Office of Water Quality
Total Maximum Daily Load Program

Total Maximum Daily Load for *Escherichia coli* (*E. coli*) For the Plummer Creek Watershed, Greene County

Prepared by:

Office of Water Quality – TMDL Program
Indiana Department of Environmental Management
100 N. Senate Avenue
Indianapolis, IN 46204

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Introduction

Section 303(d) of the Federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting Water Quality Standards (WQS). TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the sources and determine the allowable levels of *E. coli* bacteria that will result in the attainment of the applicable WQS in the Plummer Creek watershed in Greene County in Indiana.

Background

In 1998, 2002, and 2004, Indiana's Section 303(d) List cited the Plummer Creek as being impaired for *E. coli* in Greene County. In addition to the Plummer Creek, Indiana's 2004 Section 303(d) List cites Black Ankle Creek, Dry Branch, Flyblow Branch, Burcham Branch, an unnamed tributary, and Letsinger Branch for *E. coli* as well as dividing Plummer Creek into two segments according to the 14-digit hydrologic unit code boundaries. All of the above listed segments will be included on the 2006 Section 303(d) List of impaired waters.

This TMDL will address approximately 35.34 miles of the Plummer Creek watershed in Greene County where recreational uses are impaired by elevated levels of *E. coli* during the recreational season. The Plummer Creek watershed is located in the southeast portion of Greene County which is located in southwest Indiana (Figure 1). All of the four segments of the listed streams for this TMDL are located in the Lower West Fork White River watershed in hydrologic units 5120202040090 and 5120202040060. The description of the study area, its topography, and other particulars are as follows:

Waterbody Name	303(d) List ID	Segment ID Number(s)	Length (miles)	Impairment
BLACK ANKLE CREEK, DRY BRANCH	139	INW0246_00	11.11	*E. coli*
PLUMMER CREEK	139	INW0246_T1023, INW0249_T1024	15.05	*E. coli*
FLYBLOW BRANCH, BURCHAM BRANCH, LETSINGER BRANCH, UNNAMED TRIBUTARY	139	INW0249_00	9.18	*E. coli*

Plummer Creek was sampled for *E. coli* three times in 1996, gathering data to support the impairment of Plummer Creek for *E. coli* violations of the single day standard. IDEM completed an intensive survey of

the watershed for Plummer Creek in 2001. During this period IDEM sampled seventeen sites, including one site at the mouth of Richland Creek, five times, with the samples evenly spaced over a 30-day period from September 12, 2001 to October 10, 2001. Only four sites, WWL040-0042, WWL040-0043, WWL040-0046, and WWL040-0047 did not violate the geometric mean standard. However, a violation of the single day standard occurred at least once at every sample site in the watershed. (Figure 2, Attachment A).

The TMDL development schedule corresponds with IDEM's basin-rotation water quality monitoring schedule. To take advantage of all available resources for TMDL development, impaired waters are scheduled according to the basin-rotation schedule unless there is a significant reason to deviate from this schedule. Waterbodies could be scheduled based on the following:

1) Waterbodies may be given a high or low priority for TMDL development depending on the specific designated uses that are not being met, or in relation to the magnitude of the impairment.

2) TMDL development of waterbodies where other interested parties, such as local watershed groups, are working on alleviating the water quality problem may be delayed to give these other actions time to have a positive impact on the waterbody. If water quality standards still are not met, then the TMDL process will be initiated.

3) TMDLs that are required due to water quality violations relating to pollutant parameters where no EPA guidance is available may be delayed to give EPA time to develop guidance.

This TMDL was scheduled based on the data available from the basin-rotation schedule, which represents the most accurate and current information available on water quality within waterbodies covered by this TMDL.

Water quality *E. coli* load duration curves were created using IDEM's data. A flow duration interval is described as a percentage. Zero (0) percent corresponds to the highest stream discharge (flood condition) and 100 percent corresponds to the lowest discharge (drought condition). The *E. coli* values at WWL040-0047, WWL040-0042, WWL040-0039 and WWL040-0037 (combined), and WWL040-WWL040-0003 were plotted with the corresponding flow duration interval to show the *E. coli* violations of the single-sample maximum standard and geometric mean standard during the recreational season. These sampling sites have *E. coli* violations from 2001 samples. These sampling sites are representative of the hydrodynamics of the Plummer Creek watershed (Attachment B).

Numeric Targets

The impaired designated use for the waterbodies in the Plummer Creek watershed is for total body contact recreational use during the recreational season, April 1st through October 31st.

327 IAC 2-1-6(d) establishes the total body contact recreational use *E. coli* Water Quality Standard (WQS[1]) for all waters in the non-Great Lakes system as follows:

> *E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period.

[1] *E. coli* WQS = 125 cfu/100mL or 235 cfu/100mL; 1 cfu (colony forming units)= 1 mpn (most probable number)

The sanitary wastewater *E. coli* effluent limits from point sources in the non-Great Lakes system during the recreational season, April 1st through October 31st, are also covered under 327 IAC 2-1-6(d).

For the Plummer Creek watershed during the recreational season (April 1st through October 31st) the target level is set at the *E. coli* WQS of 125 per one hundred milliliters as a 30-day geometric mean based on not less than five samples equally spaced over a thirty day period.

Source Assessment

Watershed Characterization

Plummer Creek begins in southwest Greene County and flows west until it discharges into the lower West Fork of the White River. Plummer Creek is located in the southeast portion of Greene County, which is in the southwestern portion of Indiana. Plummer Creek starts flowing in a northwest direction where an unnamed tributary joins it from the north and then Dry Branch joins from the south. Plummer Creek then turns slightly to flow in a more westerly direction and then is connected to Black Ankle Creek on the south side. Plummer Creek then takes a sharp turn to flow north and then turns again to flow west, where Clifty Branch joins the creek from the north side. Flowing northwest, Flyblow Branch connects to Plummer Creek from the south and then Letsinger Branch joins from the north. Plummer Creek then turns to flow to the southwest briefly and then turns to flow in a westerly direction. Here Plummer Creek is joined by Burcham Branch and then an unnamed tributary, both from the south. Plummer Creek then is joined with Richland Creek from the north before depositing into the lower West Fork of the White River (Figure 1).

At the time the sampling surveys took place, no samples were taken on the Clifty Branch tributary watershed. Because of this, existing data is not sufficient to support the listing of this tributary on the 303(d) List, and therefore will not be discussed in this document.

Landuse information was assembled in 1992 using the Gap Analysis Program (GAP). In 1992, approximately 69.7% of the landuse in the Plummer Creek watershed was forested. The remaining landuse for the Plummer Creek watershed consisted of approximately 28.4% agricultural, 1.7% wetland, and less than 1% urban and water (Figure 3). Comparing this information to landuse data from 1976 it is shown that agricultural uses have decreased from 39% and forested areas have increased from 61%.

Wildlife is a known source of *E. coli* impairments in waterbodies. Many animals spend time in or around waterbodies. Deer, geese, ducks, raccoons, turkeys, and other animals all create potential sources of *E. coli*. Wildlife contributes to the potential impact of contaminated runoff from animal habitats, such as urban park areas, forest, and cropland.

Homes within the Plummer Creek watershed are almost entirely on septics. This is known because no regional sewer districts exist within the watershed. In addition, there are no large urban areas in the watershed offering the use of sewers for waste disposal. Conversations with the staff from Greene County Health Department indicate that septic system failure does occur (personal communication, Greene County Health Department). Personal communication with additional sources also resulted in acknowledgement of many failing septic tanks in the rural areas of Greene County and the likelihood contribution to decreased water quality. Failing septic tanks are known sources of *E. coli* impairment in waterbodies. The Greene County Health Department did not have any information regarding septic use, therefore, no tangible septic use or failure rate can be established by the Health Department at this time.

National Pollutant Discharge Elimination System (NPDES) Permitted Dischargers

There are zero (0) NPDES permitted facilities in the Plummer Creek watershed

Storm Water General Permit Rule 13

There are zero (0) municipal separate storm sewer systems (MS4) communities, in the Plummer Creek watershed.

Combined Sewer Overflows (CSO)

There are zero (0) CSO communities in the Plummer Creek watershed.

Confined Feeding Operations and Concentrated Animal Feeding Operations

The removal and disposal of the manure, litter, or processed wastewater that is generated as the result of confined feeding operations falls under the regulations for confined feeding operations (CFOs) and concentrated animal feeding operations (CAFOs). There are three (3) CFOs in the Plummer Creek watershed (Figure 4). None of the CFOs in the watershed are considered a CAFO (Table 2). The CFO and CAFO regulations (327 IAC 16, 327 IAC 15) require operations "not cause or contribute to an impairment of surface waters of the state." The currently operational animal operations in Plummer Creek watershed have no open enforcement actions at this time. Therefore, these operations are not considered a significant source of *E. coli* for the Plummer Creek watershed TMDL.

There are many smaller livestock operations in the watershed. These operations, due to their small size, are not regulated under the CFO or CAFO regulations. These operations may still have an impact on the water quality and the *E. coli* impairment. Activities such as watering animals in or near waterbodies and improper disposal of manure such as non-regulated spreading of manure can all be contributing factors to elevated levels of *E. coli* in the watershed. No specific information on these small livestock operations is currently available for the Plummer Creek watershed however; it is believed that these small livestock operations may be a source of the *E. coli* impairment.

Linkage Analysis and *E. coli* Load Duration Curves

The linkage between the *E. coli* concentrations in the Plummer Creek watershed and the potential sources of *E. coli* provides the basis for the development of this TMDL. Analysis of this relationship allows for estimating the total assimilative capacity of the stream and any needed load reductions. Water quality duration curves were created for the sampling sites in the Plummer Creek watershed that were sampled by IDEM in 2001. A flow duration interval is described as a percentage. Zero (0) percent corresponds to the highest stream discharge (flood condition) and 100 percent corresponds to the lowest discharge (drought condition). These sampling sites are representative of the hydrodynamics of the Plummer Creek watershed (Attachment B). This section will discuss the water quality durations and the linkage of Section 3.0 for Plummer Creek.

To investigate further the potential sources mentioned above, an *E. coli* load duration curve analysis, as outlined in an unpublished paper by Cleland (2002), was developed for each sampling site in the Plummer Creek watershed. The load duration curve analysis is a relatively new method utilized in TMDL development. The method considers how stream flow conditions relate to a variety of pollutant loadings and their sources (point and non-point).

In order to develop a load duration curve, continuous flow data are required. The USGS gage for the White River (gage 0360500) located in Newberry, Indiana was used for the development of the *E. coli* load duration curve analysis for the Plummer watershed TMDL. USGS gage 0360500 is located on the White River in Greene County.

There are two USGS gages that could be representative of the Plummer Creek watershed. One USGS gage (03357000) is located in Spencer, Indiana, which is upstream of Plummer Creek, and the other USGS gage (03360500) is located in Newberry, Indiana, which is downstream of Plummer Creek. The Spencer gage has not been active since 1971; therefore, the Newberry gage was used to develop load duration curves.

The flow data is used to create flow duration curves, which display the cumulative frequency of distribution of the daily flow for the period of record. The flow duration curve relates flow values measured at the monitoring station to the percent of time that those values are met or exceeded. Flows are ranked from extremely low flows, which are exceeded nearly 100 percent of the time, to extremely high flows, which are rarely exceeded. Flow duration curves are then transformed into load duration curves by multiplying the flow values along the curve by applicable water quality criteria values for *E. coli* and appropriate conversion factors. The load duration curves are conceptually similar to the flow duration curves in that the x-axis represents the flow recurrence interval and the y-axis represents the allowable load of the water quality parameter. The curve representing the allowable load of *E. coli* was calculated using the daily and geometric mean standards of 235 per 100 mL and 125 per 100 mL, respectively. The final step in the development of a load duration curve is to add the water quality pollutant data to the curves. Pollutant loads are estimated from the data as the product of the pollutant concentrations, instantaneous flows measured at the time of sample collection, and appropriate conversion factors. In order to identify the plotting position of each calculated load, the recurrence interval of each instantaneous flow measurement was defined. Water quality pollutant monitoring data are plotted on the same graph as the load duration curve that provides a graphical display of the water quality conditions in the waterbody. The pollutant monitoring data points that are above the target line exceed the water quality standards (WQS); those that fall below the target line meet the WQS (Mississippi DEQ, 2002).

Water Quality Duration Curves

Load duration curves were created for all the sampling sites in the Plummer Creek watershed. However, IDEM believes that sampling sites, WWL040-0048, WWL040-0045, WWL040-0039 and WWL040-0037 (combined), and WWL040-0032 on the Plummer Creek provide the best description of the sources of *E. coli* to the Plummer Creek watershed (Figure 2, Attachment C). These sampling sites are IDEM field sample sites and have *E. coli* sampling from 2001. The data indicate that the largest exceedances of the *E. coli* WQS are prevalent during dry weather (noted by diamonds above the curve on the right side of the figure in Attachment C). Wet weather contributions are also a source of *E. coli* to the Plummer Creek watershed (noted by the diamonds above the curve on left side of the figure in Attachment C).

Site WWL040-0048 is located on Plummer Creek and is the first sample site located closest to the headwaters. The geometric mean value for Site WWL040-0048 is 484 mpn/100mL. At this site one sampling event had an outcome that is lower than all of the others at this location. This may be explained by either having a corrupted sample or an extended period of wet weather around the time of the sampling thus flushing pollutants out of the system before the sampling took place. Examination of flow conditions provided by the USGS does indicate an increasing flow two (2) days prior to the sampling date which may have caused a flush of *E. coli* from the system, especially at this location. According to the water quality duration curves, the *E. coli* values are above the standard during all sampled flow regimes thus indicating multiple sources causing the impairment.

Site WWL040-0045 is located near the middle of Dry Branch. The average geometric mean value at this site is 241 mpn/100mL. The *E. coli* violations are highest during dry flow conditions, while there are minimal violations in other flow regimes. Sources of *E. coli* that peak during dry flow conditions are caused by direct sources in the stream such as straight pipes and livestock or stream side run-off from small rain events.

Sites WWL040-0039 and WWL040-0037 are located on Plummer Creek just before the confluence of Flyblow Branch. These two sample sites are in close proximity and therefore have been combined. The average geometric mean at site WWL040-0039 is 1070 mpn/100mL and at site WWL040-0037 is 398 mpn/100mL. Site WWL040-0039 had the highest geometric mean for all of the sample sites. These sample sites are located further downstream and are indicative of activities that occur in a larger portion of the watershed. Consistent violations occur in all flow regimes, with the highest violations spiking in dry periods. Sources of *E. coli* that peak during dry flow conditions are caused by direct sources in the stream such as straight pipes and livestock or stream side run-off from small rain events.

Site WWL040-0032 is located near the mouth of Plummer Creek after the confluence of Richland Creek and the Unnamed Tributary. The average geometric mean at this site is 349 mpn/100mL. The load duration curve shows a leveling off of concentrations, with sample results closer together than at other sample sites. This indicates that while runoff does play an important part in the water quality impairment, there are still many constant sources of *E. coli* in the watershed. This also indicates dilution plays a factor downstream which also contributes to the leveling off of *E. coli* at the mouth of Plummer Creek.

Overall, *E. coli* levels throughout the watershed are variable. Every sample site had violations within the dry flow regime. Impairments during dry flow regimes indicate point sources of pollution, in-stream sources, and near stream run-off that may occur during small rain events. This, however, is expected due to the landuse and high levels of septic tank usage within the watershed.

Compliance with the numeric *E. coli* WQS in the Plummer Creek watershed most critically depends on controlling of nonpoint sources using best management practices (BMPs). If the *E. coli* inputs can be controlled, then total body contact recreation use in Plummer watershed will be protected.

Source Linkage

The landuse in this watershed is predominately forested. This influences *E. coli* levels in the watershed because of the limited access to sewer use. Because of the small amount of urban area in this watershed, the majority of the population is using septic systems for waste disposal. Septic systems are a known source of *E. coli* for this watershed based on information provided to IDEM by the Greene County Health Department (Greene County Health Department personnel communication). The septic systems described by this information would provide a constant source of *E. coli* particularly during low to mid-range flow conditions. According to the water quality duration curve, there are consistent violations of the *E. coli* water quality standard during these flow conditions. Septic systems can also fail during higher flow conditions by leaching to a field tile or other type of pipe that discharges to the stream. Violations of the *E. coli* water quality standard are shown on the water quality duration curves during high flow, but are not violating consistently.

Row crops comprise 22% of the landuse. The soils in this sub-watershed necessitate the use of field tiles to drain excess water from the fields. These field tiles then drain to the nearest stream. Field tiles are not themselves sources of *E. coli*, but they can carry *E. coli* from land applied manure, runoff from the fields and pastures, and other sources of *E. coli* not adjacent to the streams. The high *E. coli* value during mid-range to high flow conditions indicates the presence of *E. coli* transportation by field tiles. This may also

be indicated during dry conditions due to small rain events, particularly since agricultural practices in the watershed are commonly found close to Plummer Creek and tributaries on or near stream banks.

Pasture is considered 6.9% of the landuse. This indicates the presence of non-regulated smaller animal operations in this sub-watershed. Animals located in these smaller animal operations are not as likely to enter a stream during high flow conditions. This was also observed by IDEM staff during sampling and later while touring the watershed. Since there is a continuous source of *E. coli* present in this watershed during dry conditions, this would indicate that animals have direct access to the stream.

Wildlife is a known source of *E. coli*. The predominant agricultural and forested landuses in this watershed create ideal habitat for wildlife. Wildlife would contribute during all flow conditions with possible spikes in *E. coli* levels during extreme high flow conditions due to runoff or flooding which carries large quantities of *E. coli* at one time.

A few permitted CFOs are distributed throughout the Plummer Creek watershed (Figure 4). CFOs could be a source of *E. coli* during high flow conditions on the water quality duration curve. These facilities have the potential to cause a violation of the *E. coli* water quality standard through land application or a malfunction at the facility. CFO 3781 (New Fashion Pork) has had previous violations, the last occurring in January of 2004 where manure may have reached Flyblow Branch. CFO 3584 (New Fashion Pork) has experienced four violations distributed between 2002 and 2004. However, all of these facilities are currently operating in compliance with their permit.

Conclusions

The *E. coli* data has a single sample maximum violation 47% of the time and a geometric mean violation 76% of the time. There are no known CFO or CAFO violations. Based on the water quality duration curves, it can be concluded that the majority of sources of *E. coli* in this watershed are nonpoint sources which include small animal operations, wildlife, field tiles, leaking and failing septic systems.

TMDL Development

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving the Waters Quality Standard (WQS). As indicated in the Numeric Targets section of this document, the target for this *E. coli* TMDL is 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1 through October 31. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the critical conditions that will be used when defining allowable levels. Many TMDLs are designed as the set of environmental conditions that, when addressed by appropriate controls, will ensure attainment of WQS for the pollutant. For example, the critical conditions for the control of point sources in Indiana are given in 327 IAC 5-2-11.1(b). In general, the 7-day average low flow in 10 years (Q7, 10) for a stream is used as the design condition for point source dischargers. However, *E. coli* sources to Plummer Creek watershed arise from a mixture of dry and wet weather-driven conditions, and there is no single critical condition that would achieve the *E. coli* WQS. For the Plummer Creek watershed and the contributing sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g. pounds per day). For *E. coli* indicators, however, mass is not an appropriate measure because *E. coli* is expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). The geometric mean *E. coli* WQS allows for the best characterization of the watershed. Therefore, this *E. coli* TMDL is concentration-based

consistent with 327 IAC 5-2-11.1(b) and 40 CFR, Section 130.2 (i) and the TMDL is equal to the geometric mean *E. coli* WQS for each month of the recreational season (April 1 through October 31).

Allocations

TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS. This *E. coli* TMDL is concentration-based consistent with USEPA regulations at 40 CFR, Section 130.2(i).

Wasteload Allocations (WLA)

As previously stated, there are no direct discharges in this watershed therefore, there are no waste load allocations to take into account for this TMDL. At this time it is suspected that straight pipe discharges exist in the watershed, however there is currently no evidence to support this theory.

The WLA is set at the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1st through October 31st.

Load Allocations (LA)

The LA for nonpoint sources is equal to the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1st through October 31st. The LA will use the geometric mean of each sampling location to determine the reduction necessary to comply with WQS at each site (Appendix 4).

Load allocations may be affected by subsequent work in the watershed. There are currently no watershed projects or plans in the Plummer Creek watershed. IDEM plans to work with watershed coordinators in the surrounding areas along with local government agencies to encourage interest in watershed projects. It is anticipated that watershed projects will be useful in continuing to define and address the nonpoint sources of the *E. coli* in the Plummer Creek watershed.

Margin of Safety (MOS)

A Margin of Safety (MOS) was incorporated into this TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (i.e., incorporated into TMDL analysis thorough conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS by applying a couple of conservative assumptions. First, no rate of decay for *E. coli* was applied. *E. coli* bacteria have a limited capability of surviving outside of their hosts and therefore, a rate of decay normally would be applied. However, applying a rate of decay could result in a discharge limit that would be greater than the *E. coli* WQS, thus no rate of decay was applied. Second, the *E. coli* WQS was applied to all flow conditions. This adds to the MOS for this TMDL. IDEM determined that

applying the *E. coli* WQS of 125 per one hundred milliliters to all flow conditions and with no rate of decay for *E. coli* is a more conservative approach that provides for greater protection of the water quality.

Seasonality

Seasonality in the TMDL is addressed by expressing the TMDL in terms of the *E. coli* WQS for total body contact during the recreational season (April 1st through October 31st) as defined by 327 IAC 2-1-6(d). There is no applicable total body contact *E. coli* WQS during the remainder of the year in Indiana. Because this is a concentration-based TMDL, *E. coli* WQS will be met regardless of flow conditions in the applicable season.

Monitoring

Future *E. coli* monitoring of the Plummer Creek watershed will take place during IDEM's five-year rotating basin schedule and/or once TMDL implementation methods are in place. Monitoring will be adjusted as needed to assist in continued source identification and elimination. IDEM will monitor at an appropriate frequency to determine if Indiana's 30-day geometric mean value of 125 *E. coli* per one hundred milliliters is being met. When these results indicate that the waterbody is meeting the *E. coli* WQS, the waterbody will then be removed from the 303(d) list.

Reasonable Assurance Activities

Reasonable assurance activities are programs that are in place or will be in place to assist in meeting the Plummer Creek watershed TMDL allocations and the *E. coli* Water Quality Standard (WQS).

Confined Feeding Operations and Concentrated Animal Feeding Operations

CFOs and CAFOs are required to manage manure, litter, and process wastewater pollutants in a manner that does not cause or contribute to the impairment of *E. coli* WQS.

Watershed Projects

IDEM has hired a Watershed Specialist for this area of the state. The Watershed Specialist will be available to assist stakeholders with starting a watershed group, facilitating planning activities, and serving as a liaison between watershed planning and TMDL activities in the Plummer Creek watershed.

The USDA NRCS provided information on other activities occurring in the watershed. They are working on projects with stakeholders funded by CRP, WHIP, and EQIP. These activities include filter strips, riparian corridors and creating wildlife habitat. All of these activities can lead to improvement of water quality in the watershed by decreasing pollution from nonpoint sources. The NRCS has indicated that all of these programs are in collaboration and/or have been approved by the Greene County Soil and Water Conservation District.

The Sycamore Land Trust currently owns property in Greene County and expects to continue with similar conservation projects in the future. Land ownership by this organization in riparian areas will contribute to the improvement of water quality.

TMDLs

A TMDL for the Richland Creek watershed is currently being completed. Richland Creek is listed on the 1998, 2002 and 2004 303 (d) List of impaired waterbodies. Because Richland Creek is a tributary of

Plummer Creek, any activity for improvement of the watershed will have a direct impact on the water quality of Plummer Creek.

Potential Future Activities

Non-point source pollution, which is the primary cause of *E. coli* impairment in this watershed, can be reduced by the implementation of "best management practices" (BMPs). BMPs are techniques used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities. A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, a specific way of using or handling infrastructure or resources. BMPs should be selected based on the goals of a watershed management plan. Livestock owners, farmers, and urban planners, can implement BMPs outside of a watershed management plan, but the success of BMPs would be enhanced if coordinated as part of a watershed management plan. Following are examples of BMPs that may be used to reduce *E. coli* runoff:

Riparian Area Management - Management of riparian areas protects stream banks and river banks with a buffer zone of vegetation, either grasses, legumes, or trees.

Manure Collection and Storage - Collecting, storing, and handling manure in such a way that nutrients or bacteria do not run off into surface waters or leach down into ground water.

Contour Row Crops - Farming with row patterns and field operations aligned at or nearly perpendicular to the slope of the land.

No-Till Farming - No-till is a year-round conservation farming system. In its pure form, no-till does not include any tillage operations either before or after planting. The practice reduces wind and water erosion, catches snow, conserves soil and water, protects water quality, and provides wildlife habitat. No-till helps control soil erosion and improve water quality by maintaining maximum residue plant levels on the soil surface. These plant residues: 1) protect soil particles and applied nutrients and pesticides from detachment by wind and water; 2) increase infiltration; and 3) reduce the speed at which wind and water move over the soil surface.

Manure Nutrient-Testing - If manure application is desired, sampling and chemical analysis of manure should be performed to determine nutrient content for establishing the proper manure application rate in order to avoid over-application and run-off.

Drift Fences - Drift fences (short fences or barriers) can be installed to direct livestock movement. A drift fence parallel to a stream keep animals out and prevents direct input of *E. coli* to the stream.

Pet Clean-up / Education - Education programs for pet owners can improve water quality of runoff from urban areas.

Septic Management/Public Education - Programs for management of septic systems can provide a systematic approach to reducing septic system pollution. Education on proper maintenance of septic systems as well as the need to remove illicit discharges could alleviate some anthropogenic sources of *E. coli*.

Conclusion

The identified sources of *E. coli* to the Plummer Creek watershed consist primarily of nonpoint sources. In order for the Plummer Creek watershed to achieve Indiana's *E. coli* WQS, the wasteload and load

allocations for the Plummer Creek watershed in Indiana have been set to the *E. coli* WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty day from April 1st through October 31st. Achieving the wasteload and load allocations for the Plummer Creek watershed depends on:

1) CFOs not violating their permits
2) Nonpoint sources of *E. coli* being controlled by implementing best management practices in the watershed.
3) Implementation of the *E. coli* TMDL completed on the impaired tributaries in the Plummer Creek watershed.
4) Collect additional information on septic tanks and straight pipes

The next phase of this TMDL is to identify and support the implementation of activities that will bring the Plummer Creek watershed in compliance with the *E. coli* WQS. IDEM will continue to work with its existing programs on implementation. In the event that designated uses and associated water quality criteria applicable to the Plummer Creek watershed are revised in accordance with applicable requirements of state and federal law, the TMDL implementation activities may be revised to be consistent with such revisions. Additionally, IDEM will work with local stakeholder groups to pursue best management practices that will result in improvement of the water quality in the Plummer Creek watershed.

REFERENCES

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Table 1: Permitted Confined Feeding Operations in the Plummer Creek Watershed

			Approved Animals				
Log Number	**Name**	**NPDES Permit Number**	**Nursery Pigs**	**Growers/Finishers**	**Sow/Boars**	**Beef**	**Turkeys**
66	Park Ridge Farms, Inc.		2000	0	726	0	0
3584	New Fashion Pork West, LLP		4800	0	1775	0	0
3781	New Fashion Pork West, LLP		0	0	3306	0	0

Table 2: Plummer Creek Watershed Percent Load Reductions

***E. coli* Standard = 125 mpn/100 mL**			
Stream Name	**Site Number**	***E. coli* (geometric mean)**	**Percent Reduction**
Plummer Creek	WWL040-0048	484	74.17%
Plummer Creek	WWL040-0047	39	0
Plummer Creek	WWL040-0046	14	0
Plummer Creek	WWL040-0044	138	9.42%
Dry Branch	WWL040-0045	241	48.13%
Plummer Creek	WWL040-0043	71	0
Plummer Creek	WWL040-0042	117	0
Black Ankle Creek	WWL040-0040	246	49.19%
Plummer Creek	WWL040-0039	1070	88.32%
Plummer Creek	WWL040-0037	398	68.59%
Flyblow Branch	WWL040-0036	325	61.54%
Plummer Creek	WWL040-0034	233	46.35%
Plummer Creek	WWL040-0008	468	73.29%
Burcham Branch	WWL040-0033	269	53.53%
Unnamed Tributary	WWL040-0032	540	76.85%
Plummer Creek	WWL040-0015	349	64.18%

Figure 1: Plummer Creek Watershed TMDL

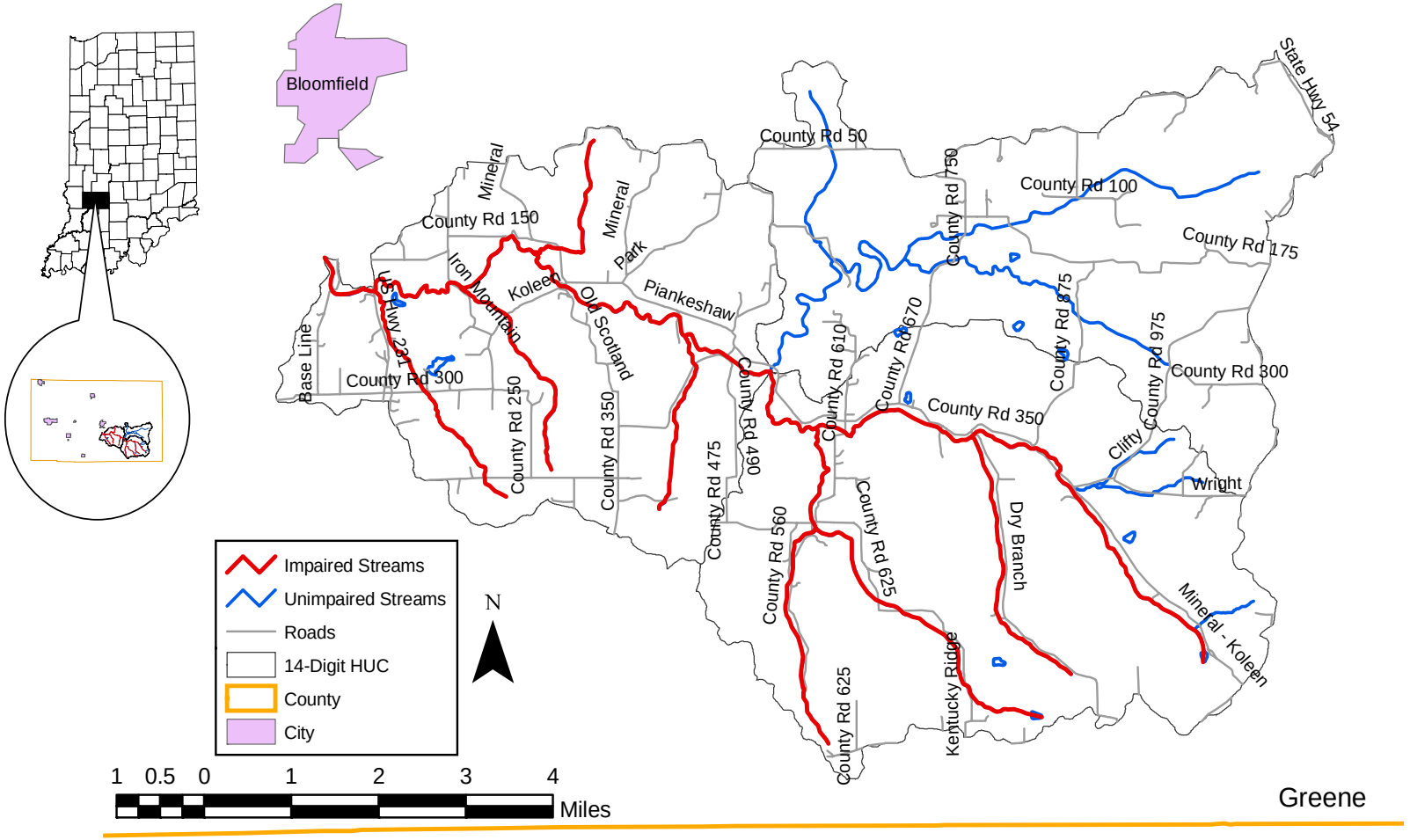


Figure 2: Sampling Sites in Plummer Creek Watershed

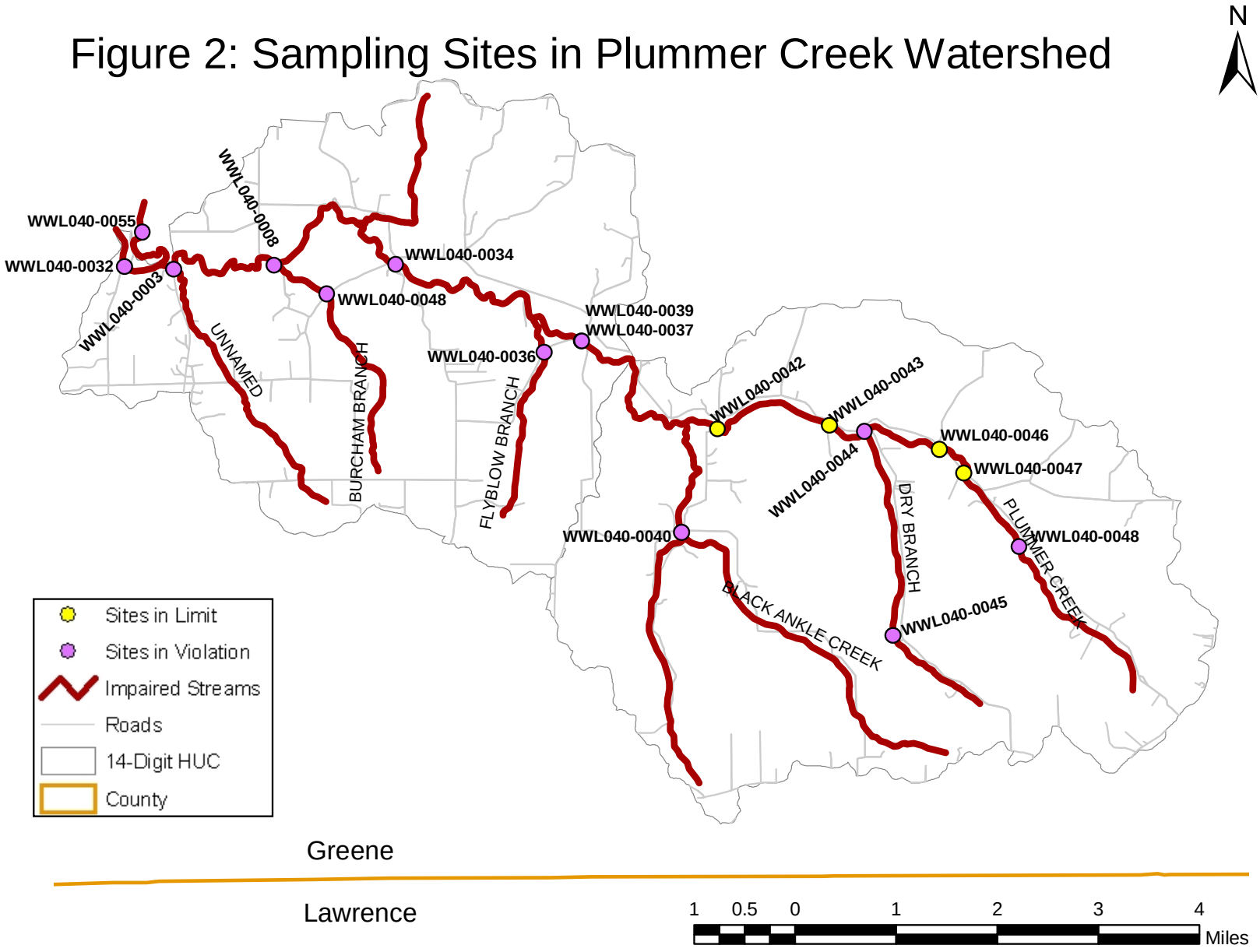


Figure 3a: Landuse in Plummer Creek Watershed

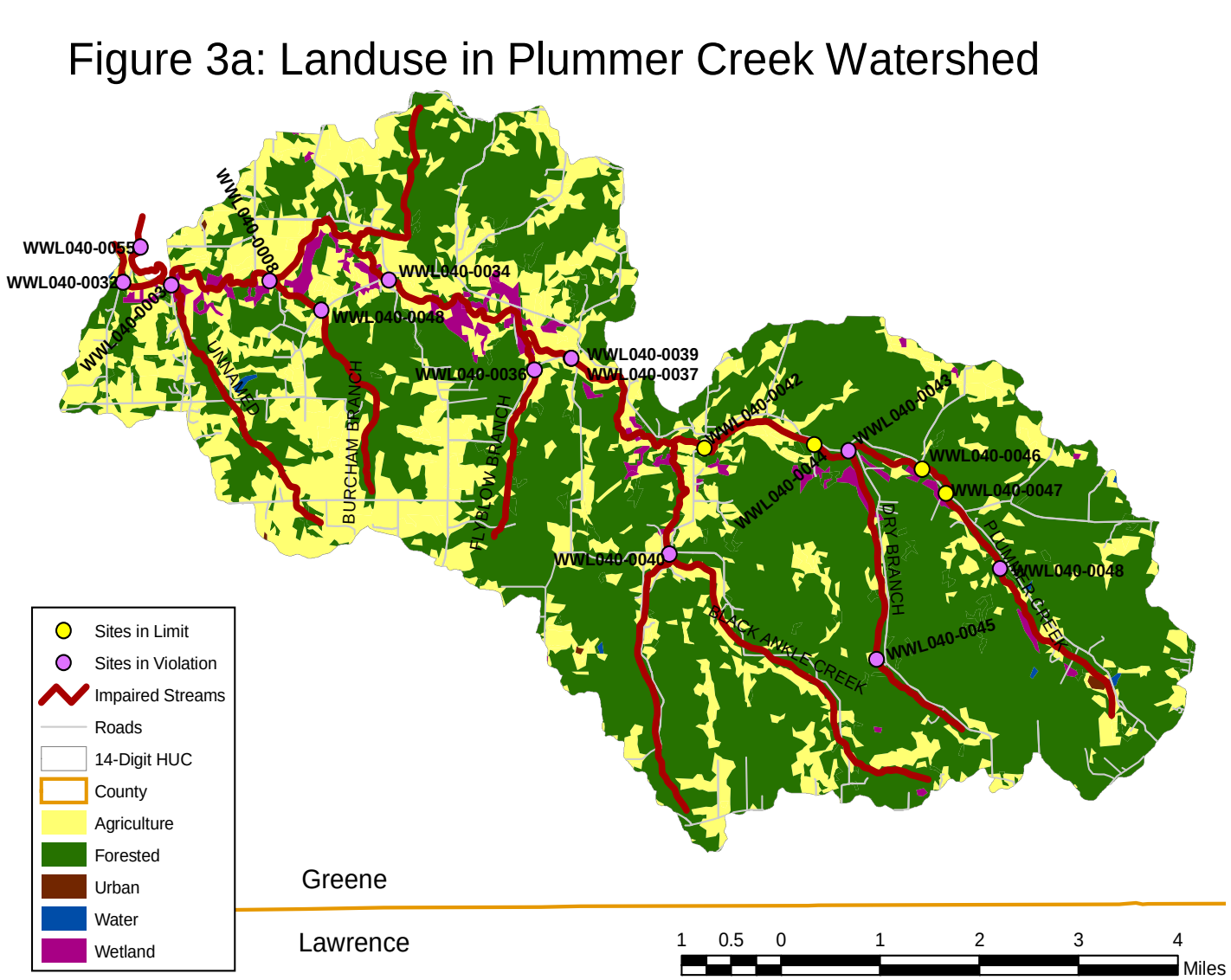
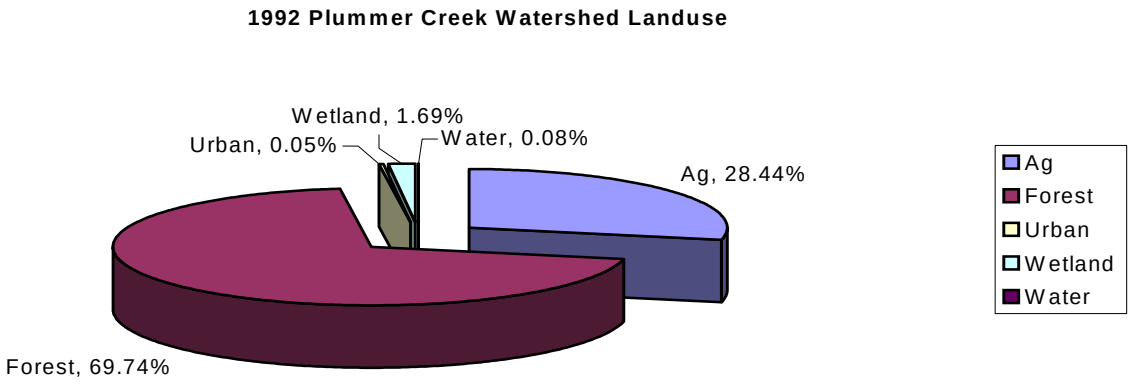


Figure 3b: Plummer Creek Landuse Breakdown



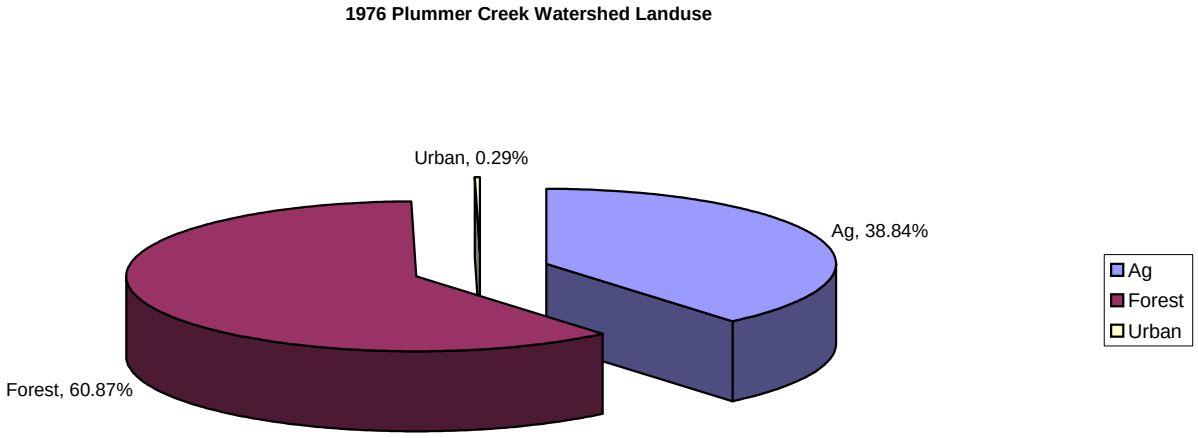
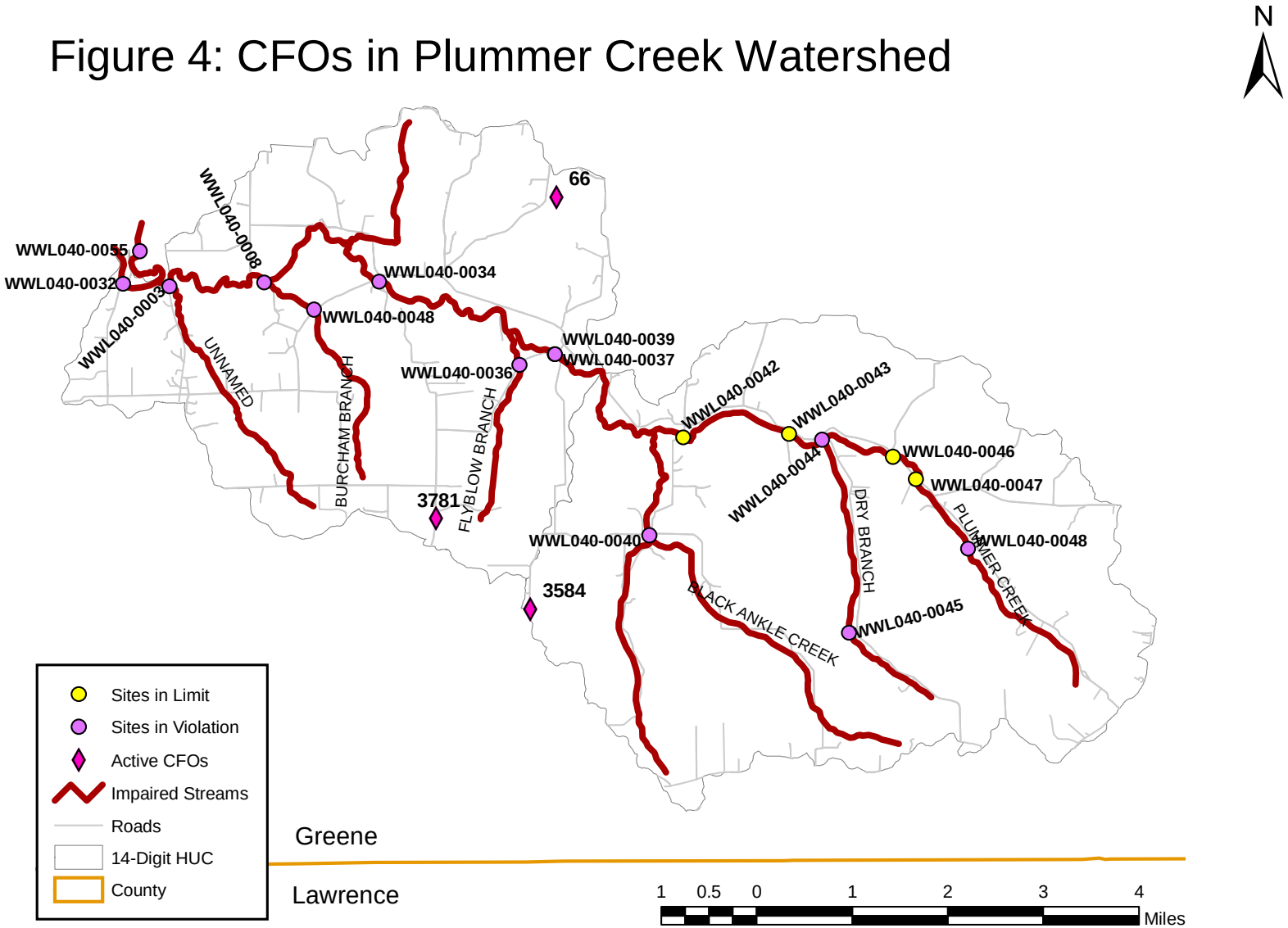


Figure 4: CFOs in Plummer Creek Watershed



Attachment A

E. coli Data for Plummer Creek Watershed TMDL

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Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E.coli (MPN/100mL)	Geometric Mean
15	1996 Synoptic	WWL040-0003	Plummer Cr	US 231, D/S Side of Bridge	DI21708	2/29/96	920	N/A
15	1996 Synoptic	WWL040-0003	Plummer Cr	US 231, D/S Side of Bridge	DI21324	6/11/96	3000	N/A
15	1996 Synoptic	WWL040-0003	Plummer Cr	US 231, D/S Side of Bridge	DI20340	7/18/96	50	N/A
1	2001 Plummer Creek Assessment	WWL040-0048	Plummer Creek	CR 635 S	AA08426	9/12/01	2400	484
					AA08648	9/19/01	2400	
					AA08818	9/26/01	2400	
					AA08984	10/3/01	160	
					AA09137	10/10/01	12	
2	2001 Plummer Creek Assessment	WWL040-0047	Plummer Creek	CR 880 E	AA08425	9/12/01	13	39
					AA08647	9/19/01	1600	
					AA08817	9/26/01	16	
					AA08983	10/3/01	16	
					AA09135	10/10/01	17	
3	2001 Plummer Creek Assessment	WWL040-0046	Plummer Creek	Mineral Koleen Rd	AA08424	9/12/01	23	14
					AA08646	9/19/01	260	
					AA08816	9/26/01	16	
					AA08982	10/3/01	6	
					AA09132	10/10/01	1	
4	2001 Plummer Creek Assessment	WWL040-0044	Plummer Creek	CR 360 S	AA08422	9/12/01	70	138
					AA08644	9/19/01	2400	
					AA08815	9/26/01	110	
					AA08981	10/3/01	25	
					AA09130	10/10/01	110	

Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E.coli (MPN/100mL)	Geometric Mean
5	2001 Plummer Creek Assessment	WWL040-0045	Dry Branch	CR 900 E	AA08427	9/12/01	140	241
					AA08649	9/19/01	980	
					AA08819	9/26/01	140	
					AA08985	10/3/01	730	
					AA09138	10/10/01	58	
6	2001 Plummer Creek Assessment	WWL040-0043	Plummer Creek	CR 725 E	AA08427	9/12/01	21	71
					AA08649	9/19/01	920	
					AA08819	9/26/01	91	
					AA08985	10/3/01	31	
					AA09138	10/10/01	32	
7	2001 Plummer Creek Assessment	WWL040-0042	Plummer Creek	CR 610 E	AA08420	9/12/01	100	117
					AA08642	9/19/01	690	
					AA08813	9/26/01	110	
					AA09123	10/3/01	52	
					AA09124	10/10/01	56	
8	2001 Plummer Creek Assessment	WWL040-0042	Black Ankle Creek	CR 450 S	AA08418	9/12/01	51	246
					AA08640	9/19/01	12000	
					AA08811	9/26/01	34	
					AA08976	10/3/01	1200	
					AA09120	10/10/01	36	
9	2001 Plummer Creek Assessment	WWL040-0039	Plummer Creek	CR 260 S	AA08416	9/12/01	1000	1070
					AA08639	9/19/01	24000	
					AA08787	9/26/01	340	
					AA08974	10/3/01	520	
					AA09116	10/10/01	330	

Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E.coli (MPN/100mL)	Geometric Mean
10	2001 Plummer Creek Assessment	WWL040-0037	Plummer Creek	CR 490 E	AA08414	9/12/01	820	398
					AA08637	9/19/01	1600	
					AA08785	9/26/01	230	
					AA08972	10/3/01	110	
					AA09114	10/10/01	300	
11	2001 Plummer Creek Assessment	WWL040-0036	Flyblow Branch	CR 410 E	AA08415	9/12/01	190	325
					AA08638	9/19/01	24000	
					AA08786	9/26/01	290	
					AA08973	10/3/01	45	
					AA09115	10/10/01	61	
12	2001 Plummer Creek Assessment	WWL040-0034	Plummer Creek	CR 300 E	AA08413	9/12/01	550	233
					AA08635	9/19/01	2800	
					AA08784	9/26/01	88	
					AA08971	10/3/01	88	
					AA09113	10/10/01	57	
13	2001 Plummer Creek Assessment	WWL040-0008	Plummer Creek	CR 150 S	AA08411	9/12/01	650	468
					AA08633	9/19/01	3000	
					AA08782	9/26/01	340	
					AA08969	10/3/01	200	
					AA09110	10/10/01	170	
14	2001 Plummer Creek Assessment	WWL040-0033	Burcham Branch	CR 200 E	AA08412	9/12/01	370	269
					AA08634	9/19/01	2400	
					AA08783	9/26/01	110	
					AA08970	10/3/01	200	
					AA09112	10/10/01	72	

Site #	Project ID	L-Site #	Stream Name	Description	Sample #	Sample Date	E.coli (MPN/100mL)	Geometric Mean
15	2001 Plummer Creek Assessment	WWL040-0003	Plummer Creek	US 231, D/S Side of Bridge	AA08409	9/12/01	1200	540
					AA08631	9/19/01	1400	
					AA08780	9/26/01	650	
					AA08967	10/3/01	490	
					AA09107	10/10/01	86	
16	2001 Plummer Creek Assessment	WWL040-0032	Plummer Creek	Base Road	AA08407	9/12/01	310	349
					AA08629	9/19/01	820	
					AA08778	9/26/01	280	
					AA08965	10/3/01	730	
					AA09152	10/10/01	99	
17	2001 Plummer Creek Assessment	WSU050-0015	Richland Creek	CR 175 S	AA08385	9/11/01	2000	362
					AA08578	9/18/01	490	
					AA08754	9/25/01	250	
					AA08956	10/2/01	180	
					AA09143	10/9/01	140	

Attachment B

Water Quality Duration Curves for Plummer Creek Watershed TMDL

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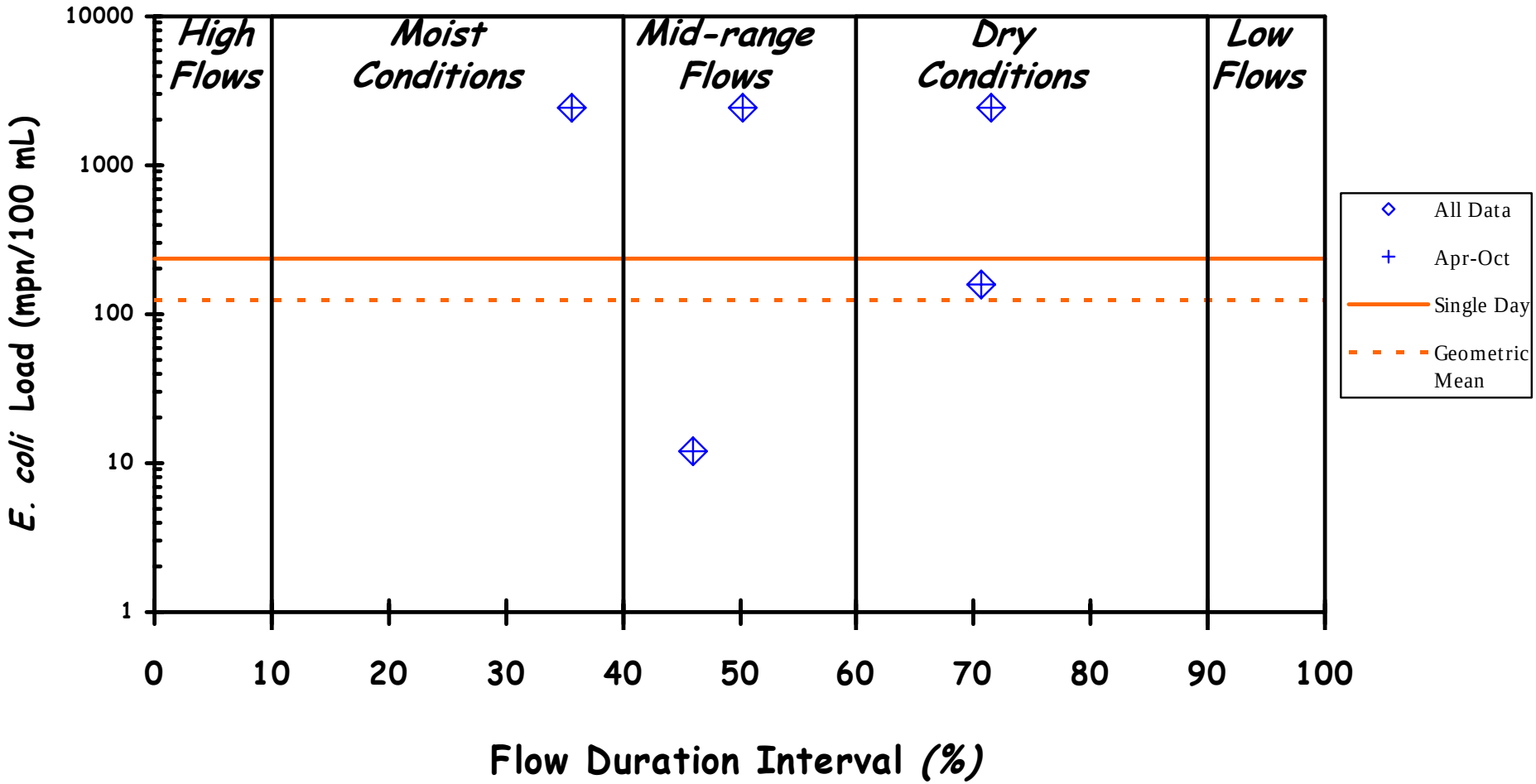
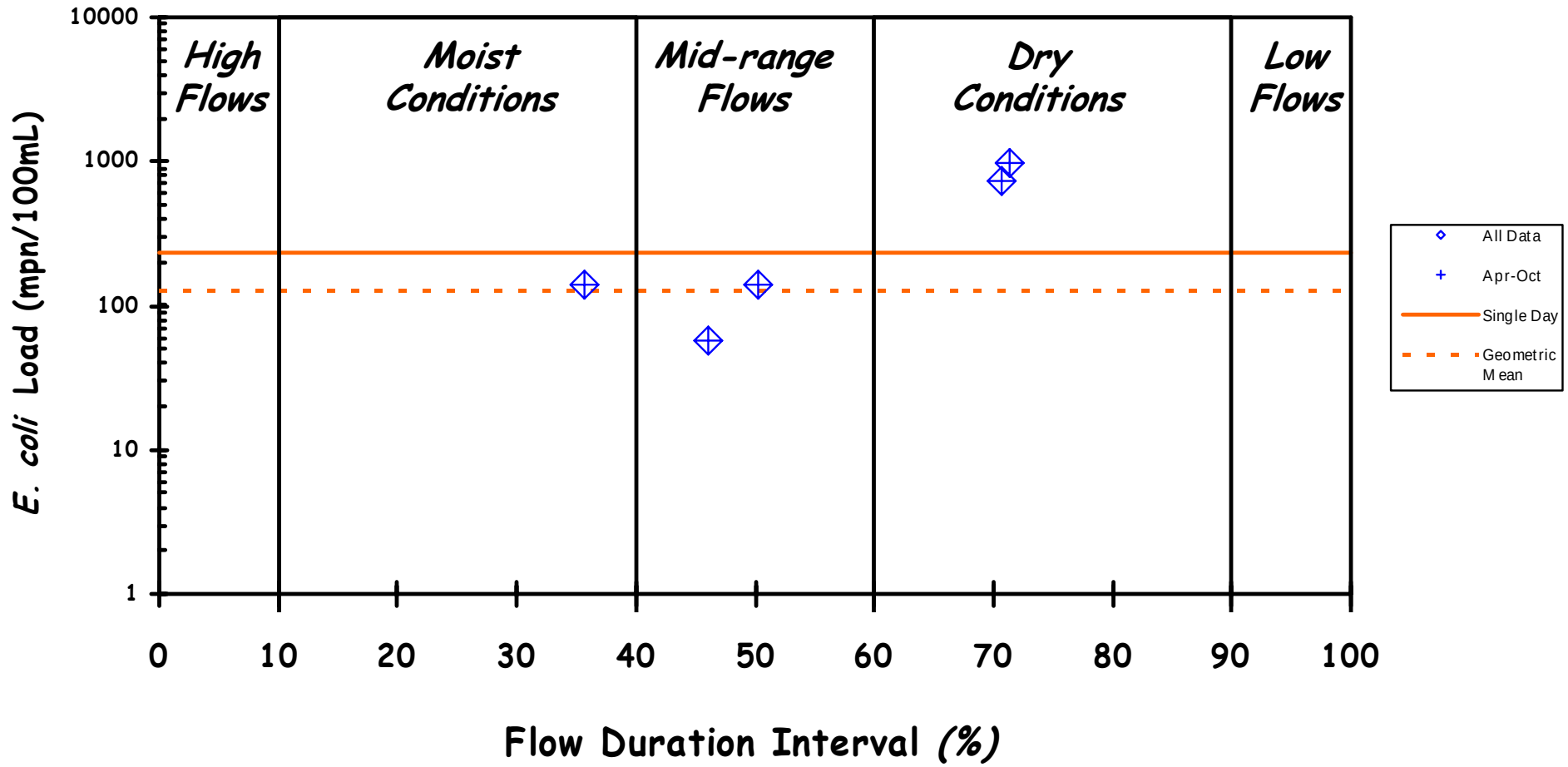
Plummer Creek
WQ Duration Curve
Site: WWL040-0048



IDEM Data & USGS Gage Duration Interval

59.32 square miles

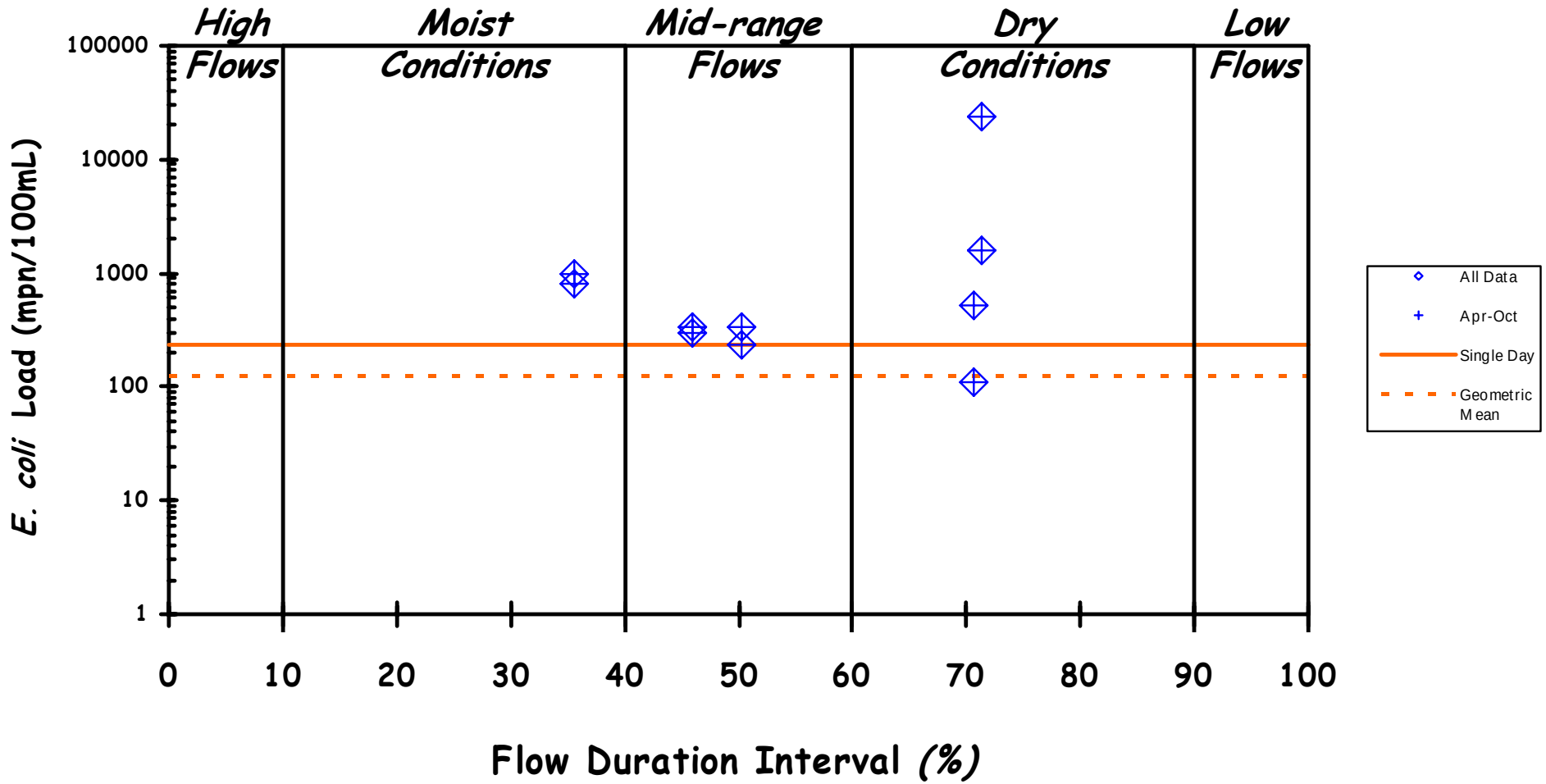
Plummer Creek
WQ Duration Curve
Site: WWL040-0045



IDEM Data & USGS Gage Duration Interval

59.32 square miles

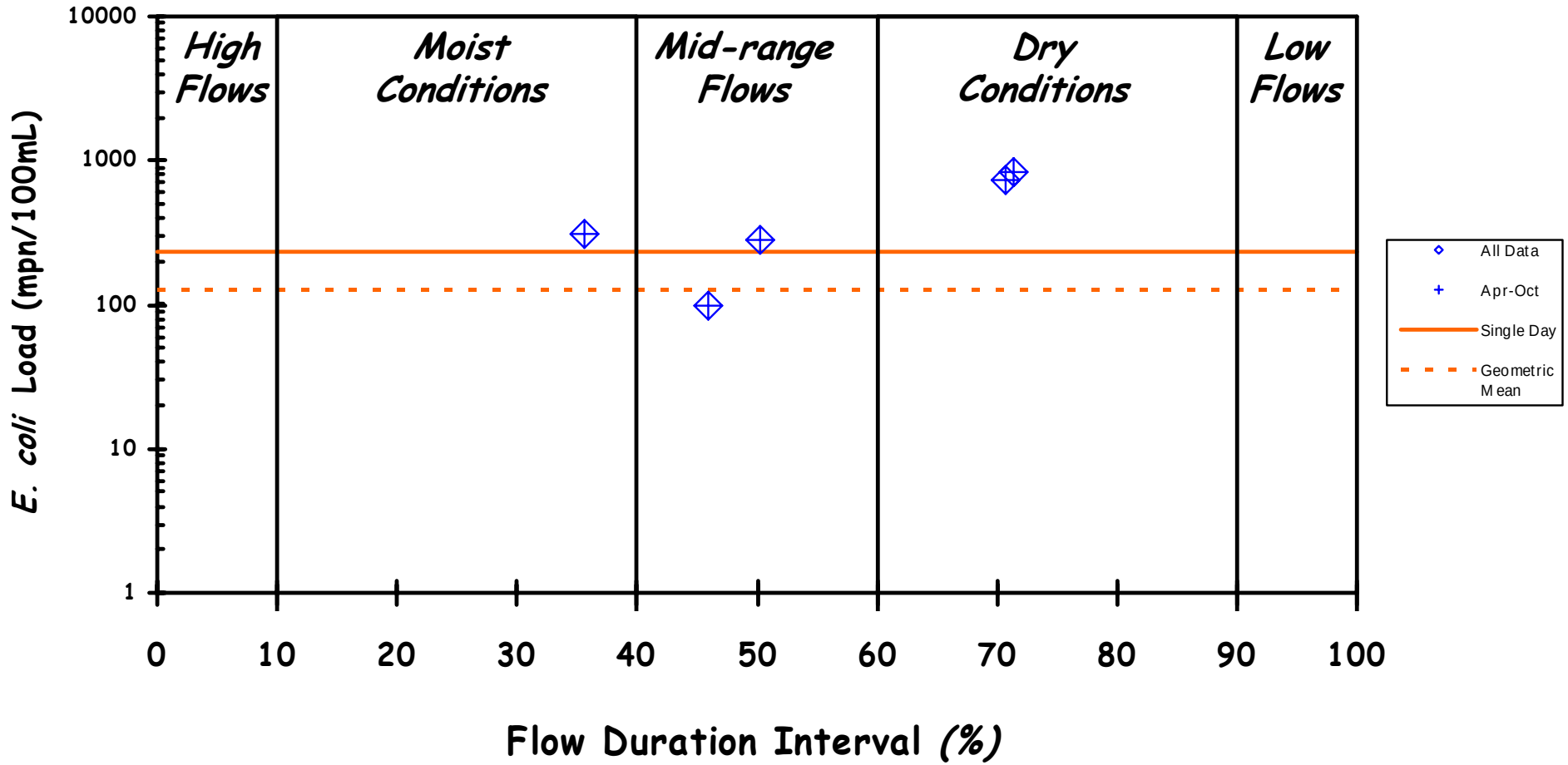
Plummer Creek
WQ Duration Curve
Sites: WWL040-0039 and WWL040-0037



IDEM Data & USGS Gage Duration Interval

59.32 square miles

Plummer Creek
WQ Duration Curve
Site: WWL040-0032



IDEM Data & USGS Gage Duration Interval

59.32 square miles

Attachment C

Load Duration Curves for Plummer Creek Watershed TMDL

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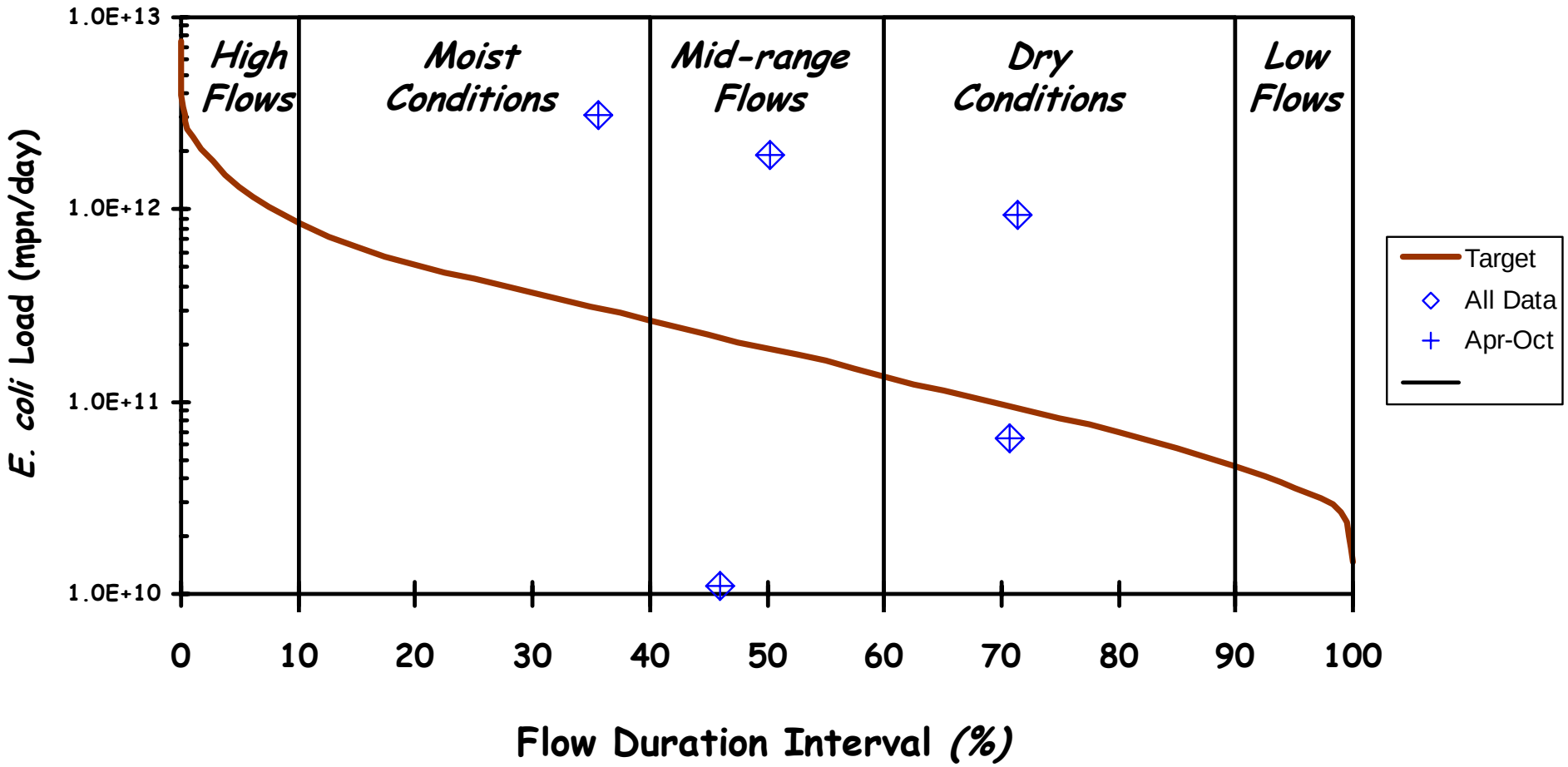
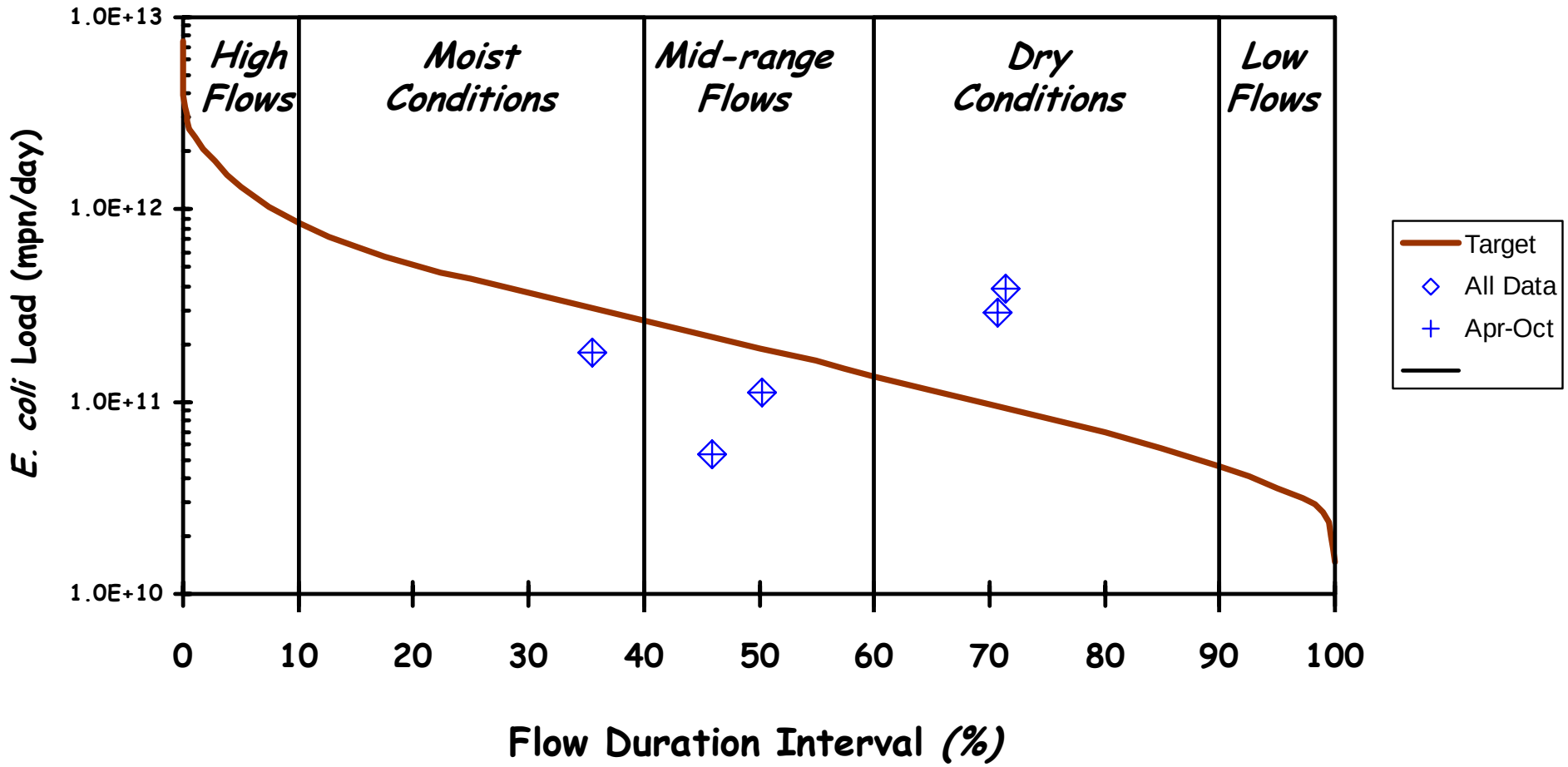
Plummer Creek
Load Duration Curve
Site: WWL040-0048



IDEM Data & USGS Gage Duration Interval

59.32 square miles

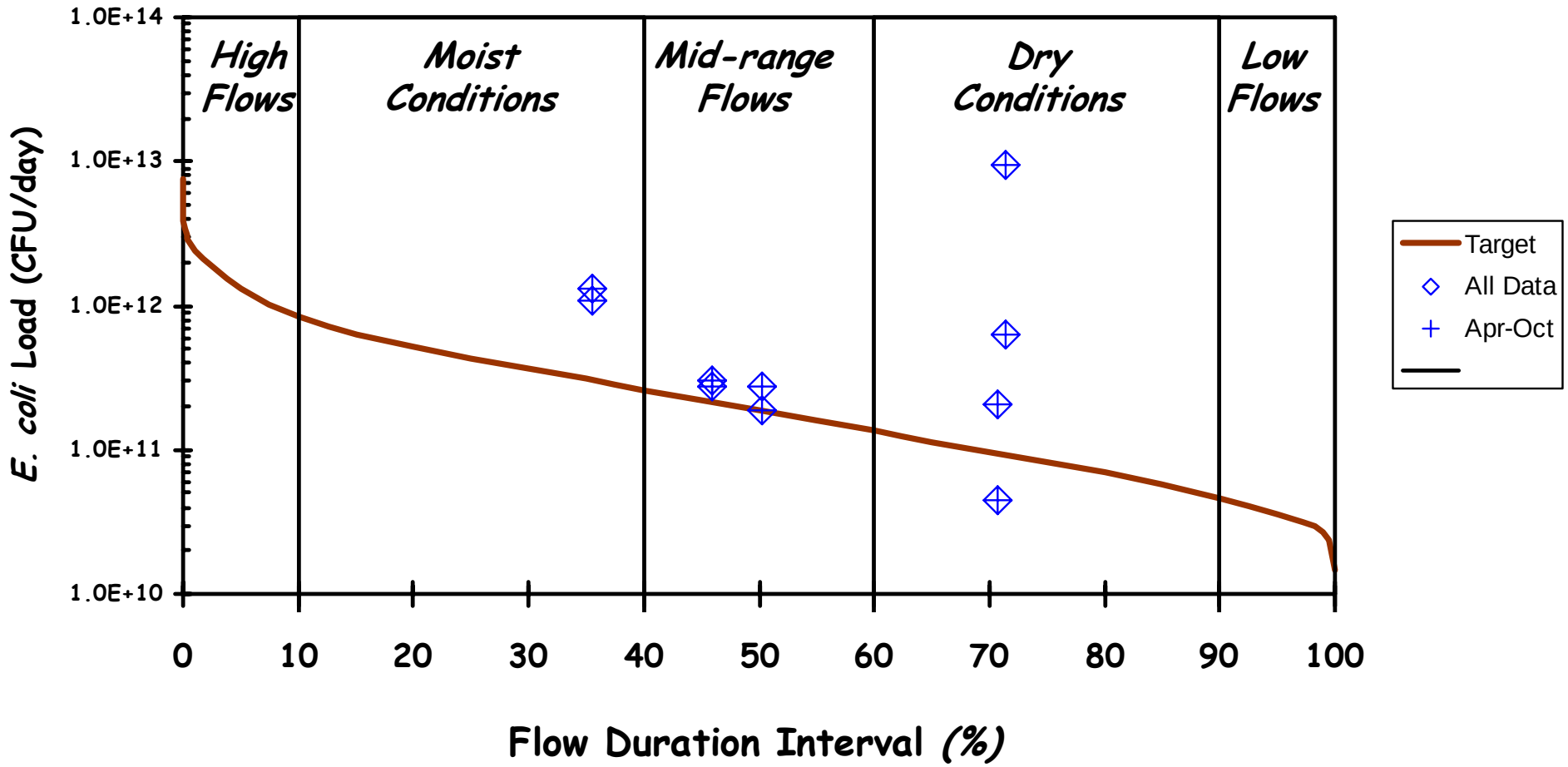
Dry Branch
Load Duration Curve
Site: WWL040-0045



IDEM Data & USGS Gage Duration Interval

59.32 square miles

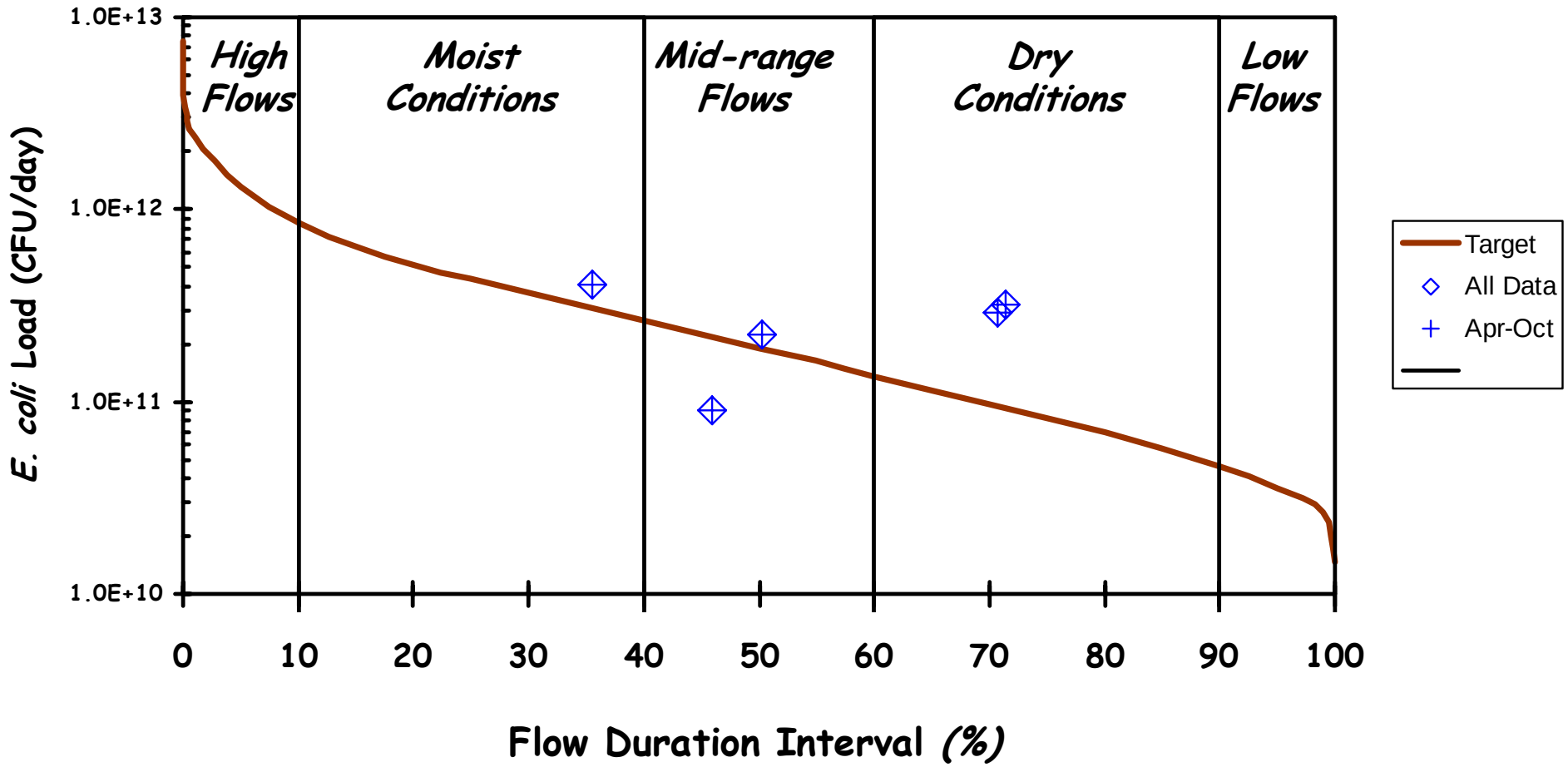
Plummer Creek
Load Duration Curve
Sites: WWL040-0039 and WWL040-0037



IDEM Data & USGS Gage Duration Interval

59.32 square miles

Plummer Creek
Load Duration Curve
Site: WWL040-0032



IDEM Data & USGS Gage Duration Interval

59.32 square miles