysis focuses on phosphorous and nitrate as the contaminants of concern. The analysis includes both a **phosphorous breakthrough analysis** and a **nitrate sensitivity** analysis, because the two contaminants behave very differently in ground water.

Phosphorous is primarily evaluated because of the potential impacts it has on surface water bodies. Phosphorous is usually the limited nutrient in area surface water bodies, and even small amounts discharged via contaminated ground water, can have significant impacts. However, phosphorous present in treated wastewater is readily absorbed by soils and aquifer materials, and transport in ground water is highly retarded. A **phosphorus breakthrough analysis** is used by DEQ to address nondegradation for phosphorus. This analysis is based on calculating the phosphorus loading to soils, determining the capacity of the soils to adsorb phosphorus, and then determining the breakthrough time for phosphorus to reach the nearest surface water body down-gradient of the septic system. The breakthrough time is typically measured in years.

Nitrate is evaluated because it is a significant pollutant in septic system effluent, is persistent in the environment, poses a human health risk above concentrations of 10 mg/l, and is a surface water nutrient. If ground water contaminated with nitrate discharges to surface water, the nitrate can promote algae growth. Unlike phosphorus, nitrate is not adsorbed by soils in the subsurface disposal area, and once it reaches the ground water, it tends to simply follow the ground water without reacting with the ground water or the aquifer materials. For nondegradation analysis, a **nitrate sensitivity analysis** is completed to evaluate the potential impacts from septic systems. Nitrate sensitivity analysis is based on looking at the background concentration of nitrate in ground water, in the area of the proposed subdivision, calculating the total amount of additional nitrate that will be discharged by the septic systems in the subdivision, and then calculate, based on dilution, what the final nitrate concentration would be in the ground water at the down gradient end of the subdivision. The following subsections focus on non-degradation analysis for nitrate since it is the primary ground water contaminant of concern in most cases.

7.5.1 DEQ Guidance and the Bauman-Shafer Model

A very good guidance document is provided by DEQ for those that plan to complete a non-degradation analysis (DEQ 2009). A classic paper by Bauman and Schafer (1984) is commonly used as a reference for completing non-degradation analysis for septic systems. This paper describes a mathematical dilution model for estimating nitrate concentrations in ground water from septic systems. This dilution model is the most commonly used method for completing a non-degradation analysis. Both documents can be downloaded at http://www.deq.mt.gov/wqinfo/Nondeg/HowToNonDeReg.mcpx.

7.5.2 Discussion of Nitrate Sensitivity Analysis for Nondegradation

There are a number of technical issues that can influence the predicted nitrate levels in ground water from septic systems, when completing a nitrate sensitivity analysis. The nitrate concentrations for background ground water nitrate, and the effluent from the septic system, directly influence the results of the dilution calculation. A background ground-water nitrate sample from shallow ground water in the immediate area of the proposed subdivision (or septic system) is best, but not always required. A background nitrate concentration that is too low will result in an under prediction of the final nitrate concentration. Conversely, the methods used assume there is no denitrification once nitrogen compounds are converted to nitrate and reach the subsurface disposal structure, which is assumed to be an aerobic environment. This is generally true in shallow alluvial aquifers that are well oxidized. However, in some cases anaerobic conditions may exist in the disposal area, and the aquifer. This could result in some denitrification in the mixing zone, and over prediction of the final nitrate concentration.

The nitrate sensitivity analysis is dependent on the aquifer properties used to complete the dilution calculations. The gradient (slope) of the water table, and the hydraulic conductivity (ability to transmit water) of the aquifer are used to calculate the volume of ground water available for dilution. While the gradient is often easy to document, the hydraulic conductivity is not, and is often estimated. The nitrate sensitivity analysis is highly sensitive to the value of hydraulic conductivity. If an unreasonably high value of hydraulic conductivity is used in the dilution calculations, nitrate concentrations in ground water will be underestimated. On-site aquifer testing using a test well is the preferred method to obtain a value for hydraulic conductivity, but this is not always required, or practical.

Non-degradation analysis is also highly sensitive to the direction of ground water flow, which is used to predict the orientation of the mixing zone and avoid contamination of down-gradient water wells. As discussed in subsection 7.2.2, use of regional ground water flow maps to determine the direction of ground water flow is ill-advised. For subdivision proposals on-site determination of ground water flow direction should be required, including consideration of seasonal changes in flow direction.

Given all of the potential factors that can influence the outcome of a nitrate sensitivity analysis, the key factors are proper use of the highest quality data available to complete the analysis, and good regulatory review of nondegradation analysis reports prepared for proposed subdivisions. The Gallatin Water Resources Task Force (English 2005) discussed non-degradation analysis at length, including the above limitations. The Task Force concluded that while the process had numerous issues, it was practical and gave reasonable results, when properly done.

CHAPTER 8
CONCLUSIONS AND RECOMMENDATIONS

8.1 General

- The report did not consider treatment and disposal of wastewater from concentrated animal feeding operations (i.e. feed lots, dairies). Wastewater from these operations is similar to domestic wastewater, but probably much higher strength. Current handling and disposal practices in Gallatin County should be evaluated to determine potential impacts to water resources.

- The Gallatin Water Resources Task Force recommended that a technical advisory committee be established to advise the County Commission and others on water resource issues. This could include issues associated with wastewater treatment and disposal. The advisory committee was never created, but the idea is still valid, and should be reconsidered.

8.2 Previous Studies

- Water quality data from all of the previous studies provide an extensive dataset which could be used to help evaluate potential cumulative impacts from discharge of treated wastewater to ground water in the Gallatin Valley. The GLWQD should compile all of this data into a single database for use in assessing cumulative impacts from wastewater treatment and disposal.

- The work completed by Kendy (2001), Fleming (2003), and Greenup (2003), generally concluded that there were no significant cumulative impacts to water quality from septic systems. Revisiting the sampling sites for these studies should be considered to determine if changes have occurred since the studies were completed.

8.3 Individual Septic Systems

- Septic systems that treat and dispose of commercial or industrial wastewater pose a greater risk to ground water quality due to the potential for a wide range of chemical waste to be disposed of into them. Additional work should be completed to document the locations of all commercial and industrial septic systems, and determine the risk they pose to ground water.

- There are probably numerous motor vehicle waste disposal wells still in use in Gallatin County, even though these systems have been banned in Montana since 1999. There has not been a systematic program implemented to try and locate and close these systems by EPA, DEQ, or EHS. Because they pose significant risk to ground water quality, these systems should be located and eliminated, in cooperation with EPA.

- There are probably a significant number of septic systems in Gallatin County that are obsolete under the current Health Code, but strict enforcement to eliminate these systems would be unreasonable. If not already established, the Health Department should make sure the policy for dealing with obsolete septic systems is fair and consistent.

- Current regulations do not require that a septic tank access port for inspecting and pumping the tank be extended to the ground surface and be visible. It would be easier, and less expensive for septic system owners to locate, inspect and maintain their septic tanks if all access ports for inspection, pumping, and effluent filters, were required to be extended to the surface.

- There are a number of nitrogen-reducing septic systems installed in Gallatin County. These systems have numerous mechanical parts, and require routine maintenance. For this reason, a condition of approval is that the owner has a maintenance contract for routine servicing. Currently there is no way to identify the locations of all these systems, and there is no oversight to make sure that maintenance contracts are in place. A process for tracking and monitoring these systems should be established, possibly using the EHS Tyler® database.

- Based on system monitoring data obtained from DEQ for nitrogen-reducing septic systems in Gallatin County, there is some question as to how well the nitrogen-reducing septic systems perform over time. EHS should review the available monitoring data for nitrogen-reducing septic systems to determine if further analysis is required. EHS should also work with DEQ to make sure they receive copies of monitoring results for systems in Gallatin County.

- The septic system GIS database and the septic system density mapping show the locations of high-density septic system usage in Gallatin County. These areas should be targeted for further study to determine if cumulative impacts to ground water are occurring.

- The septic system GIS database can be improved and refined. It is recommended that the GLWQD and EHS work together to combine septic system mapping efforts, and establish system for maintaining and updating the GIS database.

- There are some limitations with the Tyler® database that could be improved. Currently the database does not contain enough information to determine how many of the permitted septic systems are shared, or multiple-user systems. If this was possible, better estimates of septic system discharge could be made.

8.4 Public Sewage Systems

- While DEQ is generally considered to be responsible for operational oversight and inspection of public sewage systems, no information was found to determine if DEQ has any kind of structured process for routine inspection and monitoring of public sewage systems.

- It is also not clear from reviewing the applicable MCA and ARM governing public sewage systems, who at DEQ is responsible for overseeing inspection of public sewage systems. This problem should be further researched to determine current DEQ protocol.

- A significant problem noted is that information on public sewage systems is not readily accessible to the public. System information is often contained in multiple files maintained by different sections and bureaus of DEQ. DEQ does not maintain a public access database of public sewage system information, and overall, there is a poorly structured system for public access to hard copy files on public sewage systems.

- It appears that most inspections of public sewage systems in Gallatin County have been completed by DEQ staff from the State Revolving Fund (SRF) Program, primarily for systems that have received SRF funding support or technical support. However, these inspections are not coordinated with EHS, and there is no procedure in place to make sure EHS is provided with a copy of the inspection reports. In order to monitor public sewage systems in Gallatin County, an agreement with DEQ should be pursued to make sure EHS gets copies of all inspection reports.

- MCA and ARM allow DEQ to enter into agreements with local governments for inspection of public sewage systems. DEQ may also delegate review of small public sewage systems to local governments. The Health Department should consider pursuing an agreement with DEQ for local inspection of public sewage systems, and review of small public sewage systems.

- Among the various types of treatment systems, lagoons seem to be the most problematic. The quality of the effluent produced by lagoon systems is highly variable, and several of the lagoon systems in Gallatin County are known to have problems. It is recommended that all lagoon systems be further evaluated to determine if they are functioning properly, determine effluent quality, and for several systems, determine if the systems are impacting nearby surface water bodies.

- Of the 147 public sewage systems in the County, 86 (59%) are basic septic systems. This includes 2 holding tank systems, 2 seepage pit systems, 31 gravity-feed drainfield systems, and 51 pressure dosed drainfield systems. While these systems are public sewage systems, they do not provide any better treatment of wastewater than individual septic systems. Gallatin County should consider the level of treatment proposed for developments along with the type of systems (individual vs. public).

- This report focused on discharge volumes for public sewage systems. Since levels of treatment vary, the quality of the effluent from treatment systems is also an important factor. The GLWQD did not have enough information on the quality of effluent from all of the systems to evaluate total nitrogen loading or look at other aspects of effluent quality. It is recommended that data on effluent quality from public sewage systems be evaluated as a future study.

8.5 County Sewer and Water Districts

- The statutes and rules governing creation of county sewer and water districts provide that the County Commission has the authority to approve a district, including the authority to modify the proposed district boundary. However, once the district is created the Commission has no authority to regulate or manage the district. After approval by the Commission, the District can change plans from what was proposed during the approval process. The Commission should look closely at the limited control they have over these districts when considering approval.

- County sewer and water districts are usually created to facilitate construction, management and operation of public sewer and/or water systems. However, the Spain Bridge Meadows Sewer and Water District was approved with individual wells and individual septic systems. The public benefit of this type of sewer and water district is not clear, and future use for this purpose should be limited.

8.6 Septage Handling and Disposal

- The handling and disposal of septage is regulated by DEQ. Rules governing septage disposal appear adequate, but there appears to be very little oversight to assure that haulers are following the rules.

- A review of site files maintained by EHS showed that they had good documentation for the approved sites in Gallatin County, but there was no indication of routine inspections of the approved land application sites by DEQ.

- While the GLWQD has continued concerns with disposal of septage on the land surface, most areas where septage is currently being disposed of are very isolated, and significant problems could not be documented.

- As the population of Gallatin County grows, the current methods of septage disposal may become more problematic. In many states public treatment works are required to accept septage. The City of Bozeman has a formal policy not to accept septage. An effort should be made to work with the Bozeman plant to develop a septage disposal program. With all of the current and planned construction, it would be a good time to plan for a future septage dumping facility at the plant.

8.7 Biosolids Handling and Disposal

- Biosolids are residual solids processed through a mechanical treatment plant. In comparison to septage, biosolids have much lower levels of nutrients, low BOD, low to very low levels of pathogens, and do not contain non-degradable trash. The GLWQD did not find specific issues of concern with current practices for handling and disposing of biosolids in the County.

- The primary generator of biosolids is the City of Bozeman, and they have a very well organized and run biosolids program. No issues of concern were identified for handling and disposal of biosolids by the City of Bozeman, which is the primary generator of biosolids in the County.

- Where there are no specific concerns with current handling and disposal practices for biosolids in the County, one problem noted was that there was very little information available on how many of the systems that generate biosolids dispose of them. Additional research should be completed to better determine disposal practices in the County.

8.8 Ground Water Discharge Permits, Mixing Zones, and Nondegradation Analysis

- The GLWQD mapped the locations of designated ground water mixing zones using GIS software. A review of file information for this mapping effort found that the location information was of poor quality. EHS should work with DEQ to make sure that engineers submitting information for these mixing zones provide detailed maps.

- DEQ allows irrigation wells within designated mixing zones. This practice should be evaluated to determine if public contact with irrigation water containing fecal-coliform bacteria, viruses, or pathogenic organisms poses a public health risk.

- DEQ has discretion, when issuing ground water discharge permits, to require monitoring wells at the end of designated mixing zone, and because of this discretion, not all public sewage systems in Gallatin County have ground-water monitoring wells.

- Without the monitoring wells, it is difficult to monitor ground-water quality down-gradient of disposal areas and verify compliance with discharge permit requirements. Monitoring wells for compliance purposes should be required for all systems in Gallatin County that obtain a ground water discharge permit.

- Public sewage systems with ground water discharge permits are required to submit quarterly monitoring reports to DEQ for compliance monitoring. DEQ does not coordinate with EHS to make sure they also get the monitoring reports. EHS should work with DEQ to make sure that they are provided with the quarterly monitoring reports.

- Designated mixing zones for public sewage systems are allowed to cross property lines, which can limit the use and value of the adjoining property. Mixing zones should not be allowed to cross property boundaries unless the adjoining property owner agrees, and an easement is placed on the adjoining property.

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GLOSSARY OF TERMS

Anaerobic Digestion {In wastewater treatment, a process where microorganisms break down organic matter in the absence of oxygen. Anaerobic digestion of sewage sludge reduces the volume of the sludge, destroys pathogenic organisms, and produces biogases, including hydrogen, methane, carbon dioxide.

Aquifer {A water-bearing geologic deposit capable of yielding enough water for a particular purpose (Driscoll, 1986), the water-bearing reservoir can be consolidated bedrock, or unconsolidated sediments.}

Biochemical Oxygen Demand (BOD) {The BOD test is used to determine the relative oxygen requirements of wastewaters, effluents, and polluted waters. The test measures the oxygen utilized during a specified incubation period for the biochemical oxidation of organic material. It is also used to determine treatment plant efficiency.}

BOD_5 {(Five-day biochemical oxygen demand) means the quantity of oxygen used in the biochemical oxidation of organic matter in 5 days at 20 degrees centigrade under specified conditions and reported as milligrams per liter} DEQ Circular 4

Biosolids **{** Treated sewage sludge from wastewater treatment plants that contains both inorganic solids and nutrient-rich organic materials. When treated and processed, these residuals can be recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth (modified from U.S EPA).}

Class V Injection Well {Typically, a shallow on-site disposal system used to place various non-hazardous fluids below the land surface (40 CFR 144.80).}

Central Sewer System {In Montana, a term defined both in Code (MCA 75-6-102) and in Administrative Rules (ARM 17.36.101) to define a public sewage system.}

Centralized Wastewater Treatment System {A wastewater collection and treatment system that consists of collection sewers and a centralized treatment facility. These systems serve an urbanized community that may or may not be incorporated. They typically have well over 100 service connections and serve residential, commercial, and possibly industrial users. These systems are also commonly referred to as municipal systems.}

Coliform Bacteria {A broad class of bacteria found in our environment, including in soils, in human feces, and the feces of other warm-blooded animals. The presence of coliform bacteria in drinking water may indicate a possible presence of harmful, disease-causing organisms. Coliform bacteria are used as water quality indicators for because they are often associated with disease-causing organisms and they are relatively simple and inexpensive to analyze water samples for the bacteria.}

Community sewage system {A public sewage system that serves at least 15 service connections used by year-round residents or that regularly serves at least 25 year-round residents}

Dry Well {An underground structure used to dispose of rainwater, stormwater, or wastewater. Typcially a simple structure such as a rock lined pit, or a concrete cylinder with holes in the sides, and an open bottom. The wastewater is disposed of passively under gravity flow, and the structure is usually completed above the water table.}

Facultative Anaerobic Bacteria {A class of bacteria that can live with or without free oxygen}.

Geographic Information System aka GIS {A system that captures, stores, analyzes, manages, and presents data that are linked to location. In the simplest terms, GIS is the merging of cartography and database technology.}

Grey Water {Wastewater generated from domestic activities such as dish washing, laundry and bathing. It does not include wastewater from toilets. Approximately 50 to 80% of residential wastewater is grey water.}

Ground Water {a) water in the subsurface that occurs in sediments that are saturated, or b) all water present below the ground surface either in saturated or unsaturated sediments.}

High-Strength Wastewater {As compared with normal household wastewater, it is wastewater that contains greater amounts of fats, oils, greases, organic compounds, suspended solids, or chemicals such as disinfectants.}

Hydrogeology {The study of the occurrence and movement of ground water through geologic formations. In a broader sense it also includes the study of surface waters as they interact with geologic formations and ground water (ground water/surface water interaction).}

Hydrogeologic Setting {An area where the characteristics of the soils, the geology, the topography, and the movement of ground water are similar.}

Individual Wastewater System {A wastewater system that serves one living unit or commercial structure. The total number of people served may not exceed 24 (*ARM 17.36.101, Sanitation Rules*).}

Injection Well {A bored, drilled, or driven shaft, or a dug hole, whose depth is greater than its largest surface dimension; an improved sinkhole; or a subsurface fluid distribution system used to discharge fluids underground (40 CFR 144.3).}

Motor Vehicle Waste Disposal Wells {A shallow disposal system that receives fluids from vehicle repair or maintenance activities. Motor vehicle waste disposal wells are regulated as Class V injection wells by the U.S. Environmental Protection Agency. Typical motor vehicle waste disposal wells are floor drains or sinks in service bays that connect to a septic system or drywell. However, *any* underground system that receives motor vehicle waste is considered to be a motor vehicle waste disposal well. For example, cesspools, catchbasins, and sink holes are considered motor vehicle waste disposal wells if they receive motor vehicle waste.}

Multiple User Wastewater System {A nonpublic wastewater system that serves or is intended to serve3 through 14 living units or 3 thorugh 14 commercial structures. The total number of people served may not exceed 24 (*ARM17.36.101 Sanitation Rules*).}

Municipal Wastewater Treatment System {A larger wastewater treatment system that includes collection sewer lines and a central treatment facility used to treat wastewater from an incorporated municipality. The term is generally not used by the regulatory community, and is escentially the same as a Centralized Wastewater Treatment System}

Public Sewage System {A regulatory term defined in both in Code (MCA 75-6-102) and in Administrative Rules (ARM 17.36.101) as a system of collection, transportation, treatment, or disposal of sewage that serves 15 or more families or 25 or more persons daily for any 60 or more days in a calendar year. Public sewage systems are further categorized as follows: (i) "*Community sewage system*" means a public sewage system that serves at least 15 service connections used by year-round residents or that regularly serves at least 25 year-round residents; or (ii) "*Non-community sewage system*" means any public sewage system which is not a community sewage system (ARM 17.38.101).

Septage **{**Liquid or solid material removed from a septic tank, cesspool, portable toilet, or similar treatment works that receives only domestic sewage. It does not include material removed from a septic tank, cesspool, or similar treatment works that receives industrial wastewater and does not include grease removed from a grease trap at a restaurant (MCA 75.10.1201)}.

Shared Wastewater System {A wastewater system that serves or is intended to serve 2 living units or commercial structures. The total number of people served may not exceed 24 (*ARM 17.36.101 Sanitation Rules*).}

Specific Conductance {A measure of the ability of water to conduct an electrical current. It is an indirect measure of the dissolved solids (such as salt) in the water that can conduct an electrical current. Pure water, such as distilled water, has a very low specific conductance, while sea water has high specific conductance.}

Total suspended solids {A common water quality measurement that is usually abbreviated TSS. It is determined by filtering a measured volume of water sample through a pre-weighed filter of a specific size. The filter and trapped solids are then dried and reweighed to determine the weight of suspended sediment filtered from the sample.}

LIST OF ACRONYMS

ARM	Administrative Rules of Montana
BOH	Gallatin City-County Board of Health
BOD	Biochemical Oxygen Demand, see also Glossary of Terms
CAFO	Concentrated Animal Feeding Operation
COS	Certificate of Subdivision
COSA	Certificate of Subdivision Approval
DEQ	Montana Department of Environmental Quality
DNRC	Montana Department of Natural Resources and Conservation
DOR	Montana Department of Revenue
EHS	Environmental Health Services, a Division of GCCHD
EPA	United States Environmental Protection Agency
ESM	Elevated Sand Mounds
FOG	Fats, Oils, and Grease
GCCHC	Gallatin City-County Health Code
GCCHD	Gallatin City-County Health Department
GIAC	Montana State University Geographic Information and Analysis Center
GIS	Geographic Information System
GLWQD	Gallatin Local Water Quality District
gpd	gallons per day
GPS	Global Positioning System
HDPE	High Density Polyethylene
ISF	International Science Foundation
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
mgpd	Million gallons per day
mg/l	**M**illigrams per liter
mg/kg	Milligrams per kilogram
MGWPCS	Montana Ground Water Pollution Control System
MPDES	Montana Pollution Discharge Elimination System
MSU	Montana State University
NPDES	National Pollution Discharge Elimination System
OWC	Organic Wastewater Compounds
PCE	Perchloroethelyne
PE	Professional Engineer
PPCP	Pharmaceuticals and Personal Care Products
SBR	Sequenced Batch Reactor
SRF	State Revolving Fund
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UIC	U.S. Environmental Protection Agency (EPA) Underground Injection Control Program
USGS	U.S, Geologic Survey
ug/kg	Micrograms per kilogram
UV	Ultraviolet light
WWTS	Wastewater Treatment System

ATTACHMENT A
MAPS

Map A-1: Septic Systems, Septage and Biosolids Disposal Sites in Gallatin County, Montana

Map A-2: Locations of Public Sewage Systems in Gallatin County, Montana

Map A-3: Septic System Density in Gallatin County, Montana