Clarkston Creek, Newton Reservoir, and Newton Creek TMDL Study

EPA Approval
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Clarkston Creek, Newton Reservoir, Newton Creek TMDL Study

Public Draft

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Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Clarkston Creek, Newton Reservoir, and Newton Creek TMDL Study

Clarkston Creek

Waterbody ID	Clarkston Creek.
Location	Cache County, Utah.
Pollutants of Concern	Total Phosphorus.
Impaired Beneficial Uses	Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
Water Quality Assessment	TP concentration exceeds 0.05 mg/l at monitoring sites from 73% - 100%.
Water Quality Targets/Endpoints	0.05 mg/l TP instream concentration.
Implementation Strategy	• Implement or properly maintain and monitor CNMPs on all AFOs in the Clarkston Creek watershed. • Eliminate all direct animal access to Clarkston Creek. • Follow recommended manure application schedule. • Implement 30-foot conservation easement for all non-residential land adjacent to Clarkston Creek and perennial tributaries.

Utah Department of Environmental Quality
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TMDL Section

Clarkston Creek, Newton Reservoir, and Newton Creek TMDL Study

Newton Reservoir

Waterbody ID	Newton Reservoir.
Location	Cache County, Utah.
Pollutants of Concern	Total Phosphorus. Dissolved Oxygen.
Impaired Beneficial Uses	Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
Water Quality Assessment	TP concentrations exceed 0.025 mg/l at monitoring sites from 87% - 92%. DO concentrations frequently < 4.0 mg/l. Anoxic conditions in hypolimnion.
Water Quality Targets/Endpoints (Based on 0.05 mg/l TP concentration inflow from Clarkston Ck.)	• 05 mg/l TP inflow concentration from Clarkston Creek. • 0.025 mg/l TP concentration in reservoir. • Average annual TP load = 341 kg/yr. • Load reduction = 3,294 kg/yr. • A shift from blue-green algal dominance to green algal dominance. • A TSI value in the reservoir not to exceed 50. • Dissolved oxygen concentration of 4.0 mg/l for greater than 50 percent of the water column.
Implementation Strategy	• Implement recommended BMPs for Clarkston Creek. • Eliminate all direct animal access to Newton Reservoir below high water mark. • Follow recommended manure application schedule. • Implement 30-foot conservation easement for all non-residential land adjacent to Newton Reservoir.

Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Clarkston Creek, Newton Reservoir, and Newton Creek TMDL Study

Newton Creek

Waterbody ID	Newton Creek.
Location	Cache County, Utah.
Pollutants of Concern	Total Phosphorus.
Impaired Beneficial Uses	Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
Water Quality Assessment	TP concentrations exceed 0.05 mg/l at monitoring sites from 36% - 100%.
Water Quality Targets/Endpoints	• 0.05 mg/l TP instream concentration. • Average annual TP load = 77 kg/yr. • Load reduction = 4,526 kg/yr.
Implementation Strategy	• Implement or properly maintain and monitor CNMPs on all AFOs in the Clarkston Creek watershed. • Eliminate all direct animal access to Clarkston Creek. • Follow recommended manure application schedule. • No application of commercial phosphorus fertilizers. • Implement 60-foot conservation easement for all non-residential land adjacent to Newton Creek.

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CHAPTER 1: INTRODUCTION

The Total Maximum Daily Load (TMDL) study for the Newton Creek, Newton Reservoir, and Clarkston Creek area has been completed under the direction of the Utah Department of Environmental Quality – Division of Water Quality (DWQ) for submittal to the U.S. Environmental Protection Agency (EPA) as specified by section 303(d) of the Clean Water Act (CWA). The water quality and flow assessment detailed within this document addresses impairment to these water bodies due to high concentrations of Total Phosphorus (TP) and low levels of Dissolved Oxygen (DO). An extensive field effort has accompanied this assessment in order to document existing conditions and verify model outputs. As a result, it is believed that this document provides an accurate picture of the important influences on water quality in the project area.

In order for a TMDL to be effective, involvement by agencies and stakeholders at the local level is essential. Efforts have been made throughout this process to involve local agencies and stakeholders to inform them of the current status of water quality in the Newton/Clarkston area. It is not the intent of this assessment to place blame or criticism on any individual or group within the watershed, but to try and provide an accurate characterization of **all** conditions that lead to water quality impairment within the project area.

1.1 TMDL PROGRAM DESCRIPTION

A TMDL is the maximum amount of pollutant that a water body can assimilate and not violate water quality standards. TMDLs can be defined in several different ways including mass of pollutant over time, concentration, or other desired criteria. Expressed as an equation, a TMDL would include the following components:

$$\text{TMDL} = \text{LC} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS} \qquad (1)$$

Where:

LC = loading capacity
WLA = wasteload allocation
LA = load allocation
MOS = margin of safety

Loading capacity (LC) is equal to a TMDL in that it is the maximum loading a waterbody can receive without violating water quality standards. The terms of this equation reflect the manner in which pollutants are defined during a TMDL assessment. Wasteload allocations (WLA) are assigned to point sources of pollution including any discrete or confined discharge of pollution from a pipe, ditch, container, or concentrated animal feeding operation. Load allocations (LA) are assigned to nonpoint sources of pollution and include any pollutant source that is not designated as a point source. Nonpoint sources of pollution are typically more difficult to define due to their diffuse nature. Some of the nutrient sources that typically influence water quality include:

- surface runoff from residential, urban, and agricultural areas where use of insecticides, herbicides, and fertilizer is prevalent
- sediment from construction sites, crop lands, and eroding streambanks
- bacteria and nutrients from livestock operations and malfunctioning septic systems
- atmospheric deposition, mineralized geologic formations

The TMDL process is a shift from the more generalized approaches employed in the past to implement the CWA. It demands a more local focus on the target watershed, from both a scientific and an applied perspective. Water quality standards that are broadly applied can be carefully evaluated under this process in terms of restoring and maintaining beneficial uses under actual conditions that influence water quality in the Newton/Clarkston area. Successful implementation of this assessment will require cooperation between federal, state, and local entities, including local stakeholders living within the project area.

1.1.1 Previous Studies

The history of water quality assessment on the Bear River dates back to the early 1950s (Thorne and Thorne 1951; Clyde 1953). Many of the early studies addressed water quantity while water quality assessments were primarily limited to erosion and sedimentation issues. Other water quality parameters including TP began to be addressed in the mid-70s and continue up to the present time (Luce 1974; Perry 1978; Lamarra and Adams 1980; Sorenson et al 1986; Utah DWQ 1997; Bureau of Reclamation 2000). Many of these studies mentioned water bodies away from the mainstem Bear River only briefly. The water bodies assessed in this TMDL report, including Clarkston Creek, Newton Reservoir, and Newton Creek have been mentioned in two of the more recent water quality studies including the Lower Bear River Water Quality Management Plan (Lower Bear WQMP) and the Hyrum and Newton Reservoirs Resource Management Plan (Bureau of Reclamation 2000). A brief description of these documents and their assessment of water quality conditions in the project area are included below.

1.1.1.1 Lower Bear WQMP

Water quality conditions in the Lower Bear River watershed from the outlet of Oneida Reservoir extending down to the Great Salt Lake, were intensively monitored by the DWQ during 1992-93. Results from the monitoring data were included as part of the Lower Bear WQMP. Although the study primarily addressed TP and Total Suspended Solids, other water quality constituents were mentioned in the report including Nitrate, Total Coliform, Fecal Coliform, and Dissolved TP. The purpose of the report was to prepare a water quality management plan according to the recently established TMDL regulations process. Water quality conditions in Newton Creek were addressed using the DWQ stream monitoring site on lower Newton Creek (490310). Newton Reservoir did not provide any discharge flow to the Creek during the intensive monitoring period, resulting in very low flows or no flows. Subsequently, only 2 samples were collected on Newton Creek and measured for water quality. Both samples collected exceeded the state recommendation for TP concentration. Measured DO concentrations were in compliance with State standards for Cold Water Aquatic Life. Measurements of TP reported for locations on the main stem Bear River above Cutler Reservoir exceeded the TP standard between 60 and 100 percent of the time.

Four priority reaches were identified for immediate mitigation activities, based on the assessment of water quality data completed in the Lower Bear WQMP. These included the following:

- Spring Creek drainage
- Utah portion of the Cub River corridor.
- Nonpoint sources surrounding Cutler Reservoir from Benson to Cutler dam.
- Bear River corridor from Richmond to Benson.

A detailed assessment and TMDL for pollutant sources in each area was provided in the report. No mention of Newton Creek was made in the TMDL for pollutant sources contributing to Cutler Reservoir. However, many of the nonpoint pollutant sources contributing to Cutler Reservoir are similar to those found in the Newton/Clarkston area including irrigated agriculture, non-irrigated agriculture, cultivation in floodplain areas adjacent to waterways, and feedlot/dairy operations.

1.1.1.2 Bureau of Reclamation Study of Newton Reservoir

A resource management plan establishing guidelines for the proper use of land, water, and aquatic resources in Newton and Hyrum Reservoirs was completed by the Bureau of Reclamation (BOR) (2000). Some of the existing conditions addressed by the plan included geology, soils, hydrology, water quality, and water rights. A discussion of water quality in Clarkston Creek and Newton Reservoir indicated that agricultural return flows, feedlots and dairies were all contributing to high TP concentrations in Clarkston Creek. Agricultural use of land adjacent to Newton Reservoir for cattle grazing and cropland was also identified as a source of TP. High nutrient levels in the reservoir were noted to contribute to excessive algal growth including blue-green algal blooms. Fish kills in the reservoir were also observed resulting from low hypolimnetic DO levels during the summer and high Biological Oxygen Demand (BOD) levels during the winter due to decaying aquatic vegetation.

1.1.2 Plan Objectives

The goal of this TMDL assessment is to restore the beneficial uses assigned by the State of Utah to Clarkston Creek, Newton Reservoir, and Newton Creek by meeting the applicable water quality standards for TP and DO. Some of these waterbodies have been included on the State 303(d) list of impaired water bodies since 1996. A summary of the 303(d) history for these waterbodies is provided below in Table 1-1.

Table 1-1. 303(d) history of impaired water bodies within the Newton/Clarkston watershed.

303(d) list year	Water body	Pollutant of Concern	Priority for TMDL	Comments
1996	Newton Reservoir	TP, DO, pH	Low	
	Newton Creek	TP	Low	
1998	Newton Reservoir	TP, DO, temperature	Low	
	Newton Creek			Removed from 1998 303(d) list[1.]
2000	Newton Reservoir	TP, DO	Low	Temperature impairment removed from 2000 303(d)[2.]
2002	Newton Reservoir	TP, DO	High	TMDL to be completed during 2002-2004.

[1] Removed due to EPA approval of 1995 TMDL (Lower Bear WQMP).
[2] Removed due to revaluation of new temperature data.

Although Newton Reservoir is the only water body to appear on the 2002 303(d) list, Clarkston Creek and Newton Creek are also examined under this TMDL analysis. Clarkston Creek is the primary hydrologic source to Newton Reservoir and as such, must be considered in the assessment of water quality conditions for the reservoir. Newton Creek is considered to contribute periodic flows to Cutler Reservoir which is located approximately 5 miles downstream from Newton Reservoir. At the present time, Cutler Reservoir and the Bear River upstream to the Idaho border are considered to be impaired for TP.

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CHAPTER 2: PROJECT AREA DESCRIPTION

2.1 PROJECT AREA

The project area encompasses all land areas assumed to contribute surface and groundwater flow to Clarkston Creek, Newton Reservoir, and Newton Creek (see Figure 2-1). The headwaters of Clarkston Creek, including its first major tributary, Jenkins Hollow, originate in the Caribou National Forest in southern Idaho at an elevation of approximately 1,800 – 2,000 m (6,000 – 6,500 ft), at the south end of the Malad Mountains. Flow in Clarkston Creek is intermittent until its confluence with Steel Canyon, located 0.8 mile south of the Idaho border. Water in Steel Canyon originates near the north end of the Clarkston Mountains at the Utah-Idaho border, but perennial flow from this tributary does not reach Clarkston Creek. The last segment of the tributary is plowed over and incorporated in a dry farm. A spring located at the confluence of Steel Canyon and Clarkston Creek constitutes the start of perennial flow in Clarkston Creek. Several agricultural fields are located immediately above this point, and have removed all evidence of the former Clarkston Creek stream channel in the area.

In Utah, Clarkston Creek flows south through Hammond Flat, southeast past the town of Clarkston, then east before reaching Newton Reservoir, which is still part of the Clarkston Creek watershed. The watershed includes the town of Clarkston and is bordered to the west by the Clarkston Mountains, where most of the tributaries to Clarkston Creek originate. Only two of these tributaries were observed to contribute perennial flow to Clarkston Creek during 2002-2003, including an unnamed tributary roughly one-quarter mile above the confluence with Birch Creek and City Creek, which runs through the town of Clarkston before discharging into Clarkston Creek. Birch Creek is not perennial at the confluence with Clarkston Creek due to its development for municipal water use. Newton Reservoir is located near the foot of Little Mountain, a small hill that rises approximately 1,000 feet above the valley floor, on the west side of Cache Valley. Newton Creek begins immediately below Newton Reservoir, and flows south for approximately four miles, past the town of Newton, before entering Cutler Reservoir. Most of the town of Newton is located outside of the Newton Creek watershed.

The first dam across Clarkston Creek was constructed in 1871 through a cooperative effort by the Newton community. This effort was imperative to the agricultural survival of the community as Newton held only one-fourth of the water rights from Clarkston Creek. The remaining water rights were held at that time by the upstream residents of Clarkston. The water body created by the original dam was named Newton Reservoir and provided summer irrigation to 1,660 acres of farmland. A larger second dam across Clarkston Creek was completed by 1946, downstream of the original dam. It was the first project in the U.S. to be considered under the Case-Wheeler Act of 1939, which provided construction loans from federal agencies to local entities. The Newton Water User's Association has been managing the facility since the mid-1940s. In addition to its main purpose of irrigation, Newton Reservoir provides opportunities for fishing, camping, and water sports, and has experienced steady growth in recreational use over the past several decades.

Water in Clarkston Creek is drawn upon for irrigation purposes at many locations prior to entering Newton Reservoir. During the summer season, the principle flow of water discharging from Newton Reservoir is diverted into the Main Canal, which splits into the East Canal and Highline Canal approximately 0.5 miles below the Reservoir spillway. The canal system provides water to both the east and west sides of Newton Creek. Although no minimum flows are maintained in Newton Creek by Newton Reservoir, a small amount of water is typically found within the stream channel due to seepage, groundwater inflows, and agricultural return flows.

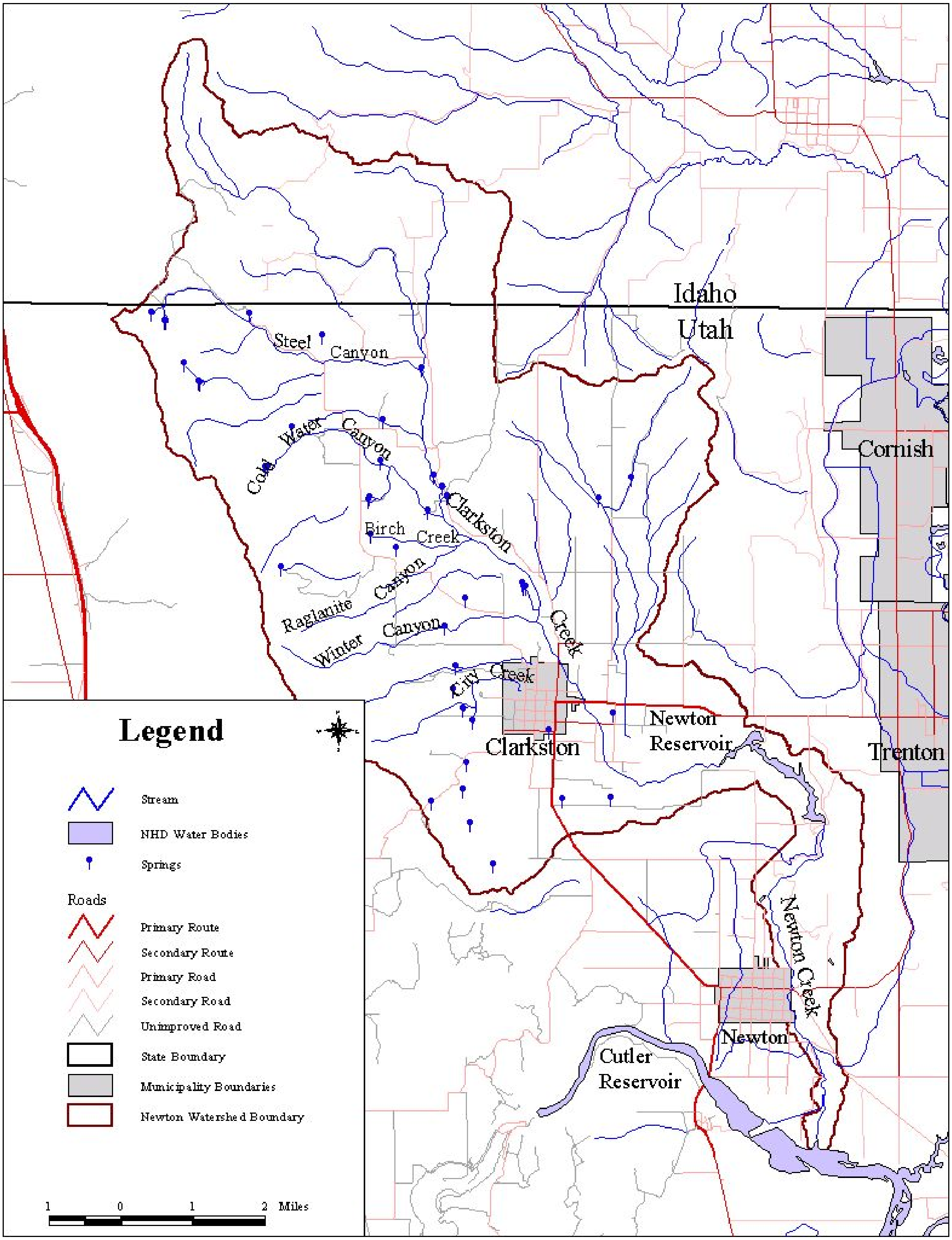

Figure 2-1. TMDL project area including Clarkston Creek, Newton Reservoir, and Newton Creek.

2.1.1 Climate

Northern Utah has a semiarid climate, with an average annual precipitation of 16.4 inches over the last 30 years. A significant portion of the precipitation is snowfall, averaging 57.3 inches per year with mean snow water content of about 10 percent. Winter temperatures typically range from –8.9°C to 16.7°C (average: 3.9°C) with extremes as low as –31.7°C. Summer temperatures typically range from 2.2°C to 30.6°C (average: 16.4°C) with extremes as high as 38.9°C. The average growing season ranges from 114 to 150 days, from May to September, with a typical frost-free period of about 4 months. Climate information was obtained from the National Climatic Data Center maintained by the National Oceanic and Atmospheric Administration.

Figure 2-2 shows average annual precipitation in the Clarkston Creek and Newton Creek watersheds. Since most of the precipitation in the project area comes during the winter and spring months in the form of snow in the Clarkston Mountains, it is necessary to store water in Newton Reservoir for local crop irrigation during the summer.

2.1.2 Topography

The watershed ranges in elevation from 1345 m (4410 ft) at the discharge of Newton Creek into Cutler Reservoir to 2440 m (8000 ft) at the top of Clarkston Mountain, east of the town of Clarkston. Figure 2-3 shows the topographic relief of the project area watershed. The northern and western parts of the watershed include steep mountainous terrain at the south end of the Malad Mountains in Idaho and on the eastern slopes of the Clarkston Mountains in Utah, while the central and southeastern parts of the watershed have much gentler slopes. The general aspect of surface slopes above Newton Reservoir are typically east and west, providing direct transport of surface runoff as well as flow from springs and tributaries to Clarkston Creek. The surface gradient below Newton Reservoir is influenced largely by the presence of Little Mountain. Moderately steep south-west facing slopes are located on the east side of Newton Creek while the west side of Newton Creek is characterized by gentle slopes maintaining a southern aspect. Topographic relief on the west side of Newton Creek creates a watershed boundary that is adjacent and roughly parallel to Newton Creek. Land areas to the west of this boundary drain to a channel locally known as "The Slough" which discharges directly to Cutler Reservoir. Surface slopes on the east side of Newton Creek are primarily influenced by Little Mountain although the total area contributing to surface runoff is greater as compared to the watershed area on the west side of Newton Creek. In general, the Newton Creek watershed below Newton Reservoir is defined by Little Mountain to the east and by The Slough on the west. The Clarkston Creek watershed (above Newton Reservoir) has a much greater contributing area with respect to surface runoff and groundwater contributions than the Newton Creek watershed.

2.1.3 Geology/Soils

The study area is located at the northwestern edge of Cache Valley, which is situated on the eastern edge of the Great Basin, known for its north-south trending, normal-faulted mountain ranges. Cache Valley is bounded to the northwest by the Clarkston Mountains, to the southwest by the Wellsville Mountains and the West Cache Fault Zone (Goessel 1999), and to the east by the Bear River Mountain Range and the East Cache Fault Zone (McCalpin 1994). Both fault zones are comprised of numerous normal faults that are responsible for the present topography.

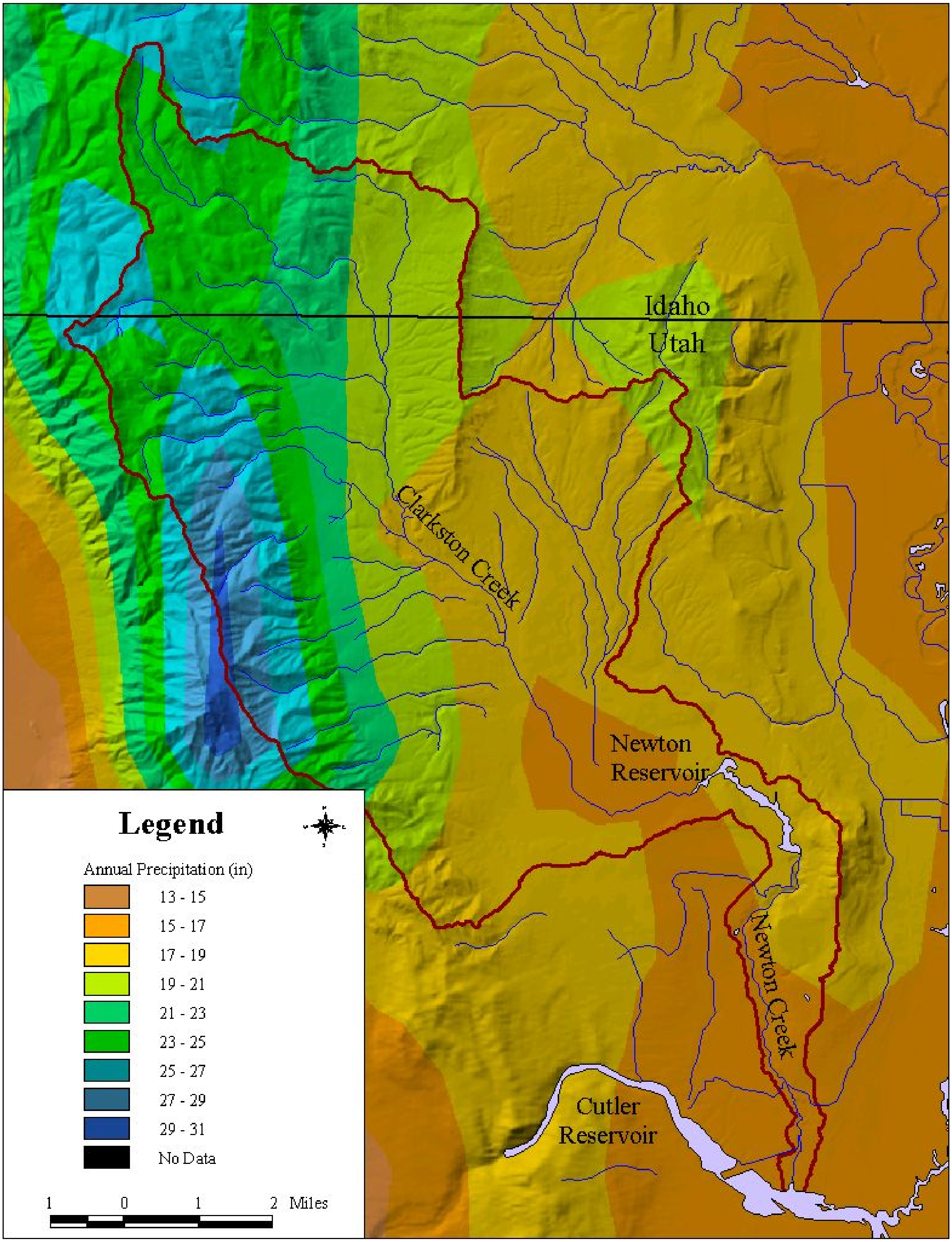

Figure 2-2. Average annual precipitation map of the TMDL project area.

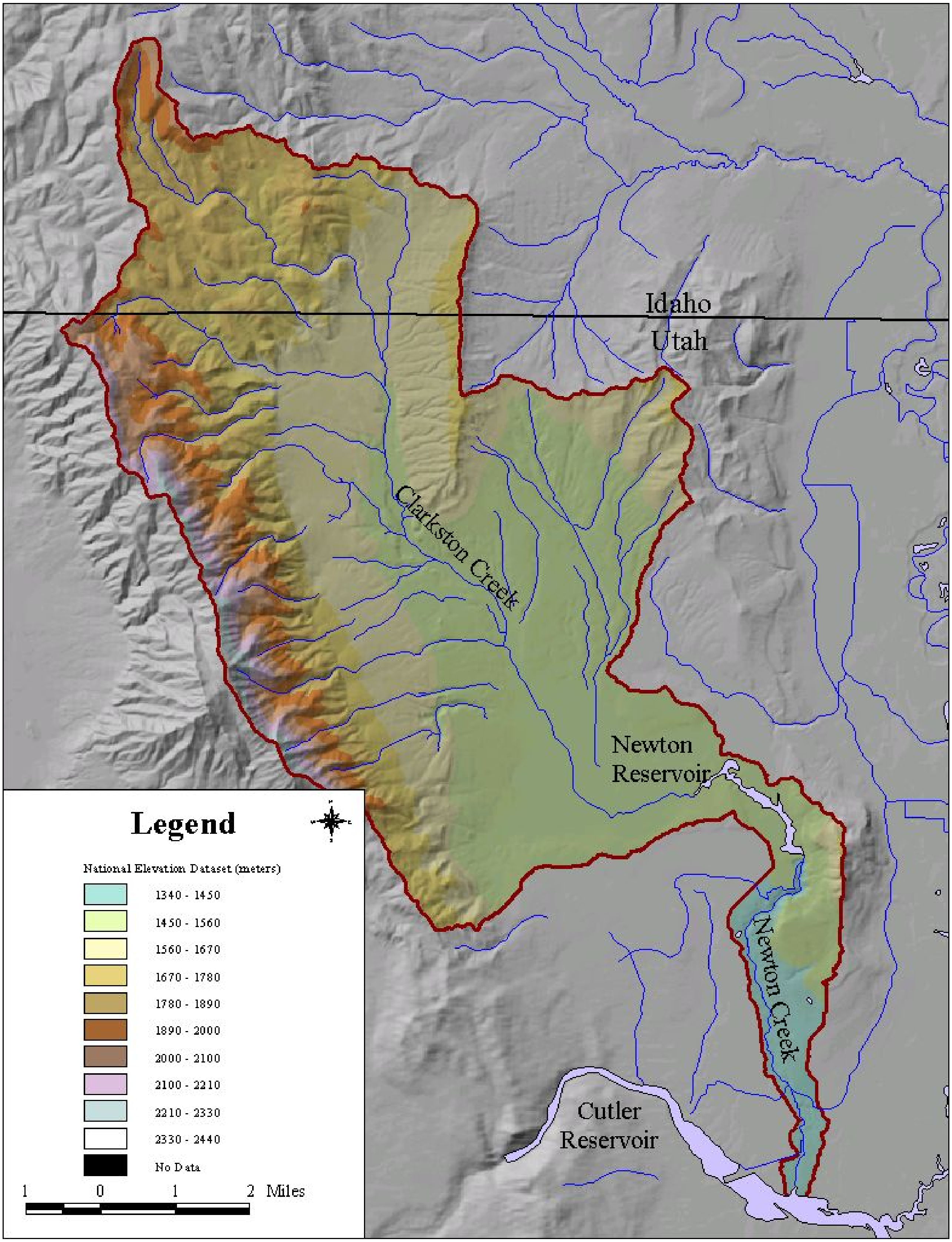

Figure 2-3. Topographic relief of the TMDL project area.

These mountains primarily consist of Precambrian to Permian sedimentary and metamorphic rocks, predominantly limestone, dolomite, and quartzite (Lowe and Wallace 1999). Mississippian and Ordovician-Silurian-Devonian deposits characterize the foothills. The valley floor is a quaternary basin fill of varying thickness. Much of the fill is lacustrine gravel, sand, and silts associated with the Pleistocene Lake Bonneville. Valley bottom areas near the Clarkston Creek and Newton Creek stream channels are predominately silt clay and silty clay loam.

The basin aquifer in Cache Valley is highly variable, and can be artesian, perched, confined, or unconfined, depending on location (Bjorkland and McGreey 1971). In general, the aquifer is unconfined on the fringes of the valley and becomes confined towards the center of the valley. Groundwater in the foothills of the Clarkston Mountains flows to the east, while groundwater in the area of Newton Reservoir commonly flows to the south (Bjorkland and McGreey 1971; Anderson et al. 1994; Kariya et al. 1994).

Figure 2-4 shows STATSGO soil mapping units in the Clarkston Creek and Newton Creek watersheds and Table 2-1 gives a brief description of the soil associations present within the study area, taken from the General Soil Map in the Cache Valley soil survey (Erickson and Mortensen 1974).

Table 2-1. Soil associations in the study area.

Cache Valley Soil Survey Mapping Unit	STATSGO Soil Mapping Unit	Soil Association	Description
Moderately well drained to poorly drained soils of the low lake terraces			
2	UT086	Trenton association	Strongly saline and alkali, somewhat poorly drained to moderately well drained, nearly level to sloping soils that have a silty clay subsoil.
Well-drained soils of the medium and high lake terraces			
5	UT089	Mendon-Avon association	Nearly level to strongly sloping soils that have a clay loam and silty clay subsoil.
6	UT090, ID128, UT069	Wheelon-Collinston association	Moderately steep to very steep slopes. Soils have a loam, silt loam, and clay loam underlying layer.
Well-drained soils of the uplands			
8	UT136, ID045	Nebeker-Hendricks association	Strongly sloping to moderately steep slopes. Soils have a silty clay loam and clay subsoil.
Well-drained and somewhat excessively drained soils of the mountains			
11	UT064	Sheep Creek-Hoskin-Curtis Creek association	Steep and very steep slopes. Soils have a gravelly and cobbly loam to clay loam subsoil.
Well-drained and somewhat excessively drained soils of the high mountains			
14	UT146, ID062	Lucky Star-Cluff-Bickmore association	Moderately steep and steep slopes. Soils have a very cobbly sandy clay loam, gravelly clay, and cobbly silty clay loam subsoil.

The shoreline of Newton Reservoir is almost entirely comprised of loam and silt loam soil textures (Erickson and Mortenson 1974; Solomon 1999), and is considered to be a significant sediment source for the reservoir (BOR 2000). Permeability in the study area is moderate, but allows for both vertical and lateral flow of water through the soils.

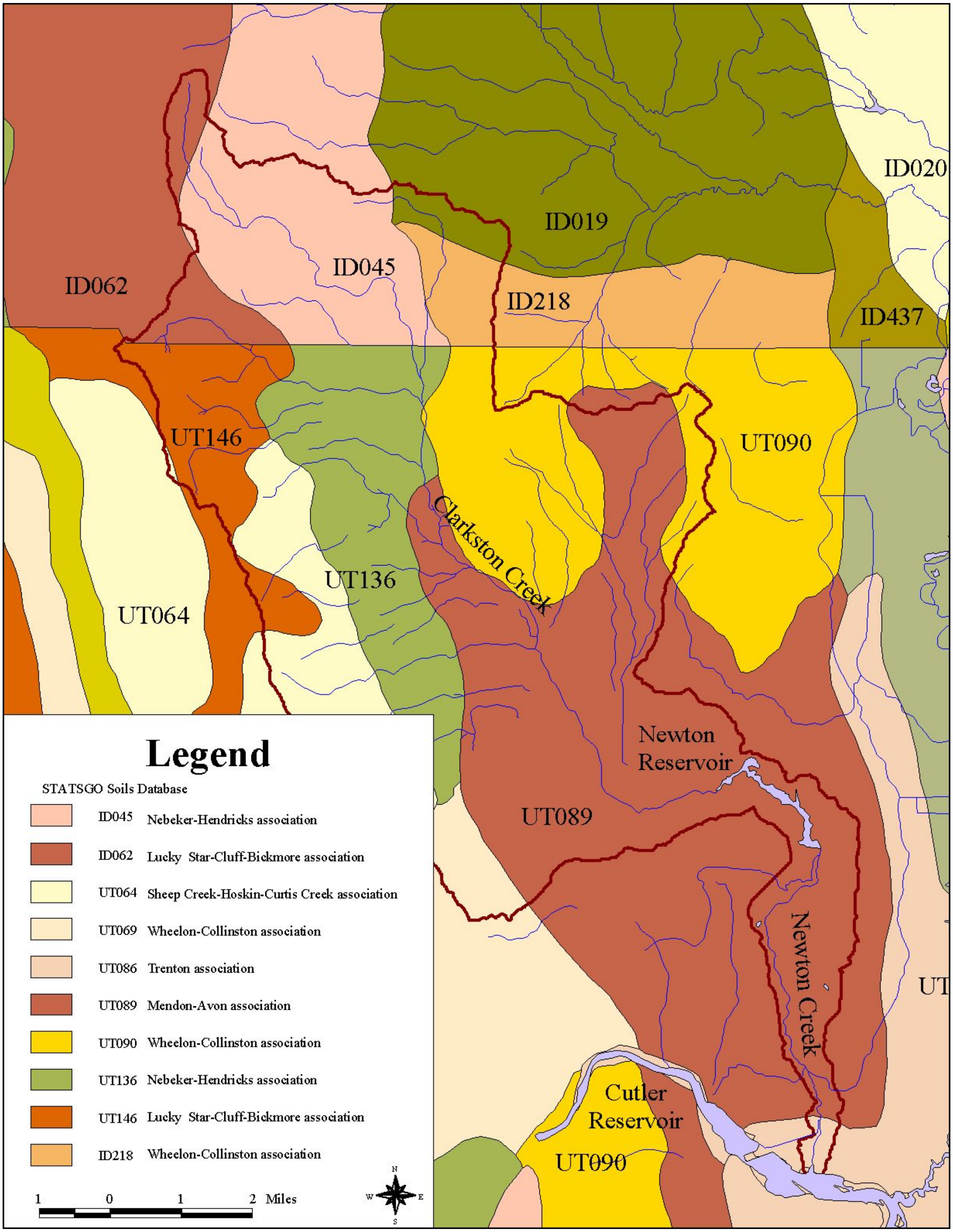

Figure 2-4. STATSGO Soils map of the TMDL project area.

2.1.4 Land Use

Historic land use in the Newton/Clarkston watershed consisted primarily of rangelands and agriculture. A detailed map of current land uses is included as Figure 2-5. Major land use categories in the study area are shown in Figure 2-6 and include rangelands (40 percent of total area), non-irrigated agriculture (28 percent), CRP lands (18 percent), irrigated agriculture (10 percent), and forest (3 percent). Urban/residential areas, open water, and wetlands are also found in the watershed but only represent a small fraction of the total area (0.4, 0.3, and 0.1 percent, respectively). Most of the land within the Utah portion of the project area is privately owned (see Figure 2-7), with some Forest Service (Caribou National Forest) and state lands on Clarkston Mountain. The majority of the Idaho portion of the project area is located within the Caribou National Forest with the remaining lands held by private landowners. The Dry Creek allotment is the only grazing allotment on public land within the Clarkston Creek watershed. This allotment is located in the northwest corner of the watershed (in the upper parts of the Headwaters and Steel Canyon subwatersheds). Only a small portion of this allotment is within the study area. Land use on private land is primarily agricultural. The most common crops are small grains, alfalfa, and corn. Significant portions of the agricultural lands are also used to support animal feeding operations with pastures, hay, and milking and feeding areas.

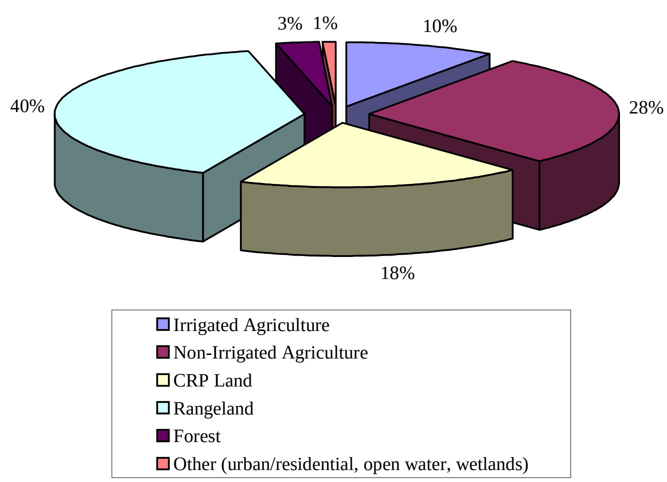

Figure 2-6. Major land use categories found within the TMDL project area.

2.1.5 Fisheries

Viable aquatic habitat in the project area has been strongly influenced by periodic drought conditions during the past decade. Low flows within Clarkston Creek and minimal water volumes within Newton Reservoir have reduced the amount of functional habitat and contributed to high water temperatures and low DO levels. Where present, riparian vegetation in the project area is comprised of various species of grasses, sedge, willow, cottonwood and box elder. Shoreline vegetation surrounding Newton Reservoir is only of benefit during periods of high water and provides no protection during drought years. Shallow wetland areas overgrown with aquatic and riparian vegetation are located at the northern end of the reservoir and provide the majority of aquatic habitat that is subsequently dependent upon water volumes contributed by Clarkston Creek.

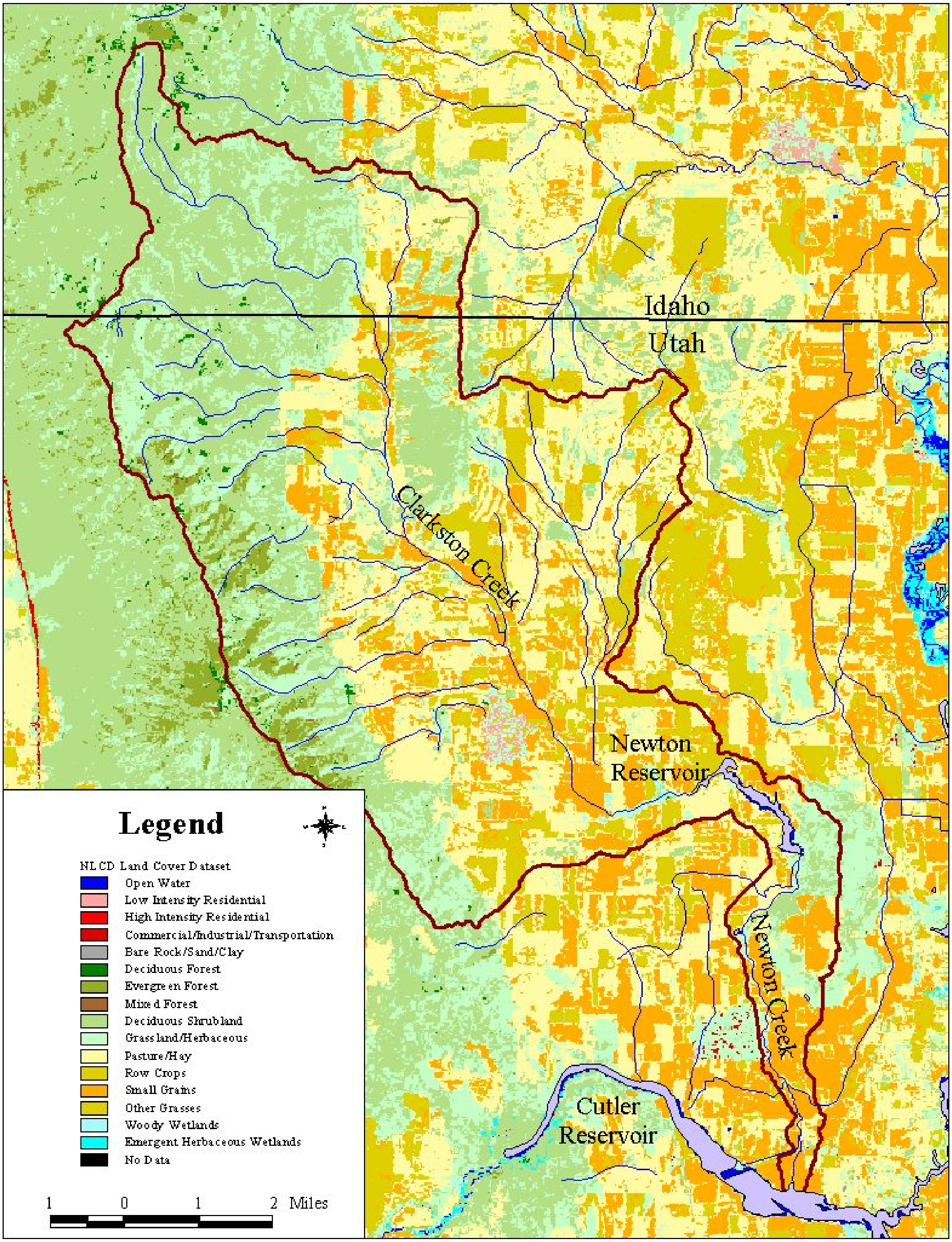

Figure 2-5. National Land Cover Dataset land cover map of the TMDL project area.

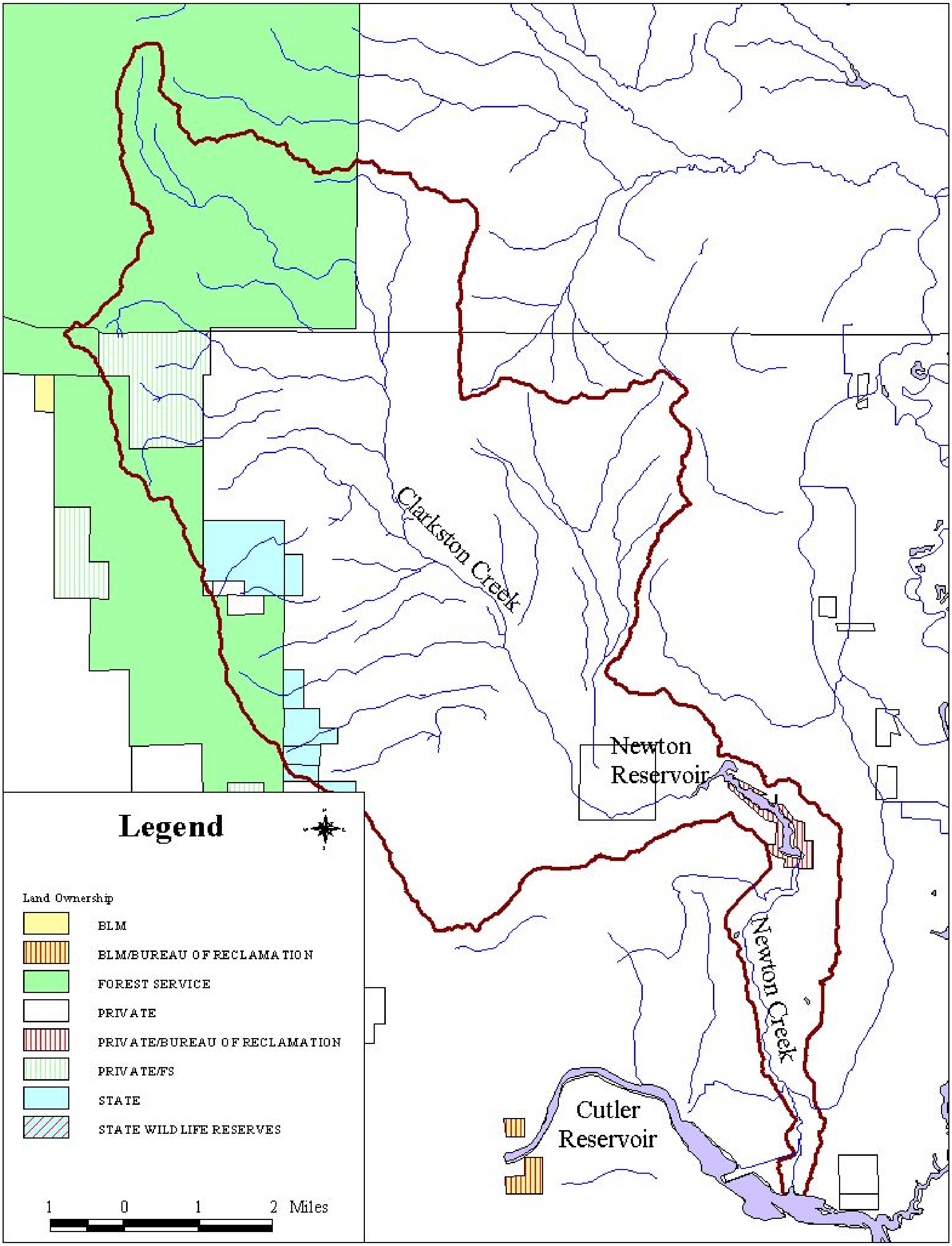

Figure 2-7. Land ownership within the TMDL project area.

Fish kills have occurred in Newton Reservoir as a result of low DO concentrations found in the lower portions of the water column (hypolimnion). Low DO concentrations in the hypolimnion have been the result of seasonal conditions occurring in the summer, fall and winter seasons. High water temperatures at depth during the summer have exceeded 21 °C (70 °F) while overturn of the hypolimnion during the fall season has introduced hydrogen sulfide into the entire water column. Fish kills have also occurred during the winter from low DO levels produced by decomposition of aquatic vegetation on the bottom of Newton Reservoir (BOR 2000).

A variety of fish populations have been supported by waters within Newton Reservoir and Clarkston Creek as shown in Table 2-2. Fisheries management in the area has included stocking of sport fish as well as periodic treatment with rotenone to remove carp and other fish species that have been illegally introduced to Newton Reservoir (BOR 2000). Trout species were stocked in the reservoir until 1985. Rotenone was applied in 1987 to remove unwanted species and restocked with populations of largemouth bass, rainbow trout fingerlings, channel catfish, bluegill, black crappie, and yellow perch. Newton Reservoir is currently stocked by DWR with tiger muskie and channel catfish (Schaugaard 2003).

Table 2-2. Fish species occurring in Clarkston Creek and Newton Reservoir. [1]

Common name (Scientific name)	**Clarkston Creek**	**Newton Reservoir**
Redside shiner (*Richardsonius balteatus*)	X	
Mountain sucker (*Catostomus platyrhynchus*)	X	
Channel catfish (*lctalurus punctatus*)		X
Tiger muskellunge (Female – *Esox masquinongy* Male – *Esox lucius*)		X
Brown trout (*Salmo trutta*)	X	X
Rainbow trout (*Oncorhynchus mykiss*)	X	X
Mottled sculpin (*Cottus bairdi*)	X	

[1] Data obtained from Sorrenson and Pettengill (1992), ERI and BRRC&D (1995) and Sorrenson (2000) as cited by BOR (2000)

2.1.6 Hydrology

The Newton/Clarkston watershed has a contributing area of approximately 38,245 acres. Clarkston Creek originates at the south end of the Malad Mountains in southern Idaho and flows southeast and discharges into Newton Reservoir in northern Utah. Water flowing within Clarkston Creek is primarily used for irrigated agriculture, with several diversions for irrigation occurring between the Clarkston Creek headwaters and Newton Reservoir (see Figure 2-8). Multiple tributary channels originate along the east slope of the Clarkston Mountains. The majority of these streams channels are seasonal in nature and deliver runoff during the early spring snowmelt season and during high-intensity storm events. Although perennial flow is discharged from Steel Canyon, water disappears about 0.75 miles before the confluence with Clarkston Creek. Flow in several stream channels, including the Birch Creek stream channel have been historically dewatered to support municipal water demands by the towns of Clarkston and Newton or agricultural needs in rural areas surrounding these towns. Only two tributary channels were observed to contribute perennial streamflow to Clarkston Creek during a comprehensive stream survey of the Clarkston and Newton Creek watersheds. These waterbodies include City Creek and an unnamed tributary located north of Clarkston. These streams increased the baseflow in Clarkston Creek by roughly 25 percent and 75 percent respectively in October 2003. City Creek originates in the foothills immediately west of Clarkston and flows through the north end of the town before entering a ditch that transports streamflow to Clarkston Creek. The unnamed tributary located on the west side of Clarkston Creek is fed by springs located one-half mile below the mouth of Winter Canyon. Discharge from the springs maintains perennial flow in 1.25 miles of stream channel before entering Clarkston Creek. Additional water enters Clarkston Creek along a zone of groundwater discharge located roughly one-half mile above the confluence with the Birch Creek and from two small siphon drains that periodically discharge low flows into the stream channel during the irrigation season (Griffin 2003).

Water is diverted from Clarkston Creek during the irrigation season at several locations before reaching Newton Reservoir. A total of 483 water rights are currently maintained within the project area, including rights to surface and groundwater resources (see Table 2-3). Of the total number of water rights held within the project area, 219 are surface water rights that allow users to withdraw water from Clarkston Creek and Newton Creek. Water is typically withdrawn from these streams from early May through September for irrigation purposes, although some water rights are associated with livestock watering. As the stream channel is deeply incised in some locations, water is removed from Clarkston Creek using pumps that deliver water to pressurized irrigation and flood irrigation systems located on either side of Clarkston Creek. The location of major irrigation ditches along Clarkston Creek is provided in Figure 2-8.

Table 2-3. Water rights and associated points of diversion in the Newton/Clarkston watersheds.

Location	**Type**	**Total number of water rights**
Clarkston Creek	Point to Point	57
	Rediversion	3
	Return	6
	Surface	215
	Underground	155
	Total	436
Newton Reservoir	Point to Point	2
	Return	1
	Surface	5
	Underground	2
	Total	10
Newton Creek	Point to Point	9
	Rediversion	5
	Surface	4
	Underground	19
	Total	37
	Total Water Rights	483

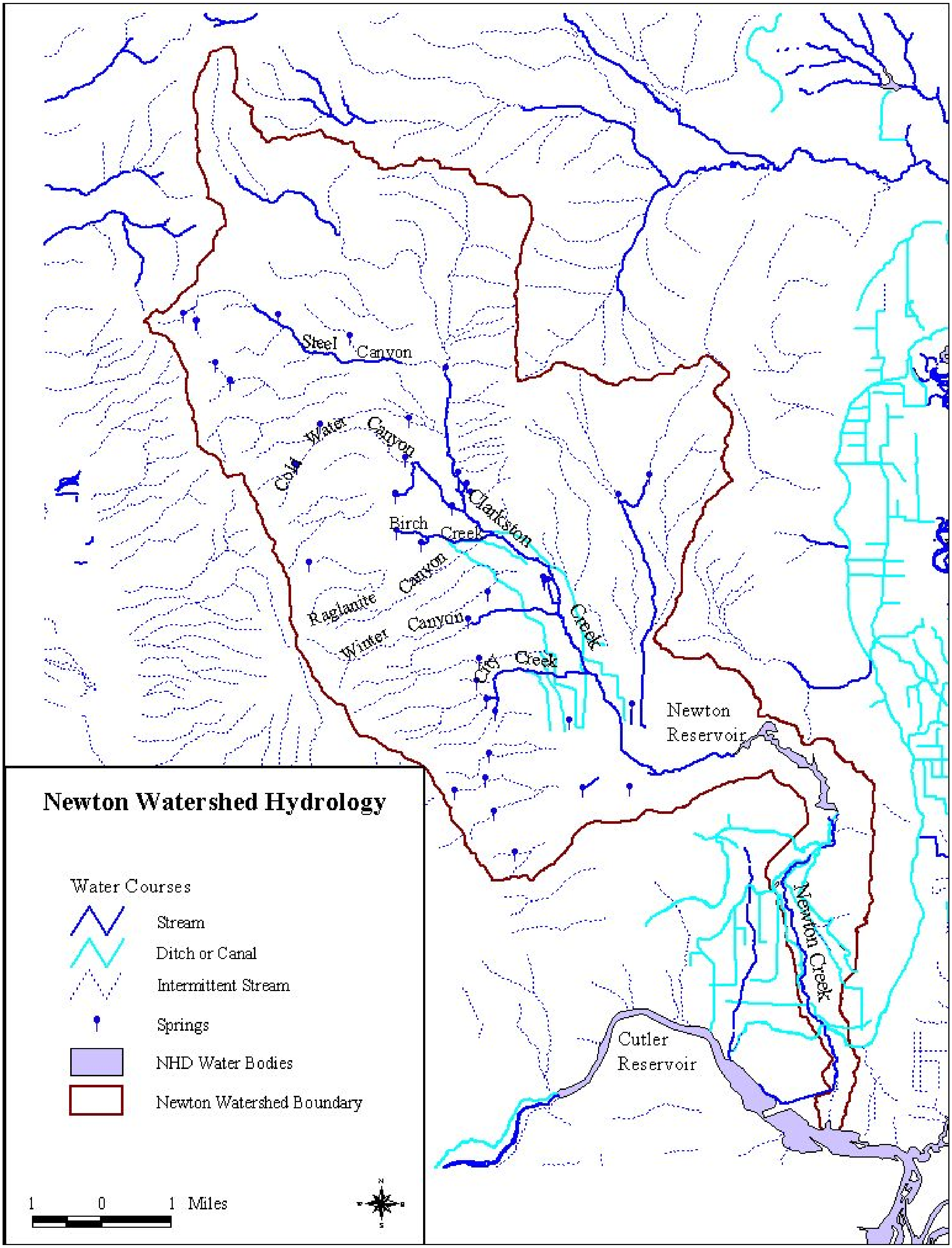

Figure 2-8. Hydrologic features in the Newton/Clarkston watershed area.

All water entering Newton Reservoir by way of Clarkston Creek is typically stored for irrigation of areas located downstream of the reservoir. Management of the reservoir is conducted by the Newton Water Users Association under agreement with the BOR. A list of physical characteristics for Newton Reservoir is provided in Table 2-4 below. Water is released from Newton Reservoir beginning in late May or early June and continues through the irrigation season (Griffin 2003). The total amount released from the reservoir during any given year is influenced by the amount of available storage and irrigation demand. During periods of drought (when contributions from Clarkston Creek have been low), all possible water that can be released from the Reservoir through the outlet works is utilized for irrigation purposes (Larsen 2003). No conservation pool is maintained in Newton Reservoir except for the dead storage volume that remains below the outlet works following maximum withdrawal from the reservoir. Water in Newton Reservoir typically achieves a minimum depth during the months of September or October.

Table 2-4. Physical dimensions of Newton Reservoir. [1]

Surface area (acres)	350
Capacity (acre-feet)	5,591
Conservation pool (acre-feet)	0
Drawdown (acre-feet)	3,041
Maximum depth (feet)	75.9
Mean depth (feet)	18
Length (feet)	11,319
Width (feet)	1,171
Shoreline (miles)	5.7
Crest Elevation of Dam (ft.)	4,781.0
Top of Joint Use (ft.) (Spillway Crest)	4,775.9
Top of Active Conservation (ft.) (Normal water surface elevation)	4,774.5
Top of Inactive Conservation (ft.) (Dead Storage below Outlet Works)	4,725.0
Streambed at Dam Axis (ft.) (Zero storage)	4,700.0

[1] BOR (2003) (DWQ Clean Lakes Study)

The annual average change in water elevation is 17 feet, which exposes 223 acres of surface area surrounding the reservoir (BOR 2000). Average annual water depth for Newton Reservoir measured in the pool located immediately above the dam is shown in Figure 2-9. Based on the physical configuration of Newton Reservoir, these averages can be assumed to represent the maximum water depths in the reservoir.

Water released from Newton Dam flows into the Main Canal, which branches into the East Canal and Highline Canal approximately 0.5 miles below the spillway. The location of this canal system is shown in Figure 2-8. The Main Canal is a concrete lined system that is 0.6 miles long and has a maximum capacity of 24.7 cfs. The East Canal is constructed primarily of earth and conveys water a distance of about 2 miles to a point roughly 1 mile east of Newton and has a capacity of 9 cfs. The Highline Canal is also constructed of earth and transports irrigation water over 4 miles on the west side of the watershed to a point roughly 1.5 miles west of Newton and has a capacity of 17.7 cfs. Lateral diversions from these canals are used primarily for irrigating agricultural land adjacent to Newton Creek below the dam. Water carried by the East Canal and by the Highline Canal irrigate land both within and outside of the watershed. In general, all of the water released from the dam during the irrigation season is transported by this canal system and used for irrigation purposes. No minimum flows are released to Newton Creek from Newton

Reservoir in order to maintain flow within the stream channel. A small amount of water is present in Newton Creek, originating from seepage, minor groundwater inputs, and, further downstream, agriculture return flows from irrigated land within the watershed.

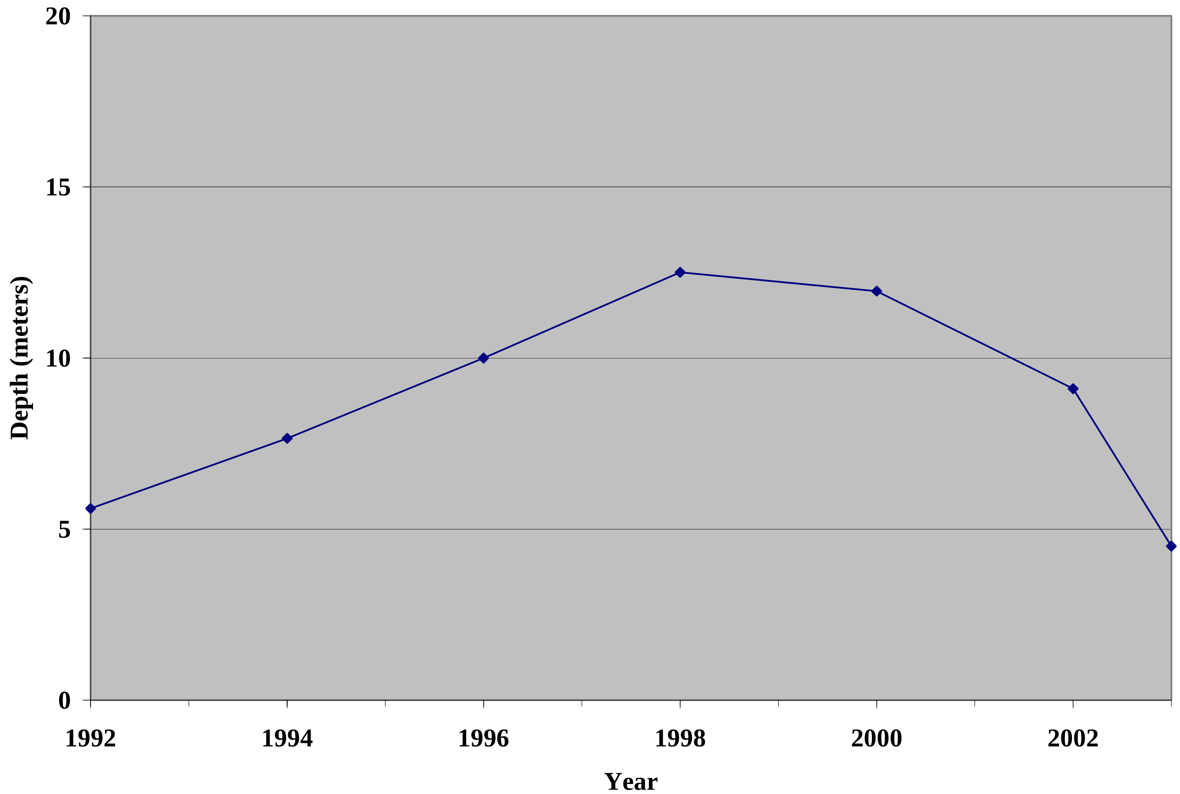

Figure 2-9. Average annual depth for Newton Reservoir above Dam (station 490313) for 1992-2003.

2.1.7 Groundwater

Groundwater resources are relied upon heavily in the state of Utah as a source of drinking water and for agriculture. Approximately 20 percent of water used in Utah is removed from groundwater sources while roughly half of the population in the state utilizes groundwater as a sole source of drinking water (Utah Department of Agriculture, 1989). Municipal water provided by the towns of Newton and Clarkston relies solely upon groundwater discharged from springs located in the Newton/Clarkston project area (Goodsell 2003). Groundwater is also drawn from wells located in the areas around Newton and Clarkston and supports rural and agricultural water demands.

The primary water-bearing units in Cache Valley, including the Newton/Clarkston watershed, are unconsolidated basin-fill deposits left by Lake Bonneville and older lakes, as well as younger alluvial formations (Anderson et al. 1994)(Kariya et al. 1994). Sediments left by Lake Bonneville are primarily silts and clays. Alluvial fans and landslide deposits begin at the foot of the mountain ranges on the margins of Cache Valley, including the Bear River Range to the east and the Wellsville and Clarkston mountains to the west. Larger sediments, including sand, gravel and cobbles, are found in the alluvial and colluvial formations. The thickness of the unconsolidated basin-fill deposits in the southern end of Cache Valley near Newton ranges up to 1,340 ft. (Bjorklund and McGreevy 1971). Although coarse-grained, highly permeable sediments dominate these deposits, they generally become finer-grained, less-permeable, and interspersed with layers of silt and clay as they approach the center of the valley. These discontinuous layers produce a complex, multi-layered system resulting in the presence of both confined and unconfined conditions in the principal aquifer (Kariya et al. 1994). Groundwater is generally unconfined at the valley margins including the base of the Clarkston mountains, and may become perched above intermittent confining layers that deliver water to springs discharging at the surface (Kariya et al. 1994). This process is evident within the project area as demonstrated by the numerous springs discharging north and west of Clarkston (see Figure 2-8).

Groundwater flow in the Newton/Clarkston project area is influenced by local topography. Subsurface flows in the Clarkston Creek area to generally move to the east while flows generally move to the south in the area below Newton Reservoir (Anderson et al. 1994) (Kariya et al. 1994). Groundwater recharge occurs within areas of highly permeable basin fill located along the base of the Clarkston mountain range which receive water infiltrating from precipitation, surface runoff and stream flow (Anderson et al. 1994).

2.2 ANNUAL WATER BUDGET

The following sections estimate an annual water budget for the Newton/Clarkston watershed, including Clarkston Creek, Newton Reservoir, and Newton Creek, in order to identify water inputs and outputs to the watershed. This hydrologic analysis was conducted in order to establish flow volumes and patterns in the watershed. This information will be used along with water quality analysis results to identify potential sources of phosphorus and evaluate possible remediation strategies. The water budget was estimated based on the available information. Assumptions are stated where applicable.

The overall water budget for the Newton Watershed was estimated under the assumption that inflows to the watershed are equal to outflows and based on available data using the following equation:

$$P + Q_{c,in} + Q_{g,in} = Q_{out} + Q_{c,out} + ET + Q_{g,out} + CU \qquad (1)$$

Inflows = Outflows

Where:
- P = Average annual precipitation
- Q_{out} = Average annual discharge from the watershed
- $Q_{c,\,in}$ = Average annual canal inflow
- $Q_{c,out}$ = Average annual canal outflow
- $Q_{g,in}$ = Average annual groundwater inflow
- $Q_{g,out}$ = Average annual groundwater outflow
- ET = Average annual evapotranspiration
- CU = Average annual consumptive use

It should be noted that there are no long-term estimates of flow in the Newton/Clarkston watershed. A limited number of flow observations have been collected by federal, state, and local agencies as part of their monitoring activities. However, due to temporal and seasonal limitations of these measurements, they are insufficient to fully characterize streamflow and reservoir discharge in the watershed. In addition, the BOR maintains a gauge that records water levels and discharge from Newton Reservoir. It has been determined, however, that some of the measurements are questionable due to the fact that there are years in which the reservoir essentially empties, but there are few, if any, recorded releases. Due to the paucity of flow information, the following assumptions were made to facilitate the completion of the water balance calculations:

1. Inflows to the watershed are equal to outflows (the change in storage in the watershed is equal to zero). On average, all water entering the reservoir during periods of spring snowmelt and runoff is discharged by the end of the irrigation season. Some minimal water remains as water levels recede below the outlet structure, but there is no net change.

2. There is one known canal inflow to the watershed. A small amount of inflow is discharged into Newton Creek by the Newton Branch of the West Cache Canal during the mid-to-late summer months to supplement baseflow in Newton Creek. It is assumed that all of this water is withdrawn from the Canal for irrigation purposes and used outside of the watershed (Larsen 2003).

3. There are no known canal outflows from the watershed above Newton Reservoir. Canal outflows below the reservoir are equal to the percentage of the reservoir releases used outside the watershed for irrigation purposes.

4. All flow released from the reservoir is diverted into the Main Canal, and no flow is released to Newton Creek below the dam year-round.

5. Canal flows released from Newton Reservoir are distributed equally to all areas irrigated by this flow.

6. Approximately 50 percent of the reservoir releases that are used for irrigation below Newton Reservoir return to Newton Creek as agricultural return flows.

7. Evapotranspiration (ET) was estimated based on the assumption that inflows to the watershed equal outflows. The difference between inflows and outflows after all terms in the water budget except (ET) have been evaluated is attributed to (ET). As calculated here, the ET estimate may incorporate infiltration losses during periods of high soil moisture. It is assumed that this amount is minimal.

8. Discharge from Newton Creek to Cutler Reservoir is equal to the flow per unit area contribution of the area below the reservoir (surface flow and base flow in the stream below the reservoir) plus agricultural return flows below the reservoir.

9. Net groundwater flux equals zero ($Q_{g,in} = Q_{g,out}$).

10. All municipal water for the towns of Newton and Clarkston is taken from springs that are within the Newton/Clarkston watershed.

11. Since nearly all of the town of Newton lies outside of the watershed, consumptive use is assumed to be 100 percent of the total water use (i.e. none of the municipal water used by

residents of the town of Newton returns to the project area watershed). Consumptive use by Clarkston is assumed to be 20 percent of the total water use (the remaining 80 percent returns to the system via septic systems, etc.).

Given these assumptions, Equation 1 reduces to:

$$P = Q_{out} + Q_{c,out} + ET + CU \qquad (2)$$

Figure 2-10 and Table 2-5 below show the results of the water budget calculations for the Newton/Clarkston watershed. All flows were normalized by the watershed area and are presented in units of inches per year. The sections following Figure 2-10 and Table 2-5 detail how the quantities in Equation 2 were calculated.

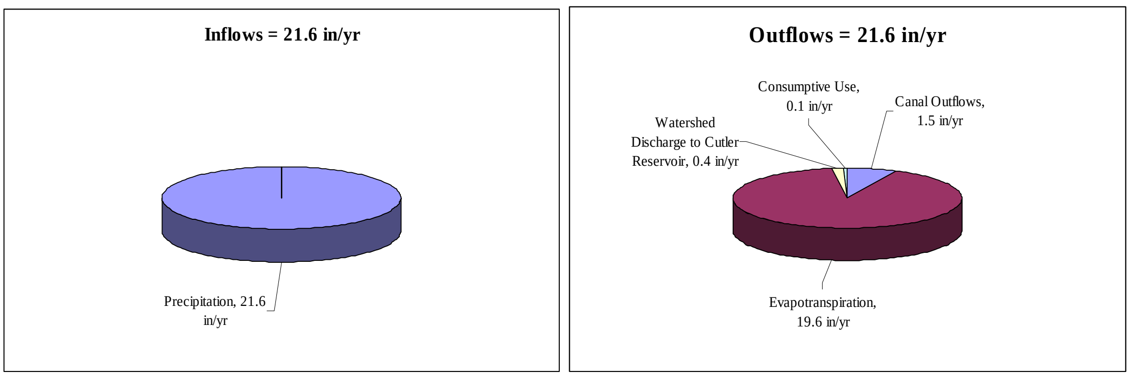

Figure 2-10. Newton/Clarkston watershed water budget results.

Table 2-5. Newton/Clarkston watershed water budget results.

	Annual Average Volume (acre-ft)	**Area Normalized Annual Average Volume (in/yr)**
Inflows		
Precipitation (P)	68,840	21.6
Canal Inflow ($Q_{c,in}$)	0	0
Total:	**68,840**	**21.6**
Outflows		
Canal Outflow ($Q_{c,out}$)	4,703	1.5
Evapotranspiration (ET)	62,538	19.6
Watershed Discharge to Cutler Reservoir (Q_{out})	1,308	0.4
Consumptive Use (CU)	291	0.1
Total:	**68,840**	**21.6**

2.2.1 Precipitation (P)

An annual average precipitation value was calculated for the Newton/Clarkston watershed by summarizing the spatially explicit precipitation data contained in the **P**arameter-elevation **R**egressions on **I**ndependent **S**lopes **M**odel (PRISM) dataset (Daly et al. 1994**).** PRISM is a modeling system that uses data collected at meteorological stations and a digital elevation model

(DEM) to generate grid estimates of climate parameters such as precipitation. The PRISM grid of spatial precipitation estimates was summarized using ArcView Spatial Analyst to calculate an average precipitation depth over the watershed area. The resulting annual average precipitation value is 21.6 inches/year.

2.2.2 Canal Outflows ($Q_{c,out}$)

Net canal flows in the Newton/Clarkston watershed were estimated using the following equation:

$$Q_{c,net} = Q_{c,in} - Q_{c,out} \tag{3}$$

Where: $Q_{c,\,in}$ = Average annual canal inflows to the watershed
$Q_{c,\,out}$ = Average annual canal outflows from the watershed

Based on the assumptions listed above, it is assumed that the net effect of canal flows into the watershed is zero ($Q_{c,in}$ = 0). It is also assumed that there are no canal outflows from the watershed above Newton Reservoir and that the canal outflows from the watershed below the reservoir are equal to the fraction of the reservoir releases used outside the watershed. Given this, canal outflows from the watershed can be given by:

$$Q_{c,out} = P_{out} Q_r \tag{4}$$

Where: P_{out} = The fraction of reservoir releases used outside of the watershed
Q_r = Average annual reservoir releases

Average annual reservoir releases were estimated using the reservoir release data obtained from BOR. Although it has been determined that some of the measurements may be questionable, the BOR record is the only available flow record within the watershed, and as such will be used. In an effort to minimize the effects of potentially spurious release values, a methodology was devised for using the available release data. This methodology is detailed in Appendix A.

Given the above caveats, it is assumed that all flow released from the reservoir is used for irrigation and is diverted via the Main Canal. Under this assumption, and as detailed in Appendix A, the average annual reservoir release volume was calculated by first estimating the average daily release volumes from the BOR reservoir release data. The daily average release volumes were then summed to calculate the average annual total reservoir release volume. This leads to an average annual release volume of 6,029.5 acre-feet.

Reservoir releases used outside the watershed were calculated under the assumption that all irrigation flows released from Newton Reservoir are distributed equally to all of the agricultural land irrigated by this volume of water. Given this, the fraction of reservoir releases used outside of the watershed is equal to the fraction of land irrigated by these reservoir releases that falls outside the watershed boundary. Using a GIS coverage of lands irrigated by Newton Reservoir (DNR 2003) and a GIS coverage of the watershed boundary delineated from the digital elevation model, it was determined that the percentage of land irrigated by releases from Newton Dam falling outside the watershed was 78 percent (1,982 out of approximately 2,538 acres). Therefore, the fraction of reservoir releases used outside the watershed is 0.78. Equation 4 can then be evaluated to give an average annual canal outflow volume from the watershed of 4,703 acre-feet. Normalized to the area of the watershed and converted to inches, this leads to an average annual canal outflow of 1.5 inches/year.

2.2.3 Evapotranspiration (ET)

Evapotranspiration (ET) is the total evaporation from all free-water surfaces plus the transpiration of water vapor through plant tissues (Bedient and Huber 1992). In order to estimate ET, the land cover distribution in the watershed must be known, along with ET rates for each land cover category. Generally speaking, ET rates are available for most agricultural land cover types, but little information is available to characterize ET rates from non-agricultural land cover classes. Due to this fact, ET for the Newton/Clarkston watershed was estimated by first quantifying all of the inflows and outflows (except ET), including precipitation, canal flows, watershed discharge, and consumptive use. The difference between the inflows and outflows was attributed to ET as indicated by equation (5) where:

$$ET = P - Q_{c,out} - Q_{out} - CU \tag{5}$$

Once all of the other terms in Equation 5 have been evaluated, the annual average ET volume in the Newton/Clarkston watershed is equal to approximately 62,538 acre-feet. Normalized by area and converted to inches, the annual average ET rate in the Newton Watershed is approximately 19.6 inches/year.

An exact measurement of ET within the watershed would need to assess surface vegetation type (native vegetation and agricultural crops), levels of precipitation and applied irrigation, as well as certain meteorological variables including net radiation, temperature, wind speed, vapor pressure deficit, and soil heat flux. Other, more broadly applicable methods measure evaporated water depths from an open water surface and empirically relate this to ET levels produced by a reference crop. A typical reference crop is considered to be a dense grass cover approximately 5 inches high growing in a soil with moisture levels representative of weekly irrigation frequencies (Shuttleworth 1993). Annual average reference crop ET levels reported by the USU Climate Center for the area surrounding Culter Reservoir were 42.7 inches during 1980 – 2002 and 44.4 inches for the Lewiston, UT area during 1928 – 1975 (USU Climate Center 2003). While these values are roughly twice those calculated for the Newton/Clarkston area, it should be noted that these values represent ET levels from a dense grass cover that is not water-limited. Vegetative growth within non-irrigated areas in the Newton/Clarkston watershed are likely water-limited. It should also be noted that only 10 percent of the total surface area within the Newton/Clarkston watershed is irrigated cropland with the remaining vegetated surface (including forest, rangeland, and dryland agriculture) is supported by precipitation.

2.2.4 Watershed Discharge (Q_{out})

There are no available measurements or estimates of flow in Newton Creek as it flows into Cutler Reservoir at the watershed outlet. Due to this fact, and due to the general lack of flow data in the Newton/Clarkston watershed, a reference watershed approach was used to provide estimated stream flows in the Newton/Clarkston watershed. Appendix A details the reference watershed approach for generating estimates of stream flow. In general, flows from a nearby reference watershed were normalized by contributing area and applied to the Newton/Clarkston watershed. A base flow separation was first done to separate the surface and base flow components of the hydrologic regime. These flows were applied to the Newton/Clarkston watershed on a per unit area basis (amount of surface flow and base flow produced per unit watershed area).

As typical discharge patterns from Newton Dam do not reach Newton Creek, any water present in the creek is a result of surface flow and base flow generated from nearby contributing areas, in addition to agricultural return flows from the irrigated lands within the watershed. Equation 6 shows these contributions to the watershed discharge.

$$Q_{out} = Q_s + Q_b + Q_{ag} \tag{6}$$

Where: Q_s = Annual average surface flow runoff to Newton Creek
Q_b = Annual average base flow contribution to Newton Creek
Q_{ag} = Annual average agricultural return flow to Newton Creek

Annual average surface (Q_s) and base flow (Q_b) volumes for Newton Creek were calculated by summing the daily average surface flow and base flow volumes over the entire year. The daily average surface and base flow volumes were generated by multiplying the daily average per unit area surface and base flows from the reference watershed analysis by the area contributing to Newton Creek as delineated from a DEM. These daily average per unit area flows were calculated by averaging the adjusted per unit area flows for each day of the year over the entire period of record for which calibrated per unit area flows are available (1991 – 2002). This process results in an annual average surface flow volume of 12.5 acre-feet and an annual average base flow volume of 632.7 acre-feet per year.

In order to calculate the annual average volume of agricultural return flows contributed to Newton Creek, it is assumed that 50 percent of all of the irrigation water that is applied to land within the Newton/Clarkston watershed below the dam returns to the creek, and that all of the irrigation water comes from Newton Reservoir (i.e., all water used for irrigation inside the Newton/Clarkston watershed below the dam comes from the reservoir). Given these assumptions, agricultural return flows to Newton Creek can be given by:

$$Q_{ag} = 0.5 P_{in} Q_r \tag{7}$$

Where: P_{in} = The fraction of reservoir releases used inside the watershed
Q_r = Average annual reservoir releases

From the analysis described above, it was determined that 22 percent of the area irrigated by releases from the reservoir lies within the watershed boundary (P_{in} = 0.22). Appendix A and the above section describing the calculation of canal outflows describe the calculation of the average annual reservoir release volume. Equation 7 can be evaluated to give an annual average agricultural return volume of 663.2 acre-feet, and Equation 6 can then be evaluated to give an annual average watershed discharge volume of 1,308 acre-feet. Normalized to the watershed area and converted to inches, the annual average watershed discharge is equal to 0.4 inches/year or 1.8 cfs. It should be noted here that this value incorporates the total amount of water generated by the processes of base flow, surface flow, and agricultural return flows that exit the project area watershed in the stream channel.

2.2.5 Consumptive Use (CU)

There are two small towns in or near the Newton/Clarkston watershed. Clarkston lies within the watershed, and Newton lies just outside the watershed boundary. Both of these towns get their water from springs that are inside the Newton/Clarkston watershed. Since the town of Newton lies almost entirely outside the watershed, it is assumed that water used in Newton is an outflow from the watershed (100 percent consumptive use). Consumptive use rates for Clarkston (i.e., the amount of total water used that is not returned to the system) are assumed to be approximately 20 percent while the other 80 percent of water used for municipal purposes is assumed to be returned to the system via septic tanks, etc.

Water use estimates for the towns of Newton and Clarkston were taken from data available on the State of Utah Division of Water Rights website (http://waterrights.utah.gov/cgi-bin/wuseview.exe?Startup). This website contains reports on the public water systems including water usage amounts. Table 2-6 summarizes the consumptive use calculations. According to the values included in Table 2-6, the combined consumptive use from Clarkston and Newton is equivalent to a total of 291 acre-feet. Normalized by watershed area and converted to inches, this is approximately 0.1 inches/year.

Table 2-6. Consumptive use calculations for Newton and Clarkston.

Connection Type	Annual Average Water Use[a] (acre-feet)	Annual Average Consumptive Use (acre-feet)
Newton		
Domestic	158.2	158.2
Commercial	1.3	1.3
Industrial	25.7	25.7
Institutional	2.0	2.0
Total for Newton	**187.2**	**187.2**
Clarkston		
Domestic	365.5	73.1
Commercial	153.8	30.8
Industrial	0	0
Institutional	0	0
Total for Clarkston	**519.3**	**103.9**
Watershed Total	**706.5**[b]	**291.1**[b]

[a] Annual average water use values estimated by averaging values for years with available data from 1990 – 2002.
[b] Totals for Newton and Clarkston combined.

CHAPTER 3: EXISTING WATER QUALITY CONDITIONS

DWQ has monitored water quality in the Newton/Clarkston watershed since 1976. A review of the existing water quality data indicates that TP concentrations exceed state recommended standards in Clarkston Creek, Newton Reservoir, and Newton Creek. Dissolved oxygen (DO) levels are also below the recommend minimum levels in Newton Reservoir. This chapter includes a detailed discussion of the available water quality and streamflow/reservoir level data measured within the project area. Although the primary focus will be upon water quality, a discussion of the available flow data will also be included.

3.1 WATER QUALITY STANDARDS

Water quality standards in the State of Utah are dependent upon the specific beneficial use assigned to a water body. Beneficial uses assigned by the State to Clarkston Creek, Newton Reservoir, and Newton Creek are provided below in Table 3-1.

Table 3-1. Assigned beneficial use class for Clarkston Creek, Newton Reservoir, and Newton Creek.

Beneficial Use	Standard
2B – Secondary contact recreation (boating, wading, etc.). 3A – Cold water species of game fish and other cold water aquatic life. 4 – Agricultural uses including irrigation of crops and stock watering	TP (streams) = 0.05 mg/l TP (reservoirs) = 0.025 mg/l DO (acute)[1] = 8.0/4.0 DO (chronic) = 6.5

[1]First number indicates acute DO standard applicable to adult-life stage, second number is applicable to early-life stage.

It should be noted here that the TP standard utilized by the State is a narrative standard. A concentration of 0.05 mg/l for streams and 0.025 mg/l for lakes has been determined to be a threshold value that will prevent eutrophication. DO standards for a specific waterbody will vary depending on the associated beneficial use class and the acute or chronic criteria. Although this assessment does not specifically address DO, it is anticipated that standards for DO will be met when TP loads adhere to the TMDL.

Although neither Clarkston Creek or Newton Creek were included on the 2000 or draft 2002 303(d) list, Newton reservoir was listed as impaired for dissolved oxygen and TP. It is the policy of the State of Utah, when considering impairment to water bodies, to treat the sources of pollutants rather than symptoms. As a result, when considering the impairment of Newton Reservoir, contributions from Clarkston Creek, as well as stream segments immediately below the reservoir spillway (due to the polluted nature of Newton Reservoir) were also examined.

3.2 WATER QUALITY AND FLOW MONITORING

3.2.1 Surface water quality data

A thorough effort was made to obtain all water quality, flow, and GIS data prior to completing the water quality analysis for the Newton/Clarkston watershed. A list of individuals who were contacted during this effort is provided below in Table 3-2. At present, all available surface water quality data in the project area have been collected by the DWQ. Surface water quality samples have been collected at a total of eleven monitoring locations throughout the watershed that have been monitored as far back as 1976 (Figure 3-1). Table 3-3 provides a list of all DWQ monitoring stations located in the project area. Three of the eleven monitoring sites are located on Newton Reservoir itself including stations[1] 313, 314, and 315. Five of the eleven monitoring sites were added in July 2002 including stations 307, 308, and 309 below Newton Reservoir as well as stations 318 and 320 above Newton Reservoir. All sites were included in the intensive monitoring cycle that extended from July 2002 through July 2003. Monitoring sites located on Newton Reservoir generally included nutrient measurements taken at two depths and are usually supplemented by a full-depth profile of field measurements including temperature, pH, specific conductivity, and DO. A summary table of water quality data identified within the project area is included in Appendix B.

Table 3-2. Individuals contacted during search for water quality, flow, and GIS data for the project area watershed.

Name	Organization	Data Requested
Arne Hultquist	Utah Division of Water Quality	STORET water quality data
Mike Allred	Utah Division of Water Quality	STORET water quality, AFO/CAFO, and GIS data
Theron Miller	Utah Division of Water Quality	Reservoir profile data
Bob Fotheringham	Utah Division of Water Rights	Flow data
Jonathon Jones	US DOI-BOR, Provo office	Flow data, water rights agreement Newton Reservoir
Ed Vidmar	US DOI-BOR, Provo office	Flow data Newton Reservoir
Phil Greenland	US DOI-BOR, Provo office	Bathymetry profile Newton Reservoir
Allen Christensen	US DOI-BOR, Provo office	Bathymetry profile Newton Reservoir
Janae Wallace	USGS – Utah office	Groundwater quality data
Matt Butler	USGS – Utah office	Groundwater quality data, well locations
Mike Enright	USGS – Utah office	Flow data Clarkston Creek gauging station
Steve Gerner	USGS – Utah office	NAWQA data
Judy Warrick	Caribou-Targhee NF	GIS data
Lee Leffert	Caribou-Targhee NF	Water quality data
Jon Hardman	NRCS – Logan office	Streambank condition, AFO/CAFO data
Wayne Greenhalgh	NRCS – Logan office	AFO/CAFO data
Jeff Barnes	NRCS – Logan office	Conservation Reserve Program data
Bruce Lundquist	USDA-FSA – Logan office	Conservation Reserve Program GIS data
Mark Teuscher	Countywide Planning and Development – Cache Co.	GIS landuse information, digitized plat map of county

[1] All DWQ monitoring stations located in the Newton/Clarkston project area are identified by a six digit number that begins with 490. For discussion purposes, the 490 will be dropped when mentioning individual stations and the remaining three numbers used. For example, station 490313 will be referred to as station 313.

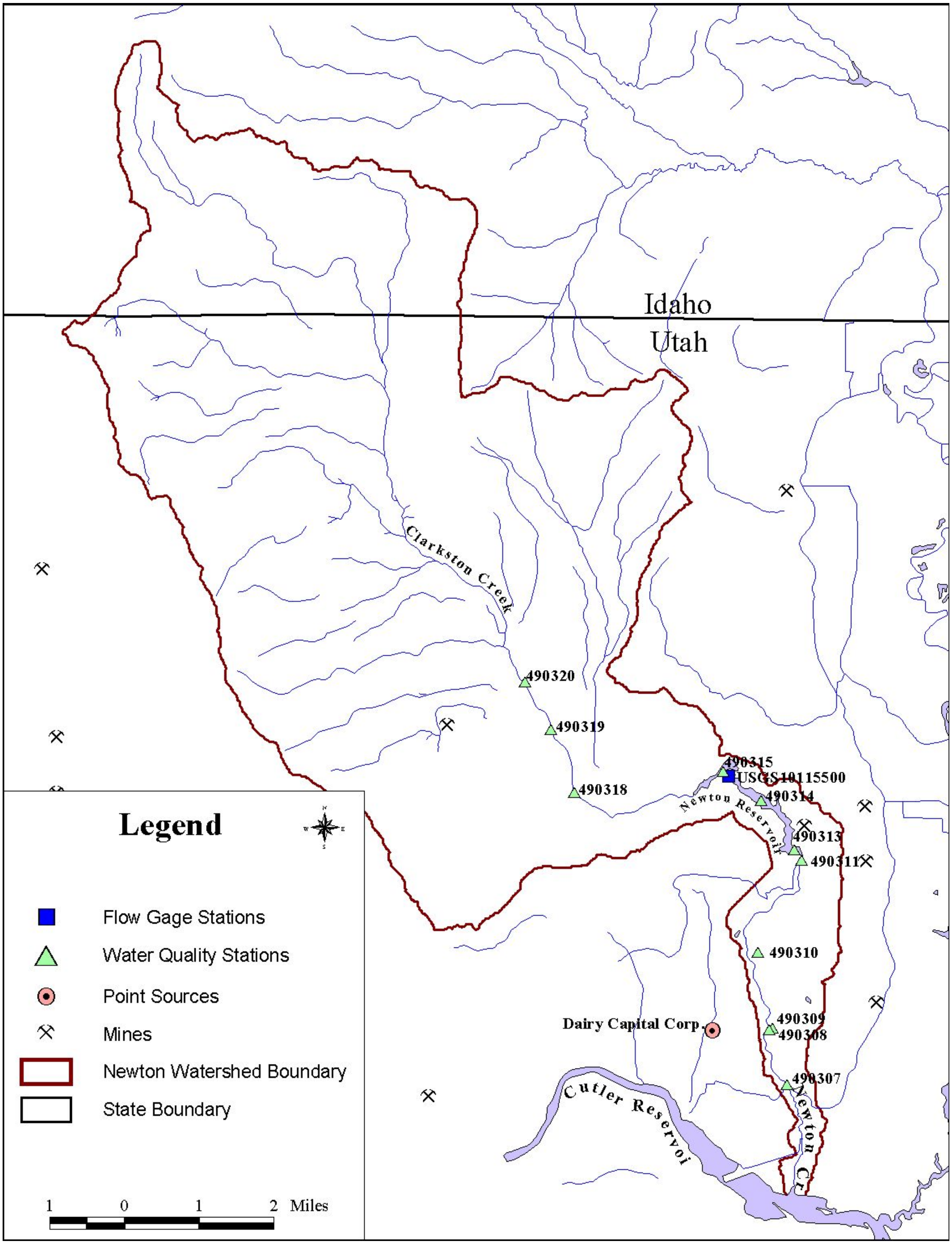

Figure 3-1. Water Quality and Flow Monitoring sites in the TMDL project area.

Table 3-3. DWQ monitoring stations located in the project area.		
ID	**Name**	**Type**
490307	Newton Creek 1 Mile Above Cutler Reservoir	Stream/River
490308	The Slough at U33 Crossing in Newton	Stream/River
490309	Newton Creek at U33 Crossing	Stream/River
490310	Newton Creek above Cutler Reservoir	Stream/River
490311	Newton Creek Below Newton Reservoir	Stream/River
490313	Newton Reservoir Above Dam 01	Lake/Reservoir
490314	Newton Reservoir Midlake 02	Lake/Reservoir
490315	Newton Reservoir Upper Lake 03	Lake/Reservoir
490318	Clarkston Creek at 600 South and 600 East	Stream/River
490319	Clarkston Creek at U142 Crossing	Stream/River
490320	Clarkston Creek at 500 North in Clarkston	Stream/River

3.2.2 Groundwater quality data

Groundwater samples have been collected by the United State Geological Survey from 5 wells within the project area watershed as part of a larger aquifer classification effort for the entire Cache Valley area (Lowe and Wallace 1999). This effort included sampling from five wells located within Clarkston that range in depth from 32 meters to 90 meters. (See Appendix B) Most wells in Cache Valley were sampled twice during late 1997 and early 1998. Sample results indicated that ground-water quality in Cache Valley was generally of high quality with Total Dissolved Solids (TDS) concentrations below 500 mg/l. However, samples collected in the northwest part of the valley, including the areas of Clarkston, Trenton and Amalga exhibited TDS levels ranging from 500 mg/l to 1000 mg/l. Bjorklund and McGreevy (1971) documented warm, saline ground water with TDS levels exceeding 1600 mg/l in wells near Newton that could be located along fault zones. Concentrations of TP measured by Lowe and Wallace (1999) in wells located near Clarkston ranged from 0.07 mg/l to 0.44 mg/l. These values can be converted to TP by multiplying by 0.437 resulting in TP concentrations of 0.03 mg/l and 0.19 mg/l respectively. Three of the five wells sampled in Clarkston also had relatively high nitrate-nitrite concentrations, ranging from 8.78 mg/l to 35.77 mg/l, which included the highest measured value of this parameter compared to any sampling point in Cache Valley. Potential sources of groundwater contamination could include leaking undergound storage tanks, confined animal feeding operations, septic tank systems, and land application of commercial and manure fertilizers in areas that contribute groundwater recharge (ERI 1999).

Although the data collected from wells in the Clarkston area provides some support to an estimation of pollutant levels contributed by shallow groundwater discharge, it is difficult to determine exact levels using only this data. It is likely that groundwater quality in the upper portions of the watershed above Clarkston is better than in the lower areas where potential sources of contamination are present.

3.2.3 Water discharge data

Historically speaking, there have been few observations of flow in the watershed. The earliest record of continuous flow measurements was collected from March 1939 through September 1947 at a gauging station (USGS 10115500) located on Newton Creek just below the old Newton Dam (Figure 3-1). Flow rates are typically measured with each water sample collected at DWQ monitoring sites, thus providing a snapshot view of stream discharge. The existing water rights agreement between the BOR and Clarkston Creek Irrigation company indicates that five days out of twenty the total flow of Clarkston Creek (up to 24 cfs) shall enter Newton Reservoir while the remaining fifteen days of flow belong to the irrigation company. This provides some indication regarding the pattern of diversion and filling of the reservoir but does not provide actual rates and volumes of water entering Newton Reservoir. Additional efforts were made to obtain flow data from local irrigation companies including the Newton Water Users Association and the Clarkston Creek Irrigation company. It was learned that no records have been kept regarding timing and amounts of water diverted for irrigation purposes. Individual water rights associated with irrigated lands above and below Newton Reservoir are presented in Chapter 2 (Table 2-3). Although water volumes and rates associated with individual water rights could provide an indication of the annual maximum amount of water that could be withdrawn from Clarkston Creek and Newton Creek in these areas, it would not provide the actual amount used within any given year, which is a function of available water and irrigation demand.

Reservoir discharge and reservoir level data were obtained from the BOR for the period 1991 through 2002. It was determined, however that the USBR release data from Newton Reservoir was questionable. This was evidenced by the fact that there are years in which the reservoir essentially drains (as shown by the water level data), but the recorded releases during these same time periods are essentially zero (i.e., the years 2000 and 2002). These false zero recorded releases posed a problem for water budget calculations because averaging false zero values into the daily average releases would have incorrectly reduced the averages. Since these were the only data available to characterize releases from the reservoir, a method was devised so that this information could be used in the water budget and modeling calculations. A detailed description of this method is included in Appendix A.

No groundwater flux data was found for streams and the reservoir within the project area. Several publications were found that provide general information regarding groundwater resources in the greater Cache Valley area as well as general patterns of groundwater flow. Several locations were observed along Newton and Clarkston Creek during field visits where streamflows appeared to be changing with no observed tributary inflow. However, no measurement of groundwater contributions to streamflow were taken at that time.

3.2.4 Sampling Frequency

Water samples were collected on an infrequent basis at many of the monitoring sites prior to July 2002. All water quality data used in this assessment including the total number of samples and range of collection dates for each measured parameter is summarized in Appendix B. A listing of selected water quality parameters measured at each station and the dates they were measured during the 2002 – 2003 intensive monitoring cycle is provided below in Table 3-4.

Table 3-4. Data availability for flow, TP, DO, and Temperature measured during the last intensive monitoring cycle (2002-03) in the project area.

	490307	490308	490309	490310	490311	490313	490314	490315	490318	490319	490320
6/11/02	-	-	-	-	-	Profile	Profile	Profile	-	X	-
7/18/02	X	X	X	X	X	Profile	Profile	Profile	X	X	X
8/20/02	X	X	X	X	X	Profile	Profile	-	X_1	X	X
10/2/02	X	X	X	X	NF	Profile	-	-	X	X	X
10/30/02	X	X	X	X	NF	-	-	-	X	X	X
12/11/02	-	X	X	X	NF	-	-	-	X	X	X
1/14/03	-	X	X	NF	NF	-	-	-	X	X	X
2/5/03	NF	X	X	X	NF	-	-	-	X	X	X
3/12/03	-	X	X	X	X	-	-	-	X	X	X
4/9/03	-	X_2	X	X_2	NF	-	-	-	X	X	X
5/14/03	-	X	X	X	NF	-	-	-	X	X	X
6/10/03	-	X	-	X	-	Profile	Profile	Profile	X	X_1	X
7/15/03-7/22/03	-	NF	NF	X_3	NF	Profile	-	-	X_3	X_3	X_3
8/21/03	-	-	-	-	-	Profile	-	-	-	-	-

X = Data available, - = no data available, NF = no flow observed at monitoring site, Profile = reservoir data collected at more than one depth.
1 Water sample collected, no flow data available.
2 No flow or DO data available.
3 No TP data available.

3.3 EXISTING WATER QUALITY

As mentioned previously, the assessment of water quality relied primarily upon monitoring data collected during the 2002 – 2003 intensive sampling effort. All monitoring data collected at each site is summarized in Appendix B. Statistical computations for selected water quality parameters measured at each monitoring station are included below in Table 3-5. Graphs provided for each monitoring station (see Appendix B) include time-series plots of TP and DO concentration, probability plots indicating the percent of samples that exceeded water quality standards, and box-and-whisker plots that assist in identifying seasonal trends in water quality. Selected reservoir profile measurements of DO and temperature are also provided for monitoring stations located on Newton Reservoir. All reservoir profile measurements collected during 2000 – 2003 can be viewed in Appendix B. Information contained in Table 3-5 and in Appendix B has been organized to display water quality conditions from lowest monitored stream site below Newton Reservoir (station 307) to the uppermost stream site (station 320). The location of DWQ monitoring stations in the Newton/Clarkston watershed are shown in Figure 3-1.

Table 3-5. Statistical assessment of water quality parameters for DWQ stream and reservoir monitoring sites in the Newton/Clarkston project area (1977-2003).

	Number Of Observations	Percent Exceedance [1]	Number Below Detection Limit	Range Of Dates	Minimum	Maximum	Mean	Median	Geometric Mean	Standard Deviation
490307 Newton Creek 1 Mile Above Cutler Reservoir										
Dissolved Oxygen (mg/l)	4	0 / 0	0	2002 - 2002	8.09	10.31	9.150	9.100	9.116	0.916
PH	4	0	0	2002 - 2002	8.00	8.45	8.308	8.390	8.306	0.208
Dissolved Phosphorus (mg/l)	4	100	0	2002 - 2002	0.17	0.49	0.302	0.275	0.281	0.133
Total Phosphorus (mg/l)	4	100	0	2002 - 2002	0.20	0.99	0.548	0.498	0.470	0.332
Water Temperature (°C)	4	25	0	2002 - 2002	3.83	25.71	15.410	16.060	12.600	9.024
490308 The Slough at U33 Crossing in Newton										
Dissolved Oxygen (mg/l)	11	0 / 18	0	2002 - 2003	6.43	11.81	9.572	9.720	9.383	1.899
PH	11	9	0	2002 - 2003	8.21	9.12	8.547	8.520	8.545	0.226
Dissolved Phosphorus (mg/l)	11	0	7	2002 - 2003	<BDL>	0.05	0.020	0.017	0.017	0.011
Total Phosphorus (mg/l)	11	36	1	2002 - 2003	<BDL>	0.21	0.066	0.050	0.049	0.057
Water Temperature (°C)	11	18	0	2002 - 2003	1.67	22.38	11.660	11.560	9.074	7.086
490309 Newton Creek at U33 Crossing										
Dissolved Oxygen (mg/l)	10	0 / 20	0	2002 - 2003	7.57	14.93	10.970	11.610	10.710	2.493
PH	10	10	0	2002 - 2003	8.34	9.22	8.662	8.665	8.659	0.251
Dissolved Phosphorus (mg/l)	10	100	0	2002 - 2003	0.12	0.23	0.175	0.172	0.171	0.035
Total Phosphorus (mg/l)	10	100	0	2002 - 2003	0.16	0.43	0.232	0.213	0.223	0.077
Water Temperature (°C)	10	20	0	2002 - 2003	0.15	28.32	10.510	9.490	4.378	9.469
490310 Newton Creek above Cutler Reservoir										
Dissolved Oxygen (mg/l)	12	0 / 25	0	1993 - 2003	5.55	16.74	10.910	11.620	10.430	3.235
PH	12	17	0	1993 - 2003	7.30	9.36	8.597	8.625	8.583	0.495
Dissolved Phosphorus (mg/l)	12	67	1	1993 - 2003	<BDL>	0.41	0.091	0.068	0.063	0.105
Total Phosphorus (mg/l)	12	92	0	1993 - 2003	0.03	1.00	0.168	0.093	0.105	0.265
Water Temperature (°C)	12	33	0	1993 - 2003	3.91	27.69	15.170	15.630	12.590	8.353
490311 Newton Creek Below Newton Reservoir										
Dissolved Oxygen (mg/l)	9	11 / 56	0	1977 - 2003	3.52	10.60	7.772	7.800	7.456	2.114
PH	10	0	0	1977 - 2003	7.80	8.70	8.100	8.090	8.096	0.268

Dissolved Phosphorus (mg/l)	3	33	0	2002 - 2003	0.04	0.07	0.050	0.050	0.049	0.015
Total Phosphorus (mg/l)	10	90	0	1977 - 2003	0.05	0.15	0.093	0.095	0.089	0.029
Water Temperature (°C)	10	10	0	1977 - 2003	5.00	21.51	13.250	12.500	12.050	5.511
490313 Newton Reservoir Above Dam 01										
Dissolved Oxygen (mg/l)	141	32 / 67	0	1980 - 2003	0.20	11.82	5.051	5.900	3.336	3.326
PH	139	0	0	1980 - 2003	6.80	8.82	8.056	8.100	8.042	0.471
Dissolved Phosphorus (mg/l)	56	86	16	1990 - 2003	<BDL>	0.36	0.078	0.033	0.031	0.098
Total Phosphorus (mg/l)	68	87	9	1980 - 2003	<BDL>	0.42	0.109	0.071	0.062	0.110
Water Temperature (°C)	144	35	0	1980 - 2003	7.60	26.48	17.390	18.100	16.430	5.453
490314 Newton Reservoir Midlake 02										
Dissolved Oxygen (mg/l)	94	35 / 77	0	1980 - 2003	0.20	11.70	4.972	5.850	3.435	3.222
PH	93	0	0	1980 - 2003	7.40	8.80	8.085	8.030	8.076	0.397
Dissolved Phosphorus (mg/l)	30	77	6	1990 - 2003	<BDL>	0.32	0.064	0.028	0.030	0.082
Total Phosphorus (mg/l)	37	87	3	1980 - 2003	<BDL>	0.45	0.097	0.044	0.057	0.099
Water Temperature (°C)	94	43	0	1980 - 2003	8.15	26.78	18.600	20.150	17.730	5.210
490315 Newton Reservoir Upper Lake 03										
Dissolved Oxygen (mg/l)	55	13 / 67	0	1980 - 2003	0.90	10.50	6.657	7.300	6.111	2.137
PH	53	0	0	1980 - 2003	7.40	8.80	8.246	8.280	8.239	0.353
Dissolved Phosphorus (mg/l)	21	91	7	1992 - 2003	<BDL>	0.21	0.044	0.030	0.027	0.050
Total Phosphorus (mg/l)	26	92	2	1980 - 2003	<BDL>	0.27	0.086	0.065	0.067	0.063
Water Temperature (°C)	55	49	0	1980 - 2003	10.40	27.39	19.860	20.200	19.350	4.267
490318 Clarkston Creek at 600 South and 600 East										
Dissolved Oxygen (mg/l)	12	0 / 25	0	2002 - 2003	7.75	12.16	9.843	9.545	9.717	1.645
PH	12	0	0	2002 - 2003	8.22	8.97	8.493	8.540	8.490	0.205
Dissolved Phosphorus (mg/l)	11	64	1	2002 - 2003	<BDL>	0.07	0.049	0.055	0.047	0.015
Total Phosphorus (mg/l)	11	100	0	2002 - 2003	0.05	0.15	0.092	0.087	0.087	0.031
Water Temperature (°C)	12	0	0	2002 - 2003	1.73	19.87	10.170	9.925	7.944	6.370
490319 Clarkston Creek at U142 Crossing										
Dissolved Oxygen (mg/l)	45	0 / 27	0	1976 - 2003	5.80	13.90	9.385	9.530	9.196	1.898
PH	50	0	0	1976 - 2003	7.70	8.94	8.329	8.350	8.325	0.256
Dissolved Phosphorus (mg/l)	29	41	1	1990 - 2003	<BDL>	0.36	0.060	0.042	0.049	0.062
Total Phosphorus (mg/l)	47	96	0	1976 - 2003	0.04	0.52	0.126	0.111	0.112	0.076

Water Temperature (°C)	46	9	0	1976 - 2003	3.13	27.00	11.240	10.460	9.626	6.060
490320 Clarkston Creek at 500 North in Clarkston										
Dissolved Oxygen (mg/l)	12	0 / 8	0	2002 - 2003	7.34	12.05	10.260	10.520	10.160	1.511
PH	12	0	0	2002 - 2003	8.10	8.79	8.432	8.400	8.430	0.179
Dissolved Phosphorus (mg/l)	11	18	1	2002 - 2003	<BDL>	0.06	0.035	0.030	0.032	0.014
Total Phosphorus (mg/l)	11	73	0	2002 - 2003	0.03	0.10	0.063	0.065	0.058	0.025
Water Temperature (°C)	12	8	0	2002 - 2003	2.64	23.45	10.900	10.290	9.078	6.402

[1] Percent exceedance based on measured sample values exceeding DWQ recommended water quality criteria associated with beneficial use class 3A cold water aquatic species. Criteria used included Dissolved Oxygen = 4.0 mg/l -adult aquatic life stage, 8.0 mg/l – early aquatic life stage, pH = 6.5 – 9.0, Dissolved Phosphorus and Total Phosphorus = 0.05 mg/l (streams) and 0.025 mg/l (reservoir), Water Temperature = 20 °C.

3.3.1 Total P assessment - Streams

The concentration of TP at DWQ stream monitoring sites generally exceeded 0.05 mg/l. At some monitoring sites, all samples measured during 2002-2003 exceeded the criterion for TP of 0.05 mg/l including stations 307, 309, and 318. Samples collected from stations 310, 311, and 319 exceeded 0.05 mg/l at least 90 percent of the time (see Table 3-5). Concentrations at the lowest monitoring site on Newton Creek (station 307) appeared to be the highest with all concentrations exceeding 0.2 mg/l. Seasonal analysis of TP at stream sites above Newton Reservoir indicated that winter season samples generally maintained the highest concentration while sites below the reservoir exhibited higher TP concentrations during the summer or fall.

3.3.2 Total P assessment – Newton Reservoir

As mentioned previously, all water quality data was used to assess reservoir impairment including samples collected at various depths from a single station (e.g., measurements taken at the surface, upper third, mid-depth, lower third, and bottom of the water column were averaged when available). A review of the water quality plots, shown in Appendix B, indicates that all sampling was completed during the summer or fall months. TP concentrations measured at upper (station 315) and mid-lake (station 314) sites are slightly higher than concentrations above the existing dam (station 313). This may be due to the low water volumes present at the upper sites. Samples measured at stations 313 and 314 exceeded the state criterion of 0.025 mg/l for 87% of all samples collected, while 92% of samples collected at station 315 exceeded the criterion. Seasonal analysis of reservoir samples indicates that TP concentrations generally decrease between summer and fall at the upper and mid-lake sites while concentrations at monitoring station 313 appear to increase slightly during the fall season.

3.3.3 Dissolved Oxygen assessment – Streams

DO concentrations in Clarkston Creek met the recommended acute standards for early aquatic life stage (8.0 mg/l) for approximately 70 percent to 90 percent of all samples measured . No samples had measured concentrations below the acute standard for adult aquatic life on Clarkston Creek. Upstream sites on Clarkston Creek maintain slightly greater concentrations of DO than downstream sites. Monitoring sites located on Newton Creek were more limited in the number of samples measured, but appeared to exhibit similar patterns in meeting the acute DO standards for early-stage and adult aquatic life. All measured DO concentrations at station 307, located approximately one mile above Cutler Reservoir, were above the standard for early aquatic life stage (8.0 mg/l). Seasonal analysis of DO concentrations at all stream monitoring sites exhibited lower DO concentrations during the summer season when high temperatures and low stream discharge rates were present.

3.3.4 Dissolved Oxygen assessment – Newton Reservoir

DO and temperature profiles measured on Newton Reservoir varied between upper and lower lake sites. DO concentrations at station 313 were generally the lowest and dropped below the acute standard for early-stage and adult aquatic life on several occasions. One of the lowest DO measurements occurred during July 2002 at station 313, and during June 2002 at station 314 when concentrations approached zero at the lowest measured depths. Some stratification of DO and temperature appears to occur at stations 313 and 314 particularly when the total water depth is 8 m or greater. Profiles measured at station 315 are typically well mixed and exhibit little or no stratification. Many of the upper DO measurements at all reservoir monitoring sites were near, but slightly below the acute standard for early aquatic life stage (8.0 mg/l). Approximately two-thirds of all samples (67 percent) collected at stations 313 and 315 had DO concentrations below

8.0 mg/l while 77 percent of the samples measured at station 314 were below 8.0 mg/l. At sites where stratification occurred, DO levels quickly dropped below the standard for adult aquatic life stage (4.0 mg/l). More than 30 percent of all samples collected at stations 313 and 314 had DO concentrations below 4.0 mg/l, while 13 percent of the samples from station 315 were below the 4.0 mg/l standard.

3.4 STREAM CHANNEL ASSESSMENT

A measure of stream health and overall channel stability can identify conditions that contribute to pollutant loading. Stream channels and near-channel areas along Clarkston Creek and Newton Creek were evaluated using the Stream Visual Assessment Protocol (SVAP) developed by the Natural Resource Conservation Service (NRCS 1998). This method quantifies the health of stream channels using several categories that can be rapidly scored during field efforts. Streambank erosion potential was also assessed using a Streambank Erosion Control Index (SECI) method. The combined score from these two measures can provide a means for organizing stream segments into groups that require similar measures to rehabilitate or restore a group of channel segments. Major categories used to evaluate stream channels by the SVAP and SECI methods are provided below in Table 3-6.

Table 3-6. Categories used to evaluate stream channel conditions in the Clarkston/Newton project area.

SVAP method	SECI method
Channel condition	Bank erosion evidence
Hydrologic alteration	Bank stability condition
Riparian zone	Bank cover/vegetation
Bank stability	Lateral channel stability
Water appearance	Channel bottom stability
Nutrient enrichment	In-channel deposition
Barriers to fish movement	
Instream fish cover	
Pools	
Invertebrate habitat	

3.4.1 Stream Groups

Final scores were determined for each stream segment and the values entered into a spreadsheet to determine potential groups of similar stream segments. Based on the manner that scores were calculated, groups with higher scores are in better condition than groups with lower total scores. It was determined that a total of 7 groups were present in the Newton/Clarkston project area. These groups are provided below in Table 3-7.

High-scoring groups were typically found in areas where stream channel banks were protected by dense vegetation and where stream channel segments were separated from adjacent cultivated fields by buffer strips. Although some stream channels were assigned a high score, water quality along some segments remained poor due to upstream reaches contributing nutrients and sediment. Low-scoring groups typically maintained deep, incised channels with high amounts of bank erosion. Adjacent fields were frequently tilled to the edge of the stream channel, providing no opportunity for riparian vegetation to establish. Animal access was also prevalent as several AFO operations were immediately adjacent to or spanned the stream channel allowing animals contained within the lot open access to the stream. A detailed description of the data obtained during this field effort is included in Appendix C.

Table 3-7. Stream channel location and characteristics by SVAP grouping.

	Reach ID	Total Score	Stream Channel Characteristics
Group 1	NC10	24	Feedlot eroding on both sides of stream, overland flow from corrals, deep and incised channel, mostly silty substrate in stream, riprap, channelization
Group 2	CC6 CC2 CC10 NC5 CC5	28 35 36 36 37	Limited to no vegetation, culverts, high erosion, some cut banks sloughing into stream, tilled to edge, channel straightening, overland flow, grazing in and around stream, high animal access
Group 3	CC7 NC3 CC9 NC8 CC4	41 43 44 45 50	Tilled to edge, culverts, reduced to no vegetation, grazing in stream and along banks, feedlot inputs, one unused irrigation structure, active erosion, evidence of past fire in CC4
Group 4	NC9 NC6 CC11	55 56 57	Stockyard flushing/channelization, unprotected banks, landscaping and construction, grazing in stream and along banks, dredging, berms, tree removal, farming to edge
Group 5	CC12 NC7 NC1	63 66 67	Dredging, berms, overland flow from crops, some animal access/grazing, ATV impacts, invasive weeds, generally stable banks
Group 6	CC8 NC4 CC13	79 81 82	Good vegetation, some buffer strips, tilled to edge, some garbage, livestock access, algal growth due to upstream loading
Group 7	NC2 CC3	98 99	Little to no erosion, stable banks, some erosion where farmed to edge, upstream reaches are the main problem increasing nutrient and sediment concentration

3.4.2 Macroinvertebrate assessment – Clarkston Creek and Newton Creek.

Macroinvertebrates are beginning to be widely accepted as a surrogate measure of water quality due to their ability to reflect biological health of a water body. Some species of macroinvertebrates are very sensitive to water quality and will only exist in streams and lakes where water quality is high. Other species are somewhat tolerant or highly tolerant to pollution and can exist under a wide range of water quality conditions. Macroinvertebrate species were identified in the field at representative sample sites during the SVAP assessment of Clarkston Creek and Newton Creek completed in October and November of 2002. Species identified during the field effort were categorized into three groups defining their ability to tolerate water quality pollution. Some of the species identified during this effort are included below in Table 3-8. Although no estimates were made of individual species abundance during the stream assessment, an effort was made to determine which species were dominant at each sample site. A limited number of sites located near points of groundwater discharge (i.e., springs or stream segments with groundwater contribution) appeared to be dominated by species that have a moderate or low tolerance to pollution. Most of the stream assessment sites were dominated by species that are highly or moderately tolerant to pollution levels. Macroinvertebrate species were not observed at several sites due to the high amount of sediment and algal growth covering the channel bottom.

Table 3-8. Macroinvertebrates identified at stream assessment sites on Clarkston Creek and Newton Creek in October and November 2002.

Common Name	Class, order or suborder	Pollution Tolerance
Aquatic Worm	*Oligochaeta*	High
Pouch Snail/Pond Snail	*Gastropoda*	High
Scud	*Amphipoda*	Moderate
Damselfly	*Zugoptera*	Moderate
Caddisfly	*Trichoptera*	Low

3.5 Trophic State Index Assessment – Newton Reservoir

The trophic state of a lake or reservoir can be considered to measure the total weight of all living biological material or biomass found within the waterbody at a given point in time (Carlson and Simpson 1996). Trophic status is generally considered to respond to nutrient inputs over time, and will reflect the biological condition of a waterbody. A trophic state index (TSI) is based on measurements of nutrient-related parameters that are believed to characterize biomass. Carlson (1977) has developed trophic state indices based on measurements of TP, chlorophyll a, and sechi disk depth, each of which can independently provide an estimate of algal biomass.

Carlson's TSI values typically range from 0 to 100, although theoretically, the range of values could exceed these bounds (Carlson and Simpson 1996). An increase of 10 units in the TSI scale is equivalent to doubling the concentration of TP or halving water transparency as measured by sechi disk depth. Calculations for determining TSI values based on TP, chlorophyll a, and sechi disk depth are provided below. Information relating Carlson TSI values to trophic state characteristics is provided in Table 3-9. TSI values calculated for Newton Reservoir along with other limnological variables of interest are included in Table 3-10.

$$\text{TSI (TP)} = 14.42 \ln (\text{TP - } \mu g/l) + 4.15 \qquad (3\text{-}1)$$

$$\text{TSI (chl–a)} = 9.81 \ln (\text{chlorophyll a - } \mu g/l) + 30.6 \qquad (3\text{-}2)$$

$$\text{TSI (SD)} = 60 - 14.41 \ln (\text{sechi disk – meters}) \qquad (3\text{-}3)$$

where:

TSI = Carlson trophic state index
ln = natural logarithm

Table 3-9. Description of lake trophic status based on Carlson TSI values (Carlson and Simpson 1996).		
TSI range	**Trophic status**	**Description**
< 35	Oligotrophic	Clear water, high oxygen levels throughout the year although shallow lakes/reservoirs may develop low DO concentrations in the hypolimnion. Salmonid fisheries dominate aquatic populations. Water may be suitable for unfiltered drinking in some cases.
35 - 50	Mesotrophic	Water is moderately clear, greater chance of low DO concentrations in the hypolimnion during the summer season. Low DO levels result in salmonid losses, walleye may predominate. Water requires filtration for drinking purposes.
50 - 70	Eutrophic	Low DO levels predominate, heavy algal growth dominated by blue-green algae. Warm water fisheries only. High biomass may discourage boating, swimming.
> 70	Hypereutrophic	Dense algal growth, heavy algal scums present at surface. Rough fish dominate; summer fish kills possible.

Table 3-10. TSI parameters for Newton Reservoir and other limnological data of interest for 1992 – 2003.

	1992	**1994**	**1996**	**1998**	**2000**	**2002**	**2003**
Surface Data							
TSI (chl-a)	61.5	53.8	40.6	60.5	48.5	54.8	
TSI (SD)	54.6	60.4	46.6	49.7	43.9	47.0	
TSI (TP)	70.8	69.0	55.3	45.8	61.4	64.0	64.3
Chlorophyll a (ug/l)	23.4	10.7	2.8	21.0	6.2	11.8	-
Transparency (m)	1.5	1.0	2.5	2.1	3.1	2.5	-
Total Phosphorus (ug/l)	101.6	90.0	34.6	18.0	53.0	63.3	64.6
PH	8.3	8.7	8.6	8.2	8.3	8.3	8.6
TSS (mg/l)	6.0	12.0	3.1	2.5	2.0	3.6	2.0
TVS (mg/l)	4.0	5.2	4.5	4.5	4.5	-	-
Temperature (degree C)	17.8	24.2	22.9	22.9	22.1	21.8	21.2
Spec. Cond. (umhos/cm)	784.4	639.7	861.8	886.5	776.0	849.7	-
Water Column Data							
Ammonia (mg/l)	0.13	0.05	0.14	0.31	0.04	0.04	0.04
Nitrate/nitrite (mg/l, dissolved)	0.03	0.01	0.01	0.05	0.07	0.05	0.05
Hardness (mg/l, dissolved Ca + Mg)	-	-	-	-	340.10	322.60	-
Hardness (mg/l, total Ca + Mg)	315	265	320	280			
Miscellaneous Data							
D.O. (mg/l) at 75% depth	1.7	0.3	-	0.9	-	1.8	0.9
Average depth (m) at site 490313	5.6	7.7	10.0	12.5	12.0	9.1	4.5
TSI deviations							
TSI (chl-a) - TSI(TP)	-9.3	-15.2	-14.6	14.6	-12.9	-9.2	
TSI (chl-a) - TSI(SD)	6.9	-6.5	-5.9	10.8	4.6	7.8	

Data averaged from STORET sites 490313, 490314, 490315.

One advantage of using a multi-parameter TSI assessment is the ability to examine associations between parameters that may indicate conditions in the reservoir which limit algal biomass or affect the TSI parameters. Average annual TSI values calculated for Newton Reservoir (see Figure 3-2) indicate that the three variables were somewhat correlated with the exception of 1998. In general, all TSI values were typically in the upper mesotrophic to lower hyper-eutropic range with the majority of TSI values occurring in the eutrophic range. TSI(chl-a) is generally considered to be the best indicator of biological material in lakes and indicates that the trophic status of Newton Reservoir ranges between mestrophic and eutrophic. The inconsistency between TSI values in 1998 may be explained by high water levels contained within the reservoir during that year, which likely reduced TP concentrations substantially. Information provided in Figure 2-9 indicates water depths in Newton Reservoir were greater in 1998 than any other year during the period of 1992-2003. TSI(chl-a) was lower than the other two variables prior to 1998 but consistently exceeded TSI(SD) after 1998. The shift in the relative order of TSI variables after 1998 may potentially indicate a change in the size of particulate matter found in Newton Reservoir from smaller non-algal particulates to larger particulates including algal species. A second method of assessing TSI parameters uses the difference between TSI(chl-a) and TSI(TP) or TSI(SD). Results from this assessment are shown in Figure 3-2 where TSI(chl-a) – TSI(TP) is plotted on the vertical axis and TSI(chl-a) – TSI(SD) is plotted on the horizontal axis. As indicated by Figure 3-2 most of the values fall below the horizontal axis, suggesting that under most situations, algal growth in Newton Reservoir is limited by nitrogen or something other than phosphorus. One point is located above the horizontal axis and represents TSI values calculated during 1998. As mentioned previously, this point is likely influenced by the water volumes present during that year as compared to other years. Points shown in Figure 3-2 located to the right of the vertical axis indicate situations where transparency is more influenced by larger particulate matter including algal growths such as blue-green algae (Cyanobacteria) and less affected by small particulate matter. Data points located to the right of the vertical axis may also be the result of zooplankton grazing that removes smaller particles and leaves larger forms of algal matter. Points located to the left of the vertical axis are situations where small, non-algal particles influence water clarity, such as suspended sediment or water color. A review of the dates associated with data points included in Figure 3-3 indicates that the two points in the lower left quadrant occurred during 1994 and 1996 while the three points in the lower right quadrant occurred during 1992, 2000, and 2002. The relative position of these points indicates a potential shift to blue-green algal dominance in Newton Reservoir during the immediate past.

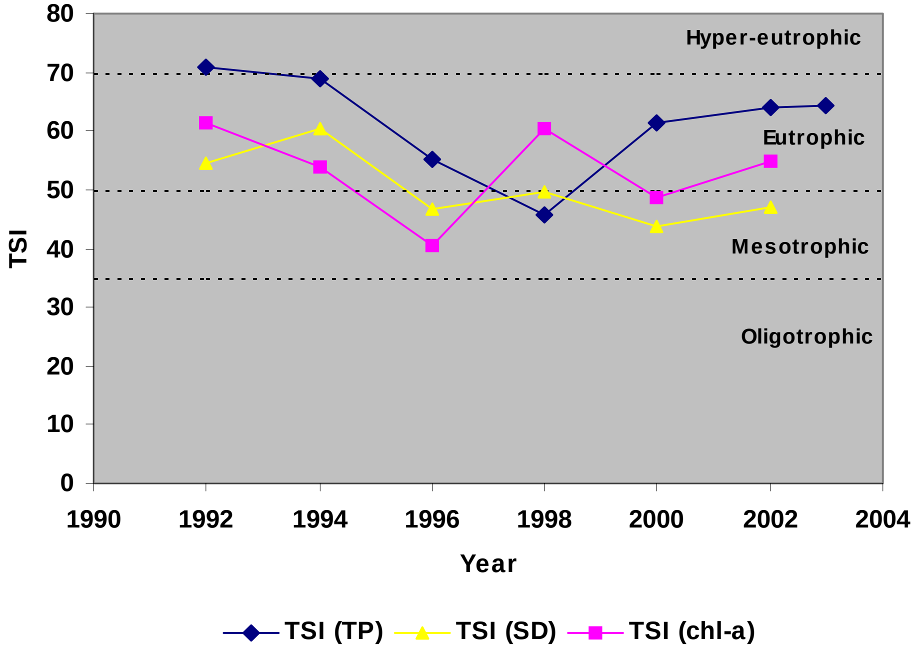

Figure 3-2. TSI values calculated for Newton Reservoir 1992 – 2003.

TSI parameters shown include Total Phosphorus, Sechi disk depth, and Chlorophyll a. Data used in calculations was averaged from all available data collected at reservoir monitoring sites 490131, 490314, and 490315. Data was typically collected during June through August of each year.

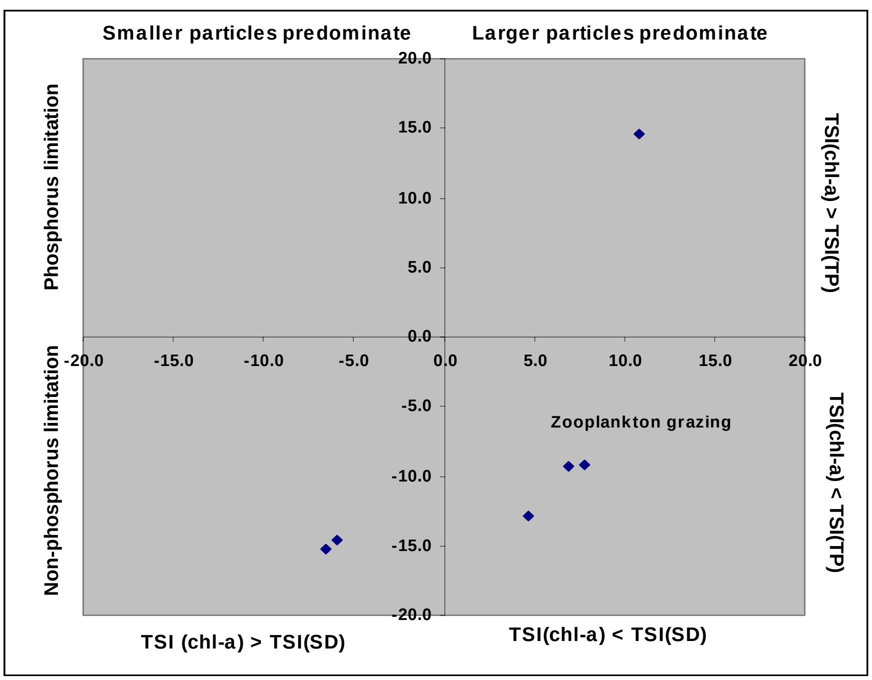

Figure 3-3. Assessment of annual TSI differences calculated for Newton Reservoir during 1992 – 2002. Based on Carslon (1996).

3.6 PHYTOPLANKTON ASSESSMENT – NEWTON RESERVOIR

Phytoplankton collected from the euphotic zone of Newton Reservoir include the species listed below in Table 3-11 (DWQ 1997). The type of taxa identified in this sample indicated that the phytoplankton community is dominated by flagellates and green algae. Historic observations made by DWQ have indicated that blue-green algae, including Ceratium and Aphanizomenon species, has dominated phytoplankton communities at Newton Reservoir. Indications assessed from TSI parameters calculated for Newton Reservoir also suggested that blue green algae are dominant both historically and at present.

Table 3-11. Phytoplankton species identified in the euphotic zone of Newton Reservoir (DWQ 1997).

Species	Cell Volume (mm^3/liter)	% density by volume
Pandorina morum	19.126	49.46
Sphaerocystis schroeteri	13.205	34.15
Fragilaria crotonensis	2.062	5.33
Melosira granulata	1.903	4.92
Pediastrum duplex	1.444	3.73
Unknown spherical green alga	0.434	1.12
Oosystis sp.	0.156	0.40
Asterionella formosa	0.095	0.24
Oscillatoria agardhii	0.056	0.14
Phacus sp.	0.056	0.14
Oscillatoria sp.	0.048	0.12
Centric diatoms	0.036	0.09
Pennate diatoms	0.033	0.09
Ankistrodesmus falcatus	0.017	0.05
Oscillatoria amphibia	0.003	0.01
TOTAL	**38.665**	
Species Richness	0.62	
Species Evenness	0.46	
Shannon-Weaver [H′]	1.27	

3.7 POLLUTANT LOAD CALCULATION – EXISTING DATA

Pollutant loads were calculated at each stream monitoring site using all available paired measurements of flow and TP concentration. Average loads were calculated by first multiplying flow by concentration for each measurement date to obtain a load for the sample date. All loads measured at a single station were then averaged. Average loads for each station are included below in Table 3-12. A complete listing of all data used in load calculations can be found in Appendix B.

The loads in Table 3-12 must be considered carefully because it is believed that these loads do not characterize the true magnitude of loadings in the Newton watershed. It has been determined that the loads in the Newton watershed are entirely from nonpoint sources, which are highly dependent on surface runoff that is generated during storm events or rapid snowmelt. Specific reasons why it is believed that the available data do not characterize nonpoint source loading include the following:

- The number of paired flow and concentration measurements collected at any one site is limited. As a result, annual variability in loading is not represented. Data collected during the most recent intensive monitoring survey (2002-2003) can be considered to represent a drought year and may not capture stream channel response during a year with high precipitation levels.

- The highest frequency monitoring that has occurred in the watershed is monthly samples (i.e., daily or even weekly variability in flows and concentration is not characterized).

- No storm sampling has been done in the watershed to characterize the magnitude of flows and concentrations associated with storm events.

Table 3-12. Average TP loads calculated at DWQ stream monitoring locations in the project area.

Station	Station Name	Number of Observations[1]	Range of Dates	Average flow (CFS)	Average Total P concentration (mg/l)	Average Observed Load[2] (kg/yr)	Min Observed Load[3] (kg/yr)	Max Observed Load (kg/yr)
490307	Newton Creek 1 Mile Above Cutler Reservoir	5	7/18/02 – 2/5/03	0.125	0.548	53.402	36.078	88.676
490308	The Slough at U33 Crossing in Newton	9	7/18/02 – 7/18/03	0.400	0.071	17.961	1.786	34.827
490309	Newton Creek at U33 Crossing	10	7/18/02 – 7/18/03	0.250	0.233	46.332	19.110	86.175
490310	Newton Creek above Cutler Reservoir	14	8/7/90 – 6/10/03	1.668	0.177	154.651	9.287	620.641
490311	Newton Creek Below Newton Reservoir	11	7/18/02 – 7/18/03	0.233	0.064	15.211	4.019	35.720
490318	Clarkston Creek at 600 South and 600 East	9	7/18/02 – 6/10/03	2.822	0.087	220.057	112.519	485.797
490319	Clarkston Creek at U142 Crossing	32	6/28/90 – 5/14/03	4.045	0.119	358.540	90.551	1085.006
490320	Clarkston Creek at 500 North in Clarkston	11	7/18/02 – 6/10/03	2.375	0.063	130.966	45.543	360.776

[1]Number of concurrent measurements of flow and total phosphorus concentration.
[2]Calculated by averaging the annual load estimates calculated from each observation of flow and concentration.
[3]Minimum loads do not include those dates when zero flow was observed at stream monitoring sites.

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CHAPTER 4: SOURCE ASSESSMENT

An accurate TMDL is based upon assessments of all potential pollutant sources including both point and nonpoint source pollution as well as contributions from natural sources (background contributions). As pollutant sources are characterized, any factors that influence the delivery of pollution to the watershed should be considered as well. Some of these factors include the location of the source with respect to receiving water bodies, magnitude of the source, the manner in which pollution is transported (e.g. surface runoff vs. infiltration), and the timing of delivery (i.e. when and how often pollution is delivered to receiving waters). The level of detail used to quantify the relative contribution from each pollutant source can utilize a wide range of techniques ranging from best professional judgement, and review of large-scale mapping information to highly detailed computer modeling efforts.

Source assessment of pollutant loads in the Newton/Clarkston watershed involved an initial review of information that was widely available through public agencies, including water quality and reservoir discharge information described under Chapter 3. A detailed field survey of existing conditions contributing to water quality impairment was also completed on stream channels and upslope locations within the project area. Field information and review of landuse/landcover information were used to define categories defining the major pollutant sources. Loads were then calculated for each of these categories, providing input to a computer modeling effort that calculated actual TP loads to Clarkston Creek, Newton Reservoir, and Newton Creek. A detailed review of these methods and the calculated loads resulting from this effort are included below.

This chapter details the loading calculations for Newton Reservoir and for Newton Creek. The loads contained in the following sections are based on the best information that was available at the time that they were calculated. All assumptions made in the calculation of TP loads contained in this chapter are described where appropriate. It is noted that the modeling effort used in this assessment should be considered largely as a tool that can assist in quantifying pollutant sources relative to one another and not necessarily in absolute terms. Modeling water quality processes requires a range of input parameters, many of which are not available for the TMDL project area. Although an extended effort was made to qualitatively assess site specific conditions in the field that may contribute to nonpoint source loads, the information needed to model surface runoff and transport of pollutants was limited. The methods used to supplement missing data followed conservative assumptions in order to fully quantify the potential for TP loading from the known pollutant sources. While the intent was not to overestimate pollutant loads, it is recognized this could have occurred in the absence of existing data that could be used to validate or verify processes that contribute to TP loading.

4.1 SUBWATERSHED DELINEATION

TP loads are summarized in this chapter by the subwatershed in which they occur and by month to illustrate the spatial and temporal distribution of these loadings. Figure 4-1 shows the subwatershed delineations used in the modeling efforts, and Table 4-1 lists the subwatersheds and gives a brief description of each. The lower outlet points for each of these subwatersheds were selected to correspond with existing DWQ stream monitoring locations, proposed stream monitoring locations, or areas where landuse or landtype changed substantially. The Clarkston Creek watershed includes eight of these subwatersheds. One subwatershed was defined around Newton Reservoir while three subwatersheds are located below the reservoir.

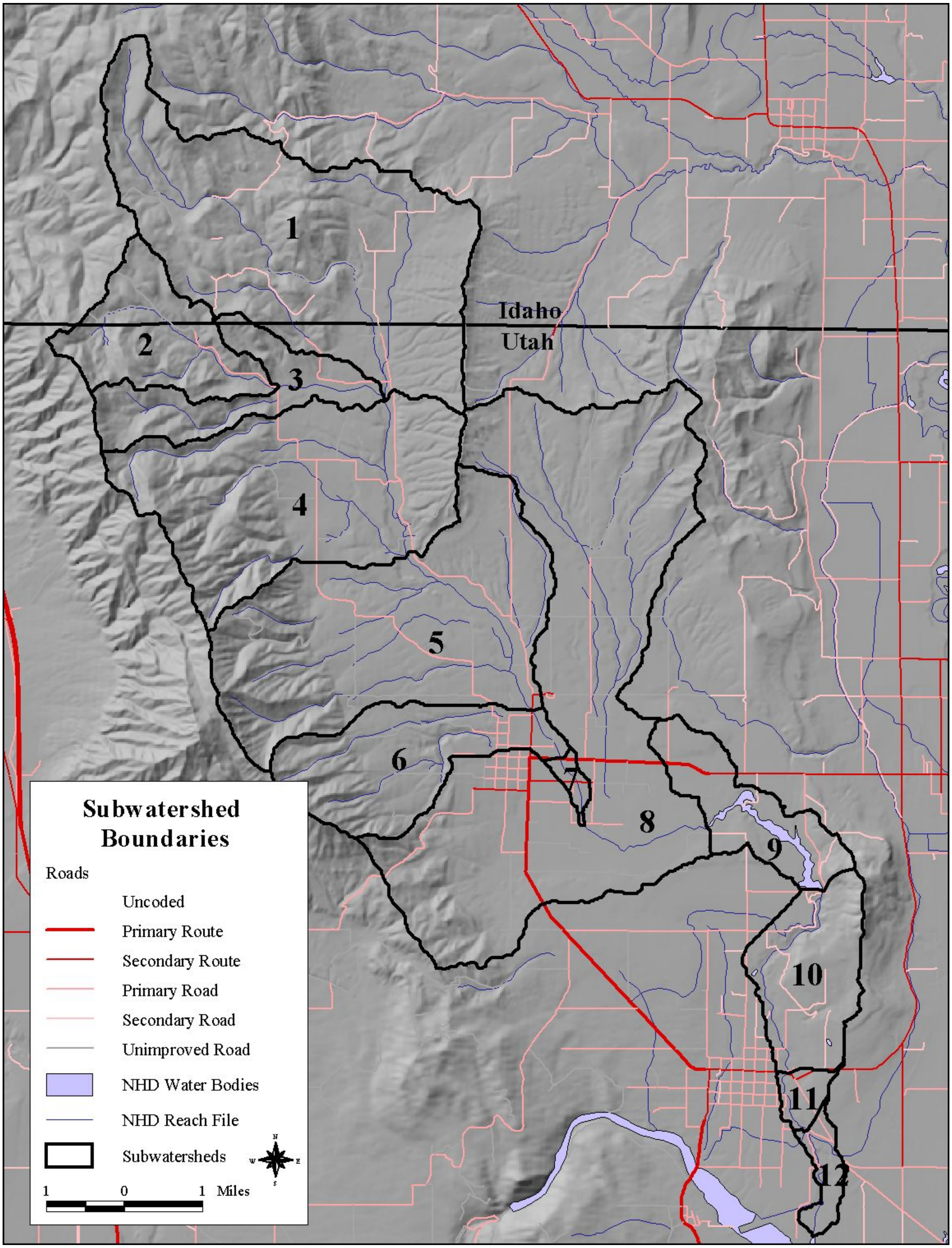

Figure 4-1. Subwatersheds used in the Newton Watershed Loading Model.

Table 4-1. Subwatersheds used in the Newton Watershed Loading Model.			
Subwatershed	**Name**	**Group**	**Total Area (km^2)**
1	Headwaters	Clarkston Creek	28.88
2	Steel Canyon	Clarkston Creek	7.58
3	Lower Steel Canyon	Clarkston Creek	6.29
4	Hammond Flat	Clarkston Creek	21.10
5	Lower Hammond Flat	Clarkston Creek	24.25
6	Upper Clarkston	Clarkston Creek	9.65
7	Lower Clarkston	Clarkston Creek	0.58
8	Lower Clarkston Creek	Clarkston Creek	40.54
9	Newton Reservoir	Newton Reservoir	5.75
10	Upper Newton Creek	Newton Creek	7.20
11	Middle Newton Creek	Newton Creek	1.06
12	Lower Newton Creek	Newton Creek	1.46

4.2 TOTAL PHOSPHORUS LOADING TO NEWTON RESERVOIR

The following sections describe the loadings to the stream reaches above Newton Reservoir and to the reservoir itself from the major sources that have been identified. Sources of TP loading identified in the Newton Reservoir watershed and summarized in the following sections include:

1. Animal Wastes
    - Direct stream loading from animal feeding operations
    - Land applied animal wastes
    - Grazing on public lands within the watershed
2. Onsite wastewater treatment systems
3. Nonpoint source loads from overland flow
4. Groundwater background

The geographical location of each of these pollutant sources is shown in Figure 4-2. The best available data was used to initially determine the location of potential pollutant sources and later refined and verified during field visits to the Clarkston Creek watershed and the area surrounding Newton Reservoir.

Average annual TP loads entering streams above Newton Reservoir were calculated by subwatershed and are included in Table 4-2 below. Average monthly TP loads reaching Newton Reservoir are included in Table 4-3 and incorporate losses of TP by stream flow diversions above the reservoir. Specific information regarding how TP loads were calculated for each pollutant source contributing to Newton Reservoir is provided below in Sections 4.2.1 through 4.2.4.

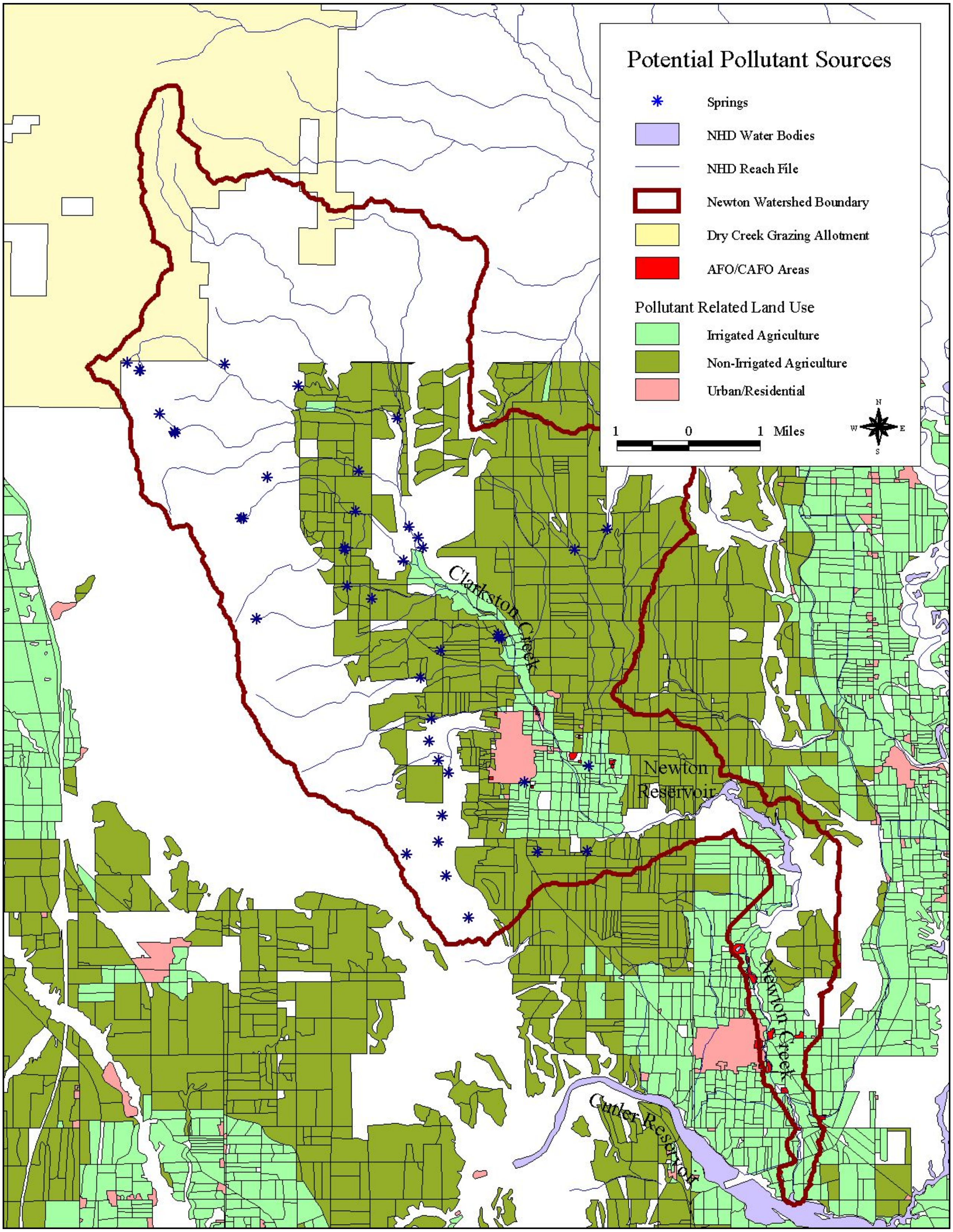

Figure 4-2. Potential pollutant sources in the TMDL project area.

Table 4-2. Average annual loading of total phosphorus (kg) by subwatershed.						
Subwatershed	**Direct stream loading from AFOs**	**Land applied animal wastes**		**Grazing on public lands**	**Onsite Wastewater Treatment Systems**	**NP Loads from Overland Flow**
		Amount applied to field	**Load to stream**			
1	0	0	0	368	0	11
2	0	0	0	187	0	.45
3	0	0	0	0	0	1.93
4	0	0	0	0	0	5.45
5	0	588	154	0	0	10.1
6	544	816	213	0	30	5.5
7	0	1,313	343	0	1.1	.58
8	120	6,360	1,663	0	52	23.2
9	0	412	108	0	0	4.57
Total	**664**	**9,489**	**2,482**	**555**	**83.1**	**62.78**

Table 4-3. Average monthly loading of total phosphorus to Newton Reservoir (1991-2001).						
Month	**Direct stream loading from AFOs**	**Land applied animal wastes**	**Grazing on public lands**	**Onsite Wastewater Treatment Systems**	**NP Loads from Overland Flow**	**Groundwater**
January	31.8	153	26.6	5.1	3.32	6.9
February	30.8	108	25.7	4.7	2.09	6.4
March	107.2	701	89.5	7.2	10.0	9.9
April	154.7	769	129.2	10.0	14.2	14
May	92.5	98.4	55.4	10.1	9.58	12
June	34.6	1.02	12.7	5.5	4.52	5.1
July	4.6	0.01	0.5	2.6	0.54	1.9
August	5.9	13.6	1.9	3.1	0.51	2.6
September	12.4	36.9	9.0	4.9	1.04	6.3
October	23.4	89.5	19.6	5.4	1.69	7.5
November	23.4	187	19.6	5.0	1.99	6.8
December	35.1	295	29.3	5.0	2.56	6.9
Total	**556**	**2,453**	**419**	**68.6**	**52.1**	**86**

4.2.1 Animal Wastes

Manure generated from animal feeding operations (AFO), including feedlots and dairy operations, is estimated to contribute roughly 20 percent of pollutant loads from agriculture operations nationwide (EPA 1998). TMDLs completed in Utah and other states have used many different methods to calculate pollutant loads from animal waste. Due to the size of some watershed areas and the need to simplify the assessment, many studies have estimated that all AFOs within a specified distance from a receiving water body contribute an equal amount of nutrients regardless of the effort that has taken place to manage manure volumes or control surface runoff at individual locations. Other studies have estimated that all manure generated by a given number of animals directly enters the stream system regardless of plant uptake, mineralization, or distance from live water. This study has made an effort to quantify site-specific conditions that influence the potential for stream loading from AFOs.

Additional sources of animal waste include land areas where animal manure has been applied as fertilizer as well as livestock grazing on public lands. The potential for land applied manure to reach receiving water bodies is dependent upon conditions that influence surface runoff and transport of manure. Pollutant loads generated public lands grazing is dependent upon the total number of animals, the total areas grazed within the project area, and the season of use associated with grazing allotments in the project area.

4.2.1.1 Direct Stream Loading from Animal Feeding Operations

Potential for animal waste contributions in the Newton/Clarkston project area from AFOs was determined during two different field efforts. Stream channels and near-channel areas along Clarkston Creek and Newton Creek were evaluated using the SVAP developed by the Natural Resource Conservation Service (NRCS 1998). This method quantifies the health of stream channels using several categories that can be rapidly scored during a field visit. During this field effort, the majority of stream channels in the project area were walked, including Clarkston Creek from the confluence with Steel Canyon down to Newton Reservoir and Newton Creek from the Reservoir down to the railroad one-half mile above Cutler Reservoir. Dairy/feedlot operations located on or immediately adjacent to stream channels were visually assessed for conditions that are known to influence runoff and pollutant contributions including:

- Distance to receiving water bodies
- Number of animals
- Surface type (paved vs. unpaved lots)
- Surface slope
- Presence or absence of vegetation
- Evidence of manure management

An additional effort was made to estimate conditions at operations located away from stream channels by completing a census of all AFOs within the project area and assessing them for these same factors. The list of operations and the site-specific factors identified at each operation were entered into a spreadsheet. This spreadsheet was delivered to the NRCS who entered the animal numbers by operation and provided subwatershed totals. Information provided by the NRCS did not reveal animal counts at individual operations, thus protecting the confidentiality maintained between the NRCS and individual operators.

Field efforts were conducted on March 25, 2003 and July 18, 2003 to determine any seasonal differences in animal numbers in the project area as well as verify total animal unit numbers provided by the NRCS for the Clarkston Creek (including Newton Reservoir) and Newton Creek watersheds. Due to the location of several AFO facilities, an accurate field count of animals was not possible. In general, no substantial variations were observed in the number or location of animals present during the spring and summer months within the project area. The total number of animals that are currently found within each watershed are included in Table 4-4 and are based on information provided by the NRCS and field data collected during the spring and summer seasons of 2003. Animals were grouped based on their location with respect to a receiving water body and included the following categories:

- Direct Impact – Animals that either had direct access to Clarkston or Newton Creek or were located immediately adjacent to the stream channel.

- Moderate Impact – Animals that had direct access to or were located immediately adjacent to canals, ditches, or springs. Flow in these water bodies is considered intermittent.
- Indirect Impact – Animals that were generally located more than 500 ft. from any receiving water body but could still contribute to pollutant loads through land application of manure.

Table 4-4. Animal unit numbers currently located within the Clarkston Creek$_1$ and Newton Creek watersheds (2003).

Watershed	Direct Impact	Moderate Impact	Indirect Impact	Total
Clarkston Creek$_1$	85	190	650	925
Newton Creek	625	0	155	780

$_1$Includes applicable locations adjacent to Newton Reservoir.

The amount of TP produced at each operation was calculated by multiplying the total number of animals by manure production rates taken from the Agriculture Waste Management Handbook (NRCS 1992). Based on site specific conditions, the mass of TP produced at an individual site was then apportioned into amounts that were assumed to be land applied to the surrounding watershed area or directly enter water bodies by surface runoff from each operation.

Table 4-2 lists the amount of direct stream loading from animal waste generated at AFOs by subwatershed. The numbers in Table 4-2 represent the portion of TP loadings in surface runoff originating from AFOs that flows directly into the stream. As noted previously, these loads were calculated using a combination of animal numbers and field information collected at each AFO facility. Some stream flow diversions above the reservoir are present that remove TP loads which would otherwise be transported all the way downstream to the reservoir itself.

It is assumed that because these loads are associated with surface runoff, the fraction of the total annual load that occurs on a given day is equal to the fraction of the total annual surface runoff volume that occurs on that day. If no surface runoff occurs on a given day the load is equal to zero for that day. Given this, the annual loads in Table 4-2 were disaggregated to daily values by multiplying the values in Table 4-2 by the fraction of the total annual surface runoff (total surface flow volume for that day divided by the total surface flow volume for the entire year) that occurs on any given day. This was done to produce daily loading values for the years 1991-2001.

The daily values produced were then routed downstream to the reservoir using the Newton Watershed Loading Model, which accounts for hydrology and streamflow diversions that occur above the reservoir. Appendix A of this report provides details on the Newton Watershed Loading Model. The output daily values at the reservoir were then summed to produce total monthly loadings, and the monthly loads were then averaged across the period from 1991-2001. Table 4-3 lists these monthly average values for the contribution of the direct stream loadings from animal feeding operations to Newton Reservoir after accounting for hydrology and subtraction of diversions above the reservoir.

4.2.1.2 Loading from Land-Applied Animal Wastes

A mass balance approach was adapted from Bicknell et al. (1993) to simulate the accumulation of TP from land-applied animal wastes on land surfaces and removal by overland flow causing loadings to stream reaches from land applied animal wastes. Equation 1 below shows this mass balance:

$$\left\{\begin{array}{l}\textit{Change in the mass of}\\ \textit{total phosphorus}\\ \textit{available for wash off},\\ \textit{plant uptake, etc.}\end{array}\right\} = \left\{\begin{array}{l}\textit{Total phosphorus}\\ \textit{loading from}\\ \textit{manure application}\end{array}\right\} - \left\{\begin{array}{l}\textit{Total phosphorus}\\ \textit{removal by immediate}\\ \textit{incorporation with}\\ \textit{soil}\end{array}\right\} - \left\{\begin{array}{l}\textit{Total phosphorus}\\ \textit{removal by plant}\\ \textit{uptake, etc.}\end{array}\right\} - \left\{\begin{array}{l}\textit{Total phosphorus}\\ \textit{removal by surface}\\ \textit{runoff}\end{array}\right\} \tag{1}$$

Equation 1 can be rewritten as:

$$\frac{dP}{dt} = A - fA - U - W \tag{2}$$

Where: P = Mass of TP in storage on the land and available for wash off, plant uptake, etc. (kg)
t = Time (day)
A = TP loading rate from manure application (kg/day)
f = Fraction of TP lost through immediate incorporation with the soil
U = TP removal rate from plant uptake, etc. (kg/day)
W = Rate of TP wash off from overland flow (kg/day)

The annual loading rate of TP from manure application (A) has been calculated by subwatershed by NRCS personnel, but no written records are available regarding the schedule of manure application by individual operators. Additional information obtained from the NRCS indicates that the annual manure application in the Newton/Clarkston area is typical of Figure 4-3 (Goodrich 2003).

The fraction of land-applied TP lost through immediate incorporation with the soil (*f*) is dependent on whether incorporation is occurring, what percentage of the TP applied is incorporated with the soil, and the fraction of the TP incorporated that would be expected to become unavailable as a result. According to Tabbara (2003), immediate incorporation of land-applied manure with the soil can reduce TP losses associated with subsequent surface runoff events by 30 to 60 percent (i.e., approximately 30 to 60 percent of the applied TP would immediately become unavailable to surface runoff if it is immediately incorporated with the soil). Given this, it is assumed that 50 percent reduction is reasonable and *f* can be modeled as:

$$f = 0.5 I_p \tag{3}$$

Where: I_p = The fraction of land-applied TP that is incorporated with the soil

August September October	Approximately 85 percent of all land-applied manure is incorporated into the soil. Some surface erosion may occur during precipitation events, transporting non-soluble P to the stream stream channel with soil particles. Roughly 60 percent of fall-season manure is applied during this time period.
November December	Land-applied manure is not typically incorporated into the soil during these time periods due to high soil moisture content or frozen soil. Remaining fall-season manure (40 percent) is applied during this time period.
January February	No manure application based on past observations. More runoff occurs from feedlots. No scraping or land application.
March	Land application of spring-season manure begins. No manure is incorporated into the soil at this time due to high soil moisture content or frozen soil. Roughly 25% of spring-season manure is applied during this period.
April	Approximately 85 percent of all land-applied manure is incorporated into the soil. Some surface erosion may occur during precipitation events, transporting non-soluble P to the stream channel with soil particles. Remaining spring-season manure (75 percent) is applied during this time period.
May	No land application. Active growing season.
June	
July	Harvest.

Figure 4-3. Calendar of typical manure application occurring in the TMDL project area.

In addition to the immediate removal of TP that occurs through incorporation with the soil, the amount of available TP continues to decrease with time since application as phosphorus uptake by plants and further adsorption with the soil occurs. A single term (U) in Equation 2 accounts for TP removal by plant uptake, adsorption of TP into the soil, and any other physical, chemical, or biological processes that contribute to the reduction of the amount of available TP. This term is expressed as a first order loss rate and is given by Equation 4:

$$U = -kP \tag{4}$$

Where: k = First order removal rate of TP (day^{-1})

The rate of TP wash off from overland flow (W) is given by Equation 5. W is a function of the magnitude of the surface runoff that occurs, the amount of TP available, and a single parameter, $Q_{s,90}$, representing the amount of surface runoff that results in 90 percent wash off of the available TP.

$$W = P\left(1 - e^{\frac{-2.3 \cdot Q_s}{Q_{s,90}}}\right) \tag{5}$$

Where: Q_s = Surface runoff rate (m/day)
$Q_{s,90}$ = Surface runoff rate that results in 90 percent wash off (m/day)

Substituting in Equations 3, 4, and 5, Equation 2 can be rewritten as:

$$\frac{dP}{dt} = A - 0.5I_p A - kP - P\left(1 - e^{\frac{-2.3 \cdot Q_s}{Q_{s,90}}}\right) \tag{6}$$

The amount of TP associated with surface runoff is calculated by evaluating the mass balance for TP on a daily time step. Parameter values in Equation 6 (k and $Q_{s,90}$) were set based on available information and professional judgment. Equation 7 shows how the mass balance in Equation 6 is implemented to calculate the amount of TP available on a daily time step.

$$P_t = P_{t-1} + A_t - 0.5I_{p,t}A_t - k_t P_{t-1} - P_{t-1}\left(1 - e^{\frac{-2.3 \cdot Q_{s,t}}{Q_{s,90}}}\right) \tag{7}$$

Where:
P_t = Mass of TP in storage on the land and available for wash off, plant uptake, etc. at time t (kg)
P_{t-1} = Mass of TP in storage on the land and available for wash off, plant uptake, etc. at time t-1 (kg)
A_t = TP loading from manure application at time t (kg)
$I_{p,t}$ = Fraction of manure that is incorporated with the soil at time t
k_t = First order removal rate of TP at time t (day^{-1})
$Q_{s,t}$ = Surface runoff rate at time t (m/day)

Table 4-2 lists the amount of TP applied to land within each subwatershed and the amount of the land-applied TP that reaches the stream as loading from overland flow. Annual average TP application rates were determined as part of the calculations made for AFOs (described above), and the annual average TP loadings to the stream were calculated using the model described above. Loadings to the stream were evaluated on a daily basis for each year during the period from 1991 - 2001, and the results were summed to produce a total annual loading for each year. Annual loadings for all of the years were then averaged to generate the values in Table 4-2. Again, the loads in Table 4-2 represent loads to the stream but not to the reservoir due to the presence of diversions above the reservoir.

The results in Table 4-2 indicate that approximately 26 percent of the TP applied to the land as manure is washed into the streams in the watershed. This is somewhat lower than similar results reported in other TMDLs (Tetra Tech, Inc., 2002) where it was estimated that approximately 50 percent of the TP produced as animal waste within the basin was transported to the streams and subsequently to the reservoir. No differentiation was made between land-applied animal wastes and direct runoff to stream from animal feeding operations, which may be responsible for the difference between the delivery rates. A relatively high rate of wash off is to be expected whenever manure is applied to soils that are frozen, as may occur on occasion in the Newton/Clarkston area (see Figure 4-3).

The daily loads to the streams produced by the model described above were routed downstream to the reservoir using the Newton Watershed Loading Model (see Appendix A) to account for hydrology and streamflow diversions occurring above the reservoir. The daily output values at the reservoir were then summed to calculate monthly values and then the monthly values were averaged across the years 1991 – 2001 to calculate the average monthly values contained in Table

4-3. These values represent the average monthly loading contribution to the reservoir from TP applied to agricultural land as manure within the watershed.

4.2.1.3 Loading from Grazing on Public Lands

There is a single grazing allotment on public land within the Newton Watershed. Table 4-5 lists the available information about the Dry Creek grazing allotment.

Table 4-5. Information on the Dry Creek grazing allotment.

Characteristic	Value
Allotment Name	Dry Creek
Land Area	38.9 mi^2
Cow/Calf Pairs	1,129
Cow/Calf Days on Allotment	122 (June 1 - September 30)
Yearlings	250
Yearlings Days on Allotment	30 (July 1 - July 30)

Only a small portion of the Dry Creek allotment intersects the Newton/Clarkston watershed, consisting of areas in the upper portions of subwatersheds 1 and 2 (see Figure 4-2). Additionally, it is assumed that only the area within 0.25 miles (0.4 km) of an existing stream contributes loading. Given these assumptions, Table 4-6 lists the area within each subwatershed that lies within the grazing allotment and contributes loading from animal waste produced by grazing animals (i.e., is within 0.25 miles of an existing stream).

Table 4-6. Subwatersheds receiving loading from grazing and associated contributing areas.

Subwatershed	Receiving Water	Contributing Area (mi^2)[1]
1	Clarkston Creek	1.24
2	Steel Canyon Creek	0.63

[1]Based on the assumption that only the area within 0.25 miles (0.4 km) of an existing stream contributes loading.

In the absence of more detailed information, it is assumed that the animals on the grazing allotment are distributed equally over the entire area of the allotment. Table 4-7 lists the distribution of livestock in the Dry Creek Allotment by animal type.

Table 4-7. Grazing livestock distribution.

Allotment	Land Area (mi^2)	Animal Type	Number of Animals	Animals Per mi^2
Dry Creek	38.9	Cow	1,129	29
		Calf	1,129	29
		Yearling	250	6.4

Table 4-8 lists TP production rates by animal type for the Dry Creek Allotment. These numbers were taken from the Agricultural Waste Management Handbook (NRCS 1992).

Table 4-8. Grazing animal Total Phosphorus production rates.

Animal Type	Equivalent Animal Unit	Average Animal Weight (lbs)	Total Phosphorus Production Rate (lbs of TP/1,000 lbs animal/day)
Cow	1	1,000	0.12
Calf	0.6	600	0.10
Yearling	0.9	900	0.11

Table 4-9 lists the unit area loads by animal type that were calculated by multiplying the animal density (number of animals per square mile) from Table 4-7 by the TP production rates for each animal type (lbs. of TP/animal/day) from Table 4-8.

Table 4-9. Calculation of Unit Area Loads.

Animal Type	Animals per mi^2	TP Production Rate (lbs TP/animal/day)	Unit Area Load (lbs TP/mi^2/day)
Cow	29	0.12	3.48
Calf	29	0.06	1.74
Yearling	6.4	0.099	0.63

TP loading from public lands grazing is provided by subwatershed and animal type in Table 4-10 and summarized in Table 4-2. These loads were calculated by multiplying the unit area loads from Table 4-9 by the contributing area in each watershed and the number of days that the animals spend on the allotment. It is assumed that the loading rate to the stream is equal to the production rate (i.e., no mineralization, reaction, or degradation occurs). This assumption is conservative. It is also noted that the loads in Table 4-10 represent loading to the streams in subwatersheds 1 and 2 and not to Newton Reservoir.

Table 4-10. Total phosphorus loading to streams from grazing on public lands.

Subwatershed	Contributing Area (mi^2)	Animal Type	Days on Allotment	Total Phosphorus Loading (lbs/year)	Total Phosphorus Loading (kg/yr)
1	1.24	Cow	122	526	239
		Calf	122	263	119
		Yearling	30	23	10
		Total:		**812**	**368**
2	0.63	Cow	122	267	121
		Calf	122	134	61
		Yearling	30	12	5
		Total:		**413**	**187**

Because the loading from grazing animal waste is associated with surface runoff, it is again assumed that the fraction of the annual loading occurring on any given day is equal to the fraction of the total annual surface runoff volume that occurs on that day. The same process used to calculate the monthly contribution of direct stream loads from animal feeding operations was used to determine the average monthly loading contribution to Newton Reservoir from grazing on public land within the watershed. Given this, Table 4-3 lists the average monthly loading of TP to Newton Reservoir from grazing animal waste after accounting for the hydrology and diversions occurring above the reservoir.

4.2.2 Onsite Wastewater Treatment Systems

Annual average loads from onsite wastewater treatment systems (septic tanks) located in subwatersheds 6, 7, and 8 were calculated using information obtained from a septic tank count for these areas. The total number of septic tanks was determined by identifying buildings in these areas that appeared to be occupied homes using aerial photos. Some difficulty was encountered separating houses from sheds, barns, and outbuildings. It is likely that this count is somewhat conservative as it is slightly greater than septic tank densities reported by Lowe et al. (2003). An average discharge of 227 gal/system/day was determined feasible for systems in this area (Lowe et al 2003). An effluent concentration of 18 mg/l TP was used, with 90 percent of this amount assumed to be removed by the soil (Canter and Knox 1985). Table 4-2 lists the average annual TP loading to streams above the reservoir from onsite wastewater treatment systems.

In order to determine the monthly contribution of these loads to the reservoir they were disaggregated to daily loads under the assumption that the total amount of loading that occurs on a given day is equal to the annual loading multiplied by the fraction of the total annual base flow volume that occurs on that day. Again, the period of 1991 - 2001 was used in the simulations. The daily loads were routed downstream to the reservoir using the Newton Watershed Loading Model (accounting for hydrology and diversions) and the resulting daily values at the reservoir were summed to get total monthly values. The monthly values were then averaged across the time period 1991 – 2001 to get the values in Table 4-3 that represent the monthly average loading to Newton Reservoir from onsite wastewater treatment systems.

4.2.3 Nonpoint Source Loads from Overland Flow

Nonpoint source loads from overland flow were calculated using the Newton Watershed Loading Model. These loads represent the amount of TP in overland flow originating from land within the watershed. It is important to note that these loads do not include the loadings calculated above (animal wastes and onsite wastewater treatment systems) or loads associated with groundwater (base flow). Rather, these loads represent the loading contribution of each land use in its base state (i.e., forest with no grazing, agriculture with no manure application, etc.). Appendix A provides a detailed description of the Newton Watershed Loading Model including more information on how these loads were calculated.

In order to calculate nonpoint source loads from overland flow, a land use coverage representing the spatial distribution of existing land use in the watershed was required. Appendix A describes the process and datasets that were used to develop an existing conditions land use dataset for the Newton Watershed. Table 4-11 lists the area of each land use within each subwatershed upstream of Newton Reservoir based on the existing conditions land use dataset, and Table 4-12 lists the land use percent by subwatershed.

The annual average TP transport to stream reaches by subwatershed and land use were computed using the Newton Reservoir Loading Model. Loads to stream reaches from each land use category were calculated on a daily basis for the years 1991 – 2001 and then summed to determine total annual loads to stream reaches for each year. The total annual loads for each year were then averaged over the 1991 – 2001 period. These loads represent annual average loads to stream reaches above the reservoir from each land use category and are shown in Table 4-13.

Table 4-11. Land use area by subwatershed.

Land Use Category	Land Use Area by Subwatershed (km^2)								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CRP Land	0.82	0	0.65	5.28	5.95	1.29	0.003	12	0.73
Forest Land	0.14	0.18	0.07	1.72	1.2	0.9	0	0.02	0.0009
Irrigated Agriculture	0.02	0	0.2	0.88	2.49	1.8	0.55	6.57	1.59
Non-Irrigated Agriculture	7.24	0.009	1.17	3.37	8.02	2.05	0	16.5	2.56
Open Water	0	0	0	0	0	0	0	0	0.43
Range Land	20.6	7.41	4.21	9.83	6.6	3.42	0.0009	4.98	0.45
Urban/Residential	0	0	0	0	0	0.14	0	0.38	0
Wetlands	0	0	0.003	0.007	0.008	0.034	0	0.11	0
Total:	**28.8**	**7.6**	**6.31**	**21.1**	**24.3**	**9.63**	**0.55**	**40.5**	**5.76**

Table 4-12. Land use percent by subwatershed.

Land Use Category	Land Use Percent by Subwatershed								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CRP Land	2.8	0	10.3	25	24.5	13.3	0.5	29.6	12.7
Forest Land	0.5	2.3	1.1	8.2	4.9	9.4	0	0.1	0
Irrigated Agriculture	0.1	0	3.2	4.2	10.3	18.7	99.3	16.2	27.6
Non-Irrigated Agriculture	25.1	0.1	18.6	16	33	21.3	0	40.6	44.4
Open Water	0	0	0	0	0	0	0	0	7.5
Range Land	71.5	97.5	66.7	46.6	27.2	35.5	0.2	12.3	7.8
Urban/Residential	0	0	0	0	0	1.4	0	0.9	0
Wetlands	0	0	0	0	0	0.4	0	0.3	0
Total:	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 4-13. Annual average total phosphorus transport to stream reaches by subwatershed estimated using the Newton Reservoir Loading Model (1991-2001).

Land Use Category	Total Phosphorus Load by Subwatershed (kg)								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CRP Land	0.04	0	0.03	0.26	0.27	0.06	0.0001	0.51	0.03
Forest Land	0.005	0.007	0.003	0.07	0.05	0.03	0	0.0006	0
Irrigated Agriculture	0.03	0	0.33	1.27	3.21	2.41	0.58	8.03	1.99
Non-Irrigated Agriculture	9.77	0.01	1.33	3.28	6.19	2.73	0	14.2	2.53
Open Water	0	0	0	0	0	0	0	0	0
Range Land	1.11	0.43	0.24	0.57	0.39	0.18	0	0.22	0.02
Urban/Residential	0	0	0	0	0	0.09	0	0.21	0
Wetlands	0	0	0.0001	0.0004	0.0004	0.002	0	0.004	0
Total:	**11.0**	**0.45**	**1.93**	**5.45**	**10.1**	**5.50**	**0.58**	**23.2**	**4.57**

The annual average TP transport to stream reaches by land use category was next calculated by summing the contribution of each land use category across all drainages. These loads represent transport to stream reaches above the reservoir prior to diversion and are listed in Table 4-14.

Table 4-14. Annual average total phosphorus transport to stream reaches summarized by land use category (1991-2001).

Land Use Category	Total Phosphorus Load (kg)
CRP Land	1.2
Forest Land	0.2
Irrigated Agriculture	17.8
Non-Irrigated Agriculture	40.0
Open Water	0
Range Land	3.2
Urban/Residential	0.3
Wetlands	0.01
Total:	**62.7**

Monthly average loadings to Newton Reservoir from nonpoint sources caused by overland flow were calculated using the results of the Newton Watershed Loading Model. The daily loads from all land uses were summed and routed downstream to the reservoir by the model, which accounts for hydrology and streamflow diversions occurring above the reservoir. The daily loads at the reservoir were then summed to get monthly values for each month in the period 1991 – 2001. These monthly values were then averaged over the 1991 – 2001 period to generate the values listed in Table 4-3.

4.2.4 Groundwater Background

Average monthly loadings of TP to Newton Reservoir from groundwater (base flow) were calculated by assuming an average groundwater concentration of 0.01 mg/L TP. This concentration was applied to base flow in the Newton Watershed Loading Model resulting in daily loads to the reservoir from groundwater for the 1991 – 2001 period. The daily loads were then summed to get monthly loads, and the monthly loads were averaged across the 1991 – 2001 period resulting in the loads shown in Table 4-3. As discussed in Chapter 3, samples have been collected from wells in the Clarkston area that indicate higher concentrations of TP (ranging from 0.03 mg/l to 0.19 mg/l). A lower, more conservative value was selected for modeling purposes based on the following assumptions:

- Samples were collected from five wells located within or adjacent to Clarkston. Lowe and Wallace (1999) indicated that these wells may be influenced by a local fault zone or from nearby pollutant sources. No samples were taken from undeveloped areas in the upper watershed where groundwater quality is likely of higher quality, or below Clarkston in the Newton area.

- Well depths for three of the five sample sites were 70 feet or greater. Groundwater quality at these depths may not be representative of groundwater that enters the Clarkston Creek or Newton Creek stream channels.

4.2.5 Newton Reservoir Source Summary

Table 4-15 and Figure 4-4 summarize the estimates of TP loading to Newton Reservoir by major source category. The bulk of the loading to the reservoir is from animal wastes applied to agricultural land (67 percent). Direct stream loading from animal feeding operations and grazing on public lands account for approximately 15 percent and 12 percent respectively. These are followed by much smaller contributions from onsite wastewater treatment systems, nonpoint source loads from overland flow, and groundwater background.

The Newton Watershed Loading Model was run on a daily basis for the period 1991 – 2001 accounting for all of the existing loadings to simulate the total loading to Newton Reservoir. Table 4-16 and Figure 4-5 summarize the loadings to Newton Reservoir from all sources as monthly averages. Average monthly values were calculated by summing the daily loading values in each month and then averaging each month across the 1991 – 2001 period.

It is clear that the majority of loading occurs during the spring and winter months with much smaller loadings occurring during the summer months. This is expected as all of these loads are related to streamflow, which is highest March through April.

It is apparent that modeled TP loads to Newton Reservoir are higher than calculated TP loads. A direct comparison between modeled loads determined in this assessment and calculated loads is difficult due to the different processes that are incorporated into each respective value. The annual modeled load provided in Table 4-2 above indicates the TP loads that reach the Clarkston Creek stream channel or in other words how much phosphorus is getting into the stream. These values do not indicate how much TP is transported downstream by streamflow. The calculated loads reported in Chapter 3 are a measure of how much loading is being transported by the streamflow as they are calculated from values of streamflow and TP concentration. It is likely that during some years there are transport limitations in Clarkston Creek during portions of the year due to low or even zero flows. As a result, even though TP is loaded to the stream channel from animal feeding operations or other sources directly in contact with the stream channel, loads may not immediately be transported downstream and would not be measured in the instream concentrations.

Table 4-15. Summary of annual average total phosphorus loads to Newton Reservoir by source category.

Loading Source	Total Phosphorus Loading (kg/yr)
Animal Wastes	
Direct Stream Loading from Animal Feeding Operations	556
Loading from Land - Applied Manure	2,453
Loading from Grazing on Public Land	419
Onsite Wastewater Treatment Systems	68.6
Nonpoint Source Loads from Overland Flow	52.1
Groundwater Background	86
Total:	**3,635**

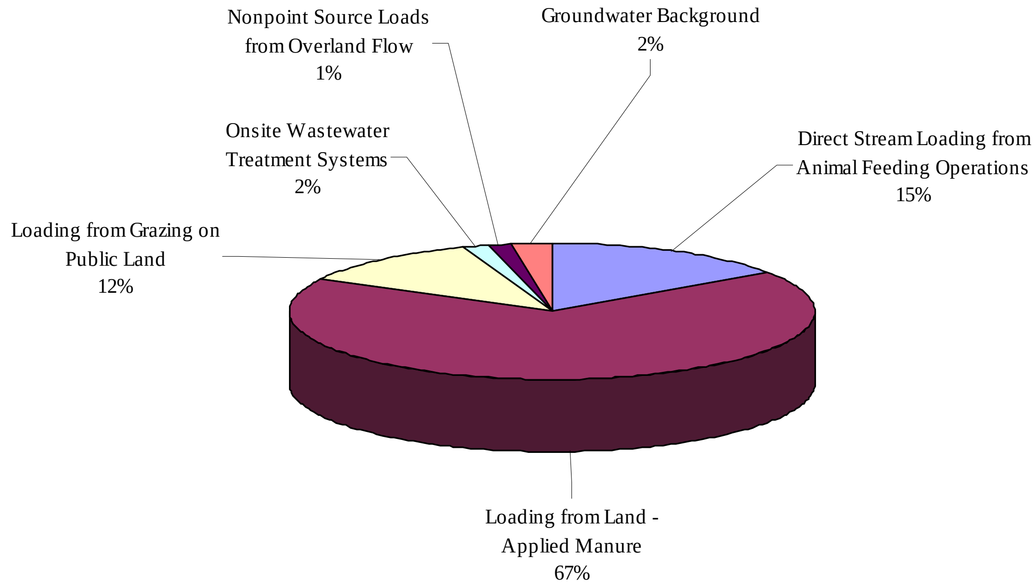

Figure 4-4. Summary of annual average total phosphorus loading to Newton Reservoir by source category.

Table 4-16. Summary of monthly average total phosphorus loads to Newton Reservoir from all sources (1991-2001).

Month	Total Phosphorus Load (kg)
January	226
February	178
March	925
April	1,091
May	278
June	63
July	10
August	28
September	71
October	147
November	244
December	374
Total:	**3,635**

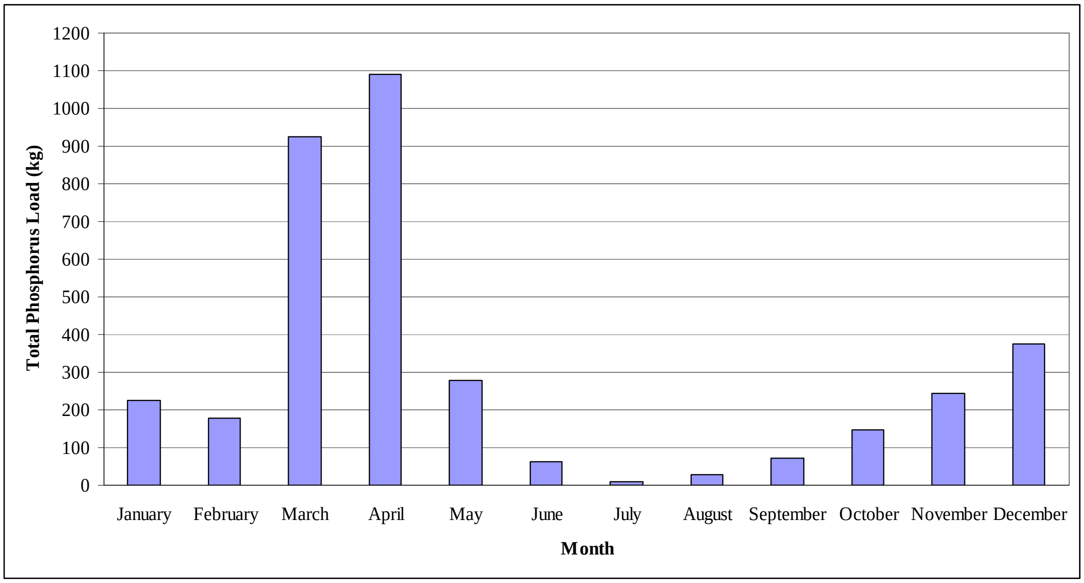

Figure 4-5. Monthly average total phosphorus loads to Newton Reservoir from all sources (1991-2001).

4.3 TOTAL PHOSPHORUS LOADING TO NEWTON CREEK

The following sections describe the loadings from the major sources that have been identified to Newton Creek below Newton Reservoir. Sources of TP loading to Newton Creek that have been identified and that are summarized in the following sections include:

1. Animal Wastes
    - Direct stream loading from animal feeding operations
    - Land applied animal wastes
2. Onsite wastewater treatment systems
3. Nonpoint source loads from overland flow
4. Groundwater background

The geographical location of each of these pollutant sources is shown in Figure 4-2. The best available data was used to initially determine the location of potential pollutant sources and later refined and verified during field visits to the Newton Creek watershed. The following sections describe the loading to Newton Creek from the sources listed above.

Average annual TP loads entering Newton Creek were calculated by subwatershed and are included in Table 4-17 below. Average monthly TP loads to Newton Creek are included in Table 4-18. Specific information regarding how TP loads were calculated for each pollutant source contributing to Newton Creek is provided below in Sections 4.3.1 through 4.3.4.

Table 4-17. Average annual loading of total phosphorus (kg) by subwatershed.					
Subwatershed	**Direct stream loading from AFOs**	**Land applied animal wastes**		**Onsite Wastewater Treatment Systems**	**NP Loads from Overland Flow**
		Amount Applied to Land	**Load to Stream**		
10	1,513	2,609	989	11.3	37.7
11	1,208	787	299	10.7	8.12
12	437	0	0	1.1	12.6
Total	**3,218**	**3,396**	**1,288**	**23.1**	**58.4**

Table 4-18. Average monthly loading of total phosphorus (kg) to Newton Creek (1991-2001).					
Month	**Direct stream loading from AFOs**	**Land applied animal wastes**	**Onsite Wastewater Treatment Systems**	**NP Loads from Overland Flows**	**Groundwater**
January	25.6	53.4	0.69	0.50	0.46
February	17.4	38.1	0.64	0.31	0.43
March	82.1	250	1.00	1.51	0.67
April	331.4	472.7	2.32	6.06	1.54
May	495.9	12.3	3.44	9.02	2.30
June	824.9	0	4.56	14.95	3.00
July	731.9	0	4.05	13.21	2.65
August	514.6	162.2	3.01	9.30	1.97
September	133.2	92.2	1.28	2.41	0.85
October	23.1	40.2	0.78	0.42	0.53
November	16.2	63.8	0.69	0.30	0.46
December	21.7	103.1	0.69	0.39	0.46
Total	**3,218**	**1,288**	**23.1**	**58.4**	**15.3**

4.3.1 Animal Wastes

Animal wastes generated in the Newton Creek watershed are produced by AFOs located directly on Newton Creek as well as other facilities located away from the creek. Several AFOs in the Newton Creek watershed apply manure to areas of land that in turn contribute surface runoff to Newton Creek.

4.3.1.1 Direct Stream Loading from Animal Feeding Operations

Table 4-17 lists the amount of direct stream loading from animal waste generated at animal feeding operations by subwatershed. The numbers in Table 4-17 represent TP loadings in surface runoff originating in animal feeding operations that flows directly into the stream. These loads were calculated using the same procedure described above for the stream reaches above Newton Reservoir. It is assumed that the sum of these loads represents the total loading to Newton Creek.

Monthly average loads to Newton Creek were calculated using the same method described above for the watersheds above Newton Reservoir. Table 4-18 lists the monthly average values for the contribution of the direct stream loadings from animal feeding operations to Newton Creek.

4.3.1.2 Loading from Land Applied Animal Wastes

The same mass balance approach described above for the subwatersheds above Newton Reservoir was used to calculate the TP loading to Newton Creek in the subwatersheds below Newton Reservoir from land-applied animal wastes. Table 4-17 lists the amount of TP applied to land within each subwatershed and the amount of the land-applied TP that reaches the stream as loading from overland flow on an annual basis. Table 4-18 lists the monthly average loading to Newton Creek from land-applied animal wastes.

4.3.2 Onsite Wastewater Treatment Systems

Annual and monthly average loads from onsite wastewater treatment systems located below Newton Reservoir were calculated using the same method described above. Table 4-17 lists the average annual TP loading from onsite wastewater treatment systems to Newton Creek by subwatershed and Table 4-18 lists the monthly average TP loading from onsite wastewater treatment systems to Newton Creek.

4.3.3 Nonpoint Source Loads from Overland Flow

Annual and monthly average nonpoint source loads from overland flow were calculated using the same approach described above for the subwatersheds above the reservoir. Table 4-19 lists the area of each land use within each subwatershed downstream of Newton Reservoir based on the existing conditions land use dataset, and Table 4-20 lists the land use percent by subwatershed.

Table 4-21 shows the annual average TP loads to Newton Creek by subwatershed and land use category. The total annual average TP transport to Newton Creek by land use category was again calculated by summing the contribution of each land use category across all subwatersheds. These loads are listed in Table 4-22.

Table 4-19. Land use area by subwatershed for the area below Newton Reservoir.

Land Use Category	Land Use Area by Subwatershed (km^2)		
	10	**11**	**12**
CRP Land	0.63	0	0
Forest Land	0	0	0
Irrigated Agriculture	3.0	0.96	1.45
Non-Irrigated Agriculture	1.6	0	0
Open Water	0.006	0	0
Range Land	1.8	0.05	0.0009
Urban/Residential	0.0009	0.005	0
Wetlands	0	0	0
Total:	**7.0**	**1.0**	**1.45**

Table 4-20. Land use percent by subwatershed for the area below Newton Reservoir.			
Land Use Category	**Land Use by Subwatershed (%)**		
	10	**11**	**12**
CRP Land	9.0	0	0
Forest Land	0	0	0
Irrigated Agriculture	43.2	94.8	99.9
Non-Irrigated Agriculture	22.2	0	0
Open Water	0.1	0	0
Range Land	25.6	4.7	0.1
Urban/Residential	0	0.5	0
Wetlands	0	0	0
Total:	**100**	**100**	**100**

Table 4-21. Annual average total phosphorus transport to Newton Creek by subwatershed and land use category (1991-2001).			
Land Use Category	**Total Phosphorus Load (kg)**		
	10	**11**	**12**
CRP Land	0.20	0	0
Forest Land	0	0	0
Irrigated Agriculture	23.5	8.09	12.6
Non-Irrigated Agriculture	13.4	0	0
Open Water	0	0	0
Range Land	0.57	0.014	0.0003
Urban/Residential	0.004	0.022	0
Wetlands	0	0	0
Total:	**37.7**	**8.12**	**12.6**

Table 4-22. Annual average total phosphorus transport to Newton Creek summarized by land use category (1991-2001).	
Land Use Category	**Total Phosphorus Load (kg)**
CRP Land	0.20
Forest Land	0
Irrigated Agriculture	44.2
Non-Irrigated Agriculture	13.4
Open Water	0
Range Land	0.58
Urban/Residential	0.03
Wetlands	0
Total:	**58.4**

Monthly average loadings to Newton Creek from nonpoint sources caused by overland flow were next calculated and are shown in Table 4-18.

4.3.4 Groundwater Background

Average monthly loadings of TP to Newton Creek from groundwater (base flow) were calculated using the same assumptions of an average groundwater concentration of 0.01 mg/L TP discussed in section 4.1.1.4 above. As was done in the subwatersheds above Newton Reservoir, this concentration was applied to base flow in Newton Creek, and the monthly loads were calculated for the 1991 – 2001 period resulting in the loads shown in Table 4-18.

4.3.5 Newton Creek Source Summary

The estimates of TP loading to Newton Creek are summarized in Table 4-23 and Figure 4-6 by major source category. The bulk of the loading to Newton Creek is from direct stream loading from animal feeding operations (70 percent). Loading from animal wastes applied to agricultural land are second in magnitude and account for approximately 28 percent of the total loading. These loads are followed by much smaller contributions from onsite wastewater treatment systems, nonpoint source loads from overland flow, and groundwater background.

Table 4-23. Summary of annual average total phosphorus loads to Newton Creek by source category.

Loading Source	Total Phosphorus Loading (kg/yr)
Animal Wastes	
Direct Stream Loading from Animal Feeding Operations	3,218
Loading from Land - Applied Manure	1,288
Onsite Wastewater Treatment Systems	23.1
Nonpoint Source Loads from Overland Flow	58.4
Groundwater Background	15.3
Total:	**4,603**

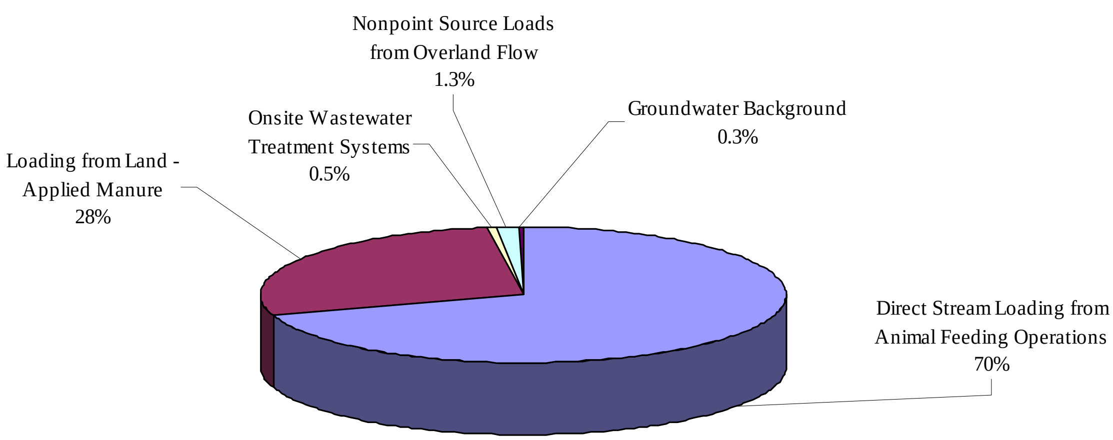

Figure 4-6. Summary of annual average total phosphorus loading to Newton Creek by source category.

The Newton Watershed Loading Model was run on a daily basis for the period 1991 – 2001 accounting for all of the existing loadings to simulate the total loading to Newton Creek. Table 4-24 and Figure 4-7 summarize the loadings to Newton Creek from all sources as monthly averages. Again, average monthly values were calculated by summing the daily loading values in each month and then averaging each month across the 1991 – 2001 period.

It is clear that the majority of loading occurs during the spring and summer months with much smaller loadings occurring during the winter months. This is expected as there is very little flow in Newton Creek during the winter due to the fact that no water is released from Newton Reservoir. In addition, agricultural return flows account for a significant portion of stream flow during the summer.

A review of modeled loads contained in Table 4-24 and calculated loads presented in Chapter 3 that were based on existing water quality data indicate that modeled TP loads are higher than calculated TP loads. Reasons for these differences include the rationale mentioned above for Newton Reservoir. Additional information describing the assumptions, methods, and data used in this modeling effort can be found in Appendix A.

Table 4-24. Summary of monthly average total phosphorus loads to Newton Creek from all sources (1991-2001).

Month	Total Phosphorus Load (kg)
January	81
February	57
March	335
April	814
May	523
June	847
July	752
August	691
September	230
October	65
November	81
December	126
Total:	4,603

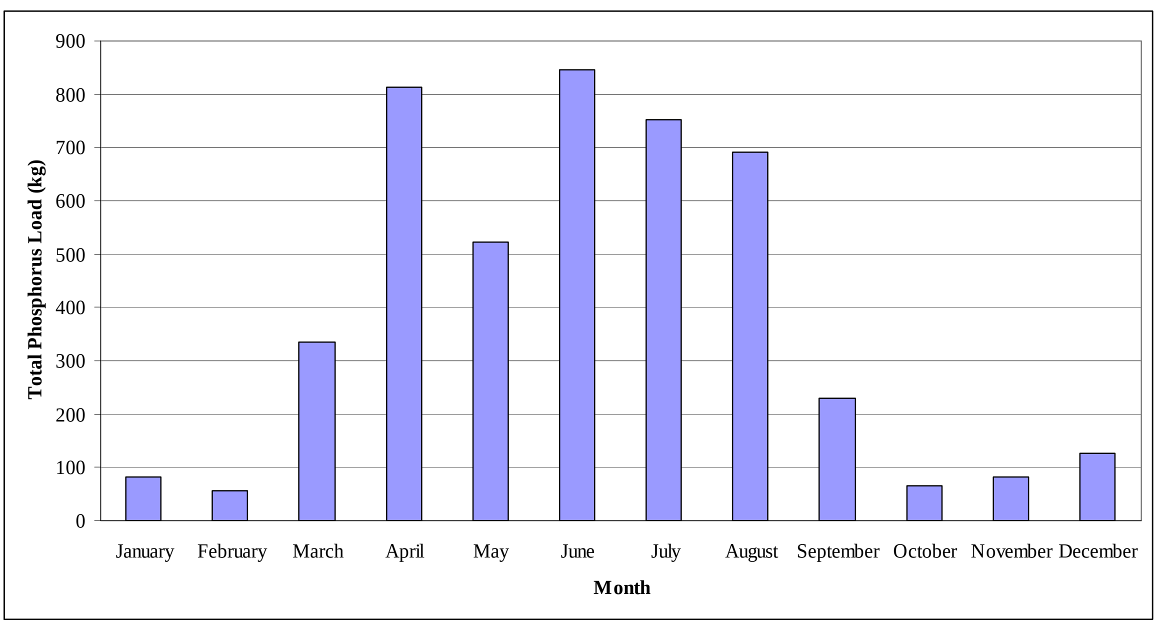

Figure 4-7. Monthly average total phosphorus loads to Newton Creek from all sources (1991-2001).

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CHAPTER 5: TMDL ANALYSIS

This chapter includes a TMDL analysis for Newton Reservoir and Newton Creek based on load calculations for all substantial pollutant sources contributing to water quality impairment in the Newton/Clarkston watershed. This analysis will be used to define the link or relationship between the water quality endpoints recommended below and the identified pollutant sources described in Chapter 4. The selection of this approach was based on several factors including the following:

- Size of project area
- Necessary level of detail
- Data availability
- Resource availability

It is believed that the modeling efforts described below incorporate the necessary level of detail to define the assimilative capacity of Newton Reservoir and Newton Creek and accurately define pollutant load reductions. It should be noted here that the modeling effort included in this chapter is based upon an assessment of existing water quality data, measured field conditions specific to the project area, and best professional judgement.

5.1 WATER QUALITY TARGETS

In order to determine the permissible loadings to Newton Reservoir and to Newton Creek, acceptable water quality targets or TMDL endpoints must be set. These endpoints define the conditions under which the beneficial use of these water bodies will be protected, and allow the evaluation of management options in terms of their overall effect on water quality. In general, TMDL endpoints are defined in terms of existing numeric water quality criteria. Although in some cases these numeric criteria are over or under protective of the beneficial use, they have been set at levels that have historically been observed to protect the beneficial use of the waters for which they are specified.

Existing numeric water quality criteria for the State of Utah specify that for lakes and reservoirs designated as Class 3A waters the TP concentration must be below 0.025 mg/l. These values will be used as initial endpoints for the TMDL for Newton Reservoir. DO standards for Class 3A waters also indicate that concentrations should not fall below 4.0 mg/l for adult aquatic life or 8.0 mg/l for early stage aquatic life. It is believed that attainment of the TP endpoint of 0.025 mg/l will subsequently allow selected DO standards to be met. Existing and potential future loadings to Newton Reservoir from Clarkston Creek and areas surrounding the reservoir will be evaluated in terms of the requirement that a TP concentration of 0.025 mg/l be maintained in the reservoir or that attainment of alternative established endpoints will be met.

In addition to TP concentration endpoints, the following endpoints were selected to evaluate attainment of water quality standards:

1. A shift from blue-green algal dominance to green algal dominance.
2. A TSI value in the reservoir not to exceed 50.
3. Dissolved oxygen concentration of 4.0 mg/l for greater than 50 percent of the water column.

Newton Creek and Clarkston Creek are also designated as a Class 3A water bodies and are protected for cold water aquatic life. The State of Utah numeric water quality criteria specify that streams with this designation must maintain a TP concentration below 0.05 mg/L and DO concentrations that do not fall below 4.0 mg/l for adult aquatic life or 8.0 mg/l for early stage aquatic life. A TP concentration of 0.05 mg/l will be used as the endpoint for the TMDL for Newton Creek. It is believed that as the TP endpoint of 0.05 mg/l is met that DO standards will subsequently be achieved. Existing and potential future loadings to Newton Creek will be evaluated in terms of the requirement that a TP concentration of 0.05 mg/L be maintained in Newton Creek.

5.2 PERMISSIBLE LOADINGS

5.2.1 Newton Reservoir

Using a TP endpoint concentration of 0.025 mg/L for Newton Reservoir, the magnitude of the permissible loadings to the reservoir were calculated so that reductions to existing loadings could be specified in efforts to meet the TP endpoint. Permissible loadings were calculated using a TP budget model for Newton Reservoir. This mass balance model, suggested by Chapra (1997) and first formulated by Vollenweider (1976), simulates the TP concentration in the reservoir by accounting for TP in the reservoir inflow, TP in the reservoir outflow, and the loss of TP due to settling. This model is given by the following equation:

$$V\frac{dP}{dt} = W - QP - vA_s P \qquad (1)$$

Where: V = Reservoir volume (m^3)
P = TP concentration (kg/m^3)
t = time (day)
W = TP inflow loading rate (kg/day)
Q = Outflow (m^3/day)
v = TP settling velocity (m/day)
A_s = Reservoir surface area (m^2)

The maximum permissible loadings to the reservoir were calculated by determining the magnitude of loadings that will maintain a constant, maximum concentration of 0.025 mg/L in the reservoir. To accomplish this, the TP concentration in the reservoir (P) was held at 0.025 mg/L and was not allowed to change with time. Therefore, dP/dt = 0 and Equation 1 reduces to:

$$0 = W - QP - vA_s P \qquad (2)$$

Now, Equation 2 can be rearranged to solve for the loading rate (W):

$$W = P(Q + vA_s) \qquad (3)$$

The TP concentration can be held constant, but the nature of Newton Reservoir is that the inflows, outflows, volume, and surface area fluctuate widely throughout the year. Because of this, it is important to account for permissible loadings on a daily basis. The permissible annual loading to the reservoir, then, is the sum of the daily loadings for the entire year. Equation 4 shows how the total annual permissible loading is calculated.

$$W_{Ann} = P\sum_{i=1}^{365}\left(Q_i + vA_{s,i}\right) \tag{4}$$

Where: W_{Ann} = Permissible annual loading rate (kg/yr)
P = 0.000025 kg/m^3 (0.025 mg/L)
Q_i = Outflow rate on day i (m^3/day)
$A_{s,i}$ = Reservoir surface area on day i (m^2)

It should be noted that the simple phosphorus budget model used here is subject to the following assumptions:

1. The reservoir is well mixed.

   This is likely true of Newton Reservoir for most of the year. The rates of drawdown and filling in the reservoir are relatively quick, and with irrigation drawdown occurring during the summer the reservoir has little chance to develop a stable stratification that would lead to incomplete mixing. In addition, the reservoir is small enough and shallow enough that significant wind storms would cause mixing to occur.

2. The interaction of the water column with the sediments is neglected.

   Although potentially significant, little information is available about potential internal loading to the reservoir from phosphorus released from the bottom sediments. Flux of phosphorus from sediments only occurs during times of very low dissolved oxygen concentration and is affected by the character of the sediments. Although low dissolved oxygen concentrations do occur at depth in Newton Reservoir, the magnitude of loading from phosphorus releases from the sediments is likely much smaller than the terms that are accounted for in the budget model. Based on available data and information, conditions resulting in phosphorus release from the sediments (dissolved oxygen concentrations less than 0.5 mg/L) are inconsistent in Newton Reservoir and potentially short lived when they do occur due to the lack of a stable stratification that lasts for long periods of time. Currently available data, however, are inadequate to determine the duration and extent of low dissolved oxygen concentrations at depth in the reservoir.

In order to evaluate Equation 4, the reservoir outflow rate and surface area must be known on a daily basis. A simple water budget model for the reservoir was developed for this and other purposes. Equation 5 (Chapra 1997) shows the water balance model for the reservoir:

$$\frac{dV}{dt} = Q_{in} - Q_{out} + G + pA_s - EA_s \tag{5}$$

Where: Q_{in} = Inflow (m^3/day)
Q_{out} = Outflow (m^3/day)
G = Groundwater flow (m^3/day)
p = Precipitation (m/day)
E = Evaporation (m/day)

Equation 6 shows how equation 5 was evaluated on a daily basis to solve for the reservoir volume.

$$V_t = V_{t-1} + V_{in,t} - V_{out,t} + V_{G,t} + p_t A_{s,t-1} - E_t A_{s,t-1} \tag{6}$$

Where:
V_t = Reservoir volume at the end of time interval t (m^3)
V_{t-1} = Reservoir volume at the end of time interval t-1 (m^3)
$V_{in,t}$ = Inflow volume in time interval t (m^3)
$V_{out,t}$ = Outflow volume in time interval t (m^3)
$V_{G,t}$ = Groundwater flow in time interval t (m^3)
p_t = Precipitation in time interval t (m)
$A_{s,t-1}$ = Reservoir surface area at the end of time interval t-1 (m^2)
E_t = Evaporation in time interval t (m)

The reservoir surface area is solved for as a function of reservoir volume according to the following regression equation that was derived from an area capacity table created as part of the original plans for the reservoir by the U.S. BOR (U.S. Bureau of Reclamation 1942).

$$A_{s,t} = (6E-15) \cdot V_t^3 - (5E-8) \cdot V_t^2 + 0.2751 \cdot V_t \tag{7}$$

Since no reliable reservoir outflow data are available, Appendix A provides details on how the reservoir releases were calculated. This appendix also provides details on how the inflows to the reservoir were determined. Net groundwater flows are assumed to be zero (groundwater inflow = groundwater outflow). Precipitation and evaporation were estimated based on data from the Utah Climate Center from a weather station at Cutler Dam, located just to the south and west of the Newton Watershed.

The reservoir water budget model was run on a daily time step for the years with available input data (1991-2001) to produce a daily output time series of reservoir volume, surface area, inflow, and outflow. The results of the water budget model (reservoir outflow and surface area) were then used on a daily basis to evaluate Equation 4. The result of the evaluation of Equation 4 is a daily time series of permissible loadings to Newton Reservoir based on a desired endpoint concentration of 0.025 mg/L TP in the reservoir.

According to Chapra (1997), the TP settling velocity (v) typically ranges from 5 to 20 m/yr (0.0137 to 0.0548 m/day). This settling velocity is related to the uptake of phosphorus by algae and their subsequent growth, death, and settling. The settling velocity is also related to the settling velocity of phosphorus attached to particulate matter. The midpoint of the range suggested by Chapra (12.5 m/yr or 0.0342 m/day) was used to calculate permissible loadings to Newton Reservoir.

In general, the higher the value of the settling rate, the more TP is lost via settling and the higher the permissible loading to the reservoir. Table 5-1 lists the permissible loadings to the reservoir by simulation year for several different values of the settling velocity, including the one chosen to predict the permissible loadings (shown in bold type). Daily loading values simulated using the model described above were summed to produce the annual values shown in Table 5-1. Table 5-2 lists the permissible monthly average loadings to the reservoir calculated using the different values for the settling velocity. Monthly values were generated by summing the daily values to get total monthly loadings for each month, and then averaging each month across the 1991 – 2001 period.

Table 5-1. Permissible annual loadings to Newton Reservoir by simulation year.				
	Permissible Loading (kg)			
Simulation Year	**v = 5 m/yr**	**v = 10 m/yr**	**v = 12.5 m/yr**	**v = 20 m/yr**
1991	232	285	**312**	392
1992	142	178	**195**	248
1993	194	232	**251**	308
1994	242	294	**320**	399
1995	244	296	**322**	400
1996	249	306	**335**	421
1997	439	567	**630**	822
1998	299	415	**473**	649
1999	325	440	**497**	670
2000	335	421	**464**	593
2001	236	292	**319**	404
Average:	267	339	**374**	482

Table 5-2. Monthly average permissible loadings to Newton Reservoir (1991-2001).				
	Permissible Load (kg)			
Month	**v = 5 m/yr**	**v = 10 m/yr**	**v = 12.5 m/yr**	**v = 20 m/yr**
January	5.5	11.0	**13.7**	22.0
February	6.2	12.4	**15.5**	24.8
March	9.3	17.8	**22.1**	35.0
April	33.9	44.0	**49.0**	64.3
May	42.1	52.9	**58.2**	74.3
June	61.0	69.6	**73.8**	86.6
July	54.3	59.3	**61.7**	69.1
August	29.9	32.1	**33.1**	36.4
September	9.1	10.8	**11.6**	14.1
October	3.7	6.7	**8.2**	12.8
November	4.4	8.8	**10.9**	17.5
December	7.7	13.5	**16.5**	25.3
Total:	267	339	**374**	482

5.2.2 Newton Creek

Permissible loads to Newton Creek were calculated by multiplying the daily flows for the period between 1991 and 2001 by the TMDL endpoint concentration of 0.05 mg/L and the appropriate units conversion factors. The daily load values were then summed to get monthly values and the monthly values were averaged across the 1991 – 2001 period. Table 5-3 shows the average monthly and average annual (the sum of the average monthly values) permissible loadings to Newton Creek.

Table 5-3. Monthly and annual average permissible total phosphorus loadings to Newton Creek.

Month	Permissible Load (kg)
January	2.37
February	2.16
March	3.42
April	8.14
May	12.06
June	16.03
July	14.19
August	10.54
September	4.42
October	2.67
November	2.33
December	2.35
Average Annual:	**81**

5.3 SEASONALITY

The Clean Water Act requires that TMDLs include seasonality. Seasonality is addressed in this TMDL through the calculation of actual and permissible loadings to Newton Reservoir and to Newton Creek on an annual and monthly basis. In both cases, the models used in the calculations were run over an 11-year time period, and as such, the calculated loads reflect seasonal changes in weather, streamflow, and other conditions that may change from year to year. However, the annual load associated with the TMDL for Newton Reservoir will be the primary value used in determining compliance. Streamflow rates in Newton Creek are influenced by seasonal changes, therefore determining compliance with the TMDL for Newton Creek will need to look at critical low flow conditions.

5.4 MARGIN OF SAFETY

The Clean Water Act also requires that TMDLs include a margin of safety. Generally, this margin of safety is incorporated into the TMDL via the use of conservative assumptions or is specified explicitly by reserving a particular amount of the permissible loading as a margin of safety. In general, this TMDL uses conservative assumptions to address the margin of safety. Conservative assumptions have been made in some of the loading calculations and are discussed, where applicable, in the text of this report. It should be noted that some degree of uncertainty is associated with using a TP pollution indicator value of 0.05 mg/l for streams as well as the fairly strict endpoint of 0.025 mg/l TP for reservoirs. Future monitoring of waterbodies in the TMDL project area may show that the TP endpoint could be higher. The TMDLs provided for Newton Reservoir and Newton Creek will be evaluated in the future as BMPs are implemented and additional WQ data is acquired.

5.5 FUTURE GROWTH

Population projections show that loading to Newton Reservoir from onsite wastewater treatment systems will increase from 83.1 kg/yr to 116 kg/yr (33 kg difference) and loading to Newton Creek from onsite wastewater treatment systems will increase from 23.1 kg/yr to 27.2 kg/yr (4 kg difference). No other potential future loadings are expected to be significant. Therefore, 33 kg of the permissible loading to Newton Reservoir and 4 kg of the permissible loading to Newton Creek will be allocated to future growth. A detailed description of future conditions anticipated in the Newton/Clarkston watershed is included in Chapter 7.

5.6 TMDL LOAD ALLOCATIONS

5.6.1 Newton Reservoir

The loading summary for Newton Reservoir is shown in Table 5-4. The necessary reduction of TP loading to Newton Reservoir is approximately 3,294 kg/yr (91 percent). Table 5-5 shows the allocation of the remaining permissible loadings to the different major source categories identified above and the required reductions in loading.

Table 5-4. Loading Summary for Newton Reservoir.

Loading Category	Total Phosphorus Loading (kg/yr)
Existing Loads	3,635
Permissible Loads (Loading Capacity)	374
Reserve for Future Growth	33
Load Allocation	341
Necessary Reduction	3,294

Table 5-5. Allocation of permissible loadings to Newton Reservoir by major source category.

Loading Source	Existing Total Phosphorus Loading (kg/yr)	Required Load Reduction (kg/yr)	Load Allocation (kg/yr)
Animal Wastes			
Direct Stream Loading from AFOs	556	519.6	36.4
Loading from Land - Applied Manure	2,453	2,314	139
Loading from Grazing on Public Land	419	368.5	50.5
Onsite Wastewater Treatment Systems	68.6	53.1	15.5
Nonpoint Source Loads from Overland Flow	52.1	38.3	13.8
Groundwater Background	86	0	86
Total	**3,635**	**3,294**	**341**

5.6.2 Newton Creek

The loading summary for Newton Creek is shown in Table 5-6. The necessary reduction of TP loading to Newton Creek is approximately 4,526 kg/yr (98 %). Table 5-7 shows the allocation of the remaining permissible loadings to the different major source categories identified above and the required reductions in loading.

Table 5-6. Loading Summary for Newton Creek.	
Loading Category	**Total Phosphorus Loading (kg/yr)**
Existing Loads	4,603
Permissible Loads (Loading Capacity)	81
Reserve for Future Growth	4
Load Allocation	77
Necessary Reduction	4,526

Table 5-7. Allocation of permissible loadings to Newton Creek by major source category.			
Loading Source	**Existing Total Phosphorus Loading (kg/yr)**	**Required Load Reduction (kg/yr)**	**Load Allocation (kg/yr)**
Animal Wastes			
Direct Stream Loading from AFOs	3,218	3,204.6	13.4
Loading from Land - Applied Manure	1,288	1,274.6	13.4
Onsite Wastewater Treatment Systems	23.1	7.4	15.7
Nonpoint Source Loads from Overland Flow	58.4	39.2	19.2
Groundwater Background	15.3	0	15.3
Total:	**4,603**	**4,526**	**77**

CHAPTER 6: PROJECT IMPLEMENTATION PLAN

In order to achieve water quality targets and TMDL endpoints, it will be necessary to implement Best Management Practices (BMP). BMPs are practices used to protect the physical and biological integrity of surface and groundwater, primarily with regard to nonpoint sources of pollution. BMPs are most effective when combined to create a BMP system that will comprehensively reduce or eliminate pollution from a single source. It should be noted that no single BMP system is considered to be the most effective way of controlling a particular pollutant in all situations. Rather, the design of a BMP system should consider local conditions that are known to influence the production and delivery of nonpoint source pollutants. The design of a BMP system should not only account for the type and source of pollutant, but should also consider background factors such as the physical, climatic, biological, social, and economic setting.

If point sources had been identified within the Newton/Clarkston watershed, practices typically described as Best Available Technology (BAT) have been recommended to reduce pollutant loads. As no permitted point sources have been identified in the study area, no BATs are recommended in this chapter.

BMPs applied to the Newton/Clarkston watersheds should include both structural and nonstructural techniques. Structural BMPs require a physical structure and a cash outlay to install and include creation of vegetative buffer strips along stream channels and reservoirs, re-establishment of vegetation in critical riparian areas, restricting cattle access to stream channels and reservoir banks, and reinforcing or stabilizing eroded areas along these same water bodies. Nonstructural techniques include practices such as improved timing of fertilizer application, tillage practices, and grazing operations. The BMPs recommended in this chapter are based upon NRCS-approved conservation practices provided in the Field Office Technical Guide used by Utah NRCS field offices. This guide contains practices that are specific to the State of Utah as well as those that are generally applied to all states.

A list of BMPs specific to the pollutant source and location in the project area is provided in this chapter, along with the estimated costs to implement these practices. Site-specific BMPs and loading analysis were developed in cooperation with local and state NRCS offices. All confidential information has been retained in NRCS case files for specific producers. This information will be available for future source assessment and progress reporting in the TMDL project area. BMP cost estimates are based upon summaries obtained from the FY 2003 Practice Cost List utilized by the NRCS and reflect costs specific to Cache County, UT. BMPs should be applied to reduce loadings from the major pollutant source categories identified in the project area including AFO/CAFOs, lands receiving fertilizer applications (including manure and commercial forms of fertilizer), grazing on public lands, and on-site wastewater treatment systems (septic tanks). Finally, tables indicating the amounts of pollutant load reduction that are expected to result from implementation of these practices are provided.

The pollutant loads quantified in Chapter 5 should be primarily interpreted in terms of the relationship they indicate rather than their magnitudes. As is the case with many computer models, the exact magnitudes of input parameters are not known, and we must rely upon estimations based on the best information available, knowledge of local conditions that influence surface runoff and transport, and professional judgement. When the necessary data was not available for locations within the project area, conservative assumptions were made and may have overestimated some processes. To the degree that modeled loads were overestimated, the TMDLs outlined in Chapter 5 could be reached earlier in the process of achieving water quality endpoints, making some of the more restrictive practices unnecessary.

6.1 EXISTING STATUS OF BMPS

A substantial effort is currently underway to reduce pollutant loading through the implementation of BMPs in the form of Conservation Nutrient Management Plans (CNMPs). These plans are developed by the landowners in cooperation with the local NRCS office. Of the 17 AFO/CAFOs identified in the project area, three facilities are known to have completed CNMPs including one plan that was designed in the early 1980s without NRCS participation. Nine additional AFO/CAFOs are currently working with the NRCS to develop CNMPs that will be completed within the next 5 years. The status of the remaining five operations with respect to development of nutrient management plans is not known at this time.

An effort was made to obtain information regarding NRCS-recommended CNMPs for AFO/CAFO operations in the project area. A summary of BMPs and estimated cost-share dollars that are currently planned for implementation on nine AFO/CAFOs in the project area is provided below in Table 6-1. These improvement projects are supported by funds from the Environmental Quality Incentives Program (EQIP). Dollar amounts shown in Table 6-1 reflect funds that were allocated during fiscal year 2003. Typical cost-share estimates for projects funded by EQUIP dollars is 3:1 between the NRCS and landowners, respectively. Following implementation of CNMPs at each operation, the NRCS will monitor the use and maintenance of the structures created with EQIP dollars for a period of 5 years.

Table 6-1. CNMPs scheduled for AFO/CAFO operations located in the Newton/Clarkston watershed with associated cost share estimates.

Subwatershed ID	Storage Bunkers	Berm/ Diversion	Fence	Buffer	Offsite Watering	NRCS Cost	Landowner Cost
6,7	3	1	1	1	1	$ 29,446	$7,362
8	5	1	-	-	-	$ 57,498	$14,375
10	1	3	4	4	1	$ 67,633	$16,908
11,12	4	-	1	-	2	$ 69,365	$17,341
TOTAL	**13**	**5**	**6**	**5**	**4**	**$223,942**	**$55,986**

[1] Data provided by the NRCS North Logan Field Office.

6.2 DIRECT STREAM LOADING FROM ANIMAL FEEDING OPERATIONS

Chapter 4 describes conditions that contribute to TP loading from AFO/CAFO facilities in the project area, including facilities located directly on the stream, adjacent to the stream, or some distance from the stream or receiving waterbody. The list of BMPs recommended in Table 6-2 is based upon observations made at all known AFO/CAFO facilities in the TMDL project area. These recommendations are not meant to replace NRCS recommendations or NRCS cost estimates for those operations currently working with the North Logan field office. Specifically, these measures have been designed to eliminate the potential for surface runoff from each facility, eliminate direct animal access to Clarkston Creek and Newton Creek, and restore riparian vegetation within the immediate area of each facility when applicable. It should be noted that in addition to these measures, it is recommended that all operations located directly on Clarkston

Creek or Newton Creek be relocated to upslope areas outside of active stream channels and floodplains.

Per-unit cost estimates have been provided for each BMP listed in Table 6-2. The total facility cost for a BMP system was not provided as this would require site-specific information provided by the owner. Total cost for a CNMP may vary widely depending upon the type of plan used to manage nutrients at a specific facility. All site-specific information provided to the NRCS during the process of developing CNMPs with local landowners has been kept confidential according to Section 2004 of the Farm Security and Rural Investment Act of 2002. As mentioned in section 6.1 above, there are five AFO/CAFO facilities in the Newton/Clarkston watershed that do not currently have a CNMP in place. It is not known if these operations are located above or below Newton Reservoir. The average cost for developing a CNMP for the nine facilities in Table 6-1 is approximately $31,000. Based on this average, a total of $155,000 would be required to complete CNMPs for the remaining five facilities in the TMDL project area.

Table 6-2. BMPs and associated cost estimates recommended for AFO/CAFO facilities in the Newton/Clarkston project area.

Location	NRCS Conservation Practice ID	Description	Number of operations associated with BMP	Per/Unit cost estimate
Clarkston Creek (subwatersheds 5-8)	313	Waste Structure (including concrete retaining wall and manure bunker)	5	$270 / yd^3
	313	Waste Structure (expand existing manure bunker)	1	$300/ yd^3
	533	Offsite watering system	2	$3,000 / system
Newton Creek (subwatershed 10-12)	393 386 390	Filter Strip Field Border Riparian Herbaceous Cover	3 1 2	Site prep = $70/ac - $100/ac Planting = $20/ac Seed or trees = $50/ac
	382	Fence	2	$2 / linear foot
	313	Waste Structure (including concrete retaining wall and manure bunker)	2	$270 / yd^3
	313A	Manure Staging Area	1	$1,500
	533	Offsite watering system	1	$3,000

The estimated reductions in direct stream loadings from AFO/CAFOs following implementation of BMPs in the Clarkston Creek subwatersheds are provided in Table 6-3. A range of reduction levels has been provided to indicate the level of phosphorus removal that would occur under different levels of effort in implementing the prescribed BMPs. A low effort includes partial implementation of one or more BMPs while a moderate effort represents the effect of implementing only one or two of the recommended BMPs or poor maintenance of BMPs following full implementation. A high level effort represents the TP loading response to full implementation of all recommended BMPs and full maintenance following implementation.

The permissible TP load allocation reported in Chapter 5 for direct stream loading by AFO/CAFOs above Newton Reservoir is 36.4 kg/yr. A review of Table 6-3 indicates that this load can be met with the high-effort implementation of BMPs. It should be noted that the values shown in Table 6-3 indicate the TP load that is delivered to the Clarkston Creek stream channel and not the amount delivered to Newton reservoir. TP loads delivered to the Clarkston Creek stream channel are further reduced by irrigation diversions above the reservoir. Load reductions for AFO/CAFOs in the Newton Creek watershed are provided in Table 6-4. The permissible TP load allocation reported in Chapter 5 for direct stream loading by AFO/CAFOs on Newton Creek is 13.4 kg/yr. A review of Table 6-3 indicates that all TP loading can be removed following a high effort of implementation of BMPs for AFO/CAFOs along Newton Creek. This reduction level is based on the assumption that **all** manure is removed from each AFO/CAFO facility in the Newton Creek watershed and managed according to BMPs recommended for areas receiving land applied manure, thus minimizing the potential for TP loading.

Although a high level of effort will be required to achieve necessary reductions in TP loading to Newton Reservoir and Newton Creek, reasonable assurance can be provided that the TMDL will be met if BMPs are properly implemented and maintained as recommended. Additional assurance is provided based on the conservative modeling assumptions that were made due to the limited amount of data available to verify model estimates of flow and water quality. It is anticipated that substantial reductions will be made in TP loading as AFO/CAFO facilities are moved off stream channels and the potential for surface runoff from these operations is eliminated.

Table 6-3. Expected reductions in annual average direct stream loading of total phosphorus from animal feeding operations in subwatersheds above Newton Reservoir and along Newton Creek.

		Expected Percent Reduction			Projected Load (kg)		
Subwatershed	**Existing Load (kg)**	**Low Effort**	**Medium Effort**	**High Effort**	**Low Effort**	**Medium Effort**	**High Effort**
Above Newton Reservoir							
1	0	50	75	95	0	0	0
2	0	50	75	95	0	0	0
3	0	50	75	95	0	0	0
4	0	50	75	95	0	0	0
5	0	50	75	95	0	0	0
6	544	50	75	95	272	136	27
7	0	50	75	95	0	0	0
8	120	50	75	95	60	30	6
9	0	50	75	95	0	0	0
Newton Creek							
10	1,513	50	75	99	757	378	15
11	1,268	50	75	99	634	317	13
12	437	50	75	99	219	109	4
Total:	3,882	-	-	-	1,941	971	65

Table 6-4. BMPs and associated cost estimates recommended for areas receiving land application of manure in the Newton/Clarkston project area.

Location	NRCS Conservation Practice ID	Description	Estimated cost
Clarkston Creek and Newton Reservoir (subwatersheds 5-9)	590	Nutrient Management	$10/ac
	370	Conservation Cover	Seedbed preparation, planting, seed = $105/ac
	393	Filter Strip (30 ft wide) where necessary at downslope end of field to prevent overland flow.	Site preparation(light), seedbed preparation, planting, seed = $165/ac
	328	Conservation Crop Rotation	$11.50/ac
	329 and 344	Residue Management	Non-structural – no cost
		Fertilizer application based on soil test phosphorus (STP) levels.	$8.50 / sample[1]
		Band applications of commercial phosphorus near the seed row.	Non-structural – no cost
Newton Creek (subwatersheds 10-12)	590	Nutrient Management	$10/ac
	370	Conservation Cover	Seedbed preparation, planting, seed = $105/ac
	393	Filter Strip (60 ft) where necessary at downslope end of field to prevent overland flow.	Site preparation(light), seedbed preparation, planting, seed = $165/ac
	328	Conservation Crop Rotation	$11.50/ac
	329 and 344	Residue Management	Non-structural – no cost
		Manure fertilizer application based on soil test phosphorus (STP) levels.	$8.50 / sample[1]
		No application of commercial phosphorus fertilizers.	No cost
		Site inspection of all areas receiving land applied manure. Prevent overland flow where manure could enter stream.	Range of costs associated with site specific variables including slope, surface vegetation, and distance to stream.

[1] Cost estimate based on analysis cost from USU Soil Testing Laboratory.

6.3 LOADING FROM LAND APPLIED ANIMAL WASTES

Delivery of TP from land applied animal wastes to receiving waters in the project area is dependent upon the rate and timing at which manure is applied. Manure loads applied during periods of surface runoff or when the ground is frozen or snow-covered are more susceptible to detachment and transport to streams and reservoirs. BMPs that will reduce loading rates to streams include practices that will either reduce the availability of manure during periods of surface runoff or increase the ability of upslope surfaces to intercept runoff and remove TP loads before they reach a receiving water body. BMPs listed in Table 6-4 address these processes and provide a dependable manner by which TP loads transported by surface runoff can be reduced. No cost estimates are provided for non-structural BMPs that merely require a change in the timing of practices that already occur in the Newton/Clarkston watershed. Cost estimates have been provided for other BMPs based on estimates summarized from the NRCS FY-2003 Practice Cost List Table. The total cost for implementing these practices would require site-specific information provided by individual landowners. It is anticipated that some of these costs have been incorporated into CNMPs developed by the NRCS for AFO/CAFO facilities in the Newton/Clarkston watershed.

A range of load reductions associated with these BMPs is provided in Table 6-5. In addition to the BMPs listed in Table 6-4, it is recommended that manure application occur on a schedule that eliminates winter-season application. Figure 6-1 indicates the recommended application schedule for lands receiving manure application in the project area.

The permissible TP load allocation reported in Chapter 5 for land applied manure above Newton Reservoir is 139 kg/yr. The expected loading from land applied manure above Newton Reservoir following a high level of BMP implementation is 137 kg/yr (Table 6-5). Load reductions for the Newton Creek watershed are provided in Table 6-5. The permissible TP load allocation reported in Chapter 5 for land applied manure along Newton Creek is 13.4 kg/yr, while the expected loading is 13 kg/yr. It is anticipated that TP loading from this pollutant source can be reduced to the necessary level if all BMPs included in Table 6-4 are implemented. Several BMPs of note that are specific to Newton Creek include the following:

- Eliminate the use of commercial phosphorus fertilizers in this area to reduce potential TP loads. Fertilizer use should be limited to land applied manure and only occur where necessary to accommodate manure management.

- Implement a 60 ft filter strip along both sides of Newton Creek where possible in order to inhibit transport of material by surface runoff.

- Complete site inspections of all areas receiving land application of manure within the Newton Creek watershed to ensure that runoff from these sites will not reach Newton Creek.

August	
September	All manure applied to soil will be disked or plowed into the soil within 24 hours of application. No manure applied to lands within 100 feet of stream channel.
October	Land application of manure only to areas greater than 250 – 750 feet from stream channels depending upon local factors that influence transport of manure by surface runoff including slope and vegetative cover. Manure will only be applied to areas that are not frozen or snow covered. Incorporation of manure into soil by disk or plow within 24 hours of application. Delay land application when heavy precipitation is forecast within 24 hours of application date.
November	
December	No land application of manure.
January	
February	
March	Land application of manure only to areas greater than 250 – 750 feet from stream channels depending upon local factors that influence transport of manure by surface runoff including slope and vegetative cover. Manure will only be applied to areas that are not frozen or snow covered. Soil moisture conditions must allow incorporation of manure into soil by disk or plow within 24 hours of application. Delay land application when heavy precipitation is forecast within 24 hours of application date.
April	All manure applied to soil will be disked or plowed into the soil within 24 hours of application. No manure applied to lands within 100 feet of stream channel. Delay land application when heavy precipitation is forecast within 24 hours of application date.
May	No land application. Active growing season.
June	
July	Harvest.

Figure 6-1. Desired application schedule of manure for a typical year.

Although a high level of effort will be required to achieve necessary reductions in TP loading from areas receiving land application of manure, reasonable assurance can be provided that the TMDL will be met if BMPs are properly implemented and the recommended schedule for manure application is followed. It is noted that quantifying nonpoint source loads is a difficult task that requires estimating many of the processes responsible for surface runoff and TP loading. As a result, the exact magnitude of TP loads from this source are not known, and we must rely upon modeled estimations that use the best information available, knowledge of local conditions that influence surface runoff and transport, and professional judgement. Conservative assumptions were made when actual data was not available and may have overestimated some processes. In addition, while estimates of the total amount of manure generated within the Newton Creek watershed are based on summaries of NRCS animal counts and are assumed to be accurate, no records have been kept as to where or how much manure is land applied within the watershed. As a result, total amounts of land applied manure may also exceed actual amounts. In all cases, information regarding the timing and amounts of manure applied within the project area are based on the best data available. However, even with the potential for overestimation, it is anticipated the TMDL can be met if the recommended BMPs are applied to areas that receive manure application.

Table 6-5. Expected reductions in annual average total phosphorus loading to streams from land applied animal wastes for subwatersheds above Newton Reservoir and along Newton Creek.

		Expected Percent Reduction			Projected Load (kg)		
Subwatershed	**Existing Load (kg)**	**Low Effort**	**Medium Effort**	**High Effort**	**Low Effort**	**Medium Effort**	**High Effort**
Above Newton Reservoir							
1	0	40	75	95	0	0	0
2	0	40	75	95	0	0	0
3	0	40	75	95	0	0	0
4	0	40	75	95	0	0	0
5	154	40	75	95	92	39	8
6	213	40	75	95	128	53	11
7	343	40	75	95	206	86	17
8	1,663	40	75	95	998	416	83
9	108	40	75	95	65	27	5
Newton Creek							
10	989	40	75	99	593	247	10
11	299	40	75	99	179	75	3
12	0	40	75	99	0	0	0
Total:	**3,770**				**2,262**	**942**	**137**

6.4 LOADING FROM GRAZING ON PUBLIC LANDS

TP loading from grazing on public lands is influenced by grazing intensity (the number of animals and duration that animals are present), proximity of animals to stream channels, and general channel conditions. These areas are managed according to guidelines outlined in the Forest Management Plan for the Caribou National Forest (CNF) and other applicable documents. The CNF is required to develop action plans that will support TMDL requirements for 303(d) listed streams located within or downstream of forest boundaries (Leffert 2002). The health of stream channels and riparian corridors on the CNF is currently managed to enhance, maintain or restore the Properly Functioning Condition (PFC) associated with these resources (USDI 1990). It is recommended that CNF personnel complete an assessment of stream and riparian areas in the Dry Creek grazing allotment that fall within subwatershed 1 and subwatershed 2 (see Figure 4-2). Action plans should be developed to restore areas that are not maintaining a condition that is typical for healthy stream channels and riparian corridors. Some of the recommended management practices that could be taken to improve areas impacted by grazing are included below in Table 6-6. No cost estimates are provided for these practices as all BMPs are associated with increased management of livestock within stream channels and riparian corridors in the Dry Creek grazing allotment. No structural BMPs are recommended for public lands grazing at this time.

The permissible total load for public lands grazing provided in Chapter 5 is 50.5 kg/yr. If all recommended BMPs are implemented and properly maintained in subwatersheds 1 and 2, TP loads will be reduced to 56 kg/yr as indicated below in Table 6-7. Although this amount is slightly above the recommended allocation provided in Chapter 5, the load from this pollutant source will be reduced to an allowable load by the time it reaches Newton Reservoir due to withdrawals associated with diversions along Clarkston Creek. This is discussed further in Section 6.7 below.

Table 6-6. Recommended grazing management practices and expected benefits for stream channels and riparian corridors located in the Dry Creek grazing allotment within subwatersheds one and two (Leffert 2002).

Practice	Expected Benefit
Maintain a minimum herbage stubble height of 4-6 inches within riparian areas, allow adequate time for regrowth of plants before reuse.	• Increased plant vigor/health, maintain species composition • Improve streambank and stream channel stability
Limit springtime grazing of herbaceous vegetation to not exceed 65 percent. Remove livestock from riparian areas when primary forage plants are still in the vegetative state.	• Increased plant vigor/health,
Limit time in pastures to 30 days or less. Reduce time to less than 15 days during the hot season when livestock use of riparian areas typically increases.	• Increased plant vigor/health, maintain species compostion • Reduced soil compaction • Improved streambank stability/protection • Improved aquatic habitat • Improved water quality
Ensure all livestock are removed from allotment at the end of the specified use period. Recovery of riparian areas is reduced if some animals remain following use period.	• Increased plant vigor/health, maintain species compostion • Reduced soil compaction • Improved streambank stability/protection • Improved aquatic habitat • Improved water quality
Implement streambank disturbance standards that require a percentage of stream channels to be in a stable condition before grazing is allowed.	• Improved streambank protection • Improved water quality • Improved aquatic habitat

Although a high level of effort will be required to achieve necessary reductions in TP loading to Newton Reservoir from grazing on public lands, reasonable assurance can be provided that the TMDL will be met if recommended grazing management practices are properly implemented and maintained.

Table 6-7. Expected reductions in annual average total phosphorus loading to streams from grazing on public lands for subwatersheds above Newton Reservoir.

		Expected Percent Reduction			Projected Load (kg)		
Subwatershed	**Existing Load (kg)**	**Low Effort**	**Medium Effort**	**High Effort**	**Low Effort**	**Medium Effort**	**High Effort**
1	368	40	50	90	221	184	37
2	187	40	50	90	112	94	19
3	0	40	50	90	0	0	0
4	0	40	50	90	0	0	0
5	0	40	50	90	0	0	0
6	0	40	50	90	0	0	0
7	0	40	50	90	0	0	0
8	0	40	50	90	0	0	0
9	0	40	50	90	0	0	0
Total:	555	-	-	-	333	278	56

6.5 Loading From Onsite Wastewater Treatment Systems

TP loads from onsite wastewater treatment systems (septic tanks) can be influenced by poor design and inadequate sizing, improper maintenance, and high groundwater levels. Although the loads associated with septic systems identified in Chapter 4 can be considered relatively minor, this TMDL must address all potential pollutant sources. BMPs considered to reduce pollutant loads from septic systems through proper design and maintenance are listed in Table 6-8 below (EPA 1999) (EPA 2002). The total annual cost for implementing these BMPs is estimated to be \$31,250. The number includes \$7,050 per year associated with properly maintaining existing systems in the Clarkston and Newton areas and \$24,200 per year for the future construction cost of additional systems. These numbers are based on individual costs provided in Table 6-8 below and reflect the total number of septic tanks identified in the project area as well as the projected growth rates for the municipal areas of Clarkston and Newton.

The anticipated reductions in pollutant loading from septic tanks are included in Table 6-9. The permissible loading from septic tanks above Newton Reservoir is 15.5 kg/yr, while septic tanks contributing discharge to Newton Creek are permitted 15.7 kg/yr. A high-level effort associated with BMP implementation to septic tanks is required to meet the load allocation above Newton Reservoir, while a low effort would be required along Newton Creek. Although a low effort would meet the existing TMDL requirements for septic tank loads, it should be noted that much of this area is adjacent to the Town of Newton. Future growth in the town will continue to add additional loads to Newton Creek. A description of the anticipated influence of future growth associated with this pollutant source is provided in Chapter 7. Reasonable assurance can be provided that the TMDL will be met from this pollutant source if BMPs recommended in Table 6-8 are properly implemented and maintained. Additional assurance is provided in the conservative assumptions used to calculate loads from this pollutant source.

Table 6-8. BMPs recommended for onsite wastewater systems for designated subwatersheds in the Newton/Clarkston project area.

Location	Recommended BMP	Estimated Cost
Subwatersheds 1 - 5	None	
Subwatersheds 6 - 12	Septic Tank polishing: • Buried sand filter • Intermittent sand filter • Recirculating filter system	New construction (including septic tank and adsorption field) = \$7,000 - \$14,000.
	Repair of existing system	\$1,200 – \$2,500 / system.
	Regular maintenance	Pump-out = \$150 every 4 years.
	Regulating inputs: • Avoid disposal of high-solids or grease containing materials • Use low-phosphate detergents.	NA

Table 6-9. Expected reductions in annual average direct stream loading of total phosphorus from onsite wastewater treatment systems in subwatersheds above Newton Reservoir and subwatersheds contributing to Newton Creek.

		Expected Percent Reduction			Projected Load (kg)		
Subwatershed	**Existing Load (kg)**	**Low Effort**	**Medium Effort**	**High Effort**	**Low Effort**	**Medium Effort**	**High Effort**
Above Newton Reservoir							
1	0	50	75	90	0	0	0
2	0	50	75	90	0	0	0
3	0	50	75	90	0	0	0
4	0	50	75	90	0	0	0
5	0	50	75	90	0	0	0
6	30	50	75	90	15	8	3
7	1.1	50	75	90	1	0	0
8	52	50	75	90	26	13	5
9	0	50	75	90	0	0	0
Total:	83.1	-	-	-	41.6	20.8	8.3
Newton Creek							
10	11.3	50	75	90	5.7	2.8	1.1
11	10.7	50	75	90	5.4	2.7	1.1
12	1.1	50	75	90	0.6	0.3	0.1
Total:	23.1	-	-	-	11.6	5.8	2.3

6.6 NONPOINT SOURCE LOADING FROM OVERLAND FLOW

Pollutant loads from nonpoint sources are considered in this assessment to be directly related to land use practices and land cover types. A detailed description of the methods used to allocate loads to these sources can be found in Chapter 4 and in Appendix A. Although the total pollutant loads associated with this category are relatively low, BMPs designed to reduce nonpoint source loading will likewise reduce loads from land-applied manure. It should be noted that BMPs mentioned in this list and in the tables provided above are not meant to recommend a duplicate effort. Instead, they are intended to address areas of the watershed that contribute TP loads to receiving water bodies but do not receive manure application from AFO/CAFOs. BMPs recommended in this section also address streambank erosion and channel instability identified during the SVAP field effort. A detailed description of BMPs associated with individual stream segments identified during the SVAP field effort is provided in Appendix C.

A list of all recommended BMPs to reduce nonpoint source loading from overland flow is provided below in Table 6-10. Cost estimates are provided based on a summary of information included in the NRCS FY-2003 Practice Cost List Table. The total cost for implementing these practices would require site-specific information associated with individual fields and pastures and would need to be provided by individual landowners. It is anticipated that some of these costs have been incorporated into CNMPs developed by the NRCS for AFO/CAFO facilities in the Newton/Clarkston watershed.

The most expensive BMP associated with nonpoint source loading from overland flow is associated with the conservation easement for all non-residential land bordering Newton Creek, Newton Reservoir, Clarkston Creek and perennial tributaries to Clarkston Creek. The total cost of purchasing a conservation easement for these areas would be $431,000 based on an average per-acre price of \$2,250/ac. This value incorporates a 30-foot-wide corridor on each side of Clarkston Creek, perennial tributaries to Clarkston Creek, and Newton Reservoir. A 60-foot-wide corridor is recommended along Newton Creek as an additional measure to prohibit loading from overland flow. Additional costs may be necessary to restore vegetation to these areas and would include costs associated with NRCS Conservation Practice 393 – Filter Strip.

Table 6-10. BMPs recommended for nonpoint source loading from overland flow.

Location	NRCS Conservation Practice ID	Recommended BMP	Estimated Cost
Subwatersheds 3-12		30 ft conservation easement for all non-residential land bordering Clarkston Creek and Newton Reservoir. 60 ft conservation easement for all non-residential land bordering Newton Creek	Varies depending on land use: Wet meadow = \$1,000/ac – \$1,500/ac Dryland crop = \$1,500/ac - \$2,500/ac Irrigated cropland = \$2,500/ac - \$3,000/ac
	322	Channel vegetation	\$750/ac
	328	Conservation Crop Rotation	\$11.50/ac
	329 and 344	Residue Management	Non-structural – no cost
	382	Fencing	\$2 - \$4/ft
	393	Filter Strip	Site preparation(light), seedbed preparation, planting, seed = \$165/ac
	584	Channel Stabilization	RipRap Structures = \$130/yd^3
	638	Sediment Control Basin	\$1.80/linear ft

The anticipated reductions in nonpoint source loading from overland flow are included in Table 6-11. Reasonable assurance is provided that these reductions can be made if the recommended BMPs are properly implemented and maintained. Additional assurance is provided based on the selection of conservative export coefficients used to estimate TP loading from this source.

6.7 Groundwater Background Loading

It is not anticipated that reductions in loading from groundwater background will be achieved with any of the prescribed BMPs. Therefore background loads allocated in Chapter 5 of 86 kg/yr above Newton Reservoir and 15.3 kg/yr for Newton Creek are anticipated to remain the same.

Table 6-11. Expected reductions in annual average total phosphorus loading to streams from nonpoint source loads generated by overland flow in subwatersheds above Newton Reservoir and subwatersheds contributing to Newton Creek.

		Expected Percent Reduction			Projected Load (kg)		
Subwatershed	**Existing Load (kg)**	**Low Effort**	**Medium Effort**	**High Effort**	**Low Effort**	**Medium Effort**	**High Effort**
Above Newton Reservoir							
1	11	40	50	90	6.6	5.5	1.1
2	0.45	40	50	90	0.3	0.2	0.0
3	1.93	40	50	90	1.2	1.0	0.2
4	5.45	40	50	90	3.3	2.7	0.5
5	10.1	40	50	90	6.1	5.1	1.0
6	5.5	40	50	90	3.3	2.8	0.6
7	0.58	40	50	90	0.3	0.3	0.1
8	23.2	40	50	90	13.9	11.6	2.3
9	4.57	40	50	90	2.7	2.3	0.5
Total:	62.7	-	-	-	37.7	31.4	6.3
Newton Creek							
10	37.7	40	50	90	22.6	18.9	3.8
11	8.12	40	50	90	4.9	4.1	0.8
12	12.6	40	50	90	7.6	6.3	1.3
Total:	58.4	-	-	-	35.1	29.2	5.8

6.8 SUMMARY

Tables 6-12 and 6-13 summarize the expected load reductions for Newton Reservoir and Newton Creek, respectively. These loads account for the hydrology and diversions that occur above the reservoir and along Newton Creek which remove both flow and TP from Clarkston Creek and Newton Creek. As a result, the projected loads in Table 6-12 indicate the contribution from pollutant source categories at the inlet to Newton Reservoir are somewhat less than the loads calculated at the outlet of individual subwatersheds.

A review of this table indicates that a high-level effort is necessary to implement BMPs that will reduce pollutant loads to a level that will allow the TMDL to be met. The permissible TP load allocation required to meet the TMDL for the area above Newton Reservoir is 341 kg/yr. The anticipated load following full implementation and proper continued maintenance of all BMPs is 298 kg/yr indicating that the TMDL can be met. The permissible TP load allocation for Newton Creek is 77 kg/yr. The anticipated load reductions indicated in Table 6-13 associated with a high level of effort and proper continued maintenance of all BMPs indicate that an annual load of 23 kg/yr could be achieved, thus achieving the TMDL for this area. It is important to note that although some sources contribute greater amounts, loads from all pollutant source categories (with the exception of background loads) must be reduced in order to meet the TMDLs for both Newton Reservoir and Newton Creek.

Although a significant level of effort will be required to achieve necessary reductions in TP loading to Newton Reservoir and Newton Creek, reasonable assurance can be provided that the TMDL will be met if BMPs are properly implemented and maintained as recommended. Additional assurance that the TDML can be achieved is provided by the conservative modeling assumptions that were made in determining TP loads and the processes that deliver these loads to

Clarkston Creek, Newton Reservoir, and Newton Creek. These assumptions were made due to the limited amount of data available as well as the need to ensure that the full magnitude of pollutant loads was accounted for.

Table 6-12. Overall total phosphorus load reduction summary for Newton Reservoir.

		Expected Percent Reduction			Projected Load (kg)		
Loading Source	**Existing Load (kg)**	**Low Effort**	**Medium Effort**	**High Effort**	**Low Effort**	**Medium Effort**	**High Effort**
Animal Wastes							
Direct Stream Loading from AFOs	556	50	75	95	278	139	27.8
Loading from Land-Applied Manure	2,453	40	75	95	1,472	613.3	122.7
Loading from Grazing on Public Lands	419	40	50	90	251.4	209.5	41.9
Onsite Wastewater Treatment Systems	68.6	50	75	90	34.3	17.15	6.86
Nonpoint Source Loads from Overland Flow	52.1	40	50	90	31.26	26.05	5.21
Groundwater Background	86	0	0	0	86	86	86
Total:	**3,635**				**2,153**	**1,091**	**290**

Table 6-13. Overall total phosphorus load reduction summary for Newton Creek.

		Expected Percent Reduction			Projected Load (kg)		
Loading Source	**Existing Load (kg)**	**Low Effort**	**Medium Effort**	**High Effort**	**Low Effort**	**Medium Effort**	**High Effort**
Animal Wastes							
Direct Stream Loading from AFOs	3,218	50	75	100	1,609	804.5	0
Loading from Land-Applied Manure	1,288	40	75	99	772.8	322	12.88
Onsite Wastewater Treatment Systems	23.1	50	75	90	11.55	5.78	2.31
Nonpoint Source Loads from Overland Flow	58.4	40	50	90	35.04	29.2	5.84
Groundwater Background	15.3	0	0	0	15.3	15.3	15.3
Total:	**4,603**				**2,444**	**1,177**	**36.33**

The final objective of BMPs recommended in this chapter is to reduce or remove those processes which contribute to TP loading in the Newton/Clarkston watershed. A summary of the BMPs recommended for the TMDL project area is provided below in Table 6-14 It is important to note that the results of this study indicate that certain changes need to occur in the way things are currently done and that these means are achievable with a coordinated effort between local stakeholders and agencies. It is reasonable to assume that pollutant sources with the most direct influence on existing water quality conditions should be addressed first, followed by those with a lesser influence. A prioritized list of recommended changes includes the following:

- Implement recommended BMPs or NRCS approved CNMPs at all AFO/CAFOs in the project area including measures that eliminate surface runoff and provide for proper manure management.

- Work with remaining AFO/CAFO facilities in the Newton/Clarkston area to implement CNMPs that will eliminate surface runoff and provide for proper manure management. Particular emphasis should be paid to any facilities located on or immediately adjacent to receiving water bodies.

- Eliminate all direct animal access to stream channels and Newton Reservoir, with the exception of public lands managed by the Caribou National Forest. This includes operations located along tributaries to Clarkston and Newton creeks, the main stems of these creeks, and lands adjacent to Newton Reservoir. Utilize off-site watering where necessary to meet the needs of animals with previous access to water bodies.

- Follow the recommended manure application schedule provided in Figure 6-1. Base manure application rates on STP data collected from individual fields receiving manure application.

- Implement a 30-foot conservation easement along all non-residential land located adjacent to Clarkston Creek and perennial tributaries to Clarkston Creek as well as Newton Reservoir. A 60-foot conservation easement is recommended along Newton Creek in order to reduce pollutant loads transported by surface runoff. Residential lots within Clarkston and Newton are not included in this recommendation.

This list is designed to eliminate direct loading to streams followed by reducing pollutant loads delivered by overland flow. Other BMPs recommended in Chapter 6 but not included on this list need to be implemented as well in order to achieve the TMDL. It is anticipated that following implementation of all BMPs recommended in this chapter, that water quality standards recommended by the State can be met and the full beneficial use of Clarkston Creek, Newton Reservoir, and Newton Creek can be restored.

Table 6-14. Summary of recommended BMPs and associated costs[1] for the TMDL project area.

Pollutant Source	**BMP**	**Responsible Agency**	**Cost of Construction**	**Annual O&M costs**
AFO/CAFO improvements	Apply scheduled CNMPs to nine operations.	NRCS / local operators	$279,928	NA
	Apply NRCS recommended CNMPs to remaining five operations.	NRCS / local operators	$155,000	NA
	Properly maintain and monitor manure management at the 17 AFO/CAFO facilities in project area.	NRCS / local operators	NA	NA
Land applied manure	Adhere to recommended schedule for manure application	Landowner	NA	NA
	Site-specific measures include nutrient management (590), conservation cover (370), residue management (329/344).	Landowner	NA	NA
Grazing on public lands	Complete PFC assessment of stream channels and riparian corridors. Implement and enforce the appropriate grazing management practices in project area associated with Dry Creek grazing allotment.	USFS Caribou National Forest	NA	NA
Onsite wastewater treatment systems[2]	Properly design and install new systems using appropriate filters. Maintain existing systems on regular basis.	Homeowner/Resident	$24,200	$7,050
	Utilize low-phosphate detergents, avoid disposal of high solids or grease.	Landowner	NA	NA
Nonpoint source loading from overland flow	30-foot conservation easement along Clarkston Creek and perennial tributaries. 60-foot conservation easement along Newton Creek.	DWQ/NRCS	$431,000	NA
	Site-specific measures include conservation crop rotation (328), residue management (329/344), filter strip (393).	Landowner	NA	NA
		Total Cost	$813,128	

[1] Total estimated costs do not include BMPs for individual locations that require site-specific information.
[2] Cost of construction for onsite wastewater treatment systems reflect the total annual amount associated with building new systems in the Clarkston and Newton areas. These numbers assume $10,000 per new system, 4 individuals per household, and growth rates of 1.3% and 0.5% for the towns of Clarkston and Newton respectively.

CHAPTER 7: FUTURE CONSIDERATIONS

7.1 FUTURE LAND USE

Existing sources of pollution within the Newton/Clarkston Creek have been identified. Water quality goals have also been defined as endpoints and means for obtaining these goals have been discussed. In order to provide meaningful information related to potential changes in water quality, accurate projections of future land use patterns and trends within the Newton/Clarkston Creek watershed are needed. This information is often difficult to obtain because many factors that influence pollutant sources in the Newton/Clarkston Creek watershed occur outside of the watershed boundaries. Such factors include general trends in agricultural economics at the county, state, and regional level, and employment and housing trends. Although it is difficult to predict with absolute certainty the extent of water quality impacts resulting from existing land use practices, a knowledge of regulations that govern land development can provide useful information in determining future impacts to water quality.

7.1.1 Municipal growth trends

Municipal growth within the Newton/Clarkston Creek watershed is confined to the cities of Clarkston and Newton. The recently completed 2000 census provides information regarding the population trends in these areas.

City zoning regulations have the ability to dictate the pattern and extent of development that occurs within a municipal area. Although zoning regulations will be adjusted periodically to meet a perceived need for development, estimates of land use trends that impact water quality can be made based on existing ordinances.

7.1.1.1 Clarkston

The town of Clarkston has experienced a decreasing rate of population growth since 1970 (Cache County 2003). Between 1990 and 2002, the population grew from 645 to 685 persons, an overall growth rate of 6.2 percent. This is compared to an overall growth rate of 33.5 percent for Cache County as a whole. Growth in the Clarkston area is much slower than that of Cache County, most likely due to its distance from the Logan area, the main population center.

Population growth in the town of Clarkston is projected to continue to increase. The annual average rate of change between 2000 and 2030 is projected to be 1.3 percent (Cache County 2003). The population in 2030 is projected to be 962 persons.

Most of the workers in the town of Clarkston commute to work. Clarkston is located approximately 21 miles from Logan, Utah, and provides residential housing for individuals and families working in Logan and throughout Cache Valley, with some of whom commute to work along the northern portions of the Wasatch Front. At the present time there are no industrial facilities within Clarkston, although there is potential for a landfill to be placed several miles north of the town. The majority of the workforce is employed in the manufacturing industry (U.S. Bureau of the Census 2000). Relatively few workers are employed in agriculture; however, the majority of the land surrounding the town of Clarkston is currently used for agriculture production. Current zoning consists of primarily residential and agriculture.

7.1.1.2 Newton

The town of Newton has experienced an increase in population since 1970, with growth over the past twenty years being much slower than during the previous 10 years (Cache County 2003). Between 1990 and 2002, the population grew from 659 to 706 persons, an overall growth rate of 7.1 percent. Like Clarkston, this rate of growth is much less than that of the county as a whole. Most of the growth in Cache County is occurring on the east and south end of the valley.

Population growth in the town of Newton is projected to continue to slightly increase. The annual average rate of change between 2000 and 2030 is projected to be 0.5 percent (Cache County 2003). The population in 2030 is projected to be 821 persons.

The workforce in the town of Newton work primarily in the industries of education, health, and social services; manufacturing; and retail trades (U.S. Bureau of the Census 2000). The town of Newton is located approximately 16 miles from Logan, Utah and also provides residential housing for individuals and families working in Logan and throughout Cache Valley, with some individuals commuting to work along the northern portion of the Wasatch Front. At the present time, no industrial facilities are located in Newton. As with Clarkston, relatively few workers are employed in agriculture, although the majority of the land surrounding the community is currently used to produce agricultural products. Current zoning consists of primarily residential and agriculture.

7.1.2 County growth trends

Between 1990 and 2002, Cache County population growth has totaled 33.5 percent (Cache County 2003). The population of Cache County in 2000 was measured at 93,695 (U.S. Census Bureau 2000). Population growth throughout Cache County can be attributed somewhat to a mixture of employment opportunities related to the industries of education, health, and social services; manufacturing; and retail trades (U.S. Bureau of the Census 2000). Although the number of commercial and industrial developments within the county have steadily increased, the number of agriculture operations have remained somewhat constant in outlying areas but overall have decreased. Growth patterns of residential and commercial/industrial growth typically occur in offsetting cycles. Over the past few years, residential growth has steadily continued with commercial/industrial growth beginning to trend upward.

Population growth in Cache County is projected to continue to increase. The annual average rate of change between 2005 and 2030 is projected to be 1.50 percent. The population in 2030 is projected to be 143,487 persons. (Cache County 2003)

Similar to municipalities, development of non-municipal areas in Cache County is guided by zoning regulations and objectives established in part by a county executive council. Zoning ordinances have been recently reviewed by the council to address inadequacies identified in the existing regulations. Current zoning categories maintained in Cache County consist of agriculture (land reserved for agricultural development), commercial (land designated for commercial development), industrial (land designated for industrial development, and FR40 (land managed by the U.S. Forest Service).

7.2 FUTURE POINT SOURCE ANALYSIS

No point sources have currently been identified within the Newton/Clarkston watershed. Although point sources could be established within the boundaries of the Newton/Clarkston watershed, plans do not currently exist. Some concerns have arisen regarding the proposed landfill and the potential for development of point source discharge of pollutants. The proposed location associated with this development is several miles north of Clarkston and east of Clarkston Creek opposite the confluence with Steel Canyon. The proposed landfill would be lined and any flows off the site would be treated to meet environmental standards within the authorization of the permits issued. It is not anticipated at this time that any effluent discharge would be created from the proposed landfill site.

7.3 Future Nonpoint Source Analysis

Potential changes to the amount and type of nonpoint source pollution would be primarily dependent upon landuse changes that occur in the non-municipal areas of the watershed. These could be the result of changes in agricultural practices (including the type and amount of crops grown in agricultural areas), presence of animal feeding operations, or development of residential areas outside of municipal boundaries. A brief discussion of each of these scenarios is provided below along with the associated potential impacts (if any) to water quality.

7.3.1 Agriculture

Nonpoint source pollution associated with crop production in the Newton/Clarkston watershed is influenced by the amount of land dedicated to farming, the type of crop grown, and cropping practices used during production including tillage and irrigation methods. Further development of agricultural land within the Newton/Clarkston watershed is limited as nearly all lands that can reasonably be farmed are being utilized. However, some changes could occur if land that is currently associated with the Conservation Reserve Program returns to active use. The type of crops that will be grown in future years within the Newton/Clarkston watershed will be similar but will vary somewhat, depending on annual market conditions. Irrigation practices that rely on flood irrigation, although somewhat limited, maintain the potential to contribute pollution through return flows and will continue to do so unless continued changes are made to sprinkler irrigation.

The primary component contributing to production of nonpoint source pollution is the use of fertilizers including both processed chemical fertilizers and non-processed fertilizers (manure). Without increased attention to CNMPs, increased use of fertilizers will result in higher pollutant loads delivered to surface waters during rain or snowmelt runoff. Excessive use of fertilizer is common in areas where regulations specifying the amount and timing of fertilizer application do not exist. It is anticipated that land-use activities will remain generally the same during the next 30 years, including lands used for farming and harvesting of crops. As a result, it is believed that fertilizer use will stay relatively the same. Based on the discussion provided in Chapter 6, it is recognized that full implementation of BMPs and CNMPs including manure management, proper application of fertilizers, and implementation of conservation easments are necessary is necessary in order to achieve the recommended TMDL.

7.3.2 AFO/CAFO

Pollution from AFO/CAFO’s can be contributed directly to streams through direct contact or indirectly by surface transport of manure during overland flow events. Contamination of shallow groundwater can also occur as nutrients from manure are leached into the soil. The number of AFO/CAFO’s in the watershed is dependent upon several factors, most of which are related in some way to the economic demand of products marketed by AFO/CAFO’s including dairy products and meat.

Available information regarding the number of cattle in Cache County during the past ten years indicates a general increase in the total number of cattle. However, livestock numbers can fluctuate widely between years. Table 7-1 shows the number of animals by year in Cache County.

Table 7-1. Available livestock numbers for Cache County.

Animal Type	**Number of Animals by Year (Head)**								
	1992	1993	1994	1995	1996	1997	1999	2000	2002
All Cattle	71,000	73,000	72,000	75,000	76,000	81,000	71,000	70,000	76,000
All Cows	27,500	29,800	30,000	31,000	28,500				
Beef Cows	6,500	6,900	8,700	9,000	8,400	11,000	8,500	7,500	8,000
Milk Cows	21,000	22,900	21,700	22,000	20,100	21,500	25,500	24,500	23,500

Source: Cache County 2003.

Information obtained from USDA Farm Service – North Logan indicates that although the number of cows has remained relatively constant, the total number of dairy operations has decreased by about 50 percent during the past twenty years from roughly 300 to 150 (Lundquist 2003). Based on this information, it is estimated that although the overall number of dairy/feedlot operations in the Newton/Clarkston area will likely decrease, the total number of animals will remain relatively constant. It is possible, due to the remote nature of the project area (with respect to developed portions of Cache Valley), that the trend towards fewer and larger AFO/CAFO facilities may attract one or more large operations to the watershed.

In any case, it is not anticipated **under the current management conditions** that the direct stream loading from animal feeding operations will change significantly. Even though it is likely that there will be fewer operations in the future, it is also likely that the number of animals (and the amount of manure produced by these animals) will not change. The assumption that direct stream loads from animal feeding operations will not change under the current management conditions in the watershed is conservative. Even though the number of animals is not anticipated to change significantly in the future, the spatial location of the animal feeding operations may change (i.e., there may be fewer, larger operations located further from the stream). Therefore, the assumption that the direct stream loadings will not change is somewhat of a "worst-case" scenario because it assumes that management and spatial relationships between animal feeding operations and existing streams remain unchanged in the future.

7.3.3 Potential Future Loadings from Land Applied Manure

The above discussion regarding future trends in animal feeding operations is also pertinent here. Although it is anticipated that the number of animal feeding operations will decrease, it is not anticipated that under current management conditions the number of animals in the watershed or the amount of manure that they produce will decrease significantly. Thus, it follows that the amount of manure that must be land applied will not change either.

Information from the 1997 Census of Agriculture does indicate a slight decrease (<1 percent) in the amount of harvested crop land, but a slight increase in the amount of total cropland. Local opinion indicates that in general, the total amount of cropland has generally decreased over the past 20 years (Lundquist 2003). This is consistent with the growth of municipalities and expansion of housing developments into agriculture areas observed within Cache Valley. If this is true, it would result in a decrease in the amount of land available for manure application, which may, in turn, have an effect on the number of animals in the watershed. It is expected that this potential decline is not significant enough to warrant additional analysis.

7.3.4 Residential Development

Pollutant loads from residential developments are contributed from a variety of sources within a municipal area, including stormwater discharge. Stormwater produced from Clarkston and Newton is currently routed to drainage ditches.

Growth projections for the municipal and non-municipal areas throughout Cache Valley, including to a limited extent the Newton/Clarkston watershed, have been calculated by the County-Wide Planning & Development Office (Cache County 1997). These projections were generated from building permit numbers collected within individual analysis zones. Annual population estimates were generated using this information and the 1990 Census as a baseline data set. Overall, population growth in the non-urbanized areas of the Newton/Clarkston watershed ranged from 5 to 6 percent for the year 2010 and from 17 to 40 percent for the year 2030. Pollutant loads created by populations in these areas would be slightly greater than pollutant loads produced by existing populations.

There is currently no legislation providing Cache County with the authority to prevent residential development outside of municipal boundaries. Standard protocol followed by the county does not provide for municipal services outside of city boundaries, including water and sewer utilities. As a result, the cost associated with residential development outside of municipal boundaries must include construction and development of a well, and transferring of water rights if necessary. These costs generally make it prohibitive to develop a residential lot or neighborhood in a non-municipal area. Therefore, development in these areas typically consists of single family dwellings. Residential development of non-municipal areas is also restricted by the State Engineer's Cache Valley Groundwater Management Plan. At the present time, additional water rights are only granted on a showing of no impact or a mitigation plan, with the exception of a single family domestic well on an existing parcel of land that is not in a subdivision. The other way in which water rights can be obtained for development is through the transfer of existing water rights, which can be costly to developers.

As mentioned in Chapter 4, private septic systems are used for wastewater generated from residential dwellings in the watershed. As population levels continue to increase, impacts to water quality could also potentially increase due to the increased number of septic systems. It is not anticipated that either Clarkston or Newton will develop public sewer systems within the next 30 years. As a result, discharge from faulty or poorly maintained systems will continue to be considered a source of TP. It is expected that onsite wastewater treatment systems will remain the primary mechanism for treating the additional municipal wastewater produced by this population growth.

Projected future loads from onsite wastewater treatment systems were calculated by first determining a per-capita load based on the existing conditions presented in Chapter 4. Future annual loads were then calculated by multiplying the per-capita load by population estimates for Newton and Clarkston (Cache County 2003). Percent contribution from each subwatershed to the existing annual total was then multiplied by future annual totals to determine future loads for each subwatershed. Projected future loads to stream reaches in subwatersheds above Newton Reservoir are shown in Table 7-2 by year, and Table 7-3 shows the contribution of these loads to Newton Reservoir after accounting for hydrology and stream flow diversions that occur above the reservoir. Table 7-2 shows the projected future loads from onsite wastewater treatment systems to stream reaches in the Newton Creek subwatersheds.

Table 7-2. Projected future loads from onsite wastewater treatment systems to stream reaches in subwatersheds above Newton Reservoir and along Newton Creek by year.

	Total Phosphorus Load by Year (kg/yr)				
Subwatershed	**2002**	**2005**	**2010**	**2020**	**2030**
Above Newton Reservoir					
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	30	28.9	31.5	36.7	42.0
7	1.1	1.06	1.2	1.4	1.5
8	52	50.0	54.6	63.6	72.7
9	0	0	0	0	0
Newton Creek					
10	11.3	11.7	12.0	12.6	13.3
11	10.7	11.0	11.3	12.0	12.6
12	1.1	1.13	1.17	1.23	1.29
Total:	106.2	103.8	111.80	127.8	143.2

Table 7-3. Projected future loads from onsite wastewater treatment systems to Newton Reservoir by year.

Year	**Total Phosphorus Load (kg)**
2002	68.6
2005	66.0
2010	72.1
2020	84.2
2030	95.8

These increases will be allowed for under the TMDL load allocations reserved for future growth mentioned in Chapter 5.

7.3.5 Potential Future Loadings from Grazing on Public Lands

Based on previous experience and observation of trends in grazing allotments on U.S. Forest Service and BLM lands, it is assumed that grazing will remain relatively constant or slightly decrease during the next 25 years. It is therefore assumed that the potential for future loading increases from grazing on public lands is small, and loads may even decrease.

7.3.6 Potential Future Nonpoint Source Loads from Overland Flow

Based on a review of general land use information for Cache Valley, actual land use patterns within the watershed will likely remain similar to existing conditions during the next 30 years. Some minor changes may be seen on the margins of Clarkston and Newton as new housing developments occur. Development of this type will result in small amounts of additional urban/residential land in and around Newton and Clarkston. It is likely that decreased nonpoint source loads from agricultural areas replaced by urban expansion will offset nonpoint source loads from overland flow in these areas. In summary, it is anticipated that although the land use patterns may change, the management of the existing land use categories will not. Therefore, potential increases in nonpoint source loads from overland flow will be small enough that they do not warrant additional analysis.

7.4 Future Regulation of Point and Nonpoint Source Pollution

Regulation of pollution sources has historically focused on point source pollution due to the relative ease with which these sources are defined. Regulation of pollutant loads contributed by these sources should continue under NPDES guidelines. Challenges will likely occur with regards to nonpoint source pollutant loads where legislation has historically been less stringent or non-existent.

The use of excessive amounts of fertilization needs to be regulated in some manner, including timing and rate of application. The existing distribution of AFO/CAFO's throughout the Newton/Clarkston watershed is a continued area of concern and should continue to be monitored with particular emphasis paid to those developments adjacent to streams or other water bodies. As mentioned under Chapter 6, a substantial effort is currently underway to improve conditions at nearly all AFO/CAFO facilities in the project area.

One pollutant source area that will likely increase by a small amount includes residential development of non-municipal areas. Although growth trends will eventually require the expansion of municipal areas, well-planned strategies guiding development of non-municipal areas can minimize impacts to water quality. Development of non-residential areas should be regulated and should fully account for impacts to water quality, regardless of additional costs required to minimize such impacts.

7.5 Future Monitoring

Dynamic management decisions in a watershed are based on the water quality monitoring, which provides a basis for assessing original planning, assumptions, and projections and subsequently refined planning. A future monitoring plan that is tailored to the need of the drainage is essential to the future of Newton/Clarkston area water quality improvements. The Newton/Clarkston watershed is currently included in the intensive water quality monitoring completed on the Utah portion of the Bear River every five to six years. As mentioned previously, the most recent monitoring round was completed this year. New stations were added to the project area including stations above and below the Reservoir.

In addition to the monitoring sites measured during the intensive water quality monitoring round, it is recommend that 3 additional nutrient monitoring and flow locations be considered. These three additional sampling locations would provide information that would be very helpful in the future refinement to the modeling efforts and load estimates contained in this report. Table 7-4 lists these sites and the justification for each and Figure 7-1 shows the location of each recommended site.

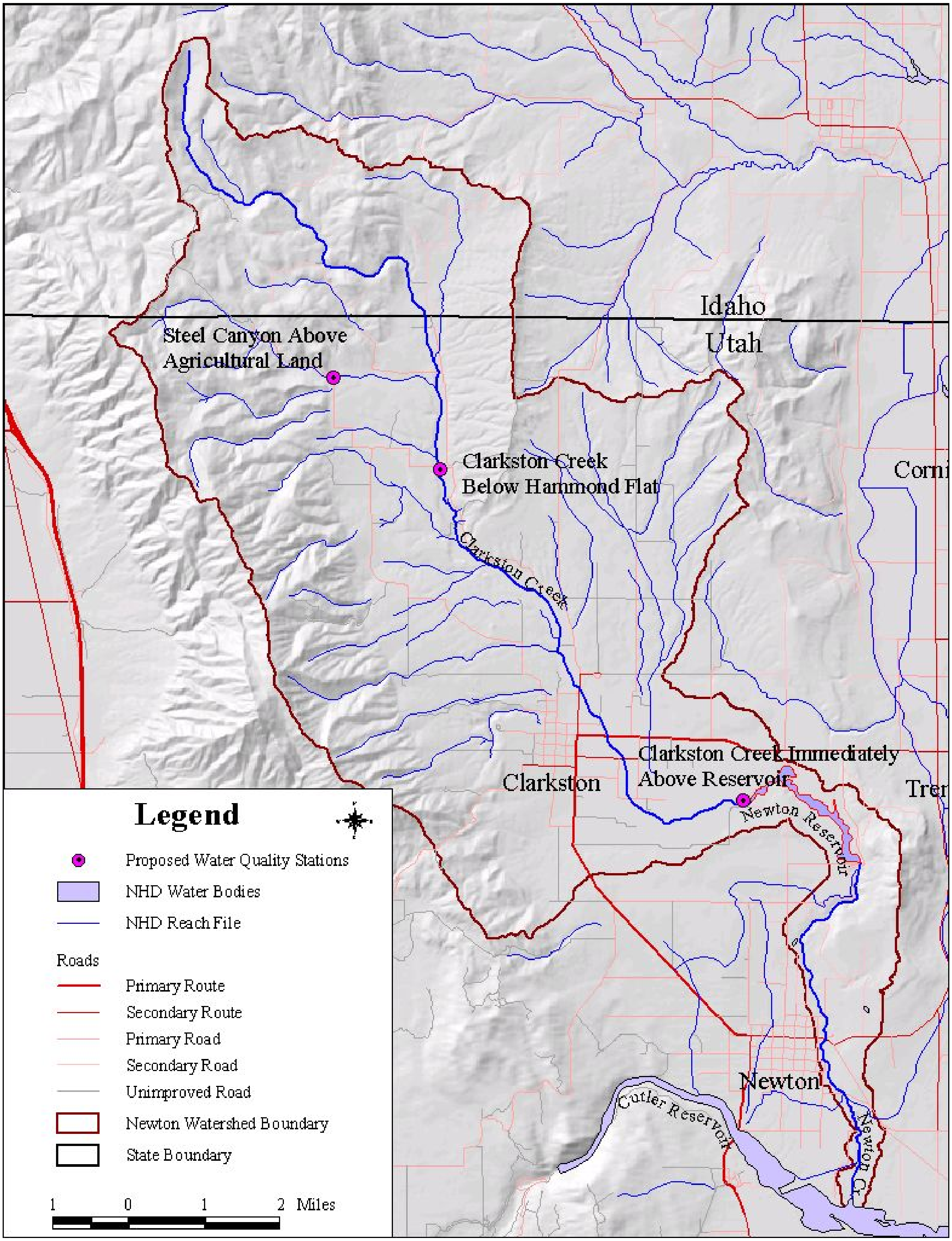

Figure 7-1. Proposed supplemental water quality monitoring stations in the TMDL project area.

Table 7-4. Suggested additional flow and Total P monitoring locations.	
Location	**Justification**
Steel Canyon above agricultural land	Land cover above this point is primarily rangeland with some forest and would represent an area unimpacted by agriculture. Information collected here would represent conditions as close to "background" or "unimpacted" as possible.
Clarkston Creek below Hammond Flat	This provides a location in the upper watershed for comparison with data collected at the 490319 site and would help characterize the longitudinal distribution of phosphorus concentrations.
Clarkston Creek immediately upstream of reservoir	This will characterize concentrations immediately upstream of the reservoir for purposes of calculating loads. Additionally, it would include any pollutant contributions downstream of the 490319 site. Continuous flow data into the reservoir would contribute to the accuracy of future modeling efforts.

In addition to the new stream monitoring sites, it is recommended that DEQ sample from Newton Reservoir during times of the year other than summer. The seasonal reservoir dynamics are important as it is suspected that DO levels in the reservoir during winter may be of concern due to the effect of freezing. Finally, it is important that a clear understanding of inflows and outflows at Newton Reservoir are clearly and accurately understood. A limited amount of daily discharge measurements from Newton Reservoir have been used in this assessment to determine streamflow values. If accurate continuous flow data are available above and below Newton Reservoir, the accuracy of modeling would be increased.

To ensure that the conclusions of this TMDL study are as accurate as possible and that any management alternatives implemented as part of the implementation plan are effective, we recommend that a regular, long term monitoring program be established within the watershed. At a minimum, this long term monitoring plan should include the additional locations above the reservoir in efforts to distinguish between the potential effects of management options that are implemented in order to meet endpoints associated with the TMDL study.

7.6 LONG TERM IMPLEMENTATION CONCERNS - OVERALL PHOSPHORUS BUDGET

In order to better understand the long-term effects of management and implementation of BMPs in the Newton watershed, the overall TP inventory and budget for the entire watershed must be considered. The current TMDL implementation plan details the use of conventional BMPs aimed at keeping phosphorus out of the water bodies in the watershed. It is expected that these measures will have a pronounced effect and will be effective in improving water quality within the watershed in the short term (10 - 15 years in the future). However, the problem with the measures that have been proposed for implementation in the Newton watershed is that they do not involve an increase in the amount of phosphorus removed or exported from the watershed. Instead, the phosphorus is merely displaced (i.e., in the short term it will no longer get directly into the stream, but it will build up in the soils, in riparian buffers, and potentially in vegetation in the watershed). Consider a simple diagram of the overall phosphorus budget for the Newton watershed (Figure 7-2).

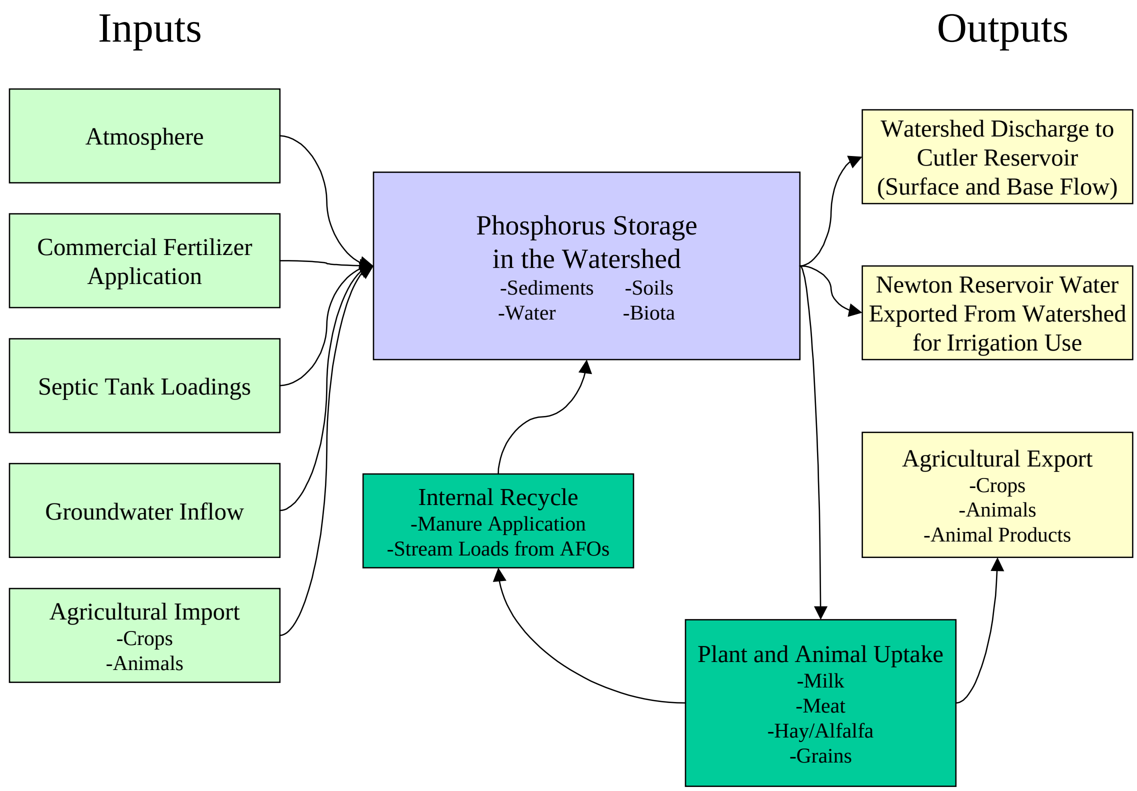

Figure 7-2. Overall phosphorus budget for the Newton watershed.

The current mass of phosphorus represented by each of the boxes shown in Figure 7-2 is not known with any certainty. However, sampling data in the watershed and this TMDL assessment show that water quality impairment from excess TP exists. In other words, the current situation in the watershed is such that a significant portion of the phosphorus being imported to and recycled within the watershed is ending up in the water bodies causing the water quality impairment.

While water quality is expected to improve in the short-term with implementation of the management practices prescribed in the TMDL implementation plan, problems may again arise in the long-term because the storage capacity of the soils, the proposed riparian buffers, etc. in the watershed is not infinite. Eventually, without a change in the amount of phosphorus imported to and/or exported from the watershed these components will become saturated (i.e., they will no longer be able to intercept phosphorus and keep it out of the water bodies in the watershed), and when this happens the phosphorus will again start impacting the water bodies in the watershed.

The long-term solution to improving water quality in the Newton/Clarkston watershed must include a change in the overall phosphorus budget shown in Figure 7-2. Essentially, there are two options. The first is to change the amount of phosphorus being *imported* to the watershed. This would involve a change in commercial fertilizer application, septic tank loadings, or agricultural import. Reducing the import of phosphorus to the watershed would eventually decrease the amount of storage in the watershed and would result in a long-term improvement in water quality.

The second option is to increase the amount of phosphorus *export* from the watershed. Little potential for change is associated with the two mechanisms for phosphorus removal with flow from the watershed (i.e., stream flow discharge to Cutler Reservoir and Newton Reservoir releases used to irrigate land outside the watershed). It is believed that phosphorus removal from the watershed by these two mechanisms is already at its highest potential. The only real opportunity to increase phosphorus export would be to either increase agricultural export from the watershed or improve the efficiency of internal recycling of phosphorus that is occurring so that the mass released in the form of animal wastes is reused to produce feed crops rather than being washed into the creeks and on downstream. In this way, as the cash crops (animals, hay, grains, other crops exported from the drainage) leave the system, the phosphorus would leave with them. Improved management may, over the long term, also reduce the need for commercial fertilizer, thereby lowering the external phosphorus inputs.

Increased agricultural export would mean exporting more of the crops produced in the watershed rather than using them to feed animals within the watershed. Obviously, this in turn affects the number of animals that could then be supported in the watershed and the amount of manure that would be produced and land applied in the watershed and so the two options are related. If the amount of animal waste produced in the watershed is to remain unchanged (i.e., no change in the number of animals in the watershed), reducing the amount of phosphorus recycled would have to involve exporting animal waste from the watershed rather than allowing it to be land applied or wash directly into the streams from animal feeding operations. Otherwise, reducing the amount of phosphorus recycling in the watershed means reducing the amount of manure produced in the watershed (i.e., fewer animal feeding operations and fewer animals in the watershed).

In summary, while it is believed that the BMPs prescribed in the TMDL implementation plan will improve water quality in the short term (i.e., 10 - 15 years) it is not believed that they are a long-term solution to phosphorus related water quality problems in the Newton watershed. Merely displacing the phosphorus will cause potential saturation in the soils, riparian buffers, etc. and eventually the phosphorus will again start impacting the water bodies in the watershed. The long-term solution must involve a change in the amount of phosphorus exported from and/or imported to the Newton watershed.

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