

Report

COST/BENEFIT STUDY OF THE IMPACTS OF POTENTIAL NUTRIENT CONTROLS FOR COLORADO POINT SOURCE DISCHARGES

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CDM



On behalf of



Colorado Department
of Public Health
and Environment



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Acronyms

µg/L	micrograms per liter
ADF	average daily flow
AOP	Advanced Oxidation Processes
Authority	Colorado Water Resources and Power Development Authority
BMP	best management practice
BNR	biological nutrient removal
BOD	biochemical oxygen demand
CDOT	Colorado Department of Transportation
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Department of Public Safety
CH ₄	methane
CO ₂	carbon dioxide
Commission	Water Quality Control Commission
CSC	Colorado Stormwater Council
CWA	Clean Water Act
CWNS	Clean Watershed Needs Survey
CWQF	Colorado Water Quality Forum
CWWUC	Colorado Wastewater Utility Council
D/DBP	Disinfection/Disinfection Byproduct
DADR	Discharge Assessment Data Report
DBP	Disinfection Byproduct
Division	CDPHE Water Quality Control Division
DOLA	Department of Local Affairs
DUWS	Direct Use Water Supply Lakes and Reservoirs
EDU	Environmental Data Unit
EMC	Event Mean Concentration
ENR	Engineering News Record
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
GHG	Greenhouse Gas
GIS	geographic information system
gpd	gallons per day
gpd/sf	gallons per day per square foot
GWP	global warming potential
HAA5	five haloacetic acids
HUCs	Hydrologic Unit Codes
IFAS	integrated fixed-film activated sludge
kWh	kilowatt hour
kWh/lb	kilowatt hour per pound
LGOP	Local Government Operations Protocol
LRAA	locational running annual average
MBBR	moving bed-bioreactor

MCLs	Maximum Contaminant Levels
mg/L	milligrams per liter
mg/m ²	milligram per square meter
mgd	million gallons per day
MLSS	mixed liquor suspended solids
MMI	Multi-Metric Index
MRLC	Multi-resolution Land Characteristics Consortium
MS	Municipal Screener
MS4	municipal separate storm sewer system
MWRD	Metro Wastewater Reclamation District
N ₂ O	nitrous oxide
NDMA	N-Nitroso-Dimethylamine
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NO ₂	nitrite
NO ₃	nitrate
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
O ₃	ozone
PF	peaking factor
ppd	pound per day
RAS	Return Activated Sludge
RBC	rotating biological contactors
RFP	Request for Proposal
RO	reverse osmosis
SBR	sequencing biological reactors
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SDWA	Safe Drinking Water Act
SIC	Standard Industrial Code
SRT	solids retention time
STORET	EPA Storage and Retrieval
Study	Cost Benefit Study
SVI	Sludge Volume Index
SWAP	Source Water Assessment and Protection
SWSI	Statewide Water Supply Initiative
TDS	total dissolved solids
TIN	total inorganic nitrogen
TKN	total kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TTHM	total trihalomethanes
UCCWA	Upper Clear Creek Watershed Association
USACE	U.S. Army Corps of Engineers

USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UV	ultraviolet
WAS	Waste Activated Sludge
WERF	Water Environment Research Foundation
WLA	Waste Load Allocation
WPCR	Watershed Protection Control Regulation
WPCRF	Water Pollution Control Revolving Fund
WTP	willingness-to-pay
WWTFs	wastewater treatment facilities



Section 1

Executive Summary

1.1 Study Goals and Objectives

The Colorado Department of Health and Environment (CDPHE) Water Quality Control Division (Division) is developing an approach to manage nutrients in Colorado waters. The primary driver for this effort has been an Environmental Protection Agency (EPA) directive to reduce nutrients in waters under jurisdiction of the federal Clean Water Act (CWA). Originally, the Division developed a nutrient management approach based solely on the establishment of numeric criteria to protect uses. In 2010, the Division revised its approach to shift its emphasis from the adoption of numeric criteria to the establishment of technology-based controls on facilities that discharge nutrients to Colorado waters.

The Division's proposal to control the discharge of nutrients relies largely on a technology-based control regulation that would establish effluent limits for both total phosphorus (TP) and total inorganic nitrogen (TIN) for many domestic and some nondomestic wastewater treatment facilities (WWTFs). WWTFs that become subject to the control regulation will have to invest in capital improvements and ongoing operation and maintenance (O&M) costs.

The Colorado Water Resources and Power Development Authority (Authority) and the Division are co-administrators of the Colorado Water Pollution Control Revolving Fund (WPCRF), a state revolving fund that provides low interest capital funding to governmental agency sponsors of water quality improvement projects. Because adoption of the proposed regulations would impact the WPCRF, for strategic planning purposes, the Authority and the Division wanted to quantify future infrastructure needs and future loan demands on the WPCRF related to potential future nutrient controls. The Authority requested and the Division agreed to prepare a statewide cost-benefit analysis (Study) related to the potential promulgation of regulations for nutrient control in order to provide the information necessary to better understand the merits of the proposed regulation and potential requirements that would be placed on the WPCRF. The Study results will be used as part of the evidence examined by the Water Quality Control Commission (Commission) when it holds a rule-making hearing to evaluate the Division's regulatory proposal.

Therefore, the goal of this Study is to inform the Division, Authority, Commission, and other interests of the statewide implications of the Division's proposed nutrient control regulations. To achieve this goal, the Study focused on three objectives:

- Estimate the statewide aggregate costs resulting from the potential implementation of a range of statewide regulations to address nutrients and impacts from any requirements for stormwater monitoring;
- Estimate the environmental benefit of implementation of those nutrient regulations; and
- Estimate the benefit to drinking water quality and any reduced treatment costs for drinking water.

The state might have selected a number of different types of impact studies to evaluate the proposed regulations, but the pursuit of a cost-benefit analysis is the appropriate study type, given the questions at hand and the present stage of deliberation. This Study attempts to answer threshold questions that are pertinent at this point in the deliberative process: (1) Are the potential public health and environmental benefits sufficient to justify the likely costs for establishing nutrient controls; and (2) Are there other levels of regulation that would be more justified?

1.1.1 Regulatory Proposal

The Division proposes to manage nutrients being discharged from point sources on a statewide basis, through adoption of a new regulation (5 CCR 1002-85 ["Regulation #85"]) and amendment of an existing regulation (5 CCR 1002-31 ["Regulation #31"]) through the addition of Sections 31.13 (d) and 31.17. The Division published the first draft of these proposed regulations on February 2, 2011. Following continuing discussions with stakeholders, the Division released revised regulatory proposals on July 5, September 30, and November 2, 2011. The Division's current proposal was published on November 21, 2011 as part of the Notice of Public Rulemaking Hearing. This proposal provides the basis of this Study.

Proposed Regulation #85 establishes effluent limitations for certain existing domestic and non-domestic WWTFs and new WWTFs (collectively referred to as "non-exempt WWTFs") (Table 1-1). These limitations would only apply where existing information indicates that the facility's effluent discharge contains nutrients at concentrations in excess of the effluent limitations. Some WWTFs are excluded from the effluent limitations presented in Table 1-1. The Study did not include any existing domestic WWTF that meets at least one of the following exclusions:

- WWTFs with a design capacity of less than or equal to 1.0 million gallons per day (mgd) that use waste stabilization pond (lagoon) technology as its means of treating wastewater
- Any WWTF owned by a disadvantaged community
- WWTFs with a design capacity of less than or equal to 0.5 mgd

Table 1-1: Summary of Proposed Effluent Limits (mg/L) for Domestic and Non-Domestic WWTFs Subject to Proposed Regulation #85 (November 21, 2011 Regulatory Proposal)

Facility Type	Discharge Status	Parameter	Annual Median ¹	95th Percentile ²
Domestic WWTFs	Existing (discharging prior to May 31, 2012) ³	Total Phosphorus	1.0	2.5 mg/L
		Total Inorganic Nitrogen as N ⁴	10.0	20 mg/L
	New (discharging on or after May 31, 2012)	Total Phosphorus	0.7	1.75 mg/L
		Total Inorganic Nitrogen as N ⁴	7.0	14 mg/L
Non-Domestic WWTFs	Existing (discharging prior to May 31, 2013)	Total Phosphorus	1.0	2.5 mg/L
		Total Inorganic Nitrogen as N ⁴	10.0	20 mg/L
	New (discharging on or after May 31, 2013)	Total Phosphorus	0.7	1.75 mg/L
		Total Inorganic Nitrogen as N ⁴	7.0	14 mg/L

¹ Running Annual Median: The median of all samples taken in the most recent 12 calendar months

² The 95th percentile of all samples taken in the most recent 12 calendar months

³ Including WWTFs for which a complete request for preliminary effluent limits has been submitted to the Division prior to May 31, 2012

⁴ Determined as the sum of nitrate as N, nitrite as N, and ammonia as N

1.1.2 Study Questions

A cost-benefit study is, by its very nature, a high level planning analysis. Its primary use is to provide comparative data to evaluate the justification for various policy alternatives. In this Study, the costs and benefits associated with the combined implementation of both TP and TIN technology-based controls formed the basis of the comparison. This approach was required given that the proposed regulations, which form the basis for this Study, would require both TP and TIN controls to be implemented in tandem, not separately. Accordingly, for the purposes of this Study, the project team assumed that compliance with both TP and TIN effluent limitations would be required.

The Division's November 21st regulatory proposal provides the baseline for this Study. As described above, these proposed regulations establish two potential tiers of nutrient effluent limits – one for existing WWTFs (Tier 1) subject to the proposed regulation; the other for new WWTFs (Tier 2). The Division requested the inclusion of a third tier (Tier 3) in the analysis to provide a contrast between the effluent limitations proposed in Regulation #85 and effluent limitations that could be required if the Commission were to adopt numeric nutrient criteria to protect classified uses (as originally proposed for adoption by the Division in 2010). This Study included analysis of all three tiers, with the assumption that all non-exempt WWTFs would need to comply either with Tier 1, Tier 2, or Tier 3 effluent limitations (Table 1-2).

Table 1-2. Effluent Limitation (Tiers 1, 2, or 3) that Provide the Baseline for the Cost-Benefit Study

Parameter	Tier1 ¹ (Annual Median)	Tier2 ² (Annual Median)	Tier3 ³ (Quarterly Average)
Total Phosphorus	1.0 mg/L	0.7 mg/L	0.11 (Cold) 0.16 (Warm)
Total Inorganic Nitrogen as N	10 mg/L	7 mg/L	0.4 (Cold) 2.0 (Warm)

¹ November 21, 2011 Division proposal for existing WWTFs subject to the proposed regulations

² – November 21, 2011 Division proposal for new WWTFs subject to the proposed regulations

³ Criteria based on Division analysis of nutrient water quality data; similar to criteria originally considered for adoption to protect classified uses in Colorado waters.

1.2 Project Methodology

As noted above, this cost-benefit analysis is a high level planning Study to guide policy makers on the adoption of statewide nutrient control alternatives for simultaneous implementation of both TP and TIN controls. It is not intended to be a facility-specific analysis and does not evaluate costs or benefits of implementation of only TP or TIN controls at any one facility. The Study does not evaluate financial impact, funding availability, or ability-to-pay. Instead, the Study estimates the direct statewide cost (including both capital and O&M costs) to upgrade existing WWTFs. It does not address the issue of how any given community would pay for such improvements or the expected effect on future sewer rates. As such, this Study is not an economic impact analysis. Indirect effects, such as impacts to the tourism industry, effects of reduced disposable income, or potential for construction stimulus were not examined. Finally, this Study only evaluated potential benefits of the implementation of point source controls at domestic and non-domestic WWTFs. Potential benefits of nutrient reductions from nonpoint sources were not analyzed. The proposed nutrient management program does not mandate nonpoint source controls.

1.2.1 Methodology Framework

The starting point for cost-benefit studies is the adoption of an accounting stance. That is, will benefits and costs be considered at the national, state, or local level? Because the regulatory decision occurs at the state level, that is the accounting stance adopted in this Study. Therefore, all costs and all benefits occurring

within state boundaries are estimated as closely as possible. Any potential benefits from the nutrient regulations potentially experienced by downstream users in other states are not included in this Study.

Figure 1-1 illustrates the methodology framework applied to this Study, beginning with the establishment of Manageable Units. These geographic units were devised by the project team to facilitate development of region-specific cost-benefit models that provide an opportunity to account for regional differences, including differences in degree of urbanization, WWTF facility type and size, opportunities for recreation and enjoyment of the environment, and socio-economic status. One immediate benefit of this approach is increased accuracy of aggregated statewide results. Benefits and costs are estimated first at the Manageable Unit level and then aggregated to the river basin and state level. This approach provides the opportunity to demonstrate the range in benefit-cost relationships that exist throughout the State of Colorado.

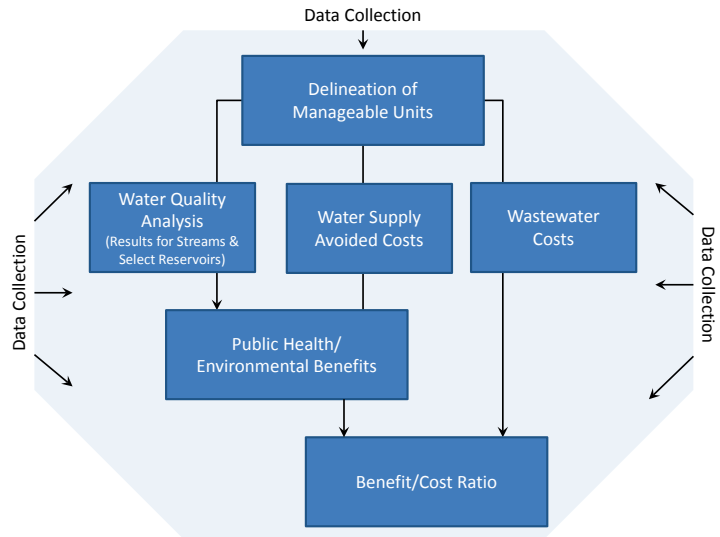


Figure 1-1. Framework for Development of Costs and Benefits

Potential secondary benefits of this approach include illustration of geographic differences in costs and benefits and having information presented in a format that can inform regional decision-making, in particular with regards to basin planning. For each of the framework components, e.g., wastewater costs or public health/environmental benefits, a specific methodology was developed, tested, and refined through the use of pilot tests before it was applied statewide.

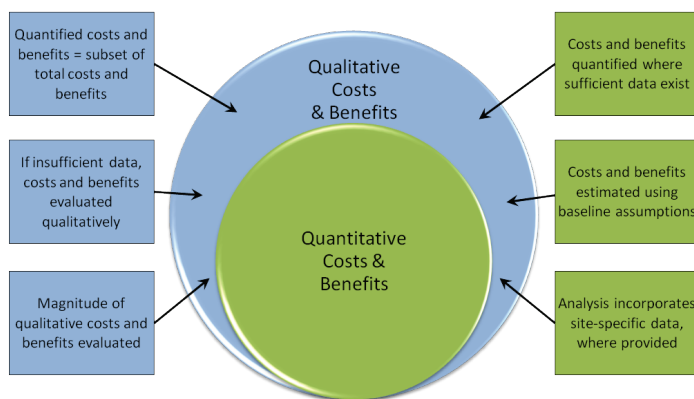


Figure 1-2. Quantitative Results are a Subset of Overall Costs and Benefits

Study results include both quantitative and qualitative components (Figure 1-2). Quantitative results were developed only where sufficient data exist to support the analysis. Where data were insufficient, results were expressed qualitatively. The lack of quantification of a particular cost or benefit element does not diminish the importance of the element. Instead, the findings of this Study should be viewed within the following context: Quantified costs and benefits, presented in the form of a benefit-cost ratio, represent a subset of the larger universe of combined quantitative and qualitative benefits.

1.2.2 Project Data Sources

This Study largely relied on data existing at the time that the Study was initiated. The project team compiled water resources data and digital data layers from state and federal agencies to support key project elements, e.g., delineation of Manageable Units, characterization of WWTFs, location of water supply facilities, and preparation of water quality analyses. State and federal data, especially WWTF data, were supplemented by information provided by the Colorado Wastewater Utility Council, wastewater survey data collected as part of this Study, and site-specific information provided by stakeholders. Additional data sources incorporated, where appropriate, included information obtained from the published literature and industry trade information. Information to support benefits analyses were obtained primarily from the published literature and reports prepared by state agencies.

1.2.3 Manageable Units

The primary purpose for delineating Manageable Units was to create watershed areas small enough to reduce the complexity of cost-benefit analyses. The Manageable Unit delineation process began with the division of the state into its eight major basin areas: South Platte, North Platte, Arkansas, Rio Grande, Southwest, Gunnison, Colorado, and Yampa-White (Green). Given the small size of the North Platte River Basin, this basin was joined with the South Platte River Basin to create a Platte River Basin, resulting in a total of seven basins for further delineation. Each river basin was sub-divided as appropriate into Manageable Units based on factors such as the locations and numbers of point source discharges and the location of water supply intakes. In total, the Study delineated 27 Manageable Units (see Figure 3-2, for example).

The use of Manageable Units as the foundation for data analysis provided the opportunity to perform pilot tests on the methodology. Early in the Study two Manageable Units were selected for pilot tests: One along the Front Range (East Slope watershed) and one West Slope watershed. Based on the pilot test outcome and stakeholder comments, the methodology was refined before it was universally applied.

1.2.4 Water Quality Analysis

The project team completed analyses of existing water quality in each of the 27 Manageable Units. This effort estimated expected changes in water quality (both TP and TIN) if the proposed regulations were implemented at all non-exempt WWTFs and compliance with Tier 1, 2, or 3 effluent limits was achieved. Water quality analyses relied on available water quality data using standard modeling practices. Where insufficient data were available to estimate water quality benefits, no attempt was made to quantify expected water quality benefits. This outcome was common for many reservoirs and lakes, due to the paucity of data. Where the team could not quantify water quality benefits for lakes or reservoirs downstream of a non-exempt WWTF, these benefits are considered within the context of qualitative benefits.

1.2.5 Wastewater Costs

There are over 400 domestic and non-domestic WWTFs located throughout Colorado; accordingly, the project team developed an approach that involved creating a baseline "typical" WWTF that could be "adjusted" and "modified" to account for different types of existing WWTF categories and site conditions. An important key to the understanding of this approach and the reported results is that the "typical" facility defined by this Study does not represent any one facility within the state. Instead, the use of a "typical" facility provides a high level cost analysis for comparison to an equally high level benefit analysis. Actual costs for a specific facility would require an independent, site-specific engineering analysis.

Figure 1-3 presents the systematic methodology used for development of WWTF costs for "typical" facilities in each Manageable Unit to meet the three effluent quality tiers analyzed for this Study. The body of the report provides detailed assumptions associated with each of these steps. Consistent with the proposed regulations, this analysis assumed that both TP and TIN controls would be required at each "typical" facility. The outcome from this effort for each effluent tier was used as input to the cost-benefit comparison, as described below.

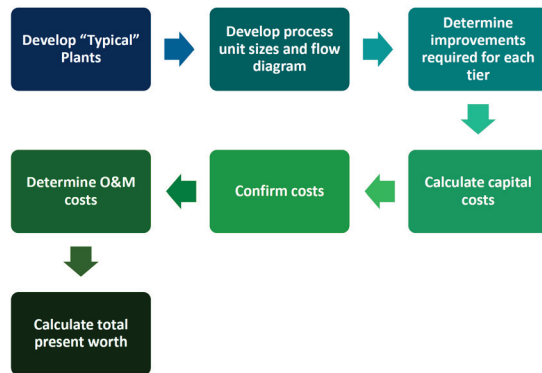


Figure 1-3. Methodology for Wastewater Treatment Cost Development

1.2.6 Public Water Supply Benefits

Where public water supply facilities are downstream of non-exempt WWTFs, reductions in source water nutrient concentrations could provide benefits. For example, benefits could occur because potable water utilities might be able to reduce their future water treatment capital investment costs as a result of reduced nutrients, or if potable water utilities made no such future investments, reduced nutrients in the drinking water supply might improve public health (e.g., reduced Disinfection Byproducts (DBP) and the aesthetic attributes of drinking water, i.e., appearance, odor, and taste).

Potential public water supply benefits were divided into quantitative and qualitative elements. Quantified elements focused on where a direct link could be made between a known water quality concern and the potential for avoided future water supply treatment costs. This linkage could only be demonstrated for requirements to comply with Safe Drinking Water Act (SDWA) regulations, specifically requirements to comply with Stage 1 and 2 Disinfection/Disinfection By-product (D/DBP) regulations.

This Study documents a number of potentially important benefits from reduced nutrients in source waters for public water supply facilities located downstream of non-exempt WWTFs that could not be quantified for various reasons. These qualitative benefits include:

- Nutrient reduction and related reductions in the volume/types of algae (particularly those types known to be toxic) might reduce adverse health effects in people particularly sensitive to those substances.
- Odor, taste, and appearance of water might be improved as a result of lower concentrations of nutrients in waters. Although this is a perceptual issue, it can be very important to water utilities and their customers
- N-Nitroso-Dimethylamine (NDMA) has been identified as an emerging contaminant that can be a DBP associated with water treatment processes. Reductions in nutrients in source water can reduce the likelihood of DBP formation, which would be an important benefit to water supply facilities.

1.2.7 Environmental Benefits

The environmental benefits analysis identifies and estimates, to the extent possible within the Study framework, each of the benefits that could accrue from nutrient reduction in Colorado waters as a result of the proposed regulation. This Study assumes that a reduction in nutrients in waterbodies would result in reduced algae growth, increased dissolved oxygen, betterment in the ecological functions of waterbodies

and their appearance, odor, and taste. By lessening these biological effects, a reduction in nutrients would create a set of avoided costs or benefits associated with the utilization of those waterbodies.

The types of benefits likely to accrue from nutrient reduction include the following:

- *Public Water Supply Benefits* – Public water supply benefits from nutrient reduction would conceivably occur because potable water utilities might be able to reduce their future water treatment capital investment costs as a result of reduced nutrients in their source water. These avoided costs, where they could be quantified, were treated as a benefit.
- *Active Recreational Benefits* – Active uses of Colorado's waterbodies include recreation of different types. With reduced nutrient levels and associated biological processes, direct water recreational uses, e.g., swimming, fishing, and boating activity, would potentially increase. Other recreational endeavors, such as picnicking, scenic drives, and watchable wildlife could also benefit.
- *Passive Benefits* - Passive benefits occur as reduced nutrients result in improved environmental conditions (Figure 1-4). With reduced nutrients, habitat is improved which, in turn, benefits animals, fish, and aquatic invertebrates and may improve the health of the aquatic community.
- *Intrinsic Benefits* – Intrinsic benefits can occur when Colorado residents perceive a value in preserving or enhancing the environment for present or future generations. These values are above and beyond the specific values quantified as passive benefits.
- *Agriculture Benefits* - Additional active water uses include irrigation and animal watering. Potential relationships between nutrient levels in water and agriculture water uses include drinking water quality for livestock, nutrient concentrations in water used for crop irrigation, and vegetation growth in irrigation water conveyances.

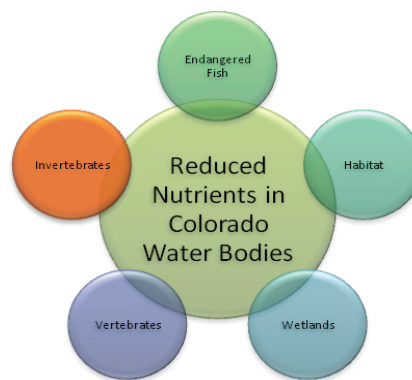


Figure 1-4. Examples of Passive Benefits from Nutrient Reduction

Information about the general impacts of nutrients, the specific benefits of nutrient reduction, and the methodological approaches for valuing these benefits were obtained from a search of the relevant literature. This literature review resulted in information being gathered on the following topics:

- The impacts of nutrients in waterbodies upon public health, environmental resources (i.e., water quality, aquatic habitat) and recreational activity;
- Methodological approaches to estimating environmental and recreational benefits, as well as other social or public benefits;
- The potential benefits resulting from the reduction of phosphorus and nitrogen, including studies describing the general benefits of nutrient reduction as well as the benefits of improvements in water quality to specific resources or activities (i.e., fish habitat or swimming activity);
- Methodology for estimating environmental benefits via the application of contingent valuation, or willingness-to-pay (WTP) for environmental improvements;

- Data about current recreational and other economic and demographic activity in Colorado; for example, the number of anglers, boaters, and swimmers; activity days for each; and expenditure data for each activity.

A number of studies were obtained, ranging from qualitative descriptions of the general impacts of nutrients to detailed academic research studies quantifying the benefits of nutrient reduction to specific resources (i.e., recreational activity, property values). Each study was reviewed and screened for usefulness based on factors such as the specific nutrients discussed, the types of recreational activities or environmental resources addressed, geographic location, and currency of the research. In addition to a review of the published literature, this Study also relied on state and federal baseline demographic data (e.g., population, household and income data) from the U.S. Census Bureau and Colorado Department of Local Affairs and various state and county level reports detailing recreational activity.

The project team faced several challenges when gathering data for use in estimating the benefits of the proposed nutrient regulations:

- Although the literature search uncovered a large number of reports, studies, and other types of information regarding the impacts of nutrients and nutrient reduction, there was a lack of applicable studies focusing on Colorado. Where appropriate, the project team made adjustments to the available data from the most relevant studies to better reflect conditions in Colorado.
- Few studies were found that directly link nutrient levels or nutrient reduction to changes in recreational activity. The project team used the available studies to the extent possible, but a number of assumptions were relied upon to estimate recreational benefits.
- Data on recreational activity days for fishing, boating, and swimming were available only at the statewide level (boating and swimming) or the county level (fishing); these data were distributed among the Manageable Units based on a number of reports and assumptions.

1.2.8 Present Worth Analysis

The time period for calculating benefits and costs is an important consideration in this Study. The capital costs of complying with the proposed regulations will occur during the construction years, but the annual WWTF operating costs and benefits will occur after the WWTFs are completed and will continue annually into the future. For the purposes of calculating benefits and costs, it is assumed that the proposed regulations would begin to be implemented within a Manageable Unit by the year 2015, design for WWTF improvements would take place in 2016, and construction would begin in 2017. This Study assumes the operating costs and benefits would last for 20 years. After that time, machinery and equipment at the WWTFs would be nearing the end of their useful life and would need to be replaced or upgraded, which would require additional capital costs.

Since construction costs take place at a different time than benefits, comparison of the two requires a discount back to present value for both benefits and costs. A discount rate is the interest rate that would be required to make a future dollar value equal to a present dollar value. The discount rate applied in this Study brings costs and benefits back to 2010 constant dollars. The discount rate derived for this Study is based upon the long-term Treasury bond yield, the long-term Treasury Inflation Protected Series bond yield, and the long-term Authority bond yield. Table 1-3 shows the derivation of the discount rate using a baseline date of July 1, 2011. The Colorado-specific discount rate of 1.4 percent was adopted for this Study.

Table 1-3. Derivation of the Discount Rate for the Cost Benefit Study (Baseline July 1, 2011)

Step	Procedure	Result
1	Obtain 20-Year Treasury Bond Yield for July 1	4.12%
2	Obtain 20-Year TIPS Bond Yield for July 1	1.47%
3	Calculate Long-Term Inflation Expectation (<i>Step 1 minus Step 2</i>)	2.65%
4	Obtain 20-Year Authority Bond Yield for July 1	4.05%
5	Input Long-Term Inflation Expectation (<i>from Step 3</i>)	2.65%
6	Calculate Discount Rate (<i>Step 4 minus Step 5</i>)	1.40%

1.2.9 Stormwater Monitoring Costs

The Study included an evaluation of potential stormwater monitoring costs associated with implementation of Regulation #85 (based on previous drafts of the regulation, e.g., the July 5th proposal). The current proposed regulation (November 21, 2011) requires municipal separate storm sewer system (MS4) permit holders to develop a Discharge Assessment Data Report (DADR) that documents existing program information and will help determine the need for additional future monitoring. The current regulatory proposal does not obligate MS4 dischargers to conduct stormwater monitoring for nutrients unless a regulatory determination is made that such monitoring is necessary.

Costs for potential future monitoring requirements (if determined necessary) were estimated using compiled information from MS4s, input through the assistance of the Colorado Stormwater Council, selected literature sources, and cost quotes from equipment vendors and environmental laboratories. Estimated costs for stormwater requirements incorporated several cost elements:

- *DADR Costs*, which included costs to develop documentation that identifies existing stormwater monitoring information and the need for additional monitoring to be conducted in the future to determine the approximate nitrogen and phosphorus contribution to receiving waters due to MS4 discharges.
- *Planning Costs*, which included costs associated with locating monitoring stations, site characterization of outfalls, and research and documentation of hydrology and characteristics of the surrounding area.
- *Implementation Costs*, which developed costs for a range of monitoring options (e.g., ranging from grab samples to renting samplers or purchasing automated samplers) and the costs associated with laboratory analyses. Costs were developed on a per outfall/per sampling event basis.

1.3 Project Results

Project results are presented in three parts: (1) cost-benefit results for each Manageable Unit; (2) cost-benefit results aggregated by river basin and statewide; and (3) estimated stormwater monitoring costs.

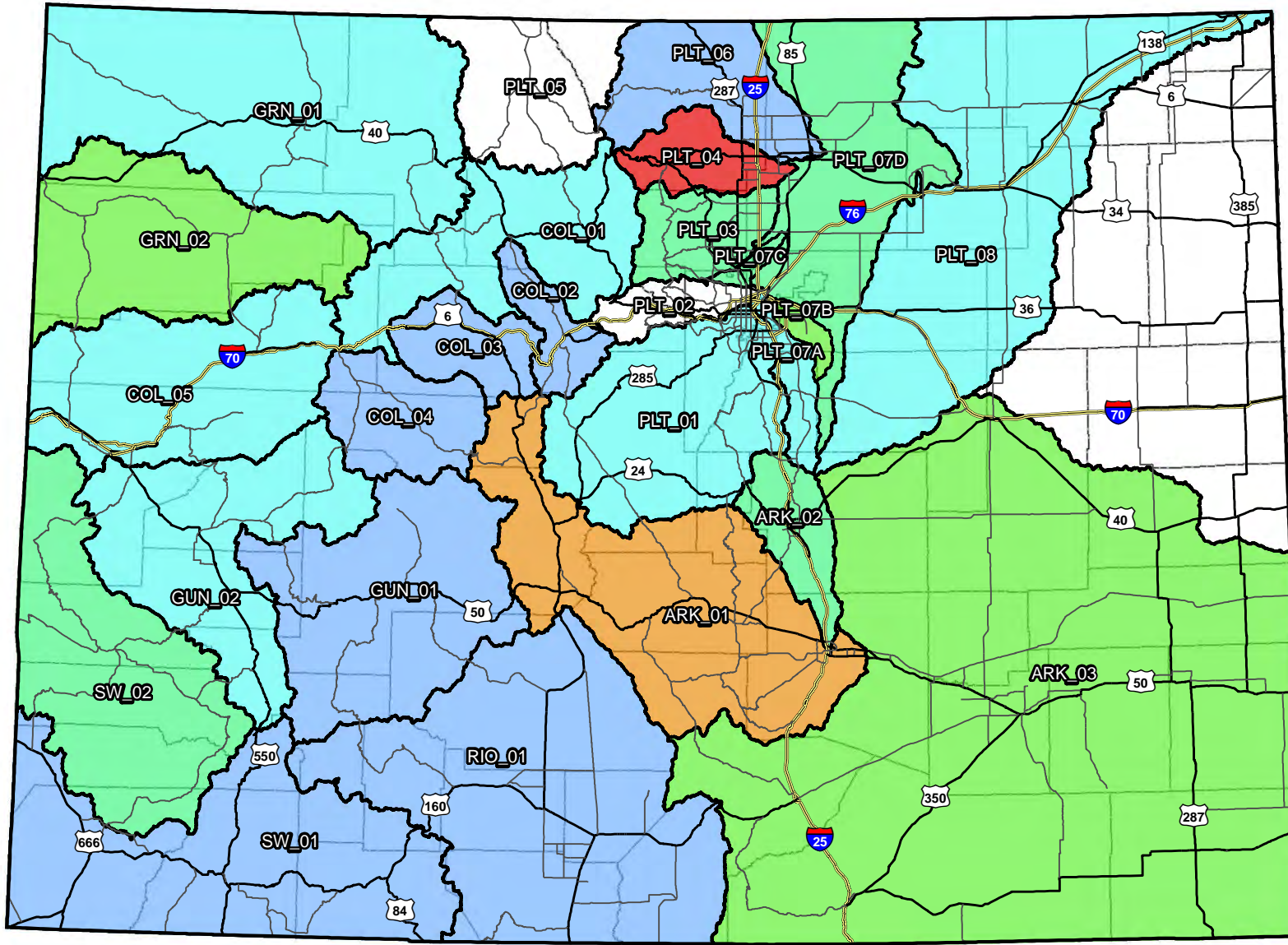
1.3.1 Manageable Unit Results

Quantified Costs and Benefits

Figure 1-1 illustrated the relationship between cost and benefits evaluated as part of this Study and how this relationship is expressed as a benefit-cost ratio. Costs and benefits are assumed to occur between the year 2014 and the year 2038 and all costs and benefits were discounted back to 2010 present value dollars. Benefit-cost ratios were developed for each Manageable Unit based on the assumption that all non-exempt WWTFs in each Manageable Unit would have to comply simultaneously with Tier 1, 2, or 3 effluent limits (see Table 1-2). A ratio greater than one indicates that, as quantified, the expected benefits are greater than costs of implementation of the proposed regulations. A ratio less than one indicates that the costs are greater than the benefits.

Figure 1-5 illustrates the variability observed in benefit-cost ratios for Tier 1 implementation across the 27 Manageable Units analyzed for this Study (see Section 7 of the report for illustrations of Tier 2 and 3 results). Key reasons for variability among Manageable Units include:

- Location of non-exempt WWTFs within a Manageable Unit, specifically:
 - The higher geographically a non-exempt WWTF is located in a watershed, the greater potential there is for more river miles to accrue benefits from improved water quality. This effect was particularly significant when comparing Manageable Units with significantly different areas. An example comparison of two Manageable Units with significantly different sizes illustrates this effect. GRN-01 in northwest Colorado is much larger in area than COL_03 (see Figure 1-6). Benefits of improved water quality accrue downstream of the non-exempt WWTFs. The larger the area, the greater potential there is for having more river miles with accrued benefits (Figure 1-6).
 - Location of non-exempt WWTF discharges relative to public water supply intakes influences the potential for avoided treatment costs for a public water supply. For example, in some Manageable Units no non-exempt WWTFs discharge upstream of public water supply intakes; as a consequence there is no potential for avoided water treatment costs to count as benefits.
- The number and size of non-exempt WWTFs within a Manageable Unit influences the potential for point source loading of nutrients to downstream waters. In many Manageable Units, especially on the West Slope, there are relatively few non-exempt WWTFs (as compared to the Front Range) and these WWTFs tend to be small in terms of effluent volume discharged (Table 1-4). As a result, the expected water quality improvements are relatively low. This outcome, coupled with the geographic considerations described above, affects the calculated benefits.
- The volume of WWTF discharge relative to the instream flow is an important variable. Where the potential for significant dilution of effluent is high, (e.g., the effluent discharge is of low volume compared to typical instream flows) the expected improvement in water quality downstream of the WWTF will be relatively small compared to locations where the WWTF effluent comprises a relatively high proportion of the typical instream flow. Given that the quantified benefits are directly linked to percent changes in water quality, if the dilution effect is high, the estimated water quality benefits will be relatively low and thus the accrued benefits will also be relatively low.

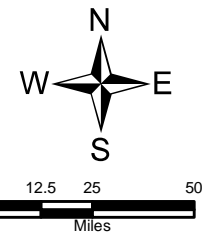


Range of Tier 1 Benefit-Cost Ratios

- >0:1 - 0.5:1
- 0.5:1 - 0.75:1
- 0.75:1 - 1:1
- 1:1 - 1.5:1
- 1.5:1 - 2:1
- 2:1 - 2.5:1
- 2.5:1 - 3:1

Roads

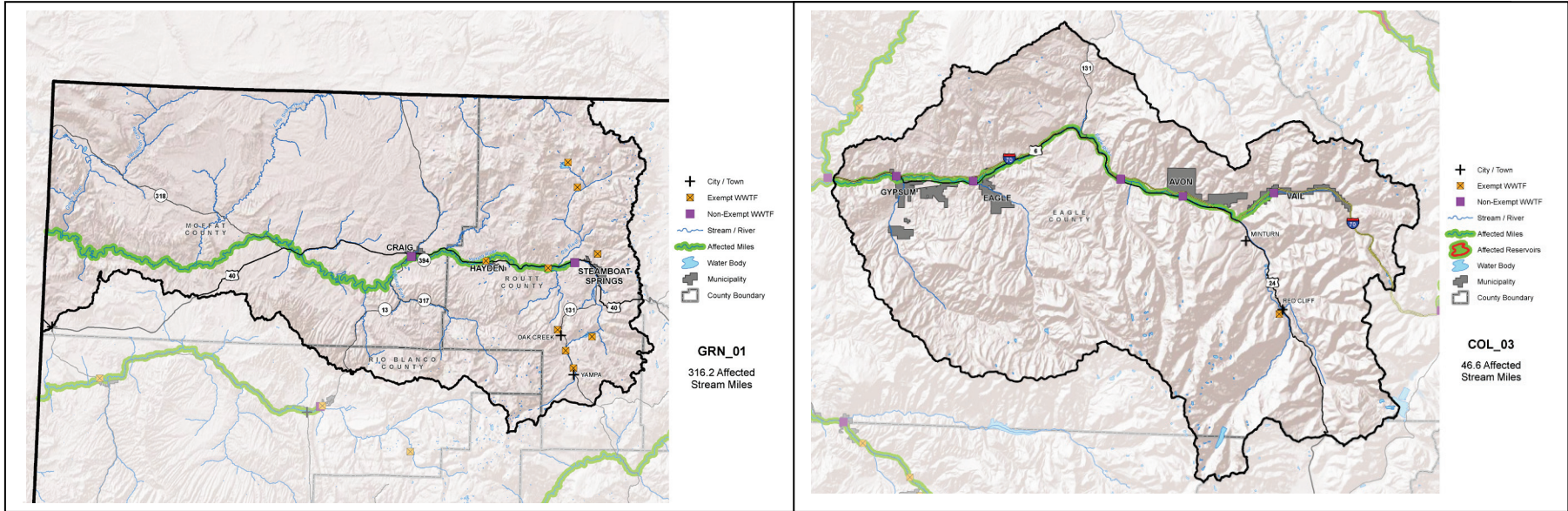
- Interstate Highway
- US Highway
- State Highway
- County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 1-5





Yampa River

Eagle River

Parameter	Manageable Unit	
	GRN_01	COL_03
Primary Stream/Rivers	Yampa River	Eagle River
Total Stream Miles	9014.2	1002.7
Affected Miles	316.2	46.6
% Change in Water Quality	14.28%	19.30%
Base Level Recreational Activity Days	735,448	432,231
Recreational Benefits	\$6.1M	\$6.7M

Figure 1-6. Example Comparative Statistics for Manageable Units of Significantly Different Area

Table 1-4. WWTfs and Associated Flows by Manageable Unit

MU	MU Name	Tier 1 Benefit:Cost	Total Number of Facilities	Total Flow (mgd)	Total Exempt*	Percent Exempt	Exempt Flow (mgd)*	Percent Exempt Flow
ARK_01	Upper Arkansas River	2.12 : 1	25	38.3	17	68%	2.7	7%
ARK_02	Fountain Creek	0.83 : 1	12	101.7	2	17%	0.1	0%
ARK_03	Lower Arkansas River	1.41 : 1	26	13.0	21	81%	5.2	40%
COL_01	Colorado River Headwaters	0.57 : 1	18	9.8	14	78%	1.7	17%
COL_02	Blue River	0.34 : 1	8	10.4	2	25%	0.1	1%
COL_03	Eagle River	0.33 : 1	6	12.6	1	17%	0.1	1%
COL_04	Roaring Fork	0.26 : 1	20	12.0	15	75%	1.7	14%
COL_05	Lower Colorado River	0.66 : 1	18	21.0	12	67%	1.2	6%
GUN_01	Upper Gunnison River	0.39 : 1	11	6.6	9	82%	1.2	18%
GUN_02	Lower Gunnison River	0.6 : 1	16	10.3	14	88%	5.2	51%
PLT_01	Upper South Platte River	0.74 : 1	29	52.3	22	76%	1.6	3%
PLT_02	Clear Creek	**	12	12.0	8	67%	0.7	6%
PLT_03	St Vrain River	0.81 : 1	24	59.9	14	58%	1.3	2%
PLT_04	Big Thompson River	2.97 : 1	12	16.6	7	58%	1.4	8%
PLT_05	North Platte River	No Non-Exempt Facilities	2	0.4	2	100%	0.4	100%
PLT_06	Cache La Poudre River	0.09 : 1	15	60.1	6	40%	0.5	1%
PLT_07A	Cherry Creek	0.67 : 1	6	227.9	1	17%	0.2	0%
PLT_07B	Sand Creek	1.17 : 1	5	11.0	3	60%	0.6	5%
PLT_07C	Big Dry Creek	0.86 : 1	3	30.4	0	0%	0.0	0%
PLT_07D	Middle South Platte River	0.88 : 1	21	23.7	14	67%	3.6	15%
PLT_08	Lower South Platte River	0.56 : 1	15	10.3	11	73%	2.0	19%
PLT_09	Republican River	No Non-Exempt Facilities	9	1.8	9	100%	1.8	100%
RIO_01	Rio Grande River	0.15 : 1	17	13.0	12	71%	2.9	22%
SW_01	San Juan and Animas Rivers	0.23 : 1	34	13.3	31	91%	4.9	37%
SW_02	San Miguel and Dolores Rivers	0.98 : 1	11	3.6	10	91%	1.5	42%
GRN_01	Yampa River	0.73 : 1	11	11.1	9	82%	1.2	10%
GRN_02	White River	1.17 : 1	5	2.6	4	80%	1.6	61%
TOTAL	STATEWIDE	0.79 : 1	391	786	270	69%	45.4	6%

* Based on the following exemptions - mechanical plants ≤ 0.5 mgd, lagoons ≤ 1.0 mgd, and disadvantaged communities

**All Non-Exempt Facilities in the Clear Creek Basin (PLT_02) have provided site-specific effluent data to indicate they are discharging below Tier 1 levels in agreement with the Stanley Lake Water Rights. Therefore, there were no costs and benefits associated with Tier 1.

Qualitative Costs and Benefits

As noted above, the overall costs and benefits of the implementation of the control regulations must consider both quantitative and qualitative elements. The quantified costs and benefits, described above, represent only a subset of the overall costs and benefits (see Figure 1-2). Qualitative effects are no less important and they apply to all Manageable Units. These effects are qualitative only because the project team was not able to obtain sufficient data or derive sufficient supportable assumptions in order to quantify the costs or benefits.

Table 1-5 summarizes the qualitative cost and benefit findings from this Study. Each of these qualitative elements represents an important consideration for policy makers in interpreting the conclusions of this Study. The following sections summarize the key cost or benefit issues associated with each element.

Table 1-5. Summary of Qualitative Costs and Benefits

Qualitative Factor	Cost or Benefit	Magnitude of Effect
Greenhouse Gas Emissions	Cost	Potentially Substantial
Potable Water Supplies	Benefit	Substantial
Private Property Values (streamside and lakeside)	Benefit	Potentially Substantial
Additional Recreational Activities (hiking, picnicking, wildlife watching)	Benefit	Moderate
Intrinsic Values	Benefit	Unknown
Agriculture (livestock source water, conveyance vegetation, crop irrigation)	Benefit/Cost	Minimal

Greenhouse Gas Emissions

The wastewater industry contributes to Greenhouse Gas (GHG) emissions primarily through combustion of fuels from mobile and stationary sources, through consumption of electricity, and from fugitive and process emissions unique to wastewater treatment. While it is possible to estimate GHG emissions from sources, these results are typically in units that cannot be readily converted into quantifiable costs. Accordingly, the potential costs associated with GHG must be viewed from a qualitative perspective.

For scope 1 type emissions (direct GHG emissions from within the operational boundary of a WWTF) the analysis of implementation of Tier 1 and 2 effluent limits showed a decrease in GHG emissions (approximately 25 to 35 percent), while Tier 3 implementation showed a decrease of about 60 to 70 percent. These decreases are associated with the types of wastewater treatment processes expected to be employed. In contrast, for scope 2 emissions (GHG emissions from outside the operational boundary of a WWTF as a result of energy purchased by the WWTF) the analysis suggests implementation of any of the effluent quality tiers will increase GHG emissions by 3 to 14 times. This increase occurs because of the expected increased electricity usage by WWTFs. The conclusion from this analysis is that the potential costs associated with GHG emissions are potentially substantial.

Potable Water Supplies

Improvements to potable water quality as a result of nutrient control might be a substantial benefit, but the project team was only able to quantify certain effects associated with reduced phosphorus and specific regulations of that element for potable water utilities. Areas where additional potential benefits should be considered include reductions in certain types of algae that might be toxic, which might reduce adverse health effects in people particularly sensitive to those substances; odor, taste, and appearance that affect perceptions of the quality of water used for drinking, and potential concerns associated with emerging contaminants, such as NDMA.

Private Property Values

Evaluations of expected improvements in water quality in a number of lakes and reservoirs were not possible given the minimal water quality data and variable, complex sources of in-lake flows. Accordingly, the private property value benefits to water quality in some of these waterbodies are likely understated by this Study. In addition, the potential exists changes in water quality will also impact property values along streams and rivers; however, insufficient data was available to quantify this potential benefit.

Additional Recreational Activities

Besides the quantified recreational benefits, other recreational activities might benefit from the proposed regulation, e.g., scenic drives, picnicking, and watchable wildlife. To some extent, these might be positively affected by improved water quality in the state's streams and lakes, but there is insufficient information to substantiate or quantify this benefit.

Intrinsic Values

It is possible that water quality improvements might have an existence bequest value to Colorado citizens. The project team was not able to distinguish such a value from the passive values already accounted for in the benefit-cost analysis. Even so, if such benefits exist, based upon studies in other regions of the country, these benefits may be substantial.

Agriculture Activities

Several studies acknowledge the potential benefits to cattle and other livestock as a result of nutrient reduction in drinking water. In addition, reduced nutrients in irrigation water might reduce the rate and volume of vegetation growth in the irrigation conveyance canals, which may provide a small benefit. The project team could not quantify these potential agricultural related benefits. However, to the extent they exist, they are expected to be minimal.

Potential reduction of nutrients in agricultural source waters has been noted as a potential cost as the presence of nutrients in irrigation water potentially reduces the need to apply nutrients directly to the growing crops. While these costs could not be quantified, it is believed to be minimal given that farming interests do not typically rely on source water nutrients to substitute for standard fertilization practices.

1.3.2 River Basin and Statewide Aggregate Results

The project team aggregated the benefit-cost ratios developed for each Manageable Unit into a benefit-cost ratio for the seven river basins (Table 1-6). This presentation of benefit-cost ratios does not include any new data or analyses. The aggregate values are the combined benefit and cost values for each Manageable Unit shown as a combined benefit-cost ratio. Benefit-cost ratios at the river basin level are lower overall simply because the variable Manageable Unit results are being averaged across the river basin. Similar to the Manageable Unit results the highest ratios are found for Tier 1.

The Manageable Unit values were also aggregated together to establish a statewide benefit-cost ratio for each effluent tier (Table 1-7). Similar to above, no new data or analyses were done. The final statewide numbers represent the combined costs and benefits for all Manageable Units presented as a total benefit-cost ratio. Similar to the river basin aggregation, aggregating all Manageable Units has the effect of averaging the wide range of benefit-cost ratios observed across the state. The highest benefit-ratio continues to be associated with the implementation of Tier 1 effluent limits.

Table 1-6. Aggregate Benefits and Costs by River Basin

Aggregate (River Basin or Statewide)	Component	Tier 1*	Tier 2*	Tier 3*
Arkansas	Benefits	\$679,062,000	\$808,956,000	\$1,056,414,000
	Costs	\$545,429,000	\$1,121,448,000	\$5,910,796,000
	Benefit-Cost Ratio	1.25 : 1	0.72 : 1	0.18 : 1
Colorado	Benefits	\$103,315,000	\$154,851,000	\$279,996,000
	Costs	\$226,322,000	\$393,719,000	\$2,840,746,000
	Benefit-Cost Ratio	0.46 : 1	0.39 : 1	0.1 : 1
Gunnison	Benefits	\$24,043,000	\$31,798,000	\$43,075,000
	Costs	\$46,947,000	\$96,172,000	\$447,136,000
	Benefit-Cost Ratio	0.51 : 1	0.33 : 1	0.1 : 1
Platte	Benefits	\$1,068,108,000	\$1,278,498,000	\$1,854,325,000
	Costs	\$1,473,367,000	\$3,152,796,000	\$14,286,950,000
	Benefit-Cost Ratio	0.72 : 1	0.41 : 1	0.13 : 1
Rio Grande	Benefits	\$10,561,000	\$12,206,000	\$16,980,000
	Costs	\$68,185,000	\$94,131,000	\$502,522,000
	Benefit-Cost Ratio	0.15 : 1	0.13 : 1	0.03 : 1
Southwestern	Benefits	\$22,418,000	\$33,428,000	\$55,024,000
	Costs	\$63,657,000	\$98,692,000	\$542,752,000
	Benefit-Cost Ratio	0.35 : 1	0.34 : 1	0.1 : 1
Yampa-White	Benefits	\$31,882,000	\$36,204,000	\$49,229,000
	Costs	\$40,990,000	\$77,461,000	\$461,614,000
	Benefit-Cost Ratio	0.78 : 1	0.47 : 1	0.11 : 1

* Expressed in Present Value 2010 Dollars

Table 1-7. Aggregate Benefits and Costs Statewide

Aggregate (River Basin or Statewide)	Component	Tier 1*	Tier 2*	Tier 3*
Statewide Aggregate	Benefits	\$1,939,389,000	\$2,355,941,000	\$3,355,043,000
	Costs	\$2,464,897,000	\$5,034,419,000	\$24,992,516,000
	Benefit-Cost Ratio	0.79 : 1	0.47 : 1	0.13 : 1

* Expressed in Present Value 2010 Dollars

1.3.3 Stormwater Monitoring Cost Results

The current regulatory proposal (November 21, 2011) does not obligate MS4 dischargers to conduct stormwater monitoring for nutrients unless a regulatory determination is made that such monitoring is necessary. Costs associated with the development of a DADR will depend on the MS4s capabilities to perform the work in-house versus contracting the work to a consultant, the size of the existing monitoring program, and the volume of available data for analysis and documentation. Table 1-8 summarizes the results from the analysis of potential stormwater monitoring costs should future monitoring be required by the Division. Overall, the estimated costs to MS4 permitted jurisdictions for potential monitoring range from approximately \$9,000 - \$20,000 per outfall and sample event based on the sampling method. Total costs are dependent on the number of outfalls sampled and the number of sampling events per year.

Table 1-8. Estimated Stormwater Monitoring Costs per Outfall/Event

MS4 Monitoring Component	Cost	Notes	
Planning	\$4,000	Background research, site characterization, documentation	
Implementation – Sampling Method	Grab Sampling	N/A	
	Rented Automated Sampler	\$11,000	
	Purchased Automated Sampler	\$17,000	Initial cost – subsequent years would be significantly less
Implementation - Laboratory	Lab Costs	\$450	N/A

1.4 Study Limitations and Uncertainties

A study of this type, which relates implementation of a proposed nutrient control regulation to expected water quality improvements and associated benefits, has never been performed for the State of Colorado. Costs and benefits of water quality improvements have been examined previously by EPA and by others for the states of Iowa, New Hampshire, Minnesota, Maine, Florida, and other locations. In addition, costs and benefits of certain water quality issues have been studied in Colorado, but these studies had a different and more limited focus than the present effort described in this Study. To the extent practicable, the project team drew methodological elements from other existing cost-benefit studies; these methodological elements were modified as appropriate to fit the goals and objectives of this Study. However, we have been careful to not quantify elements for which sufficient data are lacking. Moreover, we have been careful to note the non-quantifiable elements and indicate their probable magnitude of effect so that policy-makers can properly consider them as part of the regulatory decision-making process.

There are specific sources of uncertainty and limitations associated with this Study that have been noted by the project team or by the various Colorado stakeholders, who participated in workshops, reviewed interim work products, provided comments, or interacted directly with the project team to better understand the project methodology. These uncertainties or limitations are described below.

1.4.1 Manageable Unit Framework

From the outset, it was agreed that Study analyses would occur at a low enough level to reflect key geographic differences across the State of Colorado (e.g., Front Range vs. West Slope). This requirement was addressed through the establishment of Manageable Units. Study results show substantial differences in benefit-cost ratios across these Manageable Units. A question that still can be asked is, are there substantive differences in benefit-cost ratios within Manageable Units? For example, do the expected benefits of increased recreational activity as a result of improved water quality occur in a dispersed fashion throughout the Manageable Unit, or are there specific areas where such activities tend to primarily occur? While the Study did not allow for analyses at this level, it is important to note that based on literature and data reviewed, such data are not generally available at small geographic scales. However, the lack of such data does not discount the potential for benefits to occur in some areas of Manageable Units more than others. Further understanding of this issue would require implementation of site-specific analyses.

1.4.2 Development of Wastewater Costs

Planning Level Costs - By its nature this Study could only provide "order of magnitude" estimates (estimates range from +50 percent to -30 percent), which, per industry practice, is the acceptable level typically done for a facility or master plan. While appropriate for a study of this type, this range of uncertainty should be kept in mind when interpreting benefit-cost ratios.

Cost Validation - The Study found that the Tier 1 and 2 costs fell within acceptable ranges, based on other studies; however, significant uncertainty underlies the Tier 3 costs primarily the result from the analyses associated with brine disposal. This Study assumed brine disposal would be addressed by deep well injections; however, the use of this method and associated cost will vary significantly around the state. Further evaluation requires site-specific information on potential disposal locations and geotechnical conditions. Accordingly, the typical facility Tier 3 costs may be high relative to what could actually be incurred by some facilities following a facility-level investigation and design process.

Implementation of Facility Upgrades to Comply with Effluent Quality Tiers - This Study assumed that treatment upgrade costs to meet any of the effluent tiers was the sole capital cost incurred. This assumption assumes that no other effluent quality issues emerge related to the requirements to comply with the nutrient control regulation. For example, increased chemical use to remove phosphorus could cause other effluent quality issues that could require mitigation and therefore increased treatment costs. This uncertainty would be site-specific, and thus could not be evaluated as part of this Study.

1.4.3 Water Quality Analyses

Data Limitations - The benefits analysis relies on estimated percent changes in water quality expected from Regulation #85 implementation. This effort relied on the use of a simple mass balance approach that required assumptions regarding effluent quality of existing WWTFs. While this approach is valid for making general estimates of water quality changes, a certain degree of uncertainty exists given the assumptions and data availability. Where the uncertainty was considered too high, e.g., lakes and reservoirs, the project team relied on a qualitative approach rather than developing expected concentrations with substantial uncertainty.

The November 21, 2011 regulation does not include exceptions for nondomestic facilities; however, due to the limited information available for nondomestic facilities (in particular determining which facilities would actually be subject to the regulations) and the expected limited effect on receiving water quality by small dischargers, nondomestic facilities discharging less than 0.5 mgd were excluded from the quantification of costs and benefits.

Water Quality Improvements - Unless site-specific information was provided, this Study relied on median instream TP and TIN values and specific wastewater effluent discharge parameters (concentration and flow volume). Use of median values removes the normal seasonal variability inherent in flows in most waterbodies, which may underestimate the water quality benefits during periods of low instream flow, but overestimate the benefits during periods of high flow, e.g., during snowmelt. Use of general facility effluent parameters also may over- or underestimate downstream water quality improvements. While these assumptions simplified the water quality analysis (a necessity given data availability and project resources); the uncertainties created seem to work in both ways, i.e., to under- or overestimate water quality improvements.

Other Water Quality Factors - This Study adopted an "all other factors being equal" approach, meaning that the Study estimated water quality changes attributable solely to changes in TP and TIN in WWTF effluent discharge; however, water quality may improve or decline for a host of reasons unrelated to the proposed regulations. Such cumulative changes in water quality were beyond the scope of this Study.

1.4.4 Benefits Analyses

Relationship of Nutrient Changes to Changes in Biologic Processes – To simplify benefits analyses, this Study assumes a direct and consistent relationship between percent changes in nutrient levels and changes in the biological processes which occur in Colorado's streams and lakes. However, while the literature demonstrates that higher concentrations of TP and TIN in waterbodies leads to algae growth and adverse algae growth leads to declines in dissolved oxygen and reduced water clarity; the exact incremental response of those adverse conditions to changes in nutrient levels is unknown for Colorado waterbodies. Understanding such cause and effect relationships is a site-specific endeavor.

Elasticity Response of Active Recreation to Water Quality Changes - The Study assumed a linear response of visitor days to changes in water quality, whereas it is quite possible that the actual relationship is non-linear. If such non-linearity exists, then the change in recreational visitor days could be higher or lower than the figures derived in this Study. Even so, since no relevant studies were found that provided any reliable information regarding the potential non-linearity of this relationship, it was assumed to be linear.

Willingness-to-Pay Issues - The passive benefits identified and quantified in this Study relate to the full spectrum of environmental improvements and the value Colorado residents place on those benefits. This application of WTP relies on the proposition that, when given a choice, Colorado residents would expend monies to improve water quality. No specific Colorado survey was conducted as part of this Study; instead, literature values were applied. However, given the hypothetical applicability of these values to Colorado, based on a review of literature regarding application of adjustments, the project team attempted to reduce uncertainty by applying adjustments to the WTP estimates. For example, studies in other areas have found that WTP survey values are inflated by two to three times. Accordingly, the baseline WTP value for this Study was reduced by 2.5. In addition, the WTP was further adjusted to take into account household income differences across Manageable Units to account for differences in WTP based on available resources.

Future Values versus Current Values - This Study assumes that the WWTFs would be modified or reconstructed by the year 2018 and project benefits and operating costs would begin in the year 2019 and run into the future. However, this Study focuses on current water quality conditions, point source dischargers, recreational visitation patterns, and current estimates of WTP as compared with those conditions that might exist in 2019 and beyond. Clearly, there will be changes to these elements in the future. However, given the many factors that will influence the future trends, to avoid greater uncertainty, this Study assumed current conditions, which likely interjects some conservatism to the results.

Lack of Consideration of Nonpoint Discharges - This Study focused only on the costs and benefits associated with application of the proposed regulations to point source discharges. Nonpoint source discharges and their effects on the water quality of Colorado's waterbodies were not evaluated. The water quality analysis took this into account by estimating water quality changes associated with changes in the quality of effluent discharges. Therefore, excluding nonpoint sources did not create a bias in the water quality results. However, not including potential costs and benefits associated with the control of nonpoint sources does not provide a complete picture of the overall costs and benefits of alternative nutrient reduction strategies that could be applied, for example, at the Manageable Unit level.

1.5 Study Conclusions

To the extent data were available and within a prescribed framework, this Study quantified the costs and benefits associated with the implementation three different tiers of effluent quality for the nutrients TP and TIN. These costs and benefits were developed at a Manageable Unit level, which shows the range of benefit-cost ratios across the State of Colorado. Among the three effluent quality tiers examined, the highest benefit-cost ratios were associated with implementation of the Tier 1 effluent limitations, which are consistent with the nutrient controls proposed for existing WWTFs in Colorado that are not subject to a

regulatory exclusion. The Tier 2 effluent quality limits, which are consistent with the Division's regulatory proposal for implementation of nutrient controls on new WWTFs, showed lower benefit-cost ratios.

Geographically, the highest benefit-cost ratios, regardless of tier, were typically observed in the Manageable Units along the Front Range in the Platte River and Arkansas River basins. Where quantification was not possible because of a lack of relevant data, the Study identified additional potential costs and benefits from a qualitative perspective. Policy makers should consider these statewide qualitative elements alongside the quantified benefit-cost ratios.

This Study only focused on first order effects associated with implementation of any of the three effluent quality tiers. Studies such as this one do not take into account indirect or induced (second or third order) effects. For example, this Study did not evaluate the beneficial effect on the tourist economy in counties, Manageable Units, and the state as a whole. Similarly, from a cost perspective, this Study did not evaluate availability of capital, cost of debt service, or how the total costs are likely to affect wastewater utilities and their ratepayers. While all of these issues are important, they are not part of a cost-benefit study. Instead, such studies focus on first order effects so that the final comparison of benefits and costs is provided on an "apples to apples" basis. Second and third order effects would typically be evaluated at a more local or regional level and be part of studies such as economic impact analyses.

The Study findings are intended to provide input to deliberations by the Commission regarding adoption of the Division's proposed statewide nutrient control regulations. It has been noted by a number of stakeholders that the findings presented may not be applicable to their specific facility or may not accurately reflect local conditions below the Manageable Unit level. Examples of the specific issues identified include:

- What is the location where benefits will be accrued within a Manageable Unit relative to where the WWTF discharge occurs?
- What is the impact of a specific WWTF effluent discharge on downstream water quality?
- What is the relationship between reduced TP or TIN and the expected specific biological response in any given waterbody?
- Is there a need for both TP and TIN controls to meet downstream uses in a particular waterbody?
- What are the potential differences in the costs or benefits associated with implementation of only TP or TIN controls separately rather than in combination as evaluated in this Study?

These are appropriate questions, but they could not be addressed given the Study's original framework, schedule, and available resources. This Study is inextricably tied to the specific provisions contained within the Regulation #85 proposal. For the most part, the above concerns could be dealt with through site-specific or watershed-specific analyses. However, in many cases, the data required for more local studies, especially with regards to potential benefits (e.g., local recreational activity levels, willingness to pay by local populations, or waterbody-specific biological outcomes) are not typically available.

From the outset, the purpose of this Study was to explicate and provide a rigorous comparative analysis of all of the benefits and costs associated with implementation of the proposed nutrient control regulations. The threshold question for this Study was whether nutrient control under Tier 1, Tier 2, or Tier 3 will be a net benefit or a net cost to each of the Manageable Units and to the state as a whole? Additional statewide or regional economic and implementation considerations will have to be addressed in the future. Facility-specific or watershed-specific issues certainly will arise during the regulatory implementation phase.

This cost-benefit Study provides quantified benefit-cost ratios to support further discussion and analysis of the threshold question. However, these quantified outcomes are just part of the overall picture. Information contained in this Study regarding qualitative costs and benefits, as well as information developed outside the framework of this Study, e.g., through efforts of the Colorado Water Quality Forum Nutrient Workgroup, provide a substantial body of information for consideration, as well. In addition, as noted above under the discussion of uncertainties and limitations, a number of site-specific factors could not be taken into account given the high level purpose of this analysis. Some of these factors including eligibility of facilities for variances, exceptions, and compliance schedules would be investigated if the proposed regulations are adopted and implemented through Colorado Discharge Permit System permits.

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Section 2 Project Overview

The purpose of this section is to provide an overview of the Cost-Benefit Study (Study), including information regarding the events leading up to the initiation of this Study, the Study's goals and objectives, the proposed nutrient control regulations and required regulatory analysis, the baseline for all analyses, and a roadmap to guide the reader through this report.

2.1 Study Goal and Objectives

The Authority and the Division are co-administrators of the WPCRF, a state revolving fund that provides low interest capital funding to governmental agency sponsors of certain water quality improvement projects. For strategic planning purposes, the Authority and the Division were interested in quantifying future infrastructure needs and future loan demand on the WPCRF related to potential future nutrient controls for TP and TIN. Accordingly, the Division and the Authority agreed to prepare a statewide cost-benefit analysis related to the potential promulgation of regulations for nutrient control. The results of the analysis will be part of the evidence examined by the Commission when it holds a rule-making hearing to evaluate the State's regulatory proposal. This hearing is scheduled for March 12, 2012.

The Division's current draft proposal for controlling the discharge of nutrients relies largely on a technology-based control regulation that would establish effluent limits for many municipal and some industrial WWTFs. Many WWTFs will have to invest in capital improvements and ongoing O&M costs to meet the requirements of the proposed regulations.

The goal of the Study is to inform the Authority, Commission, and other interests of the statewide implications of these proposed control regulations. To support deliberation of the proposed regulations, the Commission recommended that the Study be consistent with the following:

- Have a scope and focus consistent with the general nutrients management approach currently being considered by the Division for its rulemaking proposal: i.e., a technology-based control regulation and limited application of numerical nutrient values as site-specific standards;
- Devote roughly equal resources to addressing the costs and benefits of nutrient reduction;
- Provide adequate resources to the Division so that it can direct and review the cost-benefit study; and
- Provide the information needed to complete a regulatory analysis under section 24-4-103(4.5), C.R.S. for this rulemaking.

This Study addresses these goals by implementing the following Study objectives:

- Estimate the statewide aggregate costs resulting from the potential implementation of a range of statewide regulations to address nutrients, as well as impacts from any requirements for stormwater monitoring;
- Estimate the environmental benefit of implementation of those nutrient regulations; and
- Estimate the benefit to drinking water quality and of reduced treatment costs.

Fulfillment of these objectives is expected to provide elements of the information needed to complete the regulatory analysis required under C.R.S. Section 24-4-103(4.5) for the proposed rulemaking.

2.2 Study Background

The development of an approach to nutrient management in the State of Colorado has been an ongoing process for a number of years. In coordination with the Colorado Water Quality Forum (CWQF), the Division has worked closely with stakeholders around the state to develop an approach that takes into account the practicality of both point and nonpoint source control of nutrients¹.

Historically, Colorado has established criteria for pollutants known to impact designated uses of state waters and set standards for individual water bodies using the criteria as a baseline. The Division's Colorado Nutrient Criteria Concept Paper (June 2010) summarized the general framework for a regulatory proposal, including the process of adoption of criteria for nutrients into the Basic Standards, subsequent consideration of the criteria for river basin standards as segment-specific or site-specific standards, followed by implementation in point source permits and nonpoint source management programs. This proposal was originally planned for consideration by the Commission in June 2011. This focus included the development of a proposal to adopt table value water quality criteria for recreation, high quality water supply, and cold and warm aquatic life classifications for inclusion in Regulation #31.

During the fall of 2010, the Division modified its proposal to emphasize the use of technology-based controls as the preferred approach for managing nutrient loads to waters of the state. It was during the evolution of the regulatory approach for nutrient management that the need for a cost-benefit study was identified. The Board of Directors of the Authority requested that such a study be completed in its December 8, 2010 letter to the Commission. The Division agreed in its December 13, 2010 letter to the Commission. Following approval by the Commission to move the rulemaking hearing on a nutrient management proposal to March 2012, the Authority and the Division worked collaboratively to initiate this Study.

The first draft regulatory proposal was released for public review February 2, 2011. Revised proposals were released on July 5, September 30 and November 2. These revised proposals were based on direct comments from stakeholders and ongoing discussions that occurred through collaboration with the CWQF Nutrient Criteria Workgroup and subgroups (e.g., effluent guidelines and monitoring). A draft Study report, which was based on the July 5th regulatory proposal, was released for public review and comment on September 13, 2011. This final report is based on the Division's regulatory proposal, published November 21, 2011, and comments received on the September draft report.

¹ All information regarding the development of Colorado's nutrient management proposal is available on the Nutrient Criteria Workgroup page located on the Colorado Water Quality Forum website, <http://www.cwqf.org/>.

2.3 Regulatory Proposal

The Division proposes to manage point-source nutrients statewide through adoption of a new regulation (5 CCR 1002-85 ["Regulation #85"]) and amendment of an existing regulation (addition of Sections 31.13 (d) and 31.17 at 5 CCR 1002-31 ["Regulation #31"]). As noted above, these proposed regulations have been under development since fall 2010 with the release of a first draft proposal on February 2, 2011 and release of a proposal for consideration for notice by the Commission on November 21, 2011. The following sections summarize the content of the proposed regulation.

Proposed Regulation #85

The Commission is authorized by Section 25-8-205 C.R.S., to promulgate control regulations to describe prohibitions, standards, concentrations, and effluent limitations on the extent of specifically identified pollutants that any person may discharge into any specific class of state waters. In addition to statements regarding applicability, severability, and definitions, Regulation 85 proposes to establish:

- *Specific Limitations for Domestic and Nondomestic WWTFs (Regulation #85.5)* - Table 2-1 summarizes the applicability of the proposed regulation to domestic and nondomestic WWTFs (non-exempt WWTFs). Where nutrient effluent limitations would be applicable to an existing or new WWTF facility, Table 2-2 summarizes the proposed effluent limits. Regulation #85.5 also establishes specific provisions for exceptions, exclusions, compliance schedules, variances, and nutrient trading (both point source to point source and nonpoint source to point source).
- *MS4 Permit Requirements for Nutrient Source Reductions (Regulation #85.5 (4))* - This section describes the nutrient control requirements proposed for incorporation into MS4 Permits issued pursuant to Regulation #61.
- *Nonpoint Source Discharges (Regulation #85.5 (5))* - Encourages implementation of Best Management Practices (BMPs) where appropriate to manage nutrients; if voluntary nonpoint source BMPs are not effective in managing nutrients by May 31, 2022, the Commission may consider the adoption of prohibitions or precautionary measures to further limit nutrient concentrations and loading from nonpoint sources.
- *Monitoring Requirements (Regulation #85.6)* - Establishes requirements for MS4 dischargers permitted under Regulation #61 to prepare a DADR. The purpose of the DADR is to document the availability of existing data and provide a gap analysis that identifies the need for additional information such as monitoring data or studies. The current regulatory proposal does not obligate MS4 dischargers to conduct stormwater monitoring for nutrients unless a regulatory determination is made that such monitoring is necessary.

The above list summarizes the key elements incorporated into Regulation #85. Not all of these elements were addressed in this Study. The full text of the November 21, 2011 proposed regulation may be found in Appendix G. Section 2.4, below, describes the specific elements included in this Study.

Table 2-1: Applicability of Proposed Regulation 85 Effluent Limits

Facility Type	Status	Category	Applicability of Regulation 85 Effluent Limitations
Domestic WWTF	Existing facilities discharging prior to May 31, 2012 or proposed new facilities that have submitted a complete request for Preliminary Effluent Limits (PELs)	Excluded Facilities	Following types of facilities are <u>excluded</u> from Regulation #85: <ul style="list-style-type: none"> ▪ Any facility with a design capacity of 1.0 million-gallons-per-day (mgd) or less that uses waste stabilization pond technology as its means of treating wastewater ▪ Any facility owned by a disadvantaged community ▪ Any facility with a design capacity of 0.5 mgd or less
		Facilities subject to a Watershed Protection Control Regulations 71-74 (5 CCR 1002-71, 5 CCR 1002-72, 5 CCR 102-73, and 5 CCR 1002-74)	Exempt from Regulation #85 prior to May 31, 2022
	Remaining facilities (not included in above categories)	Comply with Tier 1 effluent limitation requirements (see Table 2-6, below)	
	New facilities submitting a complete PEL request on or after May 31, 2012	All facilities	Comply with Tier 2 effluent limitation requirements (see Table 2-6)
Nondomestic WWTF	Existing facilities discharging prior to May 31, 2013	Facilities where the Division has determined, based on credible information regarding the quality of the untreated wastewater, that the facility may, without treatment, discharge TP or TIN concentrations in excess of the Tier 1 effluent limitations	Comply with Tier 1 effluent limitation requirements (see Table 2-6)
	New facilities discharging by May 31, 2013 or later	Facilities where the Division has determined, based on credible information regarding the quality of the untreated wastewater, that the facility may, without treatment, discharge TP or TIN concentrations in excess of the Tier 2 effluent limitations	Comply with Tier 2 effluent limitation requirements (see Table 2-6)

Table 2-2: Proposed Tier 1 and 2 Effluent Limitations (Regulation #85, November 21, 2011)

Parameter	Tier 1 Effluent Limitations		Tier 2 Effluent Limitations	
	Annual Median ¹	95 th Percentile ²	Annual Median ¹	95 th Percentile ²
Total Phosphorus	1.0 milligrams per liter (mg/L)	2.5 mg/L	0.7 mg/L	1.75 mg/L
Total Inorganic Nitrogen as N³	10 mg/L	20 mg/L	7 mg/L	14 mg/L

¹ Running Annual Median: The median of all samples taken in the most recent 12 calendar months

² 95th percentile of all samples taken in the most recent 12 calendar months

³ Determined as the sum of nitrate as N, nitrite as N, and ammonia as N

Proposed Amendments to Regulation #31

Regulation #31, adopted by the Commission pursuant to 25-8-101 et seq., and in particular, 25-8-203 and 25-8-204, C.R.S., provides criteria, an antidegradation rule and implementation process, and a system for a) classifying state surface waters; b) assigning water quality standards; c) granting temporary modifications; and d) periodic review of the classifications and standards. The Division proposes to amend Regulation #31 as follows:

- Add subsection (i) to Regulation #31.13(d), which establishes a Direct Use Water Supply Lakes and Reservoirs (DUWS) Sub-classification to the Domestic Water Supply Use Classification. The adoption of this sub-classification supports implementation of proposed new Section 31.17.
- Add new Section 31.17 that establishes interim numeric values for phosphorus, total nitrogen, and chlorophyll-*a* and also sets forth provisions regarding the use of these numeric values for the adoption of water quality standards. These interim values are as shown below in Tables 2-3, 2-4, and 2-5, respectively.

Prior to May 31, 2022, the interim phosphorus and chlorophyll-*a* values will be considered for the adoption of water quality standards for specific water bodies in Colorado only in the following circumstances.

- Waters located upstream of permitted point source dischargers with significant nutrient concentrations with preliminary effluent limits issued prior to May 2012
- Discretionary application of the values to waterbodies designated with the Direct Use Water Supply Lakes and Reservoir sub-classification (the factors that may be used by the Commission to determine if a numeric chlorophyll-*a* is appropriate are described in the proposed regulation)
- Other unanticipated circumstances where the Commission has determined that adoption of numerical standards is necessary to address existing or potential nutrient pollution because the provisions of Regulation #85 will not result in adequate control of such pollution

After May 31, 2017 and prior to May 31, 2022, the interim nitrogen values will be considered for the adoption of water quality standards for specific waterbodies in Colorado based on factors described in the proposed regulation.

Table 2.3. Interim Total Phosphorus Values (Regulation 31.17, November 21, 2011)

Waterbody Type	Interim Total Phosphorus Value
Lakes and Reservoirs, cold, >25 acres	20 micrograms per liter ($\mu\text{g/L}$) ¹
Lakes and Reservoirs, warm, > 25 acres	80 $\mu\text{g/L}$ ¹
Lakes and Reservoirs, <=25 acres	Reserved
Rivers and Streams – cold	110 $\mu\text{g/L}$ ²
Rivers and Streams - warm	170 $\mu\text{g/L}$ ²

¹ Summer (July 1 – September 30) average Total Phosphorus ($\mu\text{g/L}$) in the mixed layer of lakes (median of multiple depths); allowable exceedance frequency 1-in-5 years

² Annual median Total Phosphorus ($\mu\text{g/L}$); allowable frequency 1-in-5 years

Table 2.4. Interim Total Nitrogen Values (Regulation 31.17, November 21, 2011)

Waterbody Type	Interim Total Nitrogen Value
Lakes and Reservoirs, cold, >25 acres	410 $\mu\text{g/L}$ ¹
Lakes and Reservoirs, warm, > 25 acres	850 $\mu\text{g/L}$ ¹
Lakes and Reservoirs, <=25 acres	Reserved
Rivers and Streams – cold	1,250 $\mu\text{g/L}$ ²
Rivers and Streams - warm	2010 $\mu\text{g/L}$ ²

¹ Summer (July 1 – September 30) average Total Nitrogen ($\mu\text{g/L}$) in the mixed layer of lakes (median of multiple depths); allowable exceedance frequency 1-in-5 years

² Annual median Total Nitrogen ($\mu\text{g/L}$); allowable frequency 1-in-5 years

Table 2.5. Interim Chlorophyll-*a* Values (Regulation 31.17, November 21, 2011)

Waterbody Type	Chlorophyll- <i>a</i> Value (Not DUWS)	Chlorophyll- <i>a</i> Value (Designated DUWS)
Lakes and Reservoirs, cold, > 25 acres	8 $\mu\text{g/L}$ ²	
Lakes and Reservoirs, warm, > 25 acres	20 $\mu\text{g/L}$ ²	5 $\mu\text{g/L}$ ³
Lakes and Reservoirs, <= 25 acres	Reserved	
Rivers and Streams – recreation	150 milligram per square meter (mg/m^2) ¹	

¹ mg/m^2 chlorophyll-*a* of attached algae, single sample not to exceed

² Summer (July 1 – September 30) average chlorophyll-*a* ($\mu\text{g/L}$) in the mixed layer of lakes (median of multiple depths); allowable exceedance frequency 1-in-5 years

³ March – December average chlorophyll-*a* ($\mu\text{g/L}$) in the mixed layer of lakes (median of multiple depths); allowable exceedance frequency 1-in-5 years

2.4 Study Questions

This Study provides the estimated costs and benefits associated with the implementation of a range of potential nutrient control regulations in the State of Colorado. To complete this Study a baseline had to be established upon which to build all analyses. This baseline is the Division's regulatory proposal published November 21, 2011. These proposed regulations establish two tiers (Tier 1 and Tier 2) of nutrient effluent limits for WWTFs. At the request of the Division, a third tier (Tier 3) was included in the cost-benefit analysis. Tier 3 effluent limits are based on nutrients concentrations derived from previous Division analyses of nutrient water quality data developed within the context of the use of a Multi-Metric Index (MMI) to protect aquatic life.

Table 2-6 summarizes the Tier 1, 2, and 3 nutrient effluent limits evaluated for this Study. Each of these tiers was evaluated independently using the base assumption that all WWTFs subject to proposed Regulation #85 (i.e., not covered by an exemption) would have to upgrade their facilities to meet the Tier 1, Tier 2, *or* Tier 3 effluent limits for both TP *and* TIN². Incorporation of this assumption allows for a direct comparison of the costs and benefits of maximum implementation of each tier. The outcome of this analysis provides the State with information regarding the costs and benefits of the application of any of the tiers statewide, regardless of whether a WWTF is existing or new. While this outcome serves the goal and objectives of the Study, it is important to recognize that, as currently proposed, Regulation #85 would only apply Tier 1 effluent limits to existing non-exempt WWTFs and Tier 2 effluent limits to new WWTFs. Tier 3 would not apply to any WWTF facility.

Table 2-6. Effluent Limitations Tiers that Provide Baseline for Cost-Benefit Study

Parameter	Tier1 ¹ (Annual Median)	Tier2 ¹ (Annual Median)	Tier3 ² (Quarterly Average)
Total Phosphorus	1.0 mg/L	0.7 mg/L	0.11 (Cold) 0.16 (Warm)
Total Inorganic Nitrogen as N³	10 mg/L	7 mg/L	0.4 (Cold) 2.0 (Warm)

¹ November 21, 2011 Division proposal

² Criteria based on Division analysis of nutrient water quality data within the context of the Multi-Metric Index (MMI)

It is also important to note that, in practice, the need for any WWTF to upgrade its facility to comply with the proposed regulations would be determined through the discharge permit application process, which takes into account a number of factors including, but not limited to, site-specific conditions (e.g., range of flow conditions and existing water quality) and possibly the appropriateness of a variance or a water quality trade. The outcome of the permitting process may result in a facility needing to upgrade to meet only TP or TIN effluent limits (not both) or possibly not needing to upgrade their facility at all. As such, none of the findings in this Study can be used to identify compliance requirements applicable to a specific non-exempt facility.

The specific methods by which the costs and benefits associated with the implementation of these tiers are described in the sections that follow. However, before these methods are presented it is of critical importance to the readers of this Study to understand the framework within which this Study was implemented. The following sections describe this framework within the context of what this Study represents and does not represent.

What this Study Represents

1. Estimation of the costs and benefits associated with the Division's Regulation #85 proposal which anticipates potential WWTF upgrades to address technology-based controls on both TP and TIN.
2. Reconnaissance level survey of current wastewater treatment technology and practices in Colorado to characterize the typical TP and TIN concentrations in the final effluent produced by these various treatment processes.

² The November 21, 2011 Regulation does not include exceptions for nondomestic facilities; however, due to the limited information available for nondomestic facilities (in particular determining which facilities would actually be subject to the regulations) and the expected limited effect on receiving water quality by small dischargers, nondomestic facilities discharging less than 0.5 mgd were excluded from the quantification of costs and benefits.

3. Planning level wastewater engineering analysis, using standard engineering practices, to determine the additional wastewater treatment required to meet the TP and TIN concentrations specified in the proposed nutrient control regulation.
4. Estimation of capital and O&M costs associated with upgrading existing WWTFs to meet the TP and TIN limitations specified in the proposed nutrient control regulation; summarize results for each area of analysis and the state as a whole.
5. Estimation of TP and TIN concentrations in downstream receiving waters before and after additional nutrient removal processes are installed in non-exempt WWTFs to meet Tier 1, 2 or 3 effluent limits. This element estimated the net nutrient reduction relative to the existing nutrient load while assuming that the nutrient loads contributed by all other nonpoint sources remain unaffected by the proposed regulation.
6. Characterization of the level of water recreation activities (fishing, boating, swimming, etc.) currently occurring in each Manageable Unit and estimation of the economic value associated with those activities.
7. Estimation of the degree to which the total level of water recreation activity in each Manageable Unit is likely to change in response to the estimated change in nutrient levels (as described above) and estimation of the direct economic value associated with any projected increase in water recreation activities.
8. Estimation of the economic value the general public would place on the estimated change in water quality (measured as a percent reduction in nutrient concentrations), using established "willingness-to-pay" methodologies.
9. Estimation of the capital and O&M costs that potable water supply agencies have the potential to incur to comply with the SDWA D/DBP regulations and any avoided facility upgrade costs if the proposed nutrient control regulation is enacted.

What this Study does not Represent

1. It is not intended to be a facility-specific analysis. Estimates are based on a range of typical treatment plants in a variety of representative communities (urban/rural, large/small, east/west, mountain/plains, etc.) throughout the state. Site-specific data were used when such data were readily available; otherwise appropriate average values were used.
2. It is not a reasonable potential analysis. That is, this Study does not evaluate the ability of any specific non-exempt WWTF to comply with any of the effluent tiers analyzed for this Study.
3. It is not intended to be an original biological research study, but the biological processes and relationships found elsewhere (e.g., percent change in water quality vs. level of recreational activity) were assumed to apply to Colorado. The Colorado-specific cause and effect relationship between nutrient concentrations and algae growth and/or the population(s) of aquatic organisms was not investigated during this project.
4. It is not intended to be an original economic valuation study. The estimated economic value of improved water quality is derived from previous research studies deemed most credible and relevant to conditions in Colorado. No attempt was made to re-validate these accepted existing models.
5. It is not intended to address the need for, cost of, or benefits from nonpoint source controls. Exclusive focus was on evaluating the cost and benefits associated with proposed control regulations for non-

exempt WWTFs. The proposed control regulation is presumed to have no effect on the nutrient loads from nonpoint sources.

6. It is not intended to serve as a Total Maximum Daily Load (TMDL) or Waste Load Allocation (WLA) for any particular stream segment, lake, or reservoir. The study estimates the expected ambient TP and TIN concentrations in various receiving waters before and after the WWTFs achieve compliance with the proposed control regulations.
7. It is not an economic impact analysis. As such, indirect effects, such as those on the tourism industry, the indirect effects of reduced disposable income, construction stimulus or other effects were not examined.
8. It is not intended to evaluate financial impact, funding availability, or ability-to-pay. The Study estimates the direct statewide cost (including capital and O&M) to upgrade non-exempt WWTFs. It does not address the issue of how any given community would pay for such improvements or the expected effect on future sewer rates.
9. It is not intended to speculate on the costs or benefits that may be associated with more or less stringent requirements than those explicitly identified as Tiers 1, 2, and 3. Alternate regulatory interpretations of narrative standards were not evaluated during this study.
10. It is not intended to provide an accounting analysis for budgeting purposes. The monetized benefits do not necessarily (or even usually) accrue to the same agencies or accounts that will most likely bear the estimated costs. The Study does not examine the specific effects on cash flow for any state or local agency, municipality, special district, or utility.
11. It is not intended to describe the specific cost-benefit relationship for any particular year but, rather, to estimate the overall costs and benefits expected to occur over the next 20 years.

2.5 Regulatory Analysis Requirements

This Study has been structured in such a way that the Study also can meet the relevant parts of a formal Regulatory Analysis required under C.R.S. Section 24-4-103(4.5). The required elements of this Regulatory Analysis that are addressed at least in part by this Study include:

- Description of the classes of persons who will be affected by the proposed rule, including classes that will bear the costs of the proposed rule and classes that will benefit from the proposed rule (4.5 (a) (I));
- To the extent practicable, a description of the probable quantitative and qualitative impact of the proposed rule, economic or otherwise, upon affected classes of persons (4.5 (a) (II));
- The probable costs to the agency and to any other agency of the implementation and enforcement of the proposed rule and any anticipated effect on state revenues (4.5 (a) (III));
- A comparison of the probable costs and benefits of the proposed rule to the probable costs and benefits of inaction (4.5 (a) (IV));
- A determination of whether there are less costly methods or less intrusive methods for achieving the purpose of the proposed rule (4.5 (a) (V));

- A description of any alternative methods for achieving the purpose of the proposed rule that were seriously considered by the agency and the reasons why they were rejected in favor of the proposed rule (4.5 (a) (VI)); and
- Include quantification of the data to the extent practicable and shall take account of both short-term and long-term consequences (4.5 (b)).

Section 6 of this Study Report provides the elements of the analysis completed based on the findings from this Study.

2.6 Study Roadmap

This Document consists of two parts: (1) primary sections that provide the methods, results, and summary of findings associated with this Study; and (2) supporting appendices that provide the details regarding the data and information sources used to conduct various cost and benefit analyses. Following is a summary of the purpose and content of the remaining sections of this report:

- **Section 3** – This section provides a detailed methodology applicable to each element of the Study.
- **Section 4** – A fact sheet level presentation of the results for each of the Manageable Units is provided in this section. Appendices A, B, C, and D provide the supporting information for each of the findings in this section.
- **Section 5** - The findings for each Manageable Unit presented in Section 4 are aggregated in Section 5 to provide Basin-specific and Statewide cost-benefit results. This section also provides a summary of the qualitative benefits evaluated.
- **Section 6** – Based on the findings in Sections 4 and 5, Section 6 provides analysis to support the development of a Regulatory Analysis required under C.R.S. Section 24-4-103(4.5).
- **Section 7** – This section summarizes the findings of this Study. Included in this summary is discussion of the Study's limitations and how the findings should be interpreted and how they can be used to inform regulatory decision-making.
- **Section 8** – Documentation of references cited in the text.

The above sections are supported by the following appendices:

- **Appendix A, Supporting Manageable Unit Water Quality Data** – Supporting information regarding water quality analyses completed for each of the Manageable Units are provided in this appendix.
- **Appendix B, Supporting Wastewater Cost Development Data** – Includes the following information: B-1, Basis for the selection of non-domestic WWTFs for inclusion in the cost-benefit analysis; B-2, wastewater survey; B-3, WWTFs by Manageable Unit, treatment category, and flow bin; B-4, process improvements and associated cost development; B-5, cost development data; B-6, validation references; and B-7, greenhouse gas emission inventory data.
- **Appendix C, Supporting Public Water Supply Cost Development Data** – Provides supporting data used to evaluate potential avoided costs at selected public water supply facilities.

- **Appendix D, Supporting Environmental Benefits Development Data (including) Literature Review** – This appendix provides the findings from the literature review conducted to support the environmental benefits analysis.
- **Appendix E, Workshops** – Copy of the PowerPoint presentations made for Workshops 1, 2, 3, and 4 on May 16, June 24, July 14, and September 26, 2011, respectively.
- **Appendix F, Stakeholder Participation** – Summary of stakeholder comments received between Study inception and preparation of this Draft Report and the responses associated with each.
- **Appendix G, Proposed Regulations** – Includes November 21, 2011 proposed regulations that provided the baseline for this Study.
- **Appendix H, Stormwater Questionnaire** – Includes information request to stormwater monitoring stakeholders along with responses from stormwater utilities.

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Section 3 Project Methodology

This section describes the methodology used to develop the costs and benefits associated with this Study. The section begins with a description of the overall Methodology Framework. Subsequent sections provide the details regarding each of the specific methodologies that support the Framework.

3.1 Methodology Framework

The overarching objective of this Study was to develop statewide aggregate costs and benefits of the implementation of the proposed nutrient control regulations. To accomplish this objective, the Study was built around a framework that divided Colorado into Manageable Units, which facilitated pilot testing of the methodology and provided opportunity for stakeholder input prior to developing costs and benefits statewide (Figure 3-1).

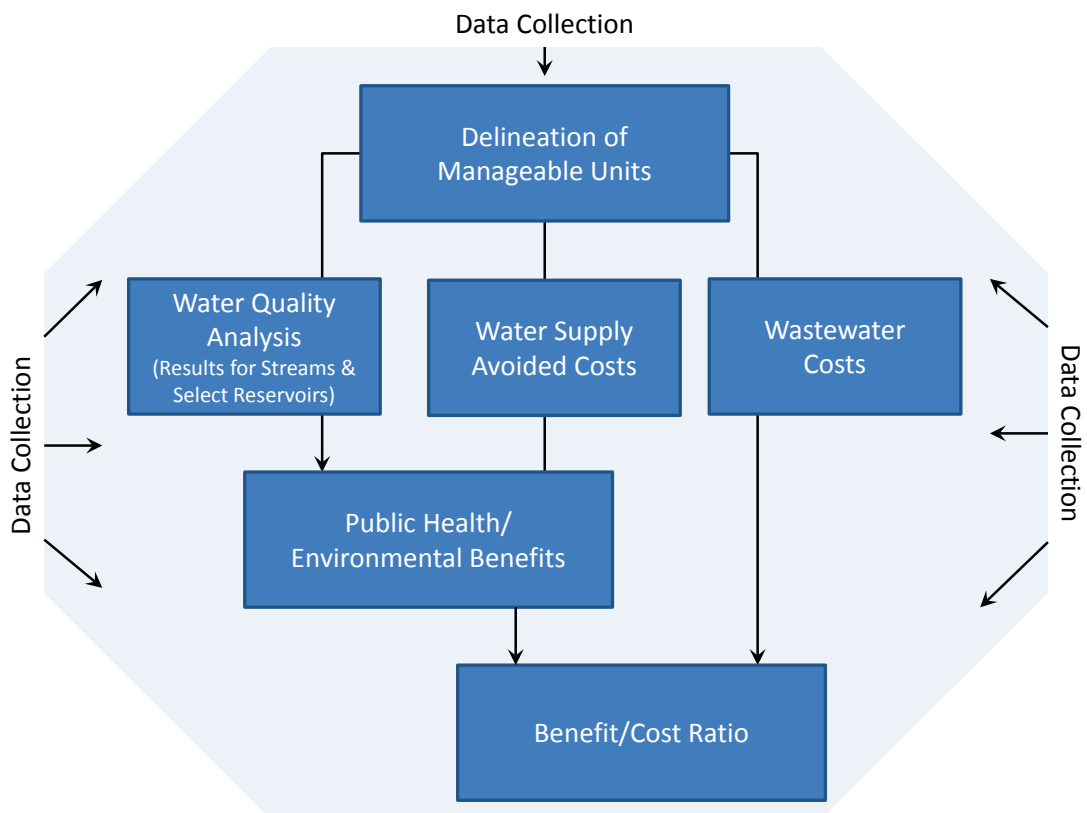


Figure 3-1. Benefit Cost Ratio Flowchart

Statewide costs and benefits include both quantitative and qualitative components. Quantitative results were developed only where sufficient data exist to support the analysis. Where data were insufficient, results were expressed qualitatively. The lack of quantification of a particular cost or benefit element does not diminish the importance of the element. Instead, the findings of this Study should be viewed in the following context: Quantified costs and benefits, presented in the form of a benefit-cost ratio, represent a subset of the larger universe of combined quantitative and qualitative benefits. The methodology sections below describe the elements that could be quantified and those elements that had to be addressed qualitatively.

3.1.1 Data Compilation and GIS Data Layers

This Study largely relied on data existing at the time that the Study was initiated. The project team compiled water resources data and digital data layers from state and federal agencies to support key project elements, e.g., delineation of Manageable Units, characterization of WWTFs, location of water supply facilities, and preparation of water quality analyses. The acquired data supported the analyses for each cost or benefit element included in this Study and provided the basis for the development of basemaps using geographic information system (GIS) software. These digital layers and their source information include:

- State and County boundaries (Environmental Systems Research Institute [ESRI])
- Major Roads (Colorado Department of Transportation [CDOT])
- Streams and reservoirs/lakes (National Hydrography Dataset [NHD], U.S. Geological Survey [USGS])
- Hydrologic Unit Codes (HUCs) (NHD, USGS)
- Municipalities (CDOT)
- WWTF and Water Supply Intake locations (Division)

State and federal data, especially WWTF data, were supplemented by information provided by the Colorado Wastewater Utility Council (CWWUC), survey data collected as part of this Study, and site-specific information provided by stakeholders. Additional data sources incorporated where appropriate included information obtained from the published literature and industry trade information. The following sections describe the specific data sources utilized for each of the key project elements.

3.1.2 Manageable Unit Approach

Colorado is a diverse state in many respects. Distinct differences occur from one geographic area to the next for a number of relevant study factors, including degree of urbanization, WWTF facility type and size, opportunities for recreation and enjoyment of the environment, and socio-economic status. Division of the state into Manageable Units facilitated the establishment of region-specific cost-benefit models that provided an opportunity to account for these regional differences. The immediate benefit of this approach is increased accuracy of aggregated statewide results. Potential secondary benefits of this approach include having information presented in a format that can inform regional decision-making, in particular with regards to basin planning. Section 3.2 further describes the delineation of Manageable Units.

3.1.3 Pilot Test

By their nature, cost-benefit studies are complex with many moving parts. This complexity can impact the degree of understanding regarding the methods used to evaluate costs and benefits, selection of data input values, or assumptions claimed. The use of the Manageable Unit approach provided opportunity to "test drive" the methodology. Two Manageable Units were selected for pilot testing: One in the Front Range, or East Slope watershed, and one West Slope watershed. The choice of pilot test locations was based on the following factors:

- Sufficient complexity in the number and types of WWTFs to provide opportunity to work through all the key elements of the wastewater cost methodology
- Need for areas with significant differences in environmental and recreational benefits to provide opportunity to work through all the key elements of the environmental benefits methodology
- Preference for watersheds with WWTFs that had indicated an interest in being available to answer questions or provide site-specific data
- Watersheds with good availability of water quality and flow data to provide opportunity to refine the water quality analysis methodology

The pilot test effort included presentations to stakeholders on the methods proposed for use. These included the planned data sources and default assumptions. Based on comments received, the project team refined the methodology. In late July 2011, the project team released the results of a pilot test of the refined methodology in two Manageable Units for public review. Comments received on this outcome of the pilot test resulted in one final refinement before the methodology was applied to all Manageable Units.

3.1.4 Stakeholder Participation

Opportunity for stakeholder input on the Study began with the development of the project scope of work (Table 3-1). Additional stakeholder input was solicited during the execution of the Study. In particular, the incorporation of the pilot test (described above) provided opportunity for stakeholders to react to the proposed cost and benefit methods prior to their application statewide and view the methodology in action prior to its use in all Manageable Units. Three workshops were held during development of the methodology (Table 3-1), and the input received was valuable in the development of the final methodology used in the Study. Appendix F provides a summary of these comments along with responses.

The project team released a draft Study report for public review on September 13, 2011. This report was based on the Division's July 5th regulatory proposal. Subsequent to the release of this draft report, a fourth workshop was held to answer stakeholder questions and receive comment on the draft Study (Table 3-1). Based on the comments on the draft report (summarized in Appendix F), and taking into account the content of the Division's final regulatory proposal (released on November 21, 2011), the project team prepared the final Study report.

Table 3-1. Summary of Key Project Milestones and Opportunities for Stakeholder Participation

Milestone	Date	Key Elements
Scope of Work Development	January – March 2011	State develops scope of services for the Study with stakeholder input; scope of services based on February 2, 2011 proposed regulations
Selection of Contractor	March – April 2011	Request for Proposal (RFP) process implemented; stakeholders provided opportunity to review and comment on responses to the RFP; State selects contractor to complete Study
Project Kickoff	April 22, 2011	Contract signed; internal project kickoff occurs; data gathering initiated
Workshop 1	May 16, 2011 (Denver)	Public workshop to kickoff Study; overview of project approach presented; data requested from stakeholders
Workshop 2	June 24, 2011 (Montrose)	Manageable Units and draft cost and benefit analysis methodologies presented; pilot test locations recommended; opportunity for comment provided

Table 3-1. Summary of Key Project Milestones and Opportunities for Stakeholder Participation

Milestone	Date	Key Elements
Revision to Division's Original Regulatory Proposal	July 5, 2011	Division releases revised regulatory proposal based on stakeholder input on February 2, 2011 proposal
Workshop 3	July 14, 2011 (Denver)	Refined cost-benefit methodology presented; opportunity for comment provided.
Pilot Test Results	July 29, 2011	Project team releases example outcomes of implementation of cost-benefit methodology at the Manageable Unit level; opportunity for comment provided
Draft Study Report	September 13, 2011	Draft Study report released for public review; analyses based on July 5, 2011 regulatory proposal
Workshop 4	September 26, 2011 (Denver)	Overview of draft Study report presented; question and answer session held with stakeholders; opportunity for comment provided
Final Study Report	December 2, 2011	Final Study report submitted to the Division; final analysis based on Division's November 21, 2011 final regulatory proposal

3.2 Manageable Unit Delineation

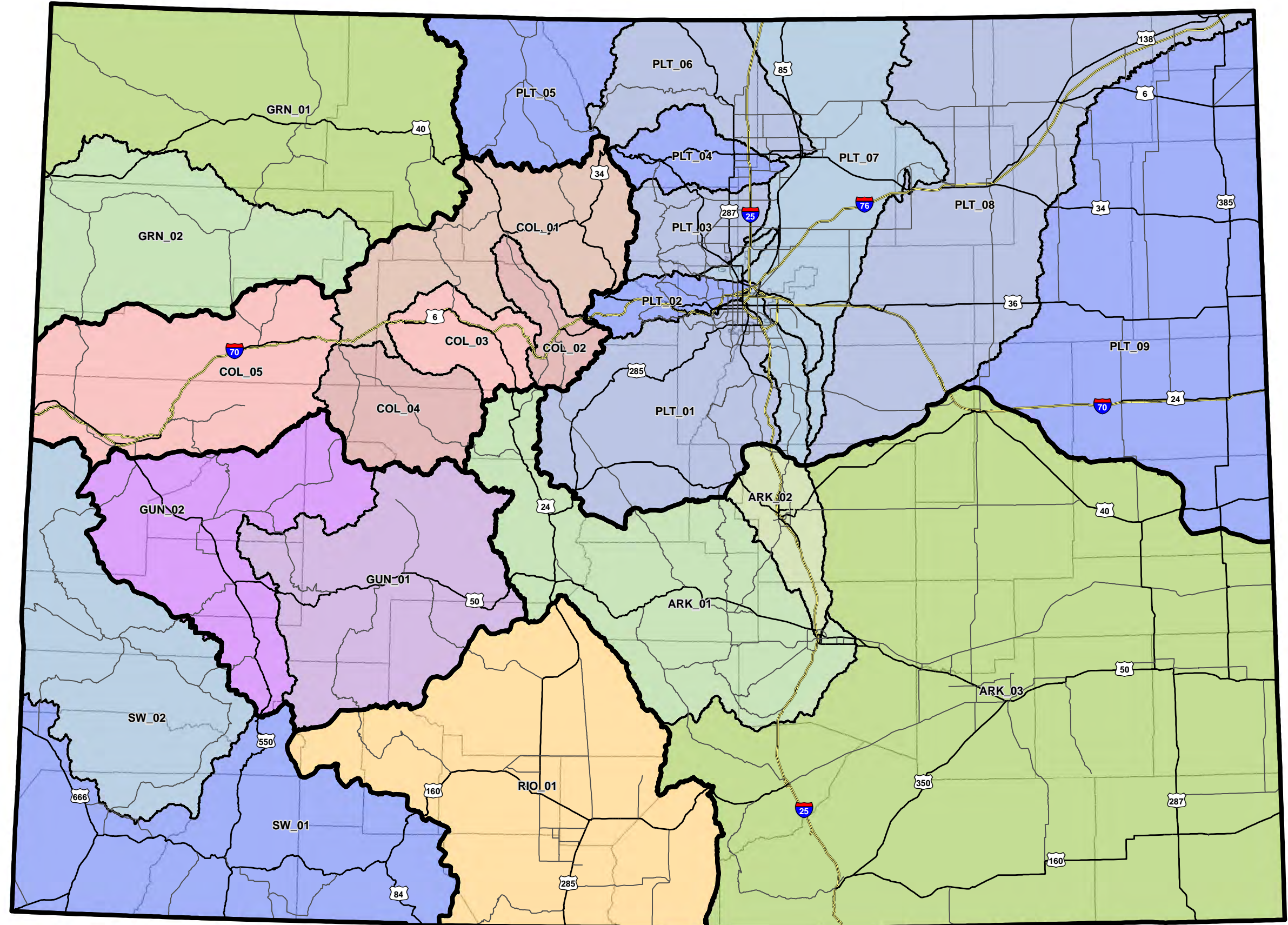
The primary purpose for delineating Manageable Units was to create watershed areas small enough to reduce the complexity of subsequent analyses. Ultimately, a Manageable Unit could be an entire river basin, a watershed within that basin, or something smaller. Rural areas were more likely to have larger Manageable Units than urban areas simply because of less complexity with regards to the numbers and types of WWTFs and water supply facilities.

The Manageable Unit delineation process began with division of the state into its eight major basin areas: South Platte, North Platte, Arkansas, Rio Grande, Southwest, Gunnison, Colorado, and Yampa-White. Given the small size of the North Platte River Basin, this basin was joined with the South Platte River Basin to create a Platte River Basin, resulting in a total of seven basins for further delineation.






Further analysis was performed on each of the seven basins to identify logical geographic breakpoints for reducing the complexity of the analysis. A lower limit for subdivision of a basin was the areas defined as HUC-8s by the USGS. The USGS has delineated 96 HUC-8 watersheds for the State of Colorado. Key factors evaluated to determine the best locations to subdivide a basin or combine HUC-8 watersheds included the locations and numbers of point source discharges and the location of water supply intakes. To facilitate the delineation process, facility data (e.g., locations of water intake and domestic/nondomestic WWTFs) were plotted along with HUC-8 boundaries on basemaps for each of the seven basins.

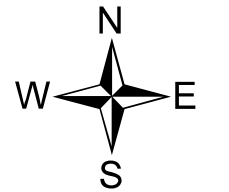
Using best professional judgment, the resulting plots were evaluated to identify appropriate Manageable Units for subsequent analyses. HUC-8s with a high number of WWTFs and water supply intakes were generally left as a stand-alone Manageable Unit. Adjacent HUC-8s with few or no WWTFs and water supply intakes were aggregated into larger Manageable Units. Ultimately, the Study delineated 27 Manageable Units (Figure 3-2). With one exception, the HUC-8 delineation served as the appropriate scale for establishing individual Manageable Units. This exception occurred in the Platte River Basin in the Denver metropolitan area where numerous large WWTFs exist (see additional discussion Section 3.2.4 below). The following sections summarize the Manageable Units established for each of the seven river basins. A basemap illustrating the Manageable Units established for each basin is provided. Section 4 provides additional detailed maps of each Manageable Unit.

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Legend

-  Major Water Feature
-  County Boundary
- Roads**
-  Interstate Highway
-  US Highway
-  State Highway



Colorado Nutrient Cost/Benefit Study

Figure 3-2



3.2.1 Arkansas River Basin

The Arkansas River Basin includes three Manageable Units (Figures 3-3, Table 3-2). The Fountain Creek watershed was kept as a single Manageable Unit due to the number and location of discharging facilities. The remainder of the basin was merged into two Manageable Units that encompass the upper Arkansas River Basin to Pueblo (excluding Fountain Creek), and the lower Arkansas River Basin downstream to the state line.

Table 3-2. Arkansas River Basin Manageable Units

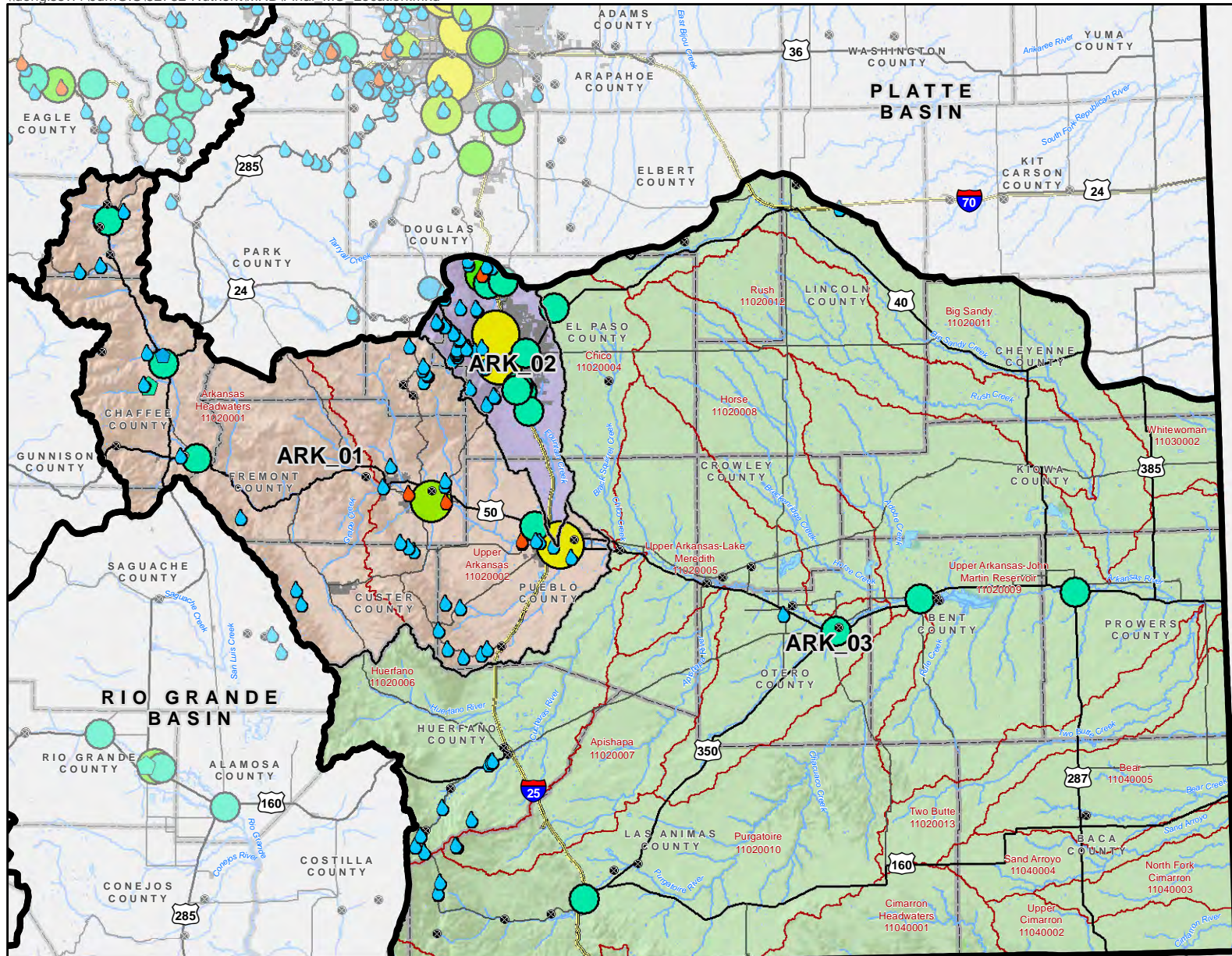
River Basin	Manageable Unit	HUC-8 No.	HUC-8 Watershed Name
Arkansas	ARK_01	11020001	Arkansas Headwaters
		11020002	Upper Arkansas
	ARK_02	11020003	Fountain
		11020004	Chico
		11020005	Upper Arkansas-Lake Meredith
		11020006	Huerfano
		11020007	Apishapa
		11020008	Horse
		11020009	Upper Arkansas-John Martin Reservoir
		11020010	Purgatoire
		11020011	Big Sandy
	ARK_03	11020012	Rush
		11020013	Two Butte
		11030001	Middle Arkansas-Lake McKinney
		11030002	Whitewoman
		11040001	Cimarron Headwaters
		11040002	Upper Cimarron
		11040003	North Fork Cimarron
		11040004	Sand Arroyo
		11040005	Bear
	11080001	Canadian Headwaters	

3.2.2 Colorado River Basin

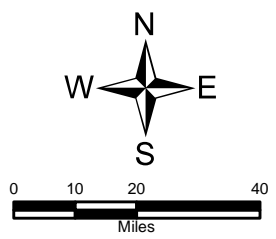
Five HUC-8 watersheds comprise the Colorado River Basin. Given the dispersed location of WWTFs and water supply intakes, each of the HUC-8 watersheds present in the basin was delineated as a separate Manageable Unit (Figure 3-4; Table 3-3).

Table 3-3. Colorado River Basin Manageable Units

River Basin	Manageable Unit	HUC-8 No.	HUC-8 Watershed Name
Colorado	COL_01	14010001	Colorado Headwaters
	COL_02	14010002	Blue
	COL_03	14010003	Eagle
	COL_04	14010004	Roaring Fork
	COL_05	14010005	Colorado Headwaters-Plateau



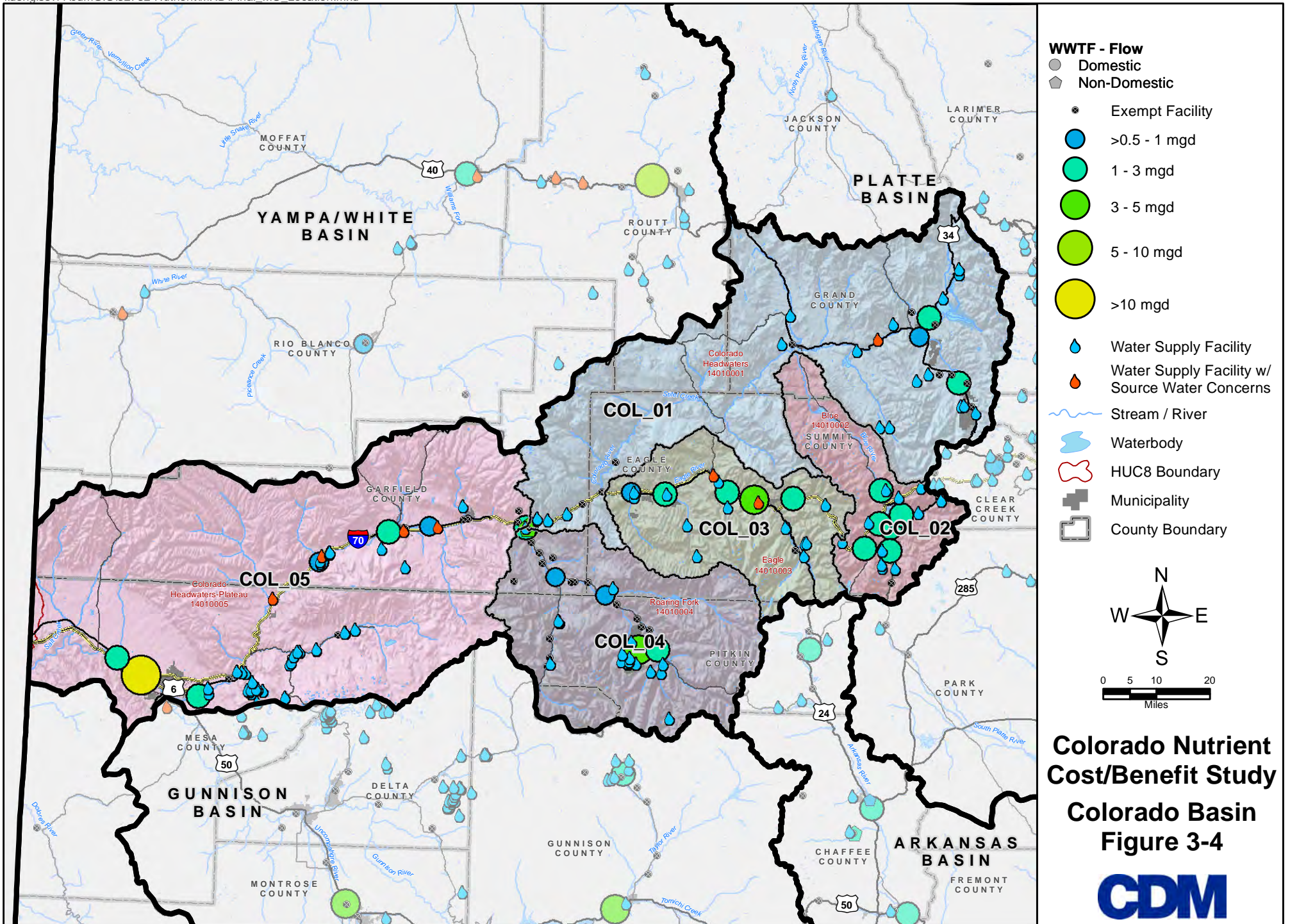
- WWTF - Flow**
- Domestic
 - Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
 - Water Supply Facility
 - Water Supply Facility w/ Source Water Concerns
 - ~ Stream / River
 - ~ Waterbody
 - ~ HUC8 Boundary
 - Municipality
 - County Boundary



Colorado Nutrient Cost/Benefit Study

Arkansas Basin Figure 3-3





3.2.3 Gunnison River Basin

The Gunnison River Basin was divided into two Manageable Units (Figure 3-5, Table 3-4). GUN_01 contains the upper Gunnison River Basin and the Town of Gunnison; GUN-02 contains the lower Gunnison River Basin and the Towns of Montrose and Delta.

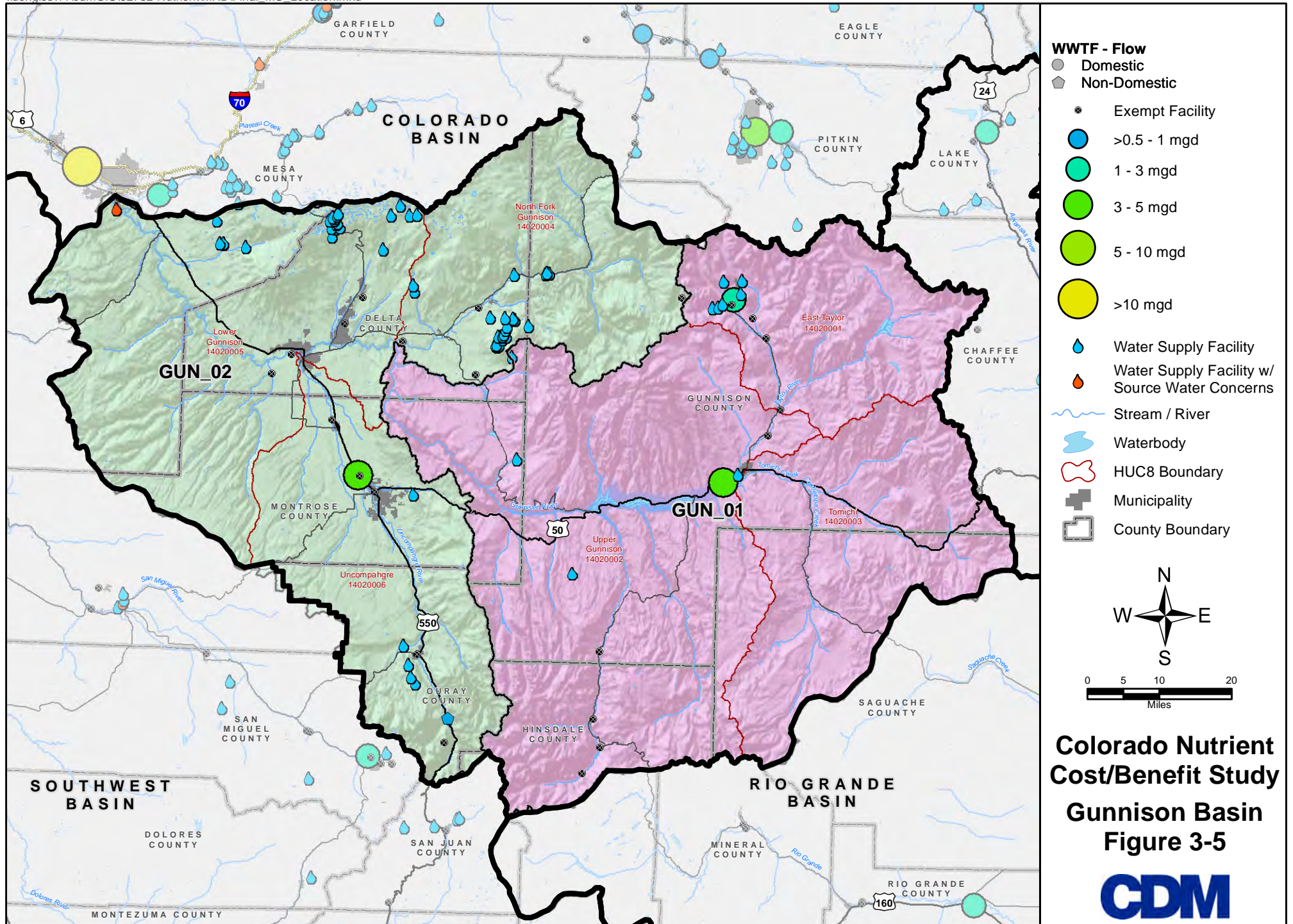
Table 3-4. Gunnison River Basin Manageable Units

River Basin	Manageable Unit	HUC-8 No.	HUC-8 Watershed Name
Gunnison	GUN_01	14020001	East-Taylor
		14020002	Upper Gunnison
		14020003	Tomichi
	GUN_02	14020004	North Fork Gunnison
		14020005	Lower Gunnison
		14020006	Uncompahgre

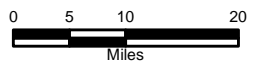
3.2.4 Platte River Basin

The Platte River Basin includes both the South Platte and North Platte River Basins in Colorado. This large basin was divided into 12 Manageable Units representing the upper, middle, and lower parts of the North and South Platte River Basins (Figure 3-6; Table 3-5):

- The North Platte River Basin, which has three HUC-8 watersheds, was aggregated into a single Manageable Unit (PLT_05).
- The Upper South Platte River Basin was divided into five Manageable Units: (01) Bear Creek and Plum Creek watersheds; (02) Clear Creek watershed; (03) St. Vrain Creek watershed; (04) Big Thompson River watershed; and (06) Cache La Poudre River watershed.
- The Middle South Platte River Basin, which includes the Denver metropolitan area, was merged with two HUC-8 watersheds north of the Denver area, which had no WWTFs (Crow Creek and Lone Tree Creek). Once aggregated, the area was then subdivided into four Manageable Units: (07a) Cherry Creek watershed; (07b) Sand Creek watershed; (07c) Big Dry Creek watershed; and (07d) an area representing the remainder of the Middle South Platte River Basin.
- The Lower South Platte River Basin, with numerous HUC-8 watersheds, was aggregated to create two Manageable Units: (08) South Platte River east of Fort Morgan to the state line; and (09) the remainder of the basin flowing east and out of state.



- WWTF - Flow**
- Domestic
 - Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
 - Water Supply Facility
 - Water Supply Facility w/ Source Water Concerns
 - ~ Stream / River
 - ~ Waterbody
 - ~ HUC8 Boundary
 - Municipality
 - County Boundary



Colorado Nutrient Cost/Benefit Study
Gunnison Basin
Figure 3-5



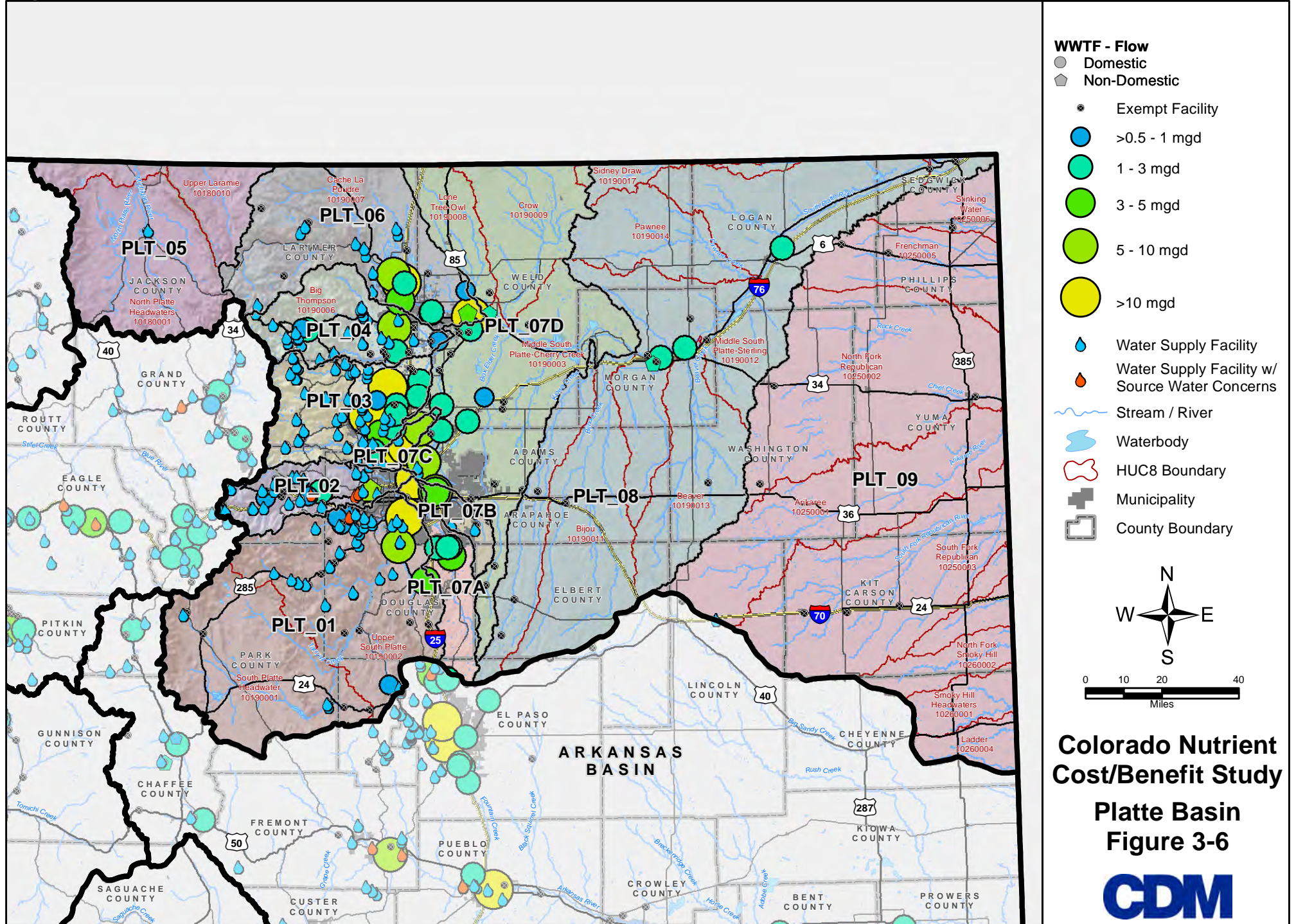


Table 3-5. Platte River Basin Manageable Units

River Basin	Manageable Unit	HUC-8 No.	HUC-8 Watershed Name
Platte	PLT_01	10190001	South Platte Headwater
		10190002	Upper South Platte
	PLT_02	10190004	Clear
	PLT_03	10190005	St. Vrain
	PLT_04	10190006	Big Thompson
		10180001	North Platte Headwaters
	PLT_05	10180002	Upper North Platte
		10180010	Upper Laramie
	PLT_06	10190007	Cache La Poudre
	PLT_07A	1019000301*	Middle South Platte-Cherry Creek: Cherry Creek
		1019000303*	
	PLT_07B	1019000302*	Middle South Platte – Cherry Creek: Sand Creek
	PLT_07C	1019000304*	Middle South Platte – Cherry Creek: Big Dry Creek
		10190003**	
	PLT_07D	10190009	Crow
		10190008	Lone Tree-Owl
	PLT_08	10190010	Kiowa
		10190011	Bijou
	PLT_09	10190013	Beaver
		10190012	Middle South Platte-Sterling
		10190014	Pawnee
		10190015	Upper Lodgepole
		10190016	Lower Lodgepole
		10190017	Sidney Draw
		10190018	Lower South Platte
		10250001	Arikaree
	PLT_09	10250003	South Fork Republican
		10250012	South Fork Beaver
		10260001	Smoky Hill Headwaters
		10260002	North Fork Smoky Hill
		10260004	Ladder
		10250002	North Fork Republican
		10250005	Frenchman
PLT_09	10250006	Stinking Water	
	10250013	Little Beaver	

*The Middle South Platte-Cherry Creek HUC-8 basin was further subdivided using HUC-10 boundaries

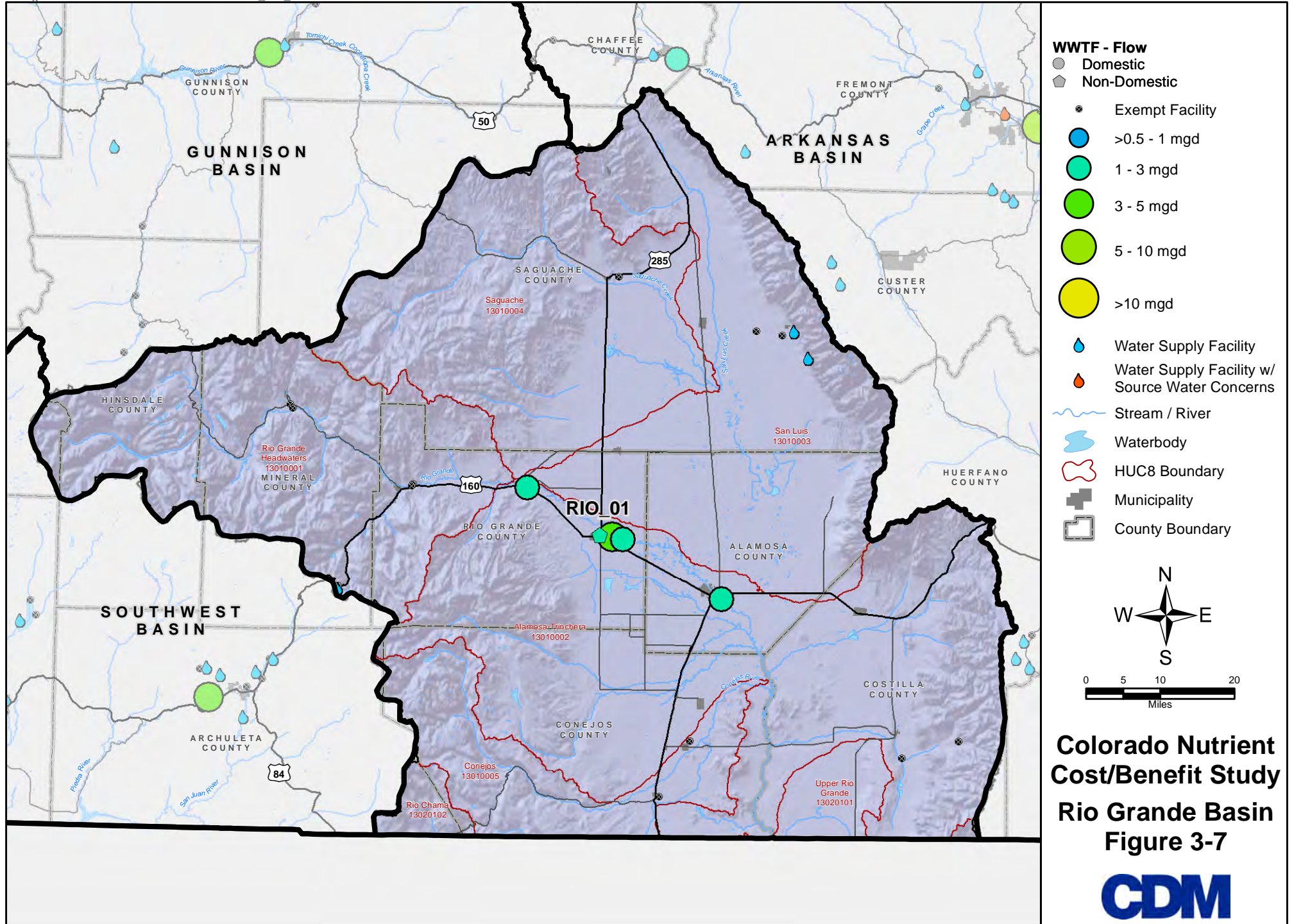
**PLT_07d contains the remaining HUC-10 sub-basins within 10190003

3.2.5 Rio Grande River Basin

There are very few WWTFs or water supply facilities in the Rio Grande River Basin. Accordingly, all seven HUC-8 watersheds in the basin were aggregated into one Manageable Unit (Figure 3-7; Table 3-6).

Table 3-6. Rio Grande River Basin Manageable Units

River Basin	Manageable Unit	HUC-8 No.	HUC-8 Watershed Name
Rio Grande	RIO_01	13010001	Rio Grande Headwaters
		13010003	San Luis
		13010004	Saguache
		13010002	Alamosa-Trinchera
		13010005	Conejos
		13020101	Upper Rio Grande
		13020102	Rio Chama



3.2.6 San Juan/Dolores River Basin (Southwest Basin)

The Southwest Basin consists of a number of watersheds that drain directly to the state line; however, all watersheds are either part of the San Juan or Dolores River Basins. There are a small number of WWTFs and water supply facilities in this basin; accordingly the 13 HUC-8 watersheds were aggregated into two Manageable Units (Figure 3-8; Table 3-7). These two areas represent the (01) Animas River and Upper San Juan River watersheds, which include Cortez, Durango, and Pagosa Springs; and (02) Dolores and San Miguel River drainages above the state line.

Table 3-7. Southwest Basin Manageable Units

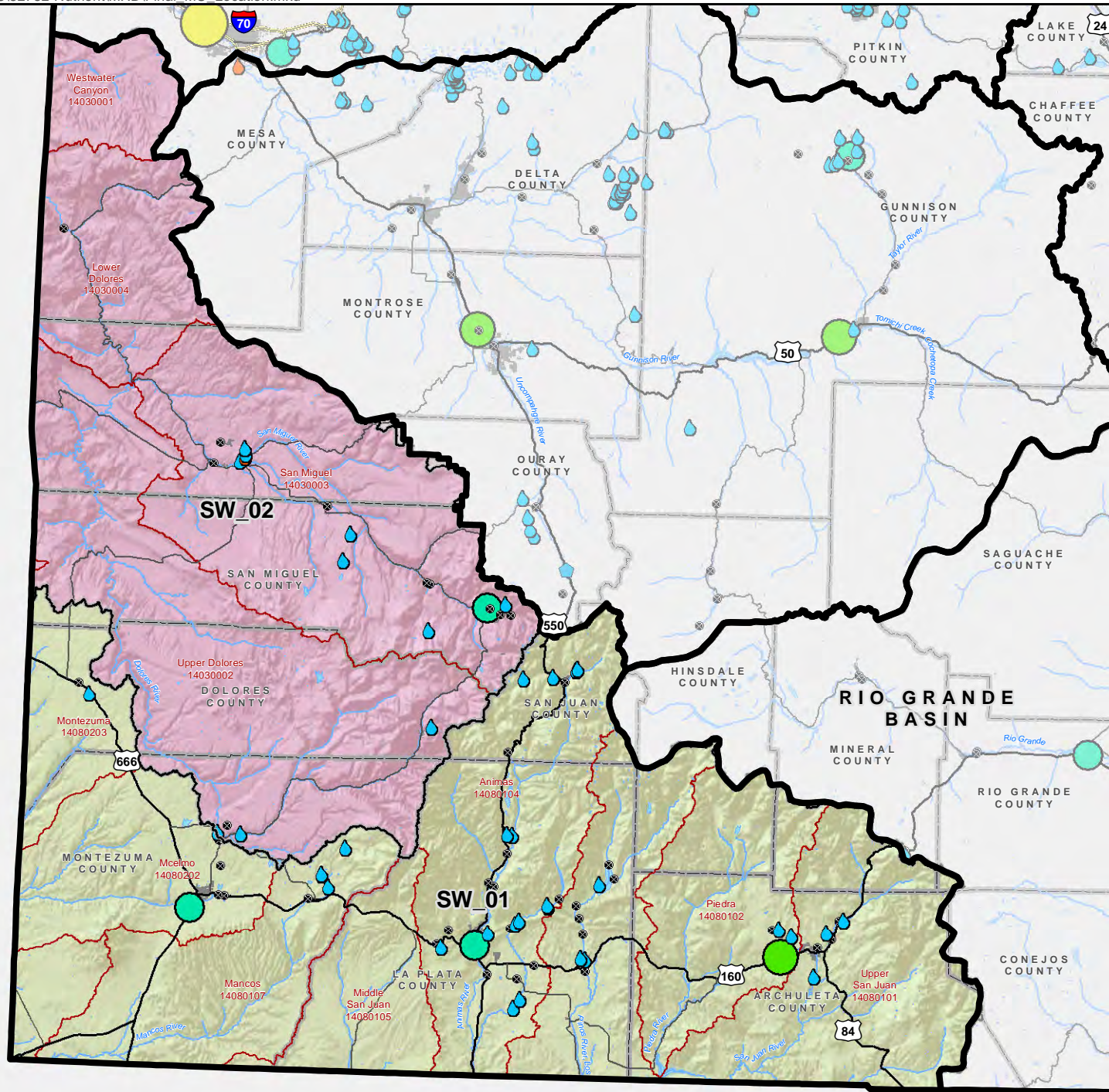
River Basin	Manageable Unit	HUC-8 No.	HUC-8 Watershed Name
Southwest	SW_01	14080104	Animas
		14080101	Upper San Juan
		14080102	Piedra
		14080105	Middle San Juan
		14080107	Mancos
		14080201	Lower San Juan-Four Corners
	SW_02	14080202	Mc Elmo
		14080203	Montezuma
		14030001	Westwater Canyon
		14030002	Upper Dolores
		14030003	San Miguel
		14030004	Lower Dolores
		14030005	Upper Colorado-Kane Springs

3.2.7 Yampa-White River Basin (Green River Basin)

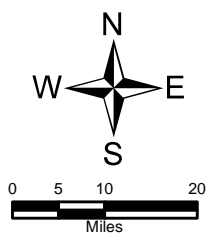
The Yampa and White River Basins are part of the larger Green River Basin. This drainage area was divided into two Manageable Units; one to represent the Yampa River Basin (an aggregation of six HUC-8 watersheds) and the White River Basin (an aggregation of three HUC-8 watersheds) (Figure 3-9; Table 3-8).

Table 3-8. Yampa-White River Basin (Green River Basin) Manageable Units

River Basin	Manageable Unit	HUC-8 No.	HUC-8 Watershed Name
Yampa/White	GRN_01	14060001	Lower Green-Diamond
		14040106	Upper Green-Flaming Gorge Reservoir
		14040109	Vermilion
		14050001	Upper Yampa
		14050002	Lower Yampa
		14050003	Little Snake
	GRN_02	14050005	Upper White
		14050007	Lower White
		14050006	Piceance-Yellow

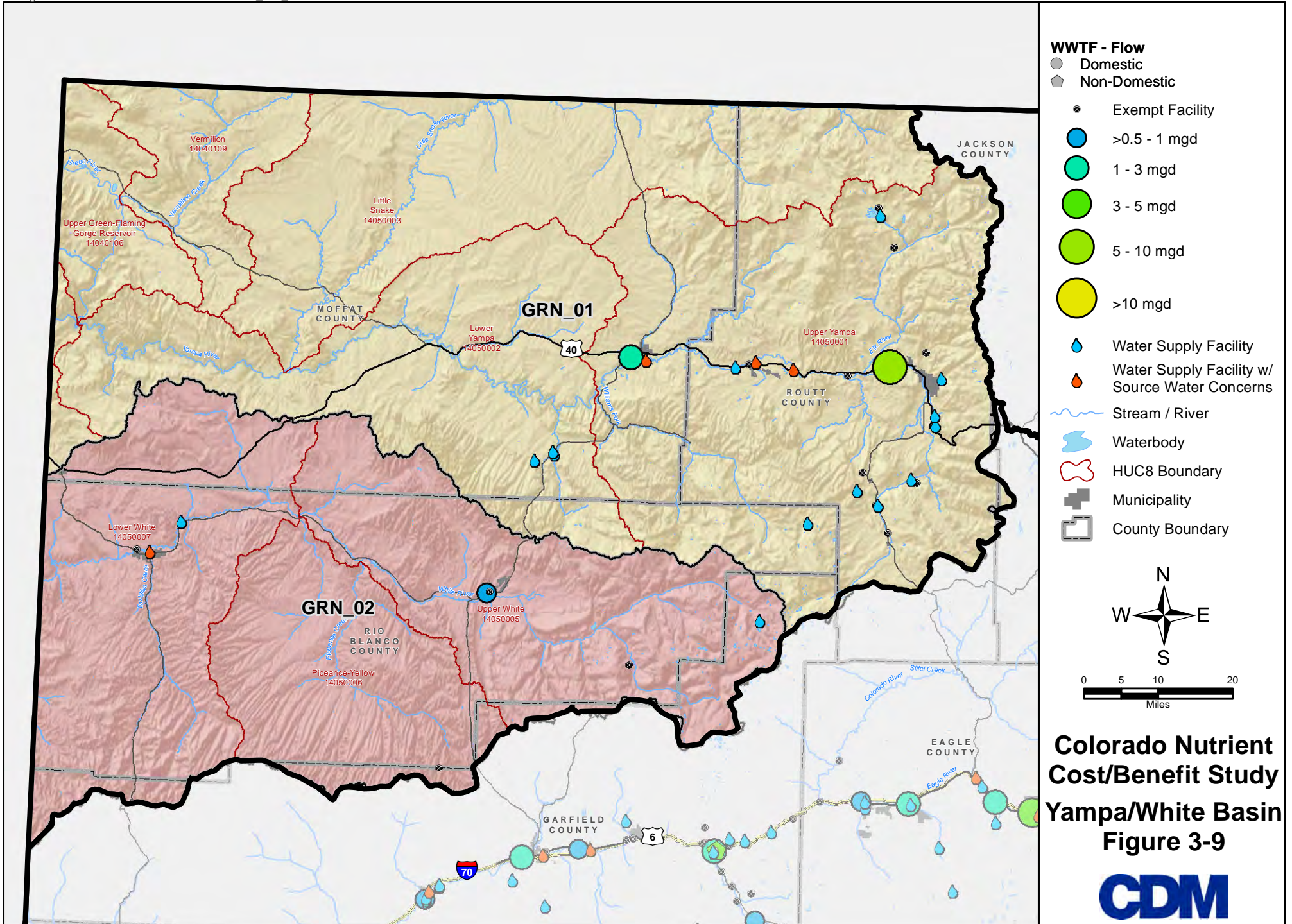


- WWTF - Flow**
- Domestic
 - Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
- Water Supply Facility
- Water Supply Facility w/ Source Water Concerns
- ~ Stream / River
- ~ Waterbody
- ~ HUC8 Boundary
- Municipality
- County Boundary



Colorado Nutrient Cost/Benefit Study
Southwest Basin
Figure 3-8





3.3 Water Quality Analyses

Analyses of existing water quality were completed for each of the 27 Manageable Units. This effort established expected changes in water quality if the proposed nutrient control regulations were implemented at all WWTFs where the regulation would be applicable and compliance with Tier 1, 2, or 3 effluent limits was achieved. This analysis required extensive data collection and analyses to develop mass balance models within spreadsheets specific to each Manageable Unit. The following sections describe the data sources, methods, and key assumptions used to complete water quality analyses.

3.3.1 Data Sources

River and Stream Water Quality Data

The Division's Watershed Program Environmental Data Unit (EDU) exists to "gather, assess, and report data regarding the chemical, physical, and biological integrity and quality of state surface waters for the Federal CWA 303(d) list of impaired waters and the 305(b) report of status of water quality in Colorado as the EPA Integrated Report." The EDU has collected nutrient water quality data from many locations across the state. Throughout the development of preliminary nutrient water quality criteria, the EDU has compiled these data along with nutrient-related data from other sources, including: USGS, Riverwatch, and U.S. Environmental Protection Agency (EPA) Storage and Retrieval (STORET) database. This compilation organizes data by sampling location, parameter, and source¹. Where at least five samples have been collected, the Standards Unit calculated median values for TP, nitrite (NO₂), nitrate (NO₃), ammonia, total kjeldahl nitrogen (TKN), and total nitrogen (TN). These datasets have periodically been made available to the nutrient criteria work group and are available online through the Colorado Water Quality Forum. Median Total Inorganic Nitrogen (TIN) concentrations were calculated from these datasets using NO₂, NO₃, and ammonia data. Median TIN and TP values were used for the water quality analyses completed for this Study.

Reservoir Water Quality Data

The EDU has also collected reservoir quality data from many sources. Data were downloaded through the nutrient workgroup and reservoirs with at least 10 historical data points were sorted by Manageable Unit. The reservoirs with adequate data from this dataset (at least 10 historical data points) were then mapped and reviewed for location. A selection of reservoirs downstream of nonexempt WWTFs were included in the water quality analysis described in Section 3.3.2. Some reservoirs that may be affected by nonexempt WWTFs were not analyzed for the purposes of this Study due to the complicated nature of water delivery to the waterbodies. The modeling technique employed to analyze reservoirs (see methodology description in Section 3.3.2) did not provide the level of detail necessary to adequately model complex delivery systems to these reservoirs. Appendix A contains a list of the reservoirs with data (from the EDU compilation), describes if the reservoir is located downstream of a nonexempt WWTF, and notes whether or not the reservoir was included in the analyses performed for this Study. The reservoir models constructed under this task are presented in the Manageable Unit-specific discussions provided in Section 4.

For the selected reservoirs, additional data were needed to complete the water quality analysis performed for this Study. General Internet searches were conducted for reservoir inflow, storage, maximum depth, and residence time. The majority of flow data for sites just upstream of the reservoirs was available from the USGS. Other inflow data were available through the U.S. Army Corps of Engineers (USACE) website or through Environmental Impact Statement studies. Depth information came from various online sources

¹ Water quality data used for this Study are available for download from the CWQF Nutrient Work Group Website: <http://www.cwqf.org/>. Data can be found under the links for "Work Groups," "Nutrient Criteria," and "DATA".

and are documented in each of the reservoir spreadsheets contained in Appendix A. Residence time information was rarely available. In cases where residence time was not documented, it was calculated using inflows and storage volume.

Nonpoint source contributions were factored into the reservoir water quality analysis. Nonpoint source data are presented below (e.g., see Table 3-9). The background concentrations calculated for stream water quality stations located closest to, and often just downstream of a reservoir, were used to account for nonpoint source contributions.

WWTF Effluent Water Quality and Discharge Rate

Evaluation of the potential water quality impacts from implementation of the three effluent quality tiers (see Table 2-6) required effluent quality data and discharge rates for the WWTFs subject to the proposed nutrient control regulations. Discharge rates were obtained from Division data. Domestic WWTFs were analyzed (for purposes of water quality calculations) at 75 percent of permit capacity. The majority of nondomestic WWTF flow data were available only as maximums, averages, and minimums. Because permit capacity/limit data were not available for these facilities, the average discharge rate was used for water quality analyses.

Existing effluent quality data for TP and TIN are limited throughout the state. The CWWUC provided facility-specific effluent quality data from a number of member utilities. Additional facility-specific data were also provided by a number of stakeholders. Average effluent quality concentrations were used when available.

Nutrient control regulations currently exist for Bear Creek Lake, Lake Dillon, Cherry Creek Reservoir, and Chatfield Reservoir. Facilities discharging upstream of these waterbodies have TP effluent limits in their National Pollutant Discharge Elimination System (NPDES) permits and these watersheds produce annual water quality reports that are available online. Facility-specific data were pulled from these documents when available and TP permit limits were used when facility-specific data were not available. In addition, the WWTFs in the Clear Creek basin (PLT_02) discharge low nutrients under an agreement developed to protect water quality in Standley Lake. Effluent quality data from these facilities were provided by the Upper Clear Creek Watershed Association (UCCWA). To determine appropriate effluent concentrations to assume for facilities that lacked effluent quality data (the majority of facilities in the state), the Division provided a table of "Technology Performance Statistics by Treatment Bins" that provided ranges of effluent quality for these parameters as determined through multiple studies performed by EPA in 2007 and 2010, and Water Environment Research Foundation (WERF) in 2008 and 2010. Based on a review of this document, discussions with the Division, and input from stakeholders, effluent concentrations of 4.5 mg/L TP and 25 mg/L TIN were assumed to be appropriate to use for water quality analyses when site-specific data were not available.

Nonpoint Sources

Estimates of nonpoint source contributions to nutrient loads to waterbodies throughout the state were calculated using land use data and associated export values for TP and TIN for each land use category. Sub-basins were delineated for each water quality data location within each Manageable Unit. Land use characteristics for each sub-basin were derived from the 2006 National Land Cover Dataset (NLCD) produced by the Multi-resolution Land Characteristics Consortium (MRLC), a consortium of state and federal agencies that release land use/land cover GIS datasets. The GIS dataset provides land cover categorization at a 30-by-30-meter resolution using a number of land use categories. The NLCD land use categories were consolidated for this Study into eight key land use categories (Table 3-9). The consolidation of categories aided in identifying reference sites and correlating data to literature-derived Event Mean Concentration (EMC) estimates for land use categories.

Table 3-9. Key Land Use Categories Used for Nonpoint Source Calculations

NLCD Land Use Categories	Key Land Use Category
Barren Land (Rock/Sand/Clay)	Barren Land
Developed, High Intensity	Developed- Medium/High Intensity
Developed, Low Intensity	Developed- Low Intensity/ Open Space
Developed, Medium Intensity	Developed- Medium/High Intensity
Developed, Open Space	Developed- Low Intensity/ Open Space
Cultivated Crops	Crops
Pasture/Hay	Pasture
Grassland/Herbaceous	Grass
Deciduous Forest	Forest
Evergreen Forest	Forest
Mixed Forest	Forest
Shrub/Scrub	Scrub
Open Water	Water/Ice
Perennial Ice/Snow	Water/Ice
Emergent Herbaceous Wetlands	Grass
Woody Wetlands	Forest

For each land use category, nutrient export concentrations were obtained using a reference site approach or by using published literature EMC values (Table 3-10). Where sufficient data were available from a stream sampling station with a contributing watershed dominated by a single land use category, the reference location approach was utilized for that land use category. Suitable reference locations were not available for several land use categories; primarily due to the lack of a sampling location in which the given land use category encompassed a significant percentage of the contributing watershed. Potential reference locations that have WWTFs within the contributing watershed were also excluded. For land use categories where suitable reference locations could not be identified, EMC values were used (Table 3-10).

Proportions of each land use category contributing to the nonpoint source loads of TP and TIN at each sampling station were calculated using GIS software. First, GIS was used to delineate the contributing watersheds for each sampling station used in the water quality model. Next, the NLCD land use dataset was clipped to each delineated sub-basin and a GIS statistical tool was used to calculate the number of 30-by-30-meter pixels of each land use category present in each sub-basin. These data were exported to MS Excel and the land use categories were consolidated into the eight key categories used in the model (Table 3-9). Finally, calculations were run to convert the land use data for each sub-basin into proportions of the total nonpoint source contributing land assigned to each of the consolidated land use categories. The Open Water and Perennial Ice/Snow land use categories are not considered as contributors to the nonpoint source loads of TP or TIN; and, therefore, were not included in land use proportion calculations.

Table 3-10. EMCs used for Water Quality Analysis

Dominant Land Use	TP (mg/L)	TIN (mg/L)	Data Source
Forest	0.02	0.04	Median values from unimpacted forest site in CO dataset
Pasture/Hay	0.14	0.801	Median values from unimpacted site in CO dataset
Crops	0.88	1.66	Median values from unimpacted site in CO dataset
Grassland/Herbaceous	0.15	0.101	Median values from unimpacted site in CO dataset
Shrub/Scrub	0.02	0.04	Median values from unimpacted forest site in CO dataset
Developed Low Intensity/Open Space (Residential)	0.27	0.85	Literature - median values for NO ₅ and NH ₃ summed to get TIN estimate*
Developed - High Intensity/Medium Intensity (Commercial/Industrial)	0.40	1.47	Literature- median values for NO ₅ and NH ₃ summed to get TIN estimate*
Barren Land (Rock/Sand/Clay)	0.02	0.04	Median values from unimpacted forest site in CO dataset

*Lin, Jeff. 2004. Review of Published Export Coefficient and EMC Data. Wetlands Regulatory Assistance Program. ERDC TN-WRAP-04-3

**EMC data were also provided for Cherry Creek Reservoir. These data were used for the Cherry Creek Reservoir water quality analysis and can be found in the Cherry Creek Reservoir calculation spreadsheet in Appendix A.

3.3.2 Water Quality Analysis Methodology

Using the data described above, water quality analyses were completed for each of the 27 Manageable Units (see Appendix A for data analysis details). The following sections describe the methodology applicable to streams and rivers and reservoirs.

Streams and Rivers

For each Manageable Unit, mass balance calculations were performed to quantify anticipated nutrient concentration reductions resulting from future WWTF upgrades based on a need to comply with each nutrient control tier (see Table 2-6). Calculations were performed for selected existing historical stream sampling sites within a given Manageable Unit. Stream sampling sites used for this Study were chosen based on location and data availability. Sites located upstream of any nonexempt WWTFs were not included as water quality would not be affected by potential effluent concentration reductions. Sites downstream of nonexempt WWTFs with historical TP and data available to calculate historical TIN were used for these analyses. These calculations rely heavily on historical measured nutrient concentration data, which have been assumed to reflect 1) both point and nonpoint sources of nutrients, and 2) WWTF effluent loads from existing point source facilities subject to the proposed nutrient control regulation². Prior to developing predictions of future impacts from expected point source load reductions, the historical water quality were used to estimate the current balance between point and nonpoint source loads for a given sample site.

Steady state mass balance equations were developed for each historical sample site in each Manageable Unit (Figure 3-9 and Equation 3-1). This equation, given current WWTF loads, can be written as:

$$C_{current}(Q_{NP} + \sum_{i=1}^n Q_{WWTF}^i) = \sum_{i=1}^n L_{WWTF}^i + C_{ref}Q_{NP} \quad (\text{Equation 3-1})$$

where,

$C_{current}$ = the median TIN or TP concentration for given sample site,

C_{ref} = estimated "background" nutrient concentration (un-impacted by point sources; including nonpoint sources),

n = number of upstream WWTF facilities,

i = WWTF index,

Q_{WWTF}^i = effluent discharge flow rate for WWTF i ,

L_{WWTF}^i = effluent nutrient load for WWTF i , and

Q_{NP} = representative nonpoint flow rate impacting given site.

The latter term (Q_{NP}) is a dilution factor if conservative mixing is assumed and represents background, or "natural," drainage flow to the site and, potentially, if nonconservative mixing is acknowledged, may also implicitly reflect instream attenuation of nutrients (see additional discussion below). Current nutrient

² The November 21, 2011 Regulation does not include exceptions for nondomestic facilities; however, due to the limited information available for nondomestic facilities (in particular determining which facilities would actually be subject to the regulations) and the expected limited effect on receiving water quality by small dischargers, nondomestic facilities discharging less than 0.5 mgd were excluded from the quantification of costs and benefits.

concentrations ($C_{current}$) are calculated as the median of values measured over the past 20 years as provided by the Division. Background nutrient concentrations (C_{ref}) were estimated as a function of drainage area land use and assumed generalized mean concentrations associated with given land use categories, as described above. Current WWTF effluent flows, concentrations, and loads were estimated based on data provided by the Division, CWWUC, and additional stakeholders, as described above.

Equation 3-1 can be rearranged to solve for the nonpoint dilution flow, Q_{NP} , as:

$$Q_{NP} = \frac{\sum_{i=1}^n L_{WWTF}^i - C_{current} \sum_{i=1}^n Q_{iWWTF}}{(C_{current} - C_{ref})} \quad (\text{Equation 3-2})$$

Equation 3-2 is solved for each targeted sampling site in a given Manageable Unit. Given the estimated nonpoint contribution to existing stream nutrient concentrations, and rearranging Equation 3-1, future impacts of tiered implementation of WWTF load reductions on instream concentrations can be calculated as:

$$C' = \frac{\sum_{i=1}^n L_{WWTF}^i + C_{ref} Q_{dil}}{(Q_{dil} + \sum_{i=1}^n Q_{iWWTF})} \quad (\text{Equation 3-3})$$

where,

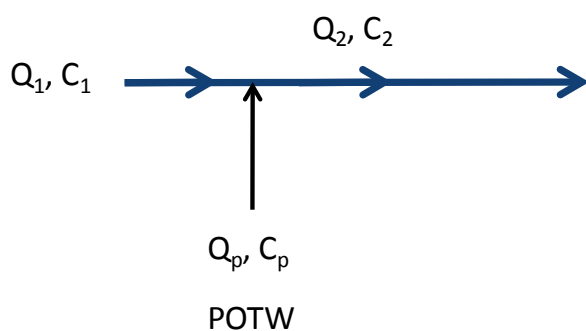
C' = future instream nutrient concentration given WWTF load reduction expected from implementation of a particular nutrient control tier; and

L_{WWTF}^i = new WWTF effluent nutrient load expected after implementation of a given nutrient control tier.

The mass balance equations described above are based on the assumption of complete conservative mixing (Figure 3-10) of WWTF effluent loads. Given the spatial scale of the Study and limitations associated with available data, explicitly quantifying instream attenuation was not feasible for this Study. However, instream attenuation is implicitly captured in the calculated nonpoint dilution flow (Q_{NP}) metric. This parameter resolves the difference between measured instream nutrient concentrations and the upstream mass balance. In other words, it provides for a lumped reduction in nutrient concentration attributable to both nonpoint flow dilution and instream attenuation. For example, if current measured instream concentrations are low relative to upstream point source effluent values, the calculated Q_{NP} will be high - reflecting some combination of dilution and instream attenuation. This high dilution factor will reduce calculated instream sensitivities to future tiered WWTF load reductions. Additionally, all calculations assume steady state using annual mean or median values and do not address water quality seasonality.

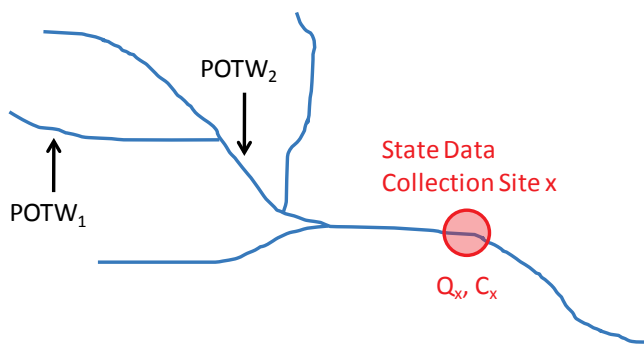
The Q_{NP} factor and instream water quality data were also assumed to account for any water diversions or transfers that may be occurring within the system. Although there are a number of trans-basin diversions with WWTFs upstream of the diversion, these situations are limited and complex and typical nutrient concentrations in the upper reaches of receiving basins were low. Due to the limitations of the spreadsheet analysis, amount of available data, use of the dilution factor, and existing water quality data, it was assumed that the water quality analyses performed for this Study adequately addressed these complexities to some degree.

The contiguousness of Manageable Units was also considered in the water quality analyses. Manageable Units were analyzed from upstream to downstream within each major river basin. Spreadsheets for downstream Manageable Units built upon the data inputs for the upstream Manageable Unit to account for the point and nonpoint source loads flowing into downstream basins and the resulting water quality after point source reductions occurred in upstream contributing Manageable Units.

Simple stream mixing

$$Q_1 C_1 + Q_p C_p = Q_2 C_2$$

$$C_2 = \frac{Q_1 C_1 + Q_p C_p}{Q_2}$$

Site-specific calculations of future stream concentrations

$$L_x = Q_x C_x$$

$$\Delta L_x = \sum \Delta POTW_i$$

$$C'_x = \frac{L_x - \Delta L_x}{Q_x}$$

Figure 3-10. Stream Water Quality Calculations: Conceptual Model

Reservoirs

As discussed in Section 3.1.1, the project team analyzed a selected set of reservoirs based on data availability, location relative to non-exempt WWTFs, and complexity of system. The following reservoirs were analyzed for this Study:

- Bear Creek Lake (PLT_01)
- Chatfield Reservoir (PLT_01)
- Cherry Creek Reservoir (PLT_07a)
- Stanley Lake (PLT_07c)
- Pueblo Reservoir (ARK_01)
- John Martin Reservoir (ARK_03)
- Lake Dillon (COL_02)
- Stagecoach Reservoir (GRN_01)

Attenuation of nutrients in reservoirs is generally higher than in streams due to a number of factors, including slower travel times, active sediment layers, and greater presence of aquatic plants. As such, in-reservoir attenuation of nutrients was incorporated into the mixing calculations performed for these reservoirs. Existing reservoir water quality data were used to quantify current conditions, including the balance between nonpoint and point source loads and order-of-magnitude attenuation rates. In contrast to the stream calculations described above, gauged flow data were used to quantify mean annual flow rates

into the reservoir. Reservoir water quality is less sensitive to dynamic flow changes compared to streams. The use of measured mean annual values is therefore justified.

The potential impacts of implementation of the proposed nutrient control regulation were conducted in two phases. First, reservoir nutrient concentrations were calculated based on the following steady state mass balance equation:

$$C_{current} = \frac{\sum_{i=1}^n L_{WWTF}^i + Q_{NP} C_{ref}}{Q + v} \quad (\text{Equation 3-4})$$

Where,

$C_{current}$ = current reservoir mean nutrient concentration,

L_{POTW}^i = current upstream WWTF nutrient loading,

Q_{NP} = gauged reservoir inflow rate (without WWTF effluent flow),

C_{ref} = background inflow nutrient concentration,

Q = total inflow rate (including WWTF effluent flow); and

v = reservoir lumped attenuation velocity (net difference between nutrient uptake and internal nutrient releases).

C_{ref} is estimated as a function of drainage area land use and mean nutrient concentrations specific to land use categories (see Table 3-10). Using measured concentration and flow data representing current conditions, Equation 3-4 was solved for the uptake velocity, v , for each targeted nutrient constituent (TIN and TP). Given this quantified attenuation rate, and estimated reductions in WWTF nutrient loads, Equation 3-4 was used to estimate future reservoir concentrations based on implementation of each of the nutrient control tiers at upstream WWTFs, where the proposed control regulation would apply.

The second phase of the reservoir calculations assessed the potential for changes in trophic level status of reservoirs following implementation of the nutrient control tiers. Trophic levels, including eutrophic, mesotrophic, and oligotrophic, are indicators of the extent of water quality impacts attributable to high nutrient loads and resulting excessive plant growth. Published Vollenweider plots (**Figure 3-11**) (Chapra 1998), which relate trophic levels to annual phosphorus loading and reservoir morphology, were used to determine whether anticipated tiered reductions in TP loadings are likely to result in changes in trophic status. The Vollenweider plots were assessed visually in this analysis using the changes in TP loading calculated as described above.

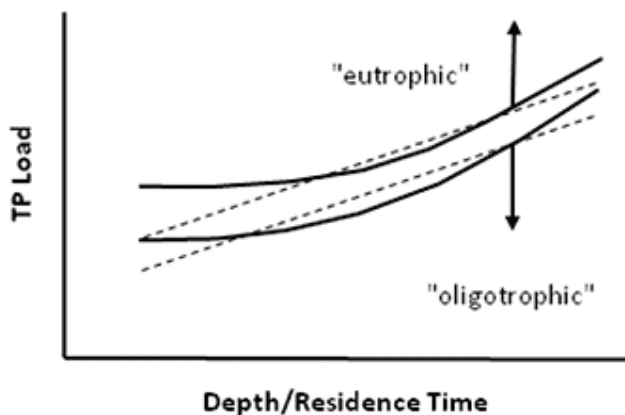


Figure 3-11. Vollenweider Plots Used to Assess Changes in Reservoir Trophic Levels

3.4 Wastewater Treatment Costs

This Study required a generalized, but methodical, approach to the development of WWTF treatment costs for the control of TIN and TP in the WWTF's effluent that takes into account variability among WWTFs across the state with regards to facility-specific site conditions and processes. There are over 400 domestic and nondomestic treatment facilities located throughout the state and a detailed analysis of each WWTF is not practical. Accordingly, the project team worked with the Division and Authority to develop an approach that allows application of key cost factors but does not require an in-depth study of each treatment facility. This approach involved creating a baseline "typical" WWTF that will be "adjusted" and "modified" to fit different existing treatment facility categories and site conditions. This "typical" facility approach allows for regional and statewide cost development within acceptable levels of accuracy and over a short period of time. It is important to understand from the outset that the "typical" facility defined by this Study does not represent any one facility within the State. Instead, the use of a typical facility allows a high level cost analysis for comparison to an equally high level benefit analysis. For any individual facility, an additional independent and detailed engineering analysis would be required to determine the actual costs that would be associated with the implementation of process changes to meet any of the tiered effluent quality requirements.

Figure 3-12 presents the methodology for development of wastewater treatment costs for typical facilities in each Manageable Unit to meet the three effluent quality tiers analyzed for this Study (see Table 2-6). The following sections describe systematically the methodology applied to each Manageable Unit that produces Unit-specific treatment costs that could then be aggregated by river basin and statewide.

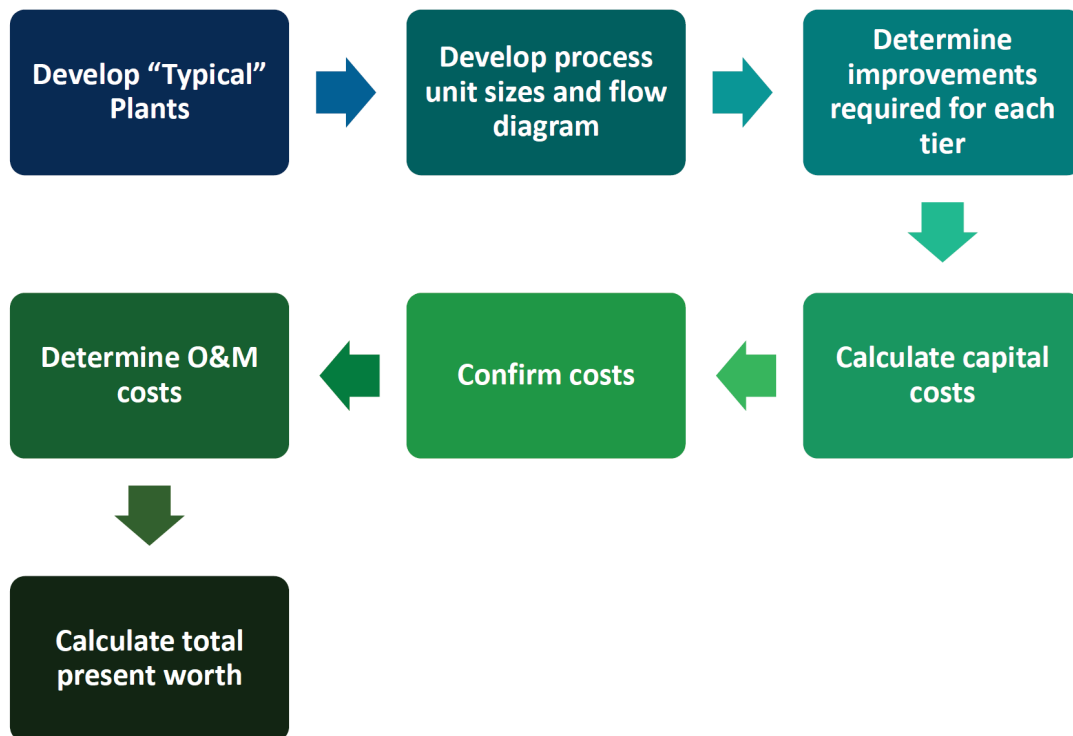


Figure 3-12. Methodology for Wastewater Treatment Cost Development

3.4.1 Step 1: Develop "Typical" Facility

The "typical" WWTF represents a theoretical baseline facility which is well run and in compliance with permitted discharge limits (assumed to be secondary limits with no deliberate nutrient removal). Using this "typical" facility allows a statewide baseline to be established and serves as the zero cost starting point. To develop costs for implementation of facility upgrades to achieve each of the effluent quality tiers, the Study needed to identify the improvements required to bring the quality of the baseline effluent discharge into compliance with each tier's nutrient concentration target for TIN and TP.

Development of this "typical" WWTF required an understanding of the processes used at existing WWTFs within each Manageable Unit. Based on knowledge of the most commonly used treatment technologies, the "typical" facility can be defined and then evaluated to identify how they could be modified to achieve each effluent quality tier. To identify the most common treatment types within the state and within each Manageable Unit, the project team gathered data from the Division's NPDES permit files, the EPA 2004 Clean Watershed Needs Survey, and a wastewater treatment provider survey. The sections below describe each of these data sources and the facility information obtained.

3.4.1.1 Division Permit Files

The Division provided a database that contains domestic WWTF discharge permit information. The project team sorted the domestic permit dataset to remove facilities that do not discharge into surface waters or groundwater under the influence of surface water since these facilities would not be governed by the proposed regulations. Facilities with expired or discontinued permits were also removed from the dataset; however, facilities with administratively continued permits were left in the dataset. The permitted discharge location for each of the facilities in the dataset were mapped by latitude and longitude and segregated into Manageable Units based upon the mapped discharge location.

Non-domestic WWTF information was provided in a separate database. Nondomestic WWTFs with terminated permits and those that discharge only to groundwater or apply their effluent to land were removed for this Study. The database did not contain information regarding the type of WWTF or if the facility discharged effluent that might contain nutrients (and would therefore be subject to the proposed regulation). To estimate which facilities could be governed under the proposed regulation, the dataset was sorted by the Standard Industrial Code (SIC) applicable to each facility. Based on the type of industrial process represented by each SIC and using best professional judgment, facilities were then grouped into the following categories: likely to discharge nutrients, may discharge nutrients, and not likely to discharge nutrients. The list of facilities categorized as "likely to discharge nutrients" was further refined to those with discharges greater than 0.1 mgd (facilities that are not exempt under Regulation #85). This final, refined list of industrial facilities was then sorted by Manageable Unit. Average daily flow information from the dataset was used for the discharge flow for each facility.

The Division's dataset contained a significant number of entries that had "No Data" for the permitted discharge flow. Where available, the individual permits were reviewed and the actual permitted discharge value was entered into the dataset. In the event these permits listed a permitted range, the upper end of the range was listed as the permitted capacity. Following review of the State's dataset and issued permits, 20 facilities remain with "No Data" for the permitted discharge flow. Based upon the location, owner, or name, these facilities appeared to be small in size and are likely exempt from the proposed regulation. Regardless, they are listed within each Manageable Unit, but noted as having "No Data."

Table 3-11 summarizes the total number of domestic and non-domestic facilities identified for each Manageable Unit.

Table 3-11. Number of WWTFs (Domestic and Non-Domestic) in each Manageable Unit

Manageable Unit ID	Number of Domestic and Non-Domestic Facilities	Manageable Unit ID	Number of Domestic and Non-Domestic Facilities	Manageable Unit ID	Number of Domestic and Non-Domestic Facilities
ARK_01	25	GUN_02	16	PLT_07C	3
ARK_02	12	PLT_01	29	PLT_7D	20
ARK_03	26	PLT_02	12	PLT_08	15
COL_01	18	PLT_03	24	PLT_09	9
COL_02	7	PLT_04	12	RIO_01	17
COL_03	6	PLT_05	2	SW_01	33
COL_04	20	PLT_06	15	SW_02	11
COL_05	18	PLT_07A	6	GRN_01	11
GUN_01	11	PLT_07B	5	GRN_02	5

Note: The number of domestic and non-domestic facilities listed only includes facilities that discharge into surface waters or groundwater under the influence. Facilities discharging to other locations would not be governed by the proposed regulation and, therefore, are not included in the above WWTF count.

3.4.1.2 EPA Clean Watershed Needs Survey

Output from the EPA 2004 Clean Watershed Needs Survey (CWNS) was matched by permit number to the list of WWTF's developed from the Division's database. The CWNS data includes information on unit processes, based on responses from individual facilities. The EPA conducts the CWNS every four years; however, the 2008 data (the most recently available survey data) did not contain as much unit process information as was provided in the 2004 CWNS. The CWNS process information and the permit data provide an indication of the treatment type for many of the WWTFs. In the event of a conflict between the data from the 2004 CWNS and the State permit database, the State's database was assumed to be more accurate. Table 3-12 summarizes the 2004 CWNS data for Colorado.

Table 3-12. 2004 CWNS Data Summary

Facility Type	Count
Oxidation Ditch	14
Aerated Lagoon	142
Conventional Activated Sludge	30
Activated Sludge – Extended Air	44
Activated Sludge – Other	12
Other Suspended Growth	2
Trickling Filter	26
Package Plant	7
Rotating Biological Contactor	8
Subtotal	265

Note: Not all facilities that responded to the 2004 CWNS provided location information; facilities without location information are not included in this count

3.4.1.3 Wastewater Service Provider Survey

In order to supplement existing datasets, the project team conducted an on-line survey administered through a web-based survey tool called SurveyMonkey. A link to the on-line survey was provided at the first stakeholder workshop and posted on the Division's web page. The web link was also provided to users through telephone calls. Participants were encouraged to forward the link to others or to make available through professional associations. Hard copies were handed when opportunity permitted.

The survey requested information regarding the existing wastewater treatment liquid and solid unit processes, staffing levels, influent and effluent data, sludge management practices, plans for improvements including availability of land, and facility performance data. The survey also requested information about planned improvements regarding treatment processes and O&M (see Appendix B-1 to view the survey questions).

A total of 70 survey responses were received (approximately 19 percent of the total number of facilities expected to be regulated under the proposed regulation) with representation from a majority of the Manageable Units (Table 3-13).

Table 3-13. Survey Participation by Manageable Unit and Facility Size (Flow Bin)

Manageable Unit	Number of Facilities by Flow Bin (mgd)						Total
	<=0.5	>0.5 to 1.0	>1.0 to 3.0	>3.0 to 5.0	>5.0 to 10	>10	
ARK_01	-	-	2	-	1	1	4
ARK_02	-	-	3	1	-	2	6
ARK_03	-	1	1	-	-	-	2
COL_01	1	1	2	-	-	-	4
COL_02	2	-	5	-	-	-	7
COL_03	-	-	3	1	-	-	4
COL_04	-	1	-	-	-	-	1
COL_05	2	-	-	-	-	1	3
GUN_01	1	-	-	1	-	-	2
GUN_02	2	-	-	-	-	-	2
PLT_01	-	1	-	1	1	1	4
PLT_02	-	-	1	-	-	-	1
PLT_03	-	-	2	1	-	2	5
PLT_04	-	1	3	-	1	-	5
PLT_05	-	-	-	-	-	-	-
PLT_06	-	-	2	-	1	1	4
PLT_07	2	1	3	1	2	2	11
PLT_08	1	-	-	-	-	-	1
PLT_09	-	-	-	-	-	-	-
RIO_01	-	-	-	-	-	-	-
SW_01	1	-	1	-	-	-	2
SW_02	1	-	-	-	-	-	1
GRN_01	-	-	-	-	-	-	-
GRN_02	1	-	-	-	-	-	1
Total	14	6	28	6	6	10	70

Examples of the relevant findings from the surveys include:

- Although over 70 percent of the surveyed WWTFs reported no plans for expansion, a majority of the facilities have adequate room available on their current site for future expansion.
- Sixty-four percent of those surveyed reported no chemical delivery issues. For those facilities with issues, a majority was related to the cost of the chemical.
- Most facilities do not produce Class A biosolids and 50 percent of the surveyed facilities land apply per their final residuals disposal plan.
- Sixty-four facilities (91 percent) reported that less than 10 percent of their total influent flow is received from an industrial source.
- As a result of WWTF expansion or the addition of enhanced treatment processes, 79 percent reported that they do not plan on hiring additional staff; however 60 percent intend to make staff improvements, which include training existing staff members.
- Ten facilities generate approximately 78 percent of the total flow. The larger facilities (over 10 mgd each) result in over 448 mgd of wastewater discharge (Figure 3-13).

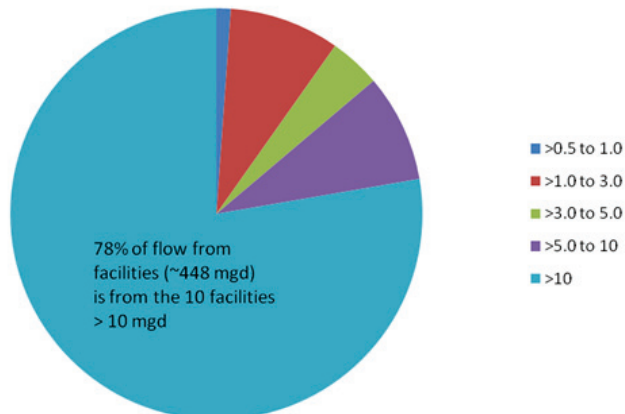


Figure 3-13. Flow Contribution by Flow Bin from Survey Responders

Following completion of the survey, follow-up outreach (primarily phone calls and emails) was conducted with over 100 facilities to clarify treatment processes, influent and effluent data, and cost information concerning both capital and O&M costs.

3.4.1.4 WWTF Categorization

The CWNS and on-line survey data were compared to the Division data. Process and flow data were screened for consistency and outliers removed. Where discrepancies occurred between flow and/or process data, information from the NPDES permits and on-line survey superseded data from the CWNS.

Based upon this consolidated dataset, the project team assigned WWTFs to one of six treatment categories. The general treatment categories are typically used for domestic and non-domestic biologically treated wastewater. Only a very few small facilities did not fit within one of these categories (e.g., a constructed wetland). In these cases, the facilities with non-standard treatment technologies were included in the category most similar or that would require in similar level of improvements to meet the nutrient effluent tiers. Because the Division's dataset did not contain process data for the non-domestic facilities, they were all assumed to be Category 1, suspended growth systems. The treatment categories and a general description include:

- *Category 1:* Suspended growth systems with aeration and mixing (aeration tanks, activated sludge, extended aeration, conventional aeration, step-feed, and/or contact stabilization processes).
- *Category 2:* First-generation fixed film systems (rotating biological contactors [RBC] and trickling filters)
- *Category 3:* Second-generation fixed film systems (integrated fixed-film activated sludge [IFAS], moving bed-bioreactor [MBBR] systems, or hybrid systems that include both a suspended growth system and a nitrifying trickling filter)
- *Category 4:* Lagoons
- *Category 5:* Sequencing Biological Reactors (SBR)
- *Category 6:* Oxidation ditches

Most of the treatment facilities (80 percent) were categorized as either mechanical activated sludge facilities (Category 1) or Lagoons (Category 4). An additional three percent have treatment processes that were grouped with the Category 4 facilities due to similarity in treatment and costing approach. The

remaining treatment categories comprise a limited number of facilities (Figure 3-14). A complete listing of treatment facilities sorted by Manageable Unit, treatment category and flow is provided in Appendix B-2.

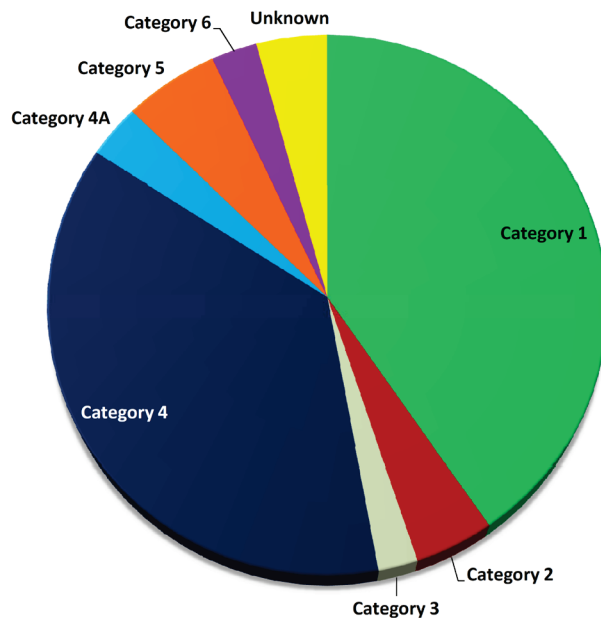


Figure 3-14. Categorization of Colorado WWTFs

3.4.2 Step 2: Develop Process Unit Sizes

The purpose of Step 2 was to identify the process types and sizes in each Manageable Unit along with the base "typical" facility flow diagrams for each flow bin. In this step, the base "typical" facility was also modeled for comparison in future steps. Input for this step included the existing process types per Manageable Unit, size distribution, and facility information identified in Step 1. Output from this step included a BioWin model of the "typical" facility. The "typical" facility model developed in this step was modified in Step 3 to incorporate the necessary infrastructure to meet the effluent quality limits for each tier.

3.4.2.1 Process Unit and Treatment Category Definition

The project team identified six general WWTF categories by using the WWTF data developed in Step 1. Separating the WWTFs by process is important because the general unit processes and WWTF configuration vary among the six treatment categories. For example, Category 1 facilities generally have a set of tanks and mechanical equipment for primary settling of solids from the wastewater, a second set of tanks and aeration equipment for biological treatment of the wastewater, and another set of tanks and mechanical equipment for final settling. The Category 4 facilities (lagoons) generally consist of a single earthen or constructed tank that may have separate zones and has limited mechanical equipment. Category 4 facilities are typically much simpler to operate than Category 1 and have lower operations and maintenance staff needs. The Category 4 facilities have limited existing components that can be reused for advance treatment required to achieve the Tier 1, Tier 2, or Tier 3 nutrient effluent limits. If the Category 4 facilities were not separated for costing, the cost estimate would not accurately reflect the additional infrastructure required to meet the effluent limits. Separating these facilities for costing provides a more reasonable and accurate estimate on a state-wide level. Within each category, there will be variation on how unit processes are arranged and differences in the connections between unit processes, but in general the WWTFs within each category do not differ significantly.

3.4.2.2 WWTF Flow Bins

Typically, the cost per gallon for the construction of treatment infrastructure is highest for small facilities and decreases as facility size increases. This means that the cost for the same improvements to a WWTF that has a capacity of 1 mgd will be higher per gallon than would be expected for a WWTF that has a permitted capacity of 20 mgd. Because this difference can become significant when considering a state-wide cost, the WWTFs needed to be separated into flow bins to reflect this unit cost difference.

Flow bins (groupings of WWTFs based on size) were determined by sorting all the permitted capacities and reviewing the best ways to divide the facilities to account for the size changes. WWTFs of one mgd and smaller were separated as a flow bin since the regulation exempts lagoon facilities of this size. This bin was additionally split to capture the difference in unit cost for the smallest facilities (≤ 0.5 mgd). Very large facilities (> 10 mgd in capacity) were separated as well. The remaining facilities were distributed into several flow bins. The final flow bin categories include:

- Bin 1: Facilities with capacities of less than or equal to 0.5 mgd
- Bin 2: Facilities with capacities greater than 0.5 mgd up to and including one mgd
- Bin 3: Facilities with capacities greater than one mgd up to and including three mgd
- Bin 4: Facilities with capacities greater than three mgd up to and including five mgd
- Bin 5: Facilities with capacities greater than five mgd up to and including 10 mgd
- Bin 6: Facilities with capacities greater than 10 mgd

3.4.2.3 WWTF Process Modeling

BioWin Process Modeling

To help determine the improvements required for a "typical" WWTF to achieve the Tier 1, Tier 2, or Tier 3 effluent quality limits, the project team used the BioWin process flow model (BioWin is software developed by EnviroSim, Ltd. of Hamilton, Ontario). Known as a "simulator," BioWin codifies a set of equations that describe the reactions (i.e., a numerical model) that take place within a WWTF. The software is comprised of a graphical user interface with drag-and-drop functionality to represent a flow schematic, input windows for each of the treatment components (clarifiers, aeration tanks, etc.), and output windows that can plot or tabulate various parameters. The model can be run either to solve for a steady-state condition or a dynamic condition.

Wastewater process modeling represents the industry's best understanding of the complex relationships among the chemical, physical, and biological processes that provide successful wastewater treatment. Nearly 50 years of research have gone into characterizing the behavior of approximately 60 of the most critical wastewater treatment processes that are intricately related. However, the numerical models that have been developed to describe the reactions related to these processes continue to evolve as understanding of these processes improves.

The ability of any model to accurately represent reality depends on the quality of the data inputs. When modeling an individual WWTF, measuring conditions at the facility can be the weakest component of modeling – understanding the sampling, laboratory analysis, and relationship of parameters is complex. For this Study, influent parameters had to be assumed and applied statewide to all "typical" facilities. Because this is a planning level assumption, the wastewater process models are not necessarily reliable to predict an *absolute* result (for example, an average effluent total phosphorus concentration of 0.54 mg/L). Regardless of this limitation, models are still excellent tools for planners, engineers, and operators for a number of reasons. They provide a complete picture of relative process performance (the relative difference in effluent nitrate concentration resulting from changes in recycle rate, for example) and allow for a better understanding of how a WWTF (or theoretical facility in the case of this Study) is operating. More importantly, models provide the ability to evaluate relative differences between proposed treatment

alternatives and future flow and load scenarios. Thus models are a valuable tool for planning level studies to determine the overall impacts from implementation of nutrient removal process improvements.

Category 1 Model Input and Assumptions

The BioWin model can produce reasonable models for the Category 1 facilities and can be manipulated to simulate the Category 2, 3 and 6 facilities. BioWin is not effective at modeling Category 4 (lagoons) or Category 5 (SBR) facilities. The input for the base Category 1 model relied on the following design criteria, which are based upon input from the Division and use of standards-of-the-industry values:

- Influent wastewater design temperature of 14 degrees C.
- Aerobic solids retention time (SRT) of 8 days (calculated according to CDM's "Activated Sludge Guidelines," June 2008, version 2, incorporating the design temperature of 14 degrees C).
- Primary clarifiers designed for a maximum of 3,000 gallons per day per square foot (gpd/sf) and 2 percent solids, no redundancy.
- Return Activated Sludge (RAS) rate of 100 percent average daily flow (ADF).
- Sludge Volume Index (SVI) of 180 ml/g.
- Mixed liquor suspended solids (MLSS) of 3,500 mg/L at maximum-month load.
- Maximum-month peaking factor (PF) of 1.2, peak hour PF of 2.0, max-day PF of 1.54.
- Primary solids dewatering of 90 percent removal, 10 percent solids.
- Waste Activated Sludge (WAS) solids dewatering of 90 percent removal, 10 percent solids.
- Process designed for maximum-month load.
- Secondary clarifiers designed for peak hour flow (no safety factor) at maximum-month MLSS concentration, no redundancy.

Table 3-14 presents the input flows and loads for various flow bins for a Category 1 facility.

Table 3-14. Input Flows and Loads for Category 1 Facility

	Average Day	Maximum Month	Maximum Day
Flow, mgd	0.5	0.6	0.8
Biochemical Oxygen Demand (BOD) load, lbs/day	1,043	1,251	1,604
Total Suspended Solids (TSS) load, lbs/day	1,001	1,201	1,540
TKN load, lbs/day	221	265	340
Ammonia load, lbs/day	167	200	257
TP load, lbs/day	25	30	38
Flow, mgd	1	1.2	1.5
BOD load, lbs/day	2,085	2,502	3,208
TSS load, lbs/day	2,002	2,402	3,079
TKN load, lbs/day	442	530	680
Ammonia load, lbs/day	334	400	513
TP load, lbs/day	50	60	77
Flow, mgd	3	3.6	4.6
BOD load, lbs/day	6,255	7,506	9,623
TSS load, lbs/day	6,005	7,206	9,238
TKN load, lbs/day	1,326	1,591	2,040
Ammonia load, lbs/day	1,001	1,201	1,540
TP load, lbs/day	150	180	231

Table 3-14. Input Flows and Loads for Category 1 Facility

	Average Day	Maximum Month	Maximum Day
Flow, mgd	5	6.0	7.7
BOD load, lbs/day	10,425	12,510	16,038
TSS load, lbs/day	10,008	12,010	15,397
TKN load, lbs/day	2,210	2,652	3,400
Ammonia load, lbs/day	1,668	2,002	2,566
TP load, lbs/day	250	300	385
Flow, mgd	10	12.0	15.4
BOD load, lbs/day	20,850	25,020	32,077
TSS load, lbs/day	20,016	24,019	30,794
TKN load, lbs/day	4,420	5,304	6,800
Ammonia load, lbs/day	3,336	4,003	5,132
TP load, lbs/day	500	600	770

For process modeling of the Category 1 facilities, several basic assumptions were made. These assumptions apply to all flow bins for activated sludge facilities.

- Facilities larger than 5 mgd use anaerobic digestion and will have phosphorus rich side stream flows
- For facilities smaller than 5 mgd, adequate air supply is available for the aerobic digesters
- All facilities include primary and final clarifiers
- The existing condition of the facility allows the process units required for Tier 1, Tier 2, or Tier 3 to be added
- There is adequate power available at the WWTF site
- Sludge processing will continue using the same process as existing
- Methanol will be used for additional carbon source
- Ferric chloride will be used to enhance precipitation in the final clarifiers
- Changes to the WWTF process will not cause non-compliance with other water quality parameters

All Category 1 WWTFs 5 mgd and larger were modeled with an anaerobic digester to estimate a side stream nutrient load (i.e., return flows from the digesters and sludge operations). Side stream load can become significant for larger facilities and result in return to the treatment process of nutrient rich flow. If the side streams are not considered in facility sizing, the treatment unit capacities will not be large enough to meet the nutrient effluent limits. Based on Division and EPA data, there are six WWTFs between 5 mgd and 10 mgd that do not have anaerobic digesters and only one WWTF over 10 mgd that does not have an anaerobic digester.

3.4.3 Step 3: Determine Required Improvements

In this step, the base model developed in Step 2 is modified and modeled until the resulting process can achieve the effluent limits associated with each of the three effluent quality tiers. Output from this step is used in Step 4 for cost development.

Because the existing base "typical" WWTF model is based on a suspended growth activated sludge process (Category 1) without nitrification/denitrification, the facility aerobic capacity is assumed to be 75 percent of that required for full nitrification/denitrification. This means that a Category 1 WWTF would need to add additional aeration basin capacity to achieve nitrification/denitrification (or Tier 1 limits). To support the cost analysis, this Study assumed that the base facility has 75 percent of the required final clarifier capacity of a full nitrification/denitrification facility. While there are likely a number of existing WWTF facilities that

have adequate capacity for nitrification/denitrification and have adequate final clarifier capacity, a detailed was not conducted to verify this baseline assumption.

3.4.3.1 Process Flow Diagrams and Model Options

Combining TIN and TP removal in a biological process was considered. However, these constituents were evaluated together given that the proposed regulations do not separate requirements for TIN and TP removal. Several wastewater processes were initially considered to determine if they could be used to achieve the Tier 1, Tier 2, and Tier 3 nutrient limits. Each potential process is briefly described below.

Modified Ludzac-Ettinger (MLE) Process Analysis

The MLE process is an activated sludge (i.e., suspended growth) process that adds an anoxic zone (where denitrification takes place and no air is provided) prior to the aeration zone and has internal recycle that sends nitrate rich mixed liquor back to the anoxic zone for denitrification (Figure 3-15). This process is essentially a conventional activated sludge process with complete mixing throughout the biological process, a clarifier to remove solids, and return of active biological material to the start of the process unit. The MLE process is typically capable of reducing the nitrogen levels to 10 mg/L or less; accordingly, it was used as the process to achieve the Tier 1 effluent quality for all flow bins.

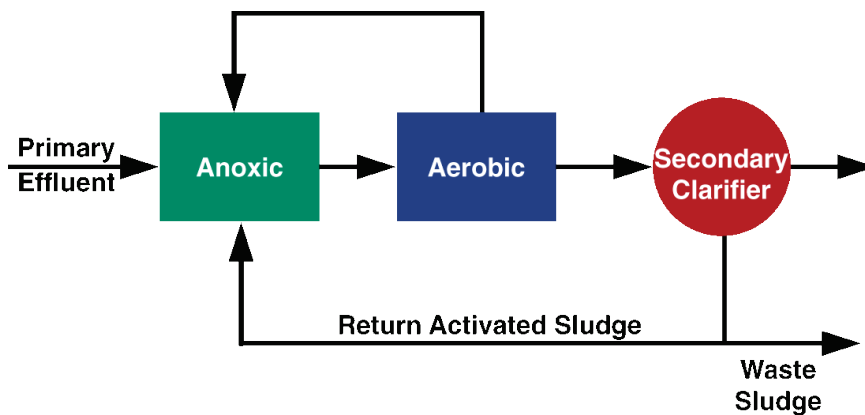


Figure 3-15. Schematic of MLE Treatment Process

Anaerobic/Anoxic/Oxic (A2O) Process Analysis

The A2O process consists of an anaerobic zone, an anoxic zone, and then an aerobic (aeration) zone (Figure 3-16). The anaerobic zone functions as a biological selector to favor organisms that take up orthophosphate in excess of growth requirements when stressed. The anoxic zone allows denitrification of nitrate to nitrogen gas. The return flow from the end of the aerobic zone is introduced in this zone.

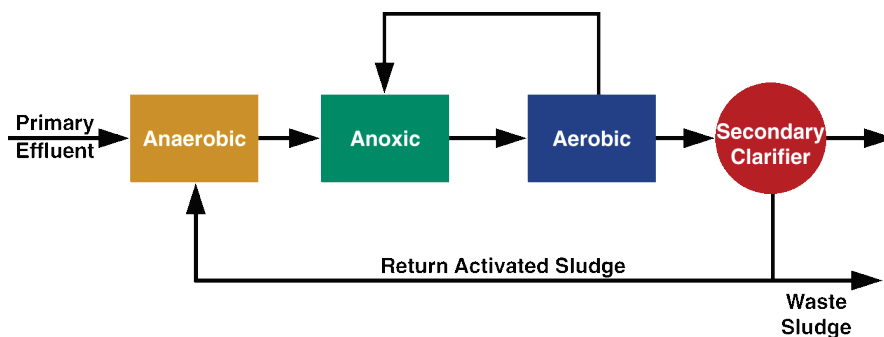


Figure 3-16. Schematic of A2O Treatment Process

The A2O process was used as the basis for achieving Tier 2 effluent quality, but only facilities of a certain size. Specifically, the A2O process can only meet Tier 2 effluent quality requirements for facilities 5 mgd and smaller (without side stream flows from the sludge digestion process) and only if an additional carbon source (i.e., methanol) is used. For WWTFs larger than 5 mgd (those assumed to have anaerobic digestion and side stream flows), the A2O process cannot meet the Tier 2 effluent quality requirements; for these facilities a 5-stage Bardenpho process is required.

Five Stage Bardenpho Process Analysis

The 5-stage Bardenpho configuration is considered common biological nutrient removal (BNR) treatment consisting of an anaerobic zone and alternating anoxic and aerobic zones (Figure 3-17). The five-stage Bardenpho process is used when both TP and TN removal is required. Carbon removal, nitrification, and phosphorus uptake occur with phosphorus release occurring in the anaerobic zone. Denitrification and some carbon removal take place in the anoxic zone. In the Bardenpho process, nitrate must not be introduced to the anaerobic zone because nitrates consume the volatile fatty acids needed for phosphorus removal.

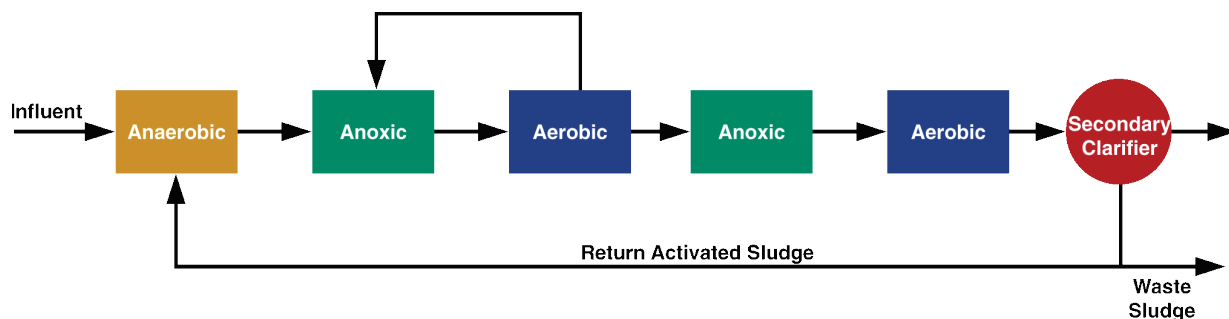


Figure 3-17. Schematic of 5-Stage Bardenpho Treatment Process

A five stage Bardenpho process removes a significant amount of nitrate and can be effective for all effluent quality tiers with progressive amounts of chemical addition for each progressively more stringent tier. The difference between tiers is the facility/tank sizing to accommodate the growth of methylotrophs and the generation of chemical solids. This Study relied on the five-stage Bardenpho process to treat wastewater to meet the Tier 2 effluent limits for facilities with capacities greater than 5 mgd and meet the Tier 3 effluent limits in all flow bins.

Selection of Process for Modeling

Summarizing the discussion above, the process modeling completed for this Study relied on the following processes to achieve the three effluent quality tiers:

- Tier 1 Effluent Quality – MLE process used for all facilities and all flow bins.
- Tier 2 Effluent Quality (flow bins up to 5 mgd) – A2O process used for facilities with aerobic digestion.
- Tier 2 Effluent Quality (flow bins greater than 5 mgd) – Five-stage Bardenpho process used for facilities with anaerobic digestion
- Tier 3 Effluent Quality – Five-stage Bardenpho process followed by reverse osmosis (RO) and deep well injection used for all facilities and all flow bins (Note: The RO process was not modeled for this Study). Brine disposal is required for this process.

The Category 1 facility model was modified to provide additional treatment units or add capacity to existing units until the model resulted in an effluent quality that complies with the effluent limits associated

with each of the three tiers. In total, 18 process modifications were made to the original 6 baseline models (a total of 24 BioWin process models were developed) as indicated below.

- Six base models (Category 1), which reflect the assumed existing conditions
- Six models based on the MLE process were developed for Tier 1 – one for each of the six flow bins
- Three models based on the A2O process were developed for Tier 2 (flow bins 1, 2, and 3)
- Three models based on the 5 stage Bardenpho process were developed for Tier 3 (flow bins 4, 5, and 6)
- Six models based on the MLE process were developed for Tier 3 facilities

Figures 3-18 through 3-23 show the process models developed using BioWin.

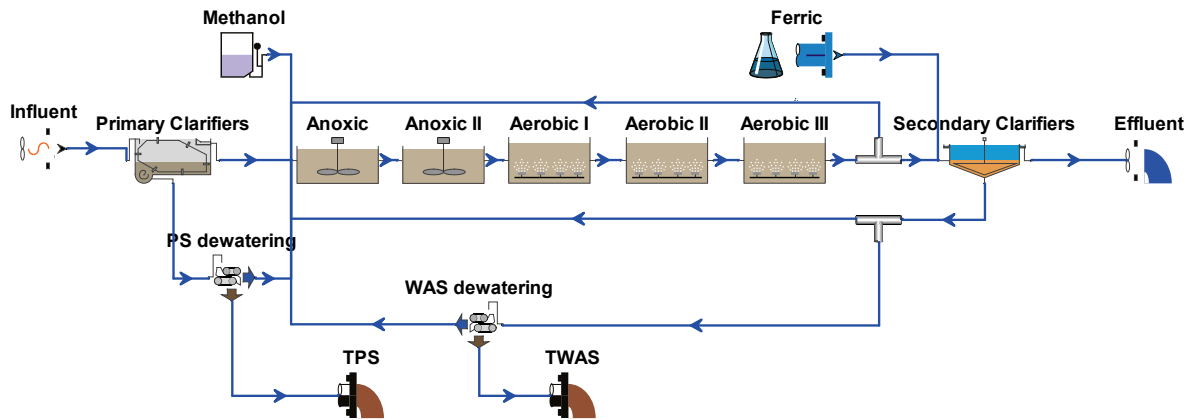


Figure 3-18. BioWin < 5 mgd Category 1 Process Flow Diagram for Tier 1

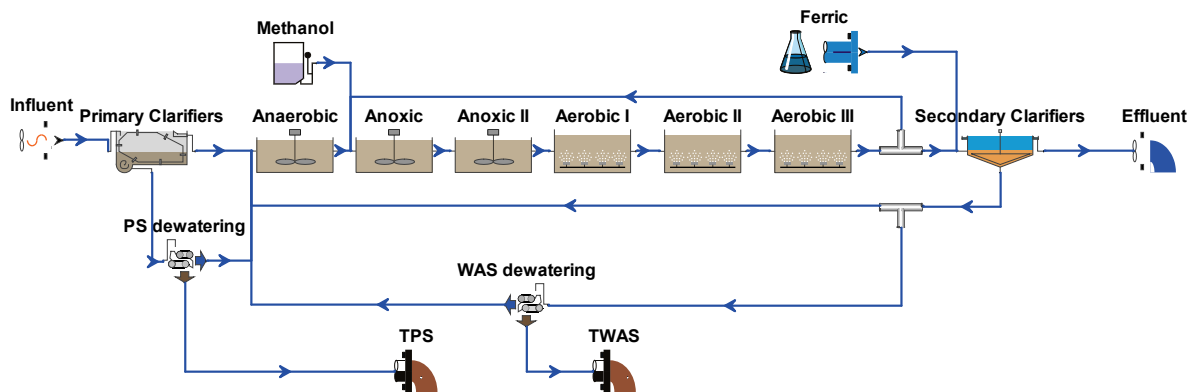


Figure 3-19. BioWin < 5 mgd Category 1 Process Flow Diagram for Tier 2

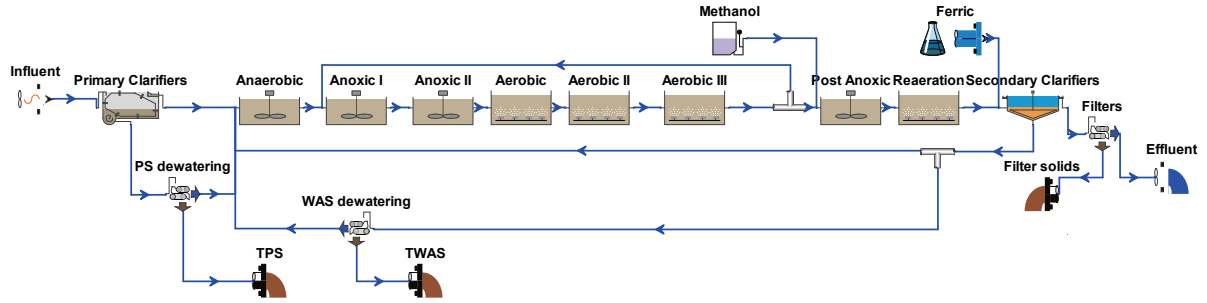


Figure 3-20. BioWin < 5 mgd Process Flow Diagram for Tier 3

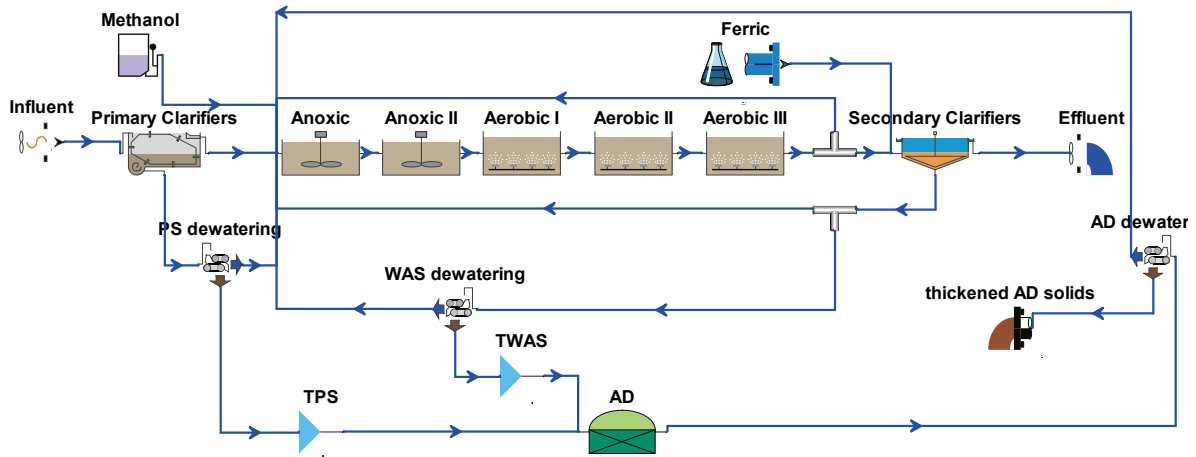


Figure 3-21. BioWin ≥ 5 mgd Process Flow Diagram for Tier 1

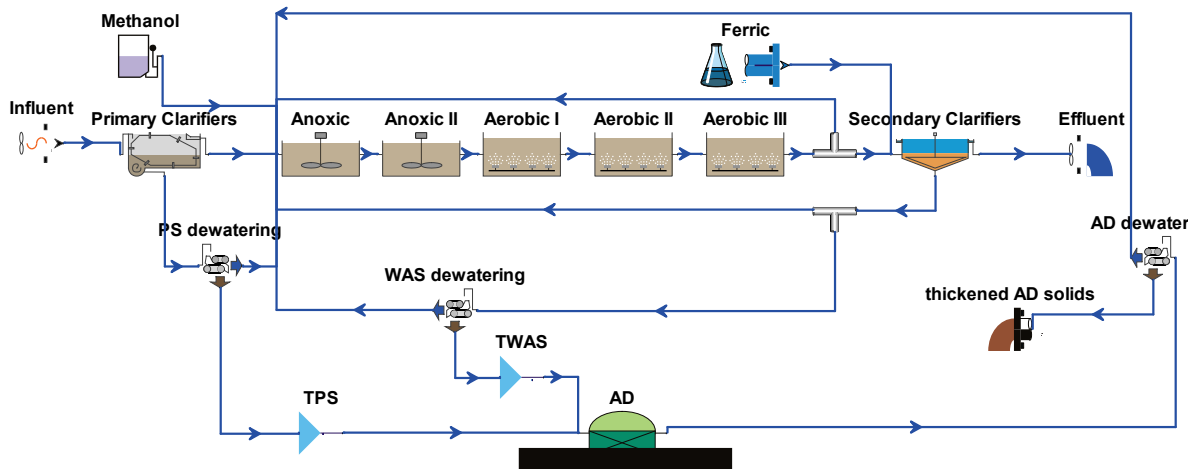


Figure 3-22. BioWin #5 mgd Process Flow Diagram for Tier 2

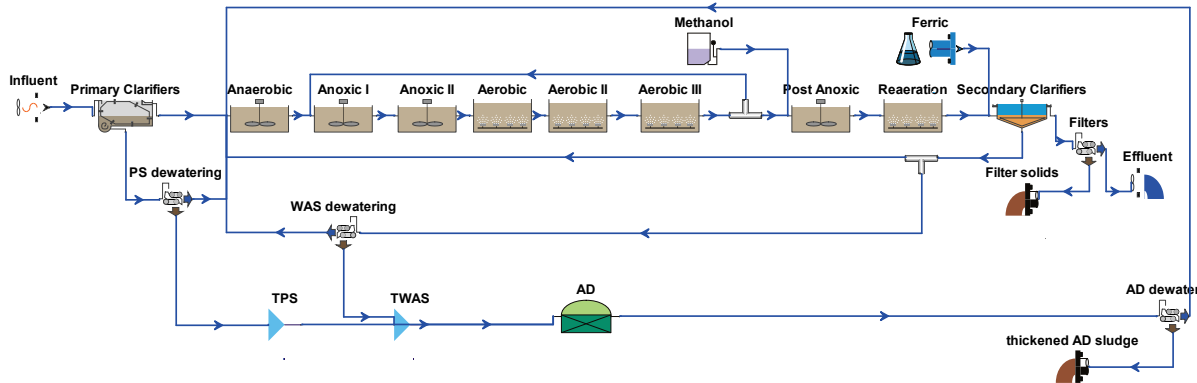


Figure 3-23. BioWin #5 mgd Process Flow Diagram for Tier 3

The model output provides the required improvements to achieve the nutrient limits within each effluent quality tier (Table 3-15).

Table 3-15. Model Output by Flow Bin for Process Unit Sizing

Model Output - 1 mgd	Baseline	MLE (Tier 1)	A2O (Tier 2)	Bardenpho (Tier 3)
Total primary clarifier surface area, ft ²	667	667	667	667
Total process (bioreactor) volume, MG	0.49	0.8	0.99	1.35
Total secondary clarifier surface area, ft ²	3,054	3,054	3,054	3,054
Effluent Total Nitrogen, mg/L N	41	12.8	10	4.2
Effluent Total Inorganic Nitrogen, mg/L N	39	9.7	6.9	1.2
Effluent Total Phosphorus, mg/L P	2.3	0.8	0.5	0.4
Ferric Chloride, gpd	0	40	0	125
Methanol, gpd	0	30	80	150
Model Output - 3 mgd	Baseline	MLE (Tier 1)	A2O (Tier 2)	Bardenpho (Tier 3)
Total primary clarifier surface area, ft ²	2,000	2,000	2,000	2,000
Total process (bioreactor) volume, MG	1.46	2.57	2.97	3.37
Total secondary clarifier surface area, ft ²	9,995	9,995	9,995	9,995
Effluent Total Nitrogen, mg/L N	40	10	10.1	6
Effluent Total Inorganic Nitrogen, mg/L N	37	6.9	6.9	3.3
Effluent Total Phosphorus, mg/L P	2.3	0.9	0.5	0.4
Ferric Chloride, gpd	0	100	0	50
Methanol, gpd	0	200	250	200
Model Output - 5 mgd	Baseline	MLE (Tier 1)	No Facilities in Study	Bardenpho (Tiers 2 and 3)
Total primary clarifier surface area, ft ²	6,667	6,667	NA	6,667
Total process (bioreactor) volume, MG	2.78	5.11	NA	7.92
Total secondary clarifier surface area, ft ²	15,843	15,843	NA	15,843
Anaerobic Digester Volume, MG	0.4	0.4	NA	0.4
Effluent Total Nitrogen, mg/L N	44	10.6	NA	6.7
Effluent Total Inorganic Nitrogen, mg/L N	41	7.5	NA	3.9
Effluent Total Phosphorus, mg/L P	3.6	1.1	NA	0.7
Ferric Chloride, gpd	0	300	NA	200
Methanol, gpd	0	300	NA	475
Thickened Primary Solids, lbs/day	7,128	7,128	NA	7,128
Thickened WAS, lbs/day	5,222	6,369	NA	6,629
Thickened digested solids, lbs/day	7,106	7,988	NA	8,385

Table 3-15. Model Output by Flow Bin for Process Unit Sizing

Model Output - 10 mgd	Baseline	MLE (Tier 1)	No Facilities in Study	Bardenpho (Tiers 2 and 3)
Total primary clarifier surface area, ft ²	6,667	6,667	NA	6,667
Total process (bioreactor) volume, MG	5.54	10.18	NA	13.77
Total secondary clarifier surface area, ft ²	31,161	31,161	NA	31,161
Anaerobic Digester Volume, MG	0.5	0.5	NA	0.5
Effluent Total Nitrogen, mg/L N	44	12.1	NA	6.3
Effluent Total Inorganic Nitrogen, mg/L N	41	9	NA	3.5
Effluent Total Phosphorus, mg/L P	3.6	0.8	NA	0.7
Ferric Chloride, gpd	0	700	NA	400
Methanol, gpd	0	450	NA	1000
Thickened Primary Solids, lbs/day	14,259	14,259	NA	14,259
Thickened WAS, lbs/day	10,268	12,592	NA	13,279
Thickened digested solids, lbs/day	13,946	16,337	NA	16,622

Note: To achieve Tier 3, additional treatment using reverse osmosis or similar membrane filtration is required. Biowin modeling does not include this additional treatment.

3.4.3.2 Categories 2 through 6 Process Improvements

To develop process needs for the Category 2 through 6 facilities, the Category 1 base model was adjusted by making assumptions regarding process available capacity and ability of unit processes to achieve nutrient removal to meet the three effluent quality tiers. Table 3-16 provides the assumptions used in the development of these models.

Table 3-16. Assumptions Used to Determine Process Improvements for Categories 2 through 6

Category	Assumptions
2: First Generation Fixed Film	Require replacement with activated sludge (Category 1) process with secondary clarifiers
3: Second Generation Fixed Film	Have primary clarifiers Have 50% of the necessary aerobic process capacity for carbon oxidation and nitrification Secondary clarifiers have 50% of the necessary capacity
4: Lagoons	Require replacement with activated sludge (Category 1) facility
5: SBRs	Have primary clarifiers Require chemical feed and sequencing modification for Tier 1 and Tier 2 Require replacement and RO for Tier 3
6: Oxidation Ditches	Have 75% of the necessary aerobic process capacity for carbon oxidation and nitrification Secondary clarifiers have 75% of the necessary capacity

Modification to some lagoon facilities may allow them to meet the Tier 1 effluent limits, but it is unlikely that modification to a standard lagoon system will allow the WWTF to consistently meet the Tier 2 requirements and will not allow the WWTF to achieve Tier 3 effluent quality. Appendix B-3 provides the process improvements required for each category and flow bin to achieve the limits in each effluent quality tier.

3.4.3.3 Use of Emerging or Innovative Technologies

The wastewater treatment market is constantly changing with new technologies, chemicals, and polymers being introduced. The MLE, A2O, and 5-stage Bardenpho processes, upon which the costs for this Study are based, are considered conventional and accepted treatment technologies. However, many different conventional and emerging or innovative technologies and chemicals can be used at any given facility to achieve the effluent quality limits for each tier. The purpose of this Study is to estimate a statewide cost and not a facility specific cost. Because on a statewide basis it is not possible to determine if a new technology or approach is applicable to each WWTF, a more conservative technical application was required. For example, a facility may find that BioMag™ technology can achieve the effluent quality limits using a small

footprint. BioMag™ technology uses magnetite to ballast the biological floc and help it settle quickly and effectively. This provides the ability to increase the MLSS concentration and reduce the treatment tank sizes required. While this may provide facilities with a more cost effective solution, it may not be applicable to all facilities statewide. As a consequence, this Study relied on more conventional processes for developing costs.

3.4.4 Step 4: Calculate Capital Costs

The purpose of this step is to calculate the capital cost for the improvements identified in Step 3. The output of this step is the total capital cost for WWTF improvements for each flow bin within each Manageable Unit. These results are used in conjunction with the Step 6 results to determine the 20-year present worth, which are compared with the potential benefits (as discussed below in Section 3.6).

The project team obtained cost data for WWTF improvements from CDM's national cost database and existing reports and similar studies. These costs were updated to 2010 dollars using Engineering News Record (ENR) cost indices. The data from these sources varied considerably in detail and applicability to this Study. However, the data is useful for identifying trends and general applicability of unit cost factor assumptions. A summary of the cost data sources is provided in Appendix B-5.

Cost Calculations

To determine the cost associated with the implementation of WWTF improvements to achieve the effluent quality in each tier for each facility category, the project team developed a spreadsheet of the required improvements based on the process model outputs (Appendices B-3, B-5). The cost is calculated for the additional facilities that must be added to the base "typical" facility to achieve the effluent quality for each tier. This required three cost calculations:

- Unit cost (cost per gallon treated) to upgrade from the base facility to a facility that can achieve Tier 1 effluent limits.
- Unit cost (cost per gallon treated) to upgrade from the base facility to a facility that can achieve Tier 2 effluent limits.
- Unit cost (cost per gallon treated) to upgrade from the base facility to a facility that can achieve Tier 3 effluent limits.

This Study did not develop unit costs for other combinations of improvements, e.g., to move a facility from Tier 1 to Tier 2, Tier 1 to Tier 3, or Tier 2 to Tier 3. The analysis assumed that implementation of the described treatment technologies and addition of chemicals would not result in the need for other capital improvements to comply with other water quality regulations. That is, this analysis assumes the resulting WWTF would be in compliance with its permit requirements.

Cost Assumptions

The cost development to move from base facility to each effluent tier is based on one-time expenditure in 2010 dollars for capital improvements. Table 3-17 presents the key cost assumptions used in costs developed for each tier, category, and major process component.

Hydraulic improvements will likely be required at individual treatment facilities, but it is not possible to identify and cost these improvements in a statewide study. To provide for hydraulic improvements, an allowance was added to each capital cost:

- Tier 1 – Allowance is equivalent to the cost of a pump station able to pump the ADF of the WWTF

- Tier 2 – Allowance is increased to the cost of a pump station able to pump 105 percent of the ADF of the WWTF
- Tier 3 – Allowance is increased to the cost of a pump station able to pump 115 percent of the ADF of the WWTF

Table 3-17. Key Cost Assumptions – Capital and Annual O&M

Assumption	Comment or Impact
Hydraulic allowance of 100% ADF for Tier 1, 105% for Tier 2, and 115% for Tier 3	Allowance provides for adjustments to accommodate new facilities. Not all WWTFs will need hydraulic changes.
Factored costs increase in percent with increased complexity of WWTF	N/A
Land cost is 2 percent of capital cost	Land costs vary greatly throughout the state. Some facilities will have adequate land while others will need to purchase. There may be some facilities for which land purchase is not an option, but this has not been detailed in the cost development and would require more in-depth analysis.
Factored cost of 25% is applied to capital for engineering, legal and administrative costs	The factored cost is intended to covered non-capital related items. These will vary greatly depending upon the complexity of the WWTF and existing condition. This cost includes permitting.
RO treatment cost is for half the WWTF flow	It is assumed that the effluent limits can be met with treating half the flow through RO then blending with the remaining flow.
Brine disposal cost is 10 times RO facility cost	Significant variation in cost for brine disposal is expected. Without site specific information, it is not possible to estimate this cost with any accuracy.
Facilities with existing control regulations have adequate chemical feed and sludge processing capacity for TP removal	The secondary clarifier, ferric chloride, and sludge processing costs are reduced to account for the existing treatment at the plants. No staffing changes are made, but chemical feed and electrical annual costs are reduced.
Repair and replacement costs are 1% of capital cost annually	These costs are intended to provide replacement and preventative maintenance of the new equipment and facilities provided to achieve the limits within each effluent quality tier. Maintenance of existing equipment is not included.
Training costs are applied to all employees – new and existing – and increase with each effluent quality tier	Not all employees will receive training. The costs are applied to all positions (administrative, operations, maintenance, groundskeeping, and laboratory) and are intended to be in excess of existing annual training budgets. As the treatment becomes more complex (moving from Tier 1 to Tier 3) the annual training budget increases per employee. It is assumed new employees will already be qualified for the position but will receive additional training annually.
Labor costs are based upon the staffing required if the WWTFs operated at 100% capacity. Electrical and chemical costs are based upon the WWTFs operating at 75% of the facility's capacity.	The Division requires plans be in place for WWTFs expansion when a facility reaches 75% of its rated capacity, so this factor was applied to the chemical and electrical costs.

The estimated pump station requirement is based upon engineering judgment and not a detailed study or analysis. Some facilities may not require any hydraulic improvements and others may require significant improvements. The provided allowances are intended to capture this cost element in the overall cost. Each WWTF would need to review its respective hydraulic profile to determine if hydraulic modifications would be required as part of a facility upgrade.

In addition to the process unit costs, other components of treatment facilities will require modification as part of WWTF improvements. To capture these costs, the capital cost estimate includes allowances for each component. Table 3-18 provides the allowance assumptions, which are based upon CDM's internal cost database and cost development protocol.

The level of accuracy for construction cost estimates varies depending on the level of detail to which the project has been defined. Feasibility studies and master plans represent the lowest level of accuracy, while

pre-bid estimates based on detailed plans and specifications represent the highest level of accuracy. Table 3-19 summarizes estimating guidelines developed by the American Associate of Cost Engineers.

Table 3-18. Allowances for Non-Process Components

Item	Percentage Increase to Capital Cost		
	Tier 1	Tier 2	Tier 3
Site Work, Capacity 0 to 1 mgd	10%	10%	10%
Site Work, Capacity 1 to 5 mgd	8%	8%	8%
Site Work, Capacity 5 to 10 mgd	6%	6%	6%
Site Work, Capacity >10 mgd	5%	5%	5%
Yard Piping	5%	6%	10%
Electrical	5%	7%	10%
Controls and Instrumentation	5%	7%	15%
Miscellaneous Repair and Maintenance Cost	2%	2%	2%
Maintaining WWTF during Construction	1%	2%	3%
Land Acquisition	2%	2%	2%

Table 3-19. Cost Estimate Guidelines

Type of Estimate	Anticipated Accuracy
Order of magnitude (Facility and Master Plan)	+50% to -30%
Budget Estimates (Pre-design Reports)	+30% to -15%
Definitive Estimate (Pre-bid)	+15% to -5%

The opinions of probable cost presented in this report are considered the order of magnitude level of accuracy, and were developed to facilitate a comparison of costs. Cost estimates were developed based on recent and historical construction cost data. The opinion of cost includes allowances for engineering, administration, and legal (25 percent of capital cost).

For each effluent quality tier and each treatment category, this Study developed an overall cost per gallon (including contingency, engineering, legal, administration, and land acquisition, referred to as "engineering in Table 3-20). Table 3-20 summarizes the outcome from these analyses.

Table 3-20. Capital Cost per Gallon for Tiers 1, 2, and 3 by Category and Flow Bin

Category and Flow Bin	Cost/Gallon (w/land & engineering included)		
	Tier 1	Tier 2	Tier 3
Category 1, Bin 0 to 0.5 mgd	\$3.61	\$4.39	\$50.92
Category 1, Bin >0.5 to 1.0 mgd	\$2.46	\$3.27	\$47.46
Category 1, Bin >1.0 to 3.0 mgd	\$1.99	\$2.51	\$40.14
Category 1, Bin >3.0 to 5.0 mgd	\$2.26	\$6.98	\$41.38
Category 1, Bin >5.0 to 10.0 mgd	\$2.08	\$5.79	\$33.66
Category 1, Bin >10.0 mgd	\$1.93	\$5.79	\$34.33
Category 2, Bin 0 to 0.5 mgd	\$11.03	\$12.23	\$58.44
Category 2, Bin >0.5 to 1.0 mgd	\$8.56	\$10.21	\$52.85
Category 2, Bin >1.0 to 3.0 mgd	\$6.58	\$7.79	\$43.56
Category 2, Bin >3.0 to 5.0 mgd	\$7.19	\$15.28	\$47.51
Category 2, Bin >5.0 to 10.0 mgd	\$6.41	\$15.71	\$41.65
Category 2, Bin >10.0 mgd	\$6.19	\$15.71	\$41.65
Category 3, Bin 0 to 0.5 mgd	\$5.83	\$6.69	\$53.75
Category 3, Bin >0.5 to 1.0 mgd	\$4.47	\$5.37	\$49.59
Category 3, Bin >1.0 to 3.0 mgd	\$3.68	\$4.51	\$41.60
Category 3, Bin >3.0 to 5.0 mgd	\$4.05	\$9.17	\$42.50
Category 3, Bin >5.0 to 10.0 mgd	\$3.74	\$7.67	\$34.54
Category 3, Bin >10.0 mgd	\$3.47	\$7.67	\$34.78
Category 4, Bin 0 to 0.5 mgd	\$11.03	\$12.23	\$58.44
Category 4, Bin >0.5 to 1.0 mgd	\$8.56	\$10.21	\$52.85
Category 4, Bin >1.0 to 3.0 mgd	\$6.58	\$7.79	\$43.56

Table 3-20. Capital Cost per Gallon for Tiers 1, 2, and 3 by Category and Flow Bin

Category and Flow Bin	Cost/Gallon (w/land & engineering included)		
	Tier 1	Tier 2	Tier 3
Category 4, Bin >3.0 to 5.0 mgd	\$7.15	\$15.26	\$47.51
Category 4, Bin >5.0 to 10.0 mgd	\$6.41	\$15.85	\$41.53
Category 4, Bin >10.0 mgd	\$6.19	\$15.85	\$41.53
Category 5, Bin 0 to 0.5 mgd	\$6.23	\$12.23	\$58.44
Category 5, Bin >0.5 to 1.0 mgd	\$4.07	\$10.21	\$52.85
Category 5, Bin >1.0 to 3.0 mgd	\$2.23	\$7.79	\$43.56
Category 5, Bin >3.0 to 5.0 mgd	\$2.04	\$15.28	\$47.51
Category 5, Bin >5.0 to 10.0 mgd	\$1.59	\$15.85	\$41.53
Category 5, Bin >10.0 mgd	\$1.21	\$15.85	\$41.53
Category 6, Bin 0 to 0.5 mgd	\$4.74	\$5.66	\$53.44
Category 6, Bin >0.5 to 6.0 mgd	\$3.54	\$4.40	\$49.28
Category 6, Bin >6.0 to 3.0 mgd	\$3.50	\$4.32	\$41.38
Category 6, Bin >3.0 to 5.0 mgd	\$3.90	\$9.03	\$42.34
Category 6, Bin >5.0 to 10.0 mgd	\$3.64	\$7.56	\$34.41

3.4.5 Step 5: Confirm and Validate Capital Costs

Validation of the estimated capital cost is critical to confirm that the costs are within the acceptable level of accuracy for planning purposes. To help validate costs, the project team reviewed reports and studies from around the United States and individual facility cost estimates (see Appendix B-6 for a list of validation references). Comparing cost estimates from others with the findings of this Study requires caution. In many cases, the reported costs from other studies includes facility specific requirements and improvements or is not detailed enough to determine which cost elements were included. The target treatment levels also vary depending upon the location or state specific requirements. Therefore, to the extent possible, we grouped the costs obtained from other studies into one of the proposed effluent quality tiers before using them for comparative purposes. Figure 3-24 presents a comparison of the calculated costs and unit costs from various studies (brought to 2010 dollars using ENR indices).

In addition to the above information, where available, data from individual Colorado facilities were used as part of the validation process. This data supports the Tier 1 and Tier 2 unit costs but does not support the Tier 3 developed costs. This is likely due to the limited number of facilities that have treat to the same limits as Tier 3 (and therefore limited actual cost information) coupled with the assumptions associated with brine disposal for the RO components required in Tier 3. For this Study a general disposal assumption was required for the "typical" facility. For this Study, brine disposal was assumed by deep well. The method and cost for brine disposal will vary significantly throughout the state. Some areas will not be suitable for deep well. It may be more cost effective to dry and landfill the brine. More detailed assumptions for brine disposal cannot be made at this time due to the significant variations in disposal locations and geotechnical conditions around the State. Individual facilities may have other options that are less costly.

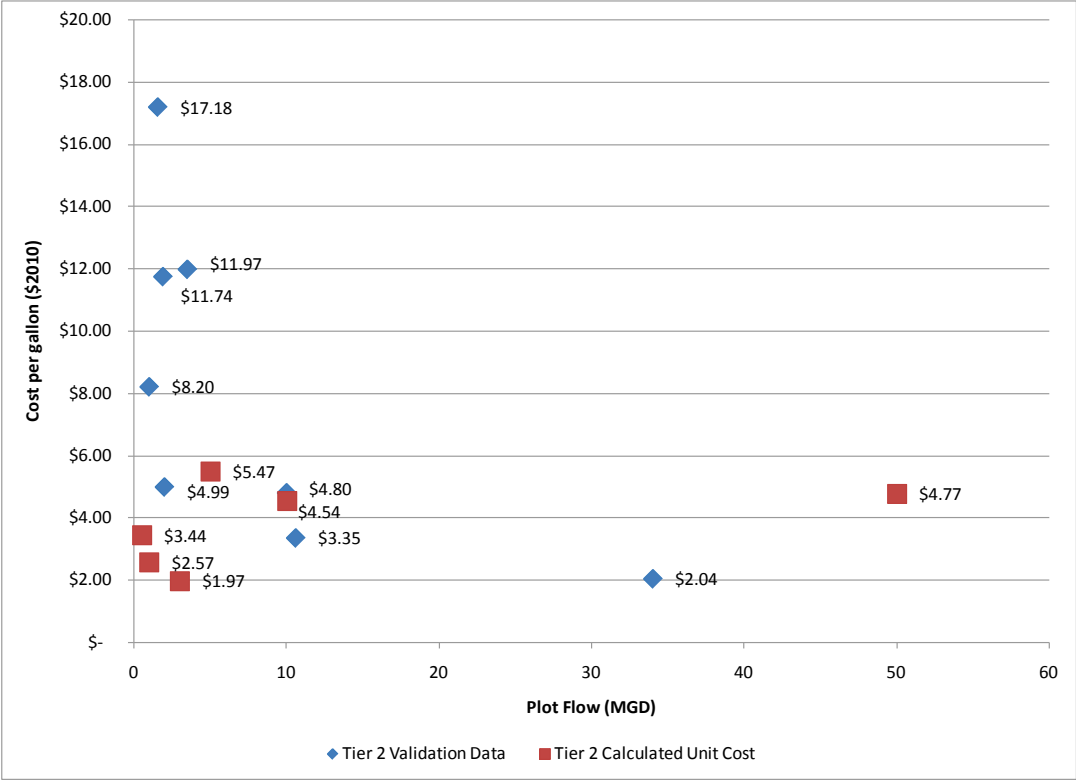
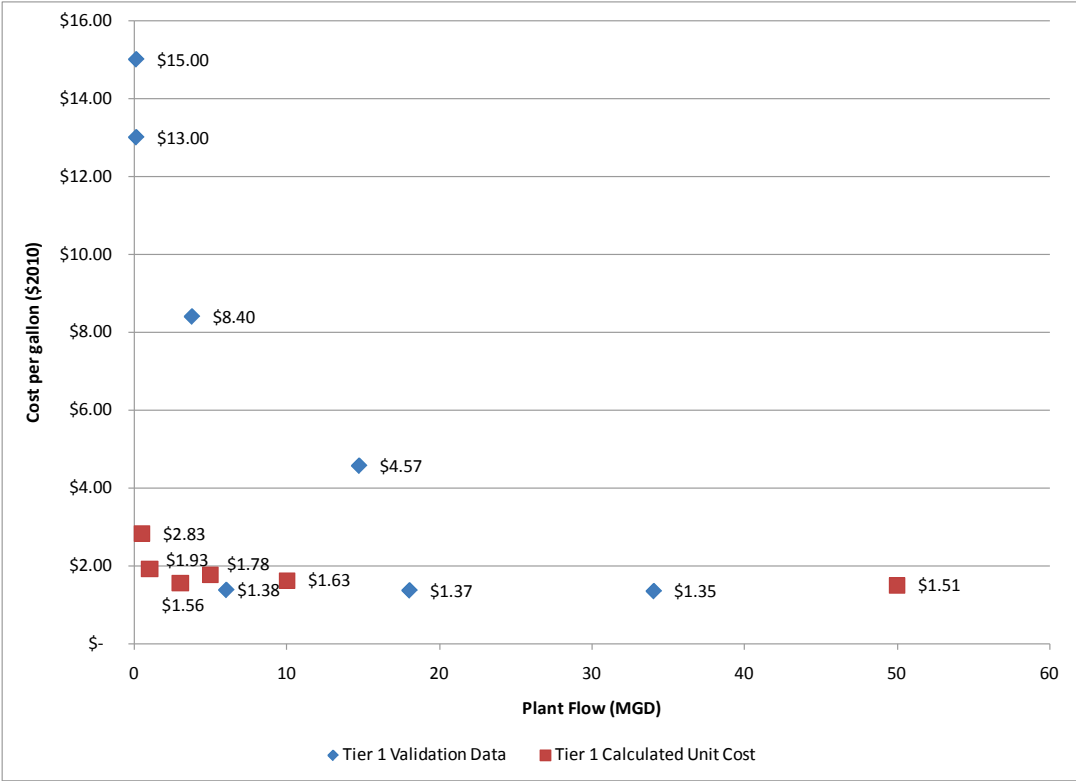


Figure 3-24. Comparison of Calculated Costs and Unit Costs from Various Studies

Available data included:

- For Littleton/Englewood facility, Brown and Caldwell estimated the costs for improvements required for Tier 1 compliance at \$46M, Tier 2 at \$69.3M, and Tier 3 at \$321.1M. The capital costs (not including engineering, administration, legal and land) equate to approximately \$1.35 per gallon for Tier 1, \$2.04 per gallon for Tier 2, and \$9.44 per gallon for Tier 3. This Study's equivalent costs are: \$1.54 for Tier 1, \$4.54 for Tier 2 and \$26.93 for Tier 3.
- A facility specific study for the Town of Greeley estimates the cost for compliance for effluent limits close to Tier 3 at \$63M. This independent study used \$1.50 per gallon for RO and \$1.50 per gallon for brine disposal. The capital cost estimated for this Study was based on \$2.50 per gallon for RO and ten times the RO cost for brine disposal, or \$25 per gallon. The facility specific Greeley cost estimate results in a Tier 3 cost ranging between \$4.30 and \$4.60 per gallon, while this state-wide approach results in a cost of \$26.93 per gallon. The biggest cost difference appears to be associated with the brine disposal.
- The capital estimates for Metro Wastewater Reclamation District (MWRD) include the costs to modify the WWTF following the current improvement projects. The current projects will allow the WWTF to meet the Tier 1 TIN requirements. The costs (including estimated cost of \$194M for current improvements that are part of the nutrient removal process) are slightly lower than estimated through this Study. The MWRD costs for improvements to meet the Tier 1 phosphorus limits are approximately \$1.01 per gallon. The costs for meeting the Tier 2 TIN and TP limits are more than \$2.64. The cost for the most stringent treatment estimated for Metro is significantly less than estimated in this Study (over \$8.60 per gallon versus \$26.93 as estimated in this Study) but does not include additional land or transfer pumping and conveyance to and from the facilities located on the additional land. The MWRD costs also assume RO concentrate disposal by thermal desalination versus the deep well injection estimate used for the state-wide estimate. The capital costs developed as part of MWRD's facility specific study, and not the unit costs developed in this study, have been used in the Manageable Unit costs.

3.4.6 Step 6: Determine O&M Impacts and Costs

Annual costs (referred to as O&M costs) include labor, chemical, electrical, and repair and replacement. For this Study, the project team developed O&M costs for a one-year period and then assumed these costs would be the same throughout the planning period. Each key O&M cost element is discussed below along with assumptions made to determine the O&M cost element. The O&M costs presented represent the difference in cost from the base "typical" facility to the facility required to meet the effluent limits in each tier.

3.4.6.1 Labor Costs

The highest annual cost to WWTFs is typically labor. The project team used EPA's Estimating Staffing for Municipal Wastewater Treatment Facilities (EPA 1973), to estimate the annual labor hours for the "typical" base facility. This guidance provides a series of graphs based upon process units and flow. The total operations and total maintenance hours per year were obtained from the graphic, and then totaled to estimate the equivalent man-hours per year for each process unit. These man-hours include all labor activities including administration, clerical, landscape/site maintenance, and laboratory testing.

For each treatment category, the O&M labor hours were calculated for the base "typical" facility and the facility required for compliance with each effluent quality tier. The difference between each tier and the base was then used as the additional O&M hours required. For lagoon facilities, the existing labor was

based upon responses to the survey, which generally indicated less than one full time equivalent is required for the lagoon O&M.

The total labor hours estimated for each category were converted to full time equivalent personnel by dividing the hours by 1050 hours per year, which represents the actual hours that an employee is at the WWTF and does not include vacation, sick and holiday time. To determine the labor cost, the number of full time equivalents was multiplied by an annual cost of \$105,000 per year. The annual cost of \$105,000 includes paid time for sick, holiday, and vacation and includes all fringe benefits. For purposes of this Study, the cost of labor for various job activities was not estimated separately – a single labor cost per year regardless of labor category was used.

Sixty-one percent of the survey responders indicated that they would need to provide additional training for existing employees if they had to add process elements or if the overall process operation was more complex due to nutrient removal requirements. Participants in the stakeholder workshops also indicated the need for O&M training to operate more complex facilities and to provide additional reporting. For this reason, training costs were included in the overall labor cost development. The training costs were applied to all employees (base plus additional employees, all labor categories) for each effluent quality tier:

- Tier 1 training costs are \$500 per employee per year
- Tier 2 training costs are \$1500 per employee per year
- Tier 3 training costs are \$3000 per employee per year

In addition to the above, for Category 4, Tier 1 and Tier 2 training, an additional \$1000 per employee per year was added since it was assumed these operators would be not familiar with mechanical plant operations.

3.4.6.2 Chemical Costs

Chemical needs at WWTFs include additional carbon source (methanol was used for the process modeling) and ferric chloride. Chemicals for disinfection were assumed to not change from the base and therefore no additional chemical costs were included for this component. Some additional costs for sludge processing are likely, but were not individually determined. The BioWin model results provided an estimated of the additional methanol and ferric chloride chemical demand associated with achieving each effluent quality tier.

The cost of chemicals varies considerably across the state making determination of a single chemical cost difficult. For methanol and ferric chloride, the statewide cost assumption was \$1.80 per gallon. Individual facilities would need to adjust cost based upon local market conditions and availability; other chemicals may be more economical on an individual facility basis.

3.4.6.3 Electrical Costs

Electrical costs can make up a large portion of facility annual costs. The major components of electrical costs are assumed to be larger motors associated with blowers and pumps. The unit processes identified in the capital cost development served as the basis for estimating the additional power required to achieve each tier of effluent quality. For each tier and category, an estimate of required increases in total motor horsepower was made based upon the unit process changes identified through process modeling (i.e., new clarifiers, new anoxic and anaerobic zones that require mixing, pumping). Each new piece of motorized equipment was assigned a typical horsepower. For example, the motor horsepower for clarifiers was assumed as 0.5 horsepower per clarifier motor.

A statewide unit electrical cost of \$0.083 per kilowatt hour (kWh) was applied to the total increase in power usage over the base typical WWTF. This unit cost factor was obtained from the State of Colorado and

is an average of public and private utility company costs based on a mix of energy generation types (coal, natural gas, renewable energy, etc.). During the stakeholder workshops, participants asked if this unit cost considered surcharges typically applied to large users, as these surcharges can become a major component of a WWTF's electrical bill. The unit costs provided by the State are listed as all inclusive, so therefore include a surcharge value.

Some facilities may have costs per kWh that are higher than this value. However, many of the smaller facilities or simple facilities with limited power consumption (like lagoons) will not have excessive surcharges and likely lower costs per kWh. Some facilities have their own power system (e.g., Colorado Springs) or have agreements with other power providers that keep costs well below this statewide average. For example, the City of Longmont pays only \$0.023/kWh and a demand charge of \$18.80, averaging well below the \$0.083 state-wide number. Another Front Range entity, who requested anonymity for this Study, has an average annual cost per kWh inclusive of demand charges of \$0.066/kWh. Holy Cross Energy confirmed their industrial cost per kWh inclusive of demand is \$0.0777. Centennial has an average power cost of \$0.064 including demand. The costs provided are based on 2010 energy costs. Centennial noted that their energy costs are projected to increase significantly over the next 10 years, supporting the need to use an electrical cost that is higher than currently occurring. Based upon these comparisons, the statewide assumption of \$0.083 is considered reasonable.

3.4.6.4 Repair and Replacement

Facility repair and replacement costs vary considerably depending upon the individual facility's equipment selection and maintenance practices. For this Study, repair and replacement was assumed at one percent of the new facility capital cost and was applied annually. This is a typical method for estimating repair and replacement costs in planning studies where facility-specific details are not available. This annual cost is intended to cover the repair and replacement of the new process units and equipment such as pumps, piping and valves. Existing equipment repair and replacement was not considered an additional cost in this Study and, therefore, has not been included in the cost estimate.

3.4.7 Step 7: Total Present Worth Costs

Present worth is used to economically compare alternatives by converting cash flows to a common point, the present (2010). Future cash flows (such as annual costs) are discounted to the present and summed with the present worth of the capital costs. Section 3.6.4 below provides the method for developing present worth costs.

3.4.8 Greenhouse Gas Emission Inventory

The Division requested that changes in GHG emissions resulting from the implementation of the nutrient limits be evaluated as part of this Study. The wastewater industry contributes to GHG emissions primarily through combustion of fuels from mobile and stationary sources, through consumption of electricity, and from fugitive and process emissions unique to wastewater treatment. In this Study, there were several changes in emissions that were analyzed according to the type of treatment required to comply with the effluent quality requirements of each tier. This included changes in energy consumption of treatment processes; changes in chemical consumption; changes in biosolids production; reduction of nutrient loads discharged to receiving waterbodies; and changes in emissions from biosolids hauling, disposal, and related energy consumption. The steps to assess GHG emissions for this Study involve the following:

1. Determine the operational boundaries and list any assumptions.
2. Assess emissions directly or indirectly caused by existing WWTF operations for all treatment category types.

3. Assess emissions directly or indirectly caused by proposed WWTF operations for all treatment category types in Tiers 1, 2, and 3.
4. Discuss results for increase/decrease of emissions as result of proposed nutrient removal criteria.

3.4.8.1 Existing Protocols and Quantification Tools

Currently, with the exception of facilities operating continuous emission monitors, GHG emissions cannot be measured directly. However, various protocols and quantification tools have been established to assess and quantify GHG emissions. Several sources for existing protocols for GHG emissions regarding WWTF operations include:

- LGOP. Local Government Operations Protocol Version 1.1, May 2010. Available at <http://www.theclimaterestry.org/downloads/2010/05/2010-05-06-LGO-1.1.pdf> (Accessed on September 08, 2011).
- IPCC. Guidelines for National Greenhouse Gas Inventories Volume 5 Chapter 6: Waste. Intergovernmental Panel on Climate Change, 2006. Available at <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html> (Accessed on September 08, 2011).
- EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009; Washington, DC, April 2011. EPA 430-R-11-005. Available at http://epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Complete_Report.pdf (Accessed on September 08, 2011).

For most published protocols, GHG emissions are categorized into three categories (Scope 1, Scope 2, and Scope 3) related to an established operational boundary:

- Scope 1 includes direct GHG emissions released from within the operational boundary.
- Scope 2 includes indirect GHG emissions released from outside of the operational boundary that are consequences of the energy purchased by the entity.
- Scope 3 involves optional indirect GHG emissions that are the indirect consequence of the entity's operations. Scope 3 emissions were not included in this Study due to the assumption that all major indirect emissions were accounted for in Scope 2.

The typical procedure for calculating GHG emissions consists of multiplying emission factors by measured activity data parameters. The calculated quantity gives the GHG emitted per unit of activity. The parameters represent measured activities such as BOD loading, vehicle miles driven, electricity consumed, and quantity of fuels combusted. Presently, reporting of process sources (i.e., release of N₂O during treatment process and from effluent discharge, indirect release from aerators, mixers, pumps, and tertiary processes) is not required by any protocols at this time and standard methods for calculating these emissions have not been developed. However, a report titled *Greenhouse Nitrogen Emission from Wastewater Treatment Operations*, to be published by the Water Environment Research Foundation, is currently being written. Once published, more information on quantifying N₂O emissions from biological nutrient removal will be available. Table 3-21 provides the emission factors determined for this Study.

Table 3-21: Emission Factors

Without Nitrification/Denitrification [g N ₂ O/capita/year]	3.2
With Nitrification/Denitrification [g N ₂ O/capita/year]	7.0
N ₂ O Effluent Discharge [kg N ₂ O/kg sewage produced]	0.005
Stationary Combustion of natural gas & petroleum products [kg CO ₂ /gallon]	7.35
Mobile Combustion of gasoline [kg CO ₂ /gallon]	8.78
Mobile Combustion of gasoline [lbs CO ₂ /gallon]	19.4
Stationary Combustion of natural gas & petroleum products [kg CH ₄ /gallon]	0.0015
Mobile Combustion of gasoline [g CH ₄ /mile]	0.0327
Stationary Combustion of natural gas & petroleum products [kg N ₂ O/gallon]	0.001
Mobile Combustion of gasoline [g N ₂ O/mile]	0.0173
Biosolids Land Application [metric ton N ₂ O/metric ton CO ₂ e]	0.01
Metric Ton CO ₂ per kWh [MTCO ₂ e/kWh]	0.0009
Pounds CH ₄ per MWh [lbsCH ₄ /MWh]	0.02288
Pounds N ₂ O per MWh [lbsN ₂ O/MWh]	0.02875

* Data provided by LGO protocol, IPCC Guidelines, and EPA

3.4.8.2 Operational Boundaries

Before beginning to calculate emissions for this Study, the project team established operational boundaries to determine the type of emission sources to be included and the GHGs to be reported for each "typical" WWTF. For this GHG emissions inventory, treatment facilities in categories 1, 3, 5, and 6 were grouped together as were categories 2 and 4. This was due to the similarity of the treatment processes that were applied to achieve the nutrient removal limits of each tier. Note that the GHG emissions associated with increased phosphorus removal and sludge processing were accounted for through increased electricity usage as a part of the Scope 2 emissions. Table 3-22 summarizes the Scope 1 and 2 emission sources for this Study.

Table 3-22. Scope 1 and 2 Emission Sources

GHG Emission Category	Emission Sources Applicable to Study
Scope 1	<p><i>Process Sources:</i> Release of methane (CH₄) and nitrous oxide (N₂O) during treatment process and from effluent discharge. CH₄ emissions from poorly-operated aerobic wastewater treatment systems were not included in this Study. It was assumed that all aerobic WWTFs were well-operated and routinely in compliance with their discharge requirements.</p> <p><i>Stationary Sources:</i> Combustion of natural gas and petroleum products and incomplete combustion of digester gas. It was assumed that there was no generation of power or heat at the WWTFs. Emissions caused by the combustion of natural gas and petroleum products could not be estimated due to the limited amount of information available.</p> <p><i>Mobile Sources:</i> Transporting chemicals to the WWTFs; combustion of gasoline and diesel to fuel vehicle fleet; and combustion of diesel to fuel trucks hauling biosolids to land application. The combustion of biofuels was not taken into account in this Study.</p> <p><i>Fugitive Sources:</i> Biosolids land application, reduction through odor control technologies (chemical scrubbers consume CO₂, biofilters consume CH₄, carbon filters consume CH₄), and ozone from ozone systems. The reduction through odor control technologies and ozone emissions was not quantified in this Study. Fugitive emissions associated with headworks processes, primary treatment, and sludge processes were negligible and therefore not included in this Study.</p>
Scope 2	External electricity purchases. This includes the electricity usage associated with additional pumping, aerators, mixers, and filters for the tertiary process.

From the various sources listed in Table 3-22, the following GHGs will be calculated: carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Due to limited resources, ozone (O₃) will not be included in this Study.

3.4.8.3 Quantifying Emissions

The estimation methodologies (i.e., calculations, equations, etc.) for calculating CO₂, CH₄, and N₂O are described below. As mentioned previously, GHG emissions created from total phosphorus removal are included in Scope 2 emissions. A global warming potential (GWP) value is assigned to the various emissions. GWP is a relative value that indicates how much heat the greenhouse gas traps in the atmosphere (higher value is more heat trapping potential). The GWP for each gas considered is listed with the calculation method.

Carbon Dioxide Emissions

Using the methods provided below, the project team quantified applicable Scope 1 and 2 emissions. For this Study, no Scope 1 emission sources for CO₂ were identified for process or fugitive sources. For stationary and mobile sources the following calculations were used (Note that for all CO₂ emission calculations the GWP is 1):

- *Mobile Source* - Combustion of gasoline and diesel from fuel vehicle fleet, fuel trucks hauling biosolids to land application, and fuel trucks hauling chemicals to WWTFs.

$$\begin{aligned} \text{CO}_2 \text{ Emissions (metric tons CO}_2\text{e)} \\ = (\text{Annual Distance (miles)} \div [\text{City FE (mpg)} \times \text{City}\%]) \div [\text{Hwy FE (mpg)} \times \text{Hwy}\%]) \\ \times \text{EF} \left(\frac{\text{kg CO}_2}{\text{gallon}} \right) \times 10^{-3} \left(\frac{\text{metric ton}}{\text{kg}} \right) \times \text{GWP} \end{aligned}$$

Electricity usage, specifically indirect emissions from electricity use, was included in the calculation of Scope 2 emissions as follows:

$$\text{CO}_2 \text{ Emissions (metric tons CO}_2\text{e)} = \text{Electricity use} \left(\frac{\text{kWh}}{\text{year}} \right) \times \text{EF} \left(\frac{\text{MT CO}_2\text{e}}{\text{kWh}} \right) \times \text{GWP}$$

Methane Emissions

Using the methods provided below, the project team quantified applicable Scope 1 and 2 emissions for methane. For this Study, Scope 1 emission sources included process, stationary, and mobile sources (for all CH₄ emission calculations the GWP is 21):

- *Process Sources* - CH₄ emissions from anaerobic conditions of the WWTF.

$$\begin{aligned} \text{Annual CH}_4 \text{ emissions (metric tons CO}_2\text{e)} \\ = (\text{BOD}_5\text{load} \times (1 - F_p) \times B_o \times \text{MCF}_{\text{anaerobic}} \times 365.25 \times 10^{-3} \left(\frac{\text{metric ton}}{\text{kg}} \right)) \times \text{GWP} \end{aligned}$$

Where:

Term	Description	Value
BOD ₅ load	Amount of BOD ₅ produced per day (influent to wastewater treatment process) [kg BOD ₅ /day]	User input
F _p	Fraction of BOD ₅ removed in primary treatment, if present	User input
B _o	Maximum CH ₄ -producing capacity for domestic wastewater [kg CH ₄ /kg BOD ₅ removed]	0.6
MCF _{anaerobic}	CH ₄ correction factor for anaerobic systems	0.8
365.25	Conversion factor [day/year]	365.25

Source: EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007, Chapter 8, 8-7 (2009).

- *Stationary Sources* - CH₄ emissions from stationary combustion due to incomplete combustion of digester gas at a centralized WWTF with anaerobic digestion of biosolids.

Annual CH₄ emissions (metric tons CO₂e)

$$= (\text{Digester Gas} \times F_{CH_4} \times \rho(CH_4) \times (1 - DE) \times 0.0283 \times 365.25 \times 10^{-6} \left(\frac{\text{metric ton}}{g}\right)) \times GWP$$

Where:

Term	Description	Value
Digester Gas	Measured standard cubic feet of digester gas produced per day [ft ³ /day]	User input
F _{CH4}	Measured fraction of CH ₄ in biogas	User input
ρ(CH ₄)	Density of methane at standard conditions [g/m ³]	662.00
DE	CH ₄ Destruction Efficiency	0.01
0.0283	Conversion from ft ³ to m ³ [m ³ /ft ³]	0.0283
365.25	Conversion factor [day/year]	365.25

Source: EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007, Chapter 8, 8-7 (2009).

- **Mobile Sources** - CH₄ emissions from mobile combustion due to combustion of gasoline and diesel from fuel vehicle fleet, fuel trucks hauling biosolids to land application, and chemicals to the WWTF

$$CH_4 \text{ Emissions (metric tons CO}_2\text{e)} = \text{Annual Distance (miles)} \times EF \left(\frac{g \text{ CH}_4}{\text{mile}}\right) \times 10^{-6} \left(\frac{\text{metric ton}}{g}\right) \times GWP$$

Electricity usage, specifically indirect emissions from electricity use, was included in the calculation of Scope 2 emissions as follows:

$$CH_4 \text{ Emissions (metric tons CO}_2\text{e)} = \text{Electricity use} \left(\frac{MW \cdot h}{\text{year}}\right) \times EF \left(\frac{lbs \text{ CH}_4}{MW \cdot h}\right) \div 2,204.62 \left(\frac{lbs}{\text{metric ton}}\right) \times GWP$$

Nitrous Oxide Emissions

Using the methods provided below, the project team quantified applicable Scope 1 and 2 emissions for nitrous oxide. For this Study, Scope 1 emission sources included process, mobile and fugitive sources (For all N₂O emission calculations the GWP is 310):

- **Process Sources** - N₂O emissions without nitrification/denitrification

$$\text{Annual N}_2\text{O emissions (metric tons CO}_2\text{e)} = \left((P_{total} \times F_{ind-com}) \times EF_{no \text{ nit/denit}} \times 10^{-6} \right) \times GWP$$

Where:

Term	Description	Value
P _{total}	Total population that is served by the centralized WWTF adjusted for industrial discharge, if applicable [person]	User input
F _{ind-com}	Factor for industrial and commercial co-discharge waste into the sewer system	1.25
EF _{no nit/denit}	Emission factor for a WWTF without nitrification/denitrification [g N ₂ O/person/year]	3.2

Source: EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007, Chapter 8, 8-7 (2009).

- **Process Sources** - N₂O emissions with nitrification/denitrification

$$\text{Annual N}_2\text{O emissions (metric tons CO}_2\text{e)} = \left((P_{total} \times F_{ind-com}) \times EF_{nit/denit} \times 10^{-6} \right) \times GWP$$

Where:

Term	Description	Value
P_{total}	Total population that is served by the centralized WWTP adjusted for industrial discharge, if applicable [person]	User input
$F_{ind-com}$	Factor for industrial and commercial co-discharge waste into the sewer system	1.25
$EF_{nit/denit}$	Emission factor for a WWTP with nitrification/denitrification [g N ₂ O/person/year]	7

Source: EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007, Chapter 8, 8-7 (2009).

- *Process Sources* - N₂O emissions from effluent discharge to rivers

$$Annual\ N_2O\ Emissions(metric\ tons\ CO_2e) = (N\ load \times EF\ effluent \times 365.25 \times 10^{-3} \times \frac{44}{28}) \times GWP$$

Where:

Term	Description	Value
N load	Measured average total nitrogen discharged [kg N/day]	User input
$EF_{effluent}$	Emission factor [kg N ₂ O-N/kg sewage-N produced]	0.005
365.25	Conversion factor [day/year]	365.25
10^{-3}	Conversion from kg to metric ton [metric ton/kg]	10^{-3}
44/28	Molecular weight ratio of N ₂ O to N ₂	1.57

Source: EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007, Chapter 8, 8-7 (2009).

- *Mobile Sources* - N₂O emissions from mobile combustion due to combustion of gasoline and diesel from fuel vehicle fleet, fuel trucks hauling biosolids to land application, and chemicals to the WWTF.

$$N_2O\ Emissions\ (metric\ tons\ CO_2e) = Annual\ Distance\ (miles) \times EF\ \left(\frac{g\ N_2O}{mile}\right) \times 10^{-6}\ \left(\frac{metric\ ton}{g}\right) \times GWP$$

- *Fugitive Sources* - Biosolids land application (IPCC Guidelines for National GHG Inventories – Agricultural Source Management [IPCC source category 4D])

$$N_2O\ Emissions\ (metric\ tons\ CO_2e)$$

$$= Biosolids\ land\ applied\ (metric\ tons) \times organic\ N\ \left(\frac{mg}{kg}\right) \times EF\ \left(\frac{metric\ tons\ N_2O}{metric\ ton}\right) \times 10^{-6}\ \left(\frac{kg}{mg}\right)$$

Electricity usage, specifically indirect emissions from electricity use, was included in the calculation of Scope 2 emissions as follows:

$$N_2O\ Emissions\ (metric\ tons\ CO_2e) = Electricity\ use\ \left(\frac{MW\ h}{year}\right) \times EF\ \left(\frac{lbs\ N_2O}{MW\ h}\right) \div 2,204.62\ \left(\frac{lbs}{metric\ ton}\right) \times GWP$$

The data compiled following the above methodology can be used to estimate changes in GHG emissions from the base "typical" WWTF to each treatment tier. Appendices B-7a and B-7b provide the technical findings of this analysis. These findings will be incorporated into the evaluation of qualitative benefits discussed in Section 5.

3.5 Public Water Supply Benefits

The evaluation of potential public water supply benefits from implementation of the proposed regulation was conducted in three parts: 1) compilation of available data to characterize water supply facilities; 2) evaluation of potential water quality impacts in relation to SDWA requirements; and 3) quantification of potential avoided water treatment costs, where appropriate.

3.5.1 Data Compilation

The Division's Source Water Assessment and Protection (SWAP) group manages geographic, demographic, and hydrologic data related to drinking water sources in Colorado. SWAP provided data for each drinking water system in the state. These systems draw water from surface water, groundwater, or groundwater under the influence of surface water. For the purposes of this Study, drinking water systems drawing water from surface water or groundwater under the influence of surface water were included; drinking water systems that rely on groundwater only were excluded. The Division provided data for all water suppliers by source in individual geodatabase files. For purposes of security, Study maps and tables only provide general information regarding the geographical location of water supply facilities. Exact locations of water supply intake structures are not shown.

The water supply facility data provided by the Division included the following information regarding each facility:

- Source of public water supply
- Primary source type and whether the source was tributary or non-tributary
- Population served
- System status, e.g. active or inactive
- List of treatment processes implemented at each facility

The Division also provided a statewide coverage of water supply stream segments as well as data layers for drinking water reservoirs categorized as "direct use," "conveyance," or "upstream drinking water" reservoirs.

3.5.2 Colorado Water Supply Facilities

The types of water supply facilities were summarized based on the available compiled data. Table 3-23 provides the number of facilities sorted by capacity (gpd) and source water type.

Table 3-23. Water Supply Facilities by Capacity¹ and Source Water Type

Source Water	< 100,000 gpd		100,000 gpd - 500,000 gpd		500,000 gpd - 1,000,000 gpd		> 1,000,000 gpd	
	Count	Percent of Total ²	Count	Percent of Total ²	Count	Percent of Total ²	Count	Percent of Total ²
Surface Water (SW)	1,251	7.7%	71	27.7%	27	52.9%	83	79.0%
Groundwater Under Influence of SW (GU)	83	5.8%	11	4.3%	2	3.9%	1	1.0%
Groundwater (GW)	1,253	86.5%	174	68.0%	22	43.1%	21	20.0%
Total Facility Count ³	2,587		256		51		105	

¹ Capacity is based on population served x 200 gallons per capita per day.

² Percent of total data represents the percent of total systems in the specific capacity category.

³ Facilities are based upon grouping identical system names together as a single count. For example, East Cherry Creek has 59 entries for wells in the database. These entries were grouped together as one facility.

For the purposes of this Study, the GW systems associated with non-tributary streams were excluded from the analysis as the proposed regulations would not impact these facilities. Table 3-24 provides the final count of water supply facilities with these systems removed.

Table 3-24. Water Supply Facilities Potentially Impacted by Proposed Regulations

Source Water	< 100,000 gpd		100,000 gpd - 500,000 gpd		500,000 gpd - 1,000,000 gpd		> 1,000,000 gpd	
	Count	Percent of Total ¹	Count	Percent of Total ¹	Count	Percent of Total ¹	Count	Percent of Total ¹
SW	125	58.1%	71	83.5%	27	90.0%	83	98.8%
GU	83	38.6%	11	12.9%	2	6.7%	1	1.2%
GW with Tributary Source	7	3.3%	3	3.5%	1	3.3%	0	0.0%
Total Facility Count ²	215		85		30		84	

¹Percent of total data represents the percent of total systems in the specific capacity category.

²Facilities are based upon grouping identical system names together as a single count. For example, East Cherry Creek has 59 entries for wells in the database. These entries were grouped together as one facility.

3.5.3 Potential Avoided Water Treatment Costs

To determine the potential costs and benefits associated with implementation of the proposed regulations, potential water quality benefits that may occur in source waters that could translate into reduced future water treatment costs, i.e., avoided costs, were evaluated. This evaluation relied on existing water quality criteria or regulations established to protect waters designated as a drinking water source (e.g., Maximum Contaminant Levels [MCLs] established under the SWDA). In addition, potential benefits of reduced phosphorus and nitrogen in source waters were evaluated separately.

Nitrogen

Nitrate/Nitrite – These nutrients (the major component associated with total nitrogen after ammonia is used biologically) have primary MCLs established by the EPA (10 mg/L of nitrate; 1 mg/L nitrite). Typical drinking water treatment technologies to remove nitrate/nitrite are RO and Ion Exchange. A review of the available water quality reviewed for this Study (see Section 3.3) found no source water concerns with any water supply facility in the State that uses surface water or groundwater under the influence of surface water as its source water. Accordingly, no potential benefits from implementation of the proposed regulations were identified with regards to management of nitrate/nitrite in surface waters.

Nitrogen Related Disinfection Byproducts (DBPs) - N-Nitroso-Dimethylamine (NDMA) has been identified by the EPA as an "emerging contaminant" and is listed as a priority pollutant in the Code of Federal Regulations (CFR) (40 CFR 136.36)³. NDMA is formed as a DBP in drinking water and wastewater. In water supply facilities, NDMA is formed when chloramines react with organic matter. Naturally occurring ammonia in the water reacting with chlorine fed in the treatment process may also form chloramines, but many water supply facilities also use a secondary source of ammonia to generate chloramines for use as a residual disinfectant.

The EPA has not established an MCL for this pollutant. NDMA is included in EPA's unregulated contaminant monitoring program which collects data for contaminants suspected to be present in drinking water, but again no human health-based standards have been set under the SDWA. The EPA has set cleanup levels to 0.7 µg/L at a site in California and 0.42 µg/L as the non-enforceable screening level for tap water in EPA Regions 3 and 6. The state of California has also set a public health goal of 3 µg/L in drinking water.

³ Emerging Contaminant N-Nitroso-dimethylamine (NDMA) Fact Sheet, December 2010, EPA 505-F-10-005, USEPA.

NDMA is a developing concern for drinking water quality, but currently no limits have been set federally or for the State of Colorado. Moreover, data were unavailable for this Study that could be used to link source water quality with the potential to form NMDA. Because no regulatory thresholds have yet been established that are applicable to Colorado and facility-specific treatment processes can also affect the formation of chloramines (i.e., whether or not the system is adding ammonia as part of the treatment process), the potential reduction in NDMA as result of implementation of the proposed regulations can only be evaluated qualitatively (see Section 5).

Phosphorus

No phosphorus MCLs have been established for waters designated as drinking water sources. Accordingly, this Study could not directly relate changes in total phosphorus to a direct human health benefit in drinking water sources. However, the presence of TP and TIN as nutrients in source waters can increase instream primary productivity resulting in increases in natural organic matter (NOM). The EPA developed Stage 1 and Stage 2 disinfection/disinfection byproduct (D/DBP) regulations to establish MCLs for total trihalomethanes (TTHM) and five haloacetic acids (HAA5), 80 µg/L, and 60 µg/L, respectively. These DBPs, which are believed to be carcinogens, form inadvertently as a result of chlorine reacting with NOM during the water treatment process. In addition, some forms of NOM may also impact the taste and odor formation potential of drinking water sources.

Reductions in TIN and TP can reduce primary productivity, reducing NOM related to this biological activity in source waters and reducing the potential for DBP formation during the water treatment process. This is a qualitative benefit to all water supply facilities downstream of WWTF outfalls.

In addition to the qualitative benefit, this Study also evaluated the potential to quantify benefits (avoided treatment costs) for those water supply facilities downstream of WWTF outfalls that have been identified by the Division as facilities with 1) existing Stage 1 compliance concerns; or 2) potential Stage 2 D/DBP compliance concerns when Stage 2 requirements are applied (full compliance with Stage 2 D/DBP regulations is not required for all facilities until 2014, although some facilities are required to comply as early as 2012).

Information provided by the Division indicated that there were 22 water supply facilities out of compliance with Stage 1 D/DBP regulations. For Stage 2 D/DBP compliance, Division data indicate that over 100 facilities currently have potential compliance concerns with Stage 2 D/DBP regulations (this count includes the facilities out of compliance with Stage 1 as well). Specifically, these facilities are expected to require system improvements assuming no reduction in DBP formation. This list of facilities provided the basis for subsequent avoided treatment cost analyses.

3.5.4 Development of Avoided Treatment Costs

Water supply facilities with potential compliance concerns were defined as any water supply facility that had a TTHM locational running annual average (LRAA)⁴ > 64 µg/L and/or an HAA5 LRAA > 48 µg/L (these thresholds include a 20-percent safety factor), as provided by the Division. All facilities that sample quarterly or those that are on reduced monitoring that had any results over 64 µg/L for TTHMs or 48 µg/L for HAA5 were also included on this facility list. The Division assumed that facilities that exceed these levels may have problems with Stage 2 D/DBP compliance due to seasonal DBP-formation variability and results that would be expected using the LRAA method. The compliance schedule for the Stage 2 D/DBP regulations vary based on the size of the water utility, but in general it is between April 2012 and July 2014.

⁴ LRAA is calculated as the running annual average at a specific sampling location and not as combined calculation across an entire distribution system.

The water intake locations of water supply facilities on the potential compliance issue facilities list were compared spatially against the WWTF discharge locations. Any water supply facility with source water not impacted by a WWTF discharge was removed from the list⁵. Those facilities that remained (27 total) were analyzed for a capital and O&M costs (Table 3-25). These costs were developed based on a typical infrastructure upgrade that could be implemented to modify the disinfection process to reduce DBP formation.

Table 3-25. WTPs Considered for Cost/Benefit Analysis

Water Supply Facility	Manageable Unit
City of Florence	ARK_01
Holcim Inc.	ARK_01
Pueblo West MD	ARK_01
XCEL Energy Comanche Plant	ARK_01
Colorado Springs Utilities	ARK_01, ARK_02
Woodmoor WSD	ARK_02
Crowley County WA	ARK_03
Town of Fowler	ARK_03
Town of Hot Sulphur Springs	COL_01
Two Rivers Village	COL_01
Red Sky Ranch	COL_03
Upper Eagle Regional WA	COL_03
City of Rifle	COL_05
Town of Debeque	COL_05
Town of Parachute	COL_05
Town of Silt	COL_05
City of Grand Junction	GUN_02
Genesee WSD	PLT_01
City of Black Hawk	PLT_02
City of Golden	PLT_02
Arapahoe County WWA	PLT_07A
City of Sterling	PLT_08
Tri-State G and T Nucla Station	SW_02
City of Craig	GRN_01
Town of Hayden	GRN_01
XCEL Energy Hayden Station	GRN_01
Town of Rangely	GRN_02

There is a wide variety of improvements that can be made at a water supply facility to reduce DBP formation. The following is a brief list identifying some of the options:

- *Optimization of Chlorine Dose* – Implemented by moving the dosing location, reducing the chlorine dose at the facility, or converting the residual disinfectant from free chlorine to chloramines.
- *Optimization of Treatment Process* - This process optimizes chemical dosages to remove NOM through the process prior to treatment, e.g., by implementing enhanced coagulation. This process could also include adding a pre-oxidant such as chlorine dioxide or ozone ahead of the chlorine dosing point.

⁵ The project team notes that some of the identified water supply facilities may be downstream of WWTFs that discharge to waterbodies that provide substantial dilution. In those instances, it is likely that the reduction in nutrients in the WWTF discharge would have minimal impact on the water quality at the downstream water supply facility intakes. Regardless, no correction was made for these circumstances where they might exist. This provides a measure of conservatism to the analysis.

- *Additional Treatment Processes* - Additional processes may be added to the conventional treatment train which directly targets removal of total organic carbon (TOC), which includes NOM. Examples include addition of granular activated carbon polishing filters, addition of ozonation followed by biologically active filtration, or use of membrane filtration.
- *Advanced Oxidation Processes (AOPs)* – AOPs are treatment technologies that reduce organic and inorganic constituent concentrations. AOPs may be used for TOC reduction, color removal, iron removal, and oxidation of organic compounds. AOPs include hydrogen peroxide, ozone, chlorine dioxide, ultraviolet (UV), or combinations such as ozone-peroxide or UV-peroxide. Hydrogen peroxide, a powerful oxidant, is applied in bulk solution to drinking water.

Typically the lowest cost improvements are those that emphasize system optimization while addition of AOPs represents the most expensive improvements. Facility optimization is specific to each individual water utility. Any improvements identified in this report are intended to provide a generalized basis for developing treatment costs. Each individual facility would need to conduct its own analysis to determine the best course of action to comply with regulatory requirements.

To develop avoided costs, the project team selected a standard process treatment upgrade to be applied to all water supply facilities. Ozone would be used as a pre-oxidant ahead of filtration with chloramines used as the residual disinfectant entering the distribution system (see Figure 3-25). This approach, which was uniformly applied to all facilities, results in estimated costs that are generally in the middle with regards to the potential range of costs that could be incurred, depending on the selected treatment upgrade approach.

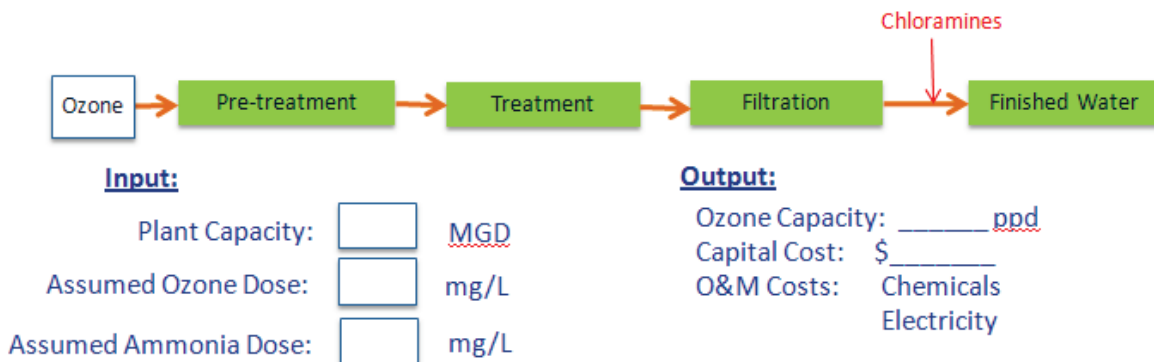


Figure 3-25. Schematic of Selected Approach for a Water Treatment Process Upgrade

To develop the capital costs for the chloramination processes, the project team utilized capital cost models developed for the EPA's 2007 Drinking Water Needs Survey and Assessment⁶ that estimate the capital cost based on facility capacity:

$$\text{Chloramination: Capital Cost} = e^{(11.53367+1.5^{12/2})} \times \text{Design Capacity (mgd)}^{0.37516}$$

$$\text{Ozone: Capital Cost} = e^{(12.5851+1.32^{2/2})} \times \text{Design Capacity (mgd)}^{0.8035}$$

It was assumed that each facility already had chlorine/hypochlorite disinfection infrastructure in place and that ozone and ammonia addition would require capital improvements, which would incur additional O&M cost for these facilities. Because the chloramination cost model includes chlorine and ammonia

⁶ 2007 Drinking Water Infrastructure Needs Survey and Assessment – Modeling the Cost of Infrastructure, produced by the United States Environmental Protection Agency dated April 2010.

improvements, the capital costs were reduced by 80-percent based on the chemical dosage ration shown in Table 3-26 to capture only the capital costs for ammonia improvements.

Table 3-26. Chemical Dosage Assumptions

Chemical	Assumed Dosage
Ozone	1 mg/L as Ozone ⁷
Chloramines	3 mg/L as Chloramines (Range between 0.2 and 4 mg/L) ⁸
Ammonia	0.75 mg/L (4:1 Chlorine/Ammonia Ratio) ⁹

A recent presentation given at the 2011 IUVA World Conference¹⁰ provided costs for ozone treatment that have been updated since EPA's 2007 publication (see above). Based on these new data a typical range of capital costs for ozone for water treatment systems less than 1 mgd is \$12,000 to \$16,000 per pound per day (ppd) of ozone generated; accordingly, this Study used a capital cost of \$14,000 ppd. For water supply facilities larger than 1 mgd a typical value of \$10,000 ppd was used.

The available data did not provide facility-specific treatment capacities. Instead, the project team estimated the treatment capacity of each facility in Table 3-26 by multiplying the population served by 200 gallons per capita per day.

In order to generate annual O&M cost estimates an assumed global chemical dosage was applied to all water supply facilities in the analysis (Table 3-27).

Table 3-27. Chemical Dosage Assumptions

Chemical	Assumed Dosage
Ozone	1 mg/L as Ozone ¹¹
Chloramines	3 mg/L as Chloramines (Range between 0.2 and 4 mg/L) ¹²
Ammonia	0.75 mg/L (4:1 Chlorine/Ammonia Ratio) ¹³

The O&M costs associated with ozone production are related to energy and labor costs. Based on engineering, the unit energy consumption of a typical ozone generation process including ancillary systems

⁷ *Ozone in Water Treatment Application and Engineering Cooperative Research Report*. American Water Works Association Research Foundation, Edited by B. Langlaiss, D. Reckhow, and D. Brink published in 1991.

⁸ *Colorado Primary Drinking Water Regulations* Department of Health and Environment 5 CCR 1003-1, Table 2-6, and 7.1.2(c)(2) Disinfection.

⁹ *Water Treatment Plant Design Fourth Edition*, American Water Works Association and American Society of Civil Engineers, 2005.

¹⁰ 2011 World Congress and Exhibition Ozone and UV: Leading-Edge Science and Technologies, "Ozone, How Much is that Really?" presentation prepared by Municipal Task Force Pan American Group Robert N. Jarnis, P.E.-Chair, Susan Neal- Vice Chair dated May 23-26 2011.

¹¹ *Ozone in Water Treatment Application and Engineering Cooperative Research Report*. American Water Works Association Research Foundation, Edited by B. Langlaiss, D. Reckhow, and D. Brink published in 1991.

¹² *Colorado Primary Drinking Water Regulations* Department of Health and Environment 5 CCR 1003-1, Table 2-6 and 7.1.2(c)(2) Disinfection.

¹³ *Water Treatment Plant Design Fourth Edition*, American Water Works Association and American Society of Civil Engineers, 2005.

is approximately 8 to 10 kilowatt hour per pound (KWh/lb) ozone produced; as a result, the O&M calculations relied on 8 KWh/lb.

The product of the ozone application rate and unit energy consumption provided the annual energy consumption of the system. A statewide unit electrical cost of \$0.083/kWh was applied to the total increase in power usage. This unit cost factor was obtained from the State and is an average of public and private utility company costs based on a mix of generation types (coal, natural gas, renewable energy, etc.) (Note: this is the same electrical cost applied to WWTFs, as described above).

The ozone labor cost was assumed to be \$12,300 per mgd per year based on an EPA 2009 estimate escalated to 2010 dollars.

The project team assumed that each facility would use anhydrous ammonia gas to convert the residual disinfectant from free chlorine to chloramines. The current commodity price of \$800.00 per ton anhydrous ammonia was used as the unit cost for purchasing this chemical. Labor associated with operation of the ammonia system was assumed to be one third of the estimated ozone labor value since it is a simpler system to operate and maintain.

Using all the factors described above, Table 3-28 provides the estimated capital and O&M costs for each of the facilities identified above. Table 3-29 summarizes the assumptions that formed the basis for this estimate.

Table 3-28. Estimated Capital and O&M Costs for Upgrades to Water Supply Facilities

Water Supply Facility	Manageable Unit	Capital Cost (2010 Dollars)	O&M Cost per Year (2010 Dollars)
City of Florence	ARK_01	\$200,000	\$27,000
Holcim Inc.	ARK_01	\$30,000	\$800
Pueblo West MD	ARK_01	\$600,000	\$120,000
XCEL Energy Comanche Plant	ARK_01	\$30,000	\$1,400
Colorado Springs Utilities	ARK_01, ARK_02	\$7,300,000	\$1,600,000
Woodmoor WSD	ARK_02	\$200,000	\$28,000
Crowley County WA	ARK_03	\$40,000	\$1,700
Town of Fowler	ARK_03	\$70,000	\$5,000
Town of Hot Sulphur Springs	COL_01	\$40,000	\$1,700
Two Rivers Village	COL_01	\$30,000	\$1,400
Red Sky Ranch	COL_03	\$20,000	\$300
Upper Eagle Regional WA	COL_03	\$300,000	\$56,000
City of Rifle	COL_05	\$200,000	\$27,000
Town of Debeque	COL_05	\$50,000	\$3,400
Town of Parachute	COL_05	\$100,000	\$6,000
Town of Silt	COL_05	\$110,000	\$9,000
City of Grand Junction	GUN_02	\$600,000	\$100,000
Genesee WSD	PLT_01	\$200,000	\$16,000
City of Black Hawk	PLT_02	\$400,000	\$58,000
City of Golden	PLT_02	\$600,000	\$110,000
Arapahoe County WWWA	PLT_07A	\$700,000	\$120,000
City of Sterling	PLT_08	\$300,000	\$54,000
Tri-State G and T Nucla Station	SW_02	\$20,000	\$300
City of Craig	GRN_01	\$300,000	\$38,000
Town of Hayden	GRN_01	\$90,000	\$6,000
XCEL Energy Hayden Station	GRN_01	\$20,000	\$400
Town of Rangely	GRN_02	\$100,000	\$8,000

Table 3-29. Summary of Assumptions Associated with Estimated Capital and O&M Costs

- Facility treatment capacity was calculated based on a consumption of 200 gallons of drinking water per person per day and population data provided by the state
- Used ENR construction cost index to bring 2007 cost model to 2010 dollars
- No data was available regarding whether facilities are currently using chloramines as residual disinfectant; cost assumes this process was added along with new equipment
- Ozone dose to be 1 mg/L
- Power consumption - 8 kWh/lb of ozone produced
- Power cost - 8.3 cents per kWh (same value used for wastewater treatment costs)
- Ozone labor costs obtained from EPA Ozone fact Sheet; assumed labor cost for disinfection is 1/3 that of ozone since it is a simpler process
- Applied 4:1 chlorine to ammonia ratio (EPA Guidance Manual, Alternative Disinfectants and Oxidants, 1999)
- Applied anhydrous ammonia to process as most water treatment facilities use this process (AWWA Water Quality and Treatment, Fifth Edition)
- Applied current price for anhydrous ammonia of approximately \$800/ton (price is a function of natural gas price)
- Power cost for disinfection is negligible
- Chloramines dose to be 3 ppm as chloramines
- Existing facilities already have chlorine infrastructure in place

3.6 Public Health and Environmental Benefits Analysis

This section describes the methods employed to develop the public health and environmental benefits element of the cost-benefit analysis. The first section provides an overview of the key elements of the approach. This overview is followed by information regarding specific methods and data or literature sources relevant to the described methods.

3.6.1 Overview of Benefit Estimation Approach

The public health and environmental benefits analysis identifies and estimates, to the extent possible within the context of this Study, each of the benefits which would accrue from nutrient reduction in Colorado water bodies as a result of the proposed regulation. Simply stated, a reduction in nutrients in water bodies would result in reduced algae growth, increased dissolved oxygen, a change in the ecological functions of water bodies and their appearance, odor and taste, according to the literature on this subject (Camargo and Alonso 2006; Dodds et. al 2008; EPA 2000; EPA 2010; EPA 2011). By lessening these biological effects, a reduction in nutrients would create a set of avoided costs or benefits associated with the utilization of those water bodies. The conceptual linkage of nutrient reduction to changes in biological processes and conditions in water bodies to the utilization of those water bodies by man and other living organisms is well documented; the quantification or estimation of those avoided costs, termed "benefits" in this Study, is the challenge and goal of this effort.

Accounting Stance

The starting point of benefit-cost studies is the adoption of an accounting stance. That is, will benefits and costs be considered at the national, state, or local level? Given that the regulatory decision occurs at a State of Colorado level, that is the accounting stance adopted in this Study. Therefore, all costs and all benefits occurring within state boundaries will be estimated as closely as possible. Any potential benefits from the nutrient regulations experienced by downstream users in other states are not included in this study. Benefits and costs will first be estimated at the Manageable Unit level, relying on regional data to the extent available, and then aggregated to the state level. This approach provides opportunity to demonstrate the range in benefit-cost relationships that exist throughout the State of Colorado.

Identification of Benefits

Based upon a review of the literature (Loomis 2006; Dodds et. al 2008; National Research Council 2005; EPA 2000), the types of benefits likely to accrue from nutrient reduction will include public water supply improvements, active benefits associated with recreation, passive benefits from ecological improvements, and intrinsic benefits. Each of these is defined and discussed below.

- *Public Water Supply* – Public water supply benefits from nutrient reduction would conceivably occur because potable water utilities might be able to reduce their future water treatment capital investment costs as a result of reduced nutrients, or if potable water utilities made no such future investments, reduced nutrients in the drinking water supply might improve public health (e.g., reduce DBP) and the market attributes of drinking water, i.e., appearance, odor and taste. As described in Section 3.5, only certain water supply benefits could be quantified for this Study. Other potential benefits, e.g., benefits accrued through a reduction regarding concerns associated with emerging but unregulated contaminants had to be addressed qualitatively where insufficient data were available to quantify a benefit. In addition, water user attributes of taste and odor, which can certainly have an effect and a cost to potable water utilities, could not be quantified given insufficient information to estimate such effects or even characterize them appropriately.
- *Active Benefits* – Active uses of Colorado's water bodies include recreation of different types. With reduced nutrient levels and associated biological processes, swimming, fishing and boating activity would increase, according to the literature reviewed for this Study. That is, kayakers and flat water boaters, for example, would increase their number of visitor days and new boating enthusiasts would be attracted to the sport because of reduced nutrient levels. Similarly, anglers would be more likely to spend more time fishing and new anglers might be attracted to the sport. The same phenomenon would occur with swimmers and tubing participants. Because these active recreational participants spend money in the pursuit of the sport, this constitutes an economic benefit to the State and the participants themselves experience a consumer surplus, as discussed in the methodological section below. Other recreational endeavors, such as picnicking, scenic drives, and watchable wildlife, are not quantified in this benefit-cost study, but are recognized as qualitative benefits.

Additional active water uses include irrigation and animal watering. Irrigators may experience minimal benefits from nutrients as these waters are applied to their lands, but this does not constitute a substitute for fertilization; therefore, a reduction of nutrients in irrigation water would not result in increased costs to irrigators. Reduced nutrients in irrigation water might reduce vegetation growth in the irrigation conveyance canals, but this would not eliminate the need for clearing such conveyances regularly. Cattle are known to increase weight gain with less nutrients in their drinking water (Brew et al., undated), but the diverse sources of nutrients in the cattle's water supply renders any benefit associated with reduction in nutrients from this regulation to be speculative. Hence, all of these agricultural effects are considered qualitative and minor.

- *Passive Benefits* - Passive benefits occur as reduced nutrients result in improved environmental conditions (Figure 3-26).

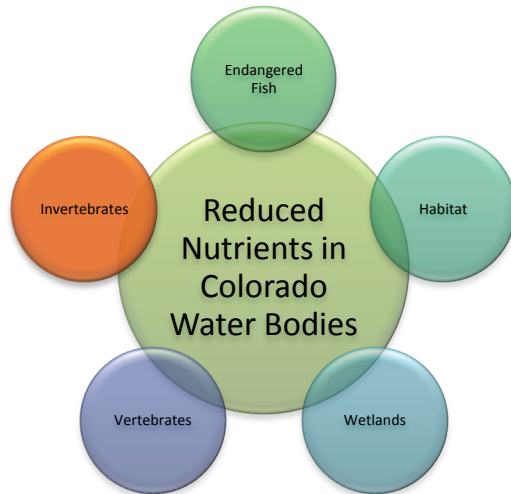


Figure 3-26. Examples of Passive Benefits from Nutrient Reduction

With reduced nutrients, habitat is improved which, in turn, benefits animals, fish and aquatic invertebrates. This may improve the health of the aquatic community. In sum, these environmental benefits are recognized as having value by the public, whether or not those members of the public actually utilize those specific water bodies. In WTP studies, the public has demonstrated a level of willingness to expend monies to improve water quality and public water bodies as part of the overall environment. These values are addressed further below.

- Intrinsic Benefits* – Intrinsic benefits can occur when Colorado residents perceive a value in preserving or enhancing the environment for present or future generations. That is, beyond specific values which the average Colorado resident might perceive in specific ecosystem benefits associated with nutrient reductions, there is an additional benefit which Colorado residents might perceive in the bequeathal value of an improved environment handed off to others and to future generations. Although intrinsic values have been noted in various studies associated with environmental improvement, there is insufficient data to distinguish that benefit from passive benefits in this instance. Therefore, this benefit is noted as a potential benefit in nutrient reduction, but it will not be accounted for further as a quantitative or qualitative benefit.

Quantitative versus Qualitative Benefits

This Study attempts to quantitatively estimate benefits when there is sufficient, supportable data and assumptions to do so; otherwise, benefits are characterized as qualitative. In order to accumulate benefits and compare them with costs, quantitative benefits are translated to dollar values, expressed as 2010 constant dollars. Qualitative benefits are those that could not be reasonably quantified, or benefits for which, insufficient data were found to develop assumptions or supportable estimates. However, it is important to recognize that qualitative benefits are no less important than quantitative benefits; they are simply not amenable to quantitative estimates, given the resources and objective of this Study. Qualitative benefits are described and characterized in magnitude.

Estimation and Accumulation of Benefits and Comparison with Costs

Changes in nutrient levels in Colorado water bodies expected under the three effluent quality tiers included in this Study are the key data which drive the benefit estimates. Changes in nutrient levels are combined to estimate a percentage change in overall water quality, which drives changes in active and passive benefits based upon elasticity assumptions. Credible and relevant studies have shown that a one percent change in

water quality would cause a certain percentage change in recreation (active benefit) or WTP for passive benefits, as described in Section 3.6.3, Benefits Methodology, below:

- *Active Benefits* – These benefits are quantified to include angling, boating, and swimming. The change in visitor days expected from reductions in nutrients is multiplied by visitor day expenditures and consumer surplus values to estimate total benefits associated with increases in each recreational activity.
- *Passive Benefits* – These benefits are estimated through a WTP estimate, adjusted as described in the methodology section, and multiplied by the number of households in each Manageable Unit to arrive at total passive values.

Both active and passive benefits are discounted to a 2010 constant dollar value. The time period and discounting procedures are discussed in the methodology section addressing discount rates (see Section 3.6.4). Active benefits are combined with passive benefits to arrive at total benefits discounted to present value for each Manageable Unit. These results for Manageable Units are then accumulated for all areas to arrive at the total quantified benefits to the State of Colorado. Benefits are then compared to costs on a comparable geographic and discounted basis for meaningful comparison.

3.6.2 Data Acquisition

Description of Data Sources

The data and information used to develop and support the estimation of environmental and recreational benefits was obtained from a wide range of sources. The literature review found in Appendix D details the data acquisition effort and provides a list of the major studies and reports used in the benefits analysis. In general, studies were gathered on the following topics:

- The impacts of nutrients in water bodies upon public health, environmental resources (i.e. water quality, aquatic habitat) and recreational activity;
- Methodological approaches to estimating environmental and recreational benefits, as well as other social or public benefits;
- The potential benefits resulting from the reduction of phosphorus and nitrogen, including studies describing the general benefits of nutrient reduction as well as the benefits of improvements in water quality to specific resources or activities (i.e., fish habitat or swimming activity);
- Methodology for estimating environmental benefits via the application of contingent valuation, or WTP;
- Data about current recreational and other economic and demographic activity in Colorado, for example, the number of anglers, boaters and swimmers; activity days for each, and expenditure data for each activity.

Information about the general impacts of nutrients, the specific benefits of nutrient reduction, and the methodological approaches to valuing these benefits were obtained from a thorough search of the relevant literature, as described in Appendix D. A number of studies were obtained, ranging from qualitative descriptions of the general impacts of nutrients to detailed academic research studies quantifying the benefits of nutrient reduction to specific resources (i.e., recreational activity, property values). Each study was reviewed and screened for usefulness based on factors such as the specific nutrients discussed, the types of recreational activities or environmental resources addressed, geographic location, and currency of the research.

Data used to develop baseline descriptions of each Manageable Unit (i.e., population, households and recreational activity days) were obtained from the U.S. Census Bureau, Colorado Department of Local Affairs (DOLA), and various state and county level reports detailing recreational activity.

Key Challenges and Resolution

The project team faced several challenges when gathering data for use in estimating the benefits of the proposed nutrient regulations:

- Although the literature search uncovered a large number of reports, studies and other types of information regarding the impacts of nutrients and nutrient reduction, there was a lack of applicable studies focusing on Colorado. Where appropriate, the project team made adjustments to the available data from the most relevant studies to better reflect conditions in Colorado. For example, two useful studies discuss impacts to property values, but are based on data from Maine and Minnesota (Michael et al. 1999 and Krysel et al. 2003), where the home values are less than in Colorado. A comparison of home values in all three states provided information regarding an appropriate adjustment to the Maine and Minnesota data for use in this Study. Each of the adjustments made to data obtained from the literature are described in the applicable Benefits Methodology section below.
- Few studies were found that directly link nutrient levels or nutrient reduction to changes in recreational activity. The project used the available studies to the extent possible, but had to make several assumptions in order to estimate recreational benefits, as described in the applicable Benefits Methodology section below. For example, one study provided data on the increased likelihood that non-swimmers would become swimmers as water quality improved; the project team expanded and adjusted these data based on other literature to estimate probabilities for fishing and boating.
- Data on recreational activity days for fishing, boating and swimming were available only at the statewide level (boating and swimming) or the county level (fishing); these data were distributed among the Manageable Units based on a number of reports and assumptions as described for each activity in the Benefits Methodology section below.

3.6.3 Benefits Methodology

This section provides a detailed description of the methods applied to each of the areas covered by the benefits analysis.

3.6.3.1 Baseline Demographic Descriptions

Population and household data were utilized in estimating WTP values for each Manageable Unit. WTP values are defined on a per household basis; therefore, the number of households in each Manageable Unit was estimated using Colorado DOLA and U.S. Census Bureau data. DOLA 2009 population data provided the starting point for base level data for the Manageable Units. These are the most recent data available at the county and municipal level. For counties that lie in two or more Manageable Units, the incorporated towns and cities were assigned to the appropriate Manageable Unit. The population in unincorporated areas was distributed utilizing maps with consideration for public lands and topography. The number of households for each Manageable Unit was then derived by applying the average persons per household for each county to the appropriate population.

WTP values were also adjusted to better reflect the specific economic conditions of each Manageable Unit based on the relationship between the average household income in the Manageable Unit compared to that of the state. U.S. Census Bureau average household income for each county was applied to the

corresponding households within each Manageable Unit and summed to estimate total Manageable Unit income. This amount was then divided by the total number of households in the Manageable Unit, to produce a weighted average income for each Manageable Unit. That figure was divided by the average household income for Colorado to determine the average Manageable Unit household income as a percent of average Colorado household income. This index was then applied to the WTP value by Manageable Unit.

3.6.3.2 Water Quality Changes

The environmental and recreational benefits of the proposed nutrient regulations are based on the overall expected change in water quality within each Manageable Unit (see Section 3.3 for discussion regarding how water quality analysis methods). Existing baseline levels of TP and TIN were compared to expected nutrient levels under each effluent quality tier for specific stream segments within each Manageable Unit. TP and TIN levels in each stream segment were weighted by segment length and averaged to represent the average expected change for all impacted streams in the Manageable Unit for each nutrient.

Estimated changes in TP and TIN were combined into one estimate of water quality improvement for use in the benefits estimation. The expected impacts of changes in these nutrients are not equal; instead they were assumed to depend on the baseline levels of each nutrient within the context of the ratio of nitrogen to phosphorus (N:P). The ratio of N:P was calculated and compared to the 7.2:1 ratio found in most aquatic plants.¹⁴ Water bodies in each Manageable Unit were assumed to be either phosphorus or nitrogen limited based on the N:P ratio and the amount of the abundant nutrient that needed to be removed before any noticeable impact on water quality occurred was calculated. Any additional reduction in the abundant nutrient was deemed an "effective" reduction, i.e. a reduction that would have an impact on water quality, along with the changes in the remaining nutrient. The percentage changes in the two nutrients (the effective change in the abundant nutrient and the change in the limited nutrient) were then averaged to estimate the overall change in water quality for the Manageable Unit. Water quality changes depend in part on the current ratio of TIN:P in streams. For example, if a stream is phosphorus limited (N in abundance), a reduction in N would improve water quality, whereas a reduction in P would not likely have an impact on water quality. Therefore, a Manageable Unit could experience small changes in nutrients, which might have varying degrees of change in water quality depending on existing water quality in the stream reach. The calculation of water quality for the Manageable Unit is the driving factors in the estimation of benefits.

For lakes or reservoirs, adequate nutrient data to assess expected water quality changes were limited to a small number of Manageable Units. For those waterbodies, changes in water quality were estimated using the methods described in Section 3.3. For lakes and reservoirs, the average change in water clarity was required to calculate changes to lakeside property values. Water clarity is defined by the Secchi depth, which is a measure of the depth of visibility in the lake.

3.6.3.3 Benefits to Drinking Water Supplies

Section 3.5 summarizes some of the benefits of nutrient reduction on source waters for public water supply facilities. The costs developed for selected facilities to achieve compliance with SDWA regulations were used directly in the benefits analysis as avoided treatment costs for public water facilities. These costs were only developed for those facilities where a clear nexus between reduced nutrients in a receiving stream resulting from implementation of the proposed regulations could potentially reduce the need to upgrade downstream water treatment facilities.

¹⁴ If the ratio of N:P is greater than 7.2:1, then the water body is phosphorus limited and nitrogen is abundant. Conversely, if the ratio is less than 7.2:1, the water body is nitrogen limited and phosphorus is in abundance.

3.6.3.4 Recreational Benefits

The proposed nutrient regulations have the potential to benefit water-based recreational activities. Fishing, boating, and swimming are all popular activities for Colorado residents as well as out-of-state visitors. The level of participation in any of these activities is dependent on a number of factors, including the quality of the water and the anticipated enjoyment of the experience. Nutrient levels have the potential to impact recreational activity in a number of ways (EPA 2010; Dodds et al. 2008; Camargo and Alonso 2006):

- The water quality of a stream or lake will have an impact on aquatic habitat as well as fish health. Degraded waters may not support the types of habitat or food sources required for recreational fish species; high levels of nutrients may reduce growth rates or reproductive success or even result in fish kills.
- Swimming and boating are recreational activities in which people may have direct skin to water contact, making them susceptible to irritants or toxins that may occur with nutrient pollution; these irritants have the potential to result in eye irritation, skin rashes, respiratory irritation, gastrointestinal issues or even severe, life-threatening allergic reactions.
- The aesthetics of a lake or streamside location may be reduced by excess decaying organic matter caused by high nutrient concentrations; decaying plant material may also cause an unpleasant odor in the area. These factors would likely deter people from recreating in areas with high nutrient concentrations.
- Recreational activities may be physically impeded by plant growth or algal blooms caused by nutrients. In extreme cases, swimming, boating or fishing may become impossible due to thick plant matter or even area closures.

General Approach to Estimating Recreational Benefits

Baseline activity days and expenditure data for swimming, boating and fishing activities were gathered either at the county or statewide level and distributed among the Manageable Units, as described for each activity separately below. Estimates of changes in activity days resulting from the proposed nutrient reductions were made based on changes in nutrient levels and information obtained from the literature review relating water quality to recreational activity. Per day expenditure data were applied to the additional activity days to obtain recreational benefit values.

Recreational Activity Discount

Fishing, boating and swimming day data were compiled at the Manageable Unit level. However, the proposed nutrient regulations would only affect a portion of the water bodies within each Manageable Unit. Because recreation does not occur in all streams and not all of the streams and lakes where recreation occurs would be affected by the regulations, a discount factor was applied to total Manageable Unit recreational activity days to capture only the portion of activity potentially affected by the proposed regulations.

The project team assumed that recreation would occur mainly on the larger streams within each Manageable Unit, stream size orders 2 through 8, according to the National Hydrographic Database. Based on the total stream miles in those orders and the number of affected stream miles (those with a WWTF upstream affected by the regulation) in those orders, a unique recreational activity discount factor was calculated for each Manageable Unit. The discount factor was applied to total recreational fishing, boating, and swimming activity days for the Manageable Unit before any additional activity days resulting from the proposed regulations were estimated. Figure 3-27 provides an example of the stream miles affected by the implementation of the proposed regulation on upstream WWTFs. Note that only the highlighted areas were counted as affected stream miles. Tributaries to the affected waterbodies and portions of any waterbody

upstream of a non-exempt WWTF (or downstream of an exempt WWTF) were not included in the calculation of recreational benefits.

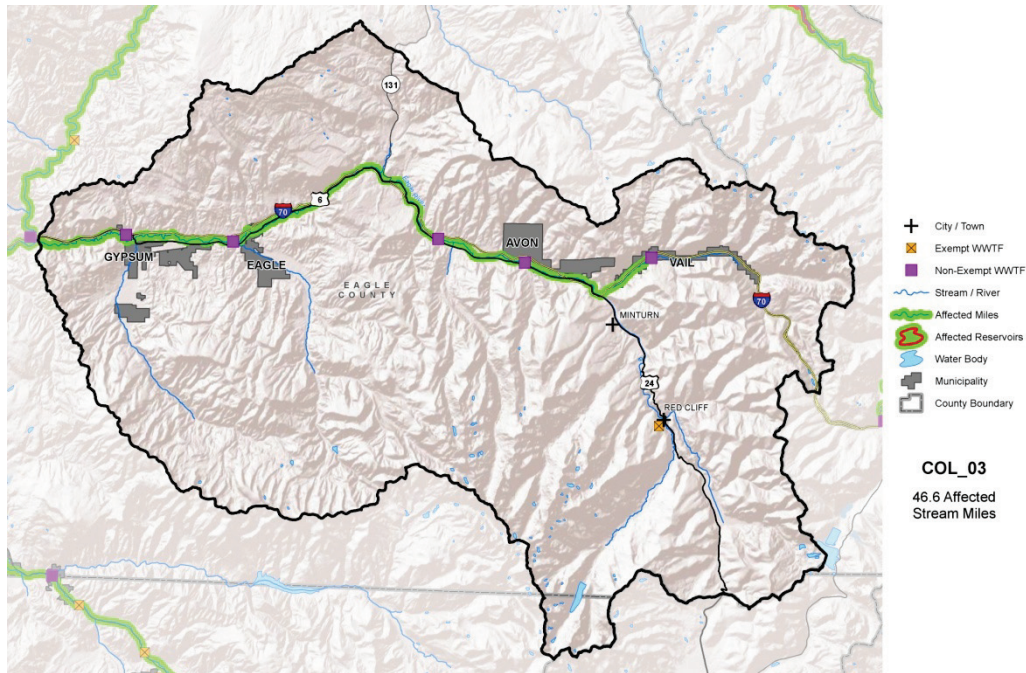


Figure 3-27. Example of “Affected Stream Miles” (waterbodies highlighted in green) Included in Analysis of Recreational Activity for Eagle River Watershed (Manageable Unit COL_03).

Additional Recreational Activity Days

Several studies cite increased frequency of participation in recreational activities as a result of improved water quality, as well as additional participation from people that do not currently engage in water based recreation. Eagan et al. 2004, estimates the change in recreational trips taken to lakes in Iowa as water quality is improved.¹⁵ Using the data provided in that study, the project team calculated a 0.2 percent increase in recreational activity resulting from a one percent increase in water quality. The 0.2 percent increase was applied to the percentage change in water quality calculated for each Manageable Unit. For example, a 10 percent reduction in nutrients would result in a 2 percent increase in activity days; that 2 percent would be applied to the existing discounted fishing, boating, and swimming activity days to estimate the additional number of days as a result of the proposed regulations, which accounts for those people currently recreating.

Additionally, more than half of Colorado residents do not currently participate in water based recreational activity. Improvements in water quality would attract some of those people to become participants. A study conducted by Needelman and Kealey, 1995, examined the relationship between water quality and participation in swimming activity, while Vesterinen and Pouta, 2008, found increased participation in a number of water based recreational activities as a result of improved water quality. In both studies, regression models were developed to explain participation in these activities; the parameters of specific model variables were used by the project team to estimate the following:

- 0.74 percent more people would swim given a one percent improvement in water quality;

¹⁵ A similar response to improved water quality was found in a yet-to-be published study by Dr. Daniel Phaneuf.

- 0.37 percent more people would boat given a one percent improvement in water quality; and
- 0.19 percent more people would fish given a one percent improvement in water quality.

These percentages were applied to the existing discounted number of anglers, boaters, and swimmers to estimate the number of new participants in each activity. It was assumed that these new participants would recreate half the number of days per year of existing recreators. Existing anglers fish an average of 11 days per year (U.S. Fish and Wildlife Service 2006), boaters average about 7 and a half days per year (Paddlesports 2009), and swimmers swim for an average of just under 4 days per year (U.S. Department of Interior 1986); therefore, new participants were assumed to fish for 5.5 days, boat for just under 4 days or swim for about 2 days per year.

Angling Benefits

Angler days per county were calculated using the Colorado Division of Wildlife report, *The Economic Impacts of Hunting, Fishing, and Wildlife Watching in Colorado*.¹⁶ Angler days by county were then assigned to the appropriate Manageable Unit. In cases where counties were divided between two or more Manageable Units, recreation maps from the Statewide Water Supply Initiative (SWSI)¹⁷ were used to allocate the county days between Manageable Units.

The estimated total number of additional angler days resulting from the improved water quality in each Manageable Unit was multiplied by the average angler expenditure per day (\$72) (Colorado Division of Wildlife [CDOW] 2008) plus the angler consumer surplus (\$39) (U.S. Department of Agriculture 2005), for a total of about \$110.50 per angler day.¹⁸ These benefits were assumed to occur annually and begin immediately after completion of WWTF construction activity.

Boating Benefits

In order to estimate the number of boating days for non-commercial boating, the percent of Coloradans participating in kayaking, canoeing, rafting, motor boating and sailing was applied to the 2009 Colorado population.¹⁹ This provided an estimate of how many people participate in each of these activities. Average number of days per participant by activity was then applied to the total number of participants.²⁰ These activity days were then allocated to each Manageable Unit based upon the number of angler days in the Manageable Unit as a percentage of total angler days in the state. The number of angler days, by Manageable Unit, appears to be the best proxy for the distribution of non-commercial boating days given the available data. In response to comments received on the Draft Report, the study team reviewed the baseline estimates of boater days in the ARK_02 MU, and found that boater day baseline figures for that MU were originally over-estimated. Stream flow conditions and smaller lakes in this MU require a different estimation technique. The number baseline boating days for the ARK_02 MU was allocated using a different method, the composite of proportionate lake perimeter miles, angler days and stream miles.

¹⁶ BBC Research & Consulting. 2008. *The Economic Impacts of Hunting, Fishing and Wildlife Watching in Colorado*.

¹⁷ Colorado Water Conservation Board. 2010. *Non-consumptive Needs Assessments*. Statewide Water Supply Initiative.

¹⁸ The angler consumer surplus is the additional value of a day of fishing beyond the anglers' expenditures.

¹⁹ Statewide Comprehensive Outdoor Recreation Plan. SCORP.

²⁰ A Special Report of Paddlesports 2009, Kayaking, Canoeing, Rafting. A Partnership Project of Outdoor Industry Association and Outdoor Foundation; and Boating Trends in the United States.

<http://www.responsivemanagement.com/boatingreports.php>

Commercial rafting days were assigned to each Manageable Unit based on the data from *Commercial River Use in the State of Colorado*.²¹ A 10-year average of user days was calculated for each river. User days were then assigned the appropriate Manageable Unit.

The estimated total number of additional boater days resulting from the improved water quality in each Manageable Unit was broken down into commercial boating and private boating components. Commercial boating days were multiplied by the average commercial boater expenditure per day (\$116) (CROIA 2010) plus a boater consumer surplus value (\$69) (U.S. Department of Agriculture [USDA] 2005), for a total of about \$184.50 per commercial boater day. Private boating days were multiplied by the average private boater expenditure per day (\$45) (Lee 2002) plus a consumer surplus value (\$69) (USDA), for a total of about \$114 per private boater day. These benefits were assumed to occur annually and begin immediately after completion of WWTF construction activity.

Swimming Benefits

The percentage of Colorado residents that participate in outdoor swimming in lakes or streams was taken from the Statewide Comprehensive Outdoor Recreation Plan (SCORP) and applied to DOLA population figures for 2009. The average number of activity days per swimmer was calculated using the *Nationwide Recreation Survey*.²² Swimmer days were apportioned to each Manageable Unit based on the combined percentages of lake circumference and population in each Manageable Unit as a percent of total lake circumference and population in the State.

The estimated total number of additional swimmer days resulting from the improved water quality in each Manageable Unit was multiplied by the average swimmer expenditure per day (\$30) (Shapiro and Kroll 2003) plus the swimmer consumer surplus (\$33) (USDA), for a total of about \$63 per swimmer day.²³ These benefits were assumed to occur annually and begin immediately after completion of WWTF construction activity.

Other Recreational Activity

Recreational activities, which are only indirectly associated with water, may also potentially be affected by the proposed nutrient regulations and the resulting improvement in water quality. For example, waterfowl hunting may be improved if the aquatic habitat and food source for duck, geese, and other birds is improved. People engaging in land based activities such as picnicking, scenic viewing, or wildlife viewing may have a better quality recreational experience as a result of improved aesthetics or reduced odors at lakes or as a result of improved wildlife habitat. These benefits were not quantified but are qualitatively recognized.

3.6.3.5 Property Value Benefits

Property values have the potential to be affected by changes in the water quality of nearby water bodies. Since the existence of excess, decaying plant materials caused by high nutrient levels may result in an unappealing scenic view, unpleasant odor or the inability to recreate; these factors would likely have an impact on property values. Many studies have documented changes in lakeside property values resulting from changes in water clarity. Generally, these studies incorporate data on property sales and water quality to estimate the change in value per foot of lakefront property from a one meter change in water clarity.

²¹Colorado River Outfitters Association. 2010. *Commercial River Use in the State of Colorado, 1998-2009*.

²²U.S. Department of the Interior. 1986. *1982-83 Nationwide Recreation Survey*. National Park Service.

²³ The swimmer consumer surplus is the additional value of a day of swimming beyond the swimmers' expenditures.

The literature search uncovered two studies with data that could be applied to the proposed nutrient regulations in Colorado (Michael et al. 1999 and Krysel et al. 2003). However, the Michael et al. study was conducted in Maine, while the Krysel et al. study was conducted with data from Minnesota properties. U.S. Census Bureau data show that the median home value in Colorado is 36 percent higher than in Maine and 13 percent higher than in Minnesota. Therefore, the results from these studies were increased by 36 percent and 13 percent respectively for consistency with Colorado home values. Once that adjustment was made, the numerous data points from these studies were averaged and adjusted to 2010 dollars. The final estimated benefit from a one-meter change in water clarity was calculated to be about \$63 per foot of lakefront property. These benefits were applied to private property surrounding lakes impacted by the proposed regulations. No property value benefits were applied to lake perimeters where the perimeter is publicly owned property. Water quality data were only available for a small number of lakes throughout the state; therefore, quantified property value benefits are likely only a portion of total property value benefits.

Changes in property values due to nutrient changes in streams were not quantified in this Study. Studies on this topic were inconclusive and therefore the estimation of such benefits was not supportable. It is possible such benefits might exist, but they cannot be documented in this Study.

3.6.3.6 Agricultural Benefits

Several studies and reports acknowledge the potential benefits to cattle and other livestock as a result of nutrient reduction in the drinking water (Brew et al. undated; EPA 2010). In general, clean water can promote healthy growth, reproduction, and milk production in these animals, while reducing illness and disease. Toxin-contaminated drinking water also has the potential for causing deaths of domestic animals in extreme cases. However, the EPA report also discusses the difficulty in linking benefits to nutrient controls since changes in on-site manure control or fertilization routines may have the largest impact on the quality of livestock drinking water supplies. Since livestock drinking water is largely influenced by the specific onsite practices of agricultural operations, no livestock related benefits were quantified as a result of the proposed nutrient regulations.

Agricultural operations of all types may benefit from reduced levels of nutrients in irrigation water due to the potential for improved flow through diversion canals and ditches. Vegetative growth in canals and ditches, caused in part by excessive nutrient levels, accumulates over time, resulting in decreased water flow through the infrastructure. The removal or reduction of vegetation often requires physical effort or the application of chemical products. Nutrient reduction would likely save operators both time and money when addressing this issue; however, the detailed data required to estimate these benefits is not available and they have not been quantified for this study.

3.6.3.7 Passive Benefits

The active benefits of nutrient reduction described above are directly related to human activities and human use of stream and lake resources. Additionally, there are a number of ecosystem functions that benefit from nutrient reduction which are not active, but for which people do have a value. These may include increased biodiversity, protection of species, and wetland functions. Passive benefits were estimated using a contingent valuation, or WTP, approach, as described below.

Baseline Value of Water Quality Improvements

In order to estimate the value of passive benefits resulting from the proposed nutrient regulations, the project gathered and reviewed a number of published contingent valuation, or WTP, studies. WTP studies estimate the value of specific environmental resources based on survey responses of both users and non-users of the resource. All the WTP studies acquired focused on improvements to surface water quality. These studies were screened for applicability to environmental conditions in Colorado, as well as by the

specific type of water quality improvement (i.e., a reduction in oil pollution was not applicable to nutrient regulation), to develop a group of studies useful in developing a WTP relationship for this analysis. Upon completion of the screening process, five studies including 16 data points were found to be relevant to the project (Croke et al. 1986-87; Stumborg et al. 2001; Lant and Tobin 1989; Hite 2002; Azevado et al. 2001). The water quality changes from these studies, along with the estimated dollar values for improvements, were averaged to develop a value of \$1.93 per one percent improvement in water quality (2010 dollars) per household per year.

Adjustment for Hypothetical Bias

Value estimates developed using the contingent valuation approach are hypothetical, in that survey respondents are not required to actually pay the amount they indicate they would be willing to pay. Some research papers suggest that the hypothetical nature of the payment causes WTP values to be overstated to some degree. Two major meta-analysis studies have analyzed a number of WTP papers to determine the degree of WTP inflation (List and Gallet 2001; Murphy et al. 2003). These studies suggest WTP values are inflated by as much as two to three times the actual WTP. Accordingly, the project team reduced the baseline WTP value by a calibration factor of 2.5 (i.e., divided the \$1.93 baseline value by 2.5) to get an adjusted WTP of \$0.77 per one percent improvement in water quality (2010 dollars) per household per year.

Income Adjustment

Because of the variation in median household income levels around the state, an adjustment was made to the baseline WTP value for each Manageable Unit to account for income differences. That is, the more disposable income a household has, the more likely it is that household will have a higher WTP. The ratio of the median household income (U.S. Census Bureau data) in a Manageable Unit to the statewide median household income was applied to the baseline WTP value to develop an income adjusted WTP value for each Manageable Unit.

Adjustment for Waters of Special Significance

Many areas of the state include special or unique water resources, such as Gold Medal streams or aquatic habitat for threatened and endangered species; the location and extent of these special environmental resources are identified in the Non-consumptive Needs Assessments component of the SWSI Report (2010). The proposed nutrient regulations could further improve some, but not all, of these special waters. To account for this potential, in Manageable Units where 20 percent or more of the existing special stream miles would be affected by the regulation, the annual household WTP values were increased by 10 percent.

Passive benefits estimates by Manageable Unit

The WTP values developed up to this point represent in general a household's total WTP for water quality improvements in the State of Colorado. However, the project team assumed that Colorado residents place a higher value on water quality improvements in their own Manageable Unit than in areas further from where they live. Therefore, several steps were followed in order to develop estimates of total passive benefits values by Manageable Unit. First, the adjusted WTP value for a Manageable Unit was multiplied by the number of households in that Manageable Unit. Second, two-thirds of that amount went directly into the value for that Manageable Unit and the remaining third was directed towards a statewide pool to be distributed among the rest of the Manageable Units in the state. The value in the statewide pool was then distributed among all Manageable Units based on a Manageable Unit ranking, which accounts for the number of stream miles impacted by the regulation, the average water quality change in the Manageable Unit and the portion of impacted stream miles that are waters of special significance. Finally, the two-thirds amount of value from households within the Manageable Unit and the amount distributed from the statewide pool were summed to estimate a total passive benefits value for each Manageable Unit.

3.6.3.8 Intrinsic Benefits

People may place values on improving Colorado's water resources for reasons other than direct use of the water. For example, a person may value the environment for use by future generations or find a value in just knowing that the resource exists in the world. These types of non-use benefits are commonly estimated via WTP studies. In this instance, the project team could not distinguish intrinsic values from passive benefits without specific surveys and analyses, which were not part of this Study. As a consequence, such benefits are recognized but not quantified.

3.6.4 Discount Rate

The time period for calculating benefits and costs is an important consideration in this Study. The capital costs of complying with the proposed regulations will occur during the construction years, but the annual WWTF operating costs and benefits will occur after the WWTFs are completed and will continue annually into the future. For the purposes of calculating benefits and costs, it is assumed that the proposed regulations would begin to be implemented within a Manageable Unit by the year 2015, design for WWTF improvements would take place in 2016, and construction would begin in 2017. This Study assumes the operating costs and benefits would last for 20 years. After that time, machinery and equipment at the WWTFs would be nearing the end of their life span and would need replacing or upgrading, which would require additional capital costs. .

Since construction costs take place at a different time than benefits, comparison of the two requires a discount back to present value for both benefits and costs. A discount rate is the interest rate which would be required to make a future dollar value equal to a present dollar value. The discount rate applied in this Study brings costs and benefits back to 2010 constant dollars.

The discount rate derived for this Study is based upon the long-term Treasury bond yield, the long-term Treasury Inflation Protected Series bond yield, and the long-term Authority bond yield. Table 3-30 shows the derivation of the discount rate using the baseline date for this Study, July 1, 2011.

Table 3-30. Derivation of the Discount Rate for the Nutrient Control Benefit Cost Study

July 1, 2011	
20-Year Treasury Bond Yield	4.12%
20-Year TIPS Bond Yield	1.47%
Difference: (Long-Term Inflation Expectation)	2.65%
20-Year CWRPDA Bond Yield	4.05%
Less: Long-Term Inflation Rate	2.65%
Discount Rate	1.40%

The long-term inflation expectation of 2.65 percent, based upon U.S. Treasury Bonds, is subtracted from Authority bond yields, to derive a Colorado-specific discount rate of 1.4 percent. That is the discount rate adopted for this Study.

3.7 Aggregation of Benefits and Costs

Cost-benefit analyses were completed for each Manageable Unit. Results for individual Manageable Units were then aggregated to the basin level and finally the results for the seven basins were aggregated to estimate statewide results, by effluent quality tier. At the Manageable Unit level, total discounted costs and benefits over the 22-year analysis period were added together to calculate the net benefits of the proposed nutrient regulations for that Manageable Unit. Additionally, a benefit-cost ratio was calculated for each Manageable Unit by dividing total discounted benefits by total discounted costs. A benefit-cost ratio greater than one indicates that the benefits outweigh the costs of the regulation for that Manageable Unit; a

benefit- cost ratio less than one indicates that the costs outweigh the benefits of the regulation. The cost-benefit analyses were completed separately for each effluent quality tier evaluated as part of this Study.

3.8 Stormwater Monitoring Costs

The final regulatory proposal requires MS4 dischargers to prepare a DADR that identifies existing stormwater monitoring information and the need for additional monitoring to be conducted in the future to determine the approximate nitrogen and phosphorus contribution to receiving waters due to MS4 discharges. Where monitoring may be required in the future, the Study developed monitoring cost estimates on a per outfall/per event basis.

Costs for potential future stormwater monitoring were estimated by incorporating several cost elements. These elements include planning costs such as locating monitoring stations, site characterization of outfalls, and research and documentation of hydrology and characteristics of the surrounding area. Costs for implementing a variety of sampling strategies including costs of renting equipment versus purchasing equipment and costs of using in-house field staff versus contracting field personnel. Utilities using these costs to develop a monitoring approach can combine a variety of these elements to produce an accurate cost estimate relevant to their specific needs should sampling be required in the future. Based on the various size categories of MS4 permit holders, costs were developed per outfall sampled, per sampling event. MS4 permit holders may derive their own estimated costs by multiplying outfall or event-specific unit costs by the number of outfalls being sampled and by the number of sampling events conducted based on their selected sampling strategy.

Unit costs were estimated using information compiled from MS4 permit holders provided through the assistance of the Colorado Stormwater Council (CSC), selected literature sources, and cost quotes from equipment vendors and environmental laboratories. Information submitted by MS4 permit holders is provided in Appendix H. A wide range of costs were quoted from the sources, and the costs presented in following sections serve to provide average potential costs to permit holders.

3.8.1 Stormwater Monitoring Costs Data Compilation

Costs were broken down into two main categories, planning costs and implementation costs. Planning costs are costs which would be required to initiate a new MS4 point source monitoring program if needed. These costs would include site visits and assessments of outfalls to identify monitoring stations, site characterizations of selected outfalls, and documentation of the representativeness of selected stations. Selected monitoring stations would be used throughout the program, therefore significantly reducing planning costs following initial implementation of the program. Site characterization would require an annual review of the continued representativeness of the data; however, these reviews would be less labor intensive than the initial assessment. Additionally, based on responses received from various MS4 permit holders (Appendix H), several jurisdictions currently implement wet weather and/or dry weather sampling programs, in which case these costs would be avoided by utilizing current monitoring sites. Planning costs were based entirely on staff resources, as there were no noted equipment needs for this portion of the program.

Implementation costs of the point source monitoring program include staff resources, sampling equipment, and laboratory analysis. Regulation #85 does not currently require monitoring, however, previous drafts of the regulation included requirements for monitoring wet weather discharge via either assessment of MS4 discharges or assessment of receiving waters in addition to assessment of dry weather discharges.

Costs for equipment and laboratory analysis were obtained through price quotes by equipment vendors and cost estimates provided in responses from MS4 permit holders. Sampling equipment varies based on

the preferences of the permit holder. Costs were subsequently developed for each of these scenarios of sample collection:

- Option A: Purchase automatic sampler
- Option B: Rent automatic sampler
- Option C: Grab samples collected by field staff

Lab costs were estimated using quotes submitted by both local and national environmental laboratories. Potential water chemistry parameters to be analyzed are total nitrogen (total kjeldahl nitrogen plus nitrate-nitrite) and total phosphorus. These parameters have 28 day hold times, therefore eliminating the need for immediate shipment of samples. All samples require sulfuric acid preservation and shipment on ice. Average shipping costs are also included in the cost estimate, as provided by major shipping carriers.

3.8.2 Stormwater Monitoring Costs Data Analysis

Total estimated potential sampling costs were calculated for each of the sampling scenarios listed above (purchase of automatic sampler, rental of automatic sampler, and utilizing field staff to collect grab samples). For utilities that may choose to purchase automatic samplers, initial wet weather and dry weather discharge monitoring program costs were estimated to average \$17,440 per outfall. Purchase costs of the portable sampler unit were estimated at \$10,000; therefore, subsequent sampling activities at the outfall would be estimated at \$7,440 following purchase of the sampler unit. For utilities that may choose to rent sampling equipment, monitoring program costs were estimated at \$11,424 per outfall with a one month rental package. For utilities utilizing field staff to collect grab samples (no automatic sampler), monitoring program costs were estimated at \$6,570 per outfall. Details of these estimated potential sampling costs can be seen in Table 4-1.

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Section 4

Manageable Unit Findings

This section provides the results from implementation of the methodology defined in Section 3. The results are organized by river basin and Manageable Unit. This section provides the results in a streamlined, summary format to focus on the key findings by basin and Manageable Unit. Appendices A through D provide supporting data for the results documented below.

4.1 Arkansas River Basin

This section provides the findings applicable to the three Manageable Units established for the Arkansas River Basin (see Manageable Unit delineation in Section 3.2 along with Figure 3-3).

4.1.1 ARK_01 - Upper Arkansas River Basin

ARK_01 is comprised of two HUC-8 watersheds and generally includes the Arkansas River Basin upstream of the City of Pueblo. Figure 4-1 illustrates the area covered by ARK_01 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.1.1.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-1 and 4-2 (see Figure 4-1 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-1; Figure 4-2) and for TIN (Table 4-2; Figure 4-3). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed. It should be noted that the confluence of the Arkansas River and Fountain Creek occurs upstream of site ARK – 1.1 and site IDs increase as they move upstream.

Table 4-1. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in ARK_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
ARK - 1.1	Mainstem	0.30	0.13	0.12	0.09
ARK - 1.1.1	Saint Charles River	0.04	0.04	0.04	0.04
ARK - 1.2	Mainstem	0.14	0.09	0.09	0.08
ARK - 1.3	Mainstem	0.02	0.02	0.02	0.02
ARK - 1.3.2	Fourmile Creek	0.07	0.07	0.07	0.07
ARK - 1.3.3	South Arkansas River	0.02	0.02	0.02	0.02
ARK - 1.4	Mainstem	0.02	0.02	0.02	0.02

Table 4-2. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in ARK_01

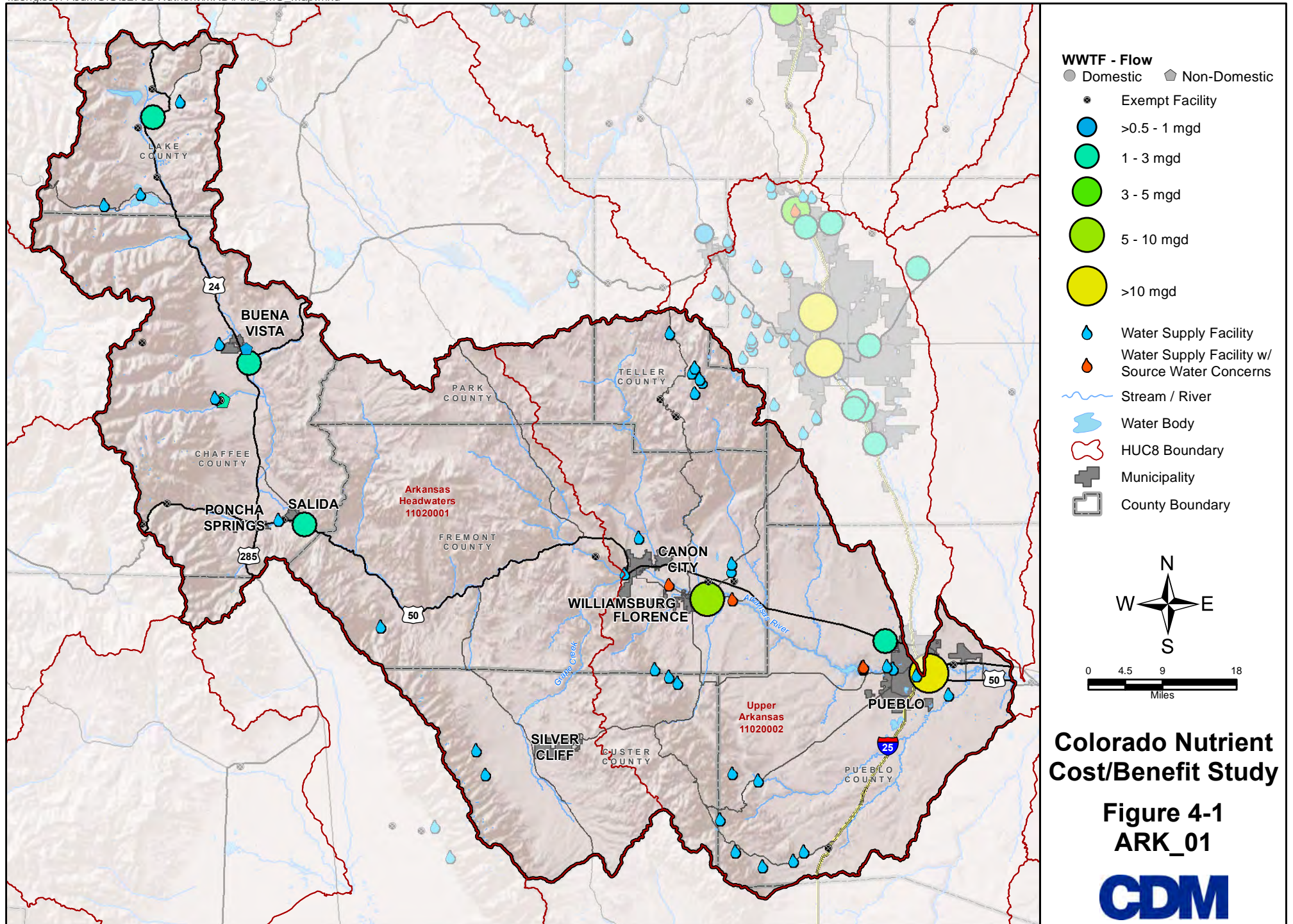
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
ARK - 1.1	Mainstem	1.86	0.83	0.63	0.17
ARK - 1.1.1	Saint Charles River	1.15	1.15	1.15	1.15
ARK - 1.2	Mainstem	1.48	0.67	0.51	0.16
ARK - 1.3	Mainstem	0.55	0.31	0.26	0.15
ARK - 1.3.2	Fourmile Creek	0.86	0.86	0.86	0.86
ARK - 1.3.3	South Arkansas River	no data	n/a	n/a	n/a
ARK - 1.4	Mainstem	0.22	0.14	0.13	0.09

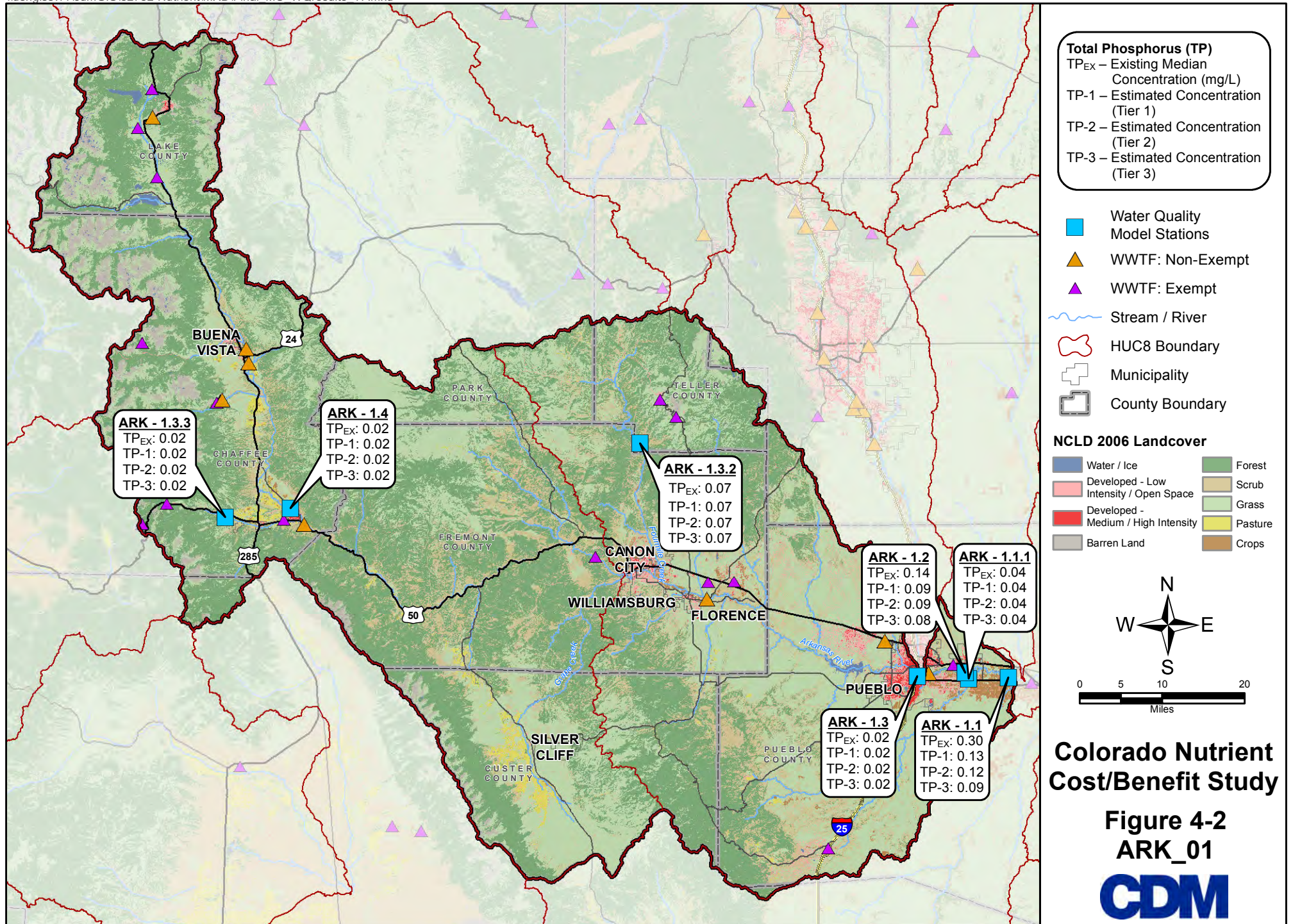
Reservoirs

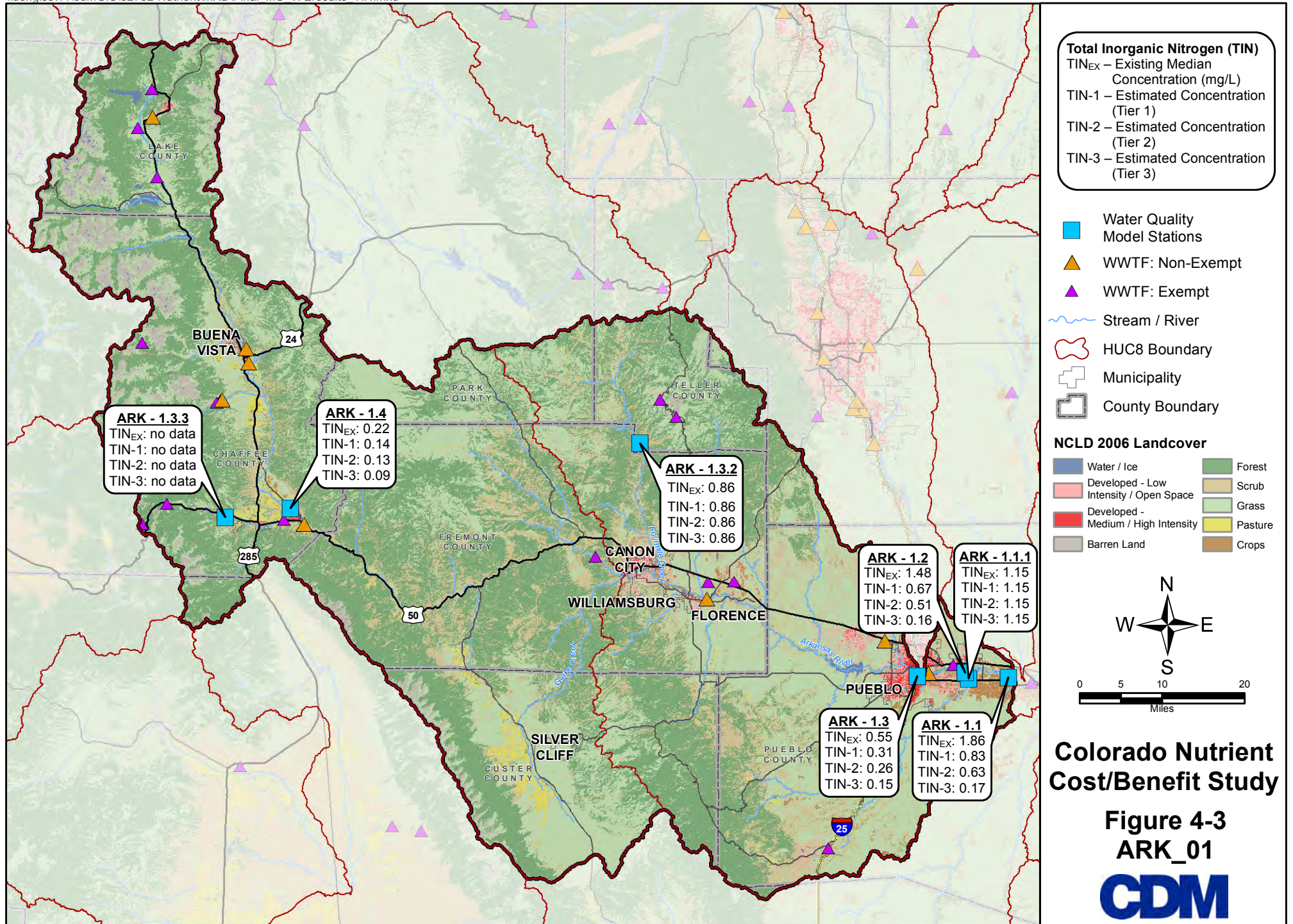
Pueblo Reservoir was analyzed within ARK_01 (see Figure 4-4). Table 4-3 summarizes existing water quality and expected water quality under implementation of Tier 1, 2, or 3 effluent limits. The median TP and TIN concentrations in the reservoir are less than upstream median nutrient concentrations. Accordingly, given the few WWTFs upstream of the reservoir, implementation of the nutrient control regulation is expected to have little impact on water quality and trophic status in Pueblo Reservoir.

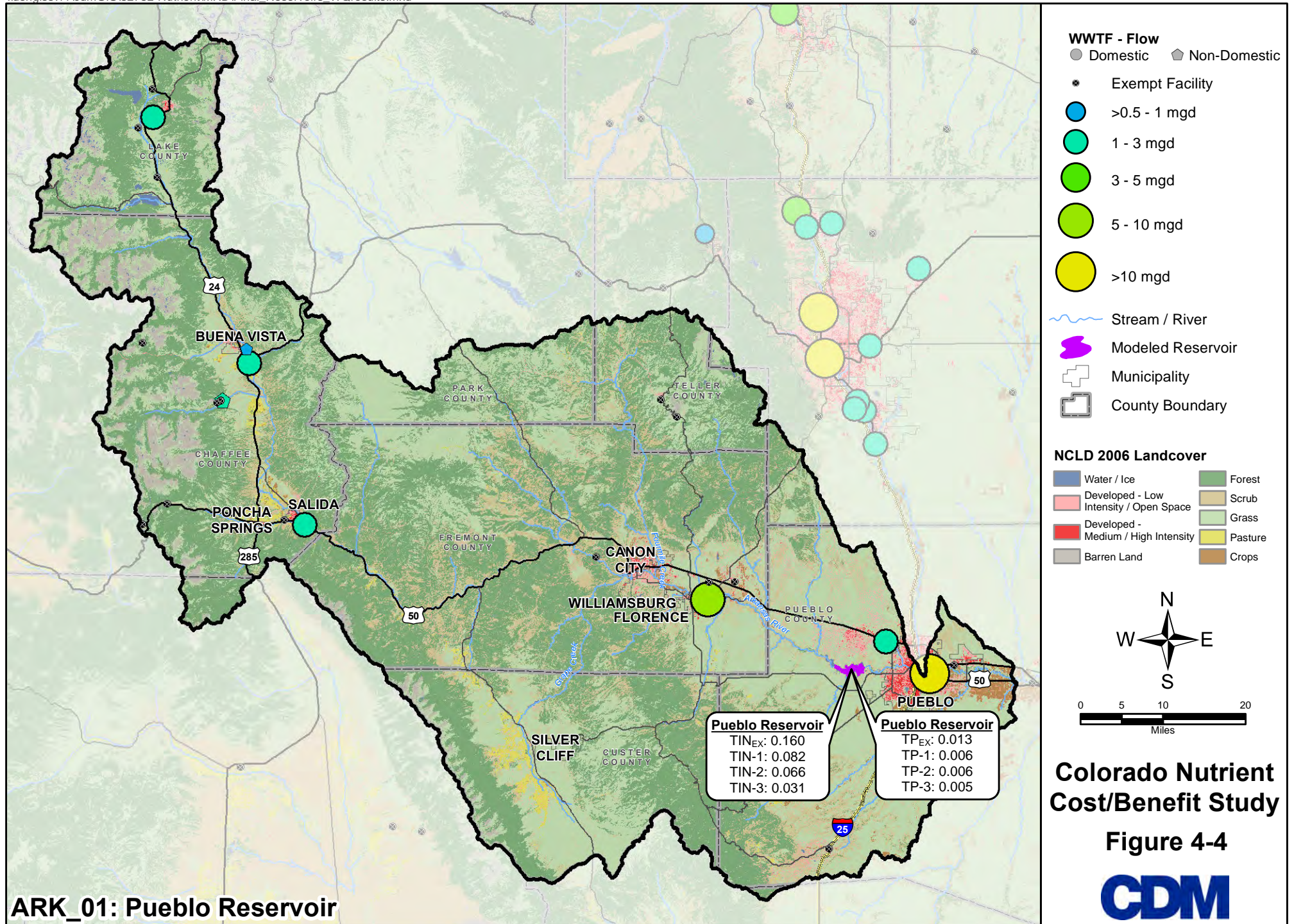
Table 4-3. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in Pueblo Reservoir

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.013	0.006	0.006	0.005
TIN	0.160	0.082	0.066	0.031









4.1.1.2 Wastewater Costs

Table 4-4 summarizes the WWTFs located in ARK_01 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-4. WWTFs in ARK_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
CO Correctional Industries	Buena Vista Unit	0.51	>0.5 to 1	1	Treatment plant category is assumed
Princeton Holdings LLC	Mt. Princeton Hot Springs Resort	1.01	>1 to 3	1	Treatment plant category is assumed
Leadville Sanitation District		1.15	>1 to 3	1	
Buena Vista Sanitation District	Buena Vista Sanitation District WWTF	1.5	>1 to 3	1	
Pueblo West Metropolitan District		1.8	>1 to 3	1	
Fremont Sanitation District	Rainbow Park Regional WWTF	8.5	>5 to 10	1	
Royal Gorge Co. of Colorado		0.018	0-0.5	1	Exempted due to capacity
Monarch Mountain Lodge	Garfield WWTF	0.041	0-0.5	1	Exempted due to capacity
Victor, City of		0.087	0-0.5	1	Exempted due to capacity
Meadowbrook Mobile Home Park, LLC	Meadowbrook Mobile Home Park WWTF	0.12	0-0.5	1	Exempted due to capacity
Salida, City of	Salida Hot Springs Aquatic Center	0.21	0-0.5	1	Exempted due to capacity
Young Life Campaign Inc.	Frontier Ranch WWTF	0.0186	0-0.5	2	Exempted due to capacity
Salida, City of		2.1	>1 to 3	3	
Pueblo, City of	James R Diiorio WRF	19	>10	3	
Cripple Creek, City of		1	>0.5 to 1	1	Exempted: Disadvantaged
Moose Haven Condos		0.0103	0-0.5	4	Exempted due to capacity
Penrose Sanitation District	Penrose WWTF	0.02144	0-0.5	4	Exempted due to capacity
Leadville MHC LLC	Lake Fork Mobile Home Park	0.043	0-0.5	4	Exempted due to capacity
Christian Mission Concerns	Silver Cliff Ranch	0.049	0-0.5	4	Exempted due to capacity
Cheyenne Wells Sanitation District No. 1		0.14	0-0.5	4	Exempted due to capacity
La Jara, Town of		0.17	0-0.5	4	Exempted due to capacity
Colorado City Metropolitan District		0.4	0-0.5	4	Exempted due to capacity
Mt. Princeton Hot Springs Resort		0.047	0-0.5	5	Exempted due to capacity
Mountain View Villages WSD	Mountain View Villages WWTF	0.1	0-0.5	5	Exempted due to capacity
Powder Monarch LLC	Monarch Ski Area	0.23	0-0.5	5	Exempted due to capacity

Table 4-5 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-6 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-6 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-5. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$103,389,000	\$219,834,000	\$1,277,649,000
Annual Operation & Maintenance Costs	\$3,385,000	\$5,475,000	\$19,134,000

Costs rounded to nearest \$1000.

Table 4-6. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$15,924,000	\$20,393,000	\$141,254,000
Annual Operation & Maintenance Costs	\$787,000	\$1,038,000	\$4,452,000

Costs rounded to nearest \$1000.

4.1.1.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The following utilities were included in the ARK_01 analysis: City of Florence, Holcim Inc., Pueblo West MD, XCEL Energy Comanche Plant, and the Colorado Springs Utilities. These avoided costs are provided in Table 4-7.

4.1.1.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in ARK_01, in present value (2010), are presented in Table 4-7.

Table 4-7. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU ARK_01

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$93,154,000	\$198,071,000	\$1,151,165,000
Operating	\$52,519,000	\$84,945,000	\$296,851,000
Total	\$145,673,000	\$283,016,000	\$1,448,016,000
Potable Water Supply Benefits			
Capital	\$4,266,000	\$4,266,000	\$4,266,000
Operating	\$18,329,000	\$18,329,000	\$18,329,000
Total	\$22,595,000	\$22,595,000	\$22,595,000
Percent Change in Water Quality (streams)			
	6.01%	6.53%	8.18%
Percent Change in Water Quality (Lakes)			
	39.38%	50.10%	65.29%

Table 4-7. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU ARK_01

	Tier 1	Tier 2	Tier 3
Projected Active Benefits			
Angling	\$68,794,000	\$87,251,000	\$113,619,000
Boating	\$203,447,000	\$257,690,000	\$335,464,000
Swimming	\$3,086,000	\$3,829,000	\$4,961,000
Total	\$275,327,000	\$348,770,000	\$454,044,000
Property Value Benefits			
	NA	NA	NA
Passive Benefits			
	\$10,940,000	\$11,442,000	\$14,723,000
Total Quantified Benefits	\$308,862,000	\$382,807,000	\$491,362,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.1.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed regulation in ARK_01 are \$163,190,000 for Tier 1, \$99,791,000 for Tier 2, and -\$956,653,000 for Tier 3. The benefit-cost ratio is 2.12:1, 1.35:1, and 0.34:1 for Tiers 1, 2, and 3, respectively (Table 4-8).

Table 4-8. Benefit Cost Summary for MU ARK_01, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$308,863,000	\$382,808,000	\$491,363,000
Total Costs	\$145,673,000	\$283,016,000	\$1,448,016,000
Net Present Value Benefits	\$163,190,000	\$99,791,000	(\$956,653,000)
Benefit Cost Ratio	2.12 : 1	1.35 : 1	0.34 : 1

4.1.2 ARK_02 - Fountain Creek

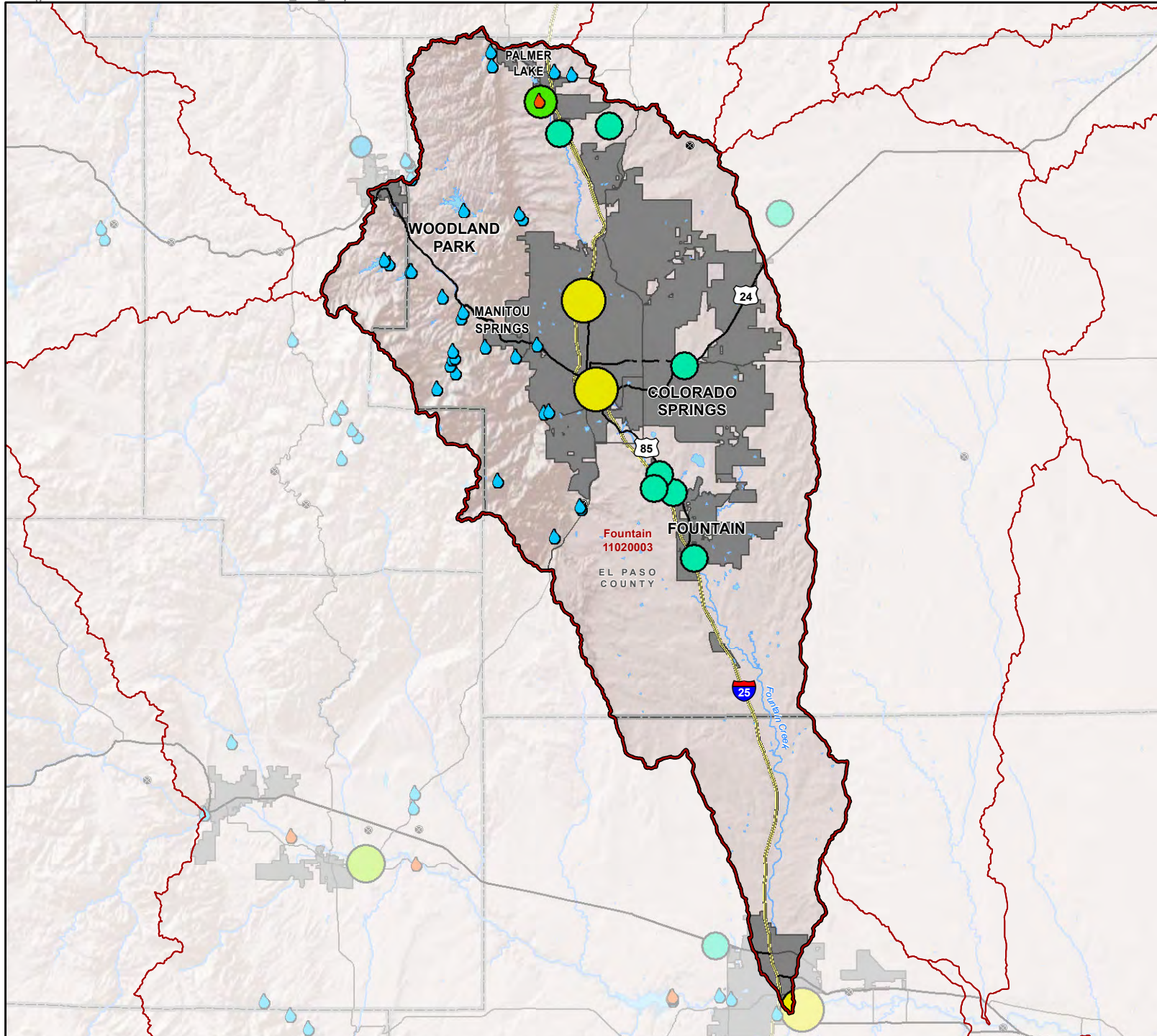
ARK_02 is comprised of the Fountain Creek drainage area and contains Colorado Springs. Figure 4-5 illustrates the area covered by ARK_02 including WWTFs, general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.1.2.1 Water Quality Analyses

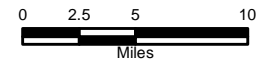
The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the majority of the facilities, 4.5 mg/L TP and 25 mg/L TIN. Fountain Sanitation District had provided effluent quality data to the CCWUC and these data were used to characterize TP and TIN contributions from this WWTF.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-9 and 4-10 (see Figure 4-5 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-9; Figure 4-6) and for TIN (Table 4-10; Figure 4-7). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed. It should be noted that Fountain Creek flows into the Arkansas River near the downstream end of ARK_01 (Section 4.1.1).



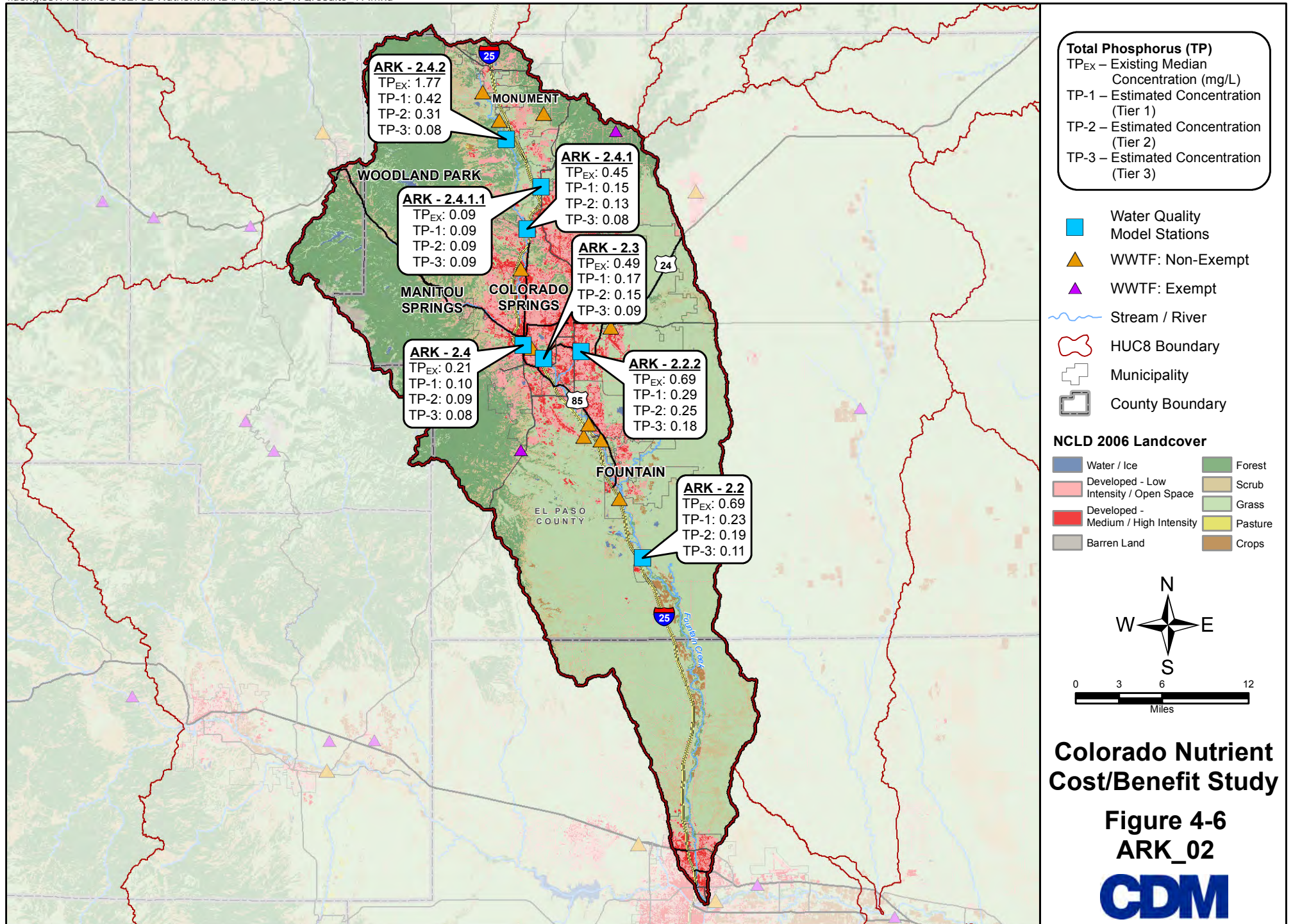
- WWTF - Flow**
- Domestic ● Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
- Water Supply Facility
● Water Supply Facility w/ Source Water Concerns
- Stream / River
— Water Body
- HUC8 Boundary
— Municipality
— County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 4-5
ARK_02

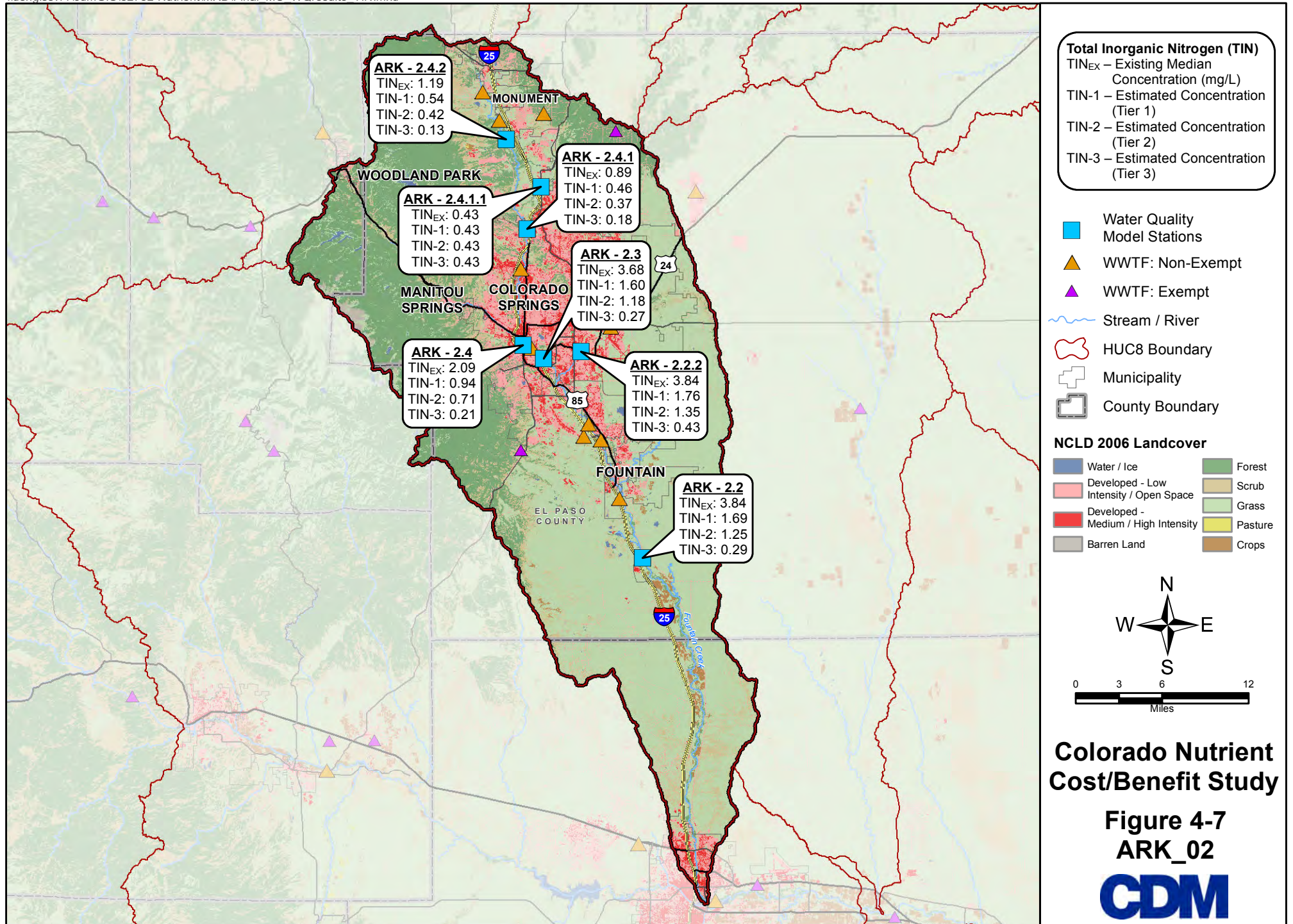




Colorado Nutrient Cost/Benefit Study

**Figure 4-6
 ARK_02**





Colorado Nutrient Cost/Benefit Study

**Figure 4-7
 ARK_02**



Table 4-9. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in ARK_02

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
ARK - 2.2	Mainstem	0.69	0.23	0.19	0.11
ARK - 2.2.2	Sand Creek	0.69	0.29	0.25	0.18
ARK - 2.3	Mainstem	0.49	0.17	0.15	0.09
ARK - 2.4	Mainstem	0.21	0.10	0.09	0.08
ARK - 2.4.1	Mainstem	0.45	0.15	0.13	0.08
ARK - 2.4.1.1	Kettle Creek	0.09	0.09	0.09	0.09
ARK - 2.4.2	Mainstem	1.77	0.42	0.31	0.08

Table 4-10. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in ARK_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
ARK - 2.2	Mainstem	3.84	1.69	1.25	0.29
ARK - 2.2.2	Sand Creek	3.84	1.76	1.35	0.43
ARK - 2.3	Mainstem	3.68	1.60	1.18	0.27
ARK - 2.4	Mainstem	2.09	0.94	0.71	0.21
ARK - 2.4.1	Mainstem	0.89	0.46	0.37	0.18
ARK - 2.4.1.1	Kettle Creek	0.43	0.43	0.43	0.43
ARK - 2.4.2	Mainstem	1.18	0.54	0.42	0.13

Reservoirs

No reservoirs were analyzed in the Fountain Creek Manageable Unit.

4.1.2.2 Wastewater Costs

Table 4-11 summarizes the WWTFs located in ARK_02 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-11: WWTFs in ARK_02

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Academy School District 20	Edith Wolford Elementary School WWTF	0.007875	0-0.5	1	Exempted due to capacity
Broadmoor Park Properties		0.049999	0-0.5	1	Exempted due to capacity
Fountain Sanitation District	Fountain SD WWTF	1.3	>1 to 3	1	
Ft. Carson STP		1.3	>1 to 3	1	
Widefield Water and Sanitation District (WSD)	Widefield WSD	2.5	>1 to 3	1	
Tri-Lakes WWTF		4.2	>3 to 5	1	
Colorado Springs Utilities	Northern WRF	20	>10	1	
Colorado Springs Utilities		65	>10	1	
Security Sanitation District		2.4	>1 to 3	2	
Academy WSD		1.2	>1 to 3	4	
Cherokee Metropolitan District		2	>1 to 3	1	Treatment Plant Category Assumed
Donala WSD	Upper Monument Creek Regional WWTF	1.75	>1 to 3	5	

Table 4-12 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-13 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-13 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-12. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$215,341,000	\$580,817,000	\$3,550,675,000
Annual Operation & Maintenance Costs	\$8,998,000	\$15,307,000	\$52,151,000

Costs rounded to nearest \$1000.

Table 4-13. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$209,000	\$254,000	\$2,947,000
Annual Operation & Maintenance Costs	\$4,000	\$17,000	\$94,000

Costs rounded to nearest \$1000.

4.1.2.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The following utilities were included in the ARK_02 analysis: Colorado Springs Utilities and Woodmoor WSD. These avoided costs are provided in Table 4-14.

4.1.2.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in ARK_02, in present value (2010), are presented in Table 4-14.

Table 4-14. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU ARK_02

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$194,023,000	\$523,317,000	\$3,199,166,000
Operating	\$139,595,000	\$237,472,000	\$809,061,000
Total	\$333,618,000	\$760,789,000	\$4,008,227,000
Potable Water Supply Benefits			
Capital	\$3,642,000	\$3,642,000	\$3,642,000
Operating	\$16,063,000	\$16,063,000	\$16,063,000
Total	\$19,705,000	\$19,705,000	\$19,705,000
Percent Change in Water Quality (streams)			
	54.37%	66.19%	81.37%
Percent Change in Water Quality (Lakes)			
	NA	NA	NA
Projected Active Benefits			
Angling	\$39,816,000	\$48,476,000	\$59,592,000
Boating	\$51,541,000	\$62,752,000	\$77,141,000
Swimming	\$25,337,000	\$30,848,000	\$37,922,000
Total	\$116,694,000	\$142,076,000	\$174,655,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$140,763,000	\$169,129,000	\$209,869,000
Total Quantified Benefits	\$277,162,000	\$330,910,000	\$404,229,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.1.2.5 Benefit-Cost Ratio

The net present value benefits of the proposed regulation in ARK_02 are -\$56,455,000 for Tier 1, -\$429,879,000 for Tier 2, and -\$3,603,998,000 for Tier 3. The benefit-cost ratio is 0.83:1, 0.43:1, and 0.1:1 for Tiers 1, 2, and 3, respectively (Table 4-15).

Table 4-15. Benefit Cost Summary for MU ARK_02, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$277,163,000	\$330,911,000	\$404,229,000
Total Costs	\$333,618,000	\$760,789,000	\$4,008,227,000
Net Present Value Benefits	(\$56,455,000)	(\$429,879,000)	(\$3,603,998,000)
Benefit Cost Ratio	0.83 : 1	0.43 : 1	0.1 : 1

4.1.3 ARK_03 – Lower Arkansas River

ARK_03 is comprised of the Lower Arkansas River drainage area and is downstream of ARK_01 and ARK_02. This Manageable Unit contains 18 HUC-8 watersheds and follows the Arkansas River from below Pueblo to the stateline. Figure 4-8 illustrates the area covered by ARK_03 including WWTFs, general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.1.3.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-16 and 4-17 (see Figures 4-8 through 4-10 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-16; Figure 4-9) and for TIN (Table 4-17; Figure 4-10). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed. It should be noted that ARK_01 and ARK_02 contribute loads to ARK_03 (Section 4.1.1 and 4.1.2).

Table 4-16. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in ARK_03

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
ARK - 3.1	Mainstem	0.02	0.02	0.02	0.02
ARK - 3.2	Mainstem	0.03	0.03	0.03	0.03
ARK - 3.2.1	Purgatoire River	0.04	0.04	0.04	0.04
ARK - 3.3	Mainstem	0.19	0.13	0.12	0.11
ARK - 3.3.2	Cucharas River	0.07	0.07	0.07	0.07

Table 4-17. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in ARK_03

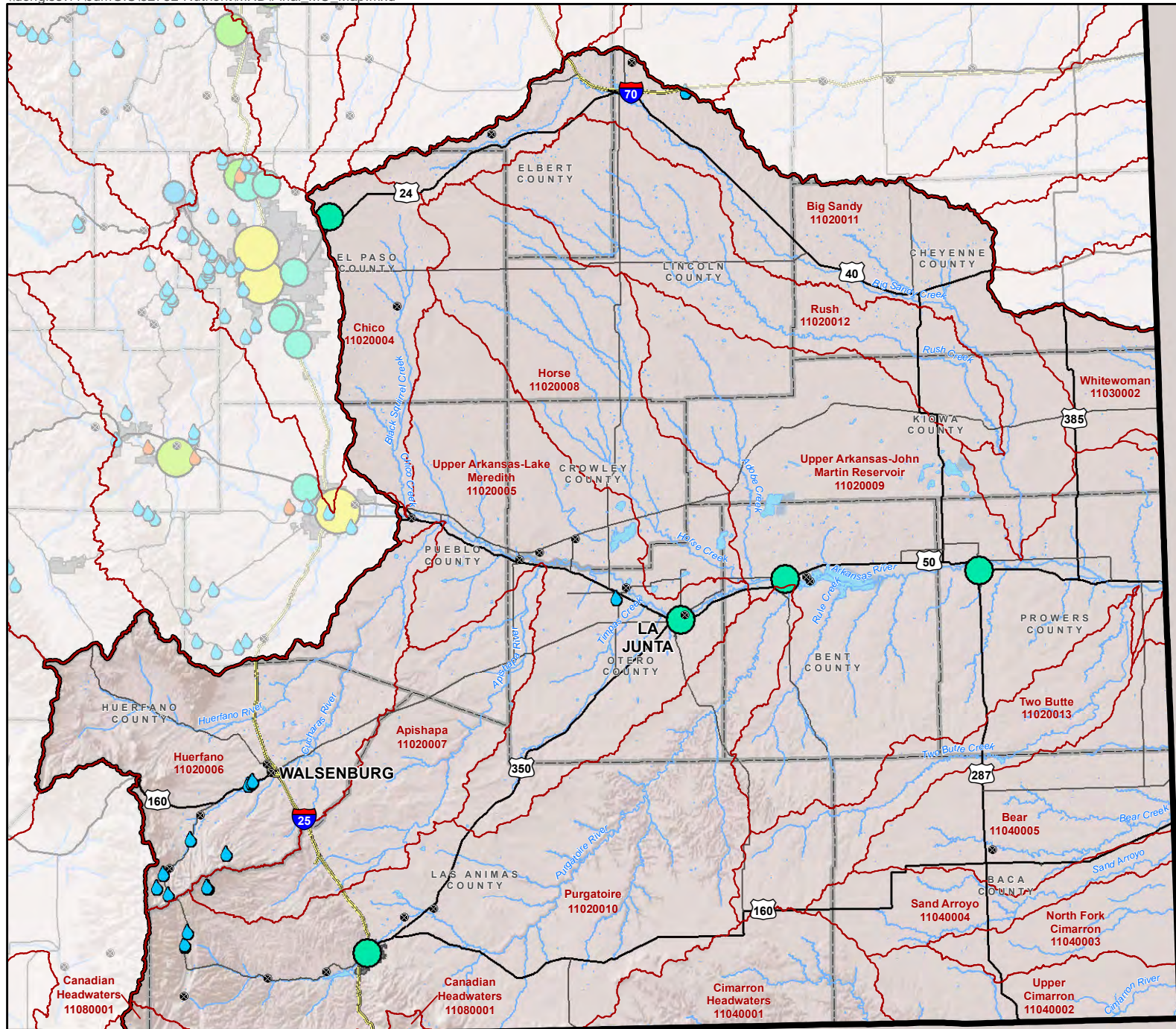
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
ARK - 3.1	Mainstem	1.18	0.59	0.47	0.21
ARK - 3.2	Mainstem	0.71	0.38	0.31	0.16
ARK - 3.2.1	Purgatoire River	0.30	0.17	0.14	0.08
ARK - 3.3	Mainstem	1.92	0.88	0.68	0.22
ARK - 3.3.2	Cucharas River	0.49	0.49	0.49	0.49

Reservoirs

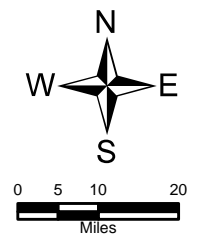
John Martin Reservoir was analyzed within ARK_03 (see Figure 4-11). Table 4-18 summarizes existing water quality and expected water quality under implementation of Tier 1, 2, or 3 effluent limits. The median TP and TIN concentrations in the reservoir are similar to upstream median nutrient concentrations. The results of the water quality mass balance for this reservoir suggest that in the trophic status will not be affected/improve until Tier 3.

Table 4-18. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in John Martin Reservoir

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.040	0.010	0.008	0.003
TIN	0.225	0.096	0.070	0.012



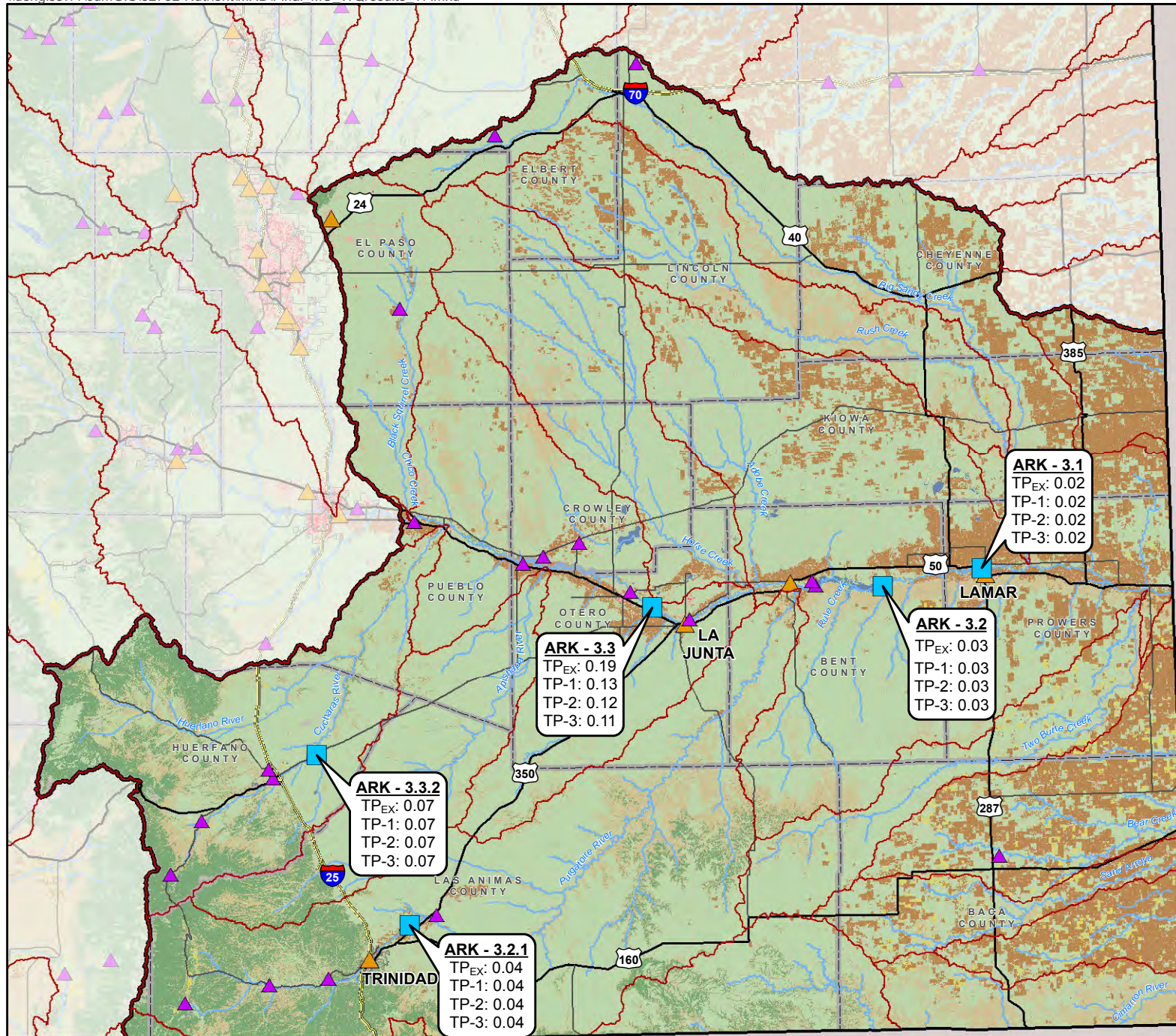
- WWTF - Flow**
- Domestic ● Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
- Water Supply Facility
● Water Supply Facility w/ Source Water Concerns
- Stream / River
Water Body
HUC8 Boundary
Municipality
County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 4-8
ARK_03

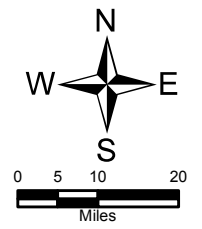




Total Phosphorus (TP)
 TP_{EX} – Existing Median Concentration (mg/L)
 TP-1 – Estimated Concentration (Tier 1)
 TP-2 – Estimated Concentration (Tier 2)
 TP-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- Stream / River
- HUC8 Boundary
- Municipality
- County Boundary

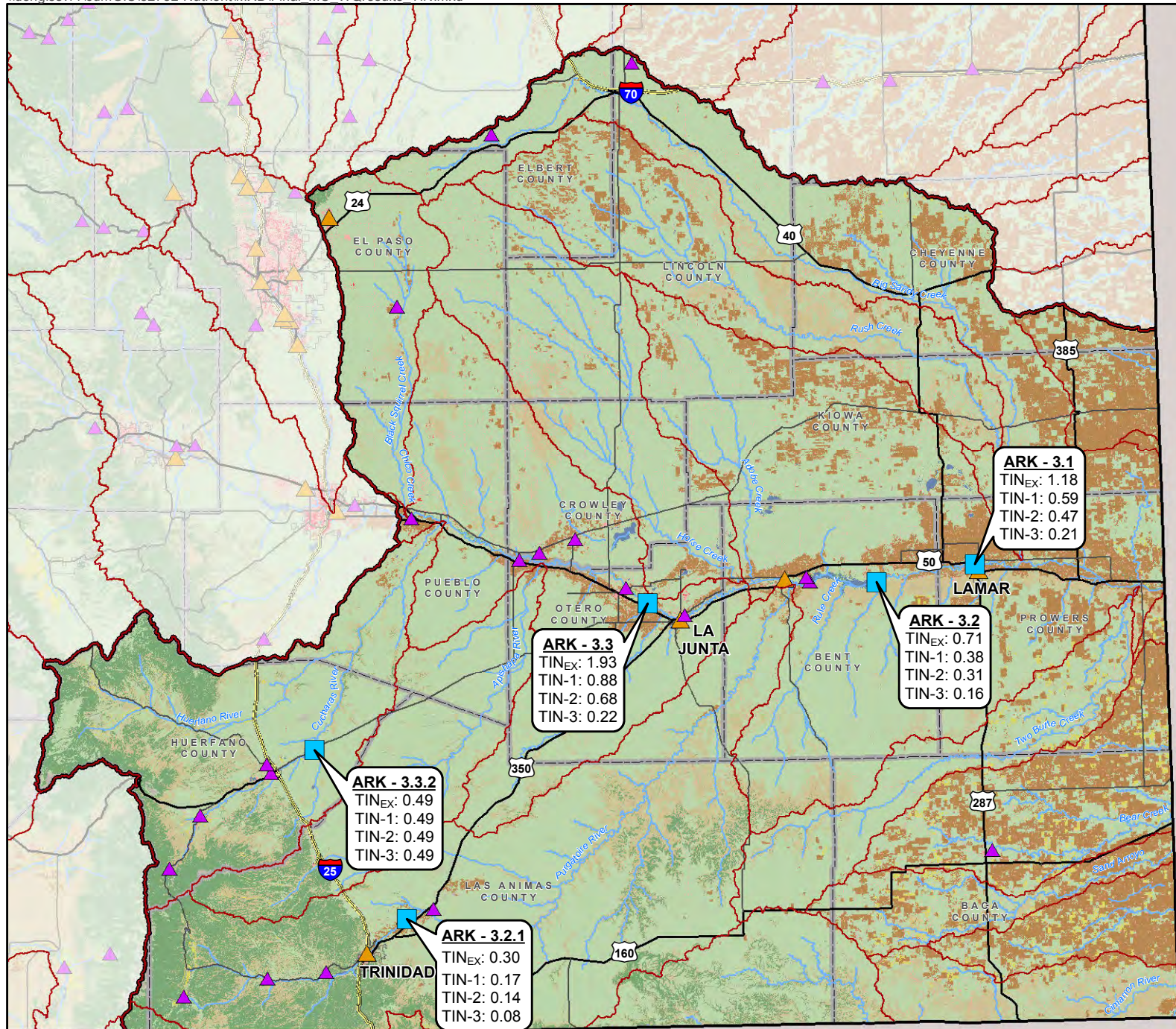
- NCLD 2006 Landcover**
- | | |
|--|---------|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



Colorado Nutrient Cost/Benefit Study

Figure 4-9
ARK_03

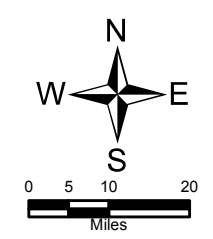




Total Inorganic Nitrogen (TIN)
 TIN_{Ex} – Existing Median Concentration (mg/L)
 TIN-1 – Estimated Concentration (Tier 1)
 TIN-2 – Estimated Concentration (Tier 2)
 TIN-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- ~ Stream / River
- HUC8 Boundary
- + Municipality
- County Boundary

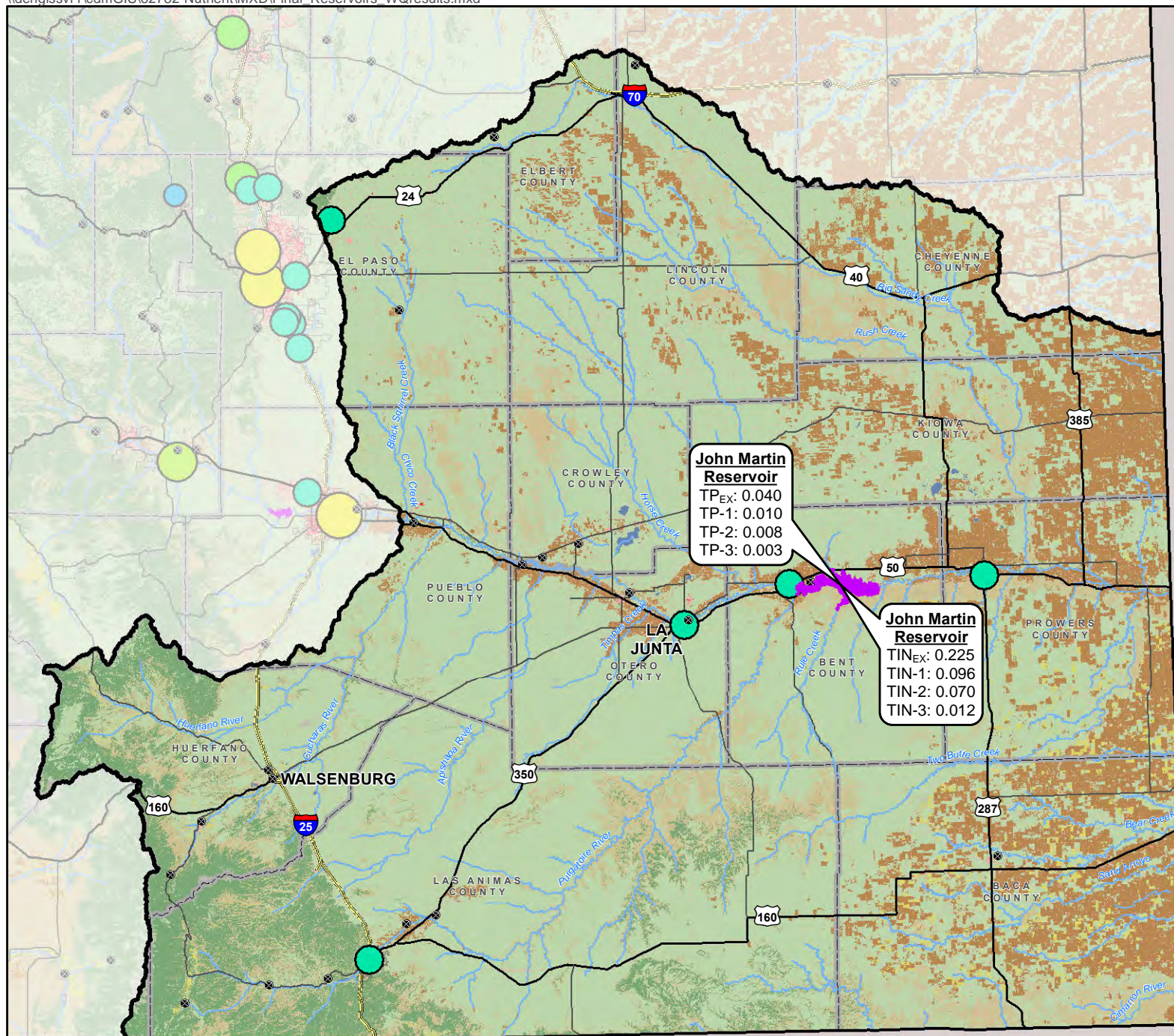
- NCLD 2006 Landcover**
- | | |
|--|---|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



Colorado Nutrient Cost/Benefit Study

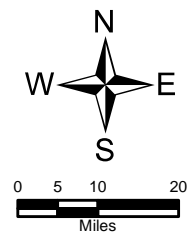
Figure 4-10
ARK_03





- WWTF - Flow**
- Domestic ◈ Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
 - ~ Stream / River
 - Modeled Reservoir
 - ⊕ Municipality
 - ▭ County Boundary

- NCLD 2006 Landcover**
- | | |
|--|---------|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



Colorado Nutrient Cost/Benefit Study

Figure 4-11



ARK_03: John Martin Reservoir

4.1.3.2 Wastewater Costs

Table 4-19 summarizes the WWTFs located in ARK_03 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-19: WWTFs in ARK_03

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Cokedale, Town of	Cokedale WWTF	0.0185	0-0.5	4	Exempt due to capacity
Colorado Department of Corrections	Trinidad Correctional Facility	No Data		0	Exempt due to capacity
Crowley Co. Correctional		No Data		4	Exempt due to capacity
Sunset Metropolitan District	Ellicott Springs WWTF	No Data		4	Exempt due to capacity
Trinidad, City of	Trinidad WWTF	2	>1 to 3	1	
La Junta, City of		2.3	>1 to 3	1	
Colorado, State of	For Lyons Correctional Facility	0.5	0-0.5	1	Exempt due to capacity
Hoehne School District R3		0.006	0-0.5	4A	Exempt due to capacity
Primero School District		0.019999	0-0.5	4A	Exempt due to capacity
Walsenburg, City of		0.75	>0.5 to 1	4	Exempt due to capacity
Limon, Town of		0.85	>0.5 to 1	4	Exempt due to capacity
Las Animas, City of	Las Animas WWTF	1.031	>1 to 3	4	
Lamar, City of		1.16	>1 to 3	4	
Rocky Ford, City of	Rocky Ford WWTF	1.2	>1 to 3	4	Exempted: Disadvantaged
Paint Brush Hills Metropolitan District		1.3	>1 to 3	4	
Avondale WSD	Avondale and Ft. Reynolds WWTFs	0.016	0-0.5	4	Exempt due to capacity
Country Host Motel		0.049999	0-0.5	4	Exempt due to capacity
North La Junta Sanitation District		0.0625	0-0.5	4	Exempt due to capacity
Fowler, Town of		0.109	0-0.5	4	Exempt due to capacity
La Veta, Town of		0.125	0-0.5	4	Exempt due to capacity
Crowley, Town of		0.17	0-0.5	4	Exempt due to capacity
Simla, Town of		0.499999	0-0.5	4	
Springfield, Town of		0.499999	0-0.5	4	Exempt due to Capacity
Trinidad, City of	Trinidad WWTF	0.025	0-0.5	5	Exempt due to capacity
Cucharas WSD		0.175	0-0.5	5	Exempt due to capacity
Colorado Department of Corrections	Fort Lyon WWTF	0.112	0-0.5	6	Exempt due to capacity

Facilities with a 4A for treatment category are treated like lagoon systems for costing purposes.

Table 4-20 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-21 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-21 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-20. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$39,444,000	\$47,361,000	\$374,642,000
Annual Operation & Maintenance Costs	\$1,972,000	\$2,254,000	\$7,542,000

Costs rounded to nearest \$1000.

Table 4-21. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$34,673,000	\$40,898,000	\$215,071,000
Annual Operation & Maintenance Costs	\$1,913,000	\$2,195,000	\$7,222,000

Costs rounded to nearest \$1000.

4.1.3.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The following utilities were analyzed within ARK_03: Crowley County WA, and the Town of Fowler. These avoided costs are provided in Table 4-22.

4.1.3.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in ARK_03, in present value (2010), are presented in Table 4-22.

Table 4-22. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU ARK_03

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$35,539,000	\$42,673,000	\$337,553,000
Operating	\$30,599,000	\$34,970,000	\$116,999,000
Total	\$66,138,000	\$77,643,000	\$454,552,000
Potable Water Supply Benefits			
Capital	\$104,000	\$104,000	\$104,000
Operating	\$128,000	\$128,000	\$128,000
Total	\$232,000	\$232,000	\$232,000
Percent Change in Water Quality (streams)			
	39.34%	40.45%	41.24%
Percent Change in Water Quality (Lakes)			
	61.22%	71.88%	92.08%
Projected Active Benefits			
Angling	\$12,803,000	\$14,343,000	\$17,106,000
Boating	\$17,494,000	\$18,377,000	\$19,554,000
Swimming	\$8,142,000	\$8,682,000	\$9,506,000
Total	\$38,439,000	\$41,402,000	\$46,166,000
Property Value Benefits			
	\$0	\$0	\$58,119,000
Passive Benefits	\$54,364,000	\$53,602,000	\$56,305,000
Total Quantified Benefits	\$93,035,000	\$95,236,000	\$160,822,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.1.3.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in ARK_03 are \$26,898,000 for Tier 1, \$17,594,000 for Tier 2, and -\$293,731,000 for Tier 3. The benefit-cost ratio is 1.41:1, 1.23:1, and 0.35:1 for Tiers 1, 2, and 3, respectively (Table 4-23).

Table 4-23. Benefit Cost Summary for MU ARK_03, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$93,036,000	\$95,237,000	\$160,822,000
Total Costs	\$66,138,000	\$77,643,000	\$454,553,000
Net Present Value Benefits	\$26,898,000	\$17,594,000	(\$293,731,000)
Benefit Cost Ratio	1.41 : 1	1.23 : 1	0.35 : 1

4.2 Colorado River Basin

This section provides the findings applicable to the five Manageable Units established for the Colorado River Basin (see Manageable Unit delineation in Section 3.2 along with Figure 3-4).

4.2.1 COL_01 – Colorado Headwaters

COL_01 is comprised of one HUC-8 watershed and generally includes the Colorado River Basin upstream of the confluence with the Roaring Fork near Glenwood Springs. The Eagle River and Blue River Basins are tributary to COL_01. Figure 4-12 illustrates the area covered by COL_01 including WWTFs, general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.2.1.1 Water Quality Analyses

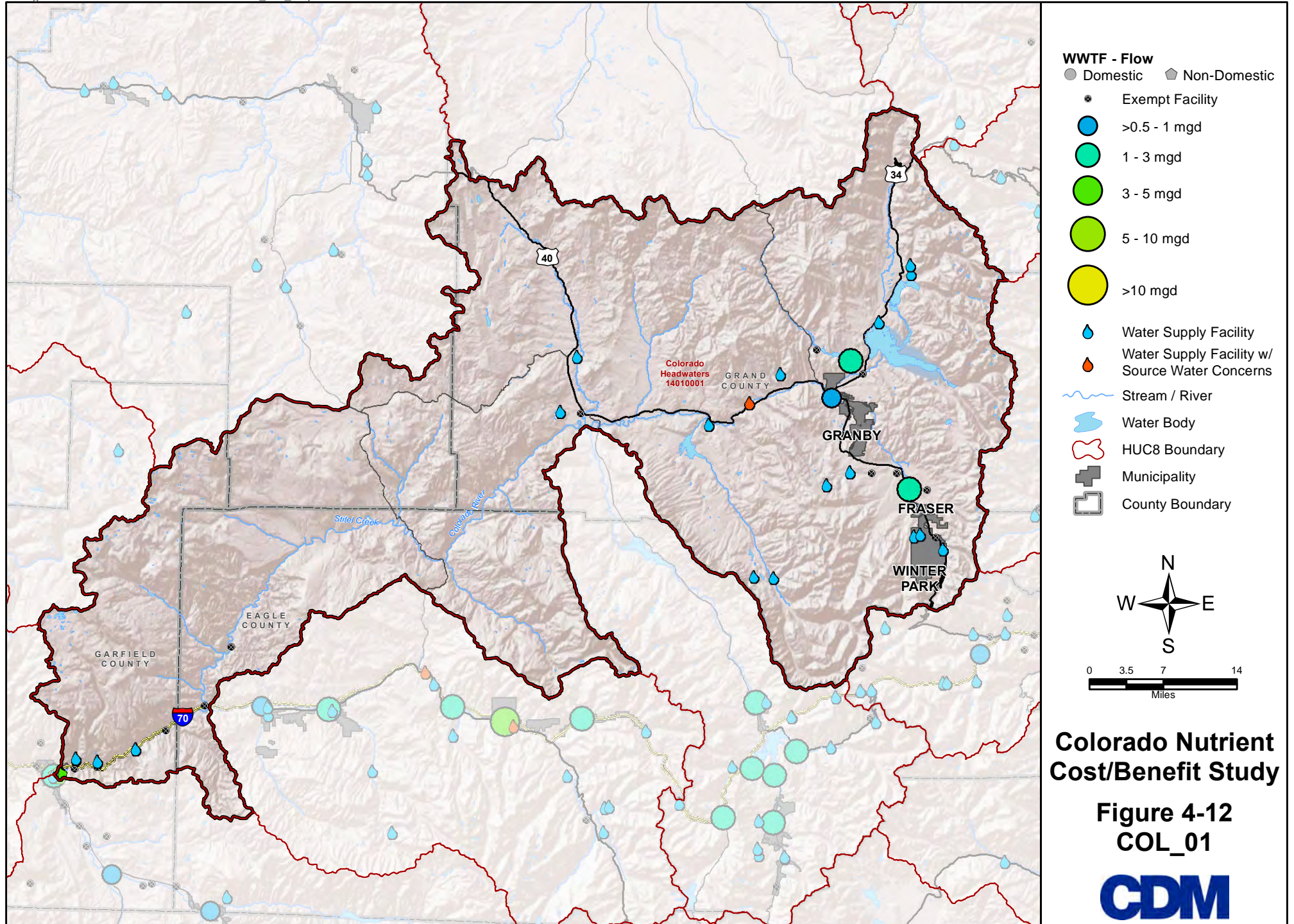
The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all of the facilities, 4.5 mg/L TP and 25 mg/L TIN.

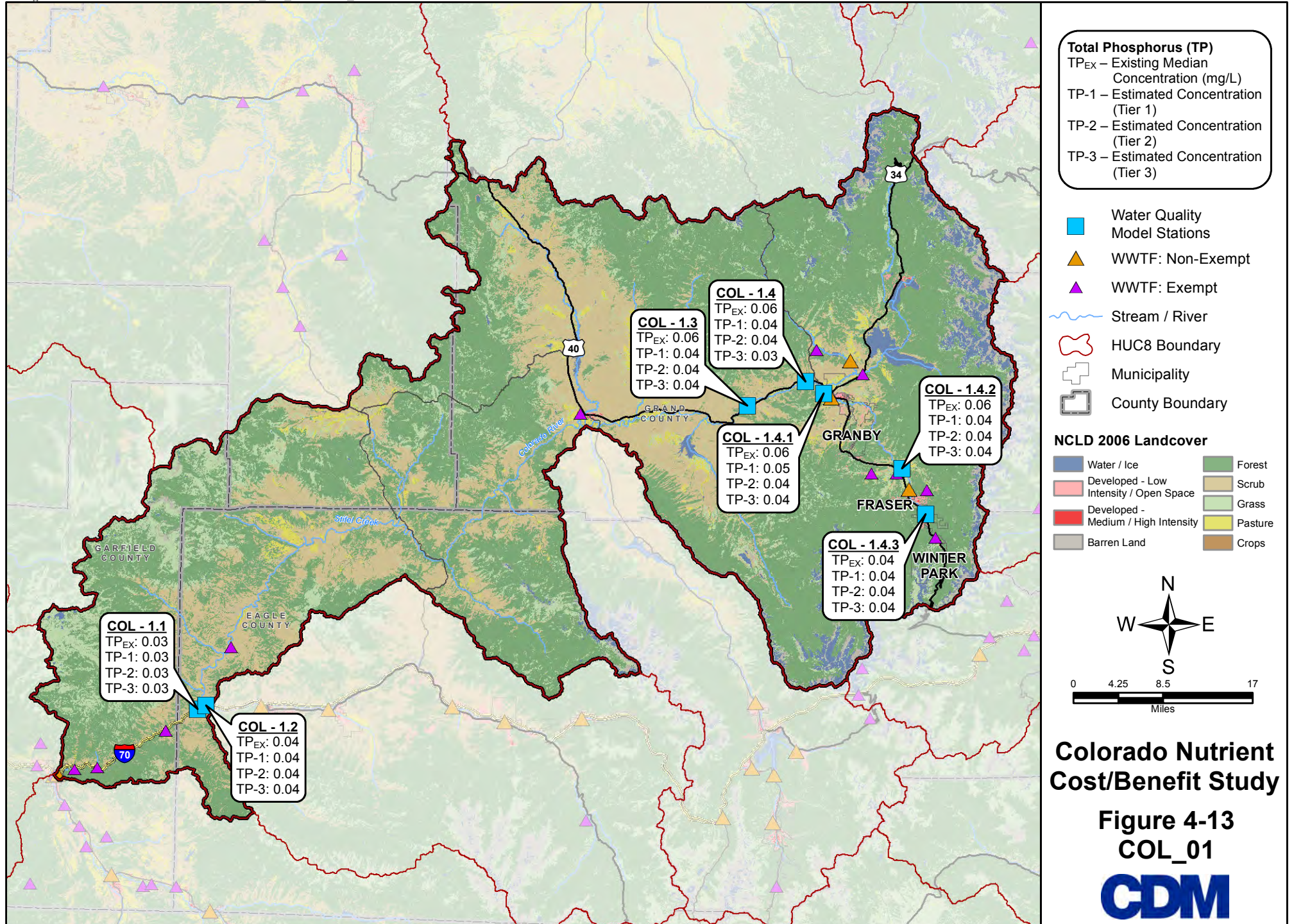
Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-24 and 4-25 (see Figure 4-12 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2 or 3 effluent limits are also provided for TP (Table 4-24; Figure 4-13) and for TIN (Table 4-25; Figure 4-14). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-24. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 1.1	Mainstem	0.03	0.03	0.03	0.03
COL - 1.2	Mainstem	0.04	0.04	0.04	0.04
COL - 1.4.2	Fraser River	0.12	0.04	0.04	0.04
COL - 1.3	Mainstem	0.06	0.04	0.04	0.04
COL - 1.4.1	Fraser River	0.06	0.05	0.04	0.04
COL - 1.4	Fraser River	0.06	0.04	0.04	0.03
COL - 1.4.3	Fraser River	0.04	0.04	0.04	0.04

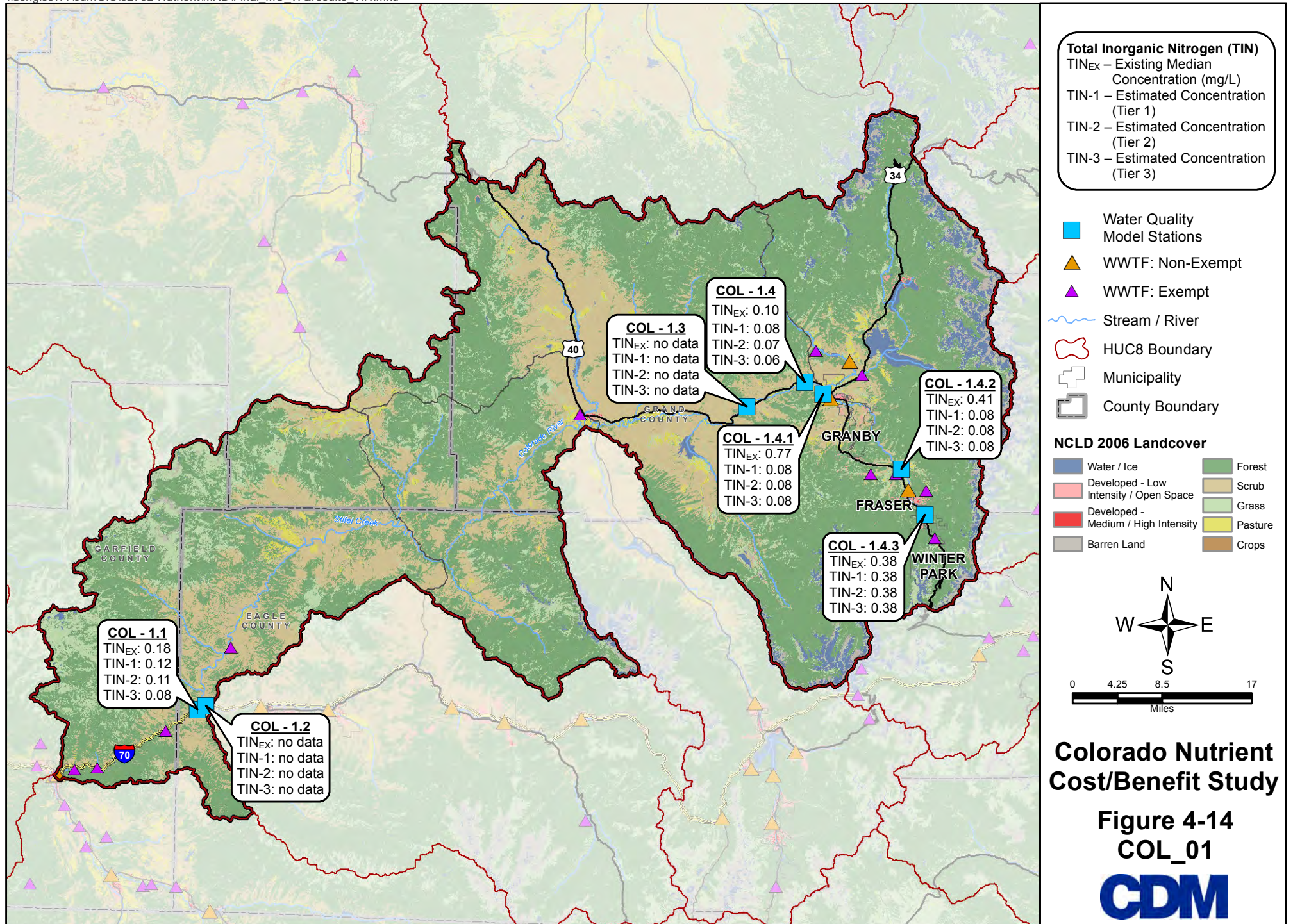




Colorado Nutrient Cost/Benefit Study

**Figure 4-13
 COL_01**





Colorado Nutrient Cost/Benefit Study

Figure 4-14
COL_01



Table 4-25. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 1.1	Mainstem	0.18	0.12	0.11	0.08
COL - 1.2	Mainstem	no data	n/a	n/a	n/a
COL - 1.4.2	Fraser River	0.41	0.08	0.08	0.08
COL - 1.3	Mainstem	no data	n/a	n/a	n/a
COL - 1.4.1	Fraser River	0.77	0.08	0.08	0.08
COL - 1.4	Fraser River	0.10	0.08	0.07	0.06
COL - 1.4.3	Fraser River	0.38	0.38	0.38	0.38

Reservoirs

There are no modeled reservoirs within the COL_01 Manageable Unit.

4.2.1.2 Wastewater Costs

Table 4-26 summarizes the WWTFs located in COL_01 along with their permitted capacity, flow bin and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-26: WWTFs in COL_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Flow Bin Included in Proposed Regulation (MGD)	Treatment Plant Category	Comment
Colorado Mountain Resort Investors LLC	Devil's Thumb Ranch	No Data	No Data	0	0	Exempt due to capacity
Granby Sanitation District		0.995	>0.5 to 1	>0.5 to 1	1	
Fraser, Town of	Fraser Sanitation District	2	>1 to 3	>1 to 3	1	
Glenwood Hot Springs	Glenwood Hot Springs Lodge & Pool	3.08	>3 to 5	>3 to 5	1	Treatment Plant category assumed
Roundup River Ranch	Roundup River Ranch WWTF	0.008	0-0.5	0	1	Exempt due to capacity
Rock Gardens MHP		0.04	0-0.5	0	1	Exempt due to capacity
West Glenwood Springs Sanitation District		0.375	0-0.5	0-0.5	1	Exempt due to capacity
Winter Park WSD		0.45	0-0.5	0-0.5	4	Exempt due to capacity
Kremmling Sanitation District	Kremmling Sanitation District WWTF	0.3	0-0.5	0-0.5	4	Exempt due to capacity
Young Life Campaign Inc	Crooked Creek Ranch	0.033	0-0.5	0	2	Exempt due to capacity
Two Rivers Metropolitan District		0.15	0-0.5	0-0.5	2	Exempt due to capacity
Ourray Ranch HOA		0.016	0-0.5	0	4	Exempt due to capacity
Hot Sulphur Springs		0.099999	0-0.5	0	4	Exempt due to capacity
Tabernash Meadows WSD		0.2	0-0.5	0	4	Exempt due to capacity
Three Lakes WSD	Willow Creek Lagoons	2	>1 to 3	>1 to 3	5	

Table 4-26: WWTFs in COL_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Flow Bin Included in Proposed Regulation (MGD)	Treatment Plant Category	Comment
Colorado Department of Transportation (DOT)		0.0033	0-0.5	0	4A	Exempt due to capacity
Colorado DOT	Grizzly Creek Rest Area WWTF	0.0036	0-0.5	0	4A	Exempt due to capacity
C Lazy U Ranch		0.0148	0-0.5	0	4A	Exempt due to capacity

¹Category 4A indicates septic system or filter, treated as lagoon for full replacement.

² Assumed Treatment Plant category

Table 4-27 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-28 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-28 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-27. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$17,861,000	\$45,339,000	\$341,093,000
Annual Operation & Maintenance Costs	\$898,000	\$1,353,000	\$5,948,000

Costs rounded to nearest \$1000.

Table 4-28. Estimated WWTF costs to meet Tier 1, 2 or 3 effluent quality for facilities exempt from proposed Regulation #85¹

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$15,541,000	\$17,396,000	\$93,432,000
Annual Operation & Maintenance Costs	\$784,000	\$951,000	\$3,419,000

Costs rounded to nearest \$1000.

4.2.1.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The following utilities were analyzed for COL_01: Town of Hot Sulphur Springs, and Two Rivers Village. These avoided costs are provided in Table 4-29.

4.2.1.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in COL_01, in present value (2010), are presented in Table 4-29.

Table 4-29. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU COL_01

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$16,093,000	\$40,851,000	\$307,326,000
Operating	\$13,924,000	\$20,984,000	\$92,270,000
Total	\$30,017,000	\$61,835,000	\$399,596,000
Potable Water Supply Benefits			
Capital	\$66,000	\$66,000	\$66,000
Operating	\$59,000	\$59,000	\$59,000
Total	\$125,000	\$125,000	\$125,000
Percent Change in Water Quality (streams)	10.73%	12.80%	17.95%
Percent Change in Water Quality (lakes)	NA	NA	NA
Projected Active Benefits			
Angling	\$2,237,000	\$2,669,000	\$3,741,000
Boating	\$6,207,000	\$7,407,000	\$10,380,000
Swimming	\$760,000	\$907,000	\$1,271,000
Total	\$9,204,000	\$10,983,000	\$15,392,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$7,789,000	\$8,841,000	\$12,839,000
Total Quantified Benefits	\$17,118,000	\$19,949,000	\$28,356,000

* Expressed in Present Value 2010 Dollars

*NA indicates not available

4.2.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in COL_01 are -\$12,899,000 for Tier 1, -\$41,885,000 for Tier 2, and \$371,238,000 for Tier 3. The benefit-cost ratio is 0.57:1, 0.32:1, and 0.07:1 for Tiers 1, 2, and 3, respectively (Table 4-30).

Table 4-30. Benefit-Cost Summary for MU COL_01, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit Cost Analysis			
Total Benefits	\$17,118,000	\$19,949,000	\$28,357,000
Total Costs	\$30,017,000	\$61,834,000	\$399,596,000
Net Present Value Benefits	(\$12,899,000)	(\$41,885,000)	(\$371,238,000)
Benefit-Cost Ratio	0.57 : 1	0.32 : 1	0.07 : 1

4.2.2 COL_02 – Blue River

COL_02 is comprised of one HUC-8 watershed and generally includes the Blue River basin upstream of the confluence with Colorado River near Kremmling. Figure 4-15 illustrates the area covered by COL_02 including WWTFs, general location of water supply intakes, public water supply reservoirs and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.2.2.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on the default effluent quality concentration of 25 mg/L TIN for the majority of facilities, and on the default effluent concentration of 4.5 mg/L TP for the Silverthorne/Dillon Joint Sewer Authority facility. Dillon Reservoir Control Regulation TP limits or site-specific data were used for the other facilities in COL_02, as shown in Table 4-31.

Table 4-31. Site-specific nutrient effluent values for WWTFs within COL_02

Facility Name	Stream Name	Current TP (mg/L)	Current TIN (mg/L)	Information Source
Dundee Realty USA LLC	Snake River	0.5	25	Dillon Control regulation (TP)
Frisco Sanitation District	Tenmile Creek	0.5	25	Dillon Control regulation (TP)
Snake River WWTF	Snake River	0.2	25	Facility provided data (TP)
Copper Mountain Consolidated Metropolitan District	Tenmile Creek	0.5	25	Dillon Control regulation (TP)
Upper Blue Sanitation District (Iowa Hill)	Mainstem	0.5	25	Dillon Control regulation (TP)
Upper Blue Sanitation District	Mainstem	0.5	25	Dillon Control regulation (TP)

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-32 and 4-33 (see Figure 4-15 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2 or 3 effluent limits are also provided for TP (Table 4-32; Figure 4-16) and for TIN (Table 4-33; Figure 4-17). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-32. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_02

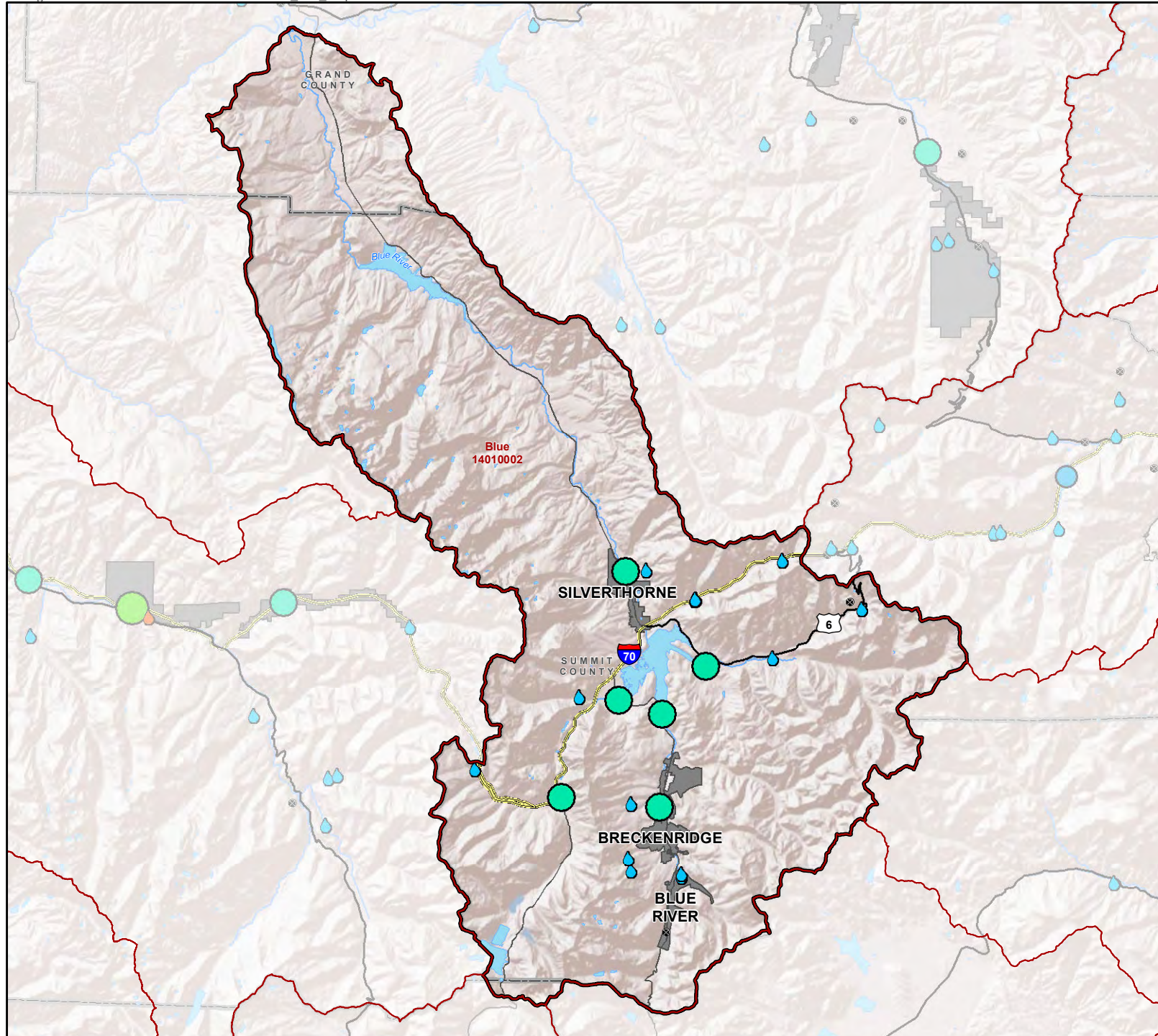
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 2.2	Mainstem	0.03	0.02	0.02	0.02
COL - 2.1.1	Tenmile Creek	0.02	0.02	0.02	0.02

Table 4-33. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_02

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 2.2	Mainstem	0.54	0.48	0.36	0.10
COL - 2.1.1	Tenmile Creek	1.07	0.48	0.36	0.10

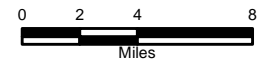
Reservoirs

Lake Dillon was analyzed within COL_02 (see Figure 4-18). Table 4-34 summarizes existing water quality and expected water quality under implementation of Tier 1, 2, or 3 effluent limits. No TIN data were available for Lake Dillon, therefore only TP values were modeled. The median TP concentration in the reservoir is less than upstream median TP concentrations. Accordingly, given the few WWTFs upstream of the reservoir and the existing control regulation for these WWTFs, implementation of Regulation 85 is expected to have minimal impact on water quality in Lake Dillon.



WWTF - Flow

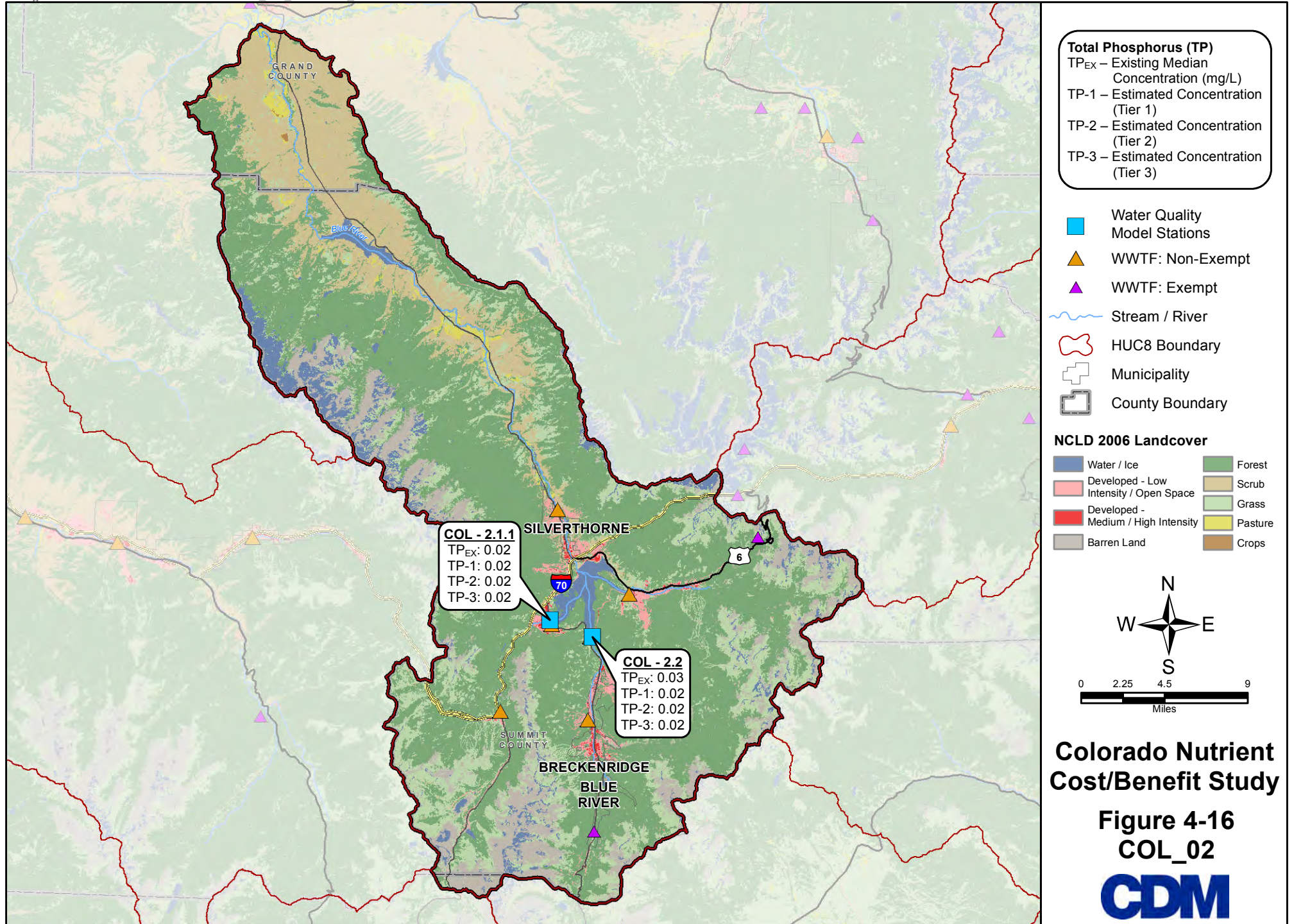
- Domestic ■ Non-Domestic
- Exempt Facility
- >0.5 - 1 mgd
- 1 - 3 mgd
- 3 - 5 mgd
- 5 - 10 mgd
- >10 mgd
- Water Supply Facility
- Water Supply Facility w/ Source Water Concerns
- ~ Stream / River
- ~ Water Body
- ~ HUC8 Boundary
- Municipality
- County Boundary

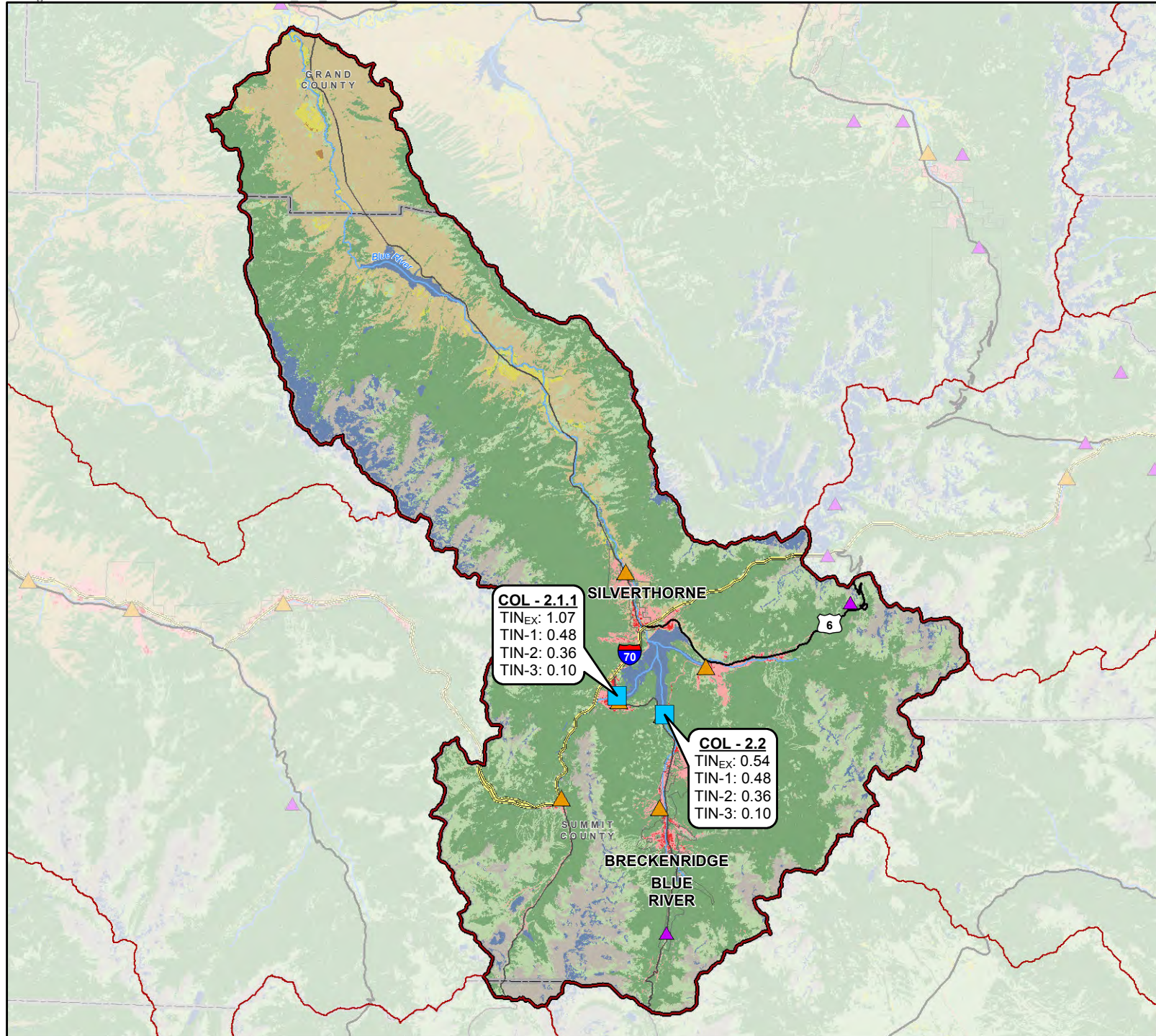


Colorado Nutrient Cost/Benefit Study

**Figure 4-15
COL_02**



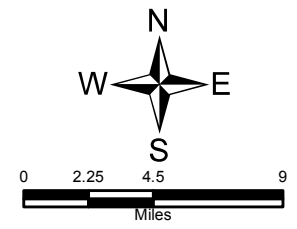




Total Inorganic Nitrogen (TIN)
 TIN_{Ex} – Existing Median Concentration (mg/L)
 TIN-1 – Estimated Concentration (Tier 1)
 TIN-2 – Estimated Concentration (Tier 2)
 TIN-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- ~ Stream / River
- HUC8 Boundary
- + Municipality
- County Boundary

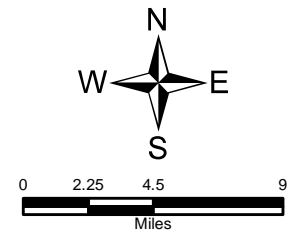
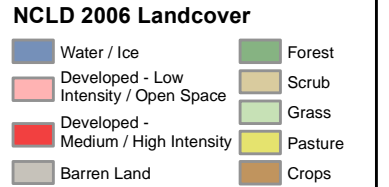
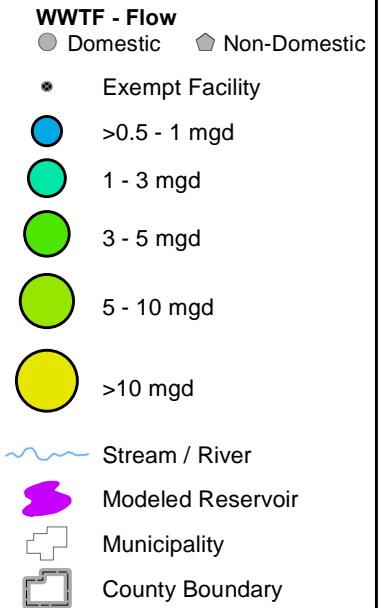
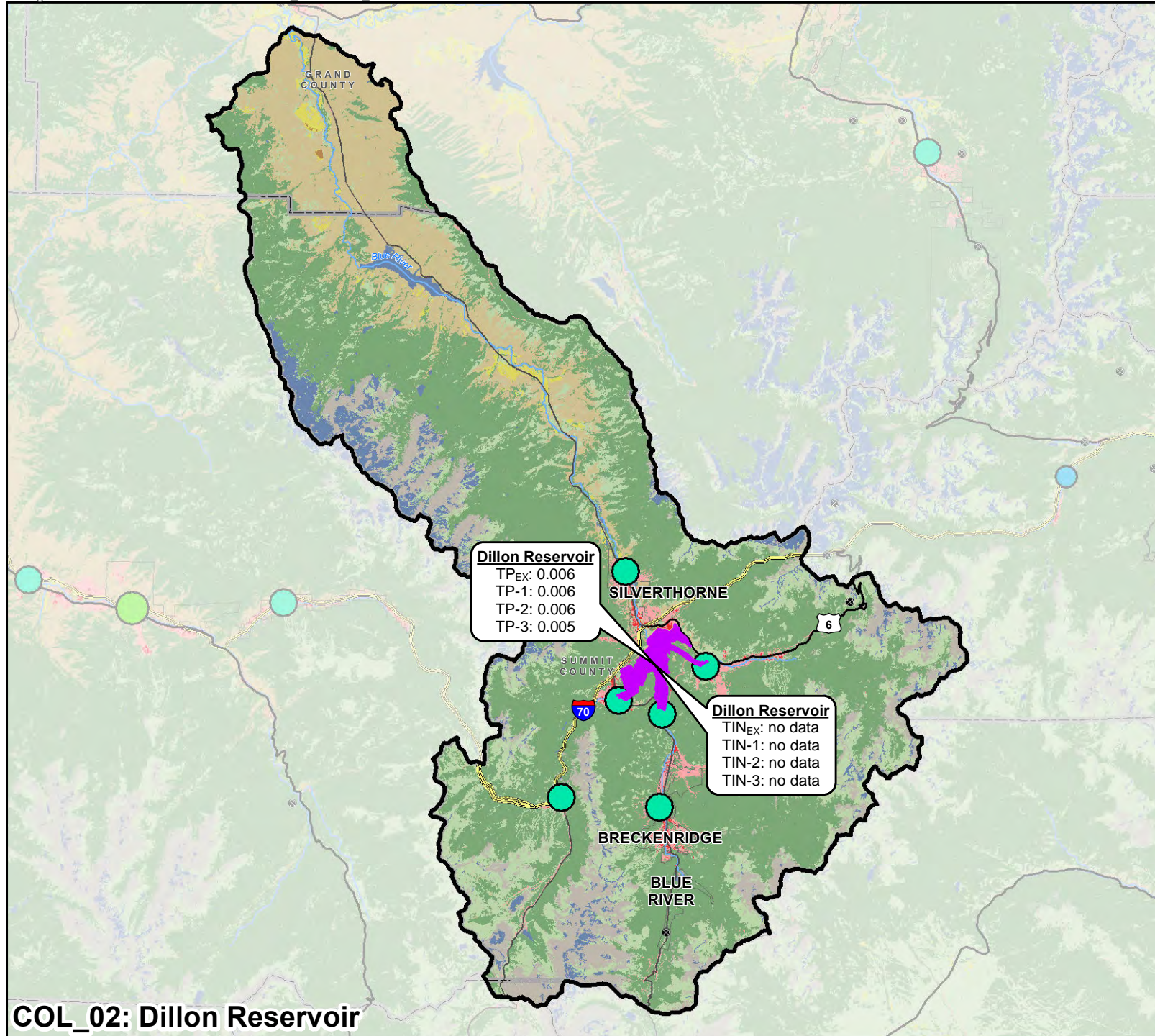
- NCLD 2006 Landcover**
- | | |
|--|---|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



Colorado Nutrient Cost/Benefit Study

**Figure 4-17
 COL_02**





Colorado Nutrient Cost/Benefit Study

Figure 4-18



Table 4-34. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in Lake Dillon

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.006	0.006	0.006	0.005
TIN	No Data	n/a	n/a	n/a

4.2.2.2 Wastewater Costs

Table 4-35 summarizes the WWTFs located in COL_02 along with their permitted capacity, flow bin and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-35: WWTFs in COL_02

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Flow Bin Included in Proposed Regulation (MGD)	Treatment Plant Category	Comment
Dundee Realty USA LLC	Arapahoe Basin Ski Area	0.012	0-0.5	0	2	Exempted due to capacity Control Regulation
Copper Mountain Consolidated Metropolitan District		1.1	>1 to 3	>1 to 3	1	Control Regulation
Silverthorne/Dillon Joint Sewer Authority	Blue River WWTF	1.5	>1 to 3	>1 to 3	1	
Snake River WWTF	Summit County Snake River WWTF	1.5	>1 to 3	>1 to 3	1	Control Regulation
Upper Blue Sanitation District	Iowa Hill Water Reclamation	1.5	>1 to 3	>1 to 3	1	Control Regulation
Frisco Sanitation District	Frisco Sanitation District WWTF	1.7	>1 to 3	>1 to 3	1	Control Regulation
Upper Blue Sanitation District	Farmers Korner WWTF	3	>1 to 3	>1 to 3	1	Control Regulation

Table 4-36 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-37 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-37 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-36. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$19,043,000	\$24,659,000	\$412,141,000
Annual Operation & Maintenance Costs	\$818,000	\$1,339,000	\$7,062,000

Costs rounded to nearest \$1000.

Table 4-37. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt from Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$132,000	\$147,000	\$679,000
Annual Operation & Maintenance Costs	\$1,000	\$4,000	\$20,000

Costs rounded to nearest \$1000.

4.2.2.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. No facilities were included in the analysis for COL_02.

4.2.2.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in COL_02, in present value (2010), are presented in Table 4-38.

Table 4-38. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU COL_02

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$17,158,000	\$22,217,000	\$371,340,000
Operating	\$12,684,000	\$20,777,000	\$109,554,000
Total	\$29,842,000	\$42,994,000	\$480,894,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)	5.82%	20.58%	43.97%
Percent Change in Water Quality (lakes)	0.00%	0.00%	27.27%
Projected Active Benefits			
Angling	\$1,952,000	\$6,904,000	\$24,211,000
Boating	\$4,716,000	\$16,680,000	\$65,156,000
Swimming	\$558,000	\$1,975,000	\$4,220,000
Total	\$7,226,000	\$25,559,000	\$93,587,000
Property Value Benefits			
Passive Benefits	\$2,978,000	\$10,104,000	\$22,239,000
Total Quantified Benefits	\$10,204,000	\$35,663,000	\$115,826,000

* Expressed in Present Value 2010 Dollars

*NA indicates not available

4.2.2.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in COL_02 are -\$19,637,000 for Tier 1, -\$7,331,000 for Tier 2, and -\$365,068,000 for Tier 3. The benefit-cost ratio is 0.34:1, 0.83:1, and 0.24:1 for Tiers 1, 2, and 3, respectively (Table 4-39).

Table 4-39. Benefit-Cost Summary for MU COL_02, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit Cost Analysis			
Total Benefits	\$10,204,000	\$35,663,000	\$115,826,000
Total Costs	\$29,842,000	\$42,995,000	\$480,894,000
Net Present Value Benefits	(\$19,637,000)	(\$7,331,000)	(\$365,068,000)
Benefit-Cost Ratio	0.34 : 1	0.83 : 1	0.24 : 1

4.2.3 COL_03 – Eagle River

COL_03 is comprised of one HUC-8 watersheds and generally includes the Eagle River Basin upstream of the confluence with the Colorado River. Figure 4-19 illustrates the area covered by COL_03 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.2.3.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the majority of facilities, 4.5 mg/L TP and 25 mg/L TIN. Specific effluent information was available for three of the facilities in COL_03, as shown in Table 4-40.

Table 4-40. Site-specific nutrient effluent values for WWTFs within COL_03

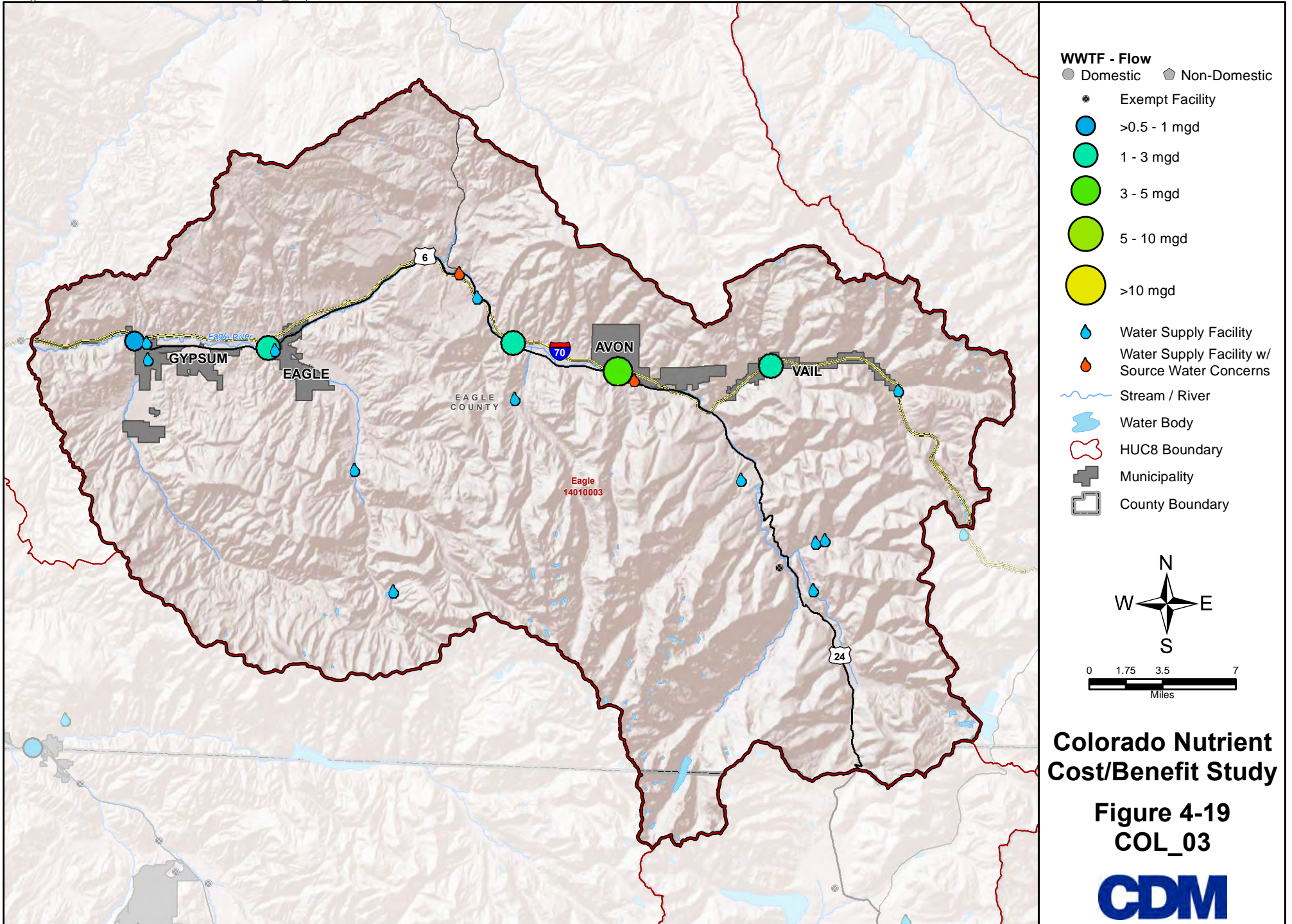
Facility Name	Stream Name	Current TP (mg/L)	Current TIN (mg/L)	Information Source
Vail WWTF	Gore Creek	1.425	11.8	Facility provided data (TP & TIN)
Edwards WWTF	Mainstem	3.585	18.455	Facility provided data (TP & TIN)
Avon WWTF	Mainstem	3.745	26.15	Facility provided data (TP & TIN)

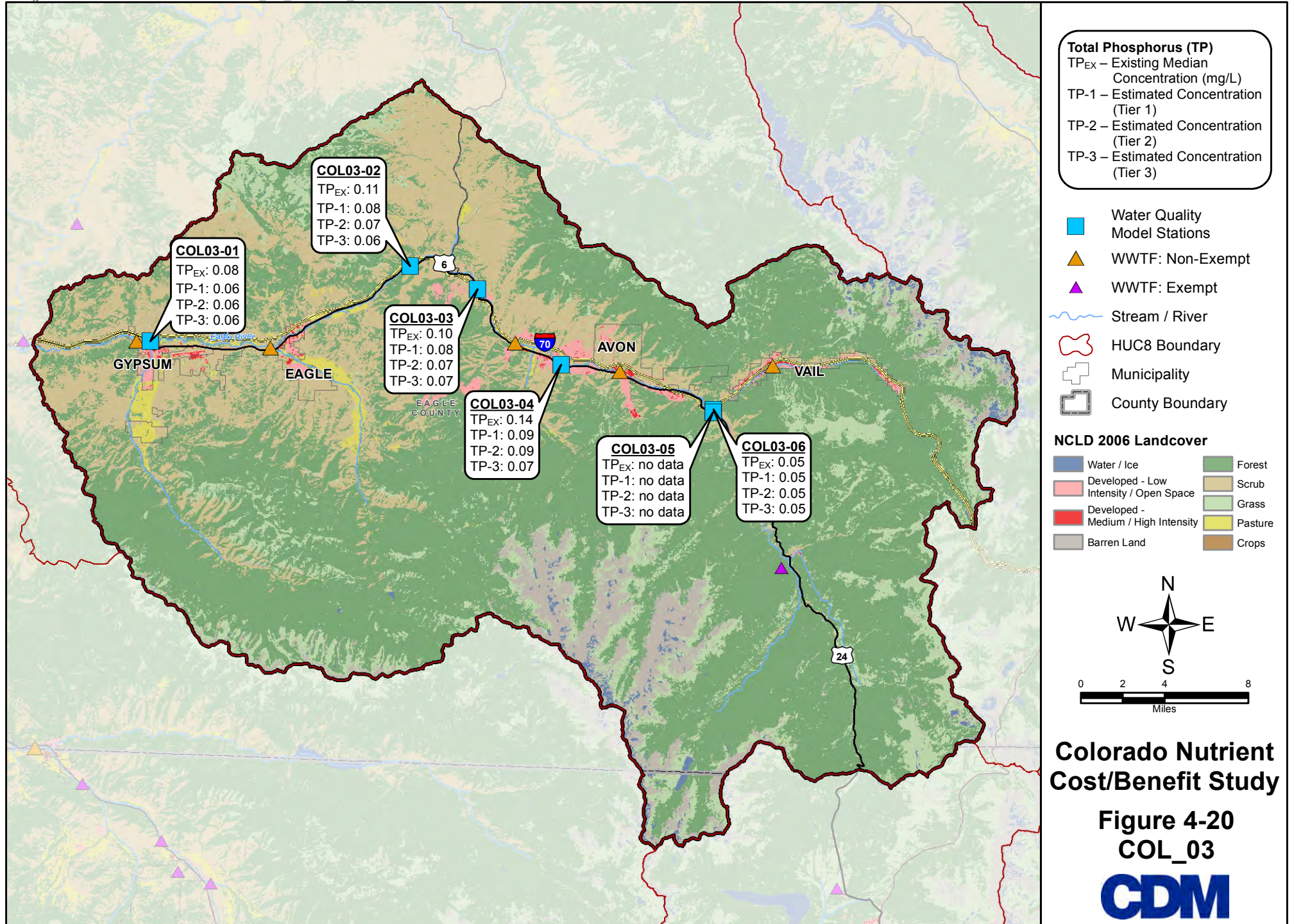
Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-41 and 4-42 (see Figure 4-19 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-41; Figure 4-20) and for TIN (Table 4-42; Figure 4-21). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-41. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_03

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COLO3-01	Mainstem	0.08	0.06	0.06	0.06
COLO3-02	Mainstem	0.11	0.08	0.07	0.06
COLO3-03	Mainstem	0.10	0.08	0.07	0.07
COLO3-04	Mainstem	0.14	0.09	0.09	0.07
COLO3-05	Mainstem	No data	n/a	n/a	n/a
COLO3-06	Mainstem	0.05	0.05	0.05	0.05





Colorado Nutrient Cost/Benefit Study

**Figure 4-20
 COL_03**



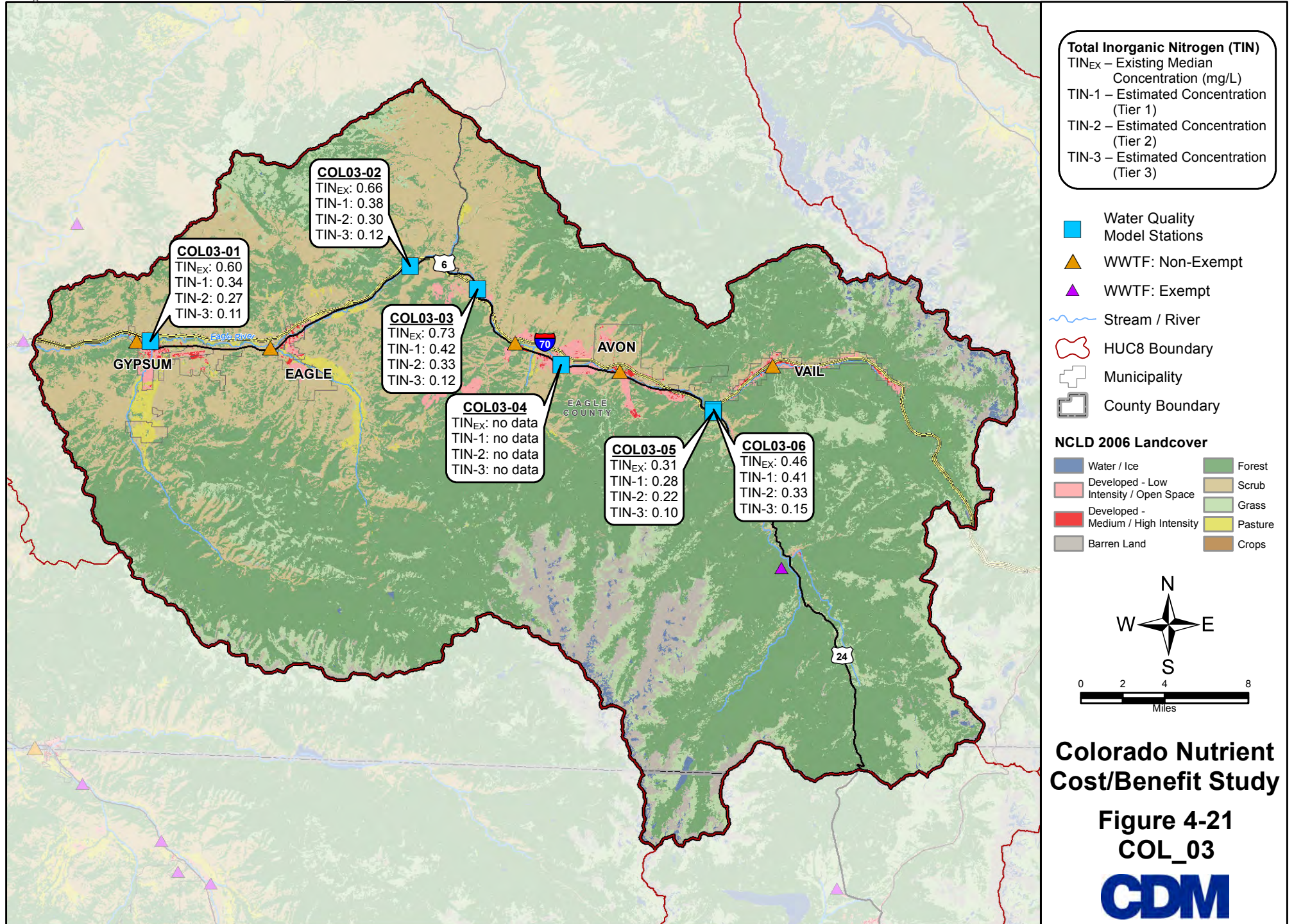


Table 4-42. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_03

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COLO3-01	Mainstem	0.6	0.34	0.27	0.11
COLO3-02	Mainstem	0.66	0.38	0.30	0.12
COLO3-03	Mainstem	0.73	0.42	0.33	0.12
COLO3-04	Mainstem	No data	n/a	n/a	n/a
COLO3-05	Mainstem	0.31	0.28	0.22	0.10
COLO3-06	Mainstem	0.46	0.41	0.33	0.15

Reservoirs

There are no modeled reservoirs within the COL_03 Manageable Unit.

4.2.3.2 Wastewater Costs

Table 4-43 summarizes the WWTFs located in COL_03 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-43. WWTFs in COL_03

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Flow Bin Included in Proposed Regulation (MGD)	Treatment Plant Category	Comment
Red Cliff, Town of	Red Cliff WWTF	0.07	0-0.5	0	1	Exempt due to capacity
Gypsum, Town of	Gypsum WWTF	0.96	>0.5 to 1	>0.5 to 1	1	
Eagle, Town of	Eagle WWTF	1.65	>1 to 3	>1 to 3	1	
Eagle River WSD	Vail WWTF	2.7	>1 to 3	>1 to 3	1	
Eagle River WSD	Edwards WWTF	2.95	>1 to 3	>1 to 3	1	
Eagle River WSD	Avon WWTF	4.3	>3 to 5	>3 to 5	1	

Table 4-44 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-45 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-45 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-44. Estimated WWTF Costs to Meet Tier 1, 2, or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$26,633,000	\$51,469,000	\$516,536,000
Annual Operation & Maintenance Costs	\$1,345,000	\$1,924,000	\$8,933,000

Costs rounded to nearest \$1000.

Table 4-45. Estimated WWTF Costs to Meet Tier 1, 2, or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$253,000	\$307,000	\$3,564,000
Annual Operation & Maintenance Costs	\$5,000	\$20,000	\$114,000

Costs rounded to nearest \$1000.

4.2.3.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. Facilities analyzed in COL_03 include: Red Sky Ranch, and Upper Eagle Regional WA. These avoided costs are provided in Table 4-46.

4.2.3.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in COL_03, in present value (2010), are presented in Table 4-46.

Table 4-46. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU COL_03

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$23,996,000	\$46,374,000	\$465,400,000
Operating	\$20,863,000	\$29,853,000	\$138,588,000
Total	\$44,859,000	\$76,227,000	\$603,988,000
Potable Water Supply Benefits			
Capital	\$303,000	\$303,000	\$303,000
Operating	\$1,079,000	\$1,079,000	\$1,079,000
Total	\$1,382,000	\$1,382,000	\$1,382,000
Percent Change in Water Quality (streams)	19.29%	24.73%	39.70%
Percent Change in Water Quality (lakes)	NA	NA	NA
Projected Active Benefits			
Angling	\$3,501,000	\$4,488,000	\$7,205,000
Boating	\$2,792,000	\$3,579,000	\$5,745,000
Swimming	\$368,000	\$472,000	\$757,000
Total	\$6,661,000	\$8,539,000	\$13,707,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$6,899,000	\$8,635,000	\$14,100,000
Total Quantified Benefits	\$14,942,000	\$18,556,000	\$29,189,000

* Expressed in Present Value 2010 Dollars

*NA indicates not available

4.2.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in COL_03 are -\$29,917,000 for Tier 1, -\$57,671,000 for Tier 2 and -\$574,799,000 for Tier 3. The benefit-cost ratio is 0.33:1, 0.24:1 and 0.05:1 for Tiers 1, 2, and 3, respectively (Table 4-47).

Table 4-47. Benefit-Cost Summary for MU COL_03, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit Cost Analysis			
Total Benefits	\$14,942,000	\$18,556,000	\$29,190,000
Total Costs	\$44,859,000	\$76,227,000	\$603,988,000
Net Present Value Benefits	(\$29,917,000)	(\$57,671,000)	(\$574,799,000)
Benefit-Cost Ratio	0.33 : 1	0.24 : 1	0.05 : 1

4.2.4 COL_04 – Roaring Fork

COL_04 is comprised of one HUC-8 watershed and generally includes the Roaring Fork Basin upstream of the confluence with the Colorado River near Glenwood Springs. Figure 4-22 illustrates the area covered by COL_04 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.2.4.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-48 and 4-49 (see Figure 4-22 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-48; Figure 4-23) and for TIN (Table 4-49; Figure 4-24). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-48. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_04

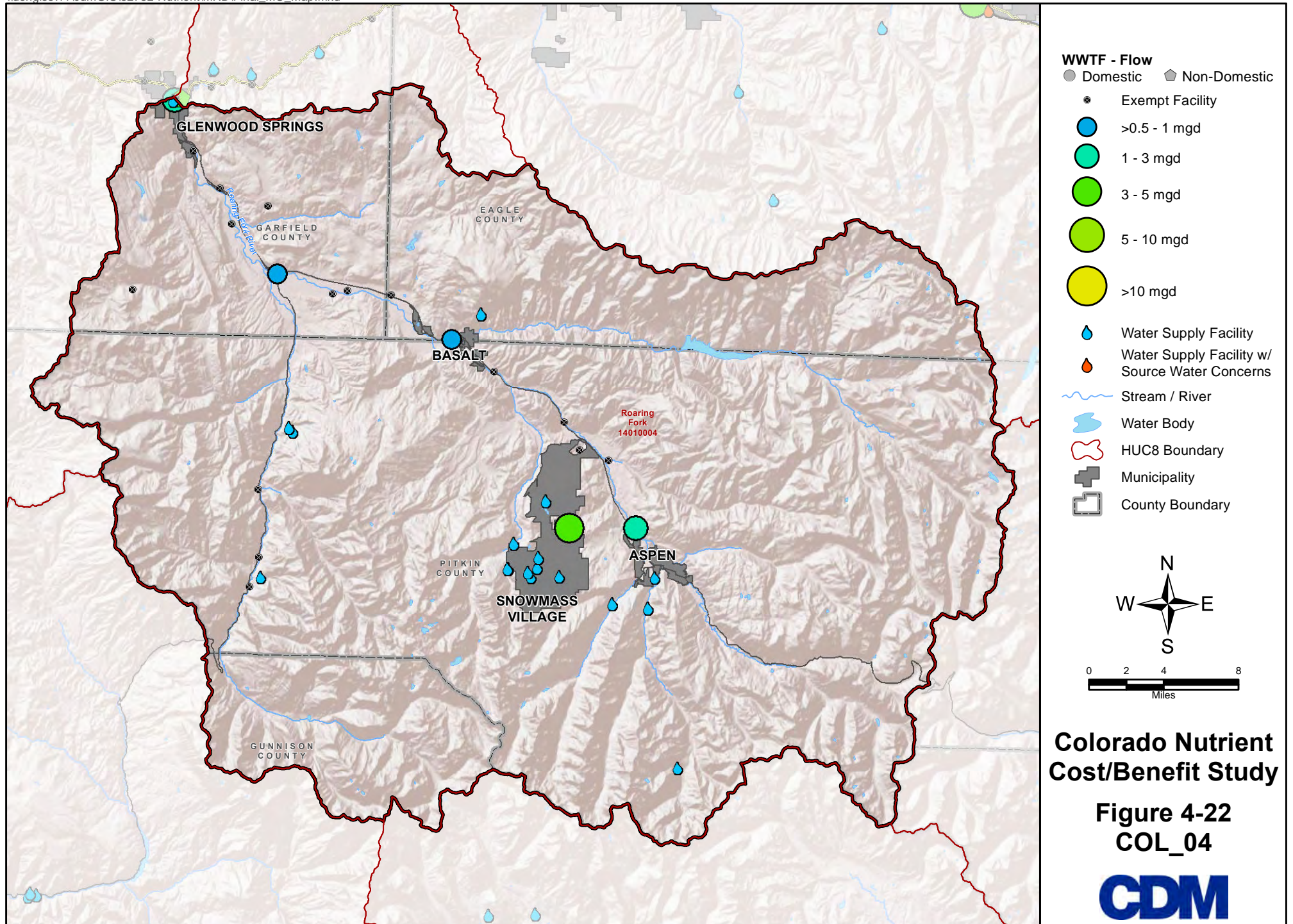
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 4.1	Mainstem	0.020	0.020	0.020	0.020
COL - 4.2	Crystal River	0.017	0.017	0.017	0.017
COL - 4.3	Mainstem	0.022	0.022	0.022	0.022

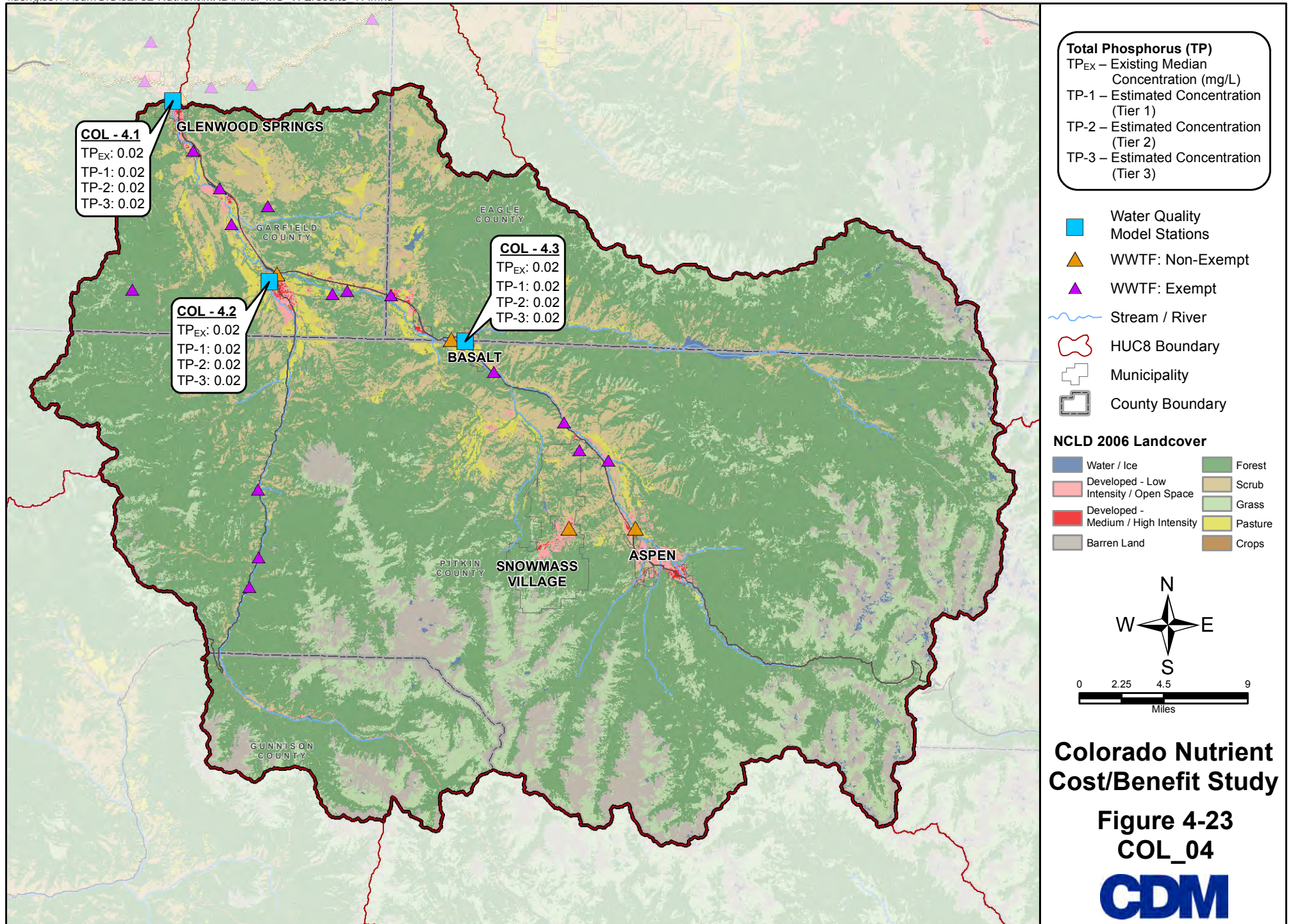
Table 4-49. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_04

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 4.1	Mainstem	0.30	0.192	0.170	0.122
COL - 4.2	Crystal River	0.17	0.173	0.173	0.173
COL - 4.3	Mainstem	0.32	0.176	0.148	0.085

Reservoirs

There are no modeled reservoirs within the COL_04 Manageable Unit.

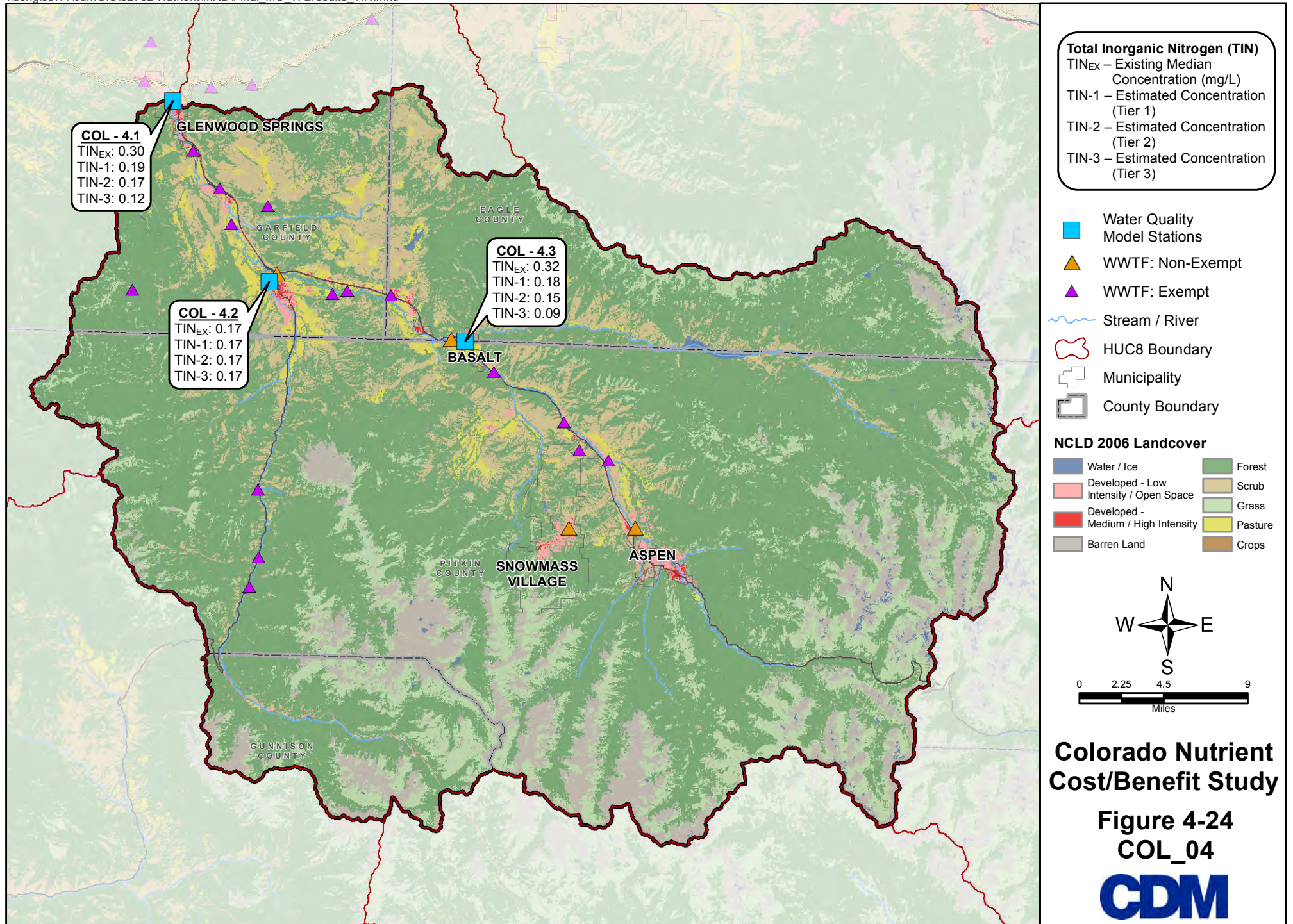




Colorado Nutrient Cost/Benefit Study

**Figure 4-23
 COL_04**





Colorado Nutrient Cost/Benefit Study

**Figure 4-24
COL_04**



4.2.4.2 Wastewater Costs

Table 4-50 summarizes the WWTFs located in COL_04 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-50: WWTFs in COL_04

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Flow Bin Included in Proposed Regulation (MGD)	Treatment Plant Category	Comment
Sopris Engineering LLC	Redstone Castle DWTW	No Data	No Data	0	0	Exempt due to capacity
Basalt Sanitation District		0.8	>0.5 to 1	>0.5 to 1	1	
Carbondale, Town of		0.999	>0.5 to 1	>0.5 to 1	1	
Aspen Consolidated Sanitation District		3	>1 to 3	>1 to 3	1	
Snowmass WSD		3.2	>3 to 5	>3 to 5	1	
Riversbend HOA	Riversbend Apartment WWTF	0.00304	0-0.5	0	1	Exempt due to capacity
El Rocko Mobile Home Park		0.01	0-0.5	0	1	Exempt due to capacity
H Lazy F LLC	H Lazy F Mobile Home Park	0.04	0-0.5	0	1	Exempt due to capacity
Mid Valley Metropolitan District		0.499999	0-0.5	0-0.5	1	Exempt due to capacity
Ranch at Roaring Fork	Ranch at Roaring Fork HOA	0.1	0-0.5	0	1	Exempt due to capacity
Redstone WSD	Redstone WSD WWTF	0.05	0-0.5	0	1	Exempt due to capacity
Roaring Fork WSD	Roaring Fork WSD WWTF	0.107	0-0.5	0-0.5	1	Exempt due to capacity
Spring Valley Sanitation District	Spring Valley Sanitation District WWTF	0.499	0-0.5	0-0.5	1	Exempt due to capacity
Sunlight Inc		0.05	0-0.5	0	1	Exempt due to capacity
Glenwood Springs, City of	Glenwood Springs WWTF	2.3	>1 to 3	>1 to 3	2	
Blue Creek Ranch LLC	Blue Creek Ranch	0.02	0-0.5	0	4A	Exempt due to capacity
Aspen Village Inc.		0.099999	0-0.5	0	4	Exempt due to capacity
Independence Environmental Services	Lazy Glen HOA	0.045	0-0.5	0	4	Exempt due to capacity
Woody Creek Mobile Home Park HOA	Woody Creek Mobile Home Park	0.035	0-0.5	0	5	Exempt due to capacity
Avalanche Ranch Cabins & Antiques	Avalanche Ranch	0.14	0-0.5	0-0.5	5	Exempt due to capacity

Table 4-51 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-52 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-52 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-51. Estimated WWTF Costs to Meet Tier 1, 2, or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$32,779,000	\$53,654,000	\$437,281,000
Annual Operation & Maintenance Costs	\$1,245,000	\$1,701,000	\$7,866,000

Costs rounded to nearest \$1000.

Table 4-52. Estimated WWTF Costs to Meet Tier 1, 2, or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$7,820,000	\$10,118,000	\$88,440,000
Annual Operation & Maintenance Costs	\$213,000	\$573,000	\$2,871,000

Costs rounded to nearest \$1000

4.2.4.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. No facilities were analyzed in COL_04.

4.2.4.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in COL_04, in present value (2010), are presented in Table 4-53.

Table 4-53. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU COL_04

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$29,534,000	\$48,342,000	\$393,991,000
Operating	\$19,309,000	\$26,384,000	\$122,031,000
Total	\$48,843,000	\$74,726,000	\$516,022,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)	14.46%	28.79%	32.94%
Percent Change in Water Quality (lakes)	NA	NA	NA
Projected Active Benefits			
Angling	\$1,849,000	\$3,682,000	\$4,211,000
Boating	\$4,793,000	\$9,545,000	\$10,919,000
Swimming	\$538,000	\$1,072,000	\$1,226,000
Total	\$7,180,000	\$14,299,000	\$16,356,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$5,636,000	\$10,943,000	\$12,745,000
Total Quantified Benefits	\$12,816,000	\$25,242,000	\$29,101,000

* Expressed in Present Value 2010 Dollars

*NA indicates not available

4.2.4.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in COL_04 are -\$36,027,000 Tier 1, -\$49,484,000 for Tier 2, and -\$486,921,000 for Tier 3. The benefit-cost ratio is 0.26:1, 0.34:1 and 0.06:1 for Tiers 1, 2, and 3, respectively (Table 4-54).

Table 4-54. Benefit-Cost Summary for MU COL_04, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit Cost Analysis			
Total Benefits	\$12,816,000	\$25,242,000	\$29,101,000
Total Costs	\$48,843,000	\$74,725,000	\$516,022,000
Net Present Value Benefits	(\$36,027,000)	(\$49,484,000)	(\$486,921,000)
Benefit-Cost Ratio	0.26 : 1	0.34 : 1	0.06 : 1

4.2.5 COL_05 – Colorado Headwaters - Plateau

COL_05 is comprised of one HUC-8 watershed and includes the Colorado River Basin upstream of the Colorado state line and downstream of the confluence with the Roaring Fork near Glenwood Springs, not including the Gunnison River Basin. Figure 4-25 illustrates the area covered by COL_05 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.2.5.1 Water Quality Analyses

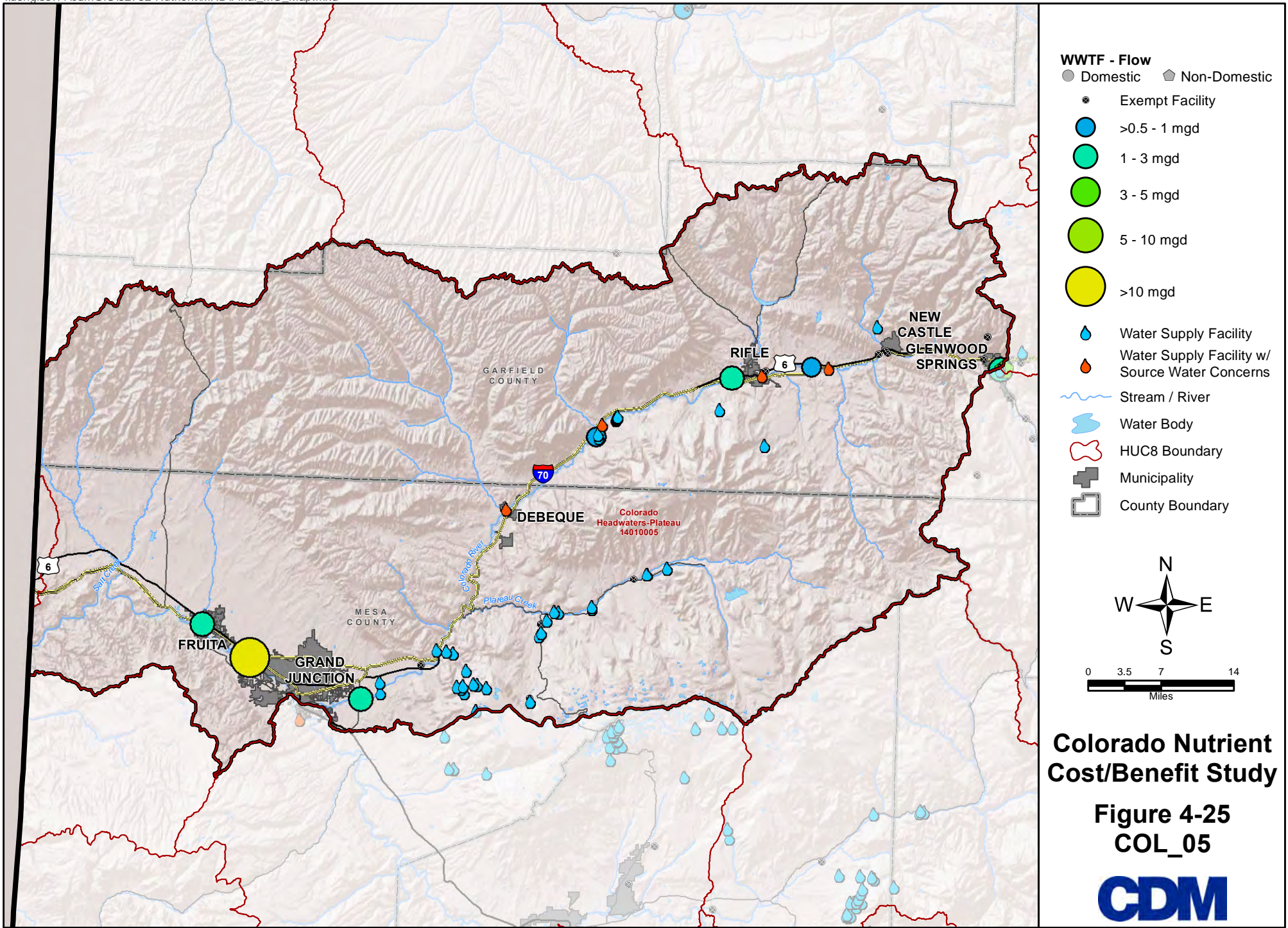
The water quality analysis for this Manageable Unit relied on default effluent quality parameters for a majority of the facilities, 4.5 mg/L TP and 25 mg/L TIN. Site-specific data were available for one facility, the Persigo WWTF, which included average effluent values of 2.46 mg/L TP and 21.4 mg/L TIN.

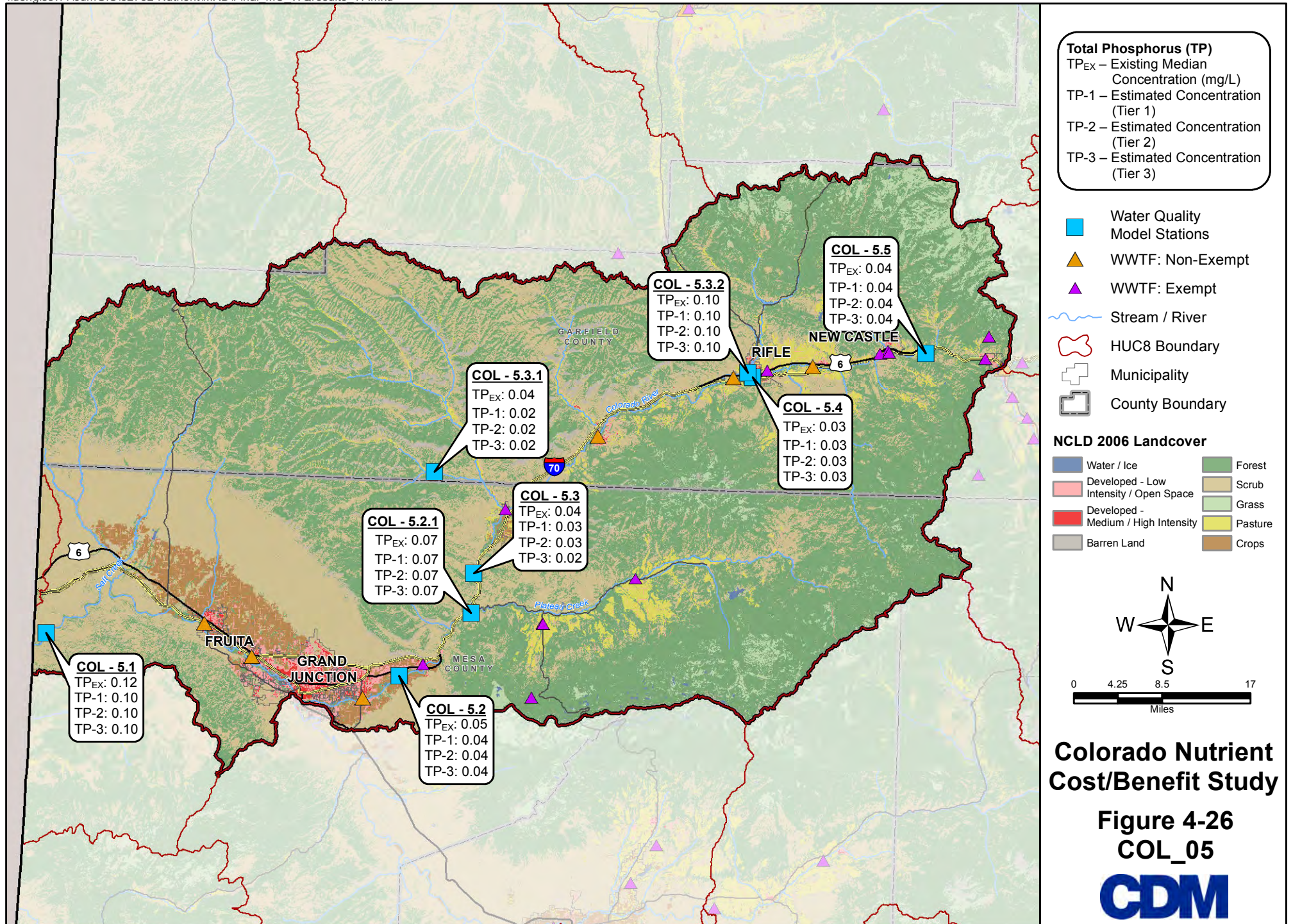
Streams and Rivers

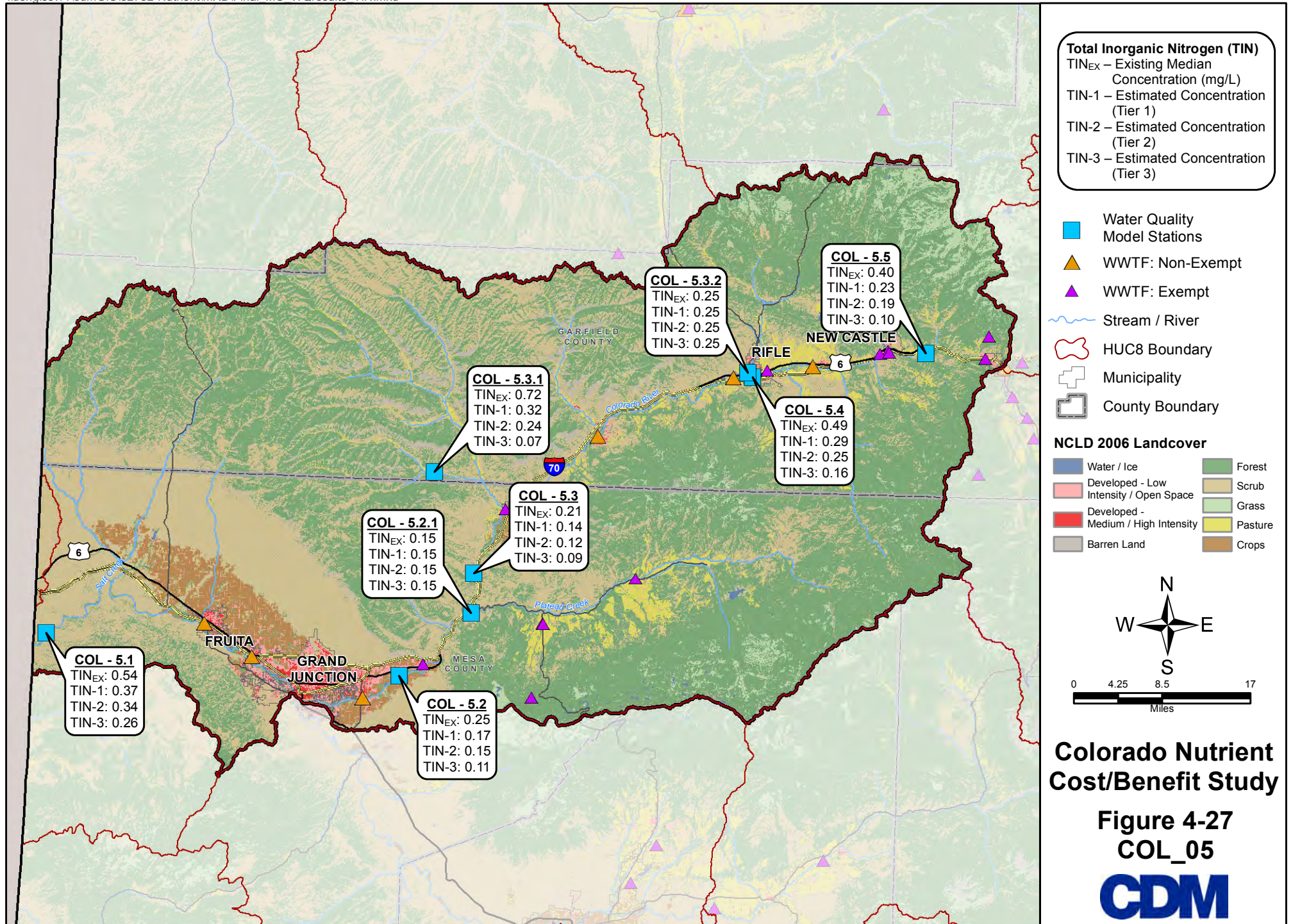
Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-55 and 4-56 (see Figure 4-25 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-55; Figure 4-26) and for TIN (Table 4-56; Figure 4-27). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-55. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_05

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 5.1	Mainstem	0.12	0.101	0.100	0.096
COL - 5.2	Mainstem	0.05	0.044	0.044	0.043
COL - 5.2.1	Plateau Creek	0.07	0.070	0.070	0.070
COL - 5.3	Mainstem	0.04	0.027	0.026	0.024
COL - 5.3.1	Dry Fork Roan Creek	0.04	0.025	0.024	0.021
COL - 5.3.2	Rifle Creek	0.10	<i>Upstream facilities exempted</i>		
COL - 5.4	Mainstem	0.03	0.030	0.030	0.030
COL - 5.5	Mainstem	0.04	0.037	0.037	0.037







Colorado Nutrient Cost/Benefit Study

Figure 4-27
COL_05



Table 4-56. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in COL_05

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
COL - 5.1	Mainstem	0.54	0.374	0.339	0.261
COL - 5.2	Mainstem	0.25	0.169	0.151	0.111
COL - 5.2.1	Plateau Creek	0.15	0.150	0.150	0.150
COL - 5.3	Mainstem	0.21	0.137	0.121	0.086
COL - 5.3.1	Dry Fork Roan Creek	0.72	0.323	0.243	0.068
COL - 5.3.2	Rifle Creek	0.25	<i>Upstream facilities exempted</i>		
COL - 5.4	Mainstem	0.49	0.293	0.250	0.156
COL - 5.5	Mainstem	0.40	0.225	0.187	0.103

Reservoirs

There are no modeled reservoirs within the COL_05 Manageable Unit.

4.2.5.2 Wastewater Costs

Table 4-57 summarizes the WWTFs located in COL_05 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-57: WWTFs in COL_05

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Flow Bin Included in Proposed Regulation (MGD)	Treatment Plant Category	Comment
Mesa WSD		0.04	0-0.5	0	4	Exempt due to capacity
Silt, Town of		0.75	>0.5 to 1	>0.5 to 1	1	
Battlement Mesa Metropolitan District		0.8	>0.5 to 1	>0.5 to 1	1	
Mesa Co/Grand Junction	Persigo WWTF	12.5	>10	>10	1	
New Castle, Town of		0.2	0-0.5	0-0.5	1	Exempt due to capacity
Colorado DOT	Hanging Lake Rest Area	0.0042	0-0.5	0	4A	Exempt due to capacity
Canyon Creek Estates	Canyon Creek Estates WWTF	0.021	0-0.5	0	2	Exempt due to capacity
Wastewater Treatment Services LLC		No Data	No Data	0	0	Exempt due to capacity
Fruita, City of		2.33	>1 to 3	0	6	
Riverbend Water & Sewer Co	Riverbend Subdivision WWTF	0.0247	0-0.5	0	4	Exempt due to capacity
Grand Mesa Metropolitan District 2		0.052	0-0.5	0	4	Exempt due to capacity
DeBeque, Town of		0.07	0-0.5	0	4	Exempt due to capacity
Talbott Enterprises Inc		0.15	0-0.5	0	4	Exempt due to capacity
Collbran, Town of	Valleywide Sewerage System	0.192	0-0.5	0	4	Exempt due to capacity and disadvantaged
Mesa WSD		0.499999	0-0.5	0	4	Exempt due to capacity

Table 4-57: WWTFs in COL_05

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Flow Bin Included in Proposed Regulation (MGD)	Treatment Plant Category	Comment
Palisade, Town of		0.47	0-0.5	0	4	Exempt due to capacity and disadvantaged
Clifton Sanitation District		1.43	>1 to 3	>1 to 3	6	
Rifle Regional WRF		2	>1 to 3	>1 to 3	6	

Table 4-58 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-59 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-59 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-58. Estimated WWTF Costs to Meet Tier 1, 2, or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$48,126,000	\$102,323,000	\$729,887,000
Annual Operation & Maintenance Costs	\$1,895,000	\$2,949,000	\$11,771,000

Costs rounded to nearest \$1000.

Table 4-59. Estimated WWTF Costs to Meet Tier 1, 2, or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$3,160,000	\$19,514,000	\$96,402,000
Annual Operation & Maintenance Costs	\$1,031,000	\$1,121,000	\$3,712,000

Costs rounded to nearest \$1000.

4.2.5.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. Facilities analyzed within COL_05 include: Rifle, Debeque, Parachute, and Silt. These avoided costs are provided in Table 4-60.

4.2.5.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in COL_05, in present value (2010), are presented in Table 4-60.

Table 4-60. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU COL_05

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$43,362,000	\$92,193,000	\$657,629,000
Operating	\$29,399,000	\$45,744,000	\$182,617,000
Total	\$72,761,000	\$137,937,000	\$840,246,000
Potable Water Supply Benefits			
Capital	\$435,000	\$435,000	\$435,000
Operating	\$870,000	\$870,000	\$870,000
Total	\$1,305,000	\$1,305,000	\$1,305,000
Percent Change in Water Quality (streams)	19.12%	22.54%	31.25%
Percent Change in Water Quality (lakes)	NA	NA	NA
Projected Active Benefits			
Angling	\$4,330,000	\$5,104,000	\$7,077,000
Boating	\$12,523,000	\$14,761,000	\$20,466,000
Swimming	\$1,447,000	\$1,706,000	\$2,365,000
Total	\$18,300,000	\$21,571,000	\$29,908,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$28,630,000	\$32,565,000	\$46,310,000
Total Quantified Benefits	\$48,235,000	\$55,441,000	\$77,523,000

* Expressed in Present Value 2010 Dollars

*NA indicates not available

4.2.5.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in COL_05 are -\$24,526,000 for Tier 1, -\$82,497,000 for Tier 2 and -\$762,724,000 for Tier 3. The benefit-cost ratio is 0.66:1, 0.4:1, and 0.09:1 for Tiers 1, 2, and 3, respectively (Table 4-61).

Table 4-61. Benefit-Cost Summary for MU COL_05, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit Cost Analysis			
Total Benefits	\$48,235,000	\$55,441,000	\$77,522,000
Total Costs	\$72,761,000	\$137,938,000	\$840,246,000
Net Present Value Benefits	(\$24,526,000)	(\$82,497,000)	(\$762,724,000)
Benefit-Cost Ratio	0.66 : 1	0.4 : 1	0.09 : 1

4.3 Gunnison River Basin

This section provides the findings applicable to the two Manageable Units established for the Gunnison River Basin (see Manageable Unit delineation in Section 3.2 along with Figures 3-1 through 3-8).

4.3.1 GUN_01 – Upper Gunnison River

GUN_01 is comprised of the Upper Gunnison River watershed. This Manageable Unit contains 3 HUC-8 watersheds and follows the Gunnison River from its headwaters through Gunnison to the confluence with the North Fork Gunnison River upstream of Delta. Figure 4-28 illustrates the area covered by GUN_01 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.3.1.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-62 and 4-63 (see Figure 4-28 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-62; Figure 4-29) and for TIN (Table 4-63; Figure 4-30). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-62. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GUN_01

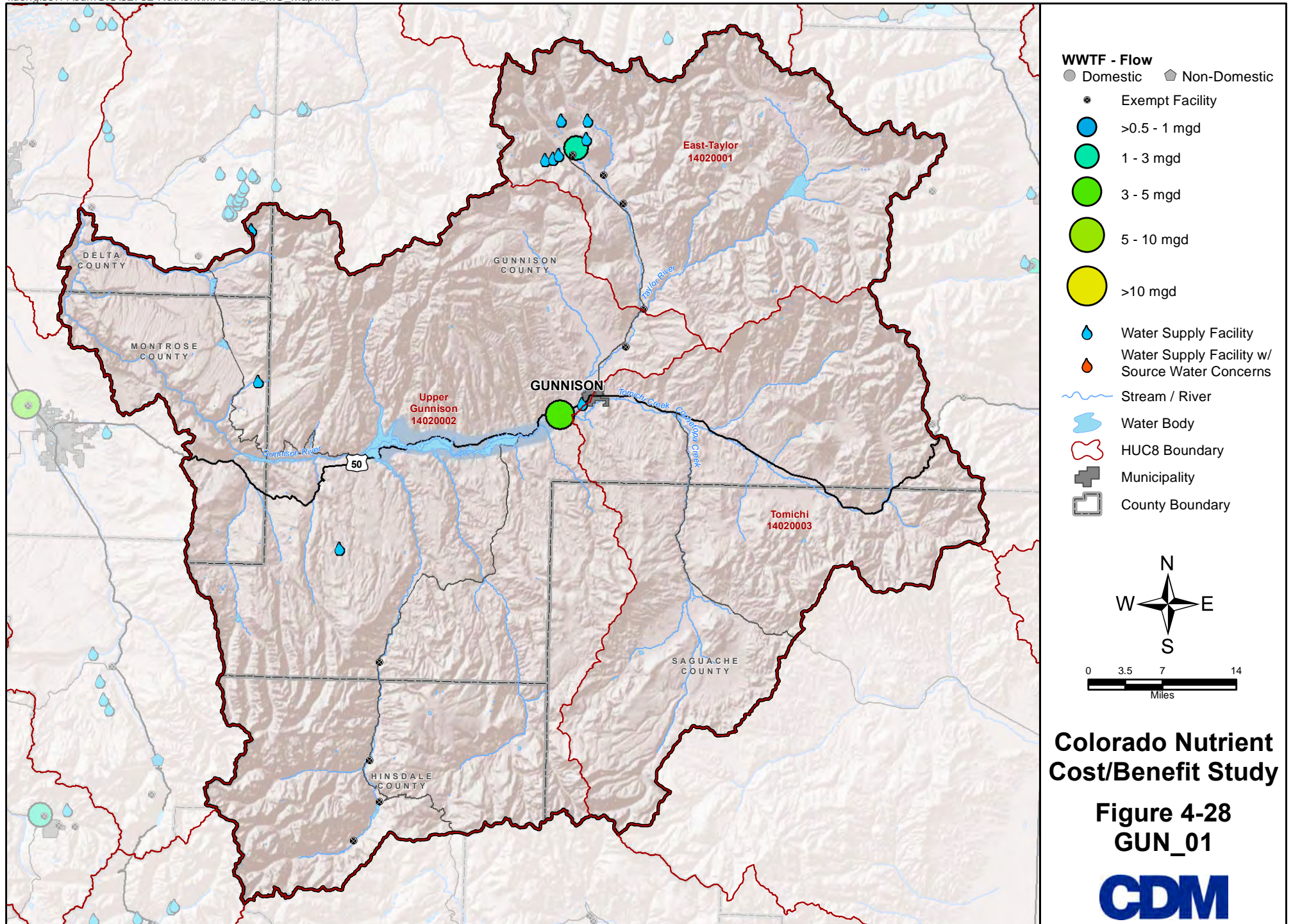
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GUN - 1.0.1	Smith Fork	0.02	0.020	0.020	0.020
GUN - 1.1	Mainstem	0.02	0.021	0.021	0.021
GUN - 1.1.1	Lake Fork	0.02	0.022	0.022	0.022
GUN - 1.2	Mainstem	0.03	0.032	0.032	0.032
GUN - 1.2.1	Mainstem	0.04	0.044	0.044	0.043
GUN - 1.3	Mainstem	0.01	0.010	0.010	0.010
GUN - 1.3.1	Mainstem	0.01	0.013	0.013	0.013
GUN - 1.3.2	Mainstem	0.03	0.030	0.030	0.030

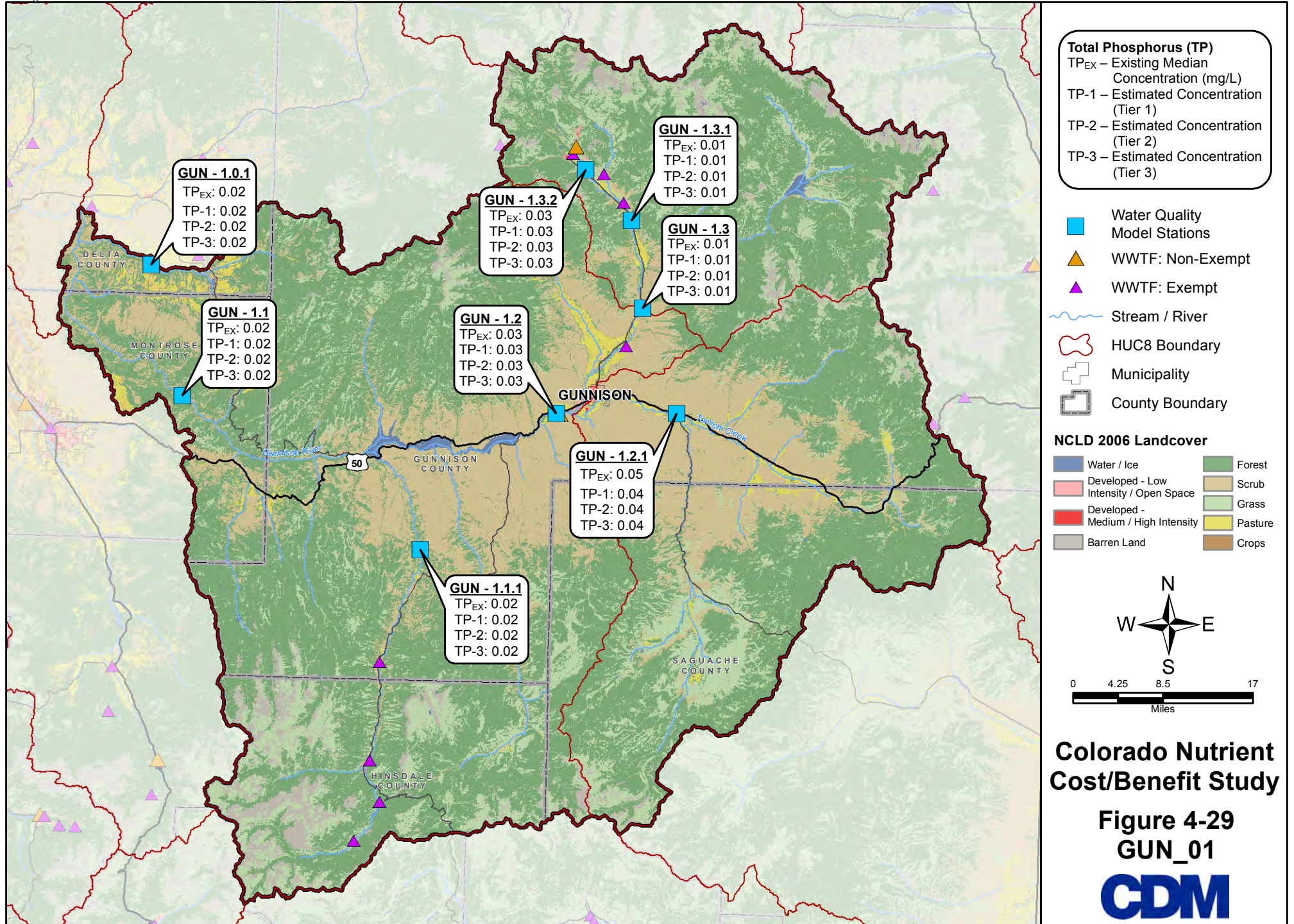
Table 4-63. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GUN_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GUN - 1.0.1	Smith Fork	no data	n/a	n/a	n/a
GUN - 1.1	Mainstem	0.04	0.044	0.044	0.044
GUN - 1.1.1	Lake Fork	0.05	0.045	0.045	0.045
GUN - 1.2	Mainstem	0.08	0.075	0.075	0.074
GUN - 1.2.1	Mainstem	no data	n/a	n/a	n/a
GUN - 1.3	Mainstem	0.09	0.086	0.085	0.082
GUN - 1.3.1	Mainstem	0.10	0.090	0.088	0.083
GUN - 1.3.2	Mainstem	0.67	0.424	0.377	0.275

Reservoirs

No reservoirs were analyzed in the Upper Gunnison River Manageable Unit.

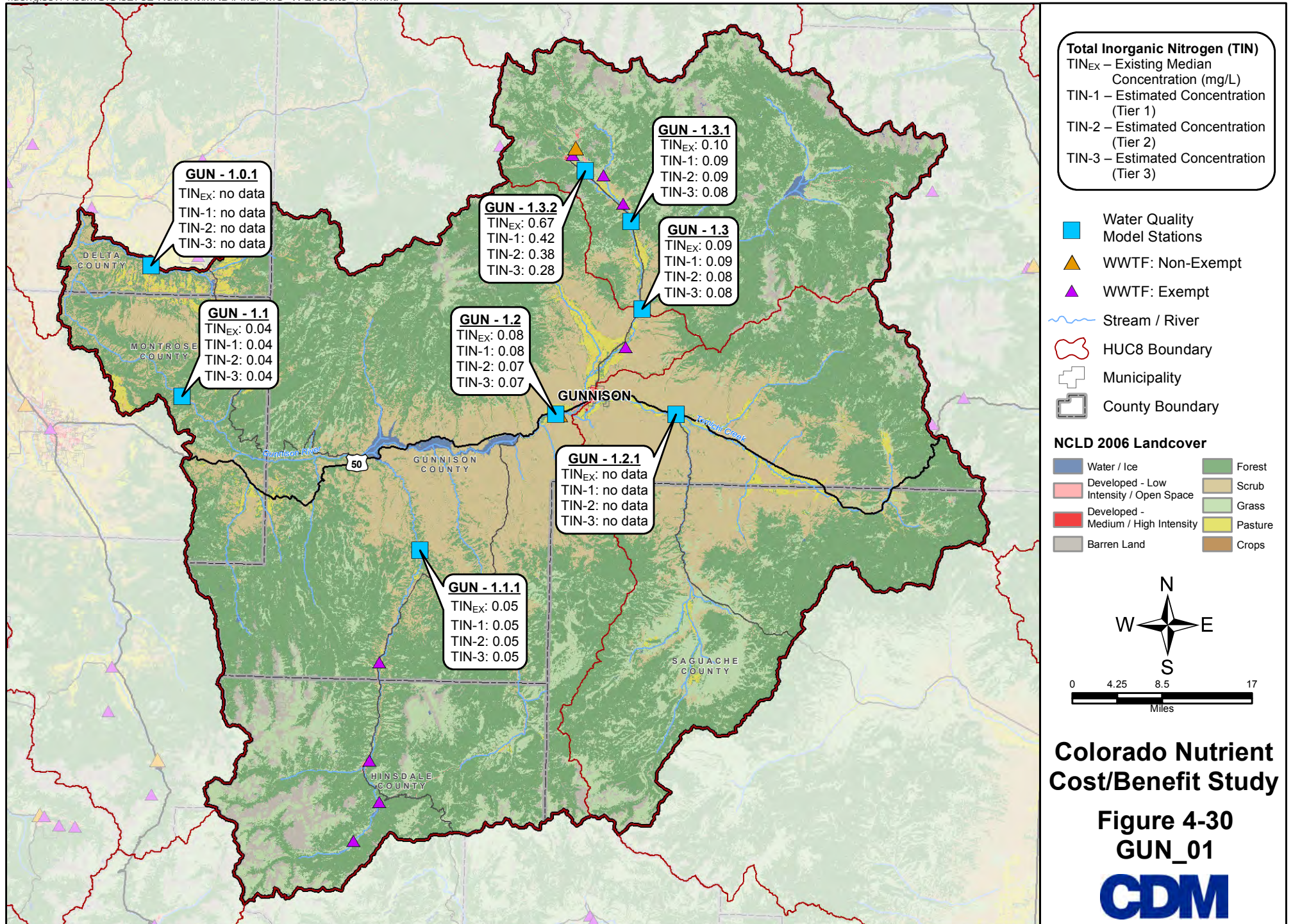




Colorado Nutrient Cost/Benefit Study

**Figure 4-29
GUN_01**





4.3.1.2 Wastewater Costs

Table 4-64 summarizes the WWTFs located in GUN_01 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-64. WWTFs in GUN_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Camp Gunnison Inc	Camp Gunnison Church Camp	No Data	No Data	0	Exempt due to capacity
Mt. Crested Butte WSD	Mt. Crested Butte WSD WWTF	1.2	>1 to 3	1	
Gunnison, City of		4.2	>3 to 5	1	
Ute Trail Ranch Foundation	Sky Ranch at Ute Trail Inc.	0.015	0-0.5	4	Exempt due to capacity
Camp Red Cloud		0.02	0-0.5	2	Exempt due to capacity
L and N Inc		0.027	0-0.5	4	Exempt due to capacity
Almont Sewage Hereafter In Transit Plant	Almont WWTF	0.035	0-0.5	2	Exempt due to capacity
Crested Butte South Metropolitan District		0.225	0-0.5	3	Exempt due to capacity
Crested Butte, Town of		0.6	>0.5 to 1	4	Exempt due to capacity and disadvantaged
East River Regional Sanitation District		0.049	0-0.5	4	Exempt due to capacity
Lake City, Town of		0.22	0-0.5	4	Exempt due to capacity

Table 4-65 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-66 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-66 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-65. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$11,901,000	\$32,315,000	\$155,376,000
Annual Operation & Maintenance Costs	\$589,000	\$926,000	\$3,518,000

Costs rounded to nearest \$1000.

Table 4-66. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$10,484,000	\$12,110,000	\$63,619,000
Annual Operation & Maintenance Costs	\$532,000	\$622,000	\$2,044,000

Costs rounded to nearest \$1000.

4.3.1.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs

thereafter. Public Water Supply cost development was presented in Section 3.5. There are no avoided costs calculated for GUN_01.

4.3.1.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in GUN_01, in present value (2010), are presented in Table 4-67.

Table 4-67. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU GUN_01

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$10,723,000	\$29,116,000	\$139,994,000
Operating	\$9,134,000	\$14,370,000	\$54,571,000
Total	\$19,857,000	\$43,486,000	\$194,565,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	5.38%	6.69%	8.67%
Percent Change in Water Quality (Lakes)			
	NA	NA	NA
Projected Active Benefits			
Angling	\$856,000	\$1,063,000	\$1,378,000
Boating	\$2,280,000	\$2,834,000	\$3,673,000
Swimming	\$415,000	\$515,000	\$668,000
Total	\$3,551,000	\$4,412,000	\$5,719,000
Property Value Benefits			
	NA	NA	NA
Passive Benefits	\$4,109,000	\$4,851,000	\$6,522,000
Total Quantified Benefits	\$7,660,000	\$9,263,000	\$12,241,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.3.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in GUN-01 are -\$12,198,000 for Tier 1, -\$34,221,000 for Tier 2, and -\$182,323,000 for Tier 3. The benefit-cost ratio is 0.39:1, 0.21:1, and 0.06:1 for Tiers 1, 2, and 3, respectively (Table 4-68).

Table 4-68. Benefit Cost Summary for MU GUN_01, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$7,659,000	\$9,264,000	\$12,241,000
Total Costs	\$19,857,000	\$43,485,000	\$194,565,000
Net Present Value Benefits	(\$12,198,000)	(\$34,221,000)	(\$182,323,000)
Benefit Cost Ratio	0.39 : 1	0.21 : 1	0.06 : 1

4.3.2 GUN_02 – Lower Gunnison River

GUN_02 is the Lower Gunnison River watershed. This Manageable Unit contains 3 HUC-8 watersheds and follows the Gunnison River from below GUN_01 through Delta to the confluence with the Colorado River in Grand Junction. Figure 4-31 illustrates the area covered by GUN_02 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.3.2.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-69 and 4-70 (see Figure 4-31 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-69; Figure 4-32) and for TIN (Table 4-70; Figure 4-33). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed. It should be noted that GUN_01 enters GUN_02 upstream of site GUN-2.1.

Table 4-69. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GUN_02

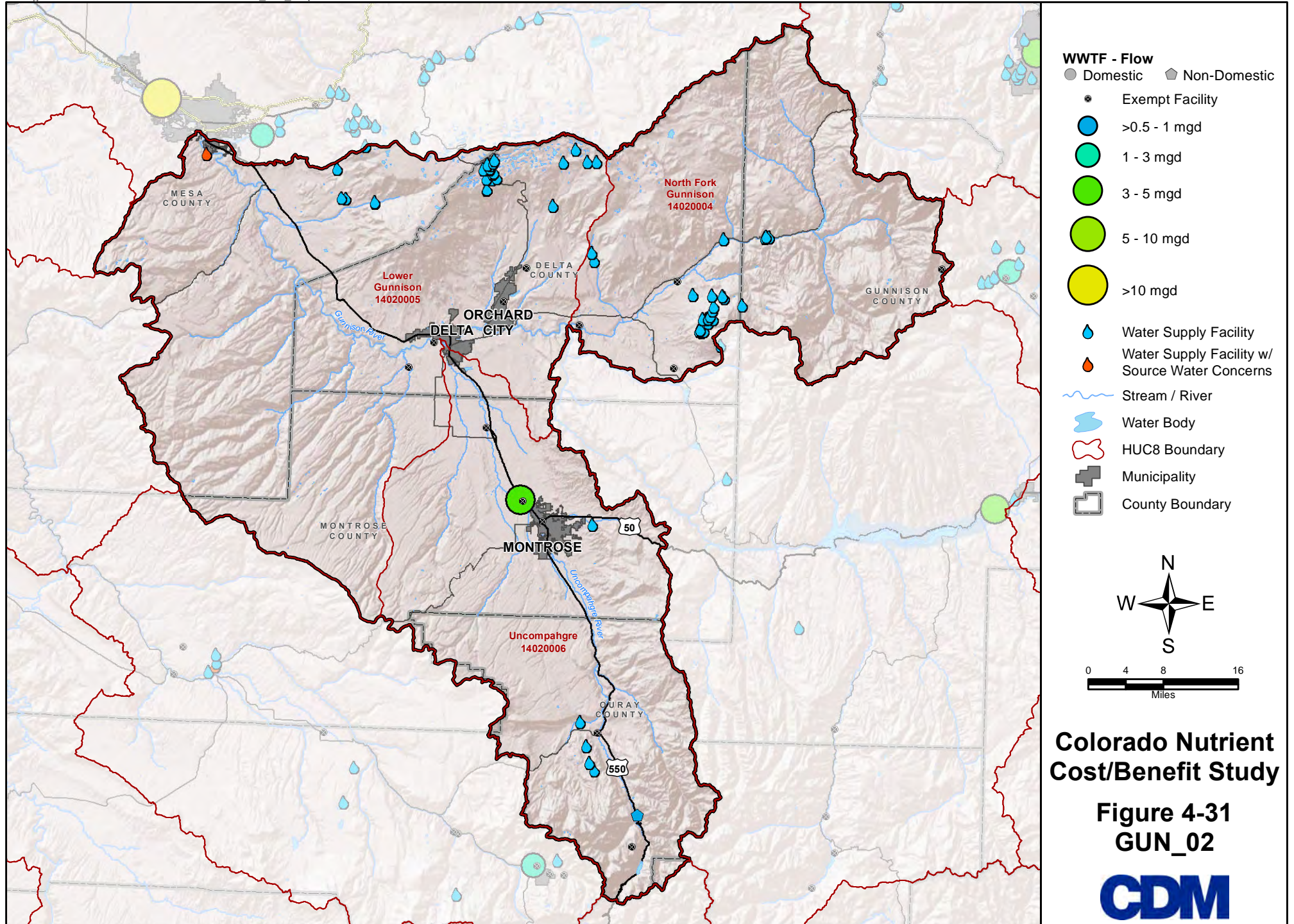
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GUN - 2.1	Mainstem	0.06	0.06	0.06	0.06
GUN - 2.1.1	Uncompahgre River	0.04	0.04	0.04	0.04
GUN - 2.2	North Fork Gunnison River	0.02	0.02	0.02	0.02

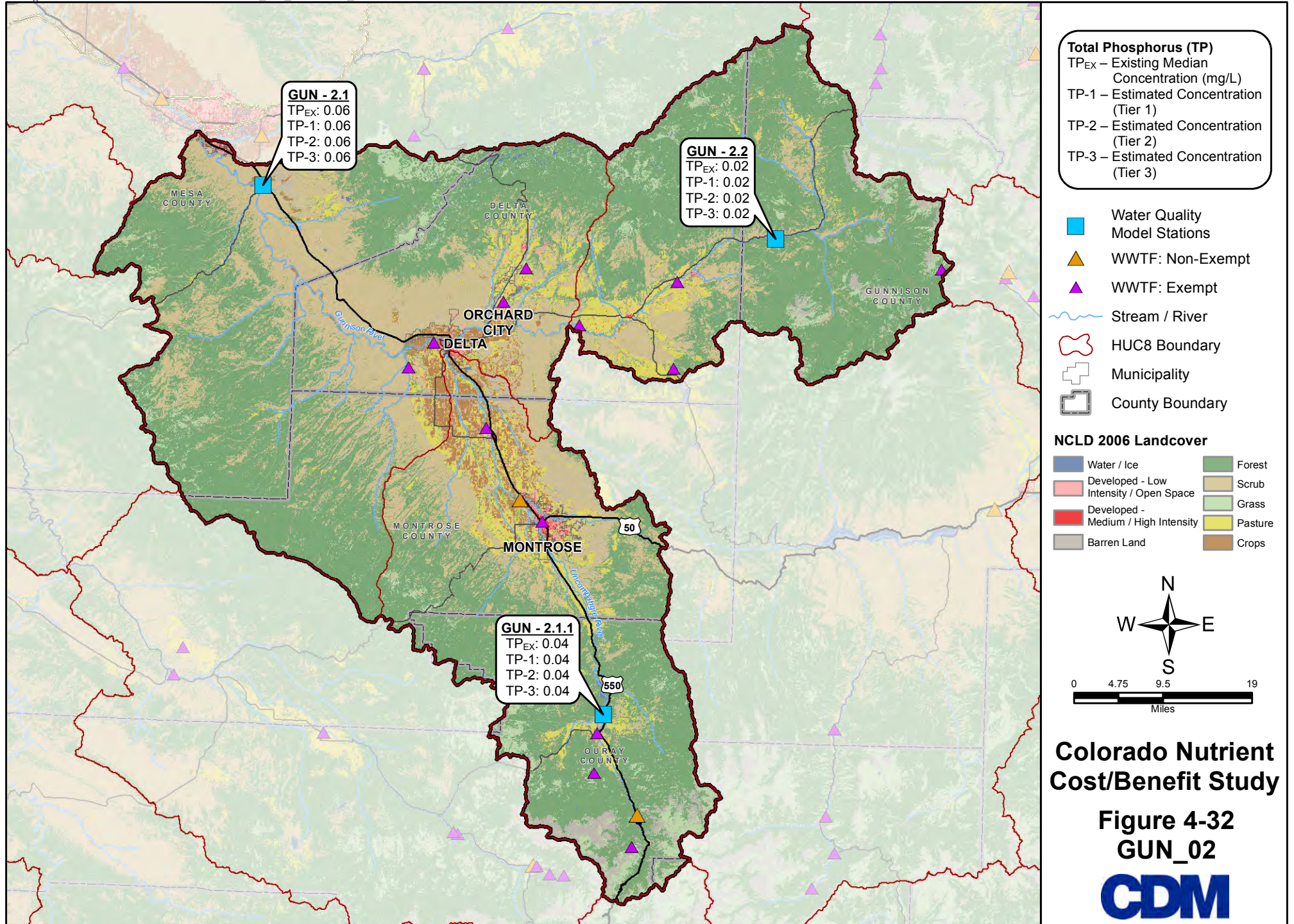
Table 4-70. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GUN_02

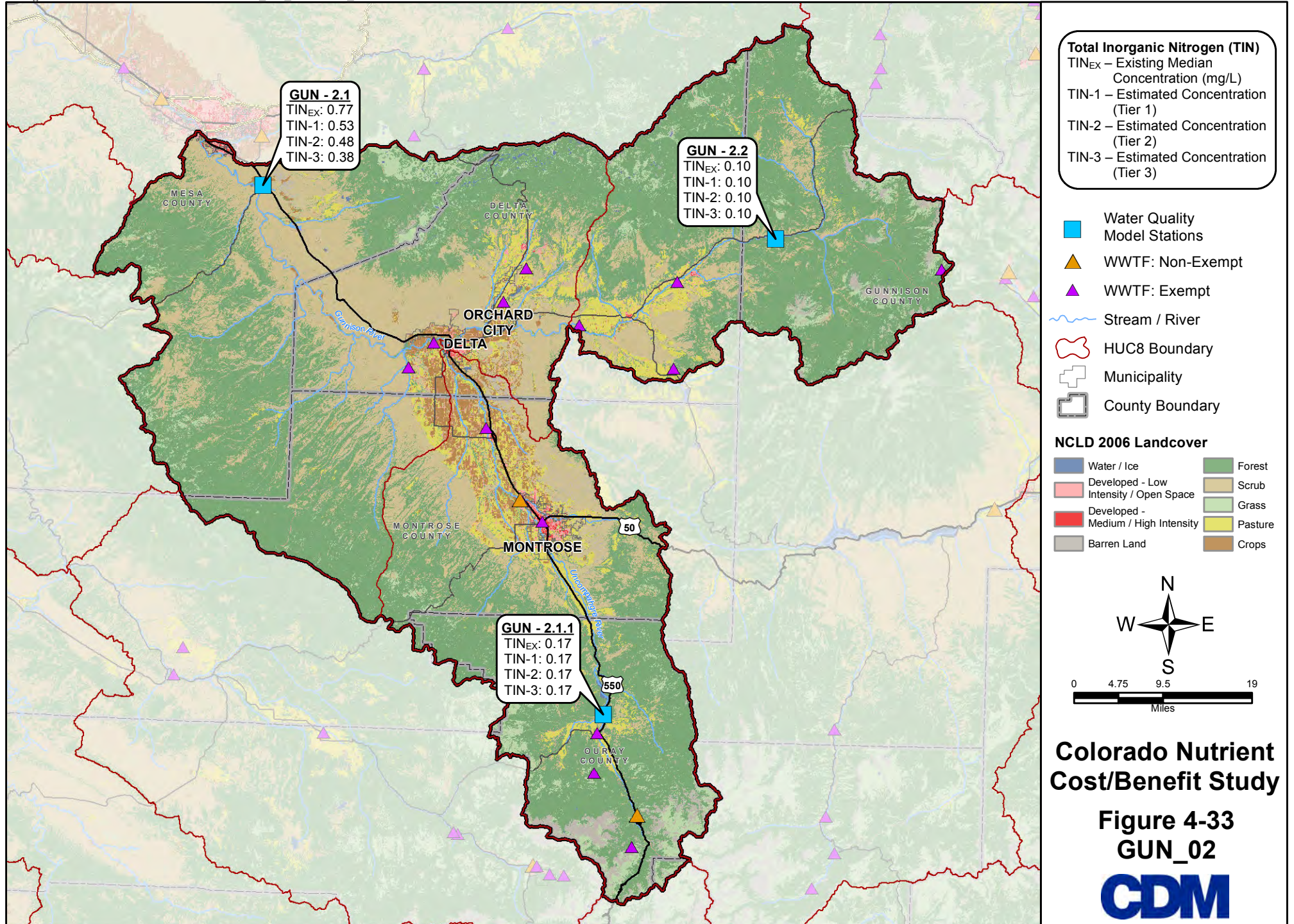
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GUN - 2.1	Mainstem	0.77	0.53	0.48	0.38
GUN - 2.1.1	Uncompahgre River	0.17	0.17	0.17	0.17
GUN - 2.2	North Fork Gunnison River	0.10	0.10	0.10	0.10

Reservoirs

No reservoirs were analyzed in the Upper Gunnison River Manageable Unit.







4.3.2.2 Wastewater Costs

Table 4-71 summarizes the WWTFs located in GUN_02 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-71: WWTFs in GUN_02

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Elk Meadows Estates	Owners of Elk Meadows	0.0133	0-0.5	4	Exempt due to capacity
Paonia, Town of		0.2	0-0.5	4	Exempt due to capacity
Delta, City of		2.45	>1 to 3	2	Exempt due to capacity and disadvantaged
Elk Mountain Resort	Elk Mountain Resort WWTF	0.049	0-0.5	4	Exempt due to capacity
West Montrose Sanitation District		0.7	>0.5 to 1	4	Exempt due to capacity
Volunteers of America Care Facility	Horizon Health Care and Retirement Community	0.015	0-0.5	4	Exempt due to capacity
Delta Correctional Center		0.06725	0-0.5	4	Exempt due to capacity
Crawford, Town of		0.18	0-0.5	4	Exempt due to capacity
Ridgway, Town of		0.194	0-0.5	4	Exempt due to capacity
Ouray, City of		0.25	0-0.5	4	Exempt due to capacity
Cedaredge, Town of		0.26	0-0.5	4	Exempt due to capacity
Olathe, Town of		0.35	0-0.5	4	Exempt due to capacity and disadvantaged
Hotchkiss, Town of		0.494	0-0.5	4	Exempt due to capacity and disadvantaged
Brookway Irwin LLC	Irwin Mountain Lodge	0.01375	0-0.5	5	Exempt due to capacity
Ouray, City of	Ouray Hot Springs Pool	0.75	>0.5-1	1	
Montrose, City of		4.32	>3 to 5	6	

Table 4-72 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-73 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-73 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-72. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$18,696,000	\$41,448,000	\$217,430,000
Annual Operation & Maintenance Costs	\$660,000	\$989,000	\$3,653,000

Costs rounded to nearest \$1000.

Table 4-73. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$37,952,000	\$43,723,000	\$255,182,000
Annual Operation & Maintenance Costs	\$2,018,000	\$2,191,000	\$7,405,000

Costs rounded to nearest \$1000.

4.3.2.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. There are no avoided costs calculated for GUN_02.

4.3.2.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in GUN_02, in present value (2010), are presented in Table 4-74.

Table 4-74. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU GUN_02

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$16,845,000	\$37,345,000	\$195,905,000
Operating	\$10,245,000	\$15,342,000	\$56,666,000
Total	\$27,090,000	\$52,687,000	\$252,571,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	11.59%	16.36%	21.98%
Percent Change in Water Quality (Lakes)			
	NA	NA	NA
Projected Active Benefits			
Angling	\$1,291,000	\$1,822,000	\$2,448,000
Boating	\$3,377,000	\$4,765,000	\$6,403,000
Swimming	\$957,000	\$1,350,000	\$1,814,000
Total	\$5,625,000	\$7,937,000	\$10,665,000
Property Value Benefits			
	NA	NA	NA
Passive Benefits			
	\$10,759,000	\$14,598,000	\$20,170,000
Total Quantified Benefits	\$16,384,000	\$22,535,000	\$30,835,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.3.2.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in GUN-01 are -\$10,707,000 for Tier 1, -\$30,153,000 for Tier 2, and -\$221,737,000 for Tier 3. The benefit-cost ratio is 0.6:1, 0.43:1, and 0.12:1 for Tiers 1, 2, and 3, respectively (Table 4-75).

Table 4-75. Benefit Cost Summary for MU GUN_02, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$16,384,000	\$22,534,000	\$30,834,000
Total Costs	\$27,090,000	\$52,687,000	\$252,571,000
Net Present Value Benefits	(\$10,707,000)	(\$30,153,000)	(\$221,737,000)
Benefit Cost Ratio	0.6 : 1	0.43 : 1	0.12 : 1

4.4 Platte River Basin

This section provides the findings applicable to the 12 Manageable Units established for the Platte River Basin (see Manageable Unit delineation in Section 3.2 along with Figures 3-1 through 3-8).

4.4.1 PLT_01 – Upper South Platte Basin

PLT_01 is comprised of two HUC-8 watersheds and includes the South Platte River Basin upstream of the confluence with Cherry Creek. Figure 4-34 illustrates the area covered by PLT_01 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.1.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the majority of facilities, 4.5 mg/L TP and 25 mg/L TIN. Specific effluent information was available for several of the facilities in PLT_01, as shown in Table 4-76.

Table 4-76. Site-specific nutrient effluent values for WWTFs within PLT_01

Facility Name	Stream Name	Current TP (mg/L)	Current TIN (mg/L)	Information Source
Bear Creek Cabins	Bear Creek	1	25	Bear Creek Control regulation (TP)
Brook Forest Inn	Bear Creek	1	25	Bear Creek Control regulation (TP)
Evergreen Metropolitan District	Bear Creek	0.15	5.3	Averages from Bear Creek Water Quality report
Forest Hills Metropolitan District	Bear Creek	1	25	Bear Creek Control regulation (TP)
Genesee WSD	Bear Creek	0.39	5.7	Averages from Bear Creek WQ report
Kittredge WSD	Bear Creek	0.377	11.945	Averages from Bear Creek WQ report
Littleton/Englewood, Cities of	Mainstem	3.2	17.2	WWTF reported averages 2006-Present
Morrison, Town of	Bear Creek	0.53	25	Averages from Bear Creek WQ report
Plum Creek Wastewater Authority Plant1	Plum Creek	0.17	3.5	WWTF reported averages
Sageport WWTF	Plum Creek	1	25	Chatfield Control regulation (TP)
Singin' River Ranch WWTF	Bear Creek	1	25	Bear Creek Control regulation (TP)
Tiny Town	Bear Creek	1	25	Bear Creek Control regulation (TP)
Waucondah WWTP	Plum Creek	1	25	Chatfield Control regulation (TP)

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-75 and 4-76 (see Figure 4-34 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-75; Figure 4-35) and for TIN (Table 4-76; Figure 4-36). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-77. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_01

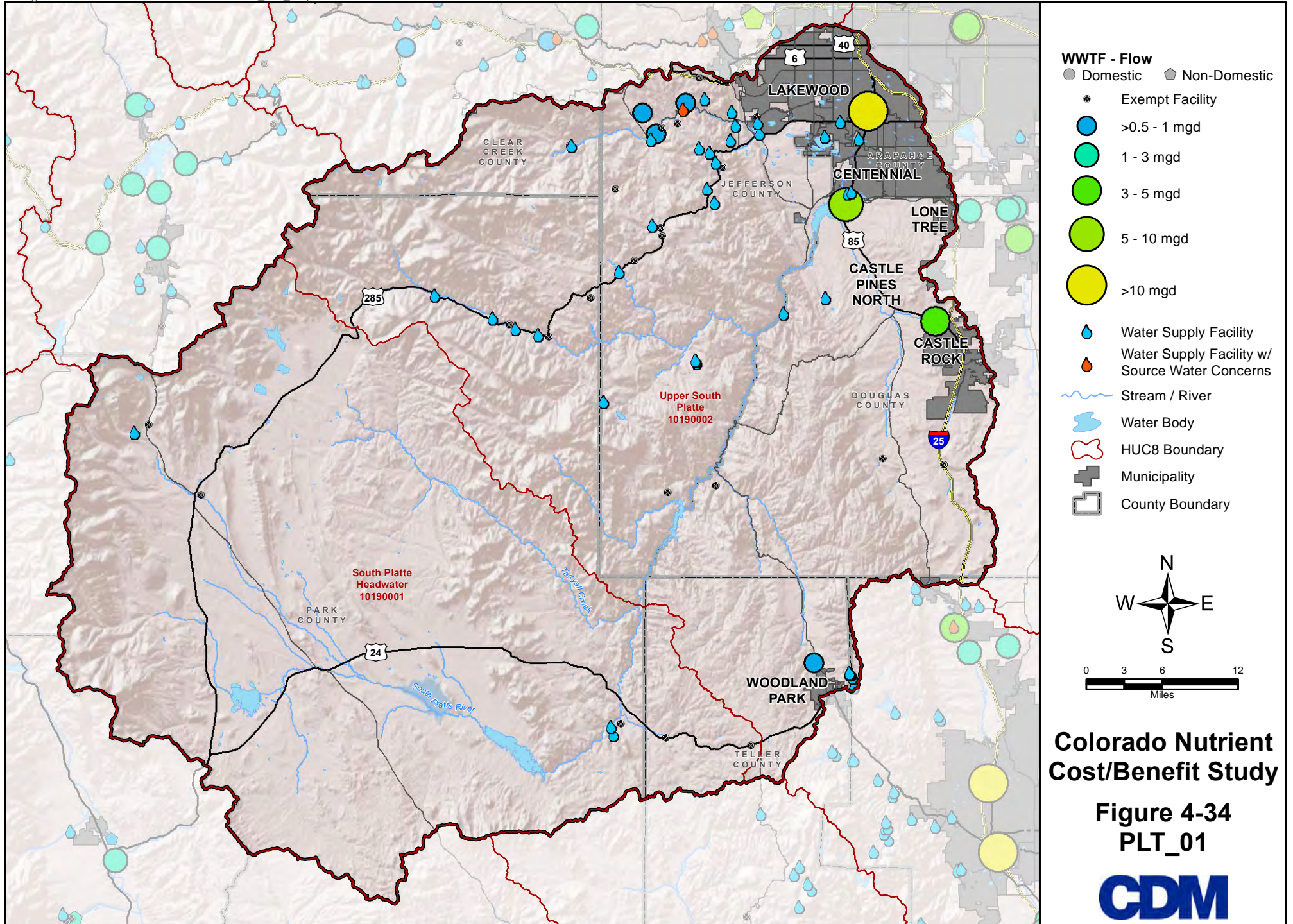
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT01-01	Mainstem	0.76	0.28	0.22	0.11
PLT01-02	Mainstem	1.06	0.37	0.28	0.11
PLT01-03	Mainstem	0.14	0.10	0.09	0.08
PLT01-04	Mainstem	0.02	0.02	0.02	0.02
PLT01-05	Mainstem	0.09	0.09	0.09	0.09
PLT01-06	Mainstem	0.05	0.05	0.05	0.05
PLT01-07	Bear Creek	0.03	0.03	0.03	0.03
PLT01-08	Bear Creek	0.04	0.04	0.04	0.04
PLT01-09	Bear Creek	0.04	0.04	0.04	0.04
PLT01-10	Bear Creek	0.03	0.03	0.03	0.03
PLT01-11	Bear Creek	0.03	0.03	0.03	0.03
PLT01-12	Bear Creek	0.03	0.03	0.03	0.03
PLT01-13	Bear Creek	0.03	0.03	0.03	0.03
PLT01-14	Bear Creek	0.01	0.01	0.01	0.01
PLT01-15	Plum Creek	0.02	0.02	0.02	0.02

Table 4-78. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT01-01	Mainstem	1.44	0.86	0.67	0.20
PLT01-02	Mainstem	9.30	5.28	3.92	0.66
PLT01-03	Mainstem	1.98	1.10	0.93	0.38
PLT01-04	Mainstem	0.22	0.19	0.19	0.15
PLT01-05	Mainstem	0.27	0.20	0.18	0.15
PLT01-06	Mainstem	no data	n/a	n/a	n/a
PLT01-07	Bear Creek	0.36	0.36	0.36	0.25
PLT01-08	Bear Creek	1.47	1.47	1.47	0.74
PLT01-09	Bear Creek	0.86	0.86	0.86	0.27
PLT01-10	Bear Creek	0.17	0.17	0.17	0.08
PLT01-11	Bear Creek	0.25	0.25	0.25	0.09
PLT01-12	Bear Creek	0.17	0.17	0.17	0.07
PLT01-13	Bear Creek	0.74	0.74	0.74	0.16
PLT01-14	Bear Creek	0.04	0.04	0.04	0.04
PLT01-15	Plum Creek	0.36	0.36	0.36	0.36

Reservoirs

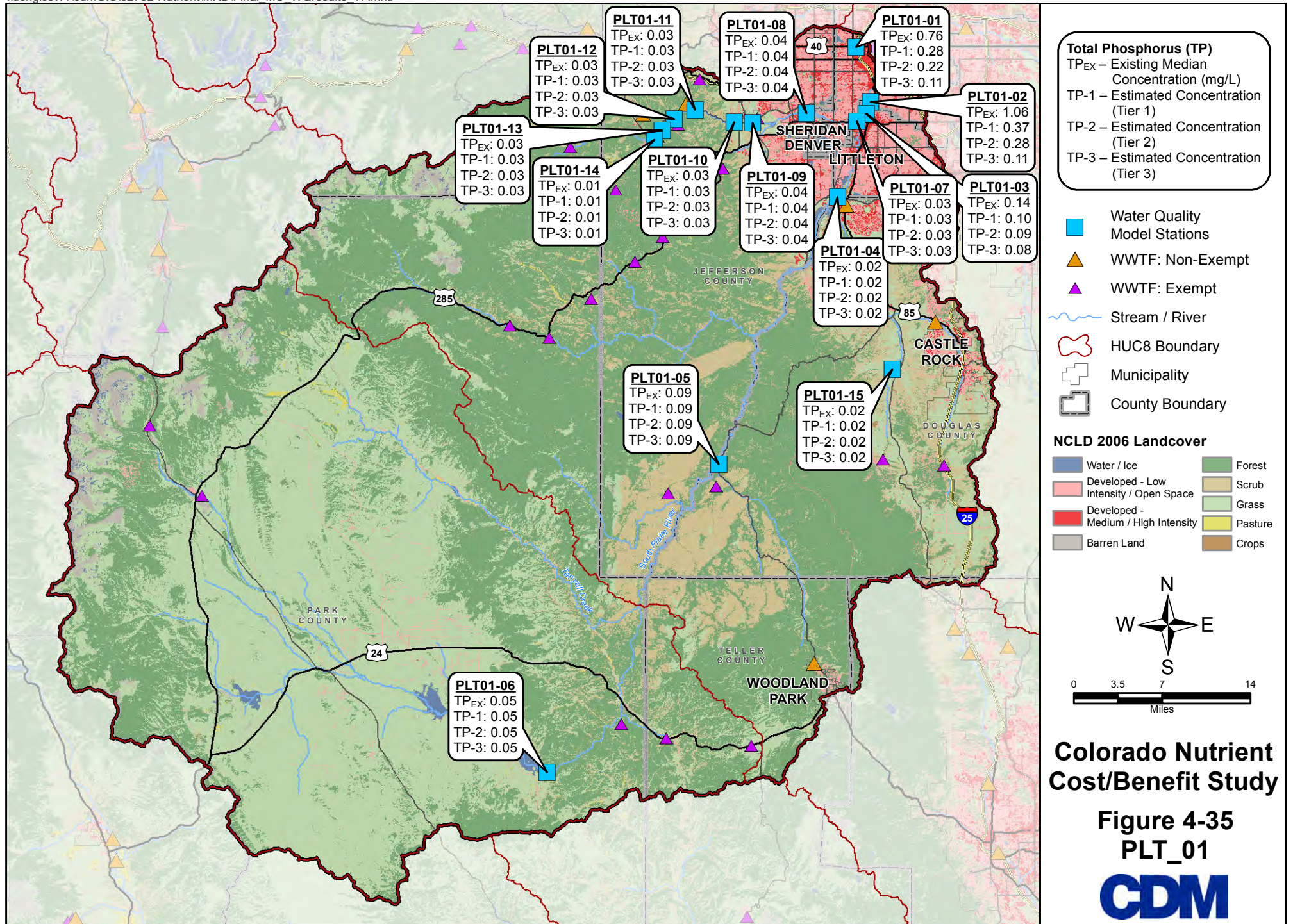
Bear Creek Lake and Chatfield Reservoir were analyzed within PLT_01 (see Figure 4-37). Table 4-79 and 4-80 summarize existing water quality and expected water quality under implementation of Tier 1, 2, or 3 effluent limits at Bear Creek Lake and Chatfield Reservoir, respectively. The median TP and TIN concentrations in both reservoirs are less than upstream median nutrient concentrations. Accordingly, given the modest number of WWTFs upstream of the reservoirs and the existing control regulations, implementation of the nutrient control regulation is expected to have only a moderate impact on water quality in either reservoir.



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**Figure 4-34
PLT_01**

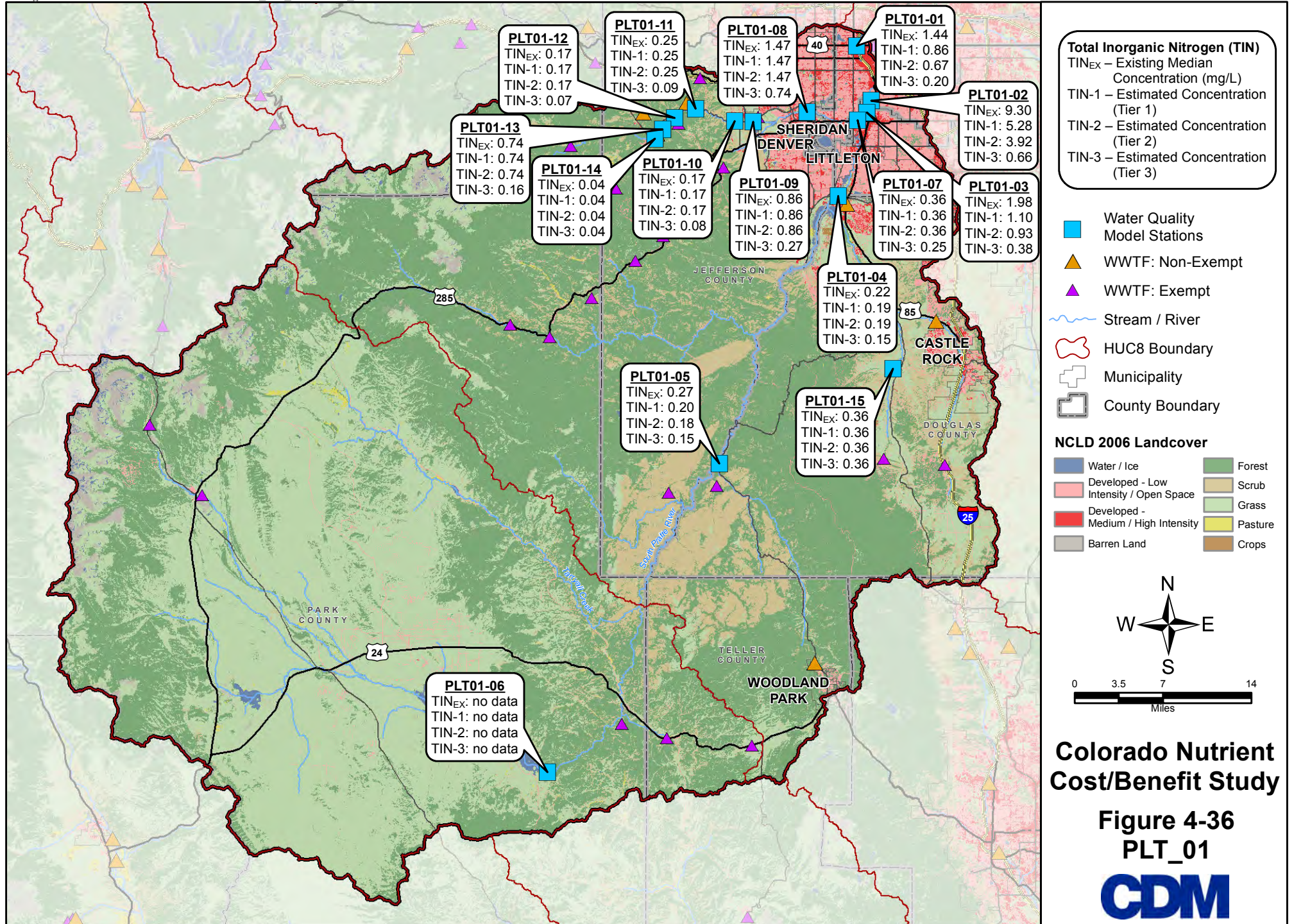




Colorado Nutrient Cost/Benefit Study

**Figure 4-35
 PLT_01**





PLT01-12
 TIN_{Ex}: 0.17
 TIN-1: 0.17
 TIN-2: 0.17
 TIN-3: 0.07

PLT01-11
 TIN_{Ex}: 0.25
 TIN-1: 0.25
 TIN-2: 0.25
 TIN-3: 0.09

PLT01-08
 TIN_{Ex}: 1.47
 TIN-1: 1.47
 TIN-2: 1.47
 TIN-3: 0.74

PLT01-01
 TIN_{Ex}: 1.44
 TIN-1: 0.86
 TIN-2: 0.67
 TIN-3: 0.20

PLT01-02
 TIN_{Ex}: 9.30
 TIN-1: 5.28
 TIN-2: 3.92
 TIN-3: 0.66

PLT01-13
 TIN_{Ex}: 0.74
 TIN-1: 0.74
 TIN-2: 0.74
 TIN-3: 0.16

PLT01-14
 TIN_{Ex}: 0.04
 TIN-1: 0.04
 TIN-2: 0.04
 TIN-3: 0.04

PLT01-10
 TIN_{Ex}: 0.17
 TIN-1: 0.17
 TIN-2: 0.17
 TIN-3: 0.08

PLT01-09
 TIN_{Ex}: 0.86
 TIN-1: 0.86
 TIN-2: 0.86
 TIN-3: 0.27

PLT01-07
 TIN_{Ex}: 0.36
 TIN-1: 0.36
 TIN-2: 0.36
 TIN-3: 0.25

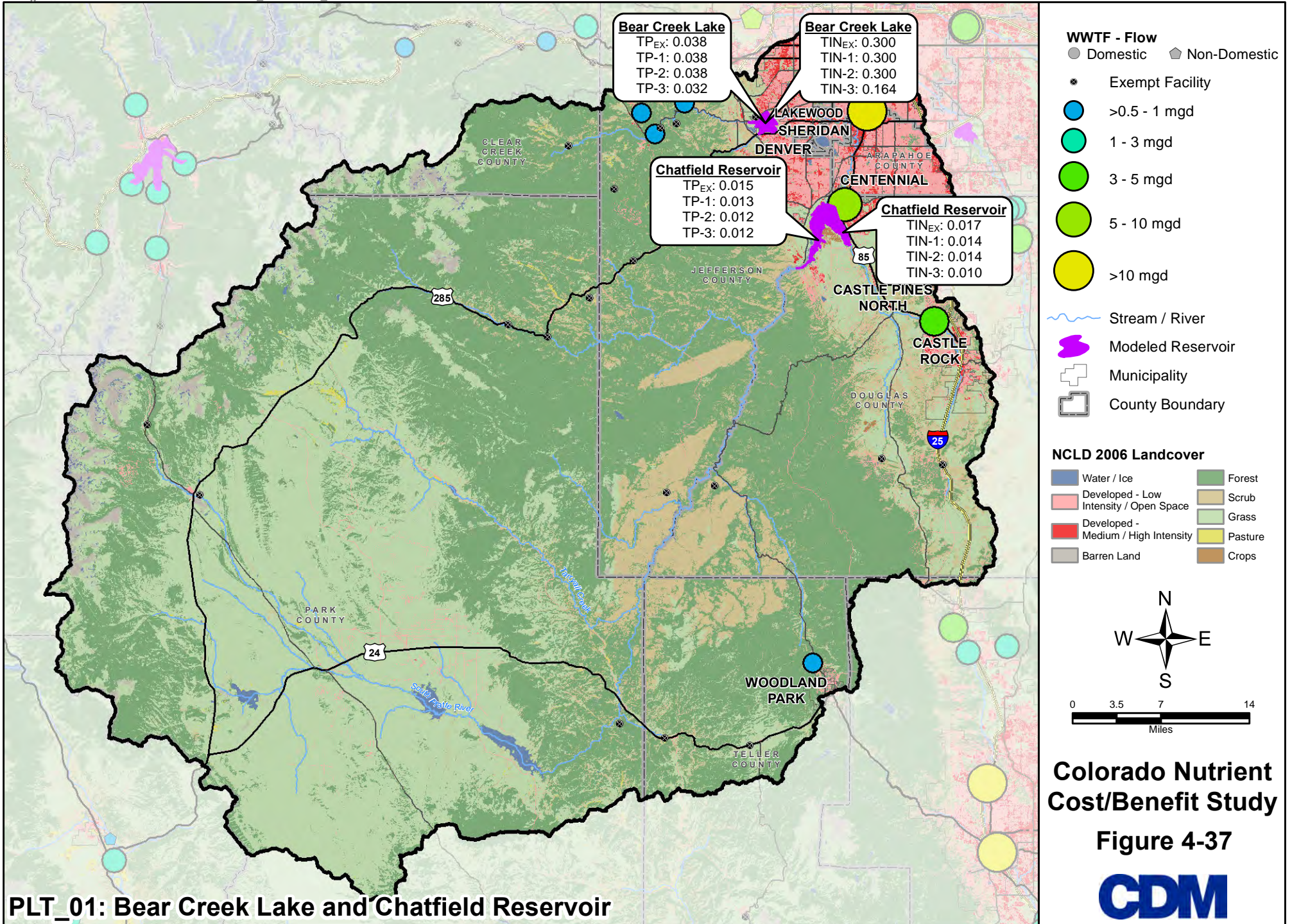
PLT01-03
 TIN_{Ex}: 1.98
 TIN-1: 1.10
 TIN-2: 0.93
 TIN-3: 0.38

PLT01-04
 TIN_{Ex}: 0.22
 TIN-1: 0.19
 TIN-2: 0.19
 TIN-3: 0.15

PLT01-05
 TIN_{Ex}: 0.27
 TIN-1: 0.20
 TIN-2: 0.18
 TIN-3: 0.15

PLT01-15
 TIN_{Ex}: 0.36
 TIN-1: 0.36
 TIN-2: 0.36
 TIN-3: 0.36

PLT01-06
 TIN_{Ex}: no data
 TIN-1: no data
 TIN-2: no data
 TIN-3: no data



PLT_01: Bear Creek Lake and Chatfield Reservoir

Table 4-79. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in Bear Creek Lake

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.038	0.038	0.038	0.032
TIN	0.300	0.300	0.300	0.164

Table 4-80. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in Chatfield Reservoir

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.015	0.013	0.012	0.012
TIN	0.017	0.014	0.014	0.010

4.4.1.2 Wastewater Costs

Table 4-81 summarizes the WWTFs located in PLT_01 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-81. WWTFs in PLT_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
W. Jefferson County Metropolitan District		0.7	>0.5 to 1	1	Control Regulation
Woodland Park		0.893	>0.5 to 1	1	
Evergreen Metropolitan District		0.99	>0.5 to 1	1	Control Regulation
Centennial WSD		8.48	>5 to 10	1	Control Regulation
Hungate Bruce and Jayne	Bear Creek Cabins	0.001	0 to 0.5	1	Exempt due to capacity
Brook Forest Inn		0.009	0 to 0.5	1	Exempt due to capacity Control Regulation
Lost Valley Ranch Corp		0.015	0 to 0.5	1	Exempt due to capacity
Conifer Metropolitan District		0.019999	0 to 0.5	1	Exempt due to capacity Control Regulation
Will-O-Wisp Metropolitan District		0.06	0 to 0.5	1	Exempt due to capacity
Mountain WSD		0.1	0 to 0.5	1	Exempt due to capacity
Perry Park WSD	Waucondah WWTF	0.32	0 to 0.5	1	Exempt due to capacity Control Regulation
Jefferson County Public Schools	Conifer HS WW Rec Plt	No Data		0	Exempt due to capacity Control Regulation
Platte Canyon School District 1		No Data		0	Exempt due to capacity
Tiny Town Company LLC		0.005	0 to 0.5	2	Exempt due to capacity Control Regulation
Forest Hills Metropolitan District		0.05	0 to 0.5	2	Exempt due to capacity Control Regulation

Table 4-81. WWTFs in PLT_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Perry Park WSD	Sageport WWTF	0.1	0 to 0.5	2	Exempt due to capacity Control Regulation
Littleton/Englewood		34	>10	3	
YMCA Camp Shady Brook		0.012	0 to 0.5	4A	Exempt due to capacity
Pikes Peak Council - BSA	Camp Alexander	0.012	0 to 0.5	4	Exempt due to capacity
Genesee WSD		0.8	>0.5 to 1	4	Exempt due to capacity Control Regulation
Amen Real Estate, LLC	Singin' River Ranch WWTF	0.014	0 to 0.5	4	Exempt due to capacity Control Regulation
Florissant WSD		0.057	0 to 0.5	4	Exempt due to capacity
Kittredge WSD		0.07	0 to 0.5	4	Exempt due to capacity Control Regulation
Alma, Town of		0.117	0 to 0.5	4	Exempt due to capacity
Fairplay Sanitation District		0.3	0 to 0.5	1	Exempt due to capacity
Teller County		0.035	0 to 0.5	5	Exempt due to capacity
Bailey WSD		0.075	0 to 0.5	5	Exempt due to capacity
Plum Creek Wastewater Authority		4.87	>3 to 5	6	Control Regulation
Morrison Town of		0.2	0 to 0.5	6	Exempt due to capacity Control Regulation

Table 4-82 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-83 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-83 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-82. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$150,543,000	\$349,690,000	\$1,790,401,000
Annual Operation & Maintenance Costs	\$4,315,000	\$7,815,000	\$26,172,000

Costs rounded to nearest \$1000.

Table 4-83. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$15,326,000	\$18,470,000	\$114,589,000
Annual Operation & Maintenance Costs	\$569,000	\$788,000	\$2,976,000

Costs rounded to nearest \$1000.

4.4.1.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The Genesee WSD was analyzed for this Manageable Unit. These avoided costs are provided in Table 4-84.

4.4.1.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_01, in present value (2010), are presented in Table 4-84.

Table 4-84. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_01

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$135,640,000	\$315,071,000	\$1,613,155,000
Operating	\$66,939,000	\$121,247,000	\$406,029,000
Total	\$202,579,000	\$436,318,000	\$2,019,184,000
Potable Water Supply Benefits			
Capital	\$189,000	\$189,000	\$189,000
Operating	\$307,000	\$307,000	\$307,000
Total	\$496,000	\$496,000	\$496,000
Percent Change in Water Quality (streams)			
	26.48%	29.97%	36.89%
Percent Change in Water Quality (Bear Creek Lake and Chatfield Reservoir)			
	3.53%	4.24%	22.49%
Projected Active Benefits			
Angling	\$21,012,000	\$24,654,000	\$92,788,000
Boating	\$46,931,000	\$53,245,000	\$74,038,000
Swimming	\$6,456,000	\$7,330,000	\$10,551,000
Total	\$74,399,000	\$85,229,000	\$177,377,000
Property Value	NA	NA	NA
Passive Benefits	\$74,342,000	\$83,444,000	\$103,303,000
Total Quantified	\$149,237,000	\$169,169,000	\$281,176,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_02 is -\$53,342,000 for Tier 1, -\$267,149,000 for Tier 2, and -\$1,738,007,000 for Tier 3. The benefit-cost ratio is 0.74:1, 0.39:1, and 0.14:1 for Tiers 1, 2, and 3, respectively (Table 4-85).

Table 4-85. Benefit Cost Summary for MU PLT_01, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$149,237,000	\$169,169,000	\$281,177,000
Total Costs	\$202,579,000	\$436,318,000	\$2,019,184,000
Net Present Value Benefits	(\$53,342,000)	(\$267,149,000)	(\$1,738,007,000)
Benefit Cost Ratio	0.74 : 1	0.39 : 1	0.14 : 1

4.4.2 PLT_02 – Clear Creek Basin

PLT_02 is comprised of one HUC-8 watershed and includes the Clear Creek Basin upstream of the confluence with the South Platte River. Figure 4-38 illustrates the area covered by PLT_02 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.2.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on effluent values provided by UCCWA for the majority of facilities. The facilities in the Manageable Unit operate under an agreement with Standley Lake and have relatively low nutrient discharges. Specific effluent information was provided for eight of the facilities in PLT_02, as shown in Table 4-86.

Table 4-86. Site-Specific Nutrient Effluent Values for WWTFs within PLT_02

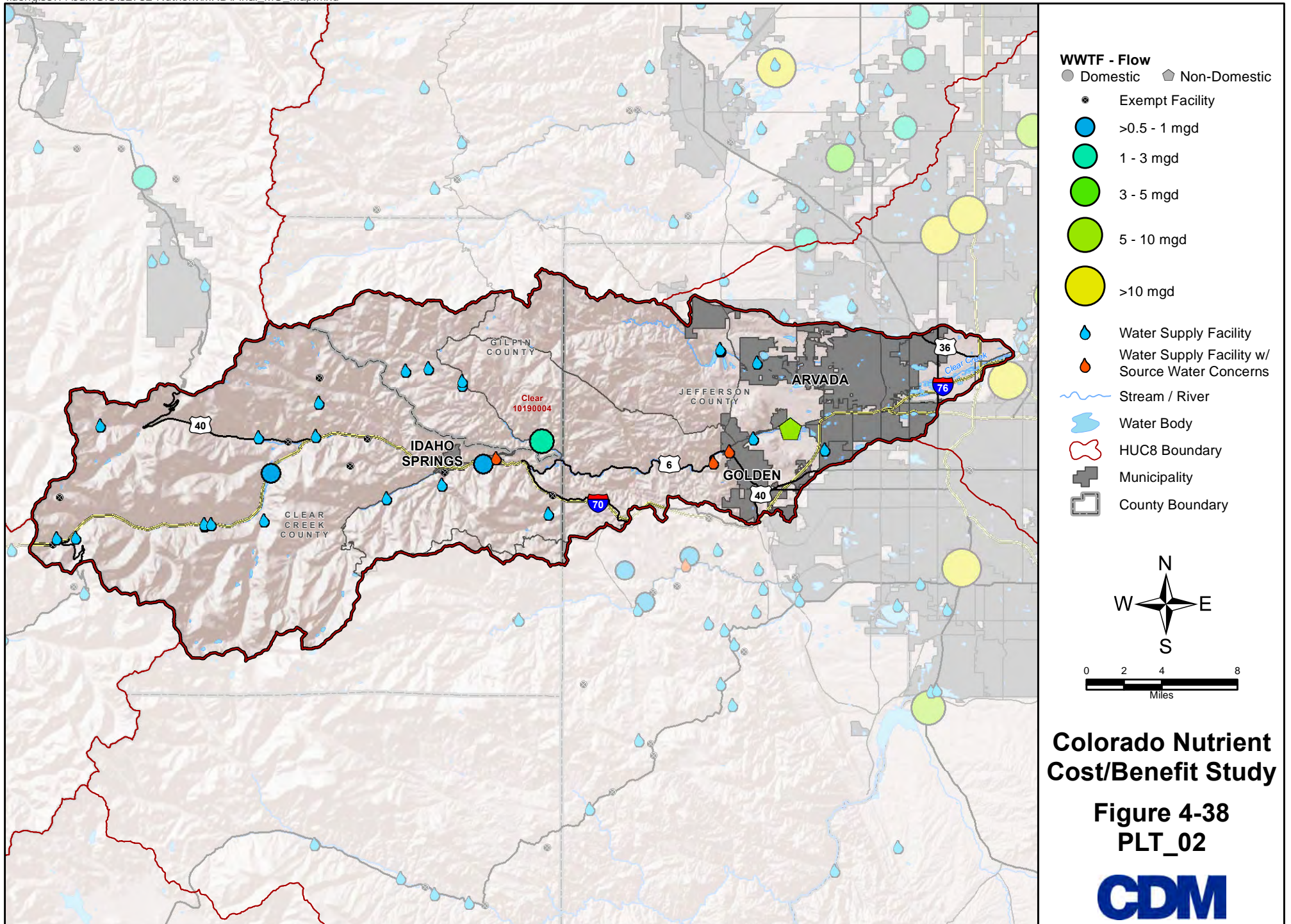
Facility Name	Stream Name	Current TP (mg/L)	Current TIN (mg/L)	Information Source
Coors Brewing Company	Mainstem	0.967	5.02	Facility provided effluent data
Black Hawk/Central City Sanitation District	North Fork Clear Creek	0.15	5.7	Facility provided effluent data
Central Clear Creek Sewer district	Mainstem	3.16	17.5	UCCWA provided site-specific data
Eisenhower Tunnel WWTF	Mainstem	0.43	2.75	UCCWA provided site-specific data
Empire, Town of	Mainstem	0.624	13.16	UCCWA provided site-specific data
Georgetown, Town of	Mainstem	0.418	5.875	UCCWA provided site-specific data
Idaho Springs WWTF	Mainstem	0.9245	2.03	UCCWA provided site-specific data
St. Mary's Glacier WSD	Mainstem	0.438	2.2	UCCWA provided site-specific data

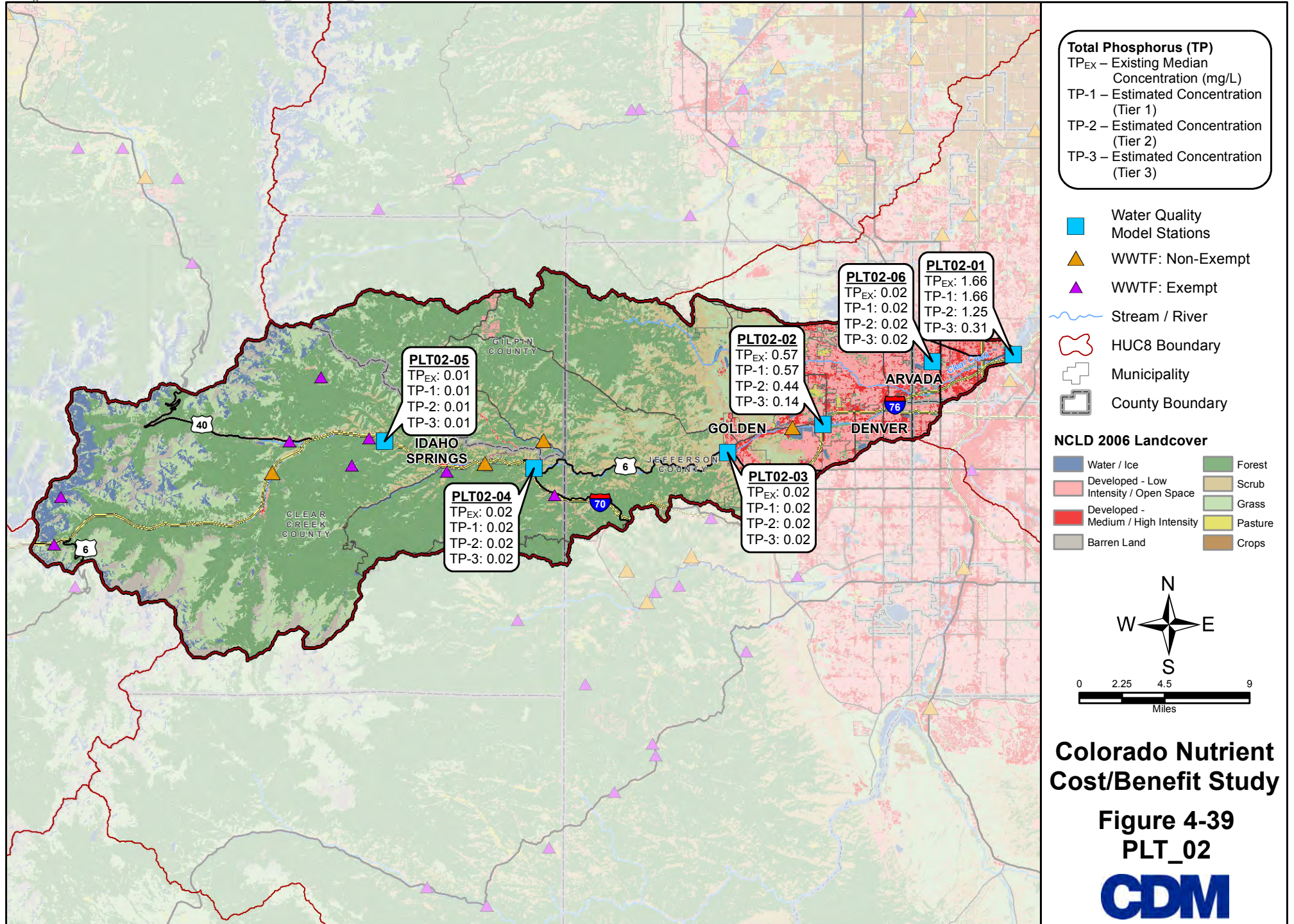
Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-87 and 4-88 (see Figure 4-38 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-87; Figure 4-39) and for TIN (Table 4-88; Figure 4-40). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-87. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_02

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT02-01	Mainstem	1.66	1.66	1.25	0.31
PLT02-02	Mainstem	0.57	0.57	0.44	0.14
PLT02-03	Mainstem	0.02	0.02	0.02	0.02
PLT02-04	Mainstem	0.02	0.02	0.02	0.02
PLT02-05	Mainstem	0.01	0.01	0.01	0.01
PLT02-06	North Fork Clear Creek	0.02	0.02	0.02	0.02





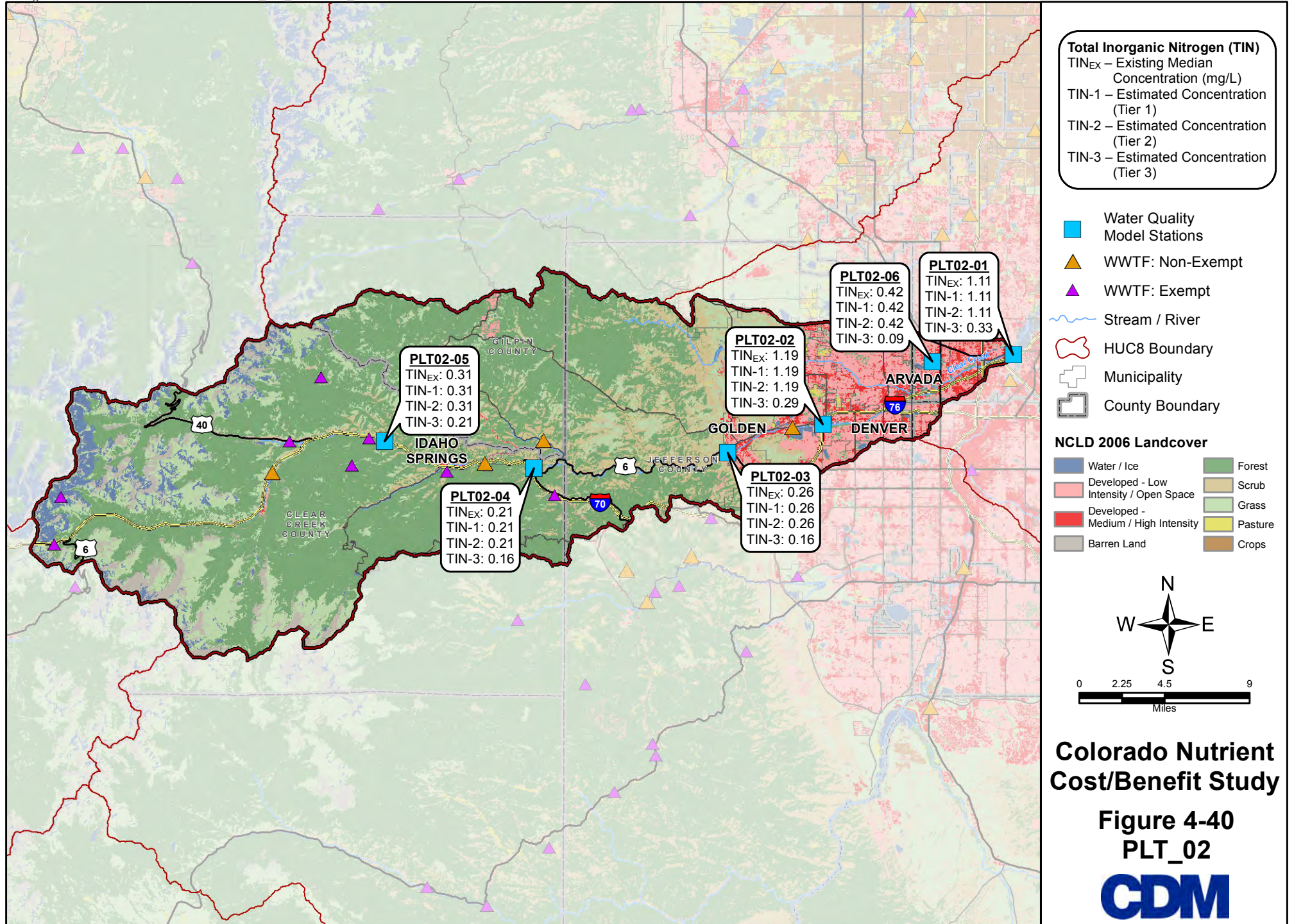


Table 4-88. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_02

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT02-01	Mainstem	1.11	1.11	1.11	0.33
PLT02-02	Mainstem	1.19	1.19	1.19	0.29
PLT02-03	Mainstem	0.26	0.26	0.26	0.16
PLT02-04	Mainstem	0.21	0.21	0.21	0.16
PLT02-05	Mainstem	0.31	0.31	0.31	0.21
PLT02-06	North Fork Clear Creek	0.42	0.42	0.42	0.09

Reservoirs

There were no modeled reservoirs within the PLT_02 Manageable Unit.

4.4.2.2 Wastewater Costs

Table 4-89 summarizes the WWTFs located in PLT_02 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-89. WWTFs in PLT_02

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Miller Coors LLC	Coors Brewing Co.	8.11	>5 to 10	1	¹
Argo Enterprises LLC	Indian Springs Resort	0.1	0-0.5	1	Exempt due to capacity
Clear Creek WWTF		0.024	0-0.5	1	Exempt due to capacity
Clear Creek Skiing Corp		0.03	0-0.5	1	Exempt due to capacity
Colorado DOT	Eisenhower Tunnel WWTF	0.072	0-0.5	1	Exempt due to capacity
Empire, Town of		0.099	0-0.5	1	Exempt due to capacity
Central Clear Creek Sanitation District		0.1	0-0.5	1	Exempt due to capacity
St Marys Glacier WSD		0.25	0-0.5	1	Exempt due to capacity, ¹
Georgetown, Town of		0.58	>0.5 to 1	1	¹
Idaho Springs, City of		0.6	>0.5 to 1	1	¹
Black Hawk/Central City Sanitation District		2	>1 to 3	1	¹
Shwayder Camp Wastewater		No Data		0	Exempt due to capacity

¹ Facilities have agreement for nutrient limits and meet Tier 1. Blackhawk/Central City, Georgetown, and St. Mary's Glacier meet Tier 2. No cost applied for those that meet Tier 1 and 2 based upon agreement.

Table 4-90 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-91 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-91 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-90. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1*	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$0	\$1,962,000	\$136,291,000
Operation & Maintenance Costs	\$0	\$105,000	\$2,757,000

Costs rounded to nearest \$1000.

*All non-exempt facilities in this basin discharge below Tier 1 levels under an agreement with Standley Lake.

Table 4-91. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$2,439,000	\$2,960,000	\$34,372,000
Operation & Maintenance Costs	\$43,000	\$196,000	\$1,098,000

Costs rounded to nearest \$1000.

4.4.2.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The facilities analyzed for PLT_02 include: the Cities of Golden and Black Hawk. These avoided costs are provided in Table 4-92.

4.4.2.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_02, in present value (2010), are presented in Table 4-92.

Table 4-92. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_02

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$0	\$1,768,000	\$122,799,000
Operating	\$0	\$1,627,000	\$42,764,000
Total	\$0	\$3,395,000	\$165,563,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$946,000
Operating	\$0	\$0	\$3,201,000
Total	\$0	\$0	\$4,147,000
Percent Change in Water Quality (streams)			
	0.00%	0.00%	61.57%
Percent Change in Water Quality (Reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$0	\$0	\$9,596,000
Boating	\$0	\$0	\$30,488,000
Swimming	\$0	\$0	\$15,354,000
Total	\$0	\$0	\$55,438,000
Property Value Benefits			
	n/a	n/a	n/a
Passive Benefits			
	\$0	\$0	\$69,339,000
Total Quantified Benefits	\$0	\$0	\$128,924,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.2.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_02 are \$0 for Tier 1 due no changes in water quality (all nonexempt WWTFs are currently discharging below Tier 1 concentrations), -\$3,395,000 for Tier 2, and -\$36,639,000 for Tier 3. The benefit-cost ratio is not applicable for Tier 1 (no costs and no benefits), 0:1 for Tier 2 because the majority of the nonexempt facilities in this Manageable Unit are also discharging below Tier 2 concentrations and there is no resulting water quality improvement with no associated benefits, and 0.78:1 for Tier 3, respectively (Table 4-93).

Table 4-93. Benefit Cost Summary for MU PLT_02, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$0	\$0	\$128,924,000
Total Costs	\$0	\$3,395,000	\$165,563,000
Net Present Value Benefits	\$0	(\$3,395,000)	(\$36,639,000)
Benefit Cost Ratio	N/A	0 : 1	0.78 : 1

4.4.3 PLT_03 – Saint Vrain River Basin

PLT_03 is comprised of one HUC-8 watershed and generally includes the St. Vrain River Basin upstream of the confluence with the South Platte River. Figure 4-41 illustrates the area covered by PLT_03 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.3.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the majority of facilities, 4.5 mg/L TP and 25 mg/L TIN. Specific effluent information was available for two of the facilities in PLT_03, as shown in Table 4-94.

Table 4-94. Site-specific nutrient effluent values for WWTFs within PLT_03

Facility Name	Stream Name	Current TP (mg/L)	Current TIN (mg/L)	Information Source
Erie, Town of	Boulder Creek	1	25	Existing effluent limit (TP)
Boulder 75 th Street WWTF	Boulder Creek	4.5	14	Facility provided data (TIN)

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-95 and 4-96 (see Figure 4-41 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-95; Figure 4-42) and for TIN (Table 4-96; Figure 4-43). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-95. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_03

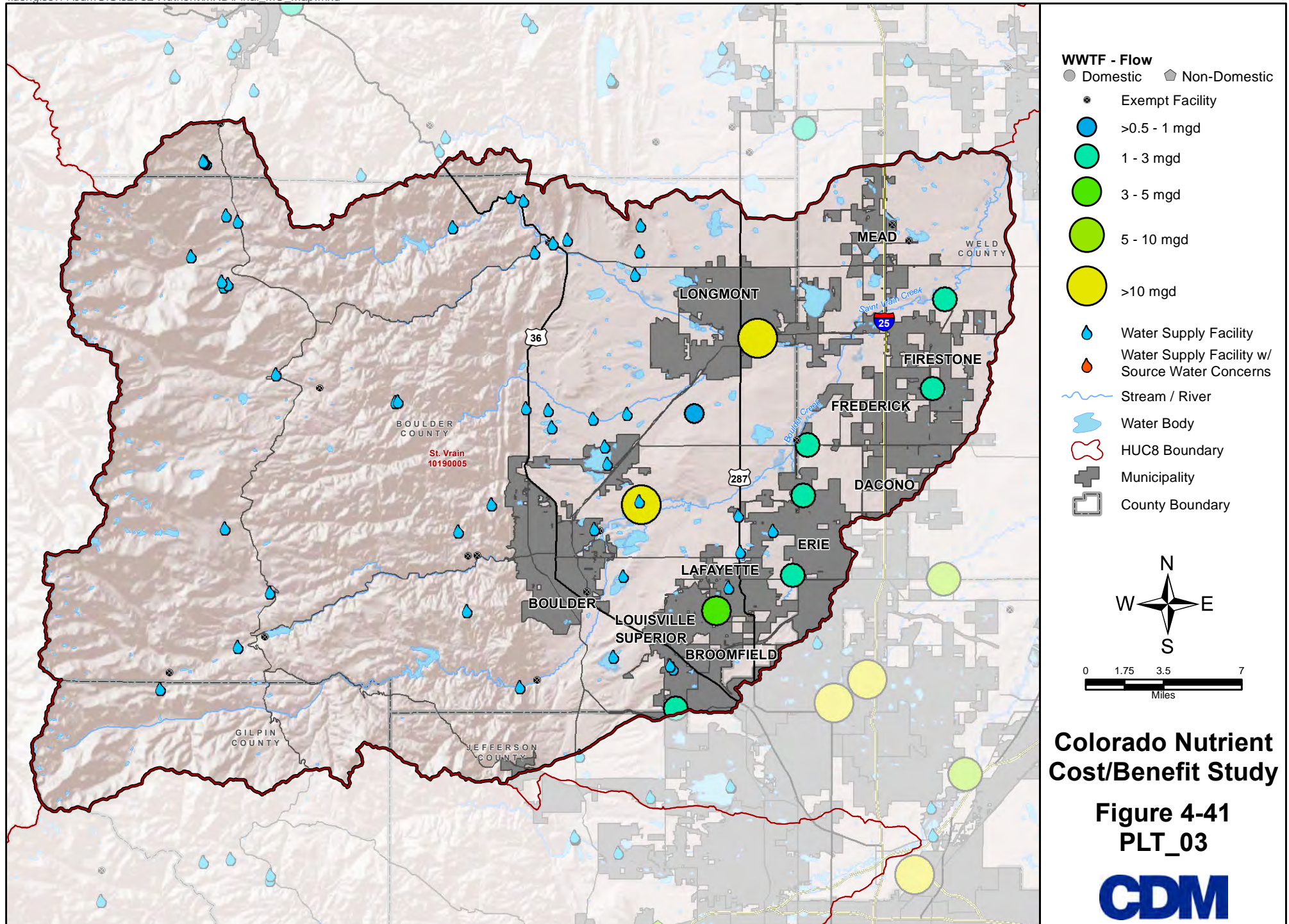
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT03-01	Mainstem	0.60	0.33	0.30	0.26
PLT03-02	Mainstem	0.80	0.33	0.29	0.20
PLT03-03	Mainstem	0.50	0.27	0.25	0.21
PLT03-06	Mainstem	0.03	0.03	0.03	0.03
PLT03-07	Mainstem	0.02	0.02	0.02	0.02
PLT03-08	Mainstem	0.02	0.02	0.02	0.02
PLT03-10	Boulder Creek	1.10	0.38	0.31	0.19
PLT03-11	Boulder Creek	0.90	0.32	0.27	0.18
PLT03-12	Boulder Creek	0.03	0.03	0.03	0.03
PLT03-13	Boulder Creek	No Data	n/a	n/a	n/a
PLT03-14	Boulder Creek	0.03	0.03	0.03	0.03
PLT03-15	Boulder Creek	0.03	0.03	0.03	0.03
PLT03-16	Boulder Creek	0.04	0.04	0.04	0.04
PLT03-17	Boulder Creek	0.02	0.02	0.02	0.02

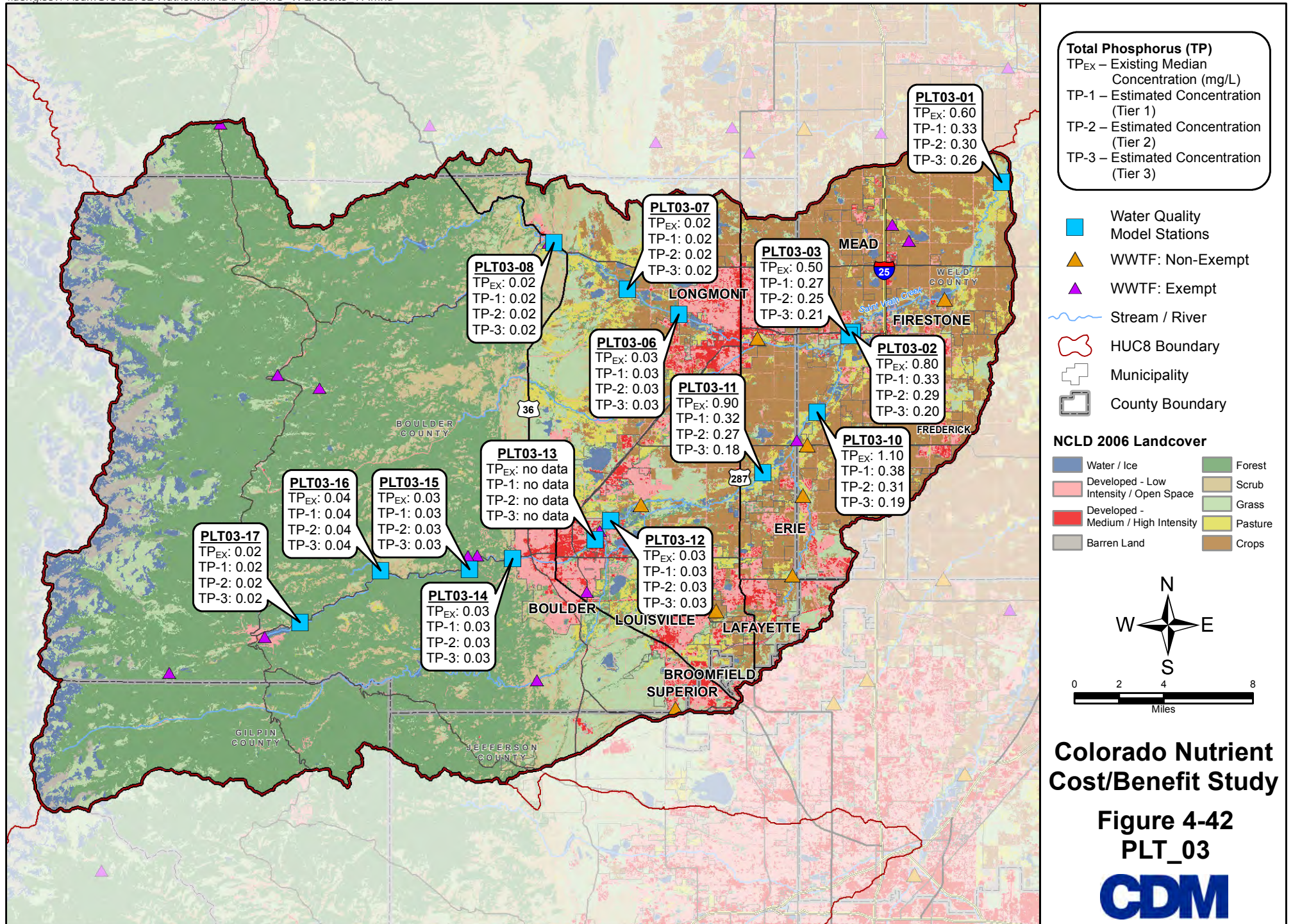
Table 4-96. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_03

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT03-01	Mainstem	3.50	2.01	1.57	0.62
PLT03-02	Mainstem	3.50	1.98	1.52	0.51
PLT03-03	Mainstem	3.20	1.83	1.42	0.51
PLT03-06	Mainstem	No Data	n/a	n/a	n/a
PLT03-07	Mainstem	0.32	0.32	0.32	0.32
PLT03-08	Mainstem	0.33	0.33	0.33	0.33
PLT03-10	Boulder Creek	5.10	3.09	2.27	0.48
PLT03-11	Boulder Creek	4.20	3.11	2.29	0.48
PLT03-12	Boulder Creek	0.40	0.40	0.40	0.40
PLT03-13	Boulder Creek	0.30	0.30	0.30	0.30
PLT03-14	Boulder Creek	0.40	0.40	0.40	0.40
PLT03-15	Boulder Creek	0.40	0.40	0.40	0.40
PLT03-16	Boulder Creek	0.40	0.40	0.40	0.40
PLT03-17	Boulder Creek	0.27	0.27	0.27	0.27

Reservoirs

There were no modeled reservoirs within the PLT_03 Manageable Unit.

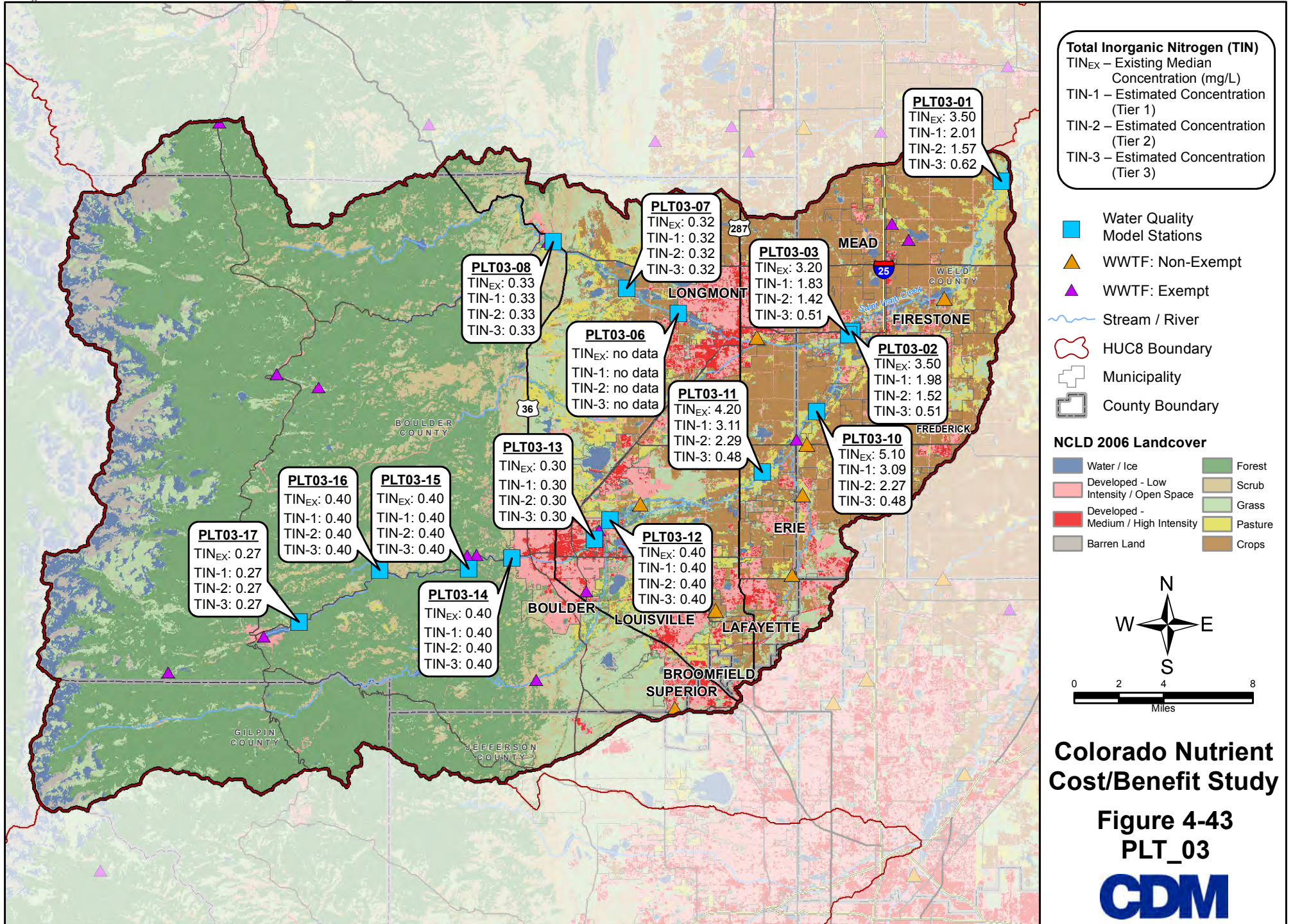




Colorado Nutrient Cost/Benefit Study

**Figure 4-42
 PLT_03**





4.4.3.2 Wastewater Costs

Table 4-97 summarizes the WWTFs located in PLT_03 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-97: WWTFs in PLT_03

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Orodel Inc.	Boulder Mountain Lodge	0.0045	0-0.5	1	Exempt due to capacity
Superior Metropolitan District No. 1		2.2	>1 to 3	1	
St. Vrain Sanitation District		3	>1 to 3	1	
Erie, Town of	North WRF	1.5	>1 to 3	1	
Boulder, City of	75th Street WWTF	25	>10	1	
Longmont, City of		17	>10	1	
Louisville, City of		3.4	>3 to 5	1	
B and B Mobile Home/RV Park		0.015	0-0.5	1	Exempt due to capacity
San Souci Mobile Home Park		0.019999	0-0.5	1	Exempt due to capacity
Eldorado Springs WW	El Dorado Springs WWTF	0.032	0-0.5	1	Exempt due to capacity
Seventh-Day Adventist Association of Colorado	Glacier View Ranch	0.04	0-0.5	1	Exempt due to capacity
San Lazaro Pk Prop. LLP	San Lazaro Mobile Home Park WWTF	0.11	0-0.5	1	Exempt due to capacity
Lyons, Town of		0.381	0-0.5	1	Exempt due to capacity
Peaceful Valley Ranch LLC	Peaceful Valley Ranch WWTF	No Data	0-0.5	0	Exempt due to capacity
Mueller Red Lion Inn	Red Lion Inn WWTF	No Data	0-0.5	0	Exempt due to capacity
Erie, Town of		1.2	>1 to 3	3	
Lafayette, City of		2.8	>1 to 3	3	
Niwot Sanitation District		0.98	>0.5 to 1	1	Exempt due to capacity
St. Vrain Sanitation District	Weld County Tri-area Sanitation	1.5	>1-3	4	
Mead, Town of	Lake Thomas Subdivision WWTF	0.012	0-0.5	4	Exempt due to capacity
Lake Eldora WSD	Lake Eldora WSD WWTF	0.03	0-0.5	4	Exempt due to capacity
Nederland, Town of	Nederland WWTF	0.189	0-0.5	4	Exempt due to capacity
WCFLP RE Wind River, LP	Wind River Ranch	0.0045	0-0.5	5	Exempt due to capacity
Mead, Town of		0.499	0-0.5	5	Exempt due to capacity

Table 4-98 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-99 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-99 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-98. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$129,128,000	\$316,609,000	\$2,099,071,000
Annual Operation & Maintenance Costs	\$5,558,000	\$8,963,000	\$32,185,000

Costs rounded to nearest \$1000.

Table 4-99. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$7,862,000	\$11,625,000	\$72,236,000
Annual Operation & Maintenance Costs	\$238,000	\$353,000	\$2,337,000

Costs rounded to nearest \$1000.

4.4.3.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed in this Manageable Unit.

4.4.3.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_03, in present value (2010), are presented in Table 4-100.

Table 4-100. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_03

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$116,345,000	\$285,266,000	\$1,891,268,000
Operating	\$86,227,000	\$139,045,000	\$499,321,000
Total	\$202,572,000	\$424,311,000	\$2,390,589,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	42.64%	52.08%	63.15%
Percent Change in Water Quality (Reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$22,890,000	\$27,957,000	\$33,900,000
Boating	\$58,517,000	\$71,471,000	\$86,665,000
Swimming	\$11,850,000	\$14,474,000	\$17,551,000
Total	\$93,257,000	\$113,902,000	\$138,116,000
Property Value Benefits			
	n/a	n/a	n/a

Table 4-100. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_03

	Tier 1	Tier 2	Tier 3
<i>Passive Benefits</i>			
	\$69,978,000	\$84,756,000	\$103,386,000
<i>Total Quantified Benefits</i>			
	\$163,235,000	\$198,658,000	\$241,502,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.3.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_03 are -\$39,337,000 for Tier 1, -\$225,652,000 for Tier 2, and -\$2,149,086,000 for Tier 3. The benefit-cost ratio is 0.81:1, 0.47:1, and 0.1:1 for Tiers 1, 2, and 3, respectively (Table 4-101).

Table 4-101. Benefit Cost Summary for MU PLT_03, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$163,235,000	\$198,659,000	\$241,502,000
Total Costs	\$202,571,000	\$424,311,000	\$2,390,588,000
Net Present Value Benefits	(\$39,337,000)	(\$225,652,000)	(\$2,149,086,000)
Benefit Cost Ratio	0.81 : 1	0.47 : 1	0.1 : 1

4.4.4 PLT_04 – Big Thompson River Basin

PLT_04 is comprised of one HUC-8 watershed and includes the Big Thompson River Basin upstream of the confluence with the South Platte River. Figure 4-44 illustrates the area covered by PLT_04 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.4.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-102 and 4-103 (see Figure 4-44 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-102; Figure 4-45) and for TIN (Table 4-103; Figure 4-46). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-102. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_04

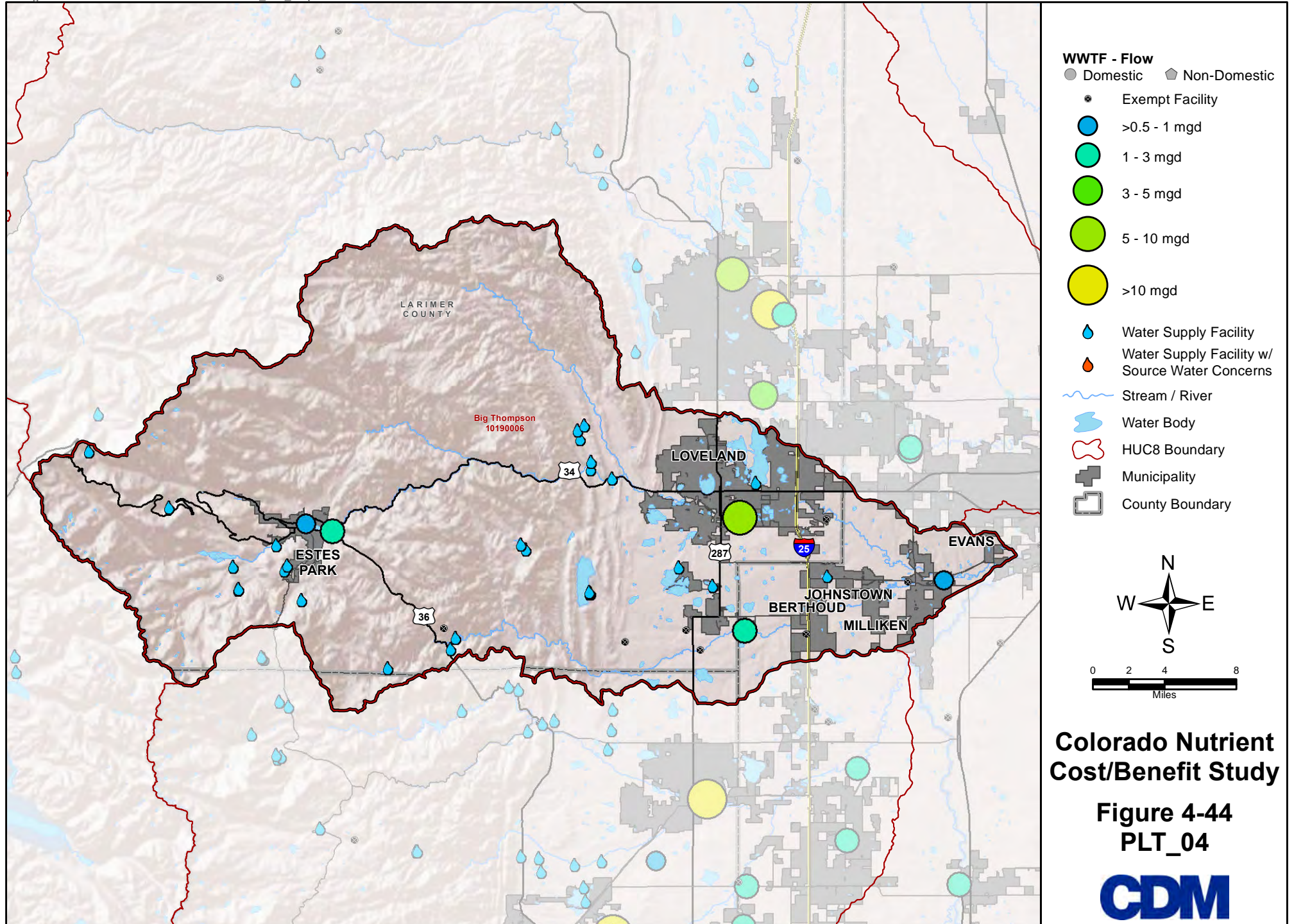
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT04-01	Mainstem	0.47	0.26	0.24	0.21
PLT04-02	Mainstem	0.87	0.30	0.25	0.16
PLT04-03	Mainstem	0.64	0.23	0.20	0.13
PLT04-04	Mainstem	0.02	0.02	0.02	0.02
PLT04-05	Mainstem	0.04	0.04	0.04	0.04
PLT04-06	Mainstem	0.03	0.03	0.03	0.03
PLT04-07	Mainstem	0.02	0.02	0.02	0.02
PLT04-08	Buckhorn Creek	0.03	<i>Upstream Facilities Exempted</i>		
PLT04-09	Little Thompson River	0.15	0.15	0.15	0.15
PLT04-10	Little Thompson River	0.08	0.08	0.08	0.08

Table 4-103. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_04

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT04-01	Mainstem	4.70	2.29	1.80	0.74
PLT04-02	Mainstem	1.82	0.91	0.73	0.33
PLT04-03	Mainstem	1.75	0.86	0.68	0.29
PLT04-04	Mainstem	0.27	0.17	0.15	0.11
PLT04-05	Mainstem	0.16	0.11	0.10	0.07
PLT04-06	Mainstem	0.50	0.24	0.19	0.08
PLT04-07	Mainstem	0.08	0.08	0.08	0.08
PLT04-08	Buckhorn Creek	0.14	<i>Upstream Facilities Exempted</i>		
PLT04-09	Little Thompson River	4.27	2.16	1.74	0.82
PLT04-10	Little Thompson River	1.77	1.77	1.77	1.77

Reservoirs

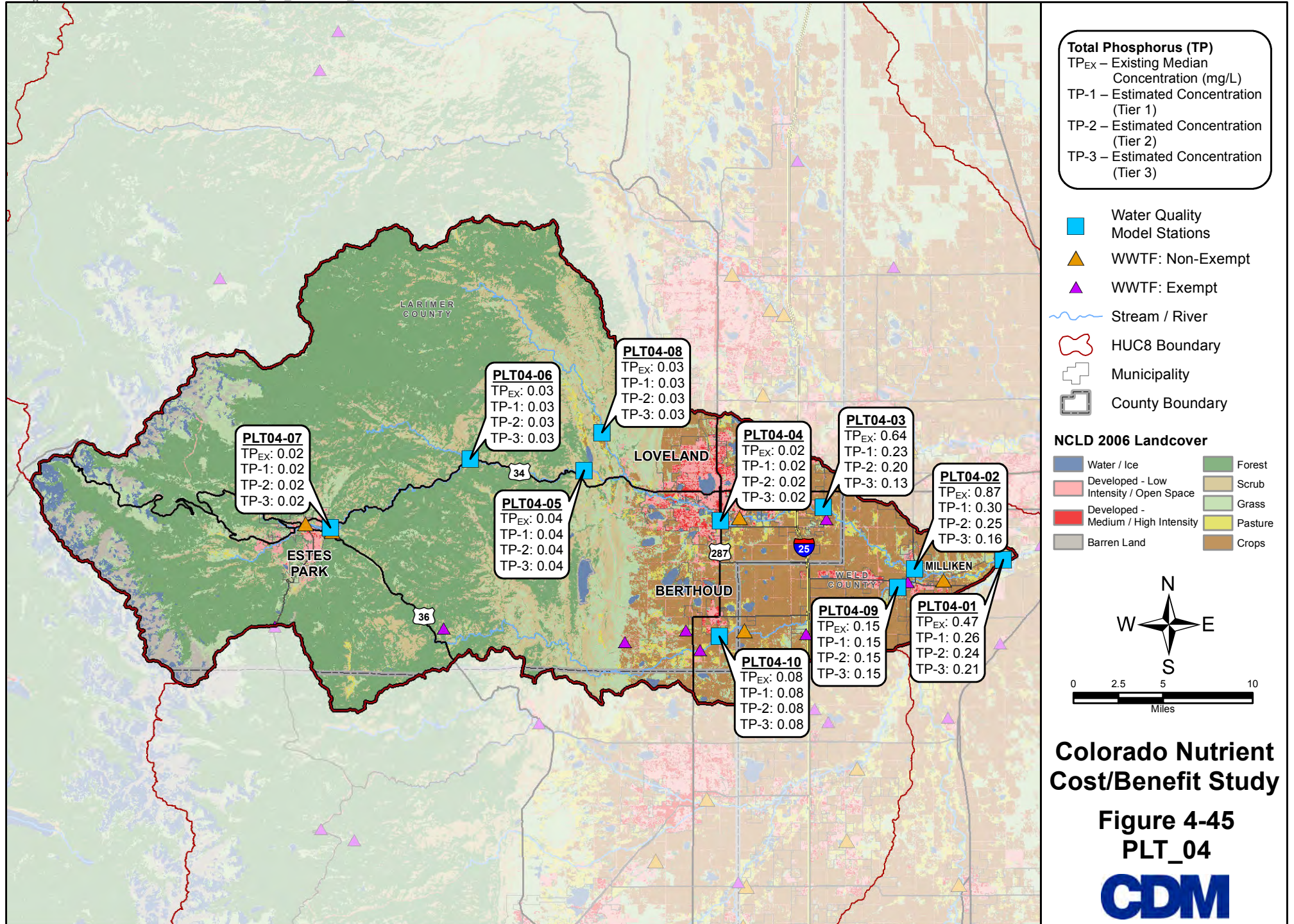
There were no modeled reservoirs within the PLT_04 Manageable Unit.

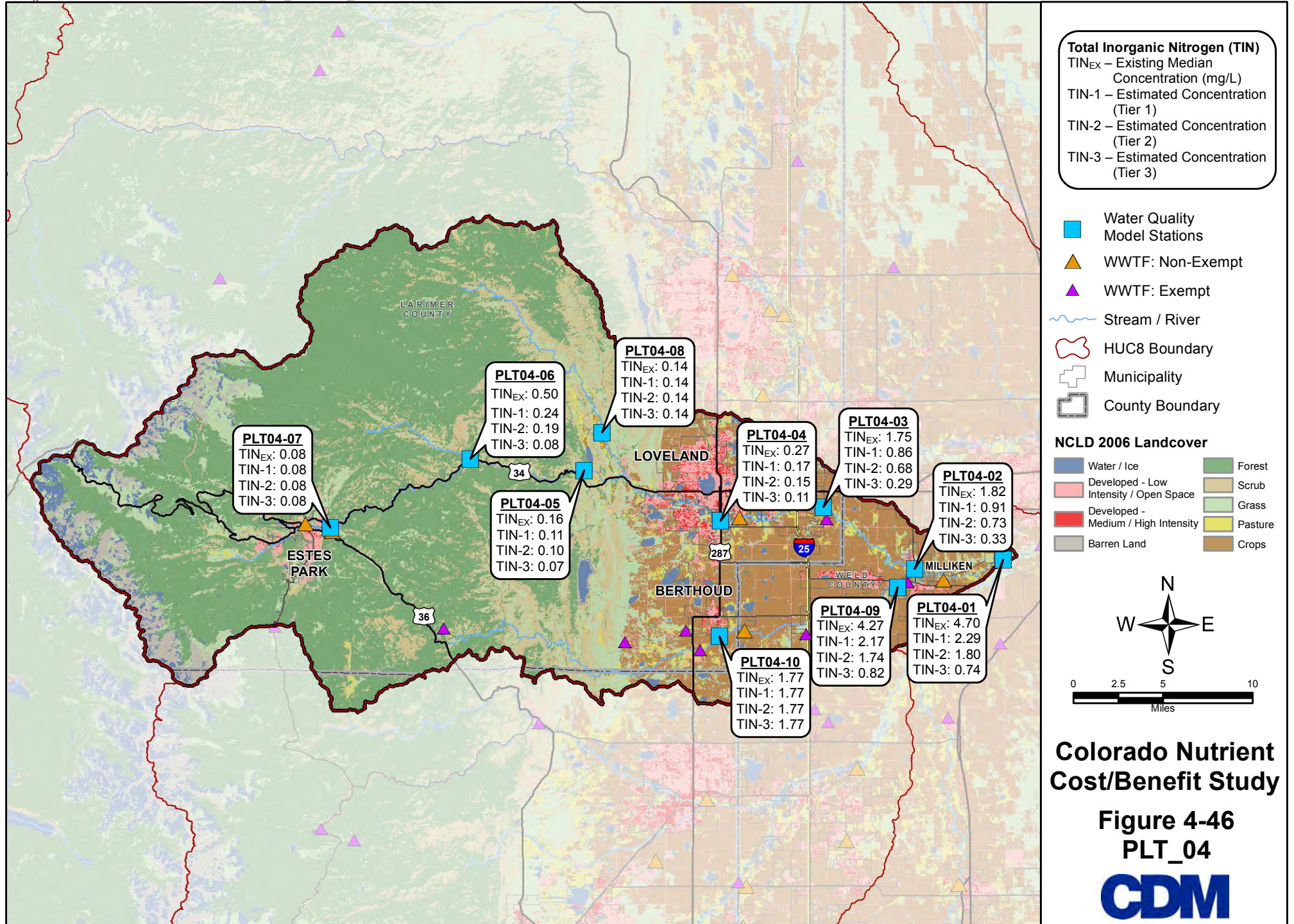


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Figure 4-44
PLT_04







4.4.4.2 Wastewater Costs

Table 4-104 summarizes the WWTFs located in PLT_04 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-104. WWTFs in PLT_04

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Serenity Ridge	Serenity Ridge WWTF	0.022	0-0.5	5	Exempt due to capacity
Milliken, Town of	Milliken Sanitation District	0.7	>0.5 to 1	1	
Estes Park Sanitation District		1	>0.5 to 1	1	
Berthoud, Town of		2	>1 to 3	1	
Loveland, City of		10	>5 to 10	1	
Western Mini-Ranch/ Vaquero Estates Sewer Assoc.		0.049999	0-0.5	4	Exempt due to capacity
Aspen Lodge at Estes Park Corp.		No Data	No Data	0	Exempt due to capacity
Upper Thompson Sanitation District		1.5	>1 to 3	3	
Johnstown, Town of		0.75	>0.5 to 1	4	Exempt due to capacity
Johnstown, Town of	Low Point WWTP	0.5	>0.5 to 1	5	Exempt due to capacity
Riverglen Homeowners Assoc		0.029	0-0.5	4	Exempt due to capacity
Berthoud Estates Community Assoc	Berthoud Estates HOA	0.052	0-0.5	4	Exempt due to capacity

Table 4-105 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-106 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-106 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-105. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$34,481,000	\$75,237,000	\$559,269,000
Annual Operation & Maintenance Costs	\$1,526,000	\$2,299,000	\$9,320,000

Costs rounded to nearest \$1000.

Table 4-106. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$11,119,000	\$15,645,000	\$75,990,000
Annual Operation & Maintenance Costs	\$504,000	\$669,000	\$2,278,000

Costs rounded to nearest \$1000.

4.4.4.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed within PLT_04.

4.4.4.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_04, in present value (2010), are presented in Table 4-107.

Table 4-107. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_04

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$31,067,000	\$67,789,000	\$503,903,000
Operating	\$23,671,000	\$35,672,000	\$144,597,000
Total	\$54,738,000	\$103,461,000	\$648,500,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	45.30%	54.33%	56.80%
Percent Change in Water Quality (Reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$33,949,000	\$40,718,000	\$42,565,000
Boating	\$86,788,000	\$104,095,000	\$108,817,000
Swimming	\$8,746,000	\$10,490,000	\$10,966,000
Total	\$129,483,000	\$155,303,000	\$162,348,000
Property Value Benefits			
	n/a	n/a	n/a
Passive Benefits			
	\$33,173,000	\$39,051,000	\$41,368,000
Total Quantified Benefits			
	\$162,656,000	\$194,354,000	\$203,716,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.4.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_04 are \$107,918,000 for Tier 1, -\$90,894,000 for Tier 2, and -\$444,784,000 for Tier 3. The benefit-cost ratio is 2.97:1, 1.88:1, and 0.31:1 for Tiers 1, 2, and 3, respectively (Table 4-108).

Table 4-108. Benefit Cost Summary for MU PLT_04, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$162,656,000	\$194,355,000	\$203,716,000
Total Costs	\$54,738,000	\$103,461,000	\$648,500,000
Net Present Value Benefits	\$107,918,000	\$90,894,000	(\$444,784,000)
Benefit Cost Ratio	2.97 : 1	1.88 : 1	0.31 : 1

4.4.5 PLT_05 – North Platte Headwaters/Upper Laramie River Basin

PLT_05 is comprised of one HUC-8 watershed and includes the North Platte and Upper Laramie River Basins until the Colorado state line. Figure 4-47 illustrates the area covered by PLT_05 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.5.1 Water Quality Analyses

Previous drafts of water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities, 4.5 mg/L TP and 25 mg/L TIN. The November 21, 2011 regulation increased the exemption level for WWTFs to 0.5 mgd. In doing so, all facilities within this Manageable Unit were excluded.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-109 and 4-110 (see Figure 4-47 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-109; Figure 4-48) and for TIN (Table 4-110; Figure 4-49).

Table 4-109. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_05

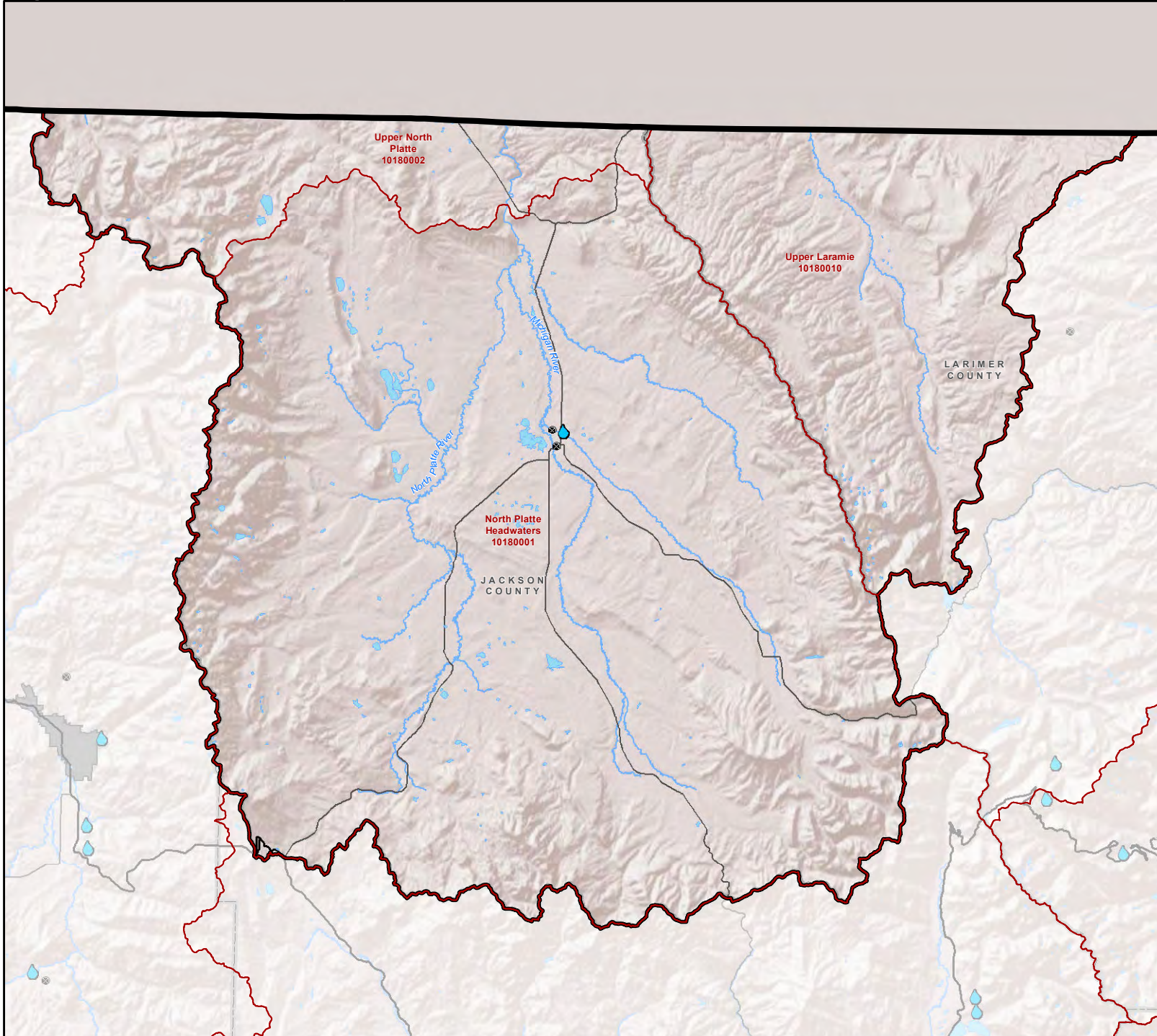
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT05-01	Mainstem	0.020			<i>Upstream facilities exempted</i>
PLT05-02	Mainstem	0.055			<i>Upstream facilities exempted</i>
PLT05-03	Illinois River	0.059			<i>Upstream facilities exempted</i>
PLT05-04	Illinois River	0.017			<i>Upstream facilities exempted</i>
PLT05-05	Michigan River	0.040			<i>Upstream facilities exempted</i>
PLT05-06	Michigan River	0.001			<i>Upstream facilities exempted</i>

Table 4-110. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_05

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT05-01	Mainstem	No data			<i>Upstream facilities exempted</i>
PLT05-02	Mainstem	No data			<i>Upstream facilities exempted</i>
PLT05-03	Illinois River	No data			<i>Upstream facilities exempted</i>
PLT05-04	Illinois River	0.035			<i>Upstream facilities exempted</i>
PLT05-05	Michigan River	No data			<i>Upstream facilities exempted</i>
PLT05-06	Michigan River	0.053			<i>Upstream facilities exempted</i>

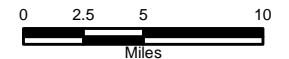
Reservoirs

There were no modeled reservoirs within the PLT_05 Manageable Unit.



WWTF - Flow

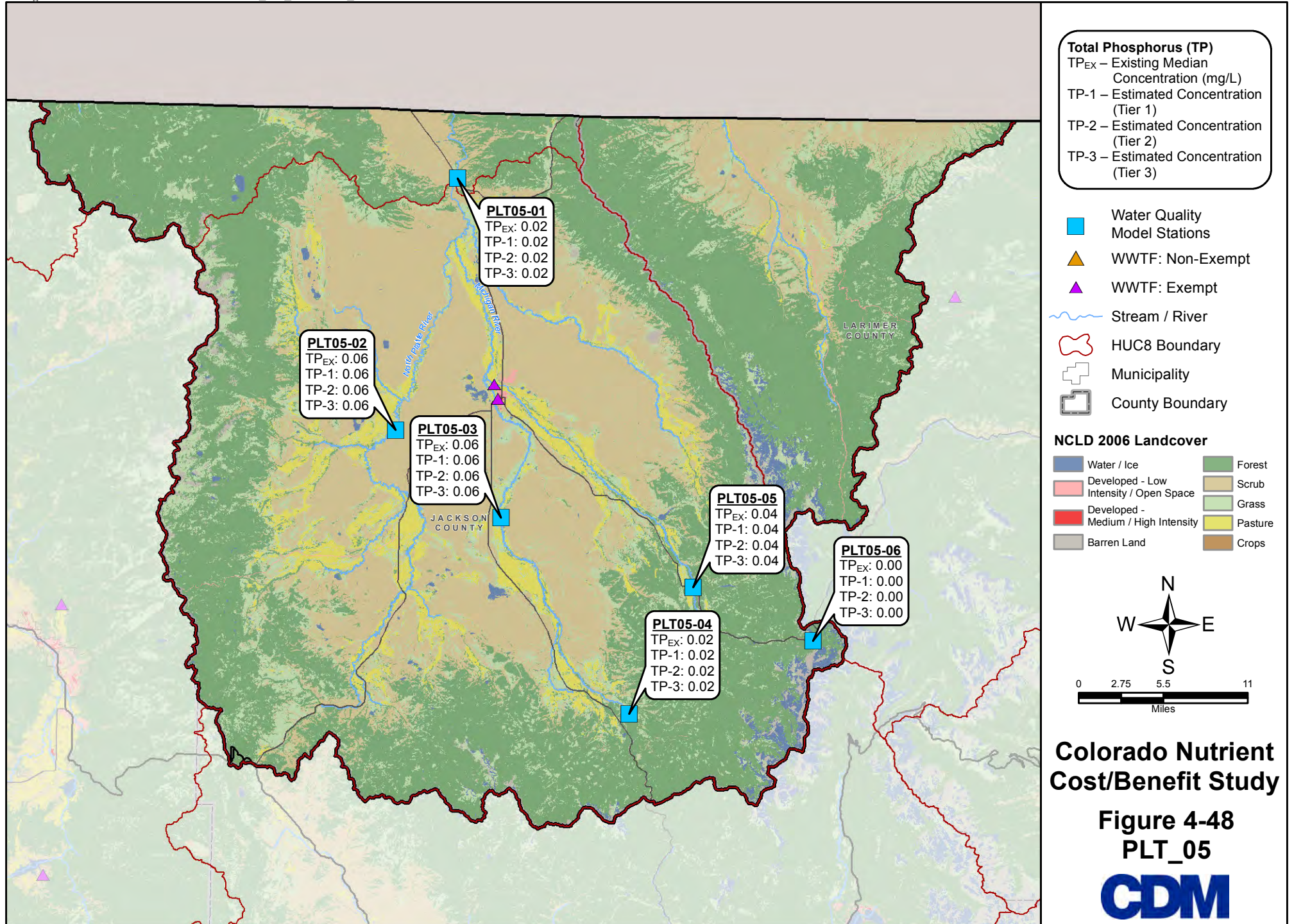
- Domestic ● Non-Domestic
- Exempt Facility
- >0.5 - 1 mgd
- 1 - 3 mgd
- 3 - 5 mgd
- 5 - 10 mgd
- >10 mgd
- Water Supply Facility
- Water Supply Facility w/ Source Water Concerns
- ~ Stream / River
- ~ Water Body
- ~ HUC8 Boundary
- Municipality
- County Boundary

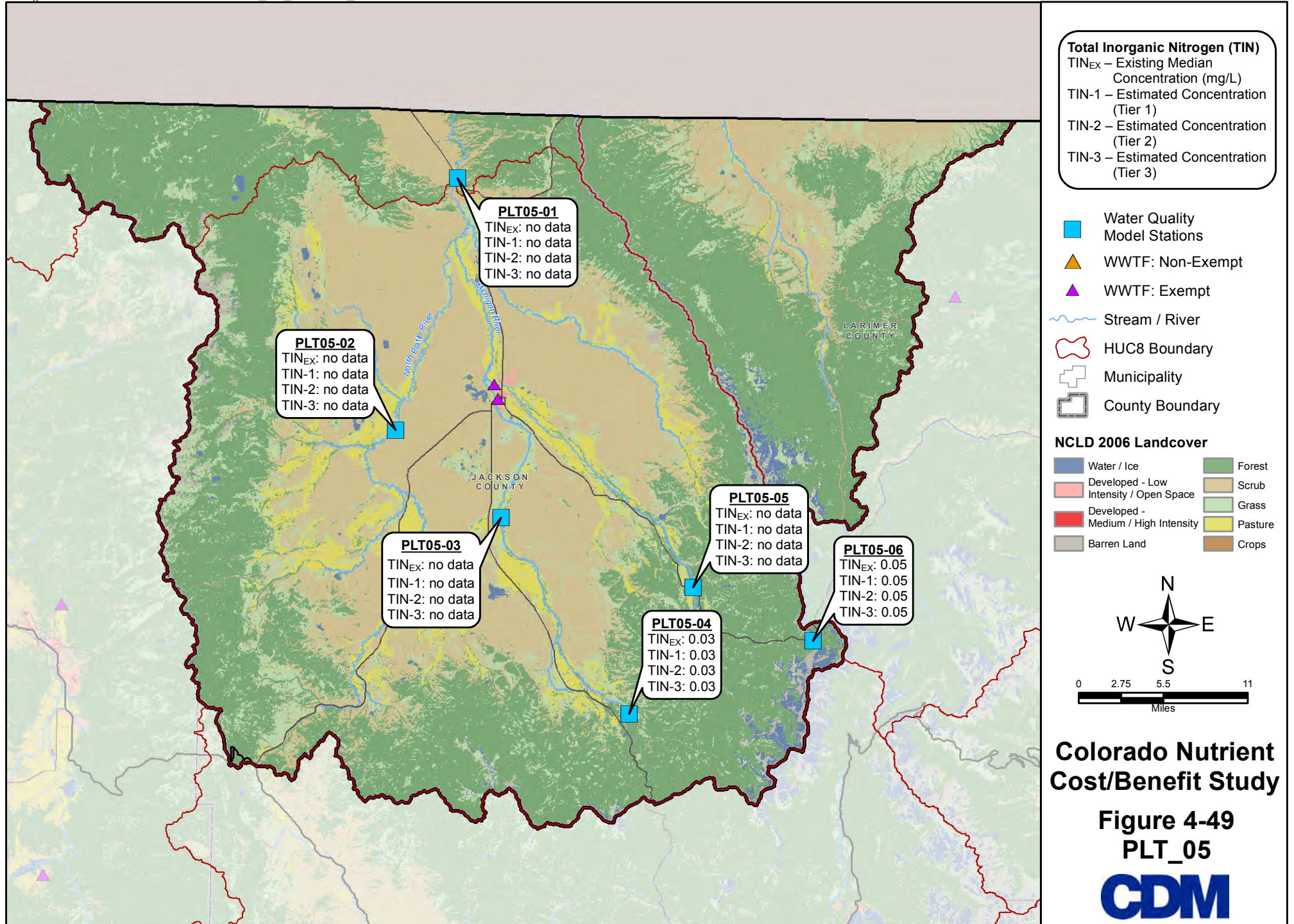


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**Figure 4-47
PLT_05**







4.4.5.2 Wastewater Costs

Table 4-111 summarizes the WWTFs located in PLT_05 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-111. WWTFs in PLT_05

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Walden, Town of		0.215	0-0.5	1	Exempt: Disadvantaged
Earth Environmental Services Inc	Blanton Mountain Mart	0.21	0-0.5	1	Exempt due to capacity

Table 4-112 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Again, because there are no nonexempt WWTFs within this basin, there are no associated costs to upgrade. Table 4-113 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-113 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-112. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$0	\$0	\$0
Annual Operation & Maintenance Costs	\$0	\$0	\$0

Costs rounded to nearest \$1000.

Table 4-113. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$1,536,000	\$1,864,000	\$21,642,000
Annual Operation & Maintenance Costs	\$27,000	\$124,000	\$691,000

Costs rounded to nearest \$1000.

4.4.5.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed within PLT_05.

4.4.5.4 Recreational and Environmental Benefits

As discussed above, there are no quantified costs and benefits of the proposed regulation in PLT_05 (Table 4-114).

Table 4-114. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_05

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	0.00%	0.00%	0.00%
Percent Change in Water Quality (Reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$0	\$0	\$0
Boating	\$0	\$0	\$0
Swimming	\$0	\$0	\$0
Total	\$0	\$0	\$0
Property Value Benefits			
	n/a	n/a	n/a
Passive Benefits			
	\$0	\$0	\$0
Total Quantified Benefits			
	\$0	\$0	\$0

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.5.5 Benefit-Cost Ratio

Because there are no nonexempt facilities in this basin, there are no benefit:cost ratios to report for this basin (Table 4-115).

Table 4-115. Benefit Cost Summary for MU PLT_05, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0
Net Present Value Benefits	\$0	\$0	\$0
Benefit Cost Ratio	N/A	N/A	N/A

4.4.6 PLT_06 – Cache La Poudre River Basin

PLT_06 is comprised of one HUC-8 watershed and includes the Cache La Poudre River Basin upstream of the South Platte River. Figure 4-50 illustrates the area covered by PLT_06 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.6.1 Water Quality Analyses

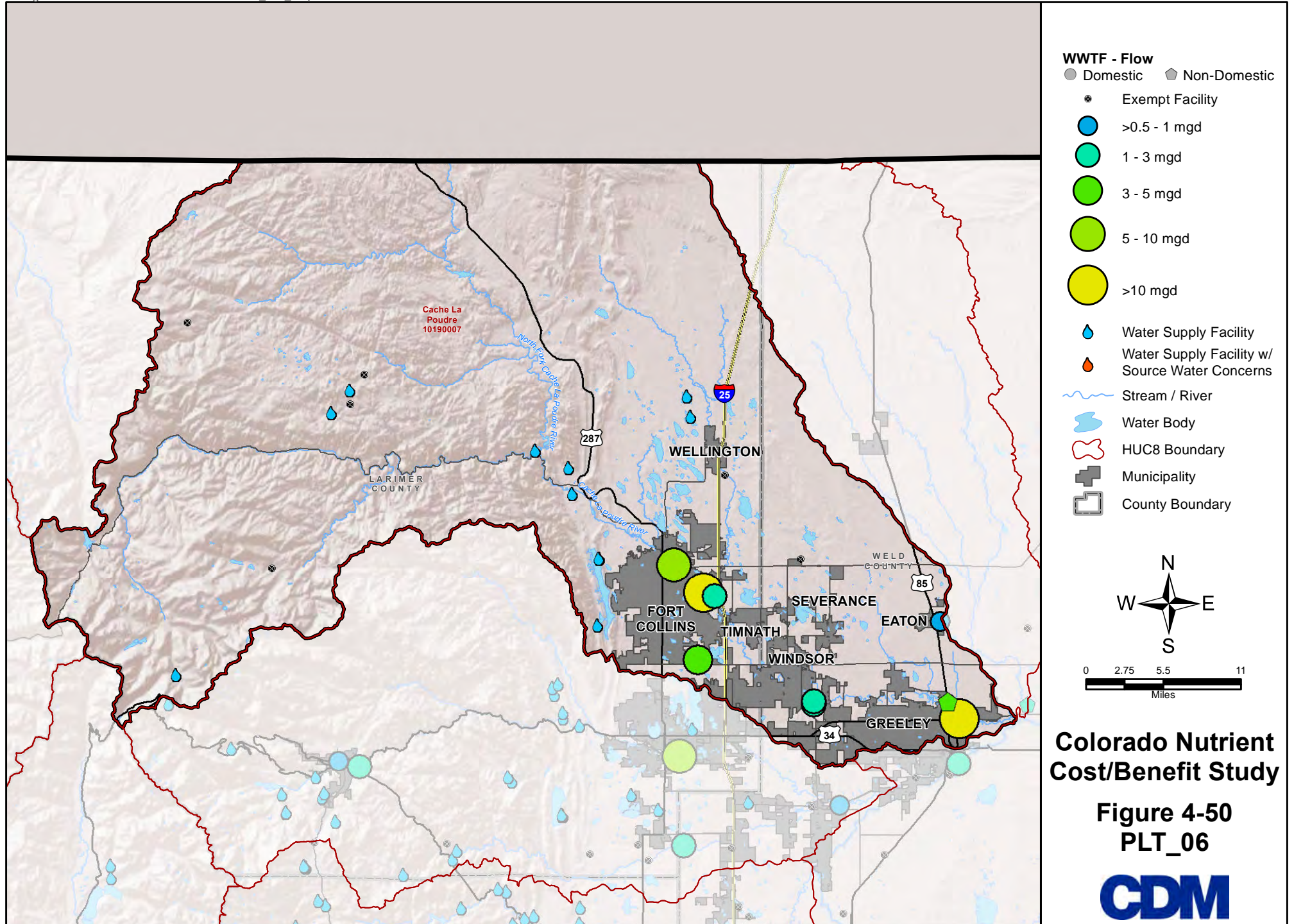
The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-116 and 4-117 (see Figure 4-50 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-114; Figure 4-51) and for TIN (Table 4-115; Figure 4-52). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-116. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_06

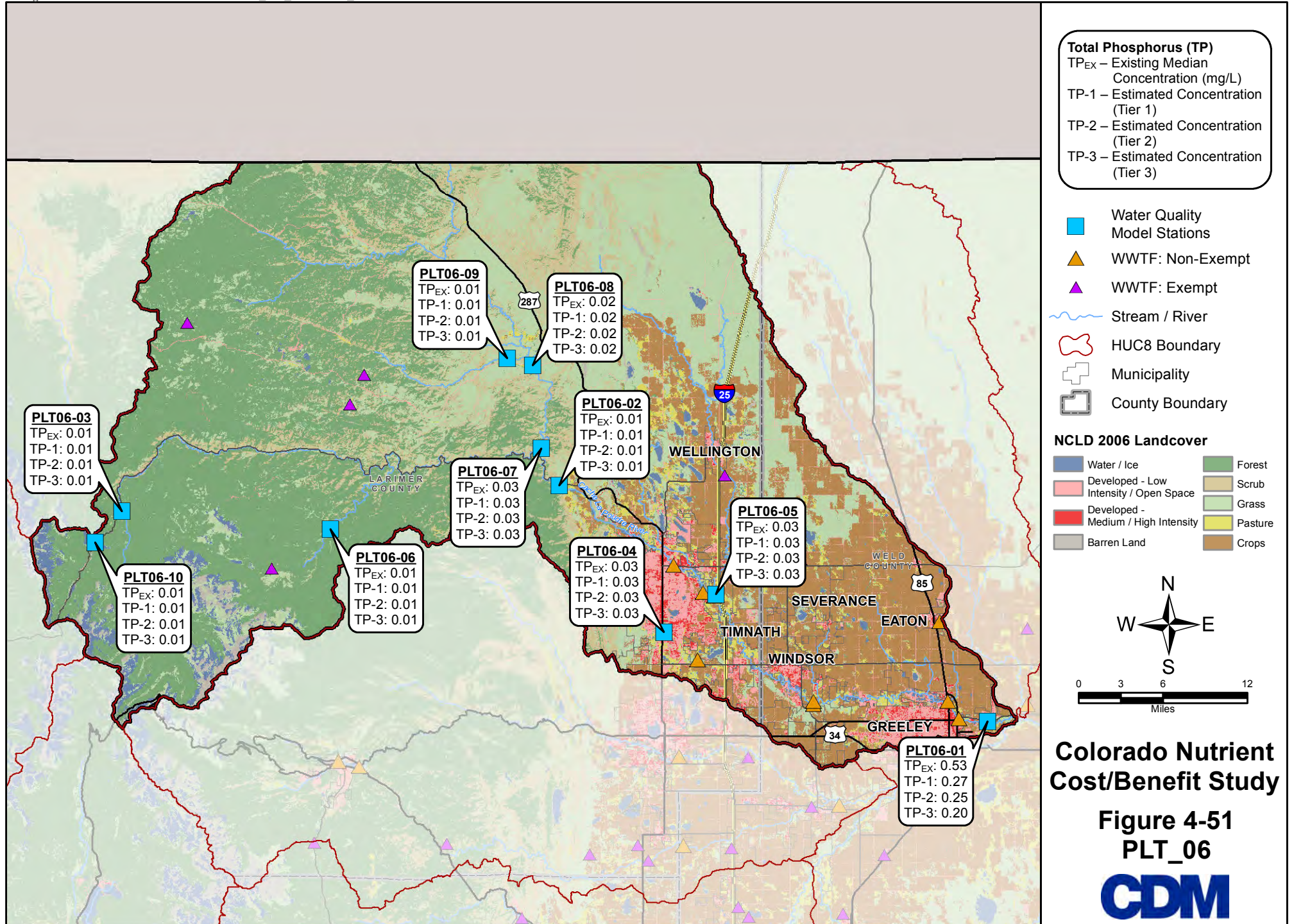
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT06-01	Mainstem	0.53	0.27	0.25	0.20
PLT06-02	Mainstem	0.01	0.01	0.01	0.01
PLT06-03	Mainstem	0.01	0.01	0.01	0.01
PLT06-04	Fossil Creek	0.03	0.03	0.03	0.03
PLT06-05	Boxelder Creek	0.03	0.03	0.03	0.03
PLT06-06	South Fork Cache La Poudre River	0.01	0.01	0.01	0.01
PLT06-07	North Fork Cache La Poudre River	0.03	0.03	0.03	0.03
PLT06-08	North Fork Cache La Poudre River	0.02	0.02	0.02	0.02
PLT06-09	Lone Pine Creek	0.01	0.01	0.01	0.01
PLT06-10	Joe Wright Creek	0.01	0.01	0.01	0.01



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Figure 4-50
PLT_06





Colorado Nutrient Cost/Benefit Study

**Figure 4-51
 PLT_06**



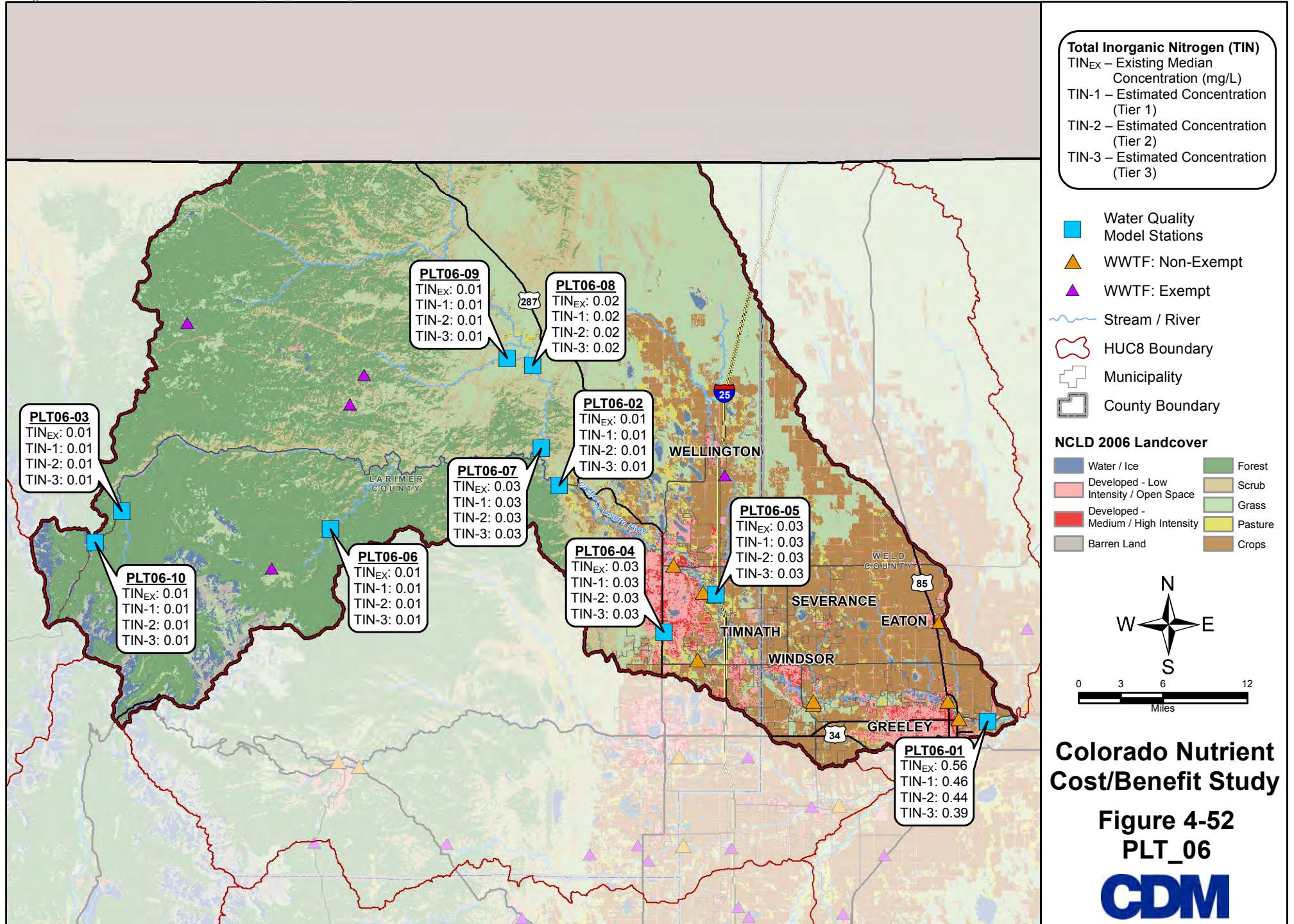


Table 4-117. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_06

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT06-01	Mainstem	0.56	0.46	0.44	0.39
PLT06-02	Mainstem	0.01	0.01	0.01	0.01
PLT06-03	Mainstem	0.01	0.01	0.01	0.01
PLT06-04	Fossil Creek	0.03	0.03	0.03	0.03
PLT06-05	Boxelder Creek	0.03	0.03	0.03	0.03
PLT06-06	South Fork Cache La Poudre River	0.01	0.01	0.01	0.01
PLT06-07	North Fork Cache La Poudre River	0.03	0.03	0.03	0.03
PLT06-08	North Fork Cache La Poudre River	0.02	0.02	0.02	0.02
PLT06-09	Lone Pine Creek	0.01	0.01	0.01	0.01
PLT06-10	Joe Wright Creek	0.01	0.01	0.01	0.01

Reservoirs

There were no modeled reservoirs within the PLT_06 Manageable Unit.

4.4.6.2 Wastewater Costs

Table 4-118 summarizes the WWTFs located in PLT_06 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-118. WWTFs in PLT_06

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Eaton, Town of		0.75	>0.5 to 1	1	
S Fort Collins Sanitation District		4.5	>1 to 3	1	
Swift and Company	Swift Beef Plant	4.4	>3 to 5	1	Treatment Plant Category Assumed
Fort Collins, City of	Mulberry WWTF	6	>5 to 10	1	
Greeley, City of		14.7	>5 to 10	1	
GS Mile-Hi Council	Magic Sky Ranch Camp	0.013	0-0.5	1	Exempt due to capacity
Wellington, Town of		0.45	0-0.5	1	Exempt due to capacity
Longs Peak Council, Inc.	Ben Delatour Boy Scout Ranch	No Data	No Data	0	Exempt due to capacity
Lutheran Ranches of The Rockies	Sky Ranch Lutheran Camp	No Data	No Data	0	Exempt due to capacity
Saddler Ridge Metropolitan District	Saddler Ridge Metropolitan District WRF	No Data	No Data	0	Exempt due to capacity
Fort Collins, City of	Drake WWTF	23	>10	3	
Carestream Health Colorado WWTF		1.1	>1 to 3	4	
Boxelder Sanitation District	Boxelder WWTF	2.34	>1 to 3	4	
Windsor, Town of	Windsor, Town of WWTF	2.8	>1 to 3	4	
Fox Acres Community Services Corp	Fox Acres WWTF	0.035	0-0.5	4	Exempt due to capacity

Table 4-119 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-120 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-120 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-119. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$183,646,000	\$409,468,000	\$2,170,599,000
Annual Operation & Maintenance Costs	\$7,082,000	\$10,757,000	\$33,557,000

Costs rounded to nearest \$1000.

Table 4-120. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$2,059,000	\$2,458,000	\$25,557,000
Annual Operation & Maintenance Costs	\$53,000	\$159,000	\$831,000

Costs rounded to nearest \$1000.

4.4.6.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed within PLT_06.

4.4.6.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_06, in present value (2010), are presented in Table 4-121.

Table 4-121. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_06

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$165,466,000	\$368,931,000	\$1,955,714,000
Operating	\$109,876,000	\$166,878,000	\$520,600,000
Total	\$275,342,000	\$535,809,000	\$2,476,314,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	12.46%	18.37%	30.64%
Percent Change in Water Quality (Reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$1,768,000	\$2,607,000	\$4,348,000
Boating	\$4,843,000	\$7,143,000	\$11,913,000
Swimming	\$1,573,000	\$2,321,000	\$3,870,000

Table 4-121. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_06

	Tier 1	Tier 2	Tier 3
Total	\$8,184,000	\$12,071,000	\$20,131,000
Property Value Benefits	n/a	n/a	n/a
Passive Benefits	\$17,358,000	\$25,284,000	\$42,539,000
Total Quantified Benefits	\$25,542,000	\$37,355,000	\$62,670,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.6.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_06 are -\$249,799,000 for Tier 1, -\$498,454,000 for Tier 2, and -\$2,413,645,000 for Tier 3. The benefit-cost ratio is 0.09:1, 0.07:1, and 0.03:1 for Tiers 1, 2, and 3, respectively (Table 4-122).

Table 4-122. Benefit Cost Summary for MU PLT_06, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$25,543,000	\$37,355,000	\$62,670,000
Total Costs	\$275,341,000	\$535,809,000	\$2,476,315,000
Net Present Value Benefits	(\$249,799,000)	(\$498,454,000)	(\$2,413,645,000)
Benefit Cost Ratio	0.09 : 1	0.07 : 1	0.03 : 1

4.4.7 PLT_07A – Middle South Platte/Cherry Creek Basin

PLT_07A is comprised of the Cherry Creek Basin upstream of the South Platte River and the South Platte River Basin between the confluences with Cherry Creek and Sand Creek. Figure 4-53 illustrates the area covered by PLT_07A including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.7.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for two of the facilities, 4.5 mg/L TP and 25 mg/L TIN. Specific effluent information was available for the remaining four facilities in PLT_07A, as shown in Table 4-123.

Table 4-123. Site-specific nutrient effluent values for WWTFs within PLT_07A.

Facility Name	Stream Name	Current TP (mg/L)	Current TIN (mg/L)	Information Source
Meridian Metropolitan District	Cherry Creek	0	25	2010 Cherry Creek Report (TP)
Parker WSD	Cherry Creek	NA	NA	2010 Cherry Creek Report (TP) ¹
Parker South Water Reclamation Facility	Cherry Creek	0.03	25	Cherry Creek Control Regulation Value (TP)
Stonegate Village Metropolitan District	Cherry Creek	0.01	25	2010 Cherry Creek Report (TP)

¹ 2010 Cherry Creek Basin Report reported no discharge for this facility

Streams and Rivers

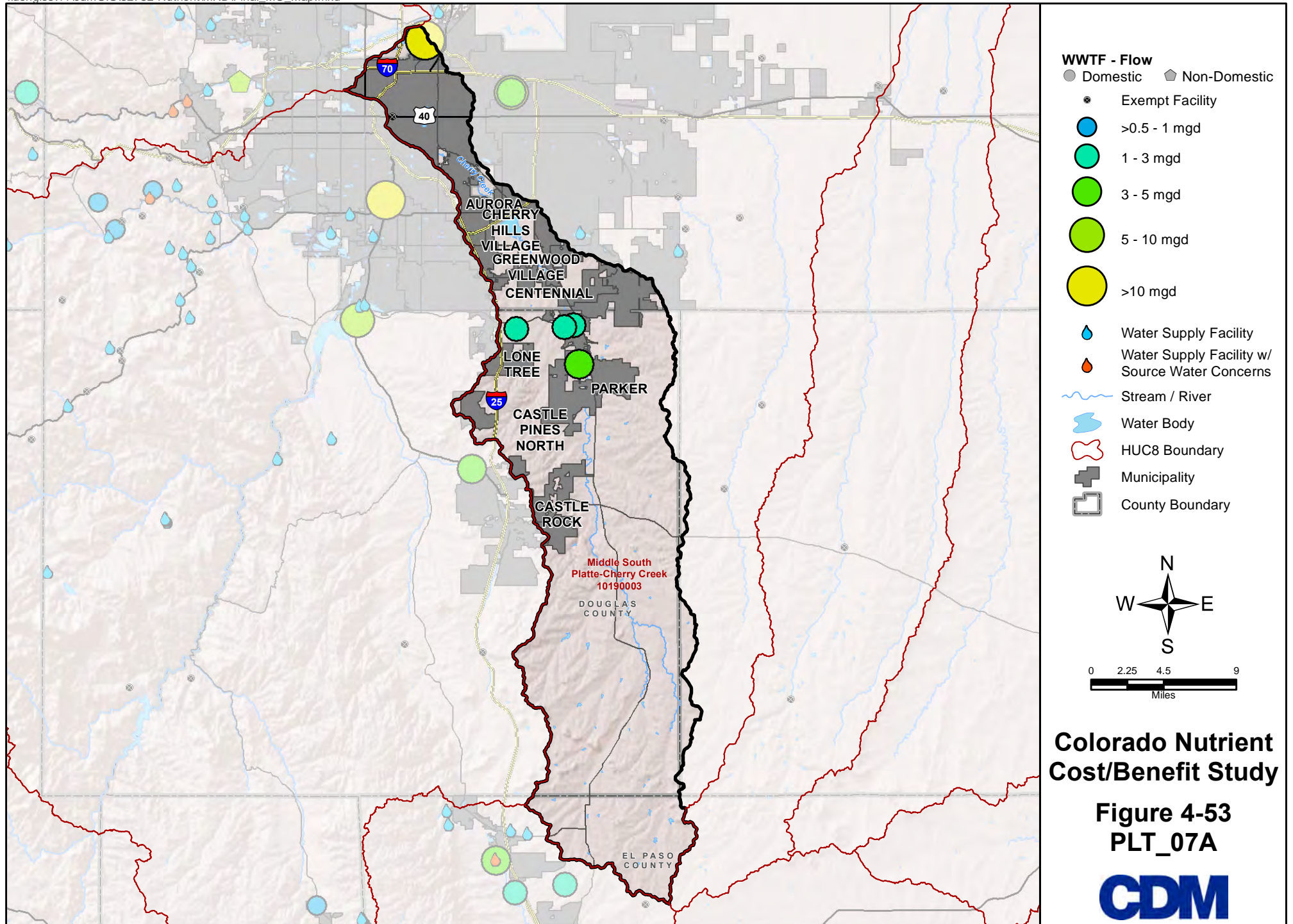
Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-124 and 4-125 (see Figure 4-53 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-124; Figure 4-54) and for TIN (Table 4-125; Figure 4-55). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

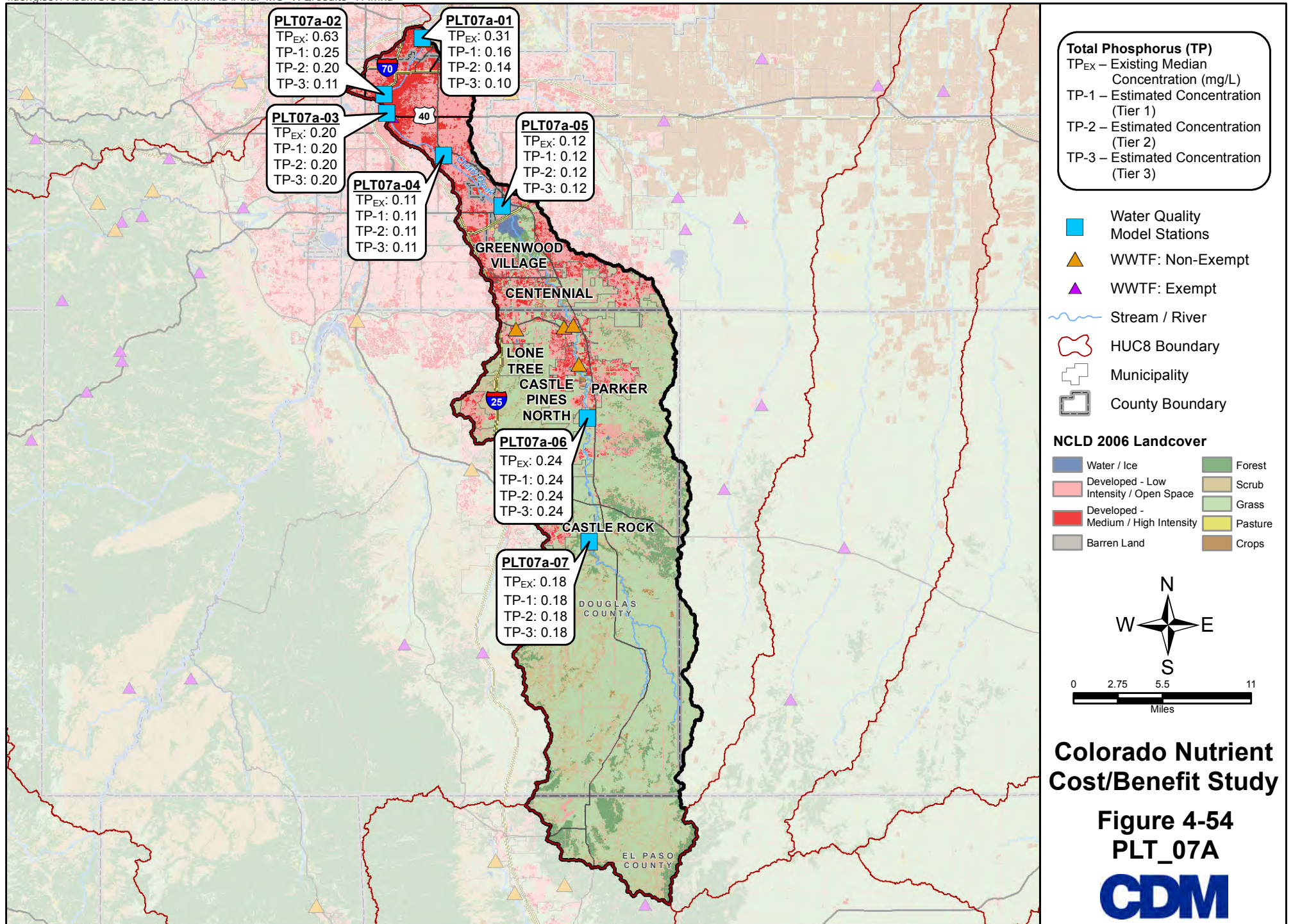
Table 4-124. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07A

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07a-01	Mainstem	0.31	0.16	0.14	0.10
PLT07a-02	Mainstem	0.63	0.25	0.20	0.11
PLT07a-03	Cherry Creek	0.20	0.20	0.20	0.20
PLT07a-04	Cherry Creek	0.11	0.11	0.11	0.11
PLT07a-05	Cherry Creek	0.12	0.12	0.12	0.12
PLT07a-06	Cherry Creek	0.24	<i>Upstream facilities exempted</i>		
PLT07a-07	Cherry Creek	0.18	<i>Upstream facilities exempted</i>		

Table 4-125. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07A

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07a-01	Mainstem	5.74	3.22	2.41	0.49
PLT07a-02	Mainstem	4.50	2.54	1.91	0.41
PLT07a-03	Cherry Creek	1.44	0.80	0.67	0.39
PLT07a-04	Cherry Creek	0.85	0.51	0.44	0.28
PLT07a-05	Cherry Creek	0.61	0.39	0.34	0.25
PLT07a-06	Cherry Creek	0.21	<i>Upstream facilities exempted</i>		
PLT07a-07	Cherry Creek	0.10	<i>Upstream facilities exempted</i>		

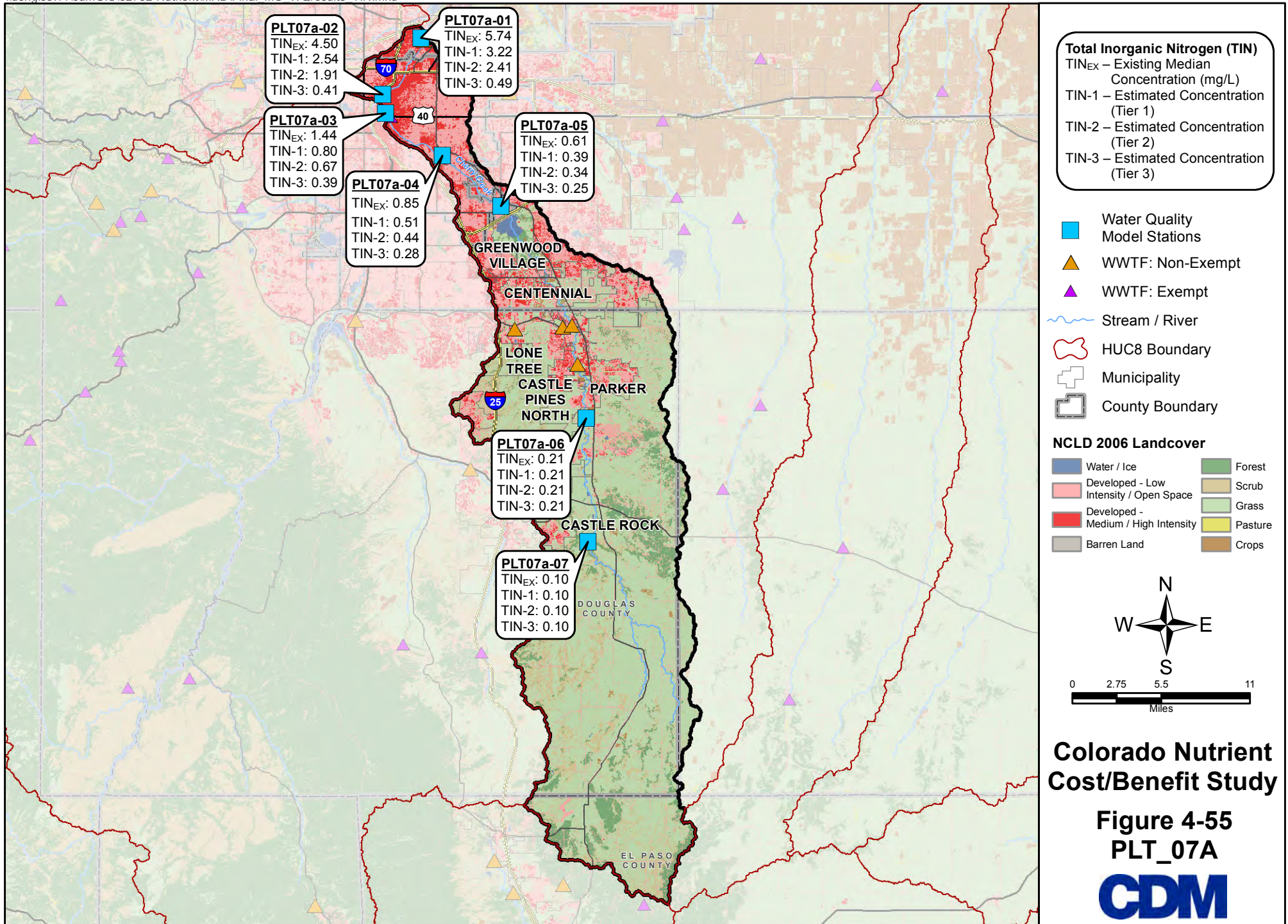


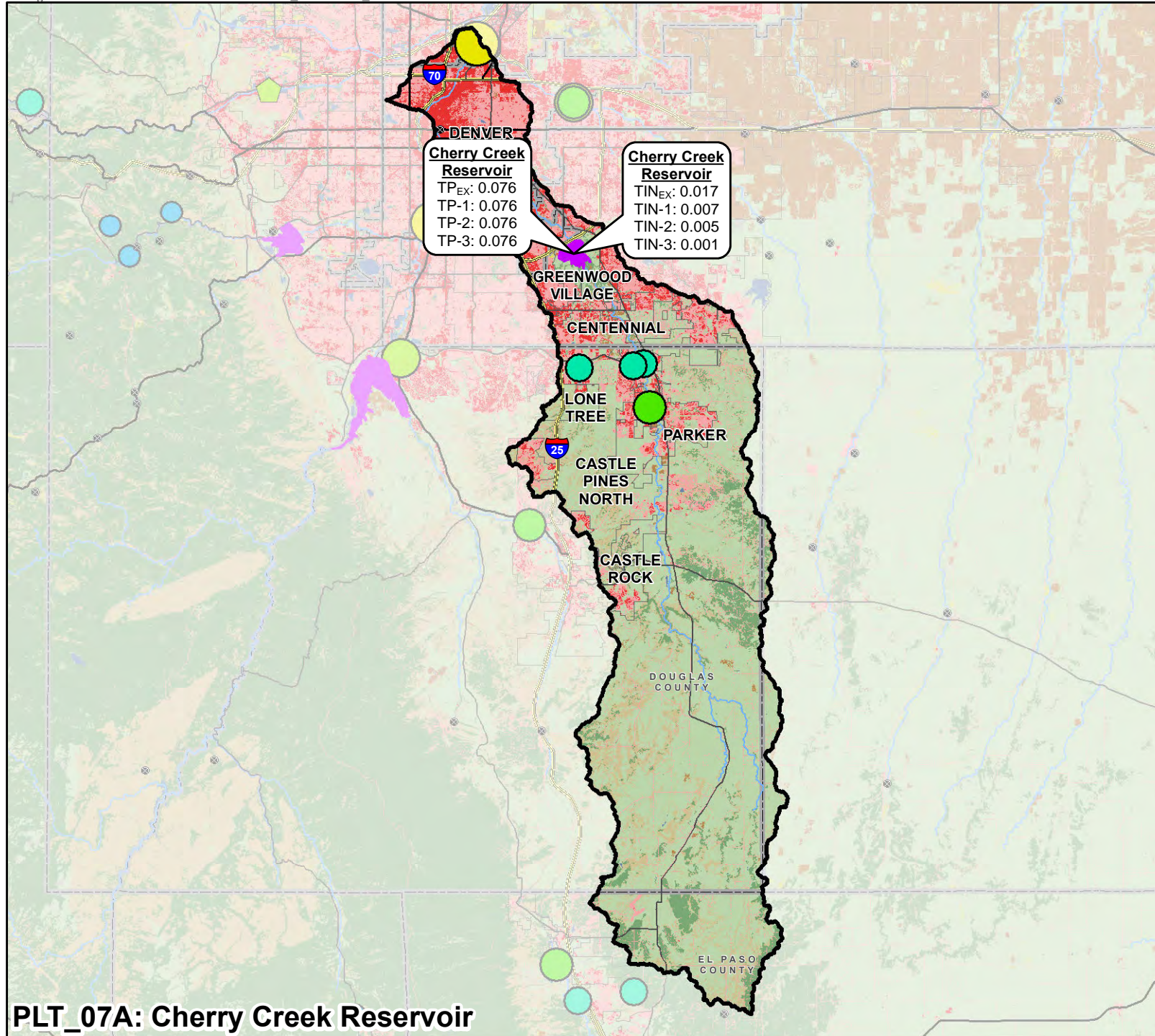


Colorado Nutrient Cost/Benefit Study

**Figure 4-54
PLT_07A**





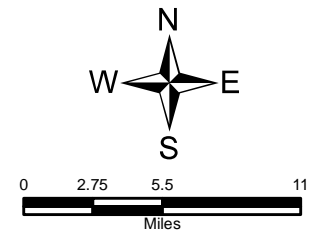


Cherry Creek Reservoir
 TP_{Ex}: 0.076
 TP-1: 0.076
 TP-2: 0.076
 TP-3: 0.076

Cherry Creek Reservoir
 TIN_{Ex}: 0.017
 TIN-1: 0.007
 TIN-2: 0.005
 TIN-3: 0.001

- WWTF - Flow**
- Domestic ◈ Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
 - ~ Stream / River
 - Modeled Reservoir
 - ⊕ Municipality
 - ⊞ County Boundary

- NCLD 2006 Landcover**
- | | |
|--|-----------|
| ■ Water / Ice | ■ Forest |
| ■ Developed - Low Intensity / Open Space | ■ Scrub |
| ■ Developed - Medium / High Intensity | ■ Grass |
| ■ Barren Land | ■ Pasture |
| | ■ Crops |



Colorado Nutrient Cost/Benefit Study

Figure 4-56



PLT_07A: Cherry Creek Reservoir

Reservoirs

Cherry Creek Reservoir and was analyzed within PLT_07A (see Figure 4-57). Table 4-126 summarizes existing water quality and expected water quality under implementation of Tier 1, 2, or 3 effluent limits at Cherry Creek Reservoir. The median TP and TIN concentration in the reservoir were less than upstream median nutrient concentrations. Accordingly, given the number of WWTFs upstream of the reservoir and the existing control regulation, implementation of the nutrient control regulation is expected to have greater impacts on TIN than TP concentrations.

Table 4-126. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in Cherry Creek Reservoir

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.076	0.076	0.076	0.076
TIN	0.017	0.007	0.005	0.001

4.4.7.2 Wastewater Costs

Table 4-127 summarizes the WWTFs located in PLT_07A along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-127. WWTFs in PLT_07A

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Stonegate Village Metropolitan District		1.1	>1 to 3	1	Control Regulation
South WRF		1.35	>1 to 3	1	Control Regulation
Metro Wastewater Reclamation District		220	>10	1	
Parker WSD		4	>3 to 5	1	Control Regulation
Denver, City and County	Van Cise-Simonet Det. Cent.	0.22	0-0.5	1	Exempt due to capacity
Meridian Metropolitan District		1.25	>1 to 3	4	Control Regulation

Table 4-128 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-129 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-129 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-128. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$243,456,000	\$623,858,000	\$2,433,005,000
Annual Operation & Maintenance Costs	\$9,953,000	\$30,083,000	\$96,366,000

Costs rounded to nearest \$1000.

Table 4-129. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$795,000	\$965,000	\$11,203,000
Annual Operation & Maintenance Costs	\$14,000	\$64,000	\$358,000

Costs rounded to nearest \$1000.

4.4.7.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The Arapahoe County WWA was included in the analysis for PLT_07A. These avoided costs are included in Table 4-129.

4.4.7.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_07A, in present value (2010), are presented in Table 4-130.

Table 4-130. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_07A

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$219,354,000	\$562,098,000	\$2,192,143,000
Operating	\$154,417,000	\$466,711,000	\$1,495,012,000
Total	\$373,771,000	\$1,028,809,000	\$3,687,155,000
Potable Water Supply Benefits			
Capital	\$662,000	\$662,000	\$662,000
Operating	\$2,300,000	\$2,300,000	\$2,300,000
Total	\$2,962,000	\$2,962,000	\$2,962,000
Percent Change in Water Quality (streams)			
	22.88%	24.23%	31.33%
Percent Change in Water Quality (Cherry Creek Reservoir)			
	28.63%	34.35%	46.95%
Projected Active Benefits			
Angling	\$89,007,000	\$105,383,000	\$143,236,000
Boating	\$88,115,000	\$96,980,000	\$127,698,000
Swimming	\$21,354,000	\$24,659,000	\$33,167,000
Total	\$198,476,000	\$227,022,000	\$304,101,000
Property Value Benefits			
	n/a	n/a	n/a
Passive Benefits	\$47,604,000	\$50,359,000	\$65,165,000
Total Quantified Benefits	\$249,042,000	\$280,343,000	\$372,228,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.7.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_07A are -\$124,729,000 for Tier 1, -\$748,464,000 for Tier 2, and -\$3,314,926,000 for Tier 3. The benefit-cost ratio is 0.67:1, 0.27:1, and 0.1:1 for Tiers 1, 2, and 3, respectively (Table 4-131).

Table 4-131. Benefit Cost Summary for MU PLT_07A, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$249,042,000	\$280,344,000	\$372,229,000
Total Costs	\$373,771,000	\$1,028,808,000	\$3,687,155,000
Net Present Value Benefits	(\$124,729,000)	(\$748,464,000)	(\$3,314,926,000)
Benefit Cost Ratio	0.67 : 1	0.27 : 1	0.1 : 1

4.4.8 PLT_07B – Middle South Platte/Sand Creek Basin

PLT_07B is comprised of one HUC-8 watershed and includes the Sand Creek Basin upstream of the South Platte River. Figure 4-57 illustrates the area covered by PLT_07B including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.8.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-132 and 4-133 (see Figure 4-57 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-132; Figure 4-58) and for TIN (Table 4-133; Figure 4-59). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-132. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07B

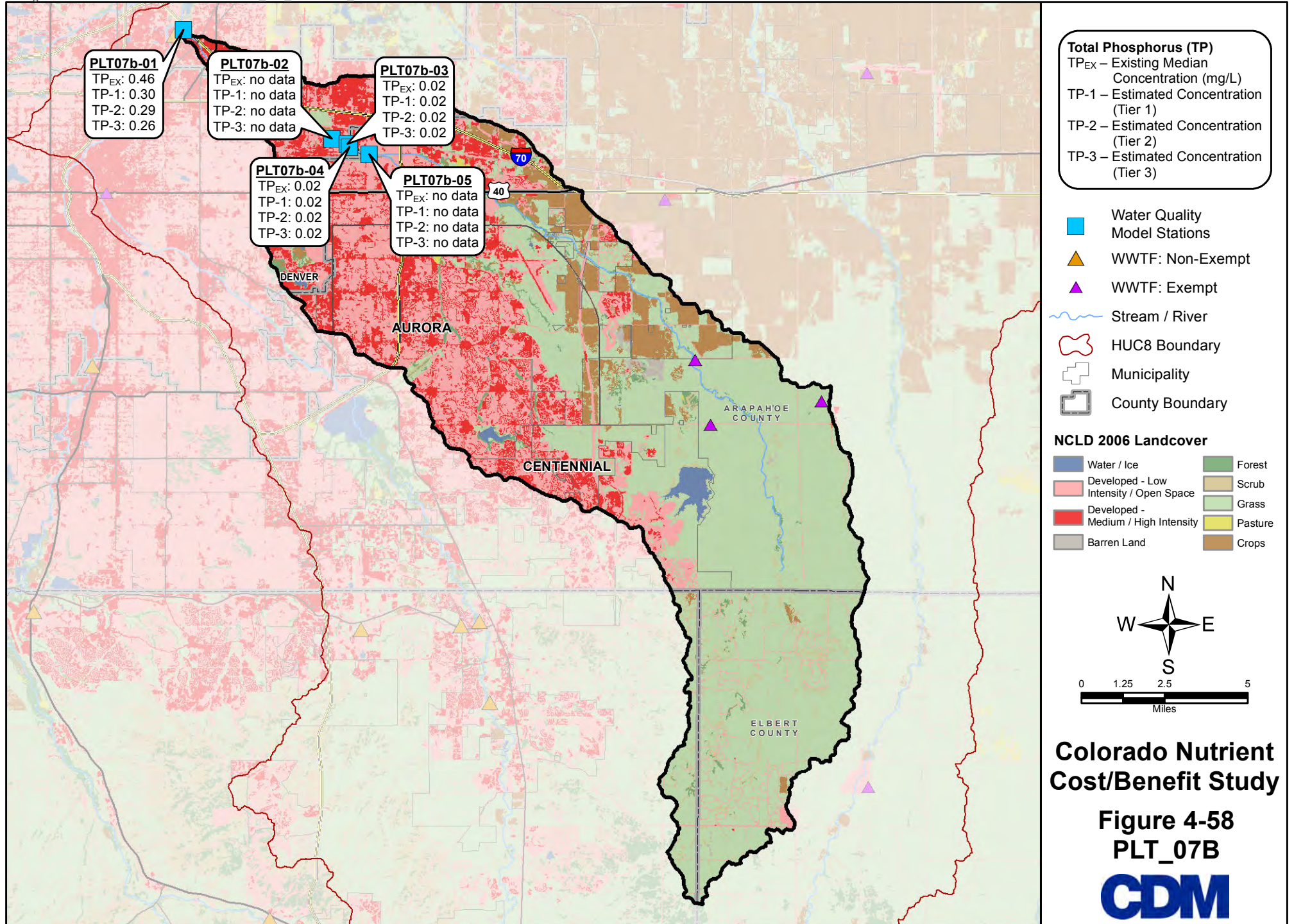
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07b-01	Mainstem	0.46	0.30	0.29	0.26
PLT07b-02	Mainstem	No data	n/a	n/a	n/a
PLT07b-03	Mainstem	0.02	0.02	0.02	0.02
PLT07b-04	Mainstem	0.02	0.02	0.02	0.02
PLT07b-05	Mainstem	No data	n/a	n/a	n/a

Table 4-133. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07B

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07b-01	Mainstem	3.57	1.84	1.50	0.74
PLT07b-02	Mainstem	2.62	1.42	1.19	0.66
PLT07b-03	Mainstem	No data	n/a	n/a	n/a
PLT07b-04	Mainstem	1.24	1.24	1.24	1.24
PLT07b-05	Mainstem	1.27	1.27	1.27	1.27

Reservoirs

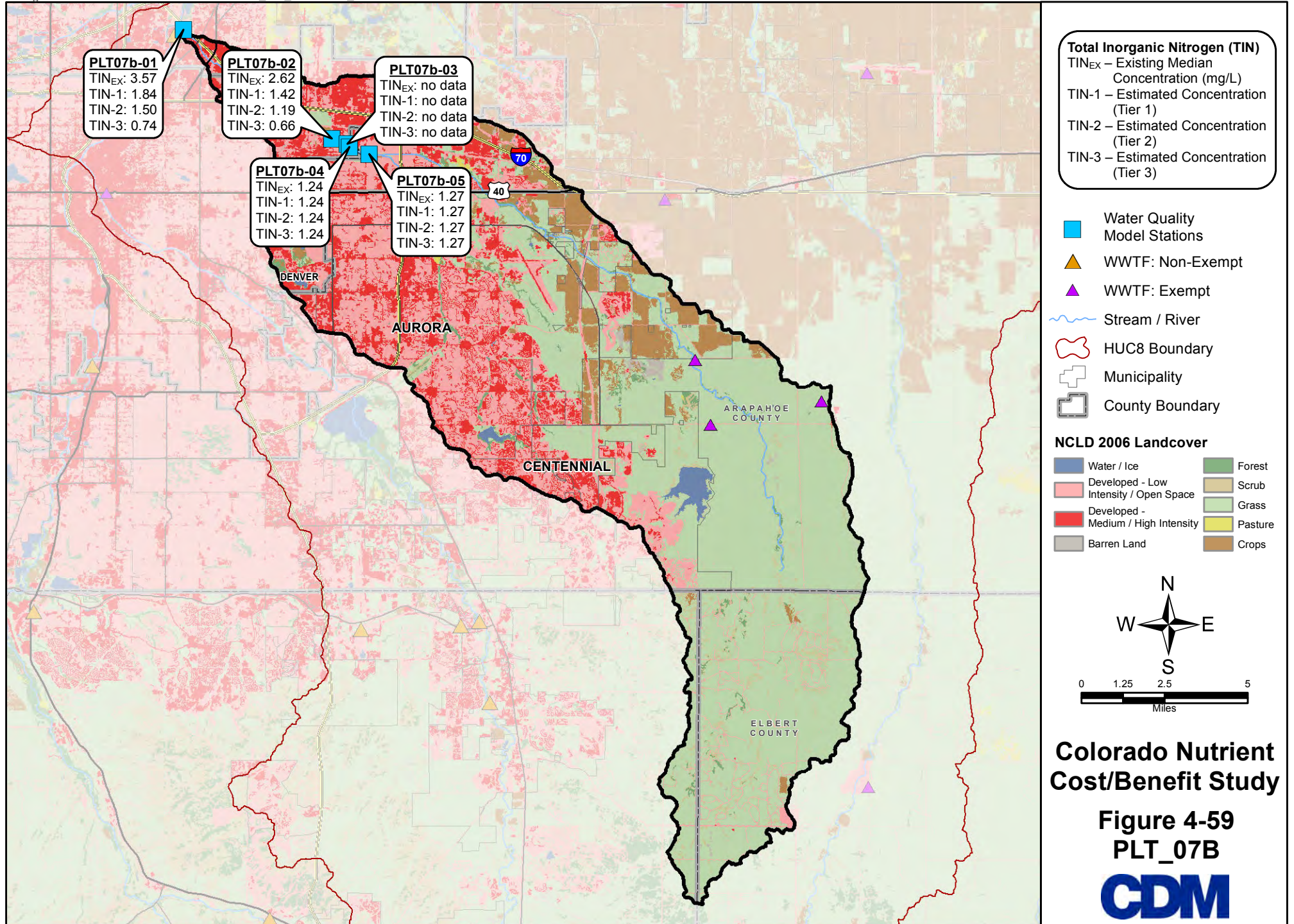
There are no modeled reservoirs within the PLT_07B Manageable Unit.



Colorado Nutrient Cost/Benefit Study

**Figure 4-58
 PLT_07B**





4.4.8.2 Wastewater Costs

Table 4-134 summarizes the WWTFs located in PLT_07B along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-134: WWTFs in PLT_07B

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Orica USA Inc		0.012	0-0.5	1	Exempt due to capacity
Mile High Racing and Enter dba Arapahoe Park	Arapahoe Park Racetrack	0.049	0-0.5	4	Exempt due to capacity
Rangeview Metropolitan District	Coal Creek Wastewater Reclamation Facility	0.499	0-0.5	4	Exempt due to capacity
Aurora, City of	Sand Creek Water Reuse Facility	5	>3 to 5	4	
Sand Creek WRF		5.4	>5 to 10	1	

Table 4-135 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-136 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-136 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-135. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$46,983,000	\$94,213,000	\$403,184,000
Annual Operation & Maintenance Costs	\$1,984,000	\$2,621,000	\$6,833,000

Costs rounded to nearest \$1000.

Table 4-136. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$6,086,000	\$6,755,000	\$31,615,000
Annual Operation & Maintenance Costs	\$371,000	\$388,000	\$1,241,000

Costs rounded to nearest \$1000.

4.4.8.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed within PLT_07B.

4.4.8.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_07B, in present value (2010), are presented in Table 4-137.

Table 4-137. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_07B

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$42,331,000	\$84,886,000	\$363,270,000
Operating	\$30,778,000	\$40,670,000	\$106,013,000
Total	\$73,109,000	\$125,556,000	\$469,283,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	36.87%	40.02%	46.32%
Percent Change in Water Quality (reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$7,837,000	\$8,507,000	\$9,844,000
Boating	\$20,034,000	\$21,747,000	\$25,166,000
Swimming	\$4,725,000	\$5,129,000	\$5,935,000
Total	\$32,596,000	\$35,383,000	\$40,945,000
Property Value Benefits	n/a	n/a	n/a
Passive Benefits	\$52,828,000	\$57,344,000	\$66,359,000
Total Quantified Benefits	\$85,424,000	\$92,727,000	\$107,304,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.8.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_07B are \$12,314,000 for Tier 1, -\$32,828,000 for Tier 2, and -\$361,979,000 for Tier 3. The benefit-cost ratio is 1.17:1, 0.74:1, and 0.23:1 for Tiers 1, 2, and 3, respectively (Table 4-138).

Table 4-138. Benefit Cost Summary for MU PLT_07B, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$85,424,000	\$92,727,000	\$107,304,000
Total Costs	\$73,110,000	\$125,556,000	\$469,282,000
Net Present Value Benefits	\$12,314,000	(\$32,828,000)	(\$361,979,000)
Benefit Cost Ratio	1.17 : 1	0.74 : 1	0.23 : 1

4.4.9 PLT_07C – Middle South Platte/Big Dry Creek Basin

PLT_07C is comprised of one HUC-8 watershed and includes the Big Dry Creek Basin upstream of the South Platte River. Figure 4-60 illustrates the area covered by PLT_07C including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.9.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the Northglenn WWTF; 4.5 mg/L TP and 25 mg/L TIN. Specific effluent information was available for the remaining two facilities in PLT_07C, as shown in Table 4-139.

Table 4-139. Site-specific nutrient effluent values for WWTFs within PLT_07C

Facility Name	Stream Name	Current TP (mg/L)	Current TIN (mg/L)	Information Source
Broomfield WWTF	Mainstem	2.97	20.5	Facility provided data (WWUC)
Big Dry Creek WWTF	Mainstem	1.59	8.5	Facility provided data (WWUC)

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-140 and 4-141 (see Figure 4-60 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-140; Figure 4-61) and for TIN (Table 4-141; Figure 4-62). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-140. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07C

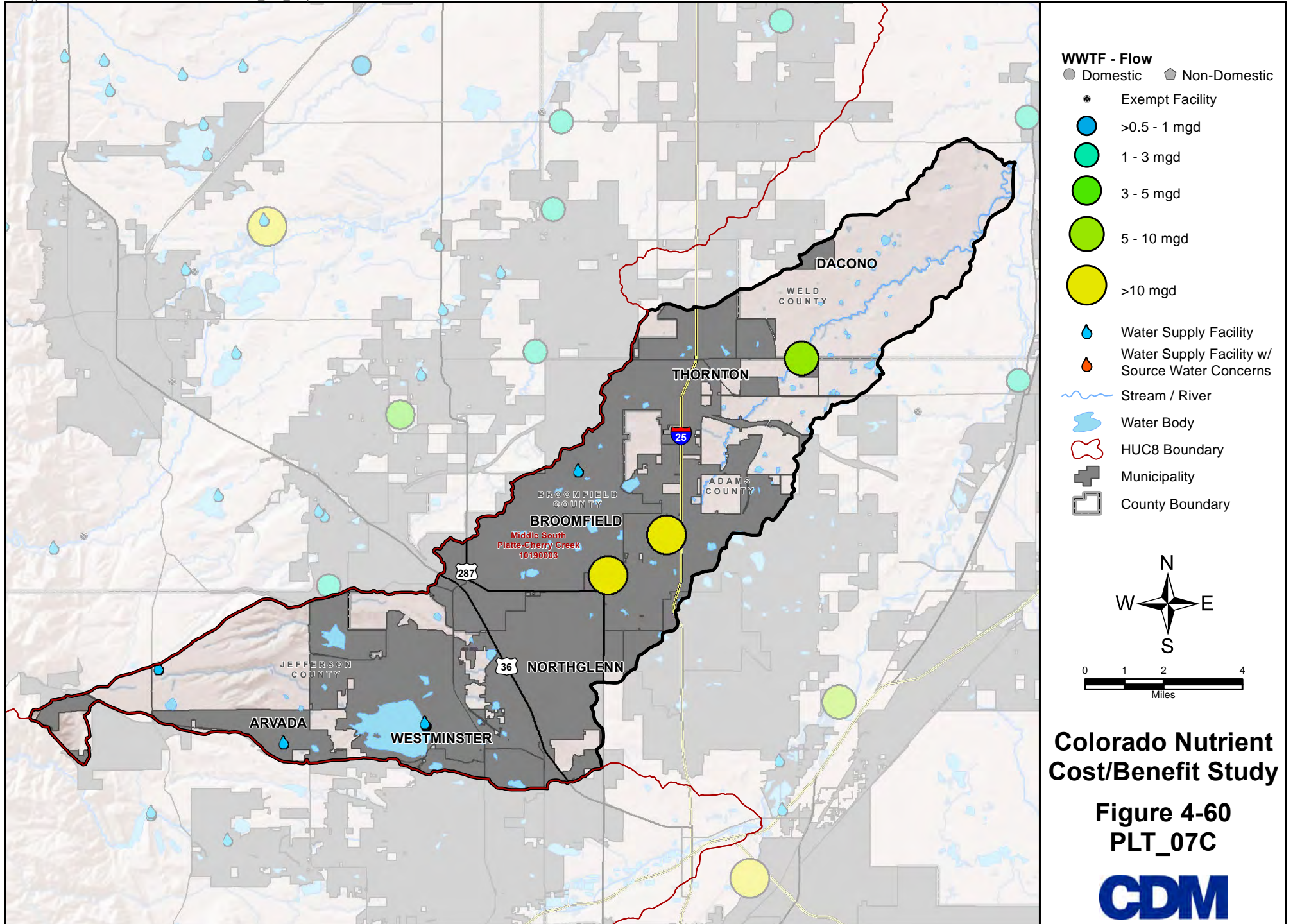
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07c-01	Mainstem	1.20	0.50	0.38	0.14
PLT07c-02	Mainstem	1.30	0.53	0.40	0.13
PLT07c-03	Mainstem	2.06	0.95	0.68	0.15
PLT07c-04	Mainstem	0.75	0.32	0.25	0.11
PLT07c-05	Mainstem	0.08	0.08	0.08	0.08
PLT07c-06	Mainstem	0.07	0.07	0.07	0.07
PLT07c-07	Mainstem	0.05	0.05	0.05	0.05

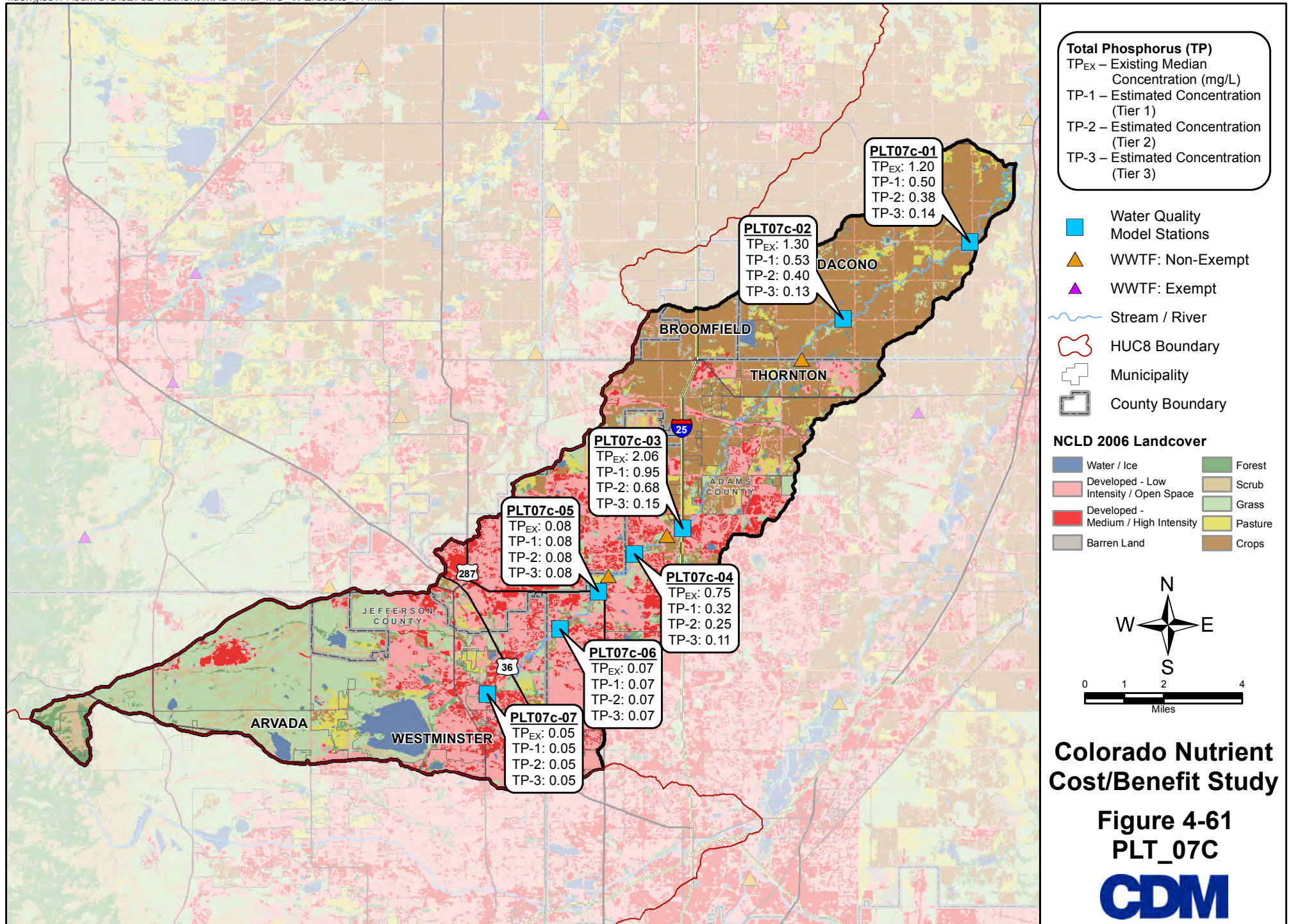
Table 4-141. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07C

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07c-01	Mainstem	7.34	4.31	3.32	0.44
PLT07c-02	Mainstem	9.50	5.54	4.24	0.48
PLT07c-03	Mainstem	12.05	7.93	6.18	0.64
PLT07c-04	Mainstem	9.04	4.82	3.61	0.56
PLT07c-05	Mainstem	1.27	1.27	1.27	0.63
PLT07c-06	Mainstem	0.68	0.68	0.68	0.38
PLT07c-07	Mainstem	0.99	0.99	0.99	0.49

Reservoirs

Standley Lake was analyzed within PLT_07C (see Figure 4-63). Table 4-142 summarizes existing water quality and expected water quality under implementation of Tier 1, 2, or 3 effluent limits at Standley Lake. Standley Lake receives water from Clear Creek (PLT_02) via a cross-basin diversion; therefore, land-use and WWTF information from the PLT_02 Manageable Unit (upstream of the diversion) were included in the reservoir nutrient model for Standley Lake. The median TP and TIN concentration in the reservoir were less than upstream median nutrient concentrations. Accordingly, given the number of WWTFs upstream of the reservoirs, implementation of the nutrient control regulation is expected to have little impact on water quality and current trophic status in the reservoir.

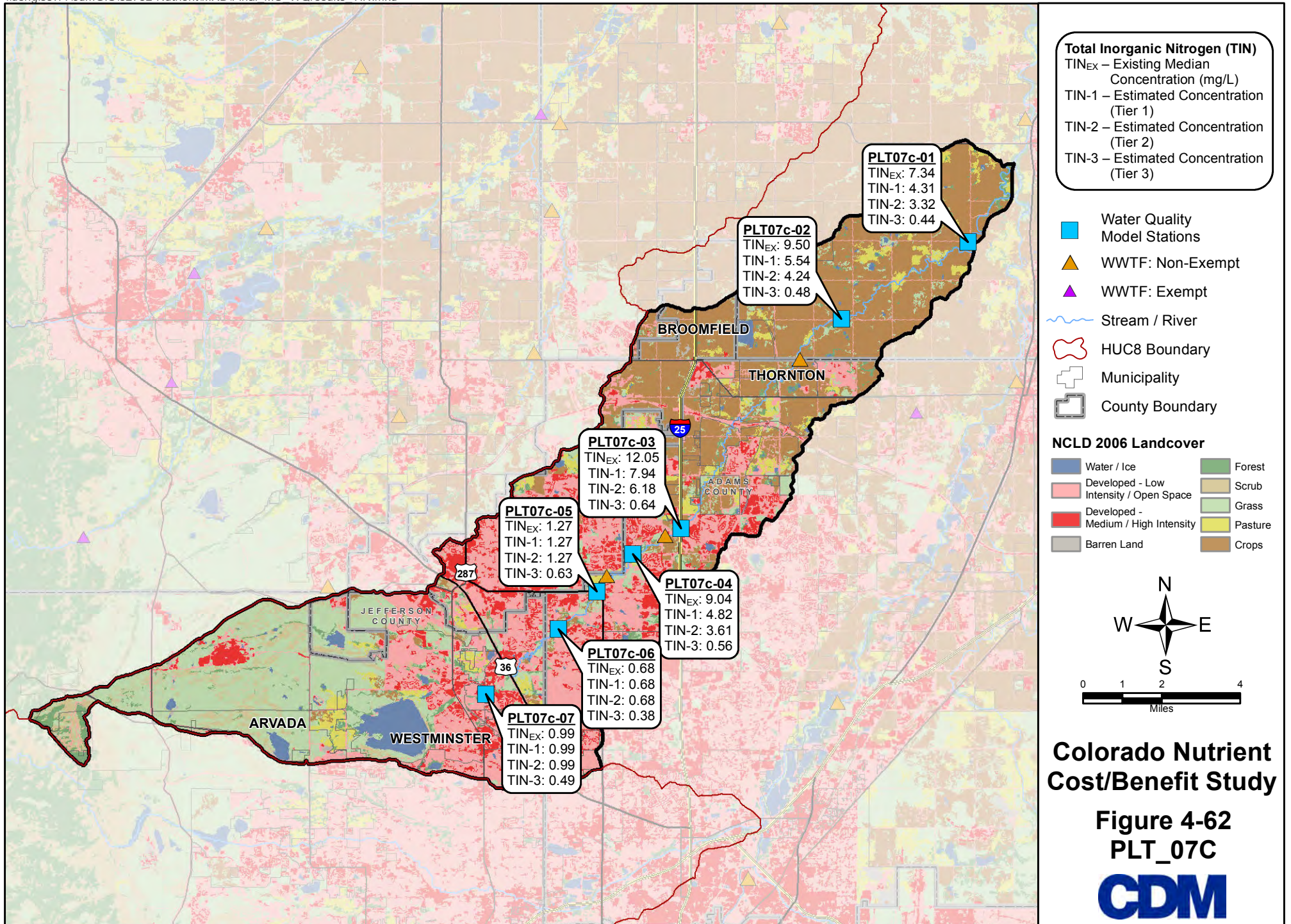




Colorado Nutrient Cost/Benefit Study

**Figure 4-61
 PLT_07C**

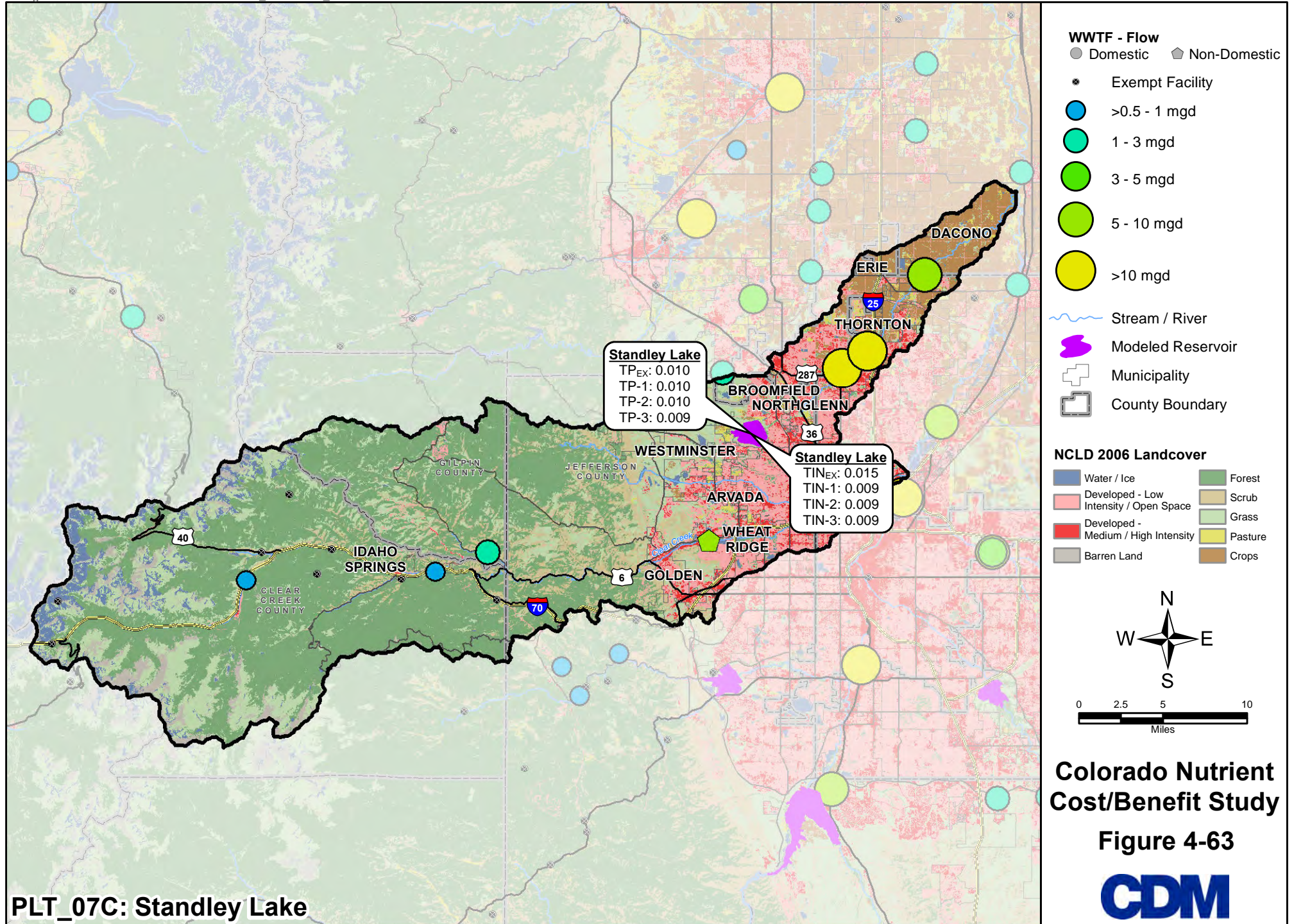




Colorado Nutrient Cost/Benefit Study

**Figure 4-62
 PLT_07C**





PLT_07C: Standley Lake

Table 4-142. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in Standley Lake

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.010	0.010	0.010	0.009
TIN	0.015	0.009	0.009	0.009

4.4.9.2 Wastewater Costs

Table 4-143 summarizes the WWTFs located in PLT_07C along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-143. WWTFs in PLT_07C

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Westminster, City of	Big Dry Creek WWTF	11.9	>10	1	
Broomfield City and County	Broomfield WWTF	12	>10	3	
Northglenn, City of	Northglenn WWTF	6.5	>5 to 10	1	

Table 4-144 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. There are no exempted facilities included in the PLT-7c watershed.

Table 4-144. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$78,083,000	\$198,576,000	\$1,037,403,000
Annual Operation & Maintenance Costs	\$2,679,000	\$4,658,000	\$14,592,000

Costs rounded to nearest \$1000.

4.4.9.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed within this Manageable Unit.

4.4.9.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_07C, in present value (2010), are presented in Table 4-145.

Table 4-145. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_07C

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$70,353,000	\$178,917,000	\$934,703,000
Operating	\$41,566,000	\$72,264,000	\$226,383,000
Total	\$111,919,000	\$251,181,000	\$1,161,086,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	42.91%	53.27%	88.82%
Percent Change in Water Quality (Standley Lake)			
	20.15%	20.15%	20.15%
Projected Active Benefits			
Angling	\$8,663,000	\$10,683,000	\$17,611,000
Boating	\$22,208,000	\$26,779,000	\$45,287,000
Swimming	\$27,761,000	\$34,467,000	\$57,465,000
Total	\$58,632,000	\$71,929,000	\$120,363,000
Property Value Benefits			
	n/a	n/a	n/a
Passive Benefits			
	\$37,720,000	\$46,830,000	\$78,080,000
Total Quantified Benefits			
	\$96,352,000	\$118,759,000	\$198,443,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.9.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_07C are -\$15,568,000 for Tier 1, -\$132,423,000 for Tier 2, and -\$962,644,000 for Tier 3. The benefit-cost ratio is 0.86:1, 0.47:1, and 0.17:1 for Tiers 1, 2, and 3, respectively (Table 4-146).

Table 4-146. Benefit Cost Summary for MU PLT_07C, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$96,351,000	\$118,758,000	\$198,442,000
Total Costs	\$111,919,000	\$251,181,000	\$1,161,086,000
Net Present Value Benefits	(\$15,568,000)	(\$132,423,000)	(\$962,644,000)
Benefit Cost Ratio	0.86 : 1	0.47 : 1	0.17 : 1

4.4.10 PLT_07D – Middle South Platte/Cherry Creek/Crow Creek/Lone Tree-Owl Creek Basin

PLT_07D is comprised of three HUC-8 watersheds and includes the Middle South Platte River between the confluences with Clear Creek in Denver and Riverside Creek near Fort Morgan. The Crow Creek and Lone Tree Creek Basins upstream of the South Platte River are also included in this Manageable Unit. Figure 4-64 illustrates the area covered by PLT_07D including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. PLT_07D receives water from the following upstream Manageable Units: PLT_01, PLT_02, PLT_03, PLT_04, PLT_06, PLT_07a, PLT_07B, and PLT_07C. Information on each of the contributing Manageable Units can be found in previous sections of this report. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.10.1 Water Quality Analyses

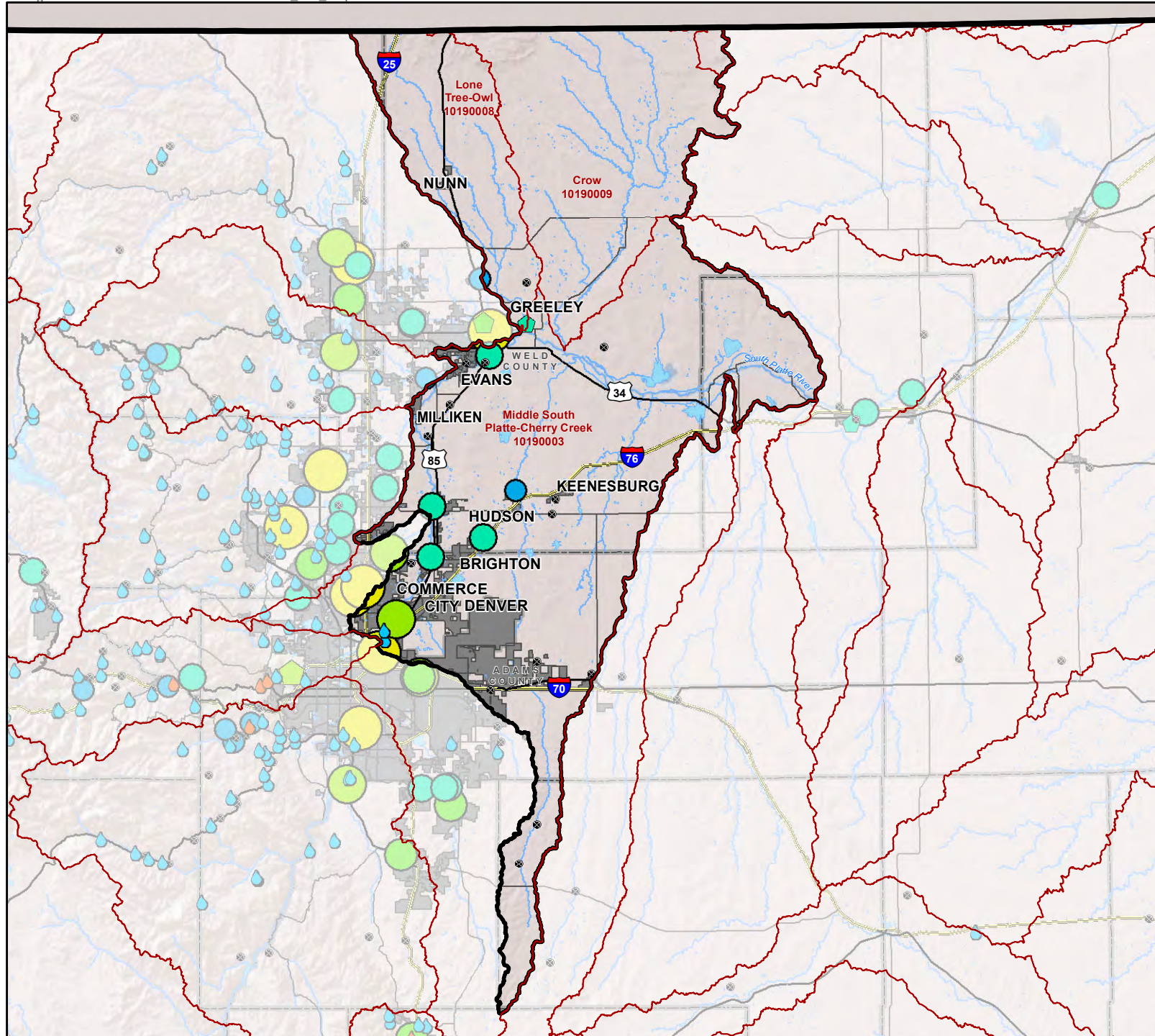
The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities within the PLT_07D Manageable Unit, 4.5 mg/L TP and 25 mg/L TIN. Facilities within the upstream contributing Manageable Units are discussed in previous sections of this report.

Streams and Rivers

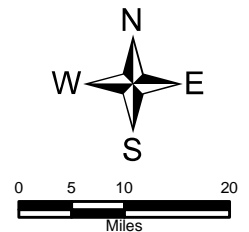
Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-147 and 4-148 (see Figure 4-64 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-147; Figure 4-65) and for TIN (Table 4-148; Figure 4-66). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-147. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07D

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07d-01	Mainstem	0.77	0.33	0.28	0.19
PLT07d-02	Mainstem	1.35	0.49	0.38	0.16
PLT07d-03	Mainstem	1.45	0.51	0.40	0.17
PLT07d-04	Mainstem	1.53	0.53	0.41	0.16
PLT07d-05	Mainstem	1.56	0.54	0.42	0.16
PLT07d-06	Mainstem	1.75	0.60	0.45	0.16
PLT07d-07	Mainstem	1.87	0.66	0.50	0.17
PLT07d-08	Mainstem	1.52	0.55	0.42	0.16
PLT07d-09	Mainstem	1.79	0.63	0.48	0.17
PLT07d-10	Lone Tree Creek	0.17	<i>Upstream facilities exempted</i>		
PLT07d-11	Lone Tree Creek	0.01	<i>Upstream facilities exempted</i>		



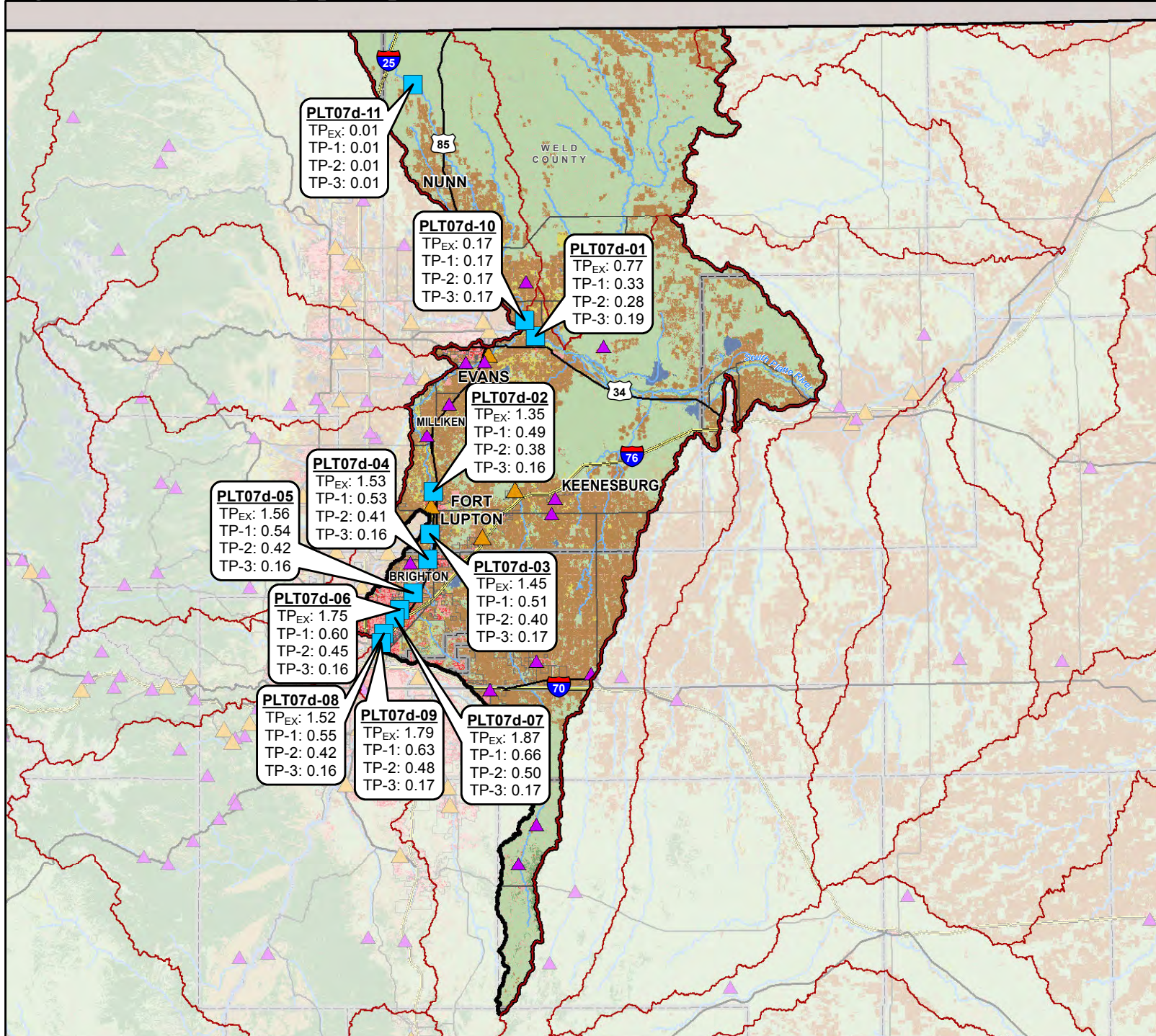
- WWTF - Flow**
- Domestic ● Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
 - Water Supply Facility
 - Water Supply Facility w/ Source Water Concerns
 - Stream / River
 - Water Body
 - HUC8 Boundary
 - Municipality
 - County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 4-64
PLT_07D

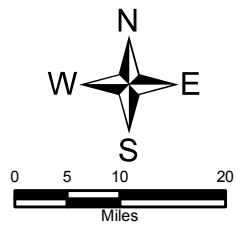




Total Phosphorus (TP)
 TP_{Ex} – Existing Median Concentration (mg/L)
 TP-1 – Estimated Concentration (Tier 1)
 TP-2 – Estimated Concentration (Tier 2)
 TP-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- ~ Stream / River
- HUC8 Boundary
- Municipality
- County Boundary

- NCLD 2006 Landcover**
- | | |
|--|---|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



Colorado Nutrient Cost/Benefit Study

**Figure 4-65
 PLT_07D**



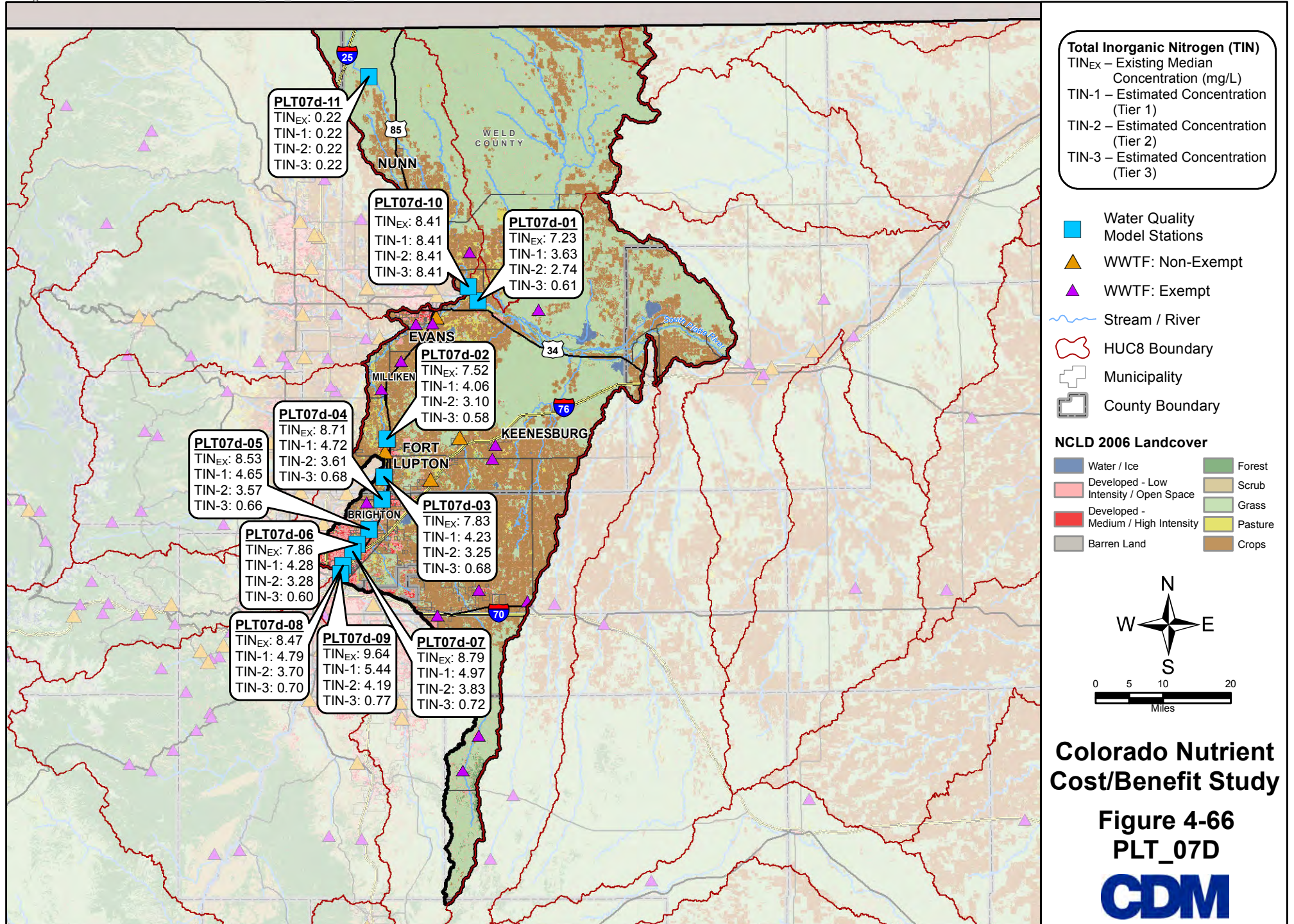


Table 4-148. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_07D

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT07d-01	Mainstem	7.23	3.63	2.74	0.61
PLT07d-02	Mainstem	7.52	4.06	3.10	0.58
PLT07d-03	Mainstem	7.83	4.23	3.25	0.68
PLT07d-04	Mainstem	8.71	4.72	3.61	0.68
PLT07d-05	Mainstem	8.53	4.65	3.57	0.66
PLT07d-06	Mainstem	7.86	4.28	3.28	0.60
PLT07d-07	Mainstem	8.79	4.97	3.83	0.72
PLT07d-08	Mainstem	8.47	4.79	3.70	0.70
PLT07d-09	Mainstem	9.64	5.44	4.19	0.77
PLT07d-10	Lone Tree Creek	8.41	<i>Upstream facilities exempted</i>		
PLT07d-11	Lone Tree Creek	0.22	<i>Upstream facilities exempted</i>		

Reservoirs

There are no modeled reservoirs within the PLT_07D Manageable Unit.

4.4.10.2 Wastewater Costs

Table 4-149 summarizes the WWTFs located in PLT_07D along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-149. WWTFs in PLT_07D

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Weld County School District RE-3J	Weld County Junior/Senior High School	0.015	0-0.5	1	Exempt due to capacity
Lochbuie, Town of		1	>0.5 to 1	1	
Fort Lupton, City of		2.75	>1 to 3	1	
Swift Beef Company	Lone Tree Facility	2.06	>1 to 3	1	
Front Range Airport WWTF		0.025	0-0.5	1	Exempt due to capacity
SW Water Company	Hi-Land Acres WSD	0.099	0-0.5	4	Exempt due to capacity
Spring Valley Ranch Metropolitan District	Spring Valley Ranch WWTF	0.3	0-0.5	1	Exempt due to capacity
La Salle, Town of		0.46	0-0.5	4	Exempt due to capacity
Bennett, Town of		0.499	0-0.5	4	Exempt due to capacity
Elizabeth, Town of	Gold Creek	0.499999	0-0.5	4A	Exempt due to capacity
South Adams Co WSD	Williams Monoco WWTF	8	>5 to 10	2	
Evans, City of	Evans City of WWTF	1.2	>1 to 3	4	
Galeton WSD		0.0185	0-0.5	4	Exempt due to capacity
Keenesburg, Town of		0.1	0-0.5	4	Exempt due to capacity
Gilcrest, Town of		0.196	0-0.5	4	Exempt due to capacity and disadvantaged
Platteville, Town of		0.348	0-0.5	4	Exempt due to capacity
Evans, City of	Hill-N-Park Sanitation District	0.5	0-0.5	4	Exempt due to capacity

Table 4-149. WWTFs in PLT_07D

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Hudson WWTF		0.5	0-0.5	5	Exempt due to capacity
Brighton, City of	Brighton WWTF	3	>1 to 3	6	
Kersey, Town of		0.38	0-0.5	6	Exempt due to capacity

¹Category 4A indicates septic system or filter, treated as lagoon for full replacement.

² Assumed Treatment Plant category

Table 4-150 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-151 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-151 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-150. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$84,013,000	\$126,008,000	\$736,148,000
Annual Operation & Maintenance Costs	\$2,392,000	\$3,311,000	\$12,084,000

Costs rounded to nearest \$1000.

Table 4-151. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition, and engineering)	\$36,147,000	\$43,027,000	\$219,118,000
Annual Operation & Maintenance Costs	\$1,930,000	\$2,300,000	\$8,075,000

Costs rounded to nearest \$1000.

4.4.10.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed within this Manageable Unit.

4.4.10.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_07D, in present value (2010), are presented in Table 4-152.

Table 4-152. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_07D

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$75,696,000	\$113,533,000	\$663,271,000
Operating	\$37,115,000	\$51,366,000	\$187,463,000
Total	\$112,811,000	\$164,899,000	\$850,734,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	32.85%	43.00%	58.26%
Percent Change in Water Quality (reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$12,407,000	\$16,242,000	\$22,008,000
Boating	\$31,718,000	\$41,521,000	\$56,263,000
Swimming	\$9,007,000	\$11,791,000	\$15,977,000
Total	\$53,132,000	\$69,554,000	\$94,248,000
Property Value Benefits	n/a	n/a	n/a
Passive Benefits	\$46,293,000	\$59,233,000	\$81,577,000
Total Quantified Benefits	\$99,425,000	\$128,787,000	\$175,825,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.10.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_07D are -\$13,386,000 for Tier 1, -\$36,112,000 for Tier 2, and -\$674,908,000 for Tier 3. The benefit-cost ratio is 0.88:1, 0.78:1, and 0.21:1 for Tiers 1, 2, and 3, respectively (Table 4-153).

Table 4-153. Benefit Cost Summary for MU PLT_07D, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$99,425,000	\$128,787,000	\$175,826,000
Total Costs	\$112,811,000	\$164,899,000	\$850,735,000
Net Present Value Benefits	(\$13,386,000)	(\$36,112,000)	(\$674,908,000)
Benefit Cost Ratio	0.88 : 1	0.78 : 1	0.21 : 1

4.4.11 PLT_08 – Middle South Platte-Sterling/Lower South Platte Basin

PLT_08 is comprised of nine HUC-8 watersheds and includes the middle and lower South Platte River between the confluence with Riverside Creek near Fort Morgan and the Colorado-Nebraska state line. The Kiowa River, Beaver Creek, Pawnee River, and several other sub-basins are also included in this Manageable Unit. Figure 4-67 illustrates the area covered by PLT_08 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. PLT_08 receives water from the following upstream Manageable Units: PLT_01, PLT_02, PLT_03, PLT_04, PLT_06, PLT_07a, PLT_07B, and PLT_07C. Information on each of the contributing Manageable Units can be found in previous sections of this report. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.11.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities within the PLT_08 Manageable Unit, 4.5 mg/L TP and 25 mg/L TIN. Facilities within the upstream contributing Manageable Units are discussed in previous sections of this report.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-154 and 4-155 (see Figure 4-67 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-154; Figure 4-68) and for TIN (Table 4-155; Figure 4-69). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-154. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_08

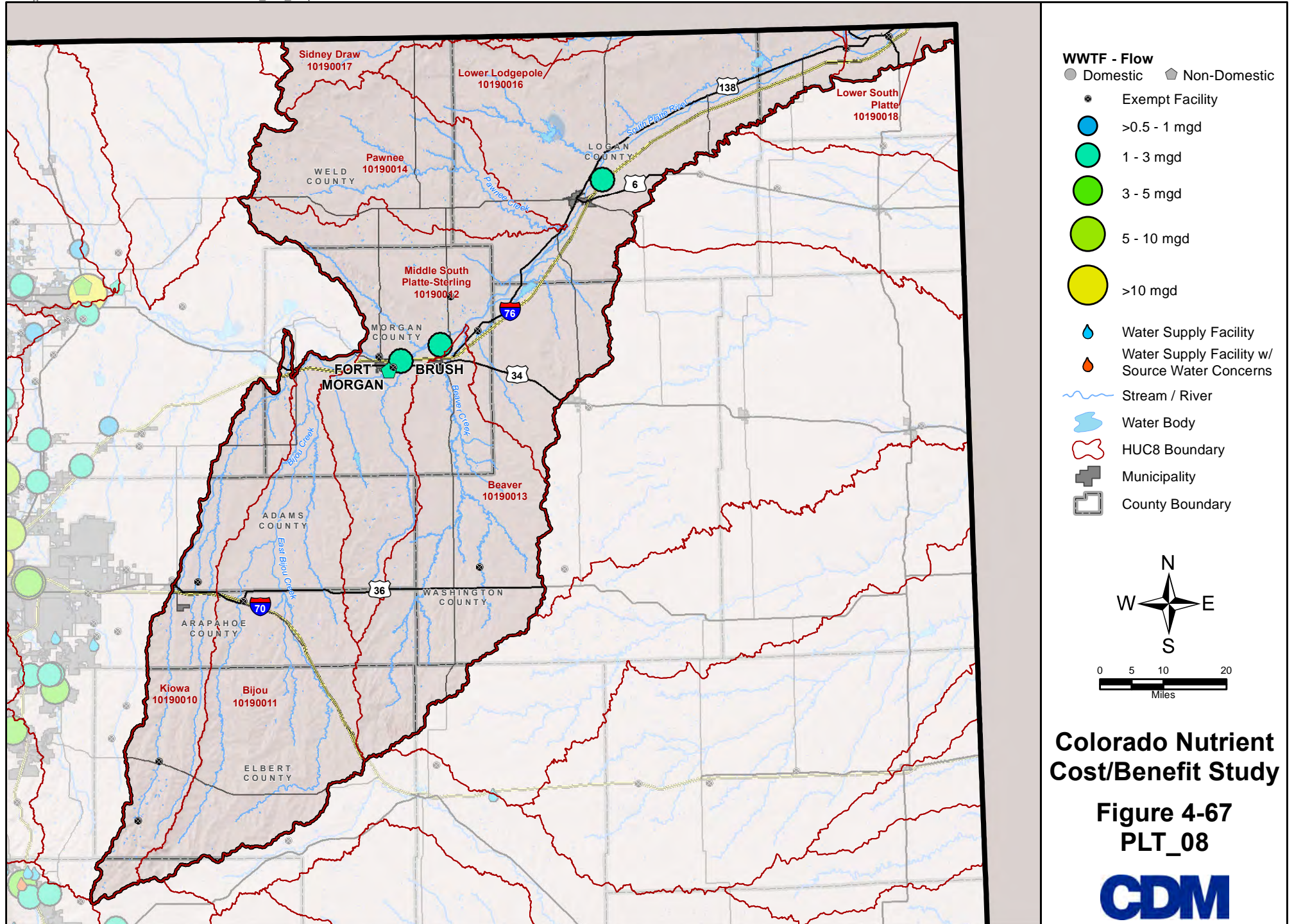
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT08-01	Mainstem	0.22	0.22	0.22	0.22
PLT08-02	Mainstem	no data	n/a	n/a	n/a
PLT08-03	Mainstem	0.32	0.28	0.28	0.27
PLT08-04	Mainstem	0.43	0.29	0.28	0.25
PLT08-05	Mainstem	0.35	0.27	0.26	0.25

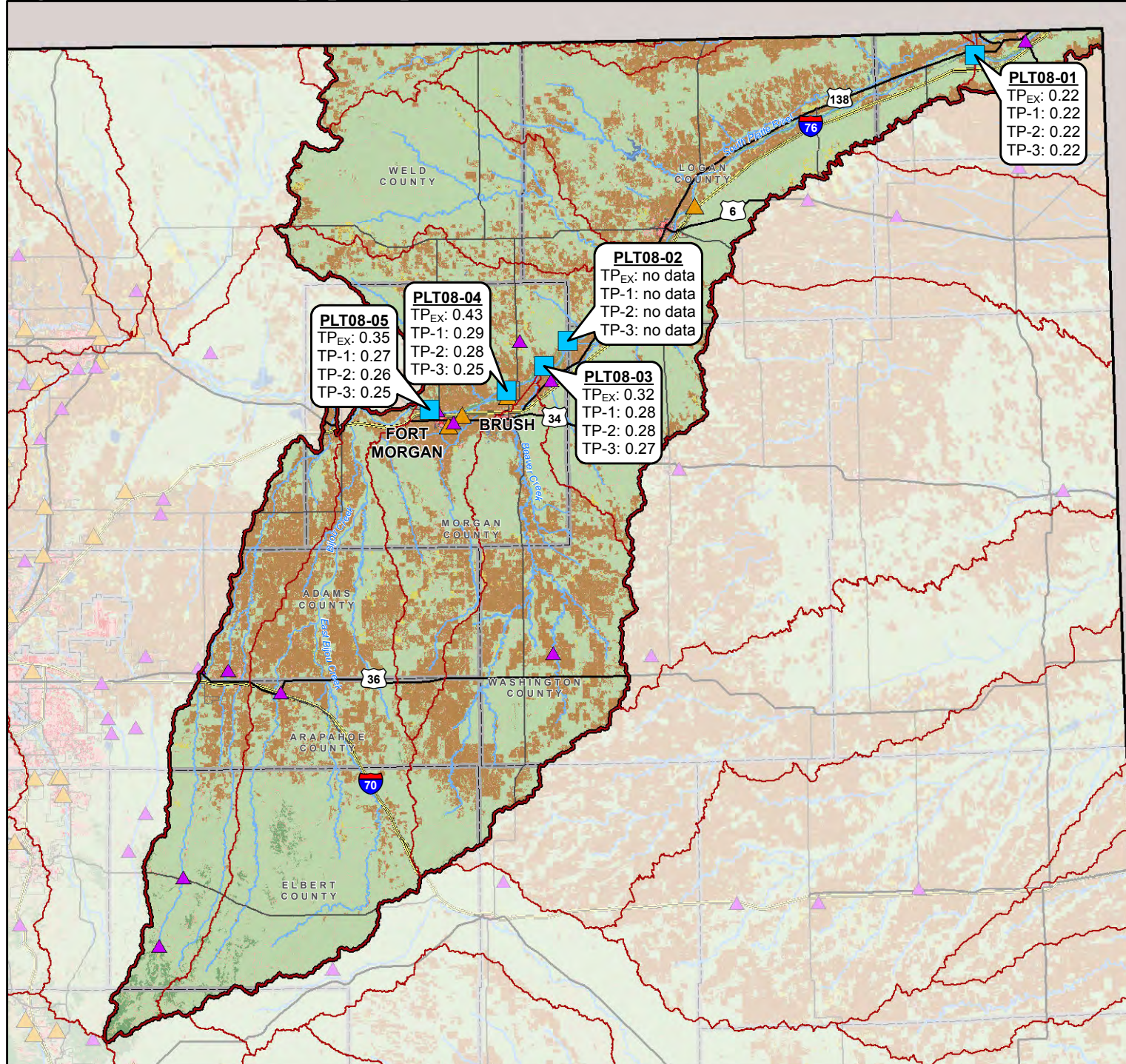
Table 4-155. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in PLT_08

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
PLT08-01	Mainstem	no data	n/a	n/a	n/a
PLT08-02	Mainstem	5.10	2.69	2.10	0.68
PLT08-03	Mainstem	4.03	2.18	1.72	0.63
PLT08-04	Mainstem	no data	n/a	n/a	n/a
PLT08-05	Mainstem	no data	n/a	n/a	n/a

Reservoirs

There are no modeled reservoirs within the PLT_08 Manageable Unit.

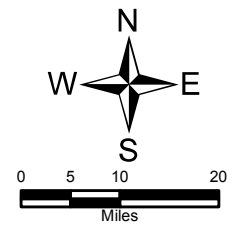




Total Phosphorus (TP)
 TP_{Ex} – Existing Median Concentration (mg/L)
 TP-1 – Estimated Concentration (Tier 1)
 TP-2 – Estimated Concentration (Tier 2)
 TP-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- ~ Stream / River
- HUC8 Boundary
- Municipality
- County Boundary

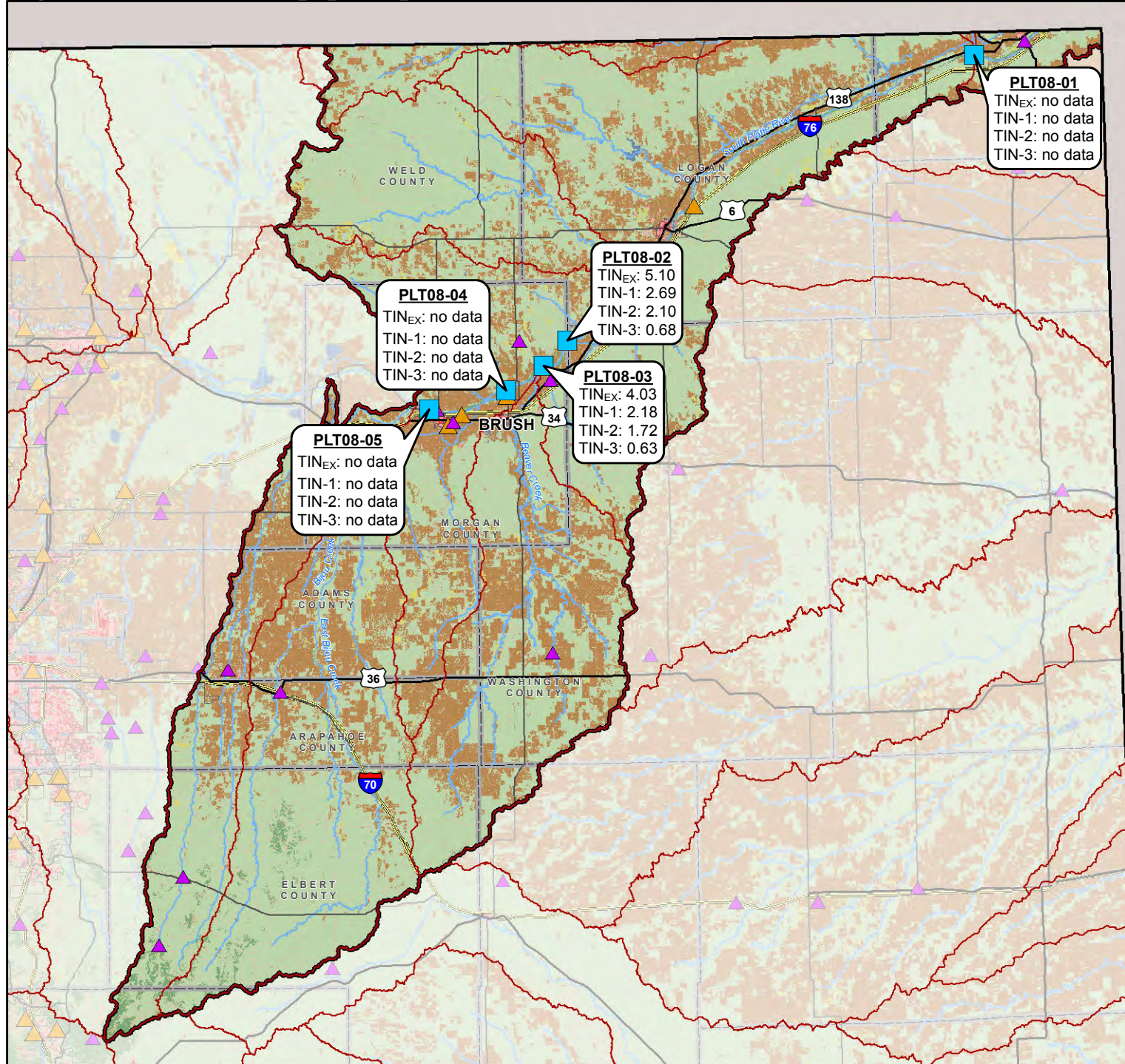
- NCLD 2006 Landcover**
- | | |
|--|---|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



Colorado Nutrient Cost/Benefit Study

**Figure 4-68
 PLT_08**

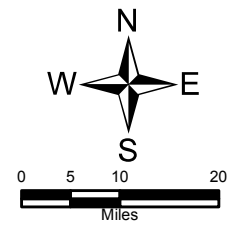




Total Inorganic Nitrogen (TIN)
 TIN_{Ex} – Existing Median Concentration (mg/L)
 TIN-1 – Estimated Concentration (Tier 1)
 TIN-2 – Estimated Concentration (Tier 2)
 TIN-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- ~ Stream / River
- HUC8 Boundary
- + Municipality
- County Boundary

- NCLD 2006 Landcover**
- | | |
|--|---|
| ■ Water / Ice | ■ Forest |
| ■ Developed - Low Intensity / Open Space | ■ Scrub |
| ■ Developed - Medium / High Intensity | ■ Grass |
| ■ Barren Land | ■ Pasture |
| | ■ Crops |



Colorado Nutrient Cost/Benefit Study

**Figure 4-69
 PLT_08**



4.4.11.2 Wastewater Costs

Table 4-156 summarizes the WWTFs located in PLT_08 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-156: WWTFs in PLT_08

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Cargill Meat Solutions	Ft Morgan Beef Plant	1.68	>1 to 3	1	Treatment plant category assumed
Woodlin School District R-104		0.007984	0-0.5	4	Exempt due to capacity
Morgan Heights WSD		0.064	0-0.5	1	Exempt due to capacity
Leprino Foods Company	Ft Morgan Cheese Factory	0.45	0-0.5	1	Exempt due to capacity
Elbert WSD		No Data	No Data	0	Exempt due to capacity
Brush, City of		1.66	>1 to 3	2	
Fort Morgan, City of		2.25	>1 to 3	2	
Ovid, Town of		0.4999	0-0.5	4	Exempt due to capacity
Julesburg, Town of		0.283	0-0.5	2	Exempt: disadvantaged
Sterling, City of		2.68	>1 to 3	4	
Snyder Sanitation District		0.018	0-0.5	4	Exempt due to capacity
Hillrose, Town of		0.049999	0-0.5	4	Exempt due to capacity
Byers WSD		0.499999	0-0.5	4	Exempt due to capacity
Kiowa, Town of	Kiowa WWTF	0.079	0-0.5	4	Exempt due to capacity
Eastern Adams County Metropolitan District		0.499999	0-0.5	5	Exempt due to capacity

Table 4-157 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-158 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-158 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-157. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$46,727,000	\$55,557,000	\$351,250,000
Annual Operation & Maintenance Costs	\$1,574,000	\$1,869,000	\$6,579,000

Costs rounded to nearest \$1000.

Table 4-158. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$15,868,000	\$20,452,000	\$110,359,000
Annual Operation & Maintenance Costs	\$587,000	\$921,000	\$3,717,000

Costs rounded to nearest \$1000.

4.4.11.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The City of Sterling was included in the analysis for PLT_08. The avoided costs are included in Table 4-159.

4.4.11.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in PLT_08, in present value (2010), are presented in Table 4-159.

Table 4-159. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU PLT_08

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$42,101,000	\$50,057,000	\$316,477,000
Operating	\$24,426,000	\$29,001,000	\$102,065,000
Total	\$66,527,000	\$79,058,000	\$418,542,000
Potable Water Supply Benefits			
Capital	\$284,000	\$284,000	\$284,000
Operating	\$1,035,000	\$1,035,000	\$1,035,000
Total	\$1,319,000	\$1,319,000	\$1,319,000
Percent Change in Water Quality (streams)			
	19.00%	30.89%	43.29%
Percent Change in Water Quality (reservoirs)			
	n/a	n/a	n/a
Projected Active Benefits			
Angling	\$2,228,000	\$3,622,000	\$5,077,000
Boating	\$5,696,000	\$9,261,000	\$12,980,000
Swimming	\$1,608,000	\$2,614,000	\$3,663,000
Total	\$9,532,000	\$15,497,000	\$21,720,000
Property Value Benefits			
	n/a	n/a	n/a
Passive Benefits	\$26,344,000	\$41,528,000	\$59,496,000
Total Quantified Benefits	\$37,195,000	\$58,344,000	\$82,535,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.4.11.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in PLT_08 are -\$29,332,000 for Tier 1, -\$20,715,000 for Tier 2, and -\$336,007,000 for Tier 3. The benefit-cost ratio is 0.56:1, 0.74:1, and 0.2:1 for Tiers 1, 2, and 3, respectively (Table 4-160).

Table 4-160. Benefit Cost Summary for MU PLT_08, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$37,195,000	\$58,344,000	\$82,535,000
Total Costs	\$66,527,000	\$79,058,000	\$418,542,000
Net Present Value Benefits	(\$29,332,000)	(\$20,715,000)	(\$336,007,000)
Benefit Cost Ratio	0.56 : 1	0.74 : 1	0.2 : 1

4.4.12 PLT_09 – Arikaree/Republican River Basin

PLT_09 is comprised of 10 HUC-8 watersheds and includes the Arikaree River, North, and South Forks of the Republican River, Smoky Hill Headwaters, and several other sub-basins in the northeastern portion of Colorado. Figure 4-70 illustrates the area covered by PLT_09 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, public water supply reservoirs, and water quality locations. All of the WWTFs in the PLT_09 Manageable Unit are exempt from the proposed regulations. Therefore, no water quality modeling of streams and rivers was performed for this Manageable Unit. The following sections provide general summary information for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.4.12.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for all facilities within the PLT_09 Manageable Unit, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

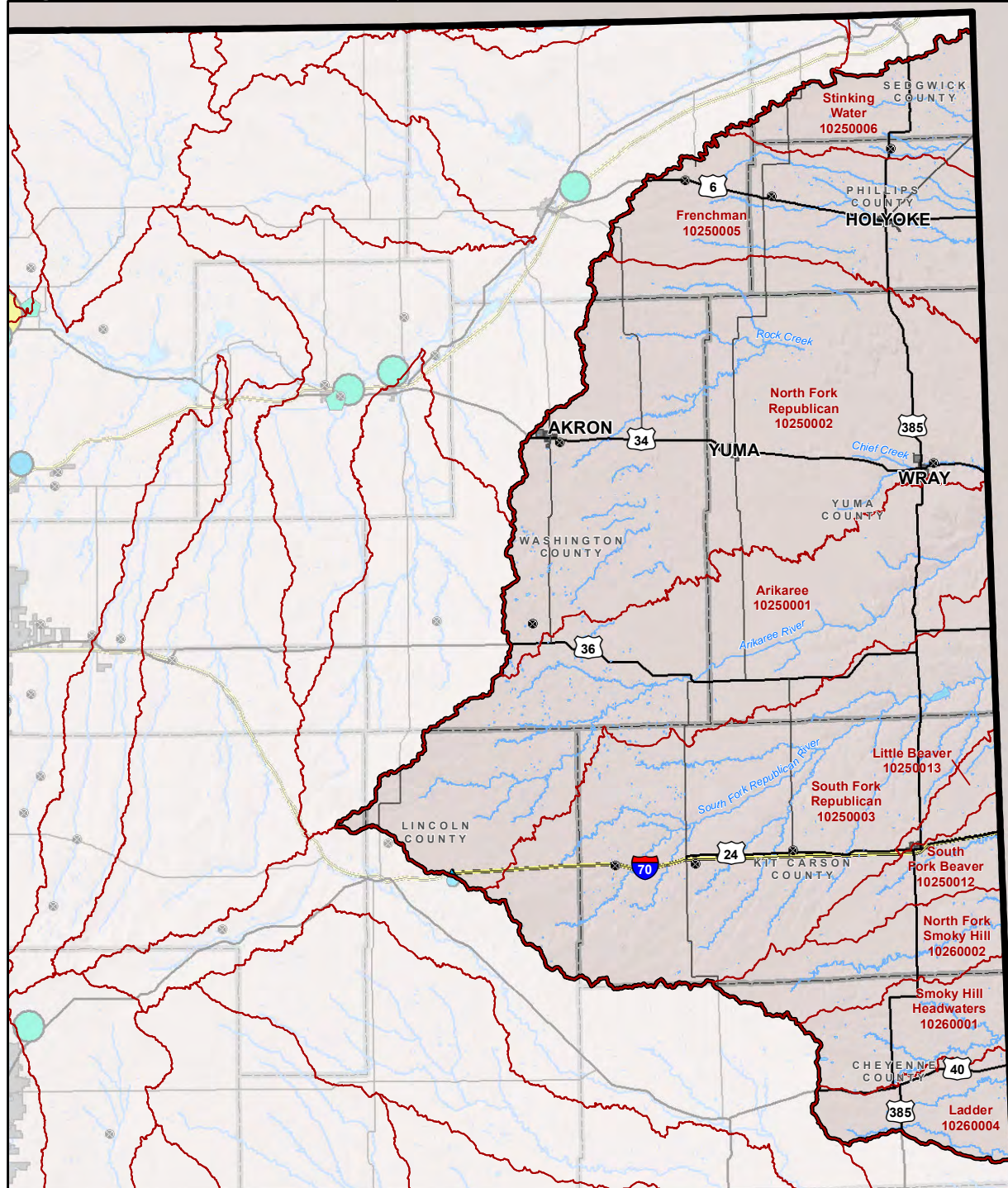
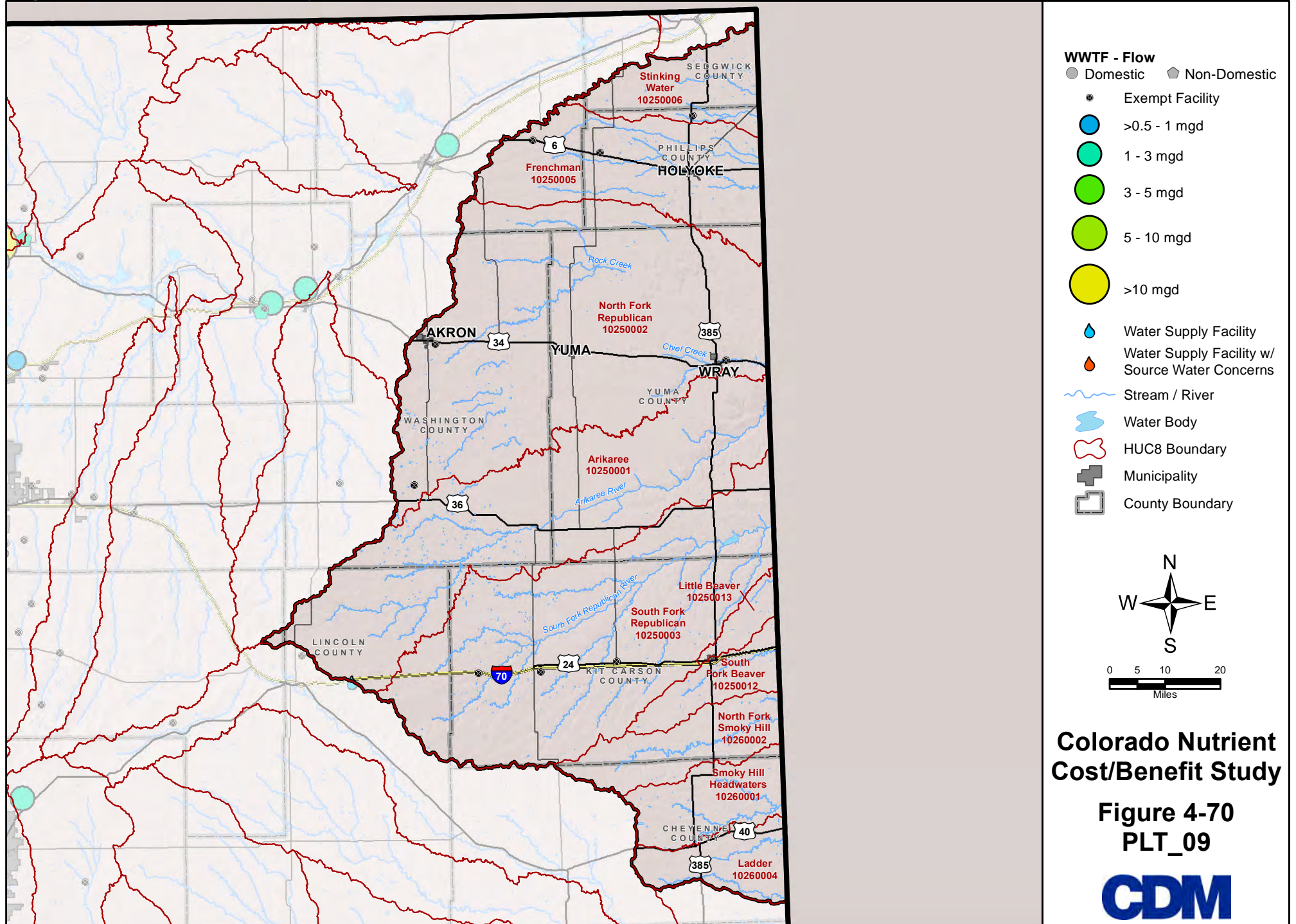
Existing median TP and TIN concentrations for this Manageable Unit are presented in Table 4-161 (see Figure 4-71 for location of water quality sample sites). No water quality modeling was performed in this Manageable Unit; therefore, there are no expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits.

Table 4-161. Observed TP (mg/L) and TIN (mg/L) Concentrations in PLT_09

Site ID	Stream Name	Existing TP Median Concentration (mg/L)	Existing TIN Median Concentration (mg/L)
PLT09-01	South Fork Republican River	0.0128	0.38
PLT09-02	South Fork Republican River	0.08	1.38
PLT09-03	Black Wolf Creek	0.078	1.065
PLT09-04	Arikaree River	0.03	0.1
PLT09-05	Arikaree River	0.02	n/a
PLT09-06	Chief Creek	0.0200	0.75
PLT09-07	Chief Creek	0.02665	n/a
PLT09-08	North Fork Republican River	0.028	1.31

Reservoirs

There are no modeled reservoirs within the PLT_09 Manageable Unit.



4.4.12.2 Wastewater Costs

Table 4-162 summarizes the WWTFs located in PLT_09 along with their permitted capacity, flow bin, and treatment plant category. All facilities are exempted from Regulation #85 as noted (see Table 2-1).

Table 4-162. WWTFs in PLT_09

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Fleming, Town of		0.039392	0-0.5	1	Exempt due to capacity
Seibert, Town of		0.049999	0-0.5	4	Exempt due to capacity
Arriba, Town of		0.049999	0-0.5	4	Exempt due to capacity
Stratton, Town of		0.099	0-0.5	4	Exempt due to capacity
Flagler, Town of		0.099999	0-0.5	4	Exempt due to capacity and disadvantaged
Haxtun, Town of		0.099999	0-0.5	4	Exempt due to capacity and disadvantaged
Wray, City of		0.35	0-0.5	4	Exempt due to capacity and disadvantaged
Holyoke, City of		0.499999	0-0.5	4	Exempt due to capacity
Akron, Town of		0.499999	0-0.5	4	Exempt due to capacity and disadvantaged

Table 4-163 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-163 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-163. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$19,429,000	\$21,563,000	\$100,959,000
Operation & Maintenance Costs	\$1,184,000	\$1,239,000	\$3,964,000

Costs rounded to nearest \$1000.

4.4.12.3 Public Water Supply Facilities

No facilities were analyzed within this Manageable Unit.

4.4.12.4 Recreational and Environmental Benefits

There are no quantified costs and benefits of the proposed regulation in PLT_09.

4.4.12.5 Benefit-Cost Ratio

There are no net present value benefits of the proposed Regulation in PLT_09.

4.5 Rio Grande River Basin

This section provides the findings applicable to the two Manageable Units established for the Rio Grande River Basin (see Manageable Unit delineation in Section 3.2 along with Figures 3-1 through 3-8).

4.5.1 RIO_01 – Rio Grande River

RIO_01 is comprised of 7 HUC-8 basins and contains the entire Rio Grande River drainage within Colorado. Figure 4-72 illustrates the area covered by RIO_01 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.5.1.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-164 and 4-165 (see Figure 4-71 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-164; Figure 4-72) and for TIN (Table 4-165; Figure 4-73). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-164. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in RIO_01

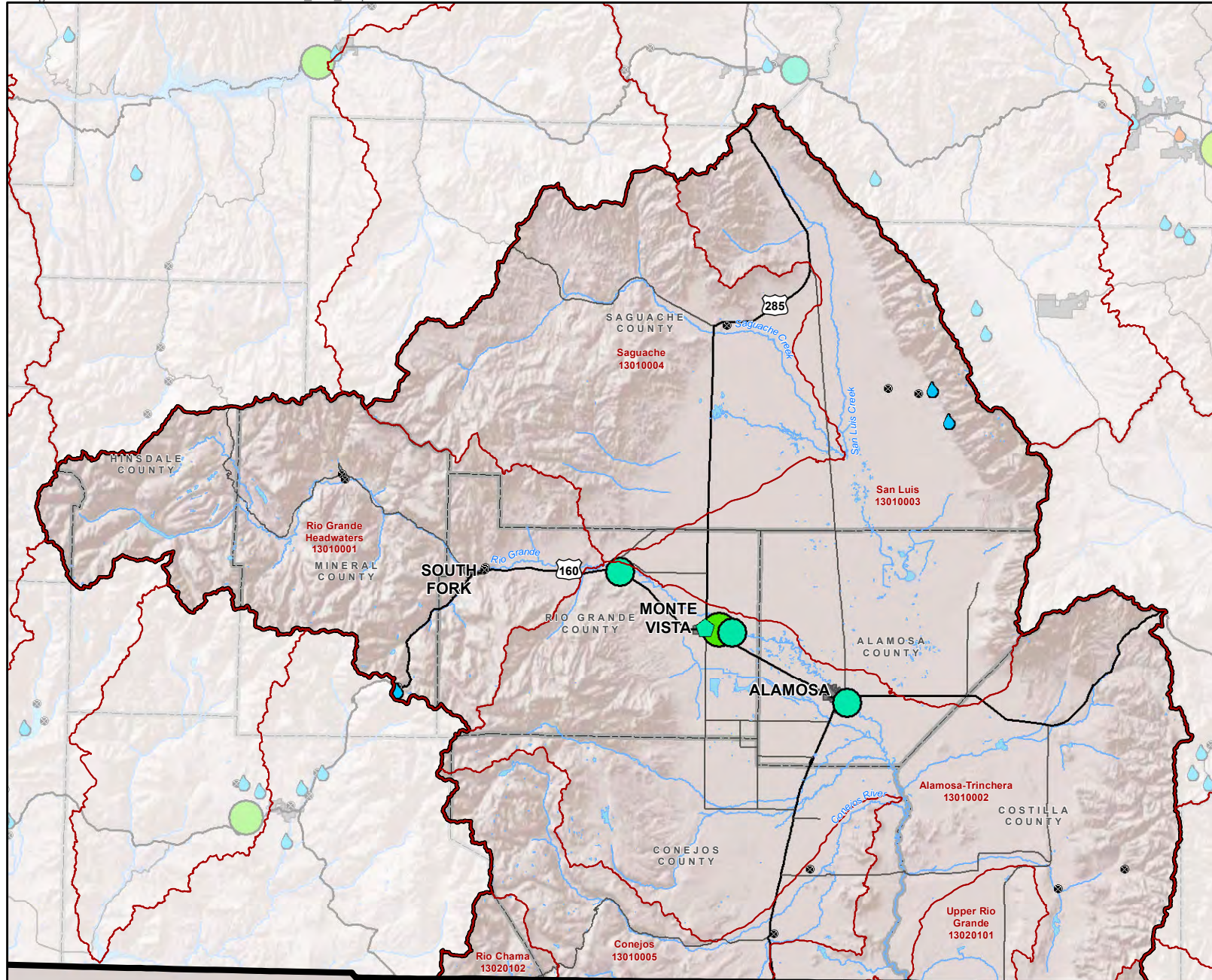
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
RIO - 1.1	Mainstem	0.08	0.07	0.07	0.07
RIO - 1.1.1	Conejos River	0.05	0.05	0.05	0.05
RIO - 1.1.2	Culebra Creek	0.13	0.13	0.13	0.13
RIO - 1.2	Mainstem	0.07	0.07	0.07	0.07
RIO - 1.3	Mainstem	0.07	0.07	0.07	0.07
RIO - 1.4	Mainstem	0.05	0.05	0.05	0.05

Table 4-165. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in RIO_01

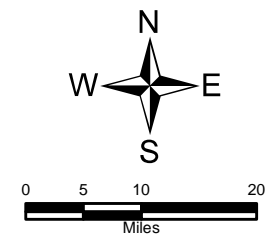
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
RIO - 1.1	Mainstem	0.35	0.25	0.23	0.19
RIO - 1.1.1	Conejos River	0.42	0.42	0.42	0.42
RIO - 1.1.2	Culebra Creek	No data	n/a	n/a	n/a
RIO - 1.2	Mainstem	0.23	0.16	0.14	0.11
RIO - 1.3	Mainstem	0.16	0.16	0.16	0.16
RIO - 1.4	Mainstem	0.10	0.10	0.10	0.10

Reservoirs

No reservoirs were analyzed in the Rio Grande River Manageable Unit.



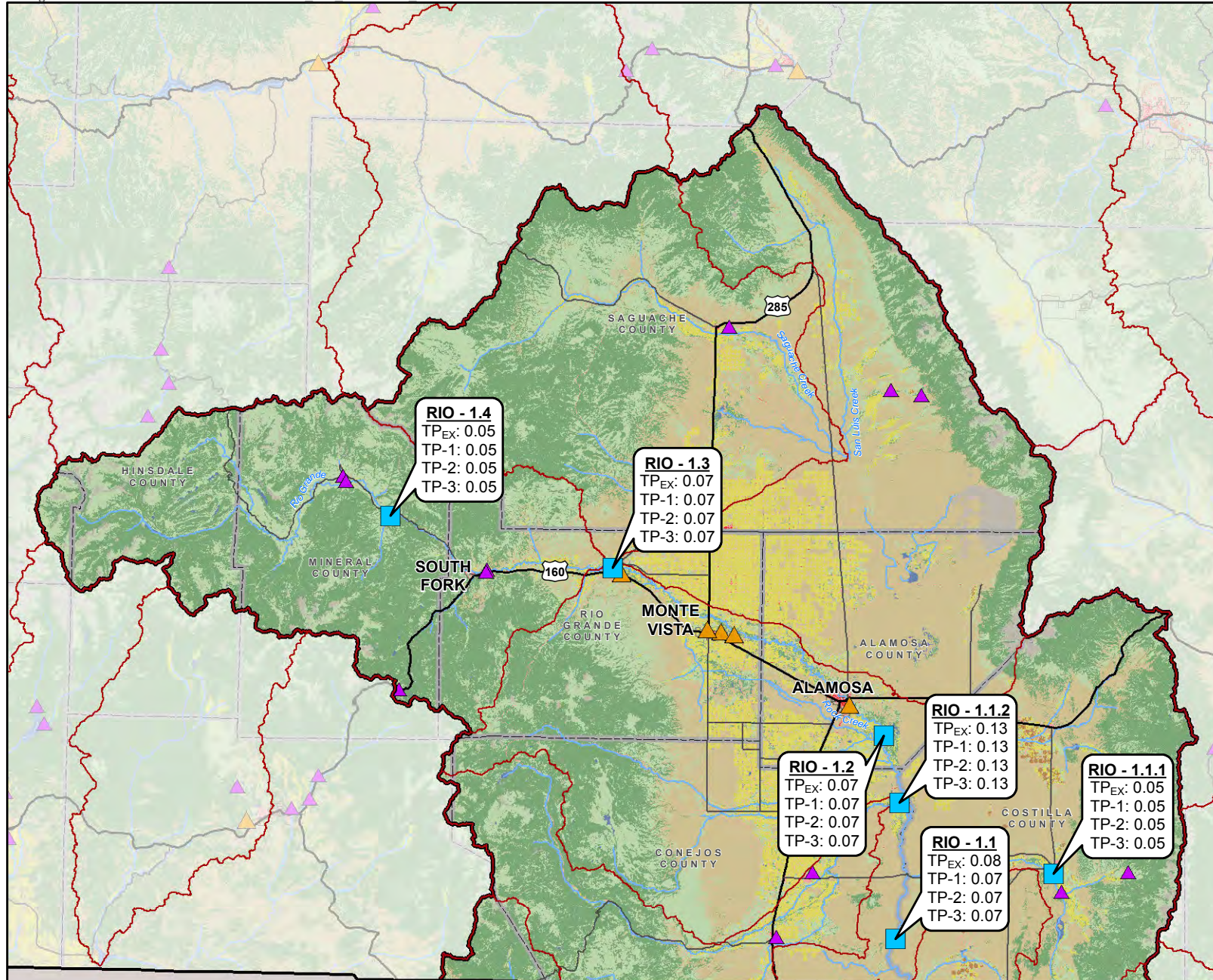
- WWTF - Flow**
- Domestic ● Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
 - Water Supply Facility
 - Water Supply Facility w/ Source Water Concerns
 - ~ Stream / River
 - ~ Water Body
 - ~ HUC8 Boundary
 - Municipality
 - County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 4-7%
RIO_01

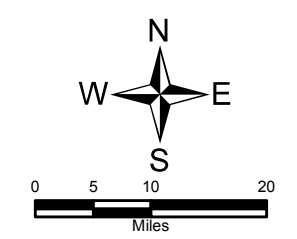




Total Phosphorus (TP)
 TP_{Ex} – Existing Median Concentration (mg/L)
 TP-1 – Estimated Concentration (Tier 1)
 TP-2 – Estimated Concentration (Tier 2)
 TP-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- ~ Stream / River
- HUC8 Boundary
- Municipality
- County Boundary

- NCLD 2006 Landcover**
- | | |
|--|---|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



Colorado Nutrient Cost/Benefit Study

Figure 4-72
RIO_01



RIO - 1.4
 TP_{Ex}: 0.05
 TP-1: 0.05
 TP-2: 0.05
 TP-3: 0.05

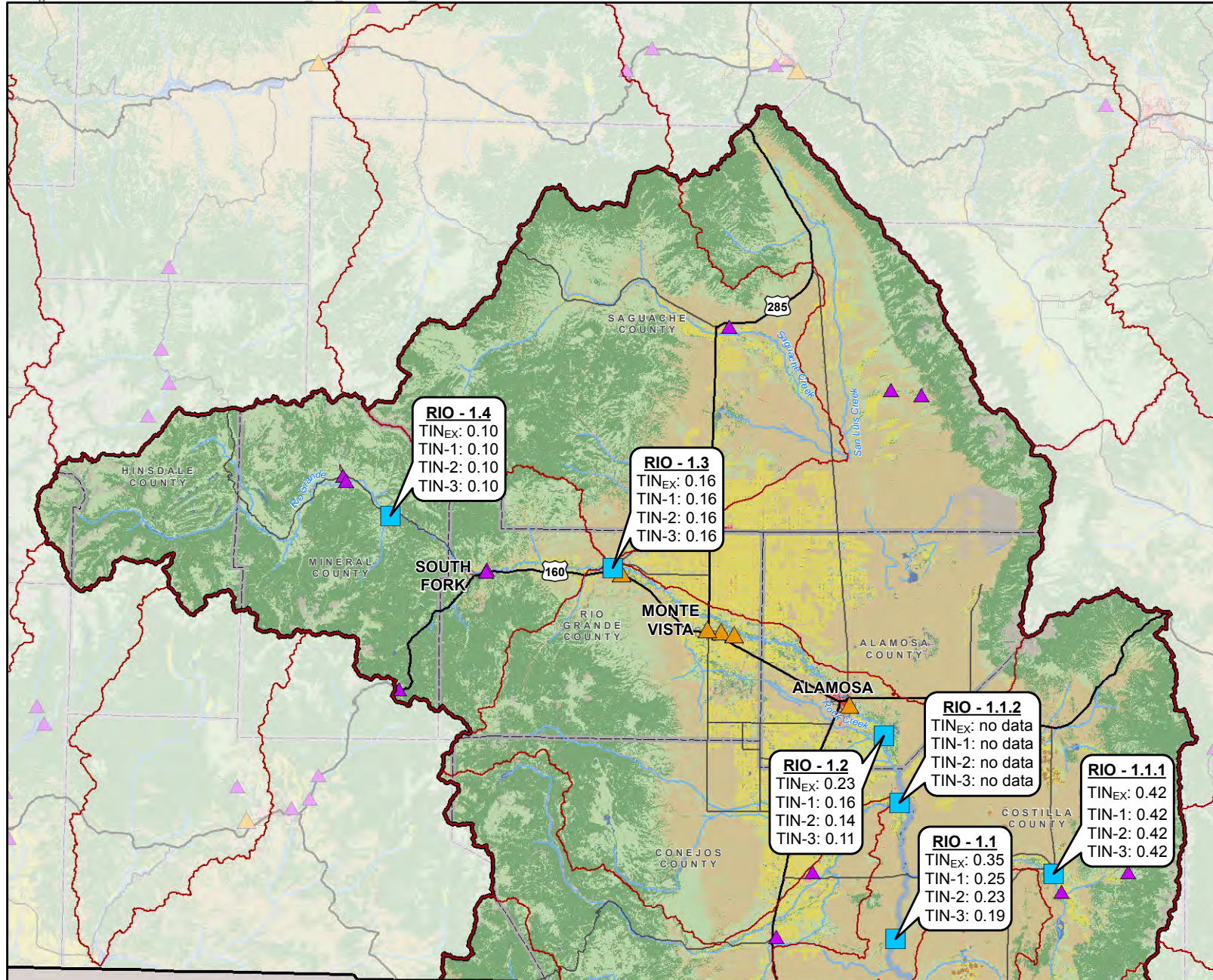
RIO - 1.3
 TP_{Ex}: 0.07
 TP-1: 0.07
 TP-2: 0.07
 TP-3: 0.07

RIO - 1.2
 TP_{Ex}: 0.07
 TP-1: 0.07
 TP-2: 0.07
 TP-3: 0.07

RIO - 1.1.2
 TP_{Ex}: 0.13
 TP-1: 0.13
 TP-2: 0.13
 TP-3: 0.13

RIO - 1.1
 TP_{Ex}: 0.08
 TP-1: 0.07
 TP-2: 0.07
 TP-3: 0.07

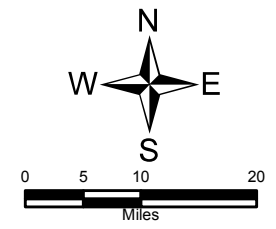
RIO - 1.1.1
 TP_{Ex}: 0.05
 TP-1: 0.05
 TP-2: 0.05
 TP-3: 0.05



Total Inorganic Nitrogen (TIN)
 TIN_{Ex} – Existing Median Concentration (mg/L)
 TIN-1 – Estimated Concentration (Tier 1)
 TIN-2 – Estimated Concentration (Tier 2)
 TIN-3 – Estimated Concentration (Tier 3)

- Water Quality Model Stations
- ▲ WWTF: Non-Exempt
- ▲ WWTF: Exempt
- Stream / River
- HUC8 Boundary
- Municipality
- County Boundary

- NCLD 2006 Landcover**
- | | |
|--|---|
| Water / Ice | Forest |
| Developed - Low Intensity / Open Space | Scrub |
| Developed - Medium / High Intensity | Grass |
| Barren Land | Pasture |
| | Crops |



RIO - 1.4
 TIN_{Ex}: 0.10
 TIN-1: 0.10
 TIN-2: 0.10
 TIN-3: 0.10

RIO - 1.3
 TIN_{Ex}: 0.16
 TIN-1: 0.16
 TIN-2: 0.16
 TIN-3: 0.16

RIO - 1.2
 TIN_{Ex}: 0.23
 TIN-1: 0.16
 TIN-2: 0.14
 TIN-3: 0.11

RIO - 1.1.2
 TIN_{Ex}: no data
 TIN-1: no data
 TIN-2: no data
 TIN-3: no data

RIO - 1.1
 TIN_{Ex}: 0.35
 TIN-1: 0.25
 TIN-2: 0.23
 TIN-3: 0.19

RIO - 1.1.1
 TIN_{Ex}: 0.42
 TIN-1: 0.42
 TIN-2: 0.42
 TIN-3: 0.42

Colorado Nutrient Cost/Benefit Study

Figure 4-73
RIO_01



4.5.1.2 Wastewater Costs

Table 4-166 summarizes the WWTFs located in RIO_01 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-166. WWTFs in RIO_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Monte Vista, City of	Veterans Center WWTF	1.96	>1 to 3	1	
Alamosa, City of	Regional WWTF	2.6	>1 to 3	1	
Grower Shipper Potato Co.	Farm Product Warehousing & Storage	1.08	>1 to 3	1	Treatment Plant Category Assumed
Mountain Views at Rivers Edge RV	Mountain Views at Rivers Edge RV RST	0.02	0-0.5	4A	Exempted due to capacity
San Luis WSD		0.499999	0-0.5	4	Exempted due to capacity
Saguache, Town of		0.499999	0-0.5	4	Exempted due to capacity
Creede, City of		0.56	>0.5 to 1	4	Exempted due to capacity and disadvantaged
Del Norte, Town of	Del Norte WWTF	1.38	>1 to 3	4	
Monte Vista, City of	Henderson Lagoon Facility	3.09	>3 to 5	4	
Baca Grande WSD	Mobile Home Estates WWTF	0.02	0-0.5	4	Exempted due to capacity
Fun Valley Resort		0.025	0-0.5	4	Exempted due to capacity
Costilla County Water and Sanitation System	Costilla County WSD	0.13	0-0.5	4	Exempted due to capacity
Antonito, Town of		0.205	0-0.5	4	Exempted due to capacity
South Fork WSD		0.3	0-0.5	4	Exempted due to capacity
Manassa, Town of		0.5	0-0.5	4	Exempted due to capacity and disadvantaged
Wolf Creek Ski Corporation		0.02	0-0.5	5	Exempted due to capacity
Baca Grande WSD	Aspen Institute WWTF	0.15	0-0.5	5	Exempted due to capacity

Table 4-167 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-168 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-168 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-167. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration, and legal)	\$42,410,000	\$63,825,000	\$422,659,000
Annual Operation & Maintenance Costs	\$1,932,000	\$2,361,000	\$7,845,000

Costs rounded to nearest \$1000.

Table 4-168. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$30,114,000	\$34,704,000	\$163,242,000
Annual Operation & Maintenance Costs	\$1,778,000	\$1,898,000	\$6,021,000

Costs rounded to nearest \$1000.

4.5.1.3 Public Water Supply Facilities

No facilities were analyzed within this Manageable Unit.

4.5.1.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in RIO_01, in present value (2010), are presented in Table 4-169.

Table 4-169. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU RIO_01

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$38,211,000	\$57,506,000	\$380,817,000
Operating	\$29,974,000	\$36,624,000	\$121,705,000
Total	\$68,185,000	\$94,130,000	\$502,522,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	9.71%	11.65%	15.78%
Percent Change in Water Quality (Lakes)			
	NA	NA	NA
Projected Active Benefits			
Angling	\$490,000	\$589,000	\$797,000
Boating	\$1,267,000	\$1,520,000	\$2,059,000
Swimming	\$626,000	\$751,000	\$1,017,000
Total	\$2,383,000	\$2,860,000	\$3,873,000
Property Value Benefits			
	NA	NA	NA
Passive Benefits			
	\$8,178,000	\$9,346,000	\$13,107,000
Total Quantified Benefits	\$10,561,000	\$12,206,000	\$16,980,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.5.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in RIO-01 are -\$57,624,000 for Tier 1, -\$81,925,000 for Tier 2, and -\$485,542,000 for Tier 3. The benefit-cost ratio is 0.15:1, 0.13:1, and 0.03:1 for Tiers 1, 2, and 3, respectively (Table 4-170).

Table 4-170. Benefit Cost Summary for MU RIO_01, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$10,561,000	\$12,206,000	\$16,980,000
Total Costs	\$68,185,000	\$94,131,000	\$502,522,000
Net Present Value Benefits	(\$57,624,000)	(\$81,925,000)	(\$485,542,000)
Benefit Cost Ratio	0.15 : 1	0.13 : 1	0.03 : 1

4.6 Southwest Basin (Dolores and San Juan Rivers)

This section provides the findings applicable to the two Manageable Units established for the Southwest Basin (see Manageable Unit delineation in Section 3.2 along with Figure 3-8).

4.6.1 SW_01 – Upper San Juan and Animas Rivers

SW_01 is comprised of 8 HUC-8 basins and both the San Juan and Animas River drainages within Colorado. Figure 4-74 illustrates the area covered by SW_01 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.6.1.1 Water Quality Analyses

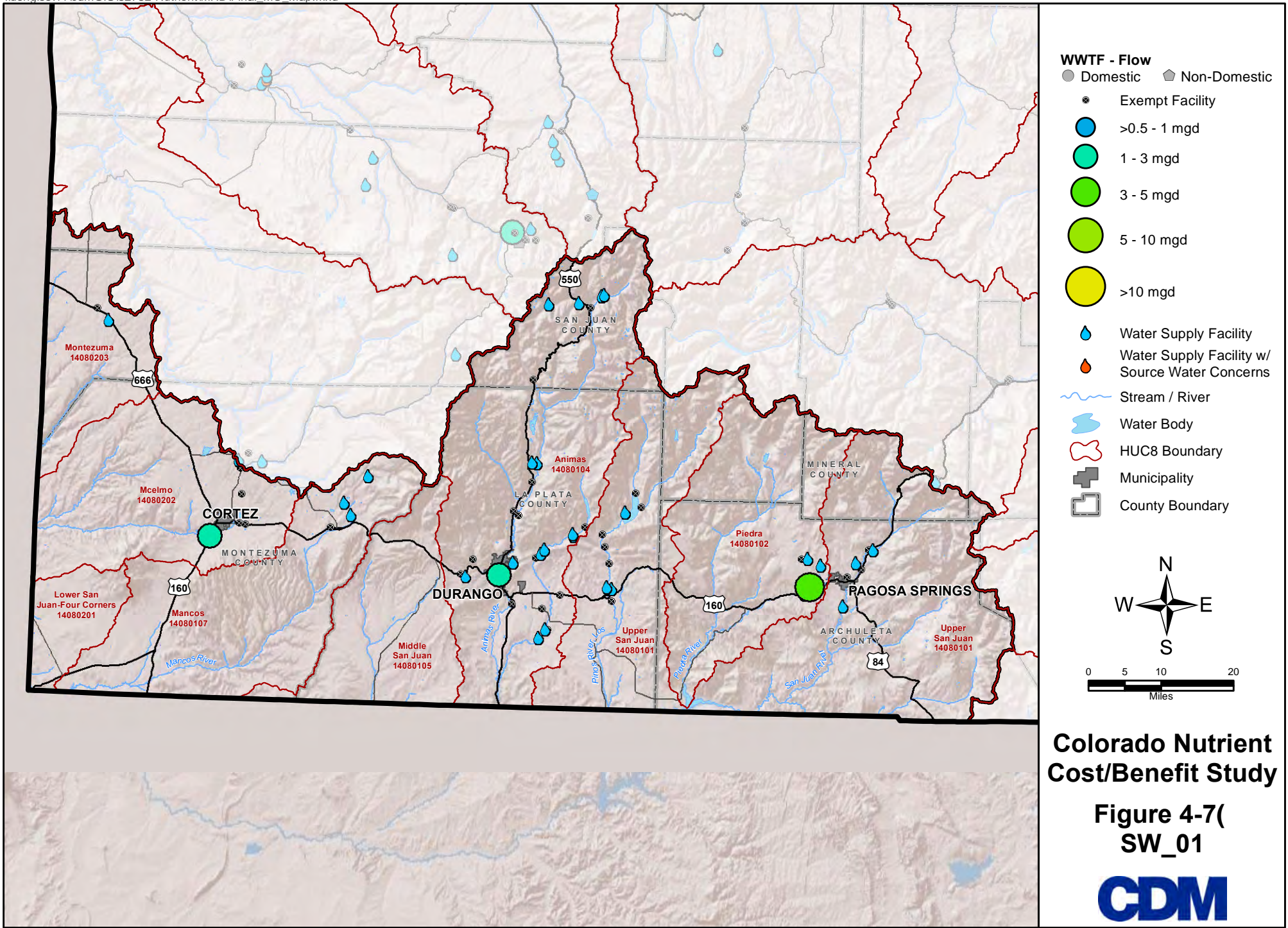
The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

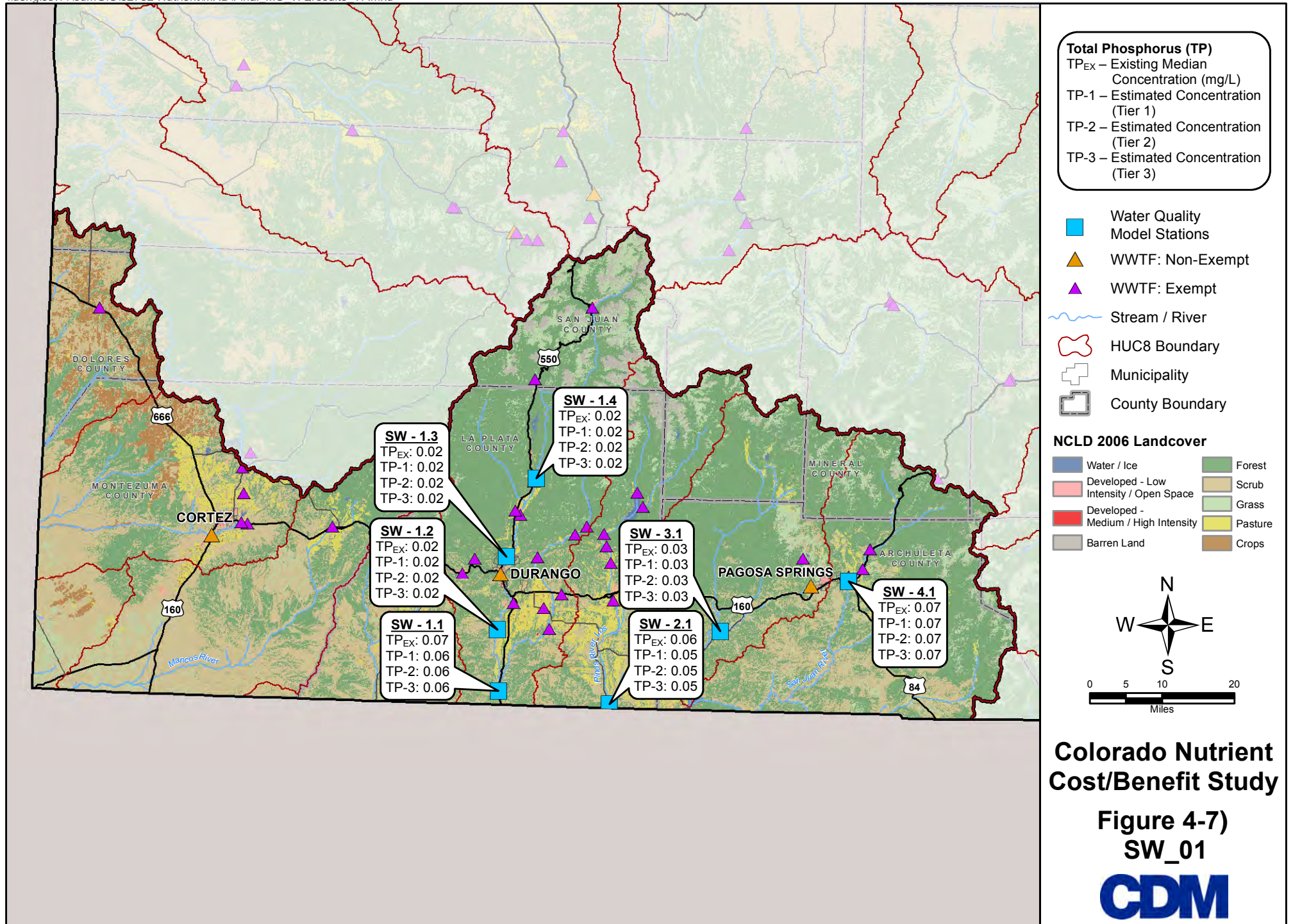
Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-171 and 4-172 (see Figure 4-74 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-171; Figure 4-75) and for TIN (Table 4-172; Figure 4-76). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-171. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in SW_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
SW - 1.1	Animas River	0.07	0.06	0.06	0.06
SW - 1.2	Animas River	0.02	0.02	0.02	0.02
SW - 1.3	Animas River	0.02	0.02	0.02	0.02
SW - 1.4	Animas River	0.02	0.02	0.02	0.02
SW - 2.1	Los Pinos River	0.06	0.05	0.05	0.05
SW - 3.1	Stollsteimer Creek	0.03	0.03	0.03	0.03
SW - 4.1	San Juan River	0.07	0.07	0.07	0.07

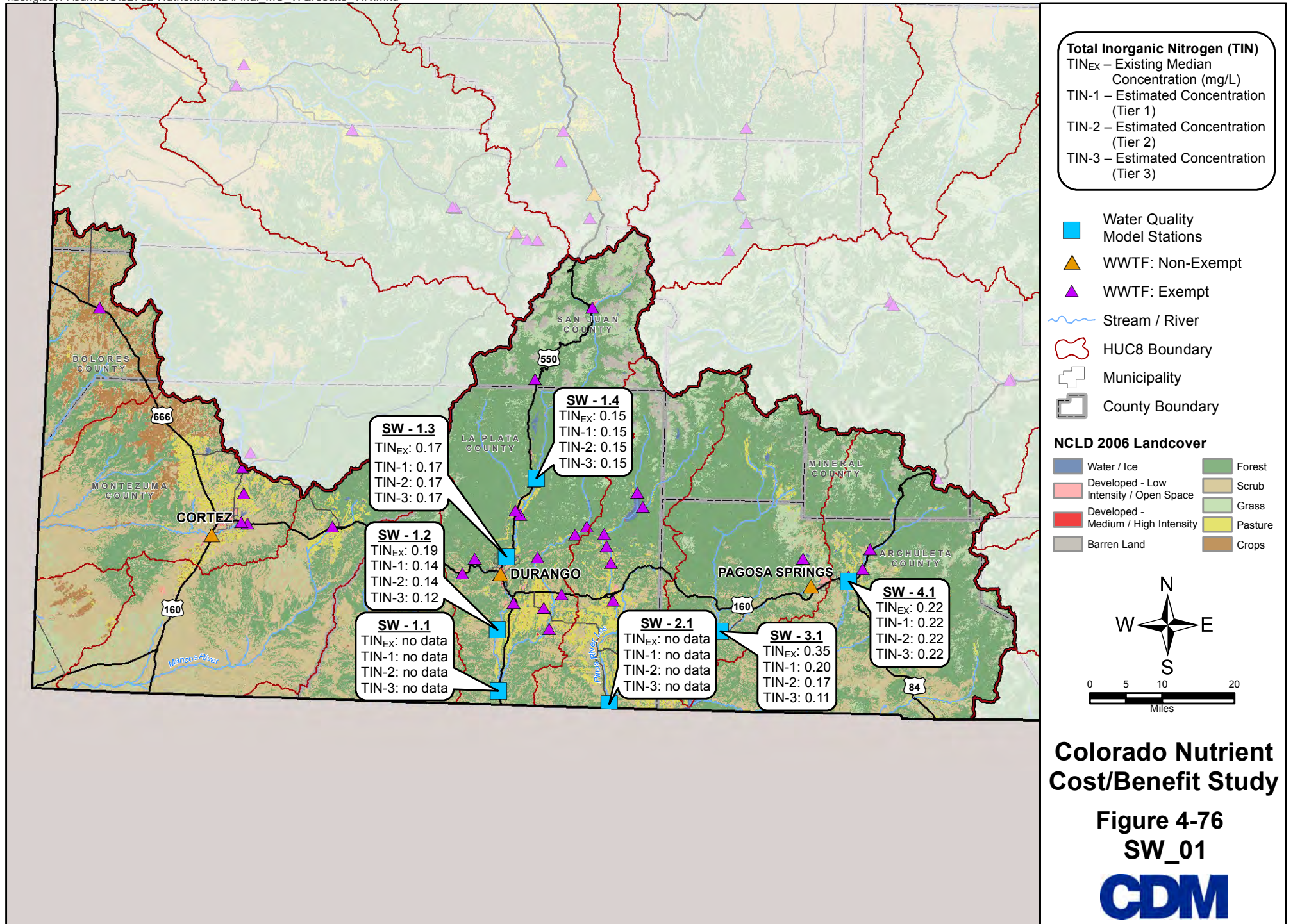




Colorado Nutrient Cost/Benefit Study

**Figure 4-7)
SW_01**





Colorado Nutrient Cost/Benefit Study

Figure 4-76
SW_01



Table 4-172. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in SW_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
SW - 1.1	Animas River	No data	n/a	n/a	n/a
SW - 1.2	Animas River	0.19	0.14	0.14	0.12
SW - 1.3	Animas River	0.17	0.17	0.17	0.17
SW - 1.4	Animas River	0.15	0.15	0.15	0.15
SW - 2.1	Los Pinos River	No data	n/a	n/a	n/a
SW - 3.1	Stollsteimer Creek	0.35	0.20	0.17	0.11
SW - 4.1	San Juan River	0.22	0.22	0.22	0.22

Reservoirs

No reservoirs were analyzed in this Manageable Unit.

4.6.1.2 Wastewater Costs

Table 4-173 summarizes the WWTFs located in SW_01 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-173: WWTFs in SW_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Cortez Sanitation District	Southwest WWTF	1.57	>1 to 3	1	
Haciendas de la FL HOA		0.004	0-0.5	1	Exempted due to capacity
Amorelli, Joe and Cheryl	Lightner Creek Campground	0.01	0-0.5	1	Exempted due to capacity
Five Branches Camper Park		0.02	0-0.5	1	Exempted due to capacity
Vista Verde Village LLC	Vista Verde Village	0.03	0-0.5	4	Exempted due to capacity
Upper Valley Sanitation		0.13	0-0.5	1	Exempted due to capacity
Durango West Metropolitan District 2		0.499	0-0.5	4	Exempted due to capacity
Dove Creek, Town of		0.499	0-0.5	4	Exempted due to capacity
Pagosa WSD		0.499999	0-0.5	4	Exempted due to capacity
Trimble Hot Springs	Trimble Hot Springs	0.03	0-0.5	1	Exempted due to capacity
Durango/La Plata Co. AP		No Data	No Data	0	Exempted due to capacity
Lakeside WWTF		No Data	No Data	0	Exempted due to capacity
Durango, City of		3	>1 to 3	2	
Pine River Camp LLC	Kanakuk CO Youth Camp	0.0205	0-0.5	4A	Exempted due to capacity
Thomas J. Feuerborn	Dolores River RV Park Cabins	0.049	0-0.5	4	Exempted due to capacity
Lee Mobile Home Park		0.049	0-0.5	4	Exempted due to capacity
Narrow Gauge MHP		0.049	0-0.5	4	Exempted due to capacity
High Country Lodge LLC	HCL Lodge WWTF	0.0054	0-0.5	4	Exempted due to capacity

Table 4-173: WWTFs in SW_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Forest Groves Estates	FGE WWTF	0.0108	0-0.5	4	Exempted due to capacity
Vallecito Resort LLC		0.0255	0-0.5	4	Exempted due to capacity
Herrick Durango Land Co	Durango N/Ponderosa KOA	0.035	0-0.5	4	Exempted due to capacity
San Juan River Village Metro		0.06725	0-0.5	4	Exempted due to capacity
Mill Creek Management Co., LLC		0.077	0-0.5	4	Exempted due to capacity
Edgemont Ranch Metropolitan District		0.1	0-0.5	4	Exempted due to capacity
Loma Linda Sanitation District	LLSD WWTF	0.125	0-0.5	4	Exempted due to capacity
Mancos, Town of		0.18	0-0.5	4	Exempted due to capacity
Forest Lake Metropolitan District		0.18	0-0.5	4	Exempted due to capacity
Hermosa Sanitation District		0.3	0-0.5	4	Exempted due to capacity
Silverton, Town of		0.42	0-0.5	4	Exempted: disadvantaged
Pagosa Springs Sanitation District		0.494	0-0.5	4	Exempted due to capacity
Bayfield Town of		0.6	>0.5 to 1	5	
S Durango San Dist		0.3	0-0.5	5	Exempted due to capacity
Pagosa Area W & San Dist	Vista WWTF	3.75	>3 to 5	6	

Table 4-174 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-175 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-175 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-174. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$39,949,000	\$67,282,000	\$381,300,000
Annual Operation & Maintenance Costs	\$1,127,000	\$1,617,000	\$6,381,000

Costs rounded to nearest \$1000.

Table 4-175. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$43,542,000	\$49,960,000	\$237,061,000
Annual Operation & Maintenance Costs	\$2,548,000	\$2,771,000	\$9,101,000

Costs rounded to nearest \$1000.

4.6.1.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. No facilities were analyzed for SW_01.

4.6.1.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in SW_01, in present value (2010), are presented in Table 4-176.

Table 4-176. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU SW_01

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$35,994,000	\$60,621,000	\$343,552,000
Operating	\$17,481,000	\$25,091,000	\$98,998,000
Total	\$53,475,000	\$85,712,000	\$442,550,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Percent Change in Water Quality (streams)			
	10.38%	10.14%	12.57%
Percent Change in Water Quality (Lakes)			
	NA	NA	NA
Projected Active Benefits			
Angling	\$721,000	\$704,000	\$873,000
Boating	\$2,052,000	\$2,004,000	\$2,484,000
Swimming	\$363,000	\$355,000	\$440,000
Total	\$3,136,000	\$3,063,000	\$3,797,000
Property Value Benefits			
	NA	NA	NA
Property Value Benefits	\$9,353,000	\$8,802,000	\$11,203,000
Property Value Benefits	\$12,489,000	\$11,865,000	\$15,000,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.6.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in SW-01 are -\$40,987,000 for Tier 1, -\$73,848,000 for Tier 2, and -\$427,551,000 for Tier 3. The benefit-cost ratio is 0.23:1, 0.14:1, and 0.03:1 for Tiers 1, 2, and 3, respectively (Table 4-177).

Table 4-177. Benefit Cost Summary for MU SW_01, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$12,488,000	\$11,865,000	\$14,999,000
Total Costs	\$53,475,000	\$85,713,000	\$442,551,000
Net Present Value Benefits	(\$40,987,000)	(\$73,848,000)	(\$427,551,000)
Benefit Cost Ratio	0.23 : 1	0.14 : 1	0.03 : 1

4.6.2 SW_02 – Dolores and San Miguel Rivers

SW_02 is comprised of 5 HUC-8 basins and both the Dolores and San Miguel drainages within Colorado. Figure 4-77 illustrates the area covered by SW_02 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.6.2.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-178 and 4-179 (see Figure 4-77 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-178; Figure 4-78) and for TIN (Table 4-179; Figure 4-79). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-178. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in SW_02

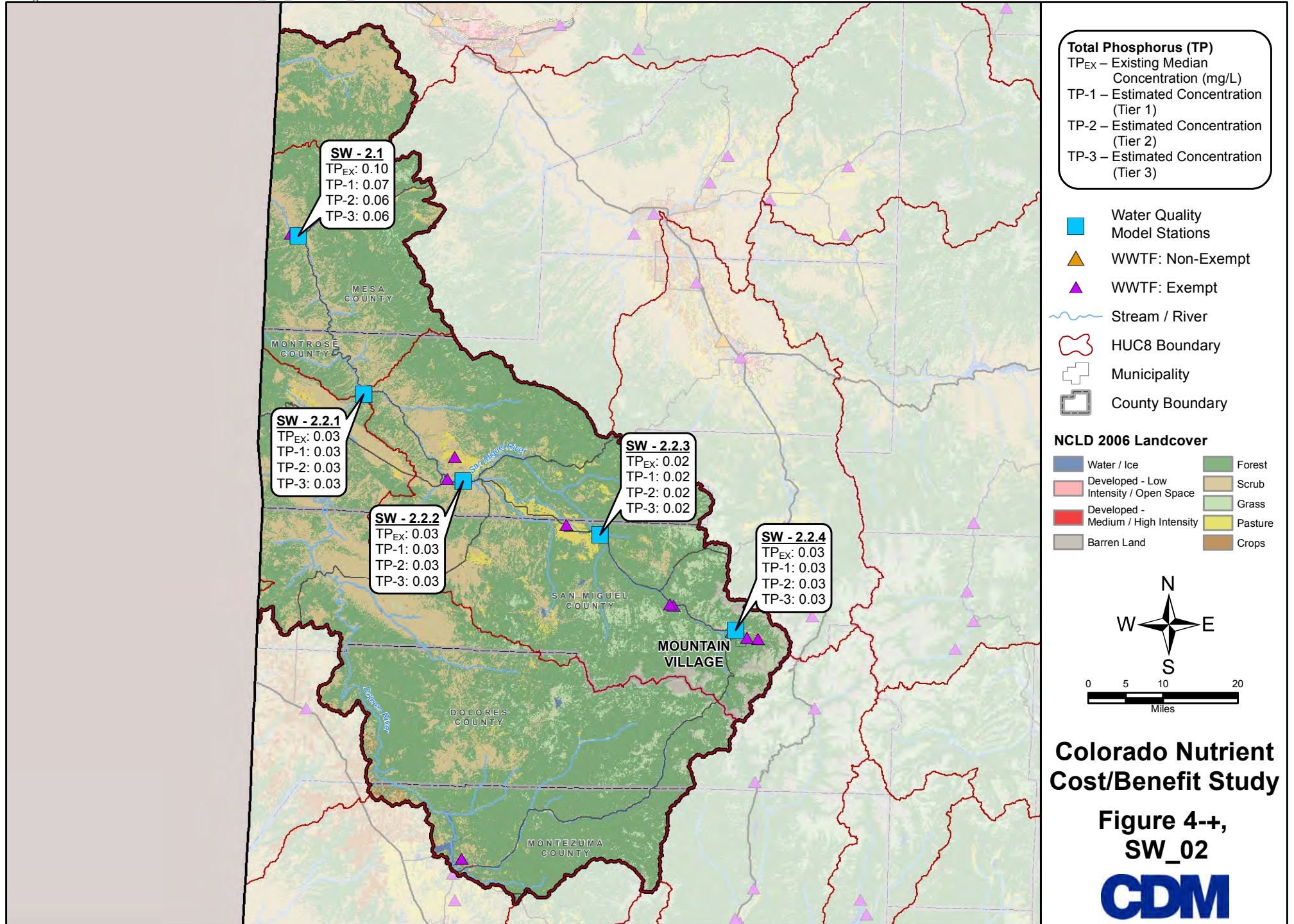
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
SW - 2.1	Mainstem	0.10	0.07	0.06	0.06
SW - 2.2.1	Mainstem	0.03	0.03	0.03	0.03
SW - 2.2.2	Mainstem	0.03	0.03	0.03	0.03
SW - 2.2.3	Mainstem	0.02	0.02	0.02	0.02
SW - 2.2.4	Mainstem	0.03	0.03	0.03	0.03

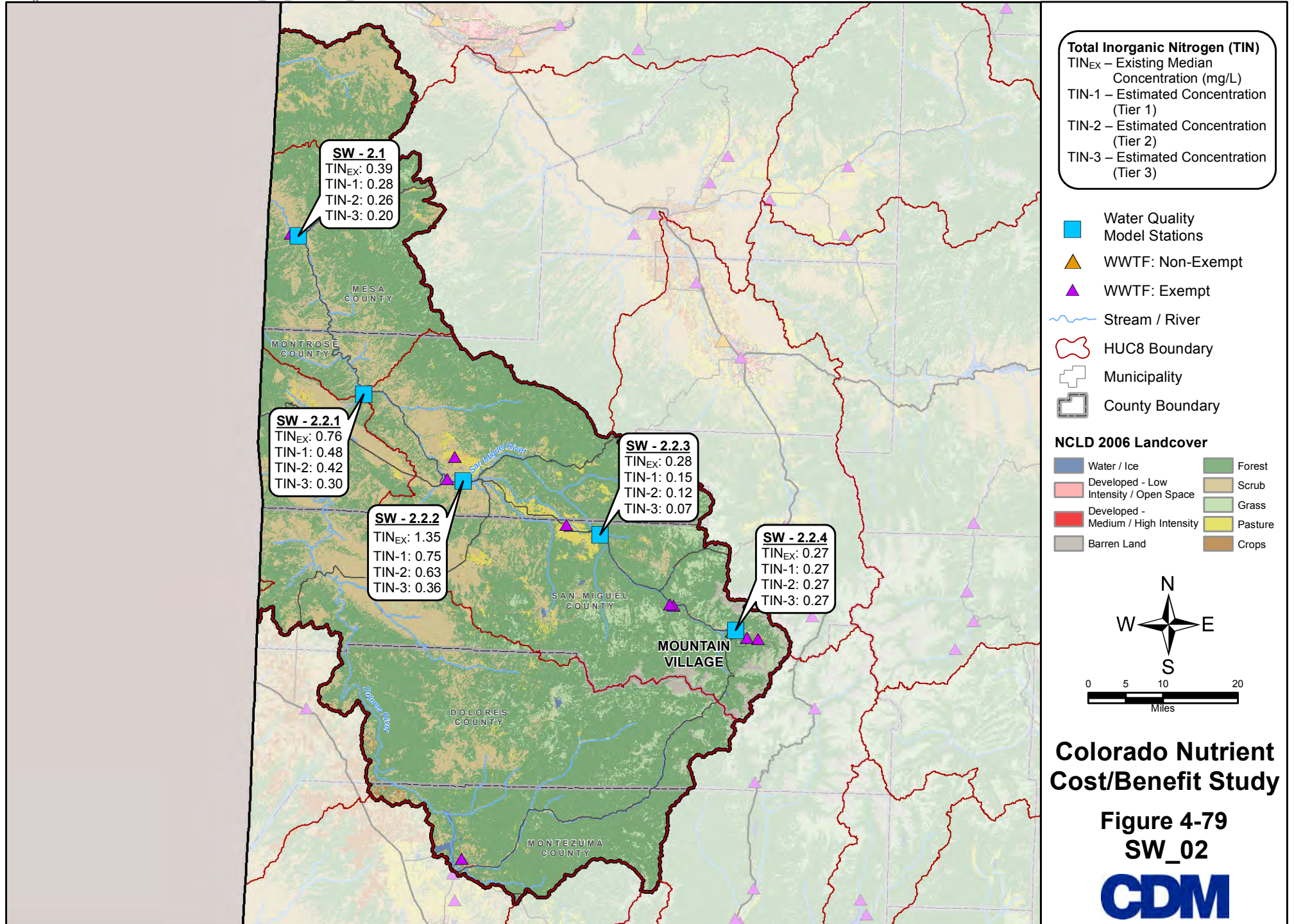
Table 4-179. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in SW_02

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
SW - 2.1	Mainstem	0.39	0.28	0.26	0.20
SW - 2.2.1	Mainstem	0.76	0.48	0.42	0.30
SW - 2.2.2	Mainstem	1.35	0.75	0.63	0.36
SW - 2.2.3	Mainstem	0.28	0.15	0.12	0.07
SW - 2.2.4	Mainstem	0.27	0.27	0.27	0.27

Reservoirs

No reservoirs were analyzed in this Manageable Unit.





4.6.2.2 Wastewater Costs

Table 4-180 summarizes the WWTFs located in SW_02 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-180. WWTFs in SW_02

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Southwest Mesa County Rural PID		0.049999	0-0.5	4	Exempted due to capacity
Norwood Sanitation District		0.499	0-0.5	4	Exempted due to capacity
Fall Creek HOA		0.00315	0-0.5	1	Exempted due to capacity
Blue Jay Lodge & Cafe		0.0053	0-0.5	4A	Exempted due to capacity
St. Barnabas Church Camp		0.0055	0-0.5	4A	Exempted due to capacity
Last Dollar PUD Imps. Assoc.		0.032	0-0.5	1	Exempted due to capacity
Telecam Partnership II Ltd.	Lawson Hill PUD Illium Vly WWTF	0.035	0-0.5	1	Exempted due to capacity
Nucla, Town of	Nucla WWTF	0.19	0-0.5	4	Exempted due to capacity
Naturita, Town of		0.2	0-0.5	4	Exempted due to capacity
Dolores, Town of		0.47	0-0.5	4	Exempted due to capacity
Telluride	Regional WWTF	2.1	>1 to 3	6	

Table 4-181 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-182 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-182 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-181. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$7,360,000	\$9,077,000	\$85,865,000
Operation & Maintenance Costs	\$229,000	\$309,000	\$1,472,000

Costs rounded to nearest \$1000.

Table 4-182. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$15,910,000	\$17,672,000	\$83,900,000
Operation & Maintenance Costs	\$964,000	\$1,017,000	\$3,280,000

Costs rounded to nearest \$1000.

4.6.2.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The Tri-State G and T Nucla Station were included in the analysis for SW_02. Avoided costs calculated for SW_02 are presented in Table 4-183.

4.6.2.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in SW_02, in present value (2010), are presented in Table 4-183.

Table 4-183. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU SW_02

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$6,632,000	\$8,179,000	\$77,364,000
Operating	\$3,550,000	\$4,800,000	\$22,837,000
Total	\$10,182,000	\$12,979,000	\$100,201,000
Potable Water Supply Benefits			
Capital	\$19,000	\$19,000	\$19,000
Operating	\$6,000	\$6,000	\$6,000
Total	\$25,000	\$25,000	\$25,000
Percent Change in Water Quality (streams)			
	9.78%	22.23%	40.00%
Percent Change in Water Quality (Reservoir)			
	NA	NA	NA
Projected Active Benefits			
Angling	\$955,000	\$2,172,000	\$3,908,000
Boating	\$25,000	\$56,000	\$101,000
Swimming	\$186,000	\$423,000	\$761,000
Total	\$1,166,000	\$2,651,000	\$4,770,000
Property Value Benefits			
	NA	NA	NA
Passive Benefits	\$8,739,000	\$18,887,000	\$35,230,000
Total Quantified Benefits	\$9,930,000	\$21,563,000	\$40,025,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.6.2.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in SW_02 are -\$251,000 for Tier 1, \$8,584,000 for Tier 2, and -\$60,176,000 for Tier 3. The benefit-cost ratio is 0.98:1, 1.66:1, and 0.4:1 for Tiers 1, 2, and 3, respectively (Table 4-184).

Table 4-184. Benefit Cost Summary for MU SW_02, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$9,930,000	\$21,563,000	\$40,025,000
Total Costs	\$10,182,000	\$12,979,000	\$100,201,000
Net Present Value Benefits	(\$251,000)	\$8,584,000	(\$60,176,000)
Benefit Cost Ratio	0.98 : 1	1.66 : 1	0.4 : 1

4.7 Yampa-White River Basin (Green River)

This section provides the findings applicable to the two Manageable Units established for the Yampa-White River Basins (see Manageable Unit delineation in Section 3.2 along with Figure 3-9).

4.7.1 GRN_01 – Yampa River

GRN_01 is comprised of 6 HUC-8 basins and contains the Yampa River from its headwaters to the state line. Figure 4-80 illustrates the area covered by GRN_01 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.7.1.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

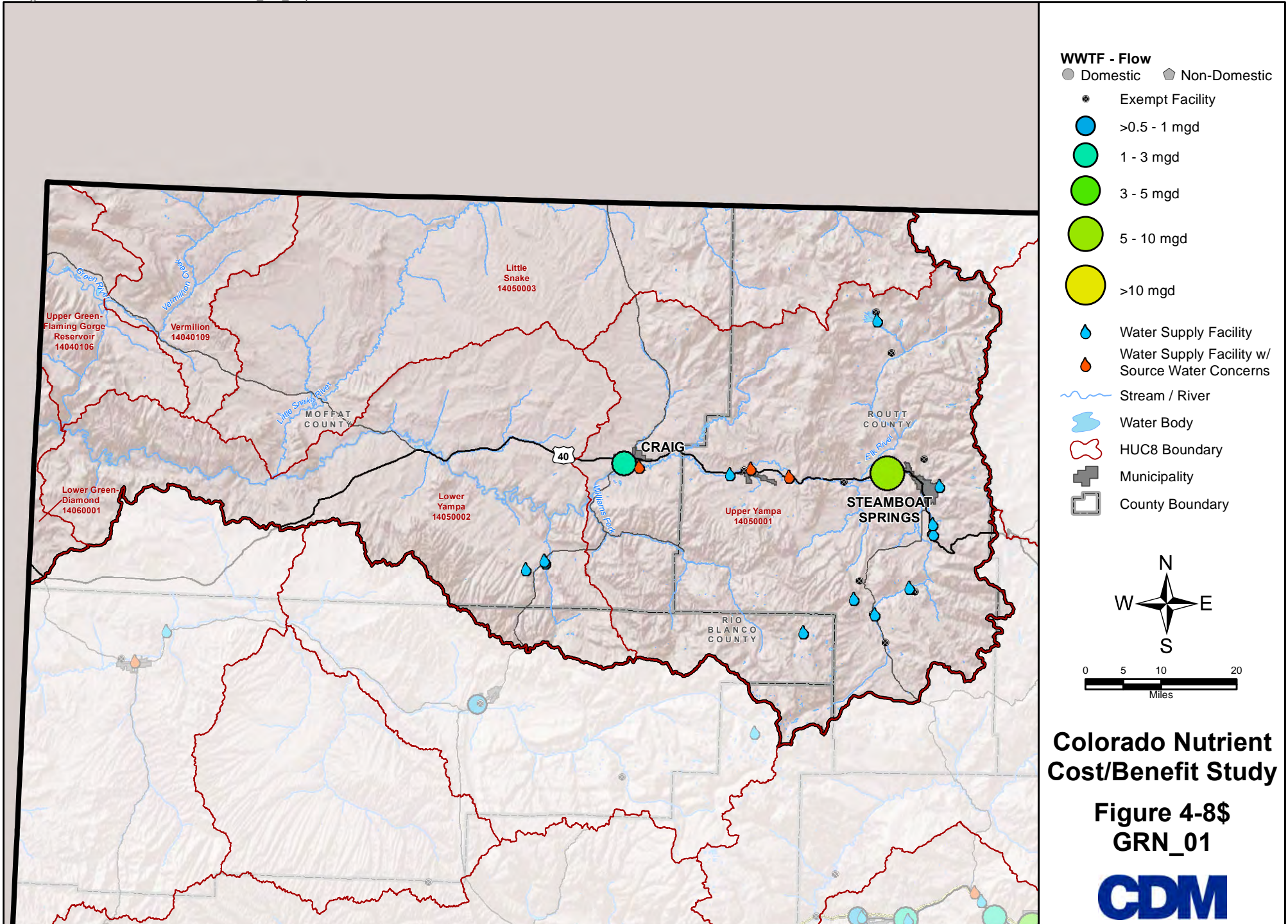
Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-185 and 4-186 (see Figure 4-80 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-185; Figure 4-81) and for TIN (Table 4-186; Figure 4-82). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

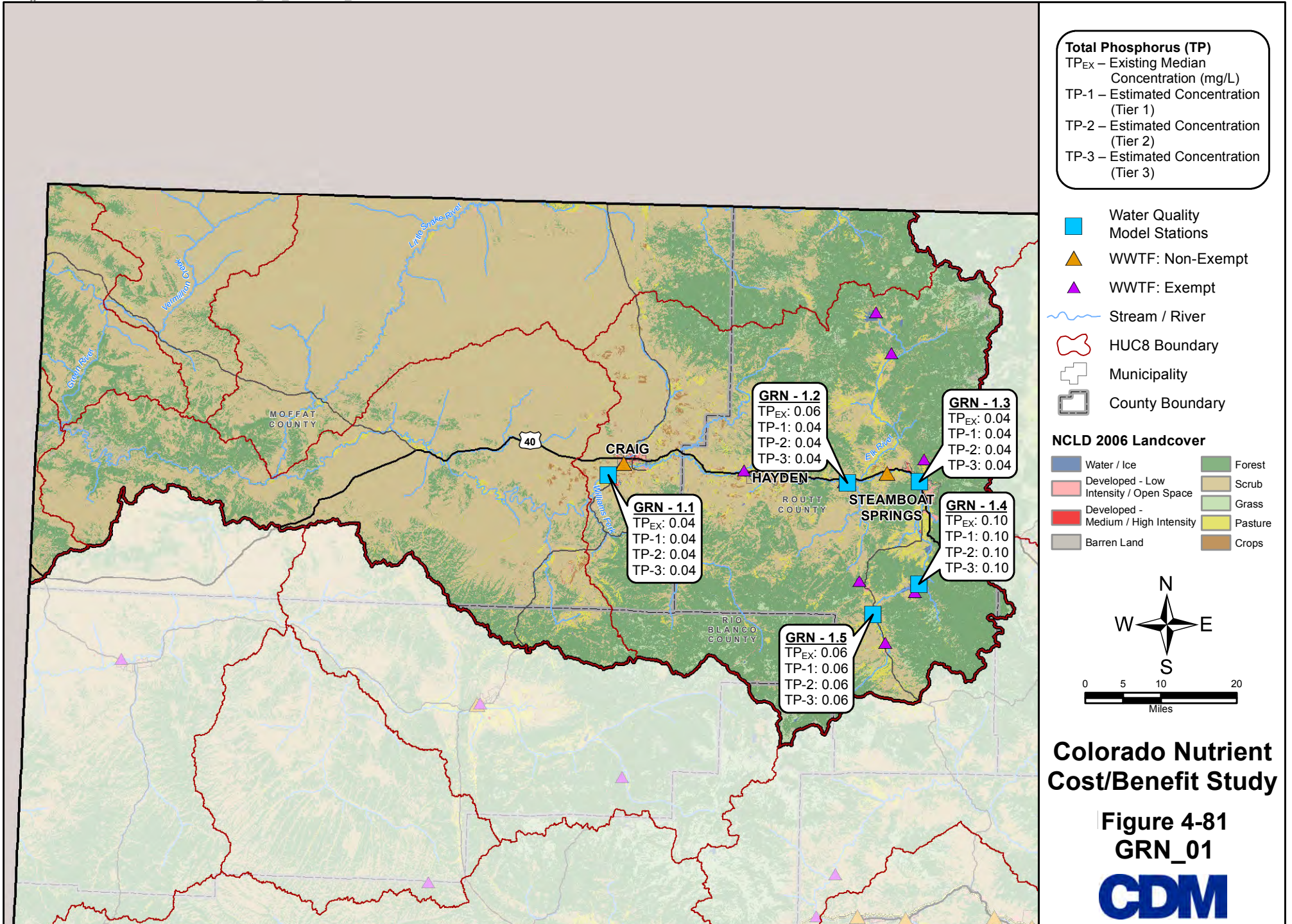
Table 4-185. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GRN_01

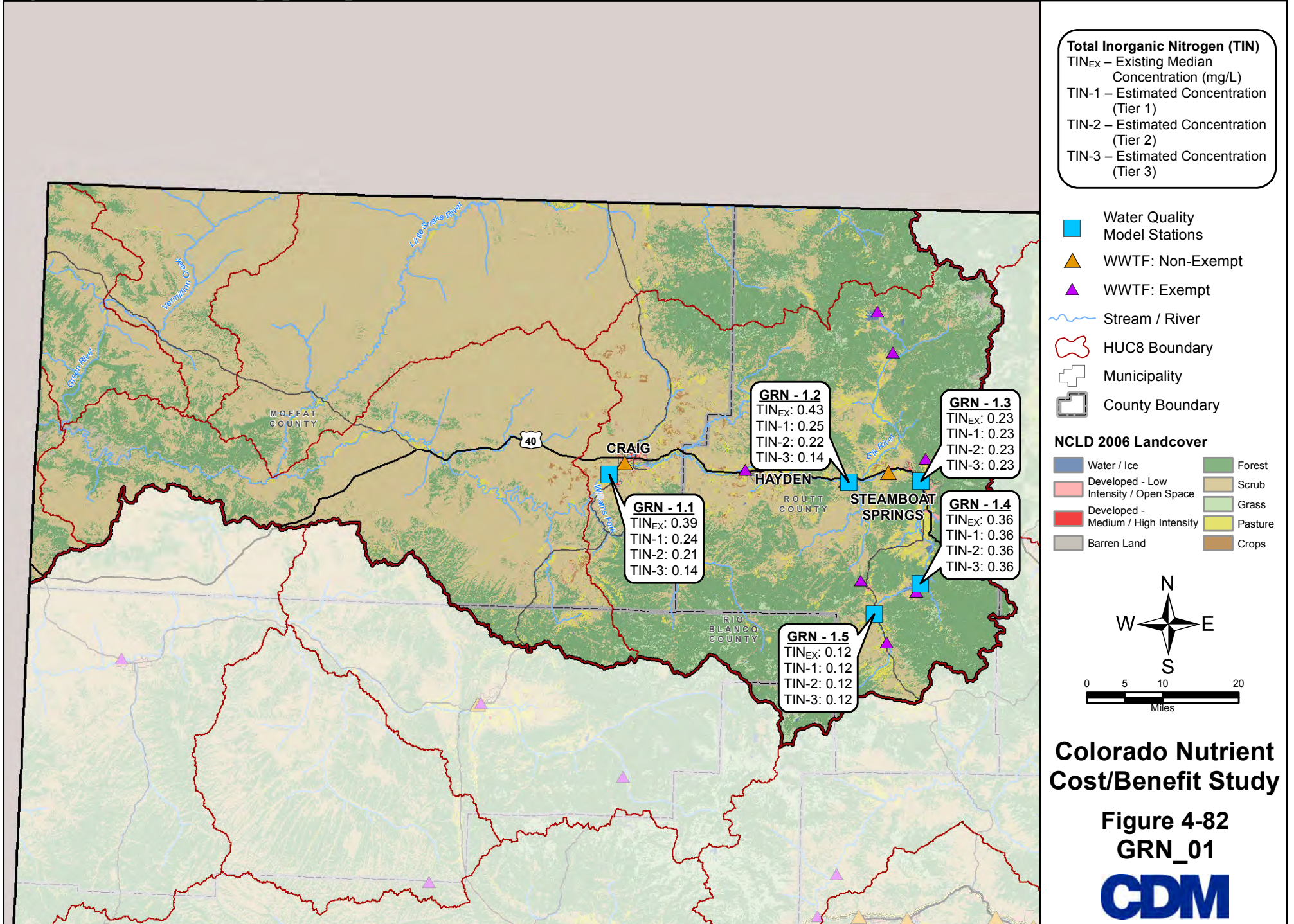
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GRN - 1.1	Mainstem	0.04	0.04	0.04	0.04
GRN - 1.2	Mainstem	0.06	0.04	0.04	0.04
GRN - 1.3	Mainstem	0.04	0.04	0.04	0.04
GRN - 1.4	Mainstem	0.10	0.10	0.10	0.10
GRN - 1.5	Mainstem	0.06	0.06	0.06	0.06

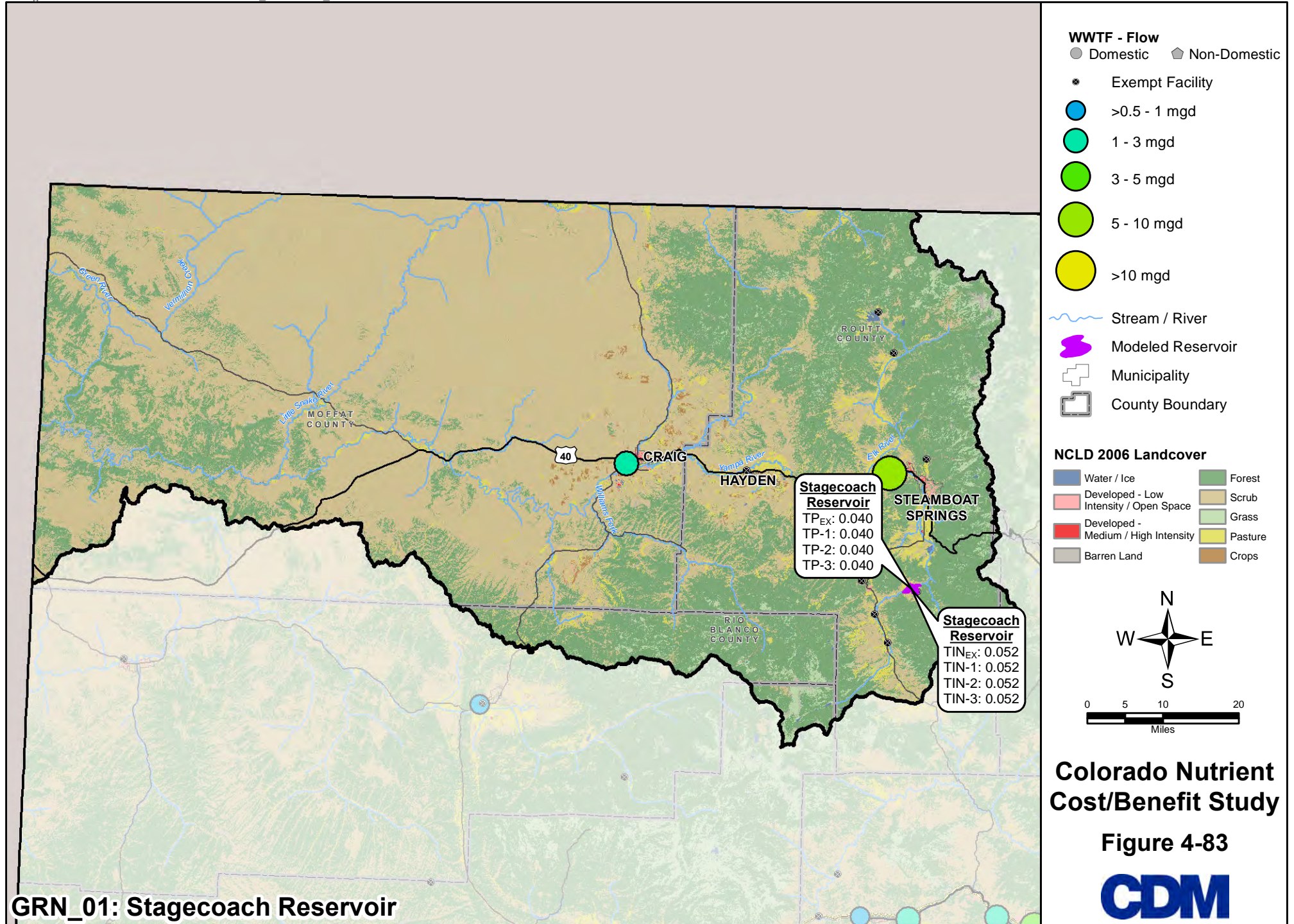
Table 4-186. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GRN_01

Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GRN - 1.1	Mainstem	0.39	0.24	0.21	0.14
GRN - 1.2	Mainstem	0.43	0.25	0.22	0.14
GRN - 1.3	Mainstem	0.23	0.23	0.23	0.23
GRN - 1.4	Mainstem	0.36	0.36	0.36	0.36
GRN - 1.5	Mainstem	0.12	0.12	0.12	0.12









GRN_01: Stagecoach Reservoir

Reservoirs

Stagecoach Reservoir was analyzed within GRN_01 (see Figure 4-84). Table 4-187 summarizes existing water quality and expected water quality under implementation of Tier 1, 2, or 3 effluent limits. Initial analysis of the reservoir under previous drafts of the regulation indicated water quality and trophic level status improvements under various tiers, however, under the current regulation (November 21, 2011), all upstream facilities are exempted. Therefore, there are no water quality effects.

Table 4-187. Comparison of Observed TP and TIN Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in Stagecoach Reservoir

Parameter	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
TP	0.040	0.040	0.040	0.040
TIN	0.052	0.052	0.052	0.052

4.7.1.2 Wastewater Costs

Table 4-188 summarizes the WWTFs located in GRN_01 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-188. WWTFs in GRN_01

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment
Steamboat Lake WSD		0.11	0-0.5	1	Exempt due to capacity
Steamboat Lake State Park		No Data	No Data	4	Exempt due to capacity
Whiteman School		0.01	0-0.5	1	Exempt due to capacity
Oak Creek, Town of		0.25	0-0.5	4	Exempt: disadvantaged
Morrison Creek Metropolitan WSD		0.35	0-0.5	1	Exempt due to capacity
Steamboat Springs		7.5	>5-10	1	
Routt County	Milner Community WWTF	0.0325	0-0.5	4	Exempt due to capacity
Routt County	Routt County for Phippsburg Comm,	0.049999	0-0.5	4	Exempt due to capacity
Phippsburg/Department of Environmental Health					
Yampa, Town of		0.105	0-0.5	4	Exempt due to capacity
Hayden, Town of		0.25	0-0.5	4	Exempt due to capacity
Craig, City of		2.45	>1 to 3	6	

Table 4-189 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-190 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-190 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-189. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$24,188,000	\$54,004,000	\$352,658,000
Annual Operation & Maintenance Costs	\$939,000	\$1,496,000	\$5,398,000

Costs rounded to nearest \$1000.

Table 4-190. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$9,279,000	\$10,469,000	\$62,830,000
Operation & Maintenance Costs	\$494,000	\$619,000	\$2,298,000

Costs rounded to nearest \$1000.

4.7.1.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The following facilities were analyzed within GRN_01: City of Craig, Town of Hayden, and the XCEL Energy Hayden Station. Avoided costs calculated for GRN_01 are presented in Table 4-191.

4.7.1.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in GRN_01, in present value (2010), are presented in Table 4-191.

Table 4-191. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU GRN_01

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$21,793,000	\$48,657,000	\$317,745,000
Operating	\$14,566,000	\$23,202,000	\$83,748,000
Total	\$36,359,000	\$71,859,000	\$401,493,000
Potable Water Supply Benefits			
Capital	\$388,000	\$388,000	\$388,000
Operating	\$851,000	\$851,000	\$851,000
Total	\$1,239,000	\$1,239,000	\$1,239,000
Percent Change in Water Quality (streams)			
	14.28%	17.13%	23.41%
Percent Change in Water Quality (Lakes)			
	0.00%	0.00%	0.00%
Projected Active Benefits			
Angling	\$1,348,000	\$1,618,000	\$2,211,000
Boating	\$4,007,000	\$4,808,000	\$6,571,000
Swimming	\$729,000	\$875,000	\$1,196,000
Total	\$6,084,000	\$7,301,000	\$9,978,000
Property Value Benefits			
	\$0	\$0	\$0
Passive Benefits			
	\$19,129,000	\$21,848,000	\$30,929,000
Total Quantified Benefits	\$26,452,000	\$30,388,000	\$42,146,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.7.1.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in GRN_01 are -\$9,908,000 for Tier 1, -\$41,472,000 for Tier 2, and -\$359,348,000 for Tier 3. The benefit-cost ratio is 0.73:1, 0.42:1, and 0.1:1 for Tiers 1, 2, and 3, respectively (Table 4-192).

Table 4-192. Benefit Cost Summary for MU GRN_01, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$26,452,000	\$30,388,000	\$42,145,000
Total Costs	\$36,359,000	\$71,859,000	\$401,494,000
Net Present Value Benefits	(\$9,908,000)	(\$41,472,000)	(\$359,348,000)
Benefit Cost Ratio	0.73 : 1	0.42 : 1	0.1 : 1

4.7.2 GRN_02 – White River

GRN_02 is comprised of 3 HUC-8 basins contains the White River from its headwaters to the state line. Figure 4-84 illustrates the area covered by GRN_02 including WWTFs (including those exempt from the proposed nutrient control regulations), general location of water supply intakes, and water quality locations. The following sections summarize the results for this Manageable Unit. Details, including supporting spreadsheet analyses, may be found in Appendices A through D.

4.7.2.1 Water Quality Analyses

The water quality analysis for this Manageable Unit relied on default effluent quality parameters for the all of the WWTFs, 4.5 mg/L TP and 25 mg/L TIN.

Streams and Rivers

Existing median TP and TIN concentrations for this Manageable Unit are presented in Tables 4-193 and 4-194 (see Figure 4-84 for location of water quality sample sites). Expected changes in water quality resulting from implementation of Tier 1, 2, or 3 effluent limits are also provided for TP (Table 4-193; Figure 4-85) and for TIN (Table 4-194; Figure 4-86). These results assume full compliance at each facility that would be subject to Regulation #85, as proposed.

Table 4-193. Comparison of Observed TP (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GRN_02

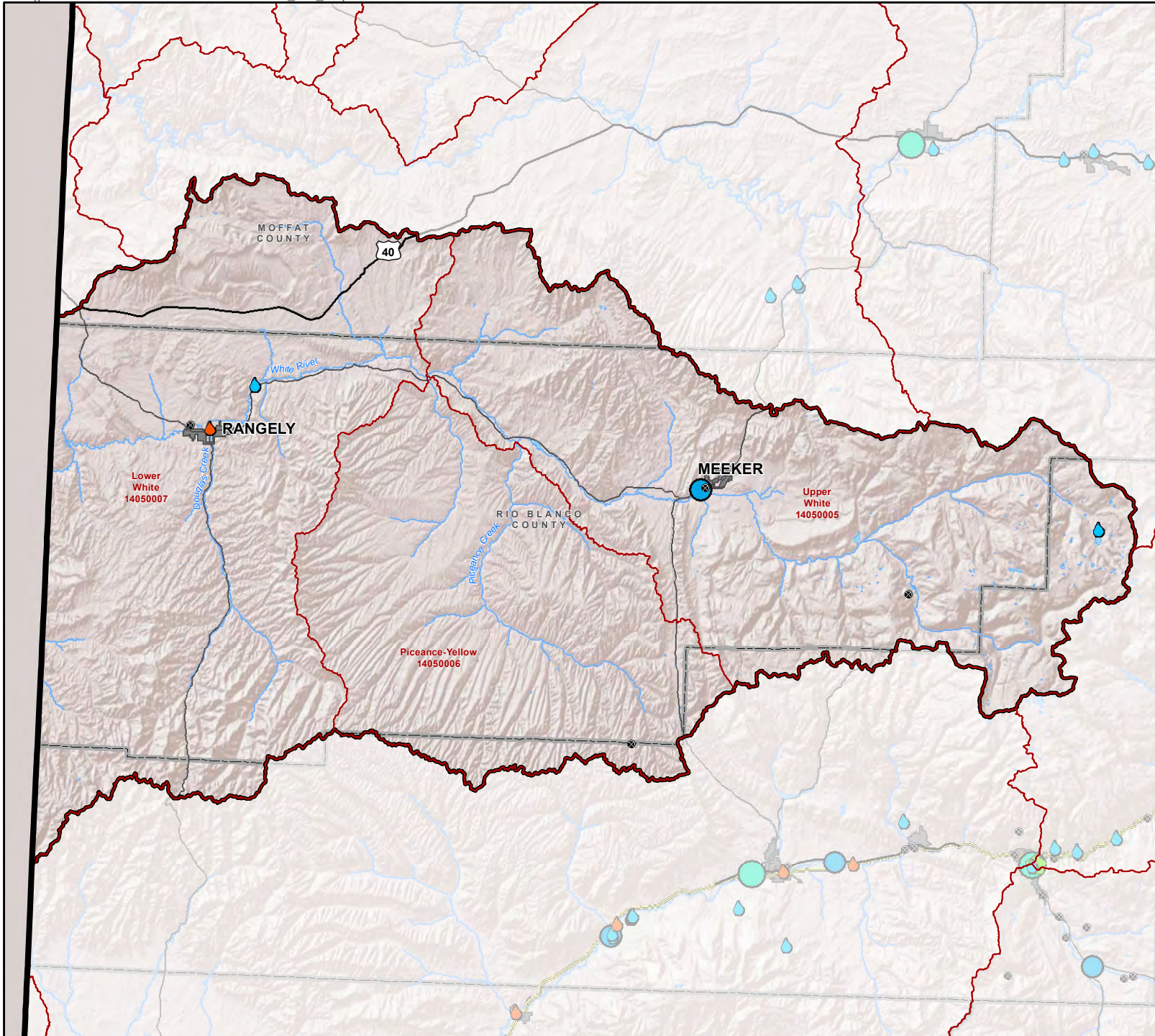
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GRN02 -1	Mainstem	0.04	0.03	0.03	0.03
GRN02-2	Mainstem	no data	n/a	n/a	n/a
GRN02-2.1	Piceance Creek	0.05	0.05	0.05	0.05
GRN02-3	Mainstem	0.02	<i>Upstream facilities exempted</i>		

Table 4-194. Comparison of Observed Total Inorganic Nitrogen (mg/L) Concentrations with Expected Concentrations Following Implementation of Tier 1, 2, or 3 Effluent Limits in GRN_02

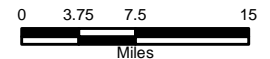
Site ID	Stream Name	Existing Median Concentration (mg/L)	Tier 1 Concentration (mg/L)	Tier 2 Concentration (mg/L)	Tier 3 Concentration (mg/L)
GRN02 -1	Mainstem	0.34	0.28	0.26	0.23
GRN02-2	Mainstem	0.11	0.10	0.10	0.09
GRN02-2.1	Piceance Creek	0.76	0.76	0.76	0.76
GRN02-3	Mainstem	0.08	<i>Upstream facilities exempted</i>		

Reservoirs

No reservoirs were analyzed in this Manageable Unit.



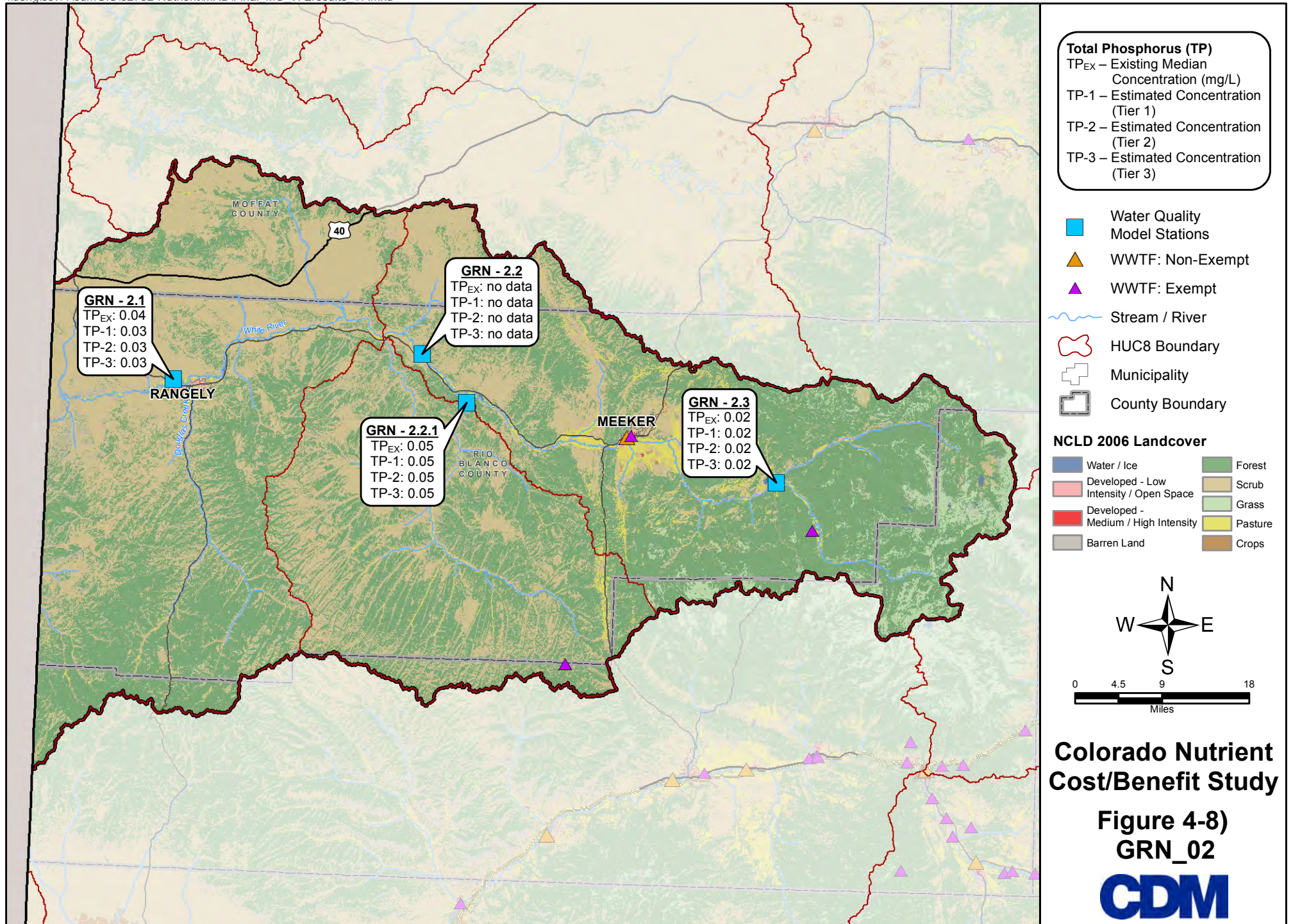
- WWTF - Flow**
- Domestic ◻ Non-Domestic
 - Exempt Facility
 - >0.5 - 1 mgd
 - 1 - 3 mgd
 - 3 - 5 mgd
 - 5 - 10 mgd
 - >10 mgd
 - Water Supply Facility
 - Water Supply Facility w/ Source Water Concerns
 - ~ Stream / River
 - ~ Water Body
 - ~ HUC8 Boundary
 - ⊕ Municipality
 - ⊞ County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 4-8(
GRN_02

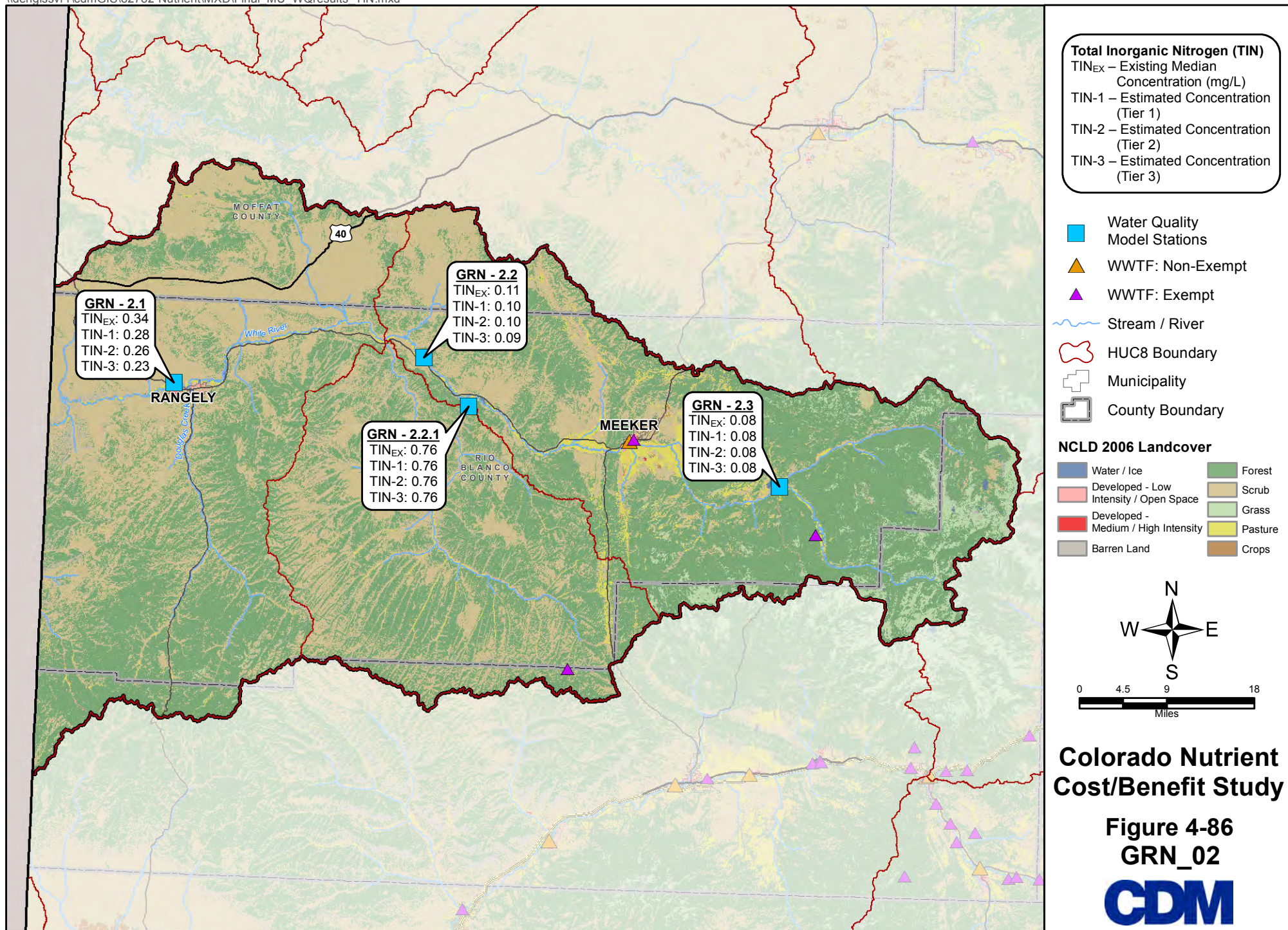




Colorado Nutrient Cost/Benefit Study

**Figure 4-8)
 GRN_02**





Colorado Nutrient Cost/Benefit Study

**Figure 4-86
GRN_02**



4.7.2.2 Wastewater Costs

Table 4-195 summarizes the WWTFs located in GRN_02 along with their permitted capacity, flow bin, and treatment plant category. The facilities that are exempted from Regulation #85 are noted (see Table 2-1).

Table 4-195. WWTFs in GRN_02

Owner	Plant Name	Permitted Capacity (MGD)	Flow Bin (MGD)	Treatment Plant Category	Comment or Footnote
Whiteriver RV LLC	Whiteriver RV LLC WWTF	0.029	0-0.5	4	Exempt due to capacity
Oak Meadows Service Company	Oak Meadows WWTF	0.035	0-0.5	1	Exempt due to capacity
Rangely, Town of		0.5	0-0.5	4	Exempt due to capacity
Meeker Sanitation District		0.99	>0.5 to 1	1	
Rifle, City of	North WWTF	0.997	>0.5 to 1	4	Exempt due to capacity

Table 4-196 provides the estimated capital and annual costs by tier for facilities subject to proposed Regulation #85. Table 4-197 provides the estimated capital and annual costs for facilities exempt from proposed Regulation #85. The costs in Table 4-197 are provided for informational purposes only; they are not included in the cost-benefit analysis.

Table 4-196. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Subject to Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land, engineering, administration and legal)	\$2,431,000	\$3,238,000	\$46,989,000
Annual Operation & Maintenance Costs	\$157,000	\$173,000	\$1,146,000

Costs rounded to nearest \$1000.

Table 4-197. Estimated WWTF Costs to Meet Tier 1, 2 or 3 Effluent Quality for Facilities Exempt From Proposed Regulation #85

Cost Category	Tier 1	Tier 2	Tier 3
Capital Cost (including land acquisition and engineering)	\$14,496,000	\$16,805,000	\$83,616,000
Annual Operation & Maintenance Costs	\$853,000	\$904,000	\$2,716,000

Costs rounded to nearest \$1000.

4.7.2.3 Public Water Supply Facilities

The avoided costs for the potable water utilities would stem from the opportunity for some affected water treatment facilities to avoid the need to enhance phosphorous removal, as described in the methodological section. Capital costs assumed to occur no later than 2014 would be avoided, as would operating costs thereafter. Public Water Supply cost development was presented in Section 3.5. The Town of Rangely was included in the analysis for GRN_02. Avoided costs calculated for GRN_02 are presented in Table 4-198.

4.7.2.4 Recreational and Environmental Benefits

The quantified costs and benefits of the proposed regulation in GRN_02, in present value (2010), are presented in Table 4-198.

Table 4-198. Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for MU GRN_02

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$2,190,000	\$2,918,000	\$42,337,000
Operating	\$2,441,000	\$2,684,000	\$17,784,000
Total	\$4,631,000	\$5,602,000	\$60,121,000
Potable Water Supply Benefits			
Capital	\$662,000	\$662,000	\$662,000
Operating	\$2,089,000	\$2,089,000	\$2,089,000
Total	\$2,751,000	\$2,751,000	\$2,751,000
Percent Change in Water Quality (streams)			
	4.68%	5.62%	7.68%
Percent Change in Water Quality (Reservoir)			
	NA	NA	NA
Projected Active Benefits			
Angling	\$38,000	\$45,000	\$62,000
Boating	\$150,000	\$180,000	\$246,000
Swimming	\$63,000	\$75,000	\$103,000
Total	\$251,000	\$300,000	\$411,000
Property Value Benefits			
	NA	NA	NA
Passive Benefits	\$2,428,000	\$2,765,000	\$3,923,000
Total Quantified Benefits	\$5,430,000	\$5,816,000	\$7,085,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

4.7.2.5 Benefit-Cost Ratio

The net present value benefits of the proposed Regulation in GRN_02 are \$799,000 for Tier 1, \$215,000 for Tier 2, and -\$53,036,000 for Tier 3. The benefit-cost ratio is 1.17:1, 1.04:1, and 0.12:1 for Tiers 1, 2, and 3, respectively (Table 4-199).

Table 4-199. Benefit Cost Summary for MU GRN_02, 2014 through 2038, Present Value 2010 Dollars

Benefit Cost Analysis	Tier 1	Tier 2	Tier 3
Total Benefit	\$5,430,000	\$5,816,000	\$7,084,000
Total Costs	\$4,631,000	\$5,602,000	\$60,120,000
Net Present Value Benefits	\$799,000	\$215,000	(\$53,036,000)
Benefit Cost Ratio	1.17 : 1	1.04 : 1	0.12 : 1

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Section 5

Statewide Cost-Benefit Analysis

This section provides the results of quantitative and qualitative analyses from a river basin and statewide perspective. Quantified results provide the aggregate of the cost benefit analysis findings for each river basin (aggregate of the Manageable Units within each basin) and the state as a whole (aggregate of all Manageable Units). Qualitative results summarize project elements where data were insufficient to quantify costs or benefits. The implication of qualitative results should be considered as part of the overall findings of the Study.

5.1 Aggregate of Quantified Costs and Benefits by River Basin

The various costs and benefits estimated for each Manageable Unit, detailed in Section 4, have been combined to develop total cost and benefit figures for the State of Colorado resulting from the proposed regulations. Costs and benefits are assumed to occur between the year 2014 and the year 2038 and all costs and benefits have been discounted back to 2010 present value dollars. Net present value figures, as well as benefit-cost ratios, are provided for each effluent quality tier at the river basin and state level. Tables 5-1 through 5-7 provide the costs and benefits of the proposed regulations for each of the State's river basins. Tables 5-8 through 5-14 provide the resulting benefit-cost ratios by river basin.

Table 5-1. Quantified Costs and Benefits of Proposed Regulations for Arkansas River Basin, 2014 through 2038

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$322,716,000	\$764,061,000	\$4,687,884,000
Operating	\$222,713,000	\$357,387,000	\$1,222,911,000
Total	\$545,429,000	\$1,121,448,000	\$5,910,795,000
Potable Water Supply Benefits			
Capital	\$8,012,000	\$8,012,000	\$8,012,000
Operating	\$34,520,000	\$34,520,000	\$34,520,000
Total	\$42,532,000	\$42,532,000	\$42,532,000
Projected Active Benefits			
Angling	\$121,413,000	\$150,070,000	\$190,317,000
Boating	\$272,482,000	\$338,819,000	\$432,159,000
Swimming	\$36,565,000	\$43,359,000	\$52,389,000
Total	\$430,460,000	\$532,248,000	\$674,865,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$206,067,000	\$234,173,000	\$280,897,000
Total Quantified Benefits	\$679,059,000	\$808,953,000	\$1,056,414,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-2: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for the Colorado River Basin

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$130,143,000	\$249,977,000	\$2,195,686,000
Operating	\$96,179,000	\$143,742,000	\$645,060,000
Total	\$226,322,000	\$393,719,000	\$2,840,746,000
Potable Water Supply Benefits			
Capital	\$804,000	\$804,000	\$804,000
Operating	\$2,008,000	\$2,008,000	\$2,008,000
Total	\$2,812,000	\$2,812,000	\$2,812,000
Projected Active Benefits			
Angling	\$13,869,000	\$22,847,000	\$46,445,000
Boating	\$31,031,000	\$51,972,000	\$112,666,000
Swimming	\$3,671,000	\$6,132,000	\$9,839,000
Total	\$48,571,000	\$80,951,000	\$168,950,000
Property Value Benefits	\$0.00	\$0.00	\$0.00
Passive Benefits	\$51,932,000	\$71,088,000	\$108,233,000
Total Quantified Benefits	\$103,315,000	\$154,851,000	\$279,996,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-3: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for the Gunnison River Basin

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$27,568,000	\$66,461,000	\$335,899,000
Operating	\$19,379,000	\$29,712,000	\$111,237,000
Total	\$46,947,000	\$96,173,000	\$447,136,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Projected Active Benefits			
Angling	\$2,147,000	\$2,885,000	\$3,826,000
Boating	\$5,657,000	\$7,599,000	\$10,076,000
Swimming	\$1,372,000	\$1,865,000	\$2,482,000
Total	\$9,176,000	\$12,349,000	\$16,384,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$14,868,000	\$19,449,000	\$26,692,000
Total Quantified Benefits	\$24,044,000	\$31,798,000	\$43,076,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-4: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for the Platte River Basin

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$898,353,000	\$2,028,316,000	\$10,556,703,000
Operating	\$575,015,000	\$1,124,481,000	\$3,730,247,000
Total	\$1,473,368,000	\$3,152,797,000	\$14,286,950,000
Potable Water Supply Benefits			
Capital	\$1,135,000	\$1,135,000	\$2,081,000
Operating	\$3,642,000	\$3,642,000	\$6,843,000
Total	\$4,777,000	\$4,777,000	\$8,924,000
Projected Active Benefits			
Angling	\$199,761,000	\$240,373,000	\$380,973,000
Boating	\$364,850,000	\$432,242,000	\$579,315,000
Swimming	\$93,080,000	\$113,275,000	\$174,499,000
Total	\$657,691,000	\$785,890,000	\$1,134,787,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$405,640,000	\$487,829,000	\$710,612,000
Total Quantified Benefits	\$1,068,108,000	\$1,278,496,000	\$1,854,325,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-5: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for the Rio Grande River Basin

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$38,211,000	\$57,506,000	\$380,817,000
Operating	\$29,974,000	\$36,624,000	\$121,705,000
Total	\$68,185,000	\$94,130,000	\$502,522,000
Potable Water Supply Benefits			
Capital	\$0	\$0	\$0
Operating	\$0	\$0	\$0
Total	\$0	\$0	\$0
Projected Active Benefits			
Angling	\$490,000	\$589,000	\$797,000
Boating	\$1,267,000	\$1,520,000	\$2,059,000
Swimming	\$626,000	\$751,000	\$1,017,000
Total	\$2,383,000	\$2,860,000	\$3,873,000
Property Value Benefits	\$0	\$0	\$0
Passive Benefits	\$8,178,000	\$9,346,000	\$13,107,000
Total Quantified Benefits	\$10,561,000	\$12,206,000	\$16,980,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-6: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for the Southwest River Basin

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$42,626,000	\$68,800,000	\$420,916,000
Operating	\$21,031,000	\$29,891,000	\$121,835,000
Total	\$63,657,000	\$98,691,000	\$542,751,000
Potable Water Supply Benefits			
Capital	\$19,000	\$19,000	\$19,000
Operating	\$6,000	\$6,000	\$6,000
Total	\$25,000	\$25,000	\$25,000
Projected Active Benefits			
Angling	\$1,676,000	\$2,876,000	\$4,781,000
Boating	\$2,077,000	\$2,060,000	\$2,585,000
Swimming	\$549,000	\$778,000	\$1,201,000
Total	\$4,302,000	\$5,714,000	\$8,567,000
Property Value Benefits	NA	NA	NA
Passive Benefits	\$18,092,000	\$27,689,000	\$46,433,000
Total Quantified Benefits	\$22,419,000	\$33,428,000	\$55,024,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-7: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for the Yampa-White River Basin

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$23,983,000	\$51,575,000	\$360,082,000
Operating	\$17,007,000	\$25,886,000	\$101,532,000
Total	\$40,990,000	\$77,461,000	\$461,614,000
Potable Water Supply Benefits			
Capital	\$1,050,000	\$1,050,000	\$1,050,000
Operating	\$2,940,000	\$2,940,000	\$2,940,000
Total	\$3,990,000	\$3,990,000	\$3,990,000
Projected Active Benefits			
Angling	\$1,386,000	\$1,663,000	\$2,273,000
Boating	\$4,157,000	\$4,988,000	\$6,817,000
Swimming	\$792,000	\$950,000	\$1,299,000
Total	\$6,335,000	\$7,601,000	\$10,389,000
Property Value Benefits	\$0.00	\$0.00	\$0.00
Passive Benefits	\$21,557,000	\$24,613,000	\$34,852,000
Total Quantified Benefits	\$31,882,000	\$36,204,000	\$49,231,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-8: Benefit-Cost Summary for the Arkansas River Basin, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$679,062,000	\$808,956,000	\$1,056,414,000
Total Costs	\$545,429,000	\$1,121,448,000	\$5,910,796,000
Net Present Value Benefits	\$133,633,000	(\$312,494,000)	(\$4,854,382,000)
Benefit-Cost Ratio	1.25 : 1	0.72 : 1	0.18 : 1

Table 5-9: Benefit-Cost Summary for the Colorado River Basin, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$103,315,000	\$154,851,000	\$279,996,000
Total Costs	\$226,322,000	\$393,719,000	\$2,840,746,000
Net Present Value Benefits	\$133,633,000	(\$238,868,000)	(\$2,560,750,000)
Benefit-Cost Ratio	0.46 : 1	0.39 : 1	0.1 : 1

Table 5-10: Benefit-Cost Summary for the Gunnison River Basin, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$24,043,000	\$31,798,000	\$43,075,000
Total Costs	\$46,947,000	\$96,172,000	\$447,136,000
Net Present Value Benefits	(\$22,905,000)	(\$64,374,000)	(\$404,060,000)
Benefit-Cost Ratio	0.51 : 1	0.33 : 1	0.1 : 1

Table 5-11: Benefit-Cost Summary for the Platte River Basin, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$1,068,108,000	\$1,278,498,000	\$1,854,325,000
Total Costs	\$1,473,367,000	\$3,152,796,000	\$14,286,950,000
Net Present Value Benefits	(\$405,261,000)	(\$1,874,298,000)	(\$12,432,625,000)
Benefit-Cost Ratio	0.72 : 1	0.41 : 1	0.13 : 1

Table 5-12: Benefit-Cost Summary for the Rio Grande River Basin, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$10,561,000	\$12,206,000	\$16,980,000
Total Costs	\$68,185,000	\$94,131,000	\$502,522,000
Net Present Value Benefits	(\$57,624,000)	(\$81,925,000)	(\$485,542,000)
Benefit-Cost Ratio	0.15 : 1	0.13 : 1	0.03 : 1

Table 5-13: Benefit-Cost Summary for the Southwest River Basin, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$22,418,000	\$33,428,000	\$55,024,000
Total Costs	\$63,657,000	\$98,692,000	\$542,752,000
Net Present Value Benefits	(\$41,238,000)	(\$65,264,000)	(\$487,727,000)
Benefit-Cost Ratio	0.35 : 1	0.34 : 1	0.1 : 1

Table 5-14: Benefit-Cost Summary for Yampa-White River Basin, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$31,882,000	\$36,204,000	\$49,229,000
Total Costs	\$40,990,000	\$77,461,000	\$461,614,000
Net Present Value Benefits	(\$9,109,000)	(\$41,257,000)	(\$412,384,000)
Benefit-Cost Ratio	0.78 : 1	0.47 : 1	0.11 : 1

5.2 Statewide Aggregation of Quantified Costs and Benefits

The various costs and benefits estimated for all Manageable Units, detailed in Section 4, were aggregated to provide total cost and benefit figures for the State of Colorado. Costs and benefits are assumed to occur between the year 2014 and the year 2038, and all costs and benefits have been discounted back to 2010 present value dollars. The findings include aggregated net present value figures, as well as benefit-cost ratios for the state as a whole. Table 5-15 provides the costs and benefits of the proposed regulations for the State; Table 5-16 provides the resulting benefit-cost ratios for each tier for the State.

Table 5-15: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, for the State of Colorado

	Tier 1	Tier 2	Tier 3
Projected WWTF Costs			
Capital	\$1,483,600,000	\$3,286,696,000	\$18,937,987,000
Operating	\$981,298,000	\$1,747,723,000	\$6,054,527,000
Total	\$2,464,898,000	\$5,034,419,000	\$24,992,514,000
Potable Water Supply Benefits			
Capital	\$11,020,000	\$11,020,000	\$11,966,000
Operating	\$43,116,000	\$43,116,000	\$46,317,000
Total	\$54,136,000	\$54,136,000	\$58,283,000
Projected Active Benefits			
Angling	\$340,742,000	\$421,303,000	\$629,412,000
Boating	\$681,521,000	\$839,200,000	\$1,145,677,000
Swimming	\$136,655,000	\$167,110,000	\$242,726,000
Total	\$1,158,918,000	\$1,427,613,000	\$2,017,815,000
Property Value Benefits			
	\$0	\$0	\$58,119,000
Passive Benefits	\$726,334,000	\$874,187,000	\$1,220,826,000
Total Quantified Benefits	\$1,939,389,000	\$2,355,941,000	\$3,355,043,000

* Expressed in Present Value 2010 Dollars

* NA indicates not available

* N/A indicates not applicable

* Numbers may not add due to rounding

Table 5-16: Benefit-Cost Summary for the State of Colorado, 2014 through 2038, Present Value 2010 Dollars

	Tier 1	Tier 2	Tier 3
Benefit-Cost Analysis			
Total Benefits	\$1,939,389,000	\$2,355,941,000	\$3,355,043,000
Total Costs	\$2,464,897,000	\$5,034,419,000	\$24,992,516,000
Net Present Value Benefits	(\$525,510,000)	(\$2,678,480,000)	(\$21,637,470,000)
Benefit-Cost Ratio	0.79 : 1	0.47 : 1	0.13 : 1

5.3 Qualitative Costs and Benefits

This Study considered both quantitative and qualitative costs and benefits. The qualitative effects identified below are no less important than the quantified benefits and costs described earlier. These qualitative effects simply mean that the project team was not able to obtain sufficient data or derive sufficient supportable assumptions in order to quantify these benefits. The lack of quantification of a particular cost or benefit element does not diminish the importance of the element. Instead, the findings of this Study should be viewed within the following context: Quantified costs and benefits, presented in the form of a benefit-cost ratio, represent a subset of the larger universe of combined quantitative and qualitative benefits. Following is a discussion of qualitative costs and benefits and potential implications to the Study's findings.

5.3.1 Qualitative Costs

The wastewater industry contributes to GHG emissions primarily through combustion of fuels from mobile and stationary sources, through consumption of electricity, and from fugitive and process emissions unique to wastewater treatment. Section 3.4.8 described the methods used to evaluate how implementation of the nutrient control regulations could impact these sources of GHG emissions.

While it is possible to estimate GHG emissions from sources, these results are typically in units that cannot be readily converted into quantifiable costs. Accordingly, the estimated wastewater treatment costs to comply with any of the three tiers of effluent quality limits did not directly incorporate the potential impacts of GHG emissions. Instead, the findings of this analysis should be viewed from a qualitative perspective. Specifically, for categories 1, 3, 5, and 6, implementation of Tier 1 and 2 showed an expected decrease in GHG emissions, approximately 25 to 35 percent, due to scope 1 emissions from the wastewater treatment processes, while Tier 3 showed a decrease of about 60 to 70 percent. Results for scope 2 emissions for these categories showed an enormous increase for all Tiers, approximately 3 to 14 times the emissions from the base plant. This was expected as scope 2 emissions are directly related to the electricity usage of the WWTFs. Similar results were obtained for categories 2 and 4 with the increase in scope 2 emissions for these categories being higher than that seen in the other categories. This was due to the fact that the WWTFs in categories 2 and 4 were completely replaced for all Tiers. Overall, while aqueous emissions to the water were reduced there was an increase in gas emissions to the air.

5.3.2 Qualitative Benefits

In addition to the qualitative costs described above, there are qualitative benefits that stem from the proposed nutrient control regulation. Table 5-17 enumerates each of these qualitative effects and the magnitude of their benefit. Following is a brief discussion of these benefits.

Table 5-17. Summary of Qualitative Costs and Benefits

Qualitative Factor	Cost or Benefit	Magnitude of Effect
GHG Emissions	Cost	Potentially Substantial
Potable Drinking Water	Benefit	Substantial
Property Values (streamside and lakeside)	Benefit	Potentially Substantial
Recreational Activities (hiking, picnicking, wildlife watching)	Benefit	Moderate
Intrinsic Values	Benefit	Unknown
Agriculture (livestock source water, conveyance vegetation, crop irrigation)	Benefit	Minimal

Water Quality Benefits

Evaluations of expected improvements in water quality in a number of lakes and reservoirs was not possible given the minimal water quality data and variable, complex sources of in-lake flows (see Section 3.2.1 for additional discussion). Accordingly, the benefits to water quality in some of these waterbodies are likely understated, which would reduce the quantified active recreational benefits and lakeside property value benefits (where private land is adjacent to a waterbody).

Public Water Supply Benefits

Improvements to potable water quality as a result of nutrient control might be a substantial benefit, but the project team was only able to quantify certain effects associated with reduced phosphorus and specific regulations of that element for potable water utilities. Areas where additional potential benefits should be considered include:

- Nutrient reduction and related reductions in the volume and types of algae (particularly those types known to be toxic) might reduce adverse health effects in people particularly sensitive to those substances.
- Odor, taste, and appearance of water might be improved as a result of lower concentrations of nutrients in waters. Although this is a perceptual issue, it can be an important one to potable water utilities.
- As described in Section 3.5., NDMA has been identified as an emerging contaminant that can be a DBP associated with water treatment processes. Reductions in nutrients in source water can reduce the likelihood of DBP formation, which would be an important benefit to water supply facilities.

Recreation

Besides the quantified active recreational benefits, other recreational activities might benefit from the proposed regulation. Specifically, scenic drives, picnicking, and watchable wildlife are known to be important recreational endeavors in Colorado. To some extent, these might be positively affected by improved water quality in the state's streams and lakes, but there is insufficient information to substantiate this benefit.

Property Values

Research indicates that lakeside property values increase as a result of improved water quality and clarity. However, water quality data were only available for a small number of lakes and therefore, property value benefits are largely qualitative.

The potential exists that with substantive changes in water quality, property values along streams and rivers might be affected; however, the project team did not find sufficient research to definitively prove this proposition.

Intrinsic Values

It is possible that water quality improvements might have an existence bequest value to Colorado citizens. The project team was not able to distinguish such a value from the passive values already accounted for in the benefit-cost analysis. Even so, if such a benefit exists, it might be substantial based upon studies in other regions of the country.

Agriculture

Although several studies and reports acknowledge the potential benefits to cattle and other livestock as a result of nutrient reduction in the drinking water, studies also have noted the difficulty in linking benefits to nutrient controls that may improve drinking water quality since changes in onsite manure control or fertilization routines may have the largest impact on the quality of livestock drinking water supplies. Accordingly, the assessment from this Study is that the qualitative benefits to livestock water sources from implementation of the nutrient control regulation are minimal.

Reduced nutrients in irrigation water might reduce the rate and volume of vegetation growth in the irrigation conveyance canals. This outcome may provide a small benefit as the need to remove vegetation, as part of standard conveyance maintenance practices, may be reduced. However, nutrient reductions in irrigation water would not eliminate the need for clearing such conveyances. Accordingly, the expected impact of the nutrient control regulation on vegetation growth in conveyance canals is minimal.

Potential reduction of nutrients in agricultural source waters has been noted as a potential detriment to crop irrigation as the nutrients in the irrigation water reduces the need to apply nutrients directly to the

growing crops. However, the difference in the nutrient load associated with applied irrigation water versus the nutrient loads contained in fertilizers applied using standard farming practices is substantial, such that the impact of reductions in nutrients in the irrigation water is minimal with regards to crop fertilization (Irrigation Water Quality Criteria, Fact Sheet No. 0.506, Nitrogen and Irrigation Management, Fact Sheet No. 0.514, Fertilizing Corn, Fact Sheet No. 0.538, University of Nebraska – Lincoln Extension (www.extension.unl.edu/publications)).

5.4 Stormwater Monitoring Costs

The November 21, 2011 regulation requires MS4s to develop and submit a DADR. Costs associated with the development of a DADR will depend on the MS4s capabilities to perform the work in-house versus contracting the work to a consultant, the size of the existing monitoring program, and the volume of available data for analysis and documentation. Although the current regulation does not obligate MS4 permit holders to perform monitoring, this Study included the development of stormwater monitoring costs associated with the potential collection of dry and wet weather samples from stormwater outfalls. Section 3.8 described the methodology used to develop these costs. The following sections provide a summary of the findings.

5.4.1 Estimated Stormwater Monitoring Costs

The project team estimated costs for stormwater monitoring on a per outfall, per event basis. Table 5-18 summarizes these estimated costs.

Table 5-18. MS4 Monitoring Cost Estimate

	Count	Units	Unit Cost	Total Cost
PLANNING				
Background Research (Site visit and assessment of current permitted outfalls to determine sampling location and equipment needs) (Cost per outfall)	4	hours	\$90	\$360
Site Characterization of Current MS4 Outfalls (Collect data on land uses, current conditions, impervious areas, and water quality BMPs)	20	hours	\$90	\$1,800
Documentation (analysis of land uses, imperviousness, and watershed hydrology, precipitation data, and irrigation practices within the permitted area)	20	hours	\$90	\$1,800
IMPLEMENTATION				
Wet Weather and Dry Weather Discharge				
Laboratory Analysis (average costs per sample set: \$40 TKN, \$30 Nitrate/Nitrite, \$30 TP - total estimated @ \$150/set to account for variation in costs)	1	sampling round	\$150	\$150
Laboratory Shipping Costs (average cost/sample set)	1	sampling round	\$100	\$100
Miscellaneous Sampling Equipment (latex gloves, safety glasses, screwdrivers and miscellaneous hand tools, coolers, ice, tape, sample labels, field notebooks and/or sample sheets, high visibility clothing and traffic cones as needed) (used for all sampling locations)	1	sampling round	\$200	\$200
Option A: Purchase Automatic Sampler				
Automatic Sampler with stormwater sampling kit (including rain sensor, flow sensor, rain gauge) (used for wet weather and dry weather at all sampling locations)	1	units	\$10,000	\$10,000
Additional equipment for sampler (tubing, decontamination equipment) (per outfall)	1	units	\$150	\$150
Field Staff - Dry Weather (per outfall)	4	hours (2 staff @ 2 hours)	\$90	\$360
Field Staff - Wet Weather (per outfall)	4	hours (2 staff @ 2 hours)	\$90	\$360
Option A Estimated Total (per outfall/unit)				\$17,440

Table 5-18. MS4 Monitoring Cost Estimate

	Count	Units	Unit Cost	Total Cost
Option B: Rent Automatic Sampler				
Automatic Sampler (one month rental period) (includes sampler, flow meter, rain gauge, mounting equipment, and data analysis package)	1	month/unit	\$3,984	\$3,984
Additional equipment for sampler (tubing, decontamination equipment) (per outfall)	1	units	\$150	\$150
Field Staff - Dry Weather (per outfall)	4	hours (2 staff @ 2 hours)	\$90	\$360
Field Staff - Wet Weather (per outfall)	4	hours (2 staff @ 2 hours)	\$90	\$360
Option B Estimated Total (per outfall/unit)				\$11,424
Option C: Grab samples collected by field staff				
Field Staff - Dry Weather (per outfall)	16	hours (2 staff @ 8 hours)	\$90	\$1,440
Field Staff - Wet Weather (per outfall)	16	hours (2 staff @ 8 hours)	\$90	\$1,440
Option C Estimated Total (per outfall/unit)				\$6,570

5.4.2 Stormwater Monitoring Cost Summary

Total estimated costs were calculated for a variety of the sampling scenarios as listed above (purchase of automatic sampler, rental of automatic sampler, and utilizing field staff to collect grab samples). For utilities that may be required to conduct nutrient monitoring in the future and choose to purchase automatic samplers, initial wet weather and dry weather discharge monitoring program costs were estimated to average \$17,440 per outfall. Purchase costs of the portable sampler unit were estimated at \$10,000; therefore, subsequent sampling activities at the outfall would be estimated at \$7,440 following purchase of the sampler unit. For utilities that choose to rent sampling equipment, monitoring program costs were estimated at \$11,424 per outfall with a one month rental package. For utilities utilizing field staff to collect grab samples (no automatic sampler), monitoring program costs were estimated at \$6,570 per outfall.

As the regulation is currently proposed (November 21, 2011), MS4 permit holders will be required to develop a DADR to document the entity's current program, practices and existing monitoring data to determine the potential to contribute to nutrient loading in receiving waters. Initial costs to MS4s would be limited to the development of the DADR. The costs to develop a DADR are dependent on a number factors: size of MS4; ability to complete the DADR in-house; amount of data available for analysis.

The DADRs will be used by the Division to determine if future monitoring is required. Potential monitoring costs were developed to provide an estimate of potential costs associated with dry and wet weather monitoring. Based on responses from MS4 permit holders, several jurisdictions currently implement wet weather and/or dry weather monitoring programs. Utilizing the equipment and results from these programs, where applicable, would significantly reduce both planning and implementation costs. Additionally, many jurisdictions have onsite laboratory capabilities, which could be utilized to reduce the costs of laboratory analysis and sample shipment.

Overall, potential monitoring costs to MS4 permitted jurisdictions for point source monitoring average approximately \$9,000 - \$20,000 per outfall based on the sampling method. Total costs are dependent on the number of outfalls sampled and the number of sampling events per year.

Section 6

Elements of a Regulatory Analysis

Commission Procedural Rule (Regulation #21), subsection 21.3.J, requires the Commission to prepare a Regulatory Analysis to support proposed regulations. The Division will draft this analysis for Regulations #85 and #31.17 as a companion document to its regulatory proposal. To support the development of this analysis, relevant information developed from the results of this Study is provided below using the format of subsection 21.3.J of the Commission's Procedural Rules. The following analysis is subject to revision by the Division during the rulemaking process, particularly if the proposed versions of Regulations #31.17 and/or #85 are revised. Based on the information below, an initial version of the Division's regulatory analysis will be provided once the Division develops information to establish its costs for implementing Regulations #31.17 and #85.

1. A description of the classes of persons who will bear the cost and or benefit from the proposed rule.

The classes of persons who will most likely and most directly bear the cost of the proposed rule include:

- Wastewater system customers in Colorado communities that: (1) have WWTFs that have a capacity > 0.5 mgd; (2) do not have a population of 5,000 or less with a median household income of less than 80 percent of the state median household income; and/or (3) that do not use lagoon (pond) technology for wastewater treatment that has a capacity of 1 mgd (serves a population of approximately 10,000) or less. Wastewater system customers in these communities, typically households and businesses, will bear the cost of the proposed rule through higher wastewater rates. These costs will vary among ratepayer groups because of variability in current levels of nutrient removal and physical infrastructure among existing wastewater facilities. This variability will directly affect the cost of treatment upgrades and the need to raise rates to fund these upgrades.
- Certain industries and other wastewater dischargers that discharge phosphorus and inorganic nitrogen at levels above the authorized effluent limits proposed in Regulation #85 or that will require additional treatment to meet effluent limits set under Regulation #31.17 will also bear the cost of this rule, along with the customers of those industries. The affected industries would generally include certain types of power plants, food processing plants, and other water intensive industries that typically have nutrients present in their discharge.

The classes of persons who will most likely and most directly be beneficiaries of the proposed rule include the following groups:

- Colorado residents and out-of-state visitors that participate in angling, boating, and swimming on the streams, rivers, lakes, and reservoirs within the State of Colorado.
- Tourism-based businesses, such as hotels, restaurants, and gasoline service stations; recreational businesses like rafting companies, fishing supply stores, guide services; and businesses that sell goods and services to boaters and swimmers in the State of Colorado.
- Potable water utility customers in certain Colorado communities where source waters will have reduced phosphorus and nitrogen concentrations.
- Engineering and construction companies in Colorado and elsewhere that design, build, and maintain WWTFs.
- Environmental management firms that design and conduct water quality monitoring, sampling, and analysis programs.

2. *To the extent practicable, a description of the probable quantitative and qualitative impact of the proposed rule, economic or otherwise, upon affected classes.*

The impacts of the proposed rule on the classes most likely to bear the cost, as described in Part 1, are as follows:

- Wastewater customers in Colorado communities that are subject to the proposed rule, i.e., not exempted as described in Part 1 above, will pay higher wastewater rates. This will lead to lower disposable income in these communities, potentially resulting in somewhat reduced levels of economic activity. The percentage increase in wastewater rates to Colorado residents was not analyzed as part of this Study; accordingly, the quantitative impacts are unknown. Such an analysis would need to consider many fiscal issues for each local municipality/district or utility.
- In those same communities, as described above, local businesses will incur higher costs of doing business, which will lead to somewhat reduced profits, or businesses will pass along these costs to customers, producing somewhat higher prices. Such price increases for basic services tend to affect those customers living on smaller fixed incomes to the greatest degree.

Section 3 of this Study report provides an analysis of the types of technologies required to meet the Tier 1, 2, or 3 effluent limits. To be clear, the current regulatory proposal would only require implementation of Tier 1 limits for nonexempt existing facilities and Tier 2 limits for new facilities. In Section 7 of this report, Tables 7-1 through 7-4 quantify the total potential estimated costs (based on the assumptions described in Section 3 of this report) to meet any of the tiered effluent limits by Manageable Unit, and Tables 7-5 and 7-6 quantify these estimated costs for each river basin and for the state as a whole. These estimated costs assume that *all* existing facilities subject to proposed Regulation #85 must meet the Tier 1, Tier 2, or Tier 3 effluent limitations defined by this Study (see Table 2-6). The cost estimate does not provide information regarding new facilities yet to be built.

The findings of this Study show that the impact of implementation of only Tier 1 effluent limits (in total dollars of capital cost and long-term O&M cost) is substantial (see Section 4 of this report data regarding costs in each Manageable Unit). However, the river basins with the highest total costs of implementation are also those basins with the highest populations and thus the cost of implementation can be divided among a larger pool of ratepayers. The relative impact of implementation in the context of ratepayers was beyond the scope of this Study. Such an analysis would need to consider many local district or utility-specific issues.

In addition to the quantified impacts described above, this Study evaluated the impacts of wastewater treatment upgrades on GHGs. The issues associated with potential increased GHG emissions and climate change potential are addressed in Sections 3.4.8, 5.3.1, and 7.1.2 of the Study report.

The impacts of the proposed rule on the classes of persons most likely to be beneficiaries, as described in the section above, are as follows:

- The tourism-based economic sector will benefit, due to higher levels of out-of-state visitors as well as in-state visitors. Businesses and the employees of businesses that sell goods and services to anglers, boaters, and swimmers will experience higher incomes and more job opportunities, respectively. Section 7 (Tables 7-1 through 7-4) quantify the estimated recreational, water supply, and property benefits to meet any of the tiered effluent limits by Manageable Unit, and Tables 7-5 and 7-6 quantify these estimated benefits by river basin and statewide.
- Potable water system owners in 27 Colorado communities will likely avoid certain treatment costs associated with the eutrophication expected from higher nutrient loads in their sources of water supply. Eutrophication is a process where water bodies receive excess nutrients that stimulate excessive aquatic plant growth. This will mean lower water rates than would have occurred and somewhat higher disposable incomes. Local businesses in those same communities will experience lower water rates than they would have experienced, thus maintaining their current profitability. The net effect was not evaluated as part of this Study, but the estimated wastewater treatment costs are substantially higher than the quantified avoided water supply facility costs. These estimated benefits assume that all existing facilities subject to the proposed regulations meet Tier 1 effluent limitations at a minimum and that the estimated water quality improvements will occur as a result of implementation. The benefit estimate does not provide information regarding new facilities yet to be built.
- Engineering and construction industry companies and their employees could experience higher revenues and more job opportunities as a result of the proposed rule. However, the potential for higher revenues and more job opportunities is dependent upon many factors.

In addition to the quantified positive impacts described above, this Study identified several positive qualitative impacts that could not be quantified (see Section 5); specifically water quality, public water supply, recreation, property values, agriculture, and intrinsic values. Some of these non-quantified benefits could be *substantial* and should be considered as important positive impacts that may occur as a result of adoption of the proposed regulations.

3. The probable costs to the Commission, the Division, or any other state agency of the implementation and enforcement of the proposed rule and any anticipated effect on state revenues.

The proposed regulations will impact three key Colorado agencies—the Commission, CDPHE, and the Authority. The probable costs of implementation to these agencies were not included in the scope of the Study. However, based on the proposed regulatory language, qualitative impacts can be described. Specific implementation cost information is being developed by the Division and will be included in the regulatory analysis.

6.1 Water Quality Control Commission

The proposed rules may require the use of the Commission's resources in the following ways:

- Regulation #31.17 contains provisions for the adoption of site-specific nutrient standards where appropriate, especially for the protection of DUWS-designated lakes and reservoirs. Implementation of these provisions could increase the length of some regulatory hearings due to the technical complexity of these regulatory issues.

6.2 Colorado Department of Public Health and Environment

The Water Quality Control Division within the CDPHE will be responsible for the implementation of the proposed regulations. No new programs will need to be established at this time; however, it is likely that existing programs will need to accommodate new work elements specific to nutrient management. This may or may not require hiring of additional staff to ensure proper distribution of internal workloads; however, at a minimum it will require reprioritization or reallocation of Division resources. Key affected program areas include:

Water Pollution Control Program

- *Nutrient Effluent Limits in WWTF CDPS Permits* – Permit applications will be required to include information regarding nutrient treatment processes and proposals for meeting Tier 1 or Tier 2 effluent quality requirements, as appropriate. The proposed regulation does not create a burden for new permit applications or change the time in which these applications would normally be received. Accordingly, the Division will not incur any additional costs with regards to the number of permit applications requiring review (in terms of both volume and frequency). However, while the Division has technical staff dedicated to conducting permit application reviews, it is expected that a percentage of these staff will require additional training to ensure complete understanding of nutrient treatment technology.

The proposed regulation includes allowances for establishment of variances and compliance schedules or the implementation of a nutrient trading program either between point sources or between point and nonpoint nutrient sources. It is expected that a number of WWTFs will request coverage under a compliance schedule, request a variance, or seek to achieve compliance through participation in a nutrient trading program. The actual number of such requests is unknown, but each request will require staff time to review and evaluate the request. For WWTFs that request a variance, or plan to participate in a nonpoint source to point source trade, Division staff in the Watershed Program will be affected as well.

- *WWTF Monitoring Requirements* – The proposed regulations include requirements for enhanced monitoring for nutrients – both in the effluent and in the receiving water downstream of the WWTF outfall. These data will be periodically submitted to the Division, which will require additional staff time for periodic data management, analysis, and reporting to inform managers and policy officials regarding the outcomes from regulatory implementation.
- *MS4 Permit Program Requirements* – The proposed regulations include additional programmatic requirements (public education/outreach; pollution prevention/good housekeeping in municipal operations) for implementation through MS4 permits issued under Regulation #61. The outcome of these programs, including review of documents and procedures, will require Division staff time; however, the impact to agency resources is expected to be minimal.

- *MS4 Permit Monitoring Requirements* – The proposed regulations include requirements for nutrient monitoring through MS4 permits issued under Regulation #61. These requirements include development of a DADR that documents the availability of existing data and provides a gap analysis that identifies the need for additional information such as monitoring data or studies. The proposed regulation requires that MS4 dischargers, either individually or collaboratively, submit a DADR by October 31, 2014. Division staff time will be required to review and evaluate each submitted DADR.
- *Compliance Assurance Section* – There is the potential for an increased burden on compliance staff where WWTFs do not meet the required milestones in a compliance schedule, fail to comply with the required effluent limits or fail to provide the required MS4 monitoring plan and/or analysis.

Operations Program

- *Financial Assistance* – The proposed regulations could result in an increased need for financial support services as more WWTFs seek Revolving Loan funds and other financing opportunities for facility upgrades.

Watershed Program

- *Nonpoint Source Management* – Regulation #85 includes BMP and public information and education elements that are voluntary in nature. However, effective implementation of the proposed regulation to address nonpoint sources of nutrients may require increased Division staff resources. The regulation also requires the Division to report on progress implementing activities that address nonpoint sources during each triennial review of the regulation. These reviews, as well as an evaluation of the effectiveness of voluntary provisions by the Commission by May 31, 2022, will require staff resources.
- *Water Quality Assessments and Identification of Impaired Waters* – Where proposed modifications to Regulation #31 result in the establishment of water quality standards on a specific waterbody, these waterbodies will need to be assessed as part of the Division’s biannual basin classifications and standards triennial water quality assessment. If a waterbody is determined to be impaired for nutrients, the Division will need to add the waterbody to the list of impaired waters (303[d]) List and a TMDL would be required to be developed. Interim nutrient values for phosphorus and chlorophyll a proposed in Regulation #31.17 will not be used for the adoption of water quality standards for specific waterbodies in Colorado prior to May 31, 2022 except in limited circumstances, e.g., waterbodies designated as DUWS. Similarly, the interim nutrient values for nitrogen will not be used for the adoption of water quality standards for any specific water bodies in Colorado prior to May 31, 2017. From May 31, 2017 to May 31, 2022, these nitrogen values may be used for the adoption of water quality standards for specific waterbodies, but only in limited circumstances. Following May 31, 2022, the numerical nutrient values adopted by the Commission may be used for the adoption of water quality standards for any surface water in Colorado. If nutrient values are adopted as water quality standards on waters throughout the state, the number of waterbodies assessed for compliance with nutrient standards may increase markedly. For any waterbodies determined to be impaired for nutrients, increased costs for TMDL development and implementation may be incurred. The additional water quality assessments and potential increase in waterbodies impaired by nutrients will require additional staff resources to be dedicated to this task.

6.3 Colorado Water Resources and Power Development Authority

Pursuant to C.R.S. Section 37-95-107.6, the Authority facilitates capital funding of WWTFs, among other utilities through its administration of the Colorado WPCRf. The WPCRf is funded by capitalization grants provided by the federal government and state match funds provided by the Authority and maintained by loan repayments. Implementation of the proposed regulations will require the Authority to expand its activities to help accommodate a need for additional capital funding for WWTFs throughout the state. Additional activities of the Authority will include increased loan volume and monitoring and an increase in the outreach to affected systems. At the Tier 1 level, some of these activities might be combined with other existing capital needs of the wastewater utilities, but under Tiers 2 and 3, the much higher level of capital funding requirements will begin to drive Authority activities. The Authority will require a significant increase in available capital. It is assumed that at least a portion of the funding will come from the Authority's ability to leverage the municipal bond market. With the increased debt burden, the affordability, or ability to repay loans, becomes a bigger consideration in the loan process. The Authority might need to undertake a special inquiry into the availability of capital funding under Tiers 2 and 3.

Other sources of funding for WWTF infrastructure improvements are available and include 'self-bonding' by communities through the municipal bond market, community development financing through the Colorado DOLA, and rural development loans through USDA.

It is also worth noting that the Authority and other financing agencies may experience a decrease in demand under the Drinking Water Revolving Fund as some utilities could avoid the capital funding needs of additional treatment to address nutrient-related impacts upon water quality.

6.4 Other State Agencies

There are other state agencies that will not have responsibility for administration or implementation of the proposed nutrient control requirements, but will bear the cost of compliance with the regulation. State agencies such as the Division of Parks and Wildlife and the Department of Corrections operate WWTFs, some of which may become subject to the proposed regulations. These facilities are identified by Manageable Unit in Section 4 of this Study report. The cost of treatment upgrades will vary by facility depending on factors such as the existing effluent quality and treatment technology used by the facilities. New state-owned WWTFs would also have to meet the proposed regulations, which may increase the capital and O&M costs associated with these facilities.

4. A comparison of the probable costs and benefits of the proposed rule to the probable costs and benefits of inaction.

6.5 Comparison of Probable Costs and Benefits

Sections 5 and 7 of this Study report provide detailed tables (in particular, see Tables 7-1 through 7-4) showing the probable costs and benefits associated with implementation of nutrient controls at the three effluent quality tiers for each of the 27 Manageable Units within the seven river basins of Colorado (see Table 2-6 for a description of the effluent limitations tiers that provide the baseline for the Cost-Benefit Study).

Table 6-1 summarizes the probable costs and benefits for each of the seven river basins with the basins ranked highest to lowest based on the Tier 1 benefit-cost ratio. Table 6-2 provides the statewide aggregate costs and benefits.

Table 6-1. Aggregate Benefits and Costs by River Basin Ranked from Highest to Lowest Based on the Tier 1 Benefit-Cost Ratio

Aggregate by River Basin	Component	Tier 1*	Tier 2*	Tier 3*
Arkansas	Benefits	\$679,062,000	\$808,956,000	\$1,056,414,000
	Costs	\$545,429,000	\$1,121,448,000	\$5,910,796,000
	Benefit-Cost Ratio	1.25 : 1	0.72 : 1	0.18 : 1
Yampa-White	Benefits	\$31,882,000	\$36,204,000	\$49,229,000
	Costs	\$40,990,000	\$77,461,000	\$461,614,000
	Benefit-Cost Ratio	0.78 : 1	0.47 : 1	0.11 : 1
Platte	Benefits	\$1,068,108,000	\$1,278,498,000	\$1,854,325,000
	Costs	\$1,473,367,000	\$3,152,796,000	\$14,286,950,000
	Benefit-Cost Ratio	0.72 : 1	0.41 : 1	0.13 : 1
Gunnison	Benefits	\$24,043,000	\$31,798,000	\$43,075,000
	Costs	\$46,947,000	\$96,172,000	\$447,136,000
	Benefit-Cost Ratio	0.51 : 1	0.33 : 1	0.1 : 1
Colorado	Benefits	\$103,315,000	\$154,851,000	\$279,996,000
	Costs	\$226,322,000	\$393,719,000	\$2,840,746,000
	Benefit-Cost Ratio	0.46 : 1	0.39 : 1	0.1 : 1
Southwestern	Benefits	\$22,418,000	\$33,428,000	\$55,024,000
	Costs	\$63,657,000	\$98,692,000	\$542,752,000
	Benefit-Cost Ratio	0.35 : 1	0.34 : 1	0.1 : 1
Rio Grande	Benefits	\$10,561,000	\$12,206,000	\$16,980,000
	Costs	\$68,185,000	\$94,131,000	\$502,522,000
	Benefit-Cost Ratio	0.15 : 1	0.13 : 1	0.03 : 1

* Expressed in Present Value 2010 Dollars

Table 6-2. Aggregate Benefits and Costs Statewide

Statewide Aggregate (Component	Tier 1*	Tier 2*	Tier 3*
Statewide Aggregate	Benefits	\$1,939,389,000	\$2,355,941,000	\$3,355,043,000
	Costs	\$2,464,897,000	\$5,034,419,000	\$24,992,516,000
	Benefit-Cost Ratio	0.79 : 1	0.47 : 1	0.13 : 1

* Expressed in Present Value 2010 Dollars

Tables 6-1 and 6-2 only provide the quantified costs and benefits. Sections 5 and 7 of the Study also presented information on a number of costs and benefits that could not be quantified. These qualitative findings should be considered in the overall costs and benefits of the proposed regulations. In some cases, these qualitative factors could provide *significant* benefits not quantified.

For the probable quantified costs and benefits several key findings emerge:

- The probable costs and benefits varied widely among river basins, with the highest costs and also the highest benefits generally associated with the two Front Range river basins (Arkansas and Platte River Basins). The majority of WWTFs subject to proposed Regulation #85 are located in these river basins. The cumulative water quality improvement could be substantial, which translates into higher accrued benefits.
- One exception to the Front Range trend was the Yampa-White River Basin, which had a relatively high benefit-cost ratio for the western slope. This relatively high benefit-cost ratio can be attributed to the fact that both Manageable Units within this basin are relatively long in terms of affected stream miles, which increase the recreational benefits.
- West Slope river basins had relatively low benefit-cost ratios, as compared to the Front Range river basins, for several reasons:

- The number of WWTFs subject to the proposed nutrient control regulations is low compared to the Front Range area. For the facilities subject to the proposed regulations, their effluent discharge is relatively small compared to the flows in the western rivers.
 - Where the larger facilities are located upstream of lakes or reservoirs subject to an existing Watershed Protection Control Regulation (WPCR), e.g., upstream of Dillon Reservoir, existing nutrient control regulations have already reduced nutrient loads to downstream waters.
 - Nonpoint sources are overall likely a greater contributor of nutrients to West Slope waterbodies than point sources; thus, the expected percent change in water quality is small. The smaller the change in water quality the fewer benefits accrued.
- The most significant water quality benefits, and thus benefits accrued, are associated with implementation of the Tier 1 effluent limits.

6.5.1 Probable Costs and Benefits of Inaction

A number of probable costs and benefits may result from inaction with respect to the proposed nutrient controls in Regulation #85. These are discussed first within the context of federal regulatory expectations, and then state-specific costs or benefits. For this analysis, "inaction" is defined as the status quo – continued reliance on the state's current regulatory approach for managing nutrients.

EPA has identified nutrient management as a high priority for the nation's waters. EPA has already demonstrated its commitment to address this priority under its own authority where states either have not acted, or not acted in a manner EPA has determined to be sufficient to address the problem. An effort to move nutrient control forward through the establishment of nutrient water quality standards is EPA's preferred approach (recently reaffirmed by EPA's March 16, 2011 memorandum to the states). EPA's CWA 304(a) criteria recommendations for streams and rivers occurring within each of the three ecoregions present within the State of Colorado are shown below in Table 6-3. If these criteria were to be promulgated by EPA for the State of Colorado, the resulting effluent limitations for WWTFs would be more stringent than any of the tiered limits that were evaluated during this Study.

The State of Colorado currently has limited regulatory controls for the nutrients phosphorus and nitrogen. Nonetheless, elevated concentrations of phosphorus and nitrogen can cause of a broad range of impacts to water quality. Some controls on nutrients have been imposed pursuant to TMDLs, and five lakes have site-specific standards for phosphorus and/or chlorophyll *a*. Instead of managing nutrients directly, the Division primarily relies upon the implementation of its narrative water quality standards in Regulation #31.11 and through the CWA Section 303(d) program, which requires periodic assessments of Colorado waters to identify impaired waterbodies. Waterbodies with impairment for pH or dissolved oxygen often have concerns with high nutrients as well, and identification of pH and dissolved oxygen concerns is being used as the basis for implementing the narrative standards applicable to nutrients through translation.

Table 6-3. EPA 304(a) Criteria Recommendations for Streams and Rivers in Ecoregions in Colorado

Colorado Ecoregion	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
Southern Rockies	0.006	0.09
Southern Great Plains, Western High Plains	0.090	0.84
Great Plains, Southwest Tablelands	0.025	0.45

Given EPA's position on nutrient control, inaction by the state, i.e., continued reliance on Regulation #31.11 as the mechanism for nutrient control, puts the state at risk of EPA using its authority under the CWA to impose extremely stringent nutrient water quality standards on the state. Actions that allow the Commission to use its discretion over how to best manage nutrients in the State of Colorado are certainly preferable.

Probable Benefits from Inaction:

- The probable capital and O&M costs described above will be avoided, or deferred.
- Avoidance or deferral of the need for capital financing and funding for O&M would reduce or delay the need for increased wastewater rates and lower the financial burden on households and businesses.
- The anticipated impact to the WPCRF or other funding sources for WWTFs would not occur, or be delayed.
- The described additional regulatory burden on state agencies and cost burden to state-owned and operated WWTFs would not occur or would be delayed.

Probable Costs from Inaction:

- Public water supply facilities that draw their water from sources downstream of WWTF discharges may incur higher long-term treatment costs as the nutrient loads from upstream wastewater effluent discharges increase along with population growth. In addition, specific facilities have been identified in this Study that may have avoided costs as a result of regulation implementation. These avoided costs may be incurred if the regulations are not implemented.
- Potential impacts from increased nutrient loading include:
 - *Lakes and Reservoirs* – Enriching nutrient supplies to lakes and reservoirs increases algal abundance, which can have a broad range of impacts to water quality. Impacts include, but are not limited to elevated pH, decreased oxygen and clarity, algal blooms, toxin formation, shifts in the nature of the fishery, and decline in property values. These impacts have the potential to impair uses for aquatic life, recreation, agriculture, and water supply. No dollar amount has been attached to the complete set of impacts.
 - *Rivers and Streams* – Increased pH and low dissolved oxygen, a common byproduct of excess algal growth, could occur, which is detrimental to other aquatic organisms. In addition, excessive abundance of attached algae could diminish the recreational use of state waters.

5. A determination of whether there are less costly methods or less intrusive methods for achieving the purpose of the proposed rule.

This Study included analysis of the costs and benefits associated with three tiers of effluent quality. The Study assumed that the selected tier would be applied to nonexempt WWTFs in an identified size range, statewide. This is consistent with the use of technology-based regulatory approaches that EPA has employed under the CWA and other environmental statutes. However, there is a potential for nutrient reductions through the voluntary implementation of nonpoint source controls or mandatory controls on very specific nutrient sources (e.g., implementation of a ban on phosphate fertilizers or detergents). In addition, it may be possible to support the purpose of the proposed rule through nutrient trading, for example, through point source to point source trades or nonpoint source to point source trades. Such trades are authorized by the proposed regulations.

6. A description of any alternative methods for achieving the purpose of the proposed rule that were seriously considered by the Commission or petitioner and the reasons the alternative methods were rejected in favor of the proposed rule.

To date, the Division has considered two alternatives for nutrient management in state waters. The current proposed alternative or method, for which there have been two variations, emphasizes technology-based control of nutrients in Colorado. The two variations represent an evolution of ideas concerning the proposed method. The other alternative method, which was under development for the better part of a decade, was based solely on a more traditional approach to development of numeric criteria for protection of uses.

In addition to the alternative methods presented here, the workgroup has seen regulatory concepts presented by other parties. However, these were never developed to the point where they could receive full consideration.

Alternative A, Adoption of Numeric Nutrient Criteria to Protect Classified Uses

The Division originally developed a set of numeric nutrient criteria specific to classified uses. Lakes and streams were considered separately, as shown below.

- *Lakes and Reservoirs, Aquatic Life and Recreation* – Criteria development focused on meeting a target trophic condition: Cold lakes should be mesotrophic, or less productive; Warm lakes should be eutrophic, or relatively more productive. Consideration was given to balancing potentially-competing interests such as fishery productivity and swimming. Target trophic conditions were defined on the basis of summer average chlorophyll *a* concentration, and the corresponding phosphorus and nitrogen criteria were set with empirical relationships developed from Colorado lakes.
- *Lakes and Reservoirs, High Quality Water Supply* – The Division also developed a chlorophyll *a* value to minimize the risk of the formation potential for DBPs in the water treatment process. This criterion could be applied optionally to a specific subclass of water supply lakes – waterbodies classified as a DUWS.
- *Rivers and Streams, Recreation* – The Division developed a chlorophyll *a* criterion that defined the level of attached algal growth considered unacceptable for recreation.
- *Rivers and Streams, Aquatic Life* – Criteria development focused on the adoption of median total nitrogen and total phosphorus concentrations based on the health of the macroinvertebrate community, using a MMI. The Division derived a relationship between MMI scores and nutrient concentrations using an EPA-recommended statistical approach (quantile regression). The Division's proposal was based on the assumption that a 5 percent decline in aquatic life condition (as defined by the regression between MMI and nutrient concentrations) is acceptable.

The Numeric Nutrient Criteria alternative is not being proposed for the following reasons:

- Reliance on the traditional standards-based approach alone (table value criteria, followed by segment-specific water quality standards, along with possible temporary modifications and discharger-specific variances, then assessment and listing decisions, TMDL development, and then incorporation into discharge permits, with compliance schedules) would result in substantially less progress in controlling nutrients in the next several years than would a technology-based approach (as described below).

- As a supplement to the implementation of a technology-based approach, the Commission has the authority to use the new interim nutrient values established in Regulation #31.17 as the basis for the adoption of segment-specific water quality standards in appropriate limited circumstances.
- Implementation of a technology-based approach is likely to yield greater reduction in nutrient loads faster than traditional standards-based control efforts alone. Moreover, the Division retains the option in the future to propose additional, more extensive criteria adoption to address nutrient control needs that are not fully addressed by the technology-based requirements now being proposed.

Alternative B, Adoption of Regulation #85 and Regulation #31.17

The original February 2, 2011 draft proposal for Regulation #85 laid the foundation for the overall approach that was later refined in subsequent regulatory proposals (July 5, September 30 and November 2, 2011) and the most recent Division proposal - November 21, 2011. The following sections describe the key provisions presently included in the November 21st regulatory proposal.

Regulation #85

Specific Nutrient Effluent Limitations for Dischargers of Nutrients

The November 21, 2011 regulatory proposal establishes effluent limitations for certain existing domestic and non-domestic WWTFs and new WWTFs. Table 6-4 summarizes the nutrient effluent limitations proposed for existing and new WWTFs, as defined below. These effluent limits are less stringent than the original February 2, 2011 proposal (Table 6-5)¹. The proposed effluent limitations would apply to any domestic WWTF not excluded by the regulation or not eligible for an exemption, as described below. The proposed effluent limitations would apply to any non-domestic WWTF where existing information indicates that the facility's effluent discharge contains nutrients at concentrations in excess of the effluent limitations shown in Table 6-4.

Compliance Schedules

Proposed Regulation #85 includes a provision that authorizes the issuance of a compliance schedule in a CDPS permit. The Division is expected to consider at least the following five factors when developing the deadlines in a compliance schedule:

- Availability of resources needed to modify or install treatment facilities, adjust operations, or other measures, including any in-house resources, the availability of consultants and contractors in the area with the appropriate expertise, and the availability of financing for any identified facility construction or other capital project, including the WPCRF;
- Current conditions at the site, including existing treatment processes, the physical characteristics of the property, and the layout of the facility on the property;
- Sufficient time for operational startup, new plant optimization, and operator training;
- Factors identified by the permittee that might significantly affect the time necessary to complete one or more of the steps necessary to attain compliance; and
- Other site-specific factors affecting the cost and timing of construction activities.

¹ Interim modifications to proposed Regulation #85 released for public review on July 5, September 30, and November 2, 2011, are available on the Nutrient Criteria Workgroup page located on the Colorado Water Quality Forum website, <http://www.cwqf.org/>.

Table 6-4. Summary of Proposed Effluent Limits (mg/L) for Domestic and Non-Domestic WWTFs (subject to the November 21, 2011 regulatory proposal)

Facility Type	Discharge Status	Parameter	Annual Median ¹	95 th Percentile ²
Domestic WWTFs	Existing (discharging prior to May 31, 2012)	Total Phosphorus	1.0	2.5
		Total Inorganic Nitrogen as N ³	10.0	20.0
	New (discharging on or after May 31, 2013)	Total Phosphorus	0.7	1.75
		Total Inorganic Nitrogen as N ³	7.0	14.0
Non-Domestic WWTFs	Existing (discharging prior to May 31, 2013)	Total Phosphorus	1.0	2.5
		Total Inorganic Nitrogen as N ³	10.0	20.0
	New (discharging on or after May 31, 2013)	Total Phosphorus	0.7	1.75
		Total Inorganic Nitrogen as N ³	7.0	14.0

¹ Running Annual Median: The median of all samples taken in the most recent 12 calendar months

² 95th percentile of all samples taken in the most recent 12 calendar months

³ Determined as the sum of nitrate as N, nitrite as N, and ammonia as N

Table 6-5. Summary of Proposed Effluent Limits (mg/L) for Domestic and Non-Domestic WWTFs (original February 2, 2011 regulatory proposal)

Facility Type	Discharge Status	Parameter	Annual Average ¹	Quarterly Average ²
Domestic WWTFs	Existing (discharging prior to May 31, 2012)	Total Phosphorus	0.7	1.0
		Total Inorganic Nitrogen as N ³	5.7	9.0
	New (discharging on or after May 31, 2013)	Total Phosphorus	0.43	0.65
		Total Inorganic Nitrogen as N ³	3.0	5.0
Non-Domestic WWTFs	Existing (discharging prior to May 31, 2013)	Total Phosphorus	0.7	1.0
		Total Inorganic Nitrogen as N ³	5.7	9.0
	New (discharging on or after May 31, 2013)	Total Phosphorus	0.43	0.65
		Total Inorganic Nitrogen as N ³	3.0	5.0

¹ Running Annual Average: Arithmetic mean of all samples taken in the most recent 12 calendar months

² Running Quarterly Average: Arithmetic mean of all samples taken in the most recent 3 calendar months

³ Determined as the sum of nitrate as N, nitrite as N, and ammonia as N

Exceptions and Exclusions

The proposed regulation includes three exceptions applicable to all dischargers. The effluent limitations in Table 6-4 shall not apply to any of the following circumstances:

- A discharger can demonstrate to the satisfaction of the Division that its discharge is unlikely to cause or contribute to ambient nutrient concentrations in its receiving waters that exceed the relevant numeric levels for total phosphorus and total nitrogen proposed in Regulation #31.17.
- Where noncontact cooling water discharges contain nutrients (phosphorus or nitrogen) and 100 percent of the nutrients in the discharge originate from the receiving water as intake water.
- Where discharges consist solely of groundwater that is pumped for the purpose of dewatering a construction site or for building sumps so long as no phosphorus or nitrogen is added to the groundwater being discharged.

In addition to the above exceptions, the proposed regulation includes exclusions from the effluent limitations in Table 6-4 for the following domestic WWTFs:

- WWTFs with a design capacity of less than or equal to 1.0 mgd that use waste stabilization pond (lagoon) technology as its means of treating wastewater.
- Any WWTF owned by a disadvantaged community.

- WWTFs with a design capacity of less than or equal to 0.5 mgd.

With regards to WWTFs already subject to Water Pollution Control Regulations #71-74 (5 CCR 1002-71, 5 CCR 1002-72, 5 CCR 1002-73, and 5 CCR 1002-74), the Division's proposed regulation defers implementation. CDPS permits issued to these facilities will not be subject to Regulation #85 until on or after May 31, 2022.

The exclusion for disadvantaged communities and the deferred implementation for WWTFs subject to existing WPCRs in the November 21st proposed regulation represent significant changes from the original February 2, 2011 proposal. The original proposal included only delayed implementation (rather than an outright exclusion) of the effluent limitations for disadvantaged communities until 2022 and did not include delayed implementation provisions for WWTFs already subject to a WPCR. In addition, the regulatory proposal raised the exclusion for small WWTFs from those with a design capacity of less than or equal to 0.1 mgd to those with a design capacity of less than or equal to 0.5 mgd. These modifications to the original February 2 regulatory proposal significantly reduced the number of WWTFs potentially impacted by the proposed regulations.

Variations

Proposed Regulation #85 includes a variance provision whereby a WWTF may be granted a variance where it is demonstrated by the permittee to the Division's satisfaction that the nutrient reduction benefits of meeting the Table 6-4 effluent limitations do not bear a reasonable relationship to the economic, environmental, or energy impacts resulting from meeting those effluent limitations. The original February 2, 2011 proposal included a variance provision, but did not provide criteria to evaluate a request for a variance. The November 21 regulatory proposal includes proposed criteria based on a Municipal Screener (MS) value. The MS is defined as the total annualized cost of water pollution control at the WWTF, including the cost of meeting the effluent limitations in Table 6-4, divided by the median household income, on a percentage basis (i.e., [annualized cost of treatment / median household income] * 100).

The proposed variance criteria vary based on such factors as the percent annual median total nitrogen or total phosphorus concentrations resulting from permitted process wastewater point source discharges and the calculated MS value for public entities or the impact to profitability for private sector entities. Requests for a variance must include a proposed alternate effluent limit that represents the highest degree of nutrient removal that is consistent with the variance criteria applicable to the discharge.

Nutrient Trading

The Division's regulatory proposal incorporates a nutrient trading provision that was not included in the original February 2, 2011 proposal. This provision provides opportunity for CDPS permit effluent limitations to be modified based on a point source to point source or nonpoint source to point source trade. Such nutrient trades may be allowed where the Division has determined that the trade achieves a net water quality or environmental benefit and does not cause adverse local impacts.

MS4 Requirements for Nutrient Source Reductions

Proposed Regulation #85 includes nutrient management requirements applicable to the public education and outreach and pollution prevention and good housekeeping elements of MS4 programs permitted under Regulation #61. These requirements may be met by an individual permittee or through contribution to a collaborative program comprised of multiple MS4 permittees.

Nonpoint Source Discharges

The regulatory proposal includes a number of nonpoint source program elements including BMP implementation, public information and education, and program reporting and evaluation requirements.

Only minor revisions occurred between the February 2 and November 21, 2011 regulatory proposals. The regulatory proposal includes the following provisions:

- Encourages implementation of BMPs by entities that may contribute nonpoint sources of nutrients to the state's waterbodies and agricultural operations where nutrients are used as part of crop production activities.
- Encourages development and implementation of public information and education programs that target nonpoint sources of nutrients.
- Requires submittal of triennial reports to the Commission on progress implementing nonpoint source control activities.
- Requires the Commission to consider adoption of additional prohibitions or precautionary measures if it is determined that by May 31, 2022 voluntary BMPs are not effective in managing nutrients.
- Requires the Commission to consider adopting control regulations specific to agricultural and silvicultural practices if it is determined that progress has not been demonstrated in agricultural nonpoint source nutrient management.

Monitoring Requirements

Regulation #85 includes requirements for nutrient monitoring that are applicable to WWTFs, permitted MS4s, and nonpoint sources:

- WWTFs subject to the effluent limitations described in Table 6-4 are required to implement a monitoring program that includes effluent monitoring and receiving water monitoring. The Division's proposal defines the locations where in-stream nutrient monitoring should be conducted to comply with monitoring requirements applicable to WWTFs.
- The monitoring requirements applicable to MS4s have gone through several iterations since the release of the original February 2, 2011 proposal. The current regulatory proposal requires MS4 dischargers permitted under Regulation #61 to prepare a DADR that documents the availability of existing data and provides a gap analysis that identifies the need for additional information such as monitoring data or studies. Submittal of the DADR, which may be developed by MS4 dischargers individually or collaboratively, is required by October 31, 2014. The current regulatory proposal does not obligate MS4 dischargers to conduct stormwater monitoring for nutrients unless a regulatory determination is made that such monitoring is necessary.
- Nonpoint sources and unpermitted point sources are encouraged to monitor and assess water quality.

Regulation #31.17 (and modification to #31.13)

The current regulatory proposal includes the following elements:

- Revises the State Use Classifications found in Regulation #31.13 to incorporate a DUWS Lakes and Reservoirs Sub-classification to the existing Domestic Water Supply use.
- Defines the factors for how the interim phosphorus and chlorophyll *a* values (see Table 2-3 and 2-5, respectively) may be used as discretionary criteria for waters designated DUWS.
- Defines the two factors for when the interim nitrogen values (see Table 2-4) may be used in the adoption of site-specific nutrient standards after May 31, 2017 and prior to May 22, 2022. These

factors define two circumstances when the interim nitrogen values may be used to establish nutrient standards: (a) waters located upstream of permitted point source dischargers with significant nutrient concentrations that are existing as of May 2012; and (b) unique circumstances where the Commission has determined that adoption of numerical standards is necessary to address existing or potential nutrient pollution because provisions of Regulation #85 will not result in adequate control of such pollution.

The proposed numerical criteria at Regulation #31.17 are not self-implementing. They would only be considered for adoption as site-specific water quality standards during water quality standard-setting hearings held for each river basin. As such they would not be used as the basis for discharge permit requirements prior to the adoption of segment-specific standards in individual river basins. The November 21, 2011 Regulation #31.17 proposal is structurally similar to the original February 2, 2011 proposal; however, modifications have been made to some of the interim values and clarifications have been added with regards to seasonal applicability.

Similar to Regulation #31.17, the proposed changes to Regulation #31.13 are also not self-implementing. Adoption of DUWS as a use classification would only occur during the water quality standards-setting process that occurs for each river basin. The Regulation #31.13 modifications were not included in the original February 2, 2011 regulatory proposal.

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Section 7 Project Summary

This section provides a summary of the quantitative and qualitative findings as reported in previous sections. In addition, we provide a cataloging of the known uncertainties and limitations associated with the Study and a synopsis of how these findings should be interpreted.

7.1 Summary of Findings

Section 5 summarized the quantified costs and benefits aggregated by river basin and statewide. These aggregations are further summarized below. In addition, we provide a summary of the qualitative findings also reported in Section 5. The overall costs and benefits of the implementation of the proposed control regulations should consider both quantitative and qualitative elements. Specifically, the quantified costs and benefits represent only a subset of the overall costs and benefits (for example see Figure 1-2). Qualitative effects are no less important and they apply to all Manageable Units. As noted in previous sections, these effects are qualitative only because the project team was not able to obtain sufficient data or derive sufficient supportable assumptions in order to quantify the costs or benefits.

7.1.1 Quantified Costs and Benefits

Tables 7-1 through 7-4 summarize the total costs, total benefits, and benefit-cost ratios quantified for each of the Manageable Units. Figures 7-1 through 7-3 illustrate the range of benefit-cost ratios observed across the State of Colorado.

The costs and benefits varied widely among Manageable Units, with the highest costs and benefits generally associated with Front Range Manageable Units. One exception was the Manageable Units in the Yampa-White River Basin where the benefit-cost ratios were high relative to other West Slope Manageable Units. Many West Slope Manageable Units had relatively low benefit-cost ratios for several reasons:

- The number of WWTFs subject to the proposed nutrient control regulations is low compared to the Front Range area. For the facilities subject to the proposed regulations, their effluent discharge is relatively small compared to the flows in the western rivers.
- Where the larger facilities are located, for example upstream of Dillon Reservoir, existing nutrient control regulations have already reduced nutrient loads to downstream waters.
- Nonpoint sources are overall likely a greater contributor of nutrients to West Slope waterbodies than point sources; thus, the expected percent change in water quality is small. The smaller the change in water quality, the fewer benefits accrued.

The relatively high benefit-cost ratios seen in the Yampa-White River Basin Manageable Units can be attributed to the fact that both Manageable Units are relatively long in terms of affected stream miles, which increase the recreational benefits. The eastern plains Manageable Units also had relatively small cost-benefit ratios for similar reasons as described above. In addition, many of these areas have limited recreation opportunities (as compared to West Slope waters).

Table 7-1: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, Arkansas River Basin

Manageable Unit	Component	Tier 1*	Tier 2*	Tier 3*
ARK_01: Upper Arkansas River	Benefits	\$308,863,000	\$382,808,000	\$491,363,000
	Costs	\$145,673,000	\$283,016,000	\$1,448,016,000
	Benefit-Cost Ratio	2.12 : 1	1.35 : 1	0.34 : 1
ARK_02: Fountain Creek	Benefits	\$277,163,000	\$330,911,000	\$404,229,000
	Costs	\$333,618,000	\$760,789,000	\$4,008,227,000
	Benefit-Cost Ratio	0.83 : 1	0.43 : 1	0.1 : 1
ARK_03: Lower Arkansas River	Benefits	\$93,036,000	\$95,237,000	\$160,822,000
	Costs	\$66,138,000	\$77,643,000	\$454,553,000
	Benefit-Cost Ratio	1.41 : 1	1.23 : 1	0.35 : 1

* Expressed in Present Value 2010 Dollars

Table 7-2: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, Colorado River Basin

Manageable Unit	Component	Tier 1*	Tier 2*	Tier 3*
COL_01: Colorado Headwaters	Benefits	\$17,118,000	\$19,949,000	\$28,357,000
	Costs	\$30,017,000	\$61,834,000	\$399,596,000
	Benefit-Cost Ratio	0.57 : 1	0.32 : 1	0.07 : 1
COL_02: Blue River	Benefits	\$10,204,000	\$35,663,000	\$115,826,000
	Costs	\$29,842,000	\$42,995,000	\$480,894,000
	Benefit-Cost Ratio	0.34 : 1	0.83 : 1	0.24 : 1
COL_03: Eagle River	Benefits	\$14,942,000	\$18,556,000	\$29,190,000
	Costs	\$44,859,000	\$76,227,000	\$603,988,000
	Benefit-Cost Ratio	0.33 : 1	0.24 : 1	0.05 : 1
COL_04: Roaring Fork	Benefits	\$12,816,000	\$25,242,000	\$29,101,000
	Costs	\$48,843,000	\$74,725,000	\$516,022,000
	Benefit-Cost Ratio	0.26 : 1	0.34 : 1	0.06 : 1
COL_05: Lower Colorado River	Benefits	\$48,235,000	\$55,441,000	\$77,522,000
	Costs	\$72,761,000	\$137,938,000	\$840,246,000
	Benefit-Cost Ratio	0.66 : 1	0.4 : 1	0.09 : 1

* Expressed in Present Value 2010 Dollars

Table 7-3: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, Platte River Basin

Manageable Unit	Component	Tier 1*	Tier 2*	Tier 3*
PLT_01: Upper South Platte River	Benefits	\$149,237,000	\$169,169,000	\$281,177,000
	Costs	\$202,579,000	\$436,318,000	\$2,019,184,000
	Benefit-Cost Ratio	0.74 : 1	0.39 : 1	0.14 : 1
PLT_02: Clear Creek	Benefits	\$0	\$0	\$128,924,000
	Costs	\$0	\$3,395,000	\$165,563,000
	Benefit-Cost Ratio	N/A	0 : 1	0.78 : 1
PLT_03: St Vrain River	Benefits	\$163,235,000	\$198,659,000	\$241,502,000
	Costs	\$202,571,000	\$424,311,000	\$2,390,588,000
	Benefit-Cost Ratio	0.81 : 1	0.47 : 1	0.1 : 1
PLT_04: Big Thompson River	Benefits	\$162,656,000	\$194,355,000	\$203,716,000
	Costs	\$54,738,000	\$103,461,000	\$648,500,000
	Benefit-Cost Ratio	2.97 : 1	1.88 : 1	0.31 : 1
PLT_05: North Platte River	N/A	N/A	N/A	N/A
PLT_06: Cache la Poudre River	Benefits	\$25,543,000	\$37,355,000	\$62,670,000
	Costs	\$275,341,000	\$535,809,000	\$2,476,315,000
	Benefit-Cost Ratio	0.09 : 1	0.07 : 1	0.03 : 1

Table 7-3: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, Platte River Basin

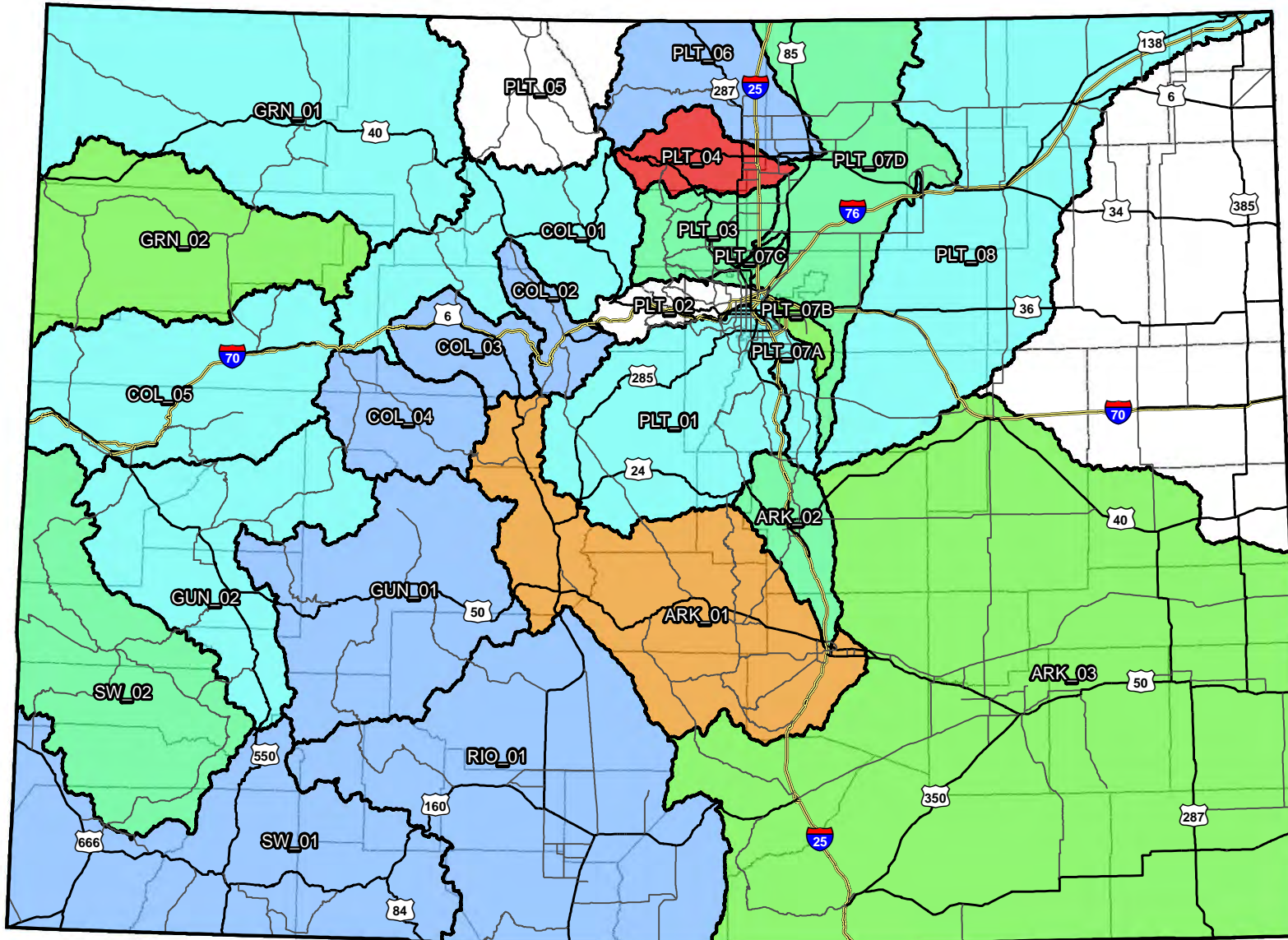
Manageable Unit	Component	Tier 1*	Tier 2*	Tier 3*
PLT_07A: Cherry Creek	Benefits	\$249,042,000	\$280,344,000	\$372,229,000
	Costs	\$373,771,000	\$1,028,808,000	\$3,687,155,000
	Benefit-Cost Ratio	0.67 : 1	0.27 : 1	0.1 : 1
PLT_07B: Sand Creek	Benefits	\$85,424,000	\$92,727,000	\$107,304,000
	Costs	\$73,110,000	\$125,556,000	\$469,282,000
	Benefit-Cost Ratio	1.17 : 1	0.74 : 1	0.23 : 1
PLT_07C: Big Dry Creek	Benefits	\$96,351,000	\$118,758,000	\$198,442,000
	Costs	\$111,919,000	\$251,181,000	\$1,161,086,000
	Benefit-Cost Ratio	0.86 : 1	0.47 : 1	0.17 : 1
PLT_07D: Middle South Platte River	Benefits	\$99,425,000	\$128,787,000	\$175,826,000
	Costs	\$112,811,000	\$164,899,000	\$850,735,000
	Benefit-Cost Ratio	0.88 : 1	0.78 : 1	0.21 : 1
PLT_08: Lower South Platte River	Benefits	\$37,195,000	\$58,344,000	\$82,535,000
	Costs	\$66,527,000	\$79,058,000	\$418,542,000
	Benefit-Cost Ratio	0.56 : 1	0.74 : 1	0.2 : 1
PLT_09: Republican River	N/A	N/A	N/A	N/A

* Expressed in Present Value 2010 Dollars

Table 7-4: Quantified Costs and Benefits of Proposed Regulation 85, 2014 through 2038, Gunnison, Rio Grande, Southwest, and Yampa-White River Basins

Manageable Unit	Component	Tier 1*	Tier 2*	Tier 3*
GUN_01: Upper Gunnison River	Benefits	\$7,659,000	\$9,264,000	\$12,241,000
	Costs	\$19,857,000	\$43,485,000	\$194,565,000
	Benefit-Cost Ratio	0.39 : 1	0.21 : 1	0.06 : 1
GUN_02: Lower Gunnison River	Benefits	\$16,384,000	\$22,534,000	\$30,834,000
	Costs	\$27,090,000	\$52,687,000	\$252,571,000
	Benefit-Cost Ratio	0.6 : 1	0.43 : 1	0.12 : 1
RIO_01: Rio Grande River	Benefits	\$10,561,000	\$12,206,000	\$16,980,000
	Costs	\$68,185,000	\$94,131,000	\$502,522,000
	Benefit-Cost Ratio	0.15 : 1	0.13 : 1	0.03 : 1
SW_01: San Juan and Animas Rivers	Benefits	\$12,488,000	\$11,865,000	\$14,999,000
	Costs	\$53,475,000	\$85,713,000	\$442,551,000
	Benefit-Cost Ratio	0.23 : 1	0.14 : 1	0.03 : 1
SW_02: San Miguel and Dolores Rivers	Benefits	\$9,930,000	\$21,563,000	\$40,025,000
	Costs	\$10,182,000	\$12,979,000	\$100,201,000
	Benefit-Cost Ratio	0.98 : 1	1.66 : 1	0.4 : 1
GRN_01: Yampa River	Benefits	\$26,452,000	\$30,388,000	\$42,145,000
	Costs	\$36,359,000	\$71,859,000	\$401,494,000
	Benefit-Cost Ratio	0.73 : 1	0.42 : 1	0.1 : 1
GRN_02: White River	Benefits	\$5,430,000	\$5,816,000	\$7,084,000
	Costs	\$4,631,000	\$5,602,000	\$60,120,000
	Benefit-Cost Ratio	1.17 : 1	1.04 : 1	0.12 : 1

* Expressed in Present Value 2010 Dollars

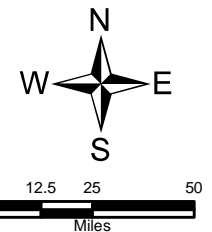


Range of Tier 1 Benefit-Cost Ratios

- >0:1 - 0.5:1
- 0.5:1 - 0.75:1
- 0.75:1 - 1:1
- 1:1 - 1.5:1
- 1.5:1 - 2:1
- 2:1 - 2.5:1
- 2.5:1 - 3:1

Roads

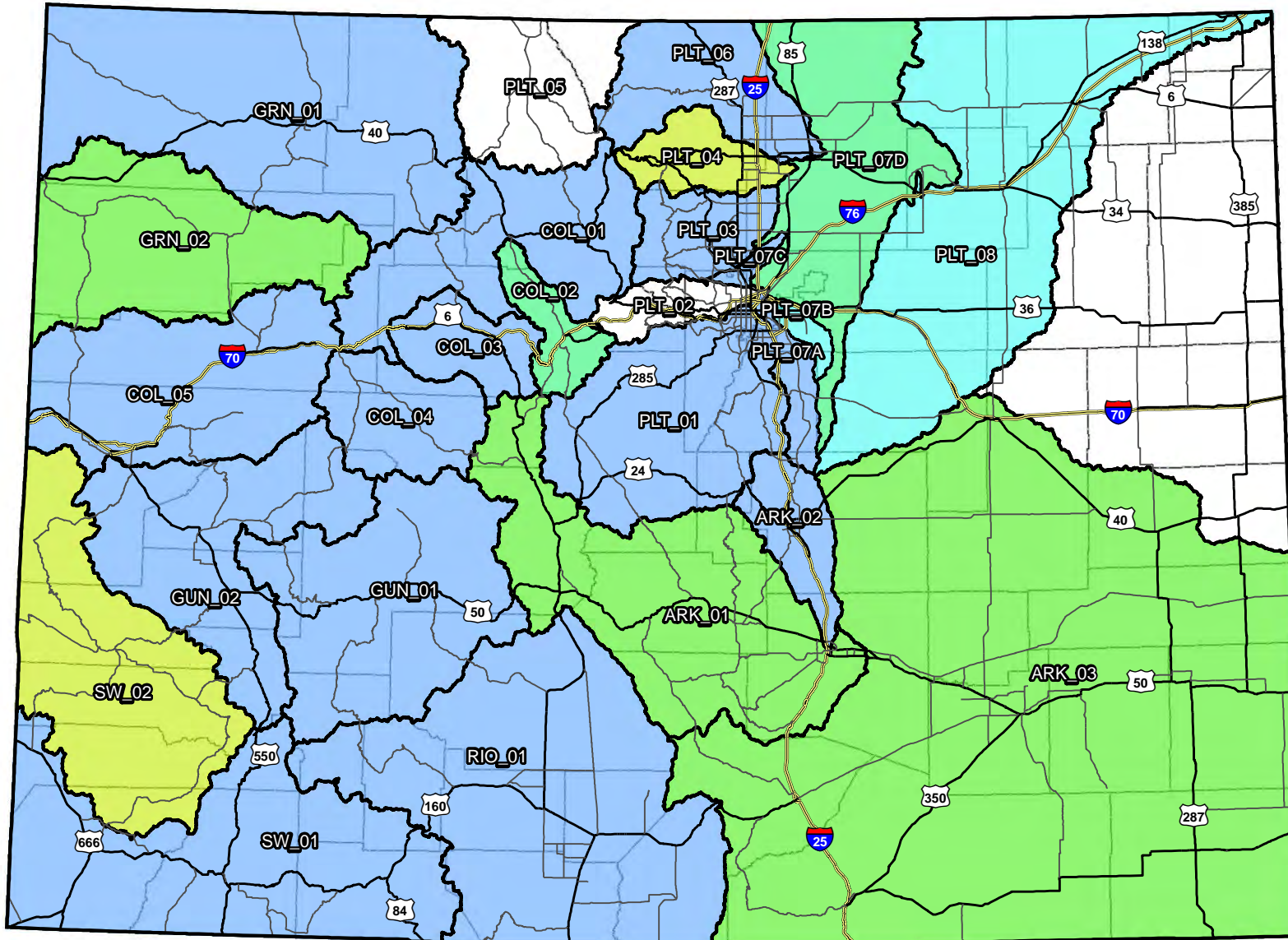
- Interstate Highway
- US Highway
- State Highway
- County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 7-1



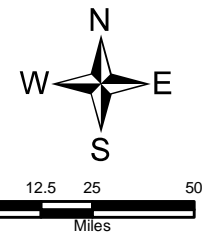


Range of Tier 2 Benefit-Cost Ratios

- >0:1 - 0.5:1
- 0.5:1 - 0.75:1
- 0.75:1 - 1:1
- 1:1 - 1.5:1
- 1.5:1 - 2:1
- 2:1 - 2.5:1
- 2.5:1 - 3:1

Roads

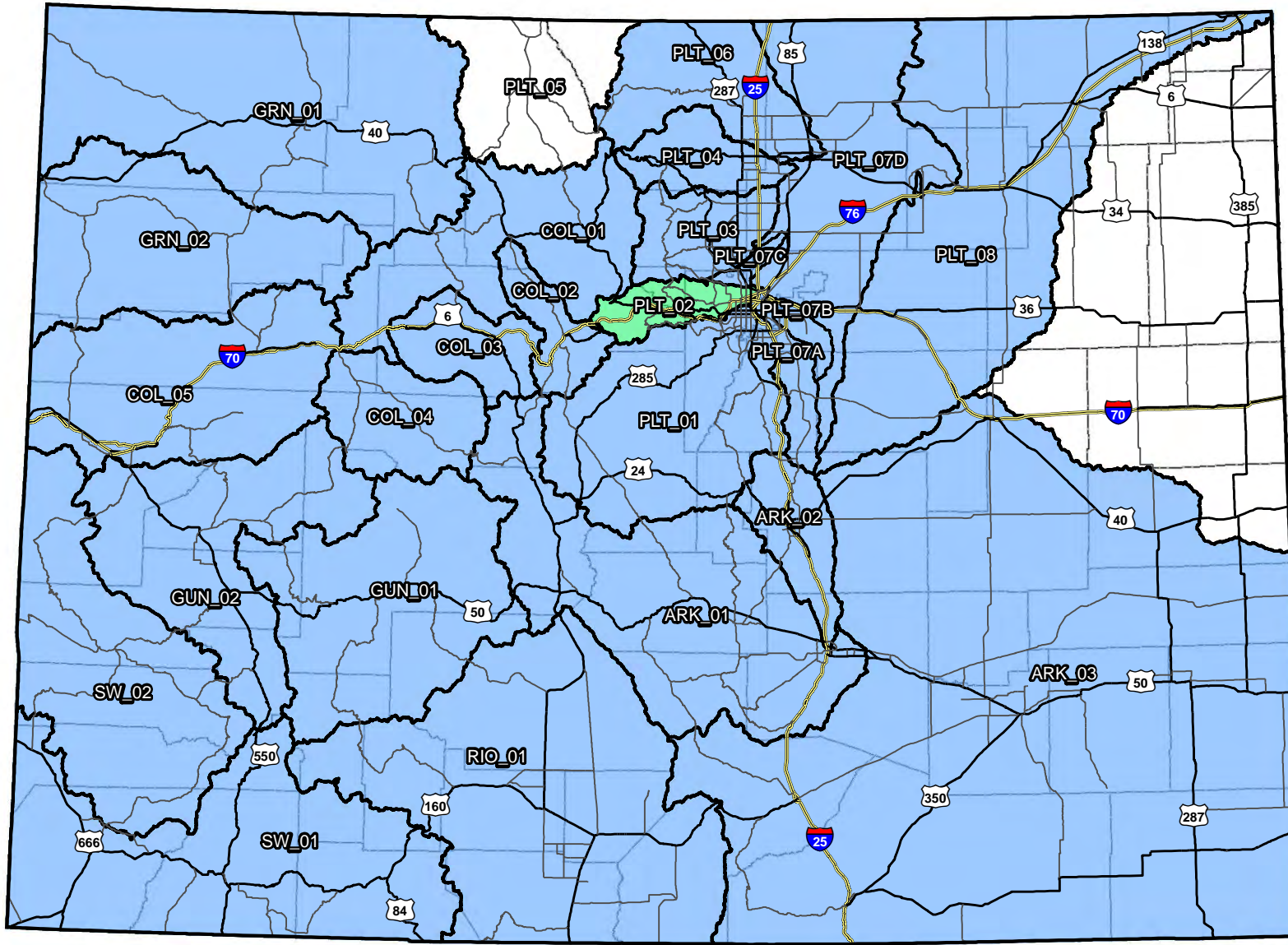
- Interstate Highway
- US Highway
- State Highway
- County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 7-2





Range of Tier 3 Benefit-Cost Ratios

- >0.1 - 0.5:1
- 0.5:1 - 0.75:1
- 0.75:1 - 1:1
- 1:1 - 1.5:1
- 1.5:1 - 2:1
- 2:1 - 2.5:1
- 2.5:1 - 3:1

Roads

- Interstate Highway
- US Highway
- State Highway
- County Boundary



Colorado Nutrient Cost/Benefit Study

Figure 7-3



Tables 7-5 and 7-6 summarize the total costs, total benefits, and benefit-cost ratios aggregated for each river basin and the state as a whole. The Arkansas River basin is the only basin that had a Tier 1 benefit to cost ratio of greater than 1. The river basins with the next highest benefit-cost ratio for Tier 1 are the Yampa-White River, and Platte River. The lowest ratios were found in the Rio Grande and Southwest River Basins. No basins had benefit-cost ratios of greater than 1.0 for Tier 2 or Tier 3.

Table 7-5. Aggregate Benefits and Costs by River Basin

Aggregate (River Basin or Statewide)	Component	Tier 1*	Tier 2*	Tier 3*
Arkansas	Benefits	\$679,062,000	\$808,956,000	\$1,056,414,000
	Costs	\$545,429,000	\$1,121,448,000	\$5,910,796,000
	Benefit-Cost Ratio	1.25 : 1	0.72 : 1	0.18 : 1
Colorado	Benefits	\$103,315,000	\$154,851,000	\$279,996,000
	Costs	\$226,322,000	\$393,719,000	\$2,840,746,000
	Benefit-Cost Ratio	0.46 : 1	0.39 : 1	0.1 : 1
Gunnison	Benefits	\$24,043,000	\$31,798,000	\$43,075,000
	Costs	\$46,947,000	\$96,172,000	\$447,136,000
	Benefit-Cost Ratio	0.51 : 1	0.33 : 1	0.1 : 1
Platte	Benefits	\$1,068,108,000	\$1,278,498,000	\$1,854,325,000
	Costs	\$1,473,367,000	\$3,152,796,000	\$14,286,950,000
	Benefit-Cost Ratio	0.72 : 1	0.41 : 1	0.13 : 1
Rio Grande	Benefits	\$10,561,000	\$12,206,000	\$16,980,000
	Costs	\$68,185,000	\$94,131,000	\$502,522,000
	Benefit-Cost Ratio	0.15 : 1	0.13 : 1	0.03 : 1
Southwestern	Benefits	\$22,418,000	\$33,428,000	\$55,024,000
	Costs	\$63,657,000	\$98,692,000	\$542,752,000
	Benefit-Cost Ratio	0.35 : 1	0.34 : 1	0.1 : 1
Yampa-White	Benefits	\$31,882,000	\$36,204,000	\$49,229,000
	Costs	\$40,990,000	\$77,461,000	\$461,614,000
	Benefit-Cost Ratio	0.78 : 1	0.47 : 1	0.11 : 1

* Expressed in Present Value 2010 Dollars

Table 7-6. Aggregate Benefits and Costs Statewide

Aggregate (River Basin or Statewide)	Component	Tier 1*	Tier 2*	Tier 3*
Statewide Aggregate	Benefits	\$1,939,389,000	\$2,355,941,000	\$3,355,043,000
	Costs	\$2,464,897,000	\$5,034,419,000	\$24,992,516,000
	Benefit-Cost Ratio	0.79 : 1	0.47 : 1	0.13 : 1

* Expressed in Present Value 2010 Dollars

7.1.2 Qualitative Costs and Benefits

Section 5 provides a summary of qualitative costs and benefits that should also be considered in parallel with the quantified results. Only one qualitative cost element was evaluated – potential for increased GHG emissions resulting from upgrades to WWTF infrastructure. The potential impact was rated as potentially substantial.

Several potential benefits could not be quantified. Of listed qualitative benefits, the most important to consider from a policy perspective are the potential non-quantified benefits to public water supplies and property values, where private land is adjacent to a waterbody.

7.1.3 Stormwater Monitoring Costs

Estimated stormwater monitoring costs were included in Section 5.4. Again, the current regulatory proposal does not obligate MS4 dischargers to conduct stormwater monitoring for nutrients unless a regulatory determination is made that such monitoring is necessary. Costs associated with the development of a DADR will depend on the MS4s capabilities to perform the work in-house versus contracting the work to a consultant, the size of the existing monitoring program, and the volume of available data for analysis and documentation. Potential monitoring costs to MS4 permitted jurisdictions average approximately \$9,000 - \$20,000 per outfall based on the sampling method. Total costs are dependent on the number of outfalls sampled and the number of sampling events per year and would only be applicable if sampling is deemed necessary by the Division.

7.2 Uncertainties and Limitations

This cost-benefit analysis of proposed nutrient control regulations is an ambitious undertaking. Such a study related to prospective and specific water quality improvements expected from implementation of a control regulation throughout the State of Colorado has never been performed. However, the costs and benefits of water quality improvements have been examined previously by EPA and by others for the states of Iowa, New Hampshire, Minnesota, Maine, Florida, and other locations, as recounted in the literature review in Appendix D. The costs and benefits of certain water quality issues have been studied in Colorado, but these studies had a different and more limited focus than the present effort described in this Study report. As a result, the project team drew methodological elements from the existing cost-benefit studies that have been performed to fit the goals and objectives of this Study. We believe the methodologies we have adopted for this Study are appropriate to accomplish the Study goals.

It is important to note that the time and financial resources available to perform this Study were limited. The time period for completing this work was effectively confined to 4 months (May through August) during 2011 and the financial resources dedicated to the effort amounted to \$482,000. Research endeavors of this type can be improved with additional time and financial resources. However, given the time and financial resources available, the project team believes that this cost-benefit analysis is a reasonably accurate portrayal of the actual costs and benefits that would occur under the three effluent quality tiers evaluated. We have been careful to not quantify elements for which it was believed sufficient data is lacking. However, we have also been careful to note the non-quantifiable elements so that policy-makers can consider them as part of the regulatory decision-making process.

There are specific sources of uncertainty and limitations associated with this Study that have been noted by the project team or by the various Colorado stakeholders, who participated in workshops, reviewed interim work products, provided comments, or interacted directly with the project team to better understand the project methodology. The primary areas of uncertainty or shortcomings are described and addressed below; further discussion of specific relevant issues is provided in the response to comments received during the course of the Study (see Appendix F).

7.2.1 Water Quality Analyses

Data Limitations

The benefits analysis relies on estimated percent changes in water quality expected from Regulation #85 implementation. This effort relied on the use of a simple mass balance approach that required assumptions regarding effluent quality of existing WWTFs. While this approach is valid for making general estimates of water quality changes, a certain degree of uncertainty exists given the assumptions and data availability. Where the uncertainty was considered too high, e.g., lakes and reservoirs, the project team relied on a qualitative approach rather than developing expected concentrations with substantial uncertainty.

The November 21, 2011 regulation does not include exceptions for nondomestic facilities; however, due to the limited information available for nondomestic facilities (in particular determining which facilities would actually be subject to the regulations) and the expected limited effect on receiving water quality by small dischargers, nondomestic facilities discharging less than 0.5 mgd were excluded from the quantification of costs and benefits. Exclusion of these facilities likely underestimates both costs and benefits proportionally.

Water Quality Improvements

Unless site-specific information was provided, this Study relied on median instream TP and TIN values and specific wastewater effluent discharge parameters (concentration and flow volume). Use of median values removes the normal seasonal variability inherent in flows in most waterbodies, which may underestimate the water quality benefits during periods of low instream flow, but overestimate the benefits during periods of high flow, e.g., during snowmelt. Use of general facility effluent parameters also may over- or underestimate downstream water quality improvements. While these assumptions simplified the water quality analysis (a necessity given data availability and project resources); the uncertainties created seem to work in both ways, i.e., to under- or overestimate water quality improvements.

7.2.2 Wastewater Costs

Planning Level

By its nature this Study could only provide planning level costs or as it was referred to in Section 3 – an "order of magnitude" estimate, which is the level typically done for a facility or master plan. By definition such estimates range from +50 percent to -30 percent, which is a fairly substantial range. While appropriate for a cost-benefit study of this type, this range of uncertainty should be kept in mind when interpreting benefit-cost ratios. However, as part of the cost validation effort, it was determined that the Tier 1 and 2 costs fell within acceptable ranges, based on other studies. There is uncertainty in the Tier 3 costs as describe in the next section.

Brine Disposal

As was noted in Section 3.4.5, the validation step included in the wastewater cost methodology found that the assumptions used for the brine disposal element incorporated into the Tier 3 analysis resulted in potentially elevated treatment costs for this tier. This is likely due to the assumptions associated with brine disposal for the RO. For this Study a general disposal assumption was required for the "typical" facility used to estimate the cost of compliance with each tier. For this Study, brine disposal was assumed to be addressed by deep well. This method and the associated cost will vary significantly throughout the state. Some areas will not be suitable for deep wells and it may be more cost-effective to dry and landfill the brine in some areas. More detailed assumptions for brine disposal could not be made due to the significant variations in disposal locations and geotechnical conditions around the state. Accordingly, it should be understood that the typical facility Tier 3 costs may be high relative to what could be incurred by some facilities.

Implementation of Facility Upgrades to Comply with Effluent Quality Tiers

This Study assumed that the costs associated with the upgrade of a WWTF to meet any of the effluent quality tiers was the sole cost associated with the upgrade. As was noted by stakeholders, this assumption assumes that no other effluent quality issues emerge that would require the WWTF to expend more capital than what is required to comply with the nutrient control regulation. For example, if a facility increases the use of chemicals to treat for phosphorus, the potential exists for the modified effluent stream to cause other water quality issues that could require mitigation. This uncertainty would be site-specific, and thus could not be evaluated as part of this Study.

7.2.3 Benefits Analyses

Changes in Water Quality

Under the three separate tiers evaluated for this Study, TP and TIN levels in the streams and other Colorado waterbodies downstream of the affected dischargers would be expected to change. The project team calculated those percent changes and translated them into changes in water quality, as described in the methodology section. This step was necessary in order to calculate the active and passive benefits identified in this Study. Refer to Section 7.2.1 above for uncertainties associated with the water quality analyses.

In addition to the above, the project team assumed that there were no changes to other components of water quality, such as total dissolved solids (TDS), or any of the other numerous constituents that comprise the state's ambient water quality conditions as a result of implementation of the proposed regulations. In isolation, this Study captures and estimates changes in water quality attributable to changes in these two nutrients, but overall, water quality could be declining or improving for a host of reasons. This Study adopted an "all other factors being equal" approach. Such cumulative changes in water quality were beyond the scope of this Study, which introduces an element of uncertainty in interpreting the effects of the proposed regulation.

Relationship of Nutrient Changes to Changes in Biologic Processes

Although the literature supports well the notion that higher concentrations of TP and TIN in waterbodies leads to algae growth and adverse algae growth leads to declines in dissolved oxygen and reduced water clarity, the exact incremental response of those adverse conditions to changes in nutrient levels in specific amounts is unknown for Colorado waterbodies. In other words, there might be specific incremental increases of TP or TIN, which do not trigger a threshold response in increased algae growth in a specific Colorado stream or lake. An expansive research undertaking would be required to demonstrate such thresholds for Colorado waterbodies; such an effort was not contemplated in the formulation of this Study. Rather, this study assumes a direct and consistent relationship with changes to these two nutrient levels, and changes in the biological processes which occur in Colorado's streams and lakes.

Elasticity Response of Active Recreation to Water Quality Changes

This Study assumes a single direct relationship between changes in water quality and changes in the number of recreational visitor days for water-based recreational activities. This response, known to economists as an elasticity response, is based upon several studies described in the methodological sections of this report and highlighted in the literature review summary (Appendix D). The project team assumed a linear response of visitor days to changes in water quality, whereas it is quite possible these changes in visitor days have a non-linear relationship to changes in water quality. That is, depending upon where the water quality changes are in the spectrum of overall water quality, the change in the number of recreation days may be less or greater than the single linear relationship. The project team recognizes the potential for this non-linearity and understands that, if that non-linearity is true, that the change in recreational visitor days could be higher or lower than the figures derived in this Study. Even so, the project team did not find any studies in Colorado or elsewhere in North America that provided any reliable information in which to assume a specific, non-linear relationship between water quality and changes in recreational activities.

Lack of Benefit-Cost Analysis below the Manageable Unit Level

This Study was performed to gather data and to calculate benefits and cost at the Manageable Unit level and to aggregate the Manageable Units together to a single benefit-cost determination for the State of Colorado. However, this Manageable Unit level approach masks specific local conditions and specific conditions within a Manageable Unit that might change the results of the Manageable Unit-level benefit-cost analysis.

For example, recreational activity might occur in certain limited areas within a Manageable Unit, but the allocation and adjustment of recreational days within a Manageable Unit cannot discern such concentrations. The active benefits analysis assumes that recreation takes place on the larger streams and lakes within a Manageable Unit distributed across the stream miles and lake area within that Manageable Unit. However, the impacts of the proposed regulation only focus on the stream miles downstream of affected point source dischargers, and lakes with affected source dischargers upstream. The focus of recreational visitor days on only affected streams and waterbodies will tend to reduce the impact of this issue on the results, but it is quite possible that the change in recreational visitor days is overstated or understated in particular Manageable Units. The project team did not identify consistent, reliable data sources for allocating angler, boater, and swimmer days in a more accurate manner for application across the state.

Willingness-to-Pay Issues

The passive benefits identified and quantified in this Study relate to the full spectrum of environmental improvements and the value Colorado residents place on those benefits, as discussed in the methodology section of this report. This application of WTP, or contingent valuation, relies on the proposition that, when given a choice regarding water quality restoration, Colorado residents would expend monies to see that accomplished. Two sources of uncertainty arise with this proposition: a project-specific or site-specific survey was not performed for this Study; and the hypothetical and uncertain nature of actual payments versus a "willingness" to pay creates an aura of uncertainty about this as a quantifiable benefit. It is true that a rigorous and well constructed study of WTP for water quality improvements as a result of nutrient reductions might be a more accurate measure of the WTP estimates used in this Study. However, if the WTP study was not performed carefully and rigorously, its results might be misleading. In fact, the utilization of meta-analyses, leading to benefits transfer, is a common tool of economists. The EPA and other researchers commonly review a host of WTP studies performed in different areas and extract central tendencies from those studies, which might be applied to the particular instance at hand, such as the current study. The EPA has even used a large number of WTP studies to develop equations to predict WTP in particular instances. Hence, the use of other studies, properly screened for suitability to this cost-benefit analysis, is appropriate and well within the standard of practicing economists.

The hypothetical nature of WTP and the inherent bias that a hypothetical versus an actual payment creates is an issue that has been noted by other practitioners. The CDM Team concurs with that skepticism and the uncertainty issues surrounding WTP estimates. Therefore, we have conducted additional research into a bias adjustment and have applied a substantial adjustment to the WTP estimates to reduce the total amount.

As a second element of conservatism, the project team decided not to include the intrinsic or existence value in this Study. We believe that one could not, in this instance, distinguish existence or bequest values (as discussed in the methodological section) from other passive values, thus those second WTP values are not quantified in this Study.

Future Values versus Current Values

This Study assumes that the WWTFs would be modified or reconstructed by the year 2018 and project benefits and operating costs would begin in the year 2019 and run into the future. However, this Study focuses on current water quality conditions, point source dischargers, recreational visitation patterns, and current estimates of WTP as compared with those conditions that might exist in 2019 carried forward through 2038 and beyond. Clearly, there will be changes to baseline water quality, wastewater treatment demands and technologies, and recreational use patterns. Point source discharges into Colorado streams are likely to increase in future years, as are recreational visitations. However, many factors will influence

these trends and to avoid greater uncertainty, this Study assumes current conditions. This assumption likely interjects some conservatism to the results.

Qualitative Benefits and Costs

It was not possible to quantify all the identified benefits and costs in this Study. Although there is a tendency to diminish the importance of qualitative effects, that should be avoided in this instance. Qualitative benefits are discussed in more detail in Section 5.3.

Lack of Consideration of Nonpoint Discharges

From the outset, this Study has focused only on point source discharges, leaving the nonpoint source discharges and their effects on the water quality of Colorado's waterbodies not evaluated. In the analysis of water quality changes in comparison to baseline conditions, the focus only on point source discharges means those changes will be reduced only on a percentage basis because the baseline water quality can be influenced more by nonpoint sources than by point sources. Therefore, excluding nonpoint sources in this Study does not create a bias in the results, but it also does not provide a complete picture of the costs and benefits of nutrient reduction in Colorado. This circumstance was recognized prior to the initiation of the Study itself.

7.3 Study Interpretation

During the course of this Study, a number of issues were raised, which together call into question the scope and interpretation of the Study results themselves. What exactly is the meaning and import of the Study results, the net present value, and benefit-cost ratio for the various Manageable Units and the state as a whole? This benefit-cost study simply is intended to define, identify, and quantify to the extent reasonable, each of the direct benefits and direct costs associated with the implementation of proposed regulations, which emphasizes nutrient controls for point source dischargers throughout the State of Colorado.

Benefit-cost studies do not take into account indirect or induced (second or third order) effects of the regulation. In other words, this Study does not account for the full effects of induced economic activity from increased visitor days and expenditures throughout the state. Hence, the full effects of the regulation on the touristic economy in the various counties, Manageable Units, and the state as a whole, are not accounted for in a strict cost-benefit study. That is an issue for economic impact studies, which are a different type of study altogether. Conversely, the costs identified in this Study only include direct costs incurred by the wastewater utilities and not the wastewater utility rate impacts such expenditures would cause on the rate payers. Further, higher rates would reduce economic activity, a relevant topic for an economic impact study, but not an economic cost-benefit analysis.

Some stakeholders raised an issue about the cost of capital in order to make WWTF improvements. Wastewater utilities are rightfully concerned about the availability of capital, the cost of debt service, and how the total costs are likely to affect them and their ratepayers. However, debt service is not an appropriate cost consideration in a cost-benefit study. The interest rate determining the debt service includes both a real interest rate and an inflation expectation. The real interest rate is already reflected in the discount rate to present value, which is part of the cost-benefit study. Inflation is not included in the cost-benefit analysis because constant 2010 dollars for both benefits and costs are the focus of the Study, so that the final comparison of benefits and costs is on an "apples to apples" basis. Certainly, debt service and availability of capital is an implementation issue, but not an appropriate issue for a cost-benefit study.

Simply stated, the cost-benefit study of the impact of nutrient controls is intended to answer a simple question: With due consideration to all of the benefits and costs of the proposed regulation, is this regulation worth considering further? There might be additional economic or implementation issues, but as a threshold question, is nutrient control under Tier 1, Tier 2, or Tier 3 a net benefit or a net cost to each of

the Manageable Units and the state as a whole? Relatively speaking, is the proposition relatively favorable, relatively unfavorable, or roughly equivalent in terms of benefits and costs? This cost-benefit analysis is a single tool, but certainly not the only tool as information for policy holders as they consider the adoption of this regulation.

7.4 Study Conclusions

To the extent data were available and within a prescribed framework, this Study quantified the costs and benefits associated with the implementation three different tiers of effluent quality for the nutrients TP and TIN. These costs and benefits were developed at a Manageable Unit level, which shows the range of benefit-cost ratios across the State of Colorado. Among the three effluent quality tiers examined, the highest benefit-cost ratios were associated with implementation of the Tier 1 effluent limitations, which are consistent with the nutrient controls proposed for existing WWTFs in Colorado that are not subject to a regulatory exclusion. The Tier 2 effluent quality limits, which are consistent with the Division's regulatory proposal for implementation of nutrient controls on new WWTFs, showed lower benefit-cost ratios.

Geographically, the highest benefit-cost ratios, regardless of tier, were typically observed in the Manageable Units along the Front Range in the Platte River and Arkansas River basins. Where quantification was not possible because of a lack of relevant data, the Study identified additional potential costs and benefits from a qualitative perspective. Policy makers should consider these statewide qualitative elements alongside the quantified benefit-cost ratios.

This Study only focused on first order effects associated with implementation of any of the three effluent quality tiers. Studies such as this one do not take into account indirect or induced (second or third order) effects. For example, this Study did not evaluate the beneficial effect on the tourist economy in counties, Manageable Units, and the state as a whole. Similarly, from a cost perspective this Study did not evaluate availability of capital, cost of debt service, or how the total costs are likely to affect wastewater utilities and their ratepayers. While all of these issues are important, they are not part of a cost-benefit study. Instead, such studies focus on first order effects so that the final comparison of benefits and costs is provided on an “apples to apples” basis. Second and third order effects would typically be evaluated at a more local or regional level and be part of studies such as economic impact analyses.

The Study findings are intended to provide input to deliberations by the Commission regarding adoption of the Division's proposed statewide nutrient control regulations. It has been noted by a number of stakeholders that the findings presented may not be applicable to their specific facility or may not accurately reflect local conditions below the Manageable Unit level. Examples of the specific issues identified include:

- What is the location where benefits will be accrued within a Manageable Unit relative to where the WWTF discharge occurs?
- What is the impact of a specific WWTF effluent discharge on downstream water quality?
- What is the relationship between reduced TP or TIN and the expected specific biological response in any given waterbody?
- Is there a need for both TP and TIN controls to meet downstream uses in a particular waterbody?
- What are the potential differences in the costs or benefits associated with implementation of only TP or TIN controls separately rather than in combination as evaluated in this Study?

These are appropriate concerns, but they could not be addressed given the Study's original framework, schedule, and available resources. This study is inextricably tied to the specific provisions contained within the Regulation #85 proposal. For the most part, the above concerns could be dealt with through site-specific or watershed-specific analyses. However in many cases, the data required for more local studies, especially with regards to potential benefits (e.g., local recreational activity levels, willingness to pay by local populations, or waterbody-specific biological outcomes) are not typically available.

From the outset, the purpose of this Study was to explicate and provide a rigorous comparative analysis of all of the benefits and costs associated with implementation of the proposed nutrient control regulations. The threshold question for this Study was whether nutrient control under Tier 1, Tier 2, or Tier 3 will be a net benefit or a net cost to each of the Manageable Units and to the state as a whole? Additional statewide or regional economic and implementation considerations will have to be addressed in the future. Facility-specific or watershed-specific issues certainly will arise during the regulatory implementation phase.

This cost-benefit Study provides quantified benefit-cost ratios to support further discussion and analysis of the threshold question. However, these quantified outcomes are just part of the overall picture. Information contained in this Study regarding qualitative costs and benefits, as well as information developed outside the framework of this Study, e.g., through efforts of the CWQF Nutrient Workgroup, provide a substantial body of information for consideration, as well. In addition, as noted above under the discussion of uncertainties and limitations, a number of site-specific factors could not be taken into account given the high level purpose of this analysis. Some of these factors including eligibility of facilities for variances, exceptions and compliance schedules would be investigated if the proposed regulations are adopted and implemented through CDPS permits.



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