Livingston, City of

SOURCE WATER DELINEATION AND ASSESSMENT REPORT

City of Livingston
Public Water System

PWSID#MT0000573

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Contact Person:

Jim Woodhull
Livingston City Planner
(406) 222-2005

Certified Operators:

Steve Briggs (Chief Operator)
Clint Tinsley
Douglas Domke

(406) 222-3850

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INTRODUCTION

Russell Levens, Hydrogeologist with Montana Department of Environmental Quality (DEQ) completed this Source Water Delineation and Assessment Report.

Purpose

This report is intended to meet the technical requirements for completion of the delineation and assessment report as required by the Montana Source Water Protection Program (DEQ, 1999) and the federal Safe Drinking Water Act (SDWA) Amendments of 1996 (P.L. 104-182).

The Montana Source Water Protection Program is intended to be a practical and cost-effective approach to protect public drinking water supplies from contamination. A major component of the Montana Source Water Protection Program is “delineation and assessment.” Delineation is a process of mapping areas that contribute water used for drinking. Assessment involves identifying locations in the delineated areas where contaminants may be generated, stored, or transported, and then determining the relative potential for contamination of drinking water by these sources. The primary purpose of this source water delineation and assessment report is to provide information that helps the residents of Livingston protect their drinking water source.

Limitations

This report was prepared to assess threats to the City of Livingston public water system and is based on published information and information obtained from local residents familiar with the community. The terms “drinking water supply” or “drinking water source” refer specifically to the source of the City of Livingston public water system and not any other public or private water system. Also, not all potential or existing sources of groundwater or surface water contamination in the Livingston area are identified. Only potential sources of contamination in areas that contribute water to the City of Livingston public water system wells are considered.

The term “contaminant” is used in this report to refer to constituents for which maximum contaminant levels (MCLs) have been specified under the national primary drinking water standards and to certain constituents that do not have MCLs but are considered to be significant health threats.

CHAPTER 1
BACKGROUND

The Community

Livingston, the seat of Park County is on the northwest bank of the Yellowstone River at the intersection of Interstate 90 and U.S. Highway 89 (Figure1). The population of Park County was estimated at 15,982 in 1999 of which 7,626 live in Livingston. The north entrance to Yellowstone Park is 53 miles south of Livingston.

Livingston was founded in the 1880s by the Northern Pacific Railroad and became the location of an important locomotive repair shop and train depot. Farming and ranching also brought early residents to the area. The current Livingston economy relies on tourism, agriculture, timber, and manufacturing businesses such as the Livingston Rebuild Center (previously the Northern Pacific locomotive repair shop).

Including the Livingston municipal system, 19 public water systems serve the Livingston area. The City of Livingston municipal public water system serves residents within the city and the other public water systems serve outlying mobile home parks, or patrons of businesses such as restaurants, hotels, and campgrounds. A municipal sewer serves Livingston and individual septic systems serve outlying areas. The largest quantities of chemicals or other potential contaminants in Livingston are found at retail gasoline outlets, the locomotive rebuild center, and agricultural supply businesses.

Geographic setting

Livingston is in the Upper Yellowstone Watershed (HUC #10070002050) at 4,557 feet above sea level, 45.66°-north latitude and 110.56°-west longitude. Four major mountain ranges characterized by steep forested slopes with rocky peaks surround Livingston (Figure1). The Absaroka and Gallatin mountains to the south are divided by the Paradise Valley of the Yellowstone River and the Bridger and Crazy mountains to the north are separated by the Shields River Valley. The Absaroka-Beartooth wilderness area covers over 900,000 acres southeast of Livingston.

The average daily high and low temperatures at Livingston are 84.6°F and 51.7°F in July and 34.8°F and 16.2°F in January. Precipitation averaging 17.9 inches annually is heaviest in May and June. The average annual snowfall is 44.2 inches.

General Aquifer Setting

The City of Livingston, most other public water systems in Livingston, and numerous private irrigation wells get water primarily from sand and gravel layers of the Livingston Aquifer that were deposited by the ancestral Yellowstone River. In addition, several public water systems draw water from shallow to moderately deep wells in bedrock that may be hydraulically connected to the Livingston Aquifer.

The Livingston Aquifer is less than 80 feet thick, approximately one mile wide and underlies almost all of town. Yields reported for public water system wells in the Livingston Aquifer range from less than 10 to as high as 1,000 gallons per minute but are mostly less than 50 gallon per minute. Yield varies with the thickness of gravel deposits within the Livingston Aquifer and well construction.

Public Water Systems

The City of Livingston public water system and six other community public water systems serve year-round Livingston residents and twelve non-community public water systems serve mostly travelers or other infrequent patrons (Table1; Figure 2). Public water systems are classified as community public water systems if they serve 25 or more year-round residents. Non-community public water systems serve 25 or more people but do not serve 25 or more year-round residents. Non-community systems are divided into two sub-classes designated as non-transient and transient by the nature and frequency of water use. Non-transient, non-community public water systems serve 25 or more of the same persons (usually workers or students) for at least six months per year (but not for the entire year). Public water systems are classified as transient, non-community public water systems if they serve travelers or business patrons for brief periods.

Table 1. Public water supplies serving the Livingston, Montana area.

PWS ID	Public Water System	Class	Service Connections	Residents Served	Non-Residents Served	Treatment
00573	City of Livingston	Community	3153	7000	0	Chlorination
00474	Windmill Trailer Park (Well #1)	Community	42	100	6	None
00475	Windmill Trailer Park (Well #2)	Community	40	60	40	None
02082	West End Mobile Park	Community	23	100	0	None
00038	Frontier Mobile Home Park	Community	28	63	0	None
00039	Edannes Mobile Home Park	Community	31	55	0	None
01592	Geyser Trailer Park	Community	15	45	0	None
01602	R-Y Timber, Inc. (Sawmill)	Non-community, Non-transient	1	0	50	Cartridge Filter UV Disinfection
03557	R-Y Timber, Inc. (Planer Mill)	Non-community, Non-transient	1	0	25	Cartridge Filter, UV Disinfection
01603	Livingston Campground	Non-community, Transient	41	10	75	None
00040	Osen Trailer Court and RV Campsites	Non-community, Transient	33	4	100	None
03981	Rosa's Pizza / Roche Jaune Galerie	Non-community, Transient	3	2	200	None
01600	Livingston Inn	Non-community, Transient	17	2	45	None
01606	Paradise Inn Café	Non-community, Transient	4	0	600	None

01598	Yellowstone Truck Stop	Non-community, Transient	2	0	300	None
03738	Livingston Kingdom Hall	Non-community, Transient	1	0	200	None
03987	Sleeping Giant Trade Center	Non-community, Transient	4	0	60	None
03676	Albertsons	Non-community, Transient	1	0	25	Cartridge Filter, Activated Carbon, Reverse Osmosis, UV Disinfection
04098	County Market	Non-community, Transient	1	0	25	None

City of Livingston
The City of Livingston serves approximately 7,000 residents with water from six wells that are all less than 100 feet deep. In addition, Albertsons and County Market public water systems purchase water from the city. Lyne-Minnesota Company drilled two of the six wells in 1955 and another in 1965 using a cable tool drilling rig (Hydrometrics, 1985). The remaining wells were drilled in 1974 (Van Dyken Drilling) and 1990 (B & H Drilling) using cable tool or power auger drilling rigs. Well yields range from 400 to 700 gallons-per-minute. Water from four of the six wells are disinfected by gas chlorination.

Community Public Water Systems other than the City of Livingston
Other community public water systems in Livingston serve mobile home parks. The Windmill Trailer Park has two public water systems supplied by separate wells and distribution systems (East Park and West Park). The East Park system serves 25 mobile homes, 10 RV units, and a utility building with toilets and a laundry. The West Park system serves 41 mobile homes and one rental house. Frontier Mobile Home Park serves 28 mobile homes with two wells. West End Mobile Park (23 units), Edannes Mobile Home Park (31 units), and Geyser Trailer Court (15 units) are served by single wells.

Non-community Public Water Systems
R-Y Timber, Inc. has two separate public water systems with single wells serving workers at their sawmill and planer mill. The Livingston Kingdom Hall, a Jehovah's Witness church, is served by a single well primarily during Sunday services and during meeting at other times. Osen Trailer Court and RV Campsites public water system has one well for eight mobile home units and 25 RV units. The Livingston Inn public water system includes a 16-unit motel and one home. Adjacent to the Livingston Inn, the Livingston Campground serves one residence, eight mobile home spaces, 30 RV spaces with a bathhouse, a greenhouse, and a flower shop. The Paradise Inn Café public water system has a single well that serves a 43-unit motel with a restaurant and lounge and on residence. Rosa's Pizza / Roche Jaune Galerie has a single well that serves a restaurant, a rental unit, and employees at the gallery. The Sleeping Giant Trade Center has two wells that serve 21 privately owned or leased units occupied by a range of businesses adjacent to Rosa's Pizza. Businesses at the Sleeping Giant Trade

Center include a hair salon, exercise spa, playhouse, and church. The final two transient, non-community public water systems, Albertsons and County Market, purchase water from the City of Livingston and do not have their own wells. Glacier Water operates water vending machines at these grocery stores.

Other than the City of Livingston, only R-Y Timber, Inc. and Albertsons public water systems treat their water. R-Y Timber, Inc. has cartridge filters and UV disinfection systems installed on both the Sawmill and Planer Mill systems. Water supplied to the water vending machine at Albertsons passes through a cartridge filter, activated carbon, reverse osmosis system, and ultraviolet disinfection system.

Water Quality

Water samples were collected from monitoring wells in the Livingston Aquifer within and around the Livingston rail yard and analyzed for common dissolved ions in addition to certain contaminants (Envirocon Inc., 1994). The purpose of this investigation was to describe the nature and extent of contamination coming from locomotive maintenance facilities at the rail yard. Average total dissolved solids in water samples was 350 parts per million with calcium and bicarbonate the dominant dissolved ions (Table 2). Petroleum compounds dissolved from diesel that leaked from piping or was spilled while filling storage tanks or refueling locomotives have been detected in water samples taken from monitoring wells at the rail yard. In addition, leaks and spills in shop areas, leaching from sludge disposal pits, or leakage from industrial waste water drain lines created an elongated plume of chlorinated solvents extending northeast from the shop complex to the Yellowstone River (Figure 3). Concentrations of chlorinated VOCs are generally below 200 parts per billion (ppb) but have been detected as high as 2,850 ppb near the shop complex (Envirocon Inc., 1994)

Groundwater and surface water are closely connected in the Livingston area. Consequently, contaminants carried in surface water can get into wells used for drinking water. The Yellowstone River upstream from Livingston is on the 303d list of impaired water bodies. DEQ develops this list as required under section 303d of the Clean Water Act and includes streams, ponds, or lakes where beneficial uses are limited by water quality. The Yellowstone River is listed as partially supporting aquatic life and trout fishery beneficial uses. The probable sources of impairment are construction, land development and habitat modification, and removal of riparian vegetation. Several tributaries of the Yellowstone River are listed as partially supporting recreation beneficial uses in addition to aquatic life and trout fishery. The level of support for drinking water as a beneficial use was not assessed for either the Yellowstone or its tributaries. The greatest potential for impairment of drinking water quality is through microbial contaminants derived from waste disposal practices associated with residential development in the watershed.

Table 2. Selected water quality data from monitoring wells in the Livingston area.

Location	Date	Depth ft	pH	Sc µS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Fe mg/L	Mn mg/L	SiO_2 mg/L	Alk. mg/L	Cl mg/L	SO_4 mg/L	NO_3 mg/L
LS-11	2/27/92	13.5	7.86	806	98	28	44	4.0	<0.03	0.98	34.6	359	18	77	0.67
LG-10	5/21/91	?	7.37	448	60	16	18	3.0	0.04	<0.02	30.1	184	9.0	38	1.41
L-87-1	5/21/91	33	7.39	404	56	13	17	2.0	<0.03	<0.02	27.8	180	7.0	26	0.36
L-87-3	5/22/91	22.6	6.82	827	110	26	48	4.0	<0.03	<0.02	34.5	324	19	103	2.59
6	5/22/91	13	7.22	551	70	18	31	3.0	0.1	<0.02	29.4	234	8.0	42	1.36
89-3	5/22/91	35	7.14	565	74	16	34	2.0	1.28	0.15	28.6	240	9.0	52.0	1.12
89-4	5/22/91	33	6.96	762	96	22	52	3.0	<0.03	<0.02	31.8	275	18	106	2.58
90-3	2/27/92	27	7.28	597	70	21	32	4.0	<0.03	<0.02	31.2	258	13	49	0.17
90-3	5/03/92	27	6.7	702	91	25	39	6.0	<0.1	-	22.3	293	22.3	81	1.98
92-2	6/04/92	25	6.83	407	55	15	25	4.0	0.24	<0.02	22.5	184	10.0	41	0.74

Monitoring and Enforcement Actions

Wells used by the City of Livingston and other public water systems in Livingston are routinely monitored for compliance with drinking water standards. Bacteriological monitoring occurs monthly. Compliance with other drinking water standards is based on additional sampling on a variety of schedules depending on system classification and population served. Nitrate was the only regulated contaminant detected in the last five years. Nitrate can come from human or animal wastes but also occurs naturally. The highest level detected in the City of Livingston's water during the past five years was 1.14 mg/l, considerably below the maximum contaminant level of 10 mg/l set by the U.S. Environmental Protection Agency (EPA).

Influencing Factors

The Livingston rail yard is a source of groundwater contamination by diesel fuel, lubricating oils, and cleaners from past maintenance and refueling activities. Contamination is flowing to the east from the rail yard away from the City of Livingston's wells however there is concern that excessive groundwater pumping near the contaminant plume may cause it to spread. In response to this concern, a controlled groundwater area has been proposed for the area of contamination to restrict groundwater development and limit spreading of the plume.

CHAPTER 2
DELINEATION

The source water protection areas for City of Livingston public water system are delineated in this chapter. The purpose of delineation is to map the source of the Livingston's drinking water and to define areas within which to prioritize source water protection efforts. Four types of management regions are mapped; they are the control zone, inventory region, surface water buffer, and recharge region. Separate control zones and inventory regions are mapped for each well whereas the surface water buffer and recharge region apply to all sources.

The goal of management in the control zone is to avoid introducing contaminants directly into public water system wells or immediate surrounding areas. Inventory region and surface water buffer should be managed to prevent contaminants from reaching a public water system well before natural processes reduce their concentrations. The goal of management in the recharge region is to maintain and improve water quality over long periods of time or increased usage.

Hydrogeologic Conditions

Descriptions of hydrogeologic conditions in the Livingston area contained in reports by Montagne and Chadwick (1982), Groff (1962), and Hydormetrics (1985) are summarized in this section. Livingston is at the junction of four mountain ranges with complex geologic histories. South of Livingston, the Paradise Valley of the Yellowstone River separates the Absaroka Range to the east and Gallatin Range to the west. The high peaks of the Absaroka Range consist of Precambrian metamorphic rocks of the Beartooth Plateau (Figure 4). These rocks estimated to be nearly 3 billion years old were uplifted along deep-seated faults and sculpted by alpine glaciers. The Gallatin Range consists of Tertiary volcanic rock overlaying folded sedimentary layers and crystalline basement rock. Near Livingston, the Yellowstone River cuts through a canyon in steeply folded and faulted sedimentary rocks that makeup the north end of both the Absaroka and Gallatin ranges. The Bridger Range northwest of Livingston consists of folded and faulted sedimentary rocks characterized by rugged limestone cliffs. The Crazy Mountains have a core of crystalline igneous intrusive rocks that were injected into tilted and folded sedimentary layers. Tertiary age volcanic rocks cover the southern flank of the Crazy Mountains and extend to the vicinity of Livingston.

Cretaceous age sedimentary rocks form bedrock under the immediate Livingston area. Sandstone and shale of the Livingston Group derived from older volcanic rock make up the Bangtail Hills north of town. Steeply dipping layers of the Cokedale Formation of the Livingston Group, the Eagle formation, and Telegraph Creek Formation underlay Livingston (Figure 5). The Livingston Group yields small amounts of water to private wells and is the source of several public water system wells in Livingston. The Eagle Sandstone is a regional aquifer and is the source of one public water system well in Livingston.

The ancestral Yellowstone River cut a 25 to 80 ft deep and roughly one-mile wide trough into bedrock beneath present day Livingston. The river later filled this trough with course sand and gravel layers that comprise the Livingston Aquifer, the source of the City of Livingston public water system wells. Fine-grained sandy clay layers are encountered when drilling the Livingston Aquifer; however, these clay layers probably are not sufficiently continuous to protect the aquifer from contamination. The absence of a continuous clay layer also makes the Livingston Aquifer vulnerable to contaminants carried by surface water. The Yellowstone River, Fleshman Creek, Billman Creek, and the Livingston Ditch are hydraulically connected to groundwater and therefore provide pathways for contaminants to reach the Livingston Aquifer. The Livingston Aquifer is classified as unconsolidated alluvium and is considered highly sensitive to contamination. Shallow aquifers in underlying bedrock that are hydraulically connected to the Livingston Aquifer are classified as shallow fractured bedrock aquifers and also are highly sensitive to contamination.

Water table contour maps of the Livingston Aquifer prepared by Envirocon, Inc. (1994) indicate gourndwater flows generally parallel to the Yellowstone River channel near the Livingston Rail Yard and that the Yellowstone River both gains and looses water to the aquifer depending on location along its channel and season. An approximate water level contour map prepared by Hydormetrics (1985) indicates that groundwater flows toward the Yellowstone River near Interstate 90. According to Hydrometrics, precipitation, losses from the Yellowstone River, Fleshman and Billman creeks and irrigation ditches, and discharge from sandstone bedrock aquifers are sources of recharge to the Livingston Aquifer.

Table 4. List of geologic or hydrogeologic maps available for the Livingston vicinity.

Title or Description	Date	Area Covered	Reference
Geology	1964	Livingston 24K Quad	Roberts, A.E. 1964. Geology of the Livingston Quadrangle Montana, U.S. Geological Survey Geologic Quadrangle Maps of the United States, one-sheet.
Boundaries of the Livingston Aquifer	1991	16 sq mi area surrounding Livingston	Envirocon, Inc. 1994. Final Livingston Rail Yard Remedial Investigation Report, Figure 5.1: Approximate Area of Livingston Aquifer.
Potentiometric Surface	1989-1990	2 sq mi area of central Livingston	Envirocon, Inc. 1994. Final Livingston Rail Yard Remedial Investigation Report, Figure 5.5 - Figure 5.8: November 1989 February 1990, May 1990, August 1990 Potentiometric Surface.
Bedrock Surface Elevation	1991	1 sq mi area around rail yard	Envirocon, Inc. 1994. Final Livingston Rail Yard Remedial Investigation Report, Figure 5.24: Bedrock Surface Elevation Contours - 10 ft contour interval
Geology	1991	1 sq mi area around rail yard	Envirocon, Inc. 1994. Final Livingston Rail Yard Remedial Investigation Report, Figure 5.27: Surface & Bedrock Geology of Livingston Rail Yard Area

Conceptual Model

Groundwater in thin, coarse-grained sand and gravel layers of the Livingston Aquifer is the source water for the City of Livingston public water system wells. Direct infiltration of precipitation and losses from the Yellowstone River, Fleshman Creek, Billman Creek, the Livingston Ditch, and areas of flood irrigation recharge the aquifer. Groundwater flows generally parallel to the Yellowstone River Channel but varies locally and seasonally depending on gains and losses between the aquifer and river. Groundwater from the Livingston Aquifer discharges to the Yellowstone River near Interstate 90 and downstream from Livingston.

Coarse aquifer materials, a shallow water table and absence of protective clay layer make the Livingston Aquifer highly sensitive to contamination. Further, communication with surface waters makes the Livingston Aquifer sensitive to contaminants released many miles upstream.

Source Wells

The following information comes from DEQ's Public Water System database and a sanitary survey conducted to assess operation and maintenance concerns for the City of Livingston public water system (copy of sanitary survey in Appendix E). The City of Livingston has six wells ranging from 33 to 78 feet deep completed in the Livingston Aquifer (Table 5). All wells were drilled by cable tool or power auger, constructed with 24-inch diameter stainless steel shutter slotted screen, and gravel-packed (Hydrometrics, 1985). The D Street Well is used only as a backup during high seasonal demand; otherwise all wells are used regularly. Well yields ranged from 500 to 1,040 gpm when they were drilled, however recent records indicate a range of approximately 400 to 700 gpm. Line shaft turbines pump water from the wells to the distribution system and to a 2 million-gallon storage tank (see Appendix A for water system plan).

Table 5. Source well information for City of Livingston Public Water System wells.

	Werner Well	**Clarence Well**	**B Street Well**	**Clinic Well**	**Billman Well**	**D Street Well**
Source ID	00573-005	00573-006	00573-007	00573-008	00573-009	00573-010
MBMG #	97097	97093	96975	124017	124018	96972
Water Right #	W194574	W194577	P003530	Unknown	Unknown	W194579
Latitude	45.6448	45.6501	45.6609	45.6482	45.6401	45.6600
Longitude	-110.5681	-110.5633	-110.5581	-110.5688	-110.5754	-110.5530
Date Completed	02/01/1955	06/06/1965	07/24/1974	11/02/1990	10/19/1990	02/01/1955
Depth	52 ft	53.7 ft	73 ft	61 ft	78 ft	33 ft
Screened Interval	42 - 52 ft	43 - 53 ft	40 - 60 ft	45 - 57 ft	60 - 72 ft	22 - 32 ft
SWL Depth	13.7 ft	11.2 ft	20 ft	21 ft	15 ft	7 ft
PWL Depth	17 ft	39.7 ft	38 ft	39 ft	39 ft	17 ft
Drawdown	3.3 ft	28.5 ft	18 ft	18 ft	24 ft	10 ft
Test Pumping Rate	500 gpm	1040 gpm	508 gpm	947	865 gpm	500 gpm
Specific Capacity	152 gpm/ft	36.5 gpm/ft	28.2 gpm/ft	52.6 gpm/ft	36.0 gpm/ft	50 gpm/ft
Source Type	Unconsolidated Alluvium, Unconfined					

Aquifer Properties

Estimates including aquifer flow properties, well discharge rate, groundwater gradient, and ambient groundwater flow direction are used to estimate one-year times-of-travel and to model "capture zones" for Livingston's wells in order to define boundaries of inventory regions for each well (Table 6). Aquifer flow properties estimated are transmissivity, hydraulic conductivity, thickness, and effective porosity. Flow test data from well logs or representative published values were used to estimate transmissivity and hydraulic conductivity. Lithology descriptions from well logs and published data were used to estimate effective porosity and thickness. Published potentiometric maps were used to estimate groundwater gradient and flow direction.

Hydraulic Conductivity and Transmissivity - Hydraulic conductivity is a measure of the ease at which water flows through porous materials such as rock or soil and transmissivity is a measure of the ease at which water flows through the full thickness of an aquifer. Estimates of hydraulic conductivity and transmissivity are based on well yield data reported on well and data for similar rocks published in texts and literature. Hydraulic conductivity estimates range from 200- to 400-ft/day and transmissivity estimates range from 7,500- to 40,000-

ft^2/day. Representative estimates for hydraulic conductivity of 240 ft/day and transmissivity of 12,000 ft^2/day were used in groundwater flow modeling and time-of-travel calculations.

Thickness - The Livingston Aquifer thickness determined from well logs and geologic investigations conducted in Livingston (Hydrometrics, 1985; Envirocon, 1994) ranges from 25 to 80 ft. A representative estimate of 50 feet was used in all calculations.

Effective Porosity - Total porosity is the percent of the Livingston aquifer that is occupied by voids. Total porosity typically varies from 25 to 50 percent depending on the size and uniformity of sand and gravel grains and compaction (Freeze and Cherry, 1979). Effective porosity, or the porosity that water actually flows through, will be less than total porosity. An effective porosity of 15 percent is used in groundwater flow modeling and time-of-travel calculations.

Groundwater Gradient and Flow Direction - Groundwater or hydraulic gradient and groundwater flow directions are estimated from potentiometric maps created during investigations of contamination at the Livingston Rail yard (Envirocon, 1994). The gradient is relatively gentle with a representative value of 0.003-ft change in water table elevation per ft of horizontal distance. Groundwater flow direction may vary by as much as 50° angle depending on location and season.

Well Production - Total water demand is estimated from published water use information. Average usage for single family households obtained from the Manual of Small Public Water Supply Systems (EPA, 1991) is 50 to 75 gallons per day per resident or 350,000 to 525,000 gallons per day (gpd) for the City of Livingston. Demand per well of 70,000 to 105,000 gpd per well, or approximately 50 to 75 gpm, is obtained by dividing total demand by the number of wells (5) regularly used by Livingston. This estimated range may be half or less of actual demand because lawn watering and other uses are excluded. Livingston's wells are capable of producing between 400 and 700 gallons per minute with potential combined production of 2.9 to 5.0 million gpd. Actual demand is estimated at 200,000 gpd per well or approximately twice the value from the Manual of Small Public Water Supply Systems.

Table 6. Estimates used to calculate time-of-travel distances for Livingston public water systems.

Input Parameter	Range	Value Used
Transmissivity	7,500 - 40,000 ft^2/d	12,000 ft^2/d
Thickness	25 - 80 ft	50 ft
Hydraulic Conductivity	200 - 400 ft/d	240 ft/d
Hydraulic Gradient	0.002 - 0.005	0.003
Flow Direction	N - N50°E	N10°E - N40°E
Effective Porosity	0.10 - 0.25	0.15
Pumping Rate (per well)	70,000 - 1,000,000 gpd	200,000 gpd per well
One-Year Time-of-Travel	1,500 - 4,500 ft	2,100 ft
Three-Year Time-of-Travel	4,500 - 12,000 ft	5,700 ft
Stagnation Point	70 - 300 ft	120 ft
Boundary Limit	200 - 900 ft	370 ft

Properties of the Livingston aquifer are naturally variable. Hydraulic conductivity varies by a factor of 100 and estimates of thickness, groundwater gradient, and effective porosity vary by a factor of 2 or more. In addition, groundwater flow direction varies seasonally by as much as 50°. Of these properties, hydraulic conductivity estimates affect the accuracy of time-of-travel estimates the most because they are highly uncertain and because time-of-travel calculations are highly sensitive to different hydraulic conductivity values. Time-of-travel calculations are sensitive to uncertainty in effective porosity and groundwater gradient but values of these properties for the Livingston Aquifer are known more accurately than are hydraulic conductivity values. In the case of the Livingston, aquifer thickness and well yield have the least affect on the accuracy of time-of-travel estimates.

Groundwater Flow Model Results

The Wellhead Analytic Element Model (WhAEM) was used to simulate areas that contribute water to each of Livingston's wells. WhAEM uses estimates of aquifer properties and pumping demand plus specified flow or head conditions at aquifer boundaries to compute water table contours and groundwater flow paths. For the Livingston Aquifer, the sides of the alluvial valley are assigned as no-flow boundaries. Recharge to the aquifer from bedrock along the western margin of the valley and leakage from the Livingston Canal are simulated together by a "line source" specified by a constant flow rate and located immediately inside the no-flow boundary. The Yellowstone River is simulated by a series of line sources specified by constant heads. The heads specified for each segment are the average of surface elevations taken from a topographic map. Line sinks specified by constant flow rates are used to represent recharge form Billman and Fleshman creeks.

WhAEM is used to simulate a range of groundwater flow paths to Livingston's wells that could result from seasonal variations in recharge and groundwater flow direction. The range of simulated flow paths also takes into account uncertainly in the configuration of the water table in the Livingston Aquifer. Areas that contribute water to Livingston's wells, also known as capture zones, are simulated for three scenarios that differ by the relative contribution of recharge to the Livingston Aquifer from the Yellowstone River, Billman and Fleshman creeks, and the combination of bedrock aquifers and leakage from the Livingston Canal.

Figure 6 illustrates how flow modeling results are used to delineate inventory regions. Scenario 1 in Figure 6 is the capture zone with associated flow paths for the Clinic Well determined by assuming recharge to the Livingston Aquifer is predominantly from Billman Creek, the Livingston Canal, and bedrock aquifers to the west. Scenario 2 is a capture zone calculated by assigning the Yellowstone River as the only source of recharge. Finally, scenario 3 represents the capture zone for the Clinic well with contribution from all recharge sources. The inventory region for the Clinic well is delineated to include each of thee possible scenarios. Possible capture zones and inventory regions for Livingston's other wells are included in Appendix C.

Delineation Results

One hundred-foot radius control zones are delineated for each public water system source. Inventory regions are aligned with aquifer boundaries and street and include a range of possible capture zones corresponding to three-year times-of-travel (see Figure 7 for map of overall inventory region and Appendix C for maps of individual inventory regions).

B Street Well - The inventory region for the B Street well is bounded by Park Street on the northwest, C Street on the northeast, the Sacagawea Lagoon and Yellowstone River on the southeast, and a three-year time-of-travel distance on the southwest.

D Street Well - The inventory region for the D Street well is bounded by Lewis Street on the northwest, E Street on the northeast, Sacagawea Lagoon and Yellowstone River on the southeast, and a three-year time-of-travel distance on the southwest.

Clarence Well - The inventory region for the Clarence well is bounded by the Livingston Canal on the northwest, Fleshman Creek on the northeast, the Yellowstone River on the southeast, and a three-year time-of-travel distance on the southwest.

Clinic Well - The inventory region for the Clinic well is bounded on the northwest by the Livingston Canal, various city street on the northeast (see map), the Yellowstone River on the southeast, and a three-year time-of-travel distance on the southwest.

Werner Well - The inventory region for the Werner well is bounded by the Livingston Ditch on the northwest, a line approximately 500 ft north of Interstate 90 on the north, the Yellowstone River on the east, and a three-year time-of-travel distance on the southwest.

Billman Well - The inventory region for the Billman well is bounded by the Livingston Ditch on the west, Billman Creek on the north, U.S. Hwy 89 on the east, and a three-year time-of-travel distance on the south.

Surface water buffers extend ten miles upstream along Fleshman and Billman creeks and a four-hour time-of-travel distance upstream along the Yellowstone River and Trail Creek (a western tributary to the Yellowstone River). Boundaries of the surface water buffer are one-half mile on either side of the respective creek or river (Figure 10). Finally, boundaries of the Yellowstone River alluvium delineate the literal boundaries of the recharge region. The upstream boundary of the recharge region is the narrow canyon of the Yellowstone River approximately three miles south of Livingston and the downstream boundary is located at the east end of Livingston.

Limiting Factors

The reader should keep in mind that inventory regions are delineated using estimates of groundwater flow and pumping conditions. Conclusions based on this interpretation are uncertain because the extent and properties of the aquifer, and the direction and rate of groundwater flow, are not precisely known. Uncertainties in inventory region delineations are addressed in two ways. First, input parameters are estimated in order to yield a conservative estimate of the time-of-travel distance used to delineate the up-gradient extent of the regions. Second, the lateral boundaries of the inventory region were expanded to take into account seasonal variations in groundwater flow direction.

CHAPTER 3
INVENTORY

An inventory of potential contaminant sources was conducted to assess the susceptibility of Livingston's wells to contamination and to provide a basis for source water protection planning. The inventory for the City of Livingston focuses on facilities that generate, use, or store potential contaminants and certain land uses in inventory regions and surface water buffers delineated in the previous section. Sources of all primary drinking water contaminants and cryptosporidium are identified, although only potential sources of contaminants that are the greatest threat to human health were selected for detailed inventory. The contaminants of concern to Livingston are nitrate, microbial contaminants, fuels, solvents, and pesticides.

Inventory Method

Databases were searched to identify businesses and land uses that are potential sources of regulated contaminants. The following steps were followed:

Step1: Land cover is identified from the National Land Cover Dataset compiled by the U.S. Geological Survey and U.S. Environmental Protection Agency (USGS, 2000). Land cover types in this dataset were mapped from satellite imagery at 30-meter resolution using a variety of supporting information.

Step 2: EPA's Envirofacts System was queried to identify EPA regulated facilities. This system accesses the following database: Resource Conservation and Recovery Information System (RCRIS), Biennial Reporting System (BRS), Toxic Release Inventory (TRI), Permit Compliance System (PCS), and Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS). The available reports were browsed for facility information including the Handler/Facility Classification to be used in assessing whether a facility is a significant potential contaminant source.

Step 3: DEQ databases were queried to identify underground storage tanks (UST), hazardous waste contaminated sites, landfills, and abandoned mines.

Step 4: A business phone directory was consulted to identify businesses that generate, use, or store chemicals in the inventory region. Equipment manufacturing and/or repair facilities, printing or photographic shops, dry cleaners, farm chemical suppliers, and wholesale fuel suppliers were targeted by SIC code.

Step 5: Major road and rail transportation routes were identified.

Step 6: All significant potential contaminant sources were identified in the inventory region, sources of nitrate and microbial contaminants were identified in the surface water buffer, and land uses and facilities that generate, store, or use large quantities of hazardous materials were identified within the recharge region.

Potential contaminant sources are designated as significant if they fall into on e of the following categories:

1) Large quantity hazardous waste generators
2) Landfills
3) Hazardous waste contaminated sites
4) Underground storage tanks

5) Major roads or rail transportation routes
6) Cultivated cropland
7) Animal feeding operations
8) Wastewater lagoons or spray irrigation
9) Septic systems
10) Sewered residential areas
11) Storm runoff
12) Floor drains, sumps, or dry wells

Inventory Results/Control Zones
Leaks from sewer or septic tank connecting lines and stormwater runoff are potential contaminant sources for all City of Livingston public water system's wells.

Inventory Results/Inventory Regions
Locations of potential contaminant sources are shown in Figure 8 for the overall Livingston area and in Appendix E for individual inventory regions. There are several significant potential contaminant sources within the inventory region of each of Livingston's wells (Table 7). There are 12 businesses, mostly retail gasoline stations, with a total of 31 underground storage tanks (USTs) in use. Volatile organic compounds contaminate groundwater at seven UST leak sites within inventory regions. An additional 20 UST leak sites are listed as inactive by DEQ where residual VOC contamination could remain. Businesses that generate, store or dispose of relatively small quantities of potential contaminants are generally not significant contaminant threats if they handle those materials properly. However, disposal of even small quantities of contaminants in sumps, floor drains, dry wells, or septic ranks that are connected directly to the aquifer (collectively referred to as Class V injection wells) are significant threats. In addition, chemicals spilled at small businesses may be flushed to storm drains and reach the Livingston Aquifer where storm sewers discharge to dry wells or infiltration basins. Volatile organic compounds are the most prevalent chemicals used or stored and therefore the most likely contaminants from Class V injection wells and stormwater runoff.

Accidental spills on highways and railways, cultivated cropland, and unsewered residential developments are other significant potential contaminant sources. Spills of large quantities of chemicals transported along U.S. highways 89 and 10, U.S. Interstate 90, or the BN Santa Fe Railway pose threats to all of Livingston's wells. The Werner well is particularly close to Interstate 90 and the Billman well is particularly close U.S. Highway 89. The acreage of cultivated crops in the Livingston area is small, but fields of irrigated hay and small grains are close to several of Livingston's wells. The areas where pesticides and fertilizer are most likely to contaminate groundwater are in the northeast and south fringes of Livingston. The threat of groundwater contamination by wastes from residential septic systems also is greatest in these fringe areas.

Inventory Results/Surface Water Buffer
Cultivated cropland and septic drainfields at rural homes are the only significant potential sources of nitrate or microbial contaminants identified in the surface water buffer. Crops, mostly in the Paradise Valley along the Yellowstone River and Trail Creek, make up approximately 20 percent of the surface water buffer (Figure 9). The remainder is undeveloped grassland or shrubs (60 percent) and evergreen or deciduous forest (15 percent). Average population density in the surface water buffer is approximately 50 persons per square mile (excluding Livingston). The highest population density is along the Yellowstone River immediately south of Livingston, in an area between the Yellowstone River and Trail Creek west of the community of Pine Creek, and to a lesser extent in the Billman creek drainage. All areas outside the city limits of Livingston are unsewered.

Inventory Results/Recharge Region

Outside of the inventory regions by far the most significant potential contaminant source in the recharge region is the Livingston Rail Yard groundwater cleanup site. A plume containing chlorinated VOCs is migrating to the east and does not present a direct threat of contaminating Livingston's wells (Figure 3). The potential for future groundwater development near the plume is limited however.

Table 7. Significant potential contaminant sources in inventory regions and surface water buffer of Livingston public water system wells.

Well		**Significant Potential Contaminant Sources**							
		Point Sources	**Groundwater Contamination**	**Livingston City Sewer**	**Septic Systems (# per sq mile)**	**Stormwater Discharges**	**Class V Injection Wells**	**Highway/Railway**	**Cultivated Farmland (%)**
Inventory Regions	Werner	3 UST	No	Yes	0	Yes	Probable	Interstate 90 Highway 89 Railway	0
	Clarence	3 UST	No	Yes	50 - 300	Yes	Probable	Interstate 90 Highway 89 Railway	0 - 20
	B Street	5 UST	3 LUST	Yes	0	Yes	Probable	Highway 89 Highway 10 Railway	0
	Clinic	4 UST	No	Yes	50 - 300	Yes	Probable	Interstate 90 Highway 89 Railway	0 - 20
	Billman	1 UST	No	No	>300	Yes	Probable	Highway 89 Railway	0 - 20
	D Street	3 UST	3 LUST	Yes	0	Yes	Probable	Highway 89 Highway 10 Railway	0
	Surface Water Buffer	No	No	No	<50	No	No	Interstate 90 Highway 89 Railway	<20

Inventory Update
The certified water system operator will update the inventory for his records every year. Changes in land uses or potential contaminant sources will be noted and additions made as needed. The complete inventory will be submitted to DEQ every five years to ensure recertification of the source water delineation and assessment report.

Inventory Limitations
The potential sources of contaminants for Livingston's public water system are identified from readily available information. Consequently, unregulated activities or unreported contaminant releases may have been overlooked. The use of multiple sources of information, however, should ensure that the major threats to the source water for Livingston have been identified.

CHAPTER 4
SUSCEPTIBILITY ASSESSMENT

The susceptibility of the City of Livingston's wells to contamination is assessed in this chapter. The proximity of a potential contaminant source to a well or the density of non-point potential contaminant sources determines the threat of contamination, referred to here as hazard (Table 8). Hazard and the existence of barriers to contamination determine susceptibility (Table 9).

Barriers can be anything that decreases the likelihood that contaminants will reach a well. Barriers can be engineered structures, management actions or natural conditions. Examples of engineered barriers are spill catchment structures for industrial facilities and leak detection for underground storage tanks. Emergency planning and best management practices can be considered management barriers. Thick clay-rich soil, a deep water table or a thick saturated zone above the well intake can be natural barriers.

Table 8. Hazard of potential contaminant sources for the City of Livingston public water system wells.

	High Hazard	**Moderate Hazard**	**Low Hazard**
Point Sources of All Contaminants	Within one-year TOT	One to three years TOT	Over three years TOT
Septic Systems	More than 300 per sq. mi.	50 - 300 per sq. mi.	Less than 50 per sq. mi
Municipal Sanitary Sewer (percent land use)	More than 50 percent of region	20 to 50 percent of region	Less than 20 percent of region
Cropped Agricultural Land (percent land use)	More than 50 percent of region	20 to 50 percent of region	Less than 20 percent of region

Table 9. Susceptibility to potential contaminant sources based on hazard and the presence of barriers.

	High Hazard	**Moderate Hazard**	**Low Hazard**
No Barriers	Very High Susceptibility	High Susceptibility	Moderate Susceptibility
One Barrier	High Susceptibility	Moderate Susceptibility	Low Susceptibility
Multiple Barriers	Moderate Susceptibility	Low Susceptibility	Very Low Susceptibility

Susceptibility ratings are presented individually for each significant potential contaminant source in each inventory region and the surface water buffer (Table 10). Susceptibilities of Livingston's wells within the urban area are generally high to very high for existing UST, active UST leak sites, Livingston sanitary sewer, and stormwater runoff. Existing barriers include spill prevention and/or leak detection (SP / LD) provisions at existing UST, sewer maintenance and/or leak detection (SM / LD) activities, and stormwater dilution. Susceptibilities of Livingston's wells on the outskirts of town are generally high to very high for septic systems. All Livingston's wells are susceptible to contamination by accidental spills on Highway 89, Highway 10, Interstate 90, or the BN Santa Fe Railway. In addition, some or all of Livingston's wells may be susceptible to contamination from Class V injection wells.

Management Recommendations

Management recommendations are listed along with the susceptibility analysis in Table 10. These recommendations can be considered additional barriers that if implemented will reduce the susceptibility of Livingston's wells to specific sources and contaminants. Recommendations fall into the following categories:

- Emergency Planning
- Oversight of UST leak sites
- Sewer maintenance and leak detection
- Sewer extension
- Agricultural best management practices
- Stormwater management
- Inventory and permitting of Class V injection wells
- Controlled groundwater area

Emergency planning - An emergency plan that includes a list of types of chemicals and the frequency with which they are transported through Livingston should be developed. The name of an emergency coordinator and a description of possible actions that can be taken if a problem arises should be included in this plan. In addition, the equipment and materials, short-term replacement water supply, and source of funds necessary in case of a spill should be specified.

Oversight of UST leak sites - Threats from UST leaks should be monitored to ensure Livingston's wells are protected from contamination. The level of contamination and progress of remediation at leak sites can be verified by contacting the DEQ Remediation Division.

Sewer Maintenance and leak detection - Early warning of leaks and scheduled replacement of aging sewer lines will reduce the susceptibility of Livingston's wells to contamination from sanitary wastes.

Sewer Extension - Installation of advanced septic treatment systems such as sand filter septic tanks can limit contamination from new rural residential development, however, annexation and extension of sewers is the only way to eliminate contamination from existing unsewered developments.

Agricultural best management practices (BMPs) - BMPs that address application and mixing of fertilizer and pesticides are a viable alternative to prohibition of their use. BMPs are generally voluntary but their implementation can be encouraged through education and technical assistance.

Stormwater management - Stormwater planning should address source and drainage control. Source control can be accomplished through educational programs focussing on residential and commercial chemical use, disposal, and recycling. Drainage control and pollutant removal can be accomplished using vegetated detention basins.

Inventory and permitting or closure of Class V injection wells - The U.S. EPA is implementing a program to identify and permit or close sumps, floor drains, dry wells, or commercial septic systems that are potential contaminant sources. This program is being implemented gradually with EPA planning to complete an assessment for Livingston within the next year. EPA's first step is to mail shallow-well inventory request forms to types of businesses that often have Class V injection wells (they concentrate on automotive service businesses). EPA makes decisions on permitting and closure based on responses they receive and subsequent inspections. Permit recipients are required to sample their shallow injection wells quarterly and ensure that the fluid being injected meets drinking water standards.

Controlled Groundwater Area - A petition for a controlled groundwater area (CGWA) is being drafted by DEQ for the City of Livingston to limit groundwater development within or immediately outside the boundaries of the plume. The purpose of this CGWA is to prevent high production wells or numerous low production wells from causing the plume to spread.

	Source	Contaminant	Hazard Rating	Barriers	Susceptibility	Management
Werner Well	Highway/Railway Accidents	SOCs / VOCs	High	None	Very High	Emergency Planning
	UST Leaks	VOCs	Moderate - High	None	High - Very High	Oversight
	Sanitary Sewer	Bacti / Nitrate	High	Maintenance	High	Diligence
	Stormwater Runoff	VOCs	High	Dilution	High	Stormwater Management
Clarence Well	Highway / Railway Accidents	SOCs / VOCs	High	None	Very High	Emergency Planning
	Sanitary Sewer	Bacti / Nitrate	High	Maintenance	High	Diligence
	Unsewered Residential	Bacti / Nitrate	Moderate	None	High	Sewer Extension
	Stormwater Runoff	VOCs	High	Dilution	High	Stormwater Management
	UST	VOCs	Moderate - High	Spill Prevention	Moderate - High	Oversight
	Cultivated Cropland	SOCs / Nitrate	Low	None	Moderate	Best Management Practices
B Street Well	UST Leaks	VOCs	Moderate	None	High	Oversight
	Sanitary Sewer	Bacti / Nitrate	High	Maintenance	High	Diligence
	Highway/Railway Accidents	SOCs / VOCs	Moderate	None	High	Emergency Planning
	Stormwater Runoff	VOCs	High	Dilution	High	Stormwater Management
	UST	VOCs	Moderate - High	Spill Prevention	Moderate - High	Oversight
Clinic Well	Highway/Railway Accidents	SOCs / VOCs	High	None	Very High	Emergency Planning
	Sanitary Sewer	Bacti / Nitrate	High	Maintenance	High	Diligence
	Stormwater Runoff	VOCs	High	Dilution	High	Stormwater Management
	Unsewered Residential	Bacti / Nitrate	Moderate	None	High	Sewer Extension
	UST	VOCs	Moderate - High	Spill Prevention	Moderate - High	Oversight
Billman Well	Unsewered Residential	Bacti / Nitrate	High	None	Very High	Sewer Extension
	Highway/Railway Accidents	SOCs / VOCs	High	None	Very High	Emergency Planning
	Stormwater Runoff	VOCs	High	Dilution	High	Stormwater Management
	Cultivated Cropland	SOCs / Nitrate	Low	None	Moderate	Best Management Practices
D Street Well	UST Leaks	VOCs	Moderate	None	High	Oversight
	Highway/Railway Accidents	SOCs / VOCs	Moderate	None	High	Emergency Planning
	Sanitary Sewer	Bacti / Nitrate	High	Maintenance	High	Diligence
	Stromwater Runoff	VOCs	High	Dilution	High	Stormwater Management
	UST	VOCs	Moderate	Spill Prevention	Moderate	Oversight

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GLOSSARY*

Acute Health Effect. An adverse health effect in which symptoms develop rapidly.

Alkalinity. The capacity of water to neutralize acids.

Aquifer. A water-bearing layer of rock or sediment that will yield water in usable quantity to a well or spring.

Best Management Practices (BMPs). Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

Coliform Bacteria. Bacteria found in the intestinal tracts of animals. Their presence in water is an indicator of pollution and possible contamination by pathogens.

Confined Aquifer. A fully saturated aquifer overlain by a confining unit such as a clay layer. The static water level in a well in a confined aquifer is at an elevation that is equal to or higher than the base of the overlying confining unit.

Confining Unit. A geologic formation that inhibits the flow of water.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Enacted in 1980. CERCLA provides a Federal "Superfund" to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through the Act, EPA was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup.

Delineation. A process of mapping source water management areas.

Hardness. Characteristic of water caused by presence of various salts. Hard water may interfere with some industrial processes and prevent soap from lathering.

Hazard. A measure of the potential of a contaminant leaked from a facility to reach a public water system source. Proximity or density of significant potential contaminant sources determines hazard.

Hydraulic Conductivity. A coefficient of proportionality describing the rate at which water can move through an aquifer.

Inventory Region. A source water management area that encompasses the area expected to contribute water to a public water system within a fixed distance or a specified ground water travel time.

Maximum Contaminant Level (MCL). Maximum concentration of a substance in water that is permitted to be delivered to the users of a public water system. Set by EPA under authority of the Safe Drinking Water Act.

Nitrate. An important plant nutrient and type of inorganic fertilizer. In water the major sources of nitrates are septic tanks, feed lots and fertilizers.

Nonpoint-Source. Pollution sources that are diffuse and do not have a single point of origin.

Pathogens. A bacterial organism typically found in the intestinal tracts of mammals, capable of producing disease.

Point-Source. A stationary location or fixed facility from which pollutants are discharged.

Public Water System. A system that provides piped water for human consumption to at least 15 service connections or regularly serves 25 individuals.

Pumping Water Level. Water level elevation in a well when the pump is operating.

Recharge Region. A source water management region that is generally the entire area that could contribute water to an aquifer used by a public water system. Includes areas that could contribute water over long time periods or under different water usage patterns.

Resource Conservation and Recovery Act (RCRA). Enacted by Congress in 1976. RCRA's primary goals are to protect human health and the environment from the potential hazards of waste disposal, to conserve energy and natural resources, to reduce the amount of waste generated, and to ensure that wastes are managed in an environmentally sound manner.

Section Seven Tracking System (SSTS). SSTS is an automated system EPA uses to track pesticide producing establishments and the amount of pesticides they produce.

Source Water Protection Area. For surface water sources, the land and surface drainage network that contributes water to a stream or reservoir used by a public water system.

Static Water Level (SWL). Water level elevation in a well when the pump is not operating.

Susceptibility (of a PWS). The potential for a PWS to draw water contaminated at concentrations that would pose concern. Susceptibility is evaluated at the point immediately preceding treatment or, if no treatment is provided, at the entry point to the distribution system.

Synthetic Organic Compounds (SOC). Man made organic chemical compounds (e.g. herbicides and pesticides).

Total Dissolved Solids (TDS). The dissolved solids collected after a sample of a known volume of water is passed through a very fine mesh filter.

Transmissivity. The ability of an aquifer to transmit water.

Unconfined Aquifer. An aquifer containing water that is not under pressure. The water table is the top surface of an unconfined aquifer.

Underground Storage Tanks (UST). A tank located at least partially underground and designed to hold gasoline or other petroleum products or chemicals.

Volatile Organic Compounds (VOC). Any organic compound which evaporates readily to the atmosphere.

* Definitions taken from EPA’s Glossary of Selected Terms and Abbreviations