EVALUATION OF UNSEWERED AREAS IN MISSOULA, MONTANA

Prepared by

Missoula Valley Water Quality District
Environmental Health Division
Missoula City-County Health Department

March, 1996

EXECUTIVE SUMMARY AND CONCLUSIONS

I. INTRODUCTION

Septic systems have frequently been identified as sources of both localized and regional groundwater contamination (Canter and Knox, 1985). Approximately 800 billion gallons of sewage is discharged to groundwater annually in the United States, via septic systems (Yates, 1985). Nationally septic systems are the most frequently reported source of groundwater contamination and they represent the single largest source of groundwater contamination by volume (Bauman and Schafer, 1985).

Septic systems are widely used over the Missoula Valley Aquifer, which is susceptible to contamination from septic systems due to the coarse nature of the aquifer materials, shallow depths to the water table and the rapid flow of groundwater through the aquifer.
Septic systems can contribute chemical pollutants such as chloride, nitrate, heavy metals and organic chemicals, and biological contaminants such pathogenic bacteria and viruses to groundwater.

II. PURPOSE AND LIMITATIONS

This study of existing high density unsewered developments, within the Missoula urban area, was completed by the Missoula Valley Water Quality District to assist City and County decision makers in evaluating the need for connection of homes and businesses in these areas to sewage treatment facilities, and to prioritize the areas for connection based on the degree of water quality degradation and potential health risks in each area. The study was completed over an 18 month period, starting in May, 1994 and ending in October, 1995.

The study analyzes, and ultimately ranks, unsewered areas according to environmental and public health factors. It does not employ epidemiological methods and does not document or quantify specific public health effects. The study was prepared for technical use by policy-makers and the public. It is not a policy statement and does not address aspects of sewering such as future growth, proximity to existing sewer mains, engineering requirements or costs for connection of high density areas to public sewer. These factors may alter the priority and feasibility of connection to public sewer.

This study only considered impacts of current development within high density, unsewered areas. It did not evaluate potential impacts of future development. A rapidly growing area may be a high priority for extension of public sewer, despite a low ranking in this study, because it makes more sense to install sewer during development than to retrofit after roads and utilities have been installed.

III. LITERATURE REVIEW

Local, regional and national studies related to water quality and public health impacts of septic systems were reviewed as part of this study. The use of septic systems in susceptible hydrogeologic environments have been documented to cause chemical and biological contamination of groundwater. A brief summary of the information reviewed is presented below.

Outbreaks of groundwater borne disease, linked to the use of septic systems, have been documented in Montana and Nationally. Montana cases include an outbreak of gastroenteritis that affected approximately 400 people in Flathead County (Damrow, 1995), and outbreaks of gastroenteritis in 1975 and 1995 in Big Sky (Cottingham, 1995, Shope,per.com., 1995). Nationally, an outbreak of typhoid fever in Yakima County, Washington, was linked to groundwater contamination from a septic system located 210 feet away from a shallow well (McGinnis and DeWalle, 1982). A study completed by the Public Health Service of a septic system at Fort Caswell, North Carolina, documented travel of coliform bacteria 232 feet in a sandy aquifer (Salvato, 1992). Five cases of Shigellosis (dysentery) in Southeastern Idaho were linked to an overflowing seepage pit that allowed sewage to flow across the ground, enter an abandoned well, contaminate groundwater, and ultimately two drinking water wells located 35-40 feet from the abandoned well (Van Every and Dawson, 1995). Shigella sonnei was implicated in an outbreak of gastroenteritis, when 1200 people in a community of 6,500 became ill (Yates, 1985). An epidemiological study indicated the water supply was the source, and further investigation linked contamination of the well to a septic system 150 feet away.

In all of the above cases except the Southeastern Idaho case, bacteria were found to have traveled more than 100 feet in groundwater. This indicates that the current requirement for a 100 foot separation between wells and septic systems may not always be sufficient in areas with coarse soils and shallow groundwater.
There are also numerous documented cases of groundwater borne disease outbreaks attributed to viruses. Table 1 presents data on eight documented outbreaks of gastroenteritis attributed to groundwater borne Norwalk-like viruses.

The literature also indicates that the standard coliform test used to determine if well water is sanitary is not always effective. This test does not check for the presence of pathogenic bacteria, viruses or parasites. A well water sample that tests negative for coliform bacteria may still be contaminated with pathogenic microorganisms (Salvato, 1992). As an example, workers in a labor camp in Florida contracted gastroenteritis from a well located in an area surrounded by septic systems. Echovirus was isolated from the well. The water tested negative for coliform bacteria. The water was chlorinated, and contained residual chlorine. This indicates that pathogens may be present even after chlorination.

TABLE 1
Outbreaks of gastroenteritis attributed to

groundwater borne Norwalk-like Virus

LOCATION	YEAR	SOURCE	# OF CASES
Colorado	1976	well	418
Pennsylvania	1978	well	350
Pennsylvania	1978	well	120
Washington	1978	well	467
California	1979	groundwater	30
N. Carolina	1979	well	146
Pennsylvania	1979	well	151
Maryland	1980	well	139

Source: Gerba (1984)

Previous local studies have also indicated that septic systems can cause chemical and biological groundwater contamination in areas with coarse sediments and shallow groundwater. A study of the Rattlesnake Valley, Grant Creek Valley, Big Flat area and the West Reserve Street area by Newman (1980) indicated that nitrate levels were elevated in the Rattlesnake Valley and portions of the West Reserve Street area.

Detailed instrumentation of two septic systems in the West Reserve Street area by Ver Hey (1987) showed that sewage from the drainfields, which were installed in coarse sediments over shallow groundwater, rapidly infiltrated to groundwater. Ver Hey found fecal coliform bacteria in groundwater 50 feet down-gradient of one of the drainfields, and nitrate-N concentrations in groundwater under the drainfields above the 10 mg/l drinking water standard. Ver Hey concluded that the septic systems were directly impacting groundwater due to the coarse nature of the sediments in the area, and that dilution was the only significant form of treatment.

Water quality sampling in the West Reserve Street area was also conducted by Woessner (1988), as part of a study of the hydrogeology of the eastern portion of the Missoula Valley Aquifer. Water quality sampling showed that nitrate-nitrogen levels were elevated above background (0.1 mg/l), but none of the samples exceeded 2 mg/l. Bacterial sampling however showed a higher percentage of positive coliform bacteria results in the West Reserve Street area. A total of 98 samples were collected, and 18 tested positive for coliform bacteria. Of the 18 positive samples, 17 were in the West Reserve Street area.

Septic systems have also been shown to cause degradation of surface water in Missoula. Sampling by the Water Quality Division of the Montana Department of Environmental Quality confirmed the contribution of nitrates to the Bitterroot River by groundwater originating from unsewered areas west of Missoula. According to a final report issued by the Water Quality Division, on phosphorous and nitrogen sources in the Clark Fork River basin, up to half of the soluble nitrogen load in the lower Bitterroot River during the summer is attributable to discharge of contaminated groundwater from the Missoula area (Ingman, 1992).

Phase II of the Missoula County Carrying Capacity study, completed by Woessner et al. (1995), documented rapid infiltration of sewage to groundwater from drainfields in the West Reserve Street area. At both of the two sites studied, the depth to seasonal high groundwater was five feet, indicating that the systems do not meet Health Code standards for separation from groundwater. At one of the sites, fecal coliform bacteria, ammonia and anaerobic conditions were documented in groundwater under the drainfield. At the other site, fecal coliform bacteria, ortho-phosphate and anaerobic conditions were found in groundwater under the drainfield. Fecal coliform bacteria were also detected in the domestic well at one of the sites, and a human enteric virus was detected in groundwater under one of the drainfields.

IV. STUDY METHODS

The following eight high density unsewered areas were evaluated:

1. **East Reserve Street Area**
2. **West Reserve Street Area**
3. **East Missoula**
4. **West Riverside**
5. **Rattlesnake Valley**
6. **Lolo**
7. **Mullan Road Area**
8. **Westview Park**

To evaluate relative health risks associated with the use of septic systems in unsewered areas, data related to septic systems, water supply wells and hydrogeology were compiled. This included septic system densities, types of septic systems, public and private well locations, soil types, depth to groundwater, groundwater flow direction, hydraulic conductivity and land use. The hydrogeologic properties (excluding groundwater flow direction) of the unsewered areas were evaluated using an aquifer sensitivity method called DRASTIC (EPA, 1987). The DRASTIC method was used to map the relative sensitivity of groundwater under the unsewered areas to degradation by septic systems. Table 2 presents the sources of data and the information obtained from existing databases for this study.

Table 2
Data obtained from other sources

AGENCY/SOURCE	DATA OBTAINED
Msla City-County Health Dept.	Septic Permits (SEWPER) Groundwater Monitoring Records
Land & Water Consulting Inc.	Hydraulic Conductivity, Hydraulic Gradient
City of Missoula Public Works Engineering Division	Sewer Connection Database
Missoula County Information Services	County Sewer RSID Assessment Records (Lolo & Elmar), Records of Mobile Homes in County, Records of Improved Properties with Classification Codes
Montana Department of Revenue	Records of Multifamily Dwellings (CAMAS database)
DEQ Water Quality Bureau	Public Water Supply Data
USDA Soil Conservation Sev.	Missoula Co. Soil Survey
MT Bureau of Mines and Geol.	Water Well Records, Drill Logs

Current water quality in unsewered areas was evaluated by obtaining recent nitrate-N data from 216 public water supply wells and collecting groundwater samples from 153 private wells and 23 monitoring wells. Nitrate-N and coliform bacteria samples were collected from private wells on a quarterly basis, starting in the Summer of 1994. During the last quarter of sampling, in the Spring of 1995, 23 monitoring wells were also sampled for nitrate-N. Limited sampling was also conducted for volatile organic compounds (VOCs) during the Summer of 1994. Previous local studies on water quality in unsewered areas were reviewed to determine if nitrate-N levels showed any trends between 1978 and 1995.

The eight unsewered areas were evaluated and ranked based on the following eight factors:

1. **Percentage of commercial properties**
2. **Overall septic system density**
3. **Total sewage loading**
4. **Percentage of septic systems using seepage pits**
5. **Percentage of septic systems replaced since 1967**
6. **Average current groundwater nitrate-N concentration**
7. **Overall water well density**
8. **Overall aquifer sensitivity based on DRASTIC analysis**

For each unsewered area, the eight factors listed above were compared on a relative scale by ranking each area from 1 to 8, for each factor considered. The highest ordinal ranking score of 8 was assigned to the unsewered area with the highest (or worst) value for the factor. For example the area with the highest density of septic systems was assigned the ordinal ranking score of 8.

The final prioritization of the unsewered areas was determined by summing the ordinal ranking scores for each of the eight factors to obtain a total score as follows:

> **Total Score = scores for (% commercial units + septic system density + % replacement septic systems + % seepage pits + average nitrate-N concentration in groundwater + well density + sewage loading + average DRASTIC value).**

The unsewered areas were then prioritized based on the total score, with the area with the highest total score being assigned the highest priority.

V. RESULTS

Geographical Information System (GIS) software was used to create a series of maps which are included as attachments to this report. The maps summarize the data collected on septic system density, locations of wells, results of nitrate and bacteria sampling, groundwater flow direction and the results of the DRASTIC aquifer sensitivity analysis. While groundwater flow direction was not used directly to rank the areas, it is presented as additional information to consider along with the final prioritization.

Percentage of Commercial Units;
The percentage of commercial properties in each unsewered area was evaluated, based on the rationale that commercial development on individual septic systems presents a documented risk of inappropriate disposal practices. The results indicate that the East Reserve Street area had by far the highest percentage of commercial units, with 211 commercial properties and an overall percentage of 6.9% commercial properties. East Missoula had the second highest percentage of commercial properties, with a total of 25 commercial properties and an overall percentage of 3.2%. The Water Quality District has documentation of three businesses in the East Reserve Street area and one business in East Missoula that disposed of chemical waste into septic systems. Table 6 shows the results and final ranking for percentage of commercial units in each area.

TABLE 6
Percentage of commercial units in unsewered areas

AREA	TOTAL UNITS	COMM. UNITS	% COMM. UNITS	RANKING VALUE
East Msla.	766	25	3.2	7
E. Reserve St.	3041	211	6.9	8
Lolo	456	13	2.9	5
Mullan Road	1017	14	1.4	4
Rattlesnake	1456	7	0.5	2
W. Reserve St.	1976	19	1.0	3
W. Riverside	570	17	3.0	6
Westview Park	364	1	0.3	1

Septic System Densities;
Septic system densities were determined by combining records of improved properties, multifamily units and mobile homes, with public sewer connection records. To account for multifamily dwellings and trailer courts, the number of unsewered units within the Water Quality District and the unsewered areas evaluated was calculated. Table 3 shows the number of parcels and units within the Water Quality District, and the percentage of units on septic systems. A unit is defined as a single commercial parcel, a single family residential parcel, a living unit within a multifamily development or a mobile home. Septic system density data is also summarized on Attachment A, which shows the boundaries of the Water Quality District, the unsewered areas evaluated, the total number of units in each quarter section and the number of units on septic systems within each quarter section.

Within the boundaries of the eight unsewered areas evaluated, the total number of living units using septic systems is estimated to be 7,431. Of these, 3,860 (52%) are in the East and West Reserve Street areas. Development densities in portions of East Missoula, East Reserve, West Riverside, Westview Park, Rattlesnake and West Reserve exceed current health based septic system density limits. Development densities are increased in most areas by high-density mobile home parks. Westview Park had the highest overall septic system density, with 2.28 units/acre. East Missoula and the East Reserve Street area had overall densities of 1.60 and 1.54 units/acre respectively. Table 4 shows the results and relative ranking of the eight areas for septic system density.

TABLE 4
Septic system densities in unsewered areas

UNSEWERED AREA	TOTAL UNITS ON SEPTIC	OVERALL DENSITY PER/ACRE	FINAL DENSITY RANKING
E. Missoula	766	1.60	7
E. Reserve St.	1977	1.54	6
Lolo	419	0.33	2
Mullan Road	627	0.23	1
Rattlesnake	825	0.57	3
W. Reserve St.	1883	0.62	4
W. Riverside	570	0.89	5
Westview Park	364	2.28	8

The septic system densities shown on Attachment A also indicate that there are still unsewered units within sewered areas, including several schools. For example one quarter section near the University of Montana shows 73 units on septic. It is unknown if this number is accurate, or if sewer connection records in this area have not been updated. The numbers in the California Street area do not reflect recent connections to public sewer in that area. In general, the data indicates that there are a maximum of 322 unsewered units in the area south of the Clark Fork River and East of the East Reserve Street area.

Trends in Public Sewer Connections and Septic System Installations;
Trends in connections of properties to public sewers and septic systems were also evaluated. During the period 1990 through 1995, 3,028 new connections were made to public sewage treatment facilities within the Water Quality District, while 1,181 permits were issued for new septic system installations. A large number of the public connections resulted from grant funded projects in the Wapikiya-Bellevue area. However, the data also reflect a recent trend toward in-fill development in areas connected to public sewer.

TABLE 3
Sewer status of improved parcels and living units in WQD

PROPERTY TYPE	NUMBER OF PARCELS	NUMBER OF UNITS	UNITS ON SEWER	UNITS ON SEPTIC
Commercial	1,798	1,798	1,123 (63%)	675(37%)
Residential	17,854	17,854	11,015(62%)	6,839(38%)
Multifamily	1,374	6,557	5,455 (83%)	1,102(17%)
Mobile Homes	1,380	4,219	1,096 (26%)	3,123(74%)
TOTALS	22,406	30,428	18,689 (61%)	11,739(39%)

Cumulative Impacts/Nitrogen Loading;
The cumulative impacts to surface water and groundwater from each unsewered area were evaluated by calculating the total volume of sewage discharged from each area and the total contribution of nitrogen from each area. Based on these calculations, the eight unsewered areas combined discharge 1,486,200 gallons/day or 542 million gallons/year of sewage to the subsurface. The total nitrogen loading to groundwater from the eight areas is estimated to be 620 pounds/day or 52,378 pounds/year. Table 5 summarizes the results for cumulative impacts/nitrogen loading and the final ordinal ranking score for each unsewered area.

TABLE 5
Cumulative impacts and nitrogen loading in unsewered areas

AREA	TOTAL UNITS	SEWAGE LOADING*	NITROGEN LOADING lbs/day**	Final Ranking
East Missoula	766	153,200	64	5
East Reserve St.	1977	395,400	165	8
Lolo	419	83,800	35	2
Mullan Road	627	125,400	52	4
Rattlesnake	825	165,000	69	6
West Reserve St.	1883	376,600	157	7
West Riverside	570	114,000	48	3
Westview Park	364	72,800	30	1
TOTAL	**7431**	**1,486,200**	**620**	

*In gallons/day, based on 200 gallons/day/unit
**Based on effluent conc. equivalent to 50 mg/l total nitrogen

The sewage volumes and nitrogen concentrations used to make these calculations are consistent with the values used in the Missoula County Carrying Capacity Study and the values used by the Montana Department of Environmental Quality for subdivision review. For purposes of relative comparison, the total nitrogen present in septic tank effluent (mainly ammonium and organic nitrogen) is assumed to be oxidized to nitrate through the process of nitrification. Although some nitrogen may be removed in soils through denitrification (conversion to nitrogen gas N_2), the relative ranking would remain the same.

For comparison, total sewage discharge and total nitrogen loading from the Missoula Waste Water Treatment Facility (WWTF) was also evaluated. Records of average monthly discharge and total nitrogen loading during the period from January 1993 through December, 1995 were used to calculate a weighted average discharge volume and total nitrogen loading from the WWTF. During this period the average daily discharge from the plant was 6.63 million gallons/day and the average daily loading of total nitrogen to the Clark Fork River was 1173 pounds/day. This compares with 1.48 million gallons/day and 620 pounds/day of discharge from the 7431 unsewered units in the eight unsewered areas evaluated.

If a comparison is made based on pounds of total nitrogen per million gallons of sewage discharged, the level of total nitrogen discharged from the WWTF is significantly lower than from the septic systems in the eight unsewered areas. The WWTF discharges an estimated 177 pounds of total nitrogen per million gallons of treated effluent, while unsewered areas discharge an estimated 417 pounds of total nitrogen per million gallons of effluent.

While the treatment process at the WWTF is not generally effective for removal of nitrogen from waste water through denitrification, some denitrification probably occurs. The main reason the total nitrogen levels are lower for the treatment plant is that a significant amount of nitrogen as organic nitrogen and other forms is removed from the process as sludge that is made into compost. The total loading of nitrogen from septic systems also assumes that septic systems are not generally effective at removing nitrogen. Some denitrification may occur after effluent leaves a septic system, but even if 50% of the nitrogen was removed through denitrification, an estimated 208 pounds of total nitrogen per million gallons of sewage would be discharged from septic systems.

In general, the comparison indicates that connection of homes to the WWTF would probably reduce total nitrogen loading to surface waters, based on the rationale that neither the WWTF or septic systems are very effective at denitrification, but a significant amount of the nitrogen entering the WWTF is removed in the sludge, and is not discharged to surface waters. Collection at a central also location allows for tertiary treatment or land application in the future, which will further limit discharges to the river.

Percentage of Seepage Pits;
The percentage of septic systems in each area that use seepage pits was determined by comparing the total number of septic system permits issued in each area to the number of permits that were

issued for seepage pits. One exception was made in this method of calculation for the Westview Park area, which only had 14 recorded permits. It is known in this case that there is one septic system for every two mobile homes in the Park, and all but 12 of the systems use seepage pits.

Prior to 1967, permits were not required to install septic systems, and all septic systems installed used either seepage pits or cesspools. Starting in 1967, permits for installation of septic systems have been required. Since 1974 drainfields have been required for new septic system installations. Because septic systems installed prior to 1967 are not included in the calculation of the percentage of seepage pits in each area, the actual percentage of seepage pits in older areas is probably higher than calculated for this report. Based on the permitted septic systems in each area, the Westview Park area had the highest percentage of seepage pits, with 93% of the systems using seepage pits. The percentage of seepage pits in the East Missoula and East Reserve Street areas is over 70%. The results for percentage of seepage pits and drainfields in each area and the final ordinal ranking score assigned for each area is presented in table 7.

TABLE 7
Percentage of drainfields and seepage pits in unsewered areas

AREA	TOTAL PERMITS	DRAIN FIELD	SEEP. PIT	% SEEP. PITS	FINAL RANK
East Missoula	244	59	185	76	7
East Reserve	880	242	638	73	6
Lolo	96	78	18	19	2
Mullan Road	146	122	24	16	1
Rattlesnake	608	256	352	58	4
West Reserve	987	629	358	36	3
West Riverside	105	34	71	68	5
Westview Park	14 *(182)	12	*(170)	93	8

* Estimated number of systems in parentheses

Percentage of Septic Systems Replaced Since 1967;
The number of replacement septic system permits issued since 1967 was compared to the total number of unsewered units in each area to estimate the percentage of septic systems replaced in each area since 1967. The results show that the Rattlesnake Valley had the highest estimated replacement rate, with 23% of the systems replaced since 1967. The East Reserve Street Area had the second highest estimated replacement rate, at 19%. The final results and the ordinal ranking score for each

unsewered area, for percentage of replacement septic systems is presented in Table 8.

TABLE 8
Percentage of replacement septic systems in unsewered areas

AREA	TOTAL UNITS ON SEPTIC	REPLACEMENT SYSTEM PERMITS	PERCENT REPLACEMENT SYSTEMS	FINAL RANKING
East Missoula	766	67	8.8	4
East Reserve	1977	378	19.1	7
Lolo	419	25	6.0	3
Mullan Road	627	26	4.2	1
Rattlesnake	825	189	22.9	8
West Reserve	1883	312	16.6	6
West Riverside	570	57	10.0	5
Westview Park	364	17	4.7	2

Current Groundwater Quality (Nitrate-N and Coliform Bacteria);
A background nitrate-N concentration in groundwater of 0.1 mg/l was established for this study. Review of other possible sources of nitrate in groundwater indicates that sewage from septic systems is the only known significant source. The only other possible sources that may contribute nitrate, that have not been quantified are leaching of nitrate from over application of lawn fertilizer and nitrate from leaky public sewer mains.

A total of 567 nitrate-N samples were collected during the study to evaluate current water quality impacts from septic systems. In addition, the most recent nitrate-N data available from 216 public water supply wells within the study area were also obtained. The average groundwater nitrate-N concentration in each area was determined by calculated a weighted average from all private wells, monitoring wells and public water supply wells within the boundaries of each area. The Rattlesnake Valley had the highest average nitrate-N concentration, with 1.41 mg/l. The nitrate-N results are summarized in map form on Attachment B, which also shows regional groundwater flow directions. The average nitrate-N levels in public wells and wells sampled during the study (private wells and monitoring wells), along with the weighted average nitrate-N concentration for each area and the ordinal ranking score assigned for each area is presented in Table 9.

In general, groundwater in all of the unsewered areas is measurably impacted by septic systems based on the nitrate-N concentrations in water supply wells contained within the delineated unsewered areas. The average nitrate-N concentrations in groundwater within the unsewered areas ranged from 1.41 to 0.38 mg/l, excluding Westview Park. The only nitrate-N data available within the Westview Park area was from public water supply wells, and none of these wells were located within or down-gradient of the area containing septic systems. Three wells outside the Westview Park area that were immediately down-gradient had nitrate-N levels above 2.5 mg/l.

Review of historical sampling data from Juday and Keller (1978) and Woessner (1988) does not indicate a trend toward increasing or decreasing nitrate-N levels within unsewered areas. Limited sampling by McMurtrey et al. (1965) indicates that levels in the Mullan Road and West Reserve areas may have increased since 1965. Nitrate-N levels in all areas were below the federal nitrate-N standard of 10 mg/l. In general, nitrate-N levels appear to be controlled by cumulative impacts from high density unsewered areas and the dilution potential of the aquifer. The dilution potential of the aquifer is controlled by the hydraulic conductivity of the aquifer and the saturated thickness of the aquifer.

TABLE 9
Average nitrate concentration in unsewered areas

AREA	AVERAGE, MWC WELLS	AVERAGE, PUBLIC WELLS	AVERAGE WQD WELLS	AVERAG E VALUE	FINAL RANK
East Missoula	0.42, *(2)	1.01 (5)	1.10 (2)	0.90	5
East Reserve	0.54, (3)	0.52 (19)	0.61 (12)	0.55	3
Lolo	no wells	1.16 (10)	0.50 (1)	1.10	6
Mullan	no wells	1.33 (10)	1.02 (9)	1.18	7
Rattlesnake	no wells	no wells	1.41 (11)	1.41	8
West Reserve	1.30, (1)	0.87 (7)	0.89 (51)	0.89	4
West Riverside	no wells	0.41 (16)	0.29 (5)	0.38	2
Westview Park	no wells	0.05 (2)	no wells	0.05	1

*(x) number of wells sampled, All values are in mg/l

A total of 554 bacteria samples were collected from private wells. Samples were analyzed for coliform and fecal coliform bacteria. The monitoring wells used for the study were not sampled for bacteria because the well casings were not sealed and the sampling techniques were not sanitary. Public water supply well data for bacteria were not used since some public systems chlorinate their water supply, and if a system gets a positive bacteria result, immediate chlorination and re-sampling is required.

The bacterial sampling results are summarized on Attachment C, which is a map showing the results for bacterial samples collected during the study. The map shows the boundaries of the unsewered areas, the types of bacterial contamination present and the regional groundwater flow directions. If a site had various types of bacterial contamination, the type of contamination with the highest risk factor was shown. For example if a site was contaminated with coliform bacteria during two quarters and fecal coliform once, the fecal coliform result is shown. Bacterial data were very limited in the East Missoula area, and no data was obtained from the Lolo area or Westview Park. Because some areas were not sufficiently sampled for bacteria, and because of the many factors that can contribute to bacterial contamination, the areas were not ranked based on bacterial data.

Table 10 shows the number of wells sampled for bacteria each quarter, the number of positive samples, and the percentage of positive samples. For all four quarters, an average of 9.4% of the samples were positive for coliform and non-coliform bacteria. The percentage of contaminated samples was 15.3% during the summer sampling period, roughly double the percentage during the rest of the year. This indicates a higher degree of bacterial contamination during the period when the water table is highest.

Coliform and non-coliform bacteria were detected in private wells. One private well in the Rattlesnake Valley tested positive for fecal coliform bacteria during one quarter. Three private wells were consistently contaminated, even after the well owners were instructed to chlorinate their well systems. Although statistical tests were not used, mapping of positive bacterial results indicate that a higher percentage of contaminated wells were located in areas of shallow groundwater within the West Reserve Street and Mullan Road areas (see Attachment C).

TABLE 10
Bacteria sampling results for private wells

QUARTER (SEASON)	# SAMPLES	# POSITIVE	% POSITIVE
1ST (Spring)	137	12	8.8
2nd (Summer)	131	20	15.3
3rd (Fall/Wtr)	137	10	7.3
4th (Wtr/Spring)	149	10	6.7

Limited sampling of private wells within unsewered areas for volatile organic compounds (VOCs), which are present in some household cleaning products did not show any significant levels of VOCs that could be attributed to unsewered areas.

Water Well Densities;
The density of public and private wells within each unsewered area was also evaluated, based on the rationale that unsewered areas with higher densities of wells represent a greater public health risk. The results showed that the West Reserve Street area had the highest total number of wells (717) and the highest overall well density (151 wells/mile^2). The West Riverside area had the

second highest overall well density with 145 wells/mile^2. The total number of wells, the overall well densities and the final ranking for well densities is presented in Table 11. Attachment D is a map showing the locations of all known wells based on Montana Bureau of Mines records for recorded well logs.

TABLE 11
Well densities in unsewered areas

UNSEWERED AREA	WEL L LOGS	AREA miles^2	WELLS/MI^2 DENSITY	WELL RANKING
East Missoula	65	0.75	87	5
E. Reserve St.	195	2.0	98	6
Lolo	121	2.0	61	3
Mullan Road	265	4.25	62	4
Rattlesnake	102	2.25	45	2
W. Reserve St.	717	4.75	151	8
West Riverside	145	1.0	145	7
Westview Park	2	0.25	8	1

Drastic Analysis;
The hydrogeologic factors that determine the overall vulnerability of the aquifer to septic systems were evaluated and ranked based on the DRASTIC values determined for each area. The DRASTIC analysis was completed for the area included within the Missoula Valley Aquifer

Protection Ordinance boundary, which covers 140 square miles. DRASTIC is an acronym for the following seven hydrogeologic factors that are considered in the analysis:

D-Depth to groundwater
R-Recharge from Precipitation (net)
A-Aquifer media
S-Soil media
T-Topography
I-Impact of the vadose zone
C-Conductivity of the aquifer (hydraulic conductivity)

The higher the DRASTIC value, the more susceptible the area is to pollution from septic systems. The West Reserve Street area had the highest DRASTIC rating, followed by the East Reserve

Street area. The Mullan Road area would have been assigned a higher value if the western portion of the area, which is over a layer of clay rich glacial lake Missoula sediments, was not included.

Attachment E shows the DRASTIC values calculated for each quarter/quarter section within the area evaluated. Most of the West Reserve Street area, the eastern half of the Mullan Road area and the northern half of the East Reserve Street area are in areas with the highest DRASTIC rating for aquifer sensitivity. DRASTIC values for the Westview Park area are relatively low, due to low published values for hydraulic conductivity.

The average DRASTIC value for each area was calculated by averaging the DRASTIC values for each quarter-quarter section within the area, using GIS software. The areas were then ranked based on the average DRASTIC value for each unsewered area. The average DRASTIC values and the final DRASTIC ranking value assigned for each area are presented in Table 12.

TABLE 12
Average DRASTIC values in unsewered areas

AREA	AVERAGE DRASTIC VALUE	FINAL DRASTIC RANKING
East Missoula	106.4	2
East Reserve Street	148.4	7
Lolo	129.4	6
Mullan Road	123.4	5
Rattlesnake Valley	107.8	3
West Reserve Street	151.2	8
West Riverside	108.1	4
Westview Park	71.0	1

It is important to note that the DRASTIC (C)onductivity factor is inversely related to average nitrate values in the study area. Areas with high hydraulic conductivity receive a higher DRASTIC rating, but due to the high conductivity, dilution of nitrate is greater. The DRASTIC values reflect the fact that while areas with high hydraulic conductivity may have lower nitrate values, microbial and chemical contaminants can travel further and faster due to the rapid movement of groundwater.

VI. FINAL SCORES AND PRIORITIZATION OF UNSEWERED AREAS

The ordinal ranking scores for each of the eight factors considered were summed to obtain a final score. The areas were then prioritized based on the final score, with the area having the highest overall score being assigned the highest priority. Table 13 shows the ordinal ranking scores assigned for each factor and the final score for each area.

TABLE 13
Final ordinal ranking of unsewered areas

AREA	COMMERCIAL UNITS	SEPTIC DENSITY	LOADING	% SEEPAGE PITS	REPLACEMENT	AVG. NO_3	WELL DENSITY	DRASTIC	FINAL SCORE
EAST MSLA.	7	7	5	7	4	5	5	2	42
EAST RESERVE	8	6	8	6	7	3	6	7	51
LOLO	5	2	2	2	3	6	3	6	29
MULLAN ROAD	4	1	4	1	1	7	4	5	27
RATTLE-SNAKE	2	3	6	4	8	8	2	3	36
WEST RESERVE	3	4	7	3	6	4	8	8	43
WEST RIVERSIDE	6	5	3	5	5	2	7	4	37
WESTVIEW PARK	1	8	1	8	2	1	1	1	23

Based on final scores the unsewered areas are ranked below in order of impact to water quality and public health risk. If the areas were sewered based just on the threat to the groundwater and surface water resources and public health risks, the recommended prioritization is as follows:

AREA	FINAL SCORE	PRIORITY	
East Reserve	**51**	**1**	**HIGHEST**
West Reserve	**43**	**2**	
East Missoula	**42**	**3**	
West Riverside	**37**	**4**	
Rattlesnake	**36**	**5**	
Lolo	**29**	**6**	
Mullan Road	**27**	**7**	
Westview Park	**23**	**8**	**LOWEST**

VII. RANKING OF HIGHEST DENSITY QUARTER SECTIONS

In addition to evaluating and ranking the eight unsewered areas by averaging the data for the eight factors considered, 14 quarter sections that have septic system densities greater than one per acre (160 unsewered units/quarter section) were also evaluated and ranked. The quarter sections were selected for evaluation based on current health standards, which allow for a maximum septic system density of one system per acre in areas with private wells. Six of the eight unsewered areas contain quarter sections with much higher septic system densities than the remainder of quarter sections in the areas. Use of septic systems within these highest density quarter sections have the greatest impact within the areas. Because of the higher densities, these quarter sections are likely to receive public sewer service before the less densely developed quarter sections do. This quarter section analysis was completed to help guide decisions to extend sewer service into the highest density quarter sections within the highest priority areas.

The quarter sections were ranked using the same methods used for the unsewered areas, with the exception that only six of the eight ranking factors were used, for the following reasons:

1) Average nitrate values were not ranked due to the limited nitrate data available at the scale of individual quarter sections. For example, there were no wells sampled in one of the quarter sections in the Rattlesnake Valley (see Attachment B).

2) Sewage Loading was not used because the ranking would be the same as the septic system density ranking because all the areas are the same size. Using the loading factor would effectively double the weighting for septic system density.

Attachment F is a map showing the locations of the 14 quarter sections evaluated, and the order of prioritization based on the six factors considered. The highest priority quarter section is assigned the number 1. The order of prioritization, the area each quarter section is located in, the ordinal ranking score, the values used to rank the quarter sections and the final scores are presented in table 14.

Based on the quarter section ranking, the three highest ranked quarter sections are located in the

East Reserve Street area. The fourth highest ranked quarter section was in East Missoula. This quarter section has the highest density with 542 commercial and residential units on septic systems.

TABLE 31
Final ordinal ranking of highest density quarter sections

PRIORITY	AREA	COMMERCIAL UNITS	SEPTIC DENSITY	PERCENT SEEPAGE	PERCENT REPLACEMENT	WATER WELL DENSITY	DRASTIC	FINAL SCORE
1	EAST RES.	13* (44)**	13 (540)	11 (81)	12 (21)	2.5 (4)	10 (145)	62.5
2	EAST RES.	11 (11)	10 (310)	12 (87)	13 (22)	4 (7)	8.5 (143)	59.5
3	EAST RES.	10 (9)	9 (296)	10 (76)	9 (18.6)	7 (17)	13 (155)	59
4	EAST MSLA	12 (21)	14 (542)	13 (89)	3 (8.7)	8 (24)	6 (132)	57
5	EAST RES.	14 (54)	11 (363)	7.5 (66)	6 (12.4)	5 (13)	8.5 (143)	52
6	WEST RIV.	7.5 (5)	8 (210)	9 (71)	8 (14.8)	12 (33)	2 (111)	47.5
7	WEST RES.	4 (1)	3 (167)	7.5 (66)	7 (13.2)	10 (30)	12 (148)	43.5
8	R. SNAKE	7.5 (5)	7 (190)	6 (59)	14 (33.7)	2.5 (4)	5 (119)	42
9	WEST RES.	1.5 (0)	6 (187)	3 (46)	10 (18.7)	14 (51)	7 (141)	41.5
10	WEST RES.	6 (3)	4 (175)	5 (54)	4 (9.7)	11 (31)	11 (147)	41
11	WEST RES.	4 (1)	5 (177)	1 (28)	5 (10.7)	9 (29)	14 (158)	38
12	WEST RIV.	9 (6)	2 (164)	4 (50)	2 (6.1)	13 (37)	3 (116)	33

13	WEST VIEW	4 (1)	12 (364)	14 (93)	1 (4.7)	1 (2)	1 (55)	28
14	R. SNAKE	1.5 (0)	1 (163)	2 (45)	11 (19.0)	6 (15)	4 (118)	25.5

* ordinal ranking score, ** value used to assign ranking scores

ons with densities above 160 units/quarter section. The Mullan Road and Lolo areas did not contain any quarter sections exceeding 160 units/quarter sections. Four quarter sections have septic system densities greater than 320 units/quarter section. Two of these quarter sections are located in the East Reserve Street area, one is located in East Missoula, and one is located in Westview Park.

Based on the quarter section ranking, the three highest priority quarter sections are located in the East Reserve Street area. The fourth highest priority quarter section was in East Missoula. This quarter section has the highest septic system density with 542 commercial and residential units on septic.

VIII. CONCLUSIONS

The following conclusions are based on the study results and related literature reviewed for the study:

Public Sewer Connections and Septic System Densities

* Records indicate that more properties were connected to public sewer than were connected to septic systems within the Water Quality District during the period from 1990 through 1995. during this period 3,028 new connections were made to public sewage treatment facilities while 1,181 permits for new septic systems were issued. A large number of these new sewer connections were a result of grant funded projects in the Wapikiya-Bellevue area. However, the data also reflects a recent trend toward infill development in areas served by public sewer.

* Overall septic system densities in the East Missoula, East Reserve Street and Westview Park areas exceed current public health standards for areas not served by public sewer and water. Current standards allow a maximum density of one unsewered dwelling per acre (160 dwellings per quarter section) if public sewer and water are not provided.

* 14 individual quarter sections within six of the unsewered areas exceed current health standards for septic system density (160 units per quarter section). Four quarter sections have septic system densities greater than two units/acre (320 per quarter section). Two quarter sections had septic system densities equal to or

greater than 540 units per quarter section.

* Overall septic system densities and quarter section septic system densities in the Mullan Road and Lolo areas do not exceed current public health standards.

* Densities in most of the areas are increased due to the presence of mobile home parks. Although Westview Park is identified as a separate area, other mobile home parks contribute to high densities in East Missoula, Lolo, East Reserve, West Reserve and West Riverside.

* Overall septic system densities in current developments are usually less than one unit/acre due to areas allotted for roads, parks and utilities. For example, the Mullan Trail subdivision uses individual wells and septic systems and has an overall density of 1.24 acres per dwelling. While this has other land use implications, current development standards are limiting density to less than one dwelling per acre.

* Records indicate there are units on septic systems within areas served by public sewer, including some schools. Efforts should continue to connect homes and businesses on septic systems, within sewered areas, to public sewer.

Cumulative Impacts and Nitrogen Loading

* Calculations of total sewage loading and nitrogen loading to groundwater from the eight unsewered areas evaluated indicate that unsewered areas are a significant source of contamination. The eight areas combined discharge approximately 542 million gallons of sewage and 52,378 pounds of nitrogen to the subsurface annually.

* Because all groundwater in the Missoula Valley Aquifer eventually discharges to surface waters, the cumulative impacts to groundwater from all unsewered areas indirectly affect surface water. Discharge of groundwater from the West Reserve Street area, which contains elevated levels of nitrate-N, is a documented source of soluble nitrogen to the lower Bitterroot River (Ingman, 1992).

* Comparison of average daily sewage and total nitrogen loading from the eight unsewered areas with the Waste Water Treatment Facility indicates that for a given number of homes, discharge to the WWTF results in less total nitrogen loading to surface waters. During the period from January, 1993 to December, 1995 the WWTF discharged an average of 6.63 million gallons/day of effluent containing 1173 pounds of total nitrogen to the Clark Fork River. The eight unsewered areas discharge approximately 1.49 million gallons of effluent containing 620 pounds of

total nitrogen to the subsurface per day For comparison, the WWTF discharges approximately 177 pounds of N/million gallons while unsewered areas discharge approximately 417 pounds of N/million gallons.

* While some denitrification may occur at the WWTF and within unsewered areas, the primary difference is probably due to the fact that significant quantities of nitrogen are removed from the WWTF in sludge which is used to make compost.

Types of Septic Systems and Failure Rates

* Based on permits issued by the Missoula City-County Health Department, since 1967, 58% of the permitted septic systems within the unsewered areas use seepage pits, which do not meet current Health Code standards.

* All eight unsewered areas evaluated contain septic systems installed prior to the 1967 permitting requirement. These systems use seepage pits or cesspools, so the percentage of septic systems in each area that do not meet current Health Code standards is actually higher than reported.

* Over 70% of the permitted septic systems in East Missoula, the East Reserve Street area and Westview Park use seepage pits. Over 90% of the systems in the Westview Park area use seepage pits.

* The highest septic system failure rates were in the Rattlesnake area (22.9%) and the East Reserve Street area (19.1%).

Nitrate-nitrogen

* A comparison of private wells sampled during this study that were also sampled by Juday and Keller (1978) and Woessner (1988) did not show any significant change in groundwater nitrate-N concentrations. Limited nitrate sampling completed by McMurtrey et al. (1965) indicates that nitrate levels in the West Reserve Street area and the Mullan road area may have increased since 1965.

* Based on the established background nitrate-nitrogen level of 0.1 mg/l, groundwater in all eight unsewered areas show measurable cumulative impacts from septic systems. However, nitrate-N levels in all wells sampled during the study, except wells in the Linda Vista area, were well below the drinking water standard of 10 mg/l.

* The highest average nitrate-N concentrations within the delineated unsewered areas were found in the Rattlesnake Valley and East Missoula. Groundwater from the Westview Park area showed the most dramatic down-gradient increase in nitrate-N levels, with up-gradient wells having less than 0.25 mg/l and down-

gradient wells having more than 2.5 mg/l nitrate-N. The nitrate-N sampling results also appear to show cumulative impacts from the East and West Reserve Street areas.

* Review of nitrate-N sampling results indicate that development density and hydraulic conductivity (dilution potential) are the most important factors controlling nitrate-nitrogen levels in groundwater. While higher hydraulic conductivity may dilute nitrates, it also results in higher aquifer vulnerability to contamination from chemical contaminants and pathogenic bacteria and viruses.

* Based on local research by Woessner et al. (1995), some removal of nitrate may occur in soils and groundwater, but the removal processes have not been identified.

* Because some nitrate removal processes may be occurring in the soils and in groundwater, it is not appropriate to use the federal drinking water nitrate-N standard as a sole measure of groundwater impacts from septic systems.

* Although the high dilution potential of the aquifer (high hydraulic conductivity) helps to reduce nitrate-N concentrations in groundwater, it also allows bacteria and viruses to travel further and faster. For this reason, the standard 100 foot separation between drinking water wells and septic systems may not always provide adequate protection.

* On a regional scale, nitrate levels do not appear to be controlled by well depth. Deeper public wells and shallower private wells and monitoring wells in most areas had similar nitrate-N levels. Deeper public wells may be less vulnerable to pathogen contamination, but the sampling results indicate that regional mixing within the aquifer is significant.

Bacteria Sampling and Pathogenic Organisms

* Bacteria sampling results indicate higher relative risk in areas of shallow groundwater and during periods of seasonal high groundwater.

* Review of available literature indicates that groundwater-borne disease outbreaks do occur, and that bacteria and viruses can travel more than 100 feet in coarse sand and gravel aquifers. Current public health standards for septic system densities and separation distances between wells and septic systems may not provide adequate protection in areas with coarse aquifer materials and shallow groundwater.

* Because the standard coliform bacteria test used to determine if well water is

sanitary will not detect pathogenic organisms, negative test results can not be relied on as a sole indicator of the biological quality of groundwater.

* Based on documented cases of waterborne disease outbreaks caused by septic system contamination of groundwater, continued use of septic systems in the East Reserve, West Reserve, East Missoula, West Riverside and Rattlesnake areas pose a threat of isolated water borne disease outbreaks. Outbreaks in areas served by private wells may affect small groups of people, whereas outbreaks in areas served by public wells may affect larger populations.

Commercial Development on Septic Systems

* Documented cases of improper disposal of chemical wastes into septic systems in Missoula indicates that unsewered areas with commercial development present an increased risk of groundwater contamination.

Hydrogeology and DRASTIC Analysis

* Hydrogeology influences the risk associated with septic systems. The primary DRASTIC factors that influence impacts from septic systems are groundwater depth, soils, vadose zone geology and hydraulic conductivity.

* The West Reserve area is particularly vulnerable to contamination due to shallow groundwater, porous soils, and high hydraulic conductivity. This area also contains 27% of the unsewered properties in the study.

* Review of available hydrogeologic reports indicate that detailed studies of the hydrogeology of the Rattlesnake Valley and Lolo are needed. Additional research is also needed in the area of the mouth of Hellgate Canyon to determine how the Rattlesnake Valley interacts with the Missoula Valley Aquifer.

General

* The East Reserve Street area scored well above the other areas, with 51 points. Scores for all other areas ranged from 42 to 23 points. The high score indicates that based on the evaluation methods used, this area represents the most significant threat to water quality and public health. It contains 27% of the total number of unsewered units with the eight unsewered areas evaluated. This area contains as many unsewered units as Lolo, Westview Park, West Riverside and Mullan Road combined. It contains the second highest density quarter section in the Missoula Valley. It is situated directly up gradient from the West Reserve area, an area of

shallow groundwater and porous soils which is served primarily by private wells. The area also contains by far the highest density of commercial development.

* The scores for the West Reserve Street and East Missoula areas are within one point, as were the scores for the Rattlesnake and West Riverside areas. These close scores indicate that the areas are very similar with respect to overall public health risk and water quality impacts.

* The Mullan Road area while not currently a high priority, is experiencing rapid growth and shows significant water quality degradation. Nitrate-N levels in groundwater within this area are already higher than all other areas except the Rattlesnake Valley. In addition, of the nine private wells sampled for bacteria in this area, four were contaminated during at least one quarter. Several of these wells showed persistent contamination.