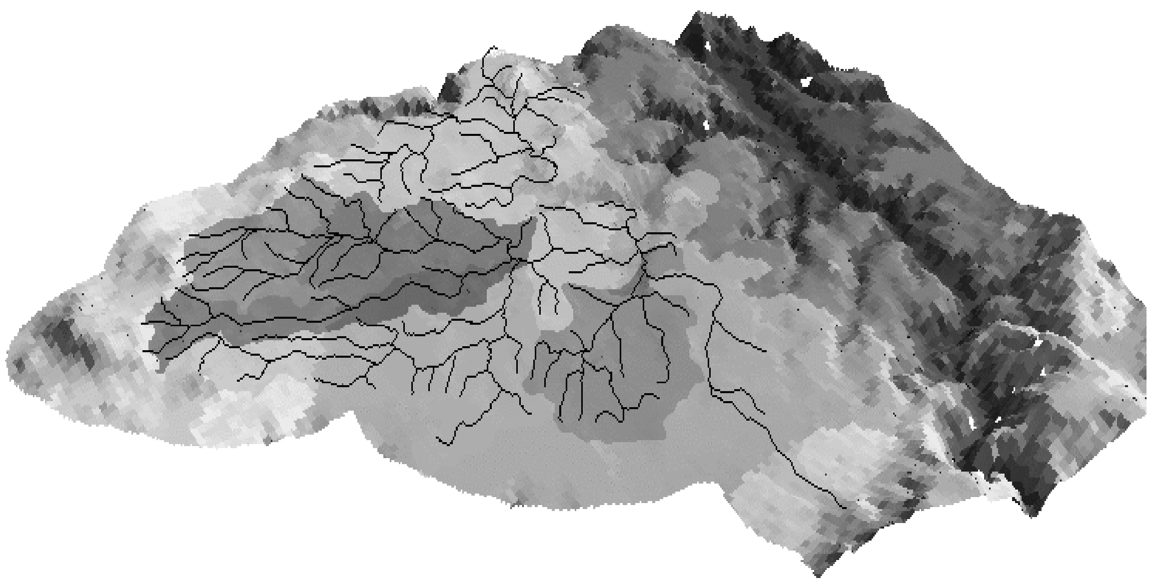
Fecal Coliform TMDL Modeling Report
Cottonwood Creek Watershed
Idaho County, Idaho

Final Report - 1/11/00



Cottonwood Creek Watershed: Outlines of subwatersheds and streams roughly draped over a 3-D topographic surface. Elevations Exaggerated 4X.

EPA Office of Water
Office of Science and Technology
Standards and Applied Science Division
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Executive Summary

At the request of the Idaho Department of Environmental Quality (IDEQ), and EPA's Region 10 Idaho Office, the EPA Office of Water, Headquarters Office conducted this study to model the loading of fecal coliform to creeks in the Cottonwood watershed, and to evaluate the level and types of controls required to reduce bacteria loading to acceptable levels. We utilized a variety of data sources (EPA BASINS system, Idaho Soil Conservation Commission, and NOAA) to inventory and quantify point and nonpoint sources in the watershed. The Cottonwood wastewater treatment plant (WWTP) is the sole point source in this largely agricultural watershed (73% cropland and 21% pasture and rangeland). We estimated that one third of the septic systems were failing for a rural population of roughly 1100. Livestock populations were significant at roughly 3300 beef cattle, 300 dairy cows, and 2300 hogs. The wildlife population was estimated to total 400 deer and elk. Manure management practices were identified with assistance from the watershed advisory group (WAG) at the 10/28/99 WAG meeting.

We used the BASINS Nonpoint Source Model (NPSM) to represent the Cottonwood watershed's hydrology and fecal coliform creek loads. We calibrated the Cottonwood model hydrology against measured Lower Cottonwood Creek flow gage data. We used a spreadsheet to calculate bacteria related NPSM input parameters, and then calibrated the model against fecal coliform monitoring data. We reran the model with a percent reduction to nonpoint source loads to creeks, in addition to cattle-in-stream and faulty septic system "point source" reductions, to determine nonpoint and point load reductions required to achieve the state water quality standard. Required nonpoint source load reductions ranged from 23% for South Fork Cottonwood to 88% for Shebang, when "cattle-in-stream" and faulty septic system loads were reduced by 80%-100%.

We ran additional control scenarios to evaluate the level of impact from individual sources and arrived at the following key conclusions:

- The Cottonwood WWTP is not a significant source of fecal coliform loadings in Upper and Lower Cottonwood Creeks;
- The cattle-in-streams (or other) point source in Upper Cottonwood, South Fork Cottonwood, Red Rock, and Stockney Creeks, in late Spring, is a significant source of fecal coliform loadings during periods of dry weather;
- Accumulation of fecal coliform on land surfaces, due to both grazing/pasturing of cattle and manure spreading from hog and dairy operations, appears to be a significant source of fecal coliform loading to creeks, particularly during wet weather events; and
- Faulty septic systems appear to be a significant contributor to exceedances of the fecal coliform criteria in Cottonwood Creek watershed.

A viable implementation plan to achieve fecal coliform criteria will require reductions from a combination of the four main fecal coliform source categories in the watershed: hog manure, dairy cow manure, beef cattle manure, and faulty septic systems.

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Cottonwood Creek, Idaho

1.0 Introduction

At the request of the Idaho Department of Environmental Quality (IDEQ), and EPA's Region 10 Idaho Office, the EPA Office of Water, Headquarters Office conducted this study to model the loading of fecal coliform to creeks in the Cottonwood watershed, and to evaluate the level and types of controls required to reduce bacteria loading to acceptable levels. This report describes the Cottonwood Creek watershed modeling conducted by EPA Office of Water.

1.1 Background

Section 303d of the Federal Clean Water Act directs States to identify waters where the currently required pollution controls are inadequate to achieve water quality standards. For each of these "water quality limited segments," the States have to establish a Total Maximum Daily Load (TMDL) of a pollutant that the waterbody can receive without violating water quality standards.

In 1994, 1996, and 1998, Cottonwood Creek, Idaho was identified as a water quality limited segment. The listed pollutants are pathogens (fecal coliform), ammonia, dissolved oxygen, habitat and flow alteration, nutrients, sediment, and temperature. The designated beneficial uses of the Cottonwood Creek watershed are salmon spawning, cold water biota, secondary contact recreation and an agricultural water supply.

Cottonwood Creek is a tributary to the South Fork Clearwater River located in Idaho County, in Northwest Idaho. It flows roughly from west to east and the mainstem is about 30 miles long. The creek has dramatic runoff in the spring from snow melt, severe soil erosion in the winter, and low flows during the summer. Cottonwood Creek watershed is relatively small, having an area of approximately 192 square miles. It consists of a basaltic mountain plateau with steep forested foothills on the west side, and deep canyons on the east side where Cottonwood Creek joins the South Fork Clearwater River (see Map I-1). The central plateau is mostly rolling prairie and the predominate land use is agricultural. Grain crops and livestock are its principle products.

1.2 Water Quality Target

Fecal bacteria are often associated with human pathogens such as viruses, protozoa, parasites, and other microorganisms. Since pathenogenic organisms are difficult to measure in water, fecal bacteria (fecal coliform and fecal streptocci) are often used as indicator organisms of human and animal wastes. Monitoring of the Cottonwood watershed from 1996 to 1998 at seven locations repeatedly found fecal coliform concentrations in excess of Idaho's primary and secondary water quality standards at all of the sampling locations. The tributaries with the greatest exceedances of state standards were Red Rock Creek, Shebang Creek and Lower Cottonwood Creek (IDEQ, 1999A).

The Cottonwood Creek modeling effort uses the current fecal coliform criteria shown below for the basis of evaluation. A negotiated rulemaking process is underway that involves changing the recreational contact criteria from one based on fecal coliform to one based on *Escherichia coli* (*E. coli*). Because this rule is not final, the existing fecal coliform criteria must be used for this TMDL. Also, *E. coli* data for the Cottonwood watershed is limited and insufficient for a loading analysis. Samples were recently collected for *E. coli* analysis in summer 1999 but results are not yet available.

The State of Idaho has set water quality criteria for surface waters for primary and secondary contact uses as reflected in Table 1. Primary contact recreation occurs between May 1 and September 30.

Table 1. State of Idaho Fecal Coliform Water Quality Criteria

Idaho Fecal Coliform Water Quality Criteria	**Not to Exceed at Any time*:**	**No Greater than*:** in 10% Samples taken within 30 days	**Not to Exceed a Geometric Mean of*:** Based on min. 5 samples within 30 days
Primary Contact Recreation	500 cfu/100 mL	200 cfu/100 mL	50 cfu/100 mL
Secondary Contact Recreation	800 cfu/100 mL	400 cfu/100 mL	200 cfu/100 mL

* - All three criteria must be met simultaneously in order for the standard to be met.

The mainstem of Cottonwood Creek is designated for secondary contact recreation use. For the undesignated tributaries, the presumed designated use is primary or secondary contact recreation, so a choice exists as to which criteria to use for the loading analysis. The government entities conducting the TMDL agreed that secondary contact recreation criteria was appropriate for all the tributaries except for Red Rock, which will be evaluated using primary contact recreation criteria.

1.3 Water Quality Monitoring Program

In the summer of 1996, the Idaho Soil and Water Conservation District initiated a water monitoring program in the Cottonwood Creek watershed. The purpose of the program was to provide baseline data to determine water quality in the watershed. The monitoring measured seven parameters at seven sampling locations. The water quality parameters measured were nitrogen compounds, total phosphorus, total suspended sediment, stream discharge, precipitation, bacteria, and water temperature.

The sampling stations are located on Stockney Creek, Upper Cottonwood Creek, Shebang Creek, South Fork Cottonwood Creek, Long Haul Creek, Red Rock Creek, and Lower Cottonwood Creek. No monitoring stations are located on Middle Cottonwood Creek (ID DEQ, 1999A).

Flow and water quality information was measured for seven of the eight subwatersheds in the Cottonwood Creek watershed. Flow measurements were recorded daily and fecal coliform measurements were taken from 1-3 times per month from early 1996 to 1998.

Results of the monitoring found “significant” exceedances of Idaho’s water quality standards for bacteria (fecal coliform) and temperature. In addition, high levels of nutrients (total phosphorous and nitrogen compounds), were conducive to algae growth, total suspended solids exceeded levels to impact aquatic life, and ammonia level exceeded EPA Goldbook criteria for fish species (IDEQ, 1999A).

Due to uncertainty in flow data from the upper monitoring stations, early on in this project, flow data only from Lower Cottonwood was used in calibrating the NPSM.

Flows and fecal coliform concentrations were also measured from the City of Cottonwood Waste Water Treatment Plant when it was discharging. Daily flow measurements were provided by the City of Cottonwood for the period of November 1996 to March, 1999. Fecal coliform measurements were also available for most months when there was discharge from the plant. Twenty seven samples were collected from February 1995 to April 1999. Data from the samples collected between 1996 to 1999 were used in the bacteria modeling. Because the Cottonwood Wastewater Treatment Plant was redesigned during 1995-96 which resulted in a significant reduction in bacteria discharge to Upper Cottonwood Creek, the 1995 samples were not used (Cottonwood, 1999; Teasdale and Funk, 1998).

2.0 Assessment of Point Sources

The Cottonwood WWTP is the only point source in the Cottonwood Creek watershed permitted through EPA's NPDES program. The Cottonwood WWTP is designed to serve a population of 800, discharges to Upper Cottonwood Creek, and is permitted to discharge bacteria, sediment, ammonia and BOD material. The Cottonwood WWTP was upgraded in 1995-96 and currently consists of a series of five connected treatment ponds, a chlorine disinfection basin, and a 40 acre hybrid poplar tree plantation (IDEQ, 1999a).

The Cottonwood WWTP is currently permitted to discharge to Upper Cottonwood Creek only between October 31 and April 1of each year although discharges have also occurred during April and May under emergency provisions (IDEQ, 1999c). Between April 30 and October 16 the WWTP is permitted to land apply wastewater onto a hybrid poplar tree plantation operated by the City of Cottonwood.

The wastewater flow into the plant is higher than expected because of high inflow from groundwater infiltration and storm water. A study of the system found no economically viable solution to correct this problem so the new plant was designed to account for these additional flow volumes.

The waste water is spray irrigated onto hybrid popular trees. The tree plantation is underlain by a tile drain system that catches any waste water that leaches or percolates through the soils. The water caught by the tile drains is then routed into the chlorine disinfection basin before discharged to the creek (Teasdale and Funk, 1998).

The current permit effluent limitations for the WWTP for fecal coliform discharge to Cottonwood Creek is:

Pollutant	Monthly Average	Weekly Average
Fecal Coliform	100 cfu/100 mL	200 cfu/100mL

(Teasdale and Funk, 1998)

The permit limitations for spray-irrigated wastewater (April 30 to October 16) are:

Maximum Total Coliform count:	Maximum Volume Allowed per year:
2.2 organisms/100 mL	42.6 mgal

(Teasdale and Funk, 1998)

Flow related design parameters for the plant are :

Population Served	800
Base Hydraulic loading	100 GPD
Average Dry Weather Flow	300,000 GPD (0.3 MGD)
Peak Wet Weather Flow	800,000 GPD (0.8 MGD)

(Teasdale and Funk, 1998)

The city of Cottonwood has requested changes to their current permit. The City wants allowable creek discharge to be based on available dilution flows in Cottonwood Creek instead of being based on a specified time frame discharge. The City also wants to eliminate treating the tile drain leachate with chlorine if bacteria are below a minimum level (IDEQ, 1999d). Daily flow data and monthly fecal coliform monitoring data from the WWTP was used as input to the watershed model (Cottonwood, 1999).

3.0 Assessment of Nonpoint Sources

IDEQ has identified the primary nonpoint sources in the Cottonwood Creek watershed as agriculture, grazing, and septic systems (IDEQ 1999a). The model for Cottonwood Creek takes into account fecal coliform loading from hog and cow manure application to cropland, beef cattle manure loadings to pastureland and rangeland, and fecal coliform accumulation and wash-off from built-up areas. It also takes into account faulty septic system loads to streams, as well as direct loads to streams from cattle or some other unknown source. The modeling took into account the following considerations:

- Subwatershed landuse (the acreage of each landuse in each of the subwatersheds)
- Estimated number of swine and beef and dairy cows per subwatershed
- Percentage of annual manure production applied to cropland, rangeland, or pastureland per month
- Assumed number of wildlife per square mile
- Population served by septic systems, and number of failing septic systems
- Cattle in streams/Other Point Source

Each of the above considerations are included as input to a spreadsheet designed to estimate NPSM/HSPF input parameters. Estimated monthly fecal coliform accumulation rates and maximum storage values (NPSM/HSPF variables MON-ACCUM and MON-SQOLIM) were determined for each subwatershed/ land use combination. The spreadsheet was also use to estimate faulty septic system direct discharge to creeks. The following sections describe in more detail the assumptions used for estimating model parameters for fecal coliform manure and septic system loading. Each of these assumptions were reviewed and revised or approved during the 10/28/99 WAG meeting.

3.1 Subwatershed Landuses

Major land uses in Cottonwood Creek are summarized by subwatershed in Table 2. Cropland represents 73% of the land use in the watershed, rangeland 12%, pastureland 9%, forest land 5%, and urban/industrial 1% (see section 4.1 for more details).

Table 2. Principal Land Uses by Subwatershed

Subwatersheds	Cropland Percent (%)	Rangeland Percent (%)	Pasture Percent (%)	Forest Percent (%)
Shebang Creek	86	0	12	1
Upper Cottonwood Creek	56	0	21	21
Stockney Creek	86	0	12	2
Red Rock Creek	80	16	3	2
Lower Cottonwood	35	50	0	14
Middle Cottonwood	72	17	6	5
South Fork Cottonwood	85	3	12	0
Long Haul Creek	70	1	25	1
Total Watershed %	73	12	9	5

(ISSC, 1999)

3.2 Livestock Estimates

Since manure from livestock can be a potential source of fecal coliform bacteria, it is necessary to roughly estimate the number of animals in a watershed, the amount of manure produced, and how it can reach the creeks and streams. The number of animals, land use, and amount of rain fall, are all important factors in estimating the loading from animal manure.

Based on input provided by Cottonwood WAG and TAG members and ICSWCD representatives, IDEQ recommended using 35-40 average cows per animal feeding unit and 55 cows per dairy (IDEQ, 1999b). The estimate for beef cattle was reduced to 20 cows per feeding unit based on comments at the 10/28/99 WAG meeting. Estimated number of hogs per producers were provided by the NRCS District Conservationist (Spencer 1999). Table 3 provides the livestock estimates for each of the subwatersheds.

Table 3. Livestock Estimation by Subwatershed

Subwatersheds	Animal Feeding Units	Feed Lot Cows[1] (Est.)	Dairies	Dairy Cows (Est.)	Total Cows (Est.)	Hog Producers	Total Hogs (Est.)
Stockney Creek	29	580	2	110	690	5	355
Upper Cottonwood Creek	11	220	3	165	385	1	139
Shebang Creek	27	540	0	0	540	2	782
South Fork Cottonwood Creek	6	240	0	0	240	0	0
Long Haul Creek	12	240	0	0	240	0	0
Red Rock Creek	34	680	0	0	680	3	1,058
Middle Cottonwood	34	680	0	0	680	0[2]	0
Lower Cottonwood	7	140	0	0	140	0	0
Totals	160	3,320	5	275	3,595	11	2,334

[1]These estimates reflect a factor-of-two reduction based on comments received at 10/28/99 WAG meeting.
[2]Revised from April 1999 draft data (IDEQ, 1999a and IDEQ, 1999b).

3.3 Manure Application

- Hogs: Hog manure is applied to cropland at a rate of 2% of annual production every month except for July, August, and September, when it's applied at a rate of 27.33%. It's assumed that no hog manure is applied to pasturelands and that its incorporated into the soil at 75% efficiency.

- Poultry: It was assumed there is no poultry production in the watershed and no litter applied to the fields in the watershed.

- Dairy Cattle: Dairy cattle are confined in feedlots so all their waste is used for manure application to cropland and pastureland. The manure is stored from November to March, and is applied to cropland, pastureland, and rangeland at the rate of 22.22% (of annual production) during April, May, and June. Dairy cow manure is applied as generated (1/12 or 8.33%) during July through October. It's assumed that dairy manure is incorporated into the soil at a 75% efficiency.

- Beef Cattle: Beef cattle are either confined in feedlots or allowed to graze. No distinction, in the Cottonwood Creek watershed model, is made (though the fecal coliform spreadsheet allows this) between these two cases since manure deposited in an open feedlot is still exposed to the environment and able to runoff. Waste from beef cattle is applied, in the model, to rangeland and pastureland and is not incorporated (0% efficiency) in the soil. It's assumed that a percentage of beef cattle in some watersheds, will have direct access to streams. The direct contribution of fecal coliform to a stream by cattle was represented as a point source in four subwatersheds in the model (see sections 3.6 and 5.3).

3.4 Wildlife Contribution

An average of 6 deer per square mile throughout the entire watershed was assumed, except for forested land, in which deer were assumed to be at a higher density of 10 deer per square mile. We also assumed a total elk population in the watershed of 60 (Richards, 1999). This translates to about 0.31 elk per square mile. Since fecal coliform production rates for elk were unavailable, a conservative assumption that elk produce 3 times the amount of fecal coliform as deer was used. The elk were then accounted for in the model as deer, making a total of 7 deer per square mile in all but forested land, and 11 deer per square mile in forested land. Table 4 provides the estimated deer per subwatershed and landuse. It's assumed that there are no deer in urban areas.

Table 4. Wildlife Estimates by Subwatershed

Watershed	**Cropland**	**Forest**	**Pasture/ Rangeland**	**Subtotals**
Stockney Creek	186	7	25	218
Upper Cottonwood Creek	61	36	24	121
Shebang Creek	174	5	24	203
Long Haul Creek	64	1	24	8
South Fork Cottonwood Creek	119	1	20	140
Red Rock Creek	230	9	53	292
Lower Cottonwood	152	47	113	312
Subtotals	986	106	283	1,375

3.5 Septic Systems

Since private septic systems can also be a source of fecal coliform bacteria, it is necessary to roughly estimate the number of failing systems in a watershed. The North Central District Health Department personnel estimated that one-third of the systems in the watershed were failing (IDEQ, 1999a and 1999c). To estimate the amount of fecal coliform being contributed by failing septic systems, the rural population was estimated, then the number of rural households, the number of septic systems and then the number of failing systems were tabulated.

Population data for Idaho County was taken from the US Bureau of Census 1990 "TIGER" data (ESRI, 1999). Detailed information for individual census blocks was overlayed with the eight subwatersheds to roughly estimate the rural population in each subwatershed. We did not include the urban population in the cities of Grangeville and Cottonwood because they have separate waste water treatment systems. The Cottonwood system discharges to Upper Cottonwood Creek and is modeled as a point source. While a part of Grangeville lies within the Cottonwood Creek watershed, the city discharges to an adjacent watershed and is not included as a bacteria source for this project.

Since the detailed census block data was from 1990, we compared it to County level population estimates for 1994 and 1995. We found that no major population changes occurred in Idaho County during this time, so we were fairly confident in using data from both 1990 and 1995.

The number of households was derived from the 1995 Idaho County population estimates. In 1995, the entire county had a population of 13,783 with 5,187 households. The estimated number of people per household ranged from 2.4 to 3.3 in each of the five census tracts. The estimated county-wide average was 2.66 people per household (ESRI, 1999).

To estimate the number of households in each of the subwatersheds, the estimated population was divided by the estimated people per household. We then assumed that each household had one septic system and the failure rate was one-third.

Here is an example for Shebang Creek subwatershed:

> 233 people in watershed (estimated from 1990 Census block data)
> 2.66 people per household (County average from 1995 Idaho County population data)
> 233 people/2.66 people per household = 88 households
> 88 households x 1 system per household = 88 septic systems
> 88 systems x 1/3 systems failing = 29 septic systems failing

Table 5 summarizes the estimated rural population, and estimated number of septic system failures for each subwatershed.

Table 5. Estimated Rural Population and Estimated Number of Failed Septic Systems

Subwatershed	Estimated Rural Population[a]	Estimated Number of Failed Septic Systems
Stockney Creek	230	29
Upper Cottonwood Creek	120	15
Shebang Creek	233	29
South Fork Cottonwood Creek	58	7
Long Haul Creek	186	23
Red Rock Creek	196	25
Middle Cottonwood Creek	43	5
Lower Cottonwood Creek	39	5

[a] Population estimates based on U.S. Census data (ESRI 1999);Population and household calculations exclude the cities of Cottonwood and Grangeville.

3.6 Cattle in Streams/ Other Point Source

During the course of the model calibration, it was clear that a direct in-stream source, rather than solely runoff driven loadings, were responsible for high fecal coliform concentrations in some creeks. Because a number of farmers, at the 10/28/99 WAG meeting, disputed the assumption that grazing cattle were the cause of the direct load, we are uncertain as to the actual cause. Additional studies at the field scale would be able to either confirm cattle as the source or identify another source. The calibration results indicated a point source loading such as cattle wading in the stream was causing high dry weather concentrations during mid-April to mid-June in South Fork Cottonwood, April and May in Red Rock, April and May in Upper Cottonwood, and mid-April to May in Stockney Creeks. See section 5.3 for additional details.

4.0 BASINS Nonpoint Source Model (NPSM) and Required Input Data

The Nonpoint Source Model (NPSM) is a Windows and ArcView GIS based interface to the legacy EPA watershed model Hydrologic Simulation Program Fortran (HSPF). HSPF calculates non-point loadings of selected pollutants for specific land uses in a watershed. HSPF determines surface runoff and interflow, as well as baseflow and links these to an instream water quality model. NPSM/HSPF also allows a user to simulate the flow and pollutant routing through a network of streams, rivers, lakes and reservoirs. NPSM/HSPF can also simulate point sources to represent the flow and concentration of a pollutant from a facility or discharger. HSPF is a continuous simulation model and requires continuous time series data for weather. Data requirements are extensive and include precipitation, evapotranspiration, temperature, and solar radiation. NPSM also automatically prepares much of the needed input data for HSPF, either those packaged with BASINS, or imported to BASINS on a site specific basis. Below is a summary of the Geographic Information System (GIS) and other data sets, and their sources, that were used in modeling the Cottonwood Creek watershed:

- Land Use/Land Cover Data - ISCC, 1999
- Watershed Boundaries - ISCC, 1999
- Stream Networks - EPA, 1998
- Stream Geometry/Cross Sections - Gilmore, 1998
- Elevation Data and River Reach Network - USEPA, 1998
- Soils Data - ISCC, 1999
- Weather Data - principally from Cottonwood weather station, supplemented by NOAA data from Fenn and Lewiston stations - see Appendix IV

4.1 Land Use/Land Cover Data

Information on land use in the Cottonwood watershed were obtained from the Idaho Department of Agriculture. Land use was mapped at 1:24,000 scale and digitized by the U.S. Department of Agriculture (USDA) National Resources Conservation Service (NRCS) in Moscow Idaho (see Map I-4). The Idaho Department of Agriculture processed the data and produced ArcView shape files (ISCC, 1999).

Land use data was also available from EPA's BASINS data set at 1:250,000 scale. EPA's data combined cropland and pasture landuse categories while the State's data set was more detailed and better differentiated between cropland and pastures. Since potential runoff from cropland and pasture could be significant in calculating bacterial loading to streams in this watershed, the Idaho data was selected.

An Anderson Level I classification system was used for the Idaho data which divided the data into the following categories: Cropland - Pasture - Rangeland -Forested Land - Wetland - Barren - Urban or Built Up Land. Cropland represents 73% of the land use in the watershed, rangeland 12%, pastureland 9%, forest land 5%, and urban/industrial 1%. See section 3.1 for more details.

The principal crops in the watershed are winter wheat, spring barley, and spring wheat. Other important crops are spring peas, oats, lentils, rape and canola. Hay and bluegrass are grown in rotation with small grains (IDEQ, 1999A).

4.2 Watershed Delineation

The watershed outline used for this project was provided by Idaho DEQ and produced by the Idaho Department of Agriculture. Idaho subdivided the watershed into eight subwatersheds corresponding to each of the major creeks (see Map I-2). Subwatersheds were delineated from 1:24,000 scale topography maps and digitized by the USDA NRCS in Moscow Idaho. The Idaho Department of Agriculture processed the data and produced ArcView shape files (ISCC, 1999). We revised the original Idaho subwaterhed delineation such that each subwatershed pour point corresponded to a flow and water quality monitoring station. The major differences from the original delineation is that the Red Rock, Upper Cottonwood, and South Fork Cottonwood subwatersheds were each split into lower and upper parts (see Map I-3).

4.3 Stream Networks- EPA River Reach Files

EPA's River Reach Files Version 1 (RF1) provided the initial stream network information for Upper and Lower Cottonwood Creeks, and Red Rock Creek. This data was developed for stream routing for modeling at 1:500,000 scale (EPA, 1998).

EPA's River Reach File Version 3 (RF3) furnished the detailed stream networks information for the subwatersheds in Cottonwood Creek. This data set was developed for more refined stream routing (a 1:100 K scale) and provided information on Stockney, Shebang, South Fork Cottonwood, and Long Haul Creeks, and more detailed information on the Upper and Lower Cottonwood, and Red Rock Creek watersheds.

The River Reach 3 files for the Pacific Northwest, were derived from River Reach 2.1 files, which results in a somewhat courser scale than the RF3 stream networks in the rest of the country, and is of a different file format. Since the Pacific Northwest RF3 streams and creeks are composed of numerous unconnected segments, each of the line segments of a stream had to be selected and then joined together to make one continuous stream or creek to mathematically represent the stream network or river reach for modeling (EPA, 1998).

4.4 Stream Geometry/Cross Sections

A set of spread sheets was supplied by Idaho that provided detailed information on the relationship between the reach depth, cross-sectional area, wetted perimeter, and the flow rate at each gage station. These data were used to calculate the hydrologic function table (FTABLE in NPSM/HSPF) parameters for each of the subwatersheds. Depth and outflow values were used directly while surface area and volume values were calculated. See section 5.2 for more details.

4.5 Digital Elevation Data

Information on elevations in the Cottonwood Creek watershed came from Digital Elevation Models (DEMs). These were used to create a profile of the topography of the watershed (see Map I-1 and Map I-6). The change in elevation or slope of stream segments is important for modeling stream flow in the Non-point Source Model (NPSM).

The DEM's came from BASINS 2.0 which obtained them from the USGS Geospatial Data Clearinghouse (EPA, 1998). They were produced by the Defense Mapping Agency in 1-degree by 1-degree units, equivalent to 1:250,000 scale.

The original data consists of a series of regularly spaced elevation measurements and are derived from USGS 7 ½ minute quadrangle maps or by photogrammetric methods. Spacing of the elevations along and between each profile is 3 arc seconds with 1,201 elevations per profile.

4.6 Soils Data

Information on soils in the Cottonwood watershed were obtained from the Idaho Department of Agriculture. Soils were mapped at 1:24,000 scale by the USDA NRCS and digitized by the Idaho Department of Lands (see Map I-5). The Idaho Department of Agriculture processed the data and produced ArcView shape files (ISSC, 1999).

Soils data was also available from EPA's BASINS data set at 1:250,000 scale. EPA's data was summarized from USDA's State Soil and Geographic Database (STATSGO) soils database. Soils were grouped into six distinct categories based on similar chemical and physical properties.

The Idaho soils data was found to be more detailed than the information provided by BASINS and for this reason, we chose to use their data set. While soils data are not used explicitly in the NPSM/HSPF model, they were used to bound the infiltration rate ranges used in calibrating the model.

4.7 Weather Data

The principle weather station for this project is the Cottonwood station, a cooperative weather station located at the St. Gertrude Monastery about two miles WSW of the City of Cottonwood. This data is believed to be fairly representative of the central part of the Cottonwood watershed and will be used to calibrate the modeling for the Cottonwood watershed.

Most smaller cooperative weather stations do not have complete data coverage; they either do not record all the parameters, record only at a daily or longer time step, have time periods with no observations, or a combination of all three. The Cottonwood station was no exception to this generalization.

Nonpoint source modeling (NPSM) in BASINS requires hourly data for several meteorological parameters. Various methods exist to estimate these parameters, for example, “disaggregating” daily to hourly temperature based on a reasonable distribution throughout the day and the observed maximum and minimum values, extrapolating temperature values from one station to another based on consistent elevational influences, or calculating potential evapotranspiration from air temperature.

To help fill in the gaps in the Cottonwood data set we choose Fenn Ranger Station and Lewiston station, both of which are located outside of the watershed. Fenn Ranger station is located about 35 miles east of the watershed and Lewiston is about 40 miles NNW. Although Fenn is also a cooperative station, there was a complete WDM file for Fenn that had been prepared for BASINS 2.0 for the period from1/1/1970 to 12/31/1995. Lewiston is a primary NOAA weather station, and therefore it has a much more complete data set, which could also be used to help calculate missing data. The period of record we prepared for use in modeling for Cottonwood was 1/1/90 to 7/31/98, and for Fenn Ranger Station 1/1/90 to 12/31/98.

Cottonwood station had fairly complete daily data on precipitation and maximum and minimum air temperatures, but had significant gaps in hourly precipitation data, and was entirely lacking in data on dewpoint temperature, wind, potential evapotranspiration, evaporation, cloud cover, and solar radiation. None of these weather data sets included the needed information about pan evaporation rates and the percent of cloud cover. According to the Western Regional Climate Center, many of the small stations have been automated in recent years and no longer collect, or do not accurately collect cloud cover information. Since no cloud cover information was available for the area so it was estimated by comparing “summary of the day”data from Boise, Idaho to data from Fenn Ranger station. Since no pan evaporation data was available, it was calculated using various data souces: maximum and minimum temperature (observed Cottonwood), dewpoint temperature and wind (calculated from Fenn and Lewiston) and solar radiation (calculated from Boise)

Please refer to Appendix IV for more detailed information how surrogate data was constructed for the missing Cottonwood data values.

4.8 Map Projection

The Idaho DEQ requested use of the local State Plane projection for the Cottonwood TMDL project. The specifics of this projection are listed below:

Category:	State Plane - 1983
Type:	Idaho, Central
Projection:	Transverse Mercator
Spheroid:	GRS 80
Central Meridian	-114
Reference Latitude	41.667
False Northing	0
False Easting	500000
Units	meters

5.0 NPSM Model Application

The Nonpoint Source Model (NPSM) was applied to the Cottonwood Creek watershed in order to establish first that the model accurately represented the watershed and then to evaluate alternative scenarios for controlling bacteria water column concentrations. To properly run the NPSM, an accurate representation of the hydrology of the watershed is needed. Watershed hydrology is represented in NPSM with a series of water-storage components (e.g. surface ponding, snow pack, water below ground but above the water table [i.e. unsaturated zone], and groundwater) and linkages between these components are described with mathematical equations. The model can be thought of as a hydrologic budget, with pre-defined relationships between different budget components. The two most important inputs to the model are precipitation and potential evapotranspiration (similar to pan evaporation) which are taken from meteorological station measurements. Water input to the model as precipitation is tracked as it moves through the water components, is lost from the watershed system (e.g. through evapotranspiration) and flows out through the watershed pour point. Additionally, the model contains input that describes the sources of pollutants, whether applied to the land surface (non-point source), or applied directly to a stream (point source).

Calibration of the model is an essential aspect of using the NPSM in predicting what-if scenarios. Calibration is the process in which model parameters (i.e. the numbers that define how readily water and pollutants are transferred from one model component to another) are adjusted until the model reproduces known historical flow rates and pollutant concentrations in the watershed. That is, historical precipitation rates and pollutant loading data are applied to the model, and the model output is compared with historical records of flow rate and pollutant concentrations. Model parameters are adjusted until the model output is as close as possible to the historical data. Once the model is calibrated, adjustments to pollutant loading rates (e.g. reduction in amount of fecal coliform discharged from a wastewater treatment plant) are made representing what-if control scenarios. The output from these control scenarios is then a prediction of what would have happened, during the years over which the model was calibrated, if the pollutant loading rates had been different (eg. had been reduced according to the control scenario). Confidence in these predictions depends directly on the confidence in how accurately the model calibration represents the watershed.

In the following sections, the process through which we derived the final bacteria calibration is described in detail. The process begins with an initial hydrology calibration using a simplified model of the watershed. The next step entailed describing the watershed in more detail in order to represent each creek and associated subwatershed separately, and in evaluating how the more detailed model represented the hydrology of the watershed. Finally, fecal coliform sources were added to the model according to known livestock populations, assumed manure management practices, known septic system failure rates, and wastewater treatment plant (WWTP) monitoring. The model was then calibrated against monitored fecal coliform concentrations, until a best fit was achieved.

Recommendations for further investigations to reduce model uncertainty, as well as to improve the monitoring program's ability to assess baseline and post load-reduction outcomes, are provided in section 9.0.

5.1 Setup and Hydrology Calibration of Simple Watershed Model

Initially, the Nonpoint Source Model (NPSM) was set up to model the entire watershed as a whole, using a simplified description of the watershed - i.e. all land segments drain to a single reach segment - Lower Cottonwood Creek. Doing so allowed for rapid model development and comparison with stream flow gage data for the Lower Cottonwood.

To set up this simple model of the Cottonwood Creek basin, the hydrologic function table for Lower Cottonwood was derived from a table provided by the State of Idaho and modified as described below (see section 5.2). The initial run used the "starter.def" default data set provided with the BASINS system. Model results using this data set produced a clearly inadequate calibration. Then, as a next approximation, the HSPF Parameter Database (HSPFParm) was searched to identify the nearest previously applied HSPF project. The input data for the Tualatin River project were extracted from HSPFParm using the UCI file format export utility. Values for each hydrology parameter in the model were then manually input to a new default file we created in NPSM called "tualatin.def." This set of input data also produced an inadequate calibration for Cottonwood Creek.

We refined the model calibration, through the following steps:

- Develop an overall water mass balance that compares well with the monitoring data by adjusting overall gains and losses of water in the watershed from precipitation, evapotranspiration, and loss to deep groundwater;

- Adjust the high-flow/low-flow distribution to match the monitoring data by adjusting the rates at which water percolates through the soil, enters groundwater, and recharges streams;

- Match peak storm volumes and reproduce the number of days required for flow to return to normal levels; and

- Fit the seasonal distribution of flows taking into account seasonal variation in evapotranspiration, soil moisture, and changes in groundwater recharge to streams.

The final hydrology calibration (Figure 1) shows an excellent fit to the stream gage data.

NPSM Hydrology Calibration

Cottonwood Creek - 10/96 - 5/98

Simulated vs. Observed

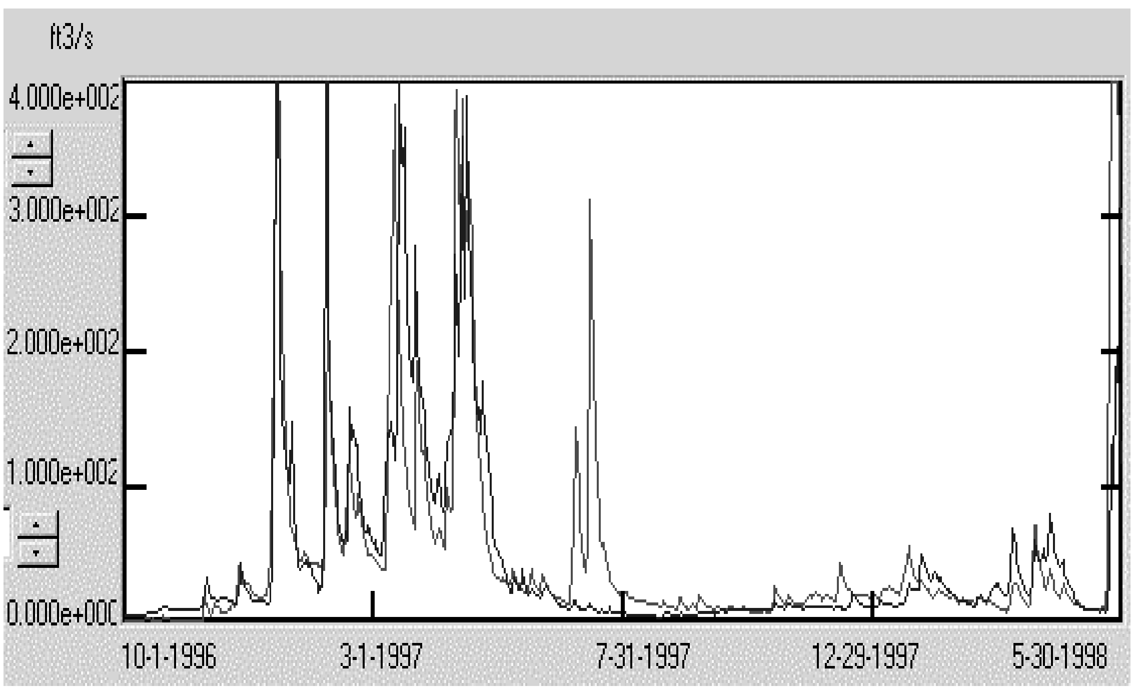

Figure 1. Hydrology Calibration at Lower Cottonwood Creek Gage Station

The first step in the calibration process was to develop an overall water mass balance that nearly equaled that in the monitoring data. Overall gains and losses of water from the watershed system are from precipitation, evapotranspiration, and loss to deep groundwater. To achieve this balance, a high value, beyond that reported as a “possible maximum,” for the parameter controlling loss to deep groundwater (DEEPFR) was used. It should be noted that total evapotranspiration from the watershed was at or near maximum during the course of each simulation year, and precipitation input data were not altered. Loss of water to deep groundwater is essentially where groundwater flows beneath the pour point of the watershed and eventually shows up at a lower elevation, or recharges low-lying aquifers. To confirm this extensive loss would require a groundwater study designed to evaluate the fraction of water entering the groundwater table, which does not show up in baseflow in the Lower Cottonwood Creek. Other possibilities are that precipitation at the Cottonwood weather gage is regularly high relative to precipitation to the watershed as a whole.

Whether precipitation or evapotranspiration is not representative, or the loss is truly through groundwater, should not significantly affect the most significant flows in the model - surface and interflow. Other parameters adjusted during this phase of the calibration were the evapotranspiration parameters: FOREST, LZSN, MON-LZETPARM, MON-INTERCEP, BASETP, and AGWETP. Note: the large storm in July, 1998, present in the simulation, though not in the gage flow data, is thought to be due to either an isolated storm that struck only a small portion of the watershed, including the Cottonwood meteorological station, or an error in the meteorological data log. We took this excess modeled storm flow into account when evaluating the overall mass balance. The modeled and monitored total flow through the Lower Cottonwood gage, corrected for the July, 1998 storm, are within 10%.

The second step in the hydrology calibration for the simple Cottonwood Creek watershed model was to match the high-flow/low-flow distribution in the monitoring data. This step was accomplished by adjusting model parameters representing infiltration (INFILT), interflow (INTFW), and groundwater recession (AGWRC).

The third step was to match storm flow (i.e. storm peaks height, timing, and recession curves) by adjusting parameters for interflow (IRC), upper zone storage (UZSN), and surface flow (LSUR, NSUR, and SLSUR).

The fourth and final step in the hydrology calibration was to match the seasonal distribution of flows. Adjusted parameters included evapotranspiration (MON-INTERCEP, MON-LZETPARM) , upper zone storage (UZSN), evapotranspiration from baseflow (BASETP), and groundwater recession (KVARY).

The resulting values for each model input parameter are included in Table V-1. The table shows the parameter values for the default data set provided with BASINS (starter.def file), the input data set used in the previous modeling work on the Tualatin River (tualatin.def file), as well as the input data set from the final hydrology calibration for Cottonwood Creek. In depth explanations for each parameter, as well as the range of “typical” and “possible” values are provided in BASINS Technical Note 6, which is available from the BASINS web page at: http://www.epa.gov/ost/basins/bsnsdocs.html.

A generic NPSM/HSPF hydrology sensitivity analysis for each of these parameters conducted to demonstrate the impact of each parameter on the flow rate output will be the subject of a web document on the BASINS web page scheduled for release by February, 2000. Key calibration parameters were: LZSN, INFILT, AGWRC, DEEPFR, INTFW, IRC, MON-INTERCEP, and MON-LZETPARM. All other parameters had little to no impact on the modeled flow rate output.

At the time this project was started, it was thought that additional, adjusted stream flow data would be made available for each of the seven gage stations throughout the watershed. Minor adjustments to each input parameter could then be made for each subwatershed, in a subwatershed-by-subwatershed calibration. Since the adjustments to the subwatershed flow data were considered unreliable at the time this model was being constructed, subwatershed specific calibrations could not be performed. Instead, calibrated input parameters were applied uniformly to each subwatershed in the detailed model (see next section).

5.2 Development of Detailed Cottonwood Watershed Model

While the model hydrology parameters were to be applied uniformly across the watershed, bacteria related parameters could not be. That is, each subwatershed has its own set of fecal coliform point and nonpoint sources and was treated separately so that subwatershed specific controls could be examined. This section describes the development of a more detailed model of the Cottonwood Creek watershed and concludes with a hydrological comparison of the simple and detailed versions of the model.

Hydrologic Function Tables

A set of tables were supplied by the State of Idaho which detailed the relationship between reach depth, cross-sectional area, wetted perimeter, and flow rate. The Nonpoint Source Model (NPSM) requires a hydrologic function table (FTABLE) for each reach segment in the model. The FTABLE defines the relationship between depth of water, top surface area, volume, and outflow rate for the segment. The key relationship, in the model, from a hydrology standpoint, is the depth/outflow relationship. The volume value is used in determining concentrations given pollutant loads; and the surface area is used in determining volatilization rates and other physio/bio/chemical reactions involving the air/water interface. Since the modeling in this project focused solely on a simple first-order decay description of the fate and transport of bacteria in the stream, the surface area then becomes an insignificant (in fact unused) parameter, though it is still required as a model input.

A spreadsheet was developed to automatically calculate the surface area and volume FTABLE values given the depth, and cross-sectional areas supplied by the State. The tables for each reach segment are included in Appendix V. The surface area calculation assumed a rectangular channel, calculated the surface width as the wetted perimeter minus two times the depth ($W = P_w - 2d$); and then calculated the surface area as the surface width times the reach length ($W * L$). It should be noted, that though the assumption of a rectangular cross-section is an over-simplification of the true cross-sectional morphology of these streams, the spreadsheet calculated surface area is not used by the model. The reach volume, on the other hand, was calculated in the spreadsheet using the cross-sectional areas supplied in the Idaho tables, multiplied by the reach length. Additional rows in the FTABLE, beyond the depths and flows measured and reported in the State-supplied tables, were required when simulated flows exceeded those measured/reported. For these greater depths, flows were calculated from the regression equations provided in the tables. Top surface area and volume values were linearly extrapolated. The two depths added were 10 feet and 20 feet for each table, or about 4-5 times the maximum measured depth (see Appendix V) in these calculations.

During the construction of the detailed Cottonwood Creek watershed model, the model was run using the default cross-section hydrologic function tables derived by BASINS from the RF1 stream width and depth data. Though the FTABLEs produced by BASINS and by the spreadsheets using Idaho's local data were dramatically different, there was no visible difference in the model prediction of flow rate at the Lower Cottonwood pour point. That is, the model does not appear to be sensitive to the channel cross-section.

Watershed Sub-delineation

NPSM/HSPF allows the modeler to output any variable associated with the reaches and reservoirs (RCHRES) module at any pour point defined in the model. The purpose of refining the Cottonwood Creek watershed delineation was to define subwatersheds with pour points which coincided with each of the seven sampling locations. This revised subwatershed delineation allows the direct comparison of predicted versus sampled fecal coliform concentrations. A previous Cottonwood Creek watershed sub-delineation made available by the State of Idaho was based on pour points defined by the confluence of each of the eight named creeks (see Map I-2). This delineation was further subdivided to add pour points corresponding with each of the seven water quality monitoring stations. A figure displaying the final subwatershed delineation used in the detailed Cottonwood Creek model is shown in Appendix I (Map I-3). In a few cases, multiple subwatersheds were defined for a single reach segment. The convention used in naming the subwatersheds in these cases was to name the uppermost watershed the original reach name and to name the subsequent downstream subwatersheds the reach name plus a number corresponding to their upstream-to-downstream sequence.

Reach Network and Characteristic Data

Two additional reach segments were added to the model to construct an accurate reach network diagram. These reaches were a segment for the lowermost part of Upper Cottonwood Creek, and the upper part of Middle Cottonwood Creek. These reaches route flow from upstream reaches, but do not receive any hydraulic or pollutant loads from land segments. Rather, all loads from Middle Cottonwood subwatershed land segments are applied to the Middle Cottonwood Creek 2 reach segment and all loads from Upper Cottonwood 2 subwatershed are applied to the Upper Cottonwood Creek 2 reach segment. Reach lengths (miles), mean elevations (feet), and elevation drop over the length of the reach (feet) were all measured from the BASINS GIS using the measuring tool, as well as the identify tool with the DEM data layer. Reach depth/flow relationships were available for only seven of the reach segments as defined in this project. Reaches without established depth/flow relationships were assigned equivalent hydrologic characteristics (i.e., the same FTABLES) as a similar segment. For example, the Middle Cottonwood segments were assigned the same cross-section as the Upper Cottonwood, but were given the appropriate lengths. The same cross-sections were given to all downstream numbered segments with the same name (e.g., Upper Cottonwood Creek 2 and Upper Cottonwood Creek 3 have the same cross-section as Upper Cottonwood Creek). For all reaches, FTABLE values for top surface area and volumes were calculated using the cross-section and reach length data as described previously.

Testing of the Detailed Cottonwood Model

Once the reach network and characteristic data were applied to all reaches in the detailed version of the model, the calibration parameter values from the initial hydrology calibration, were assigned to each land segment and reach in the model as shown in Table V-1. The model was then run with just the hydrology modules (i.e. ATMP, SNOW, PWATER, IWATER, HYDR, and ADCALC sections of HSPF) to test the performance of the model against the initial hydrology calibration. The results of the test showed remarkable similarity between the two predictions of the flow rate at the base of the Lower Cottonwood, retaining the excellent baseline hydrology calibration of the simpler hydrology model. Therefore, the initial input data assignments were not changed; no additional refinements to the watershed hydrology of the simpler model were required.

5.3 Bacteria Calibration

The first step in calibrating the model to simulate the loading of fecal coliform in the seven subwatersheds was to characterize the sources. Key sources identified were faulty septic systems, the Cottonwood Wastewater Treatment Plant (WWTP), cattle (grazing on the land and wading in the creeks), as well as land application of dairy and hog manure from animal feeding operations (AFOs). The loading rates for each of these sources was determined using a spreadsheet designed explicitly for this use (as discussed in a previous section).

The spreadsheet calculates the monthly fecal coliform accumulation rate (MON-ACCUM, in cfu/acre-day) and maximum storage (MON-SQOLIM, in cfu/acre) for each landuse in each subwatershed, and the flow (cfs) and fecal coliform load (cfu/hr) for septic systems and cattle wading in streams. While the fecal coliform accumulation rate and maximum storage values are applied to model land segments, septic systems and cattle in streams are treated as point sources in the model, such that the calculated waste flow and loads to the creek is applied directly to the model creek. Model land segments are the total area of a given land use (e.g. forest, pastureland) in a given subwatershed (e.g. Long Haul Creek, Upper Cottonwood Creek 2). Only one septic system and one cattle (where needed) "point source" is applied to each reach segment associated with a monitoring station. Thus these loads represent all additional cattle loads between any upstream monitoring stations and the reach name monitoring station. (When referring to the loadings from cattle in streams, the term "point source" is used solely to describe how the model is simulating the load. The term is not used in the regulatory context of a source requiring a discharge permit.)

Baseflow loads were also too high for a few creeks, indicating the default interflow/groundwater concentrations (IOQC and AOQC values in the model) were too high. These concentrations were iteratively reduced on a subwatershed-by-subwatershed basis until the modeled baseline concentrations matched those from the monitoring data.

The bacteria calibration was performed in the following order: 1) start with subwatershed with beef cattle only, i.e. South Fork Cottonwood and Long Haul Creeks; 2) then calibrate subwatersheds with both beef cattle and hogs - i.e. Shebang and Red Rock Creeks; 3) then calibrate subwatersheds with beef cattle, hogs, and dairies - Upper Cottonwood and Stockney Creeks; and 4) finally calibrate Lower Cottonwood which receives loads from all six of the previous subwatersheds.

The following are notes regarding the addition of a point source - (initially assumed to be "cattle-in-streams") and the addition of higher accumulation and maximum storage rates (of fecal coliform). Point sources were introduced in the calibration only when it was clear that high bacteria loads were occurring during periods of dry weather, and where existing model point sources (i.e. Cottonwood WWTP and septic systems in each subwatershed) did not account for the high concentrations. Table 6 summaries the bacteria load used in the model calibration for each subwatershed and the equivalent manure load (direct to creek waters) required to achieve that load.

Table 6. Estimated Subwatershed Point Source Loadings and Cattle in Stream Load Equivalents

Creek Name	**Bacteria Load[1] (cfu/hr)**	**Manure Load[2] (Cattle-days)**	**Manure Load[3] (lbs)**
S.F. Cottonwood (4/97-6/97)	6.0E9	1.3	58
Red Rock (4/97-5/97) (2/98-4/98)	1.3E10	2.7	126
Red Rock (2/98-4/98)	6.5E9	1.4	63
Upper Cottonwood (4/97-5/97) (4/98-5/98)	 1.5E9 5.0E8	 0.3 0.1	 15 5
Stockney (4/97-5/97) (4/98-5/98)	 6.5E9 3.0E9	 1.4 0.6	 63 29

1 - Direct, in-stream, fecal coliform loads used to improve model calibration.
2 - Number of cattle in stream on a continuous basis over the course of a day required to produce the bacteria load. For example, one cattle day is the equivalent of 24 cows spending one hour per day in the creek.
3 - Each beef cow is assumed to produce 46 pounds of manure a day (ASAE, 1998).

Higher accumulation and maximum storage rates were added to improve the calibration when unexplained high bacteria concentrations corresponded with wet weather:

- *Shebang:* Increased accumulation rate and maximum storage in May/June by a factor of 10 for pastureland. Also found a good fit by increasing only maximum storage (and no accumulation rate) by a factor of 10 for April/May/June - this could potentially be explained as bacteria regrowth on the land surface.
- *Long Haul:* Increased accumulation rate and maximum storage by factor of two from June to November for Rangeland and Pastureland.
- *South Fork Cottonwood:* Increased number of beef cows back to original 240 from 120.
- *Lower Cottonwood:* Increased accumulation and maximum storage for pasture and rangeland by factor of four for April, May, and June.

The above deviations from the initial estimated loads indicate that, during these limited time periods, either the assumptions used in the spreadsheet or the processes described by the model inadequately describe what actually occured. These discrepancies suggest additional studies might be required to identify some other manure management or other practice not taken into account.

An analysis was performed to test the sensitivity of the model to variations in two key input parameters in the pervious land segment general quality constituent (PQUAL) and in-stream general quality constituent (GQUAL) modules. WSQOP, the rate of surface runoff that will remove 90 percent of the stored pollutant per hour, affects peak concentration and has a slight impact on how the peaks are spread. FSTDEC, the in-stream first order decay rate for the pollutant, has a dramatic impact on the effect of cattle-in-stream. Both values were modified within the bounds of reasonable limits for each parameter in order to achieve the best fit for the calibration.

The final calibration for Lower Cottonwood Creek (figure 2) appears to provide a good fit to the monitoring data. Calibration graphs are shown for each monitoring station in Appendix II. The not-to-exceed secondary contact standard (reduced by the 10% Margin of Safety - see next section) is included in each graph as a threshold. The bacteria calibration results were used to calculate the exceedance rates for each creek, the results of which are presented in Table 9 (section 7.0).

Fecal Coliform Calibration for Lower Cottonwood Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

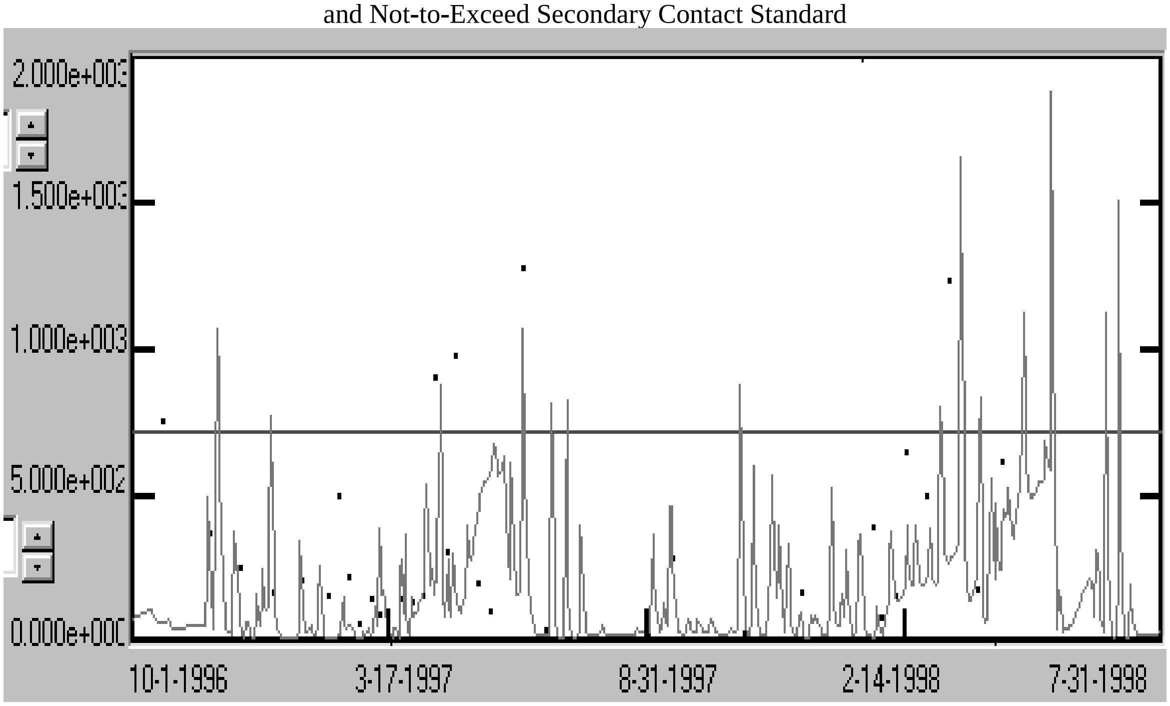

Figure 2. Fecal Coliform Calibration for Lower Cottonwood Creek

5.4 Margin of Safety and Seasonality

The Clean Water Act and its implementing regulations require that a TMDL include a margin of safety (MOS) to account for uncertainty in the analysis. The model was calibrated to produce unbiased simulations of flow and bacteria concentrations. An explicit 10% Margin of Safety (MOS) was added to both primary and secondary recreational contact criteria to account for model variance from observed:

- The not-to-exceed secondary standard (800 cfu/100ml) becomes a target maximum of 720 cfu/100ml;
- The not-to-exceed primary standard (500cfu/100ml) becomes a target maximum concentration of 450 cfu/100ml;
- The 30-day geometric mean secondary standard of 200 cfu/100ml becomes 180cfu/100ml; and
- The 30-day geometric mean primary standard of 50 cfu/100ml becomes 45 cfu/100ml.

Considerable effort was put into working with the Cottonwood Creek WAG and TAG to derive representative assumptions regarding animal populations, and manure management in the watershed; these assumptions are thought to provide a substantial backing to this MOS level.

The BASINS NPSM Postprocessor has the ability to automatically calculate and plot the geometric mean for any time step (e.g. 30-days), a function to overlay a threshold value on the pollutant concentration time series graph, and the ability to perform statistical analysis to determine the percent time the threshold (water quality standard with MOS adjustments) is exceeded. The NPSM Postprocessor, however, does not contain any method to readily compare model results against the 10%-exceedances-in-30-day-period standard. Instead, bacteria pollutographs were visually inspected for evidence of a “10% standard” violation. When deriving the percent load reductions required to achieve the standard, the “10% standard” was never found to drive the required reduction.

Section 303(d)(1) requires TMDLs to be “established at a level necessary to implement the applicable water quality standards with seasonal variations.” Thus, the analysis must be conservatively based to address seasonal peaks, if any, that might occur in pollutant concentrations. This TMDL addresses seasonality by the use of a continuous simulation model.

5.5 Uncertainties

A few notes on scientific uncertainties in the representation of the watershed with the NPSM are necessary. First, bottom sediments, thought to have the potential to store and later release (during a storm) fecal coliform do not appear to be of great significance in this watershed since the model appears to predict in-stream bacteria concentration well despite neglecting to describe this sedimentation/resuspension process. On the other hand, the effects of the process, in this watershed may be significant but masked by incorrect assumptions regarding manure application rates and/or cattle-in-stream loads. This issue could be evaluated further by taking coincident suspended solids samples and modeling fecal coliform as a sediment associated constituent. Additional sampling to measure fecal coliform concentrations in bottom sediments would further elucidate the importance (or lack thereof) of this process.

Another model uncertainty is that seasonal stream temperature variations, and their effect on fecal coliform in-stream degradation rates, were not taken into account in this model. Due to current limitations in the NPSM, as well as water temperature measurements being available only for summer months, the impact of yearly water temperature variations could not be modeled. While in-stream first-order degradation rate does have a significant impact on the effect of point source fecal coliform loads on downstream fecal coliform concentrations, a limited sensitivity analysis shows water temperature variation to have little impact on model results, particularly relative to the uncertainty in the assumed manure application rates.

A final scientific issue that introduces an unknown degree of uncertainty to the model is that of bacteria regeneration, i.e. the regrowth of bacteria after some decay in the bacteria population has already occurred. Fecal coliform on the land surface is modeled in a simple manner in this model with a first order decay rate that establishes the relationship between the accumulation rate and maximum storage (#/acre). The effect of regeneration, however, can be thought of as being part of the dynamic equilibrium between loss and regrowth, which still results in stable maximum storage, that varies seasonally in response to meteorological conditions. Thus, it can be thought of as being included implicitly, whereby if significant, the accumulation rate is artificially high, and includes an implicit regrowth factor on top of the actual accumulation rate.

6.0 Load Estimates and Capacities

Relative stream loadings from each subwatershed, from the baseline model calibration, are shown in Table 7.

Table 7. Stream Loading by Source (Billions fecal Coliform per year [Bfc/year])

Subwatershed	Septic System Load (Bfc/year)	Cattle-in-Streams Load [2] (Bfc/year)	Cottonwood WWTP Load (1997/Max[3]) (Bfc/year)	Manure Application, Grazing Cattle (Bfc/year)
Shebang Creek	757	-	-	107,000,000
Upper Cottonwood	392	1,440	120/829	28,000,000
Stockney Creek	757	5,130	-	72,200,000
Red Rock Creek	653	16,370	-	47,500,000
Lower Cottonwood[1]	261	-	-	168,000,000
South Fork	183	8,640	-	9,610,000
Long Haul Creek	601	-	-	14,400,000

1 - Loads to Middle and Lower Cottonwood subwatersheds were combined for these estimates.
2 - 0.0, 0.2, 1.0, 2.1, 0.0, 1.3, and 0.0 cattle per creek, respectively.
3 - Based on continuous 600,000 GPD flow and 100 cfu/100 ml concentration.

Table 8 lists the fecal coliform load (in Bcfu/yr) for the current loading (based on the baseline model calibration). It also lists the load which will achieve the water quality standard, and the percent reduction in the current load that this new load represents. Finally, the table shows the Load allocation for each subwatershed, which is based on the model simulation in which water quality standards were achieved in each subwatershed.

Table 8. Load Estimates and Allocations

Watershed	Current Estimated Load (bcfu/year)	Load to Achieve WQ Std. (bcfu/year)	% Reduction	Load Allocation
Stockney Creek	72,200,000	20,900,000[1]	71	20,900,000[1]
Upper Cottonwood Creek	28,000,000	15,400,000[2]	45	WLA - 829
				LA - 15,400,000[2]
Shebang Creek	107,000,000	12,800,000[3]	88	12,800,000[3]
Long Haul Creek	14,400,000	8,930,000[2]	38	8,930,000[2]
South Fork Cottonwood Creek	9,610,000	7,400,000[3]	23	7,400,000[3]
Red Rock Creek - Secondary Red Rock Creek - Primary	47,500,000 47,500,000	25,200,000[3] 15,700,000[4]	47 67	25,200,000[3] 15,700,000[4]
Lower Cottonwood Creek*	168,000,000	82,300,000[2]	51	82,300,000[2]

*Load to Lower Cottonwood Creek includes load to Middle Cottonwood Creek.

1 - Includes reduction in current "cattle-in-stream" and faulty septic system loads by 80%.

2 - Includes reduction in current faulty septic system loads by 80%.

3 - Includes reduction in current "cattle-in-stream" load by 95%, and reduction in current faulty septic system loads by 80%.

4 - Includes reduction in current "cattle-in-stream" load by 100%, and reduction in current faulty septic system loads by 90%.

7.0 Modeling Control Scenarios

In this section, control scenarios are provided that illustrate the modeled outcome for example control scenarios. During the TMDL implementation phase, the Cottonwood Creek WAG will direct how reductions will be accomplished in the watershed. These model scenarios serve as tools to help the WAG plan those reductions. Additional scenarios, as generated by the WAG, could also be evaluated with additional model runs. All control scenarios were compared against the applicable water quality criteria, reduced by 10% for the MOS. The percent of time the MOS-adjusted criteria is expected to be exceeded is summarized in Table 9 for the baseline (existing) and each of the control scenarios.

Scenario A - Cattle-out-of-stream
Preventing the cattle from directly wading in streams was the first control scenario. This scenario, depending on the current conditions and management practices in the watershed, would be implemented by methods such as fencing the stream bank to prevent direct access, and/or by providing a source of water away from the stream itself. Since cattle in the stream were included in the baseline (existing) bacteria calibration as point source dischargers, cattle were removed from the model simply by applying a 0.0 multiplier to both the flow and fecal coliform load. This control scenario had a clear and dramatic effect on the bacteria concentration graph, reducing the "not-to-exceed" standard exceedance rate to less than 5% for all creeks with a "cattle-in-stream" point source. This control scenario also reduced the geometric-mean criteria exceedance rate to zero for three subwatersheds (Upper Cottonwood, South Fork Cottonwood, and Lower Cottonwood Creek). The resulting primary contact standard exceedance rates for Red Rock Creek were still quite high: 3.3% and 54.0%, for the "not-to-exceed" and geometric mean criteria, respectively. The model results indicate that additional controls would be necessary to meet standards.

Scenario B - Delayed Dairy Manure Application with Composting, and Cattle-out-of-stream
This scenario assumed that instead of 22.22% of the dairy manure application taking place in each of the months of April, May, and June, it is composted instead; resulting in an 80% reduction in fecal coliform concentration in the final compost produced which is then applied in July, August, and September. Additionally, the "cattle-in-stream" point sources were removed as in Scenario A.

Scenario C - Zero Hog Manure, WWTP at Permit, and Cattle-out-of-stream
In this scenario, hog manure impact was reduced to zero in the watershed to test the relative impact of the current hog manure management practices as represented in the model. The Cottonwood WWTP was set to a constant discharge of 0.4642 cfs (or 300,000 GPD) and 100 cfu/100mL for the months of October through the end of March. Additionally, the "cattle-in-stream" point sources were removed as in Scenario A.

Scenario D - Zero Beef Manure, WWTP at Permit, and Cattle-out-of-stream
In this scenario, the beef cattle manure impact was reduced to zero in the watershed to test the

relative impact of the current beef cattle manure management practices as represented in the model. Additionally, WWTP was set at its permitted level, and the “cattle-in-stream” point sources were removed as in Scenario A.

Scenario E - Zero Beef Manure, WWTP at Permit, Cattle-out-of-stream, and Zero Septic Load

This scenario is Scenario D, with the additional loss of the septic system load in each subwatershed. This scenario demonstrates that septic systems may be significantly impacting the watershed.

Scenario F - Zero Dairy Cow Manure, WWTP at Permit, and Cattle-out-of-stream

In this scenario, the dairy cattle manure impact was reduced to zero in the watershed to test the relative impact of the current dairy cattle manure management practices as represented in the model. Additionally, WWTP was set at its permitted level, and the “cattle-in-stream” point sources were removed as in Scenario A.

Additional model runs

An additional model run was performed to evaluate the impact of the Cottonwood WWTP. The WWTP load was set to zero and resulted in no significant reductions in water quality standard exceedances.

A model run was also performed to evaluate the simple moving of the dairy cow manure application (22.22% rate) from April/May/June to July/August/September. The rate of water quality standard exceedances remained essentially the same. Exceedances in spring were only traded for exceedances in summer.

Table 9. Comparison of Modeling Scenarios

	Scenario 0		Scenario A		Scenario B		Scenario C		Scenario D		Scenario E		Scenario F	
	Calibration (Baseline-Existing)		Cattle-out-of-stream		Delayed Dairy Manure Application with Composting, and Cattle-out-of-stream		Zero Hog Manure, WWTP at Permit, and Cattle-out-of-stream		Zero Beef Cow Manure, WWTP at Permit, and Cattle-out-of-stream		Zero Beef Cow Manure, WWTP at Permit, and Cattle-out-of-stream, and Zero Septic Load		Zero Dairy Cow Manure, WWTP at Permit, and Cattle-out-of-stream	
	% Exceedance[a] Secondary Standard		% Exceedance[a] Secondary Standard		% Exceedance[a] Secondary Standard		% Exceedance[a] Secondary Standard		% Exceedance[a] Secondary Standard		% Exceedance[a] Secondary Standard		% Exceedance[a] Secondary Standard	
Reach	Any time (720 cfu /100mL)	30-day Geo. Mean (180 cfu /100mL)	Any time (720 cfu /100mL)	30-day Geo. Mean (180 cfu /100mL)	Any time (720 cfu /100mL)	30-day Geo. Mean (180 cfu /100mL)	Any time (720 cfu /100mL)	30-day Geo. Mean (180 cfu /100mL)	Any time (720 cfu /100mL)	30-day Geo. Mean (180 cfu /100mL)	Any time (720 cfu /100mL)	30-day Geo. Mean (180 cfu /100mL)	Any time (720 cfu /100mL)	30-day Geo. Mean (180 cfu /100mL)
Stockney	10.9	17.2	4.2	4.5	3.4	4.5	3.7	4.5	0.2	4.3	0.2	0.0	3.0	4.5
Upper Cottonwood	6.3	18.5	1.1	0.0	0.6	0.0	1.2	6.0	0.3	6.0	0.2	0.0	0.3	6.0
Shebang	5.5	9.0	5.5	9.0	5.5	9.0	5.1	8.1	0.0	3.0	0.0	0.0	2.2	4.8
South Fork Cottonwood	13.8	19.3	0.5	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0
Long Haul	1.8	13.2	1.8	13.2	1.8	13.2	1.8	13.2	0.6	8.2	0.0	0.0	1.1	11.1
Red Rock	20.0	29.0	1.5	4.3	1.5	4.3	1.2	4.3	0.0	4.3	0.0	0.0	1.5	4.3
Lower Cottonwood	3.0	24.7	2.2	0.0	2.2	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.5	0.0
	% Exceedence [b] Primary Standard		% Exceedence [b] Primary Standard		% Exceedence [b] Primary Standard		% Exceedence [b] Primary Standard		% Exceedence [b] Primary Standard		% Exceedence [b] Primary Standard		% Exceedence [b] Primary Standard	
	Any time (450 cfu /100 mL)	30-day Geo. Mean (45 cfu /100mL)	Any time (450 cfu /100 mL)	30-day Geo. Mean (45 cfu /100mL)	Any time (450 cfu /100 mL)	30-day Geo. Mean (45 cfu /100mL)	Any time (450 cfu /100 mL)	30-day Geo. Mean (45 cfu /100mL)	Any time (450 cfu /100 mL)	30-day Geo. Mean (45 cfu /100mL)	Any time (450 cfu /100 mL)	30-day Geo. Mean (45 cfu /100mL)	Any time (450 cfu /100 mL)	30-day Geo. Mean (45 cfu /100mL)
Red Rock	15.0	61.7	4.2	41.6	4.2	41.6	2.7	38.1	0.0	7.2	0.0	0.0	4.2	41.6

[a]Percentage determined based on year-round comparison

[b]Percentage based on comparison with May to September period (period in which primary contact criteria apply)

8.0 Conclusions

- The Cottonwood WWTP is not a significant source of fecal coliform loadings in Upper and Lower Cottonwood Creeks.

- The cattle in streams (or other) point source in Upper Cottonwood, South Fork Cottonwood, Red Rock, and Stockney Creeks, in late Spring, is a significant source of fecal coliform loadings during periods of dry weather. Some source other than cattle in streams could be the cause of these loads; this could ultimately be confirmed with a targeted field scale study.

- Accumulation of fecal coliform on land surfaces, due to both grazing/pasturing of cattle and manure spreading from animal feeding operations, appears to be a significant source of fecal coliform loading to creeks, particularly during wet weather events.

- Faulty septic systems appear to be a significant contributor to exceedances of the fecal coliform criteria in Cottonwood Creek watershed.

- A viable implementation plan to achieve fecal coliform criteria would require reductions from a combination of the four main fecal coliform source categories in the watershed: hog manure, dairy cow manure, beef cattle manure, and faulty septic systems.

9.0 Recommendations

The following recommendations, derived during the course of this modeling effort, are intended to inform stakeholders of studies or investigations that could be used to further reduce model uncertainty and to develop an effective implementation plan.

- *Collect Additional Data on Current Manure Management Methods in the Watershed* - While a substantial amount of data was collected at the subwatershed level, with feedback from the WAG, farm level manure management data will be essential in deriving an effective implementation plan.

- *Additional Bacteria Sampling* - Multiple samples taken during the course of storms would confirm the timing of the model predictions, as well as develop the timing required of samplers to collect samples at peak concentrations. This would greatly improve the confidence in the models predictions of peak bacteria concentrations during storms. Despite the not-to-exceed value being the key comparison point for the secondary contact standard, sample results rarely corresponded with modeled peak concentrations, and were instead on the modeled storm concentration upslope and downslope. Samples collected during concentration peaks, especially if collected during peaks of storms of different magnitudes, would also greatly improve confidence in the parameter value used for the surface runoff rate removing 90% of a constituent (WSQOP), as well as the maximum storage of bacteria on the land surface (MON-SQOLIM). Another key bacteria modeling input parameters, accumulation rate (MON-ACCUM) could be improved by insuring that equal fractions of the samples are taken during storms preceded by dry weather as for those samples taken during storms preceded by wet weather. Multiple sampling stations along the same reach segment, downstream of a relatively uniform land use, or a dominating point source, with samples taken synoptically, could be used to accurately estimate the in-stream first-order decay rate (FSTDEC) for fecal coliform.

- *Use Subwatershed Flow Data* - The final recommendation is that reliable streamflow gage data be used for each subwatershed. Landuse specific hydrology and pollutant input variables could be derived based on calibrations for subwatersheds dominated by a single landuse. The collection of additional flow data would allow more accurate modeling of each subwatershed separately, increasing confidence in the model results, particularly with landuse specific hydrology and fecal coliform loads.

10.0 References

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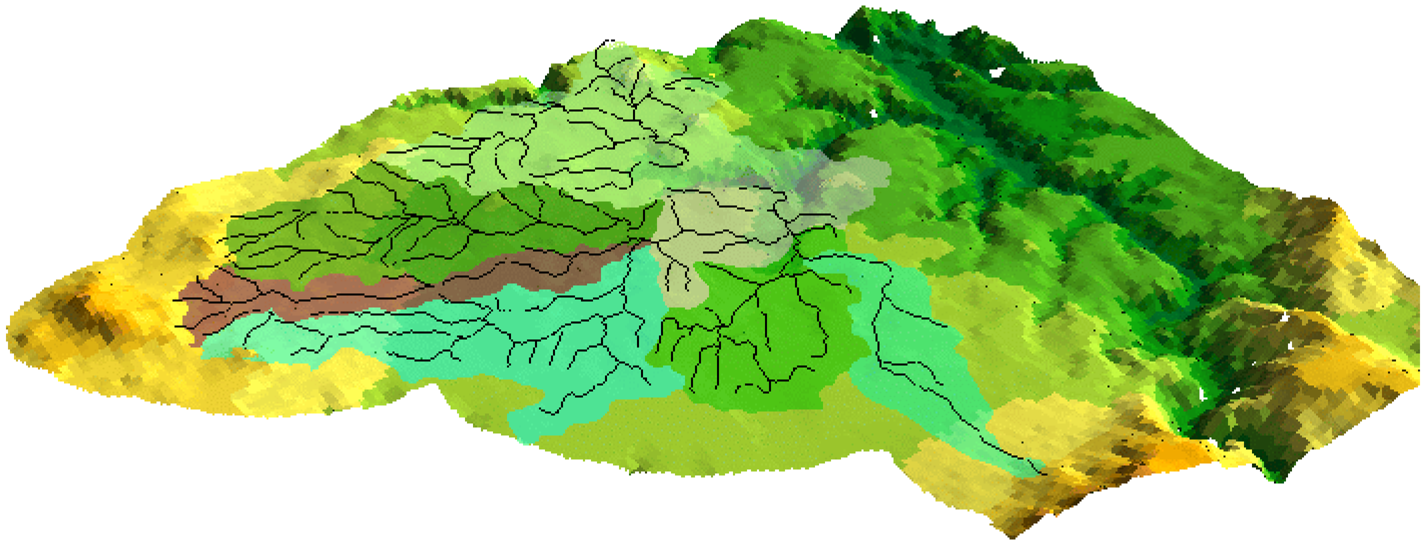
Appendix I
Maps

Map I-1

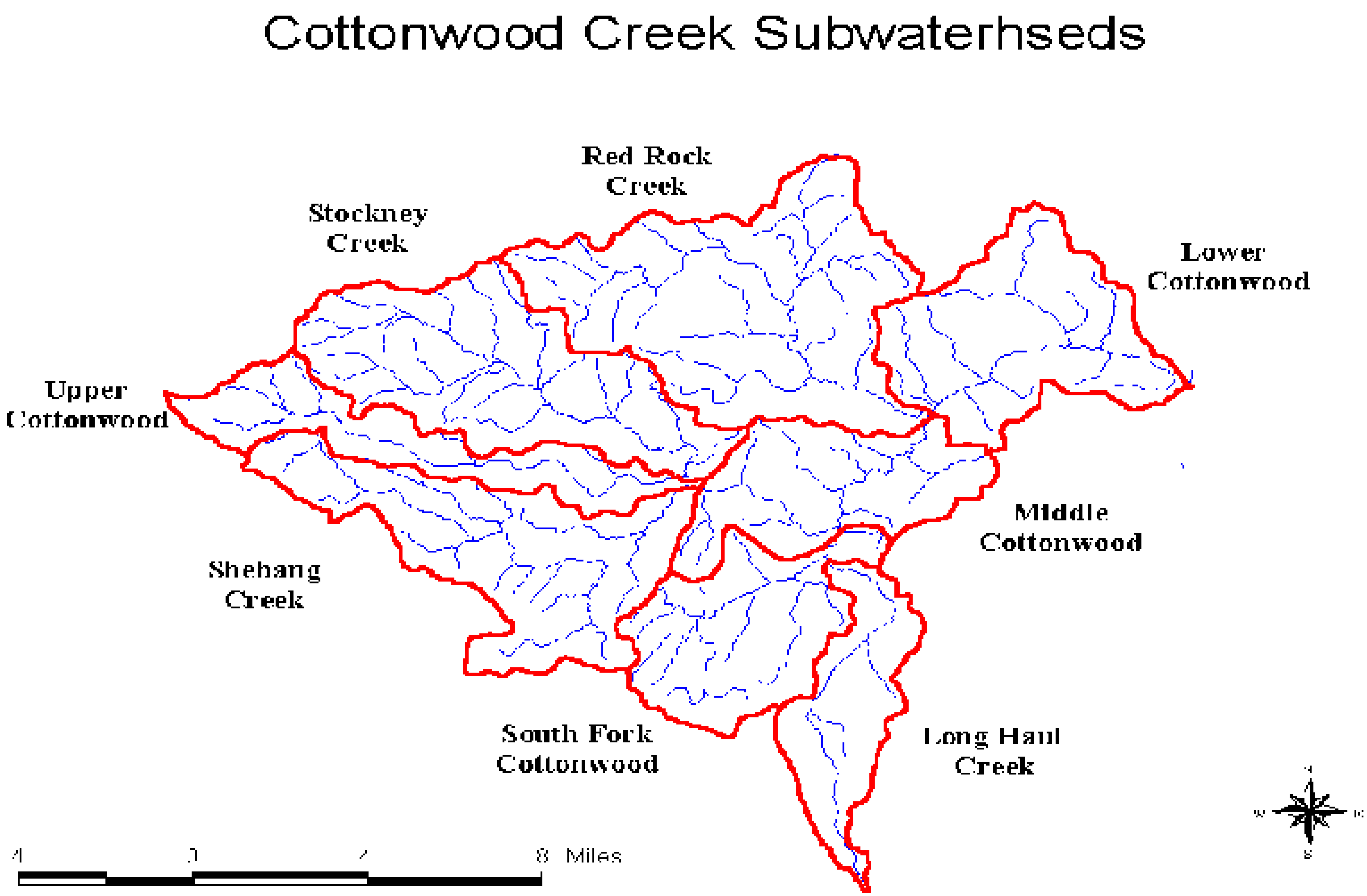
Digital elevations and Subwatersheds
Cottonwood Creek Watershed



Outlines of subwatersheds and streams roughly draped over a 3-D topographic surface - Elevations Exaggerated 4X

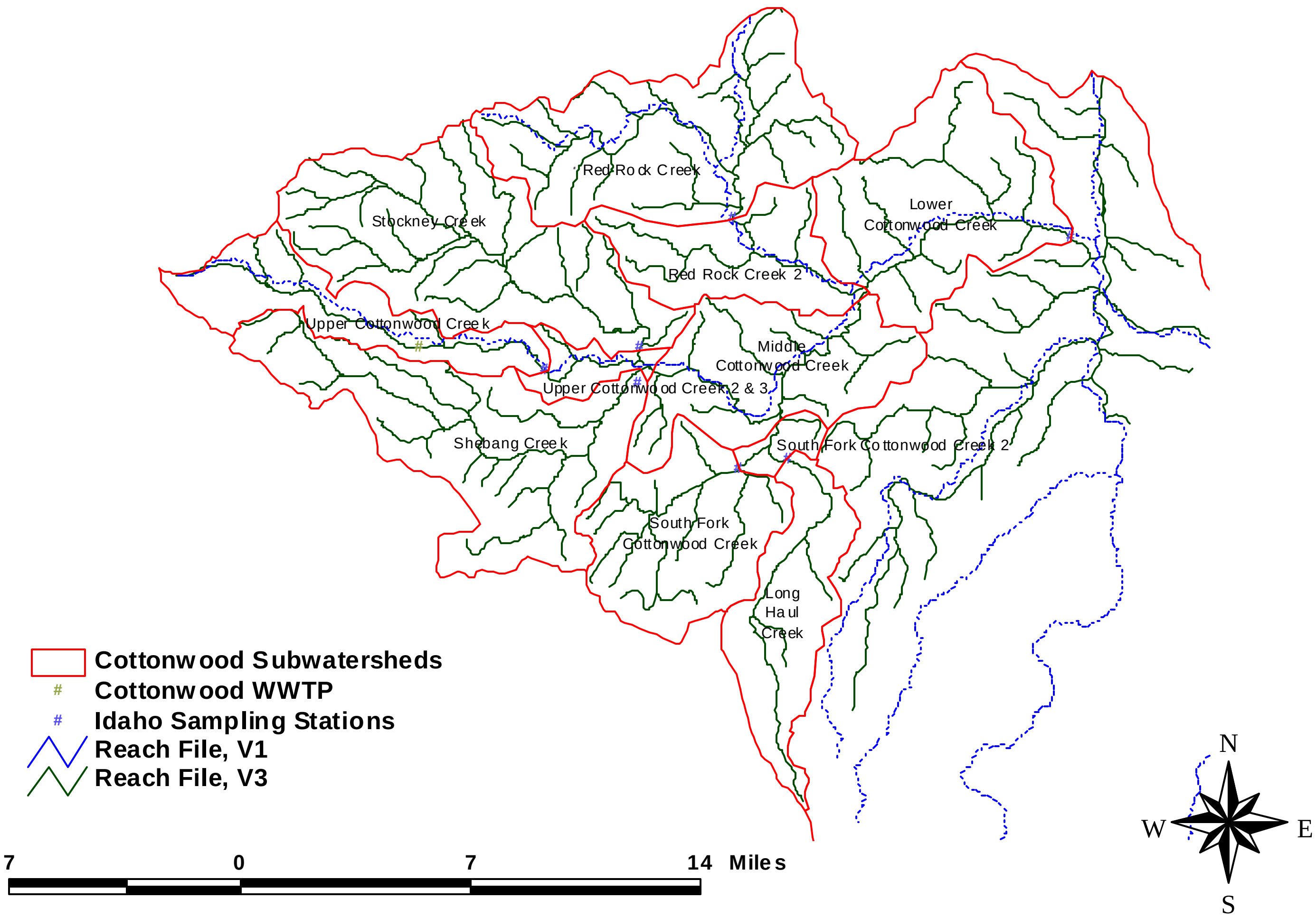
Source: DEM from BASINS (EPA, 1998); Subwatershed boundaries from Idaho DEQ (ID DA, 1999)

Map I-2
Source: Idaho DEQ (IDEQ, 1999)



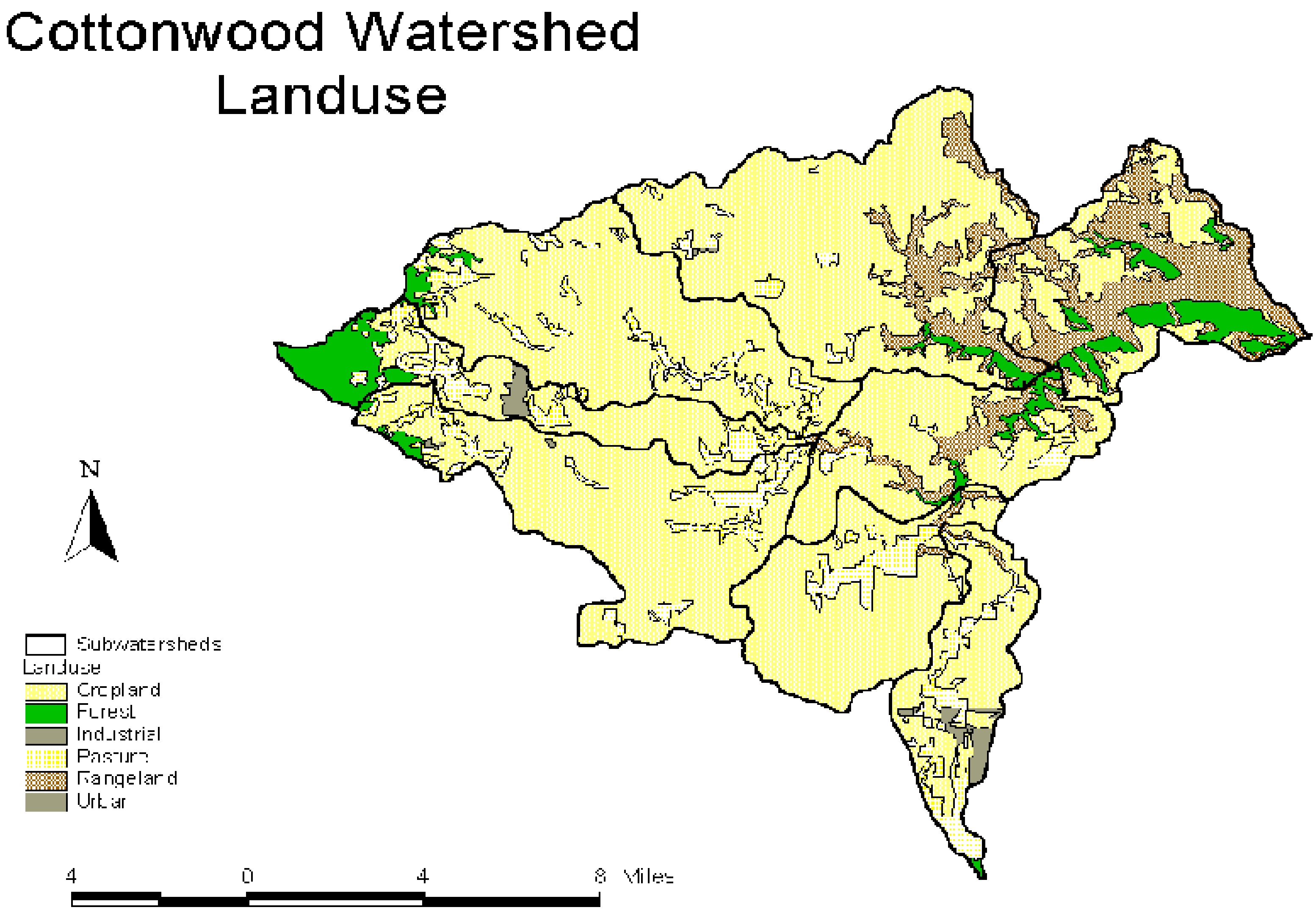
Map I-3

Modeled Subwatersheds
Cottonwood Creek



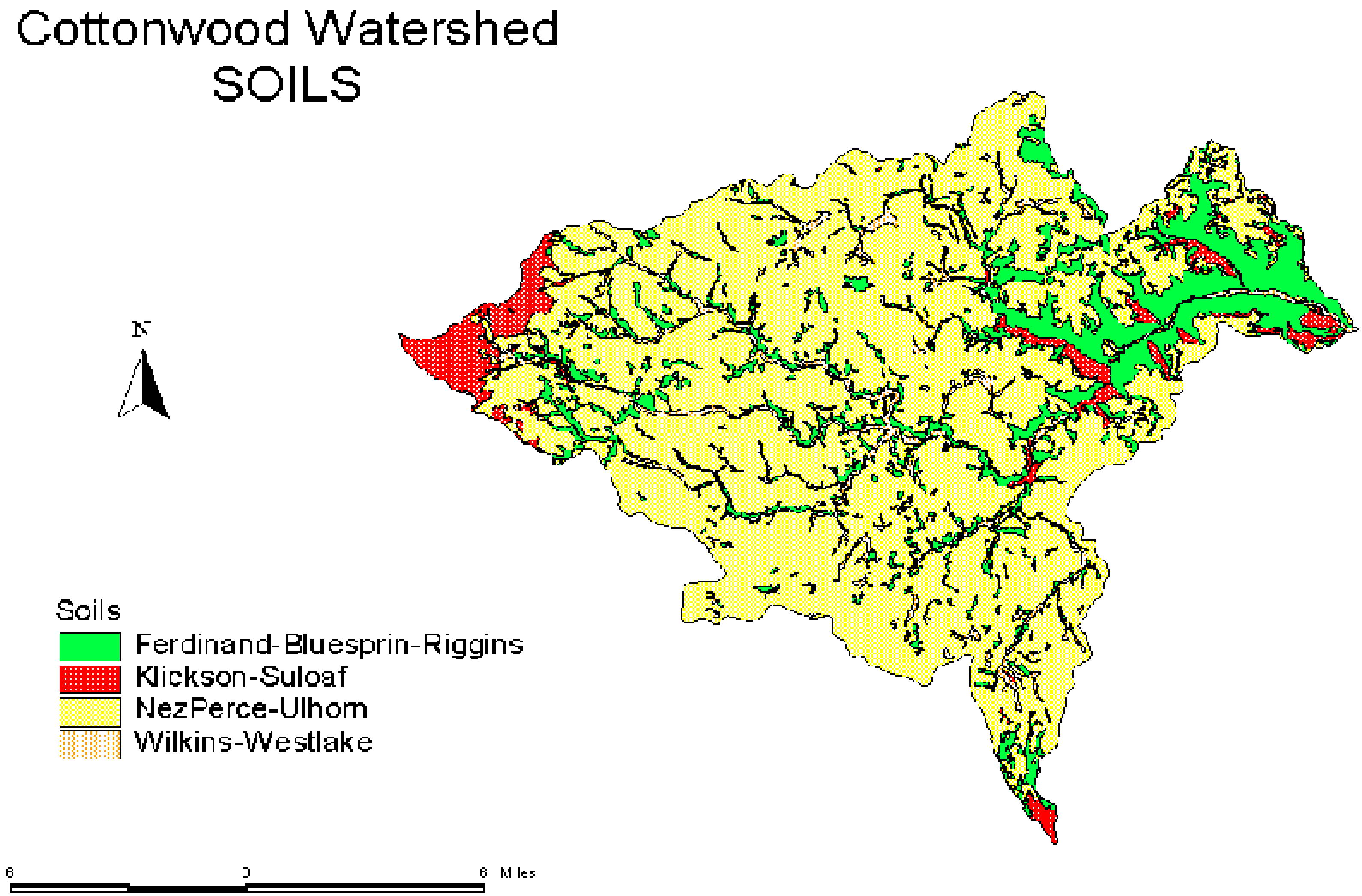
Map I-4

Source: Idaho Department of Agriculture; National Resource Conservation Service-NRCS (ISCC, 1999)



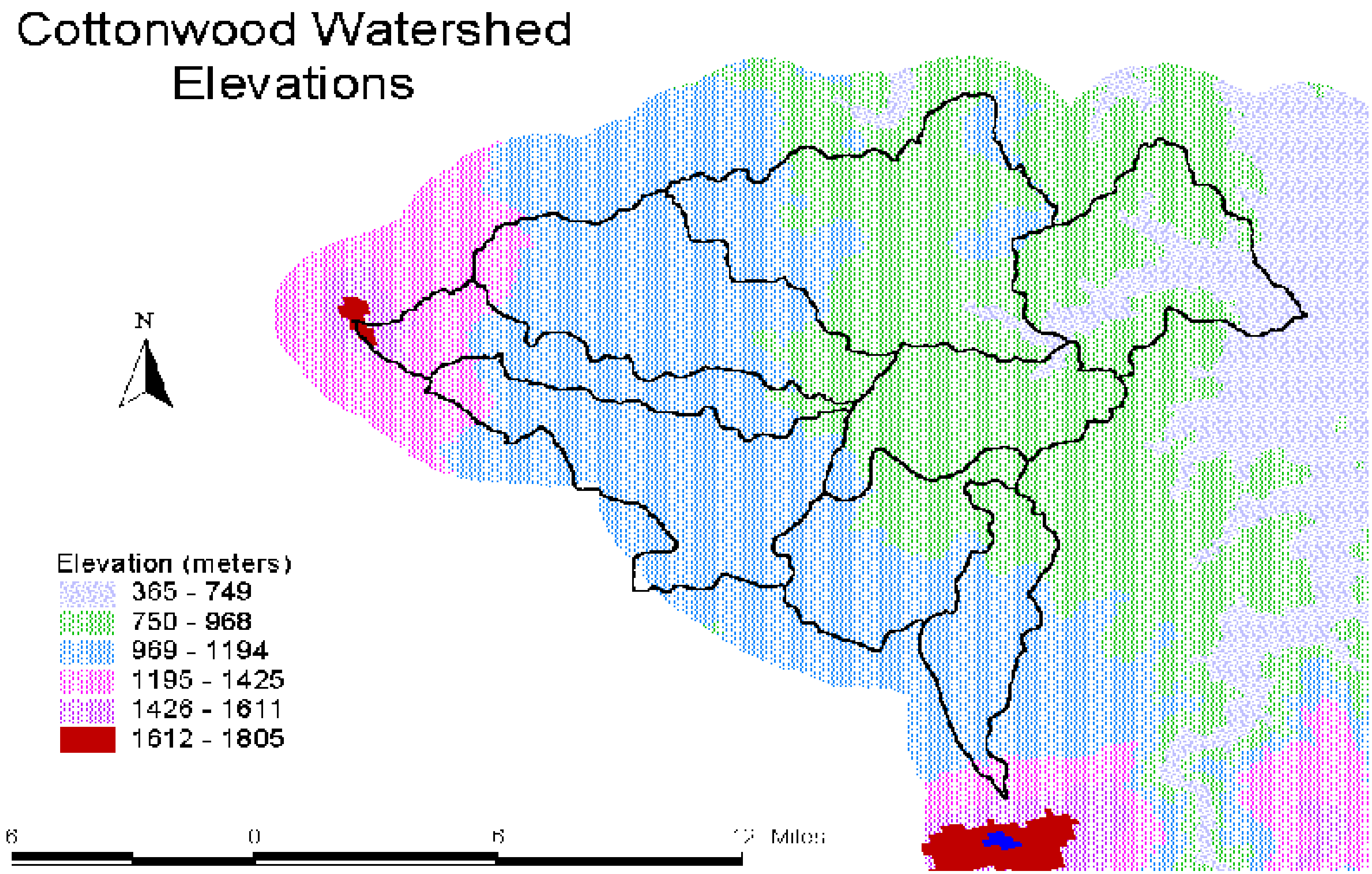
MAP I-5

Source: Idaho Department of Agriculture (ISSC, 1999)



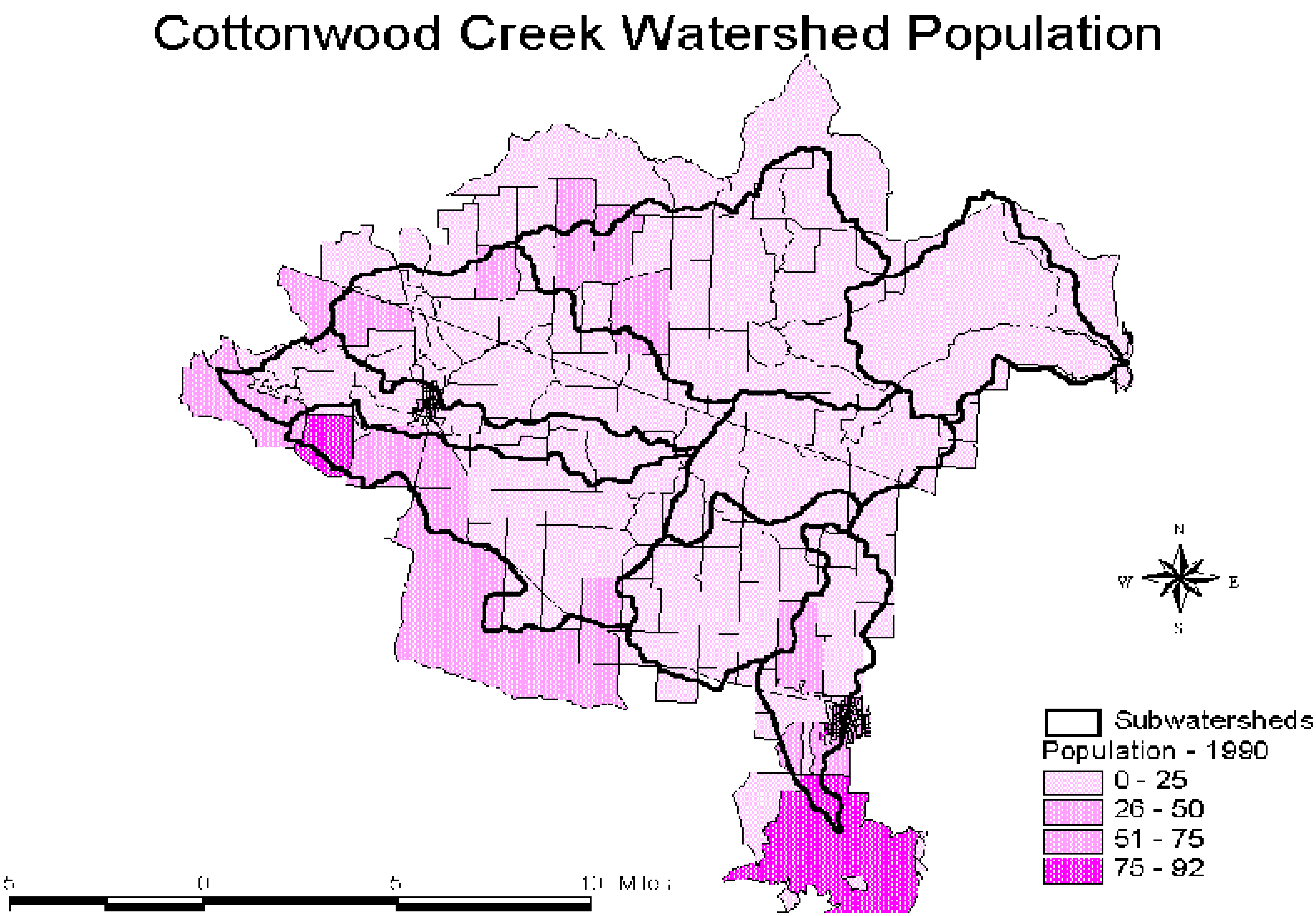
Map I-6

Source: BASINS 2.0 (USEPA, 1988)



MAP I-7

Source: U.S. Bureau of Census, 1990 "TIGER" data (E.S.R.I., 1999)



Appendix II
Graphs

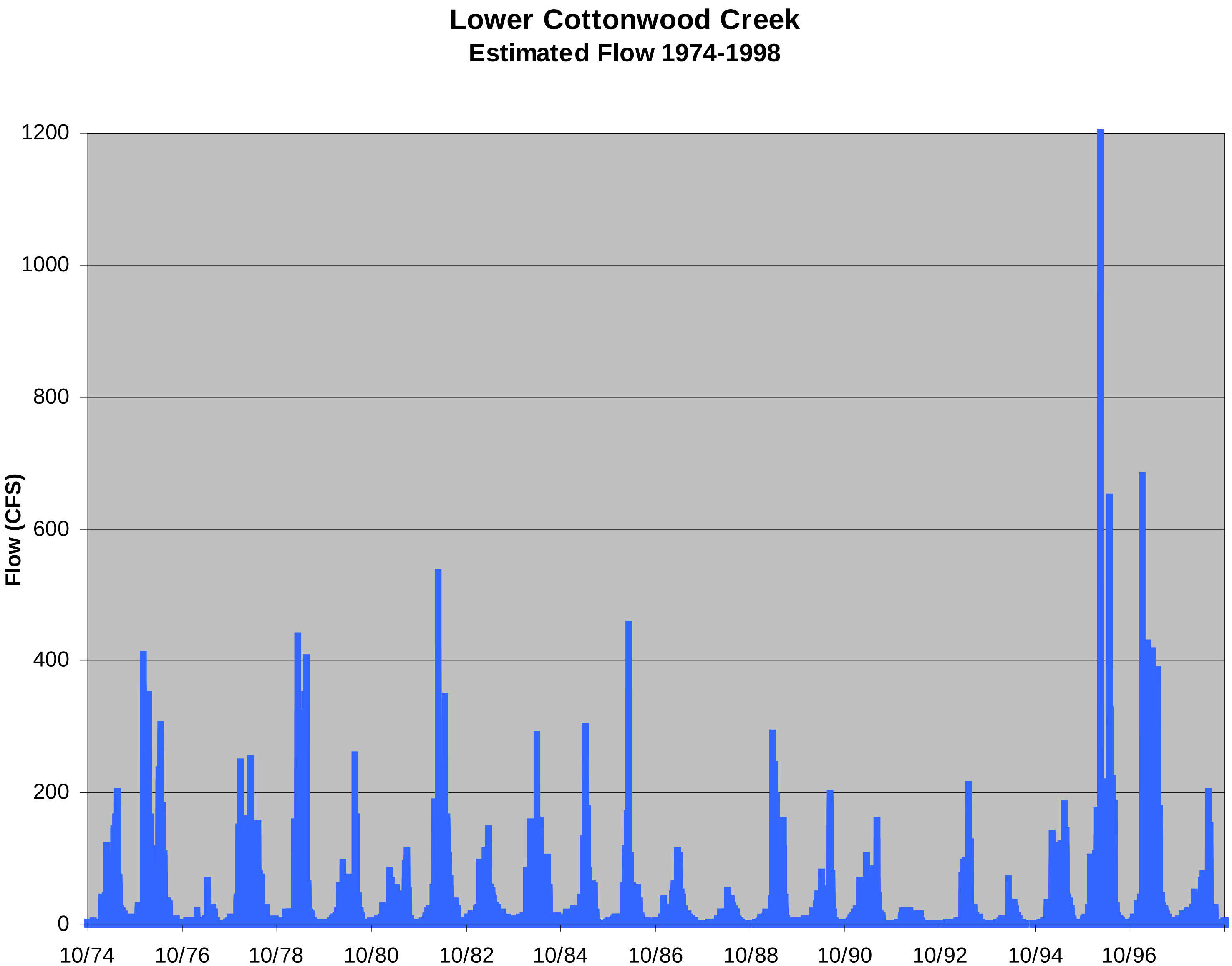


Figure II-1: Lower Cottonwood Creek, Estimated Flow 1974-1998

Fecal Coliform Calibration for Stockney Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

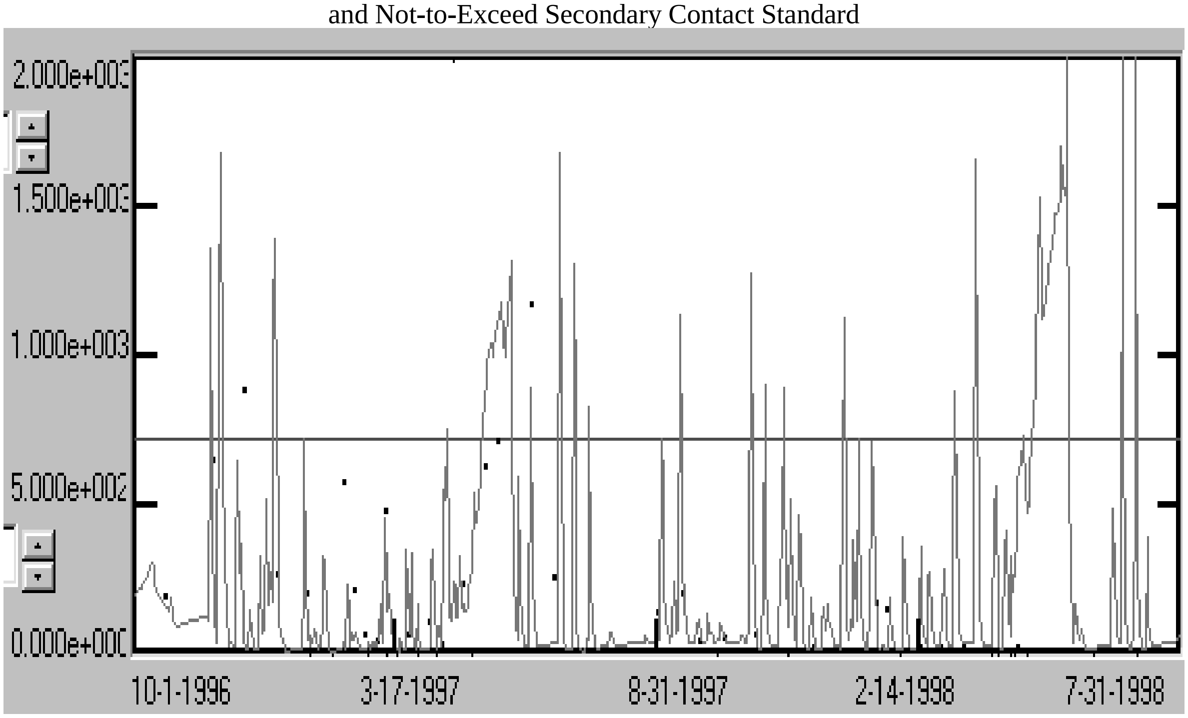


Figure II_2: Fecal Coliform Calibration for Stockney Creek

Fecal Coliform Calibration for Upper Cottonwood Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

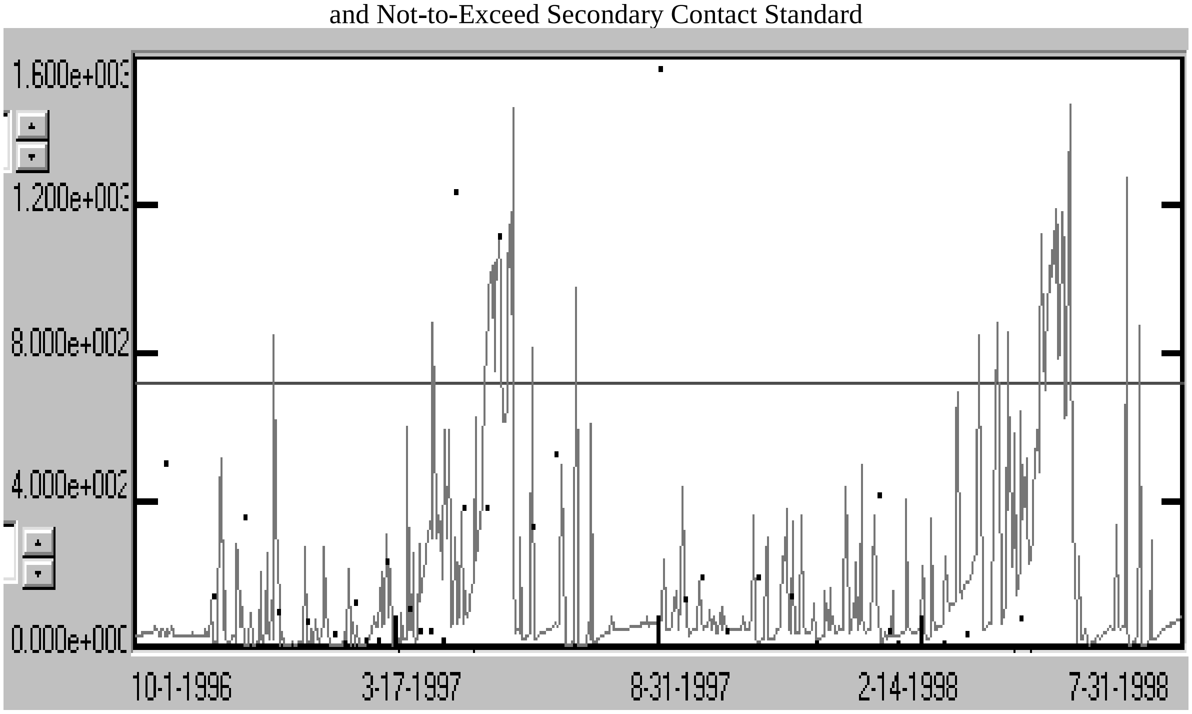


Figure II_3: Fecal Coliform Calibration for Upper Cottonwood Creek

Fecal Coliform Calibration for Shebang Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

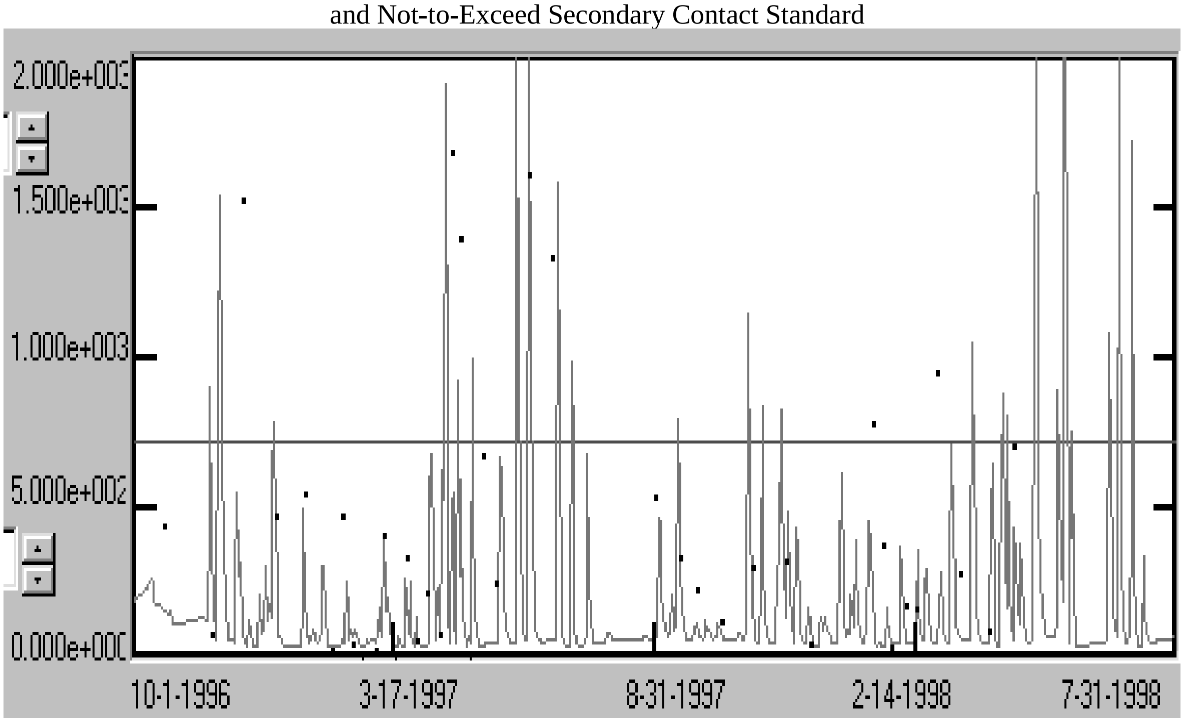


Figure II_4: Fecal Coliform Calibration for Shebang Creek

Fecal Coliform Calibration for Long Haul Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

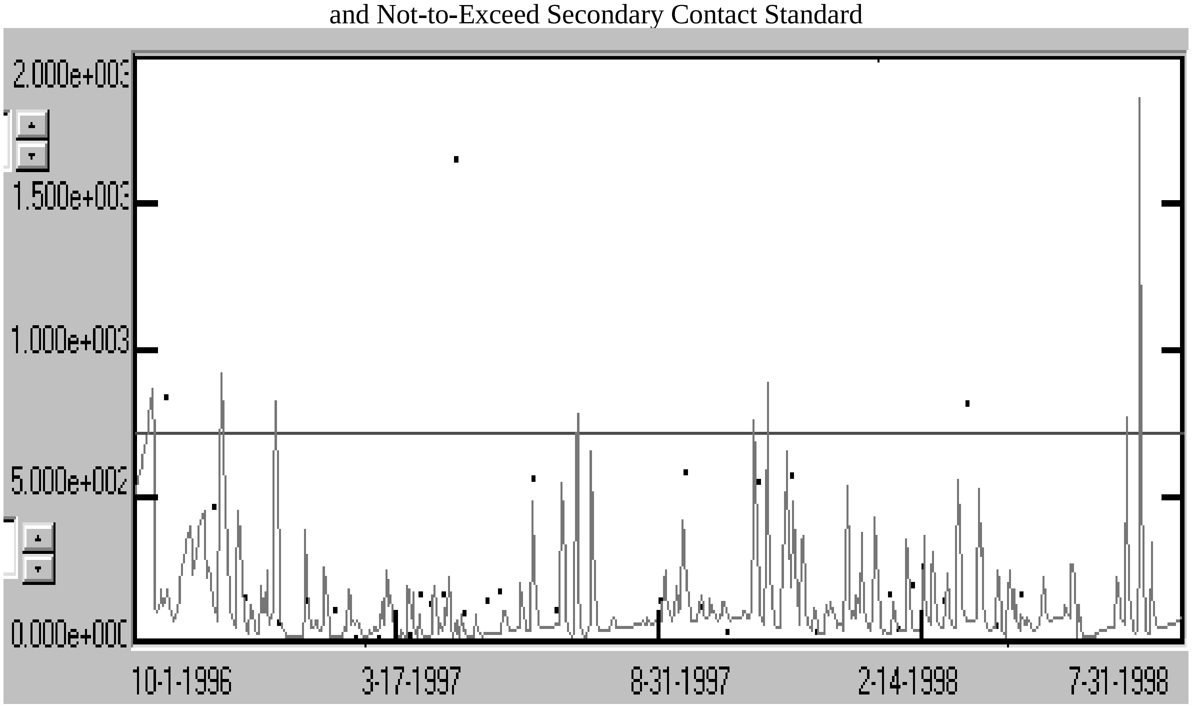


Figure II_5: Fecal Coliform Calibration for Long Haul Creek

Fecal Coliform Calibration for South Fork Cottonwood Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

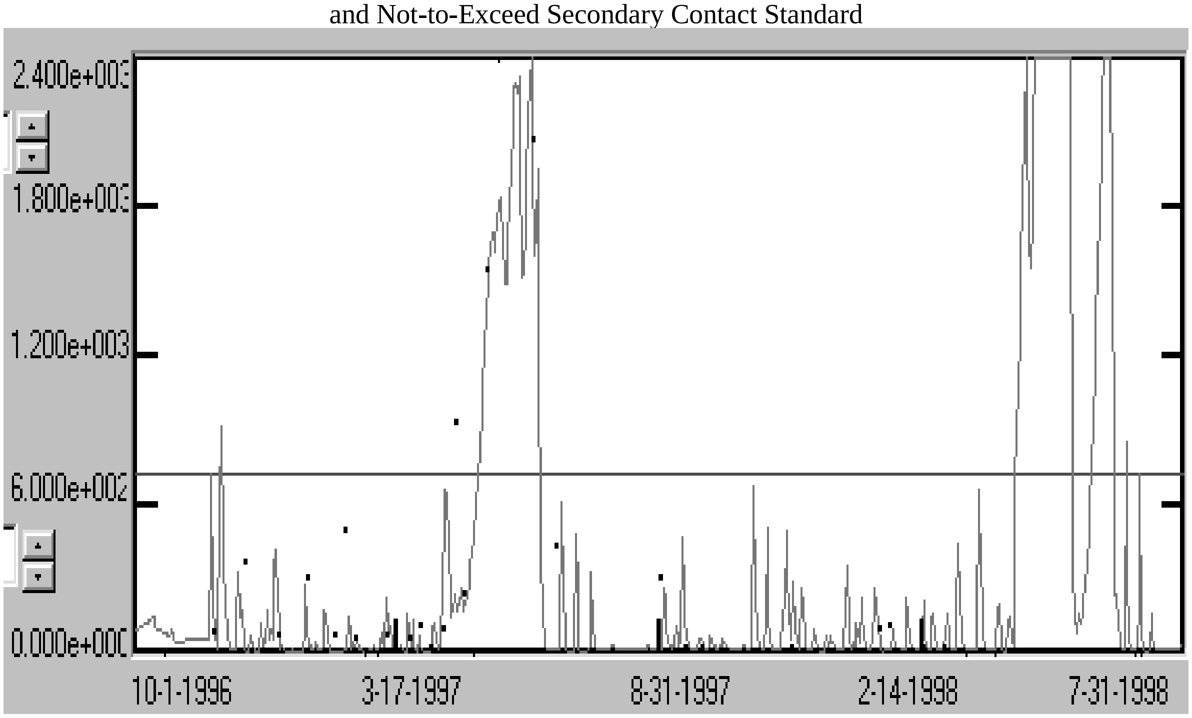


Figure II_6: Fecal Coliform Calibration for South Fork Cottonwood Creek

Fecal Coliform Calibration for Red Rock Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

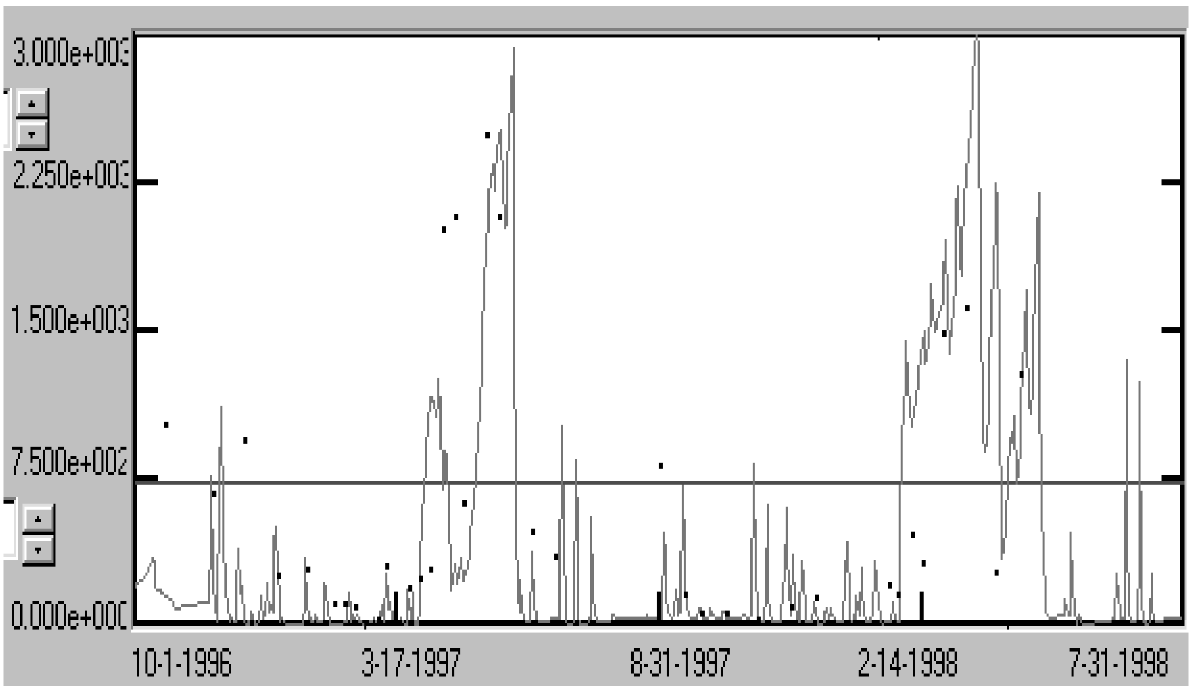


Figure II_7: Fecal Coliform Calibration for Red Rock Creek

Fecal Coliform Calibration for Lower Cottonwood Creek
Modeled (line) vs. Monitored (dots) (cfu/100 ml)
and Not-to-Exceed Secondary Contact Standard

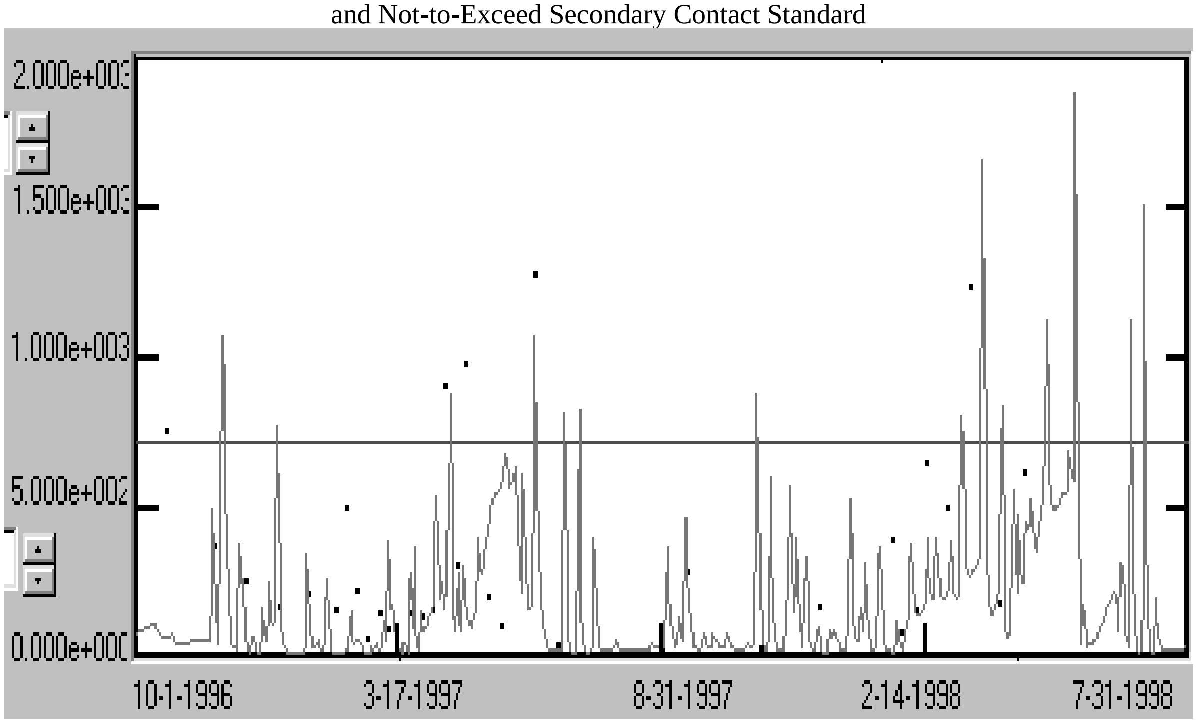


Figure II_8: Fecal Coliform Calibration for Lower Cottonwood Creek

Fecal Coliform Concentration (cfu/100 ml) for Stockney Creek
with 71% Nonpoint Load Reduction
and Not-to-Exceed Secondary Contact Standard

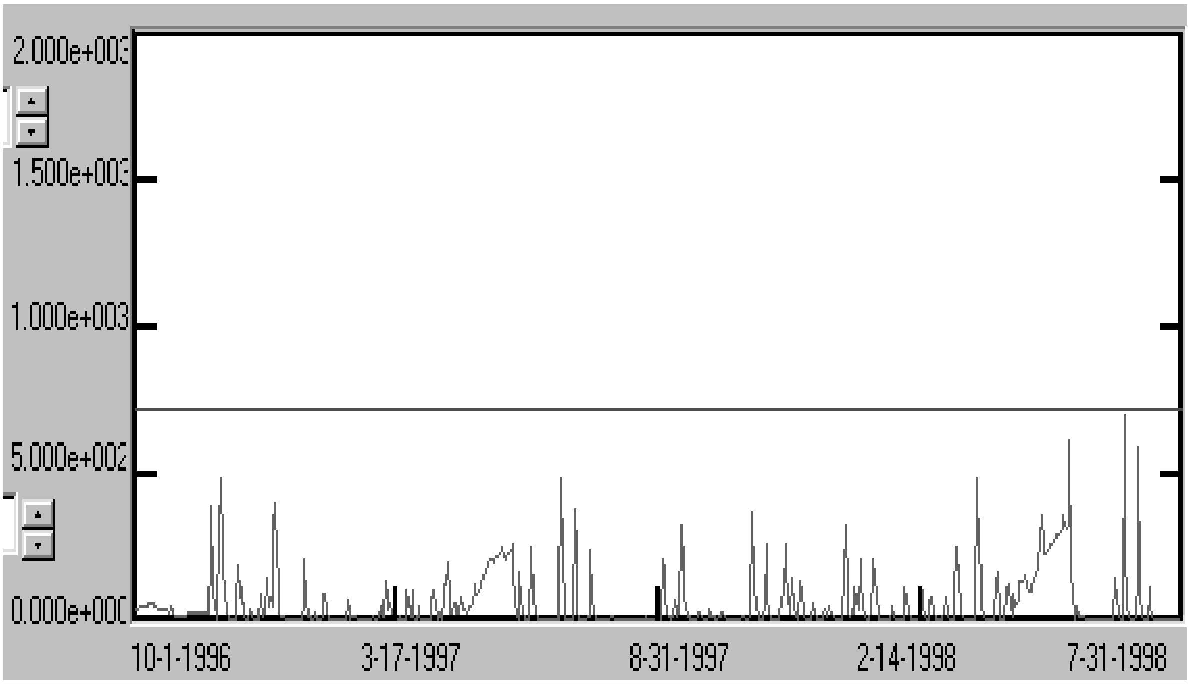


Figure II_9: Fecal Coliform Concentration for 71% Nonpoint Load Reduction to Stockney Creek

Fecal Coliform Concentration (cfu/100 ml) for Upper Cottonwood Creek
with 45% Nonpoint Load Reduction
and Not-to-Exceed Secondary Contact Standard

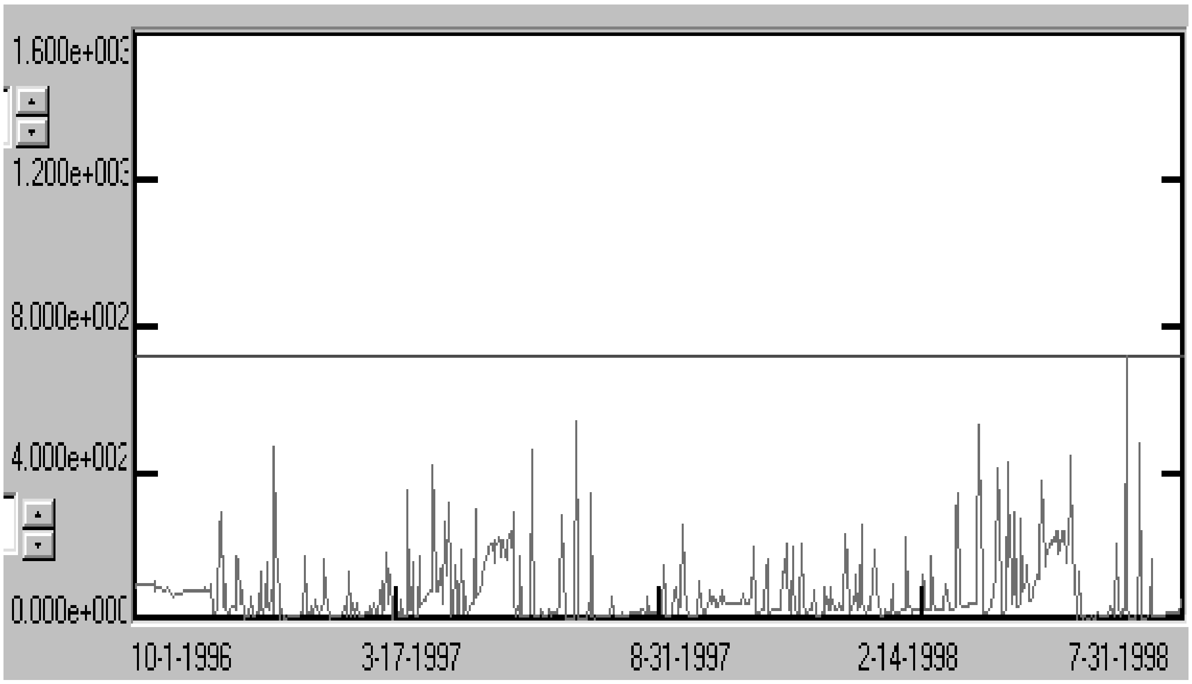


Figure II_10: Fecal Coliform Concentration for 45% Nonpoint Load Reduction to Upper Cottonwood Creek

Fecal Coliform Concentration (cfu/100 ml) for Shebang Creek
with 88% Nonpoint Load Reduction
and Not-to-Exceed Secondary Contact Standard

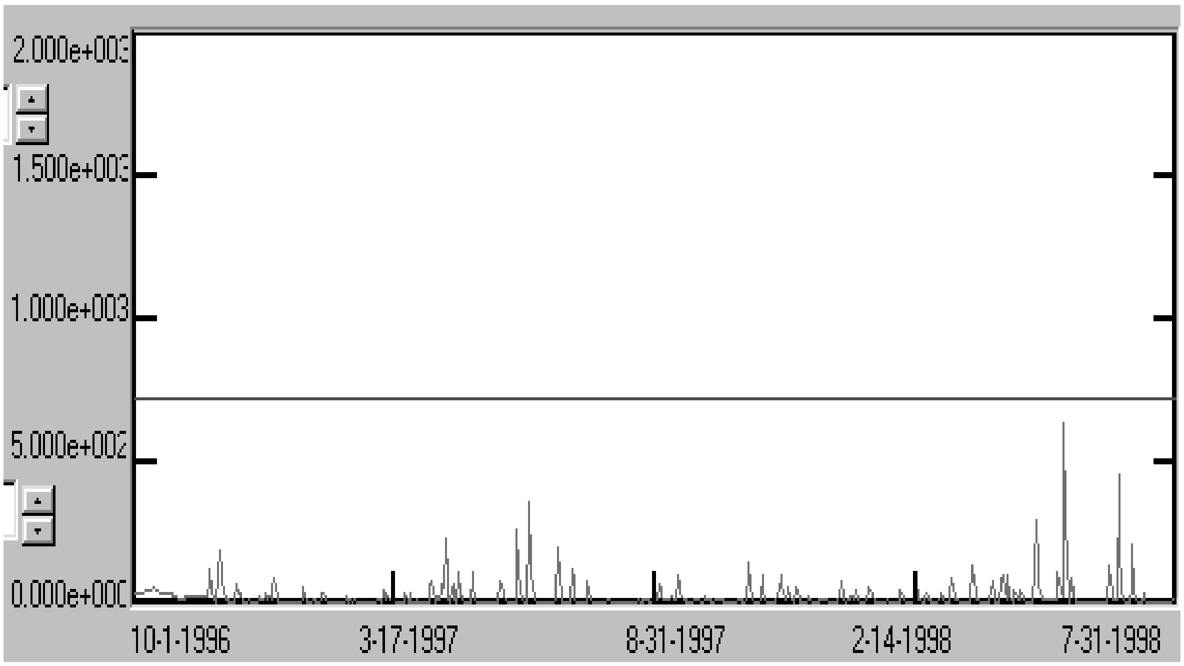


Figure II_11: Fecal Coliform Concentration for 88% Nonpoint Load Reduction to Shebang Creek

Fecal Coliform Concentration (cfu/100 ml) for Long Haul Creek
with 38% Nonpoint Load Reduction
and Not-to-Exceed Secondary Contact Standard

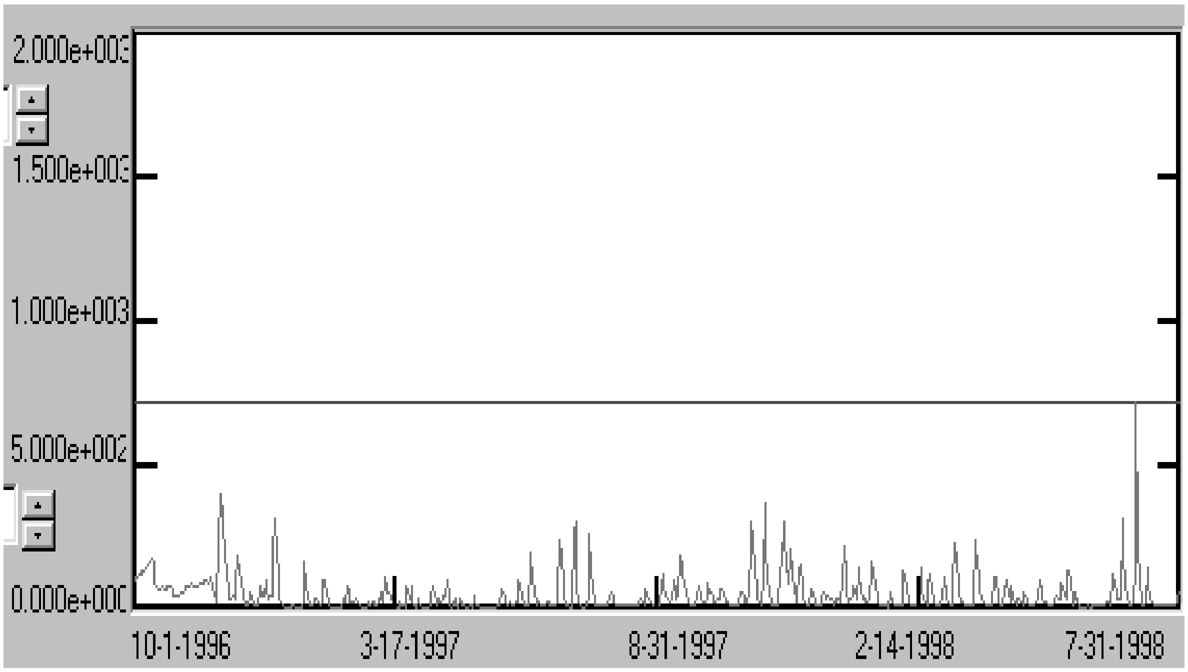


Figure II_12: Fecal Coliform Concentration for 38% Nonpoint Load Reduction to Long Haul Creek

Fecal Coliform Concentration (cfu/100 ml) for South Fork Cottonwood Creek
with 23% Nonpoint Load Reduction
and Not-to-Exceed Secondary Contact Standard

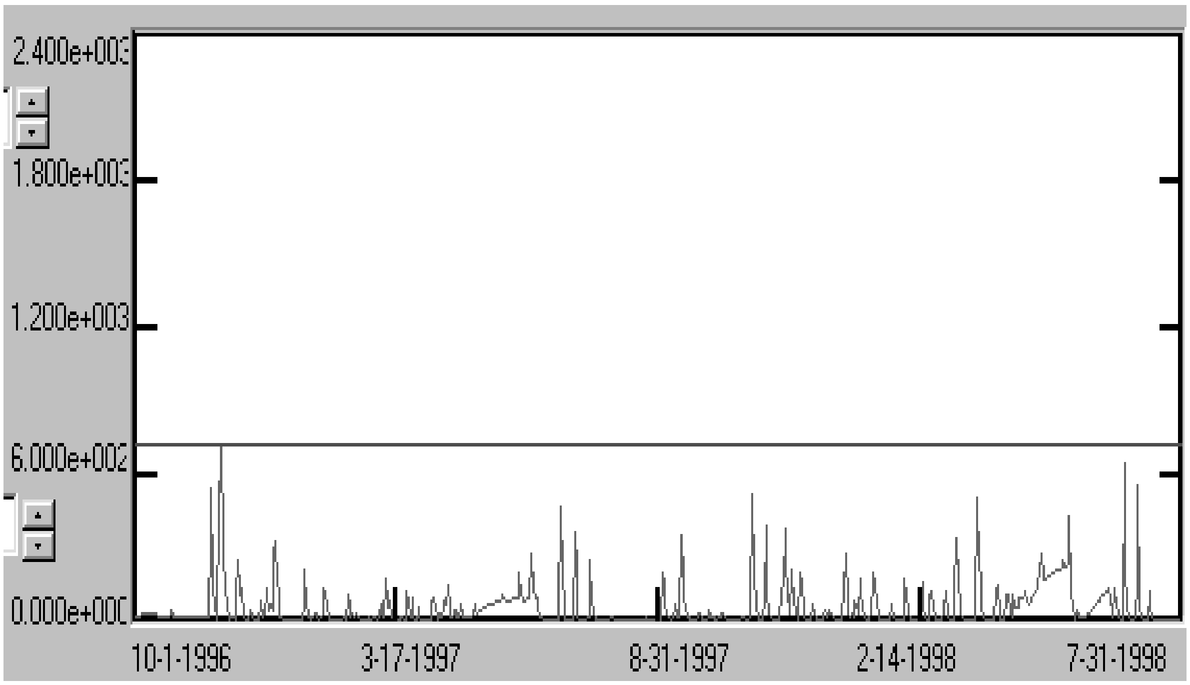


Figure II_13: Fecal Coliform Concentration for 23% Nonpoint Load Reduction to South Fork Cottonwood Creek

Fecal Coliform Concentration (cfu/100 ml) for Red Rock Creek
with 47% Nonpoint Load Reduction
and Not-to-Exceed Secondary Contact Standard

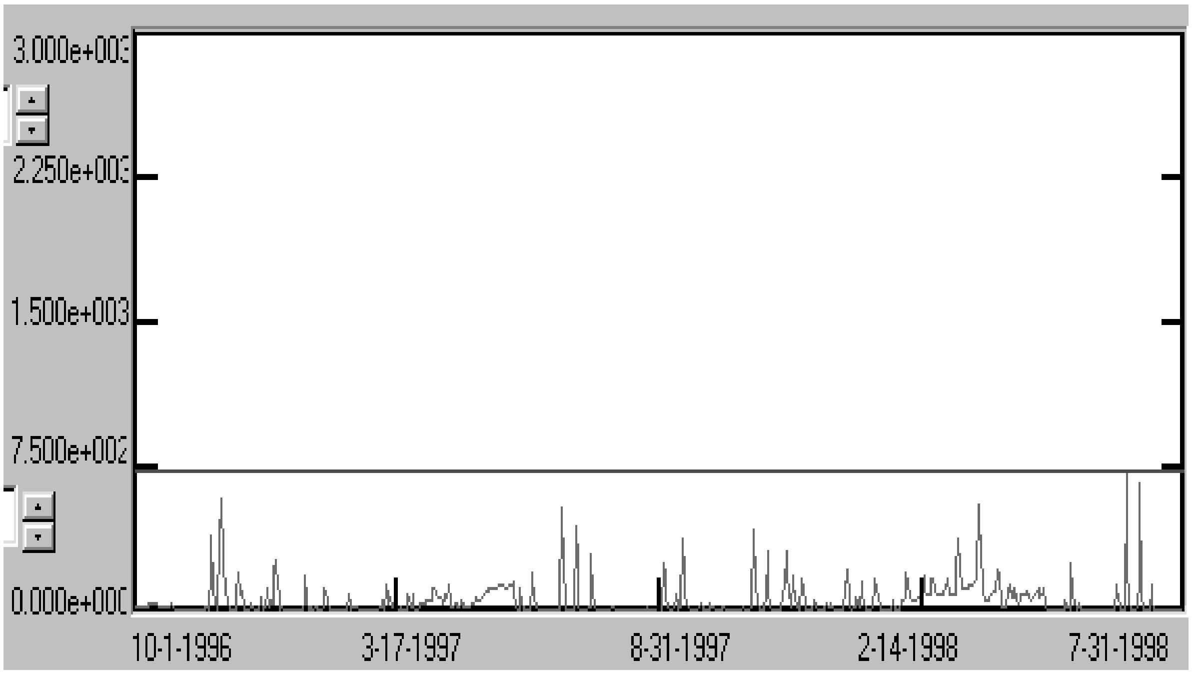


Figure II_14: Fecal Coliform Concentration for 47% Nonpoint Load Reduction to Red Rock Creek (to meet Secondary Contact Standard)

Fecal Coliform Concentration (cfu/100 ml) for Red Rock Creek
with 67% Nonpoint Load Reduction
and Not-to-Exceed Primary Contact Standard

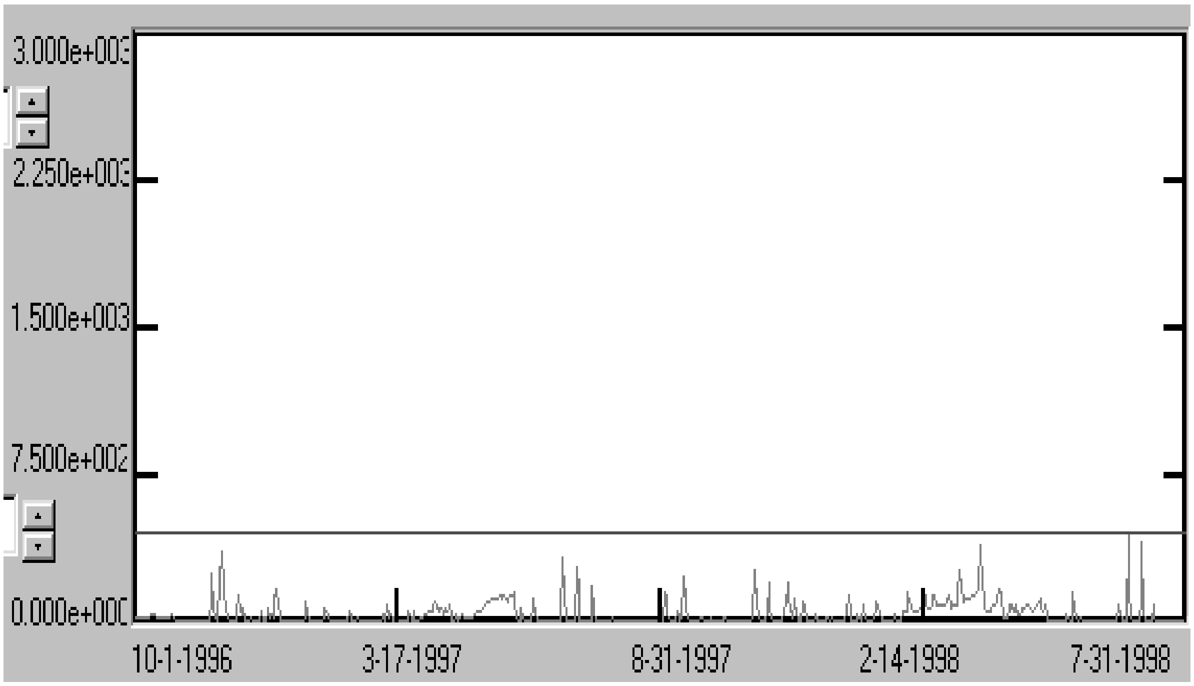


Figure II_15: Fecal Coliform Concentration for 67% Nonpoint Load Reduction to Red Rock Creek (to meet Primary Contact Standard)

Fecal Coliform Concentration (cfu/100 ml) for Lower Cottonwood Creek
with 51% Nonpoint Load Reduction
and Not-to-Exceed Secondary Contact Standard

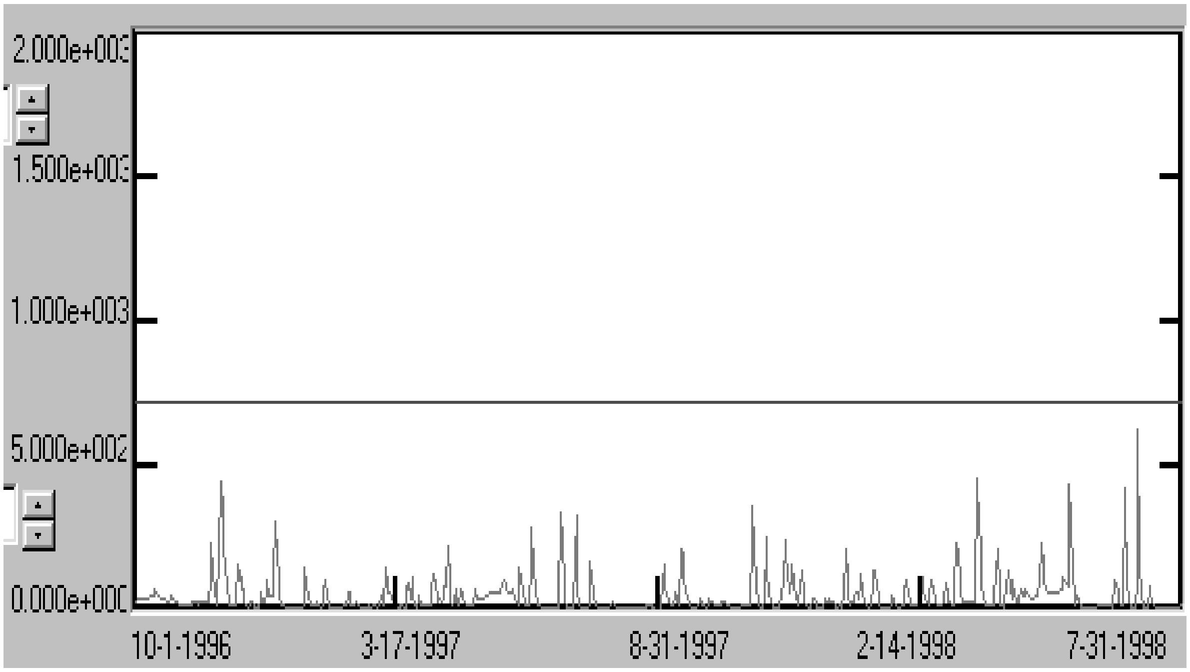


Figure II_16: Fecal Coliform Concentration for 51% Nonpoint Load Reduction to Lower Cottonwood Creek

Appendix III
EPA Fecal Coliform Spreadsheet for Cottonwood Creek Watershed

This quantifies the fecal coliform bacteria contribution from multiple sources.

It is based on a modeling study of 7 subwatersheds composed of 4 landuses (Cropland, Forest, Built-up, and Pastureland).

BLUE text found throughout the spreadsheet presents valuable information and assumptions.

RED text designates values which should be specified by the user.

BLACK text generally presents information which is calculated by the spreadsheet or that should not be changed.

Cottonwood Creek Calibration

There are 7 subwatersheds in this study.

The modeled landuses were derived from the original landuses.

Modeled landuses

Areas are listed in acres.

SUBSHED	CROPLAND	FOREST	BUILT-UP	PASTURE	TOTAL	
P1-Shebang Creek	15885	263	32	2188	18368	
P2-Upper Cottonwood	5597	2117	181	2160	10055	
P3-Stockney Creek	17022	419	4	2306	19751	
P4-Red Rock Creek	21109	535	15	4813	26472	Pasture includes Rangeland
P5-Lower Cottonwood	13924	2737	0	10354	27015	Lower Cottonwood includes Middle Cottonwood
P6-South Fork	10897	38	4	1839	12778	
P7-Long Haul Creek	5821	57	337	2156	8371	
P8	0	0	0	0		
P9	0	0	0	0		
TOTAL	90255	6166	573	25816	122810	

Original landuses

Areas are listed in acres.

Modeled land use category	Original Land u	P1	P2	P3	P4	P5	P6	P7	P8	P9	Total acres
CROPLAND	CROPLAND	15885	5597	17022	21109	13924	10897	5821	0	0	90255
FOREST	DECIDUOUS FC	263	2117	419	535	2737	38	57	0	0	6166
LAKES	LAKES	0	0	0	0	0	0	0	0	0	0
BUILT-UP	COMMERCIAL	0	0	0	0	0	0	0	0	0	0
BUILT-UP	MXD URBAN OI	32	181	4	15	0	4	337	0	0	573
BUILT-UP	RESIDENTIAL	0	0	0	0	0	0	0	0	0	0
BUILT-UP	TRANS, COMM	0	0	0	0	0	0	0	0	0	0
PASTURELAND	PASTURELANC	2188	2160	2306	4813	10354	1839	2156	0	0	25816
		18368	10055	19751	26472	27015	12778	8371			122810

The total number of animals in the 7 subwatersheds are as follows.

Fecal contributions from these animals are used to derive loading estimates for all landuses except for Built-up.

Agricultural Animals

SUBSHED	BEEF COWS	SWINE (HOGS)	DAIRY COWS	POULTRY
P1	540	782	0	0
P2	220	139	165	0
P3	580	355	110	0
P4	680	1058	0	0
P5	820	0	0	0
P6	240	0	0	0
P7	240	0	0	0
TOTAL	3320	2334	275	0

Wildlife

The deer population is the only major wildlife source considered. The same deer density is assumed for all subwatersheds.

Deer/sq mile (other lands)	7
Deer/acre (other lands)	0.0109375
Deer/sq mile (forest land)	11
Deer/acre (forest land)	0.0171875

This sheet contains information relevant to land application of waste produced by agricultural animals in the study area.

Application of hog manure, cattle manure, and poultry litter are considered.

The information is presented based on monthly variability of waste application.

It is assumed that cattle manure is applied to both Cropland and Pastureland using the same method.

Hog Manure Available for Wash-off

This is the percentage of manure applied by month.

	January	February	March	April	May	June	July	August	September	October	November	December	
% of annual manure applied in month	0.02	0.02	0.02	0.02	0.02	0.02	0.2733	0.2733	0.2733	0.02	0.02	0.02	0.9999

The percent manure available for runoff is dependent on method of manure application. Computations below are based on assumed % incorporation into soil.

% available for runoff = (1 - % incorporated) + (% incorporated * 0.5)	0.625

The following is the resulting manure application based on the monthly percentage applied and incorporation into the soil.

Subwatershed	January	February	March	April	May	June	July	August	September	October	November	December
P1	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P2	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P3	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P4	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P5	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P6	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P7	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P8	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125
P9	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.170813	0.1708125	0.1708125	0.0125	0.0125	0.0125

Cattle Manure Available for Wash-off Used only for dairy cow manure application in this version of the spreadsheet

This is the percentage of manure applied by month.

	January	February	March	April	May	June	July	August	September	October	November	December	
% of annual manure applied in month	0.0192	0	0	0.2222	0.2222	0.2222	0.0833	0.0833	0.0833	0.0833	0	0	1.01903077

The percent of manure available for runoff is dependent on method of manure application. Computations below are based on assumed incorporation into soil.

% available for runoff = (1 - % incorporated) + (% incorporated * 0.5)	0.625

The following is the resulting manure application based on the monthly percentage applied and incorporation into the soil.

Subwatershed	January	February	March	April	May	June	July	August	September	October	November	December
P1	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P2	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P3	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P4	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P5	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P6	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P7	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P8	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0
P9	0.012019	0	0	0.138875	0.138875	0.138875	0.052063	0.0520625	0.0520625	0.0520625	0	0

Poultry Litter Available for Wash-off

Used for Beef Cow manure application rates in this version of the spreadsheet.

This is the percentage of manure applied by month.

	January	February	March	April	May	June	July	August	September	October	November	December	
% of annual manure applied in month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.9996

The percent of manure available for runoff is dependent on the method of manure application. Computations below are based on assumed incorporation into soil.

% available for runoff = (1 - % incorporated) + (% incorporated * 0.33)	1

The following is the resulting manure application based on the monthly percentage applied and incorporation into the soil.

Subwatershed	January	February	March	April	May	June	July	August	September	October	November	December
P1	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P2	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P3	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P4	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P5	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P6	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P7	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P8	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833
P9	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833

This sheet contains information relevant to cattle farming in the study area.

Dairy Cattle

Assume that dairy cattle are only kept in feedlots. Therefore all of their waste is used for manure application (divided between Cropland and Pastureland).

Beef Cattle

Beef cattle are assumed to be either kept in feedlots or allowed to graze (depending on the season). When grazing, a certain percentage are assumed to have direct access to streams.
Beef cattle waste is therefore either applied as manure to Cropland and Pastureland, contributed directly to Pastureland, or contributed directly to streams (referred to as Cattle in Streams).

	Beef Cattle Grazing	***Assumed Cattle Access to Streams***
Month	**Percentage of Time not Confined (0.0 or 1.0)**	**Percentage of Time (0.0 to 1.0)**
January	1.00	0.00
February	1.00	0.00
March	1.00	0.00
April	1.00	0.00
May	1.00	0.00
June	1.00	0.00
July	1.00	0.00
August	1.00	0.00
September	1.00	0.00
October	1.00	0.00
November	1.00	0.00
December	1.00	0.00

	Total Cattle Grazing Days
Month	
January	31
February	28
March	31
April	30
May	31
June	30
July	31
August	31
September	30
October	31
November	30
December	31
Total Grazing Days:	365

These data accessed from the following references are used in the remaining worksheets.

From ASAE

Animal	Total Manure prod (lb/day per 1,000 lb animal)	Typical Animal Mass (lb)	Manure prod per animal (lb/day)	Fecal Coliform (cfu/day E10 per 1,000 lb animal)	Fecal Coliform (cfu/day)	Manure prod (lb/yr)
Beef cow	58	794	46	7.2	1.14E+11	16802
Dairy cow	86	1411	121	13	1.83E+11	44290
Hog	84	134	11	8	1.08E+10	4123
Sheep	40	60	2	20	1.19E+10	869
Chicken	64	4	0	3.4	1.35E+08	93
Broiler	85	2	0	3.4	6.75E+07	62
Turkey	47	15	1	0.62	9.29E+07	257
Duck	110	3	0	81	2.50E+09	124

original value for beef cows was 5.71 E 10 - modified for use in Cottonwood.

From Metcalf & Eddy

Estimated Fecal Coliform Production Rates by Animal

Animal	#/day	Reference
Cow	5.40E+09	Metcalf & Eddy, 1991
Hog	8.90E+09	Metcalf & Eddy, 1991
Sheep	1.80E+10	Metcalf & Eddy, 1991
Chicken	2.40E+08	Metcalf & Eddy, 1991
Turkey	1.30E+08	Metcalf & Eddy, 1991
Duck	1.10E+10	Metcalf & Eddy, 1991
Deer	5.00E+08	BPJ
Geese	4.90E+10	LIRPB, 1982

From: Horner, 1992

Fecal Coliform Loading Rates by Landuse

	median #/ha-y	#/acre/day
Road	1.80E+08	2.00E+05
Commercial	5.60E+09	6.21E+06
Single family low density	9.30E+09	1.03E+07
Single family high density	1.50E+10	1.66E+07
Multifamily residential	2.10E+10	2.33E+07

Sources of fecal coliform bacteria for the Cropland are wildlife, hog manure application, cattle manure application, and poultry litter application.

Note that all hog waste produced is applied to Cropland in the form of manure. Application varies by month.

Note that not all cattle waste is applied to the Cropland.
Assume that dairy cattle are only kept in feedlots. Therefore all of their waste is used for manure application (divided between Cropland and Pastureland).
Beef cattle are assumed to be either kept in feedlots or allowed to graze (depending on the season). When grazing, a certain percentage is assumed to have direct access to streams.
Beef cattle waste is therefore either applied as manure to Cropland and Pastureland, contributed directly to Pastureland, or contributed directly to streams (referred to as Cattle in Streams).
*The FC produced (as listed in the Cattle Manure Application section) does not consider the amount produced by grazing cattle or cattle in the streams.

Note that all poultry manure or litter is applied only to Cropland and is based on variable monthly application.

This column has been edited from original

CROPLAND

			Wildlife		Hog Manure Application						Cattle Manure Application							
			FC prod	FC accum		FC prod	FC prod	Available for	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod*	Available for	FC applied	FC accum
January	AREA (AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	(#/acre/day)	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day	(#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.24E+12	7.79E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.20E+11	3.93E+07	165	220	3.03E+13	2.51E+13	1.10E+16	1.33E+14	4.28E+12	5.52E+08
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.62E+11	3.30E+07	110	580	2.02E+13	6.62E+13	7.36E+15	8.85E+13	2.86E+12	1.48E+08
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.68E+12	7.94E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Total	#REF!																	

			Wildlife		Hog Manure Application						Cattle Manure Application							
			FC prod	FC accum		FC prod	FC prod	Available	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied	FC accum
February	AREA (AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	for month	per day	(#/acre/day)	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day	(#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.37E+12	8.63E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.44E+11	4.35E+07	165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00	0.00E+00
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	6.22E+11	3.66E+07	110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00	0.00E+00
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.85E+12	8.79E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

			Wildlife		Hog Manure Application						Cattle Manure Application							
			FC prod	FC accum		FC prod	FC prod	Available for	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied	FC accum
March	AREA (AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	(#/acre/day)	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day	(#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.24E+12	7.79E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.20E+11	3.93E+07	165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00	0.00E+00
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.62E+11	3.30E+07	110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00	0.00E+00
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.68E+12	7.94E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

			Wildlife		Hog Manure Application						Cattle Manure Application							
			FC prod	FC accum		FC prod	FC prod	Available for	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied	FC accum
April	AREA (AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	(#/acre/day)	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day	(#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.28E+12	8.05E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.27E+11	4.06E+07	165	220	3.03E+13	2.51E+13	1.10E+16	1.53E+15	5.11E+13	6.59E+09
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.81E+11	3.41E+07	110	580	2.02E+13	6.62E+13	7.36E+15	1.02E+15	3.41E+13	1.76E+09
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.73E+12	8.20E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

			Wildlife		Hog Manure Application						Cattle Manure Application							
			FC prod	FC accum		FC prod	FC prod	Available for	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied	FC accum
May	AREA (AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	(#/acre/day)	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day	(#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.24E+12	7.79E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.20E+11	3.93E+07	165	220	3.03E+13	2.51E+13	1.10E+16	1.53E+15	4.95E+13	6.38E+09
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.62E+11	3.30E+07	110	580	2.02E+13	6.62E+13	7.36E+15	1.02E+15	3.30E+13	1.71E+09
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.68E+12	7.94E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

			Wildlife		Hog Manure Application						Cattle Manure Application							
			FC prod	FC accum		FC prod	FC prod	Available for	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied	FC accum
June	AREA (AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	(#/acre/day)	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day	(#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.28E+12	8.05E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.27E+11	4.06E+07	165	220	3.03E+13	2.51E+13	1.10E+16	1.53E+15	5.11E+13	6.59E+09
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.81E+11	3.41E+07	110	580	2.02E+13	6.62E+13	7.36E+15	1.02E+15	3.41E+13	1.76E+09
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.73E+12	8.20E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!		#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

		Wildlife			Hog Manure Application						Cattle Manure Application							
July	AREA (AC)	#deer	FC prod (#/day)	FC accum (#/acre/day)	# hogs	FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	# dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	5.25E+14	1.69E+13	1.07E+09	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	9.32E+13	3.01E+12	5.37E+08	165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.86E+13	2.39E+09
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	2.38E+14	7.68E+12	4.51E+08	110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.24E+13	6.40E+08
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	7.10E+14	2.29E+13	1.08E+09	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

		Wildlife			Hog Manure Application						Cattle Manure Application							
August	AREA (AC)	#deer	FC prod (#/day)	FC accum (#/acre/day)	# hogs	FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	# dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	5.25E+14	1.69E+13	1.07E+09	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	9.32E+13	3.01E+12	5.37E+08	165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.86E+13	2.39E+09
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	2.38E+14	7.68E+12	4.51E+08	110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.24E+13	6.40E+08
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	7.10E+14	2.29E+13	1.08E+09	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

		Wildlife			Hog Manure Application						Cattle Manure Application							
September	AREA (AC)	#deer	FC prod (#/day)	FC accum (#/acre/day)	# hogs	FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	# dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	5.25E+14	1.75E+13	1.10E+09	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	9.32E+13	3.11E+12	5.55E+08	165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.92E+13	2.47E+09
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	2.38E+14	7.94E+12	4.66E+08	110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.28E+13	6.61E+08
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	7.10E+14	2.37E+13	1.12E+09	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

			Wildlife				Hog Manure Application							Cattle Manure Application				
October	AREA (AC)	#deer	FC prod (#/day)	FC accum (#/acre/day)	# hogs	FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	# dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.24E+12	7.79E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.20E+11	3.93E+07	165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.86E+13	2.39E+09
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.62E+11	3.30E+07	110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.24E+13	6.40E+08
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.68E+12	7.94E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

			Wildlife				Hog Manure Application							Cattle Manure Application				
November	AREA (AC)	#deer	FC prod (#/day)	FC accum (#/acre/day)	# hogs	FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	# dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.28E+12	8.05E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.27E+11	4.06E+07	165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00	0.00E+00
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.81E+11	3.41E+07	110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00	0.00E+00
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.73E+12	8.20E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

			Wildlife				Hog Manure Application							Cattle Manure Application				
December	AREA (AC)	#deer	FC prod (#/day)	FC accum (#/acre/day)	# hogs	FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	# dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)
P1	15885	173.7422	8.69E+10	5.47E+06	782	8.41E+12	3.07E+15	3.84E+13	1.24E+12	7.79E+07	0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P2	5597	61.21719	3.06E+10	5.47E+06	139	1.50E+12	5.46E+14	6.82E+12	2.20E+11	3.93E+07	165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00	0.00E+00
P3	17022	186.1781	9.31E+10	5.47E+06	355	3.82E+12	1.39E+15	1.74E+13	5.62E+11	3.30E+07	110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00	0.00E+00
P4	21109	230.8797	1.15E+11	5.47E+06	1058	1.14E+13	4.15E+15	5.19E+13	1.68E+12	7.94E+07	0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P5	13924	152.2938	7.61E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P6	10897	119.1859	5.96E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P7	5821	63.66719	3.18E+10	5.47E+06	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

CROPLAND

January	# turkeys	Poultry Litter Application poultry FC prod (#/day)	poultry FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.34E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.97E+08
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E+08
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.48E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
Total							

February	# turkeys	Poultry Litter Application poultry FC prod (#/day)	poultry FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.18E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.90E+07
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E+07
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.33E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

March	# turkeys	Poultry Litter Application poultry FC prod (#/day)	poultry FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.34E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.48E+07
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.85E+07
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.48E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

	Poultry Litter Application						TOTAL
	# turkeys	poultry FC prod	poultry FC prod	Available for	FC applied	FC accum	FC accum
April		(#/day)	(#/year)	month	per day	(#/acre/day)	(#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.60E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.64E+09
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E+09
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.75E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

	Poultry Litter Application						TOTAL
	# turkeys	poultry FC prod	poultry FC prod	Available for	FC applied	FC accum	FC accum
May		(#/day)	(#/year)	month	per day	(#/acre/day)	(#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.34E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.42E+09
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E+09
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.48E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

	Poultry Litter Application						TOTAL
	# turkeys	poultry FC prod	poultry FC prod	Available for	FC applied	FC accum	FC accum
June		(#/day)	(#/year)	month	per day	(#/acre/day)	(#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.60E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.64E+09
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E+09
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.75E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

		Poultry Litter Application					TOTAL
	# turkeys	poultry FC prod	poultry FC prod	Available for	FC applied	FC accum	FC accum
July		(#/day)	(#/year)	month	per day	(#/acre/day)	(#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+09
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E+09
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E+09
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+09
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

		Poultry Litter Application					TOTAL
	# turkeys	poultry FC prod	poultry FC prod	Available for	FC applied	FC accum	FC accum
August		(#/day)	(#/year)	month	per day	(#/acre/day)	(#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+09
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E+09
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E+09
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+09
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

		Poultry Litter Application					TOTAL
	# turkeys	poultry FC prod	poultry FC prod	Available for	FC applied	FC accum	FC accum
September		(#/day)	(#/year)	month	per day	(#/acre/day)	(#/acre/day)
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E+09
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.03E+09
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+09
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+09
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

October	# turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
	Poultry Litter Application						
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.34E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E+09
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.78E+08
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.48E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

November	# turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
	Poultry Litter Application						
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.60E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.61E+07
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.96E+07
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.75E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

December	# turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Available for month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
	Poultry Litter Application						
P1	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.34E+07
P2	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.48E+07
P3	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.85E+07
P4	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.48E+07
P5	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P6	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P7	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!

The deer population is the only wildlife considered as a fecal coliform contributor to the Forest.

FOREST LAND

All Months	AREA (AC)	#deer	Wildlife FC prod (#/day)	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	263	4.520313	2.26E+09	8593750	8.59E+06
P2	2117	36.38594	1.82E+10	8593750	8.59E+06
P3	419	7.201563	3.60E+09	8593750	8.59E+06
P4	535	9.195313	4.60E+09	8593750	8.59E+06
P5	2737	47.04219	2.35E+10	8593750	8.59E+06
P6	38	0.653125	3.27E+08	8593750	8.59E+06
P7	57	0.979688	4.90E+08	8593750	8.59E+06
P8	#REF!	#REF!	#REF!	#REF!	#REF!
P9	#REF!	#REF!	#REF!	#REF!	#REF!
	#REF!				

Due to lack of animal counts, etc. for Built-up land, literature values are used.

A single, weighted Built-up loading value is quantified for each subwatershed based on individual built-up landuses present and their corresponding loading rates.

URBAN LAND

All Months	COMMERCIAL AND SERVICES AREA (AC)	FC accum (#/acre/day)	MIXED URBAN OR BUILT-UP AREA (AC)	FC accum (#/acre/day)	RESIDENTIAL AREA (AC)	FC accum (#/acre/day)	TRANS, COMM UTIL AREA (AC)	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	0	0.00E+00	32	1.13E+07	0	0.00E+00	0	0.00E+00	1.13E+07
P2	0	0.00E+00	181	1.13E+07	0	0.00E+00	0	0.00E+00	1.13E+07
P3	0	0.00E+00	4	1.13E+07	0	0.00E+00	0	0.00E+00	1.13E+07
P4	0	0.00E+00	15	1.13E+07	0	0.00E+00	0	0.00E+00	1.13E+07
P5	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0.00E+00
P6	0	0.00E+00	4	1.13E+07	0	0.00E+00	0	0.00E+00	1.13E+07
P7	0	0.00E+00	337	1.13E+07	0	0.00E+00	0	0.00E+00	1.13E+07
P8	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0.00E+00
P9	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0.00E+00

Sources of fecal coliform bacteria for the Pastureland are wildlife, cattle manure application, and beef cattle grazing.

Note that not all cattle waste is applied to the Cropland.

Assume that dairy cattle are only kept in feedlots. Therefore all of their waste is used for manure application (divided between Cropland and Pastureland).

Beef cattle are assumed to be either kept in feedlots or allowed to graze (depending on the season). When grazing, a certain percentage is assumed to have direct access to streams.

Beef cattle waste is therefore either applied as manure to Cropland and Pastureland, contributed directly to Pastureland, or contributed directly to streams (referred to as Cattle in Streams).

* The total FC produced (as listed in the Cattle Manure Application section) does not consider the amount produced by grazing cattle or cattle in the streams.

Beef cattle are assumed to graze only from April through November. During this period a specified percentage of these cattle also have direct access to streams.

* Note that the Beef Cattle Grazing section takes into account the number of cattle with access to rivers. See the Cattle in Streams worksheet.

PASTURELAND

This column has been edited from original.

		Wildlife			Local Hog Manure Application						Local Cattle Manure Application						
	AREA		FC prod	FC accum		FC prod	FC prod	Applied in	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod*	Available for	FC applied
January	(AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	#/acre/day	#dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day
P1	2188	23.93	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.63	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	1.33E+14	4.28E+12
P3	2306	25.22	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	8.85E+13	2.86E+12
P4	4813	52.64	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06		No hog manure applied to pasture lands					0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.11	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.58	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
	25816																

		Wildlife			Local Hog Manure Application						Local Cattle Manure Application						
	AREA		FC prod	FC accum		FC prod	FC prod	Applied in	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied
February	(AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	#/acre/day	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day
P1	2188	23.93	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.63	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00
P3	2306	25.22	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00
P4	4813	52.64	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.11	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.58	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

		Wildlife			Local Hog Manure Application						Local Cattle Manure Application						
	AREA		FC prod	FC accum		FC prod	FC prod	Applied in	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied
March	(AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	#/acre/day	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day
P1	2188	23.93	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.63	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00
P3	2306	25.22	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00
P4	4813	52.64	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.11	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.58	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

April	AREA (AC)	Wildlife #deer	Wildlife FC prod (#/day)	Wildlife FC accum (#/acre/day)	Local Hog Manure Application # hogs	FC prod (#/day)	FC prod (#/year)	Applied in month	FC applied per day	FC accum #/acre/day	Local Cattle Manure Application # dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	1.53E+15	5.11E+13
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	1.02E+15	3.41E+13
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

May	AREA (AC)	Wildlife #deer	Wildlife FC prod (#/day)	Wildlife FC accum (#/acre/day)	Local Hog Manure Application # hogs	FC prod (#/day)	FC prod (#/year)	Applied in month	FC applied per day	FC accum #/acre/day	Local Cattle Manure Application # dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	1.53E+15	4.95E+13
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	1.02E+15	3.30E+13
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

June	AREA (AC)	Wildlife #deer	Wildlife FC prod (#/day)	Wildlife FC accum (#/acre/day)	Local Hog Manure Application # hogs	FC prod (#/day)	FC prod (#/year)	Applied in month	FC applied per day	FC accum #/acre/day	Local Cattle Manure Application # dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	1.53E+15	5.11E+13
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	1.02E+15	3.41E+13
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

July	AREA (AC)	Wildlife #deer	Wildlife FC prod (#/day)	Wildlife FC accum (#/acre/day)	Local Hog Manure Application # hogs	FC prod (#/day)	FC prod (#/year)	Applied in month	FC applied per day	FC accum #/acre/day	Local Cattle Manure Application # dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.86E+13
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.24E+13
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

			Wildlife		Local Hog Manure Application						Local Cattle Manure Application						
	AREA		FC prod	FC accum		FC prod	FC prod	Applied in	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied
August	(AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	#/acre/day	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.86E+13
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.24E+13
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

			Wildlife		Local Hog Manure Application						Local Cattle Manure Application						
	AREA		FC prod	FC accum		FC prod	FC prod	Applied in	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied
September	(AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	#/acre/day	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.92E+13
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.28E+13
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

			Wildlife		Local Hog Manure Application						Local Cattle Manure Application						
	AREA		FC prod	FC accum		FC prod	FC prod	Applied in	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied
October	(AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	#/acre/day	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	5.75E+14	1.86E+13
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	3.83E+14	1.24E+13
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

			Wildlife		Local Hog Manure Application						Local Cattle Manure Application						
	AREA		FC prod	FC accum		FC prod	FC prod	Applied in	FC applied	FC accum			dairy FC prod	beef FC prod	FC prod	Available for	FC applied
November	(AC)	#deer	(#/day)	(#/acre/day)	# hogs	(#/day)	(#/year)	month	per day	#/acre/day	# dairy cattle	# beef cattle	(#/day)	(#/day)	(#/year)	month	per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

December	AREA (AC)	Wildlife #deer	Wildlife FC prod (#/day)	Wildlife FC accum (#/acre/day)	Local Hog Manure Application # hogs	FC prod (#/day)	FC prod (#/year)	Applied in month	FC applied per day	FC accum #/acre/day	Local Cattle Manure Application # dairy cattle	# beef cattle	dairy FC prod (#/day)	beef FC prod (#/day)	FC prod (#/year)	Available for month	FC applied per day
P1	2188	23.931	1.20E+10	5.47E+06							0	540	0.00E+00	6.17E+13	0.00E+00	0.00E+00	0.00E+00
P2	2160	23.625	1.18E+10	5.47E+06							165	220	3.03E+13	2.51E+13	1.10E+16	0.00E+00	0.00E+00
P3	2306	25.222	1.26E+10	5.47E+06							110	580	2.02E+13	6.62E+13	7.36E+15	0.00E+00	0.00E+00
P4	4813	52.642	2.63E+10	5.47E+06							0	680	0.00E+00	7.77E+13	0.00E+00	0.00E+00	0.00E+00
P5	10354	113.25	5.66E+10	5.47E+06							0	820	0.00E+00	9.36E+13	0.00E+00	0.00E+00	0.00E+00
P6	1839	20.114	1.01E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00
P7	2156	23.581	1.18E+10	5.47E+06							0	240	0.00E+00	2.74E+13	0.00E+00	0.00E+00	0.00E+00

PASTURELAND

January	FC accum (#/acre/day)
P1	0.00E+00
P2	5.52E+08
P3	1.48E+08
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

February	FC accum (#/acre/day)
P1	0.00E+00
P2	0.00E+00
P3	0.00E+00
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

March	FC accum (#/acre/day)
P1	0.00E+00
P2	0.00E+00
P3	0.00E+00
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

April	FC accum (#/acre/day)
P1	0.00E+00
P2	6.59E+09
P3	1.76E+09
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

May	FC accum (#/acre/day)
P1	0.00E+00
P2	2.29E+10
P3	1.43E+10
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

June	FC accum (#/acre/day)
P1	0.00E+00
P2	2.37E+10
P3	1.48E+10
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

July	FC accum (#/acre/day)
P1	0.00E+00
P2	8.59E+09
P3	5.36E+09
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

August	FC accum (#/acre/day)
P1	0.00E+00
P2	8.59E+09
P3	5.36E+09
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

September	FC accum (#/acre/day)
P1	0.00E+00
P2	8.88E+09
P3	5.54E+09
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

October	FC accum (#/acre/day)
P1	0.00E+00
P2	2.39E+09
P3	6.40E+08
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

November	FC accum (#/acre/day)
P1	0.00E+00
P2	0.00E+00
P3	0.00E+00
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

December	FC accum (#/acre/day)
P1	0.00E+00
P2	0.00E+00
P3	0.00E+00
P4	0.00E+00
P5	0.00E+00
P6	0.00E+00
P7	0.00E+00

PASTURELAND

January	Beef Cattle Grazing*					Poultry Litter Application						TOTAL
	# beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	# turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							1.22E+10
P3	580	580	1.00	6.62E+13	2.87E+10							2.89E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09		No poultry litter applied to pasture lands					9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

February	Beef Cattle Grazing					Poultry Litter Application						TOTAL
	# beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	# turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							1.16E+10
P3	580	580	1.00	6.62E+13	2.87E+10							2.87E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

March	Beef Cattle Grazing					Poultry Litter Application						TOTAL
	# beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	# turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							1.16E+10
P3	580	580	1.00	6.62E+13	2.87E+10							2.87E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

April	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							1.82E+10
P3	580	580	1.00	6.62E+13	2.87E+10							3.05E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

May	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							3.45E+10
P3	580	580	1.00	6.62E+13	2.87E+10							4.30E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

June	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							3.53E+10
P3	580	580	1.00	6.62E+13	2.87E+10							4.35E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

July	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							2.02E+10
P3	580	580	1.00	6.62E+13	2.87E+10							3.41E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

August	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							2.02E+10
P3	580	580	1.00	6.62E+13	2.87E+10							3.41E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

September	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							2.05E+10
P3	580	580	1.00	6.62E+13	2.87E+10							3.43E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

October	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							1.40E+10
P3	580	580	1.00	6.62E+13	2.87E+10							2.94E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

November	Beef Cattle Grazing # beef cattle	# grazing	% of time grazing	FC prod (#/day)	FC accum (#/acre/day)	Poultry Litter Application # turkeys	poultry FC prod (#/day)	poultry FC prod (#/year)	Applied in month	FC applied per day	FC accum (#/acre/day)	TOTAL FC accum (#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							1.16E+10
P3	580	580	1.00	6.62E+13	2.87E+10							2.87E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

	Beef Cattle Grazing					Poultry Litter Application						TOTAL
			% of time	FC prod	FC accum	# turkeys	poultry FC prod	poultry FC prod	Applied in	FC applied	FC accum	FC accum
December	# beef cattle	# grazing	grazing	(#/day)	(#/acre/day)		(#/day)	(#/year)	month	per day	(#/acre/day)	(#/acre/day)
P1	540	540	1.00	6.17E+13	2.82E+10							2.82E+10
P2	220	220	1.00	2.51E+13	1.16E+10							1.16E+10
P3	580	580	1.00	6.62E+13	2.87E+10							2.87E+10
P4	680	680	1.00	7.77E+13	1.61E+10							1.61E+10
P5	820	820	1.00	9.36E+13	9.04E+09							9.05E+09
P6	240	240	1.00	2.74E+13	1.49E+10							1.49E+10
P7	240	240	1.00	2.74E+13	1.27E+10							1.27E+10

This sheet contains information related to the direct contribution of beef cattle fecal coliform bacteria to streams.

The direct contribution of fecal coliform from cattle to a stream can be represented as a point source in the model. Required input for point sources in NPSM are flow (cfs) and loading rate (#/hr).

It is assumed that only beef cattle are grazing and therefore have access to streams. They have access to the stream based on information in the Cattle Farming worksheet.

Assume the following:

Beef Cattle Waste: 46 (lbs/animal/day)

The density of cattle manure (including urine) is approximately the density of water: 62.4 (lbs/cubic foot)

CATTLE AS A POINT SOURCE

January	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

February	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

March	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)

P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

April	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

May	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

June	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00

P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

July	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

August	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

September	# grazing beef cattle	# cattle in streams	FC rate (#/hr)	Waste Flow (cfs)
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00

P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

October	# grazing beef cattle	# cattle in streams	**FC rate (#/hr)**	**Waste Flow (cfs)**
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

November	# grazing beef cattle	# cattle in streams	**FC rate (#/hr)**	**Waste Flow (cfs)**
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00
P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

December	# grazing beef cattle	# cattle in streams	**FC rate (#/hr)**	**Waste Flow (cfs)**
P1	540	0	0.00E+00	0.00E+00
P2	220	0	0.00E+00	0.00E+00
P3	580	0	0.00E+00	0.00E+00

P4	680	0	0.00E+00	0.00E+00
P5	820	0	0.00E+00	0.00E+00
P6	240	0	0.00E+00	0.00E+00
P7	240	0	0.00E+00	0.00E+00
P8	0	0	0.00E+00	0.00E+00
P9	0	0	0.00E+00	0.00E+00

This sheet contains information related to the contribution of failing septic systems to streams.

The direct contribution of fecal coliform from septics to a stream can be represented as a point source in the model. Required input for point sources in NPSM are loading rate (#/hr) and flow (cfs).

The following assumptions are made for septic contributions.

Estimated # septics:	417	
Avg # people served per septic:	2.7	people/septic
Assume a failure rate for septics in the watershed:	33	%
Therefore the number of failing septics in the watershed is:	137.61	
Assume failing septics are distributed evenly across watershed based on land area. Therefore, density of failing septics is:	0.00112051	
Assume the average FC concentration reaching the stream (from septic overcharge) is:	1.00E+04	#/100 ml
Assume a typical septic overcharge flow rate of:	70	gal/day/person
	(Horsely & Whitten, 1996)	

SEPTICS AS A POINT SOURCE

Subwatershed	Total area (acres)	# failing septics	Tot. # people served	Septic flow (gal/day)	Septic flow (mL/hr)	FC rate (#/hr)	Septic flow (cfs)
P1	18368	29	78.3	5481	864399.375	8.64E+07	8.50E-03
P2	10055	15	40.5	2835	447103.125	4.47E+07	4.39E-03
P3	19751	29	78.3	5481	864399.375	8.64E+07	8.50E-03
P4	26472	25	67.5	4725	745171.875	7.45E+07	7.32E-03
P5	27015	10	27	1890	298068.75	2.98E+07	2.93E-03
P6	12778	7	18.9	1323	208648.125	2.09E+07	2.05E-03
P7	8371	23	62.1	4347	685558.125	6.86E+07	6.74E-03
P8	0	0	0	0	0	0.00E+00	0.00E+00
P9	0	0	0	0	0	0.00E+00	0.00E+00
Total:	122810	138					

ACQOP and SQOLIM by Landuse

This sheet contains values for ACQOP (or MON-ACCUM if monthly) and SQOLIM (or MON-SQOLIM if monthly).
These parameters represent the rate of fecal coliform accumulation and the maximum storage of fecal coliform bacteria.
The value for SQOLIM is derived from Horsley & Whitten 1986, where the following equation was used to represent the surface die-off of fecal coliform bacteria:

$N1 = N0(10^{(-kt)})$ where:

N1 = number of fecal coliforms at time t
N0 = number of fecal coliforms at time 0
t = time in days
k = first order die-off rate constant. Typical values for warm months = 0.51 and for cold months = 0.36

Using the above equation and assuming the die-off rates presented, the maximum buildup during warm months is approximately 1.5 x daily buildup rate; for colder months is 1.8 x daily buildup rate.
Assume that warmer months are April through September while colder months are October through March.

Assume a buildup limit of 1.8 x daily buildup rate for non-monthly varying SQOLIM.

CROPLAND

January

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.34E+07	1.50E+08
P2	5.97E+08	1.07E+09
P3	1.86E+08	3.35E+08
P4	8.48E+07	1.53E+08
P5	5.47E+06	9.84E+06
P6	5.47E+06	9.84E+06
P7	5.47E+06	9.84E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

February

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	9.18E+07	1.65E+08
P2	4.90E+07	8.82E+07
P3	4.20E+07	7.57E+07
P4	9.33E+07	1.68E+08
P5	5.47E+06	9.84E+06
P6	5.47E+06	9.84E+06
P7	5.47E+06	9.84E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

March

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.34E+07	1.50E+08
P2	4.48E+07	8.06E+07
P3	3.85E+07	6.93E+07
P4	8.48E+07	1.53E+08
P5	5.47E+06	9.84E+06
P6	5.47E+06	9.84E+06
P7	5.47E+06	9.84E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

PASTURELAND

January

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	5.07E+10
P2	1.22E+10	2.19E+10
P3	2.89E+10	5.20E+10
P4	1.61E+10	2.91E+10
P5	9.05E+09	1.63E+10
P6	1.49E+10	2.68E+10
P7	1.27E+10	2.29E+10
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00

February

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	5.07E+10
P2	1.16E+10	2.09E+10
P3	2.87E+10	5.17E+10
P4	1.61E+10	2.91E+10
P5	9.05E+09	1.63E+10
P6	1.49E+10	2.68E+10
P7	1.27E+10	2.29E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

March

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	5.07E+10
P2	1.16E+10	2.09E+10
P3	2.87E+10	5.17E+10
P4	1.61E+10	2.91E+10
P5	9.05E+09	1.63E+10
P6	1.49E+10	2.68E+10
P7	1.27E+10	2.29E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

FOREST

All Months

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.59E+06	1.55E+07
P2	8.59E+06	1.55E+07
P3	8.59E+06	1.55E+07
P4	8.59E+06	1.55E+07
P5	8.59E+06	1.55E+07
P6	8.59E+06	1.55E+07
P7	8.59E+06	1.55E+07
P8	#REF!	#REF!
P9	#REF!	#REF!

BUILT-UP

All Months

	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	1.13E+07	2.04E+07
P2	1.13E+07	2.04E+07
P3	1.13E+07	2.04E+07
P4	1.13E+07	2.04E+07
P5	0.00E+00	0.00E+00
P6	1.13E+07	2.04E+07
P7	1.13E+07	2.04E+07
P8	0.00E+00	0.00E+00
P9	0.00E+00	0.00E+00

April	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.60E+07	1.29E+08
P2	6.64E+09	9.96E+09
P3	1.80E+09	2.71E+09
P4	8.75E+07	1.31E+08
P5	5.47E+06	8.20E+06
P6	5.47E+06	8.20E+06
P7	5.47E+06	8.20E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

April	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	4.23E+10
P2	1.82E+10	2.73E+10
P3	3.05E+10	4.57E+10
P4	1.61E+10	2.42E+10
P5	9.05E+09	1.36E+10
P6	1.49E+10	2.24E+10
P7	1.27E+10	1.91E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

May	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.34E+07	1.25E+08
P2	6.42E+09	9.64E+09
P3	1.75E+09	2.62E+09
P4	8.48E+07	1.27E+08
P5	5.47E+06	8.20E+06
P6	5.47E+06	8.20E+06
P7	5.47E+06	8.20E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

May	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	4.23E+10
P2	3.45E+10	5.18E+10
P3	4.30E+10	6.46E+10
P4	1.61E+10	2.42E+10
P5	9.05E+09	1.36E+10
P6	1.49E+10	2.24E+10
P7	1.27E+10	1.91E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

June	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.60E+07	1.29E+08
P2	6.64E+09	9.96E+09
P3	1.80E+09	2.71E+09
P4	8.75E+07	1.31E+08
P5	5.47E+06	8.20E+06
P6	5.47E+06	8.20E+06
P7	5.47E+06	8.20E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

June	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	4.23E+10
P2	3.53E+10	5.30E+10
P3	4.35E+10	6.53E+10
P4	1.61E+10	2.42E+10
P5	9.05E+09	1.36E+10
P6	1.49E+10	2.24E+10
P7	1.27E+10	1.91E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

July	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	1.07E+09	1.61E+09
P2	2.93E+09	4.40E+09
P3	1.10E+09	1.64E+09
P4	1.09E+09	1.63E+09
P5	5.47E+06	8.20E+06
P6	5.47E+06	8.20E+06
P7	5.47E+06	8.20E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

July	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	4.23E+10
P2	2.02E+10	3.03E+10
P3	3.41E+10	5.11E+10
P4	1.61E+10	2.42E+10
P5	9.05E+09	1.36E+10
P6	1.49E+10	2.24E+10
P7	1.27E+10	1.91E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

August	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	1.07E+09	1.61E+09
P2	2.93E+09	4.40E+09
P3	1.10E+09	1.64E+09
P4	1.09E+09	1.63E+09
P5	5.47E+06	8.20E+06
P6	5.47E+06	8.20E+06
P7	5.47E+06	8.20E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

September	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	1.11E+09	1.66E+09
P2	3.03E+09	4.55E+09
P3	1.13E+09	1.70E+09
P4	1.13E+09	1.69E+09
P5	5.47E+06	8.20E+06
P6	5.47E+06	8.20E+06
P7	5.47E+06	8.20E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

October	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.34E+07	1.50E+08
P2	2.44E+09	4.39E+09
P3	6.78E+08	1.22E+09
P4	8.48E+07	1.53E+08
P5	5.47E+06	9.84E+06
P6	5.47E+06	9.84E+06
P7	5.47E+06	9.84E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

November	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.60E+07	1.55E+08
P2	4.61E+07	8.30E+07
P3	3.96E+07	7.13E+07
P4	8.75E+07	1.57E+08
P5	5.47E+06	9.84E+06
P6	5.47E+06	9.84E+06
P7	5.47E+06	9.84E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

December	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	8.34E+07	1.50E+08
P2	4.48E+07	8.06E+07
P3	3.85E+07	6.93E+07
P4	8.48E+07	1.53E+08
P5	5.47E+06	9.84E+06
P6	5.47E+06	9.84E+06
P7	5.47E+06	9.84E+06
P8	#REF!	#REF!
P9	#REF!	#REF!

August	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	4.23E+10
P2	2.02E+10	3.03E+10
P3	3.41E+10	5.11E+10
P4	1.61E+10	2.42E+10
P5	9.05E+09	1.36E+10
P6	1.49E+10	2.24E+10
P7	1.27E+10	1.91E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

September	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	4.23E+10
P2	2.05E+10	3.08E+10
P3	3.43E+10	5.14E+10
P4	1.61E+10	2.42E+10
P5	9.05E+09	1.36E+10
P6	1.49E+10	2.24E+10
P7	1.27E+10	1.91E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

October	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	5.07E+10
P2	1.40E+10	2.53E+10
P3	2.94E+10	5.29E+10
P4	1.61E+10	2.91E+10
P5	9.05E+09	1.63E+10
P6	1.49E+10	2.68E+10
P7	1.27E+10	2.29E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

November	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	5.07E+10
P2	1.16E+10	2.09E+10
P3	2.87E+10	5.17E+10
P4	1.61E+10	2.91E+10
P5	9.05E+09	1.63E+10
P6	1.49E+10	2.68E+10
P7	1.27E+10	2.29E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

December	ACQOP (#/acre/day)	SQOLIM (#/acre)
P1	2.82E+10	5.07E+10
P2	1.16E+10	2.09E+10
P3	2.87E+10	5.17E+10
P4	1.61E+10	2.91E+10
P5	9.05E+09	1.63E+10
P6	1.49E+10	2.68E+10
P7	1.27E+10	2.29E+10
P8	#REF!	#REF!
P9	#REF!	#REF!

Appendix IV
Stream Temperature and Weather Data

Stream Temperature Data

Stream temperature data was supplied by the Idaho DEQ and are summarized below. The data originated from Shelly Gilmore's 1998 monitoring program and recorded temperature at each of the seven monitoring location during the late spring through fall during 1996 and 1997.

Water Temperatures (Monthly Average Cº)								
	Shebang Creek		Upper Cottonwood		Stockney Creek		Red Rock Creek	
Month	1996	1997	1996	1997	1996	1997	1996	1997
May	-	16.7*	-	14.6*	-	16.1*	-	15.5*
June	13.4*	18.1	17.8*	16.6	15.4*	15.8	16.8*	17.1
July	15.5	19.8	18.9	18.8	18.7	17.3	20.9	19.3
August	18.2	19.3	15.1	17.9	15.0	16.7	18.0	19.7
September	21.1*	17.0*	12.8*	16.5*	13.2*	15.7*	15.8*	17.1*
	Lower Cottonwood		Middle Cottonwood		South Fork Cottonwood		Long Haul Creek	
Month	1996	1997	1996	1997	1996	1997	1996	1997
May	-	16.2*	-	-	-	16.4*	-	17.1*
June	-	18.4	-	-	15.7*	17.3	-	18.0
July	22.0	20.6	-	-	17.8	19.8	-	20.3
August	19.4	20.3	-	-	15.9	18.1	-	18.4
September	15.3	18.5*	-	-	14.1*	16.4*	-	17.1*

* incomplete data (less than a full month of samples)

Note: There is no monitoring station for the Middle Cottonwood subwatershed

WDM (Weather Data) File - Parameter Definitions

Parameter Type	Parameter Name	Weather Station			Method of Computation (When Used)
		Cottonwood	Fenn Ranger Station	Lewiston	
Precipitation: daily (in.)	DPRC	Observed[11]	Observed[8,11]	Observed[9]	

Precipitation: hourly (in/hr)	PREC	Observed[9] + Computed	Observed[8,9]	Observed[10]	Disaggregated from daily data using METCMP
Evaporation: daily (in.)	DEVP[1]	Computed[11]	Computed[8]	-	
Evaporation: hourly (in/hr)	EVAP	Computed[11]	Computed[8]	-	Disaggregated from daily to hourly
Air temperature: daily maximum (deg. F)	TMAX[5.]	Observed[11]	Observed[8,11]	Observed[9]	
Air temperature: daily minimum (deg.F)	TMIN[5.]	Observed[11]	Observed[8,11] + Computed	Observed	
Air temperature: hourly (deg. F)	ATEM	Computed	Observed[8,11]	-	Disaggregated Daily to Hourly
Dewpoint temperature: daily (deg. F)	DPTP	Computed	Observed[8]	Observed[10]	Aggregated hourly to daily
Dewpoint temperature: hourly (deg. F)	DEWP	Observed	Observed	Computed	Cottonwood estimated from Fenn Station & Lewiston
Cloud cover: daily (tenths)	DCLO	Computed[2,9]	Observed[8]	-	
Cloud cover: hourly (tenths)	CLOU	Computed	Observed[8]	-	Disaggregated from daily
Wind movement: daily (miles)	DWND	Computed	Observed[8]	Computed[9]	Cottonwood copied from Fenn & Lewiston
Windspeed: daily average (mph)	AWND	-	-	Observed[9]	
Windspeed: hourly (mph)	WIND[6.]	Computed	Observed[8]	Observed[10]	Cottonwood copied from Fenn & disaggregated daily to hourly from Lewiston
Solar radiation: daily (Langleys)	DSOL	Computed	Observed[8]	-	

Solar radiation: hourly (Langleys/hr)	SOLR[4.]	Computed	Observed[8]	-	Disaggregation of Daily to Hourly
Potential evapo-transpiration: daily (in)	DEVT	Computed	Computed[8]	-	Cottonwood computed by Hamon method using WDM Utility
Potential evapo-transpiration: hourly (in/hr)	PEVT[3]	Computed	Computed[8]	-	Disaggregated PET - Daily to Hourly

Some Notes and Assumptions

1.DEVP computed from max & min temperature, dewpoint temperature wind & solar radiation using WDM Utility

2.Daily Cloud Cover (DCLO) **-** Data was also used from the Boise Idaho station

3.Evapotranspiration (PEVT) - Disaggregating daily PET (in. or cm) to hourly, assumes a distribution based on latitude (deg, min, sec)and time of year

4.Solar Radiation (SOLR) - Disaggregating solar radiation data to hourly uses a empirical distribution based on latitude and is recommended for use only between 25 degrees N. to 50 degrees N.

5.Temperature (TMAX, TMIN) - Disaggreagating daily minimum and maximum air temperature data to hourly assumes minimum temperature occurs at 6 AM and maximum at 4 pm.

6.Wind (WIND) - Disaggregation of daily wind movement (“wind travel”) to hourly wind speed uses an empirical hourly distribution

7.PSUN (***) data was used from the Boise Idaho Station

DATA SOURCES
8.BASINS version 2 CDs
9.NOAA On-line data
10.NOAA CDs (HUSWO)
11.Idaho State Climate Services
12.Earth Info CDs

Memorandum

AQUA TERRA CONSULTANTS

To: Marjorie Coombs Wellman

Date: August 27, 1999

Copies for: P. Cocca, A. Donigian, J. Kittle

Client: EPA/OST

Project Number: 9820-106

From: P. Hummel

Subject: EPA Contract No. 68-C-98-010, WA 1-06,
Notes on Technical Assistance in Response to TDD #28 for Development of Meteorological Data for Cottonwood Station

This memo describes the steps taken to formulate the meteorological data specified by EPA for the Cottonwood station in the Cottonwood TMDL study. With the exception of the percent sun data from Boise, ID, all original data were collected and provided by EPA. Software used to compile the data included WDMUtil (beta version), GenScn 1.1b, ANNIE 2.0, and METCMP (unpublished version 3.0). A spreadsheet describing the available data, its source, its quality, and where it was stored is found in the file 'CottonTS.xls'. A map showing the location of the relevant stations for the data compilation is found in the file 'Stations_Map.gif' (note: Fenn Ranger Station is the first station on the Selway River, upstream of its confluence with the Lochsa River, located near the eastern border of the map). Other supplemental files referenced in the detailed descriptions of the data compilation include 'Cottonwood_HPCP.mis', 'Cott_Prcp_Sum.txt', 'TMin_Mon_Ave.txt', and 'TMax_Mon_Ave.txt'.

Development of the WDM file for the Cottonwood watershed study began by extracting the data sets for Fenn Ranger Station from the existing BASINS Idaho WDM file. This was done using ANNIE to export data sets 71 - 86 for the years 1990 through 1995 (1996 for precip). A new WDM file was built in ANNIE and the exported Fenn data sets were imported into the new WDM file (Cotton.wdm).

Precip

- Read hourly Cottonwood precip data (Cottonwood_HPCP.ncd, 1/1/75 - 3/31/99), provided by NOAA On-Line data purchase, into WDMUtil and wrote it to data-set number 11.
- Summarized data for period of concern (1990 - current) and saved results in file 'Cottonwood_HPCP.mis'. Significant periods of missing data found.
- Read daily Cottonwood precip data (extracted from cottemp.log, 1/1/90 - 12/31/98), provided by Idaho St. Climate Services, into WDMUtil and wrote it to data-set number 27. Minimal missing data found (8 days over period).

- Read hourly Lewiston precip data (Lewiston_NOAA.dat, 1/1/90 - 12/31/95), retrieved from NOAA CD, into WDMUtil and wrote it to data-set number 91.
- Read daily Lewiston precip data (Lewiston_SOD.ncd, 1/1/90 - 7/31/98), retrieved from the NOAA free summary of the day ftp site, into WDMUtil and wrote it to data-set number 107.
- Read hourly Fenn precip data (Fenn_HPCP.ncd, 1/1/90 - 3/31/99), provided by NOAA On-Line data purchase, into WDMUtil and wrote it to data-set number 1071.
- Ran METCMP to disaggregate daily precip values from Cottonwood. Used Fenn and Lewiston as nearby stations to perform disaggregation. Used 24 as observation hour since this was not provided with the data. Wrote disaggregated data to data-set number 1011.
- Listed spans of missing data for hourly Cottonwood (11) alongside daily Cottonwood (27) and hourly data for Fenn (71), Lewiston (91), and disaggregated Cottonwood (1011). Copied and pasted values from disaggregated Cottonwood when METCMP distributed effectively; otherwise disaggregated daily total by hand based on Lewiston and Fenn. When appropriate, distributed Cottonwood slightly ahead (2 - 3 hours) of Fenn as comparing valid recorded values for both stations indicated this was typical. If no corresponding values existed for Fenn or Lewiston, used triangular distribution in middle of the day to distribute daily totals (e.g. daily total of 1 inch distributed to .03 for hour 11, .04 for hour 12, and .03 for hour 13).
- Generated listing of daily and hourly precip at Cottonwood summed to monthly totals. Compared monthly totals for periods where daily values were distributed to hourly to make sure totals matched. Corrected erroneous values when found and generated listing again for final QA check (file Cott_Prcp_Sum.txt).

Temperature

- Read daily Cottonwood min/max temperature data (cottemp.log, 1/1/90 - 12/31/98), provided by Idaho St. Climate Services, into WDMUtil and wrote it to data-set numbers 20 and 19. This was done using a user-defined format on the Data Initialization form - Y4,M2,X2,31V4. It was also necessary to change the M characters in the file (indicating missing data values) to -999. Values missing for 1/94 - 7/96.
- Read daily Fenn min/max temperature data (fennrs.log, 1/1/96 - 12/31/96), provided by Idaho St. Climate Services, into WDMUtil and added it to existing data-set numbers 80 and 79. (Presently this is done by writing the new data to temporary data sets, using ANNIE to export the temporary data sets, renumbering the data sets on the export file to match the data numbers to which the data is to be added, and then using ANNIE to import the data and append it to the desired data sets).
- Generated monthly average listings for Fenn and Cottonwood min and max temperatures (files TMin_Mon_Ave.txt and TMax_Mon_Ave.txt). Calculated that Cottonwood max temperature was on average 90% of Fenn and that Cottonwood min temperature was on average 97% of Fenn. There was no significant seasonal variation in these values.
- Used Gener program in GenScn (also available in ANNIE and METCMP) to compute min (multiply by .97) and max (multiply by .9) temperature data, based on Fenn, for Cottonwood during the span of missing data (1/94 - 7/96). Used import/export functionality in ANNIE to add computed values to existing data sets (19 and 20).

- Used disaggregate function in WDMUtil to disaggregate daily min/max temperature data (data sets 20/19) to hourly temperature data and stored values on data-set number 13.

Dew Point

- No dewpoint temperature data was available for the Cottonwood station.
- Read daily Lewiston dewpoint temperature data (Lewiston_SOD.ncd, 1/1/90 - 7/31/98), retrieved from the NOAA free summary of the day ftp site, into WDMUtil and wrote it to data-set number 103. Twenty one short missing intervals were filled by hand by comparing with Fenn (1990 - 1995) or by interpolation between values just before and after the missing period.
- Used disaggregate function in WDMUtil to disaggregate Lewiston daily dewpoint temperature data (data set 103) to hourly dewpoint temperature data and stored values on data-set number 97.
- Based on analyses of min/max temperature data, determined that Cottonwood temperatures corresponded more closely with Fenn than Lewiston, particularly min temperature. Thus, used Fenn dewpoint temperature values for Cottonwood during 1990 - 1995. These values were stored on data-set number 17.
- Analysis of Fenn and Lewiston dewpoint temperatures revealed that average Fenn dewpoint was typically 90% of Lewiston. Thus, used Gener program to compute dewpoint temperature data for 1/96 - 7/98 by multiplying Lewiston dewpoint values by 0.9. Computed data was stored on a temporary data set and then added to the existing Cottonwood dewpoint data set (17) using ANNIE import and export functions.

Wind

- No wind data was available for the Cottonwood station.
- Read daily Lewiston wind data (Lewiston_SOD.ncd, 1/1/90 - 7/31/98), retrieved from the NOAA free summary of the day ftp site, into WDMUtil and wrote it to data-set number 101. Sixteen short missing intervals, but only one during 1996 - 1998 (period needed). Missing values filled by interpolation.
- Used Gener program to calculate total daily wind movement (needed for disaggregation from daily to hourly) for Lewiston during 1996 - 1998 (multiplied daily average by 24). Stored values on data-set number 108.
- Wrote existing Fenn daily and hourly wind data to Cottonwood data sets (21 and 14 respectively) for the period 1990 - 1995.
- Appended daily wind movement from Lewiston (108) to daily Cottonwood wind data set (21).
- Used disaggregate function in WDMUtil to disaggregate Lewiston daily wind movement (108) to hourly wind movement during 1996 - 1998. Stored results on a temporary data set and then used ANNIE import and export functions to append disaggregated data to existing Cottonwood hourly data (14).

Potential ET

- No potential evapotranspiration (PET) data was available for the Cottonwood station.

- Used compute function in WDMUtil to compute daily PET using Hamon's method. Used daily min and max temperature data at Cottonwood (data sets 19 and 20) for computations. Stored computed daily PET on data-set number 25
- Used disaggregate function in WDMUtil to disaggregate daily PET (data set 25) to hourly. Stored hourly PET on data-set number 18.

Cloud Cover

- No cloud cover data was available for the Cottonwood station.
- Read daily Boise percent sun data (Boise_SOD.ncd, 1/1/70 - 7/31/98), retrieved from the NOAA free summary of the day ftp site, into WDMUtil and wrote it to data-set number 1000. Eleven short missing intervals, but none after 1980.
- Used compute function in WDMUtil to compute daily cloud cover data for Boise from the daily percent sun data (data set 1000). Stored computed daily cloud cover data on data-set number 1001.
- Wrote existing Fenn daily cloud cover data (data set 82) to Cottonwood daily cloud cover data set (22) for the period 1990 - 1995.
- Used WDMUtil to generate listing of monthly average values of cloud cover, during the period 1970 - 1975, for Fenn and Boise. Used listing to calculate cumulative average monthly difference between the two stations. Saved the twelve monthly values as a time series that repeats each year for the period 1996 - 1998.
- Read the time series of repeating monthly values into a temporary data set in WDMUtil. Listed the data set at a daily interval with the monthly value being listed for each day of that month. Saved daily listing to a file and then read that same file into WDMUtil and stored the data on a temporary data set.
- Used Gener program to subtract the difference between Boise and Fenn (stored in temporary data set from previous step) from the Boise values for the period 1/96 - 7/98. Used ANNIE import and export functions to append adjusted Boise values to the Cottonwood daily cloud cover data set (22).
- Used disaggregate function in WDMUtil to disaggregate the daily cloud cover data (data set 22) to hourly cloud cover and stored values on data-set number 18.

Solar Radiation

- No solar radiation data was available for the Cottonwood station.
- Used compute function of WDMUtil to compute daily solar radiation data from daily cloud cover data (data set 22) and stored the values on data-set number 24.
- Used disaggregate function of WDMUtil to disaggregate daily solar radiation data (24) to hourly solar radiation and stored values on data-set number 15.

Evaporation

- No evaporation data was available for the Cottonwood station.
- Used compute function of WDMUtil to compute daily evaporation data from max temperature (data set 19), min temperature (data set 20), dewpoint temperature (data set 23), wind (data set 21), and solar radiation (data set 22) and stored the values on data-set number 26.
- Used disaggregate function of WDMUtil to disaggregate daily evaporation data (26) to hourly evaporation and stored values on data-set number 12.

WEATHER DATA

DAILY MEAN OBSERVED TMAX

Time		Tran	COTTON WD	FENN
1990	JAN Ave		37.2	41.1
1990	FEB Ave		37.3	42.9
1990	MAR Ave		48.7	56.6
1990	APR Ave		57.5	67.7
1990	MAY Ave		58.8	67.6
1990	JUN Ave		67.6	81.4
1990	JUL Ave		80.2	92.2
1990	AUG Ave		78.1	88.4
1990	SEP Ave		79.1	85.6
1990	OCT Ave		54.3	64.3
1990	NOV Ave		43.5	50.9
1990	DEC Ave		26.8	27.6
1991	JAN Ave		32.8	32.4
1991	FEB Ave		47.5	51.3
1991	MAR Ave		43.7	53
1991	APR Ave		51.8	59.1
1991	MAY Ave		56.9	67.2
1991	JUN Ave		63.4	76.7
1991	JUL Ave		78	92.7
1991	AUG Ave		83.2	92.4
1991	SEP Ave		74.4	80.1
1991	OCT Ave		59.1	65.2
1991	NOV Ave		38.8	44.3
1991	DEC Ave		38.2	39.7
1992	JAN Ave		38.1	41.2
1992	FEB Ave		48	52.2
1992	MAR Ave		54.7	62.9
1992	APR Ave		57.3	67.8

1992	MAY Ave	69.4	80.5
1992	JUN Ave	75.3	83.4
1992	JUL Ave	74.8	86.9
1992	AUG Ave	81.1	90
1992	SEP Ave	70.2	78
1992	OCT Ave	60.6	67.5
1992	NOV Ave	38.6	40.5
1992	DEC Ave	32.5	34.7
1993	JAN Ave	30.9	30.8
1993	FEB Ave	35.3	35.7
1993	MAR Ave	47.9	49.1
1993	APR Ave	51.9	57.7
1993	MAY Ave	68.4	76
1993	JUN Ave	67.9	74
1993	JUL Ave	66.3	78.8
1993	AUG Ave	74	83.1
1993	SEP Ave	70.7	79.1
1993	OCT Ave	59.9	65.6
1993	NOV Ave	39.6	45
1993	DEC Ave	37.5	41.1

DAILY MEAN OBSERVED TMIN

Time	Tran	COTTONWD	FENN
1990	JAN Ave	25.48	27
1990	FEB Ave	23.64	25.23
1990	MAR Ave	30.71	32.24
1990	APR Ave	39.73	42.11
1990	MAY Ave	39.03	43.68
1990	JUN Ave	47.6	52.8
1990	JUL Ave	57	60.52
1990	AUG Ave	55.87	59.91
1990	SEP Ave	53.67	54.68
1990	OCT Ave	36.32	37.87
1990	NOV Ave	31.1	31.18
1990	DEC Ave	12.94	8.93
1991	JAN Ave	20.94	16.33
1991	FEB Ave	33.57	31.61
1991	MAR Ave	28.68	32.76
1991	APR Ave	34.37	37.33
1991	MAY Ave	39.45	42.54

1991	JUN Ave	43.7	48.59
1991	JUL Ave	55.39	58.82
1991	AUG Ave	57.65	61.48
1991	SEP Ave	49.37	51.46
1991	OCT Ave	37.81	38.82
1991	NOV Ave	28.07	30.37
1991	DEC Ave	26.26	23.96
1992	JAN Ave	25.68	25.44
1992	FEB Ave	32.24	32.27
1992	MAR Ave	35.39	35.84
1992	APR Ave	38.33	42.15
1992	MAY Ave	45.35	48.13
1992	JUN Ave	52.93	56.14
1992	JUL Ave	51.84	55.97
1992	AUG Ave	55.65	58.4
1992	SEP Ave	46.33	49.35
1992	OCT Ave	41.35	41.62
1992	NOV Ave	27.73	28.44
1992	DEC Ave	21.13	22.48
1993	JAN Ave	17.61	18.84
1993	FEB Ave	19.43	21.99
1993	MAR Ave	31.61	34.23
1993	APR Ave	33.9	38.09
1993	MAY Ave	46.1	50.42
1993	JUN Ave	45.67	49.72
1993	JUL Ave	46.13	51.65
1993	AUG Ave	50.81	54.18
1993	SEP Ave	47	47.86
1993	OCT Ave	40.71	40.77
1993	NOV Ave	24.3	20.95
1993	DEC Ave	26.84	26.15

MONTHLY COMPARISON OF HOURY AND DAILY PRECIPITATION AT COTTON WOOD STATION

Note: Months where all hourly values were disaggregated from daily are marked with a '*'

Time	Tran		PREC	DPRC
1990	JAN	Sum	1.9	2.15
1990	FEB	Sum	1.5	1.59

1990	MAR	Sum 1.3	1.36
1990	APR	Sum 2.5	2.63
1990	MAY	Sum 7.3	7.29
1990	JUN	Sum 1.7	2.05
1990	JUL	Sum 1.1	1.29
1990	AUG	Sum 0.9	1.12
1990	SEP	Sum 0	0.02
1990	OCT	Sum 3.1	3.36
1990	NOV	Sum 2.7	2.83
1990	DEC	Sum 1.93	1.93 *
1991	JAN	Sum 1.17	0.99
1991	FEB	Sum 0.5	0.29
1991	MAR	Sum 1.3	1.28
1991	APR	Sum 2.8	2.92
1991	MAY	Sum 5.8	5.8
1991	JUN	Sum 2.7	3.05
1991	JUL	Sum 0.6	0.62
1991	AUG	Sum 0	0.01
1991	SEP	Sum 0.3	0.36
1991	OCT	Sum 0.4	0.26
1991	NOV	Sum 2.83	2.65
1991	DEC	Sum 1.23	1.23 *
1992	JAN	Sum 0.59	0.59 *
1992	FEB	Sum 1.03	1.03 *
1992	MAR	Sum 0.79	0.79 *
1992	APR	Sum 2.46	2.46 *
1992	MAY	Sum 1.13	1.13 *
1992	JUN	Sum 1.78	1.78 *
1992	JUL	Sum 2.61	2.61 *
1992	AUG	Sum 0.28	0.28 *
1992	SEP	Sum 1.65	1.65 *
1992	OCT	Sum 1.27	1.27 *
1992	NOV	Sum 1.7	1.7 *
1992	DEC	Sum 1.01	1.01 *
1993	JAN	Sum 2.29	2.29 *
1993	FEB	Sum 0.93	0.93 *
1993	MAR	Sum 1.47	1.17 * (missing day filled with 0.3 from Fenn)
1993	APR	Sum 3.42	3.42 *
1993	MAY	Sum 3.56	3.56 *
1993	JUN	Sum 4.27	4.27 *
1993	JUL	Sum 4.11	4.11 *
1993	AUG	Sum 1.63	1.82
1993	SEP	Sum 0.2	0.13
1993	OCT	Sum 1	1.15
1993	NOV	Sum 0.7	0.67

1993	DEC	Sum 1	1.08	
1994	JAN	Sum 1.2	1.02	
1994	FEB	Sum 1.7	1.92	
1994	MAR	Sum 0.7	0.62	
1994	APR	Sum 2.3	2.46	
1994	MAY	Sum 2.1	2.43	
1994	JUN	Sum 2.5	2.71	
1994	JUL	Sum 0.8	0.88	
1994	AUG	Sum 0.2	0.32	
1994	SEP	Sum 0.2	0.2	
1994	OCT	Sum 1.9	1.65	
1994	NOV	Sum 2.59	2.78	
1994	DEC	Sum 1.98	1.85	
1995	JAN	Sum 2	1.6	
1995	FEB	Sum 1.3	1.43	
1995	MAR	Sum 2.9	2.53	
1995	APR	Sum 4.1	4.01	
1995	MAY	Sum 2.5	2.35	
1995	JUN	Sum 3.4	3.14	
1995	JUL	Sum 3	3.48	
1995	AUG	Sum 1.55	1.55	*
1995	SEP	Sum 0.6	0.6	*
1995	OCT	Sum 3.17	3.17	*
1995	NOV	Sum 3.63	3.63	*
1995	DEC	Sum 3.17	2.57	* (missing day filled with 0.6; ave of
1996	JAN	Sum 2.68	2.68	* Fenn and Lewiston)
1996	FEB	Sum 2.66	2.66	*
1996	MAR	Sum 0.91	0.91	*
1996	APR	Sum 3.2	3.2	*
1996	MAY	Sum 4.31	4.31	*
1996	JUN	Sum 1.13	1.13	*
1996	JUL	Sum 0.26	0.26	*
1996	AUG	Sum 0.24	0.24	*
1996	SEP	Sum 1	1	*
1996	OCT	Sum 1.44	1.44	*
1996	NOV	Sum 2.96	2.96	*
1996	DEC	Sum 5.07	5.07	*
1997	JAN	Sum 2.43	2.43	*
1997	FEB	Sum 1.33	1.33	*
1997	MAR	Sum 3.52	3.52	*
1997	APR	Sum 3.97	3.97	*
1997	MAY	Sum 1.34	1.34	*
1997	JUN	Sum 2.95	1.95	
1997	JUL	Sum 3.57	3.57	*
1997	AUG	Sum 0.93	0.97	
1997	SEP	Sum 2.2	1.46	

1997	OCT	Sum 2.55	2.55	*
1997	NOV	Sum 1.57	1.57	*
1997	DEC	Sum 1.29	1.29	*
1998	JAN	Sum 1.92	1.92	*
1998	FEB	Sum 0.4	0.42	
1998	MAR	Sum 1.3	1.2	
1998	APR	Sum 2.1	2.1	
1998	MAY	Sum 4.7	4.24	
1998	JUN	Sum 2.6	2.81	
1998	JUL	Sum 2.5	2.59	
1998	AUG	Sum 0.25	0.25	*
1998	SEP	Sum 3.36	3.36	*
1998	OCT	Sum 1.78	1.78	*
1998	NOV	Sum 4.03	3.81	
1998	DEC	Sum 2.7	2.93	

WDM File (COTTON.WDM) data for Cottonwood TMDL Study

Time Series	WDM File (COTTON. Location	Time Step	DSN	Start Date	End Date	File	Source	Missing Data	Fill Method

Precip	Cottonwood	day	27	1/1/90	12/31/98	cottemp.log	Idaho St Climate Services	8 days missing over entire period	
	Cottonwood	hour	11	1/1/75	3/31/99	Cottonwood_HPCP.ncd	NOAA On-Line, $$	significant missing (1538 days total), also some not reported	Disaggregated daily (dsn 27) using Fenn and Lewiston for distribution
	Fenn	hour	71	1/1/90	12/31/96		BASINS WDM		
	Fenn	hour	1071	1/1/90	3/31/99	Fenn_HPCP.ncd	NOAA On-Line, $$	significant missing (275 days total)	
	Fenn	hour		1/1/90	12/31/95	Fenn_EI.NCD	Earthinfo CD		
	Fenn	day		1/1/96	6/30/99	fennrs.log	Idaho St Climate Services		
	Lewiston	day	107	1/1/90	7/31/98	Lewiston_SOD.ncd	NOAA On-Line SOD		
	Lewiston	hour	91	1/1/90	12/31/95	Lewiston_NOAA.dat	NOAA CD	18 missing 1 - 4 day periods	
Evap	Fenn	hour	72	1/1/90	12/31/95		BASINS WDM		
	Fenn	day	86	1/1/90	12/31/95		BASINS WDM		
	Cottonwood	day	26	1/1/90	7/31/98				Computed from TMAX (19), TMIN (20), Dew Point (23), Wind (21), and Solar Radiation (22
	Cottonwood	hour	12	1/1/90	7/31/98				disaggregated from daily evap (dsn 26)
Air Temp	Cottonwood	daily min/max	20/19	1/1/90	12/31/98	cottemp.log	Idaho St Climate Services	missing 94 - 7/96	Filled with Fenn (TMAX * .9, TMIN * .97 based on monthly aves)
	Cottonwood	hour	13	1/1/90	12/31/98		DSNs 19, 20		disaggregated from daily min/max (dsns 20 and 19), obs. hr. = 24
	Fenn	hour	73	1/1/90	12/31/95		BASINS WDM		
	Fenn	daily min/max	80/79	1/1/90	12/31/95		BASINS WDM		
	Fenn	daily min/max	80/79	1/1/96	12/31/96	fennrs.log	Idaho St Climate Services	added to existing BASINS data, 3 invalid TMINs at end	set TMINs to same as preceeding (TMAX was the same for each day)
	Lewiston	daily min/max	100/99	1/1/90	7/31/98	Lewiston_SOD.ncd	NOAA On-Line SOD	few short periods	filled with Fenn
	Lewiston	hour		1/1/90	12/31/95	Lewiston_NOAA.dat	NOAA CD		
Dew Point	Fenn	hour	77	1/1/90	12/31/95		BASINS WDM		
	Fenn	day	83	1/1/90	12/31/95		BASINS WDM		
	Lewiston	hour		1/1/90	12/31/95	Lewiston_NOAA.dat	NOAA CD		
	Lewiston	day	103	1/1/90	7/31/98	Lewiston_SOD.ncd	NOAA On-Line SOD	21 short missing intervals	estimated from Fenn through 95, interpolated 96 - 98
	Lewiston	hour	97	1/1/90	7/31/98	disagg fr DSN 103			
	Cottonwood	hour	17	1/1/90	7/31/98		Fenn, Lewiston		copied fr Fenn through 95, disagg Lewiston (96-98) and multiplied by .9 based on monthly
	Cottonwood	day	23	1/1/90	7/31/98		DSN 17		Aggregated from hourly dewpoint (dsn 17)
Cloud Cover	Fenn	hour	78	1/1/90	12/31/95		BASINS WDM		
	Fenn	day	82	1/1/90	12/31/95		BASINS WDM		
	Lewiston	hour		1/1/90	12/31/95	Lewiston_NOAA.dat	NOAA CD		
	Boise (% sun)	day	1000	1/1/70	7/31/98	Boise_SOD.ncd	NOAA On-Line SOD	11 short missing periods, none after 1980	
	Boise	day	1001	1/1/70	7/31/98		DSN 1000		Computed using % sun (dsn 1000)

	Cottonwood	day	22	1/1/90	7/31/98	Boise_SOD.ncd (1996 +)	NOAA On-Line SOD	Used Fenn (dsn 82) through 1995, fill after w/adjusted Boise	Adjust Boise values using ave monthly differences between Boise and Fenn
	Cottonwood	hour	18	1/1/90	7/31/98		DSN 22		Disaggregated dsn 22
Vind mph,	Fenn	hour	74	1/1/90	12/31/95		BASINS WDM		
unless oted)	Fenn	daily wind movemen	81	1/1/90	12/31/95		BASINS WDM		
	Lewiston	hour		1/1/90	12/31/95	Lewiston_NOAA.dat	NOAA CD		
	Lewiston	day	101	1/1/90	7/31/98	Lewiston_SOD.ncd	NOAA On-Line SOD	16 short missing periods, only one during 96-98	interpolated for one missing value during 96-98
	Lewiston	daily wind movemen	108	1/1/96	7/31/98		DSN 101		multiplied daily ave (dsn 101) to get daily wind movement
	Cottonwood	hour	14	1/1/90	7/31/98		Fenn, Lewiston		copied fr Fenn (dsn 74) through 95, disagg Lewiston (dsn 108) for 96 - 98
	Cottonwood	day	21	1/1/90	7/31/98		Fenn, Lewiston		copied fr Fenn (dsn 81) through 95, Lewiston for 96 - 98 (dsn 108)
olar Rad	Fenn	hour	75	1/1/90	12/31/95		BASINS WDM		
	Fenn	day	84	1/1/90	12/31/95		BASINS WDM		
	Cottonwood	day	24	1/1/90	7/31/98		DSN 22		Computed using daily cloud cover (dsn 22)
	Cottonwood	hour	15	1/1/90	7/31/98		DSN 24		Disaggregated using daily solar radiation (dsn 24)
otential T	Cottonwood	hour	16	1/1/90	12/31/98		DSN 25		disaggregated from daily PET (dsn 25)
	Cottonwood	day	25	1/1/90	12/31/98		DSNs 19, 20		computed w/Hamon method (dsns 19,20)
	Fenn	hour	76	1/1/90	12/31/95		BASINS WDM		
					12/31/				

Misc.

For Data-set number 10001 (OBSERVED COTTONWD HPCP)

1252 hours of missing values after 1990/12/1 13:0:0
6923 hours of missing values after 1991/11/17 13:0:0
8349 hours of missing values after 1992/9/3 18:0:0
72 hours of missing time distribution after 1994/1/24 21:0:0
9 hours of missing time distribution after 1994/2/25 3:0:0
153 hours of missing values after 1994/11/25 2:0:0
127 hours of missing values after 1994/12/13 9:0:0
11 hours of missing time distribution after 1995/5/1 8:0:0
11 hours of missing values after 1995/5/14 6:0:0
16356 hours of missing values after 1995/7/22 2:0:0
774 hours of missing values after 1997/6/30 12:0:0
400 hours of missing values after 1997/8/3 18:0:0
747 hours of missing values after 1997/12/31 24:0:0

1164 hours of missing values after 1998/9/30 24:0:0
655 hours of missing values after 1999/3/4 17:0:0
15 period(s) of missing or bad data.

DSN/ID	Increments	Periods	Total	Periods	Total	Periods	Total
10001	81048	12	36911	3	92	0	0

Also note: No data reported for periods 10/97 - 12/97 and 8/98 - 9/98.

Appendix V
Tables

NPSM/HSPF HYDROLOGY PARAMETERS AND VALUE RANGES

NAME	DEFINITION	UNITS	RANGE OF VALUES TYPICAL MIN	TYPICAL MAX	POSSIBLE MIN	POSSIBLE MAX	STARTER DEFAULT*	TUALATIN DEFAULT*	FINAL CALIBR.*	FUNCTION OF ...	COMMENT
PWAT - PARM2											
FOREST	Fraction forest cover	none	0	0.5	0	0.95	0.0, 1.0	0.56, 0.98	0.05, 0.98	Forest cover	Only impact when SNOW is active
LZSN	Lower Zone Nominal Soil Moisture Storage	inches	3	8	2	15	14.1	7.82	7	Soils, climate	Calibration
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.5	0.16	0.21	0.05	Soils, land use	Calibration, divides surface and subsurface flow
LSUR	Length of overland flow	feet	200	500	100	700	300	)186, 17225	500	Topography	Estimate from maps or GIS
SLSUR	Slope of overland flow plane	none	0.01	0.15	0.001	0.3	0.035	0.19, 0.25	0.19, 0.25	Topography	Estimate from maps or GIS
KVARY	Variable groundwater recession	1/inches	0	3	0	5	0	1	0	Baseflow recession variation	Used when recession rate varies with GW levels
AGWRC	Base groundwater recession	none	0.92	0.99	0.85	0.999	0.98	0.988	0.98	Baseflow recession	Calibration
PWAT - PARM3											
PETMAX	Temp below which ET is reduced	deg. F	35	45	32	48	40	40	32	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temp below which ET is set to zero	deg. F	30	35	30	40	35	35	30	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2	2	1	3	2	4	2	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2	2	1	3	2	2	2	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0	0.2	0	0.5	0.1	0.15	0.6	Geology, GW recharge	Accounts for subsurface losses
BASETP	Fraction of remaining ET from baseflow	none	0	0.05	0	0.2	0.02	0	0.05	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0	0.05	0	0.2	0	0.02	0.01	Marsh/wetlands extent	Direct ET from shallow GW
PWAT - PARM4											
CEPSC	Interception storage capacity	inches	0.03	0.2	0.01	0.4	0.1	0.1	monthly	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.1	1	0.05	2	1.128	0.68	0.5	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Mannings' n (roughness) for overland flow	none	0.15	0.35	0.1	0.5	0.2	0.21, 0.25	0.25, 0.35	Surface conditions, residue, etc.	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1	3	1	10	0.75	3	10	Soils, topography, land use	Calibration, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.7	0.3	0.85	0.5	0.6	0.7	Soils, topography, land use	Often start with a value of 0.7, and then adjust
LZETP	Lower zone ET parameter	none	0.2	0.7	0.1	0.9	monthly	0.36, 0.4	monthly	Vegetation type/density, root depth	Calibration

* - Note: where two values listed, first for all land uses but forested, second for forested land use

NPSM/HSPF HYDROLOGY PARAMETERS AND VALUE RANGES (Monthly Values)

NAME	DEFINITION/Months	UNITS	RANGE OF VALUES TYPICAL MIN	TYPICAL MAX	POSSIBLE MIN	POSSIBLE MAX	STARTER DEFAULT*	TUALATIN DEFAULT*	FINAL CALIBR.*	FUNCTION OF ...	COMMENT
MON-INTERCEP	Monthly interception storage capacity	inches	0.03	0.2	0.01	0.4				Vegetation type/density, land use	Monthly values usually used
	January						0.1	0.1	0.03		
	February						0.1	0.1	0.03		
	March						0.1	0.1	0.03		
	April						0.1	0.1	0.03		
	May						0.1	0.1	0.1		
	June						0.1	0.1	0.2		
	July						0.1	0.1	0.2		
	August						0.1	0.1	0.2		
	September						0.1	0.1	0.05		
	October						0.1	0.1	0.04		
	November						0.1	0.1	0.03		
	December						0.1	0.1	0.03		
MON-LZETPARM	Monthly lower zone ET parameter	none	0.2	0.7	0.1	0.9				Vegetation type/density, root depth	Calibration
	January						0.2	0.36, 0.4	0.3		
	February						0.2	0.36, 0.4	0.3		
	March						0.3	0.36, 0.4	0.3		
	April						0.3	0.36, 0.4	0.3		
	May						0.4	0.36, 0.4	0.5		
	June						0.4	0.36, 0.4	0.8		
	July						0.4	0.36, 0.4	0.8		
	August						0.4	0.36, 0.4	0.8		
	September						0.4	0.36, 0.4	0.6		
	October						0.3	0.36, 0.4	0.4		
	November						0.2	0.36, 0.4	0.3		
	December						0.2	0.36, 0.4	0.3		

* - Note: where two values listed, first for all land uses but forested, second for forested land use

NPSM/HSPF HYDROLOGY PARAMETERS AND VALUE RANGES											
			RANGE OF VALUES								
NAME	DEFINITION	UNITS	TYPICAL		POSSIBLE		STARTER	TUALATIN	FINAL	FUNCTION OF ...	COMMENT
			MIN	MAX	MIN	MAX	DEFAULT*	DEFAULT*	CALIBR.*		
ATMP											
ELDAT	Elevation diff. bet. gage and pervious land	feet			-60	140	1576	-779	-779		"Tualatin" values based on Cottonwood watershed
AIRTMP	Initial temp. above pervious land segment	deg. F			-50	60	36	42	42		"Tualatin" values based on Cottonwood watershed
SNOW-PARM1											
LAT	latitude (+ in northern hemisphere)	deg.			-90	90	40	46	46		"Tualatin" values based on Cottonwood watershed
MELEV	mean elevation	feet			0	30000	800	3166	3166		"Tualatin" values based on Cottonwood watershed
SHADE	fraction of PLS covered by shade (veg.)	none			0.0	1.0	0.3	0.3, 0. 7, 0.9	0.3, 0. 7, 0.9		urban = 0.3, agricultural = 0.7, forest = 0.9
SNOWCF	correction factor to account for poor catch	none			1.0	100.0	1.2	1.45	1.0		
	efficiency of the gage										
COVIND	maximum pack (water equiv.) at which	inches			0.01	none	10	0.5	0.5		
	entire PLS will be covered by snow										
SNOW-PARM2											
RDCSN	density of cold (<0 F), new snow rel. to water	none			0.0	1.0	0.2	0.15	0.15		
TSNOW	baseline air temp, below which precip is snow	deg. F			30.0	40.0	32.0	32.0	32.0		
SNOWEVP	adapts the snow evaporation (sublimation)	none			0.0	1.0	0.1	0.1	1.0		
	equation to field conditions										
CCFACT	adapts the snow condensation/convection	none			0.0	2.0	1.0	1.0	1.0		
	melt equation to field conditions										
MWATER	max liquid water content snow pack,	none			0.0	1.0	0.03	0.03	0.03		
	in depth water per depth water equiv.										
MGMELT	max. rate snowmelt by ground heat,	in/day			0.0	1.0	0.01	0.01	0.01		
	in depth of water equiv. per day										

****************** FTABLE ******************

Reach: Stockney Creek
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 11.0

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.80	3.20	2.40	0.67
1.30	5.20	6.13	2.31
1.70	4.67	9.60	4.68
2.30	4.67	16.00	9.85
3.00	5.13	25.60	18.92
3.70	11.44	40.53	29.47
4.40	18.44	63.20	48.99
5.50	34.57	116.80	98.37
6.50	34.51	176.27	188.74
7.50	34.51	238.67	302.49
10.00	34.51	394.67	586.87
20.00	34.51	1018.67	1724.37

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Upper Cottonwood Cr.
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 9.4

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.30	3.53	0.91	1.75
1.30	6.61	6.95	22.48
2.30	10.60	18.57	82.69
3.30	10.14	34.41	171.95
4.30	10.14	50.59	301.45
5.30	10.14	66.77	445.40
10.00	10.14	142.81	1121.97
20.00	10.14	304.61	2561.47
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Upper Cottonwood Cr. 2
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 4.5

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.30	1.69	0.44	1.75
1.30	3.16	3.33	22.48
2.30	5.07	8.89	82.69
3.30	4.85	16.47	171.95
4.30	4.85	24.22	301.45
5.30	4.85	31.96	445.40
10.00	4.85	68.37	1121.97
20.00	4.85	145.82	2561.47
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Upper Cottonwood Cr. 3
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 0.3

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.30	0.11	0.03	1.75
1.30	0.21	0.22	22.48
2.30	0.34	0.59	82.69
3.30	0.32	1.10	171.95
4.30	0.32	1.61	301.45
5.30	0.32	2.13	445.40
10.00	0.32	4.56	1121.97
20.00	0.32	9.72	2561.47
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Shebang Creek
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 12.8

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.20	3.41	1.09	0.10
0.30	3.65	2.33	0.40
0.40	3.72	4.08	0.90
0.50	3.65	6.21	1.80
0.70	3.57	10.78	4.30
1.00	3.57	15.59	7.90
1.30	3.57	23.16	14.80
1.40	3.69	25.72	17.00
1.90	7.57	42.02	27.20
2.30	7.57	55.67	41.10
2.70	7.57	69.32	62.30
3.10	7.57	82.98	80.00
3.50	7.57	96.66	98.40
3.90	7.57	110.31	117.40
4.70	7.57	137.62	156.90
10.00	7.57	318.53	418.59
20.00	7.57	659.86	912.34

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Long Haul Creek
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 10.1

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.10	0.34	0.24	0.04
0.40	1.54	2.94	0.89
0.70	3.38	7.59	2.72
1.10	4.60	16.65	7.93
1.50	5.83	27.91	15.74
1.80	6.48	37.71	23.74
2.10	7.03	49.21	34.35
2.40	7.49	61.70	47.02
3.20	10.43	99.65	84.91
3.50	11.63	115.32	101.28
4.20	13.75	154.99	147.64
10.00	31.30	483.65	531.77
20.00	61.55	1050.30	1194.05

****************** FTABLE ******************

Reach: S. Fork Cottonwood
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 5.8

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.10	0.66	0.11	0.02
0.30	0.56	0.51	0.21
0.50	6.40	2.59	0.86
0.80	10.59	7.59	4.22
1.10	10.50	13.84	11.25
1.30	10.42	18.05	17.34
1.90	10.42	30.79	40.39
2.70	10.42	47.78	77.30
3.90	10.42	73.26	150.42
5.30	10.42	102.99	268.57
10.00	10.42	192.21	623.02
20.00	10.42	370.64	1331.92

****************** FTABLE ******************

Reach: S. Fork Cottonwood 2
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 1.8

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.10	0.21	0.03	0.02
0.30	0.17	0.16	0.21
0.50	1.99	0.80	0.86
0.80	3.29	2.36	4.22
1.10	3.26	4.29	11.25
1.30	3.23	5.60	17.34
1.90	3.23	9.56	40.39
2.70	3.23	14.83	77.30
3.90	3.23	22.73	150.42
5.30	3.23	31.96	268.57
10.00	3.23	59.65	623.02
20.00	3.23	115.03	1331.92

****************** FTABLE ******************

Reach: Red Rock Creek
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 9.2

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.70	5.58	1.78	0.56
1.20	11.71	7.36	3.72
2.20	24.09	30.22	24.56
3.20	25.20	59.49	70.61
4.20	25.20	89.04	132.27
5.20	25.20	118.60	204.55
6.70	25.20	162.92	327.68
10.00	25.20	260.44	598.57
20.00	25.20	555.96	1419.43

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Red Rock Creek 2
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 4.2

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.70	2.55	0.81	0.56
1.20	5.35	3.36	3.72
2.20	11.00	13.80	24.56
3.20	11.51	27.16	70.61
4.20	11.51	40.65	132.27
5.20	11.51	54.14	204.55
6.70	11.51	74.38	327.68
10.00	11.51	118.90	598.57
20.00	11.51	253.81	1419.43

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Lower Cottonwood
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 5.9

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.40	1.43	1.14	0.26
1.00	2.72	5.72	2.34
1.40	12.59	12.01	3.49
1.60	13.95	18.31	6.55
2.50	18.82	54.07	32.14
3.40	23.96	95.83	70.51
4.50	31.04	153.90	130.36
4.90	32.19	176.79	159.42
5.60	40.70	222.56	202.44
6.40	53.00	286.63	262.34
10.00	108.35	574.98	531.89
20.00	262.11	1375.95	1280.64

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Middle Cottonwood Cr.
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 4.0

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.30	1.50	0.39	1.75
1.30	2.81	2.96	22.48
2.30	4.51	7.90	82.69
3.30	4.32	14.64	171.95
4.30	4.32	21.53	301.45
5.30	4.32	28.41	445.40
10.00	4.32	60.77	1121.97
20.00	4.32	129.62	2561.47
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00

Last two rows from linear extrapolation.

****************** FTABLE ******************

Reach: Middle Cottonwood Cr. 2
Date: 09/20/1999
Analyst: Paul Cocca
Length (mi): 4.5

Depth (feet)	Area (acres)	Volume (acre-feet)	Outflow (cfs)
0.30	1.69	0.44	1.75
1.30	3.16	3.33	22.48
2.30	5.07	8.89	82.69
3.30	4.85	16.47	171.95
4.30	4.85	24.22	301.45
5.30	4.85	31.96	445.40
10.00	4.85	68.37	1121.97
20.00	4.85	145.82	2561.47
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00

Last two rows from linear extrapolation.