ATTACHMENT B – 2009 LOWER GALLATIN TMDL PLANNING AREA NUTRIENT, ALGAE AND *E. COLI* SOURCE ASSESSMENT

2009 LOWER GALLATIN TMDL PLANNING AREA

NUTRIENT, ALGAE AND *E. COLI* SOURCE ASSESSMENT

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1 INTRODUCTION

In fall 2009, OASIS Environmental, Inc. (OASIS) completed a GIS and field-based pollutant source assessment on twelve streams within the Lower Gallatin TMDL planning area (LGTPA) (Table 1, Figure 1) as part of Montana Department of Environmental Quality's (DEQ) effort to develop a TMDL plan for the LGTPA. A source assessment report was completed for each of the twelve streams as a standalone document (Appendix A).

The source assessment had two primary objectives: (1) to assess existing conditions within the watersheds of the twelve streams of interest with regards to land use and riparian condition, and (2) identify potential pollutant sources within the watershed and their ability to impact each stream during late-summer flow conditions. The source assessment was built on water quality monitoring completed in September, 2008. This document serves as an introduction to the source assessment reports completed for each of the twelve streams.

Table 1. Streams assessed during the 2009 source assessment

Stream	Length Assessed (mi)
Bear Cr	10
Bridger Cr	18.5
Camp Cr	25.5
Dry Cr	16.5
East Gallatin River	42
Godfrey Cr	7
Hyalite Cr	35.5
Jackson Cr	8
Reese Cr	7.5
Smith Cr	14
Sourdough Cr	16
Thompson Spring Cr	6.5

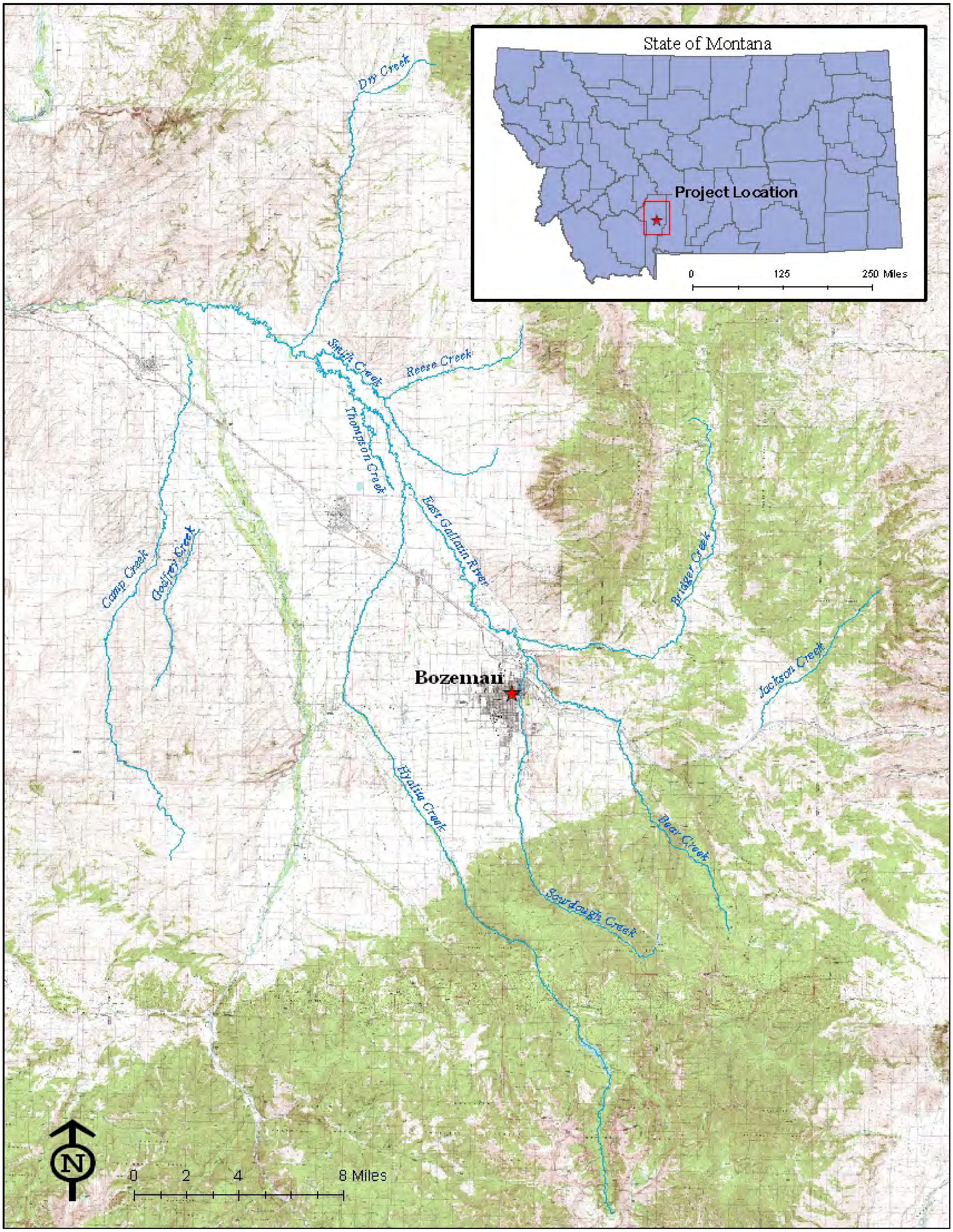

Figure 1. Location of 12 streams assessed for 2009 lower Gallatin TPA pollutant source assessment

2 SOURCE ASSESSMENT APPROACH

The source assessment employed a multi-tiered approach using both desktop GIS-based analysis and field groundtruthing, consisting of:

1. Reach stratification,
2. GIS-based source assessment,
3. Groundtruthing of reach conditions and potential pollutant sources, and
4. Reporting on the existing conditions and potential pollutant sources identified in each reach

2.1 Reach Stratification

Each stream was stratified into discrete reaches based on land use, riparian type and field knowledge gathered during the 2008 water quality monitoring effort. The DEQ sediment stratification layer for the LGTPA (*strat_nut_061609.shp*) was obtained from DEQ and used as the starting point for stratifying reaches for the pollutant source assessment.. The sediment reaches were merged to form longer reaches more appropriate for the objectives of the pollutant source assessment using the 2005 National Agriculture Imagery Program (NAIP) color aerial imagery ("aerials"). This reach stratification resulted in 57 reaches distributed across the twelve streams. The source assessment reaches are distinguished from the sediment reaches by the addition of "N" to the end of the reach ID field.

2.2 GIS-Based Source Assessment

The 57 reaches stratified from the DEQ sediment stratification layer were assessed using several digital data sources including the NAIP color aerials, infrared aerial imagery, and additional GIS layers to identify existing watershed conditions and potential pollutant sources (Table 2). The NAIP color aerials were flown during late summer, thus increasing their usefulness in determining irrigated versus non-irrigated land uses, irrigation withdrawals and returns, and riparian-upland transitions. Despite this, it was often difficult to discern such characteristics in the naturally or artificially sub-irrigated bottomland of the Gallatin Valley (e.g. along the lower East Gallatin River), or in the forested headwater areas. Characteristics were refined during the field groundtruthing effort where possible but it was outside the scope of the assessment to groundtruth all reaches on foot, with the exception of Sourdough Creek, as described below.

Two shapefiles were generated from the GIS-based assessment, *Final_reach.shp* and *Final_points.shp*. Both shapefiles were initially derived solely from the GIS-based assessment. Additional data obtained during the field groundtruthing effort was then added to each shapefile for a more accurate assessment of reach-scale and discrete conditions along the 57 reaches.

2.2.1 Reach Attributes

For each reach a polyline layer of reach-scale attributes was developed including both existing reach-scale conditions, as well as reach-scale potential pollutant sources (e.g. septic system density). The electronic GIS file for the reach-scale layer is called *Final-reach.shp*. The method

Table 2. Reach-scale attributes in shapefile *final_reach.shp*, method of assessment and source of each attribute

Field	Description	Method	Derived From	Field Verify?
ENTITY_ID	DEQ waterbody segment ID	MT DEQ Segment ID	MT DEQ sediment stratification GIS layer (*strat_nut_061609.shp)*	
STREAM	Stream Name	Common stream name	MT DEQ sediment stratification GIS layer (*strat_nut_061609.shp)*	
PRI_ECOREG	Level IV Dominant Ecoregion	Dominant ER is the Level IV ecoregion that makes up >75% of the reach.	MT DEQ sediment stratification GIS layer (*strat_nut_061609.shp)*	
STREAM_ORD	Strahler Stream Order	Taken from sediment stratification layer	MT DEQ sediment stratification GIS layer (*strat_nut_061609.shp)*	
REACH_ID_N	Unique Reach Identifier for Source Assessment	Use same convention as Sediment Stratification	Source assessment reach stratification	
SEDHAB_RCH	DEQ sediment stratification reach ID's merged		MT DEQ sediment stratification GIS layer (*strat_nut_061609.shp)*	
LENGTH_FT	Length of reach in feet	Calculated in GIS	Calculated in GIS	
RBRK_TRIG	Reach Break Trigger	Record reason for reach break (riparian Veg change, LU change, etc...)		
RBRK_COM	Reach Break Comments	Describe reason for reach break		
DOMLU	Dominant Land Use within 1000 ft of the stream	Determined from aerial imagery (not NLCD) within 1000 ft of stream	2005 NAIP digital aerial imagery	
NAT	Is this a natural condition	Record whether the reach is predominantly of 'natural' condition (>90%)	2005 NAIP digital aerial imagery/Field	Y
NO_UPROADX	Number of unpaved road or driveway crossings	Counted in GIS/ assessed in field	2005 NAIP digital aerial imagery/Field	Y
SEPTIC_150	Number of septic systems within 150 ft	# of septic systems within 150 ft of the stream. Extracted in GIS	Gallatin Water Quality Planning District GIS point layer	
SEPTIC_1000	Number of septic systems in 150-1000 ft belt	# of septic systems within a belt area from 150 to 1000 ft of the stream. Extracted in GIS	Gallatin Water Quality Planning District GIS point layer	
SEPTIC_TRB	Septic system density in tributary streams	# of septic systems within a belt area from 150 to 1000 ft of the stream. Extracted in GIS	Gallatin Water Quality Planning District GIS point layer	
ROAD_ENCR	Streamside parallel road segments within 50 ft of stream	Length of parallel road segments (paved or unpaved) within 50 ft of stream	2005 NAIP digital aerial imagery/Field	Y
BANK_ERO	Level of Bank Erosion through the reach	H=extensive erosion associated with anthropogenic activities throughout the reach; M=most erosion associated with bends or local impacts; L=very little to no erosion observed	Field	Y
AVG_RBW	Average Riparian Belt Width through segment	Measure multiple (5) representative RBW through segment (total cross-valley, includes stream width) and calculate the mean RBW	2005 NAIP digital aerial imagery/Infrared imagery/Field	Y

of assessment for each reach-scale field assessed in *Final_reach.shp*, and the source used for each field are detailed in Table 2. Additional details on *Final_reach.shp* can be found in the metadata within the shapefile in ArcCatalog.

2.2.2 Point Data

Final_points.shp is a point layer of discrete attributes including both existing conditions (e.g. irrigation withdrawals), as well as discrete potential pollutant sources. This point layer consists of several GIS layers that were edited and merged into a single shapefile, *Final_points.shp*. The method of assessment for each field assessed in *Final_point.shp*, and what each field is derived from (e.g. an existing GIS layer, field groundtruthing, or a combination) is detailed in Table 3. Source types (SRC_TYPE) are further broken down into twelve different discrete attributes identified during the assessment. Additional details on *Final_point.shp* can be found in the metadata within the shapefile in ArcCatalog. Additional information on the point layer is included below.

Most point attributes obtained from the initial GIS layers were further assessed on the aerial photos for accuracy. Point attributes were also groundtruthed in the field when possible. Generally only the confluences of tributary streams listed on the National Hydrography Dataset ("NHD layer") as "perennial" were maintained on the final point attribute layer. Intermittent tributaries which are often dry by late-summer were not considered significant for pollutant delivery and were thus removed unless there was a significant green channel that could be seen on the aerial photo, the intermittent tributary was 2nd order or greater, or the tributary was flowing during the late-summer assessment.

The goal of documenting irrigation withdrawal locations was to assess changes in discharge longitudinally thereby altering the assimilative capacity of the waterbody. Water withdrawals included headgate, ditch, instream and pump diversion types as indicated on the MT DNRC irrigation GIS layer. All irrigation withdrawals and returns were included in the point attribute layer unless there was clearly no discernable channel visible on the aerial at the supposed withdrawal or return location. Pump-type diversions were generally removed from the point layer for this reason. If there was any question of the likelihood that a withdrawal was present at a location indicated on the MT DNRC layer, the error went in favor of including the feature rather than omitting it. In some cases it was determined that a withdrawal or return was close to but not located directly at, an obvious withdrawal or return and the point was therefore relocated to what was most likely the true location. Withdrawals and returns were noted in the comment field of the ArcGIS attribute table as to whether the point was confirmed or unconfirmed on the aerial or in the field. In some cases where it was determined that there was likely a withdrawal or return at a given location, it was denoted that the point was "roughly determined on the aerial".

In each of the reports, septic system density was reported in Table 1 as number of septic systems per mile within both 150 ft of the stream and within a belt from 150 ft to 1000 ft from the stream. The number of septic systems per reach was calculated in ArcGIS by intersecting the 150 ft buffer and 150-1000 ft belt with the septic system point layer.

TABLE 2 CONTINUED. REACH-SCALE ATTRIBUTES IN SHAPEFILE *FINAL_REACH.SHP*, METHOD OF ASSESSMENT AND SOURCE OF EACH ATTRIBUTE

Field	Description	Method	Derived From	Field Verify?
RPVEG_BARE	Percent Riparian Vegetation - Bare Ground	Estimate of percentage of each type of vegetation type along streambank throughout the reach. Average values for both RB and LB (e.g if the reach is 100% shrubs on the LB and 0% shrubs on the RB - the results is 50% shrub coverage)	2005 NAIP digital aerial imagery/Field	Y
RPVEG_GRASS	Percent Riparian Vegetation - Grass			
RPVEG_SHR	Percent Riparian Vegetation - Shrubs			
RPVEG_CONF	Percent Riparian Vegetation - Mature Coniferous			
RPVEG_DEC	Percent Riparian Vegetation - Mature Deciduous			
RPVEG_COM	Riparian Vegetation Comments	Additional reach-scale comments on riparian vegetation	Field	Y
LBLU_FOR	Left Bank Land Use - Forest	Estimate of the percentage of each land use type within 100 ft on each side of the streambank	2005 NAIP digital aerial imagery/Infrared imagery/Field	Y
LBLU_RANGE	Left Bank Land Use - Rangeland			
LBLU_I_PAS	Left Bank Land Use - Irrigated Pasture			
LBLU_D_PAS	Left Bank Land Use - Dry Pasture			
LBLU_I_CRO	Left Bank Land Use - Irrigated Agriculture			
LBLU_D_CRO	Left Bank Land Use - Dryland Agriculture			
LBLU_GOLF	Left Bank Land Use - Golf Course			
LBLU_RES	Left Bank Land Use - Residential			
LBLU_URBAN	Left Bank Land Use - Urban			
LBLU_RURES	Left Bank Land Use - Rural Residential			
RBLU_FOR	Right Bank Land Use - Forest			
RBLU_RANGE	Right Bank Land Use - Natural Rangeland			
RBLU_I_PAS	Right Bank Land Use - Irrigated Pasture (livestock)			
RBLU_D_PAS	Right Bank Land Use - Dry Pasture (livestock)			
RBLU_I_CRO	Right Bank Land Use - Irrigated Agriculture			
RBLU_D_CRO	Right Bank Land Use - Dryland Agriculture			
RBLU_GOLF	Right Bank Land Use - Golf Course			
RBLU_RES	Right Bank Land Use - Residential			
RBLU_URBAN	Right Bank Land Use - Urban			
RBLU_RURES	Right Bank Land Use - Rural Residential			
BMP_CODE	Best Management Practice code	Record BMP codes. RPF: riparian fencing; OSW: off-site water; WG: water gap; SWB: stormwater basin; PRB: pasture buffer; WBR: water bar	Field	Y

Table 3. Point attributes in shapefile *final_points.shp*, method of assessment and source of each attribute. Source types are also detailed.

Field		Description	Method	Derived From
ENTITY_ID		DEQ Waterbody Segment ID	MT DEQ Segment ID	MT DEQ sediment stratification GIS layer
STREAM		Stream Name	Common stream name	MT DEQ sediment stratification GIS layer
REACH_ID_N		Unique Reach Identifier for Source Assessment	Use same convention as Sediment Stratification	Source assessment reach stratification
SRC_TYPE (Source Type)	IRR_W	Irrigation Withdrawal	Initially assessed using GIS layer; refined using aerial photo and field identification	MT DNRC irrigation GIS layer
	IRR_R	Irrigation Return	Initially assessed using GIS layer; refined using aerial photo and field identification	National Hydrography Dataset GIS layer
	LCA	Livestock Confinement Area	Initially assessed using GIS layer; refined using aerial photo and field identification. Assigned point to closest reach perpendicularly (see CON_REACH)	MT DEQ GIS layer
	MPDES	MPDES Permit	Merged Montana and national pollution discharge elimination system permit points into single layer. Assigned point to closest reach perpendicularly (see CON_REACH)	from MT DEQ MPDES GIS layer or NPDES GIS layer
	TRIB	Tributary Input	Initially assessed using GIS layer; refined using aerial and groundtruth. Generally included only perennial streams	National Hydrography Dataset GIS layer
	SPRG	Spring Input	Aerial photo and field identification	2005 NAIP digital aerial imagery/Field
	PIPE_SW	Stormwater Pipe Outfall	Field assessment	Field
	PIPE_UK	Unknown Pipe Outfall	Field assessment	Field
	PIPE_WW	Wastewater (septic) Pipe Outfall	Field assessment	Field
	GOLFCSE	Golf Course	Aerial photo and field identification	
	SODFM	Sod Farm	Aerial photo and field identification	
	PLTN	Discrete Pollutant Source (observed)	Discrete pollutant source identified from field assessment (e.g. yard clippings, manure piles)	Field
NEW_SRC		New source	A new source is any source not previously identified on an existing GIS layer; Y or N	All existing GIS layers
NPDES_ID		NPDES Permit ID	Used NPDES or MPDES permit ID #'s	from MT DEQ MPDES GIS layer or NPDES GIS layer
NPDES_TYPE		NPDES Permit Type	Individual, general, stormwater or groundwater	from MT DEQ MPDES GIS layer or NPDES GIS layer
MEANOFDIV		Means of Diversion (e.g. headgate, ditch)	Used means of diversion from irrigation GIS layer; refined in field when possible	MT DNRC irrigation GIS layer
CON_REACH		Actual Hydrologically Connected Reach (for MPDES permit and LCA only)	Used aerial photo and NHD GIS layer to assess configuration of tributaries and ditches to determine the most likely hydrologically connected to the MPDES or LCA discharge, if different from closest perpendicular reach	2005 NAIP digital aerial imagery; National Hydrography Dataset GIS layer /Field

2.3 Groundtruthing

The reach-scale characteristics and potential nutrient and E. coli sources identified in the GIS-based analysis were groundtruthed in the field by vehicle at accessible stream crossings. Four reaches on Sourdough were groundtruthed in their entirety on foot by walking below the high water mark, or on the bank where possible without obtaining permission (e.g. along adjacent roads or public land corridors such as the Gallatin Valley Land Trust trail system). Sourdough Cr reaches 3 through 6 (from the confluence with the East Gallatin River, upstream to just south of Goldenstein Rd) were groundtruthed on foot.

For each reach, a *Lower Gallatin TMDL Planning Area Aerial Assessment Field Verification* data sheet was completed after the reach was groundtruthed. These data sheets documented the riparian composition and condition, extent of bank erosion, encroachment of crop, pasture land, and road, condition of unpaved road crossings, observations of best management practices (BMP's), and discrete characteristics such as irrigation withdrawals, returns, tributaries,and springsas well as potential nutrient and E. coli sources. The completed field data sheets are compiled in Appendix B and included as a separate file to the source report.

Field verification data was added to the existing reach and point shapefiles as appropriate (*Final_reach.shp* or *Final_points.shp).* Discrete points documented in the field were GPS'd and the GPS location was uploaded into ArcGIS and incorporated into the existing point shapefile.

2.4 Reporting

The GIS analysis and field observations were integrated into a source assessment report for each of the twelve streams organized by reach. The individual source reports for the 12 streams are included in Appendix A. Each report includes an introduction to the stream, maps of individual reaches, details on the existing reach characteristics, and an assessment of documented potential pollutant sources in light of the listed impairments for that stream (e.g. nutrient or E. coli impairment).

Potential pollutant sources and significance were identified for respective reaches in an assessment table. Potential significance of a pollutant was qualitatively assessed as “low”, “med” or “high” based on the following conditions: prevalence of a source, the potential of that source to reach a stream given the transport pathway (surface and/or groundwater), distance of a source from the stream, and the quality of the riparian buffer zone. Pollutant source prevalence values for the most common sources are described in Table 4. Source prevalence is reported as either a discrete number which is then assigned to a low, medium or high category (e.g septic density or % irrigated agriculture), or assigned directly to a category (for example, septic density within tributary drainages flowing to each reach were visually estimated and assigned a qualifier of none, low, med, high). Residential yard encroachment was considered a significant source of nutrients and E. coli to Sourdough Creek and was therefore also included in the pollutant source tables for that report. Descriptions of the four riparian quality categories used are detailed in Table 5.

Table 4. Description of common pollutant source categories and scoring

Pollution Source	Description
Irrigated crops ave % (LB/RB)	% irrigated agriculture averaged over left and right banks. ***Low:*** 1-25%, ***Med:*** 26-50%, ***High: 51-100%***
Pasture ave % (LB/RB)	% total pasture (both dry and irrigated) averaged over left and right banks. ***Low:*** 1-25%, ***Med:*** 26-50%, ***High: 51-100%***
Septic system per mi (150 ft/1000 ft)	Septic system density (#/mi) within 150 ft of the stream and within the 150-1000 ft belt from the stream. ***Low***: 0.1-3 septic/mi, ***Med***: 3-5 septic/mi, ***High***: 5+ septic/mi
Septic in tributaries	Qualitative assessment of the density of septics along tributary streams joining the reach (none, med, low, high)
Unpaved road crossings	# of unpaved crossings in the reach
LCA	# of livestock confinement areas within the reach
MPDES	# of Montana Pollution Discharge Elimination System permits within the reach
Stormwater	# of stormwater pipes draining to the reach, identified during the field assessment
Wastewater	# of wastewater pipes draining to the reach, identified during the field assessment
Other pollutant sources	# of locations of discrete pollutant sources e.g. piles of grass clippings on the stream bank identified during the field assessment

Table 5. Description of riparian quality scores

Riparian Quality	Description
Poor	Very overgrazed, high yard/pasture encroachment, excessive bank trampling, bare, very weedy (generally thistle and tansy)
Fair	Understory grazed, moderate yard/pasture encroachment, some trampling, moderate weeds
Good	Low grazing and yard/pasture encroachment, minimal trampling and weeds, densely vegetated
Excellent	No grazing, yard/pasture encroachment, no trampling, minimal weeds, dense, healthy vegetation

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APPENDIX A

LOWER GALLATIN TPA SOURCE ASSESSMENT REPORTS FOR TWELVE STREAMS

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Bear Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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BEAR CREEK

Bear Creek has its headwaters in the Gallatin Range south of Bozeman (Figure 1). In the upper reaches it flows through the Gallatin National Forest and other public lands upstream of the Bear Canyon Trailhead. Downstream of the trailhead it flows through a rural residential area in Bear Canyon, then through rural residences and agriculture, prior to its confluence with Rocky Creek to form the East Gallatin River downstream of Interstate 90. Water quality in Bear Creek (Waterbody ID MT41H003_40) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: algal growth, total phosphorus, suspended solids, and sediment.

For the purposes of assessing pollutant sources, Bear Creek was divided into four reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients. Reach-scale conditions on Bear Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below. **It should be noted that many of the photos in this report were taken the day after a heavy rainstorm and hence depict turbid stream water.**

1.1. Summary

Bear Creek is only marginally impacted by anthropogenic sources throughout its ten mile length. Residential septic systems and unpaved road crossings were identified as the most significant potential sources of nutrients to Bear Creek. The upper reach (BEAR 01 N) flows primarily through U.S. Forest Service land, with the only potential anthropogenic nutrient source being bank and trail erosion associated with recreation, grazing, and naturally-erosive soils. Reach BEAR 02 N remains relatively unaltered, with the exception of the encroachment of Bear Canyon Road, and an increased density of rural residences and associated septic systems and unpaved driveway crossings (Table 1). Although the stream and driveway crossings along Bear Canyon Road were well-vegetated, the encroaching road and driveway crossings were considered to be potential nutrient and sediment sources during storm events. The two lower reaches are primarily agricultural, surrounded by pasture and cropland. With the dense riparian buffer in these reaches, pasture and cropland were not considered very significant nutrient sources. Septic systems, however, continued to be a potential nutrient source in the lower two reaches.

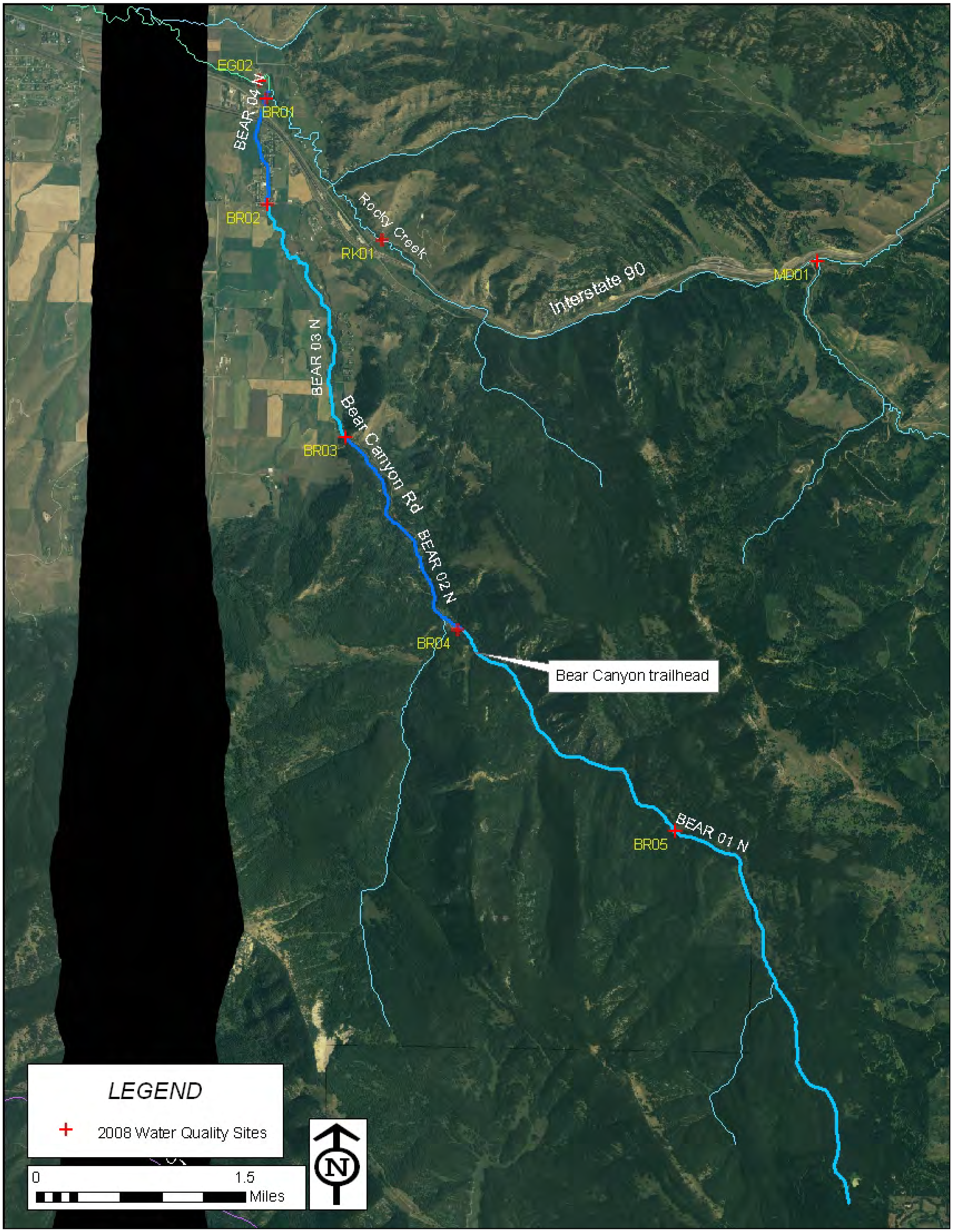

FIGURE 1. OVERVIEW OF BEAR CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID N	Reach length (mi)	Ecoreg.	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP	Septic 150 ft per mi	Septic 1000 ft per mi
BEAR 01 N	5.57	17g	2	FOREST	Y	1	0	L	110	WBR	0.0	0.9
BEAR 02 N	1.71	17g	3	RURAL RESIDENCE	N	7	1700	L	70	NA	5.3	19.9
BEAR 03 N	1.98	17w	3	HAY	N	4	300	L	70	PBR	0.5	14.1
BEAR 04 N	0.88	17w	3	RURAL SUBDIVISION	N	0	0	L	50	PBR	6.8	56.9

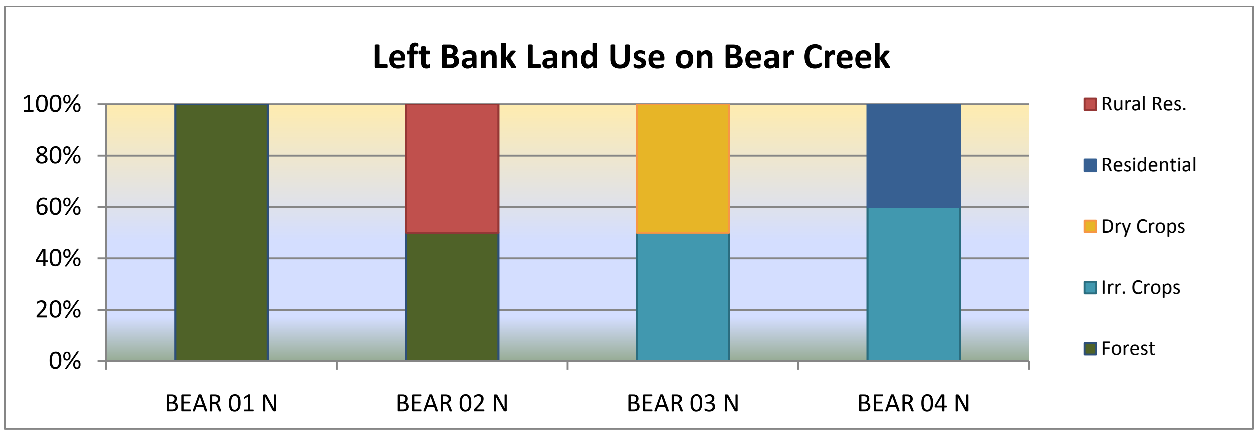

FIGURE 2. LAND USE TYPES ALONG THE LEFT BANK OF BEAR CREEK

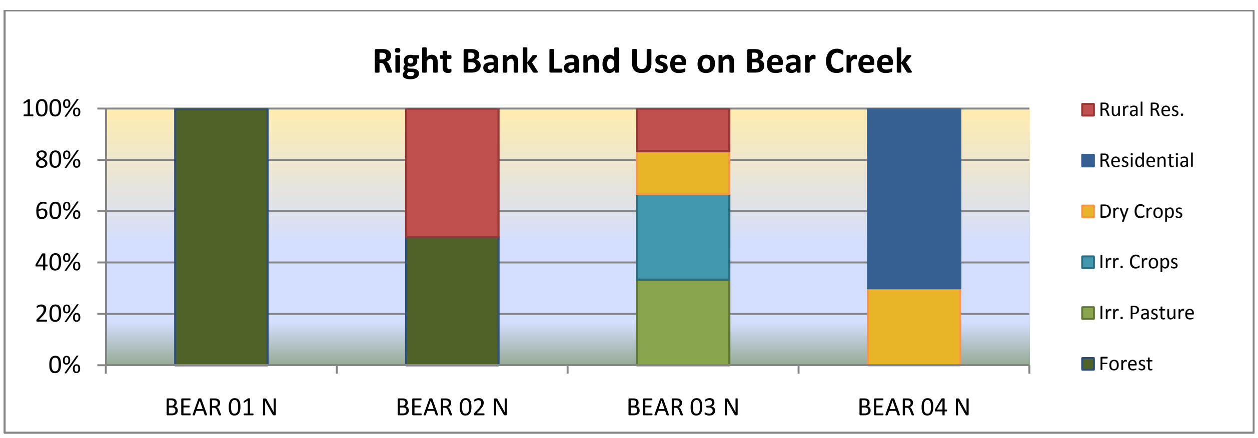

FIGURE 3. LAND USE TYPES ALONG THE RIGHT BANK OF BEAR CREEK

2. BEAR 01 N

Reach 1 is a second order stream in the Gallatin Mountains south of Bozeman. The reach spans from the Bear Creek headwaters, downstream to water quality sample site BR04 (Figure 4). The entire reach is upstream of the end of Bear Canyon Road, which ends at the Bear Canyon trailhead. The dominant Level 4 PRI ecoregion of the reach is 17g, mid-elevation sedimentary mountains.

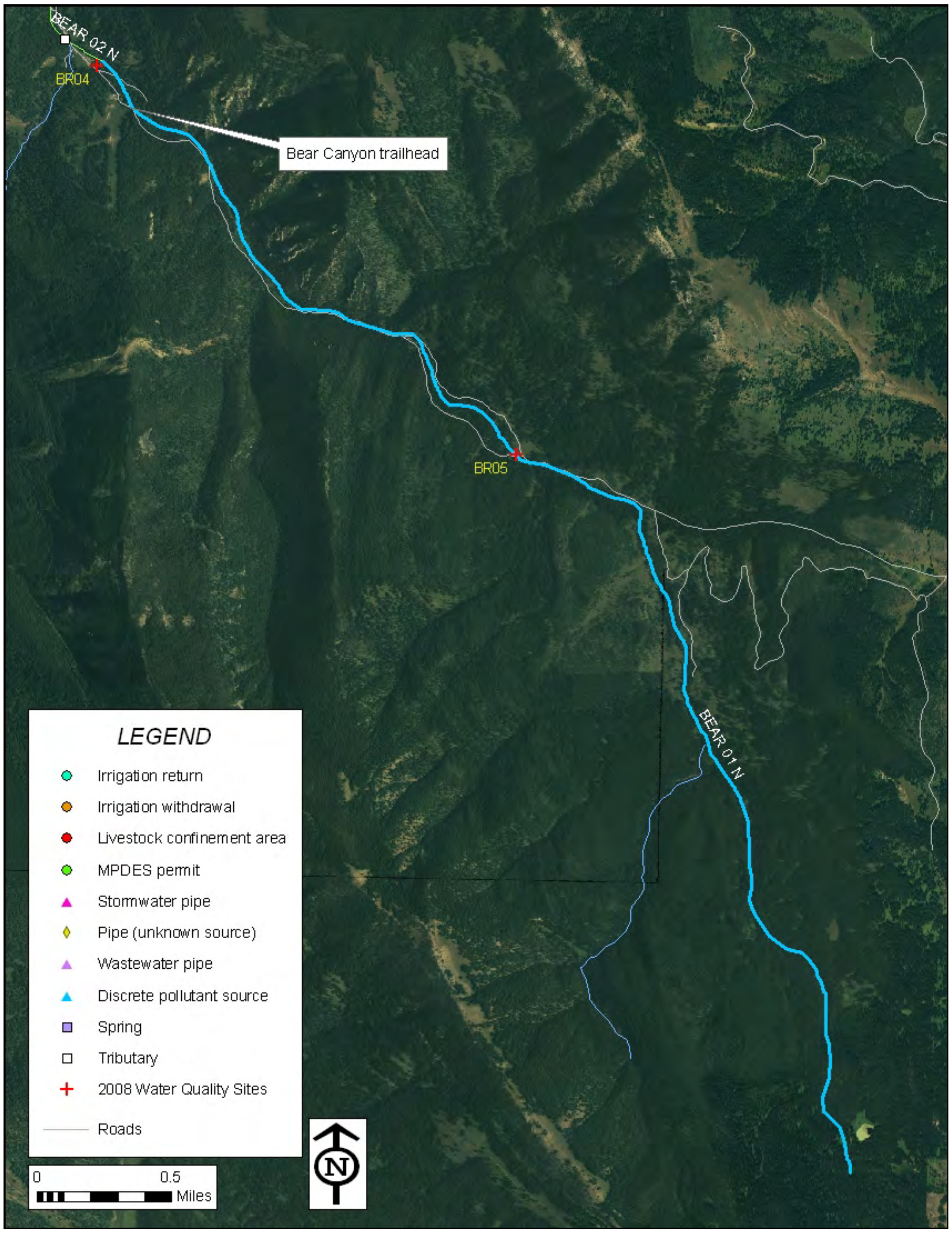

FIGURE 4. REACH BEAR 01 N

2.1. Reach Condition

The reach is located almost entirely within the Gallatin National Forest, and is primarily in its natural condition with the dominant land use being recreation. The riparian vegetation is very robust and healthy, consisting of a mixed conifer-cottonwood overstory with a willow-grass-forb understory (Figure 5). Severe bank erosion was observed in select areas, but overall erosion within the reach was considered low. Erosion was associated with cattle grazing and motorized-use trail crossings (Figures 6 and 7), and natural erosion due to the highly erosive soil. The Gallatin National Forest rerouted the trail between approximately miles 2-4 from the trailhead, reducing recreation-related stream erosion in that area. In addition, several water bars have been installed across the trail to route water off of the trail during storm events, thereby mitigating trail erosion that could deliver sediment to the stream. No roads encroach on the stream within the reach.

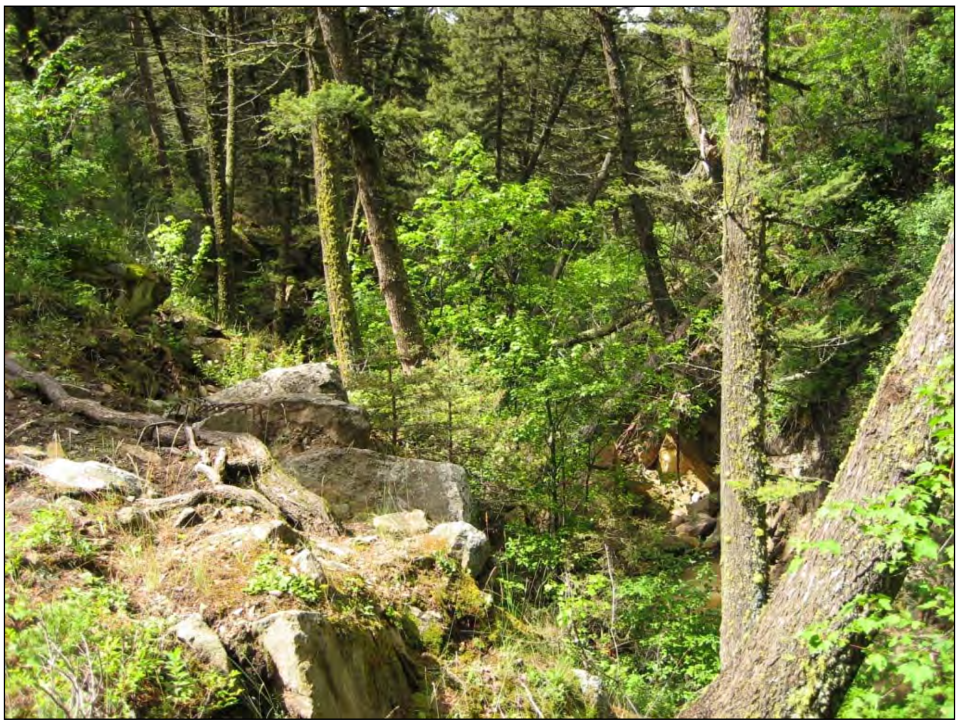

FIGURE 5. ROBUST RIPARIAN VEGETATION IN REACH BEAR 01 N (STREAM IN RIGHT SIDE OF PHOTO)

FIGURE 6. BANK EROSION AGAINST OLD ROAD WHICH IS NOW A TRAIL. CATTLE IN BACKGROUND.

FIGURE 7. BANK EROSION AT TRAIL CROSSING.

2.2. Nutrient Source Characterization

Recreational use and cattle grazing were the only potential pollution sources identified within the reach (Table 2). While the grazing impact appeared significant in some areas, it was concentrated near a few stream crossings and was not widespread throughout the reach. Therefore the potential significance of grazing was considered low. No septic systems were identified within 150 feet of the stream and only 0.9 septic systems were identified per mile within 1000 feet. A single unpaved driveway crosses the stream at the lower end of the reach near the Bear Canyon trailhead (Figure 4). The condition of the driveway was not observed.

TABLE 2. POTENTIAL NUTRIENT SOURCES WITHIN REACH BEAR 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Recreational use	Low	SW	Excellent	some erosion at trail crossings; mostly related to motorized use	Low
Cattle grazing	Low	SW	Excellent	concentrated areas of erosion and trampling within grazing allotments on the National Forest	Low
Septic system per mi (150 ft/1000 ft)	0.0/0.9	GW	Excellent		Low
Unpaved road crossings (#)	1	SW	Excellent	unpaved driveway	Low

3. BEAR 02 N

Reach 2 is a third order stream that flows through Bear Canyon from the Bear Canyon trailhead, downstream to near the canyon mouth at water quality site BR03 (Figure 8). The dominant Level 4 PRI ecoregion of the reach is 17g, Mid-Elevation Sedimentary Mountains.

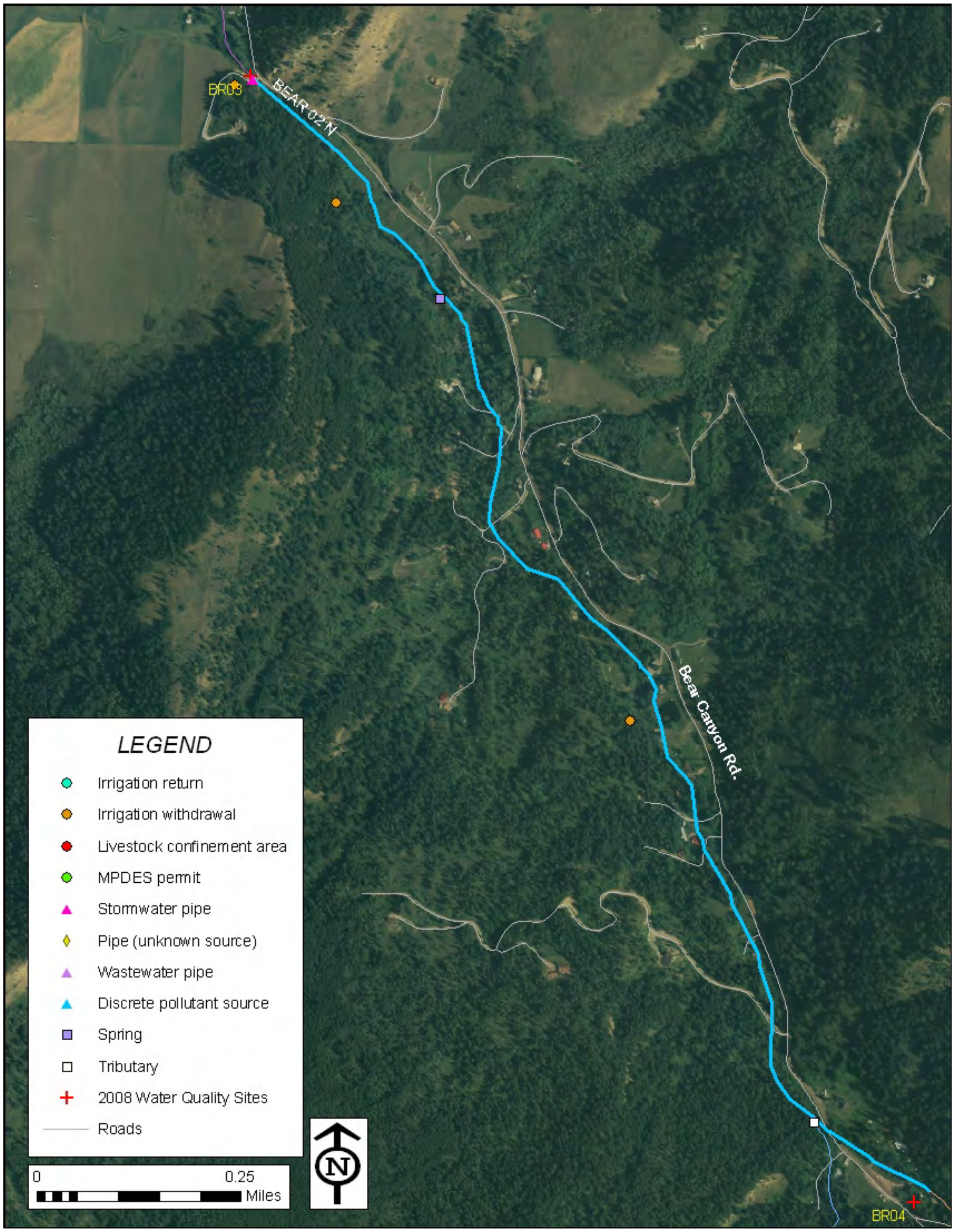

FIGURE 8. REACH BEAR 02 N

3.1. Reach Condition

The dominant land uses within the reach are forested land and rural residential. Although several residences are located along the reach, overall the riparian vegetation is robust and healthy, consisting of a mixed conifer-cottonwood overstory with a willow-grass-forb understory (Figure 9). Bank erosion was very low and was limited to natural erosion in the fine, erosive soils present within Bear Canyon. The unpaved Bear Canyon Road encroaches on the stream for a third of a mile within the reach (Figure 10). Vegetation along the encroached area was generally dense, but the unpaved road could potentially be a sediment source during large storm events and during spring snowmelt. Two small irrigation withdrawals were identified within the reach. The irrigation withdrawals were not confirmed on the aerial or in the field.

FIGURE 9. DENSE CONIFER-COTTONWOOD RIPAIRAN IN REACH BEAR 02 N

FIGURE 10. BEAR CANYON ROAD ENCROACHMENT ALONG REACH BEAR 02 N

3.2. Nutrient Source Characterization

Potential nutrient sources within reach BEAR 02 N are identified in Table 3. With the abundance of residences, septic system density was rather high within the reach. However, with the robust riparian buffer the potential significance of septic systems was considered moderate. Seven unpaved road crossings were identified within the reach. One crossing was Bear Canyon Road which is very well maintained and not likely a sediment source. The other crossings were driveways, most of which were well-maintained (e.g. Figure 11) and not considered a sediment source but could potentially deliver sediment during storm events. Both the spring and the tributary identified within the reach drain were relatively unimpacted forested lands and were not considered significant nutrient sources.

TABLE 3. POTENTIAL NUTRIENT SOURCES WITHIN REACH BEAR 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Septic system per mi (150 ft/1000 ft)	5.3/19.9	GW	Good	high septic density but good riparian buffering quality	Low/Med
Unpaved road crossings (#)	7	SW	Good	most well-vegetated at abutments, some considered a sediment source	Low/Med

FIGURE 11. WELL-MAINTAINED DRIVEWAY CROSSING WITHIN REACH BEAR 02 N

4. BEAR 03 N

Reach 3 is a third order stream that extends from the mouth of Bear Canyon at water quality site BR03, downstream to Bozeman Trail Road (Figure 12). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

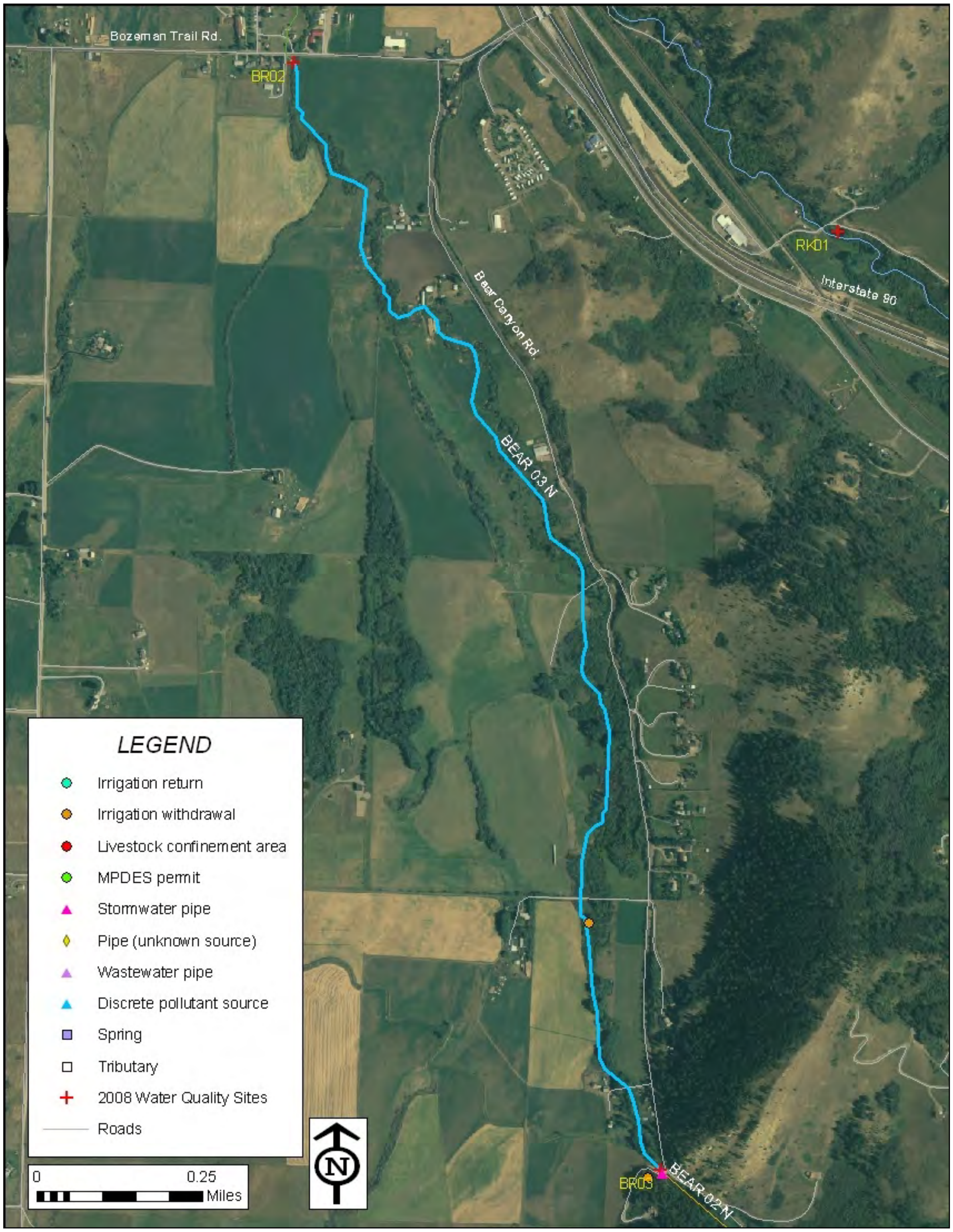

FIGURE 12. REACH BEAR 03 N

4.1. Reach Condition

The dominant land uses within the reach are hay production, irrigated horse and cattle pasture, and scattered residences. Although the riparian zone is narrower than in reach BEAR 02 N, it is still relatively dense and robust, composed of cottonwood with a shrub understory in the upper reach, and willow, dogwood and alder in the lower reach (Figure 13). Bank erosion was low within the reach, limited to areas of pasture encroachment where stabilizing riparian vegetation has transitioned to shallower-rooted cultivar grasses (Figure 14). The unpaved Bear Canyon Road encroaches on the stream for 300 feet within the reach (Figure 15). Vegetation along the encroached area was generally dense, but the unpaved road could potentially be a sediment source during large storm events and during spring snowmelt. Two irrigation withdrawals remove water within the reach. Neither of the withdrawals were observed in the field.

FIGURE 13. ROBUST SHRUB RIPARIAN ZONE IN LOWER REACH BEAR 03 N

FIGURE 14. LIMITED BANK EROSION ON OUTER MEANDER BEND BEHIND LAMOTTE SCHOOL

FIGURE 15. BEAR CANYON ROAD ENCROACHMENT WITH GOOD RIPARIAN BUFFER IN BEAR 03 N

4.2. Nutrient Source Characterization

Potential nutrient sources within the reach are identified in Table 4. Irrigated crops comprised a moderate proportion of the reach, but with the good riparian quality, their potential significance as a nutrient source was considered low to moderate. The proportion of pasture land was quite low, and the observed pasture was in relatively good condition, not overgrazed, and with a substantial riparian buffer. Therefore pasture was assigned a low potential significance as a nutrient source.

Septic density within 150 feet of the stream was lower than in reach BEAR 02 N, while density within 1000 feet remained high. With a relatively healthy riparian buffer, the potential significance of septic systems was considered to be low. Three well-maintained driveway crossings and one ford (Figure 16) were identified within the reach. Substrate at the ford was gravel and small cobble but was nonetheless considered a sediment source when vehicles crossed (a truck was observed crossing during the assessment). A metal stormwater pipe was located just downstream of water quality site BR03 at the upstream end of the reach (Figure 17). The pipe drained the borrow ditch along Bear Canyon Road and was located within 15 feet of the stream. Evidence of flow from a rainstorm the previous night was observed during the assessment.

TABLE 4. POTENTIAL NUTRIENT SOURCES WITHIN REACH BEAR 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	45	GW	Good	primarily hay production	Low/Med
Pasture (Ave. % LB/RB)	20	SW/GW	Good	horse and cattle grazing; pasture in good condition	Low
Septic system per mi (150 ft/1000 ft)	0.5/14.1	GW	Good	med septic density but relatively good riparian buffering quality	Low
Unpaved road crossings (#)	4	SW	Good	3 well-maintained driveways, 1 ford causing some sedimentation	Med
Stormwater (# pipes)	1	pipe, SW	Good	metal stormwater pipe from unpaved Bear Cyn Rd. 15 ft bet. pipe and stream; evidence of recent flow.	Low

FIGURE 16. FORD CROSSING WITHIN REACH BEAR 03 N

FIGURE 17. PIPE DRAINING BEAR CANYON ROAD DITCH WITHIN REACH BEAR 03 N

5. BEAR 04 N

Reach 4 is a third order stream that extends from Bozeman Trail Road downstream to its confluence with Rocky Creek to form the East Gallatin River (Figure 18). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

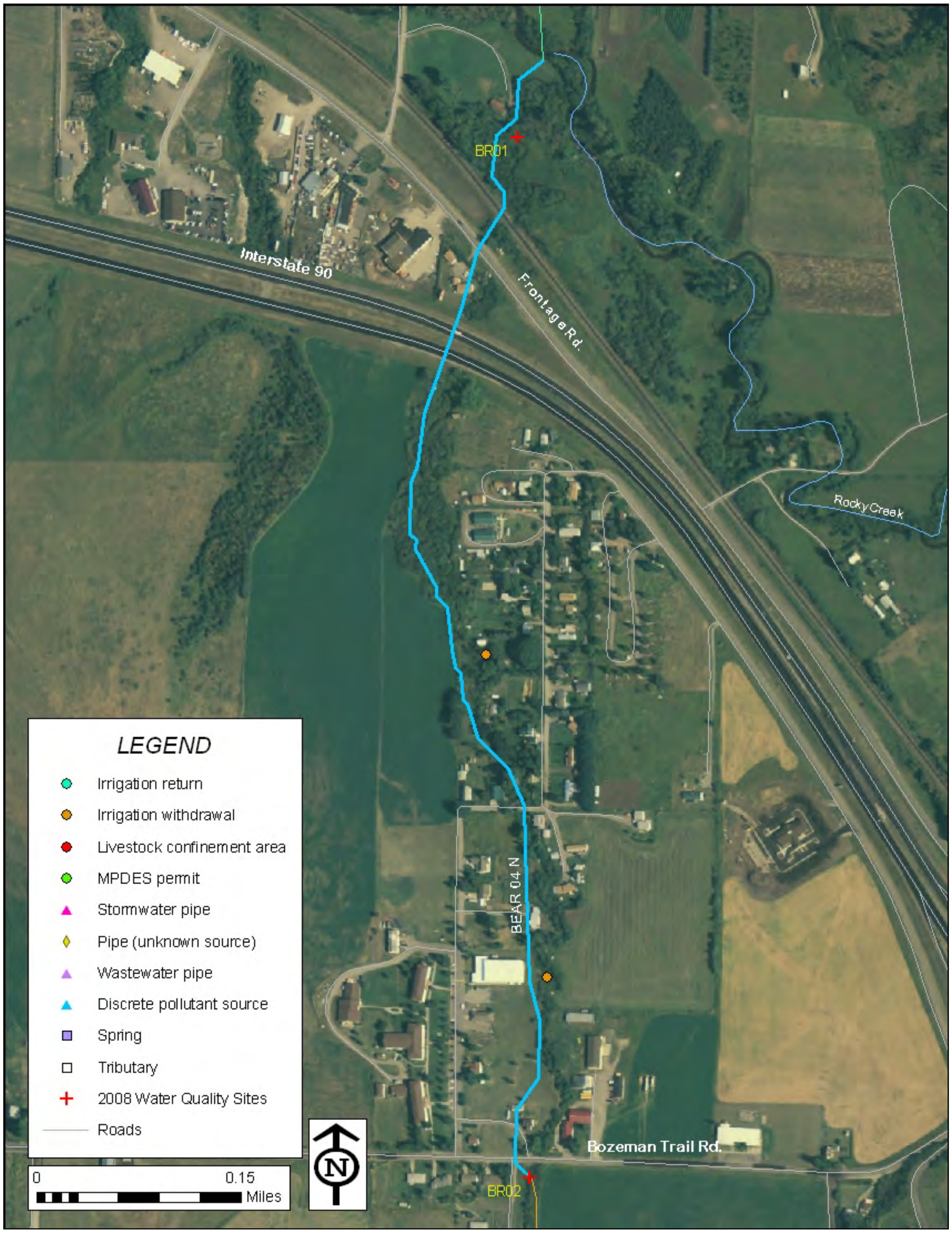

FIGURE 18. REACH BEAR 04 N

5.1. Reach Condition

The dominant land uses within the reach are hay production and residential. Although there are several residences along the stream, the riparian zone remains dense with a cottonwood overstory and dense alder, dogwood and willow understory (Figures 19 and 20). Bank erosion was low within the reach; the only bank disturbance observed was some minor trampling downstream of Bozeman Trail Road near the Mt. Ellis Academy. Three irrigation withdrawals were identified within reach BEAR 04 N.

FIGURE 19. DENSE RIPARIAN DOWNSTREAM OF THE FRONTAGE ROAD WITHIN BEAR 04 N

FIGURE 20. YARD ENCROACHMENT ON STREAM WITH DENSE RIPARIAN BUFFER ON REACH BEAR 04 N

5.2. Nutrient Source Characterization

Potential nutrient sources within the reach are identified in Table 5. Irrigated crops comprised a moderate proportion of the reach but with the good riparian buffer, the potential significance of irrigated crops as a nutrient source was considered low. Septic density along the reach was rather high both within 150 and 1000 feet of the stream; with the good riparian buffer, the potential significance of septic systems was considered low to moderate. No unpaved road crossings or road encroachment were identified.

TABLE 5. POTENTIAL NUTRIENT SOURCES WITHIN REACH BEAR 04 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	30	GW	Good	moderate level of irrigated crops but riparian buffer is in good condition	Low
Septic system per mi (150 ft/1000 ft)	6.8/56.9	GW	Good	high septic density but with a good riparian buffer	Low/Med

Sourdough Creek (aka Bozeman Creek)

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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SOURDOUGH CREEK

Sourdough Creek has its headwaters in the Gallatin Range south of Bozeman. In the upper reaches it flows through forested lands on the Gallatin National Forest, then through agricultural land, rural residential and subdivisions south of Bozeman, prior to transitioning to a true urban stream as it flows through the City of Bozeman. It joins the East Gallatin River just north of Interstate 90 in Bozeman. Sourdough Cr is locally known as Bozeman Cr, thus the reaches on Sourdough Cr follow the naming convention initiated by MT DEQ, labeling Sourdough Cr reaches "BOZE". Sourdough Cr is the only stream in the 2009 source assessment that was groundtruthed on foot rather than from a vehicle. Reaches 3-6 were walked in the stream while the most upstream, least impacted reaches were groundtruthed by vehicle. Reach 1 was only groundtruthed from the trail within the first two miles upstream of the Bozeman Cr trailhead.

Water quality in Sourdough Creek (Waterbody ID MT41H003_040) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: E. coli, total phosphorus, sedimentation/siltation, and Total Kjeldahl Nitrogen. For the purposes of assessing pollutant sources, Sourdough Creek was divided into six reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients. Reach-scale conditions on Sourdough Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

Sourdough Creek is progressively more impacted from upstream to downstream along its sixteen mile length. From its headwaters, downstream to the Bozeman Creek trailhead (reach 1), Sourdough Creek is minimally impacted as it flows through Gallatin National Forest land. From the Bozeman Creek trailhead to approximately Goldenstein Rd (reach 2) it is an agricultural stream, with adjacent pasture land and hay fields. Between Goldenstein Rd, downstream to Bogert Park (reaches 3 and 4), residential and urban impacts increase. However, where residential lawns do not encroach on the stream, the riparian vegetation is still relatively healthy and bank erosion is limited to areas of pasture and lawn encroachment. The greatest potential water quality influences to reaches 3 and 4 are likely tributary streams (Limestone Creek, Spring Creek) and residential lawn encroachment along South Church St.

Urban impacts greatly increase downstream of Bogert Park as the stream flows through downtown Bozeman and residential areas along Rouse Ave. This section is comprised almost exclusively of reach 5, which is by far the most impacted reach along the entire stream with several potential sources of nutrients and E. coli. Residential lawns encroach directly on the stream for most of the length, banks were generally eroding and trampled, and the riparian quality was very poor to non-existent in most areas. Sixteen pipes were identified entering the stream. Several of these were stormwater pipes with current flow, or recent evidence of flow. Reach 6, the most downstream reach from Tamarack St to the confluence with the East Gallatin River, was less impacted by urban development than reach 5, with a wider riparian buffer, less residential lawn and pasture encroachment, and minimal bank erosion. This reach did flow through some livestock grazing and industrial areas, both of which are likely nutrient and E. coli sources.

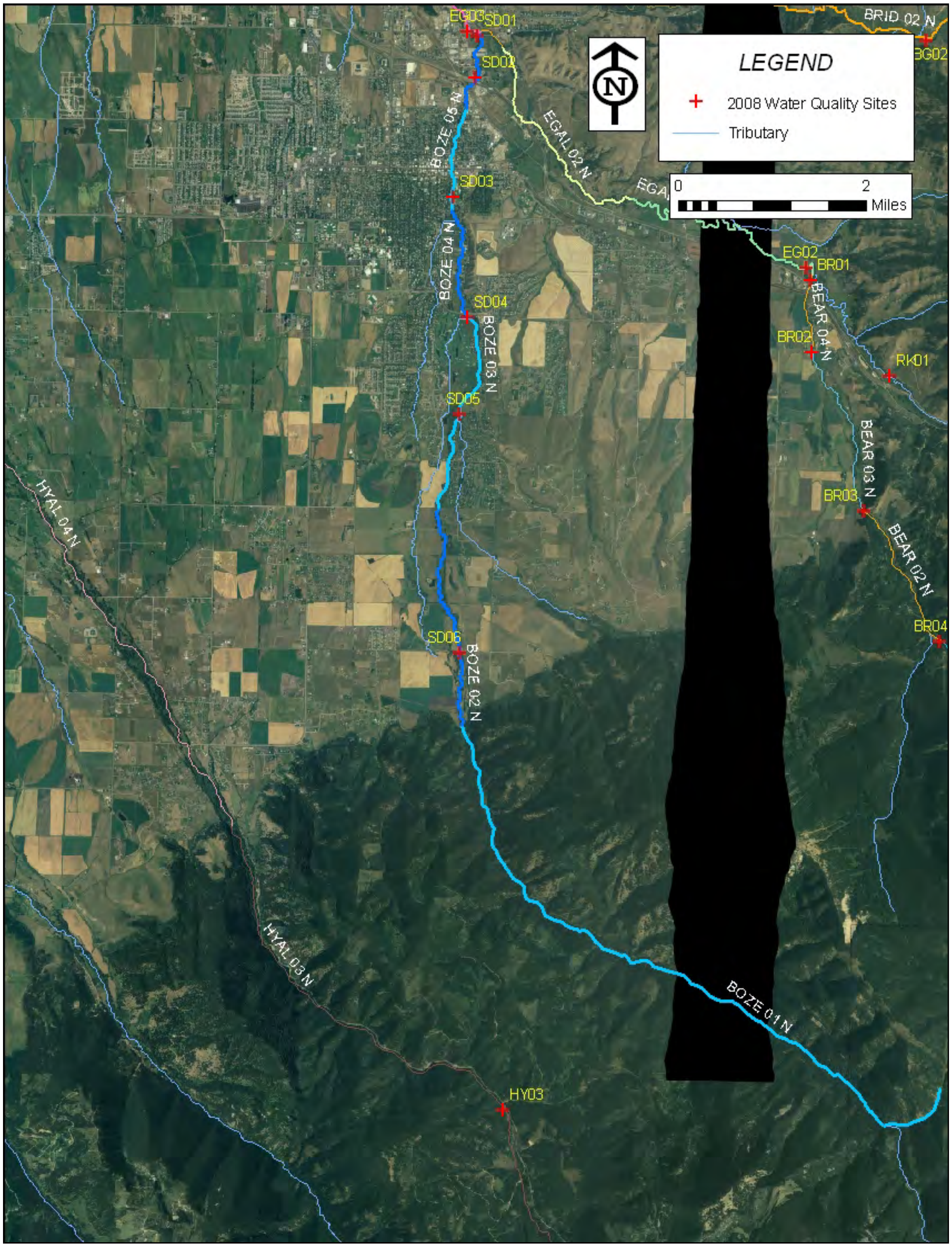

FIGURE 1. OVERVIEW OF SOURDOUGH CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID N	Reach length (mi)	Ecoreg.	Ord.	Dom. LU	Nat.	# UP Rd xing	Rd. Encr. (ft)	Bank Ero.	Rip. Width	BMP*	Septic/ mi 150	Septic/ mi 1000
BOZE 01 N	7.64	17g	2	FOREST	Y	1	2500	L	150	NA	0.0	0.1
BOZE 02 N	2.58	17w	2	HAY	N	1	0	L	150	NA	0.0	5.8
BOZE 03 N	2.27	17w	2	RESIDENCE/ HAY	N	3	0	L	130	NA	7.0	55.1
BOZE 04 N	1.23	17w	3	URBAN	N	2	150	L	70	OSW, RPF	0.8	2.4
BOZE 05 N	1.14	17w	3	URBAN	N	2	3900	H	30	SILT FENCE	0.0	0.0
BOZE 06 N	0.93	17w	3	URBAN	N	1	0	L	60	RPF	0.0	0.0
*OSW: off-site water; RPF: riparian fencing												

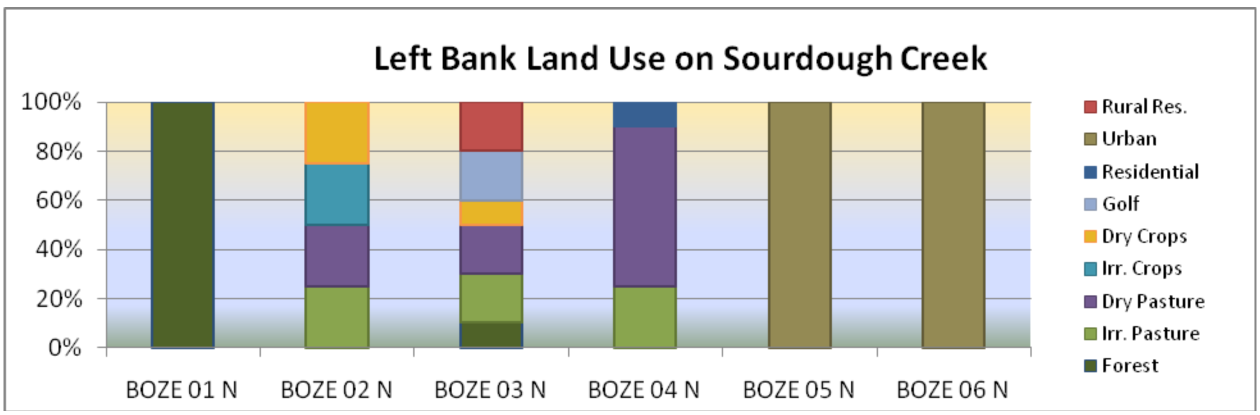

FIGURE 2. LAND USE TYPES ALONG THE LEFT BANK OF SOURDOUGH CREEK

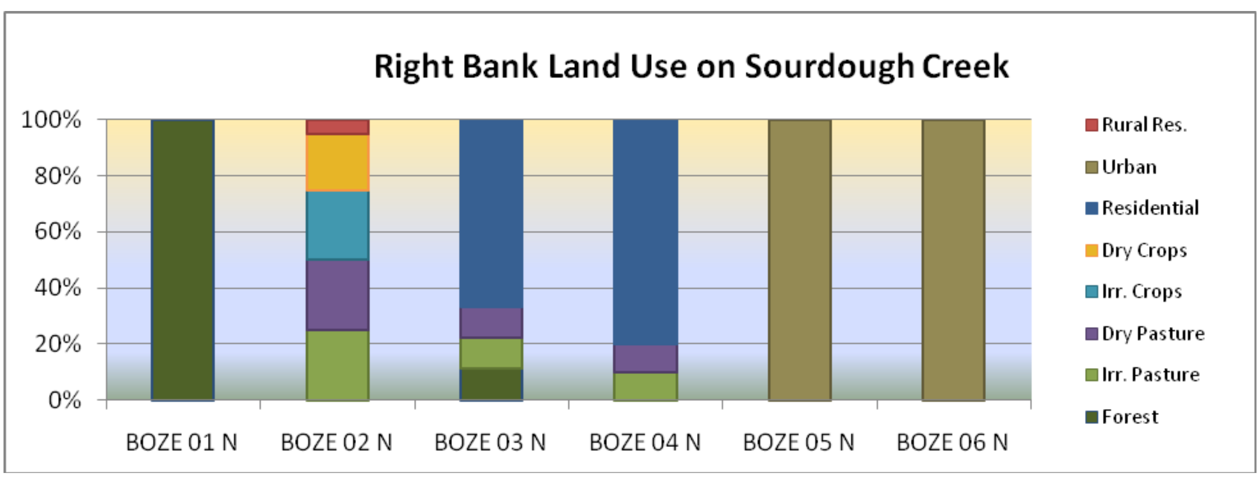

FIGURE 3. LAND USE TYPES ALONG THE RIGHT BANK OF SOURDOUGH CREEK

2. BOZE 01 N

Reach 1 is a second order stream high in the Gallatin Mountains south of Bozeman. The reach spans from the stream headwaters, downstream to Bozeman Creek trailhead (Figure 4). The dominant Level 4 PRI ecoregion of the reach is 17g, mid-elevation sedimentary mountains.

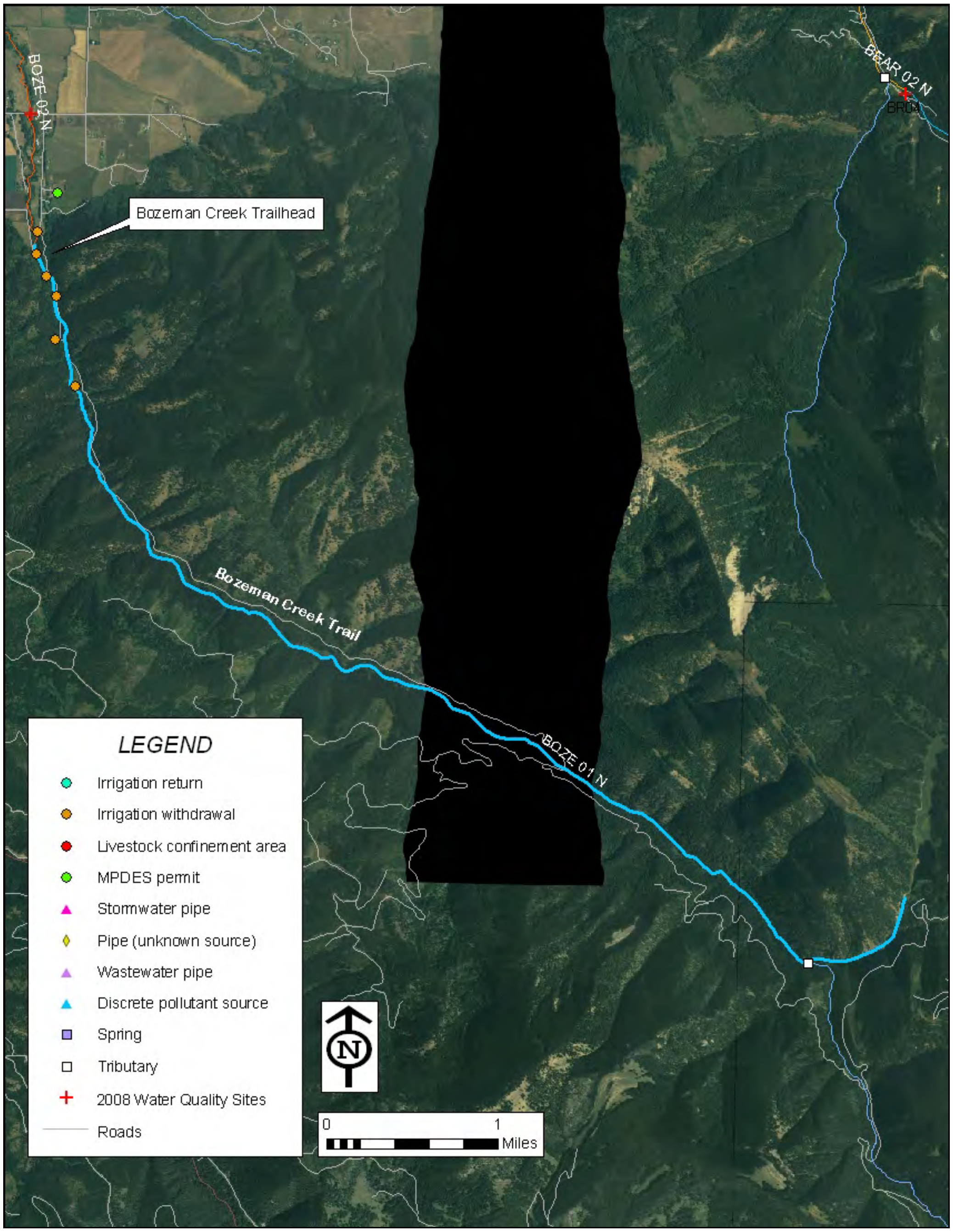

FIGURE 4. REACH BOZE 01 N

2.1. Reach Condition

The reach is located within the Gallatin National Forest, and is primarily in its natural condition with land use limited to recreation and historic logging on the hillsides. The riparian vegetation is robust and healthy, consisting of a mixed conifer-cottonwood overstory with a shrub-grass-forb understory (Figures 5). Bank erosion was limited to a handful of locations in the most downstream mile of the reach where small side trails extend from the Bozeman Creek trail, which is directly adjacent to the stream (Figure 6). The trail encroaches on the stream for approximately one half mile upstream of the trailhead. Five irrigation withdrawals were identified, all located at the downstream end of the reach. Of these, two significant withdrawals were confirmed in the field. The City of Bozeman water treatment plant withdrawal is located approximately one mile upstream of the trailhead. Another relatively large withdrawal was observed at the trailhead.

FIGURE 5. DENSE COTTONWOOD-CONIFER RIPARIAN UPSTREAM OF THE BOZEMAN CREEK TRAILHEAD

FIGURE 6. BOZEMAN CREEK TRAIL WITHIN 5 FEET OF SOURDOUGH CREEK, WITHIN THE FIRST MILE UPSTREAM OF THE TRAILHEAD

2.2. Potential Nutrient and E. coli Sources

The few potential nutrient and E. coli sources within the reach are detailed in Table 2. This is a very popular trailhead, leading to excessive dog waste accumulation during all seasons, primarily in the first mile upstream of the trailhead where the stream is directly adjacent to the trail (Figure 6). Dog waste was considered a moderately significant nutrient and E. coli source. The Bozeman Creek trail, an old logging road, crosses the stream at a bridge five miles upstream of the trailhead. The trail and bridge are well-maintained and the crossing is not considered a significant nutrient source.

TABLE 2. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH BRID 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Recreation (dog waste)	med	SW/GW	Excellent	Dog waste is abundant in the first mile upstream of the Bozeman Creek trailhead; potentially significant E. coli and nutrient source	med
Unpaved road crossings (#)	1	SW	Excellent	Bridge; Bozeman Creek trail crossing 5 miles from trailhead	low

3. BOZE 02 N

Reach 2 spans from the Bozeman Creek trailhead, downstream to south of Goldenstein Rd (Figure 4). Due to the length of the reach, the dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

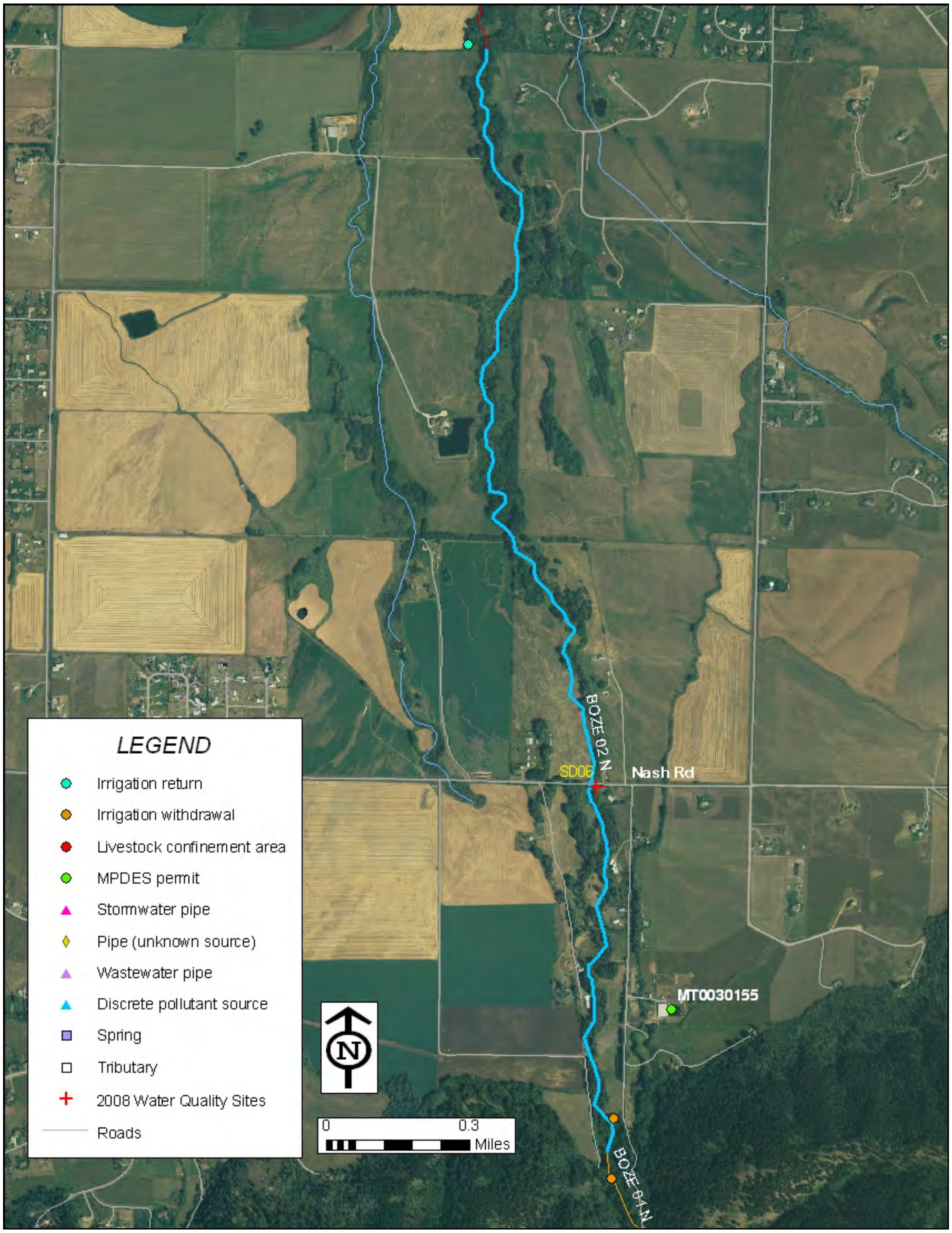

FIGURE 7. REACH BOZE 02 N

3.1. Reach Condition

The dominant land uses within the reach are irrigated and dry pasture and hay production (Figure 8). The riparian vegetation is healthy and dense throughout the reach (Figure 9), composed of a willow understory with a cottonwood overstory. Almost no bank erosion was documented throughout the reach. One irrigation withdrawal was identified at the upstream end of the reach but was not confirmed in the field.

FIGURE 8. IRRIGATED HAY FIELD DOWNSTREAM OF NASH RD. SOURDOUGH CR RIPARIAN IN LEFT OF PHOTO

FIGURE 9. DENSE WILLOW-COTTONWOOD RIPARIAN

3.2. Potential Nutrient and E. coli Sources

Potential nutrient and E. coli sources within the reach are detailed in Table 3. Pasture land comprised a moderate proportion of land use within the reach, but it was in relatively good condition, and was observed encroaching on the stream in only select locations. Combined with the wide, dense riparian buffer, pasture was considered to have a low potential significance as a nutrient source. One two-track ford was identified within the reach, located between Abigail Ranch Rd on the west side of stream and Cobble Creek Rd on the east side (Figure 10). Substrate at the ford was rather coarse and appeared infrequently crossed and was considered a minor sediment source. The City of Bozeman water treatment plant has an individual MPDES permit for discharge at the upstream end of the reach (Table 3).

TABLE 3. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH BRID 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (LB/RB)	50	SW/GW	Excellent	good condition, generally not overgrazed or encroaching on stream	low
Septic system per mi (150 ft/1000 ft)	0/5.8	GW	Excellent		low
Unpaved road crossings (#)	1	SW	Excellent	ford between Abigail Ranch Rd on west side of stream and Cobble Creek Rd on east side	low
MPDES (# permits)	1	SW	Excellent	ID: MT0030155. City of Bozeman Water Treatment Plant; individual permit;	low

FIGURE 10. TWO-TRACK FORD ACROSS STREAM BETWEEN ABIGAIL RANCH RD AND COBBLE CREEK RD

4. BOZE 03 N

Reach 3 begins upstream of Goldenstein Rd and extends downstream to Kagy Boulevard (Figure 11). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

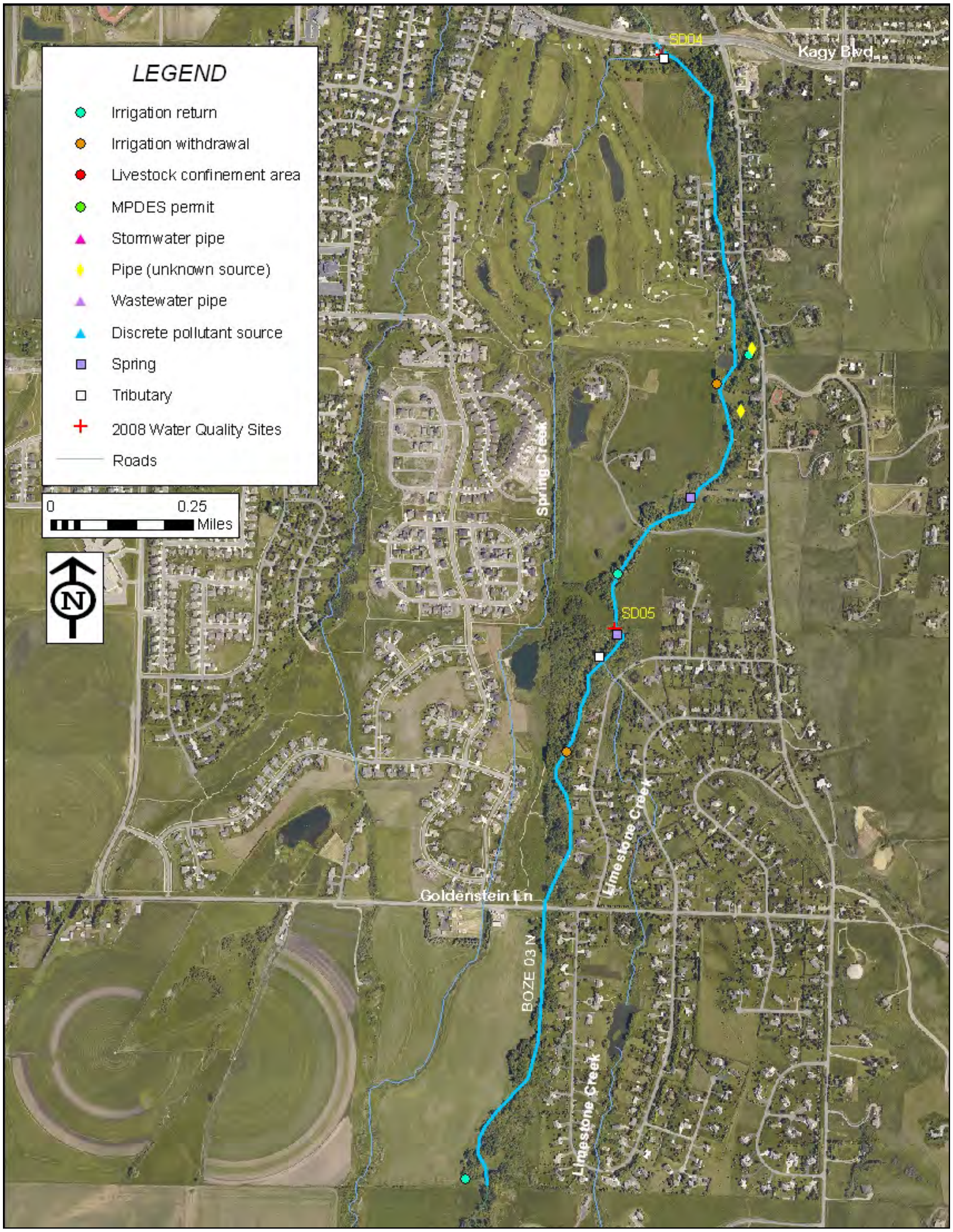

FIGURE 11. REACH BOZE 03 N

4.1. Reach Condition

The dominant land uses within the reach are residential, pasture and natural forest associated with the Gallatin Valley Land Trust (GVLT) linear trail greenbelt. The riparian vegetation is healthy and dense with minimal yard and pasture encroachment throughout approximately two thirds of the reach (Figure 12). The remaining portion of the reach, such as the section along South Sourdough Rd, has significant yard and pasture encroachment, and associated bank erosion (Figures 13 and 14). Two irrigation withdrawals were identified in the reach. One was located along the GVLT trail downstream of Goldenstein Rd, very low flow was in the withdrawal ditch at the time of observation. The other withdrawal was observed farther downstream and appeared to be used for a residential pond (Figures 15 and 16), but this could not be confirmed without trespassing. Two tributaries, Spring Cr and Limestone Cr, enter within the reach (Figure 11).

FIGURE 12. HEALTHY COTTONWOOD RIPARIAN UPSTREAM OF GOLDENSTEIN RD

FIGURE 13. EROSION AND PASTURE ENCROACHMENT UPSTREAM OF KAGY BLVD

FIGURE 14. EROSION AND YARD ENCROACHMENT DOWNSTREAM OF GOLDENSTEIN RD

FIGURE 15. SANDBAGS DIVERTING WATER FOR WITHDRAWAL FOR RESIDENTIAL POND

FIGURE 16. WITHDRAWAL IN FIGURE 15 APPEARS TO LEAD TO RESIDENTIAL POND ON WEST SIDE OF STREAM

4.2. Potential Nutrient and E. coli Sources

Potential nutrient and E. coli sources within the reach are detailed in Table 4. Pasture was generally in good condition, not overgrazed or encroaching on the stream. Residential lawns encroached on the stream for approximately a quarter of the reach (e.g. Figure 14), mainly along South Sourdough Rd, with no riparian buffer separating the stream from potential nutrient and E. coli sources such as lawn fertilizers, grass clippings and pet waste. The Valley View Golf Club is not located directly adjacent to Sourdough Creek, as there is a good riparian buffer between the golf course and the stream. However, with the high concentrations of fertilizers used on the golf greens, the golf course was considered a potential ground water nutrient source to this reach.

Spring Cr, a significant tributary (Figure 17), flows through the golf course and enters just upstream of Kagy Blvd. Limestone Cr drains agricultural and residential land, and appears to flow through at least one residential in-line pond (Figure 11). Due to the land uses within their watersheds, both tributaries are likely significant sources of nutrients and E. coli. Two small springs and three irrigation returns were identified. These flows drain agricultural lands and residential areas and could be potential nutrient and E. coli sources. Two pipes of unknown origin enter the stream (e.g. Figure 18), neither of which were flowing at the time of the assessment.

Septic system density was relatively high within the reach, primarily within 1000 feet of the stream, and was considered a significant potential nutrient and E. coli source. Three unpaved crossings were identified: a private driveway, the GVLT linear trail footbridge at water quality site SD05 (Figure 19), and a two-track ford located just downstream of the GVLT footbridge (Figure 20). The footbridge and the ford were considered minor potential sediment sources.

TABLE 4. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH BOZE 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (LB/RB)	30%	GW/SW	Good/Excellent	Pasture generally in good condition, not encroaching on stream	low
Residential lawns (% directly encroaching on stream)	25%	GW/SW	Poor (no riparian where lawn encroaches)	Lawns encroach directly on the stream along South Sourdough Rd; potential nutrient and E. coli source	med
Golf % (LB/RB)	10	GW/SW	Good	Good riparian buffer with some residences; potential nutrient source	low/med
Tributaries	2	SW	Good	Significant tribs; lower trib flows through golf course	med/high
Irrigation returns/springs	5	SW	Good	Drain agricultural lands and residential areas; potential nutrient and E. coli source	low/med
Pipe of unknown source	2	SW	NA	Not flowing during assessment	low
Septic system per mi (150 ft/1000 ft)	7/55.1	GW	Good/Excellent	Significant potential nutrient and E. coli source	med
Unpaved road crossings (#)	3	SW	Good/Excellent	Ford, GVLT footbridge, private drive	low

FIGURE 17. SPRING CR TRIBUTARY ENTERS UPSTREAM OF KAGY BLVD AFTER FLOWING THROUGH THE VALLEY VIEW GOLF COURSE

FIGURE 18. PIPE OF UNKNOWN SOURCE ENTERING STREAM; NOT FLOWING

FIGURE 19. GALLATIN VALLEY LAND TRUST LINEAR TRAIL FOOTBRIDGE AT WATER QUALITY SITE SD05

FIGURE 20. TWO-TRACK FORD DOWNSTREAM OF GVLT FOOTBRIDGE

5. BOZE 04 N

Reach 4 begins at Kagy Boulevard and extends along South Church St downstream to where a large diversion dam diverts water to the east, at the north end of Bonner St (Figure 16). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

FIGURE 21. REACH BOZE 04 N

5.1. Reach Condition

The dominant land uses within the reach are pasture land and residential. The riparian condition varies throughout the reach. Through most of the pasture land areas the riparian vegetation is characterized by dense, healthy stands of willow and cottonwood, with stable banks (Figure 22). In contrast, yard encroachment, bank erosion, and significant trampling are common through residential and industrial sections along South Church St (Figures 23 and 24). One significant tributary, Mathew Bird Cr, enters at the lower end of the reach (Figures 11 and 25).

FIGURE 22. DENSE WILLOW RIPARIAN DOWNSTREAM SOUTH CHURCH STREET

FIGURE 23. TRAMPLING AND RESIDENTIAL ENCROACHMENT DOWNSTREAM OF MARTEL BRIDGE ALONG SOUTH CHURCH STREET

FIGURE 24. ERODING BANK DOWNSTREAM OF KAGY BLVD

FIGURE 25. MATHEW BIRD CR ENTERING NEAR THE DOWNSTREAM END OF THE REACH

5.2. Potential Nutrient and E. coli Sources

Potential nutrient and E. coli sources within the reach are detailed in Table 5. Open fields along the reach were classified as pasture land but appeared to be open residential fields, and not lands used for feeding or holding of livestock. Pasture lands/residential fields were therefore considered a low potential nutrient and E. coli source. Residential lawns encroach on the stream for approximately 10% of the reach along South Church St (Figure 26) and were considered a moderately significant potential nutrient and E. coli source. A significant tributary, Mathew Bird Cr enters at the lower end of the reach (Figure 25). This tributary flows through dense residential areas with duck ponds, and along the GVLT linear trail and is considered a moderate to high potential nutrient and E. coli source. Two unpaved private bridges cross the stream but both were in good condition and well vegetated. Kagy Blvd encroaches on the stream for about 150 ft but was not considered a pollutant source due to the short distance of encroachment.

Two pipes of unknown origin were identified exiting a single yard just downstream of South Church St. A small diameter PVC pipe was identified dripping into the stream (Figure 27). A second pipe was noted at the same location entering below base flow. A large stormwater pipe enters Sourdough Creek at the Manion residence off East Lincoln St, across the stream from the power station on South Church St. This is a concrete stormwater pipe with significant flow (Figure 28) witnessed during a dry period, suggesting significant infiltration and/or inflow into the storm sewer system. Because of the significant flow, this pipe was considered a moderately significant source of nutrients and E. coli. One livestock confinement area, a horse corral located directly adjacent to the stream, was identified just downstream of Kagy Blvd. Only a single horse in the corral during the assessment but manure was observed on the stream bank. Although this single corral is likely acting as a nutrient and E. coli source, because there was only one it was considered a relatively small pollutant source relative to the entire reach.

TABLE 5. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH BOZE 04 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	55%	SW/GW	Good	primarily dry pasture; riparian condition is generally good along pasture areas but potential nutrient/E. coli source	low
Septic system per mi (150 ft/1000 ft)	0.8/2.4	GW	Good		low
Tributaries	1	SW	Good	Mathew Bird Cr is significant; potential nutrient/E. coli source	med/high
Unpaved road crossings (#)	2	SW	Good	Two private bridge crossings in good condition	low
Pipe of unknown source (#)	2	SW	NA	Exit same yard; one under water, one dripping. Likely just drains	low
Pipe (stormwater) (#)	1	SW	NA	Large concrete pipe enters at Manion residence (SDP01 in 2009 LGTPA monitoring). Flowing	med
LCA (#)	1	SW/GW	Fair	observed only one horse but manure on bank	low
Residential lawns (% directly encroaching on stream)	10%	GW/SW	Poor (no riparian where lawn encroaches)	Lawns encroach directly on the stream along South Church St; potential nutrient and E. coli source	med

FIGURE 26. RESIDENTIAL LAWN ENCROACHMENT

FIGURE 27. PVC PIPE ENTERING LEFT BANK JUST DOWNSTREAM OF SOUTH CHURCH ST. DRIPPING AT TIME OF ASSESSMENT

FIGURE 28. STORMWATER PIPE ENTERING AT MANION PROPERTY. 2009 WATER QUALITY SAMPLING SITE SDP01.

6. BOZE 05 N

Reach 5 begins where a large diversion dam diverts water to the east, at the north end of Bonner St (Figure 29), and extends downstream to Tamarack St. The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

FIGURE 29. REACH BOZE 05 N

6.1. Reach Condition

Reach 5 is the most impacted by urban development and is in very poor physical condition. The reach flows through downtown Bozeman, thus the dominant land use is urban for its entire length. The stream flows under streets and businesses in a large culvert under downtown Bozeman for approximately one city block. It goes into the culvert downstream of Babcock St just west of Rouse St, and re-surfaces downstream of the alley between Main St and Mendenhall St (Figure 30).

Typical of an urban stream, it is channelized along roads and residences in many locations, using a variety of materials from traditional boulder and concrete rip-rap to car bodies, old appliances and stone walls (Figure 31). The riparian zone is in very poor condition for the entire length of the reach. Vegetation is characterized by tree willows, cottonwoods and green ash, with extensive trampling underneath and minimal understory vegetation (Figure 32). Bank erosion is common (Figure 33), but is also mitigated by extensive rip-rap along residential back yards (Figure 34). Lawns associated with both residences and Bogert Park encroach on the stream for most of its length (Figures 32, 34, 35 and 36).

FIGURE 30. BRIDGE UNDER ALLEY BETWEEN MAIN ST AND MENDENHALL ST WHERE STREAM RE-SURFACES FROM BEING CHANNELIZED UNDER MAIN ST AND BUSINESSES

FIGURE 31. OLD APPLIANCES ADJACENT TO THE STREAM DOWNSTREAM OF ROUSE AVE

FIGURE 32. TRAMPLED BANK DOWNSTREAM OF PEACH ST

FIGURE 33. ERODING BANK

FIGURE 34. RIP-RAPPED BANK BEHIND RESIDENCE

FIGURE 35. LAWN ENCROACHMENT UPSTREAM OF OLIVE ST

FIGURE 36. LAWN ENCROACHMENT AND BANK EROSION AT BOGERT PARK

6.2. Potential Nutrient and E. coli Sources

Reach 5 is highly impacted by several urban-related pollutant sources such as pipes that drain to the stream, and runoff from yards and roads. Potential nutrient and E. coli sources within the reach are detailed in Table 6. Residential lawns encroach on the stream for most of the reach with significant trampling and bank erosion, and have a moderate to high potential to function as a nutrient and E. coli source to the reach (Figures 32-36). The parking lot adjacent to where the stream enters the culvert under Main St is encroaching on the stream and is completely devoid of vegetation. However, a silt fence was installed to protect sediment from entering the stream.

Two unpaved trail foot bridges cross the stream, the foot bridge at Bogert Park and the GVLT trail bridge upstream of Tamarack St (Figure 37). Both were in good condition and well vegetated but with erosion around the abutments. Rouse Ave encroaches on the stream for about 3000 ft and Bonner St encroaches in the upstream end of the reach for about 900 ft. No vegetation is present along 1500 ft of the encroachment along Rouse Ave and could be a significant nutrient source (Figure 38).

Eight pipes of unknown origin were identified entering the stream, none of which were flowing during the assessment, nor did any of the pipe exhibit evidence of recent flow such as sediment within the pipe or erosion below the pipe. Most were likely residential drain pipes and/or sump pump drains to mitigate high groundwater tables during snowmelt and storm events. These pipes were not considered a highly significant nutrient or E. coli source. In contrast, the eight stormwater pipes pose a greater potential to be nutrient and E. coli sources. Of these, three were flowing and one contained evidence of recent flow (sediment build up in the pipe). Two of the flowing stormwater pipes are particularly noteworthy. The pipe at Peach St enters on the left bank, and the water was warm with a distinctly chlorine odor (Figure 39). The pipe adjacent to Rouse Ave smelled very strongly of methane and sewage, and brown, solid, dime-sized particles were observed floating out of the pipe. The latter pipe was since confirmed to contain very high levels of E. coli (greater than 2000 cfu/100 ml) during the September 2009 water quality monitoring effort.

Discrete pollutant sources, specifically grass piles on the stream banks at four locations, were identified as potentially significant nutrient sources. Karst Stage and the City of Bozeman have stormwater MPDES permits (Table 7), located approximately 1000 ft from the stream. Stormwater discharges enter the stream via municipal storm drains and could potentially deliver runoff pollutants to the stream.

TABLE 6. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH BOZE 05 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Unpaved road crossings (#)	2	SW	Fair	Two footbridges: GVLT trail and Bogert Park	low
Road encroachment	3900 ft	SW	Poor	Rouse and Bonner streets, potential nutrient sources	low/med
Pipe of unknown source (#)	8	SW	NA	None flowing, most likely drain pipes	low
Pipe (stormwater) (#)	8	SW	NA	Some flowing; significant nutrient/E. coli source	med/high
Discrete pollutant source (#)	4	SW/GW	NA	piles of grass clippings on bank	med
MPDES permit (#)	2	SW	NA	see Table 7	low
Residential lawns (% directly encroaching on stream)	75%	GW/SW	Poor (no riparian where lawn encroaches)	Lawns encroach directly on the stream along Rouse St; potential nutrient and E. coli source	med/high

TABLE 7. MPDES PERMITS DISCHARGING TO REACH BOZE 05 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTR040002	City of Bozeman	Stormwater/Small MS4	located ~ 1000 ft from stream, enters stream via storm drains	BOZE05
MTR000402	Karst Stage	Stormwater	located ~ 1000 ft from stream, enters stream via storm drains	BOZE05

FIGURE 37. RECREATION EROSION AT GVLT TRAIL FOOTBRIDGE UPSREAM OF TAMARACK ST

FIGURE 38. ROUSE ST ENCROACHES ON THE STREAM

FIGURE 39. FLOWING STORMWATER PIPE DOWNSTREAM OF PEACH ST, WATER WARM AND SMELLED OF CHLORINE

7. BOZE 06 N

Reach 6 begins at Tamarack St and ends at the confluence with the East Gallatin River just downstream of East Griffin Dr (Figure 40). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

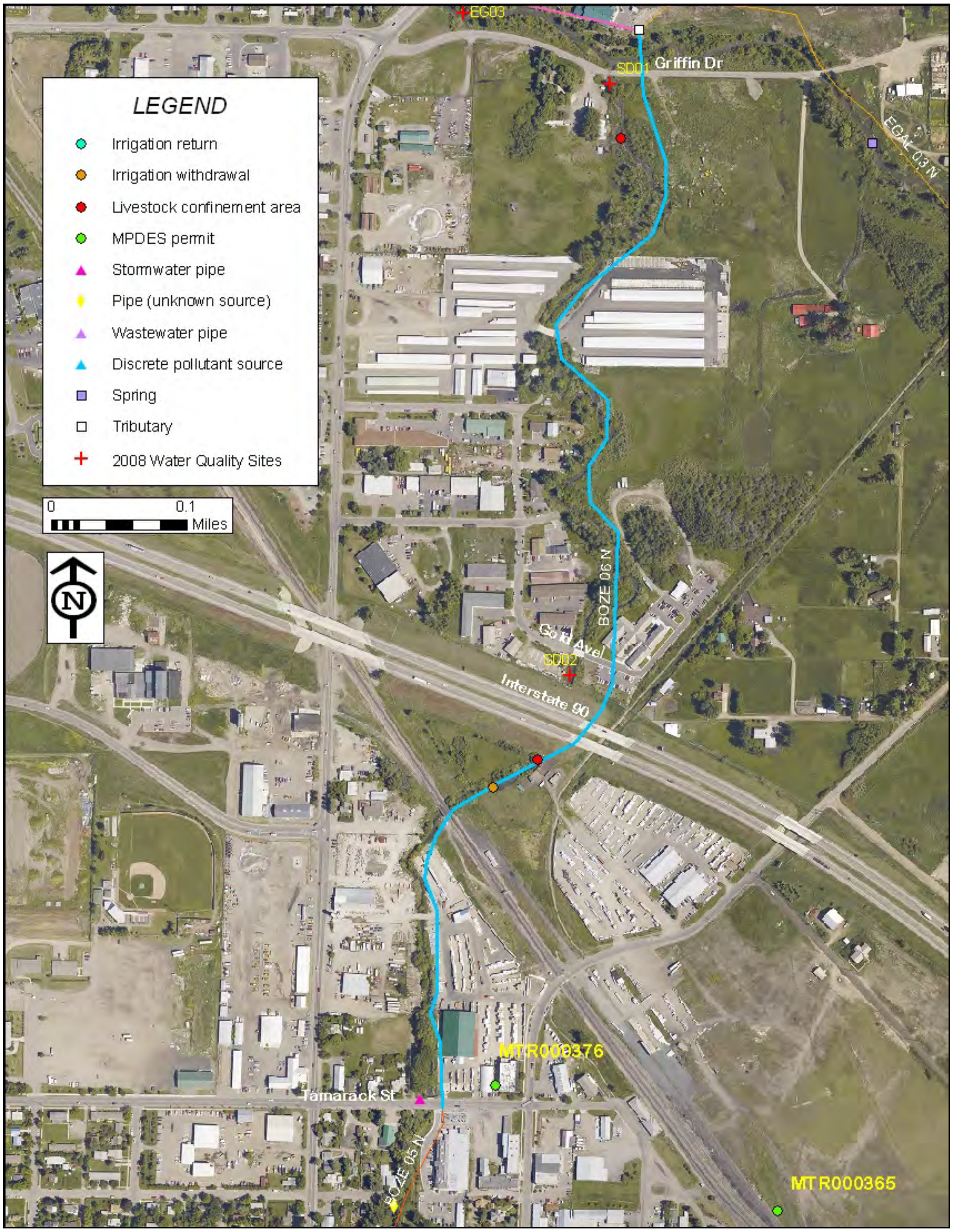

FIGURE 40. REACH BRID 06 N

7.1. Reach Condition

Reach 6 is also an urban reach but it is in better condition than reach 5, with higher quality riparian buffers, and less bank erosion, trampling and lawn encroachment. The reach flows through an industrial/residential section of Bozeman and the dominant land use is urban for its entire length. Riparian vegetation is characterized by a cottonwood, tree willows, and green ash overstory and a willow-dogwood-reed canarygrass understory (Figure 41). Bank erosion was minimal, observed only in select locations of pasture or lawn encroachment (Figures 42 and 43); however, fine sediments were observed in the slackwater areas. Some erosion was also observed in areas of sparse understory. One irrigation withdrawal was identified on the aerial just upstream of interstate 90 but was not observed during the groundtruthing.

FIGURE 41. DENSE COTTONWOOD-WILLOW RIPARIAN

FIGURE 42. BANK EROSION AND PASTURE ENCROACHMENT UPSTREAM OF INTERSTATE 90

FIGURE 43. LAWN ENCROACHMENT DOWNSTREAM OF INTERSTATE 90

7.2. Potential Nutrient and E. coli Sources

Potential nutrient and E. coli sources within the reach are detailed in Table 8. Residential lawns and small horse pastures encroach on the stream for a limited portion of the reach but are associated with some bank erosion (Figures 42 and 43). Lawns and small pastures were considered a potential nutrient and E. coli source via both overland flow and groundwater delivery.

One unpaved driveway crosses the stream but it was well-vegetated near the abutments and is not likely a sediment source. Although no roads encroached, parking lots through the industrial areas were located directly adjacent to the stream, often with no riparian buffer. Gravel was pushed into the stream from one adjacent parking lot, likely causing sediment input during storm events (Figure 44). Two LCAs were identified adjacent to the stream and were considered potential nutrient and E. coli sources through both overland and groundwater delivery. One of the LCAs, observed just upstream of Interstate 90, was associated with manure piles located within 3 feet of the active channel (Figure 45).

One small stormwater pipe drains to the stream under the Tamarack St Bridge. It was not flowing at the time of the assessment but could be a potential pollutant source during storm events. Kenyon Noble Ready Mix (concrete manufacturer) maintains a stormwater MPDES permits (Table 9), located approximately 1000 ft from the stream. Stormwater discharges enter the stream via municipal storm drains and could potentially deliver runoff pollutants to the stream.

TABLE 8. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH BOZE 06 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Unpaved road crossings (#)	1	SW	Good	Bozeman Brick bridge, not a sediment source	low
Pipe (stormwater) (#)	1	SW	NA	Enters under Tamarack St bridge, no flow during assessment, potential nutrient source during storm events	low
LCA (#)	2	SW/GW	Fair/Good	Horse corrals adjacent to stream; potential nutrient and E. coli sources	med
MPDES permit (#)	2	SW	NA	see Table 9	low
Residential lawns (% directly encroaching on stream)	10%	GW/SW	Poor (no riparian where lawn encroaches)	Lawns encroach directly on the stream only in a few locations	low

TABLE 9. MPDES PERMITS DISCHARGING TO REACH BOZE 06 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTR000095	Kenyon Noble Ready Mix	Stormwater	City storm drain to Sourdough Cr	BOZE 06 N

FIGURE 44. GRAVEL PUSHED INTO RIPARIAN FROM ADJACENT PARKING LOT

FIGURE 45. HORSE CORRAL DIRECTLY ADJACENT TO STREAM UPSTREAM OF INTERSTATE 90

Bridger Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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BRIDGER CREEK

Bridger Creek has its headwaters on the east side of the Bridger Mountains north of Bozeman. In the upper reaches it flows through forested lands on the Gallatin National Forest and private lands, then through rural residential lands in Bridger Canyon prior to its confluence with the East Gallatin River on the southern end of the Bridger Mountains.

Water quality in Bridger Creek (Waterbody ID MT41H003_100) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: Total Phosphorus, and Total Kjeldahl Nitrogen. For the purposes of assessing pollutant sources, Bridger Creek was divided into six reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients to Bridger Creek. Reach-scale conditions on Bridger Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

Bridger Creek is marginally impacted by anthropogenic sources throughout its eighteen mile length, with pasture land and the Bridger Creek Golf Course identified as the most significant potential sources of nutrients. Pasture land encroached on the reach primarily in reach BRID 02 N, while golf course turf was often mowed adjacent to the stream in reach BRID 06 N. The riparian quality was good to excellent throughout all of the reaches, with unaltered conifer forest in the headwater reaches, and dense cottonwoods and willows along the remaining reaches. Bank erosion was limited to areas of heavy livestock grazing, primarily in reach BRID 02 N, and in the more urban reaches of BRID 05 and 06 where historic and new rip-rap were quite common. Septic systems were generally not very dense, with the exception of reach BRID 05 N where septic density was the highest

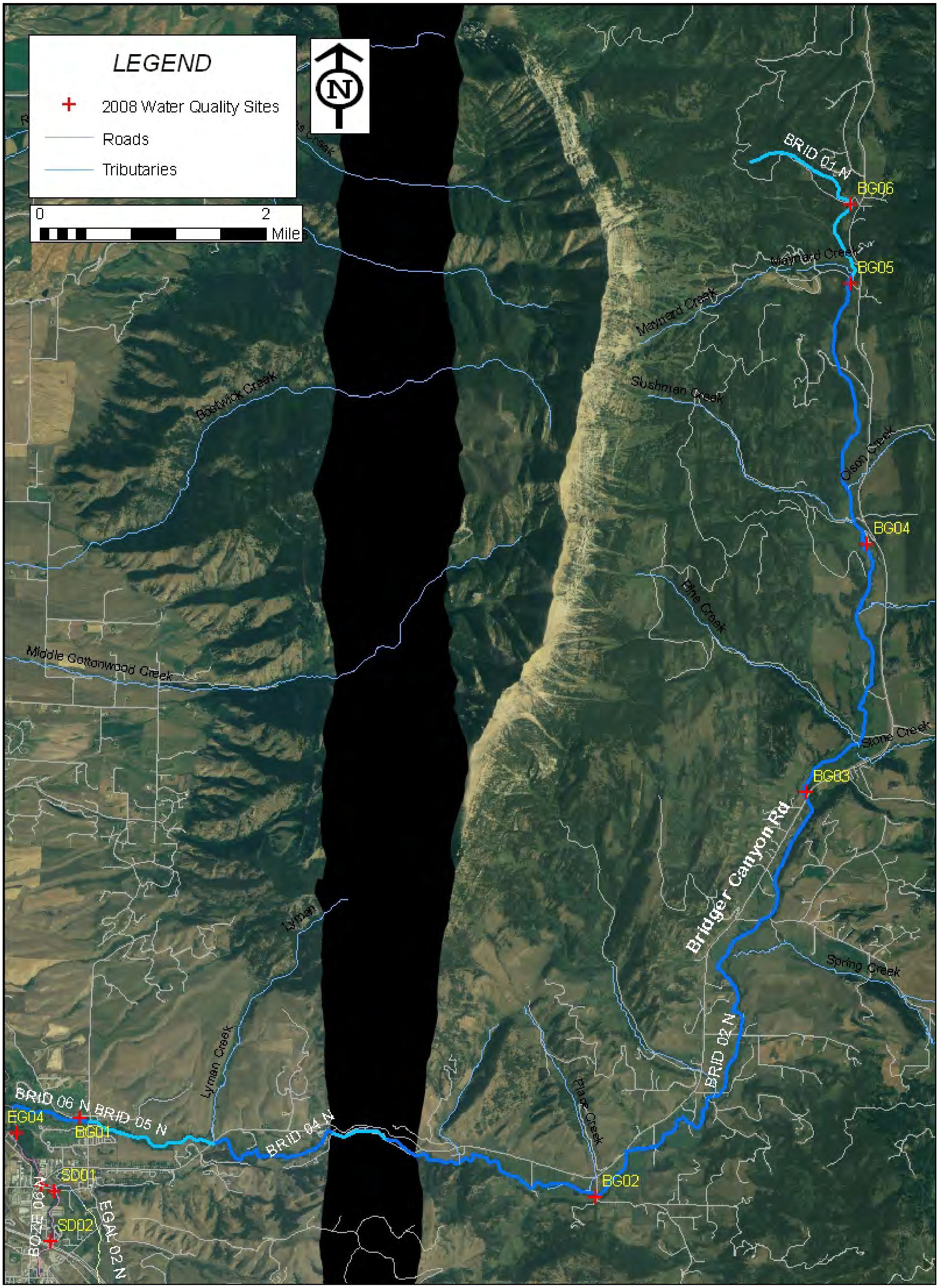

FIGURE 1. OVERVIEW OF BRIDGER CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID N	Reach length (mi)	Ecoreg.	Ord.	Dom. LU	Nat.	# UP Rd xing	Rd. Encr. (ft)	Bank Ero.	Rip. Width	BMP	Septic/mi 150	Septic/mi 1000
BRID 01 N	1.89	17g	2	FOREST	N	2	0	L	100	NA	0.5	4.8
BRID 02 N	12.48	17g17w	3	RURAL RESIDENTIAL	N	13	0	L	175	NA	0.3	5.4
BRID 03 N	0.54	17w	3	ROAD	N	1	2000	L	40	NA	1.8	0.0
BRID 04 N	1.40	17w	3	PASTURE/ RURAL RESIDENCE	N	0	700	L	175	NA	0.0	10.7
BRID 05 N	1.26	17w	3	HAY/ RESIDENTIAL	N	1	0	L	130	NA	3.2	9.6
BRID 06 N	0.72	17w	3	RECREATION/ GOLF	N	1	550	L	80	NA	0.0	1.4

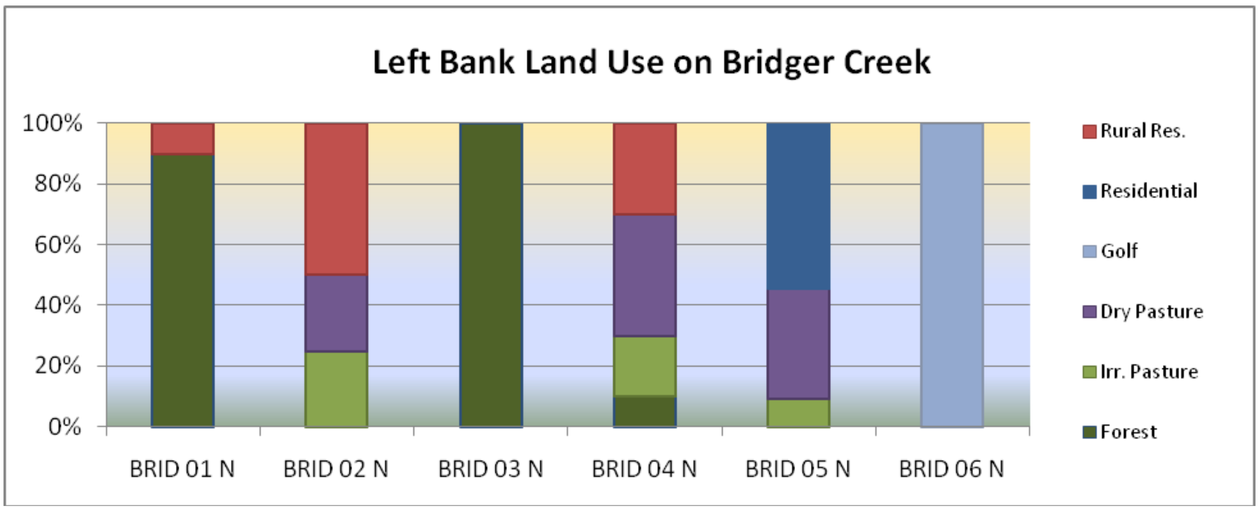

FIGURE 2. LAND USE TYPES ALONG THE LEFT BANK OF BRIDGER CREEK

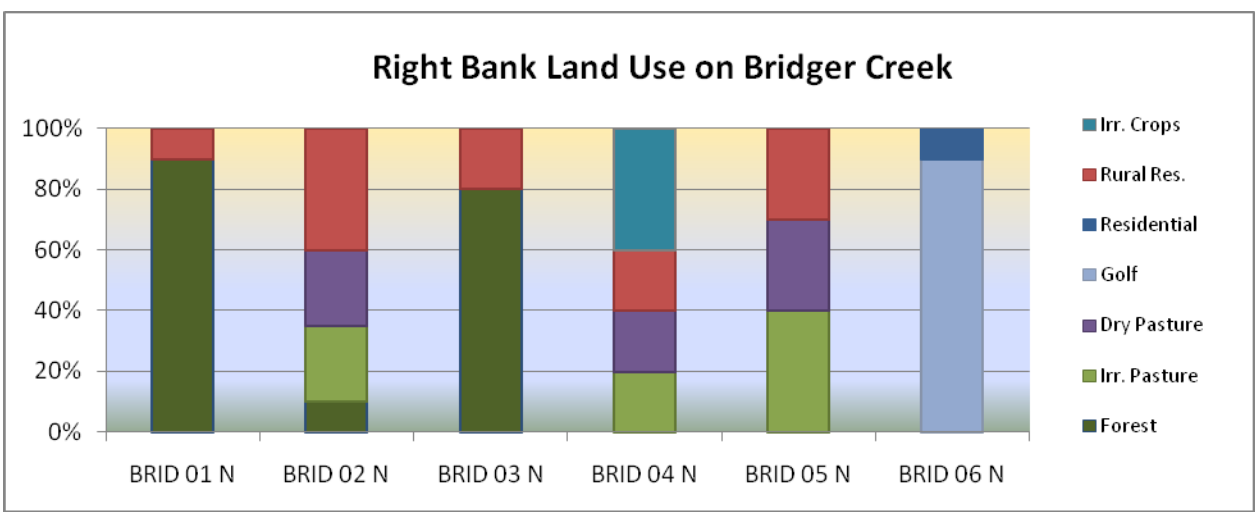

FIGURE 3. LAND USE TYPES ALONG THE RIGHT BANK OF BRIDGER CREEK

2. BRID 01 N

Reach 1 is a second order stream high in the Bridger Mountains north of Bozeman. The reach includes Bridger Creek from its headwaters, downstream to the Bridger Bowl driveway where Maynard Cr enters (Figure 4). The dominant Level 4 PRI ecoregion of the reach is 17g, mid-elevation sedimentary mountains.

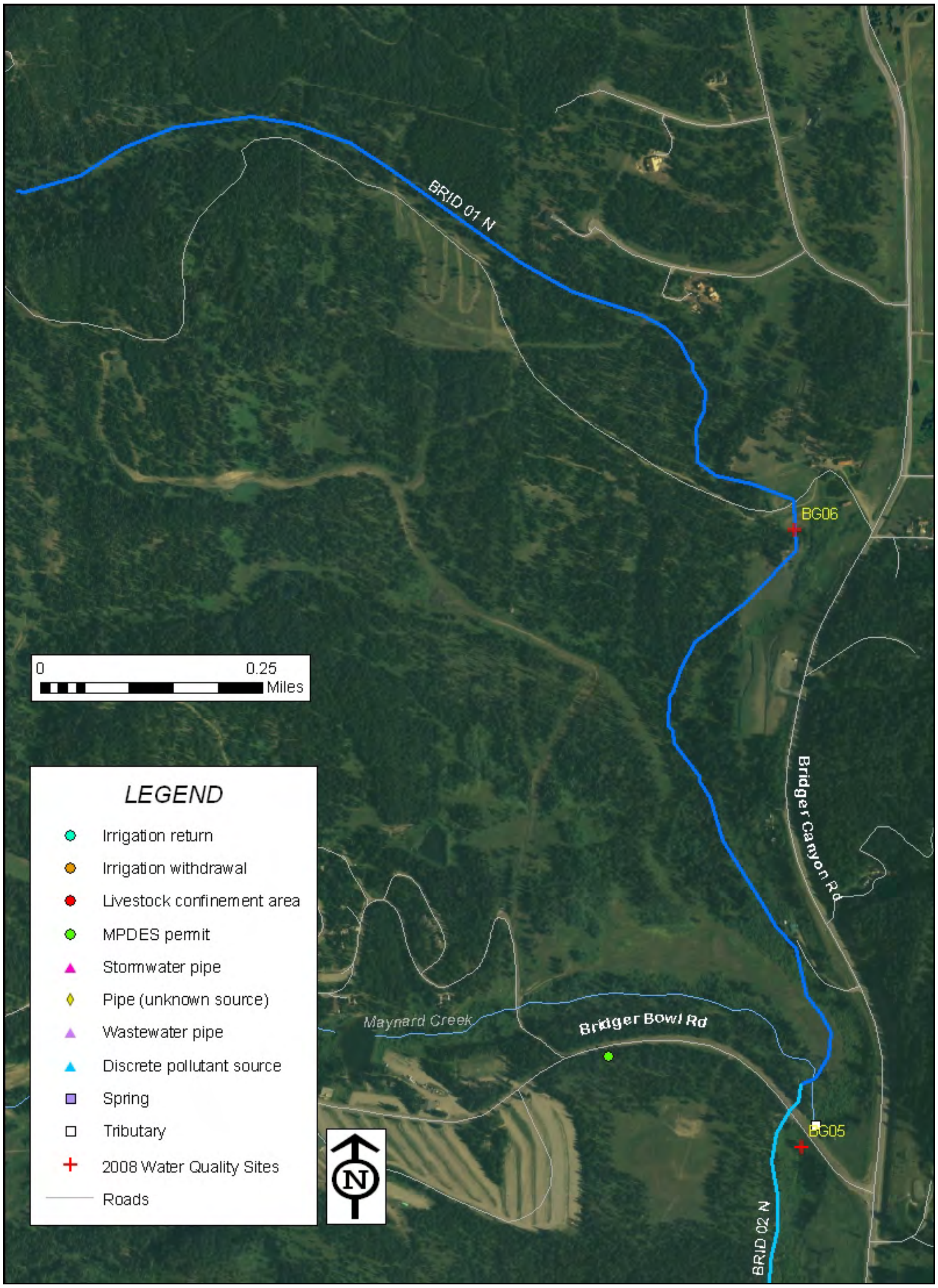

FIGURE 4. REACH BRID 01 N

2.1. Reach Condition

The upper section of the reach is located within the Gallatin National Forest, and is primarily in its natural condition. Land use is forest and recreation, with scattered rural residences. The reach flows through Bohart Ranch Cross Country Ski Center for much of its length. The riparian vegetation is very robust and healthy, consisting of a mixed conifer overstory with a willow-grass-forb understory (Figures 5 and 6). No bank erosion was observed within the reach, and no roads encroach upon the stream.

FIGURE 5. DENSE WILLOW RIPARIAN COVERING STREAM

FIGURE 6. REACH BRID 01 N IN FOREGROUND

2.2. Potential Nutrient Sources

The few potential nutrient sources within the reach are detailed in Table 2. Septic system density within the reach was very low and was not considered a potential nutrient source. The two unpaved road crossings were actually ski/hiking trails located at Bohart Ranch (Figure 7). Both culvert crossings were well vegetated and only infrequently traveled by vehicles and were therefore not considered significant nutrient sources.

TABLE 2. POTENTIAL NUTRIENT SOURCES WITHIN REACH BRID 01 N

Nutrient Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Septic system per mi (150 ft/1000 ft)	0.5/4.8	GW	Excellent		low
Unpaved road crossings (#)	2	SW	Excellent	culverted ski/hiking trail crossings at Bohart Ranch	low

FIGURE 7. SKI TRAIL CROSSING AT BOHART RANCH

3. BRID 02 N

Reach 2 is a 12.5 mile long reach that spans the length of Bridger Canyon. It begins at the Bridger Bowl driveway and extends downstream to where the stream channel becomes highly constricted, upstream of the Maiden Rock Rd crossing (Figure 4). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

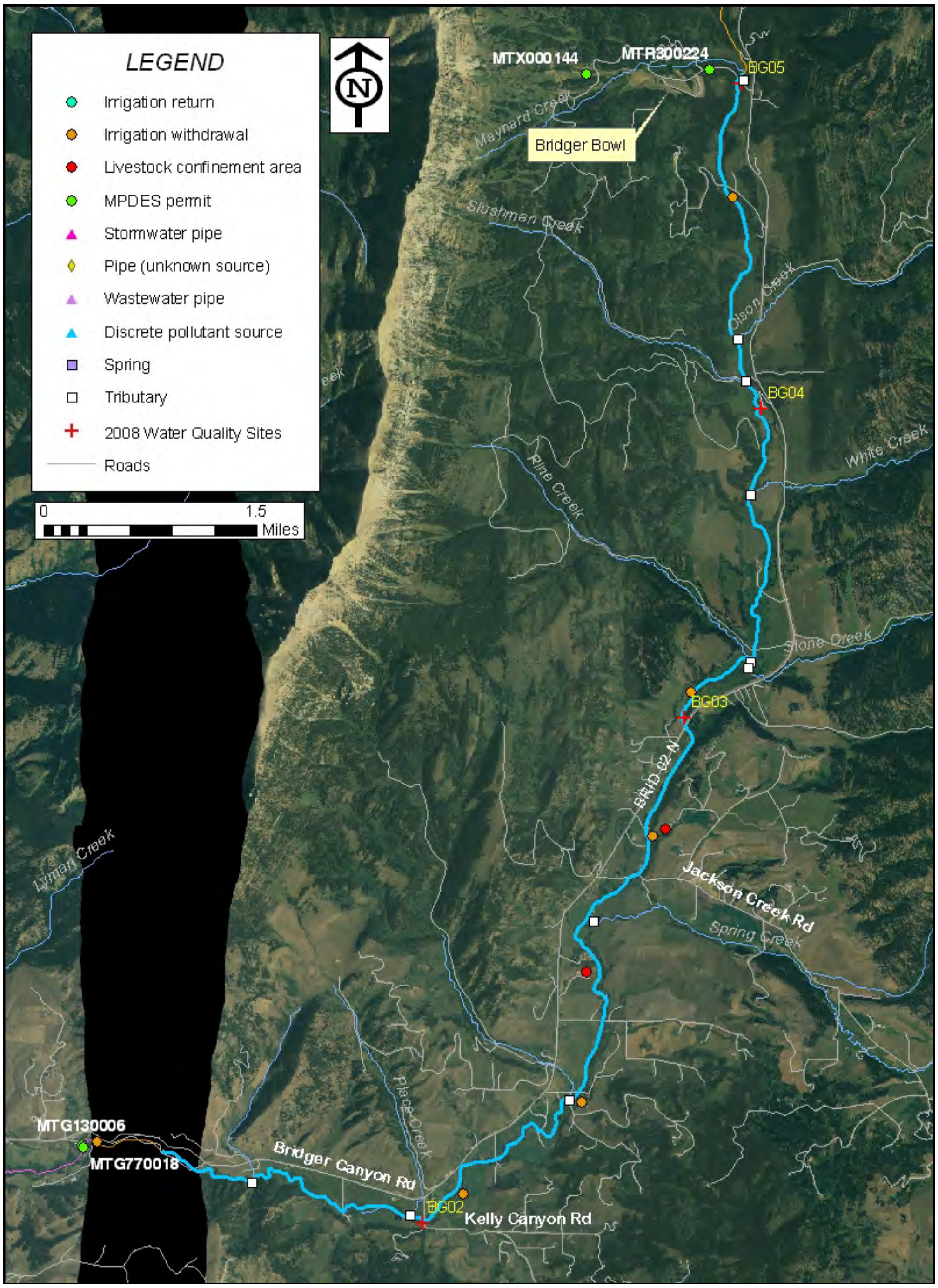

FIGURE 8. REACH BRID 02 N

3.1. Reach Condition

The dominant land uses within the reach are rural residential and irrigated and non-irrigated pasture land. The riparian vegetation is healthy and dense throughout the reach (Figures 9 and 10), composed of a willow understory with a conifer overstory in the upper section and cottonwood overstory in the mid to lower section. Very little bank erosion was documented throughout the reach. However, rip-rap was observed at several road crossings and along meander bends, indicating that bank erosion was possible, and likely present where the stream was not observed in the field. No roads encroach on this reach.

Five irrigation withdrawals were identified on the GIS layer, and were potentially confirmed on the aerial based on potential flow paths, but were not confirmed in the field. Due to the wide, sub-irrigated riparian zone, it was difficult to discern from aerial photographs whether the withdrawals were present or not.

FIGURE 9. DENSE WILLOW RIPARIAN DOWNSTREAM OF BRIDGER BOWL DRIVEWAY

FIGURE 10. DE NSE WILLOW-COTTONWOOD RIPARIAN DOWNSTREAM OF KELLY CANYON RD

3.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 3. Pasture land comprised a moderate proportion of land use within the reach, and was in relatively good condition. Combined with the wide, dense riparian buffer, pasture was considered to have a medium to low potential significance as a nutrient source. Surface nutrient inputs appear to be mitigated well. The relative significance of ground water nutrient inputs is unknown, but may be significant depending on level of use and amount of fertilizer application.

Although septic system density per mile was low, certain areas had rather high concentrations of septics, such as just downstream of Bridger Bowl, and near the Stone Cr confluence. These areas could potentially function as nutrient sources to Bridger Cr. Several tributary streams enter within the reach including Olson Cr and Stone Cr, primarily draining forested land. Septic system density along tributaries was moderate: these tributary septics were considered a minor nutrient source.

Eleven unpaved road crossings were identified within the reach, or roughly one unpaved crossing per mile. Larger unpaved crossings included Kelly Canyon Rd and the Bridger Bowl driveway. The remaining crossings were smaller roads and private driveways. Most driveways were well maintained and were not considered a significant nutrient or sediment source (Figure 11).

Bridger Bowl ski area holds a groundwater permit (MTX000144) that allows groundwater discharge of onsite sewerage systems (Table 4). Two LCAs were identified in the reach. These LCAs were not accessible for observation in the field, and it was difficult to confirm whether they were indeed active LCAs based on the aerial. One additional potential nutrient source was identified, a cattle operation located at the southeast corner of Jackson Creek Rd and Bridger Canyon Rd. This operation was not specifically an LCA, as animals were not confined in a corral, but high animal densities and a very degraded intermittent tributary stream have been observed in the past at this location.

TABLE 3. POTENTIAL NUTRIENT SOURCES WITHIN REACH BRID 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (LB/RB)	50	SW/GW	Good/ Excellent	good condition, generally not overgrazed or encroaching on stream	Low/med
Septic system per mi (150 ft/1000 ft)	0.3/5.4	GW	Good/ Excellent		low
Septic in tributaries	Med	Tributary	Excellent		low
Unpaved road crossings (#)	11	SW	Good/ Excellent	Kelly Canyon Rd and Bridger Bowl driveway. Several private driveways, mostly in good condition	med
LCA (#)	2	GW/SW	Good/ Excellent		low
MPDES (# permits)	1	SW	Good/ Excellent	see Table 4	low

FIGURE 11. PRIVATE DRIVEWAY CROSSING

TABLE 4. MPDES PERMITS IDENTIFIED IN REACH BRID 02 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTX000144	Bridger Bowl	Groundwater/Sewerage system	Short distance from Maynard Creek & Bridger Creek	BRID 02 N

4. BRID 03 N

Reach 3 is a short 0.5 mile long reach that flows directly adjacent to the road through the narrow canyon at the downstream end of Bridger Canyon. The reach spans from Maiden Rock Rd, downstream to Fish Hatchery Rd at the USFWS Bozeman Fish Technology Center (Figure 12). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

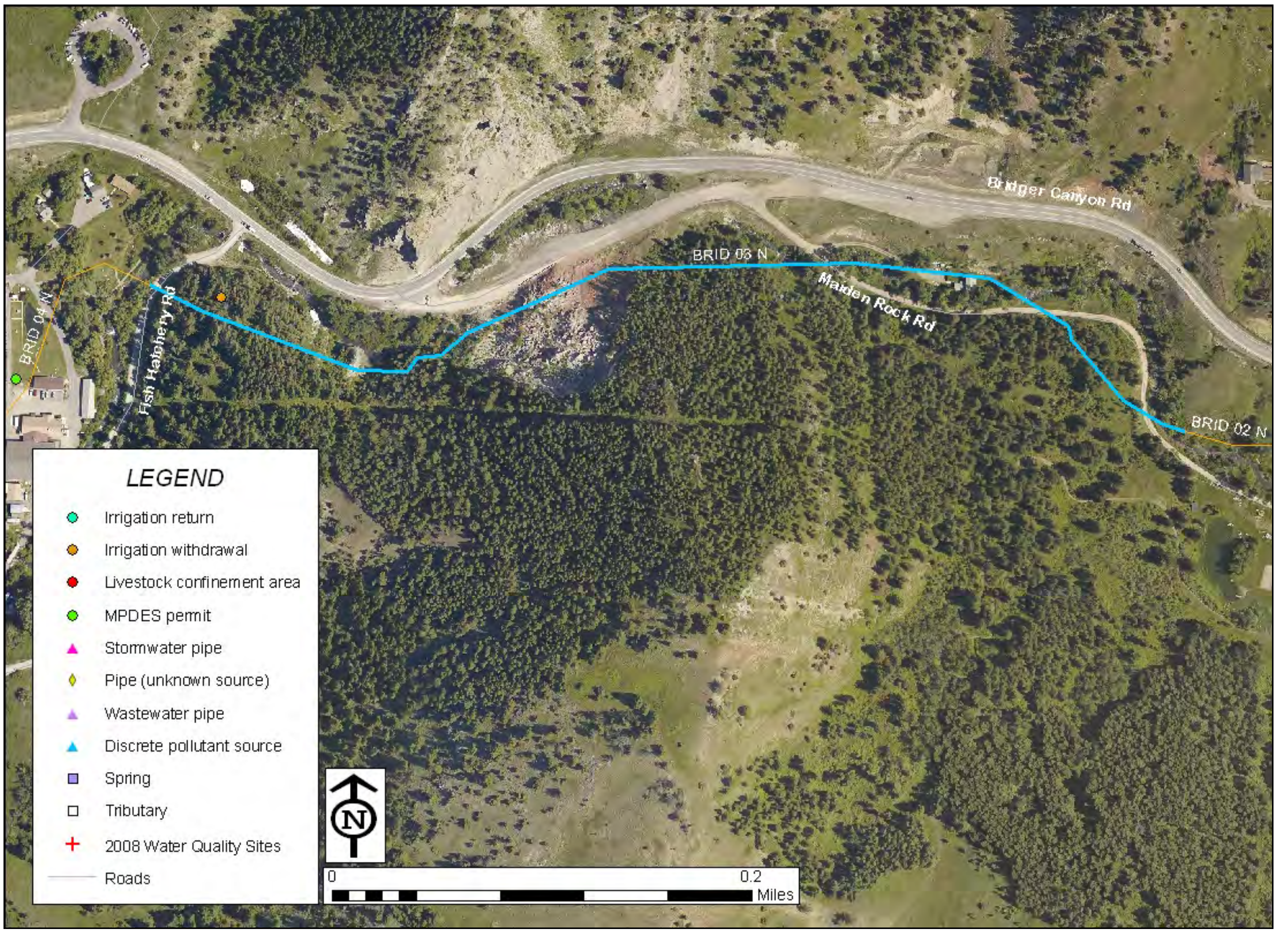

FIGURE 12. REACH BRID 03 N

4.1. Reach Condition

Due to the canyon nature of the reach it is not suitable for many uses, and the dominant land uses within the 0.5 mile reach is forest, with significant road encroachment. The riparian buffer is a narrow strip of young cottonwood, willows and grasses, constricted by Bridger Canyon Rd and the old highway on either side (Figure 13). Although the riparian was narrow, most banks were well-vegetated and stable, with the exception of erosion caused from poor drainage off of Bridger Canyon Rd (Figure 14). One irrigation withdrawal was identified within the reach, located just upstream of Fish Hatchery Rd (in background of Figure 13).

FIGURE 13. REACH BRID 03 N IN CANYON, UPSTREAM OF FISH HATCHERY RD, ADJACENT TO BRIDGER CANYON RD. IRRIGATION WITHDRAWAL IN BACKGROUND

FIGURE 14. EROSION FROM POOR DRAINAGE OFF BRIDGER CANYON RD

4.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 5. Septic system density was low within the reach, as only one residence is located along the stream. The area downstream of the bridge at the unpaved Maiden Rock Rd was actively eroding, causing sediment to enter the stream (Figure 15). Bridger Canyon Rd encroaches on the stream for approximately 2000 ft, causing some sediment and erosion.

TABLE 5. POTENTIAL NUTRIENT SOURCES WITHIN REACH BRID 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Septic system per mi (150 ft/1000 ft)	1.8/0.0	GW	Good		low
Unpaved road crossings (#)	1	SW	Good	Maiden Rock Rd, some erosion occurring downstream	low

FIGURE 15. EROSION DOWNSTREAM OF MAIDEN ROCK RD BRIDGE

5. BRID 04 N

Reach 4 extends from Fish Technology Rd, approximately 1.5 miles downstream to Bridger Canyon Rd. (Figure 12). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

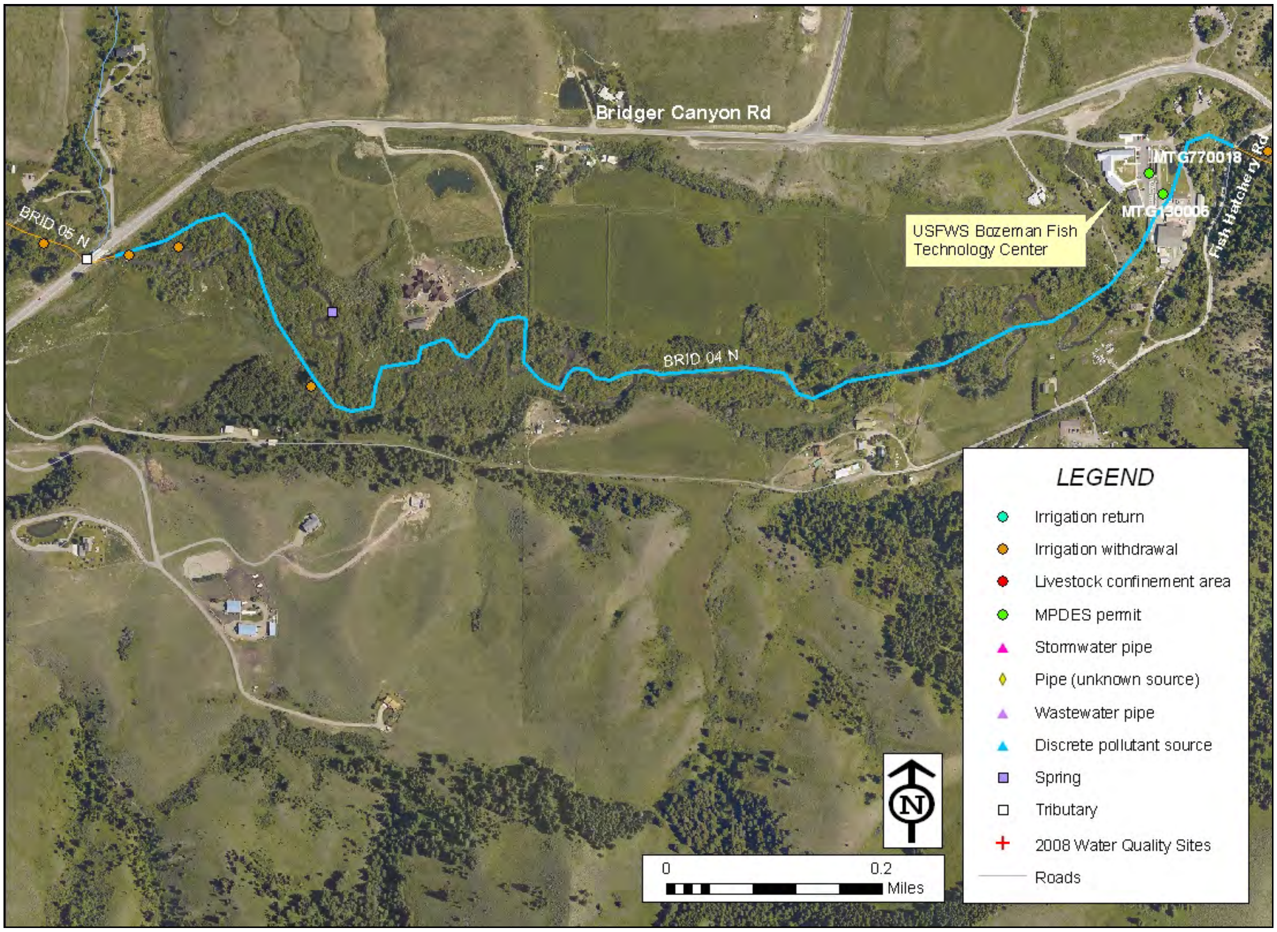

FIGURE 16. REACH BRID 04 N

5.1. Reach Condition

The dominant land uses within the reach are rural residence, hay production, and irrigated and dry pasture land. The riparian vegetation is quite healthy, with dense willows and scattered cottonwoods (Figure 17), with very little bank erosion observed. Rip-rapped banks were observed in the section through the USFWS Bozeman Fish Technology Center (Fish Tech Center) (Figure 16). Three irrigation withdrawals were identified within the reach, two of which were definitively confirmed on the aerial and one was confirmed in the field.

FIGURE 17. DENSE WILLOW RIPARIAN DOWNSTREAM OF DRINKING HORSE SUBDIVISION FOOTBRIDGE

5.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 6. Pasture land which was primarily irrigated, was abundant along the reach and was considered a low to moderately significant nutrient source. No septic systems were located within 150 feet of the stream; the density within 1000 feet was moderate. Overall, septic systems were considered to have a low potential for nutrient delivery to the stream. The unpaved Fish Hatchery Rd encroaches on the stream for approximately 700 ft, but the area between the road and the stream is densely vegetated and was not considered a significant sediment source (Figure 18). The Fish Tech Center parking lot is also located directly adjacent to the stream (Figure 19) and could be a potential pollutant source. The Fish Tech Center has two MPDES permits to discharge hatchery water into Bridger Cr (Table 7).

TABLE 6. POTENTIAL NUTRIENT SOURCES WITHIN REACH BRID 04 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	50%	SW/GW	Good	primarily irrigated	low/med
Septic system per mi (150 ft/1000 ft)	0.0/10.7	GW	Good		low
MPDES (# permits)	2	SW/GW	Good	BRID 04 N	low

TABLE 7. MPDES PERMITS DISCHARGING TO REACH BRID 04 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTG770018	Bozeman Fish Technology Center	General	Fish hatchery discharging to Ground Water	BRID 04 N
MTG130006	USFWS-Bozeman Fish Tech Center	General	Fish hatchery discharging directly to Bridger Creek	BRID 04 N

FIGURE 18. FISH HATCHERY RD ENCROACHMENT LOOKING UPSTREAM

FIGURE 19. BRIDGER FISH TECHNOLOGY CENTER PARKING LOT ADJACENT TO STREAM

6. BRID 05 N

Reach 5 extends from Bridger Canyon Rd downstream to Story Mill Rd (Figure 12). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

FIGURE 20. REACH BRID 05 N

6.1. Reach Condition

The dominant land uses within the reach are residential subdivision and irrigated and dry pasture land. The riparian vegetation is robust with a dense willow-cottonwood overstory (Figure 21), with very little bank erosion observed. Several old cars are placed as rip-rap along the reach indicating the current and historic potential for bank erosion (Figure 22). Two irrigation withdrawals were identified within the reach, neither of which were confirmed in the field. One tributary, Lyman Cr, enters from the north at the start of the reach.

FIGURE 21. DENSE WILLOW-COTTONWOOD RIPARIAN VEGETATION DOWNSTREAM OF BRIDGER CANYON RD

FIGURE 22. CAR BODIES USED AS RIP-RAP

6.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 8. Irrigated pasture land was abundant along the reach and was considered a moderately significant nutrient source. With an increase in residences at the lower end of the reach, septic systems are potentially a moderately significant nutrient source. A single unpaved crossing was identified, the footbridge at Cottonwood Subdivision. The footbridge was recently constructed with silt fences still in place; however this bridge had the potential to function as a sediment source near the abutments (Figure 23).

TABLE 8. POTENTIAL NUTRIENT SOURCES WITHIN REACH BRID 05 N

Pollution Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	60	SW/GW		mostly irrigated pasture	med
Septic system per mi (150 ft/1000 ft)	3.2/9.6	GW			med
Unpaved road crossings (#)	1	SW		footbridge at Cottonwood subdivision	low

FIGURE 23. FOOTBRIDGE AT COTTONWOOD SUBDIVISION

7. BRID 06 N

Reach 6 extends from Story Mill Rd downstream through the Bridger Creek Golf Course to the confluence with the East Gallatin River (Figure 24). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

FIGURE 24. REACH BRID 06 N

7.1. Reach Condition

The Bridger Creek Golf Course comprises the majority of the land use along the reach, with a small subdivision. Golf course turf was mowed directly adjacent to the stream in several locations (e.g. Figure 25). Where the stream was buffered from the turf the riparian was healthy and dense, composed of a cottonwood overstory and willow understory (Figure 26). Bank erosion was minor, limited to select outer meander bends (Figure 27). However, both rock and car body rip-rap was quite common, indicating the potential for significant bank erosion.

FIGURE 25. GOLF COURSE TURF ENCROACHMENT AND RIP-RAP

FIGURE 26. DENSE COTTONWOOD RIPARIAN DOWNSTREAM OF STORY MILL RD

FIGURE 27. MINOR BANK EROSION ON OUTER MEANDER BEND

7.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 9. The golf course was identified as the primary nutrient source within the reach, as it extends the length of the reach on both sides of the stream. The riparian buffer was dense in some areas while turf encroached directly on the stream in many locations (e.g. Figure 25). The paved McIlhatten Rd and Story Mill Roads encroach within 50 feet of the stream for a total of 550 feet. Vegetation along both roads is relatively dense, with some rip-rap. Neither of the roads was considered a significant nutrient source. One unpaved crossing, a golf cart bridge, crosses the stream but this bridge receives only minimal usage by electric vehicles and was well vegetated at the abutments (Figure 28).

TABLE 9. POTENTIAL NUTRIENT SOURCES WITHIN REACH BRID 06 N

Pollution Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Golf course (Ave. % LB/RB)	95%	SW/GW	Good	golf course turf encroaches in several areas; significant nutrient source	Med/high
Septic system per mi (150 ft/1000 ft)	0.0/1.4	GW	Good		low
Unpaved road crossings (#)	1	SW	Good	golf cart bridge, very little vehicle traffic	low

FIGURE 28. GOLF CART BRIDGE

Camp Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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CAMP CREEK

Camp Creek is an agricultural stream that flows through Churchill and Amsterdam west of Bozeman, Montana. It flows through rangeland, dairy, hay, pasture, and crop operations prior to flowing into the Gallatin River northeast of Manhattan. Water quality in Camp Cr (Waterbody ID MT41H002_010) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutant impairments: fecal coliform, total nitrogen, and sedimentation/siltation.

Camp Creek was divided into seven reaches based on stream order, land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients and E. coli. Reach-scale conditions on Camp Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

Water quality in Camp Creek is highly impacted by agricultural and livestock operations throughout its length, with the most severe impacts evident downstream from reach Camp 03 N, north of Norris Rd. The riparian vegetation in this section was heavily grazed and weedy with thistles, and banks were actively eroding. Nutrient and E. coli loading may become more difficult to assess in the downstream reaches, as several large irrigation withdrawals and returns remove and return water to the stream from other agricultural areas throughout the valley. Riparian quality and bank stability improved progressively downstream starting near the upstream end of reach CAMP 06 N. Excellent riparian quality and bank stability was observed upstream of the confluence of Camp Cr with the Gallatin River.

Pastures and irrigated crop lands were identified as the most significant sources of nutrients and E. coli to Camp Cr. The potential impact of these land uses was accentuated by the general lack of best management practices such as riparian exclosure fencing, allowing livestock full access to the stream. However, it should be recognized that only areas that could be accessed from road crossings were observed and that BMPs were likely missed in the assessment.

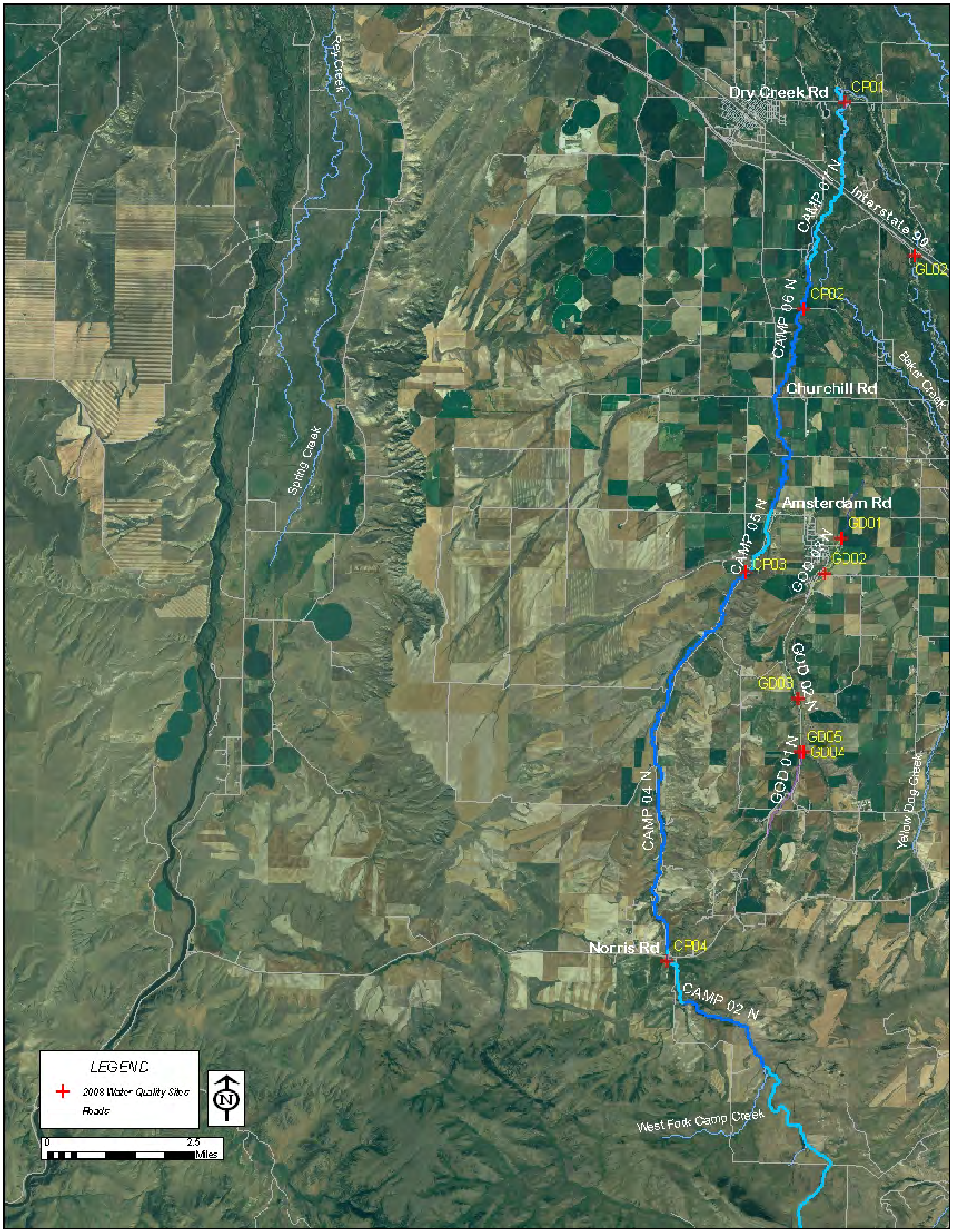

FIGURE 1. OVERVIEW OF CAMP CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID	Reach length (mi)	Ecoreg.	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP	Septic 150 ft per mi	Septic 1000 ft per mi
CAMP 01 N	3.98	17w	1	RANGE/ HAY	N	1	0	L	50	NA	0.0	0.0
CAMP 02 N	2.04	17w	3	RANGE/ CROP	N	0	0	L	100	NA	0.0	0.0
CAMP 03 N	1.11	17w	3	CROP	N	1	0	M	80	NA	0.0	3.6
CAMP 04 N	7.80	17w	3	PASTURE/ RANGE	N	19	7400	M	25	NA	0.6	2.8
CAMP 05 N	1.28	17w	3	RURAL SUBDIVISION	N	0	0	L	15	NA	0.0	2.3
CAMP 06 N	5.34	17w	3	ROWCROPS/ PASTURE	N	2	0	L	20	NA	0.6	1.3
CAMP 07 N	3.80	17w	4	PASTURE	N	1	0	L	60	NA	0.0	1.3

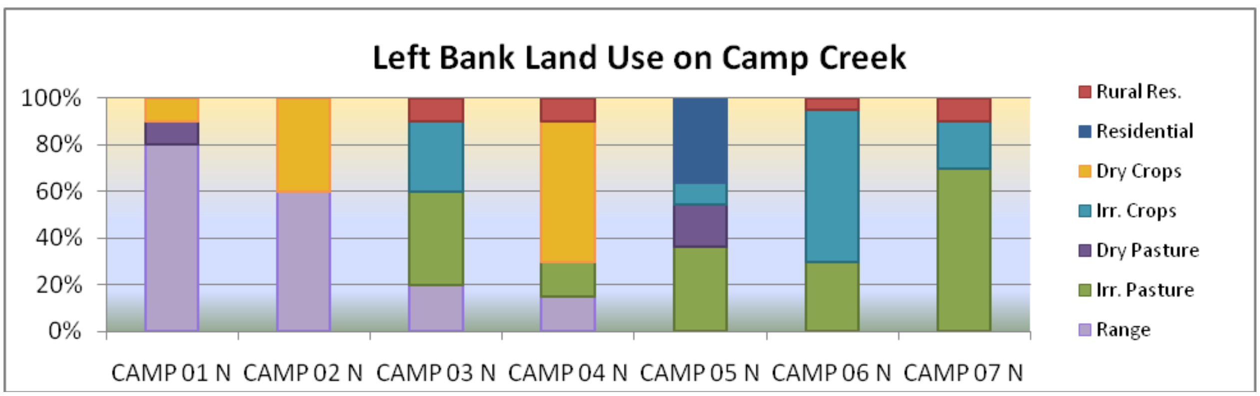

FIGURE 2. RELATIVE LAND USE TYPES ALONG THE LEFT BANK OF CAMP CREEK

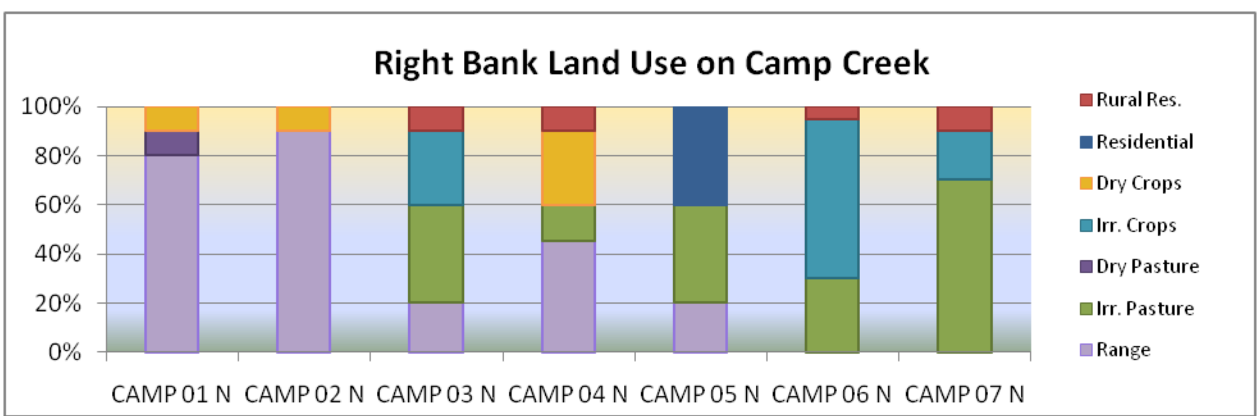

FIGURE 3. RELATIVE LAND USE TYPES ALONG THE RIGHT BANK OF CAMP CREEK

2. CAMP 01 N

Reach 1 is a first order stream that begins in the foothills of the Gallatin Mountains south of Axtell Anceny Rd and extends for nearly four miles to the confluence of West Fork Camp Cr (Figure 4). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

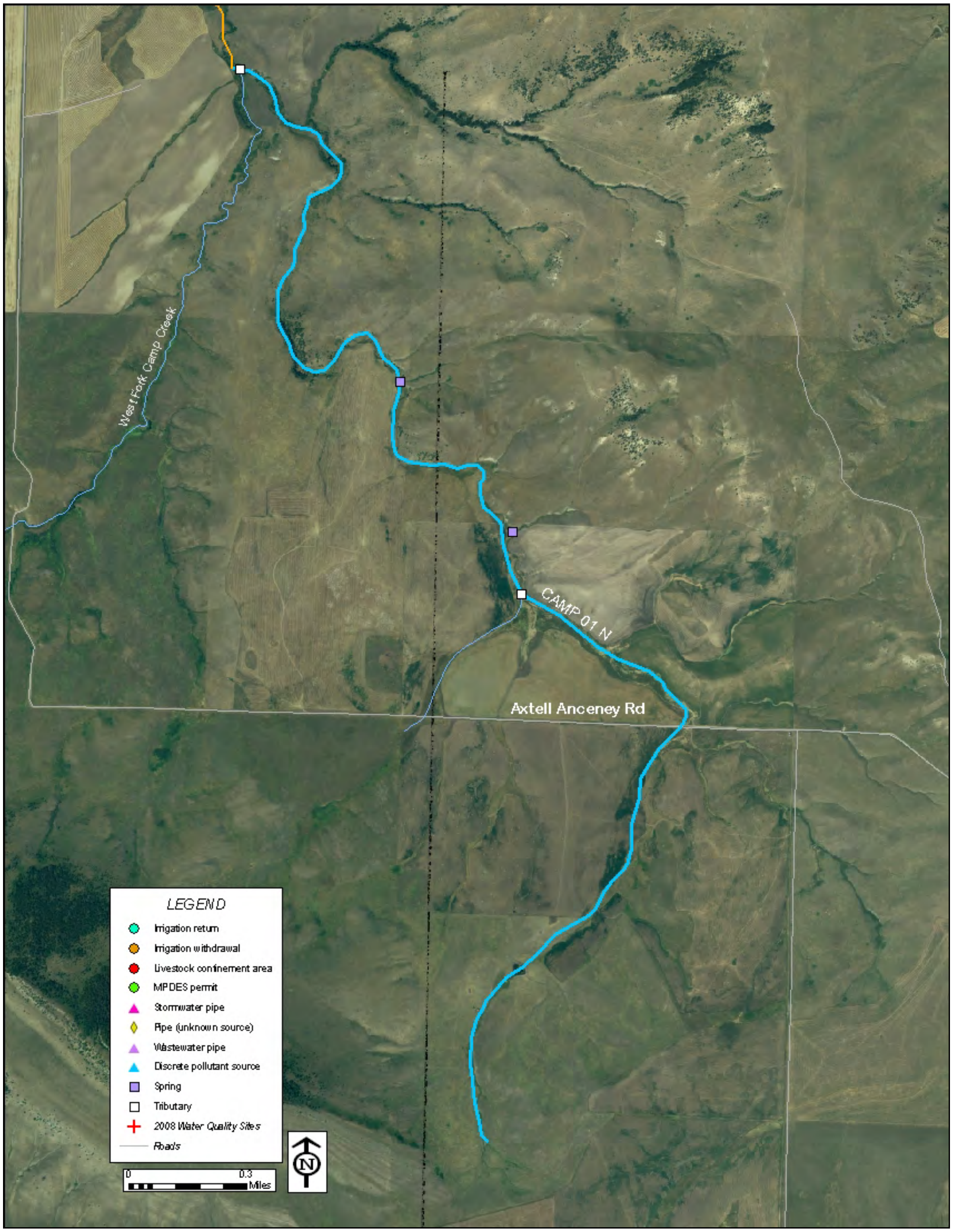

FIGURE 4. REACH CAMP 01 N

2.1. Reach Condition

Land use within the reach is primarily rangeland (Figure 5), with limited non-irrigated pasture and crop production (Figure 6). The riparian zone was comprised of dense herbaceous species (Figure 7) with some cattle impacts and crop encroachment. Low levels of bank erosion were observed, typically associated with livestock use. No road encroachment was observed within the reach nor were any irrigation withdrawals identified.

FIGURE 5. RANGELAND IN THE HEADWATERS OF CAMP CREEK AT THE AXTELL ANCENY RD CROSSING

FIGURE 6. LIMITED NON-IRRIGATED CROPS ALONG REACH CAMP 01 N

FIGURE 7. DENSE WETLAND AT AXTELL ANCENY ROAD CROSSING

2.2. Potential Nutrient and E. coli Sources

Potential pollutant sources to reach CAMP 01 N are listed in Table 2. The unpaved but well-maintained Axtell Anceny Rd crosses the reach. Although sediment could potentially be delivered to the stream at the culvert crossing, the riparian was very dense (Figure 5) and thus the crossing was not considered a significant sediment source. Two springs enter the reach (Figure 1) but because they drain dry pasture and cropland they do not likely delivery a significant amount of nutrients and E. coli. Pasture and range lands comprise the majority of land use in the reach: livestock use was evident throughout the reach and it appears that livestock had full stream access.

TABLE 2. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH CAMP 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture & Range (Ave. % LB/RB)	90%	SW/GW	good	nutrient and E. coli source	med
Unpaved road crossings (#)	1	SW	good	culvert at Axtell Anceny Rd, potential sediment source, but dense riparian	low

3. CAMP 02 N

Reach 2 is a third order stream that begins at the confluence of West Fork Camp Cr and extends for two miles downstream to where an intermittent tributary enters from the west at the location of a historic barn and other outbuildings (Figures 8 and 9). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

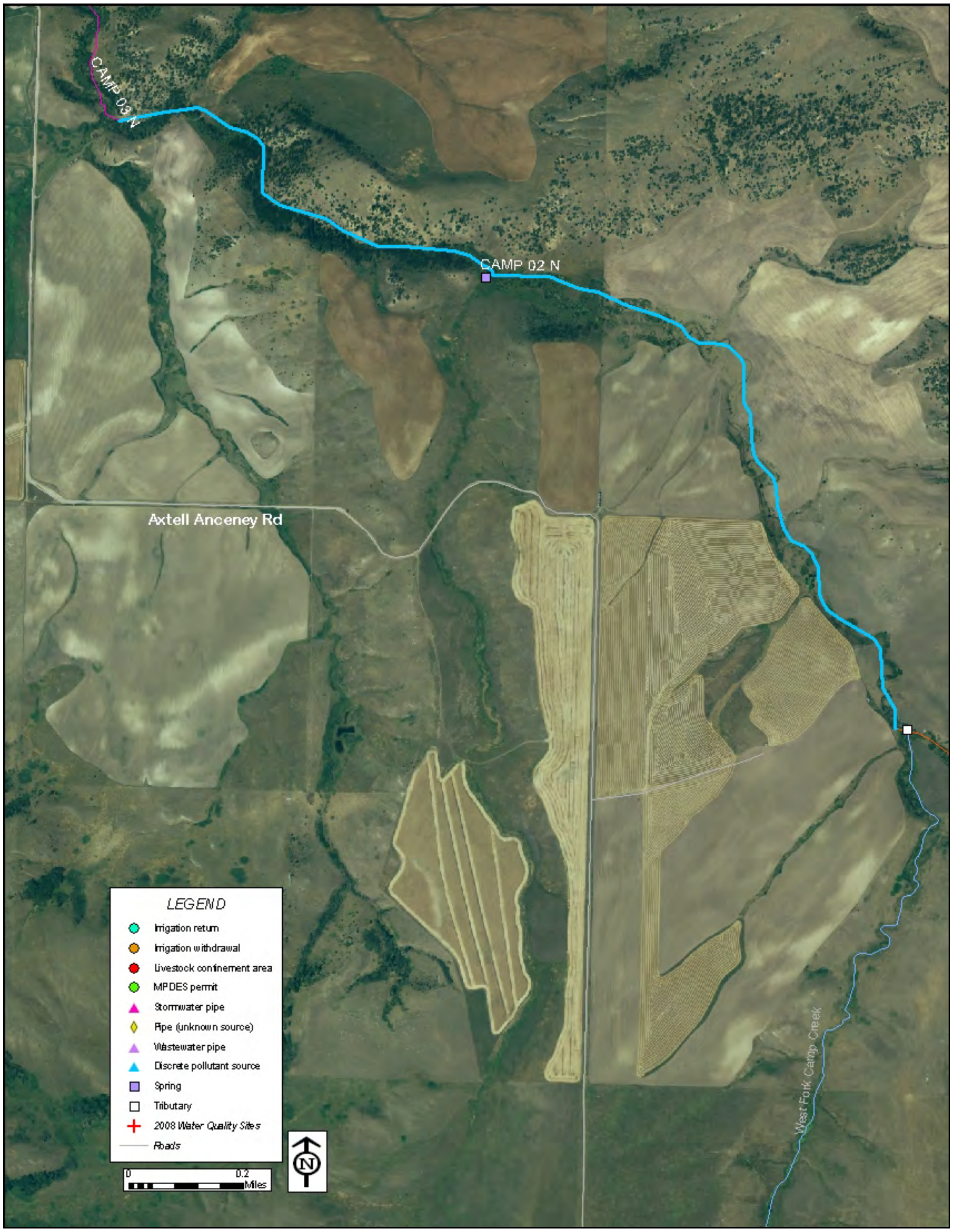

FIGURE 8. REACH CAMP 02 N

FIGURE 9. INTERMITTANT TRIBUTARY ENTERING FROM WEST AT THE DOWNSTREAM END OF REACH CAMP 02 N. CAMP CR IN BACKGROUND BEHIND SMALL HILL

3.1. Reach Condition

Land use within reach 2 is primarily rangeland and non-irrigated crops. The riparian zone was relatively intact, comprised of dense herbaceous wetlands in the upper section and dense willow-juniper and scattered cottonwood in the lower section (Figures 10 and 11). Banks were generally stable however some livestock trampling was observed (Figure 11).

FIGURE 10. WILLOW-JUNIPER RIPARIAN BOTTOMLAND EAST OF AXTELL ANCENY ROAD

FIGURE 11. DENSE WILLOW-JUNIPER RIPARIAN WITH LIVESTOCK ACCESS AND TRAMPLING

3.2. Potential Nutrient and E. coli Sources

Livestock grazing on the rangeland within the reach, as indicated by bank trampling at livestock crossings (e.g. Figure 12), was identified as a moderate potential nutrient and E. coli source. Pasture and range lands comprise the majority of land use in the reach: livestock use was evident throughout the reach and it appears that livestock had full stream access at locations observed in the field (figures 7.1 and 7.2).

FIGURE 12. BANK TRAMPLING AT LIVESTOCK CROSSING EAST OF AXTELL ANCENY ROAD

TABLE 3.1. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH CAMP 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Range (Ave. % LB/RB)	85%	SW/GW	good	Livestock access to stream evident is several places	med

4. CAMP 03 N

Reach 3 is a third order stream that begins where an intermittent tributary enters from the west at the location of a historic barn and other outbuildings and extends downstream to Norris Road (Figures 13 and 14). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

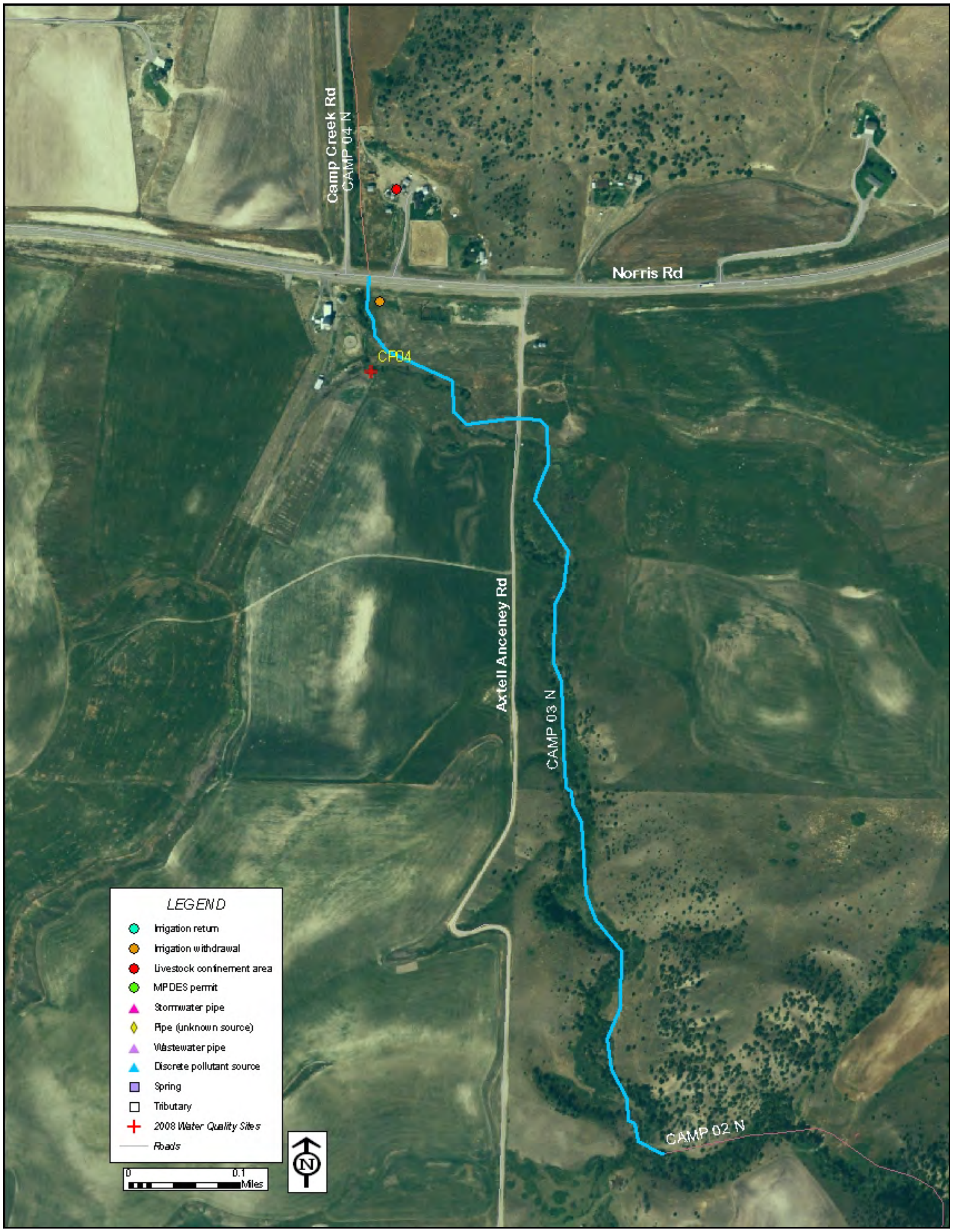

FIGURE 13. REACH CAMP 03 N

4.1. Reach Condition

Land use within the reach is primarily rangeland and non-irrigated crops. Upstream of Axtell Anceny Rd the riparian zone was comprised of healthy cottonwoods and willows, with minimal bank erosion (Figure 14). Riparian quality decreased downstream of the crossing, with significant bank erosion, livestock trampling, and pasture encroachment observed (Figure 15). No road encroachment was observed within the reach. One irrigation withdrawal was identified at the lower end of the reach but was not confirmed in the field.

FIGURE 14. LOOKING NORTH ON AXTELL ANCENY ROAD, ROBUST COTTONWOOD-WILLOW RIPARIAN

FIGURE 15. NARROW RIPARIAN, ERODING BANKS & ALGAL GROWTH: LOOKING WEST AT AXTELL ANCENY ROAD CROSSING

4.2. Potential Nutrient and E. coli Sources

Potential pollutant sources to reach CAMP 03 N are listed in Table 3. Irrigated crops were present throughout a third of the reach and were considered to have a moderated potential as a nutrient source. Pasture land comprised 40% of the reach. While pasture encroachment was sparse in the upper section of the reach, pasture encroachment and associated bank erosion were common in the lower section. Therefore pasture was considered a moderate potential nutrient and E. coli source. No riparian fencing or other BMPs were observed. The unpaved Axtell Anceny Rd crosses the lower section of the reach and the crossing was considered a potential sediment source (Figure 16). Due to the low prevalence of unpaved crossings, this single culvert was considered to have low relative significance for nutrient delivery.

TABLE 4. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH CAMP 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	30	GW	good	potential nutrient source	med
Pasture (Ave. % LB/RB)	40	SW/GW	good	pasture encroachment and bank erosion on lower end of reach	Med
Septic system per mi (150 ft/1000 ft)	0/3.6	GW	good		low
Unpaved road crossings (#)	1	SW	good	Axtell Anceny Rd culvert, potential sediment source	low

FIGURE 16. CULVERT AT AXTELL ANCENY ROAD WITHIN REACH CAMP 03 N; POTENTIAL SEDIMENT SOURCE

5. CAMP 04 N

Reach 4 is a third order stream that begins just south of the Norris road and extends downstream nearly eight miles along Camp Creek Rd to water quality site CP03, upstream of the town of Amsterdam (Figure 17). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

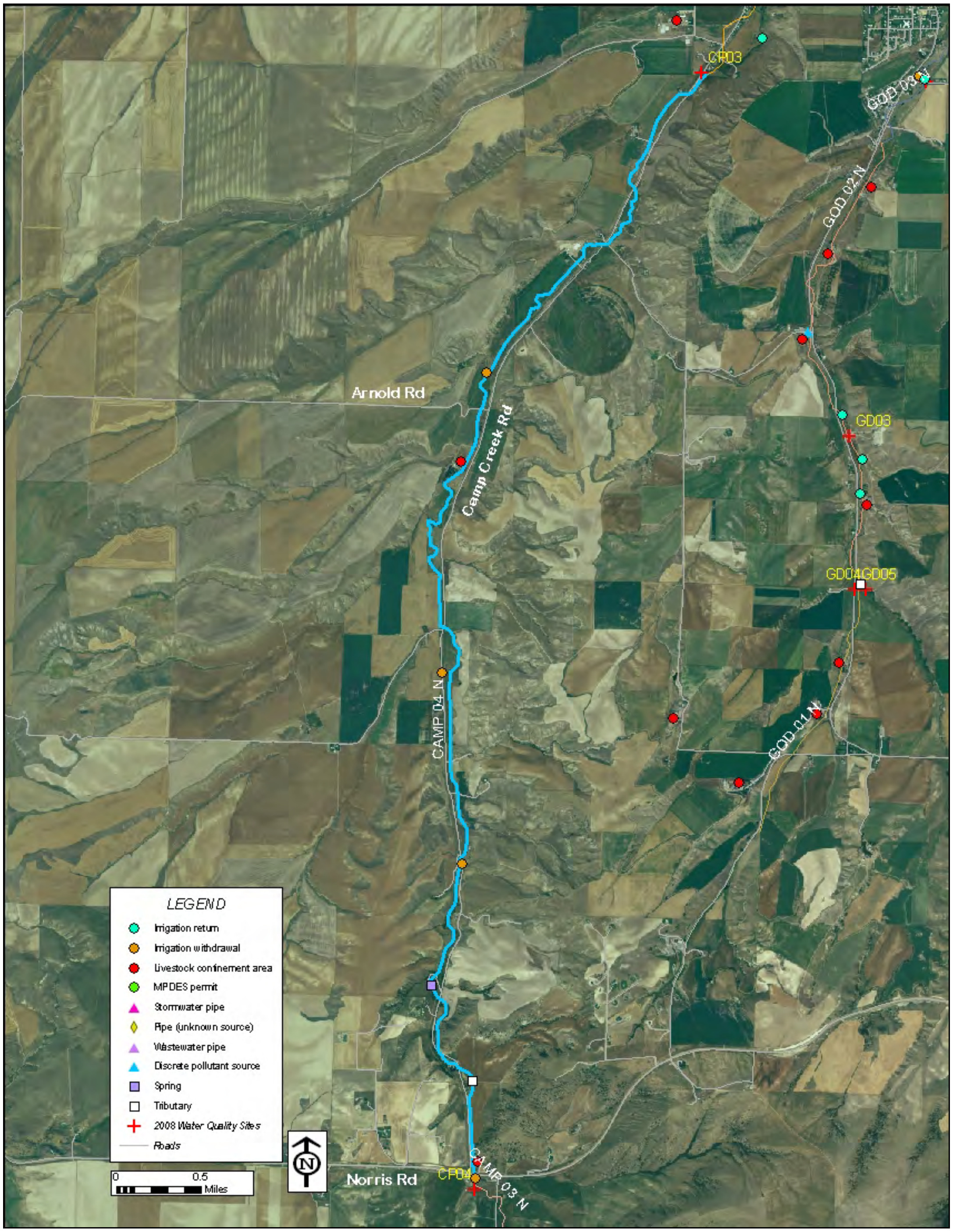

FIGURE 17. REACH CAMP 04 N

5.1. Reach Condition

Land use within the reach is primarily non-irrigated crops and rangeland with some pasture and rural residential. Riparian quality was significantly lower in this reach compared to upstream reaches. Select areas were comprised of dense willows (e.g. Figure 18) while the majority of the reach was highly degraded with overgrazed, weedy vegetation, eroding banks and pasture encroachment (Figures 19 & 20). Camp Creek Rd encroaches on the stream for 1.4 miles, often channelizing the stream against the road (Figure 18 and 21). Vegetation was generally dense between the road and the stream but due to the length of encroachment Camp Creek Rd was likely delivering sediment to the stream during storm events. Three irrigation withdrawals were identified within the reach. Of these, the withdrawal downstream of Arnold Rd (Figure 17) was identified in the field as a pipe delivering water from Camp Creek to an adjacent irrigation canal. The other two withdrawals were not identified in the field.

FIGURE 18. DENSE WILLOW RIPARIAN ZONE ALONG CAMP CREEK RD IN UPPER SECTION OF REACH

FIGURE 19. HIGHLY GRAZED RIPARIAN ZONE WITH ERODING BANKS

FIGURE 20. DEGRADED RIPARIAN ZONE DOWNSTREAM OF CAMP CREEK RD

FIGURE 21. CAMP CREEK ROAD ENCROACHES ON REACH CAMP 04 N

5.2. Potential Nutrient and E. coli Sources

Potential pollutant sources to reach CAMP 04 N are listed in Table 4. The range/pasture adjacent to the stream was generally highly grazed, weedy, and associated with significant bank erosion (Figures 19 and 20). Adjacent rangeland and pasture was therefore considered a highly significant potential source of nutrients and E. coli. Although pasture land comprised an average of only 15% of the land use along the reach, it was considered a moderately significant nutrient and E. coli source. Riparian fencing and other BMPs were limited, allowing livestock direct access to the creek. Two livestock confinement areas were identified, located adjacent to the stream upstream of Arnold Rd and at the intersection of Norris Rd and Camp Creek Rd (Figure 22). Nineteen unpaved crossings were identified. The crossings were both bridge and culverts, located on Camp Creek Rd, private driveways, and other small roads. Due to their high number, unpaved crossings were considered a moderately significant sediment source.

TABLE 5. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH CAMP 04 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Rangeland	30	SW/GW	poor	Bank erosion and trampling common	high
Pasture (Ave. % LB/RB)	15	SW/GW	poor	Significant pasture encroachment observed	high
Septic system per mi (150 ft/1000 ft)	.6/2.8	GW	poor	Sparse rural residential	low
Septic in tributaries	Low	Tributary	poor		low
LCA	2	SW/GW	poor	livestock operation adjacent to stream upstream of Arnold Rd	med
Unpaved road crossings (#)	19	SW	poor	Culverts and bridges on Camp Creek Rd, private driveways, other small roads	med

FIGURE 22. LCA LOCATED AT INTERSECTION OF NORRIS AND CAMP CREEK ROADS

6. CAMP 05 N

Reach 5 is a short, third order stream reach that begins at water quality site CP03, upstream of the town of Amsterdam and extends to just downstream of Amsterdam Rd (Figure 23). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

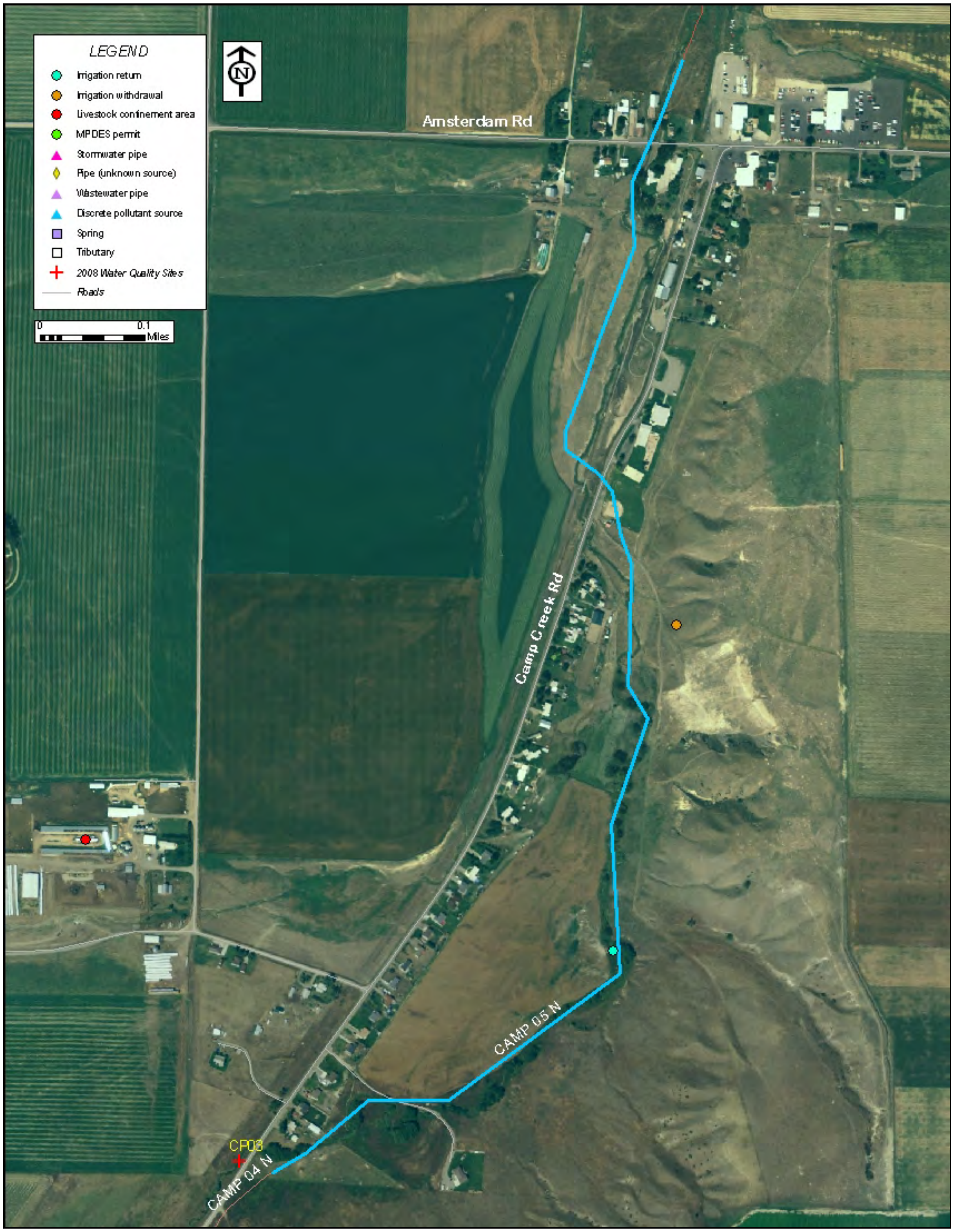

FIGURE 23. REACH CAMP 05 N

6.1. Reach Condition

Land use within the reach is primarily pasture, residential and cropland. The riparian zone was rather narrow (Figure 24), comprised of native sedges, rushes, invasive reed canarygrass and scattered willows (Figure 25). Despite the narrow riparian zone bank erosion was limited. Yard encroachment was common throughout the reach (Figure 26). One irrigation withdrawal was identified within the reach but was not confirmed in the field.

FIGURE 24. WEEDY, NARROW RIPARIAN, UPSTREAM OF OLD RAILROAD GRADE

FIGURE 25. SEDGE-RUSH-GRASS RIPARIAN WITH SCATTERED WILLOWS.

FIGURE 26. YARD ENCROACHMENT WITH TALL WILLOWS, DOWNSTREAM OF CAMP CREEK RD

6.2. Potential Nutrient and E. coli Sources

Potential pollutant sources to reach CAMP 05 N are listed in Table 5. Pasture land comprised a majority of the adjacent land use within the reach, and was considered to be of moderate significance as a nutrient and E. coli source. Residential yards, which commonly encroached on the stream within the reach (Figure 26) may also contribute nutrients to Camp Creek in this reach, but were considered less significant than pasture lands. A single livestock confinement area, located approximately 1/3 mile from the stream, was not considered a significant potential nutrient and E. coli source.

TABLE 6. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH CAMP 05 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	50	SW/GW	fair/good	Some pasture encroachment	med
Residential (Ave. % LB/RB)	40	SW/GW	fair/good	Significant amount of yard encroachment	low
Septic system per mi (150 ft/1000 ft)	0/2.3	GW	fair/good		low
Septic in tributaries	Low	Tributary	fair/good		low
LCA (#)	1	GW/SW	fair/good	located ~1/3 mi from stream	low

7. CAMP 06 N

Reach 6 is a third order stream that begins just downstream of Amsterdam Rd and extends downstream to where a tributary enters from the west at a private driveway crossing downstream of water quality site CP02 (Figure 27). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

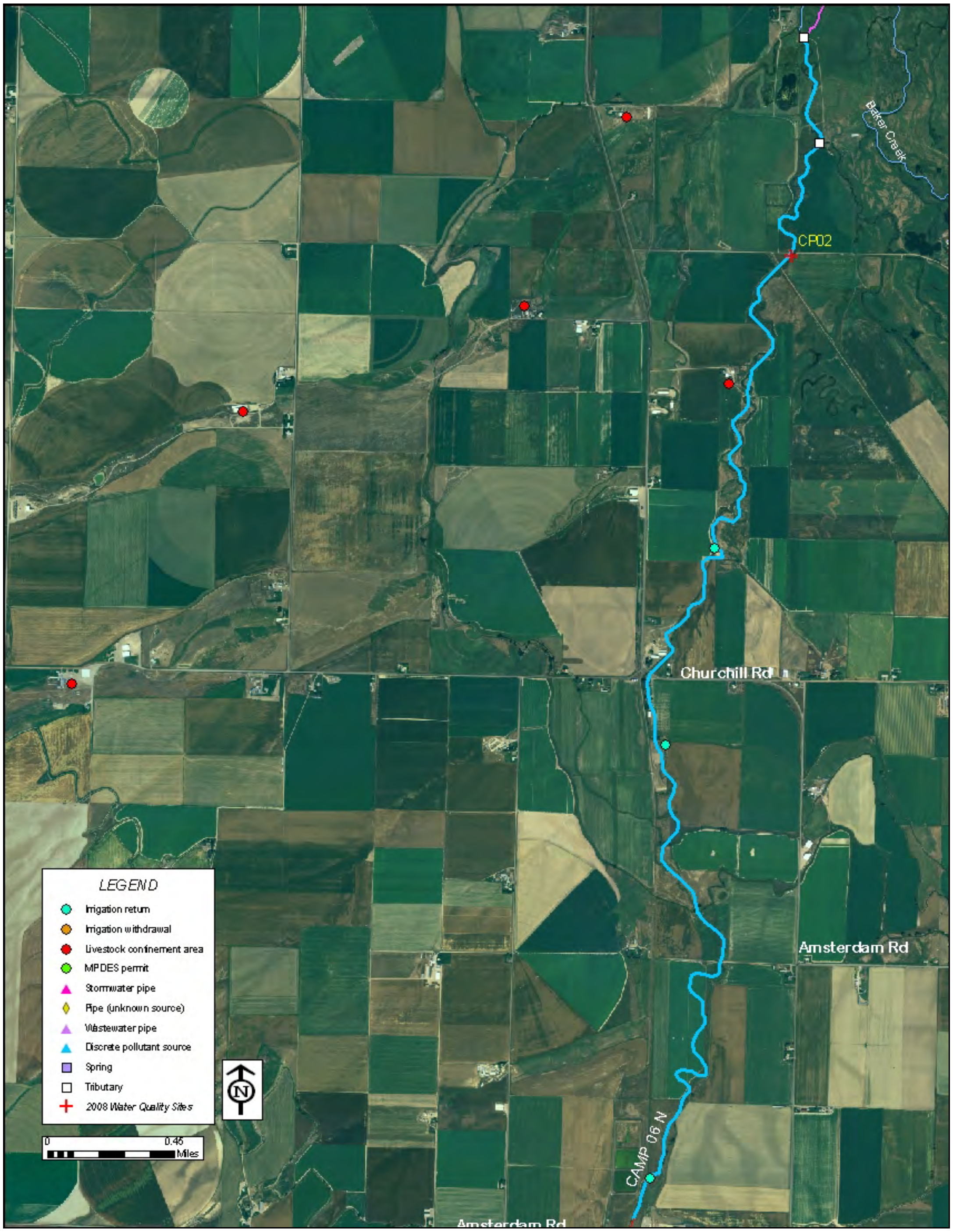

FIGURE 27. REACH CAMP 05 N

7.1. Reach Condition

Land use within the reach is primarily irrigated crops and pasture. The riparian zone varied from dense reed canarygrass and weedy thistles (Figure 28), to heavily grazed vegetation where pasture encroached (Figure 29). Banks were generally very stable with the exception of the section at a private driveway crossing west of Amsterdam Rd-Churchill Rd intersection where heavy grazing and trampling were observed (Figures 27 and 30).

FIGURE 28. WEEDY BUT DENSE RIPARIAN, DOWNSTREAM OF WATER QUALITY SITE CP02 AT PRIVATE DRIVEWAY IN LOWER REACH

FIGURE 29. GRAZED RIPARIAN AND PASTURE ENCROACHMENT DOWNSTREAM OF CHURCHILL RD

FIGURE 30. HEAVY GRAZING AND BANK TRAMPLING DOWSTREAM OF PRIVATE DRIVE WEST OF AMSTERDAM-CHRUCHILL RD INTERSECTION

7.2. Potential Nutrient and E. coli Sources

Potential pollutant sources to reach CAMP 06 N are listed in Table 6. The Amsterdam wastewater treatment ponds are located within 100 feet of Camp Creek, downstream of Amsterdam Rd (Figure 31) and are considered a potentially moderately significant source of nutrients and E. coli. Irrigated crops make up a high percentage of land use along the stream and were considered a highly significant nutrient source. Pasture land often encroached on the stream (Figure 29) and was a moderately significant nutrient and E. coli source. No riparian fencing or other BMPs were observed. Three unpaved crossings were identified. All were private driveways, with the driveway west of Amsterdam Rd considered a minor sediment source (Figure 32).

Five LCAs were identified, only one was located directly adjacent to Camp Cr (Figure 27). The remaining are located adjacent to tributaries and ditches (Figure 33). Pollutants would flow first to these smaller water bodies, and then a minimum of ¾ mi downstream to Camp Cr. The farthest north LCA would most likely impact reach CAMP 07 N rather than CAMP 06 N. The moderately-sized tributary stream identified at the lower end of the reach (Figure 33) could potentially be significant nutrient and E. coli sources, as it drains a large agricultural area.

TABLE 7. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH CAMP 06 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Wastewater treatment plant	NA	GW	fair/good	Amsterdam wastewater treatment ponds	med
Irrigated crops (Ave. % LB/RB)	65	GW	fair/good	significant nutrient source	high
Pasture (Ave. % LB/RB)	30	SW/GW	fair/good	significant nutrient and E. coli source	med
Septic system per mi (150 ft/1000 ft)	.6/1.3	GW	fair/good		low
Septic in tributaries	Medium	Tributary	fair/good		low
Unpaved road crossings (#)	3	SW	fair/good	private driveways; one a minor potential sediment source	low
Tributary	2	SW	unknown	farthest downstream is larger; drains large agricultural area, could be significant nutrient/E. coli source	med
LCA (#)	5	GW/SW	fair/good	CAMP 07 N	med

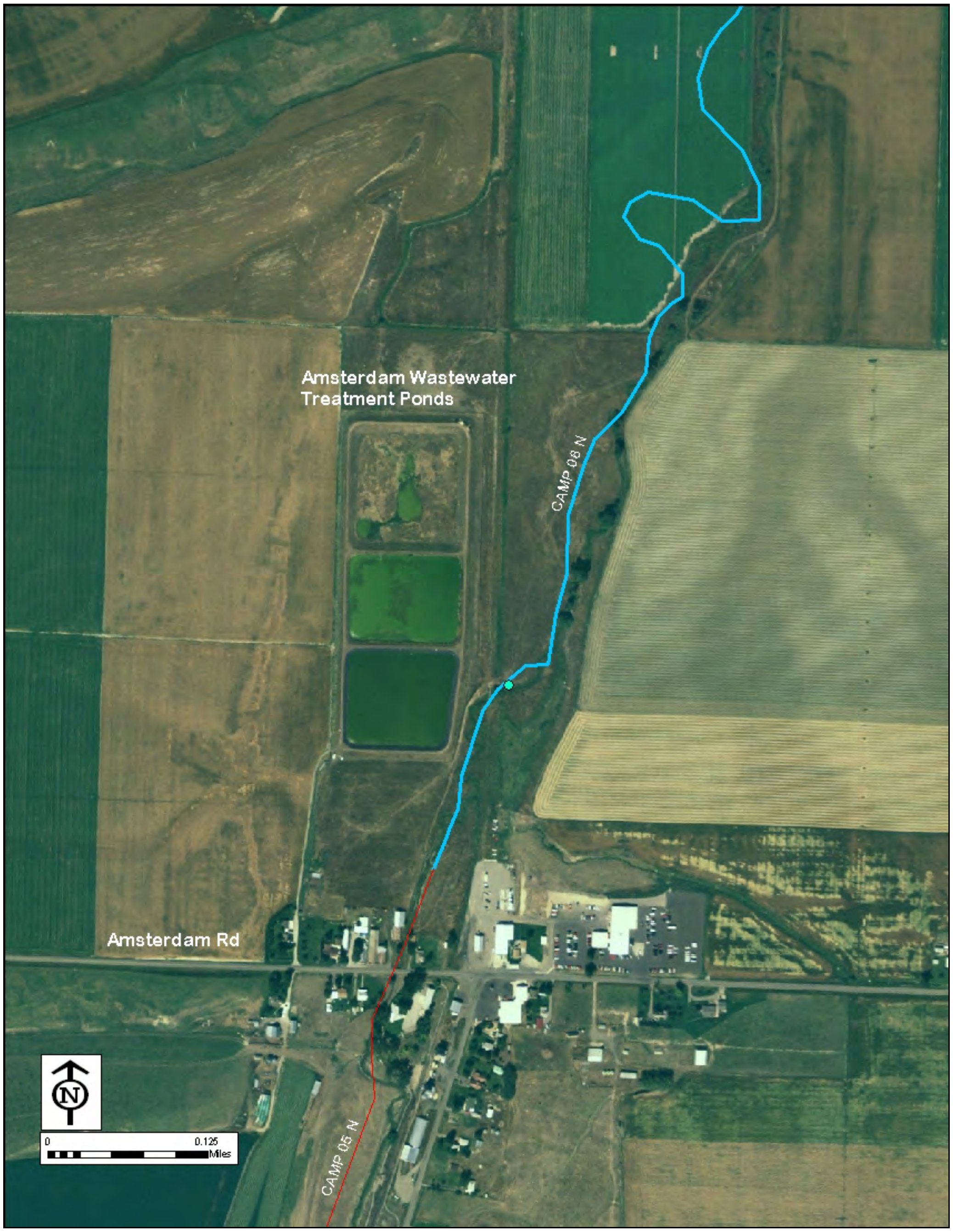

FIGURE 31. AMSTERDAM WASTEWATER TREATMENT PONDS ADJACENT TO CAMP CREEK

FIGURE 32. CULVERT AT DRIVEWAY WEST OF AMSTERDAM RD

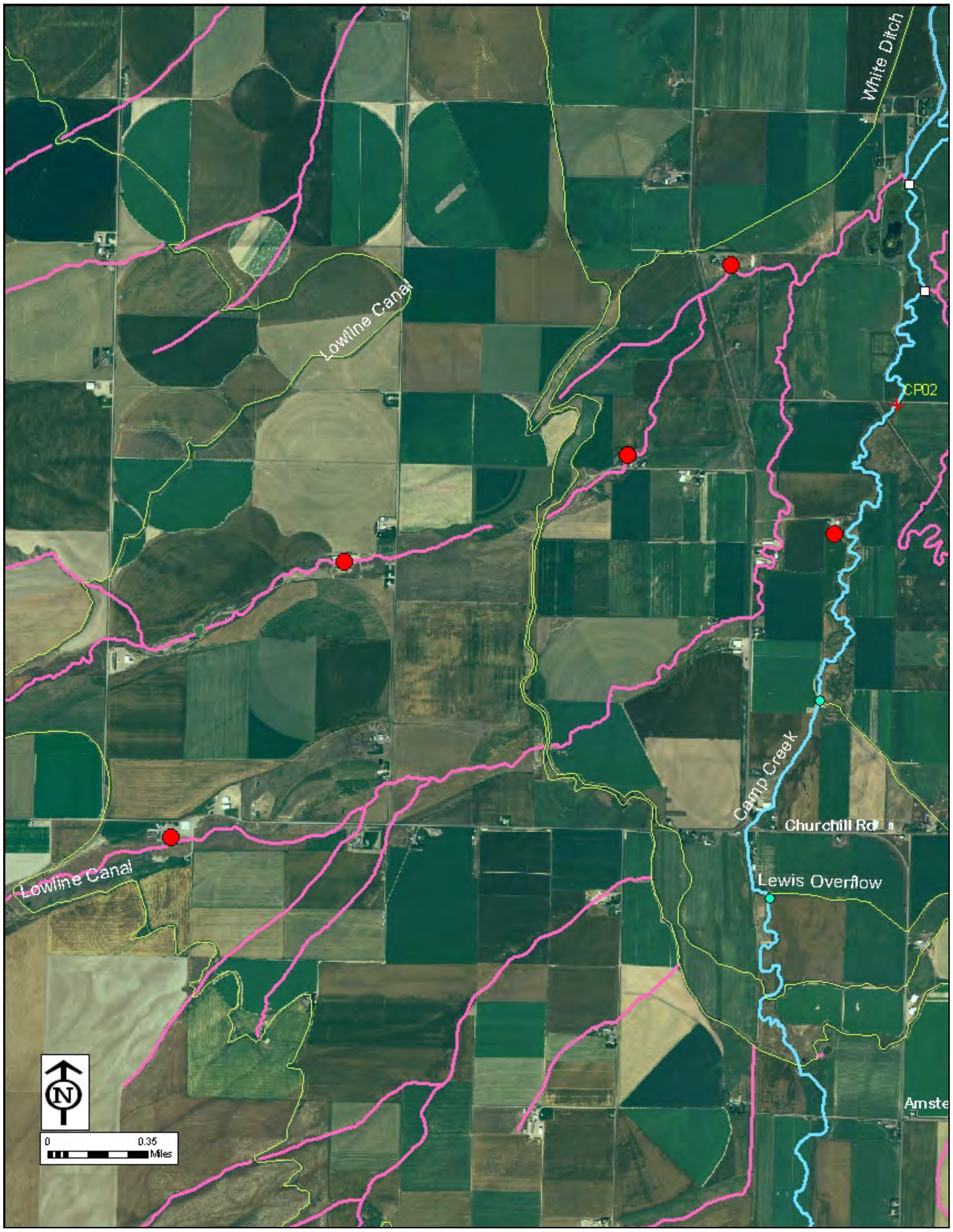

FIGURE 33. FIVE LCA'S (RED DOTS) LOCATED ON REACH CAMP 06 N, AND ADJACENT INTERMITTENT TRIBUTARIES (PINK LINES) AND DITCHES (YELLOW LINES)

8. CAMP 07 N

Reach 7 is a fourth order stream that begins where a tributary enters from the west at a private driveway crossing downstream of water quality site CP02, and extends downstream to the confluence with the Gallatin River east of Manhattan (Figure 34). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

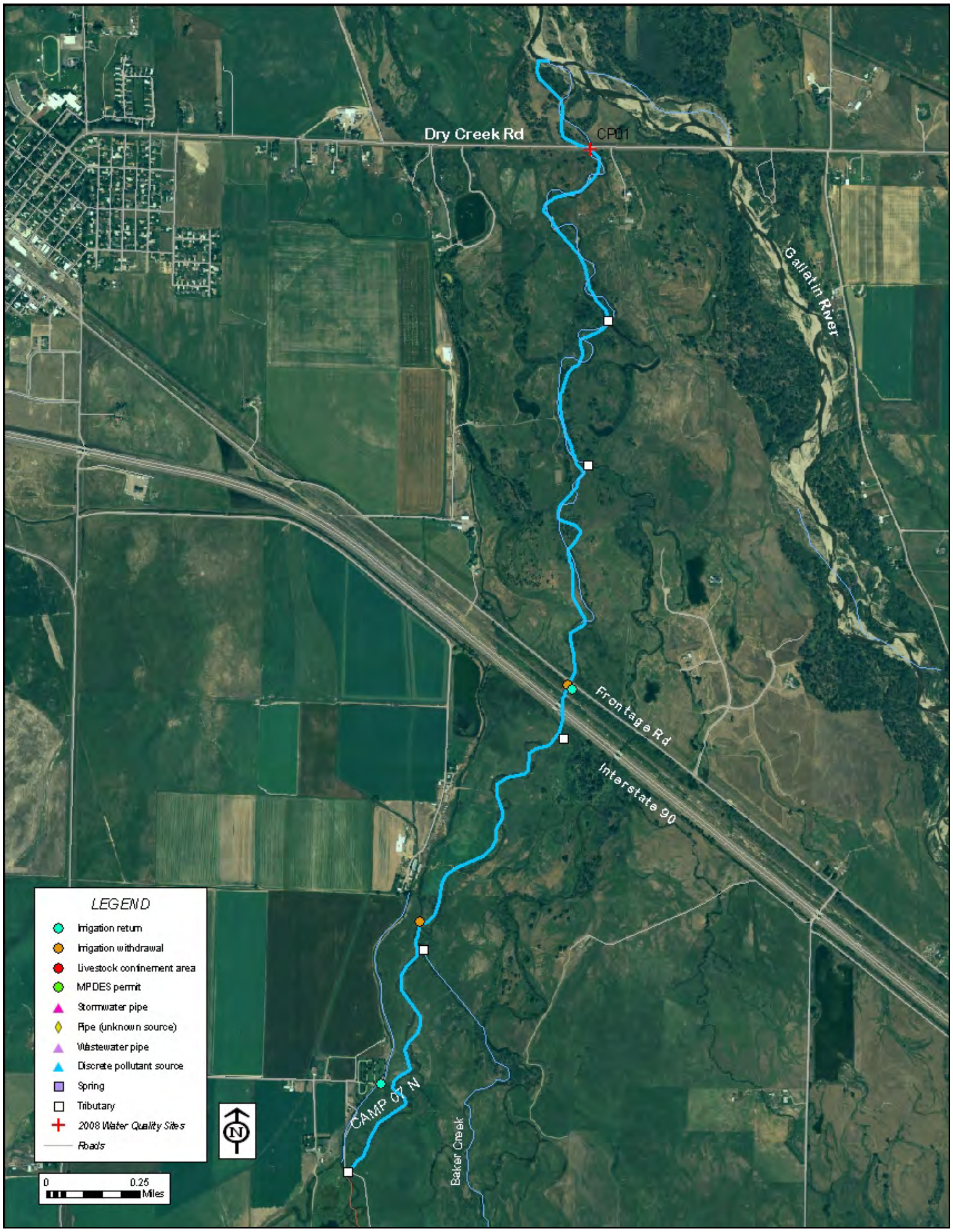

FIGURE 34. REACH CAMP 05 N

8.1. Reach Condition

Reach 6 lies within the floodplain of the Gallatin River and receives groundwater and spring inputs throughout its length. Land use within the reach is primarily irrigated pasture and hay fields, with scattered residences. The riparian zone was very robust, with willows and dense sedges and weedy reed canarygrass (Figures 35). Pasture and irrigated hay fields encroached on the stream in some locations, but banks were very stable due to the dense riparian vegetation (Figure 36). Four tributary streams and two irrigation withdrawals were identified within the reach.

FIGURE 35. ROBUST RIPARIAN ZONE, DOWNSTREAM OF FRONTAGE RD

FIGURE 36. HAY/PASTURE ENCROACHMENT WITH DENSE, HERBACEOUS RIPARIAN. VIEWED FROM MOUNTAIN VIEW CEMETARY. IRRIGATION RETURN IN FOREGROUND.

8.2. Potential Nutrient and E. coli Sources

Potential pollutant sources to reach CAMP 07 N are listed in Table 7. Irrigated hay fields were a potential nutrient source but were not as common as irrigated pasture. The abundance of irrigated pasture land was deemed to have a potentially high significance for delivery of nutrients and E. coli to Camp Cr. No riparian fencing or other BMPs were observed. One unpaved crossing, a private driveway, was confirmed but was not directly observed in the field due to private property issues. The four tributary streams identified entering the reach could potentially be significant nutrient and E. coli sources, as they drain large agricultural areas (Figure 34). The two irrigation returns were both relatively large (e.g. Figure 36) and could also be significant nutrient and E. coli sources.

TABLE 8. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH CAMP 07 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	20	GW	good/excellent	some hay field encroachment	low
Pasture (Ave. % LB/RB)	70	SW/GW	good/excellent	All irrigated, some naturally subirrigated	high
Septic system per mi (150 ft/1000 ft)	0/1.3	GW	good/excellent		low
Septic in tributaries	Low	Tributary	good/excellent		low
Tributaries	4	Tributary	unknown	drain large agricultural areas; nutrient/E. coli sources	med
Irrigation returns	2	SW	good/excellent	drain large agricultural areas; nutrient/E. coli sources	med
Unpaved road crossings (#)	1	SW	good/excellent	private driveway, not observed in field	low

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Dry Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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DRY CREEK

Dry Creek starts in the foothills on the west side of the northern Bridger Mountains north of Belgrade. It flows south through dry rangeland and agricultural areas for approximately fifteen miles to its confluence with the East Gallatin River (Figure 1). Note that two Dry Creek Roads exist. The road connecting from Belgrade, north to the Dry Creek community, and west to Manhattan, is called Dry Creek Road. To differentiate this road from the road heading north from the Dry Creek community, north to Menard, the latter is denoted in this assessment as “North Dry Creek Road”.

Water quality in Dry Creek (Waterbody ID MT41H003_100) is listed on the State of Montana’s 2008 303(d) List as being impaired for the following pollutants: total nitrogen, total phosphorus, and sediment. For the purposes of assessing pollutant sources, Dry Creek was divided into three reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients. Reach-scale conditions on Dry Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

Dry Creek is only marginally impacted by anthropogenic sources throughout its sixteen mile length, with pasture land and irrigated crops identified as the most significant potential sources of nutrients. The upper reach (DRY 01 N) flows primarily through non-irrigated cropland and rangeland which were not considered significant nutrient sources. Pasture encroachment and bank erosion in the naturally-erosive soils increased in the lower two reaches. However, the quality of the riparian buffer remained relatively high, reducing potential nutrient delivery to the steam. The exception was an approximately 1 mile section downstream of Menard Road, where significant overgrazing and a lack of riparian fencing contributed to bank erosion.

Although most of the unpaved road crossings along the stream length were stable, well vegetated and not likely to act as a sediment source during storm events, some of the crossings had a significant amount of gravel and fine substrate on the bridge decking and could potentially contribute sediments and nutrients to the stream. With the low number of residences, septic systems were not considered a potential nutrient source.

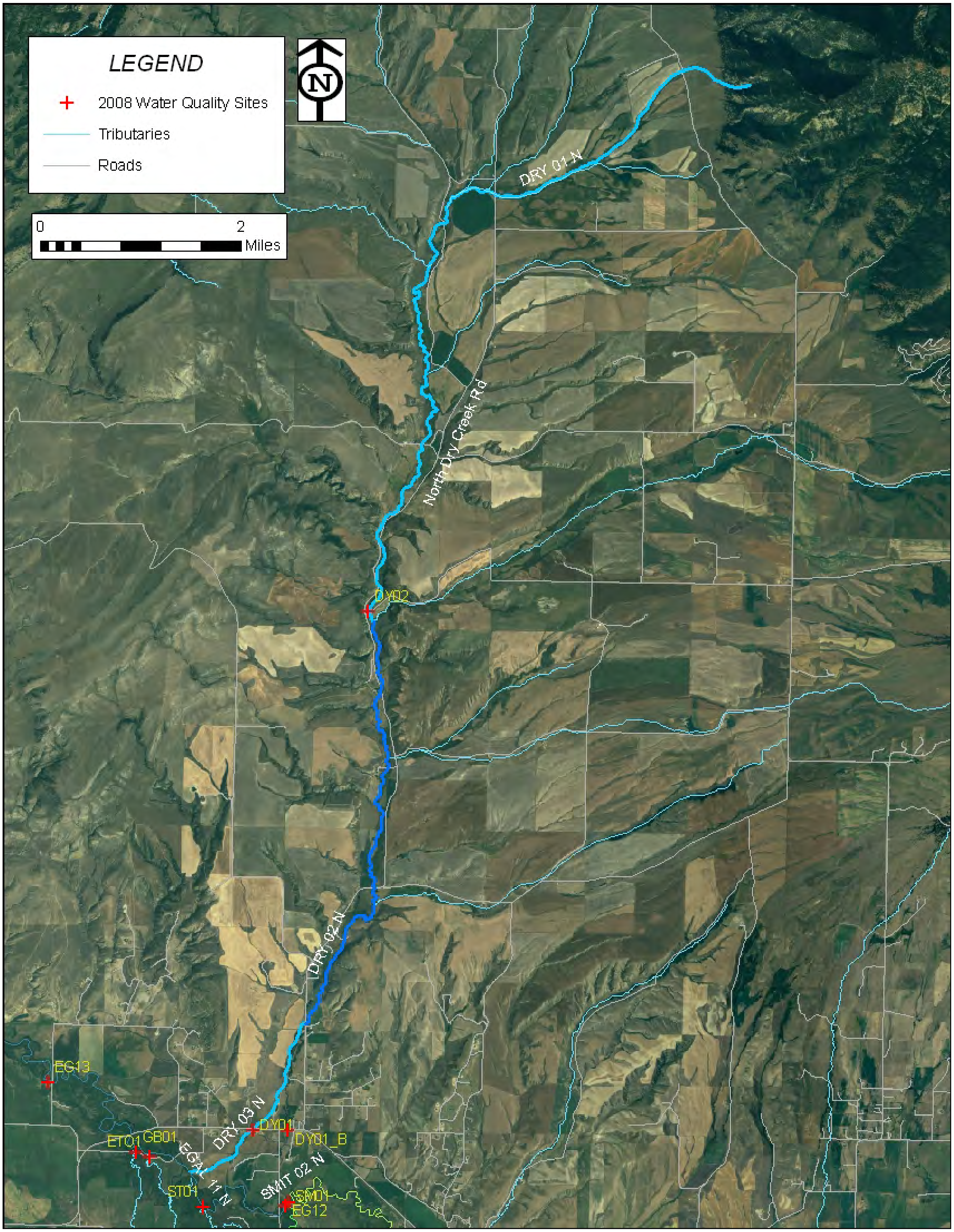

FIGURE 1. OVERVIEW OF DRY CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID	Reach length (mi)	Ecoreg.	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP	Septic 150 ft per mi	Septic 1000 ft per mi
DRY 01 N	9.10	17w	3	RANGE/ CROPS	Y	0	0	L	40	PBR	0.0	0.9
DRY 02 N	5.02	17w	4	RANGE/ CROPS	N	2	0	L	40	SILT_ FENCE, PBR	0.0	5.2
DRY 03 N	2.10	17w	4	HAY/ CROPS	N	1	150	L	50	PBR	0.0	0.0

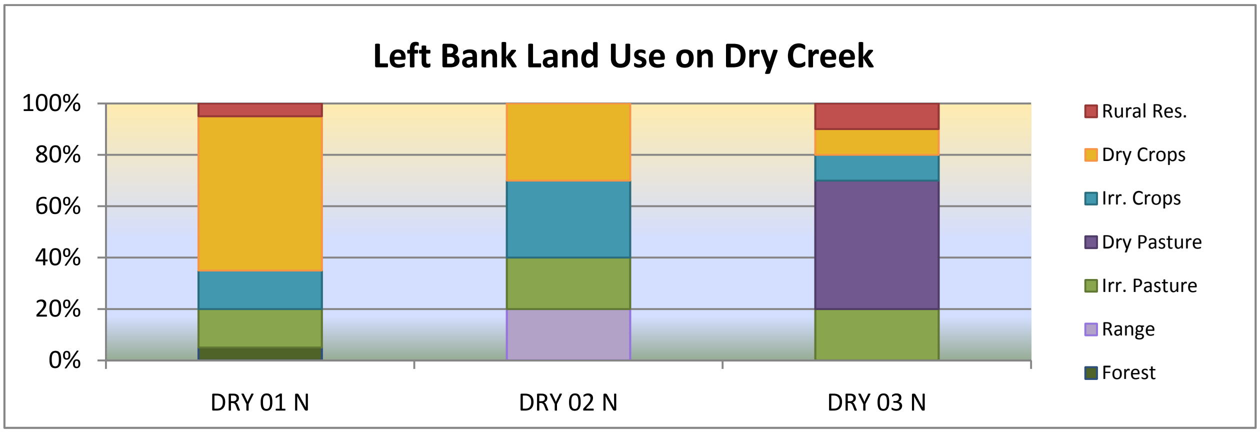

FIGURE 2. LAND USE TYPES ALONG THE LEFT BANK OF DRY CREEK

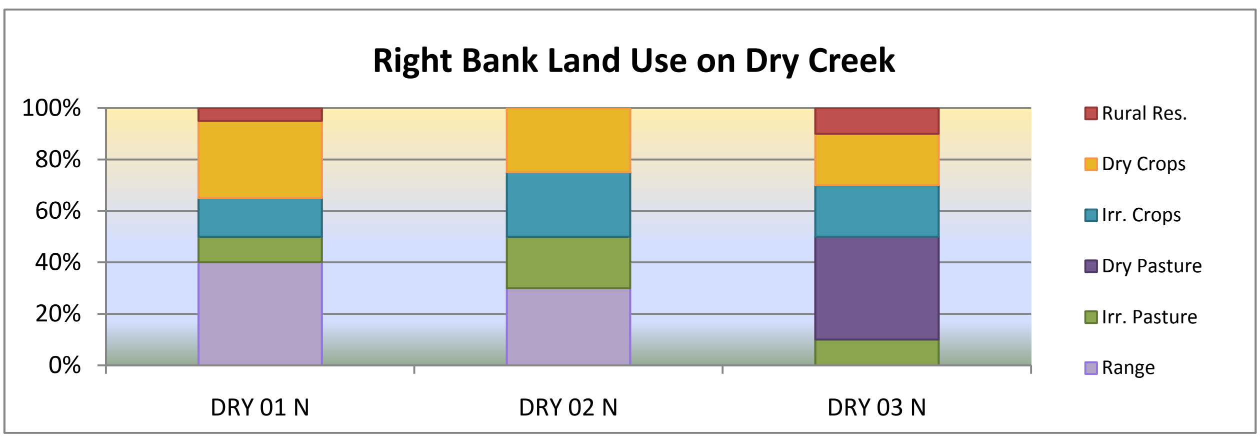

FIGURE 3. LAND USE TYPES ALONG THE RIGHT BANK OF DRY CREEK

2. DRY 01 N

Reach 1 begins in the foothills of the west side of the northern Bridger Mountains north of Belgrade and extends downstream approximately nine miles to where Pass Creek enters downstream of Biggs Haugland Road (Figure 4). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

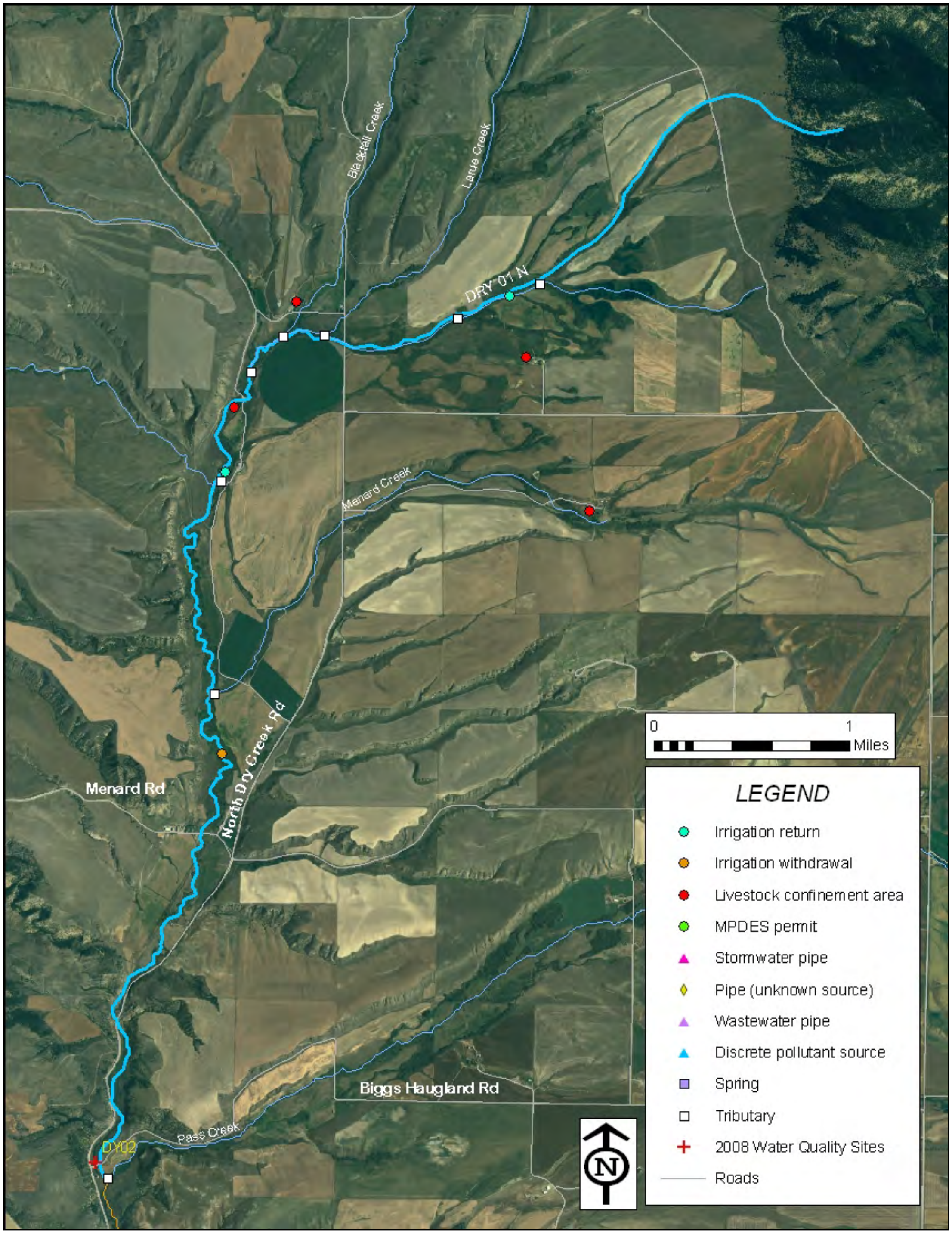

FIGURE 4. REACH DRY 01 N

2.1. Reach Condition

The dominant land uses within the reach are rangeland, and irrigated and dry crops (primarily hay production). The riparian vegetation is relatively healthy and dense throughout the reach, composed of willow, chokecherry, reed canarygrass and scattered juniper (Figure 5). The exception to the healthy riparian is the section for ¾ of a mile downstream of Menard Road which is heavily grazed and devoid of riparian vegetation in certain areas (Figure 6). Bank erosion was considered moderate with banks ranging to highly stable where riparian vegetation was dense, to severe erosion such as downstream of Menard Road (Figure 6). Soils within the reach are also highly erosive, leading to some areas of partly-natural erosion on outer meander bends where some grazing has also reduced stabilizing vegetation (Figure 7). North Dry Creek Road encroaches for a total of approximately 1000 ft in two locations: upstream (Figure 8) and downstream of Biggs Haugland Road. Both sections of encroachment are well vegetated and were not considered significant potential sediment sources. One irrigation withdrawal was identified on the aerial north of Menard Rd but was not confirmed in the field.

FIGURE 5. DENSE RIPARIAN UPSTREAM OF NORTH DRY CREEK RD

FIGURE 6. POOR RIPARIAN QUALITY AND ERODING BANKS DOWNSTREAM OF MENARD ROAD

FIGURE 7. BANK EROSION IN HIGHLY-EROSIVE SOILS

FIGURE 8. NORTH DRY CREEK ROAD ENCROACHMENT

2.2. Nutrient Source Characterization

Potential nutrient sources within reach DRY 01 N are detailed in Table 2. Because the proportion of land use in pasture or irrigated crops was low, these land uses were not considered significant nutrient sources. The exception was the short ¾ mile segment downstream of Menard Road (Figure 6) where the pasture was very overgrazed, banks were actively eroding, and no riparian fencing was observed. This section is likely a sediment and nutrient source during storm events and during spring runoff.

Five livestock confinement areas were identified along this section of the stream. Four of the LCA's are located along tributaries to Dry Creek rather than on the main channel. Of these, three are located 1 to 2.5 miles upstream of the main Dry Creek channel (Figure 4). Therefore, only the LCA located on the main channel was considered a potential pollutant source, but this LCA was not observed in the field to assess the degree of potential influence. Tributaries included Menard, Larue and Blacktail Creeks, all small streams draining from the west side of the Bridger Mountains which due to their mountainous/rangeland headwaters were not considered potential nutrient sources. Septic system density within the reach was very low and was not considered a potential nutrient source. Two irrigation returns enter the reach downstream of the North Dry Creek Road crossing. Because these returns flow through irrigated and non-irrigated cropland they could potentially be a source of nutrients.

Seven unpaved road crossings were identified within the reach, including Biggs Haugland Road, Rocky Mountain Road, two crossings on North Dry Creek Road, and several driveways. Abutments at the Biggs Haugland Road crossing were well vegetated and stable. Rocky Mountain Road, and several of the driveways, were not observed in the assessment. The two crossings on North Dry Creek Road were considered potential sediment sources during storm events, as there was gravel on the decking at the lower crossing (Figure 9), and evidence of flooding over the road on the upper crossing.

TABLE 2. POTENTIAL NUTRIENT SOURCES WITHIN REACH DRY 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	15	GW	Good	wheat/barley/hay production	Low
Pasture (Ave. % LB/RB)	12	SW/GW	Good	pasture in good condition; one area of severe pasture encroachment observed downstream of Menard Rd	Low
Irrigation returns (#)	2	SW	Unknown	drains agricultural land	Low
Septic system per mi (150 ft/1000 ft)	0.1/0.7	GW	Good		Low
Septic in tributaries	Low	Tributary	Good	almost no residences along tribs	Low
Unpaved road crossings (#)	7	SW	Good	Two Dry Cr Rd crossings considered potential sediment sources	Low
LCA (#)	5	GW/SW	Good	one on main channel, four located on tributaries	Low

FIGURE 9. GRAVEL ON BRIDGE DECKING AT DOWNSTREAM CROSSING ON NORTH DRY CREEK ROAD

3. DRY 02 N

Reach 2 begins where a tributary enters downstream of Biggs Haugland Road crossing and extends approximately five miles downstream to North Dry Creek Road (Figure 10). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

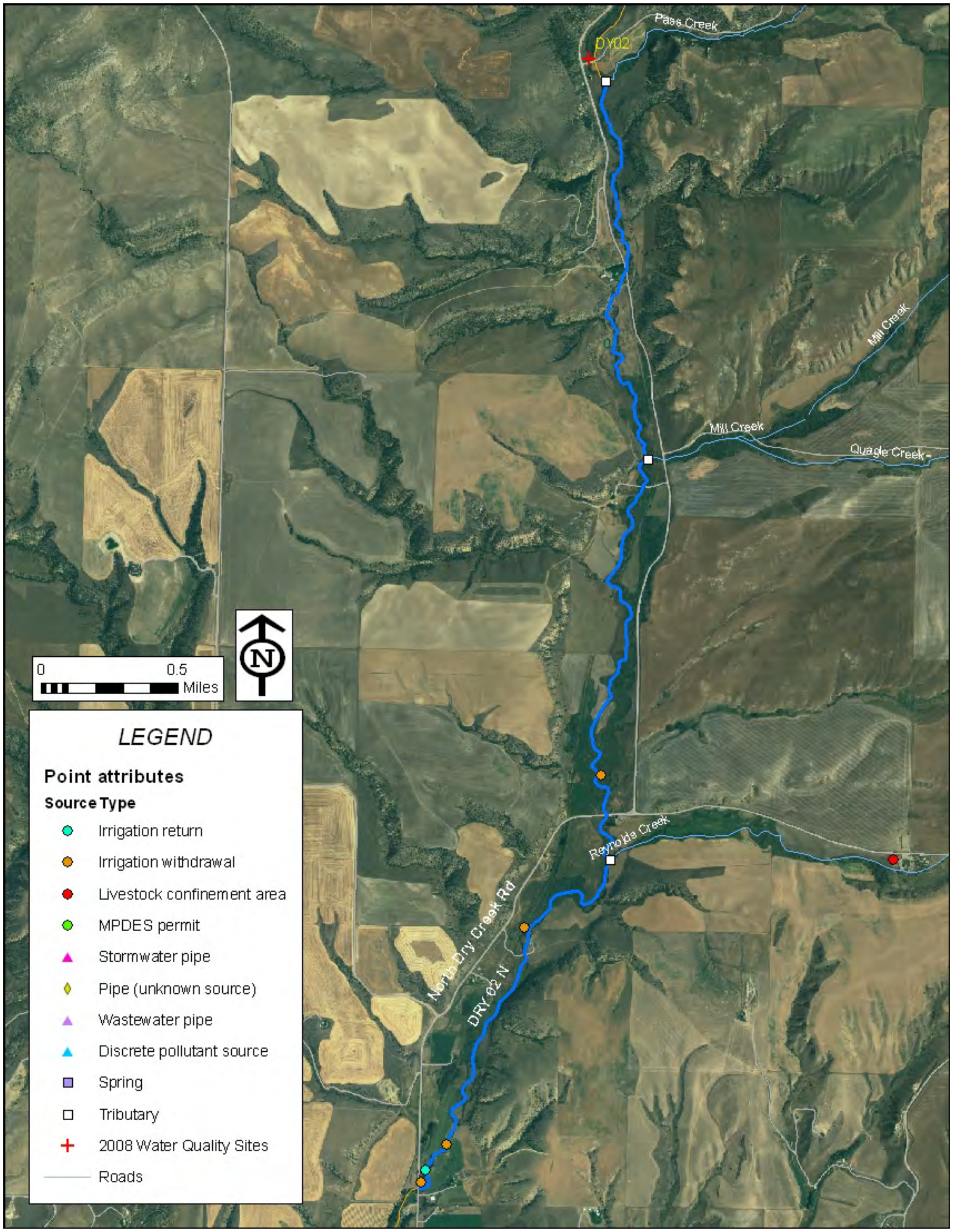

FIGURE 10. REACH DRY 02 N

3.1. Reach Condition

The dominant land uses within the reach are wheat and barley production, hay production, pasture, and rangeland. The riparian vegetation is generally healthy, although significant pasture encroachment was observed (Figure 11). Riparian vegetation was composed of a chokecherry, willow and juniper understory with dense reed canarygrass; cottonwoods were present in the lowest 1 to 3 miles of the reach (Figure 12). Banks were generally stable due to the dense riparian, however soils are naturally erosive and some erosion was observed where pasture encroached on the stream at outer meander bends (Figure 11). Four irrigation withdrawals were identified during the assessment. Of those, two were only possibly confirmed on the aerial while the other two were more definitively confirmed as significant diversions based on potential flow paths. None of the withdrawals were confirmed in the field. No roads encroach on the stream in this reach.

FIGURE 11. PASTURE ENCROACHMENT AND BANK EROSION ON MEANDER BEND

FIGURE 12. DENSE RIPARIAN UPSTREAM OF PRIVATE DRIVEWAY OFF NORTH DRY CREEK ROAD

3.2. Nutrient Source Characterization

Potential nutrient sources within reach DRY 02 N are detailed in Table 3. Irrigated crops were considered a moderate potential nutrient source. Pasture land was observed to be in relatively good condition but frequently encroached on the stream. However, with a robust riparian buffer throughout most of the reach pasture was considered to have a low to moderate potential as a nutrient source. Small but significant tributaries included Mill Creek and Reynolds Creek, neither of which was considered significant potential nutrient sources because they flow primarily through non-irrigated rangeland, cropland and pasture.

Both of the two LCA's were located on tributary streams. Potential sources from one LCA would flow to Quagle Creek, then to Mill Creek, then to the main stem of Dry Creek, for a total travel distance of approximately three miles. The second LCA is located on Reynolds Creek, approximately one mile upstream of Dry Creek. Due to their distance from the main channel, both LCA's were considered to have low potential significance. Septic system density within the reach was low and combined with the good quality riparian, septic systems were not considered a potential pollutant source. There were likely additional irrigation withdrawals and returns within the reach but with paleochannels and subirrigated riparian this was difficult to discern from aerial photographs.

Five unpaved road crossings were identified within the reach, including two crossings on North Dry Creek Road and three driveways. Both of the North Dry Creek Road crossings were considered potential sediment sources during storm events due to gravel and fine sediment observed on their bridge decking (Figure 13). However, due to their low prevalence the crossings were considered to have a low potential significance. Abutments at all of the observed crossings were stable and well vegetated (Figure 13).

TABLE 3. POTENTIAL NUTRIENT SOURCES WITHIN REACH DRY 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	27	GW	Good	hay, wheat and barley production	Med
Pasture (Ave. % LB/RB)	20	SW/GW	Good	pasture in good condition but significant encroachment on stream observed	Low/Med
Irrigation returns (#)	1	SW	Unknown	drains agricultural land	Low
Septic system per mi (150 ft/1000 ft)	0.2/1.6	GW	Good		Low
Septic in tributaries	Low	Tributary	Good	very few residences	Low
Unpaved road crossings (#)	5	SW	Good	two of the crossings had sediment on bridge decking and could be a sed. source during storm events	Low
LCA (#)	2	GW/SW	Good	both located on tributary streams at least 1 mi upstream of Dry Cr	Low

FIGURE 13. GRAVEL ON BRIDGE DECKING AT NORTH DRY CREEK ROAD WITH STABLE, WELL-VEGETATED ABUTMENTS

4. DRY 03 N

Reach 3 begins at North Dry Creek Road and extends approximately two miles downstream to its confluence with the East Gallatin River (Figure 14). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

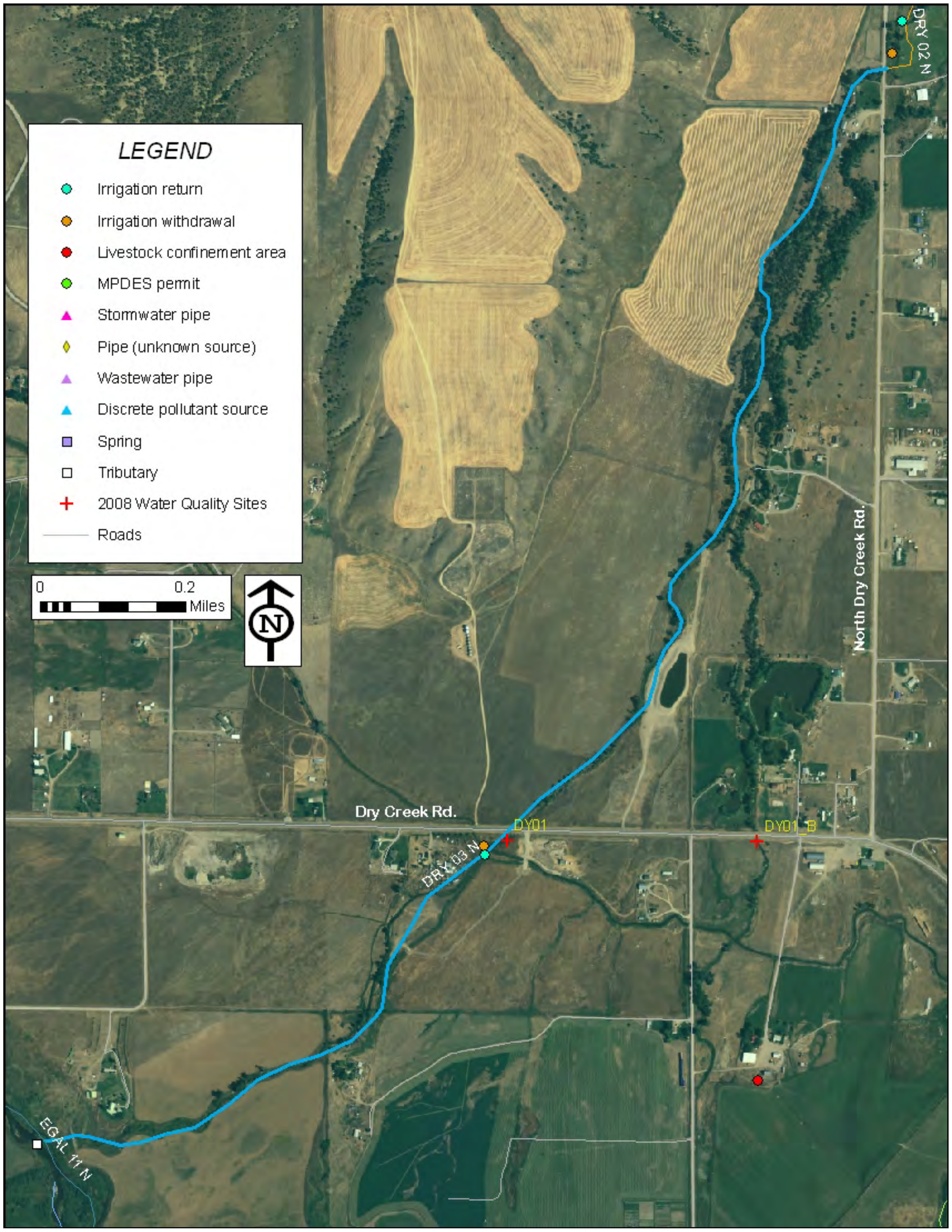

FIGURE 14. REACH DRY 03 N

4.1. Reach Condition

The dominant land uses within the reach are pasture land mixed with irrigated and dry cropland. The reach was only accessible at the North Dry Creek Road and Dry Creek Road crossings. Where observed, the riparian zone is rather narrow, but vegetation is dense with reed canarygrass and scattered cottonwoods (Figures 15 and 16). Banks were generally stable due to the dense riparian vegetation; however erosion is possible in the pastures between Dry Creek Road and the East Gallatin confluence. One significant irrigation ditch exits just downstream of Dry Creek Road (Figure 16). No roads encroach on the stream in this reach.

FIGURE 15. DENSE RIPARIAN WITH COTTONWOOD OVERSTORY DOWNSTREAM OF NORTH DRY CREEK ROAD

FIGURE 16. DENSE REED CANARYGRASS VEGETATOPM WITH LARGE HEADGATE ON RIGHT BANK IN BACKGROUND, DOWNSTREAM OF DRY CREEK ROAD

4.2. Nutrient Source Characterization

Potential nutrient sources within the reach are identified in Table 4. Pasture land comprised the bulk of the land along the reach. Although it was observed only at two crossings, pasture appeared to be in good condition with minimal stream encroachment and was therefore was considered a low to moderate potential nutrient source. One LCA was located south of Dry Creek Road; potential sources from the LCA would likely flow first to a large canal, then west to the main stem of Dry Creek approximately 0.4 mi downstream. Due to its distance from the main channel, the LCA was considered to have low potential significance. A large irrigation return entering from the east downstream of Dry Creek Road was confirmed on the aerial but not on the field. Because this canal drains a large agricultural area it has the potential to deliver a significant amount of nutrients to the stream.

No septic systems were located within 150 ft of the stream, and density within the 150 to 1000 ft buffer was moderate. With the good riparian quality, septic system density within the reach was determined to have low potential significance. There were likely additional irrigation withdrawals and returns within the reach but with paleochannels and subirrigated riparian this was difficult to discern on the aerial. North Dry Creek Road was the only unpaved crossing. The culvert was relatively well-armored but some sedimentation likely occurs and the culvert was considered to be a minor sediment source (Figure 17).

TABLE 4. POTENTIAL NUTRIENT SOURCES WITHIN REACH DRY 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	15	GW	Good	hay, wheat and barley production	Low
Pasture (Ave. % LB/RB)	60	SW/GW	Good	pasture in good condition with some encroachment on stream	Low/Med
Irrigation returns (#)	1	SW	Unknown	large canal, drains agricultural land	Med
Septic system per mi (150 ft/1000 ft)	0.0/4.8	GW	Good		Low
Unpaved road crossings (#)	1	SW	Good	culvert at North Dry Cr Rd; minor sediment source	Low

FIGURE 17. CULVERT DOWNSTREAM OF NORTH DRY CREEK ROAD; MINOR SEDIMENT SOURCE

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East Gallatin River

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

EAST GALLATIN RIVER

The East Gallatin River (“E. Gallatin”) is the primary water body within the Lower Gallatin TMDL Planning Area (LGTPA). With the exception of Camp Creek which drains to the Gallatin River, all of the MT 303d-listed tributaries within the LGTPA drain to the E. Gallatin. The E. Gallatin begins east of Bozeman at the confluence of Rocky Creek and Bear Creek. Rocky Creek has its headwaters in the Bangtail Mountains north and south of Bozeman Pass while Bear Creek drains the northern Gallatin Mountains.

For the purposes of assessing pollutant sources, the E. Gallatin was divided into eleven reaches based on land use and riparian type (Figure 1). These eleven reaches are divided between three water body segments on the State of Montana’s 2008 303(d) List (Table 1). Reaches 1-5, from the confluence of Rocky and Bear Creeks, downstream to Bridger Creek, (Figure 2), are associated with DEQ water body segment ID, MT41H003_010. Water quality in this upper segment is listed on the State of Montana’s 2006 303(d) list as being impaired for total phosphorus and total nitrogen. This fourth order segment flows through agricultural and rural residential areas east of Bozeman and through light urban areas within Bozeman.

Reaches 6-10, from the Bridger Creek to the confluence with Smith Creek (Figure 3), are associated with DEQ water body segment ID MT41H003_020. This segment is a fourth order stream and is listed as being impaired for low flow alterations, algae, pH, total phosphorous, and total nitrogen. Reach 11, DEQ water body segment, MT41H003_030, is a fifth order stream that extends from the confluence with Smith Creek to the where it joins the Gallatin River. Water quality in this upper segment is listed as being impaired for total nitrogen and pH. These middle and lower segments are characterized by agricultural and rural residential land use.

Each of the eleven reaches was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients. Reach-scale conditions on the E. Gallatin are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 4 and 5. See Appendix B for descriptions of the reach-scale fields displayed in Table 1, as well as details on the potential nutrient sources evaluated.

1.1. Summary

The East Gallatin River varies greatly in its approximately 40 mile length from its headwaters on Bozeman Pass to where it meets the Gallatin River north of Manhattan. The upstream segment (reaches 1-5), from the Bear Cr-Rocky Cr confluence to Bridger Cr, is predominantly a mountain-foothills stream with the riparian vegetation characterized by a cottonwood overstory and dense willow-dogwood understory. The middle segment (reaches 6-10), from Bridger Cr to Smith Cr, flows through urban areas on the northeast side of Bozeman, and through agricultural land and golf courses within the valley bottom. The lower segment (reach 11), from Smith Cr to its confluence with the Gallatin River, is a larger, more sinuous river flowing through both irrigated and dry agricultural land. Reach characteristics and potential nutrient sources for each of the three segments are summarized below.

Upper Segment: Bear Cr-Rocky Cr confluence to Bridger Cr

Land use in the upper segment is dominated by moderately-utilized horse pasture, rural residential neighborhoods, and portions of the urban area within the Bozeman city limits. Pasture land and associated bank erosion, the recently closed stockyard on East Griffin Drive, and the Bozeman urban area were identified as the most significant potential nutrient sources within this segment. Upstream of Bohart Dr the river is only marginally impacted by anthropogenic sources, with pasture land buffered from the river by healthy riparian vegetation, and stable, well-vegetated banks. Downstream of Bohart Dr the riparian becomes narrower as pasture land encroaches, and invasive weeds such as tansy and thistle are common along banks. Commercial and residential development, and associated impermeable surfaces and yard encroachment also increase through the short section of the river through northeast Bozeman. With the reduction in stabilizing riparian vegetation, bank stability decreased and banks were sloughing along several meander bends. However, due to extensive riprap, bank erosion downstream of Bohart Dr was still only moderate.

The stockyard on East Griffin Dr is located directly adjacent to the river. With a rather narrow riparian buffer along the stockyard it was considered a significant potential nutrient source to the river. Sourdough/Bozeman Cr (aka Bozeman Cr), a MT DEQ 303d-listed stream, is a tributary to this river segment. Due to its urban watershed and identified water quality impairments, Sourdough/Bozeman Cr is considered a significant potential nutrient source to the E. Gallatin. The lower portion of this segment of the East Gallatin River flows adjacent to Bridger Creek Golf Course, with turf grass was mowed directly adjacent to the river in some locations. The golf course was also considered a moderated potential nutrient source.

Middle Segment: Bridger Cr to Smith Cr

Land use in the middle section is dominated by irrigated and dry pasture land, rural residential neighborhoods, and golf courses (Bridger Creek and Riverside Golf Courses). The riparian quality was good throughout most of the segment with dense cottonwoods and willows. Residential yards, golf course turf, and pasture land did encroach on the river in several locations within the reach. Overall banks were relatively stable, with erosion concentrated in the areas where riparian vegetation was grazed or cleared. Banks were commonly stabilized using boulders, concrete, and old cars.

Nutrient inputs from golf course and pasture lands and two wastewater facilities were identified as the most significant potential nutrient sources within this segment. Livestock utilization was greater in the lower portion of this segment than in the upper, with some bank trampling observed in pasture areas. The City of Bozeman discharges treated effluent water directly to the river under an MPDES permit., The Riverside Country Club wastewater treatment ponds are also located adjacent to the river, and have the potential to impact the East Gallatin River through ground water infiltration Several tributaries enter this segment, and may contribute significant nutrient loads to the mainstem East Gallatin River.

Lower Segment: Smith Cr to Gallatin River confluence

The river increases in size and sinuosity in the lower segment, with several tributary streams entering this reach. Irrigated and dry pasture land, and hay production are the primary land uses in this segment. The riparian quality was excellent throughout most of the segment, characterized by dense cottonwoods and willows in the upper portion and a mix of willows, buffaloberry and juniper in the lower portion. Pasture land did encroach on the river in several locations, and livestock utilization was moderate. Although soils are quite erosive along the lower segment, banks were relatively stable, with erosion observed where pasture land encroached along outer meander bends, or where hay fields or lawns were mowed directly adjacent to the stream. Riprap was less common than in the middle segment.

Pasture land and tributary streams were identified as the most significant potential nutrient sources within this segment. Six tributaries enter the reach: Smith Cr, Story Cr, Dry Cr, Cowan Cr (called “East Gallatin Unknown Trib” during the 2008 and 2009 water quality monitoring), Gibson Cr, and Bullrun Cr. Tributary streams drain areas dominated by agricultural use, are influenced heavily by groundwater inputs and may contribute significant nutrient loads to the mainstem East Gallatin River.

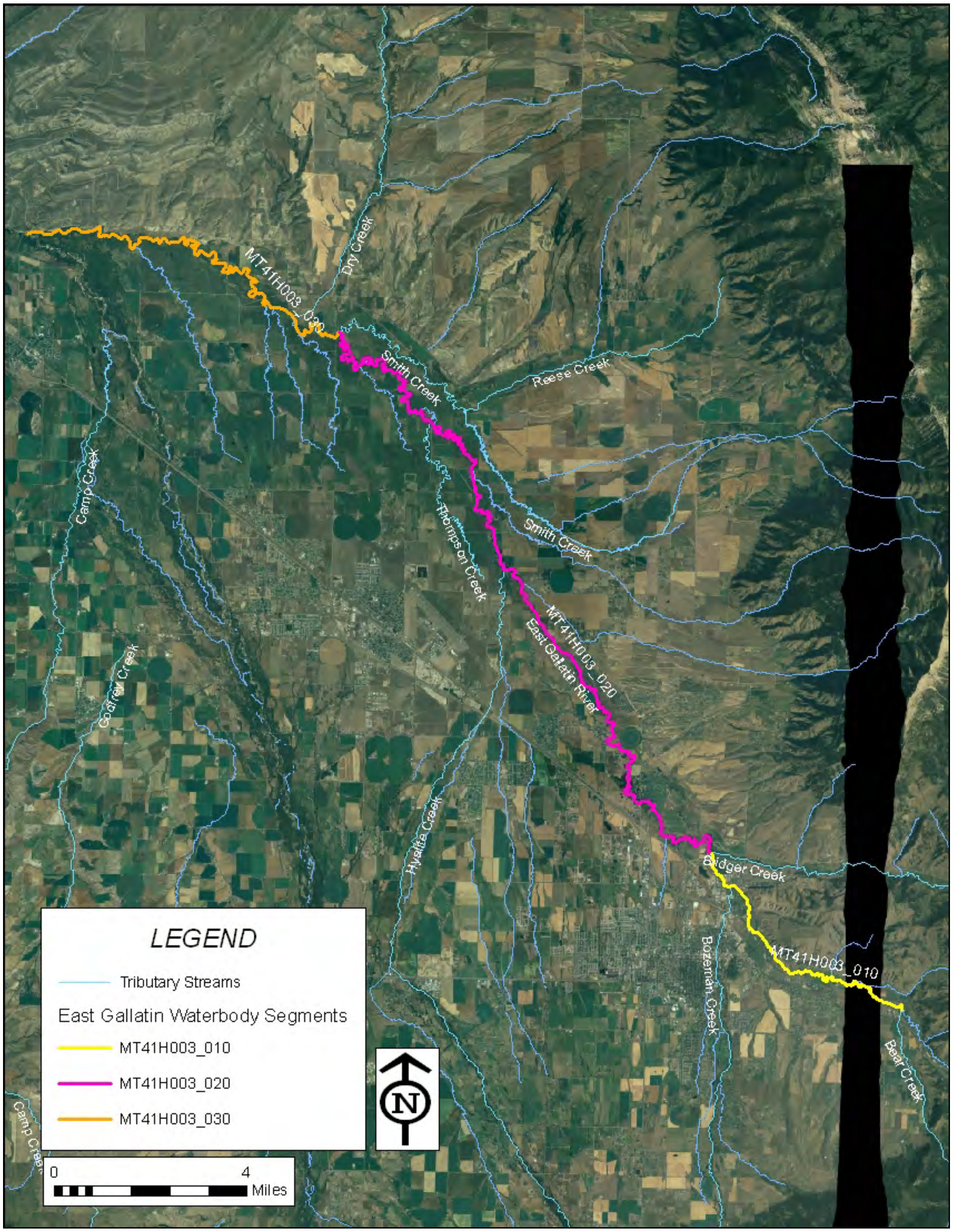

FIGURE 1. OVERVIEW OF THE THREE DEQ WATERBODY SEGMENTS FOR THE EAST GALLATIN RIVER

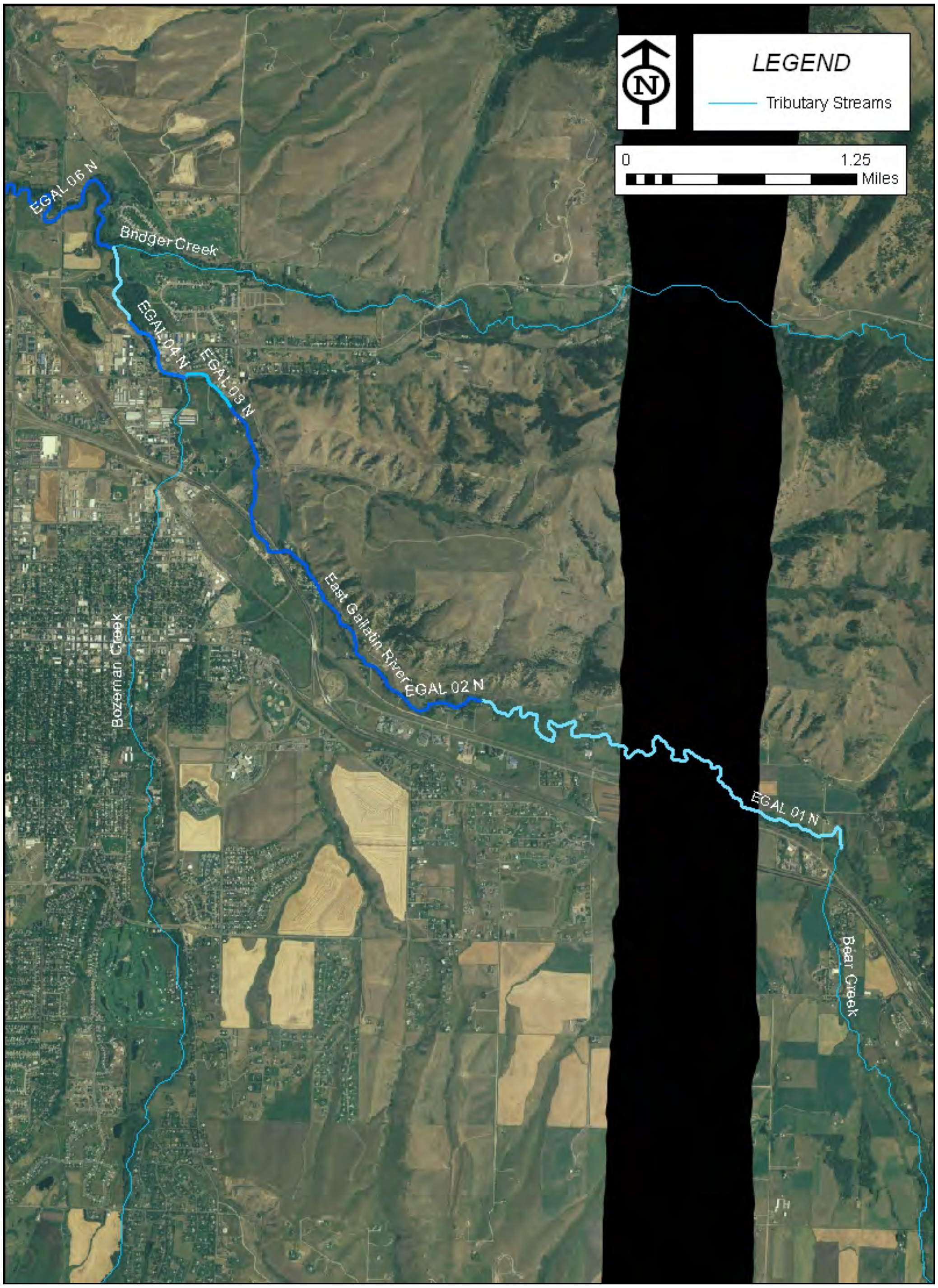

FIGURE 2. OVERVIEW OF UPPER EAST GALLATIN RIVER WATERBODY SEGMENTS (REACHES 1-5). WATER BODY SEGMENT ID MT41H003_010, FROM THE ROCKY CR-BEAR CR CONFLUENCE TO BRIDGER CR

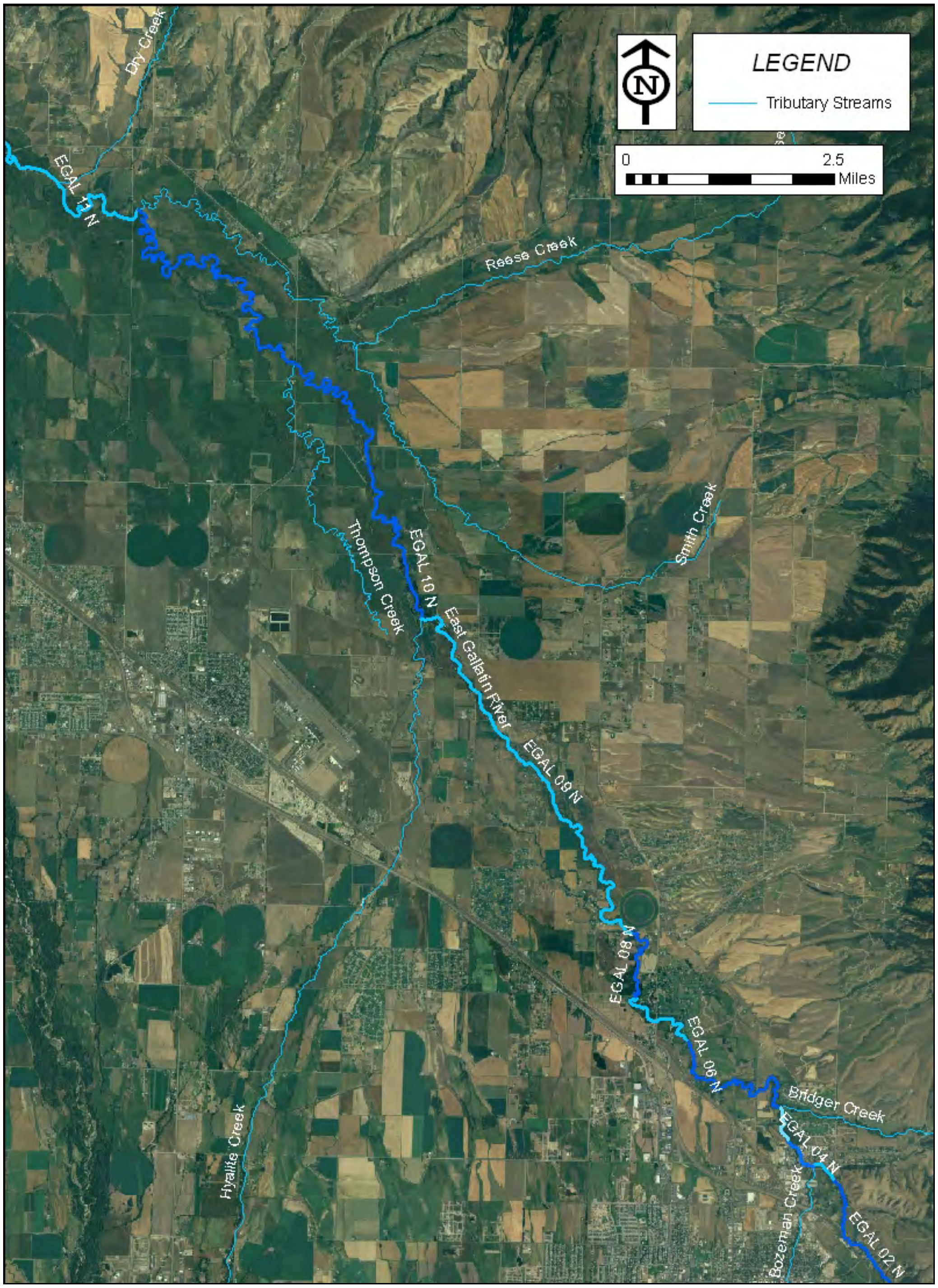

FIGURE 3. OVERVIEW OF UPPER EAST GALLATIN RIVER WATERBODY SEGMENTS (REACHES 6-10). WATER BODY SEGMENT ID MT41H003_020, FROM BRIDGER CREEK TO SMITH CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Waterbody Seg. ID	Listed Impairments	Reach ID	Reach length (mi)	Ecoreg.	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP*	Septic 150 ft per mi	Septic 1000 ft per mi
MT41H003_010 Bear Cr-Rocky Cr confluence to Bridger Cr	Total phosphorous, total nitrogen	EGAL 01 N	3.16	17w	4	RURAL RESIDENCE/ PASTURE	N	4	0	L	80	WG, RPF	1.6	9.2
		EGAL 02 N	2.56	17w	4	RURAL RESIDENCE/ PASTURE	N	4	2000	M	70	RPF	0.4	5.9
		EGAL 03 N	0.34	17w	4	PASTURE	N	0	0	L	100	NA	0.0	2.9
		EGAL 04 N	0.49	17w	4	URBAN	N	0	50	L	50	NA	0.0	0.0
		EGAL 05 N	0.45	17w	4	GOLF/RURAL RESIDENCE	N	0	0	L	175	NA	0.0	0.0
MT41H003_020 Bridger Cr to Smith Cr	Low flow, algae, pH, total phosphorous, total nitrogen	EGAL 06 N	2.58	17w	4	PASTURE/ HAY	N	0	0	M	120	RPF	0.0	7.0
		EGAL 07 N	1.31	17w	4	GOLF/ RECREATION	N	0	0	L	250	RIP_ BUFF	0.0	0.0
		EGAL 08 N	1.21	17w	4	PASTURE	N	0	0	L	100	NA	0.0	2.5
		EGAL 09 N	5.96	17w	4	RURAL RESIDENCE/ PASTURE/HAY	N	1	0	M	110	NA	0.2	7.0
		EGAL 10 N	12.01	17w	4	PASTURE/HAY	N	2	0	M	120	NA	0.0	1.2
MT41H003_030 Smith Cr to Gallatin River	Total nitrogen, pH	EGAL 11 N	11.75	17w	5	PASTURE/ RANGE	N	3	0	L	150	NA	0.2	1.9

***RPF: riparian fencing; WG: water gap; RIP_BUFF: riparian buffer**

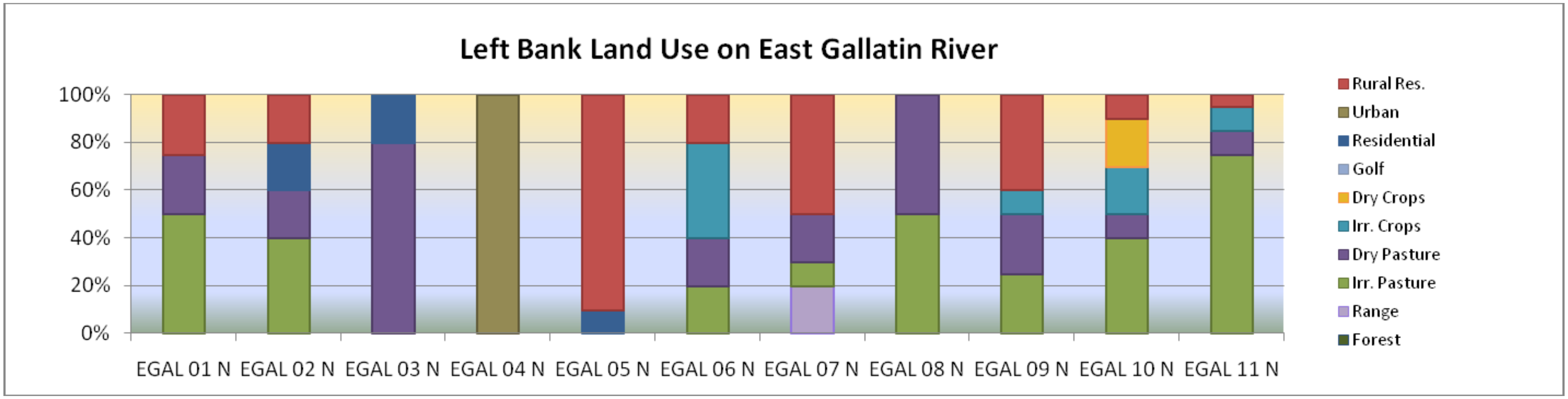

FIGURE 4. LAND USE TYPES ALONG THE LEFT BANK OF THE EAST GALLATIN RIVER

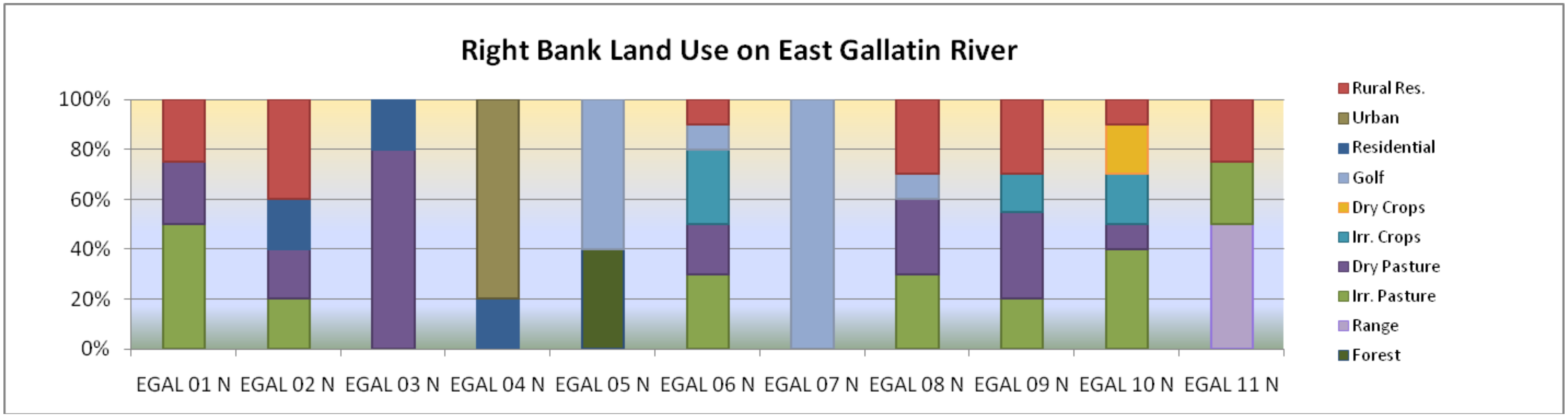

FIGURE 5. LAND USE TYPES ALONG THE RIGHT BANK OF THE EAST GALLATIN RIVER

2. EGAL 01 N

The E. Gallatin begins where Rocky Cr and Bear Cr merge north of Interstate 90 east of Bozeman. Rocky Cr has its headwaters in the Bangtail Mountains north and south of Interstate 90 on the west side of Bozeman Pass. Bear Cr flows north from the Gallatin Mountains south of Interstate 90. The reach spans from the confluence of the two creeks, downstream past Story Hill Rd (Figure 6). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

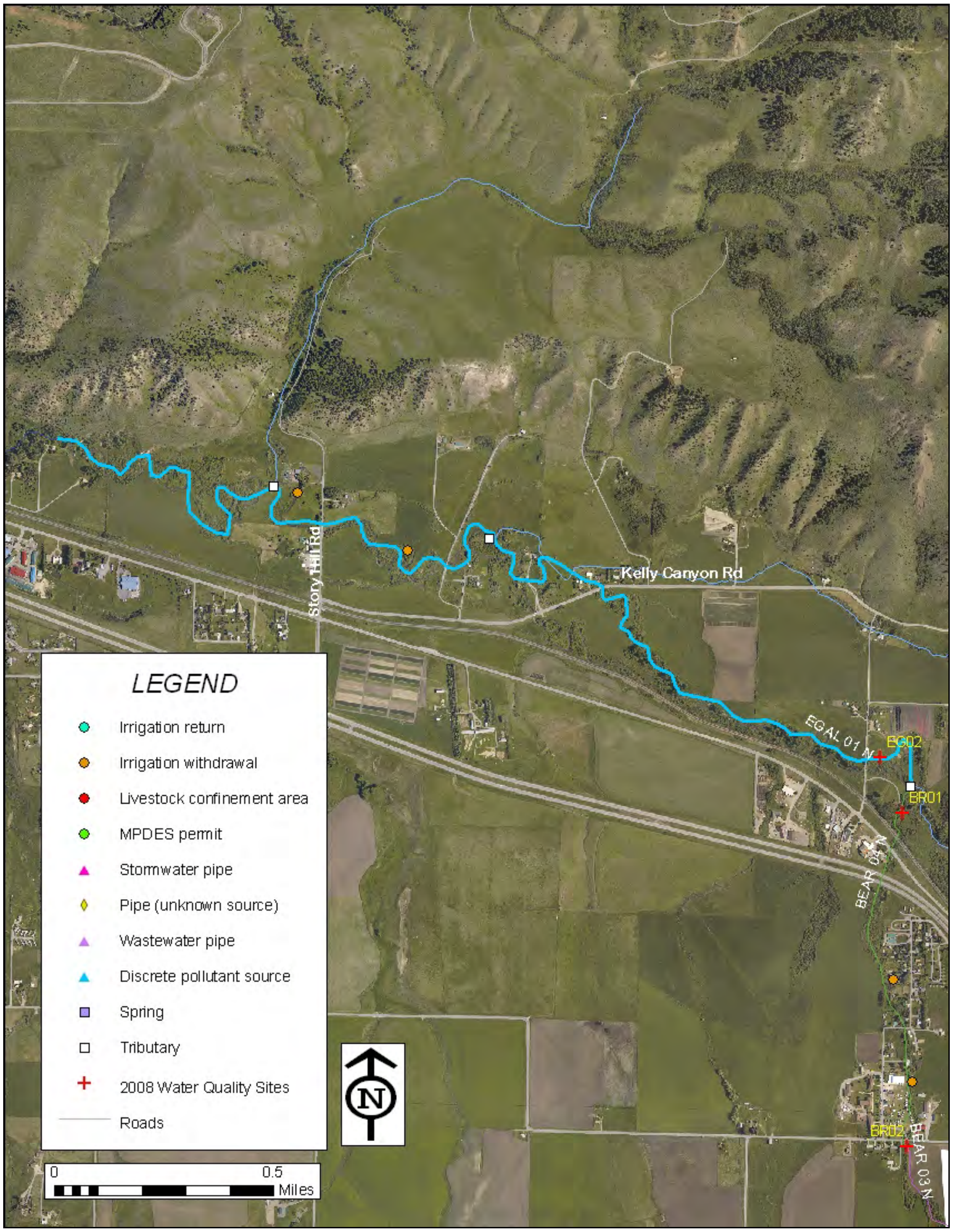

FIGURE 6. REACH EGAL 01 N

2.1. Reach Condition

The dominant land uses within the reach are rural residence and irrigated and dry pasture land. The riparian vegetation is quite healthy, with dense willows and cottonwoods and adjacent pasture land (Figures 7 and 8). Very little bank erosion and pasture encroachment were observed. Two irrigation withdrawals were identified within the reach, both of which were definitively confirmed on the aerial. Two small tributary streams enter within the reach, Kelly Cr and Little Bridger Cr. A water gap extending approximately 20 feet into the channel was observed downstream of Kelly Canyon Rd. Riparian fencing was observed upstream of Story Hill Rd and is likely common in this reach where land use is dominated by low livestock densities on pasture land associated with small-acreage landowners (e.g. Figure 7).

FIGURE 7. DENSE WILLOW/COTTONWOOD RIPARIAN WITH ADJACENT PASTURE AND RIPRAP

FIGURE 8. DENSE WILLOW/COTTONWOOD RIPARIAN WITH WATER GAP ON RIGHT BANK

2.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 2. Although pasture land was abundant along the reach, pasture was considered only a moderate potential nutrient source as livestock densities were rather low and best management practices such as riparian fencing and a water gap were observed. The two tributary streams were small, with robust riparian zones observed on the aerial and were therefore not considered a significant nutrient source. Septic system density within 150 feet of the stream was low while density within 1000 feet was moderate. The four unpaved crossings were well armored and vegetated at the abutments and were not considered a significant nutrient or sediment source. No road encroachment was observed.

TABLE 2. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (average LB/RB)	75	GW/SW	Excellent	Low density livestock on the pasture, riparian fencing observed	Med
Tributaries (#)	2	SW	Excellent	Small tribs Kelly Cr, Little Bridger Cr	Low
Septic in tributaries	LOW	SW	Excellent		Med
Septic system per mi (150 ft/1000 ft)	1.6/9.2	GW	Excellent		Low
Unpaved road crossings (#)	4	SW	Excellent	Two roads, two driveways, all well-armored and vegetated at abutments	Low

3. EGAL 02 N

Reach 2 begins downstream of Story Hill Rd, flows north of Interstate 90, and ends upstream of the stockyards off of East Griffin Dr (Figure 9). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

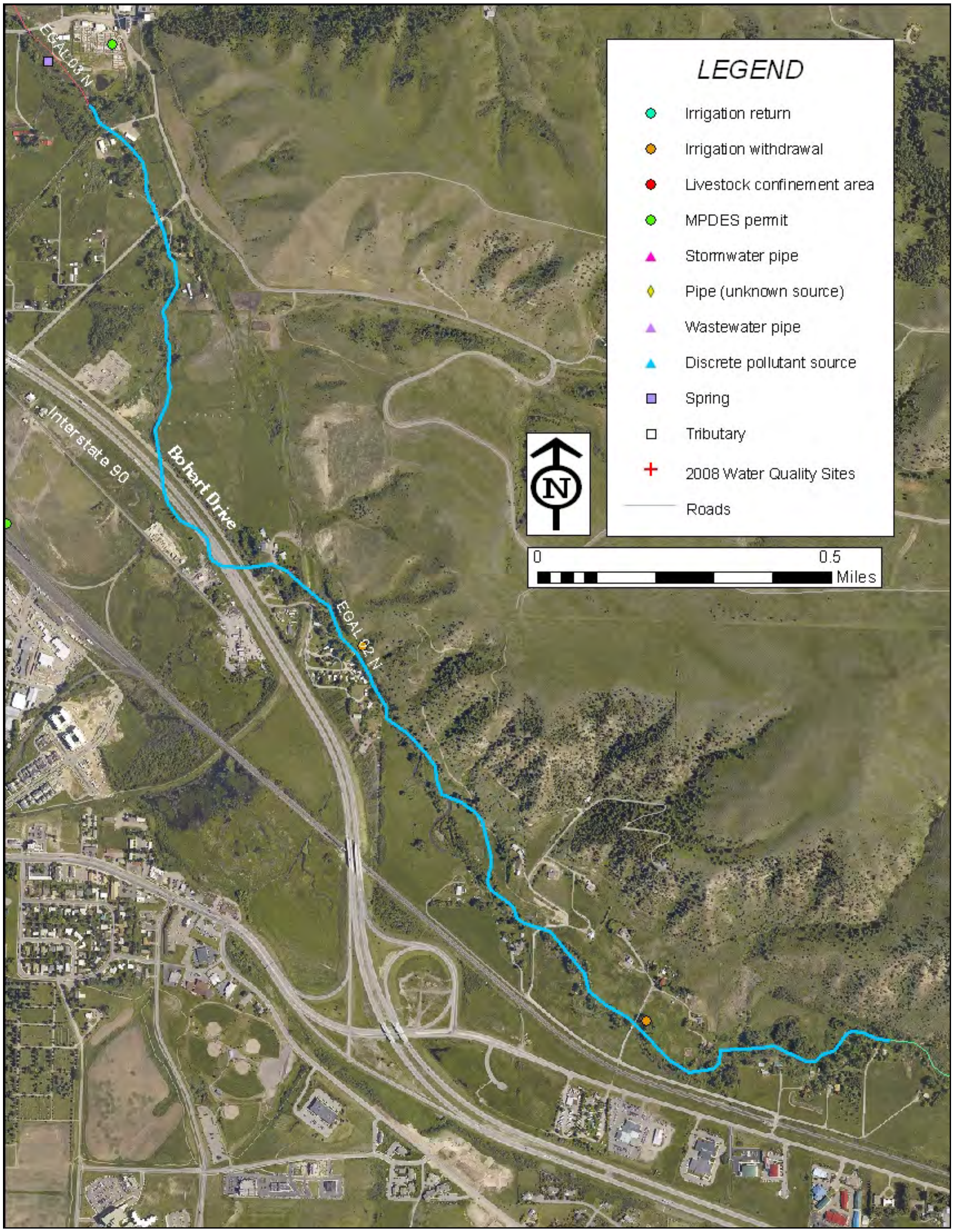

FIGURE 9. REACH EGAL 02 N

3.1. Reach Condition

The dominant land uses within the reach are irrigated pasture and rural residential neighborhoods. Upstream of Bohart Drive (on the north side of Interstate 90), the riparian vegetation is healthy with dense willows and cottonwoods and relatively stable banks (Figure 10). Downstream of Bohart Dr residential density and pasture encroachment increases, riparian quality and bank stability decrease significantly, and invasive weeds become common along banks (Figures 11 and 12). Bank erosion was moderate throughout the reach. Bohart Dr encroaches on the river for approximately 2000 ft. One irrigation withdrawal was identified within the reach and confirmed on the aerial. Riparian fencing was observed near the North Wallace crossing and is likely present along additional stretches of the reach.

FIGURE 10. ROBUST WILLOW-COTTONWOOD RIPARIAN JUST DOWNSTREAM OF STORY HILL RD

FIGURE 11. ERODING BANK ALONG BOHART DRIVE, INVASIVES KNAPWEED AND TANSY ON BANK

FIGURE 12. BOHART DRIVE ENCROACHING ALONG RIVER, RIPRAP, AND INVASIVES KNAPWEED AND TANSY ON BANK

3.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 3. Pasture and residential yard encroachment downstream of Bohart Dr, and associated poor riparian quality and bank instability were the primary potential nutrient sources within the reach. Although Bohart Dr encroachment on the stream was not likely causing direct sedimentation into the river, the road was altering the natural channel pattern, causing increased erosion along encroachment areas (Figure 12). Three unpaved driveways and the chip-sealed North Wallace St cross the river along this reach. All of the crossings were well armored and vegetated and were not considered significant nutrient or sediment sources.

TABLE 3. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (average LB/RB)	50	GW/SW	Poor/Good	Minimal pasture encroachment upstream of Bohart Dr, often overgrazed and weedy downstrm of Bohart Dr.	Med/high
Residential yard encroachment	Mod/high	GW/SW	Poor	High downstream of Bohart Dr	Med/high
Septic system per mi (150 ft/1000 ft)	0.4/5.9	SW	Excellent	Septics concentrated upstream of Bohart Dr where riparian quality is excellent	Low
Unpaved road crossings (#)	4	SW	Good	3 driveways and N. Wallace St (chip-sealed). All crossings well armored and vegetated.	Low

4. EGAL 03 N

Reach 3 begins upstream of the old Headwaters Livestock Auction facility off of East Griffin Drive and extends only 1/3 mile downstream to the confluence with Sourdough/Bozeman Cr (Figure 13). This short reach was delineated due to the distinct land use present, specifically the stockyard. The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

FIGURE 13. REACH EGAL 03 N

4.1. Reach Condition

The dominant land use within the reach is dry pasture in the form of the old Headwaters Livestock Auction stockyard adjacent to the river, and other moderately-used pasture land. Overall the riparian vegetation is robust with healthy cottonwoods (Figure 14), yet it is narrow in some places and dense tansy and pasture grasses are common in the understory (Figure 15). Pasture encroachment was specifically noted on the aerial adjacent to the stockyard, and bank failures and extensive rip-rap were observed on the banks adjacent to the old stockyard. Bank erosion was also observed downstream of the Gallatin Valley Land Trust trail footbridge (Figure 16).

FIGURE 14. HEALTHY COTTONWOOD RIPARIAN DOWNSTREAM OF GALLATIN VALLEY LAND TRUST FOOTBRIDGE

FIGURE 15. NARROW RIPARIAN WITH ADJACENT PASTURE

FIGURE 16. BANK EROSION DOWNSTREAM OF GALLATIN VALLEY LAND TRUST FOOTBRIDGE

4.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 4. The recently closed Headwaters Livestock Auction stockyard adjacent to the river is the most significant potential nutrient source within the reach. Since sale of Headwaters Livestock Auction property, some site cleanup has occurred, and while livestock are no longer present on the property, the stockyard has the potential to deliver 'legacy' nutrients directly to the river via both surface and groundwater, and also through potential bank failure of nutrient-rich soils. Pasture along the remainder of the reach was not heavily utilized by livestock, and was generally buffered by at least a narrow riparian buffer strip (Figure 15). An irrigation return also flows through a lot on the old stockyard and enters into the head of the reach, and may be a potential nutrient source to this reach.

TABLE 4. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (average LB/RB)	35	GW/SW	Good	Well-buffered, low utilization	Low
Stockyard	high	GW/SW	Poor	Narrow riparian, stockyard directly adjacent to river	Med
Irrigation returns/springs (#)	1	SW	Good	Irrigation return flows though previous cattle holding pens.	Low/med
Septic system per mi (150 ft/1000 ft)	0/2.9	SW	Good		Low

5. EGAL 04 N

Reach 4 begins at the confluence with Sourdough/Bozeman Cr and extends downstream only ½ mile to where the adjacent land use transitions from primarily urban to the relatively undeveloped East Gallatin Recreation area (Figure 17). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

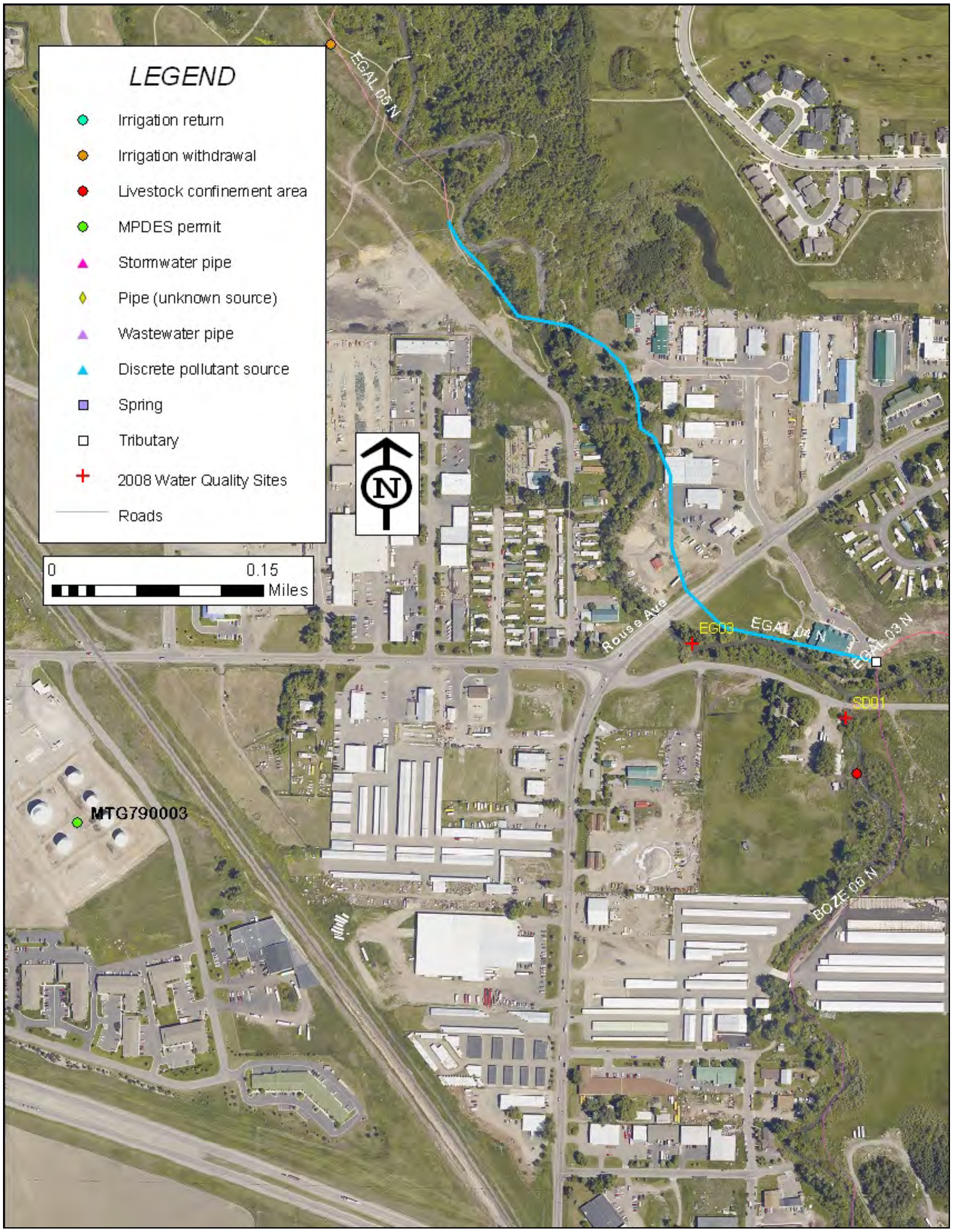

FIGURE 17. REACH EGAL 04 N

5.1. Reach Condition

The river flows through primarily urban land use within this reach, including both industrial and residential areas. The riparian condition and bank stability varied throughout the reach. At the Rouse Ave crossing riparian quality was very low, consisting of a narrow strip of cottonwoods directly adjacent to commercial and residential yards (Figure 18). Bank stability at this location was moderate, with banks heavily rip-rapped (Figure 19). Upstream and downstream of Rouse Ave the riparian area was wider, with healthy willows and cottonwoods and stable banks (Figure 20). Sourdough/Bozeman Cr enters at the upstream end of the reach. Road encroachment was limited to 50 ft along the paved North Rouse Avenue.

FIGURE 18. RIPARIAN DOWNSTREAM OF NORTH ROUSE AVE COMPRISED OF NARROW STRIP OF COTTONWOODS

FIGURE 19. RIPRAP DOWNSTREAM OF NORTH ROUSE AVE, LOW RIPARIAN QUALITY

FIGURE 20. HEALTHY RIPARIAN AT DOWNSTREAM END OF REACH

5.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 5. Sourdough/Bozeman Cr enters the river at the upstream end of the reach. This large tributary drains primarily urban areas within the City of Bozeman and is considered a significant potential nutrient source to the East Gallatin River. Commercial and residential development within the reach is associated with areas of impermeable surface and yard encroachment, which could function as nutrient sources to the river. One MPDES permit for Exxon Mobile's Bozeman Terminal (Table 6, Figure 17) was identified approximately ½ mile from the river. Due to this distance from the river, this MPDES permit was not considered a likely potential pollutant source.

TABLE 5. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 04 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Tributary	high	SW	NA	Sourdough/Bozeman Cr enters at start of reach, significant potential pollutant source	Med/high
Commercial and residential development	high	SW/GW	Poor	Abundant encroachment of impermeable surfaces and yards	Med
MPDES permits (#)	1	SW/GW	Poor	See Table 7	Low/Non

TABLE 6. MPDES PERMITS LOCATED WITHIN REACH HY04 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTG790003	Exxon Mobile Bozeman Terminal	General	Located nearly ½ mile from river, not likely pollutant source	EGAL 04

6. EGAL 05 N

Reach 5 extends from the East Gallatin Recreation Area, downstream to the confluence with Bridger Creek (Figure 21). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

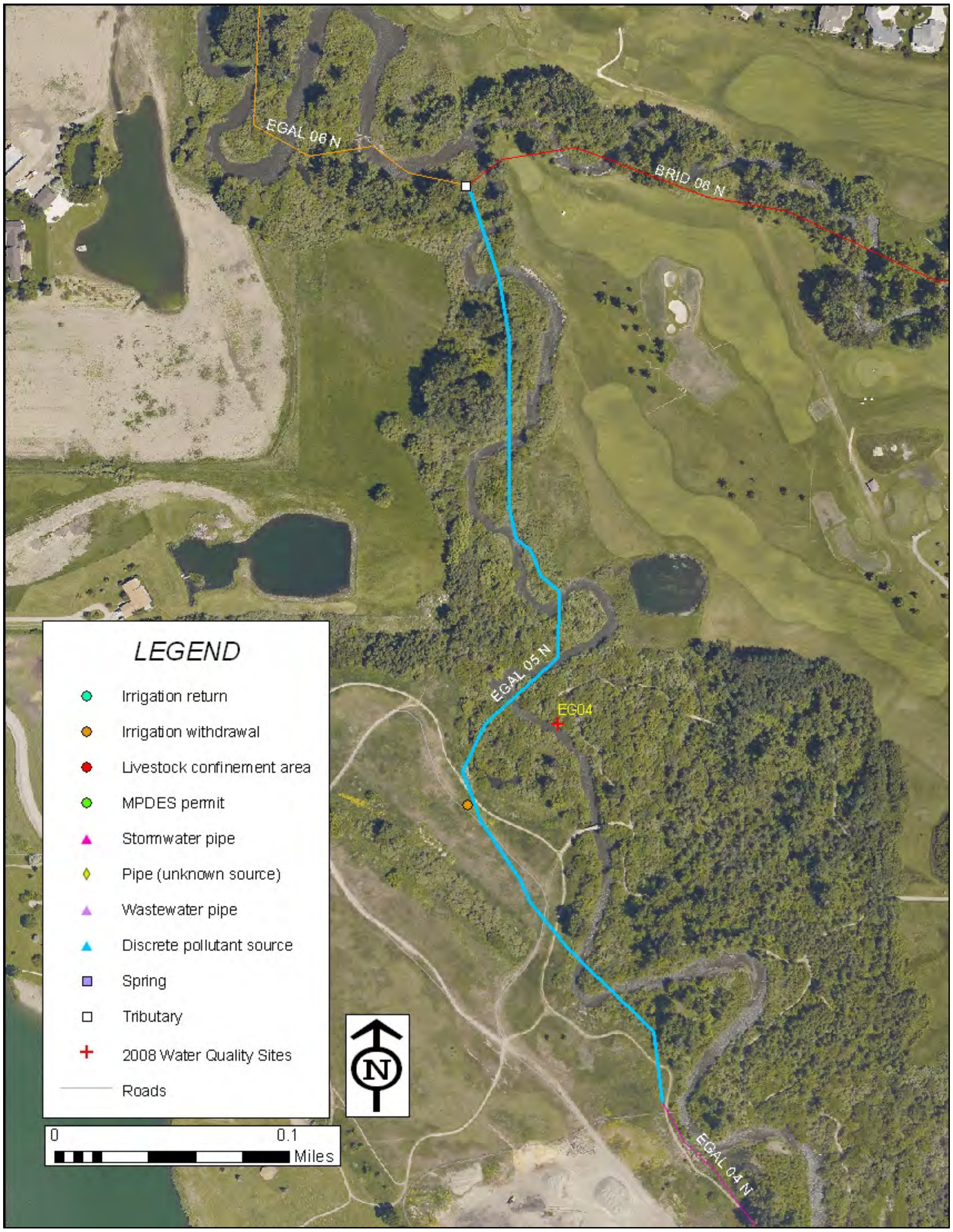

FIGURE 21. REACH EGAL 05 N

6.1. Reach Condition

In the upper section the river is in a relatively natural state as it flows through the East Gallatin Recreation Area. Land use in the lower section is dominated by both the recreation area as well as the Bridger Creek Golf Course. The riparian area is wide and robust throughout most of the reach, with dense cottonwoods, alders, dogwoods and willows (Figure 22), with the exception of limited areas of turf encroachment along the golf course. No bank erosion was observed. One irrigation withdrawal was identified on the aerial but was not confirmed in the field.

FIGURE 22. DENSE WILLOW-COTTONWOOD RIPARIAN VEGETATION WITHIN EAST GALLATIN RECREATION AREA

6.2. Potential Nutrient Sources

The golf course was the only potential nutrient source identified within the reach (Table 7). The golf course was considered a moderately significant potential source due to turf encroachment observed in certain areas and associated fertilizers that could enter the river via surface runoff and/or groundwater transport.

TABLE 7. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 05 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Golf % (average LB/RB)	30	GW/SW	Good	Some areas of turf encroachment, potential nutrient source	Med

7. EGAL 06 N

Reach 6 extends from the confluence with Bridger Creek downstream to where the river enters the Riverside Country Club (Figure 23). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

FIGURE 23. REACH EGAL 06 N

7.1. Reach Condition

Land use in reach 6 is primarily residential, pasture land, and hay production (Figure 24), with the Bridger Creek Golf Course located adjacent to the river on the right bank in the upper-most section of the reach (Figure 23). Riparian vegetation in the reach is a mix of dense cottonwoods and willows (Figure 25), yet pasture and residential yard encroachment are common (Figure 26). Golf course turf was mowed directly adjacent to the stream in several locations along the golf course. Largely due to encroaching pasture land and lawns, bank erosion was considered moderate, with several areas of erosion noted on meander bends (Figure 27). The river also flows through the MT Fish, Wildlife and Parks Cherry River Fishing Access Site (FAS), where the riparian area is in a relatively natural state, yet historic land uses in the area have resulted in extensive bank erosion and riprap (Figure 27 and 28) including car bodies used to stabilize banks. Downstream of the Cherry River FAS, riparian continued to be dense where residential yard encroachment was not occurring. A bank stabilization project at a private residence was also observed in the lower portion of the reach (Figure 29).

Bridger Cr is a primary tributary to the reach and drains a variety of land uses, primarily rural residential lands and pasturelands. Mandeville Creek also enters the East Gallatin River within the reach. Mandeville Creek drains residential and urban areas of Bozeman and may be a significant source of nutrients to the Eats Gallatin River. Two irrigation withdrawals were identified within the reach, both of which were possibly, but not definitively, confirmed on the aerial.

FIGURE 24. HAY PRODUCTION AND DENSE, HEALTHY RIPARIAN UPSTREAM OF MANLEY RD

FIGURE 25. DENSE COTTONWOOD-WILLOW RIPARIAN UPSTREAM OF MANLEY RD

FIGURE 26. PASTURE ENCROACHMENT AND DENSE COTTONWOOD RIPARIAN DOWNSTREAM OF MANLEY RD

FIGURE 27. BANK EROSION AND RIPRAP WITHIN THE CHERRY RIVER FAS

FIGURE 28. HEALTHY RIPARIAN AND RIPRAP, WITHIN THE CHERRY RIVER FAS

FIGURE 29. HEALTHY RIPARIAN IN BACKGROUND, BANK STABILIZATION PROJECT IN FOREGROUND

7.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 8. Pasture and irrigated agriculture were the primary potential nutrient sources within the reach. The golf course and residential lawn encroachment could also act as nutrient sources through fertilizers entering the river through surface and groundwater. The LCA identified was located approximately 1/3 of a mile from the river, and with the good riparian quality was not considered a potential nutrient source. MPDES permits are located within the reach (Table 9). The Manley Meadows Homeowners Association has a groundwater permit approximately ¾ of a mile from the river, which is not likely a significant nutrient source. The City of Bozeman has a stormwater permit for the landfill, located within a ½ mile of both Bridger Cr and the river. Although regulated through the permit, landfill stormwater runoff could be a potential source of nutrients to the river during severe events..

TABLE 8. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 06 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (LB/RB)	45	GW/SW	Good	Relatively low density utilization but often encroaching	Low/med
Irrigated crops % (average LB/RB)	35	GW	Good	Often encroaching	Low/med
LCA (#)	1	GW/SW	Good	Located ~1/3 mi from river, not likely significant nutrient source	Low
Tributaries (#)	2	SW	Good	Bridger Cr , Mandeville Creek	Low/med
MPDES permits (#)	2	GW, SW	Good	see Table 10	Low
Septic system per mi (150 ft/1000 ft)	0/7.0	SW	Good	Healthy riparian buffer throughout most of reach	Low

TABLE 9. MPDES PERMITS LOCATED WITHIN REACH EGAL 06 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTR000403	City of Bozeman	Stormwater	Located ~1/2 mi from the river, associated with landfill. Very possibly flows to Bridger Cr first.	EGAL 06, pos. BRID 06
MTX000153	Manley Meadows Homeowners Association	Groundwater	Located ~3/4 mi from the river, not likely potential nutrient source	EGAL 06

8. EGAL 07 N

Reach 7 flows through the Riverside Country Club and along the City of Bozeman Wastewater Treatment Plant, ending downstream at the Springhill Sod Farm off of Springhill Rd (Figure 30). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

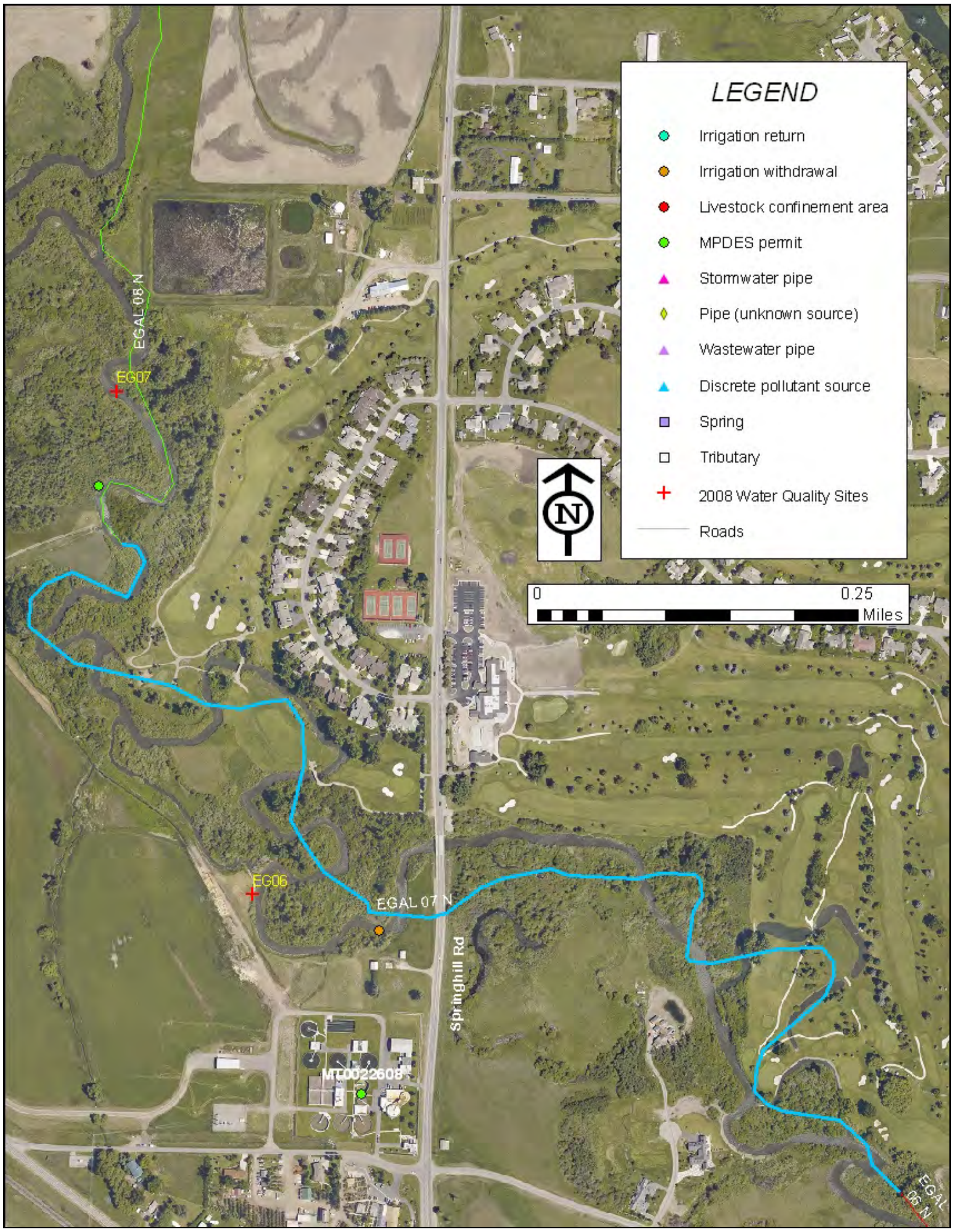

FIGURE 30. REACH EGAL 07 N

8.1. Reach Condition

Golf course and pasture land comprise most of the land use along reach 7 (Figure 30). The riparian area along the reach is comprised of dense cottonwoods and willows (Figure 31), with areas of pasture, residential yard, and turf grass encroachment (Figure 32). Golf course turf was observed mowed within 20 feet of the river for approximately ½ mile upstream of Springhill Rd. While narrow, the 20 foot riparian buffer was considered better than removal of all riparian vegetation and mowing of turf directly to the river's edge. Minimal bank erosion was observed due to the robust riparian vegetation throughout most of the reach.

No tributaries enter the reach, but an historic oxbow on the river channel, now filled with water within the golf course, returns water to the river at the upstream end of the reach (see oxbow noted on Figure 30). This oxbow channel now functions as a pond feature on the golf course (Figure 33). Golf course turf is mowed directly to its edges, and it is eutrified with dense algal growth. One irrigation withdrawal was identified but was not confirmed on the aerial or in the field.

FIGURE 31. DENSE COTTONWOOD-WILLOW RIPARIAN UPSTREAM OF SPRINGHILL RD

FIGURE 32. COTTONWOOD-WILLOW RIPARIAN ALONG THE RIVERSIDE COUNTRY CLUB. PASTURE ENCROACHMENT AND BANK EROSION IN BACKGROUND.

FIGURE 33. NUTRIENT-RICH OXBOW CHANNEL (NOW GOLF POND) WITHIN RIVERSIDE COUNTRY CLUB GOLF COURSE, DRAINS THROUGH CHANNEL TO REACH EGAL 07

8.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 10. Pasture land and the Riverside Golf Course were the most significant potential nutrient sources within the reach. Although the riparian buffer was generally wide along the golf course, it covers a significant portion of the reach and turf was observed mowed within 20 feet of the river in several areas. Therefore turf fertilizers were considered a significant potential nutrient source along reach 7. The oxbow channel discussed in the previous section could be a significant source of nutrients as it drains fertilized golf course turf, contains dense algal growth, and has no riparian buffer to protect it from overland inputs. The MPDES permit shown in Figure 30 is located at the offices of the City of Bozeman Wastewater Treatment Plant, however the actual permitted discharge for the WWTP is located downstream at the start of reach 8 (see Figure 34).

TABLE 10. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 07 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (average LB/RB)	5	GW/SW	Good/ excellent		Low
Golf % (average LB/RB)	50	GW/SW	Good/ excellent	High prevalence, often narrow riparian, golf course returns water to river	Med

9. EGAL 08 N

Reach 8 extends from the Riverside Country Club, downstream to the Springhill Sod Farm off of Springhill Rd (Figure 34). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

FIGURE 34. REACH EGAL 08 N

9.1. Reach Condition

Pasture comprises most of the land use along reach 8, with the Riverside Country Club Golf Course and City of Bozeman Wastewater Treatment Plant outfall located at the upstream end of the reach (Figure 34). The riparian zone is relatively healthy in the upper and lower sections of the reach, with dense cottonwoods and minimal bank erosion, although some riprap was observed along banks (Figures 35 and 36). Riparian quality was poor in the middle section of the reach with heavily grazed pasture encroachment, a narrow riparian, and bank erosion on outer meander bends (Figure 37). Based on assessment of the aerial there appears to be a wide riparian buffer between the golf course and the river.

FIGURE 35. HEALTHY, WIDE RIPARIAN IN UPPER SECTION OF REACH AT CITY OF BOZEMAN WASTEWATER TREATMENT PLANT

FIGURE 36. DENSE, WIDE COTTONWOOD RIPARIAN WITH RIPRAP ON BANK, AT DOWNSTREAM END OF REACH

FIGURE 37. NARROW RIPARIAN WITH PASTURE ENCROACHMENT, INVASIVE WEEDS AND ERODING BANKS IN MIDDLE SECTION OF REACH

9.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 11. Potentially significant nutrient sources within this reach include agricultural pasturelands, the Riverside Subdivision wastewater treatment lagoons, and the City of Bozeman WWTP discharge. Pasture land is heavily utilized in the middle section of the reach and was considered a moderately significant potential nutrient source. The City of Bozeman WWTP discharges treated effluent water directly to the East Gallatin River, and is regulated under an MPDES permit (Table 12). The Riverside Subdivision wastewater treatment lagoons are located directly adjacent to the river, and are not regulated under an MPDES permit. Due to their proximity to the river and what appears on the aerial to be a narrow riparian buffer, the treatment lagoons were considered a potential nutrient source.

TABLE 11. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 08 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (average LB/RB)	40	GW/SW	Fair/Good	Fair/good where pasture most prevalent; excellent in upper and lower where pasture not common	Med
Waste water treatment lagoons (#)	1	GW	Fair/Good	Riverside Subdivision lagoons, located adjacent to river	Med
Golf % (average LB/RB)	5	GW/SW	Excellent	Appears to be wide buffer where golf course located; only present on short stretch of river	Low
Irrigation returns/springs (#)	1	SW	NA		Low
MPDES permits (#)	1	SW	NA	see Table 14	High
Septic system per mi (150 ft/1000 ft)	0/2.5	SW	Good		Low

TABLE 12. MPDES PERMITS LOCATED WITHIN REACH EGAL 08 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MT0022608	City of Bozeman Wastewater Treatment Plant	Individual	Treated wastewater discharges directly to river	EGAL 08

10. EGAL 09 N

Reach 9 is a longer reach, extending from Springhill Sod Farm off of Springhill Rd, downstream approximately six miles to the confluence with Hyalite Creek (Figure 38). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

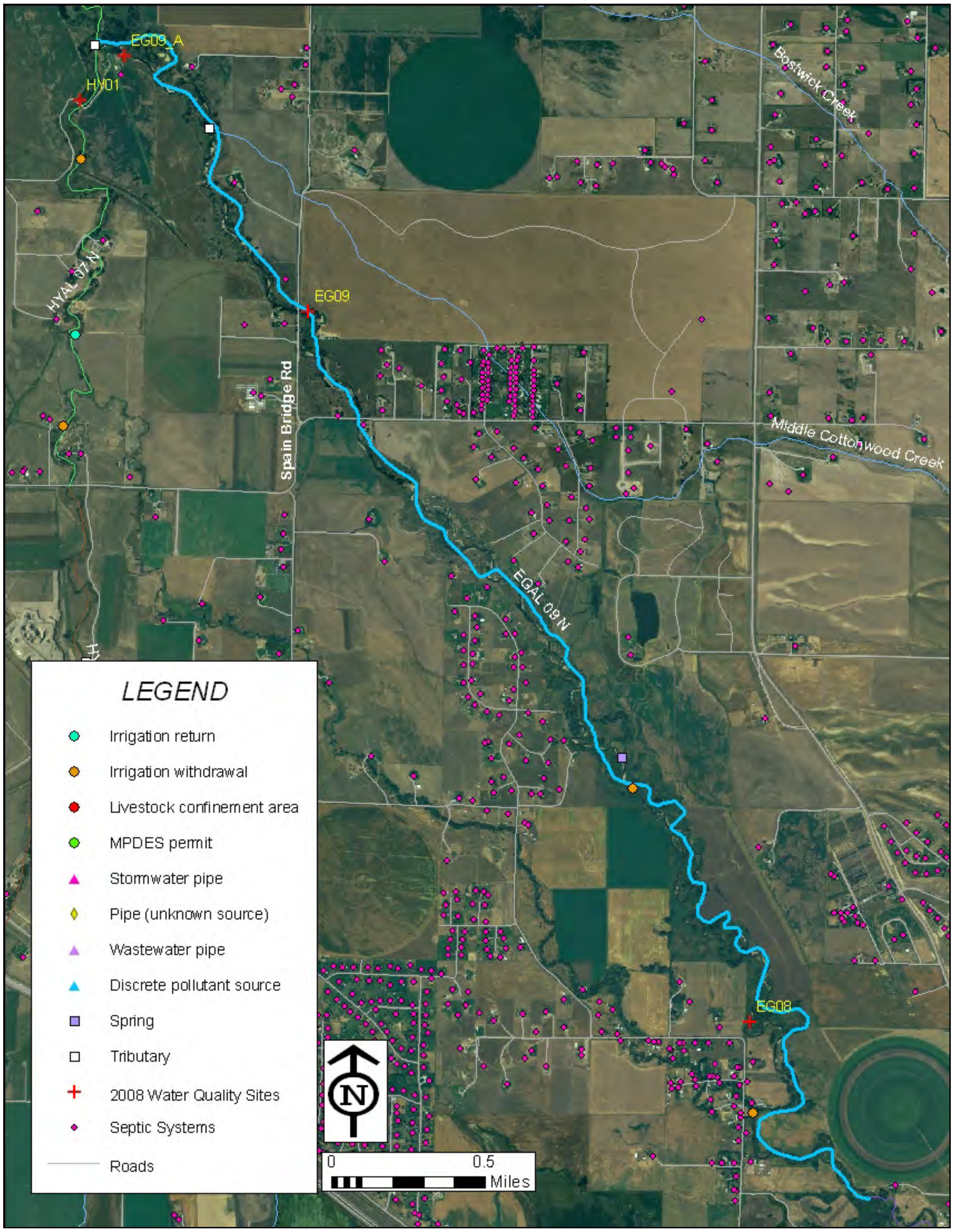

FIGURE 38. REACH EGAL 09 N

10.1. Reach Condition

Primary land uses within reach 9 were pasture and hay production, and residential subdivisions. Access was difficult in this reach due to a lack of road crossings, and was only directly observed at four locations along the six mile reach (at the Springhill Sod Farm, water quality site EG08 off of Nelson Rd, water quality site EG09 at Spain Bridge Rd, and at the confluence with Hyalite Cr). Riparian quality was relatively good where the river was observed (Figure 39), with some pasture encroachment and invasive weeds noted (Figures 40 and 41). However, based on the aerial it appears that pasture encroachment was common throughout the reach. Bank erosion was moderate within the reach, with erosion observed on outer meander bends. Extensive areas of riprap indicate low bank stability in the erodible soils within the river bottom (Figure 41).

The MT 303d tributaries GIS layer indicates that Middle Cottonwood Creek enters near the downstream end of the reach, yet on the aerial it appears to flow into a series of irrigation ditches prior to entering the river farther upstream (Figure 38). Two irrigation withdrawals were identified within the reach. A distinct channel was confirmed associated with the upstream withdrawal, while confirmation of the downstream withdrawal was difficult to confirm on the aerial due to the subirrigated riparian area near the river at the withdrawal location.

FIGURE 39. DENSE COTTONWOOD-WILLOW RIPARIAN NEAR NELSON RD AT WATER QUALITY MONITORING SITE EG08

FIGURE 40. COTTONWOOD RIPARIAN WITH YARD/PASTURE ENCROACHMENT NEAR NELSON RD AT WATER QUALITY MONITORING SITE EG08

FIGURE 41. INVASIVE TANSY AND HIGH SLOUGHING BANK ON OUTER MEANDER

10.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 13. Pasture encroachment and associated bank erosion was the primary potential pollutant source within reach 9. Pasture was common and was often encroaching on the river and was considered a moderately significant nutrient source. Septic systems along Middle Cottonwood Cr appeared high based on the GIS coverage (Figure 38), however based on the aerial it appears that the creek enters an irrigation ditch prior to flowing through the densest area of septics, reducing the potential of the tributary septics as a nutrient source. The unpaved Spain Bridge Rd crosses the reach (Figure 42) but the crossing was in good condition, with stable, vegetated banks, and was not considered a potential nutrient source.

TABLE 13. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 09 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (average LB/RB)	53	GW/SW	Good	Pasture frequent, encroachment common, associated with bank erosion	Med
Irrigated crops % (average LB/RB)	13	GW	Good		Low
Tributaries (#)	1	SW	Unknown	Middle Cottonwood Cr; flows through agricultural areas	Low/med
Septic in tributaries	High	SW/GW	Good	Middle Cottonwood Cr likely does not flow through neighborhood where septics are dense, as shown on GIS coverage	Med
Irrigation returns/springs (#)	1	SW	NA		Low
Septic system per mi (150 ft/1000 ft)	0.2/7.0	SW	Good		Low
Unpaved road crossings (#)	1	SW	Good	Spain Bridge Rd, well-vegetated and stable at crossing	Low

FIGURE 42. STABLE BANKS AT UNPAVED SPAIN BRIDGE RD CROSSING

11. EGAL 10 N

Reach 10 is the longest reach delineated on the E. Gallatin, extending from the confluence with Hyalite Cr, downstream twelve miles to where Smith Cr enters (Figure 43). It is also the last fourth order reach on the E. Gallatin prior to transitioning to a fifth order stream. The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

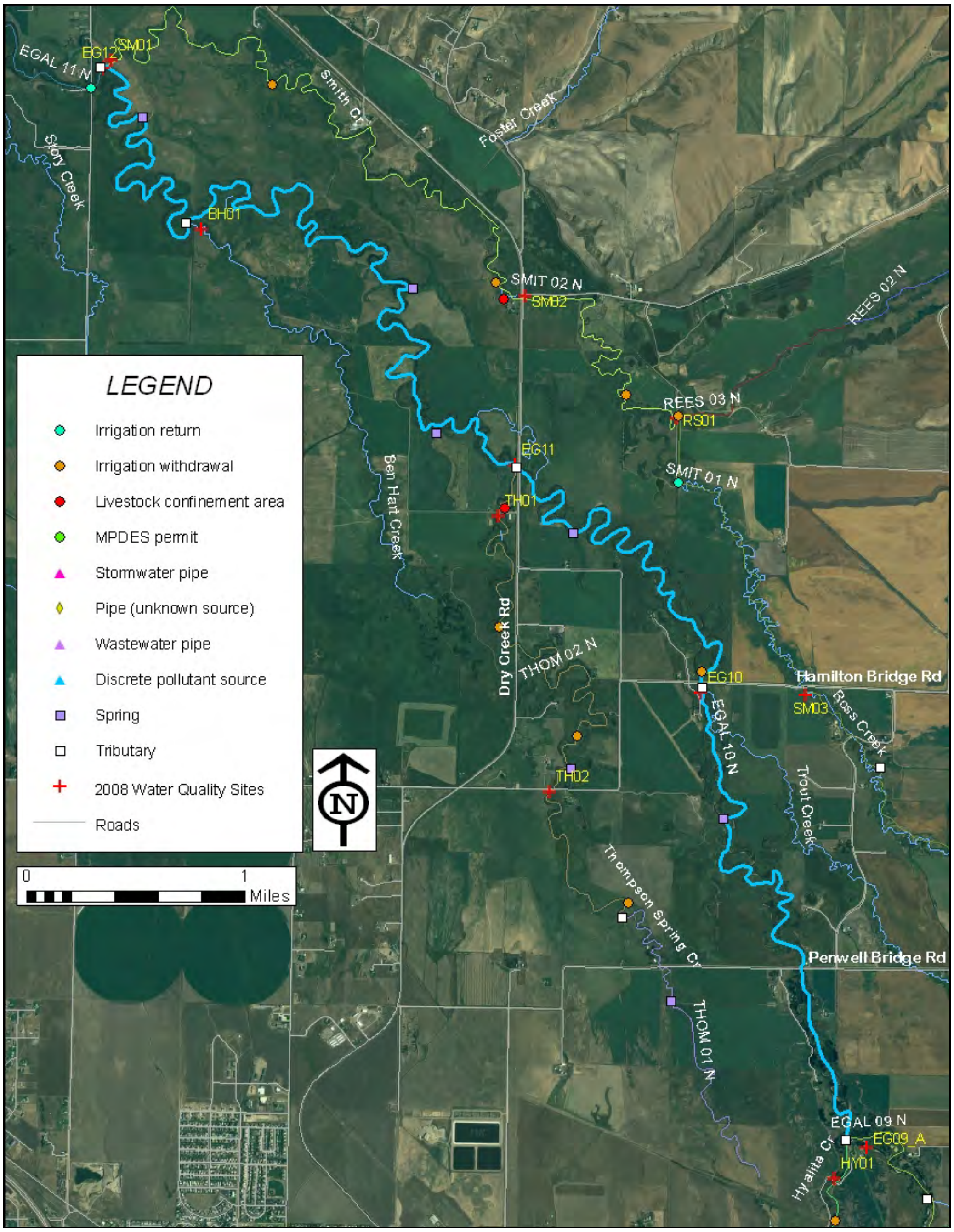

FIGURE 43. REACH EGAL 10 N

11.1. Reach Condition

Reach 10 is highly sinuous, flowing through the subirrigated agricultural valley north of Belgrade. The twelve mile reach was observed at the Hyalite Cr confluence, at Penwell Bridge Rd, Hamilton Bridge Rd, Dry Creek Rd, and at the Ben Hart Cr and Smith Cr confluences. Primary land uses along the reach are hay production and pasture land with springs common within the valley bottom. Riparian vegetation was a mosaic of cottonwoods with willow understory (Figure 44), willows only, and pasture and hay land (Figure 45). Invasive weeds such as reed canarygrass and thistles were abundant along the banks. Bank erosion was moderate throughout the reach, with instability and sloughing observed on meander bends and in areas of pasture encroachment and livestock trampling (Figures 46 and 47).

The irrigation withdrawal located downstream of Hamilton Bridge road was confirmed on the aerial, as a ditch can be seen trending northwest from the river at that location. Four major tributaries enter the reach, Hyalite Cr, Trout Cr, Thompson Spring Cr and Ben Hart Cr.

FIGURE 44. HEALTHY RIPARIAN UPSTREAM OF PENWELL BRIDGE RD

FIGURE 45. WILLOW RIPARIAN WITH PASTURE AND DENSE REED CANARYGRASS ON BANKS DOWNSTREAM OF HAMILTON BRIDGE RD

FIGURE 46. BANK EROSION DOWNSTREAM OF HAMILTON BRIDGE RD

FIGURE 47. DRY CREEK ROAD CROSSING; LIVESTOCK TRAMPLING ON BANK

11.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 14. Pasture land and tributary streams were identified as the primary potential sources of nutrients within reach 10. Pasture land was often grazed to very near the stream and direct trampling by livestock was only observed at one location visited (Figure 47). Adjacent land was often hayed directly to the edge of the river. Due to the natural and artificial irrigation within the valley bottom, hay fields were considered a low to moderately significant potential nutrient source. The springs along the reach were located in areas of good riparian quality, yet because they drain agricultural land they were identified as potential nutrient sources.

The Hamilton Bridge Rd and Penwell Bridge Rd crossings were both well-vegetated and stable and were not considered potential nutrient sources, although some sedimentation likely occurs during runoff events (Figure 48).

TABLE 14. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 10 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (LB/RB)	50	GW/SW	Fair	Riparian area narrow and weedy where pasture encroaches	Med
Irrigated crops % (average LB/RB)	20	GW	Fair	Crops often planted to edge of river	Low/med
Tributaries (#)	4	SW	Good	Hyalite, Trout, Thompson and Ben Hart Creeks	Med/high
Irrigation returns/springs (#)	5	SW	Excellent	Good riparian quality in bottom land but abundant springs draining agricultural land	Low/med
Unpaved road crossings (#)	2	SW		Hamilton Bridge Rd and Penwell Bridge Rd, both stable, well-vegetated at crossings	Low

FIGURE 48. STABLE BANKS AND WELL-VEGETATED AT PENWELL BRIDGE CROSSING

12. EGAL 11 N

Reach 11 extends from the confluence of Smith Cr, nearly twelve miles downstream to where it meets the Gallatin River north of Manhattan. The river transitions from a fourth order stream in reach 10 to a fifth order in reach 11, with a notable increase in size (Figure 49). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

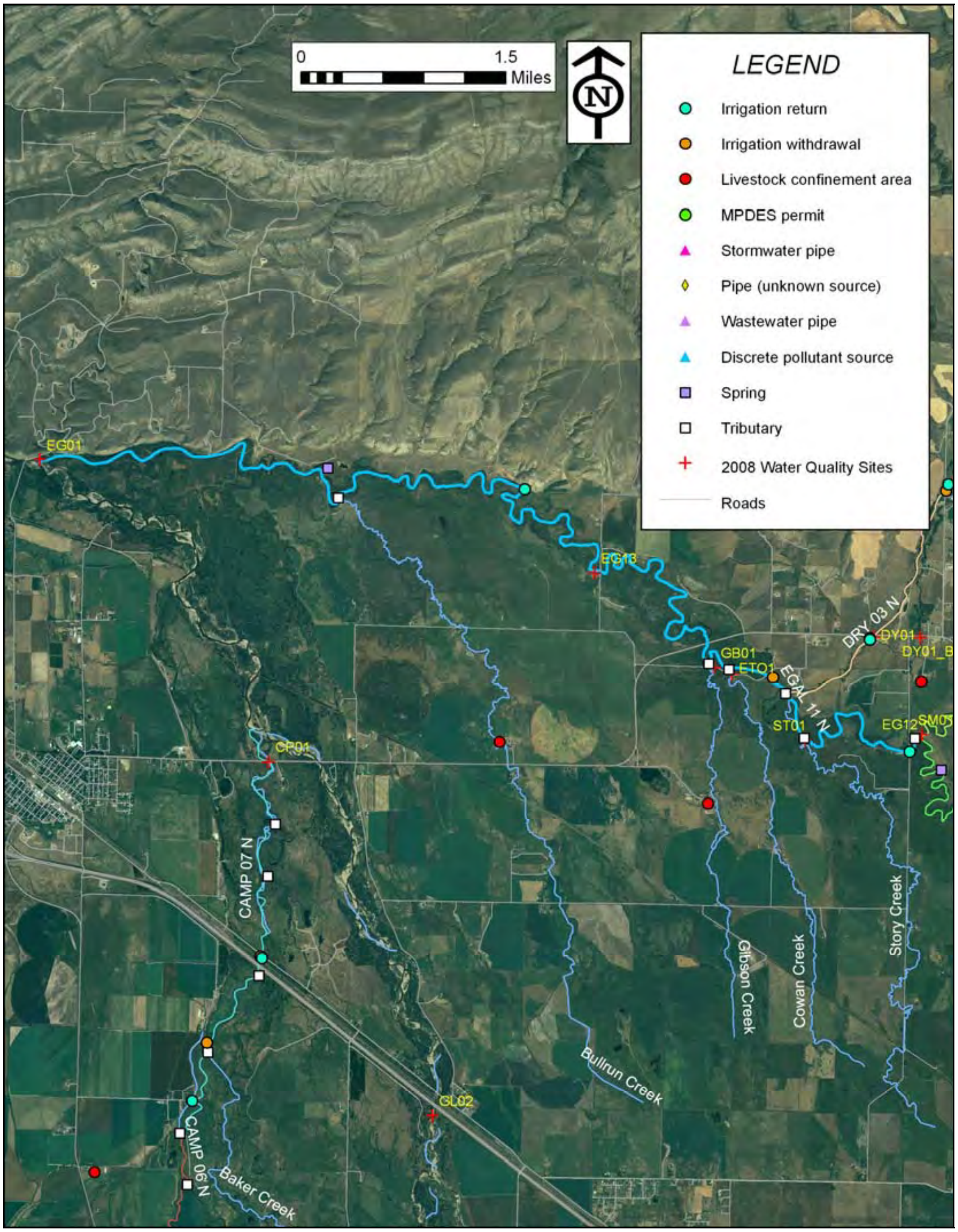

FIGURE 49. REACH EGAL 11 N

12.1. Reach Condition

The river size increases in reach 11, winding through the agricultural valley bottom north of Manhattan. Primary land uses along the reach are hay production and pasture land. The adjacent landscape is dryer than in reach 10 where springs and seeps were common. Riparian vegetation transitions from the cottonwood overstory and reed canarygrass in the upper reach (Figure 50), to primarily willows, buffaloberry and juniper, with dense reed canarygrass and pasture grasses in the lower reach (Figure 51). Riparian vegetation is generally healthy, although pasture encroachment is common (Figure 52). Soils are naturally erosive throughout the reach, with instability and sloughing observed on meander bends and in areas of pasture encroachment (Figures 52 and 53).

Six tributaries enter the reach: Smith Cr, Story Cr, Dry Cr, Cowan Cr (called "East Gallatin Unknown Trib" during the 2008 and 2009 water quality monitoring), Gibson Cr, and Bullrun Cr (Figure 49). One irrigation withdrawal was confirmed on the aerial near the downstream end of the reach, and was associated with a National Hydrography Dataset (NHD) canal flow line in GIS. Two irrigation returns were identified. The return located just upstream of Swamp Rd was identified in the field, entering the river through a culvert (Figure 54). The source of the culvert was not observed. The other irrigation return was confirmed on the aerial and was associated with an NHD flow line.

FIGURE 50. COTTONWOOD-WILLOW RIPARIAN IN UPPER REACH, DOWNSTREAM OF SWAMP CREEK RD

FIGURE 51. WILLOW-REED CANARYGRASS RIPARIAN DOWNSTREAM OF WEST DRY CREEK RD

FIGURE 52. BANK EROSION AND PASTURE ENCROACHMENT DOWNSTREAM O FSPAULDING BRIDGE RD AT WATER QUALITY SITE EG13

FIGURE 53. BANK EROSION ON OUTER MEANDER BEND DOWNSTREAM OF DRY CREEK SCHOOL RD

FIGURE 54. CULVERT ENTERING UPSTREAM OF SWAMP CREEK RD (MIDDLE OF PHOTO)

12.2. Potential Nutrient Sources

Potential nutrient sources within the reach are detailed in Table 15. Pasture land and tributary streams were identified as the primary potential sources of nutrients within reach 11. Pasture land was often grazed to very near the stream although direct trampling by livestock was not observed within the reach. The two livestock confinement areas were confirmed on the aerial, and are located on Gibson and Bullrun Creeks, approximately one and two miles upstream of their confluences with the E. Gallatin respectively. Because they are few in number, and are located on tributaries of the river, the LCA's were not considered significant nutrient sources. However, the LCA's could potentially act as nutrient sources to the tributary streams. In addition, septic system density within these tributary watersheds is moderate, increasing their potential as significant nutrient sources.

Three unpaved roads cross the reach, Swamp Creek Rd, Dry Creek School Rd, and Spaulding Bridge Rd. Minor erosion was noted upstream of Swamp Creek Rd where the culvert returns water to the river (Figure 54). The other two crossings were well vegetated and were not considered a significant nutrient source. The two irrigation returns were considered low to moderately significant potential nutrient sources. Both returns drain agricultural land, yet no channel indicating the source of the return upstream of Swamp Creek Rd was identified.

TABLE 15. POTENTIAL NUTRIENT SOURCES WITHIN REACH EGAL 11 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (LB/RB)	55	GW/SW	Good/ Excellent	Encroachment common but minimal bank erosion observed	Low/med
Irrigated crops % (ave LB/RB)	5	GW/SW	Good/ Excellent		Low/med
LCA (#)	2	GW/SW	Good/ Excellent	Located on Bullrun Cr (2 mi upstrm) and Gibson Cr (1 mi upstrm)	Low
Tributaries (#)	6	SW	Good/ Excellent	Smith, Story, Dry, Cowan (ET), Bullrun, Gibson	Med
Septic in tributaries	Med	SW	Good/ Excellent		Low
Irrigation returns/springs (#)	3	SW	Good/ Excellent	One identified in field upstrm of Swamp Creek Rd, unidentified source	Low/med- Unknown
Septic system per mi (150 ft/1000 ft)	0.2/1.9	SW	Good/ Excellent		Low
Unpaved road crossings (#)	3	SW	Good/ Excellent	Swamp Creek Rd, Dry Creek School Rd, Spaulding Bridge Rd, none were signif. sed. source	Low

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Godfrey Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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1. GODFREY CREEK

Godfrey Creek is a small, second order agricultural stream that flows through Churchill west of Bozeman, Montana. It flows through dairy, hay, pasture, and crop operations prior to flowing into an irrigation ditch north of Churchill; historic alterations to Godfrey Creek's watercourse and adjacent irrigation infrastructure have changed flow patterns so that Godfrey Creek no longer maintains a natural channel in its lower reaches. Water quality in Godfrey Creek (Waterbody ID MT41H002_020) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: algal growth, fecal coliform, total nitrogen, total phosphorus, and sediment.

Godfrey Creek was divided into four separate reaches based on stream order, land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients and E. coli. Reach-scale conditions on Godfrey Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

Godfrey Creek is impacted by agricultural practices throughout most of its seven mile length. Pastures and livestock confinement areas were identified as the most significant sources of nutrients and E. coli to Godfrey Creek, but the abundance of irrigated croplands was also considered a significant pollutant source. The potential impact of these land uses was accentuated by the general lack of best management practices. Narrow pasture buffers were common in reaches 3 and 4 but generally absent in reaches 1 and 2. The lack of riparian exclosure fencing allowed livestock full access to the stream even where pasture buffers were present. The only riparian fencing noted during the assessment was located upstream of Cameron Bridge Road, which was effectively keeping cattle out of the riparian zone. However, it should be recognized that only areas that could be accessed from road crossings were observed and some BMP's were likely missed in the assessment.

The stream was more impacted in the upper two reaches (reaches GOD 01 N and GOD 02 N) than in the lower two reaches. Reach GOD 01 N was less impacted upstream of Little Holland Road (Figure 1), with a denser riparian and less bank erosion observed. Downstream of Little Holland Road and through reach GOD 02 N was the most significantly impacted by grazing and livestock confinement areas, resulting in trampled, eroding banks, and very poor riparian zone quality. Reaches GOD 03 N and GOD 04 N were less impacted by grazing and livestock operations, with less bank erosion and a denser riparian zone observed.

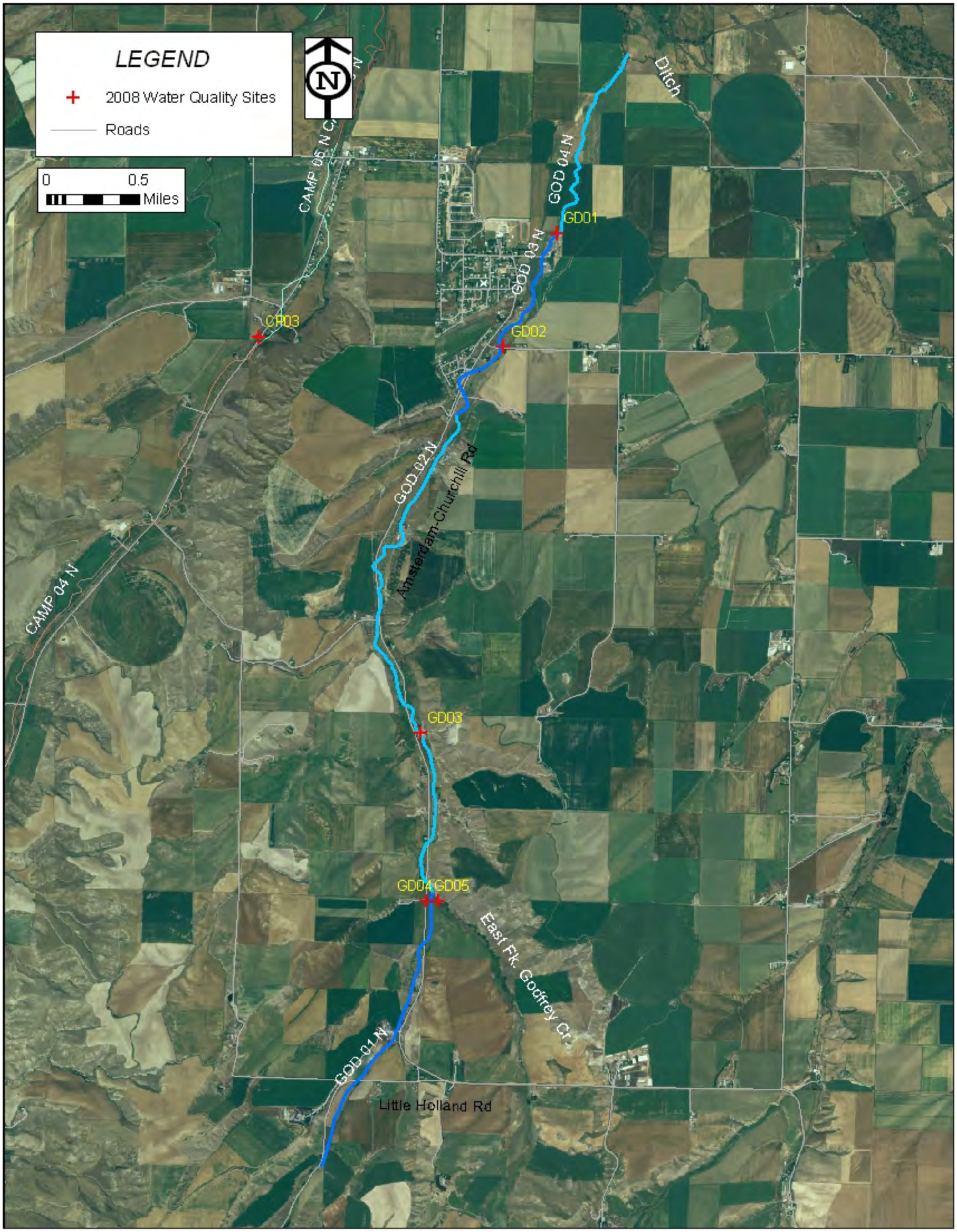

FIGURE 1. OVERVIEW OF GODFREY CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID N	Reach length (mi)	Ecoreg.	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP*	Septic 150 ft per mi	Septic 1000 ft per mi
GOD 01 N	1.66	17w	2	ROW CROPS	N	5	200	M	15	NA	1.8	5.4
GOD 02 N	3.01	17w	3	ROW CROPS/HAY	N	4	0	M	10	NA	0.7	5.7
GOD 03 N	1.30	17w	3	URBAN RL/ROWCROP RR	N	2	0	M	15	RPF, PBR	3.1	38.4
GOD 04 N	1.15	17w	3	ROWCROPS	N	0	0	L	15	PBR	0.0	0.0

***RPF: riparian fencing**

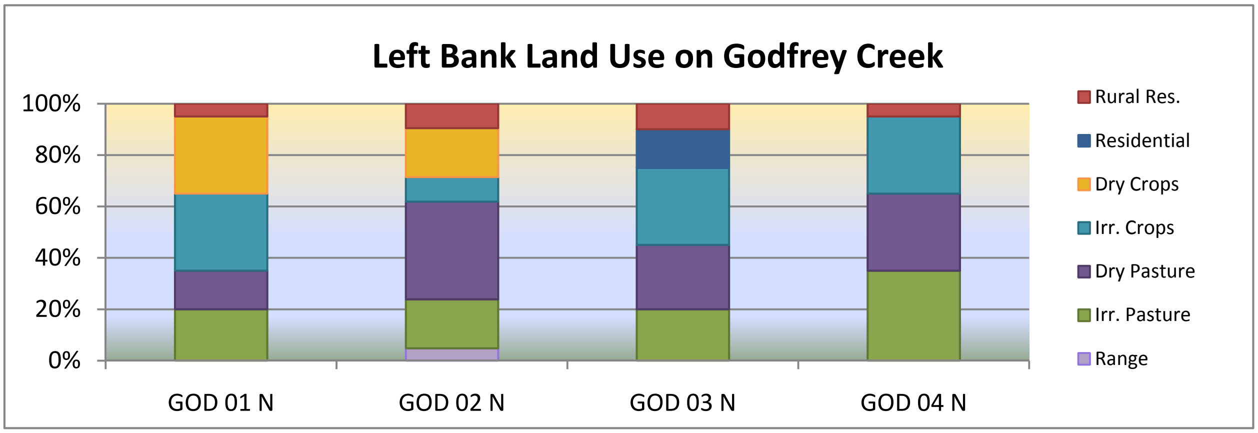

FIGURE 2. RELATIVE LAND USE TYPES ALONG THE LEFT BANK OF GODFREY CREEK

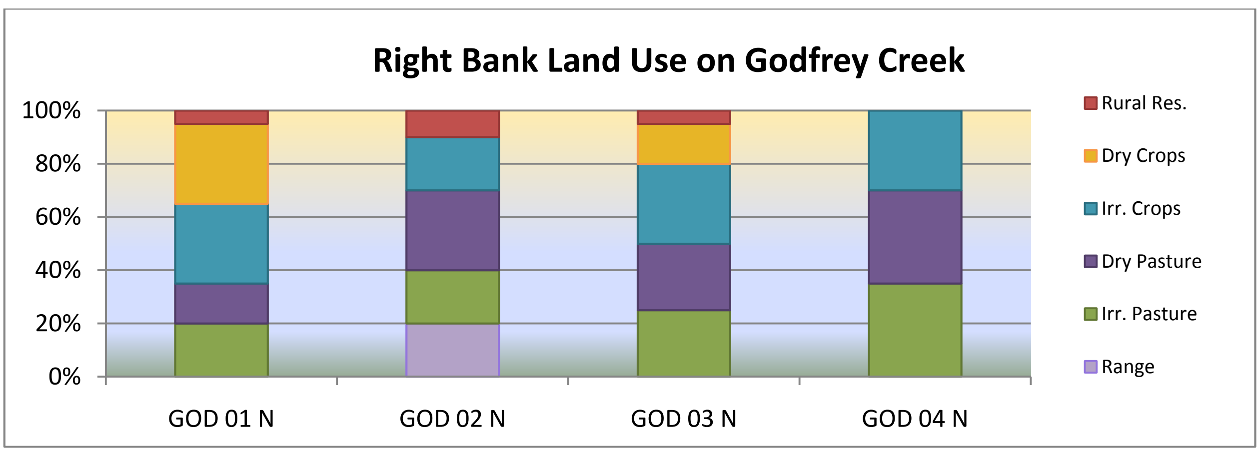

FIGURE 3. RELATIVE LAND USE TYPES ALONG THE RIGHT BANK OF GODFREY CREEK

2. GOD 01 N

Reach 1 is a second order stream, also known as the West Fork of Godfrey Creek. The reach spans from south of Little Holland Road, downstream to the confluence with East Fork Godfrey Creek (Figure 4). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

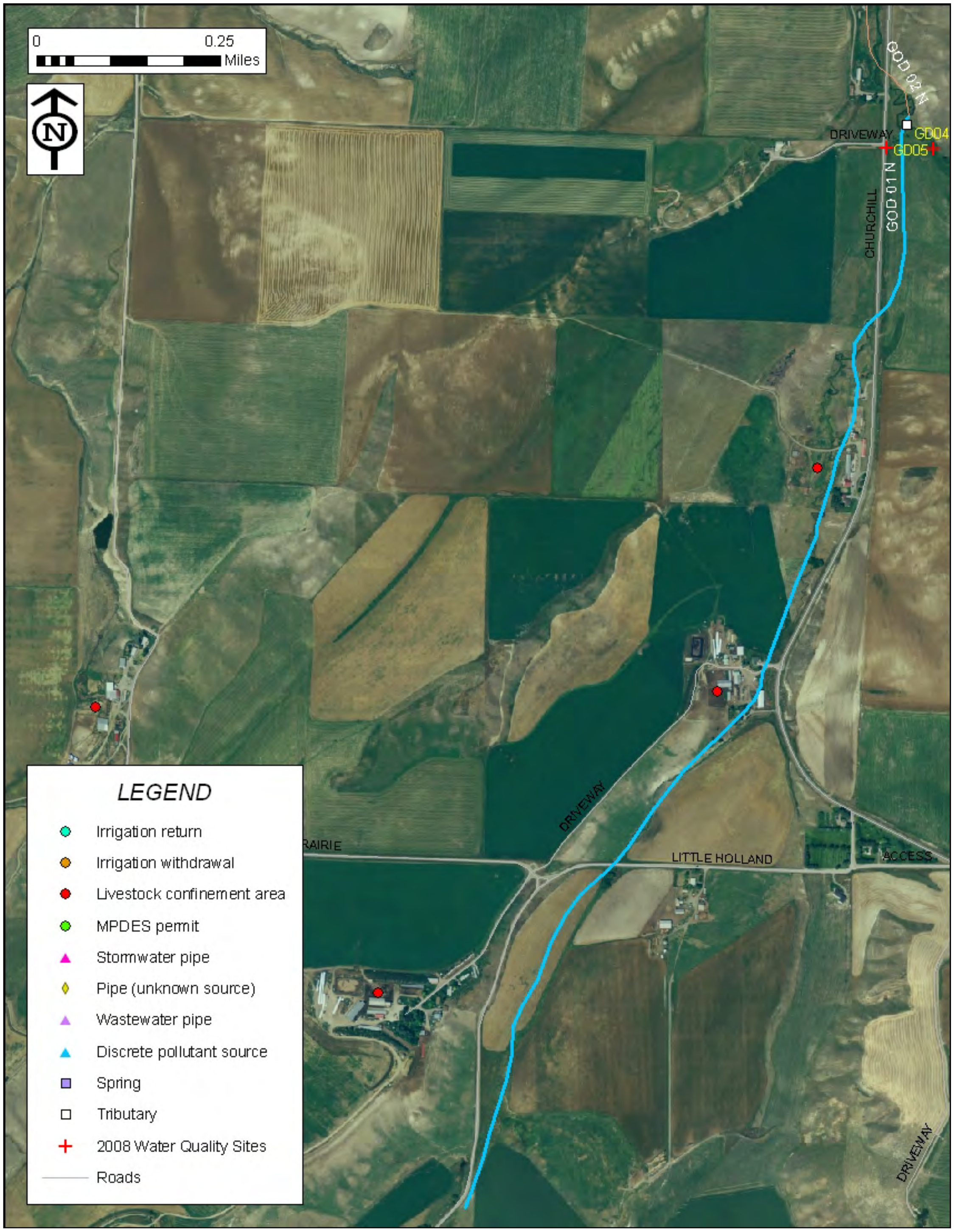

FIGURE 4. REACH GOD 01 N

2.1. Reach Condition

Land use within the reach is primarily cattle grazing, resulting in an unhealthy overgrazed riparian zone in many areas (Figure 5), with select sections of dense grass and ungrazed riparian in the upper portion of the reach (Figure 6). Although the riparian zone was encroached by crop production and impacted by cattle in several areas, due to the small size of the stream and low flow, bank erosion was generally moderate (Figure 6). However, select areas of bank erosion were observed (Figure 7). The paved Amsterdam-Churchill road encroached on the stream for ~200 ft at the lower end of the reach but the bank between the stream and the road was well vegetated, reducing the likelihood of pollutant delivery. No significant irrigation withdrawals were identified within the reach.

FIGURE 5. GRAZED, WEEDY RIPARIAN UPSTREAM OF CHURCHILL ROAD WITH NO PASTURE BUFFER

FIGURE 6. DENSE GRASS RIPARIAN BUFFER UPSTREAM OF LITTLE HOLLAND ROAD

FIGURE 7. ERODING BANK DOWNSTREAM OF LITTLE HOLLAND ROAD

2.2. Nutrient and E. coli Source Characterization

Potential pollutant sources to reach GOD 01 N are listed in Table 2. The high percentage of irrigated crops within the reach was considered to have a moderate to high potential significance for nutrient delivery to the stream due to the poor riparian buffer quality. The potential significance of irrigated pasture as a source of nutrients and E. coli was considered high within the reach, due to the high prevalence of irrigated pasture and poor riparian quality throughout much of the reach. In addition, no riparian fencing was observed, allowing livestock what appeared to be unlimited access to the steam within pastures. The impact of livestock was most apparent starting downstream of Little Holland Road (Figure 7). The riparian buffer was in better condition upstream of Little Holland Road, with less bank erosion and trampling observed (Figure 6).

Four LCA's were identified during the survey (Table 2). Two of the LCA's are located adjacent to Godfrey Creek, while the other two are located greater than 1,000 ft from the creek. One of the farther LCA's is in fact located on an intermittent tributary approximately 2.5 miles upstream of Godfrey Creek, which discharges to reach GOD 02 rather than GOD 01. Due to their proximity and poor riparian buffer quality the two LCA's adjacent to the stream were considered to have a high potential significance for delivering nutrients and E. coli to the stream. The two LCA's farther from the stream were of lower potential significance.

Septic system density was relatively low, with 1.8 per mile within 150 ft and 5.4 per mile within the 150 to 1,000 ft buffer (Table 2). Five unpaved crossings were identified within the reach. Two of the crossings were well-maintained County roads with a low potential for sedimentation; three crossings were ranch driveways.

TABLE 2. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH GOD 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	30%	GW	Poor	Potatoes, corn, hay	Med/High
Pasture (Ave. % LB/RB)	35%	SW/GW	Poor	Dry pasture also common. Primary degradation along stream is cattle related	High
Septic system per mi (150 ft/1000 ft)	1.8/5.4	GW	Poor	Septic density relatively low almost no intact riparian buffer	Low
Unpaved road crossings (#)	5	SW	Poor	2 crossings on well-maintained County rds, 3 were ranch driveways. None likely a sediment source	Low
LCA (#)	4	GW/SW	Poor	Two adjacent to GOD 01 N, two >1000 ft from stream (one likely discharges to GOD 02 N rather than GOD 01 N)	High

3. GOD 02 N

Reach 2 is a third order stream that begins at the confluence of the West and East Forks of Godfrey Creek and extends downstream to where a small ditch enters from the west near Moonlight Road (Figure 8). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

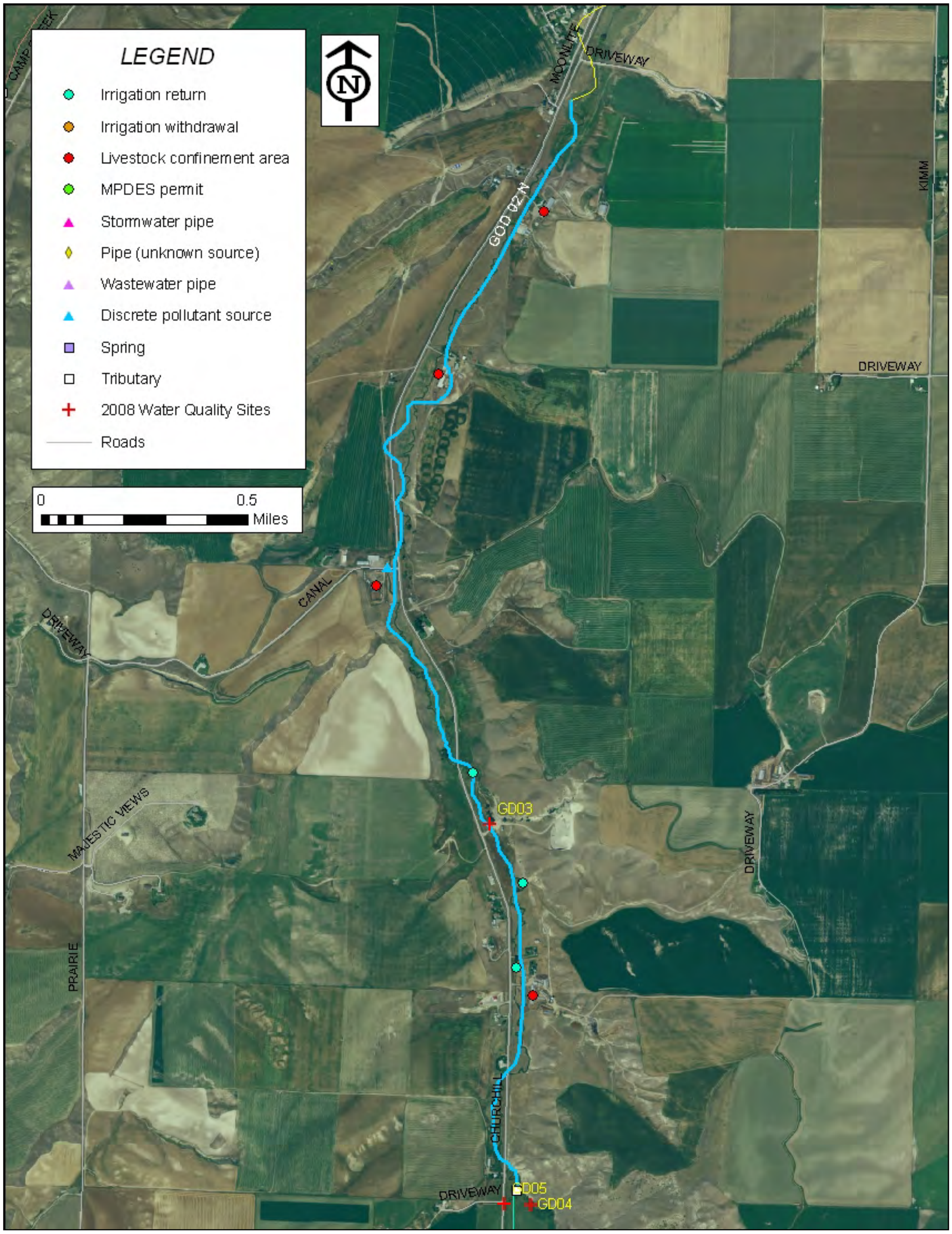

FIGURE 8. REACH GOD 02 N

3.1. Reach Condition

Land use within the reach is primarily cattle grazing and livestock confinement areas, resulting in a very unhealthy, nearly non-existent overgrazed riparian zone. Due to the small stream size and low flow energy, some areas were overgrazed but not actively eroding (such as the area downstream of Churchill Road seen in Figure 9), while other areas were highly erosive and trampled, especially through livestock confinement areas (Figure 10). The paved Amsterdam-Churchill Road encroached on the stream for ~200 ft at the lower end of the reach but the bank between the stream and the road was well vegetated, reducing the likelihood of pollutant delivery from surface runoff.

FIGURE 9. OVERGRAZED RIPARIAN DOWNSTREAM OF CHURCHILL ROAD BUT RELATIVELY STABLE BANKS

FIGURE 10. ERODING, TRAMPLED BANKS WITHIN LIVESTOCK CONFINEMENT AREA

3.2. Nutrient and E. coli Source Characterization

In addition to the East Fork of Godfrey Creek, three irrigation returns enter the stream within the reach. Collectively these returns could have a moderate potential nutrient and E. coli delivery to the stream, as they drain agricultural lands. The prevalence of irrigated crops was low (Table 3) but due to the poor riparian quality, the potential significance of irrigated crops for nutrient delivery was considered moderate. Both dry and irrigated pasture land was prevalent throughout the reach, and often encroached along the stream. Due to its high prevalence, poor riparian quality, and abundance of trampling, pasture had a very high significance for nutrient and E. coli delivery to the stream. In addition, no riparian fencing was observed, allowing livestock what appeared to be unlimited access to the steam within pastures.

Four LCA's and a discrete pollutant source were also identified during the survey (Table 3). All of the LCA's were located within 300 ft of the stream and should be considered a significant potential nutrient source (Figure 10 above). One of the LCA's was located directly adjacent to the stream, with a large mound of stockpiled manure within 30 feet of the stream (Figure 11). Septic system density was relatively low, with 0.7 per mile within 150 ft and 5.7 septic systems per mile within the 150 to 1,000 ft buffer. Four unpaved crossings were identified within the reach. One of the crossings was the well-maintained Canal Road with a low potential for sedimentation (Figure 12); three crossings were ranch driveways. The discrete pollutant source, a pile of dirt located between the Canal Road bridge abutment and the stream downstream of Canal Road, was considered to be a potential sediment source during storm events (Figure 13).

TABLE 3. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH GOD 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	15%	GW	Poor	Primarily hay and crops	Med
Pasture (Ave. % LB/RB)	55%	SW/GW	Poor	Pasture encroachment and bank trampling common; pasture in very poor, overgrazed condition.	High
Irrigation returns (#)	3	SW	Unknown		Med
Septic system per mi (150 ft/1000 ft)	0.7/5.7	GW	Poor	Relatively low density	Low
Septic in tributaries	Low	Tributary	Poor		Low
Unpaved road crossings (#)	4	SW	Poor	Well-maintained Canal Rd and driveways	Low
LCA (#)	4	GW/SW	Poor	Located w/in 300 ft of stream; one w/ large manure pile w/in 30 ft of stream	High
Other pollutant sources (#)	1	Pipe, SW	Poor	Pile of dirt dumped on LB downstream of Canal Rd.	Low

FIGURE 11. LIVESTOCK CONFINEMENT AREA WITH MANURE PILE WITHIN 30 FT OF STREAM

FIGURE 12. STABLE, WELL-VEGETATED ABUTMENT AT CANAL ROAD CROSSING

FIGURE 13. PILE OF DIRT DUMPED NEXT TO STREAM AT CANAL ROAD CROSSING

4. GOD 03 N

Reach 3 is a third order stream that begins where a small ditch enters from the west near Continental Road, and extends to just downstream of water quality site GD01 east of Churchill (Figure 14). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

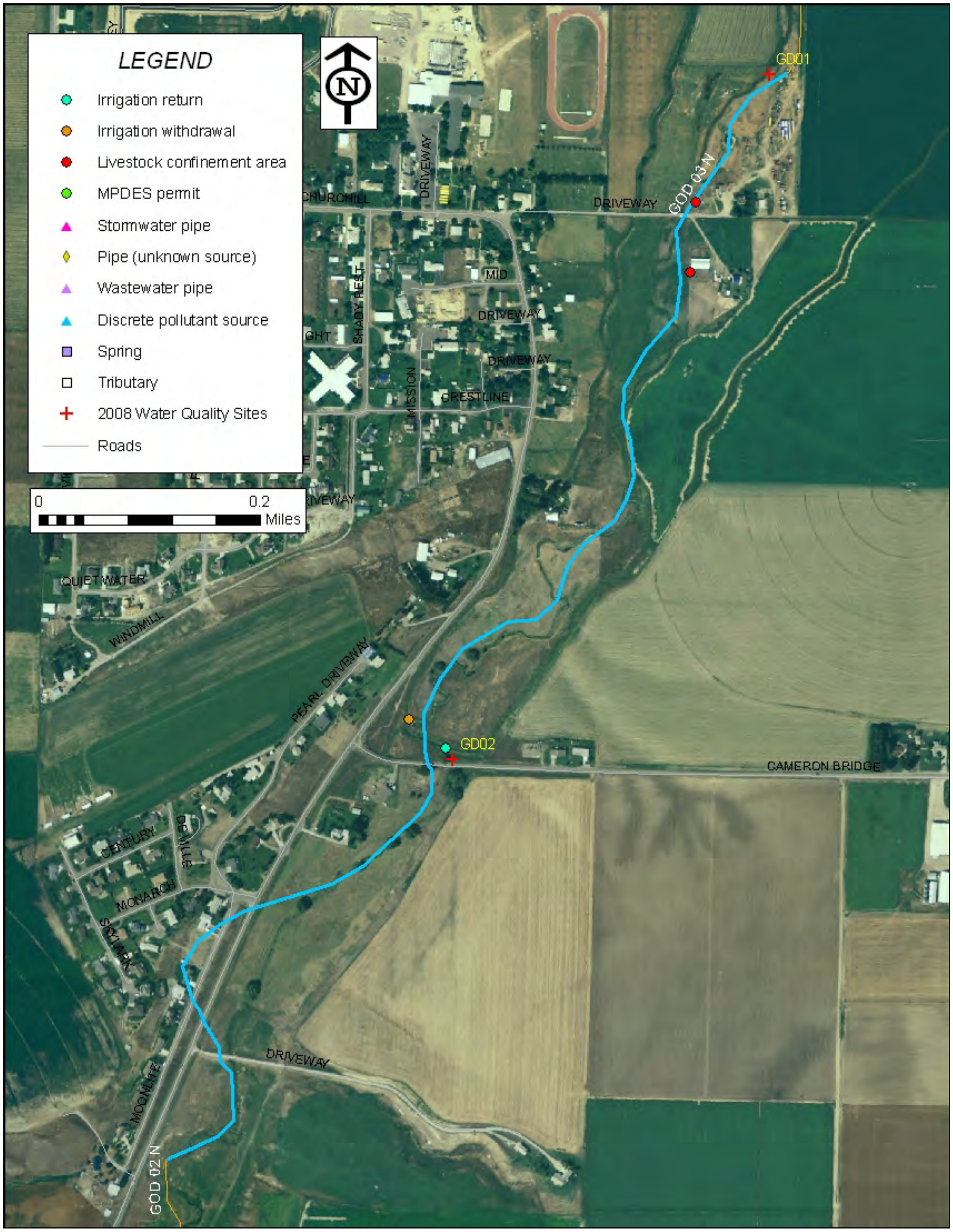

FIGURE 14. REACH GOD 03 N

4.1. Reach Condition

Land uses within the reach are primarily pasture, crop and hay production, with fewer livestock observed in or near the stream. The riparian zone appeared to be in better condition than reach GOD 02 N upstream, with areas of dense riparian grass (Figure 15). Bank erosion was considered moderate, with erosion observed primarily upstream and downstream of the driveway upstream of water quality monitoring site GD01 (Figure 16). Bank erosion throughout the remainder of the reach was relatively minor due to the dense riparian vegetation. No roads encroached within this reach; the stream does not cross the road upstream of Cameron Bridge Road, as indicated in Figure 14. One significant irrigation withdrawal was identified, located just downstream of Cameron Bridge Road. This withdrawal is likely a continuation of the irrigation return that enters at the same location across the stream, constituting the crossing of a large canal.

FIGURE 15. DENSE GRASS RIPARIAN IN DOWNSTREAM PORTION OF REACH

FIGURE 16. TRAMPLED AND ERODING PASTURE JUST UPSTREAM OF WQ SITE GD01

4.2. Nutrient and E. coli Source Characterization

An irrigation return, two LCA's, and two unpaved road crossings were identified within the reach (Table 4). The irrigation return was rather large, entering from the right bank just downstream of Cameron Bridge Road (Figure 17). This canal flows through irrigated and dry crop land and could potentially be a significant nutrient source. Overall, irrigated crops had a moderate potential for nutrient delivery to the reach. Less pasture encroachment was observed in this reach as compared to reach GOD 02 N. Although only one area of riparian fencing was observed, livestock were not often observed directly in and adjacent to the stream. With the good riparian vegetation quality, pasture was considered to have moderate potential significance for nutrient and E. coli delivery to this reach.

Residences and septic density increased within this reach. Septic system density was moderate, with 3.1 per mile within 150 ft and 38.4 per mile within the 150 to 1,000 ft buffer. Although the riparian zone quality was good, the potential significance of septic density was considered moderated due to its prevalence. Two unpaved driveway bridge crossings were identified within the reach. The driveway upstream of Cameron Bridge road was relatively well-vegetated but was identified as a potential mild sediment source during storm events (Figure 18). Two LCA's were confirmed in the field, upstream and downstream of the driveway upstream of water quality site GD01. One was a manure-filled horse corral located within 150 ft of the stream; the other was likely a riding arena, located within 200 ft of the stream. Due to their low prevalence the LCA's were considered low potential nutrient and E. coli sources.

TABLE 4. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH GOD 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	30%	GW	Good	Primarily hay and crops	Med
Pasture (Ave. % LB/RB)	47%	SW/GW	Good	Some pasture encroachment but pasture in relatively good condition; very little bank trampling observed.	Med
Irrigation returns (#)	1	SW	Good	Large canal	Med
Septic system per mi (150 ft/1000 ft)	3.1/38.4	GW	Good	Moderate density	Med
Unpaved road crossings (#)	2	SW	Good	Driveway bridges, one is potentially a mild sediment source during storm events	Low
LCA (#)	2	GW/SW	Fair/ Good	Corrals upstream and downstream of driveway upstream of WQ site GD01	Low

FIGURE 17. IRRIGATION RETURN PRIOR TO FLOWING INTO REACH GOD 03 N; LOCATED JUST DOWNSTREAM OF CAMERON BRIDGE ROAD.

FIGURE 18. MINOR SEDIMENTATION POTENTIAL AT DRIVEWAY UPSTREAM OF CAMERON BRIDGE ROAD

5. GOD 04 N

Reach 4 is a third order stream that begins just downstream of water quality site GD01 and extends approximately one mile downstream to where it flows into a ditch, no longer reaching a larger stream body (Figure 19). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

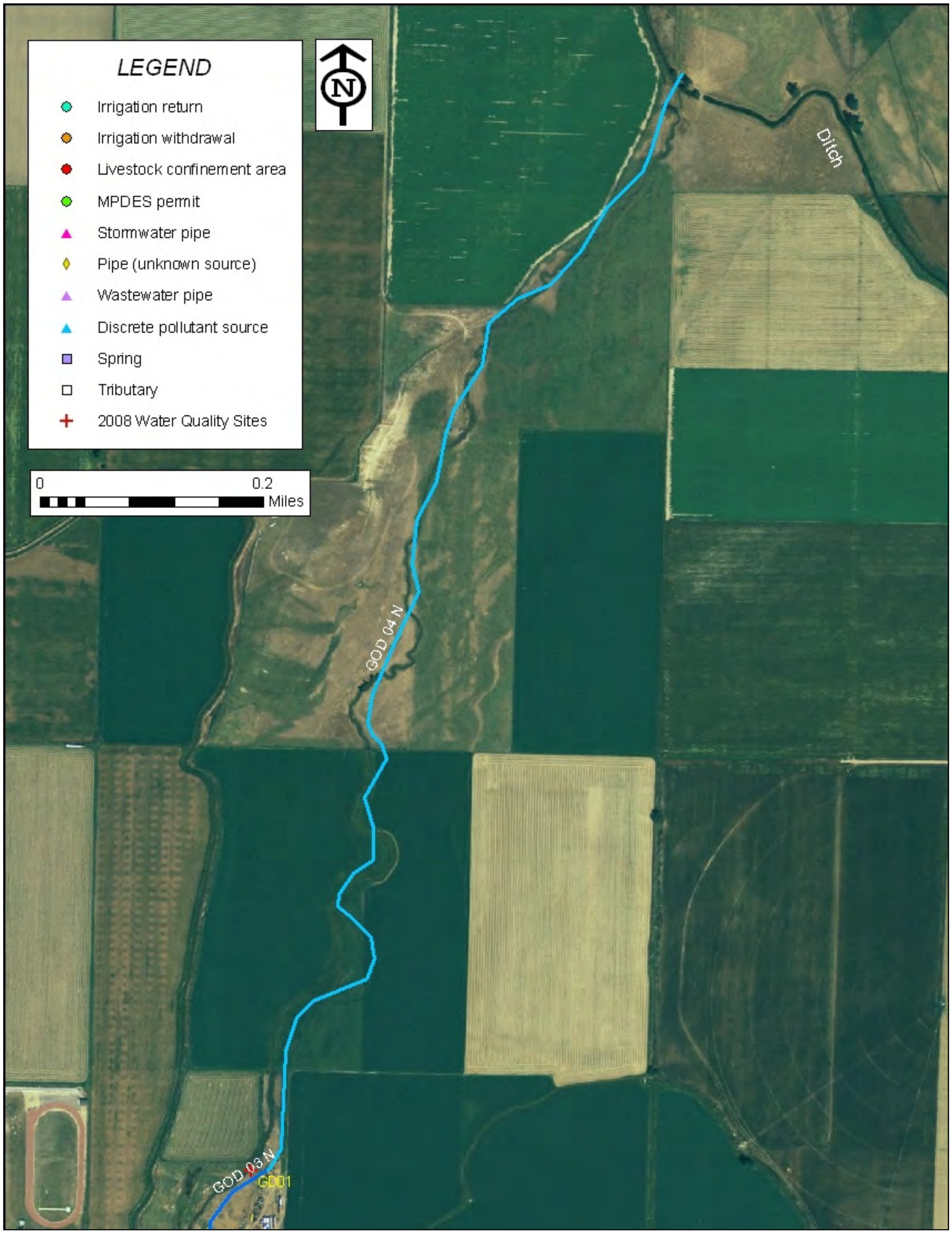

FIGURE 19. REACH GOD 04 N

5.1. Reach Condition

Land use within the reach is a mixture of irrigated and dry pasture, and hay production. The reach was only observed in approximately the upper 1/3 mile, where landowner permission was obtained. In this section, the riparian zone was narrow but dense, composed of weeds and other invasives such as reed canarygrass and meadow foxtail, mixed with native sedges (Figure 20). Due to the stabilizing riparian vegetation erosion was low within the section of the reach that was observed. No roads encroached within this reach.

FIGURE 20. DENSE RIPARIAN WITH WEEDY AND NATIVE SPECIES

5.2. Nutrient and E. coli Source Characterization

Irrigated crop fields, primarily hay production, were considered to have a moderate potential for nutrient delivery to the reach (Table 5). Horse and cattle pasture comprised the bulk of the land adjacent to the reach. Although the prevalence was high, very few animals and almost no bank trampling was observed during the assessment. Therefore pasture was considered to have a low potential significance for nutrient and E. coli delivery to the reach. No septic systems or unpaved roads were located within the reach. However, an ATV ford was identified in the upper portion of the reach which was causing some minor sedimentation (Figure 21). The ford did not appear to be frequently used.

TABLE 5. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH GOD 04 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	30%	GW	Good	Alfalfa hay	Med
Pasture (Ave. % LB/RB)	67%	SW/GW	Good	Few animals observed; pasture in relatively good condition.	Med

FIGURE 21. SEDIMENTATION OCCURING AT ATV FORD IN UPSTREAM PORTION OF REACH

Hyalite Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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1. HYALITE CREEK

Hyalite Creek has its headwaters within the Gallatin Range south of Bozeman (Figure 1). In the upper reaches it flows through Hyalite Canyon within the Gallatin National Forest, until reaching the valley floor where it meanders through rural residential neighborhood prior entering the East Gallatin River east of Belgrade. For the purposes of assessing pollutant sources, Hyalite Creek was divided into seven reaches based on land use and riparian type (Figure 1). These seven reaches are divided between three water body segments on the State of Montana's 2008 303(d) List (Table 1). The three upper reaches, from the headwaters downstream to the mouth of Hyalite Canyon (Figure 1), are associated with DEQ water body segment IDs, MT41H003_131 (upper Hyalite Creek) and MT41H006_010 (Hyalite Reservoir). The four lower reaches, from the mouth of Hyalite Canyon to its confluence, are associated with DEQ water body segment ID MT41H003_132. Water quality in upper Hyalite Creek (segment MT41H003_131) is listed on the State of Montana's 2006 303(d) list as being impaired for pollutants, total phosphorous (TP) and total Kjehldahl nitrogen (TKN).

Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients to Hyalite Creek. Reach-scale conditions on Hyalite Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

The condition and potential nutrient sources are highly varied throughout Hyalite Creek's thirty-five mile length from its forested headwaters to the agricultural bottomlands at its confluence with the East Gallatin River. The upper three reaches (HYAL 01N - 03N, Figure 1) appear to be functioning in a relatively natural state, with very few anthropogenic water quality influences evident throughout the reaches. The exception is below the outlet to Hyalite Reservoir, where excessive algal growth is evident, presumably the result of nutrient export from the reservoir outlet. Several small tributaries enter the stream throughout the three upper reaches; these tributaries drain natural areas and do not contribute appreciable amounts of anthropogenic pollutant loads to Hyalite Creek.

The lower four reaches (HYAL 04N – 07N, Figure 1) are more significantly impacted by anthropogenic sources, namely septic systems, pasture land that encroaches on the stream in areas with poor riparian buffer quality, and irrigated cropland (primarily wheat and hay). Riparian quality was relatively good throughout the lower reaches, with some areas of pasture or residential lawn encroachment. BMP's consisted primarily of pasture buffers along the valley reaches (reaches 4-7). Riparian fencing and water gaps were limited throughout these lower reaches, and only observed within reach HYAL 04 N. However, it should be recognized that only areas that could be accessed from road crossings were observed and that some BMP's were likely missed in the assessment.

Although few BMP's were observed, in general pastures were not excessively overgrazed or encroaching on the stream, with the exception of reach HYAL 06 N downstream of Valley Center Road. Reach HYAL 06 N was the most significantly impacted by livestock grazing, with poor riparian quality and eroding banks in the downstream portion of the reach. While reach HYAL 05 N had a higher quality riparian zone with less bank erosion, with more residences it had the highest density of septic systems of all the reaches.

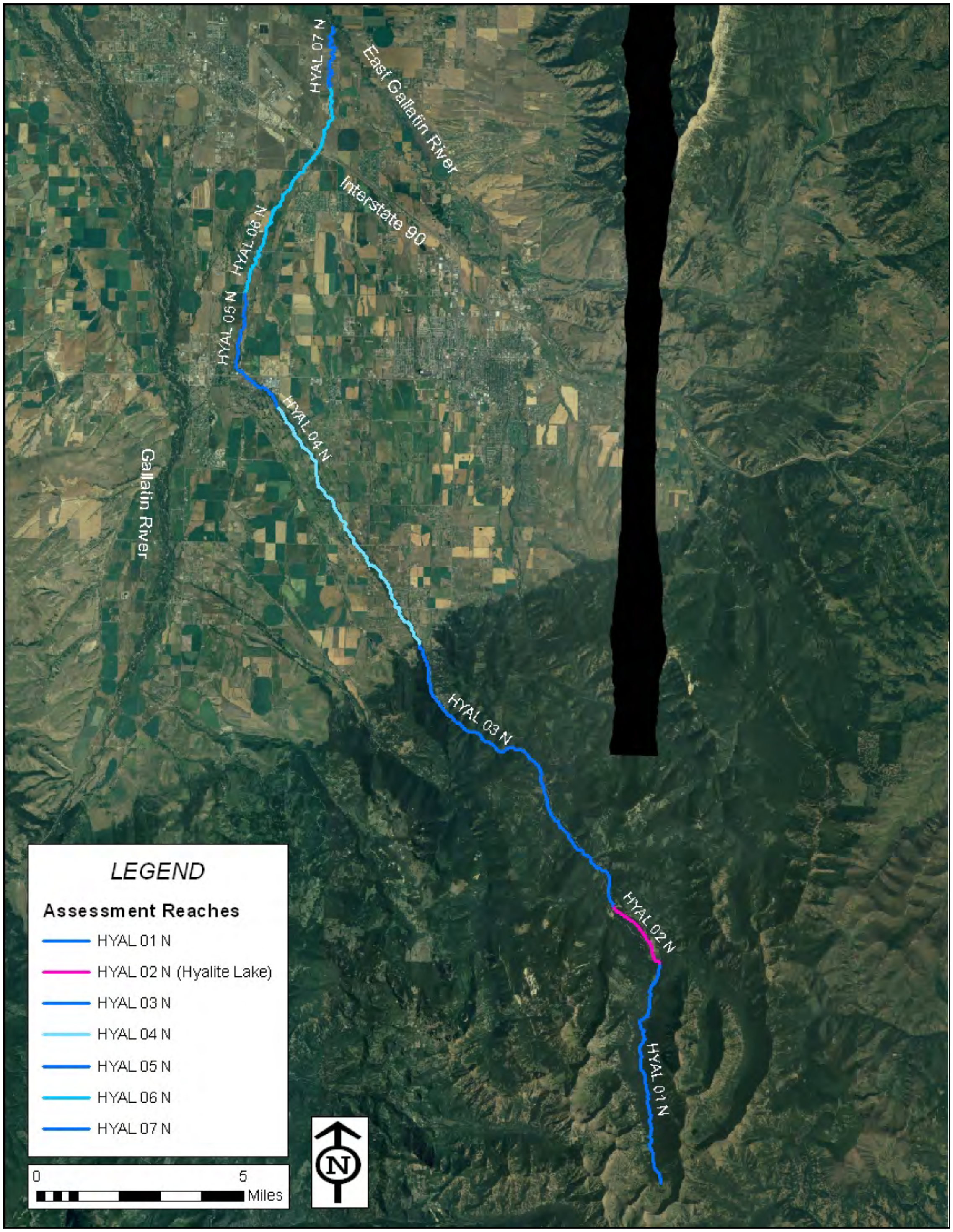

FIGURE 1. HYALITE CREEK OVERVIEW

TABLE 1. REACH-SCALE ATTRIBUTES

Waterbody Segment ID	Listed Impairments	Reach length (mi)	Reach ID	Ecoreg.	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP*	Septic 150 ft per mi	Septic 1000 ft per mi
MT41H003_131	Total phosphorous, total Kjehldahl nitrogen	5.87	HYAL 01	17i	2	FOREST	Y	3	0	L	125	NA	0.0	0.0
		1.88	HYAL 03	17g	3	FOREST	N	2	18000	L	120	NA	0.2	0.4
MT41H006_010	None	8.92	HYAL 02 (Hyalite Lake)	17g	3	FOREST	N	1	0	L	NA	NA	0.0	0.0
MT41H003_132	Low Flow alterations	7.24	HYAL 04	17w	3	RURAL RESIDENCE	N	4	700	L	60	WG RPF, PBR	0.4	15.3
		3.41	HYAL 05	17w	3	RESIDENCE	N	1	1000	L	50	PBR	3.5	26.6
		5.96	HYAL 06	17w	3	HAY/PASTURE	N	2	0	L	40	PBR	0.3	2.9
		1.96	HYAL 07	17w	4	PASTURE	N	1	0	L	75	PBR	0.5	6.1

***RPF: riparian fencing; WG: water gap; PBR: pasture buffer**

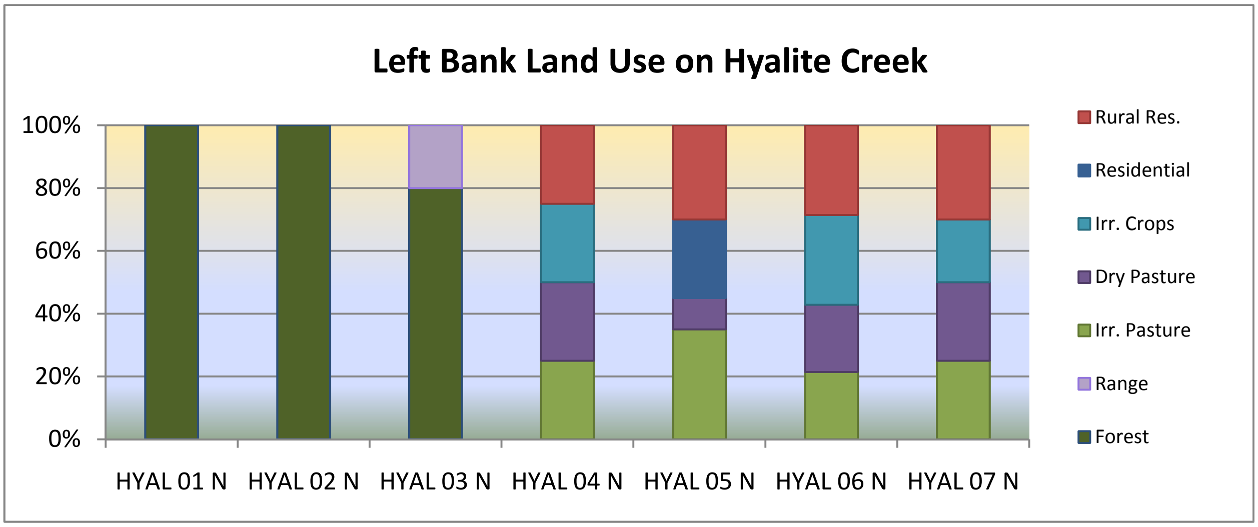

FIGURE 2. LAND USE TYPES ALONG THE LEFT BANK OF HYALITE CREEK

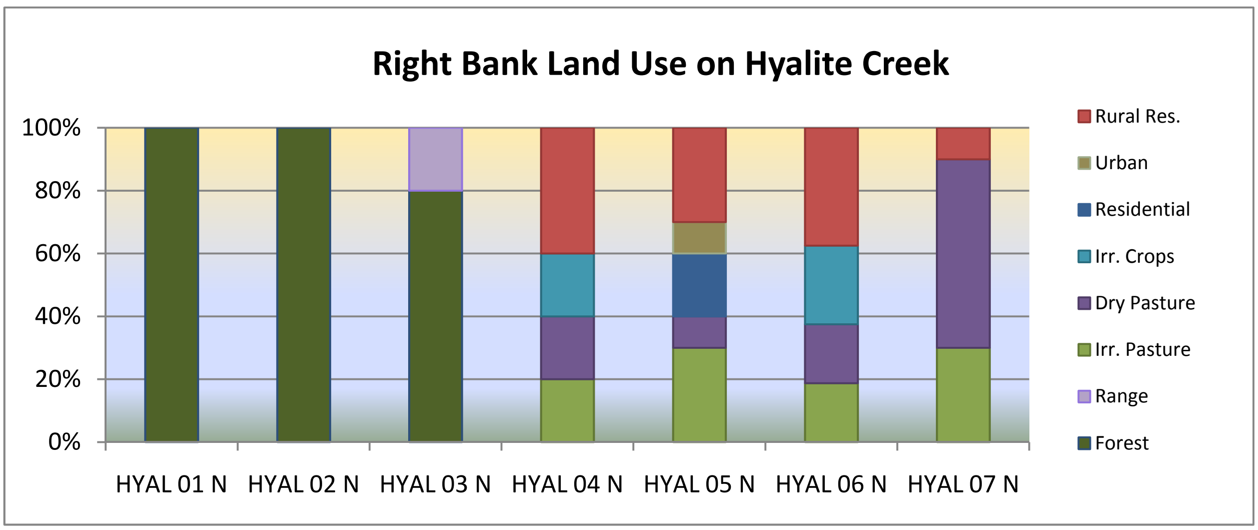

FIGURE 3. LAND USE TYPES ALONG THE RIGHT BANK OF HYALITE CREEK

2. HYAL 01 N

Reach 1 is a second order stream high in the Gallatin Mountains south of Bozeman, MT. The reach spans from the Hyalite Creek headwaters, downstream to the inlet of Hyalite Reservoir (Figure 4). Eighty percent of the reach is upstream of the end of Hyalite Canyon Road, at the Hyalite Lake trailhead. The dominant Level 4 PRI ecoregion of the reach is 17i, Absoroka-Gallatin Volcanic Mountains.

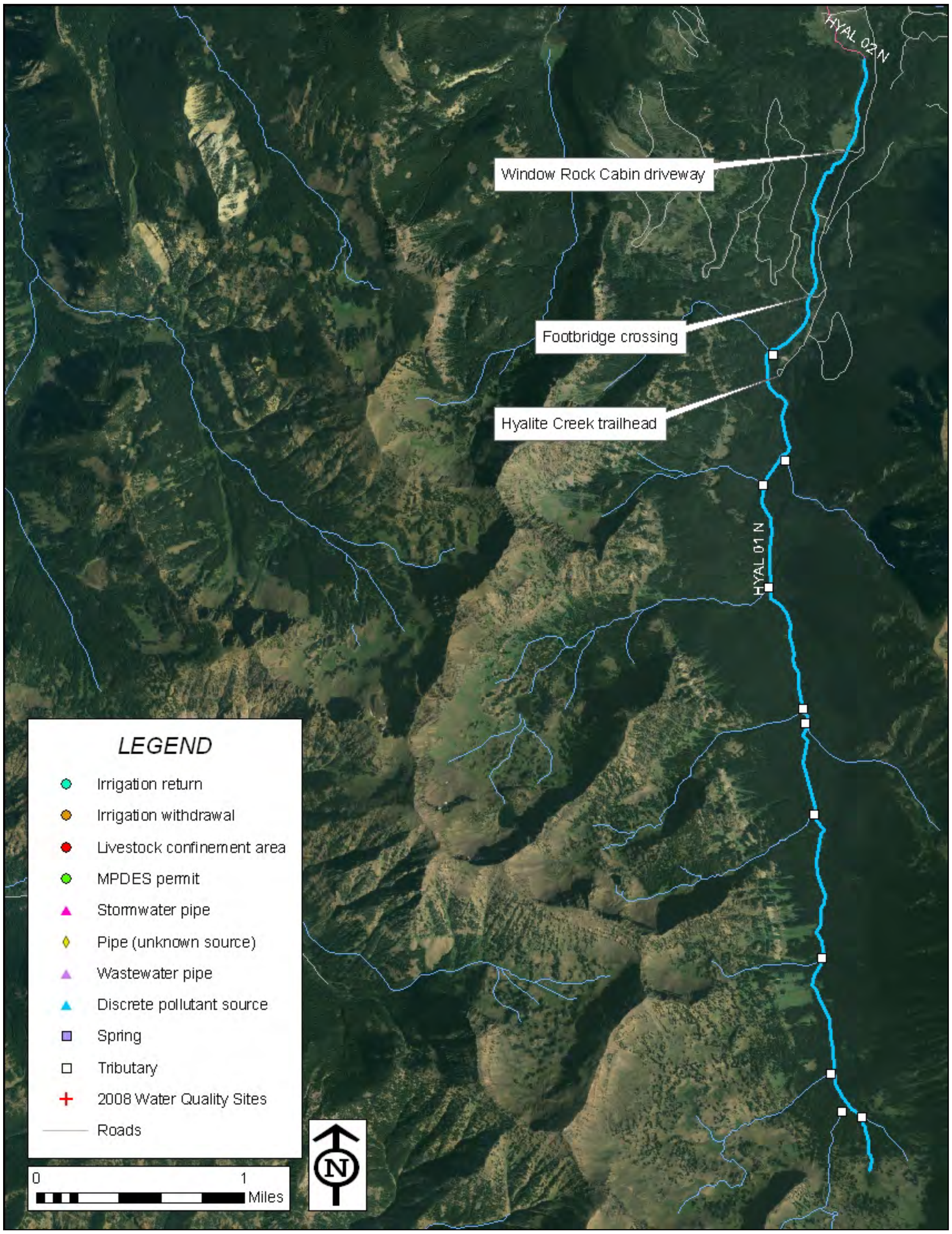

FIGURE 4. REACH HYAL 01 N

2.1. Reach Condition

The reach is located entirely within the Gallatin National Forest, and is primarily in its natural condition with dominant land use being recreation. The riparian vegetation is very robust and healthy, consisting of a mixed conifer overstory with a willow-grass-forb understory (Figure 5). Bank erosion within the reach was considered to be low and was limited to mild recreation-related bank trampling near the Hyalite Creek trailhead, and at the Grotto Falls overlook. No roads encroach the stream within the reach.

FIGURE 5. REACH HYAL 01 NEAR THE HYALITE CREEK TRAILHEAD.

2.2. Nutrient Source Characterization

Several small mountain tributary streams enter this reach but no discrete anthropogenic pollutant sources were identified. Table 2 identifies general potential pollutant sources within the reach. Forest Service toilets located at cabins and trailheads are vault toilets which are pumped and are therefore not considered to be a pollutant source. No septic systems exist within the reach (Table 1). The driveway to the Window Rock cabin is the only unpaved road that crosses the stream within the reach (Figure 4). This bridge crossing is well vegetated and does not likely contribute a significant amount of sediment to the stream. A decommissioned two-track bridge which now functions as a trail footbridge does cross the stream within the reach but receives little traffic and is well vegetated at the abutments.

TABLE 2. POTENTIAL NUTRIENTSOURCES WITHIN REACH HYAL 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Light recreational use	Low	SW/GW	Excellent	Campsites and turnouts along main and forest roads	Low
Unpaved road crossings (#)	1	SW	Excellent	Window Rock cabin driveway- low erosion potential	Low

3. HYAL 02 N

Reach 2 is composed of Hyalite reservoir (Figure 6) which serves as a primary water supply for the City of Bozeman, and as a popular recreation destination for boaters, picnickers and campers. The reach spans from the inlet of the reservoir, to the dam spillway. The dominant Level 4 PRI ecoregion of the reach is 17g, Mid-Elevation Sedimentary Mountains.

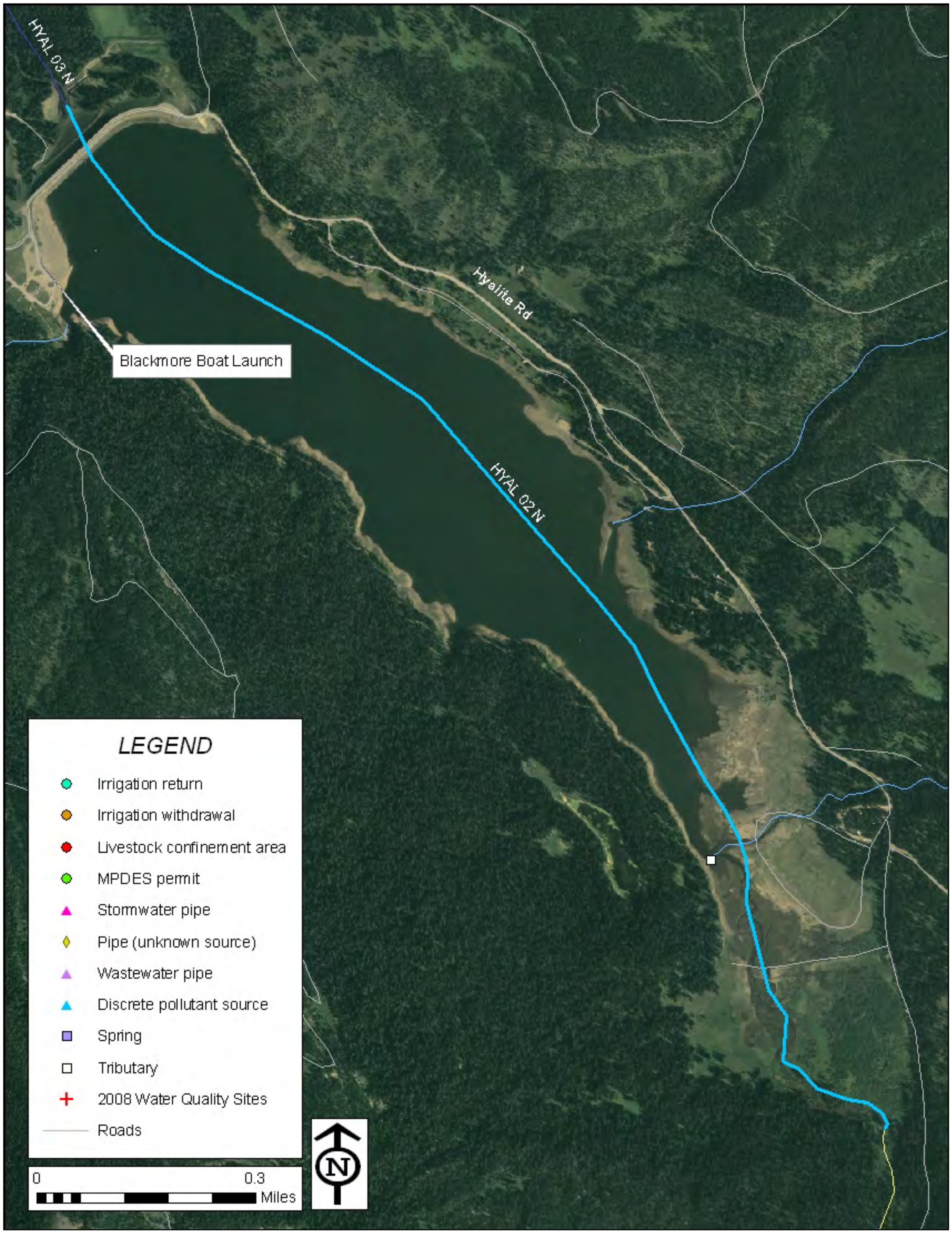

FIGURE 6. HYALITE RESERVIOR, REACH HYAL 02 N

3.1. Reach Condition

The reach is located entirely within the Gallatin National Forest, with dominant land use being recreation. The level of the lake fluctuates significantly, with low summer lake levels exposing a bare shoreline. Overall lakeside vegetation is very robust and healthy, consisting of a mixed conifer overstory with a willow-grass-forb understory. Bank erosion and disturbance within the reach is limited to picnicker and camper trampling at access sites, a Forest Service campground, and a private youth camp, located on the east side of the lake, and the Blackmore Boat Launch, located on the west side of the lake.

FIGURE 7. HYALITE RESERVOIR LOOKING TOWARDS INLET.

3.2. Nutrient Source Characterization

Potential nutrient sources within the reach are identified in Table 3. Light recreational use includes USFS campgrounds, turnouts, and other recreational sites along the reservoir. Collectively, these sources were determined to have a low significance as a nutrient source to the reservoir. Forest Service toilets located at the campground and trailheads are vault toilets which are pumped and are therefore not considered to be a nutrient source.

The reservoir itself was also identified as a potential nutrient source (Table 3). Excessive algal growth was observed below the reservoir outlet (Figure 6) in the summers of 2008 and 2009, possibly a result of nutrient-enriched reservoir water flowing from the reservoir outlet.

TABLE 3. POTENTIAL NUTRIENT SOURCES WITHIN REACH HYAL 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Light recreational use	Med	SW/GW	Good	USFS campground, Blackmore boat launch and turnouts along main and forest roads	Low
Reservoir	High	SW	NA	Nutrient export from the reservoir may be in ammonia form from, and quickly oxidizes to nitrate. Both forms are utilized by plants (algae).	Med

4. HYAL 03 N

Reach 3 extends from the Hyalite Reservoir dam, downstream to the mouth of Hyalite Canyon at Black Bear Road, where the stream flows from the mountains into the valley (Figure 8). The dominant Level 4 PRI ecoregion of the reach is 17g, Mid-Elevation Sedimentary Mountains.

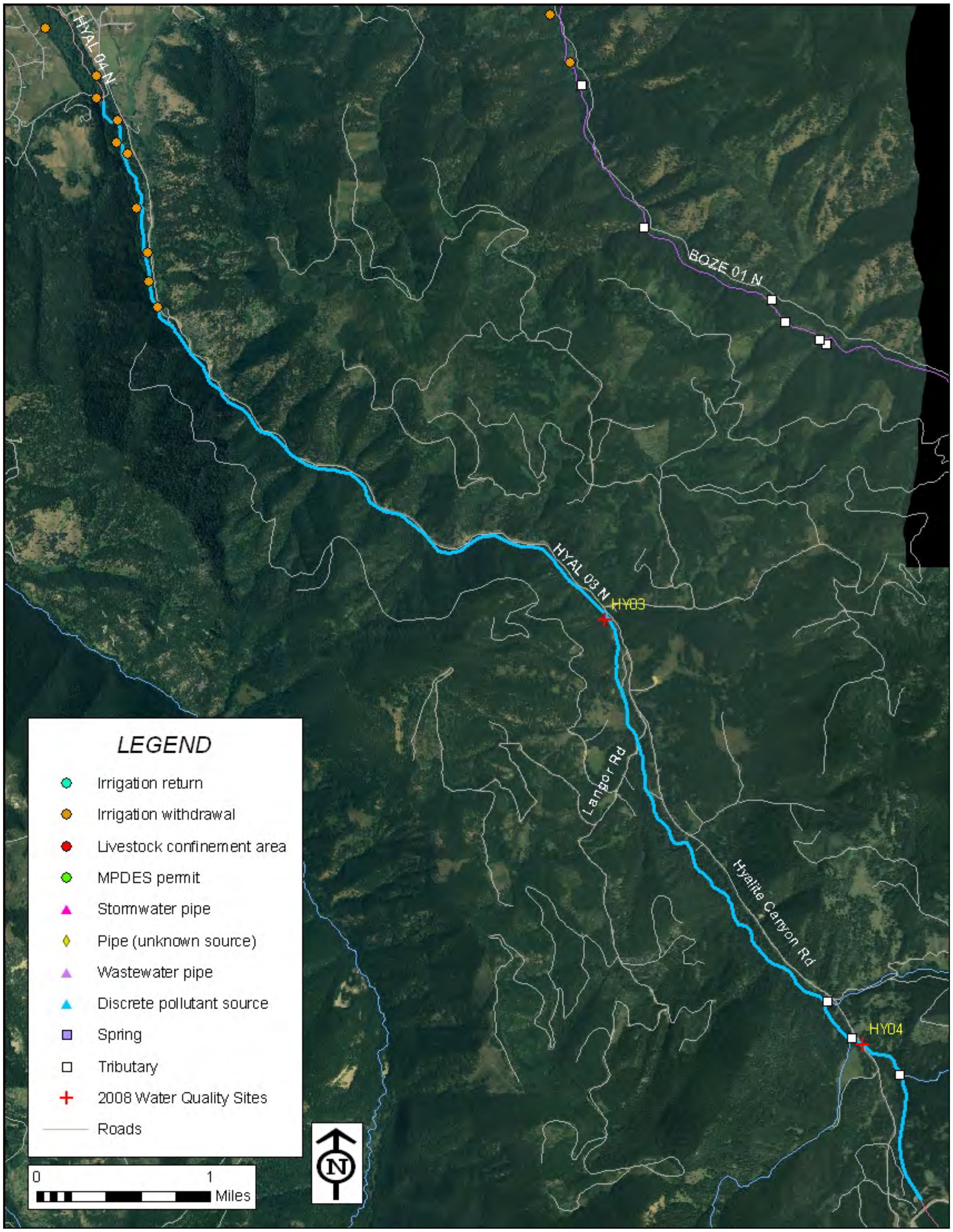

FIGURE 8. REACH HYAL 03 N

4.1. Reach Condition

Reach 3 is located entirely within the Gallatin National Forest, with the dominant land use being recreation. Although limited in width due to the confined channel throughout Hyalite Canyon, the riparian vegetation is very robust and healthy, consisting of a mixed conifer overstory with a willow-grass-forb understory (Figure 9). Bank erosion within the reach was considered to be low and was limited to mild recreation-related bank trampling in and around the Langhor Campground. The paved Hyalite Canyon Road encroaches within 50 ft of the stream for approximately 18,000 ft, or 3.4 miles, in the lower end of the reach. The bank between the road and the stream is steep, but well-vegetated and/or well-armored (Figure 10), therefore the road is not considered to be a significant sediment or nutrient source. Several irrigation withdrawals are located within the lower portion of reach HYAL 03 N, some of which withdraw a significant amount of flow from the creek.

FIGURE 9. REACH HYAL 03 N UPSTREAM OF LANGHOR ROAD

FIGURE 10. ROAD ENCROACHMENT ALONG HYALITE CANYON ROAD

4.2. Nutrient Source Characterization

Several small mountain tributary streams enter throughout reach HYAL 03 N but no discrete pollution sources were identified. Table 4 identifies general potential pollutant sources within the reach. The significance of all potential pollutant sources was considered low, given the low source presence and healthy riparian buffer. Light recreation within the reach was identified as a potential anthropogenic pollutant source within the reach. Forest Service toilets located at campgrounds and trailheads are vault toilets which are pumped and are therefore not considered to be a pollutant source. Very few septic systems exist within the reach with a density of 0.2/mi within 150 ft and 0.4/mi within the 150-1000 ft buffer (Table 4).

Two unpaved roads cross the reach: a driveway at the lower end of the reach, and the Langhor Road. The driveway did not appear to be causing significant sedimentation as the abutment areas were well vegetated. The Langhor Road crossing itself was not causing sediment delivery, yet the bridge allowed people from the adjacent campsite to access the stream downstream of the bridge causing trampling and minor erosion (Figure 11).

TABLE 4. POTENTIAL NUTRIENT SOURCES WITHIN REACH HYAL 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Light recreational use	Low	SW	Excellent	USFS campground and turnouts along main and forest roads	Low
Septic system (150 ft, #/mi)	0.2	GW	Excellent	Very low septic system density	Low
Unpaved road crossings (#)	2	SW	Excellent	Two crossings, low sediment delivery potential	Low

FIGURE 11. MINOR TRAMPLING DOWNSTREAM OF LANGHOR ROAD

5. HYAL 04 N

Reach 4 is a third order stream that extends from the mouth of Hyalite Canyon at Black Bear Road, to Elk Road upstream of Huffine Lane near Four Corners (Figure 12). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

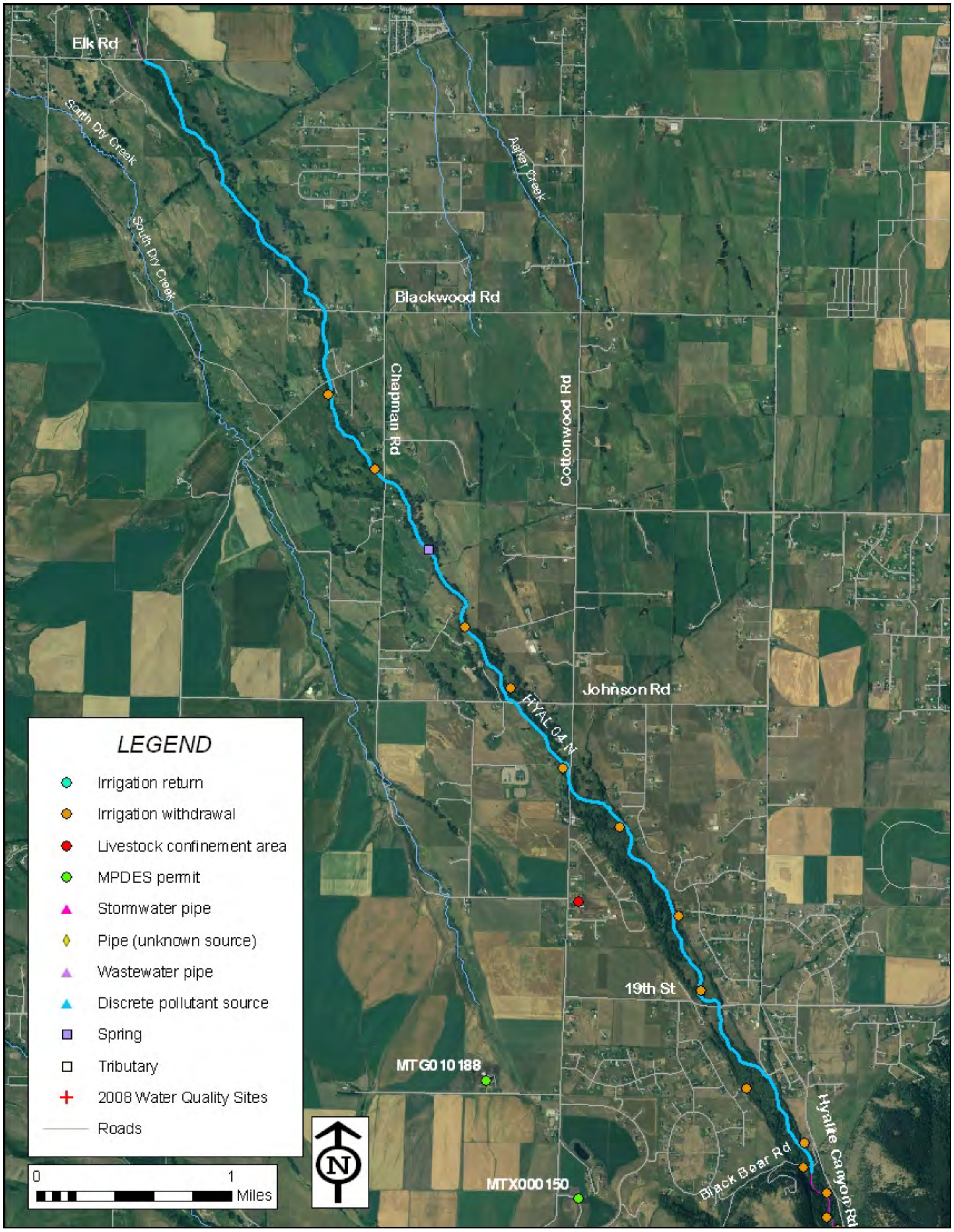

FIGURE 12. REACH HYAL 04 N

5.1. Reach Condition

The dominant land use within reach HYAL 04 N is residential, mixed with hay production and irrigated and dryland pasture. The riparian area is relatively healthy throughout the reach, with an overstory of cottonwood and a willow/dogwood/grass understory (Figure 13). However, isolated areas of significant cattle and horse grazing-related impact do exist, such as upstream of Elk Road, downstream of Blackwood Road, and downstream of Johnson Road. Bank erosion was relatively low within the reach and observed primarily at the road crossings mentioned above (Figure 14). Overall, banks appeared well-vegetated and stable.

Cottonwood Road and South 19th Avenue encroach on the stream within this reach. Cottonwood Road encroaches within 35 ft for approximately 400 ft; South 19th encroaches within 20 ft for approximately 300 ft. Both areas of encroachment are well vegetated and relatively well buffered from these paved roads (Figure 15).

Several irrigation withdrawals divert water within the reach. Two large ditches are displayed in the National Hydrography Dataset, and were observed on the aerial photo, crossing reach 4 upstream of Chapman Road and downstream of Blackwood Road. No withdrawals were identified on the MT DNRC layer, and these ditches were not considered to be associated with irrigation withdrawals or returns, as they most likely cross over or under Hyalite Creek in culverts. However, these situations were not confirmed in the field.

FIGURE 13. REACH HYAL 04 N AT BLACKWOOD ROAD CROSSING

FIGURE 14. EXAMPLE OF ERODING/TRAMPLED BANK UPSTREAM OF ELK ROAD IN HYAL 04 N

FIGURE 15. WELL-VEGETATED BANK WHERE COTTONWOOD ROAD ENCROACHES IN HYAL 04 N

5.2. Nutrient Source Characterization

Potential nutrient sources to reach HYAL 04 N are listed in Table 5. Although a high proportion of the land use within the reach is pasture, it was in relatively good condition, with little overgrazing and pasture encroachment observed. Pasture was therefore considered to have a low potential for nutrient input to the stream by overland delivery, however the potential for groundwater nitrate loading exists.

A spring and two livestock confinement areas were identified within the reach. One LCA identified during the field survey located just downstream of Blackwood Road, was situated within 5 ft of the stream and would likely function as a nutrient source during storm events, as manure and soil are washed into the stream (Figure 16). Four unpaved roads cross the reach: Blackwood Road, Chapman Road, Johnson Road and Black Bear Road. No significant potential for sediment input was observed at any of these unpaved crossings (Figure 17). While septic system density was only 0.4 septic/mi within 150 ft of the stream, density was 15.3 septic/mi from 150 to 1,000 ft (Table 5), with the highest density of septics occurring at the head of the reach near the mouth of Hyalite Canyon.

Three MPDES permit locations were identified perpendicular to reach HYAL 04 N, however it is unlikely that any of the permitted discharges impact this reach. Instead, the discharges flow to tributary streams that enter Hyalite Creek a minimum of 7.5 miles downstream of the permitted location. Details on the MPDES permits and pathways to Hyalite Creek are included in Table 6.

TABLE 5. POTENTIAL NUTRIENT SOURCES WITHIN REACH HYAL 04 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (ave% LB/RB)	23%	GW	Good	Primarily hay production	Low
Pasture (ave% LB/RB)	45%	SW/GW	Good	Cattle and horse pasture, some grazing noted directly adjacent to stream but overall pasture in good condition; pasture buffer generally present	Low /Med
Septic system per mi (150 ft/1000 ft)	0.4/ 15.3	GW	Good	Relatively low septic density	Low
Septic in tributaries	High	Tributary	Good	High density of septics in tributaries	Med
Unpaved road crossings (#)	4	SW	Good	No significant sedimentation potential observed at crossings	Low
LCA	2	GW/SW	Fair	One far from stream, one within 5 ft of stream with manure piles and minimal riparian buffer	Med
MPDES (see Table 6)	3	GW	Good	All three are far from stream and likely only impact downstream reaches HYAL 06 N and 07 N	Low

FIGURE 16. HORSE CORRAL WITHIN 5 FT OF STREAM IN HYAL 04 N

FIGURE 17. EXAMPLE OF STABLE, NON-EROSIVE CROSSING AT JOHNSON ROAD IN HYAL 04

TABLE 6. MPDES PERMITS LOCATED WITHIN REACH HY04 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTG010188	Faith Dairy	General	South Dry Cr, then either 7.5 mi to reach HYAL 05 N via a ditch, or continues downstream in Dry Cr another 8 mi downstream to reach HYAL 07 N	HYAL 05 N and/or HYAL 07 N
MTX000117	Rae Water and Sewer	Groundwater	Groundwater discharge likely flows towards Aijker Cr, then 8 mi to reach HYAL 06 N	HYAL 06 N
MTX000150	Homelands Development Co. LLC	Groundwater	Groundwater discharge likely flows towards South Dry Cr, then either 7.5 mi to reach HYAL 05 N via a ditch, or continues downstream in Dry Cr another 8 mi downstream to reach HYAL 07 N	HYAL 05 N and/or HYAL 07 N

6. HYAL 05 N

Reach 5 is a third order stream that extends from Elk Road upstream of Huffine Lane near Four Corners, downstream to Baxter Street (Figure 18). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

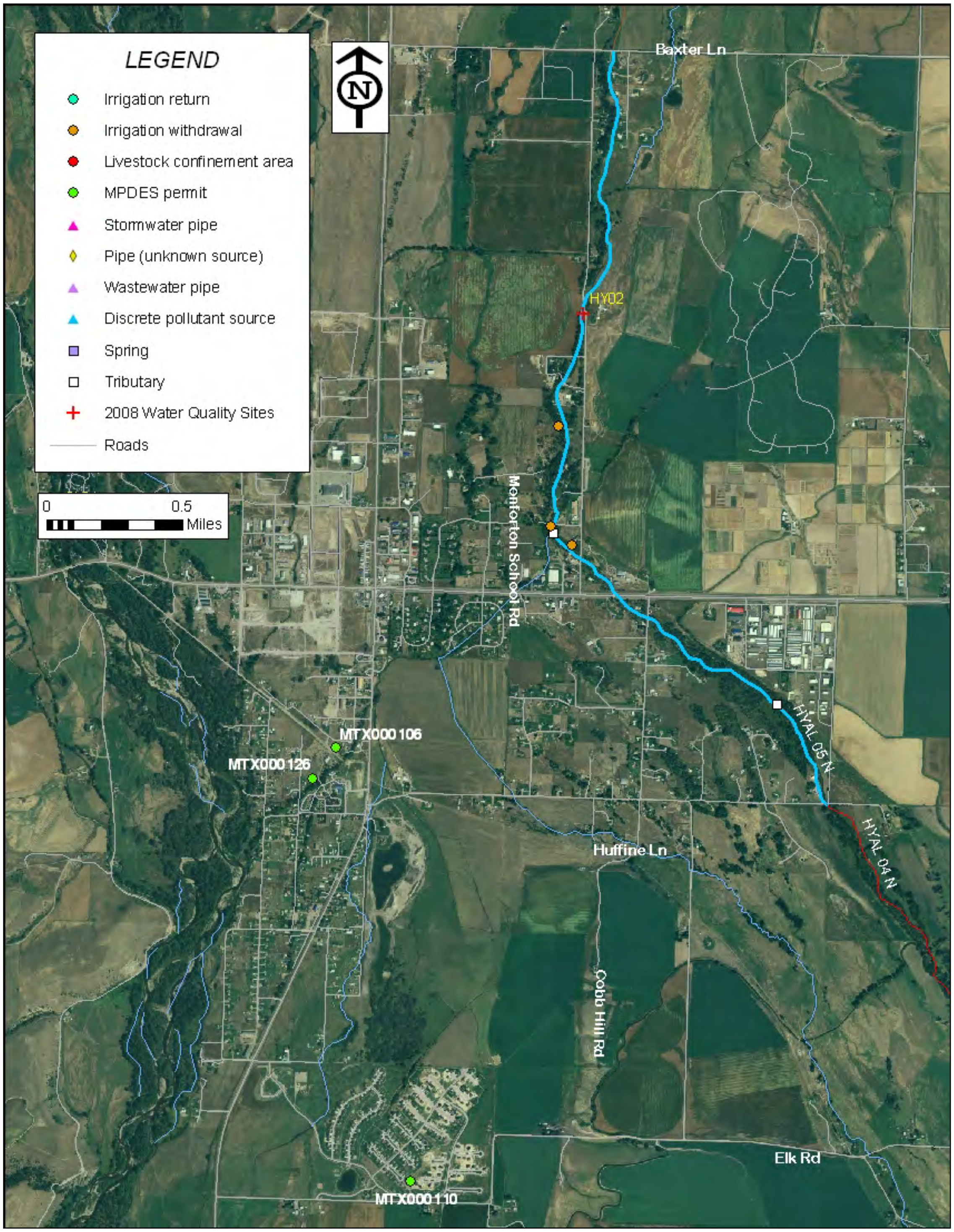

FIGURE 18. REACH HYAL 05 N

6.1. Reach Condition

The dominant land use within reach HYAL 05 N is residential, mixed with hay production and irrigated and dryland pasture. The riparian area is relatively healthy throughout the reach, with an overstory of cottonwood and a willow/chokecherry understory, with limited grazing impact (Figure 19). There is some concentrated yard encroachment around the Cobb Hill-Huffine Lane and Monforton School Road crossings (Figure 20). Overall banks appeared well-vegetated and erosion was limited to areas of yard and pasture encroachment, of which there were few. Monforton School Road, which is paved, encroaches within 30 ft for approximately 1,000 ft. The bank between the road and the stream is well-vegetated for the entire length of encroachment, buffering the stream from the road (Figure 21).

Three irrigation withdrawals were identified within the reach. A large ditch is displayed in the National Hydrography Dataset, and was observed on the aerial photo, crossing the reach downstream of Monforton School Road. No withdrawals were identified on the MT DNRC layer at this location, and this ditch was not considered to be associated with an irrigation withdrawal or return, as it most likely crosses over or under Hyalite Creek in a culvert. However, this was not confirmed in the field.

FIGURE 19. REACH HYAL 05 N DOWNSTREAM OF MONFORTON SCHOOL ROAD

FIGURE 20. YARD ENCROACHMENT UPSTREAM OF COBB HILL ROAD

FIGURE 21. MONFORTON SCHOOL ROAD ENCROACHING ON REACH HYAL 05 N

6.2. Nutrient Source Characterization

Potential nutrient sources to reach HYAL 05 N are listed in Table 7. Pasture land comprised a large amount of land use within the reach, but little pasture encroachment or overgrazing was observed. Combined with the good riparian buffer, pasture was considered a moderate potential nutrient source. The rural nature of the reach lends itself to increased concentration of septic systems, primarily in the upper portion of the reach. Septic density was 3.5 within 150 ft and 26.6 within the 150 to 1,000ft buffer, and was therefore considered a moderated potential source of nutrients to the stream. One significant tributary enters the reach, downstream of Huffine Lane. Septic system density was relatively high within this tributary watershed. Because the riparian zone quality along this tributary was not observed, the potential significance of the tributary septics as a nutrient source was considered moderate. Only one unpaved crossing was identified during the survey, at Elk Road. This bridged crossing had stable concrete abutments and clean decking and was not considered to be a sediment source (Figure 22).

Three MPDES permit locations were identified perpendicular to reach HYAL 05 N, however it is possible that none of the permitted discharges impact the reach. Instead, the discharges flow to tributary streams that enter Hyalite Creek a minimum of 7.5 miles downstream of the permitted location. Details on the MPDES permits and pathways to Hyalite Creek are included in Table 8.

TABLE 7. POTENTIAL POLLUTION SOURCES WITHIN REACH HYAL 05 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (ave% LB/RB)	23%	GW	Good	Irrigated crops throughout reach - return flows evident	Low
Pasture (ave% LB/RB)	43%	SW/GW	Good	Floodplain pasture and hay production - good riparian, generally buffered from the stream	Med
Septic system per mi (150 ft/1000 ft)	3.5/26.6	GW	Good	Medium amount of septic systems in proximity of stream	Med
Septic in tributaries	High	Tributary	Not Investigated	High density of septics in tributaries draining to stream	Med
Unpaved road crossings (#)	1	SW	Good	One unpaved crossing (Elk Rd), not considered to be a sediment source	Low

FIGURE 22. CONCRETE ABUTMENT AT ELK ROAD CROSSING

TABLE 8. MPDES PERMITS LOCATED WITHIN REACH HY05 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTX000110	Utility Solutions LLC	Groundwater	Groundwater discharge likely flows towards Elk Grove Slough, then to Dry Cr, then either 7.5 mi to reach HYAL 05 N via a ditch, or continues downstream in Dry Cr another 8 mi downstream to reach HYAL 07 N	HYAL 05 N or HYAL 07 N
MTX000106	Utility Solutions LLC	Groundwater	Groundwater discharge likely flows towards Dry Cr, then either 7.5 mi to reach HYAL 05 N via a ditch, or continues downstream in Dry Cr another 8 mi downstream to reach HYAL 07 N	HYAL 05 N or HYAL 07 N
MTX000126	Bozeman KOA	Groundwater	Groundwater discharge likely flows towards Dry Cr, then either 7.5 mi to reach HYAL 05 N via a ditch, or continues downstream in Dry Cr another 8 mi downstream to reach HYAL 07 N	HYAL 05 N or HYAL 07 N

7. HYAL 06 N

Reach 6 is a third order stream that extends from Baxter Road, downstream to Airport Road (Figure 23). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

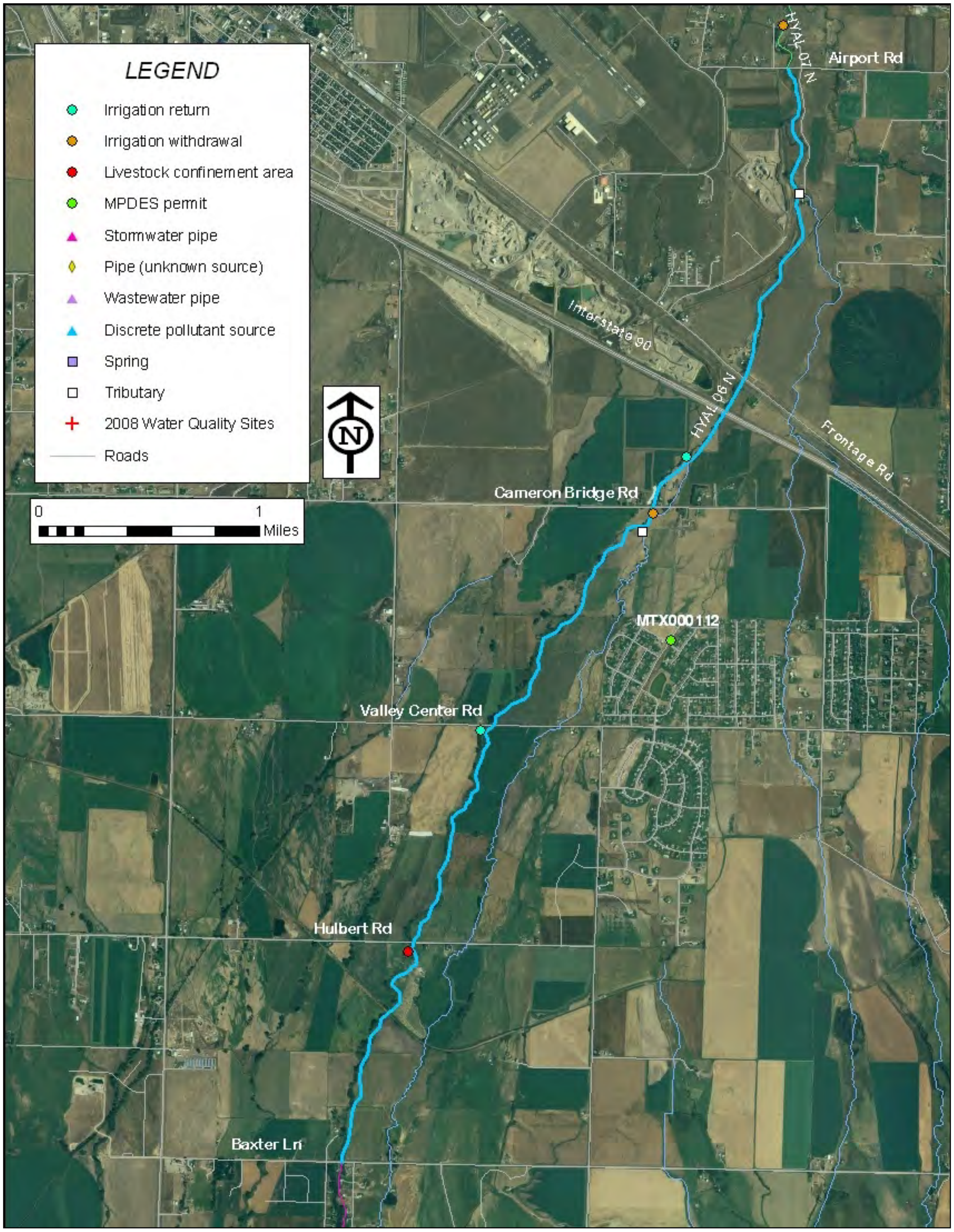

FIGURE 23. REACH HYAL 06 N

7.1. Reach Condition

The dominant land use within reach HYAL 06 N is pasture mixed with hay production. Riparian condition was rather poor in the lower section of the reach downstream of Valley Center Road, often very weedy and overgrazed with unhealthy cottonwoods and yard encroachment (Figure 24). Riparian condition improved in the upstream sections, with a healthy cottonwood overstory and willow/grass understory (Figure 25). Pasture was still common in the upper sections but overgrazing was not observed.

Although riparian condition was poor in the lower section, banks were observed to be relatively stable and bank erosion was limited to areas of pasture and yard encroachment throughout the reach. No roads encroached on the stream within the reach, and one irrigation withdrawal was identified upstream of Cameron Bridge Road. This withdrawal was not confirmed in the field.

FIGURE 24. OVERGRAZED RIPARIAN WITH UNHEALTHY COTTONWOODS UPSTREAM OF CAMERON BRIDGE ROAD

FIGURE 25. HEALTHY RIPARIAN AT VALLEY CENTER ROAD

7.2. Nutrient Source Characterization

Two irrigation returns and two tributary streams enter reach HYAL 06 N. Because these returns and tributaries flow through agricultural land prior to reaching Hyalite Creek they are considered a potential nutrient source to the reach. Pasture comprises a high proportion of the land use in reach HYAL 06 N (Table 9). Due to the low quality, overgrazed, narrow riparian buffer observed downstream of Valley Center Road, and a lack of BMP's such as riparian fencing observed, pasture was considered to have a moderated potential for nutrient delivery to the stream.

One MPDES permitted discharge, an LCA, and two unpaved road crossings were also identified within reach HYAL 06 N (Table 9). The MPDES permit is a groundwater discharge permit for a the Valley Grove subdivision, located on a tributary stream approximately ½ mile upstream of Hyalite Creek (Table 10, Figure 23). With fewer residences in this reach the septic system influence was lower, with a septic density of 0.3/mi within 150 ft and 2.9/mi within the 150 to 1,000 ft buffer (Table 9). Septic density was considered high in tributary streams, primarily due to the Valley Grove subdivision. It was confirmed with the Gallatin Local Water Quality District newer residences within the Valley Grove Subdivision are connected to a central sewer system for which there is an MPDES permit, while older residences are on individual septic systems.

Two unpaved road crossings were identified. The bridge at Cameron Bridge road was well-vegetated around the abutments and was not likely causing any significant sediment delivery. Hulbert Road had gravel covering the decking and was potentially a sediment source during storm events (Figure 26). The LCA was a small sheep operation located adjacent to the stream just upstream of Hulbert Road. The area was overgrazed but it was difficult to discern whether the sheep were fenced from the creek (Figure 27).

TABLE 9. POTENTIAL NUTRIENT SOURCES WITHIN REACH HYAL 06 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture % (LB/RB)	50%	SW/GW	Fair/Good	Overgrazed, weedy, with significant pasture encroachment with almost no pasture buffer downstream of Valley Center Rd. Riparian improves upstream.	Med
Irrigation returns (#)	2	SW	Unknown	Drains agricultural land	Med
Septic system per mi (150 ft/1000 ft)	0.3/2.9	GW	Fair/Good	Relatively low septic density near stream throughout reach	Low
Septic in tributaries	High	Tributary	Fair/Good	High septic density in tribs	High
Unpaved road crossings (#)	2	SW	Fair/Good	Hulbert Rd xing potentially causing some sedimentation during storm events from gravel/fines on decking	Med
LCA (#)	1	GW/SW	Fair	Sheep operation close to stream, overgrazed pasture and lawn adjacent to LCA	Med
MPDES (# permits)	1	GW	Good	Valley Grove Water and Sewer	Low

TABLE 10. MPDES PERMIT LOCATED WITHIN REACH HY06 N

MPDES ID	Permittee Name	Permit Type	Pollutant Pathway	Discharge Reach
MTX000112	Valley Grove Water and Sewer	Groundwater	Groundwater discharge likely flows to tributary, then to Hyalite Cr approximately 0.5 mi downstream	HYAL 06 N

FIGURE 26. GRAVEL ON BRIDGE DECKING AT HULBERT ROAD

FIGURE 27. SHEEP OPERATION IN DISTANCE, UPSTREAM OF HULBERT ROAD

8. HYAL 07 N

Reach 7 is a fourth order stream that extends from Airport Road, downstream to the confluence with the East Gallatin River (Figure 28). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

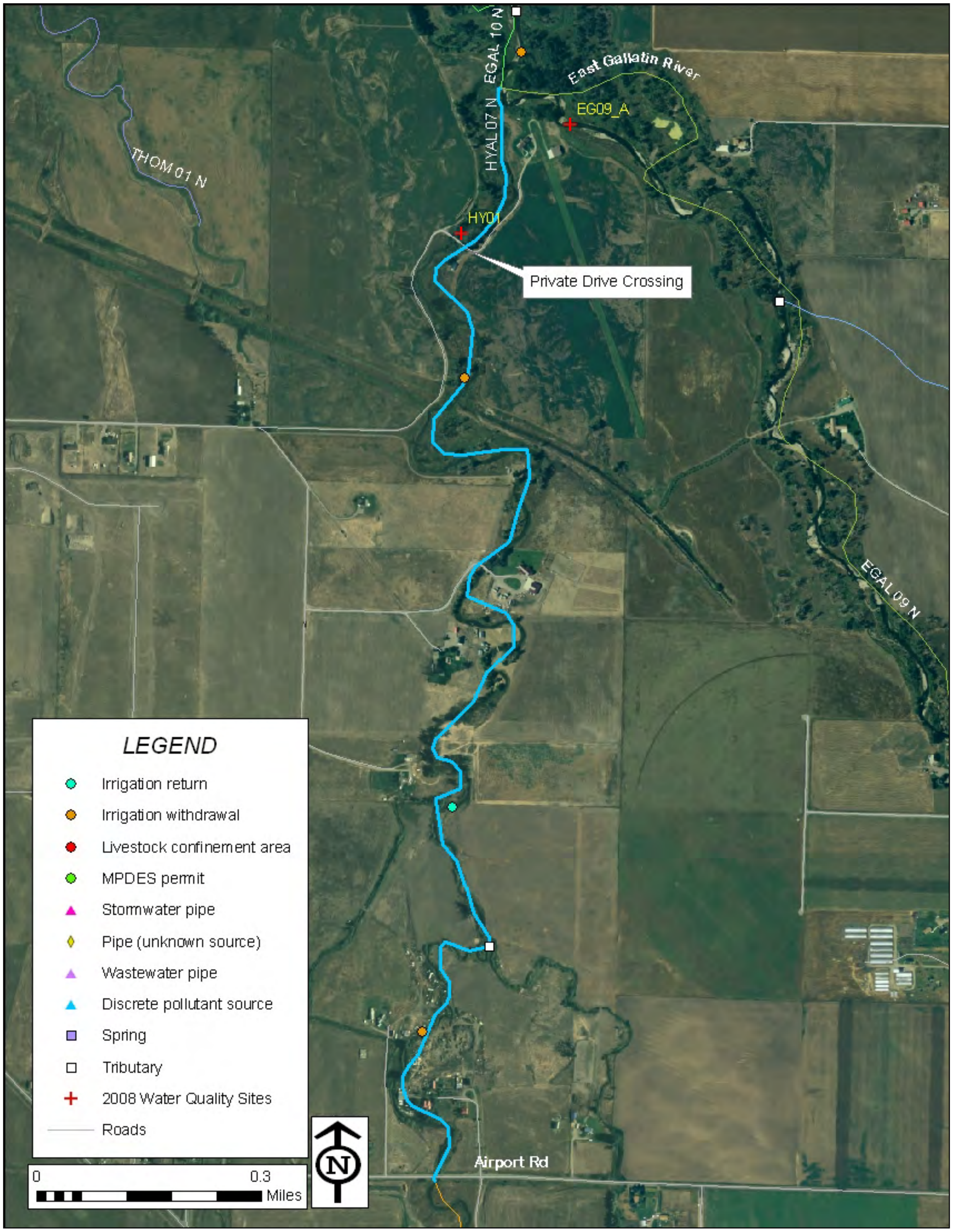

FIGURE 28. REACH HYAL 07 N

8.1. Reach Condition

The dominant land use within reach HYAL 07 N is pasture, mixed with irrigated and dryland crops and rural residential. Riparian condition was considered fair to good throughout the reach, with some areas dominated by weedy, overgrazed pasture, as seen at the crossing of Airport Road (Figure 29). Other areas, such as upstream of the confluence with the East Gallatin River, the riparian was dense, although thick with invasive reed canarygrass (Figure 30). Although weedy and overgrazed in some areas, banks appeared to be relatively stable and not highly erosive. No roads encroached on the stream within the reach and two irrigation withdrawals were identified. One of the withdrawals was not confirmed on the aerial or in the field.

FIGURE 29. REACH 7 DOWNSTREAM OF AIRPORT ROAD. RIPARIAN IS WEEDY AND OVERGRAZED ON LEFT BANK, DENSE WILLOWS RIGHT BANK.

FIGURE 30. REACH 7 UPSTREAM OF THE CONFLUENCE WITH THE EAST GALLATIN RIVER

8.2. Nutrient Source Characterization

Irrigated crops comprised a relatively low percentage of land use within the reach (Table 11) and although the riparian buffer quality was low, irrigated crops were considered to have a low potential for nutrient delivery. Pasture land was abundant within the reach. Combined with relatively low riparian quality, observed pasture encroachment and a lack of riparian fencing pasture was considered to have a moderate potential significance for nutrient delivery.

One irrigation return and one tributary were identified entering the reach. The one unpaved road crossing was a well-maintained driveway bridge that was well-vegetated near the abutments (Figure 31) and was not considered to be a sediment or nutrient source. Septic system influence was relatively low, with a septic density of 0.5/mi within 150 ft and 6.1/mi within the 15 to -1,000 ft buffer (Table 11).

TABLE 11. POTENTIAL NUTRIENT SOURCES WITHIN REACH HYAL 07 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (ave% LB/RB)	10%	GW	Fair/Good	Hay and some wheat production	Low
Pasture (ave% LB/RB)	70%	SW/GW	Fair/Good	Some pasture encroachment (e.g. downstream of Airport Rd), with areas of healthy riparian	Med
Irrigation returns (#)	1	SW	Unknown	Drains agricultural land	Low
Septic system per mi (150 ft/1000 ft)	0.5/6.1	GW	Fair/Good	Low septic density through reach	Low
Unpaved road crossings (#)	1	SW	Good	One well maintained driveway bridge	Low

FIGURE 31. UNPAVED DRIVEWAY CROSSING WITH WELL-VEGETATED ABUTMENTS UPSTREAM OF THE CONFLUENCE WITH THE EAST GALLATIN RIVER

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Jackson Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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JACKSON CREEK

Jackson Creek has its headwaters in the Bangtail Mountains east of Bozeman. It flows through forested lands on the Gallatin National Forest prior to converging with Timberline Cr to form Rocky Cr, just north of Interstate 90 (Figure 1). The 2008 water quality site JK01 was actually located on Rocky Cr.

Water quality in Jackson Creek (Waterbody ID MT41H003_050) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: total phosphorus, and sedimentation/siltation. For the purposes of assessing pollutant sources, Jackson Creek was divided into two reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients to Jackson Creek. Reach-scale conditions on Jackson Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

Jackson Creek is only marginally impacted by anthropogenic sources throughout its eight mile length, with logging, unpaved fords, and livestock grazing on pasture land identified as the most significant potential nutrient sources. Active logging on RY Timber Company land in the upper reaches is generally buffered from the stream by dense riparian vegetation, but increased sediment and nutrient delivery remains potentially significant in these areas. Three two track roads were observed fording the stream in the upper reach, and more are likely present due to logging and recreation in the area. These fords are a potentially significant source of sediment and nutrients. Livestock grazing on pasture land was common in the lower reach, and some grazing-associated erosion was observed at cattle crossings and areas of pasture encroachment. The riparian quality was good to excellent throughout both the reaches, with conifer forest in the headwater reach, and dense willows along the lower reach.

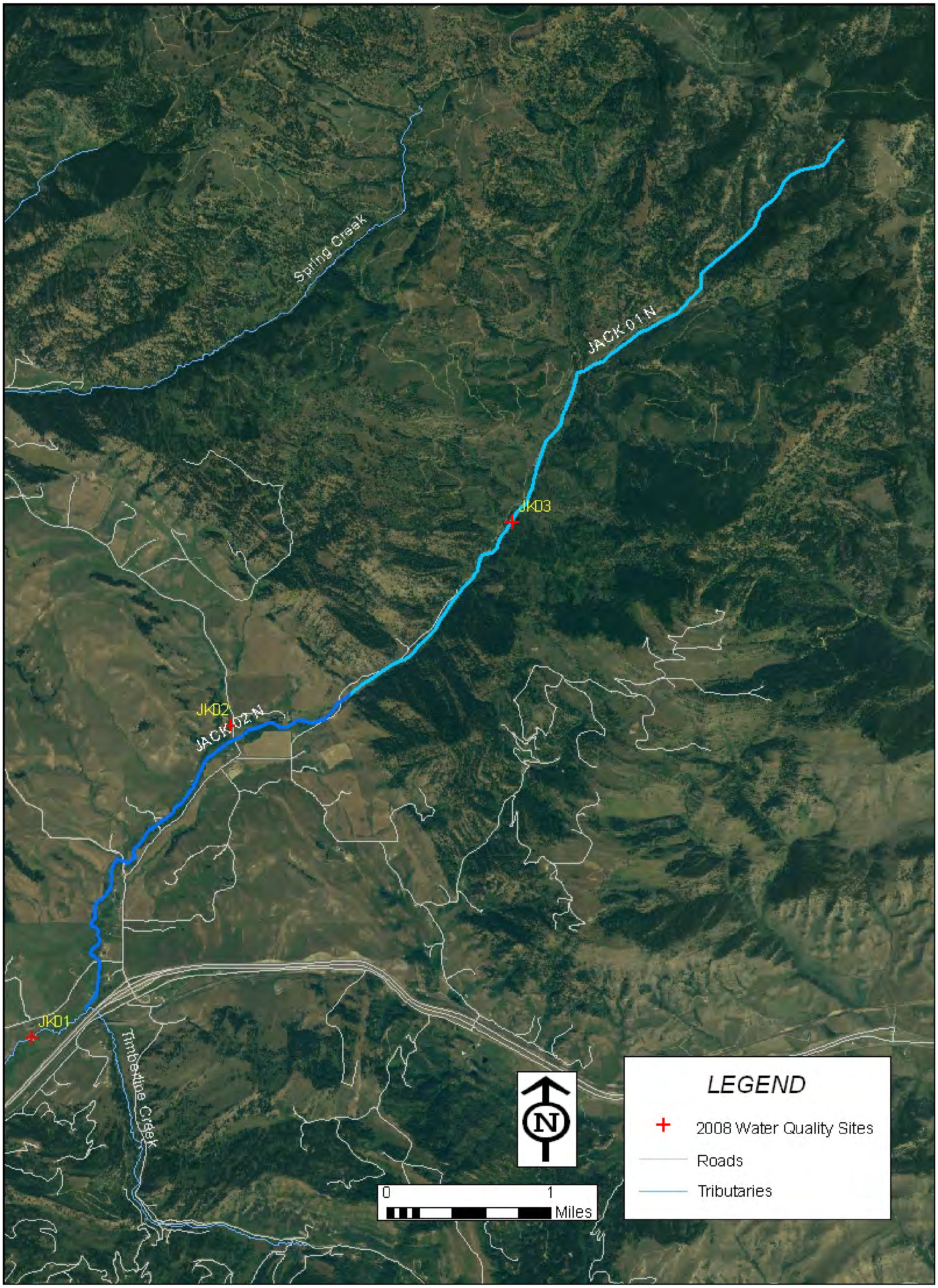

FIGURE 1. OVERVIEW OF JACKSON CREEK

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID	Reach Length (mi)	Ecoreg.	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP	Septic 150 ft per mi	Septic 1000 ft per mi
JACK 01 N	4.76	17i	2	FOREST	N	3	0	L	40	NA	0.0	0.2
JACK 02 N	3.02	17w	2	HAY/PASTURE	N	2	0	L	80	NA	0.3	4.6

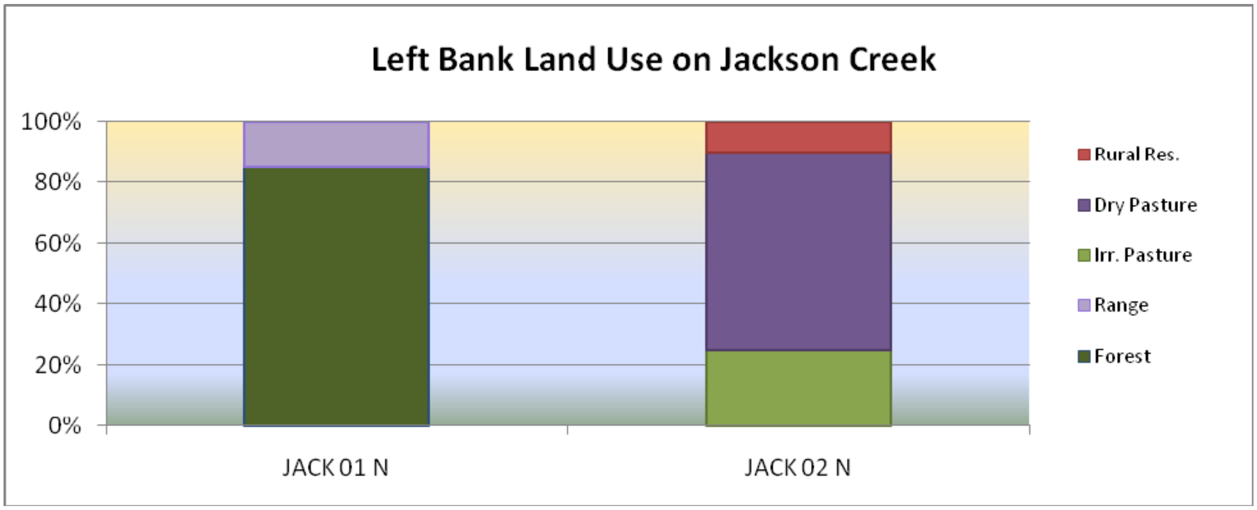

FIGURE 2. LAND USE TYPES ALONG THE LEFT BANK OF JACKSON CREEK

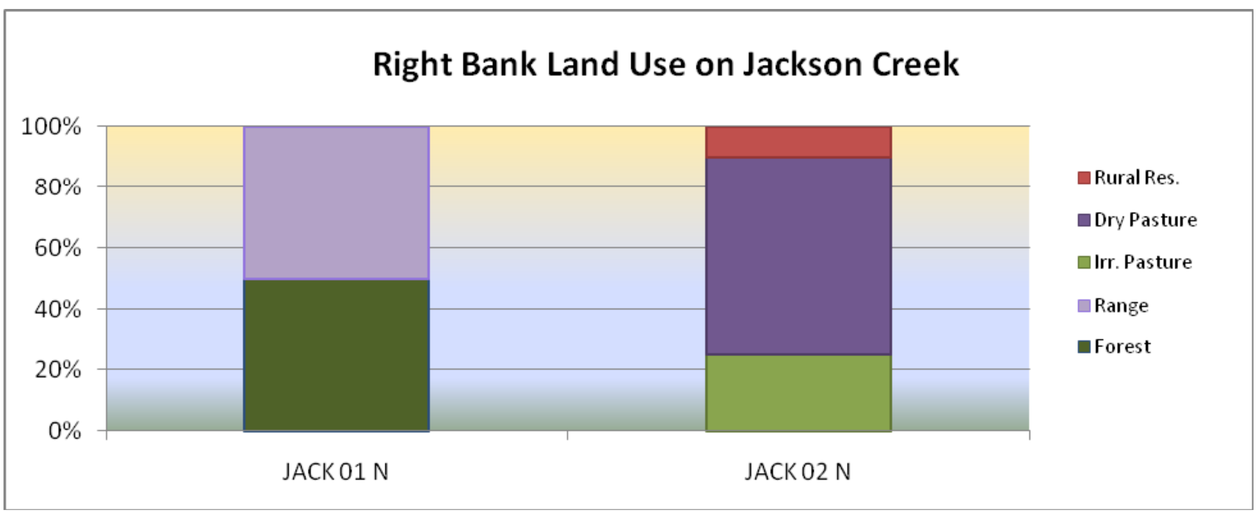

FIGURE 3. LAND USE TYPES ALONG THE RIGHT BANK OF JACKSON CREEK

2. JACK 01 N

Reach 1 is a second order stream high in the Bangtail Mountains east of Bozeman. The reach spans from the stream headwaters, downstream to where it crosses Jackson Creek Rd (Figure 4). The dominant Level 4 PRI ecoregion of the reach is 17i, Absoroka-Gallatin Volcanic Mountains.

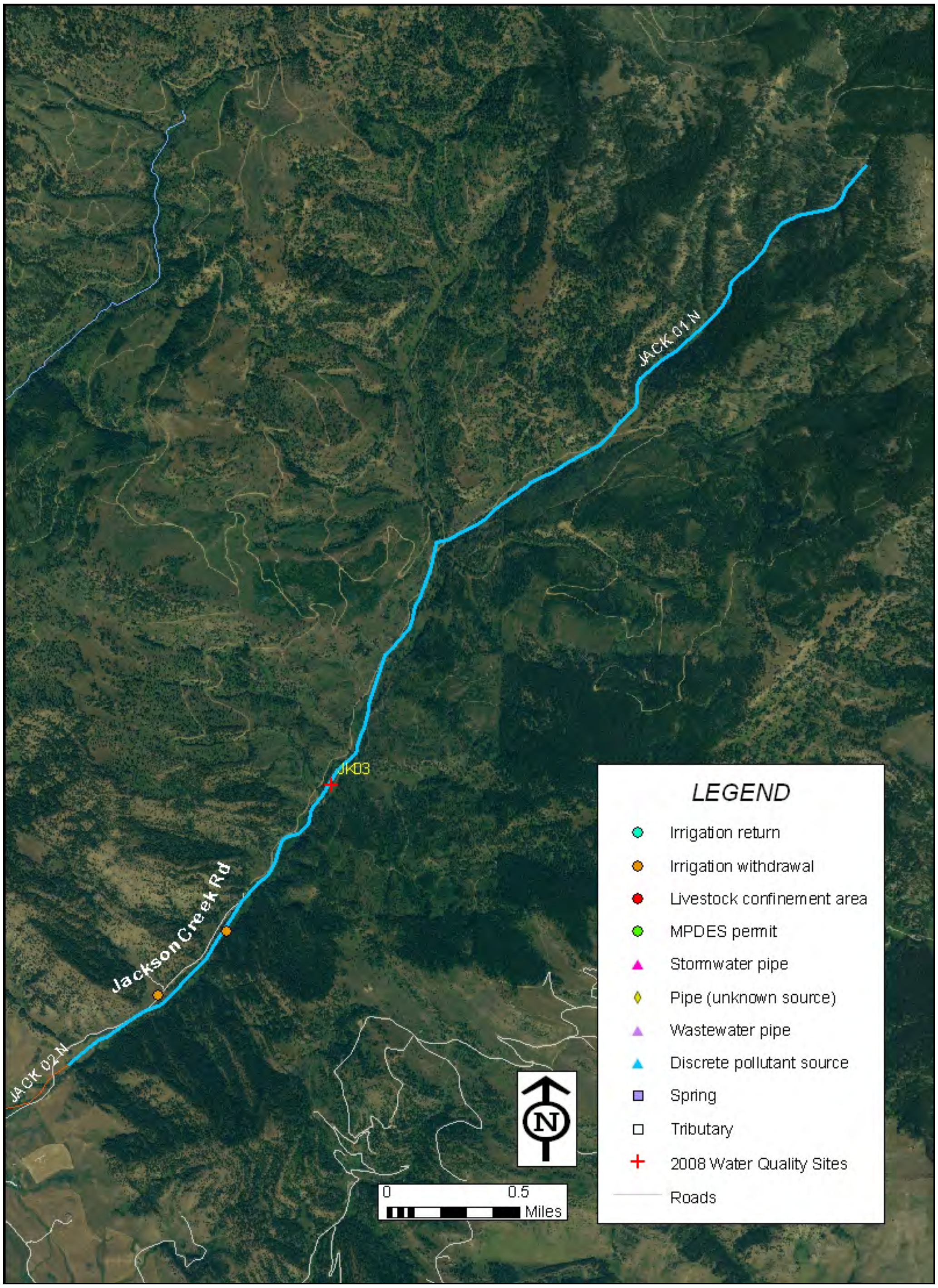

FIGURE 4. REACH JACK 01 N

2.1. Reach Condition

The reach flows through a mosaic of Gallatin National Forest and RY Timber Company land. Dominant land uses are logging, recreation and grazing. The riparian vegetation is generally robust and healthy, consisting of a mixed conifer overstory with a willow-grass-forb understory (Figures 5 and 6), with select areas of grazing impact, and forest/logging road crossings. Bank erosion was limited to natural erosion of high banks on outer meander bends (Figure 6), and logging road crossings (Figure 7). Livestock grazing did not appear to be a significantly impacting on the riparian vegetation.

FIGURE 5. DENSE WILLOW-CONIFER RIPARIAN

FIGURE 6. WILLOW-CONIFER RIPARIAN WITH NATURAL BANK EROSION ON OUTER MEANDER BEND.

FIGURE 7. LOGGING ROAD CROSSING IN UPPER SECTION

2.2. Potential Pollution Sources

Potential nutrient sources within the reach are detailed in Table 2. Recreational uses could be causing minimal nutrient and sediment input from dispersed campsites along the stream. Historic and active logging in the upper watershed was considered a low to moderate potential nutrient source. Three logging two-track roads cross the stream at fords, causing active sedimentation into the stream (e.g. Figure 7).

TABLE 2. POTENTIAL NUTRIENT SOURCES WITHIN REACH JACK 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Light recreational use	low/med	SW	Excellent	Dispersed campsites could be causing minimal nutrient input. Recreation impact likely related to two-track crossings	low
Logging	Historic and active	SW	Excellent	Historic and active logging is buffered from stream by riparian but some sedimentation is likely	low/med
Septic system per mi (150 ft/1000 ft)	0.0/.02	GW	Excellent		low
Unpaved road crossings (#)	3	SW	Excellent	logging road/two track fords, actively causing sedimentation	med

3. JACK 02 N

Reach 1 is a second order stream high in the Bangtail Mountains east of Bozeman. The reach spans from the stream headwaters, downstream to where it crosses Jackson Creek Rd (Figure 4).

The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

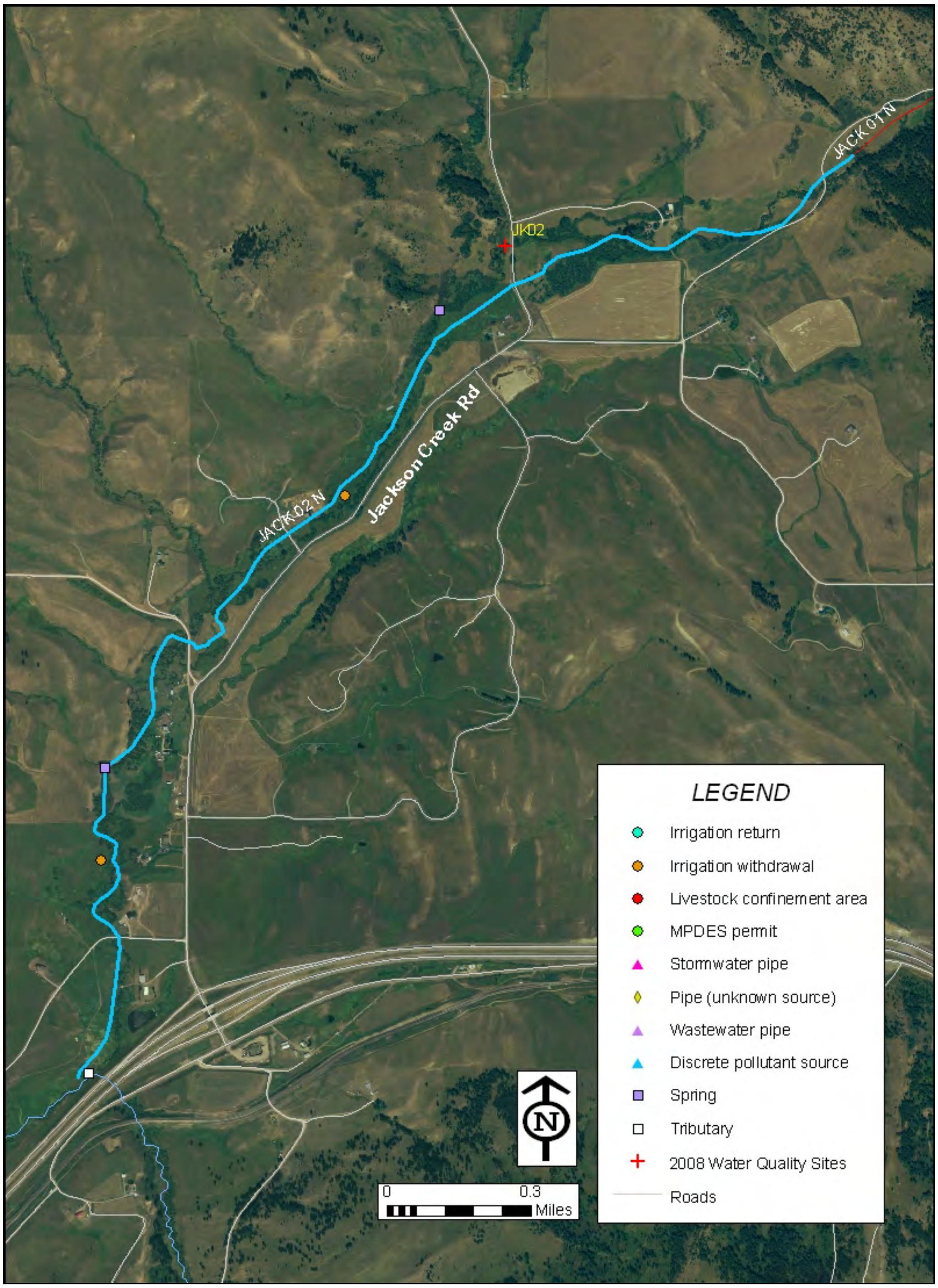

FIGURE 8. REACH JACK 02 N

3.1. Reach Condition

The dominant land use in the reach is irrigated and dry pasture, with scattered residences. The riparian vegetation is generally robust and healthy, consisting of a dense willow overstory with sedge-grass understory (Figure 9). Low to moderated bank erosion was observed, primarily associated with livestock grazing, such as the area downstream of Jackson Creek Rd where there was an active cattle crossing (Figure 10), and cattle were observed within the riparian zone and in the stream. Two irrigation withdrawals were identified but neither was confirmed in the field.

FIGURE 9. DENSE WILLOW RIPARIAN; LOOKING DOWNSTREAM AT JACKSON CREEK RD CROSSING

FIGURE 10. CATTLE CROSSING DOWNSTREAM OF JACKSON CREEK RD AT 2008 WATER QUALITY SITE JK02

3.2. Potential Pollution Sources

Potential nutrient sources within the reach are detailed in Table 3. Pasture land was identified as the primary potential nutrient source for the reach. Although livestock are not grazed in high density in this section of the stream, pasture land was considered a moderately significant nutrient source, as no best management practices were noted and cattle were observed to have unlimited access to the reach for most of its length. Septic system density was relatively low. Two unpaved crossings were identified. The Forest Service Rd was in good condition with vegetation at the culvert, but some sedimentation could be occurring during storm events (Figure 11). The condition of the lower unpaved private road was not observed due to private land access issues.

TABLE 3. POTENTIAL NUTRIENT SOURCES WITHIN REACH JACK 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	90%	SW/GW	Good	livestock not in high density	med
Septic system per mi (150 ft/1000 ft)	0.3/4.6	GW	Good		low
Unpaved road crossings (#)	2	SW	Good	Forest Service Rd in good condition	low

FIGURE 11. DOWNSTREAM FROM FOREST SERVICE RD CROSSING

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Reese Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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REESE CREEK

Reese Creek starts in the foothills on the west side of the Bridger Mountains north of Bozeman. It flows through agricultural lands and rural residential areas to its confluence with Smith Creek upstream of Dry Creek Road (Figure 1). Water quality in Reese Creek (Waterbody ID MT41H003_070) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: total nitrogen, total phosphorus, fecal coliform, and suspended sediments. For the purposes of assessing pollutant sources, Reese Creek was divided into three reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients and E. coli. Reach-scale conditions on Reese Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 4 and 5. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

The routing of Reese Creek at its confluence with Smith Creek is incorrect on both the NHD and the 303d layer. The NHD routing has "Ross Creek" flowing west under a ditch from the East Gallatin River, under a private two-track road, and merging with Reese Creek downstream of this road (Figure 2). The 303d layer routing also depicts Smith Creek flowing under the private two-track road and merging with Reese Creek. In reality, Smith Creek flows to the private road and takes a sharp bend to the north where it is channelized along the road (Figure 3). The appearance of a channel west of the road on the aerial photo is misleading, as this channel is long abandoned, with no evidence of recent or yearly flow under the road and into the old channel downstream. Reese Cr enters Smith Cr just before Smith Cr flows under the private road. In 2008 water quality site RS01 was placed on Smith Creek rather than Reese Creek, as it was assumed that the channel entering from the south was indeed a ditch as indicated on the NHD layer.

1.1. Summary

Reese Creek appears minimally impacted by anthropogenic sources throughout its seven mile length. Potential nutrient sources were determined to have a low potential significance in reaches REES 01 and 02. These upper reaches flow primarily through irrigated and non-irrigated cropland, pasture, and native rangeland. Where observed, this agricultural land was generally in good condition and not overgrazed or encroaching significantly on the stream. The riparian zone in the upper two reaches was healthy, with dense shrubs, grasses, and sparse cottonwoods.

Irrigated crops, primarily wheat, barley and hay, were identified as having a moderate potential significance for nutrient delivery in reach REES 03. Some crop field encroachment was observed in this reach, and the riparian buffer was rather narrow and weedy. Pasture buffers were the only best management practices observed during the assessment.

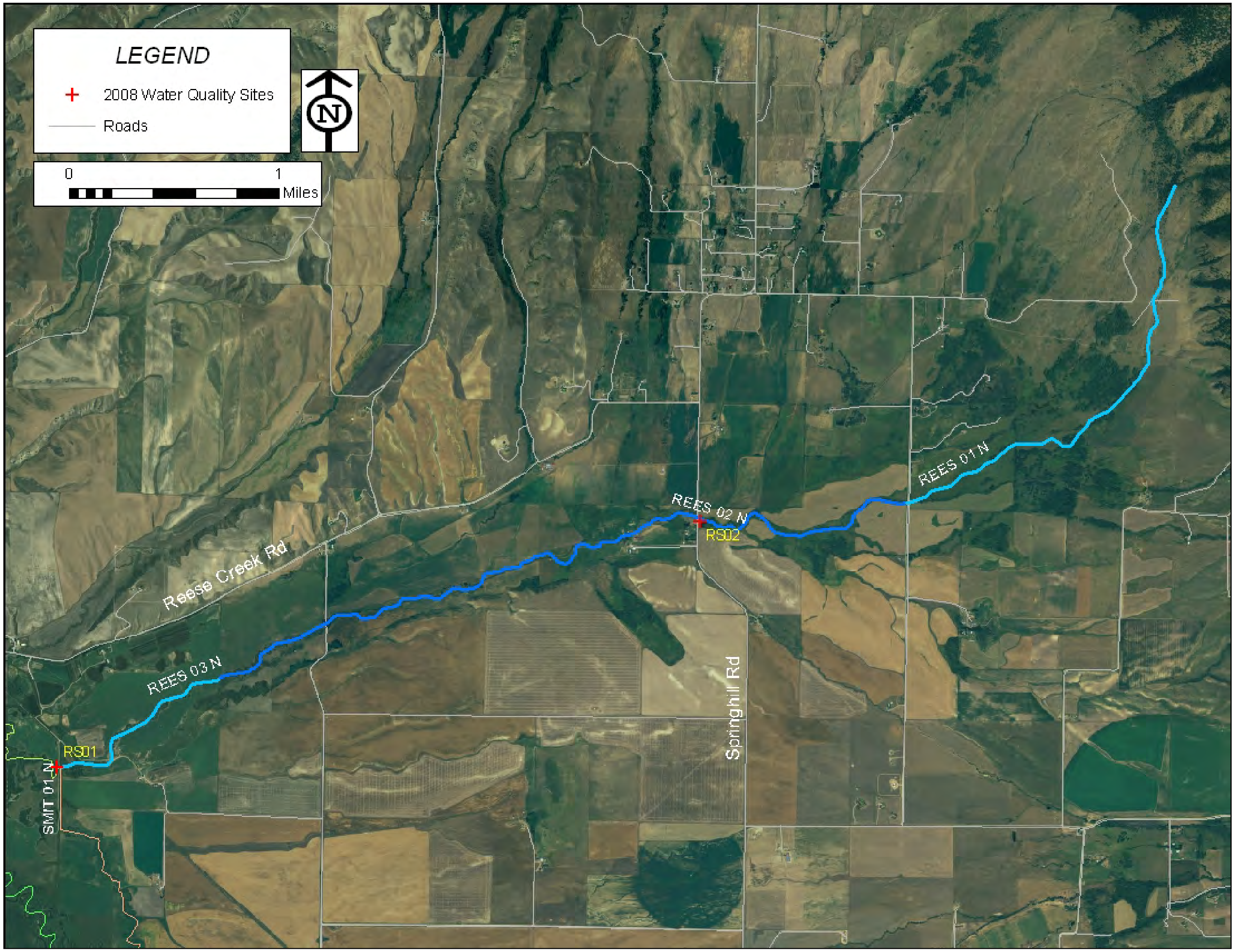

FIGURE 1. OVERVIEW OF REESE CREEK NORTH OF BOZEMAN AND BELGRADE

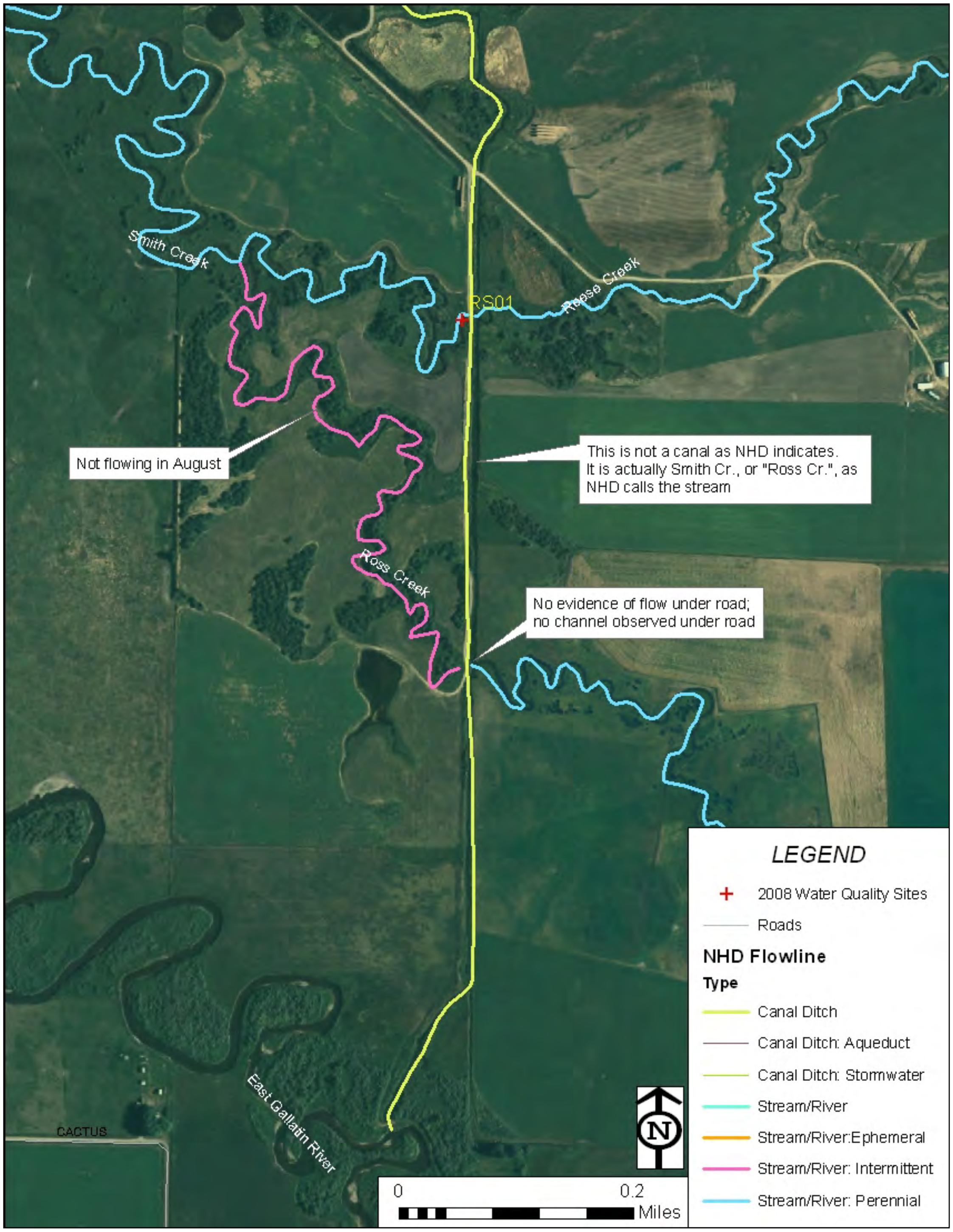

FIGURE 2. NHD GIS LAYER ROUTING OF SMITH, "ROSS", AND REESE CREEKS NEAR THEIR CONFLUENCE

FIGURE 3. ACTUAL ROUTING OF SMITH AND REESE CREEKS NEAR THEIR CONFLUENCE

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID	Ecoreg.	Reach length (mi)	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP	Septic 150 ft per mi	Septic 1000 ft per mi
REES 01 N	17w	2.35	2	RANGE/ PASTURE	Y	0	0	L	40	PBR	0.0	0.9
REES 02 N	17w	3.83	4	HAY	N	2	0	L	40	PBR	0.0	5.2
REES 03 N	17w	1.26	4	HAY	N	1	150	L	50	PBR	0.0	0.0

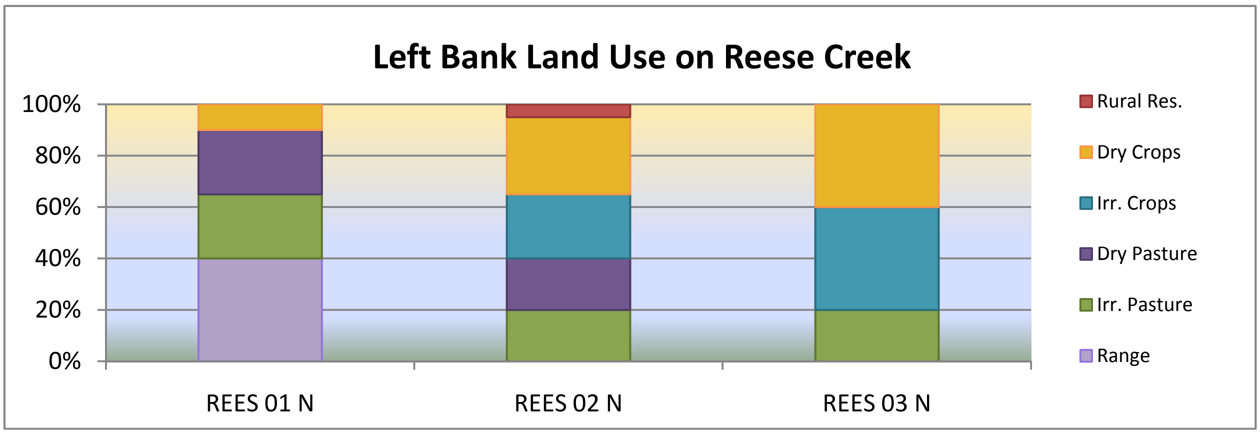

FIGURE 4. LAND USE TYPES ALONG THE LEFT BANK OF REESE CREEK

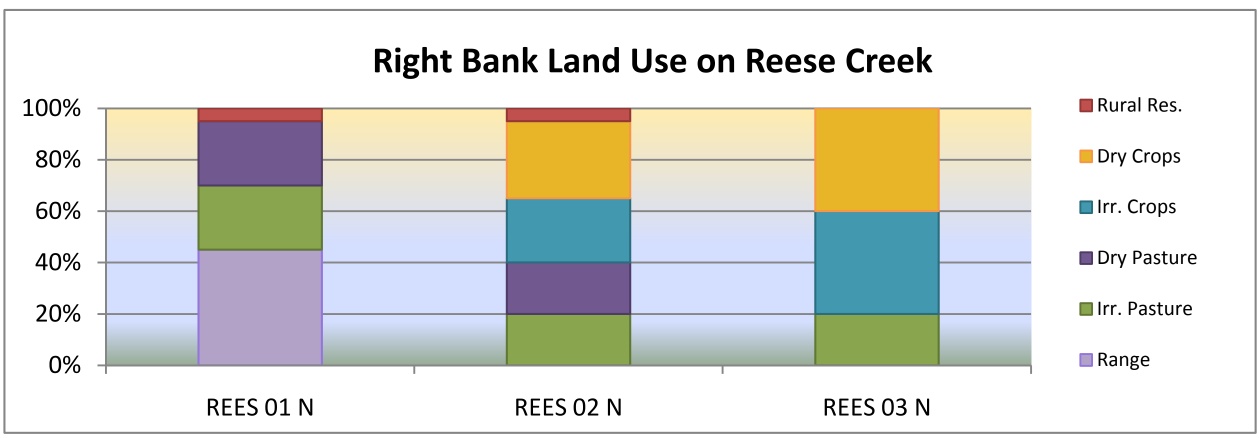

FIGURE 5. LAND USE TYPES ALONG THE RIGHT BANK OF REESE CREEK

2. REES 01 N

Reach 1 begins in the foothills of the west side of the Bridger Mountains north of Bozeman and extends downstream to Gee Norman Rd (Figure 6). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

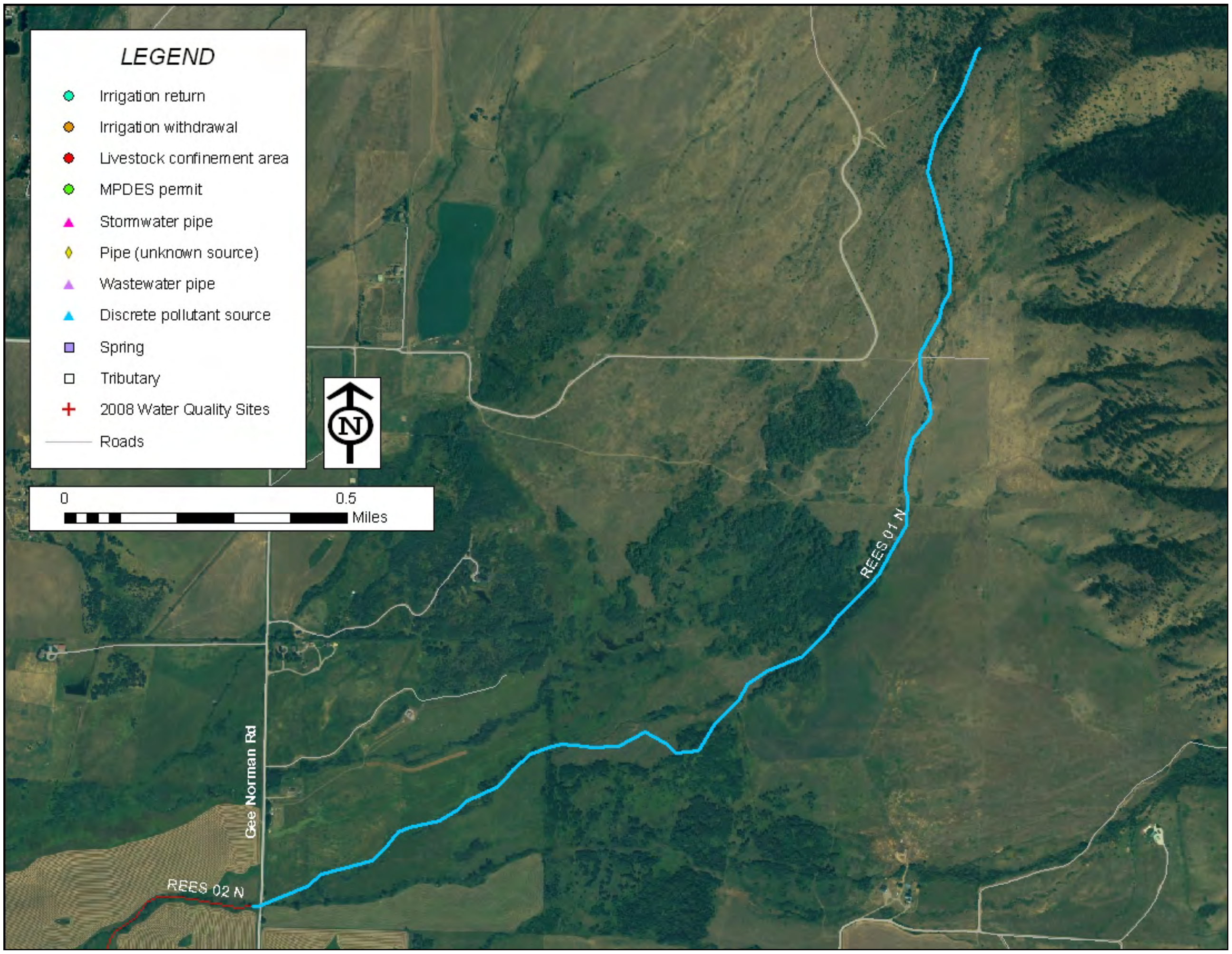

FIGURE 6. REACH REES 01 N

2.1. Reach Condition

The dominant land uses within the reach are rangeland and pasture. The reach was only observed at the Gee Norman Rd crossing at the downstream end of the reach. From this crossing looking upstream into the Bridger Mountain foothills, the riparian vegetation appeared very healthy, consisting of dense willows, alders, forbs and grasses, with sparse cottonwoods (Figure 7). Consequently, bank erosion was considered low but could be more common upstream of Gee Norman Rd (Figure 8). No roads encroach within the reach.

FIGURE 7. HEALTHY RIPARIAN WITH STABLE BANKS UPSTREAM OF GEE NORMAN RD

FIGURE 8. HEALTHY RIPARIAN ALONG REACH REES 01 N LOOKING UPSTREAM FROM GEE NORMAN RD

2.2. Nutrient Source Characterization

Potential nutrient and E. coli sources within the reach are identified in Table 2. On the aerial there appears to be an irrigation withdrawal approximately 0.5 miles upstream of Gee Norman Rd, and a subsequent return on the upstream side of Gee Norman Rd. However, no irrigation return was observed in the field and it was thus not added to the point attributes. The relative percent of pasture throughout the reach is moderate, but it appears to be in good condition (Figure 8) and with the dense riparian, this was considered to be of low potential significance. No septic systems were identified within 150 feet of the stream, and density was very low within the150-1000 foot buffer. The reach is not crossed by any unpaved roads.

TABLE 2. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH REES 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	50	SW/GW	excellent	appears to be in good condition with dense riparian; hence considered of low significance	low/med
Septic system per mi (150 ft/1000 ft)	0.0/0.9	GW	excellent		low

3. REES 02 N

Reach 2 begins downstream of Gee Norman Rd and extends downstream through pasture and hay fields to approximately ¾ of a mile downstream of Hamilton Rd. (Figure 9). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

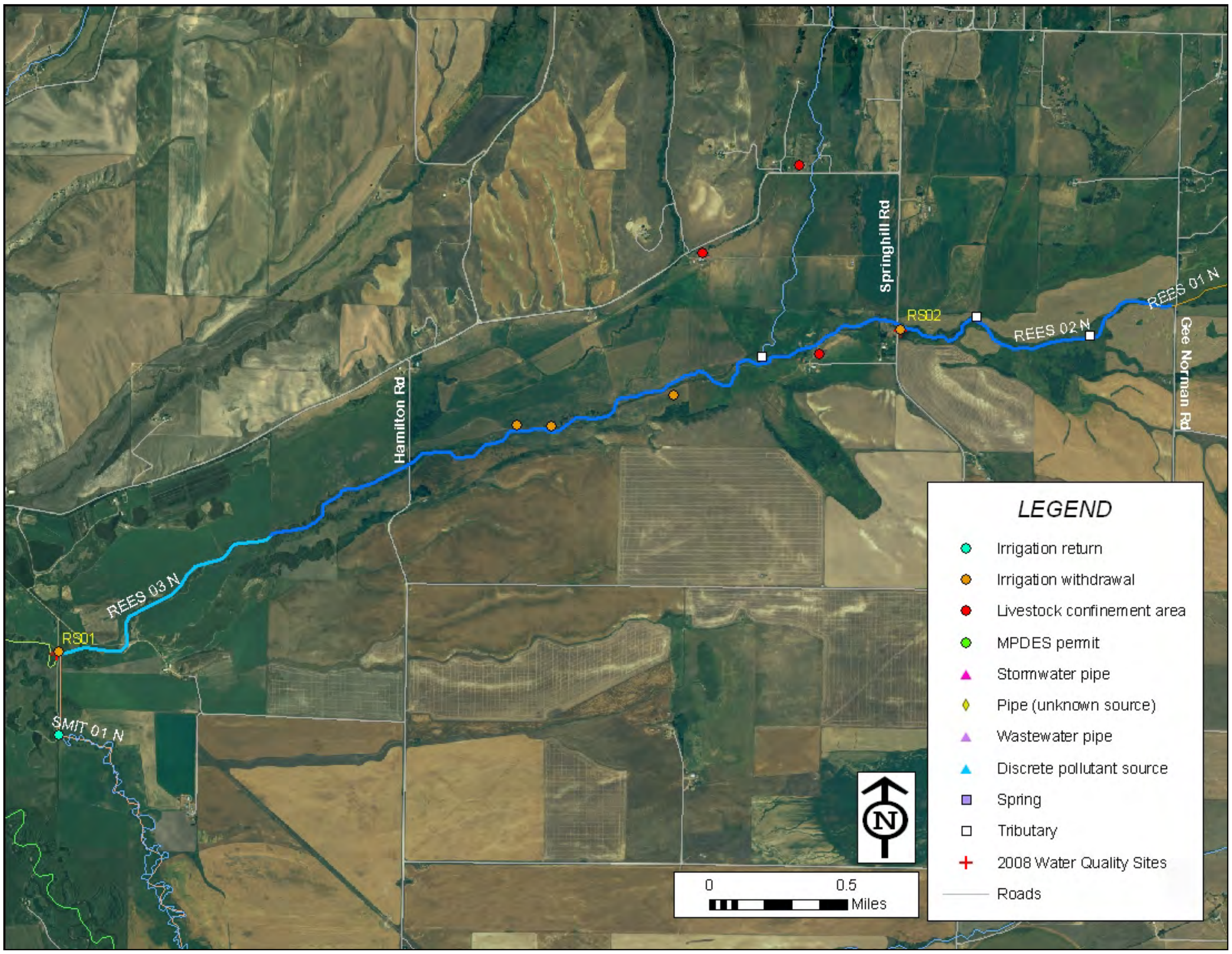

FIGURE 9. REACHES REES 02 N AND REES 03 N

3.1. Reach Condition

The dominant land uses within the reach are hay production and pasture, with scattered residences. The riparian vegetation appeared very healthy within the reach, consisting of willows and cottonwoods with a forb-grass understory (Figures 10 and 11). No bank erosion was observed from either the Hamilton Rd or Gee Norman Rd crossings, both of which are unpaved. Four irrigation withdrawals were identified on the GIS layer, but none of these withdrawals were confirmed in the field. It is also very difficult to discern whether they are present or not based on the aerial, due to the presence of paleochannels and the irrigated bottomland.

FIGURE 10. DENSE RIPARIAN WITH STABLE BANKS DOWNSTREAM OF HAMILTON RD

FIGURE 11. WILLOW-GRASS RIPARIAN ALONG STREAM IN DISTANCE DOWNSTREAM OF HAMILTON RD

3.2. Nutrient Source Characterization

Potential nutrient and E. coli sources within the reach are identified in Table 2. Although pasture comprised a moderate amount of land use, it appeared to be in good condition and was not overgrazed or significantly encroaching on the stream. Therefore it was considered to have a low to moderate potential as a nutrient and E. coli source. Irrigated crops, primarily wheat, barley, and hay, were also considered to have a low potential for nutrient delivery.

One of the LCAs was located near the stream and could be a potential nutrient source. Another LCA flows to a ditch 0.7 mile upstream of Reese Cr. The third would most likely impact only a ditch that never enters Reese Cr but rather flows west along Dry Creek Rd for some distance. Irrigated pasture and irrigated crops were both low within the reach and were considered to have low potential significance. No septic systems were identified within 150 feet of the stream, and density was moderate within the 150-1000 foot buffer. With the healthy riparian buffer, the potential significance of septic systems was considered low.

Tributaries entering the reach include Limestone Cr, Bill Smith Cr and North Cottonwoods Cr, all small streams draining from the west side of the Bridger Mountains which were not considered significant potential nutrient sources. The Hamilton Rd crossing, with concrete abutments, was not considered a potential sediment source. The culvert at Gee Norman road was covered with gravel and could potential act as a sediment source during storm events (Figure 12).

TABLE 3. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH REES 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	40	SW/GW	excellent	appeared to be in good condition with dense riparian	low/med
Irrigated crops (Ave. % LB/RB)	25	GW	excellent	wheat, barley, hay production	low
Septic system per mi (150 ft/1000 ft)	0.0/5.2	GW	excellent		low
Septic in tributaries	Medium	Tributary	excellent		low
Unpaved road crossings (#)	2	SW	excellent	Hamilton Rd very stable; Gee Norman Rd minor potential sediment source	low
LCA (#)	3	GW/SW	unknown	one within 200 ft; two flow to ditches, not directly to reach	low

FIGURE 12. GRAVEL ON CULVERT AT GEE NORMAN RD

4. REES 03 N

Reach 3 begins approximately ¾ of a mile downstream of Hamilton Rd and extends downstream to its confluence with Smith Cr, upstream of Dry Creek Rd (Figure 9). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

4.1. Reach Condition

The dominant land uses within the reach are hay production and pasture. Although narrow, the riparian was dense, consisting of weedy reed canarygrass, pasture grasses and thistles, with patches of willows and buffaloberry (Figure 14). Pasture/hay field encroachment was observed in some areas (Figure 15). Banks were generally stable due to the dense riparian vegetation. However, bank erosion was observed in areas where pasture encroached along meander bends (Figure 15). No roads encroach on the reach.

FIGURE 13. DENSE REED CANARYGRASS RIPARIAN WITH BUFFALOBERRY AND WILLOWS

FIGURE 14. BANK EROSION WHERE PASTURE ENCROACHES ON A MEANDER BEND

4.2. Nutrient Source Characterization

Potential nutrient and E. coli sources within the reach are identified in Table 5. The irrigated agriculture along the stream was considered to be of moderate potential significance, due to the moderate source prevalence and sometimes narrow riparian buffer. An unpaved private ranch road crosses the stream within the reach. The road is well-maintained gravel and is infrequently used, but loose gravel was observed on top of and around the culvert and some minimal sedimentation could be occurring during storm events (Figure 16).

TABLE 4. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH REES 03 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	40	GW	Good	moderate	med
Pasture (Ave. % LB/RB)	20	SW/GW	Good	low prevalence but often encroaching	low/med
Unpaved road crossings (#)	1	SW	Good	well maintained culvert crossing, minor sedimentation could be occurring during storm events	low

FIGURE 15. CULVERT AT RANCH ROAD CROSSING

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Smith Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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SMITH CREEK

Smith Creek starts in the foothills on the west side of the Bridger Mountains north of Bozeman. It flows through agricultural lands and rural residential areas for approximately 11 miles to its confluence with the East Gallatin River just upstream of Swamp Road near the Dry Creek area (Figure 1).

Water quality in Smith Creek (Waterbody ID MT41H003_060) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: fecal coliform, nitrates, and sediment. For the purposes of assessing pollutant sources, Smith Creek was divided into two reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients and E. coli. Reach-scale conditions on Smith Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 4 and 5. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

The disagreement between the National Hydrography Dataset (NHD) and the MT 303d streams GIS layers regarding the naming and routing of Smith Creek requires a short discussion. From the headwaters, downstream to the confluence with Reese Creek, the NHD GIS layer labels Smith Creek as "Ross Creek", while the MT 303d GIS layer labels this section "Smith Creek". Incidentally, when locals were asked what they called this section of the creek, they concurred that they called it "Ross Creek" upstream of the confluence with Reese Creek. For the purpose of this assessment, the MT 303d layer convention was used, calling the entire length Smith Creek.

The routing of Smith Creek at the confluence with Reese Creek is incorrect on both the NHD and the 303d layer. The NHD routing has "Ross Creek" flowing west under a ditch from the East Gallatin River, under a private two-track road, and merging with Reese Creek downstream of this road to then form Smith Creek (Figure 2). The 303d layer routing also depicts Smith Creek flowing under the private two-track road and merging with Reese Creek. In reality, Smith Creek flows to the private road and takes a sharp bend to the north where it is channelized along the road (Figures 3 and 4). The appearance of a channel west of the road on the aerial photo is highly misleading, as this channel is long abandoned with no evidence of recent or yearly flow under the road and into the old channel downstream. Reese Cr enters Smith Cr just before Smith Cr flows under the private road. In 2008 water quality site RS01 was placed on Smith Creek rather than Reese Creek, as it was assumed that the channel entering from the south was indeed a ditch as indicated on the NHD layer.

1.1. Summary

Throughout its fourteen mile length Smith Creek flows primarily through horse and cattle pastures, and irrigated and non-irrigated cropland planted primarily with wheat, barley and hay. Therefore pasture land and irrigated crops were identified as the most significant potential sources of nutrients and E. coli to the stream. While the riparian area was dense and healthy in some areas with decent pasture buffers, other sections had significant pasture or cropland encroachment with a very narrow, weedy, overgrazed riparian zone. In these areas, the banks were often eroding due to the lack of stabilizing vegetation and naturally-erosive soils. Pasture buffers were more prevalent in reach 2 than in reach 1. Limited riparian fencing was observed; even where pasture buffers existed, livestock had full access to the stream in both reaches where the stream flowed through pasture land.

Unpaved road crossings were also considered a potential sediment source in reach SMIT 01 N, due to loose sediment and gravel observed on bridge decking and on top of culverts. Septic systems and livestock confinement areas were considered minor but not significant potential nutrient sources within both reaches.

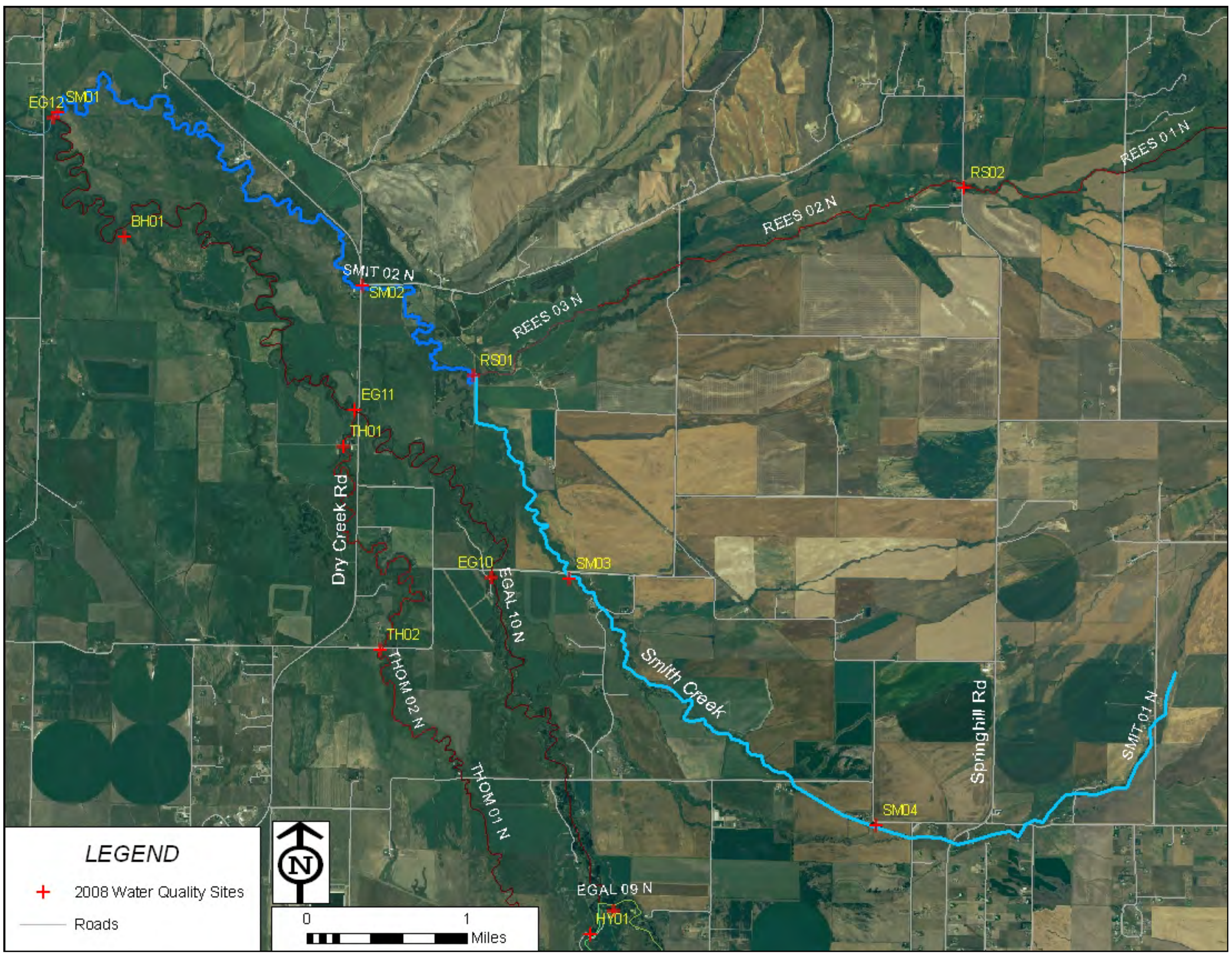

FIGURE 1. OVERVIEW OF SMITH CREEK NORTH OF BOZEMAN AND BELGRADE

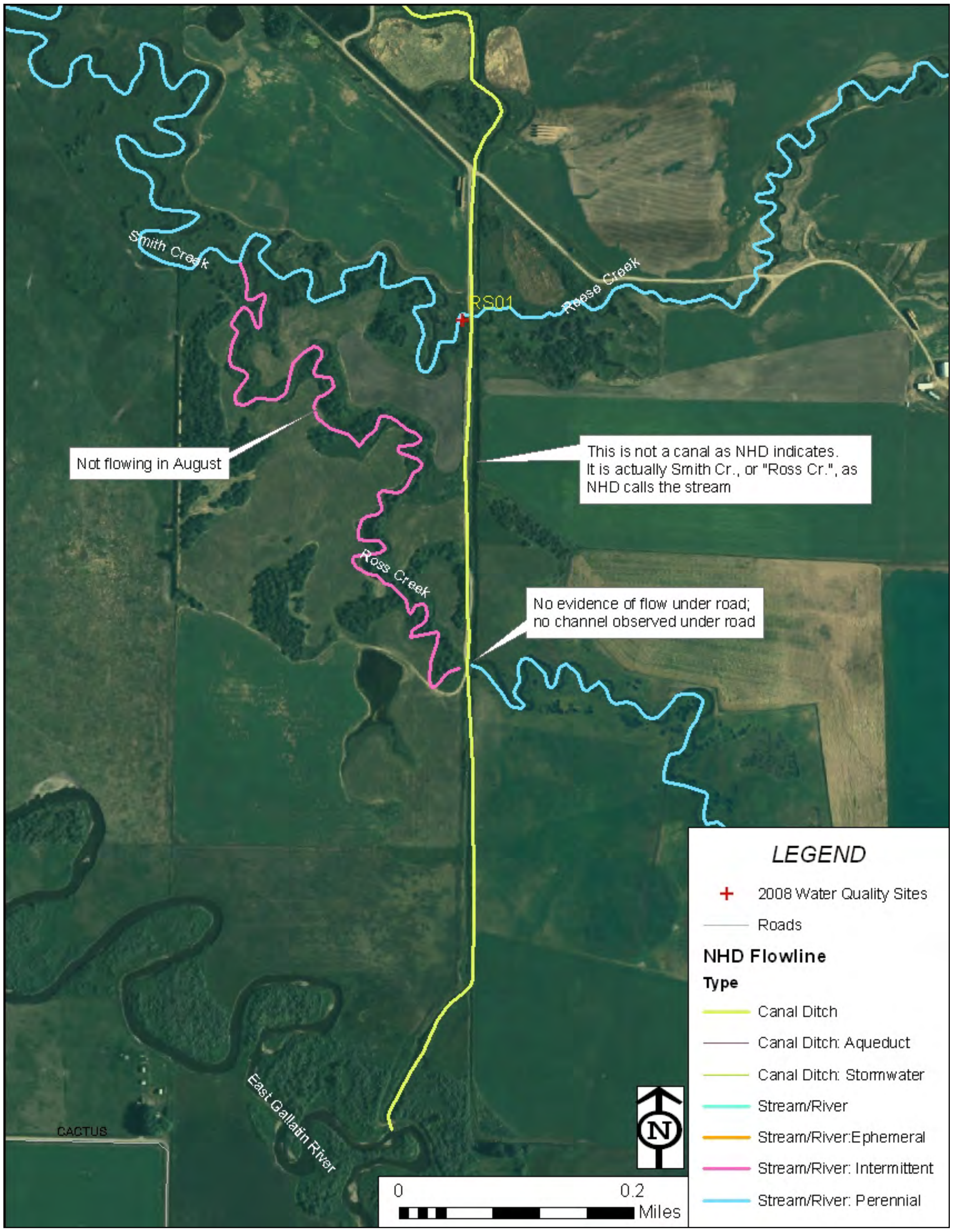

FIGURE 2. NHD GIS LAYER ROUTING OF SMITH, “ROSS”, AND REESE CREEKS NEAR THEIR CONFLUENCE

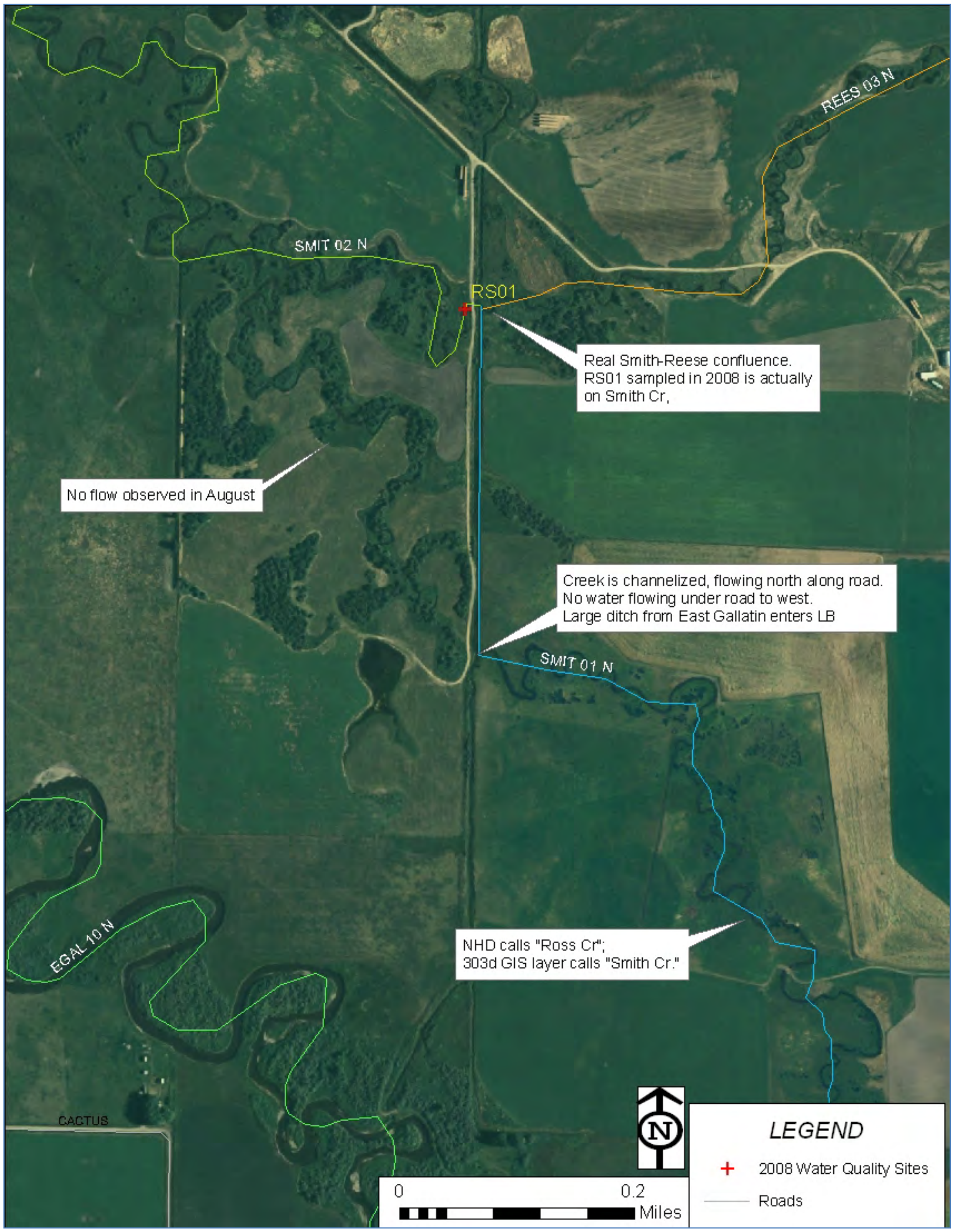

FIGURE 3. ACTUAL ROUTING OF SMITH AND REESE CREEKS NEAR THEIR CONFLUENCE

FIGURE 4. SMITH CREEK CHANNELIZED UPSTREAM OF REESE CREEK CONFLUENCE

TABLE 1. REACH-SCALE ATTRIBUTES

Reach ID	Ecoreg.	Reach length (mi)	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP*	Septic 150 ft per mi	Septic 1000 ft per mi
SMIT 01 N	17w	7.67	2	HAY/ CROPS	N	6	1400	M	30	RPF, PBR	0.3	3.7
SMIT 02 N	17w	6.30	4	HAY	N	0	1000	M	45	RPF, PBR	0.0	7.9
***RPF: riparian fencing; PBR: pasture buffer**												

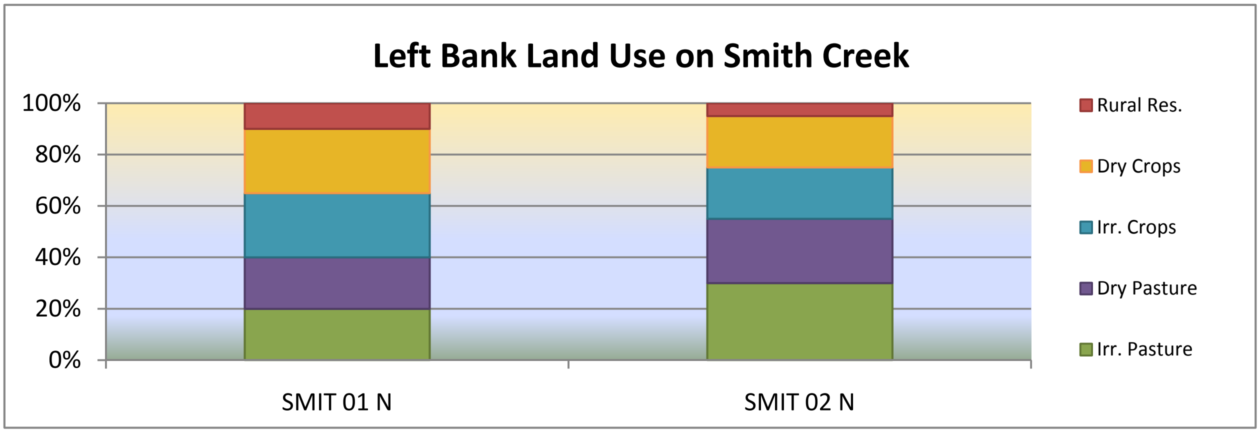

FIGURE 5. LAND USE TYPES ALONG THE LEFT BANK OF SMITH CREEK

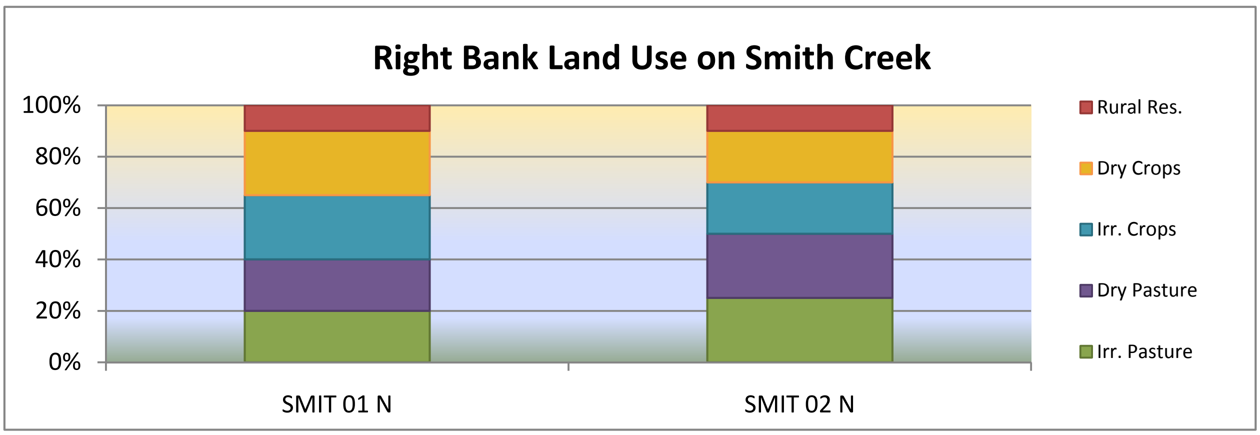

FIGURE 6. LAND USE TYPES ALONG THE RIGHT BANK OF SMITH CREEK

2. SMIT 01 N

Reach 1 begins in the foothills of the west side of the Bridger Mountains north of Bozeman and extends downstream to where Reese Creek enters, upstream of Dry Creek Road (Figure 7). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

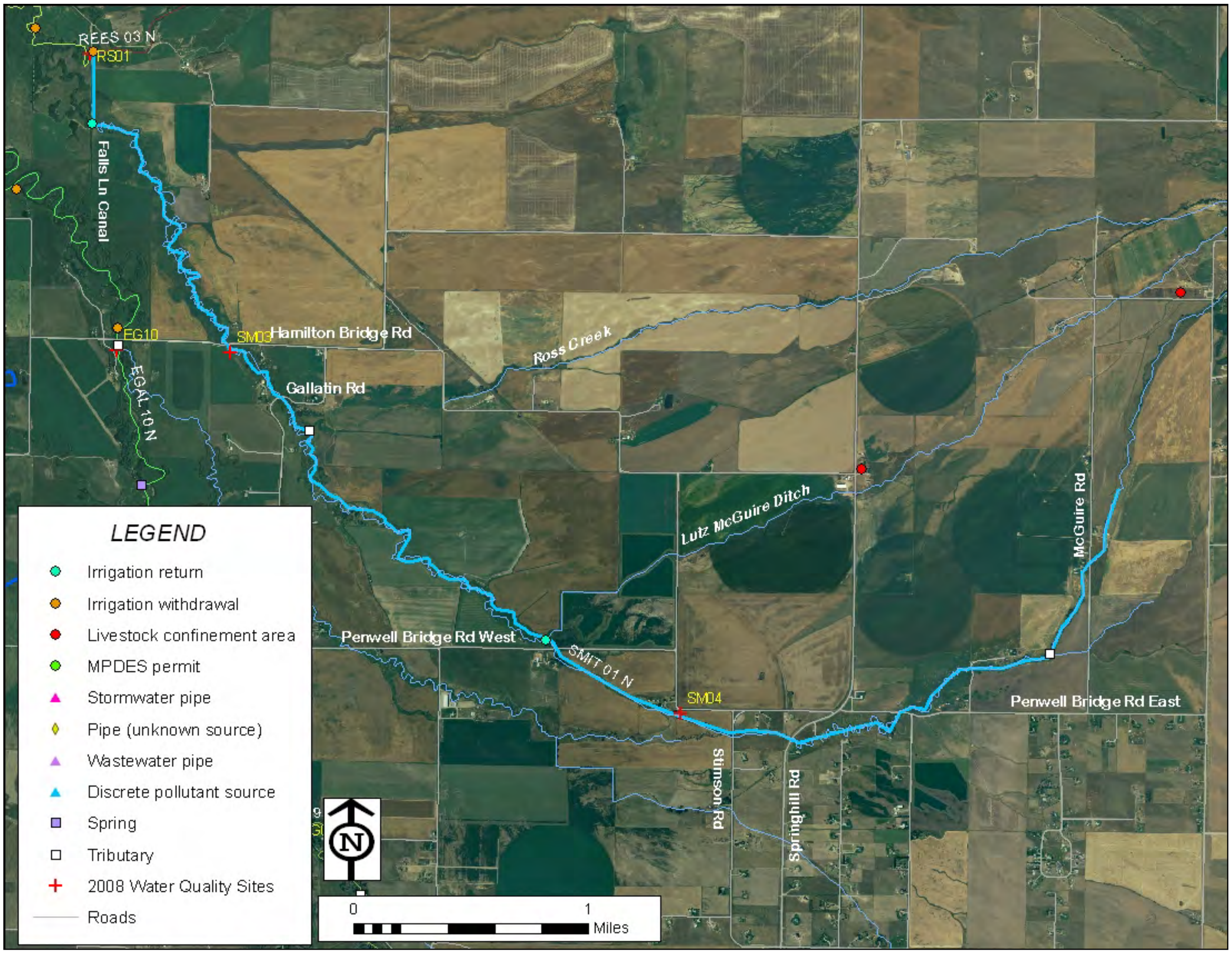

FIGURE 7. REACH SMIT 01 N

2.1. Reach Condition

The dominant land use within the reach is hay production and pasture, with scattered residences. The riparian condition varied widely throughout the reach. In the upstream section the riparian zone ranged from a narrow dense grass buffer (Figure 8) to no riparian where pasture and lawns were directly adjacent to the stream (Figures 9 and 10). Lower in the reach, starting downstream of Penwell Bridge Rd to the west of Springhill Rd, the riparian zone was wider, consisting of dense willows and grasses (Figure 11). Limited riparian fencing was observed within the reach. Due to the naturally-erosive soils and the prevalence of livestock grazing, bank erosion was considered moderate throughout the reach. Although pasture encroachment was common in the upper reach, due to the small stream size and low flow energy, erosion was not as severe as in the lower reach where bank erosion was commonly documented (Figures 12 and 13).

The unpaved Hamilton Bridge Road encroaches within 5 ft of the stream for approximately 50 feet; the private two-track road upstream of the Reese Cr confluence encroaches within 25 ft of the stream (Figure 4). Vegetation along the stream is very dense along Hamilton Rd, thus the road was not considered a significant sediment source. Vegetation was sparser along the private road, yet the road is very narrow and not frequently traveled and was therefore also not considered to be a significant sediment source.

FIGURE 8. REED CANARYGRASS RIPARIAN DOWNSTREAM OF PENWELL BRIDGE RD EAST

FIGURE 9. PASTURE ENCROACHMENT IN UPPER REACH, DOWNSTREAM OF MCGUIRE RD

FIGURE 10. TRAMPLED RIPARIAN UPSTREAM OF STIMPSON RD

FIGURE 11. HEALTHY RIPARIAN ZONE UPSTREAM OF GALLATIN RD

FIGURE 12. BANK EROSION DOWNSTREAM OF GALLATIN RD WHERE PASTURE ENCROACHES

FIGURE 13. BANK EROSION IN PASTURE UPSTREAM OF REESE CR CONFLUENCE

2.2. Nutrient Source Characterization

Potential nutrient and E. coli sources within the reach are identified in Table 2. Irrigated crops (primarily wheat, barley and hay production), have a low to moderate prevalence within the reach. Combined with a fair to good riparian buffer, crops were considered to have a low to moderate potential for nutrient delivery to the stream. Pasture land had a higher prevalence than irrigated crops and a moderate amount of encroachment and overgrazing was observed. The riparian buffer was often narrow (Figures 9, 10, 12 and 13). Therefore, pasture land was considered to have a moderate potential for nutrient and E. coli delivery to the reach.

Two irrigation returns enter the stream within the reach (Figure 7). The Lutz McGuire ditch returns to Smith Cr just downstream of Penwell Bridge Rd West. A large canal enters from the East Gallatin River just downstream of the Reese Cr confluence at the lower end of the reach. The canal was signed as the “Falls Ln Canal” on a marker at the ditch confluence. The potential significance of nutrient and E. coli delivery from these ditches was considered moderate, as they drain an agricultural area within the valley bottom. One tributary, Ross Cr, enters from the east just upstream of Gallatin Rd (Figure 7). On the NHD layer it appears that Ross Cr is channelized for approximately 0.5 mile upstream of its confluence with Smith Cr, and therefore this section is not depicted as a tributary line on Figure 7. This tributary was considered a moderate potential source of nutrients and E. coli, as it drains agricultural lands within the valley bottom.

The two LCA’s were located approximately 1.5 miles upstream of reach SMIT 01 N along the Lutz McGuire ditch (Figure 7) and were therefore determined to be of low to moderate potential significance. Septic system density was low within 150 feet and moderate within the 150-1000 foot buffer. Six unpaved crossings were identified within the reach, located at Gallatin Rd, Hamilton Bridge Rd, Penwell Bridge Rd East (east of Springhill Rd), Penwell Bridge Rd West (west of Springhill Rd), a private driveway and McGuire Rd. All of the crossing had fairly well-vegetated abutments; with the exception of McGuire road, all crossings could potentially be a minor sediment source during storm events due to either gravel on bridge decking (e.g. Figure 14) or gravel on top of culverts. Although each unpaved crossing was considered a minor sediment source, their cumulative potential significance was considered low to moderate.

TABLE 2. POTENTIAL NUTRIENT AND E. COLI SOURCES WITHIN REACH SMIT 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	25	GW	good/fair	hay, barley, wheat production	low/med
Pasture (Ave. % LB/RB)	40	SW/GW	good/fair	horse and cattle grazing with moderate bank erosion and overgrazing observed	med
Septic system per mi (150 ft/1000 ft)	0.3/3.7	GW	good/fair		low
Irrigation returns (#)	2	SW	good/fair	Lutz McGuire ditch, Falls Ln Canal from East Gallatin R	med
Unpaved road crossings (#)	6	SW	good/fair	all had well-vegetated abutments but most were considered a minor sediment source during storm events	low/med
LCA (#)	2	GW/SW	good/fair	LCA's flow to Lutz McGuire ditch, then downstream to reach SMIT 01 N	low/med

FIGURE 14. WELL-VEGETATED ABUTMENT WITH GRAVEL ON DECKING AT HAMILTON BRIDGE RD

3. SMIT 02 N

Reach 2 begins upstream of Dry Creek Road and extends to Smith Creek's confluence with the East Gallatin River (Figure 15). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

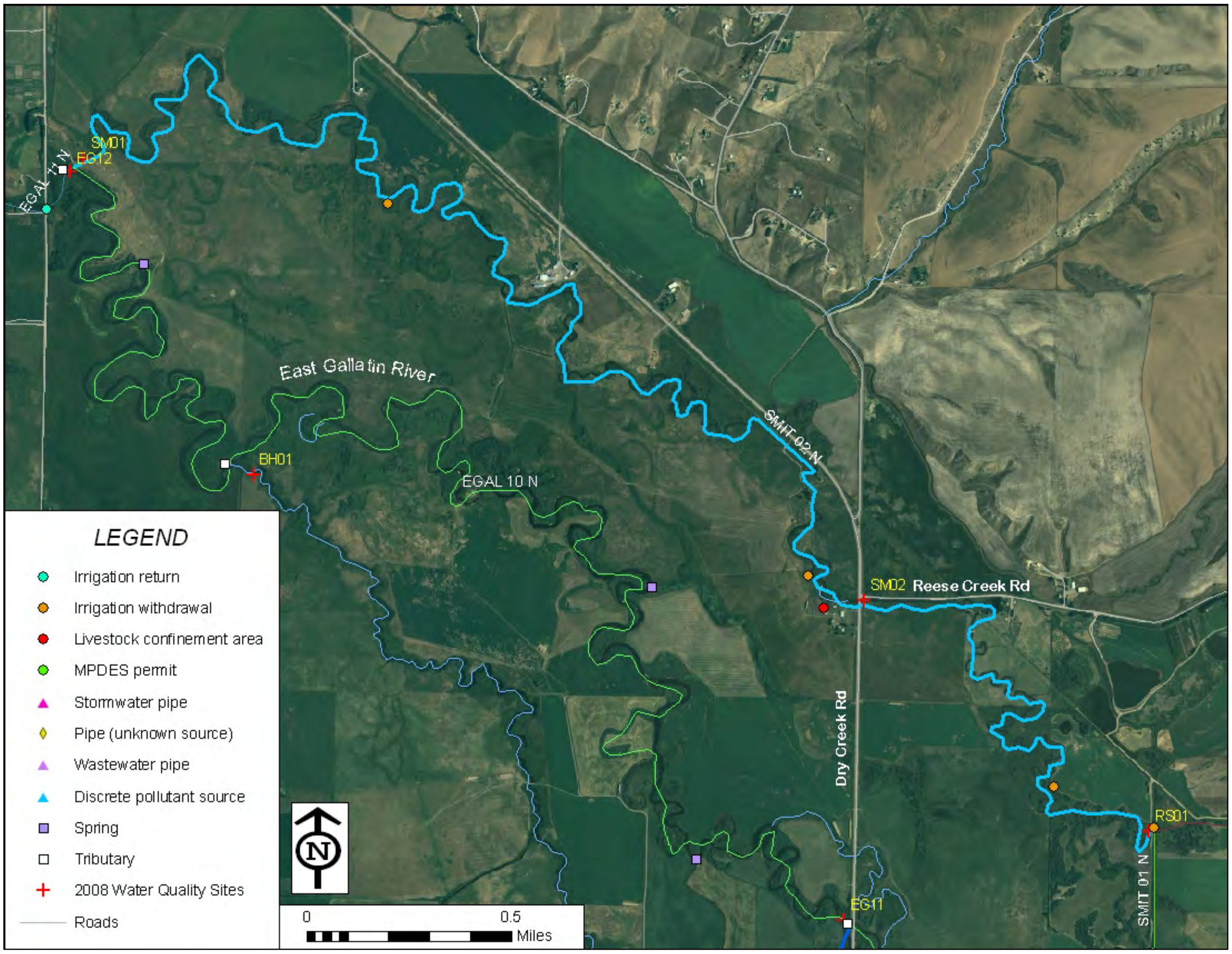

FIGURE 15. REACH SMIT 02 N

3.1. Reach Condition

The dominant land use within the reach is crop production and pasture, with scattered residences. The riparian was generally dense but very weedy with thistle and reed canarygrass. Willows and buffaloberry were present in sparse clumps throughout the reach (Figure 16), and pasture and yard encroachment were also common (Figure 17). While areas with dense riparian vegetation are relatively stable, areas with cropland and pasture encroachment are actively eroding in the highly erosive, fine silty loam soils (Figures 16 and 17). Limited riparian fencing was observed within the reach. Overall, bank erosion was considered moderate throughout the reach.

The unpaved Reese Creek Road encroaches within 30 ft of the stream for approximately 0.2 miles, upstream of Dry Creek Rd (Figure 18). Riparian grasses along the stream are very dense along the road and thus it was not considered a significant sediment source. Four irrigation withdrawals were identified on the GIS layer (Figure 15), only one of which was confirmed in the field. The confirmed withdrawal was relatively large, exiting at the upper end of the reach, just downstream of the Reese Cr confluence. The other three withdrawals were roughly confirmed on the aerial, but this was difficult to discern due to the abundance of paleochannels and the irrigated bottomland.

FIGURE 16. DENSE BUT WEEDY RIPARIAN WITH SCATTERED SHRUBS, DOWNSTREAM OF REESE CR

FIGURE 17. CROP ENCROACHMENT DOWNSTREAM OF REESE CR

FIGURE 18. REESE CREEK RD ENCROACHES UPSTREAM OF DRY CREEK RD

3.2. Nutrient Source Characterization

Potential nutrient and E. coli sources within the reach are identified in Table 3. Irrigated crops comprised a relatively low proportion of the land use and were considered a potential, but minor source of nutrients to the stream. In contrast, pasture land was more prevalent and encroached on the stream in certain areas. Therefore pasture was considered a moderate potential source of nutrients and E. coli. No septic systems were identified within 150 feet while septic density was moderate in the 150-1000 foot buffer. Therefore the potential significance of septic systems was considered low. One LCA was located downstream of Dry Creek Rd relatively close to the stream, but was not observed in the field. While this single LCA could be functioning as a source of nutrient and E. coli, cumulatively, LCA's were considered to be a minor pollutant source within the reach. No unpaved roads cross this reach.

TABLE 3. POTENTIAL NUTRIENT AND E. COLI WITHIN REACH SMIT 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Irrigated crops (Ave. % LB/RB)	20	GW	good/fair	wheat, barley and hay production	low
Pasture (Ave. % LB/RB)	52	SW/GW	good/fair	horse and cattle grazing, sometimes encroaching on stream	med
Septic system per mi (150 ft/1000 ft)	0.0/7.9	GW	good/fair		low
LCA (#)	1	GW/SW	good/fair	close to the stream but rather small	low

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Thompson Spring Creek

Pollutant Source Assessment Report

2009 Lower Gallatin TMDL Planning Area

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THOMPSON SPRING CREEK

Thompson Spring Creek ("Thompson Creek") begins as a spring north of Baseline Road northeast of Belgrade (Figure 1). It flows north through the agricultural fields and grazing lands in the lowlands of the Gallatin Valley, prior to its confluence with the East Gallatin River just downstream of Dry Creek Road.

Water quality in Thompson Creek (Waterbody ID MT41H003_090) is listed on the State of Montana's 2008 303(d) List as being impaired for the following pollutants: total nitrogen, chlorophyll-a, and sediment. For the purposes of assessing pollutant sources, Thompson Creek was divided into two reaches based on land use and riparian type (Figure 1). Each reach was assessed for general reach characteristics with regards to adjacent land use, streambank stability, and riparian condition and composition. Pollutant sources, both discrete and reach-scale, were identified and evaluated for their potential to function as sources of nutrients. Reach-scale conditions on Thompson Creek are summarized in Table 1 and the relative percentages of left and right bank land uses are depicted in Figures 2 and 3. See the *Introduction to the 2009 Lower Gallatin TPA Pollutant Source Assessment Reports* for descriptions of the reach-scale fields displayed in Table 1, as well as details on potential pollutant sources evaluated in each of the reach sections below.

1.1. Summary

Pasture land and irrigated crops were identified as the most significant potential sources of nutrients throughout both reaches of Thompson Creek. The upper reach flows through irrigated and non-irrigated cropland, planted primarily with wheat, barley and hay. Horse and cattle pastures comprise the majority of the lower reach, but where observed this pasture land was generally in good condition and not overgrazed or encroaching significantly on the stream. Pasture buffers were observed along both reaches. The riparian area was rather weedy with reed canarygrass and thistles, but vegetation throughout both reaches was dense and considered a relatively good buffer for mitigating surface nutrient inputs. Septic system, livestock confinement areas, and unpaved road crossings were considered minor but not significant potential nutrient sources within both reaches.

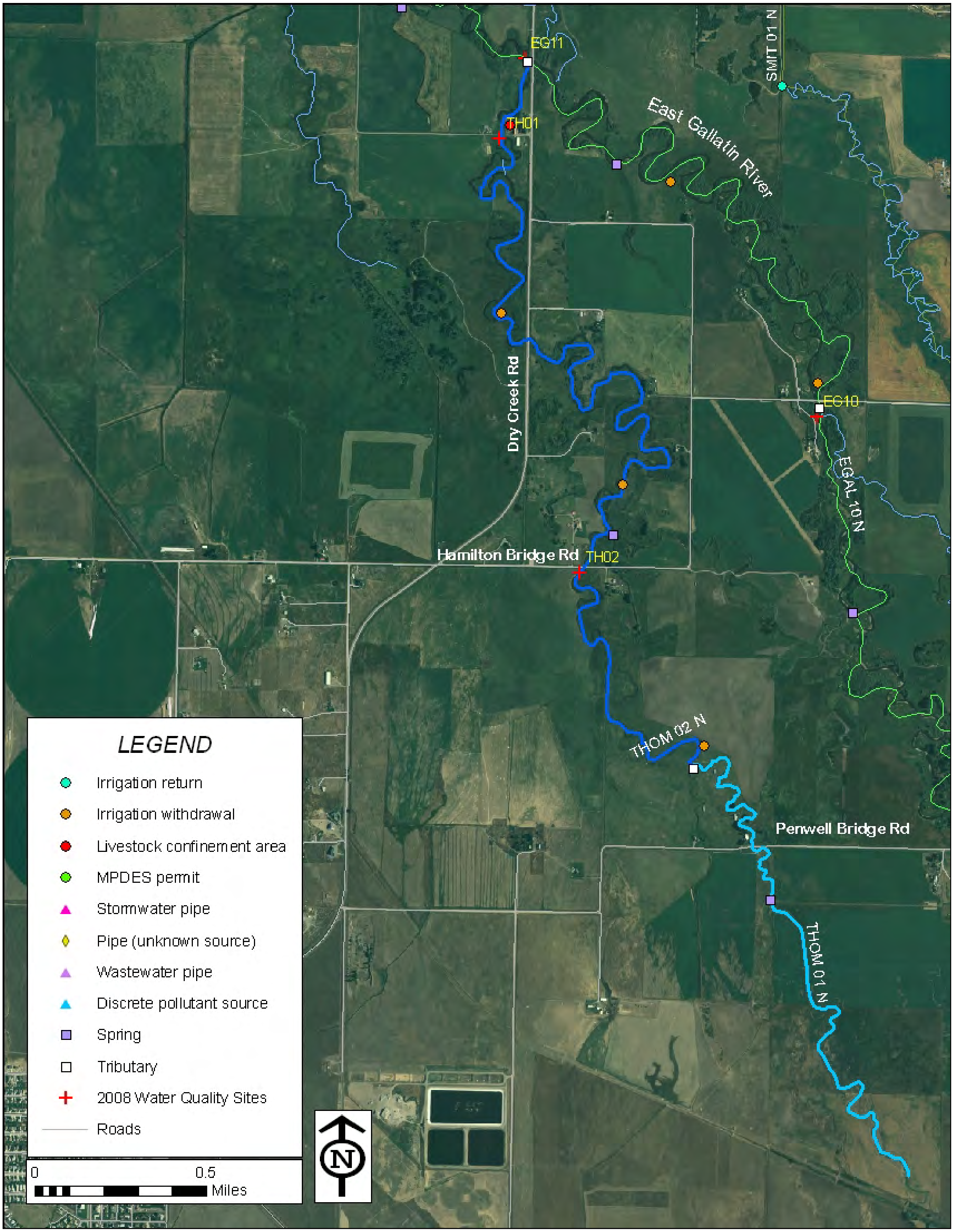

FIGURE 1. REACHES THOM 01 N AND THOM 02 N

TABLE 1. REACH-SCALE ATTRIBUTES ON THOMPSON CREEK

Reach ID N	Ecoreg.	Reach length (mi)	Strm. Ord.	Dom. Land Use	Nat.	Unpaved Rd. xings	Rd. Encr. (ft)	Bank Ero.	Rip. Width (ft)	BMP*	Septic 150 ft per mi	Septic 1000 ft per mi
THOM 01 N	17w	2.09	1	HAY/ROW CROPS	N	1	150	L	40	PBR	0.5	0.5
THOM 02 N	17w	4.14	2	PASTURE	N	2	100	L	60	RPF, PBR	0.0	1.4

***RPF: riparian fencing**

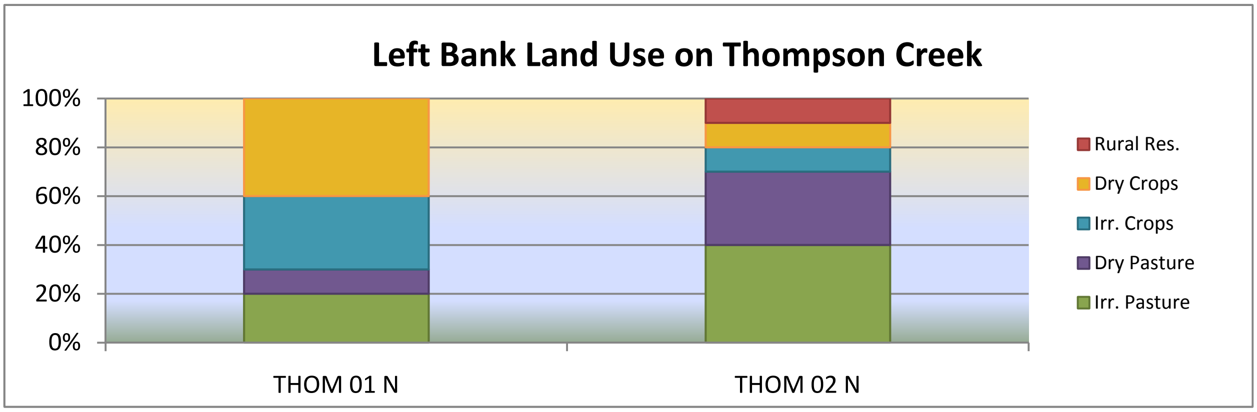

FIGURE 2. LAND USE TYPES ALONG THE LEFT BANK OF THOMPSON CREEK

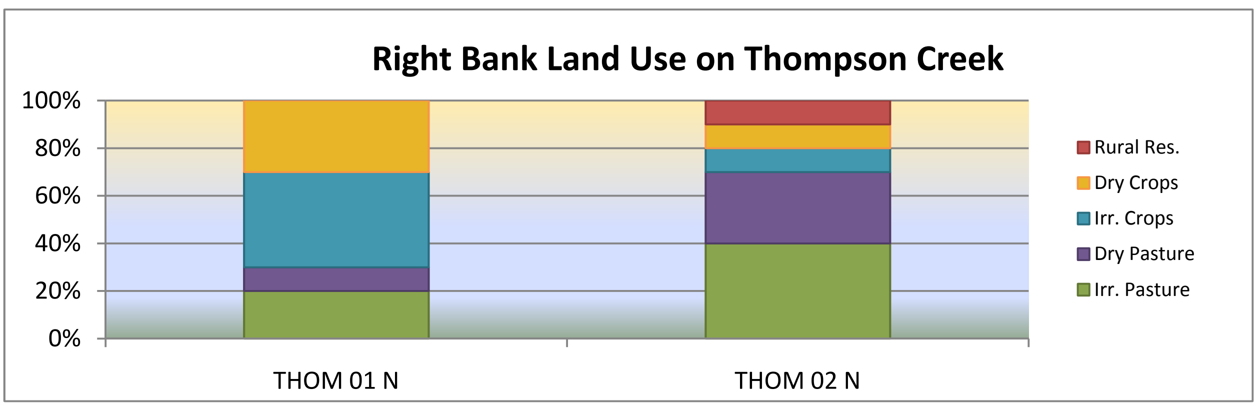

FIGURE 3. LAND USE TYPES ALONG THE RIGHT BANK OF THOMPSON CREEK

2. THOM 01 N

Reach 1 is a first order spring creek that begins north of Baseline Road near Belgrade. Although the Montana 303d list stream GIS layer indicated that Thompson Creek started farther upstream at Interstate 90, it was determined from aerial photos that there was no discernable channel until north of Baseline Road. The stream reach flows through irrigated and dry hay fields downstream to its confluence with another small spring creek entering from the southwest, downstream of Penwell Bridge Road (Figure 1). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin. It should be noted that reach THOM 01 N was only observed at Penwell Bridge Road due to a lack of access along the reach.

2.1. Reach Condition

The dominant land use within the reach is pasture and a few scattered residences. Where the stream was observed, the riparian was dense with sedges and scattered willow, as well as invasive thistles and reed canarygrass (Figure 4). Vegetation within the riparian zone was not overgrazed. Due to the dense riparian and low-energy spring-fed flow, minimal bank erosion was observed, but increased bank erosion is possible where the stream was not observed, due to the likelihood of pasture encroachment and grazing influences.

FIGURE 4. DENSE SEDGE AND REED CANARYGRASS RIPARIAN UPSTREAM OF PENWELL BRIDGE RD

2.2. Nutrient Source Characterization

Potential nutrient sources within the reach are identified in Table 2. Pasture comprised a moderate proportion of land use within the reach, but combined with the good riparian buffer and lack of encroachment observed, it was considered to have a low potential significance as a nutrient source. The other dominant land use within the reach was irrigated cropland (primarily wheat, barley and hay) which was considered to potentially act as a moderate nutrient source.

Septic system density was very low within 150 feet and in the 150 to 1000 foot buffer. The culvert at Penwell Bridge Road was the only unpaved crossing within the reach; the crossing was not fully vegetated and could potentially be a minor sediment source during storm events (Figure 5). The unpaved Penwell Bridge Road encroaches within 25 feet of the stream for 150 feet within the reach (Figure 6). The bank between the road and the stream was only partially vegetated but due to the short distance of encroachment the road was not considered a significant sediment source. A spring that enters upstream of Penwell Bridge Road was not considered a potential nutrient source. Although the spring potentially flows through irrigated cropland in an historic channel, the channel was dry during base flow conditions, at the time the aerial photo was taken.

TABLE 2. POTENTIAL NUTRIENT SOURCES WITHIN REACH THOM 01 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	30	SW/GW	Good	good condition with little encroachment where observed	Low/Med
Irrigated crops (Ave. % LB/RB)	35	SW/GW	Good	wheat, barley and hay production	Med
Septic system per mi (150 ft/1000 ft)	0.5/0.5	GW	Good	good riparian buffer reduces significance	Low
Unpaved road crossings (#)	1	SW	Good	Penwell Bridge Road, minor potential for sediment delivery	Low

FIGURE 5. CULVERT AT PENWELL BRIDGE ROAD

FIGURE 6. PENWELL BRIDGE ROAD ENCROACHMENT

3. THOM 02 N

Reach 2 is a second order stream that begins at the confluence with another small spring creek entering from the southwest, downstream of Penwell Bridge Road, and extends downstream to its confluence with the East Gallatin River near Dry Creek Road (Figure 1). The dominant Level 4 PRI ecoregion of the reach is 17w, Townsend Basin.

3.1. Reach Condition

The dominant land use within the reach is irrigated and non-irrigated pasture with some hay production. The riparian zone is generally robust, composed of sedges, native wetland grasses, mixed with non-native pasture grass, thistles, and invasive reed canarygrass (Figure 7). Although there is some pasture encroachment (Figure 8), vegetation within the riparian zone was generally not overgrazed. Due to the dense riparian vegetation, its small size and low, spring-fed flow, minimal bank erosion was observed within the reach. The paved Dry Creek Road encroaches for 100 feet but with densely vegetated banks this was not considered a significant nutrient source. Three irrigation withdrawals were identified on the GIS layer, but they were not definitively observed on the aerial nor confirmed in the field.

FIGURE 7. ROBUST RIPARIAN, UPSTREAM OF HAMILTON ROAD

FIGURE 8. PASTURE ENCROACHMENT LEFT BANK BUT GENERALLY DENSE RIPARIAN

3.2. Nutrient Source Characterization

Potential nutrient sources within the reach are identified in Table 3. Pasture was the dominant land use throughout the reach. Although it comprised a high proportion of the reach it was observed to be in relatively good condition, was generally not overgrazed or encroaching on the stream. Combined with a dense riparian buffer, pasture was considered a moderate potential as a nutrient source.

The LCA was a horse corral just downstream of water quality site TH01, upstream of the confluence with the East Gallatin River (Figure 9). Due to the low prevalence of LCA's throughout the reach, this single LCA was not considered to be a significant nutrient source. Septic system density was low throughout the reach. Two unpaved crossings were identified. The culverts at Hamilton Bridge Road and a private driveway could potentially function as a minor sediment sources but the area of exposed gravel at the crossings is relatively small (Figure 10). Thus the unpaved crossings were considered to have low potential significance as nutrient sources.

TABLE 3. POTENTIAL NUTRIENT SOURCES WITHIN REACH THOM 02 N

Pollutant Source	Source Prevalence	Pathway	Riparian Quality	Comments	Potential Significance
Pasture (Ave. % LB/RB)	70	SW/GW	Good	good riparian buffer reduces potential significance of high amount of pasture	Med
Irrigated crops (Ave. % LB/RB)	10	SW/GW	Good	hay production	Low
Septic system per mi (150 ft/1000 ft)	0.0/1.4	GW	Good		Low
Septic in tributaries	Low	Tributary	Unknown		Low
Unpaved road crossings (#)	2	SW	Good	Hamilton Bridge Rd; driveway	Low
LCA (#)	1	GW/SW	Good	horse corral	Low

FIGURE 9. HORSE CORRAL ON REACH THOM 02 N UPSTREAM OF EAST GALLATIN CONFLUENCE

FIGURE 10. HAMILTON BRIDGE ROAD CROSSING