WATER QUALITY ASSESSMENT
FOURMILE CREEK
OAK MEADOWS SERVICE COMPANY WWTF

Table 1 Assessment Summary	
Name of Facility	Oak Meadows Service Company WWTF
CDPS Number	CO-0045802
WBID - Stream Segment	Colorado River Basin, Upper Colorado Sub-basin, Stream Segment 03a: Mainstem of the Roaring Fork River, including all tributaries and wetlands, from a point immediately below the confluence with Hunter Creek, to the confluence with the Colorado River except for those tributaries included in Segment 1 and specific listings in Segments 3b through 10. COUCRF03a
Classifications	Cold Water Aquatic Life Class 1 Class 1 Recreation Agriculture Water Supply
Designation	Undesignated/Reviewable

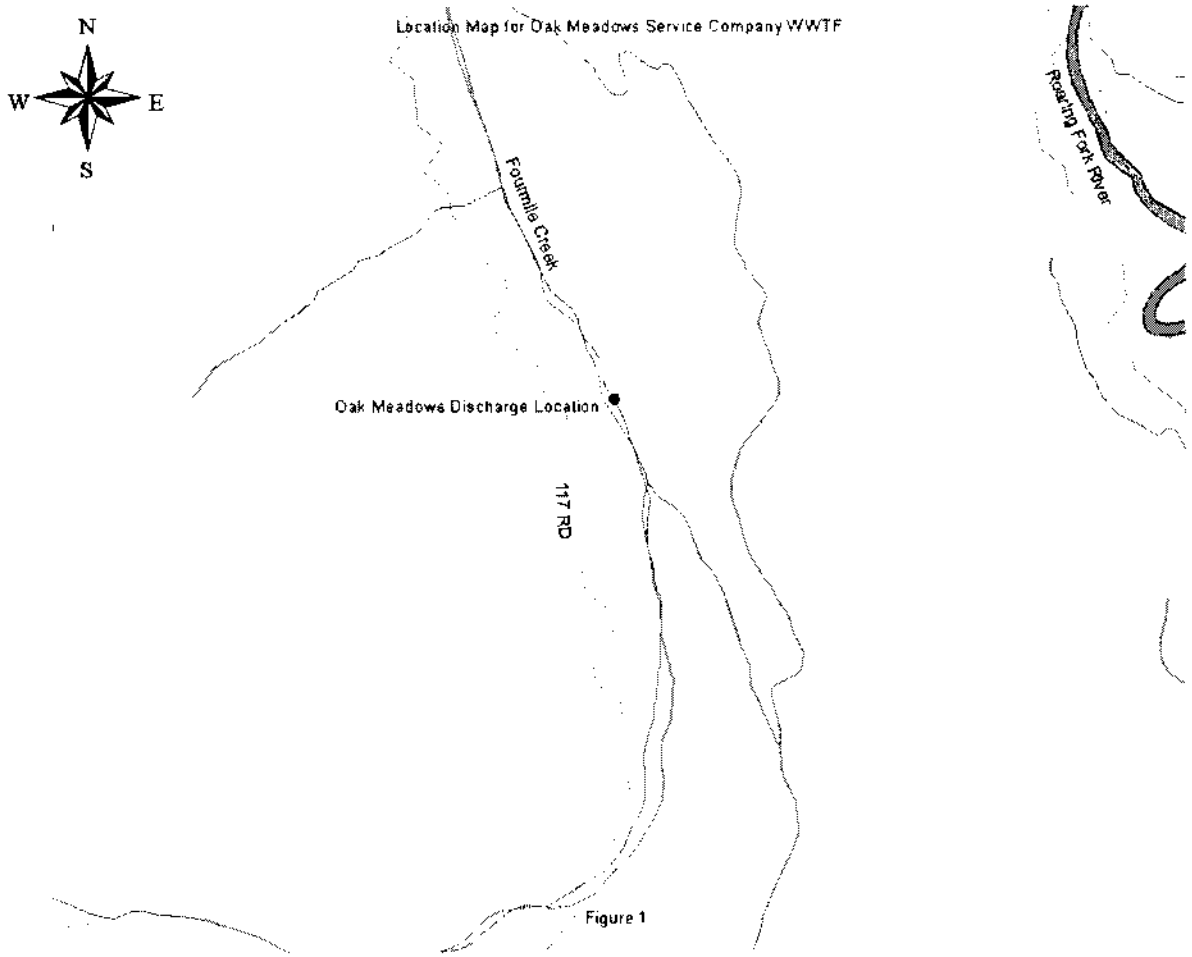
I. Introduction

The Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (Division) developed the water quality assessment (WQA) of Fourmile Creek near the Oak Meadows Service Company Wastewater Treatment Facility (WWTF). The WQA was prepared to facilitate issuance of the Colorado Discharge Permit System (CDPS) permit for the Oak Meadows Service Company WWTF, CDPS Permit No. CO-0045802, and is intended to determine the assimilative capacities available to the Oak Meadows Service Company WWTF for pollutants of concern.

Figure1 contains a map of the study area evaluated as part of this WQA.

The Oak Meadows Service Company WWTF discharges to Fourmile Creek The ratio of the low flow of Fourmile Creek to the Oak Meadows Service Company WWTF design flow is 2.4:1

Information used in this assessment includes data gathered from the Oak Meadows Service Company WWTF, and the Colorado Water Quality Control Division (WQCD). The data used in the assessment consist of the best information available at the time of preparation of this WQA.



II. Water Quality

The Oak Meadows Service Company WWTF discharges to Water Body Identification (WBID) stream segment COUCRF03a, which is the Colorado River Basin, Upper Colorado Sub-basin, Stream Segment 03a. This segment is composed of the "Mainstem of the Roaring Fork River, including all tributaries and wetlands, from a point immediately below the confluence with Hunter Creek, to the confluence with the Colorado River except for those tributaries included in Segment 1 and specific listings in Segments 3b through 10." Stream segment COUCRF03a is classified for:

- Cold Water Aquatic Life Class 1
- Class 1 Recreation
- Agriculture
- Water Supply

Numeric standards are developed on a basin-specific basis and are adopted for particular stream segments by the Water Quality Control Commission. To simplify the listing of the segment-specific standards, many of the aquatic life standards are contained in a table at the beginning of each chapter

of the regulations. The standards in Table 2 have been assigned to stream segment COUCRF03a in accordance with the *Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12).*

Table 2

In-stream Standards for Stream Segment COUCRF03a

Physical and Biological
Dissolved Oxygen (DO) = 6 mg/l, minimum
pH = 6.5 - 9 su
Fecal Coliform chronic = 200 colonies/100 ml
E. coli chronic = 126 colonies/100 ml
Inorganic
Un-ionized ammonia acute = TVS
Un-ionized ammonia chronic = 0.02 mg/l
Chlorine acute = 0.019 mg/l
Chlorine chronic = 0.011 mg/l
Free Cyanide acute = 0.005 mg/l
Sulfide chronic = 0.002 mg/l
Boron chronic = 0.75 mg/l
Nitrite acute = 0.05 mg/l
Nitrate acute = 10 mg/l
Chloride chronic = 250 mg/l
Sulfate chronic = Greater of ambient water quality as of January 1, 2000 or 250 mg/l
Metals and Cyanide
Total Recoverable Arsenic acute = 50 µg/l
Dissolved Cadmium acute for trout and Dissolved Cadmium chronic = TVS
Total Recoverable Trivalent Chromium acute = 50 µg/l
Dissolved Trivalent Chromium acute and chronic = TVS
Dissolved Hexavalent Chromium acute and chronic = TVS
Dissolved Copper acute and chronic = TVS
Dissolved Iron chronic = Greater of ambient water quality as of January 1, 2000, or 300 µg/l
Total Recoverable Iron chronic = 1000 µg/l
Dissolved Lead acute and chronic = TVS
Dissolved Manganese chronic = Greater of ambient water quality as of January 1, 2000, or 50 µg/l
Dissolved Manganese acute = TVS
Total Mercury chronic = 0.01 µg/l
Dissolved Nickel acute and chronic = TVS
Dissolved Selenium acute and chronic = TVS
Dissolved Silver acute and Dissolved Silver chronic for trout = TVS
Dissolved Zinc acute and chronic = TVS

Standards for metals are generally shown in the regulations as Table Value Standards (TVS), and these often must be derived from equations that depend on the receiving stream hardness or species of fish present. The Classification and Numeric Standards documents for each basin include a specification for appropriate hardness values to be used.

The mean hardness was computed to be 203 mg/l based on sampling data from WQCD stations 12711, Fourmile Creek near Glenwood Springs, 12765, Castle Creek near Ashcroft, 12762, Castle Creek near Aspen, and 12761, Brush Creek at the mouth near Snowmass. The period of record for these stations is from 1996 through 1999. This hardness value and the formulas contained in the TVS were used to calculate the in-stream water quality standards for metals with the results shown in Table 3.

Table 3

TVS-Based Metals Water Quality Standards

Calculated Using the Following Value for Hardness as $CaCO_3$:		203 mg/l		
Parameter	***In-Stream Water Quality Standard***			***Formula Used***
Cadmium, Dissolved	Acute	8	µg/l	$[1.13667-0.04184\ln(\text{hardness})][e^{(1.128(\ln(\text{hardness}))-3.828)}]$
	Chronic	3.8	µg/l	$[1.10167-0.04184\ln(\text{hardness})][e^{(0.7852(\ln(\text{hardness}))-2.715)}]$
Trivalent Chromium, Dissolved	Acute	1,018	µg/l	$e^{(0.819(\ln(\text{hardness}))+2.5736)}$
	Chronic	132	µg/l	$e^{(0.819(\ln(\text{hardness}))+0.5340)}$
Hexavalent Chromium, Dissolved	Acute	16	µg/l	Numeric standards provided, formula not applicable
	Chronic	11	µg/l	Numeric standards provided, formula not applicable
Copper, Dissolved	Acute	26	µg/l	$e^{(0.9422(\ln(\text{hardness}))-1.7408)}$
	Chronic	16	µg/l	$e^{(0.8545(\ln(\text{hardness}))-1.7428)}$
Lead, Dissolved	Acute	138	µg/l	$[1.46203-0.145712\ln(\text{hardness})][e^{(1.273(\ln(\text{hardness}))-1.46)}]$
	Chronic	5.4	µg/l	$[1.46203-0.145712\ln(\text{hardness})][e^{(1.273(\ln(\text{hardness}))-4.705)}]$
Manganese, Dissolved	Acute	3,780	µg/l	$e^{(0.3331(\ln(\text{hardness}))+6.4676)}$
	Chronic	2,088	µg/l	$e^{(0.3331(\ln(\text{hardness}))+5.8743)}$
Nickel, Dissolved	Acute	852	µg/l	$e^{(0.846(\ln(\text{hardness}))+2.253)}$
	Chronic	95	µg/l	$e^{(0.846(\ln(\text{hardness}))+0.0554)}$
Selenium, Dissolved	Acute	18	µg/l	Numeric standards provided, formula not applicable
	Chronic	4.6	µg/l	Numeric standards provided, formula not applicable
Silver, Dissolved	Acute	6.9	µg/l	$\frac{1}{2}\, e^{(1.72(\ln(\text{hardness}))-6.52)}$
	Chronic	0.25	µg/l	$e^{(1.72(\ln(\text{hardness}))-10.51)}$
Uranium, Dissolved	Acute	5,242	µg/l	$e^{(1.1021(\ln(\text{hardness}))+2.7088)}$
	Chronic	3,274	µg/l	$e^{(1.1021(\ln(\text{hardness}))+2.2382)}$
Zinc, Dissolved	Acute	214	µg/l	$e^{(0.8473(\ln(\text{hardness}))+0.8618)}$
	Chronic	215	µg/l	$e^{(0.8473(\ln(\text{hardness}))+0.8699)}$

Ambient Water Quality

The Division evaluates ambient water quality based on a variety of statistical methods as prescribed in Section 31.8(2)(a)(i) and 31.8(2)(b)(i)(B) of the *Colorado Department of Public Health and Environment Water Quality Control Commission Regulation No. 31*. Ambient water quality is evaluated in this WQA for use in determining assimilative capacities and in completing antidegradation reviews for pollutants of concern, where applicable.

To conduct an assessment of the ambient water quality of the Oak Meadows Service Company WWTF, data were gathered from WQCD stations 12711, Fourmile Creek near Glenwood Springs, 12765, Castle Creek near Ashcroft, 12762, Castle Creek near Aspen, and 12761, Brush Creek at the mouth near Snowmass. A summary of the data from these sources is presented in Table 4. Note that although these data are based on samples collected at downstream locations, they are comparable to data representative of upstream water quality.

Table 4

Ambient Water Quality for Fourmile Creek

Parameter	*Number of Samples*	*15th Percentile*	*50th Percentile*	*85th Percentile*	*Mean*	*Chronic Stream Standard*
DO (mg/l)	39	9.14	N/A	N/A	N/A	6
pH (su)	44	8.05	N/A	8.6	N/A	6.5-9
Fecal Coliform (#/100 ml)	23	N/A	N/A	N/A	11	200
Hardness (mg/l CaCO3)	47	N/A	203	N/A	N/A	NA
NH_3, Tot (mg/l)	70	N/A	N/A	0.0051	N/A	NA

III. Water Quantity

The Colorado Regulations specify the use of low flow conditions when establishing water quality based effluent limitations, specifically the acute and chronic low flows. The acute low flow, referred to as 1E3, represents the one-day low flow recurring in a three-year interval. The chronic low flow, 30E3, represents the 30-day average low flow recurring in a three-year interval.

Low Flow Analysis

The annual 1E3 and 30E3 low flows were calculated using United States Environmental Protection Agency (EPA) DFLOW software, Fourmile Creek daily flow data and a watershed area correlation. The river flow was taken used from USGS Gages 09084500 near Carbondale on the Roaring Fork River and 09084600 near Glenwood. The two flow records were combined to form a daily flow/watershed area record with a period of record (POR) of 1942-1965. The watershed area above Oak Meadows was multiplied times the flow/watershed area record to generate a flow record for Fourmile Creek just above Oak Meadows. The watershed area above Oak Meadows is 26.11 square

miles. This watershed area above Oak Meadows was calculated from a 1:50,000 scale Garfield and Pitkin county maps using a model 620000 K&E planimeter (WQA, 2000). Based on the low flow analysis described, the upstream low flows available to the Oak Meadows Service Company WWTF were calculated and are presented in Table 5.

Table 5

Low Flows for Fourmile Creek at the Oak Meadows Service Company WWTF

Low Flow (cfs)	*Annual*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
1E3 Acute	0	0.35	0.35	0.60	0.60	2.5	0.35	0.2	0	0	0.10	0.35	0.36
30E3 Chronic	0.13	0.35	0.35	0.06	0.09	2.5	0.45	0.2	0.13	0.13	0.13	0.5	0.35

During the months of January, February, May, and July, the acute low flow calculated by DFLOW exceeded the chronic low flow. In accordance with Division standard procedures, the acute low flow was thus set equal to the chronic low flow for these months.

IV. Technical Analysis

In-stream background data and low flows evaluated in Sections II and III are ultimately used to determine the assimilative capacity of Fourmile Creek near the Oak Meadows Service Company WWTF for pollutants of concern. For all parameters except ammonia, it is the Division's approach to conduct a technical analysis of stream assimilation capacity using the lowest of the monthly low flows (referred to as the annual low flow) as calculated in the low flow analysis. For ammonia, it is the standard procedure of the Division to determine assimilative capacities for each month using the monthly low flows calculated in the low flow analysis, as the regulations allow the use of seasonal flows when establishing assimilative capacities.

The Division's standard analysis consists of steady-state, mass-balance calculations for most pollutants and modeling for pollutants such as ammonia. The mass-balance equation is used by the Division to calculate the maximum allowable concentration of pollutants in the effluent, and accounts for the upstream concentration of a pollutant at the existing quality, critical low flow (minimal dilution), effluent flow and the water quality standard. The mass-balance equation is expressed as:

$$M_2 = \frac{M_3 Q_3 - M_1 Q_1}{Q_2}$$

Where,

Q_1 = Upstream low flow (1E3 or 30E3)
Q_2 = Average daily effluent flow (design capacity)

Q_3 = Downstream flow ($Q_1 + Q_2$)
M_1 = In-stream background pollutant concentrations at the existing quality
M_2 = Calculated maximum allowable effluent pollutant concentration
M_3 = Maximum allowable in-stream pollutant concentration (water quality standards)

Pollutants Evaluated

The Division identified the following parameters as pollutants to be evaluated for this facility:

- Total Residual Chlorine
- Fecal Coliform
- *E. coli*
- Ammonia

Based upon the size of the discharge, the lack of industrial contributors, dilution provided by the receiving stream and the fact that no unusually high metals concentrations are expected to be found in the wastewater effluent, metals are not evaluated further in this water quality assessment.

During assessment of the facility, nearby facilities, and receiving stream water quality, no additional parameters were identified as pollutants of concern.

Oak Meadows Service Company WWTF

The Oak Meadows Service Company WWTF is located at SE 1/4 of the NW 1/4 of Section 15, T7S, R89W in Garfield County. The current design capacity of the facility is 0.035 MGD (0.054 cfs). Wastewater treatment is accomplished using a mechanical wastewater treatment process. The technical analyses that follow include assessments of the assimilative capacity based on this design capacity.

Nearby Sources

Sunlight, Inc. is located approximately four miles upstream of Oak Meadows Services Company WWTF. The design capacity of Sunlight, Inc. is 0.03 MGD (0.046 cfs). Based on the small volume of discharge, the dilution with Fourmile Creek, and the distance from Oak Meadows WWTF, this discharge is not expected to have an influence on the assimilative capacity for Oak Meadows WWTF.

Non-point sources were not considered in this assessment.

Total Residual Chlorine

The mass-balance equation was used to determine the assimilative capacity for chlorine. There are no point sources discharging total residual chlorine within one mile of the Oak Meadows Service Company WWTF. Because chlorine is rapidly oxidized, in-stream levels of residual chlorine are detected only for a short distance below a source. Ambient chlorine was therefore assumed to be zero.

Using the mass-balance equation provided in the beginning of Section IV, the acute and chronic low flows set out in Section III, the chlorine background concentration of zero as discussed above, and the in-stream standards for chlorine shown in Section II, assimilative capacities for chlorine were calculated. The data used and the resulting calculations of the allowable discharge concentrations, M_2, are set forth below in Table 6.

Table 6

Assimilative Capacity for Total residual Chlorine

Parameter	Q_1 *(cfs)*	Q_2 *(cfs)*	Q_3 *(cfs)*	M_1 *(mg/l)*	M_3 *(mg/l)*	M_2 *(mg/l)*
Acute Chlorine	0	0.054	0.054	0	0.019	***0.019***
Chronic Chlorine	0.13	0.054	0.184	0	0.011	***0.038****

* Level will be set equal to acute because acute will govern

Fecal Coliform and *E. coli*

Available studies indicate that *Escherichia coli* (*E. coli*), which is a subset of fecal coliform, is a better predictor of potential human health impacts from waterborne pathogens. Currently, the Water Quality Control Commission has adopted standards for both pathogens and intends that dischargers will have the option of either parameter being used in establishing their effluent limits. However, when there is only ambient fecal coliform data available, this data shall be used to reflect what the ambient *E. coli* levels are for effluent calculations. This methodology should provide a conservative estimate of the pathogen levels in the water body.

There are no point sources discharging these pathogens within one mile of the Oak Meadows Service Company WWTF. Thus, assimilative capacities were evaluated separately.

Using the mass-balance equation provided in the beginning of Section IV, the chronic low flow set out in Section III, the background concentration contained in Section II and discussed above, and the chronic in-stream standards for fecal coliform and *E. coli* shown in Section II, the assimilative capacities for fecal coliform and *E. coli* were calculated. The data used and the resulting calculations of the allowable discharge concentrations, M_2, are set forth below in Table 7.

Table 7

Assimilative Capacity for Fecal Coliform and E. coli

Parameter	Q_1 *(cfs)*	Q_2 *(cfs)*	Q_3 *(cfs)*	M_1 *(#/100 ml)*	M_3 *(#/100 ml)*	M_2 *(#/100 ml)*
Fecal Coliform	0.13	0.054	0.184	11	200	***655***
E. coli	0.13	0.054	0.184	11	126	***402***

Ammonia

Ammonia is present in the aqueous environment in both ionized and un-ionized forms. It is the un-ionized form which is most toxic and which is addressed by water quality standards. The proportion of total ammonia present in un-ionized form in the receiving stream is a function of the combined upstream and effluent ammonia concentrations, and the pH and temperature of the effluent and receiving stream, combined.

The Colorado Ammonia Model (CAM) is a software program designed to project the downstream effects of ammonia and the ammonia assimilative capacities available to each discharger based on upstream water quality and effluent discharges. To develop data for the CAM, an in-stream water quality study must be conducted of the upstream receiving water conditions, particularly the pH and corresponding temperature, over a period of at least one year.

Temperature and corresponding pH data sets reflecting upstream ambient receiving water conditions were not available for Fourmile Creek Oak Meadows Service Company. Consequently, default values were utilized for the set-point conditions (Oppelt, 2005). However, data were available for the monthly average headwater conditions for temperature, pH, and total ammonia.

The CAM may be calibrated for a number of variables in addition to the data discussed above. The values used for the other variables in the model are listed below:

- Stream velocity = $0.3Q^{0.4d}$
- Default ammonia loss rate = 6/day
- pH amplitude was assumed to be medium
- Default times for pH maximum, temperature maximum, and time of day of occurrence
- Threshold percent un-ionized ammonia was taken as 5.4 percent
- pH rebound was set at the default value of 0.2 s.u. per mile
- Temperature rebound was set at the default value of 0.7 degrees C per mile.

The results of the ammonia analyses for the Oak Meadows Service Company WWTF are presented in Table 8.

Table 8

Ammonia Assimilative Capacities for Fourmile Creek at the Oak Meadows Service Company WWTF

Month	*Total Ammonia Chronic (mg/l)*	*Total Ammonia Acute (mg/l)*
January	17	> 30
February	20	> 30
March	7	> 30
April	15	> 30
May	> 30	> 30
June	18	> 30
July	5	> 30
August	7	30
September	6	27
October	8	> 30
November	15	> 30
December	21	> 30

V. Antidegradation Review

As set out in *The Basic Standards and Methodologies of Surface Water*, Section 31.8(2)(b), an antidegradation (AD) analysis is required except in cases where the receiving water is designated as "Use Protected." Note that "Use Protected" waters are waters "that the Commission has determined do not warrant the special protection provided by the outstanding waters designation or the AD review process" as set out in Section 31.8(2)(b). The AD section of the regulation became effective in December 2000, and therefore AD considerations are applicable to this WQA.

According to the *Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12)*, stream segment COUCRF03a is Undesignated. Thus, an AD review is required for this segment if new or increased impacts are found to occur. However, because there is no increase in design capacity the provisions of the AD Reviews for most parameters of concern are not required, except for *E. coli* that had no previous limit. *Escherichia coli* standards were not inplace the last time the Oak Meadows Service Company WWTF was written.

Antidegradaton Based Effluent Limits (ADBEL) were previously established for all parameters of concern except *E. coli* in the last WQA for Fourmile Creek. Consistent with current WQCD

procedures, the baseline water quality (BWQ) for *E. coli* must be established so that it can be used as part of this antidegradation review.

BWQ is defined by the WQCD as the condition of the water quality as of September 30, 2000. Furthermore, the WQCD specifies that BWQ will include the influence of the discharger if it was in place on September 30, 2000. The significant concentration threshold (SCT) for most pollutants equals the BWQ plus the additional 15 percent of the remaining assimilative capacity, and is calculated by the following equation:

$$SCT = 0.15 \times (WQS\text{-}BWQ) + BWQ$$

ADBEL were then determined by re-calculating the mass- balance equation using the SCT in place of the water quality standard as in the following equation:

$$ADBEL = \frac{SCT \times Q_3 - M_1 Q_1}{Q_2}$$

where:

Q_1 = Upstream low flow (1E3 or 30E3)
Q_2 = Average daily effluent flow (design capacity)
Q_3 = Downstream flow ($Q_1 + Q_2$)
M_1 = In-stream background pollutant concentration
SCT = Significant concentration threshold

The ADBEL for *Escherichia coli* are established in Table 9 below. The Oak Meadows Service Company WWTF has the option of picking either the new *E. coli* ADBEL or the calculated NIL.

Table 9
ADBEL for *E. coli*

Parameter	BWQ	BAI	SCT	ADBEL
Escherichia coli (#/100ml)	11	126	28	69

The Oak Meadows Service Company WWTF is not increasing their design capacity, thus there is not an increase in water quality impacts. Consequently, the Oak Meadows Service Company WWTF must maintain their existing effluent standards (Non Impact Limits (NIL)), if those standards are not greater than the water quality-based effluent limits (WQBEL). In the event that the assimilative capacity for Fourmile Creek is not sufficient for the previous effluent limits, new effluent limits shall be applied that do not exceed the WQBEL. Specifically, the old ADBEL/NIL limits cannot be greater than the current WQBEL. Table 10 includes a comparison of the old ADBEL/NIL to the new WQBEL, based on current stream conditions.

Table 10

Comparison of Non-Impact Limits to New WQBEL's

Month	*Chronic WQBEL*	*Current ADBEL/NIL*
Tot. Amm. Jan. (mg/l) 2	17	8.9
Tot. Amm. Feb. (mg/l) 2	20	8.4
Tot. Amm. March (mg/l) 1	7	9.6
Tot Amm. April (mg/l) 2	15	9.6
Tot. Amm. May (mg/l) 2	45	16.8
Tot. Amm. June (mg/l) 2	18	3.4
Tot. Amm. July (mg/l) 2	5	1.5
Tot. Amm. Aug. (mg/l) 2	7	1.9
Tot. Amm. Sep. (mg/l) 2	6	1.4
Tot. Amm. Oct. (mg/l) 2	8	2.8
Tot. Amm. Nov. (mg/l) 2	15	6.2
Tot. Amm. Dec. (mg/l) 2	21	7.4
TRC (mg/l) 1	0.019	0.019
Fecal Coliform (#/100ml) 2	655	457
E. coli 3	402	69/144

1—WQBEL are less than or equal to the previous limits
2—Previous limits are less than WQBEL, thus maintain load at current limits
3—No previous ADBEL/NIL limit, thus NIL will equal 630/2000 X Fecal coliform NIL

VI. References

Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12), Regulation No. 33, CDPHE, WQCC, effective January 20, 2004

The Basic Standards and Methodologies for Surface Water, Regulation 31, CDPHE, WQCC, Effective March 22, 2005.

Antidegradation Significance Determination for New or Increased Water Quality Impacts, Procedural Guidance, CDPHE, WQCD, December 2001.

Memorandum Re: First Update to Guidance Version 1.0, CDPHE, WQCD, April 23, 2002.

Oak Meadows Service Company, Water Quality Assessment, 2000.

New Strategy for Calculating Total Ammonia Assimilative Capacities, Oppelt, 2005.