water quality, accumulation of malodorous scum in beach areas, algal production of toxins potent enough to poison both aquatic and terrestrial organisms, and algal production of taste-and-odor compounds that cause unpalatable drinking water. Simulated algae biomass concentrations associated with Existing Conditions and No Action scenarios would not be expected to pose any health issues or produce any taste-and-odor problems in Pueblo Reservoir (Graham, 2006).

Chlorophyll-*a* is the primary pigment in plants responsible for photosynthesis and can be used as a general indicator of primary production and the quantity of algae present in a water body. Because chlorophyll-*a* concentrations can be affected by various environmental and nutritional factors without affecting algal biomass (Britton and Greeson, 1989), chlorophyll-*a* measurements are considered to provide only an approximation of primary production and algal biomass. Nevertheless, a widely used measure of algal and blue-green algal biomass is the chlorophyll-*a* concentration. Peak values of chlorophyll-*a* for an oligotrophic lake are about 1 to 10 micrograms per liter (µg/L). Concentrations in a eutrophic lake can reach 300 µg/L (Chorus and Bartram, 1999). For protection from health outcomes not due to cyanotoxins, but due to the irritative or allergenic effects of other cyanobacterial compounds, a guideline level of 10 µg/L of chlorophyll-*a* (under conditions of cyanobacterial dominance) can be derived from the prospective epidemiological study by Pilotto and others (1997). In temperate regions of the United States, the occurrence of cyanobacteria and the potential presence of microcystin are most common during late summer and early autumn and may last 2 to 4 months. Blooms of microcystis (a toxin-forming cyanobacteria) typically are found in lakes with average summer chlorophyll-*a* concentrations of 20 to 50 µg/L and a secchi depth of 3 to 6 ft (Chorus and Bartram, 1999). Secchi depth is a measurement of the clarity of a reservoir defined as the depth at which an 8-inch diameter black and white disk is no longer visible in the water column.

Annual median chlorophyll-*a* concentrations in the epilimnion and hypolimnion near the dam (site 7B) were similar for the No Action scenario and the Existing Conditions scenario (fig. 20, table 2). In the epilimnion, the differences in median concentrations between the two scenarios differed by no more than 0.02 µg/L over the three simulated years; the percent change from the Existing Conditions scenario was less than 4 percent for all simulated years (table 2). In the hypolimnion, annual median concentrations differed by no more than 0.02 µg/L over the three years. Concentrations were consistently larger in the epilimnion where photosynthesis was greater than in the hypolimnion.

Annual median chlorophyll-*a* concentrations in the epilimnion and hypolimnion at site 3B were similar between the No Action and Existing Conditions scenarios (table 3). Generally, concentrations differed by no more than 0.1 µg/L at any depth.

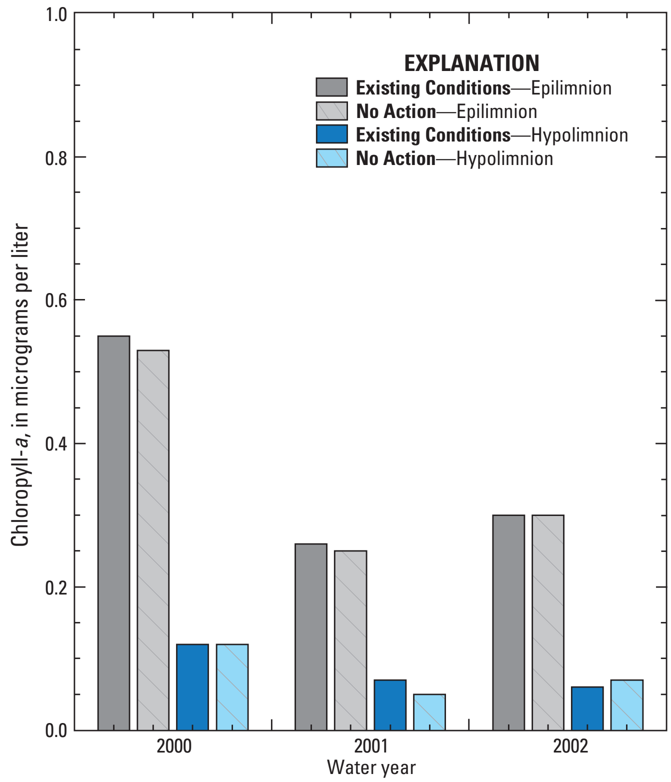

Figure 20. Annual median chlorophyll-*a* concentrations in the epilimnion and hypolimnion at site 7B for the Existing Conditions (water years 2000 through 2002) and No Action (direct-effects analysis) scenarios.

Comparison of No Action Scenario and Other Simulation Scenarios

The following comparisons were made between the No Action scenario and each of the other scenarios as described in the previous section entitled "Description of Simulation Scenarios." Specifically, the No Action scenario was compared individually to the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios. Comparisons were made to describe changes in the annual median, 85th percentile, or 15th percentile concentration between the No Action scenario and each of the other three simulation scenarios. Comparisons between scenario results in this section of the report will be similar to those described in the section "Comparison of Existing Conditions Scenario and No Action Scenario."

Water-Surface Elevations

Simulated water-surface elevations in Pueblo Reservoir generally were similar between the No Action scenario and each of the other three simulation scenarios (fig. 21). However, differences in reservoir water-surface elevation (storage) among the four scenarios did increase each year. Reservoir storage for the Master Contract Only and Comanche South scenarios was greater than the No Action scenario, whereas,

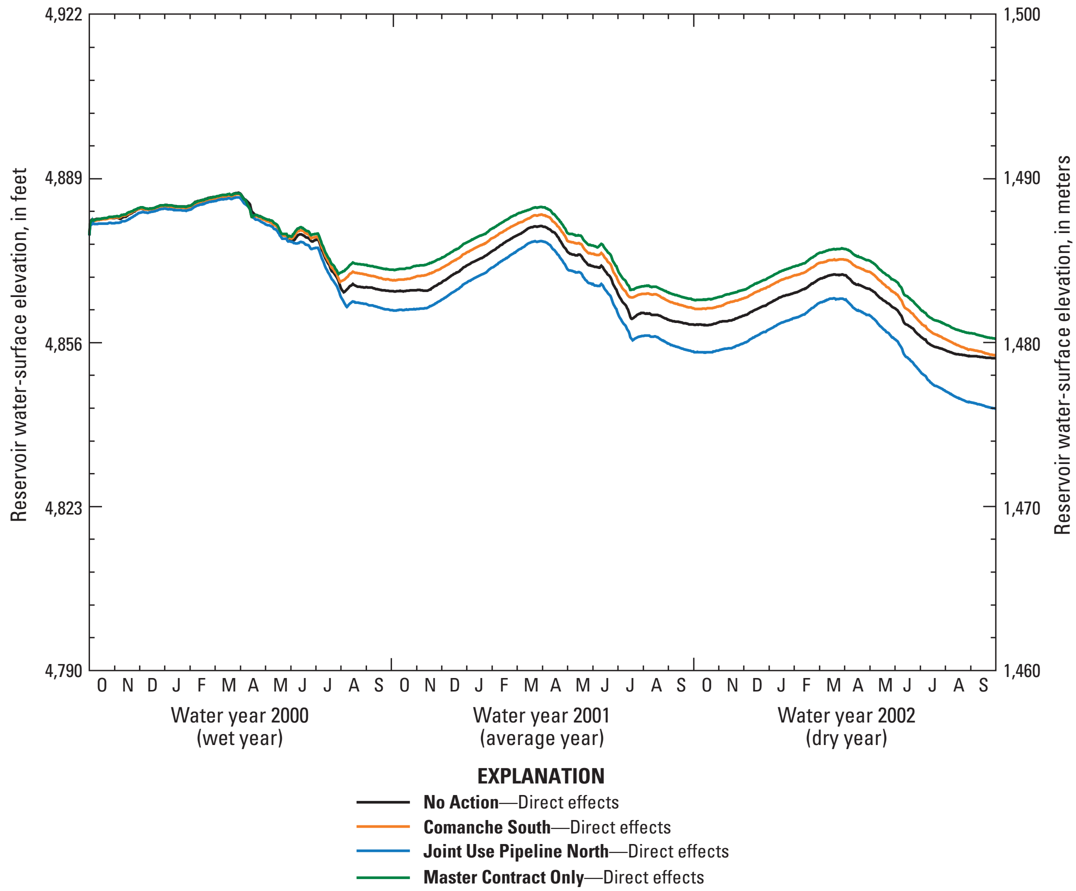

Figure 21. Comparison of water-surface elevations in Pueblo Reservoir for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses). Datum is North American Vertical Datum of 1988 (NAVD 88).

storage for the Joint Use Pipeline North was less. Overall, there was a temporal decrease in water-surface elevations from WY 2000 through WY 2002 for all the simulated scenarios. At the peak annual storage, the difference between the surface-water elevation for the No Action scenario and any other comparable simulated elevation was no more than 1 ft in WY 2000, 3 ft in WY 2001, and 6 ft in WY 2002. Typically, maximum storage occurred in late March of each year as winter storage was nearly complete and releases of water to downstream irrigators had yet to start.

Water Temperature

Comparisons of the results between the No Action scenario and each of the other three simulation scenarios for water temperature indicated that the simulated scenarios generally provided similar results (fig. 22). At site 7B, the percent change from the No Action scenario in the epilimnion was less than 5 percent for all simulated years (table 6). Water temperatures in the hypolimnion were similar but more variable between the simulation scenarios. In WY 2000, there were no differences in the simulated annual hypolimnetic water temperature between the No Action scenario and the other three modeled simulations. In WY 2001, the difference in annual median water temperature between the No Action and the Master Contract Only scenarios was 1 °C (11 percent) increasing to 1.7 °C (18 percent) in WY 2002. The water temperature associated with the Master Contract Only scenario was higher during both years. Generally, temperatures in the hypolimnion were 4 °C to 5 °C lower than those in the epilimnion. Annual median water temperatures in the epilimnion and the hypolimnion at site 3B between scenarios also were similar; the differences were within 10 percent when compared to the No Action scenario (table 7).

Dissolved Oxygen

Comparisons between the No Action scenario and the three other scenarios indicated that the annual median values of simulated DO concentrations in the epilimnion at site 7B generally were similar (fig. 23). Typically, the percent change from the No Action scenario was within 2 percent in the epilimnion for the simulated scenarios for any simulated year at site 7B (table 6). The percent change from the No Action scenario in the hypolimnion was less than 6 percent for the simulated scenarios for any simulated year (table 6).

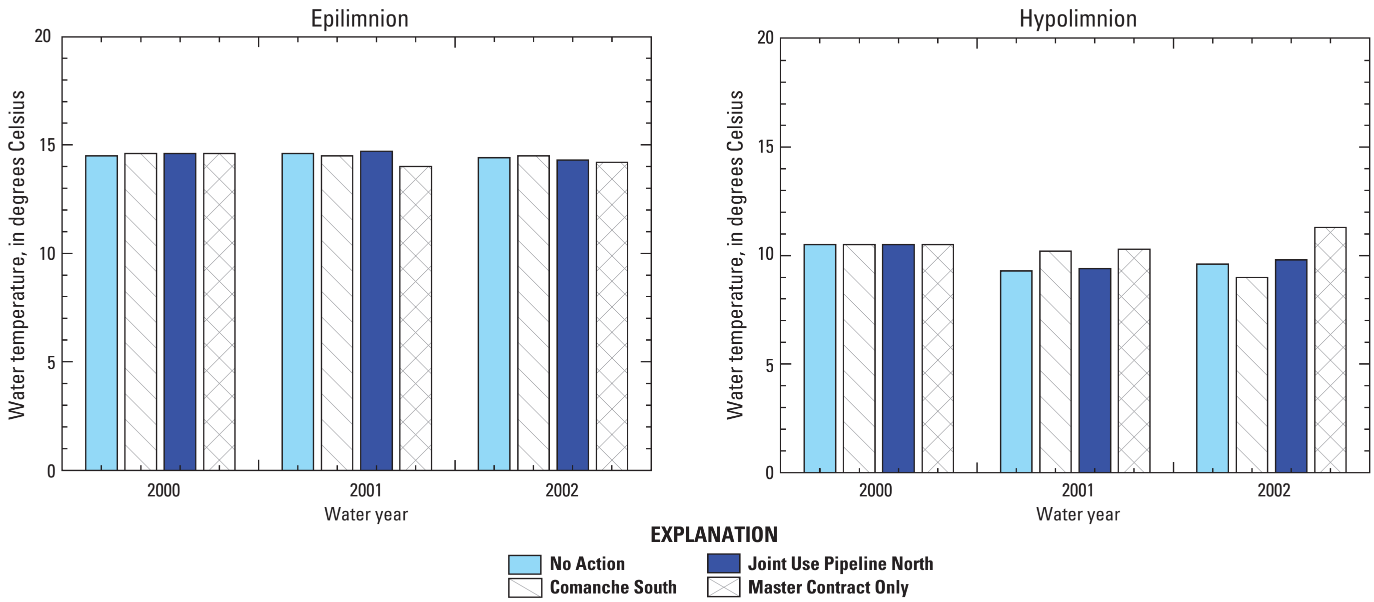

Figure 22. Annual median water temperature in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

Comparisons of DO concentrations in the epilimnion and hypolimnion at site 3B generally showed similar results for WY 2000 through WY 2002 (table 7). The Joint Use Pipeline North scenario had a median concentration in 2002 that was substantially higher than the No Action (18 percent), however, only 83 percent of data were available to compute this statistic; the Joint Use Pipeline North scenario was the only scenario that “dried up” during model simulations.

Differences between the annual 15th percentile DO concentrations in the epilimnion at site 7B were similar to the differences observed for the annual median values at this depth. The results from the No Action scenario differed by no more than 2 percent (0.1 mg/L) from any of the other three compared scenarios (table 8). Overall, the annual 15th percentile values in the epilimnion at site 7B were at least 4.9 mg/L for any of the simulation scenarios.

Seasonal periods of anoxic conditions in Pueblo Reservoir have been documented by Edelmann (1989). Simulated results for the No Action scenario show depleted concentrations of DO during the summer months in the hypolimnion at site 7B (fig. 6). Simulated results for the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios also show similar results (fig. 7). The 15th percentile concentration was 1.6 mg/L or less in the hypolimnion for all of these scenarios (table 8).

The minimum DO concentration suitable to meet the DO water-quality standard in Pueblo Reservoir (measured in the epilimnion) was 6.0 mg/L (Colorado Department of Public Health and Environment, 2007). The standard is compared to the 15th percentile of the data. The standard value was not always attained when compared to the simulated annual 15th percentile value in the epilimnion at sites 7B and 3B (tables 8 and 9). Caution should be used when comparing these results to the water-quality standard because the absolute mean error of the DO calibration for the Pueblo Reservoir model was 1.42 mg/L at site 7B (Galloway and others, 2008).

Dissolved Solids

Comparisons of simulated dissolved solids concentrations indicated that the annual medians were relatively similar between the No Action and the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios in the epilimnion and hypolimnion at site 7B (near-dam site) (fig. 24). Simulated results for the No Action scenario were no more than 3 percent larger than the annual medians for the other three scenarios during WY 2000 through WY 2002 (table 6). The results were similar for both the epilimnion and the hypolimnion. For the most part, similar results also were observed in the epilimnion and hypolimnion at site 3B (table 7).

No water-quality standard for dissolved solids exists for Pueblo Reservoir. However, a guideline does exist to assist managers of public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. The secondary maximum contaminant level is set at 500 mg/L (U.S. Environmental Protection Agency, 1992). The largest annual median dissolved solids concentration was reported at site 3B (284 mg/L) in WY 2000 (tables 6 and 7). No annual 85th percentile value exceeded the recommended guideline for any of the simulated scenarios at sites 7B and 3B (tables 8 and 9).

Table 6. Percent change between annual median values for selected constituents in the epilimnion and hypolimnion at site 7B for direct-effects analyses for the Comanche South, Joint-Use Pipeline North, and Master Contract Only scenarios as compared to the No Action scenario.

[N, nitrogen; P, phosphorus; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; NA, not applicable; <, less than]

Water year	Simulation scenario	Percent of annual results available	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved solids (mg/L)	Dissolved ammonia as N (mg/L)	Dissolved nitrate as N (mg/L)	Total phosphorus as P (mg/L)	Total iron (mg/L)	Chlorophyll-*a* (µg/L)
					Epilimnion					
	No Action	100	14.5	7.9	281	0.003	0.006	0.014	<0.001	0.53
	Comanche South	100	14.6	7.9	280	.003	.006	.014	<.001	.54
	Percent change		.7%	0%	–.4%	0%	0%	0%	NA	1.9%
	No Action	100	14.5	7.9	281	.003	.006	.014	<.001	.53
2000	Joint Use Pipeline North	100	14.6	7.8	281	.003	.006	.014	<.001	.53
	Percent change		.7%	–1.3%	0%	0%	0%	0%	NA	0%
	No Action	100	14.5	7.9	281	.003	.006	.014	<.001	.53
	Master Contract Only	100	14.6	7.8	278	.003	.006	.014	<.001	.52
	Percent change		.7%	–1.3%	–1.1%	0%	0%	0%	NA	–1.9%
					Hypolimnion					
	No Action	100	10.5	7.6	281	.009	.005	.015	.005	.12
	Comanche South	100	10.5	7.6	281	.009	.005	.015	.005	.12
	Percent change		0%	0%	0%	0%	0%	0%	0%	0%
	No Action	100	10.5	7.6	281	.009	.005	.015	.005	.12
2000	Joint Use Pipeline North	100	10.5	7.6	281	.010	.006	.015	.005	.12
	Percent change		0%	0%	0%	11%	20%	0%	0%	0%
	No Action	100	10.5	7.6	281	.009	.005	.015	.005	.12
	Master Contract Only	100	10.5	7.6	279	.009	.005	.015	.005	.12
	Percent change		0%	0%	–.7%	0%	0%	0%	0%	0%
					Epilimnion					
	No Action	100	14.6	7.8	231	.003	.009	.017	<.001	.25
	Comanche South	100	14.5	7.9	227	.002	.009	.016	<.001	.25
	Percent change		–.7%	1.3%	–1.7%	–33%	0%	–5.9%	NA	0%
	No Action	100	14.6	7.8	231	.003	.009	.017	<.001	.25
2001	Joint Use Pipeline North	100	14.7	7.9	233	.002	.008	.016	<.001	.26
	Percent change		.7%	1.3%	.9%	–33%	–11%	–5.9%	NA	4.0%
	No Action	100	14.6	7.8	231	.003	.009	.017	<.001	.25
	Master Contract Only	100	14.0	7.8	224	.003	.012	.017	<.001	.26
	Percent change		–4.1%	0%	–3.0%	0%	33%	0%	NA	4.0%
					Hypolimnion					
	No Action	100	9.3	7.7	234	.007	.009	.018	.003	.05
	Comanche South	100	10.2	7.5	231	.006	.009	.017	.003	.05
	Percent change		9.7%	–2.6%	–1.3%	–14%	0%	–5.6%	0%	0%
	No Action	100	9.3	7.7	234	.007	.009	.018	.003	.05
2001	Joint Use Pipeline North	100	9.4	7.7	235	.007	.007	.017	.003	.06
	Percent change		1.1%	0%	.4%	0%	–22%	–5.6%	0%	20%
	No Action	100	9.3	7.7	234	.007	.009	.018	.003	.05
	Master Contract Only	100	10.3	7.5	228	.006	.008	.018	.003	.04
	Percent change		11%	–2.6%	–2.6%	–14%	–11%	0%	0%	–20%
					Epilimnion					
	No Action	100	14.4	8.0	235	.004	.007	.017	<.001	.30
	Comanche South	100	14.5	8.0	230	.003	.009	.017	<.001	.26
	Percent change		.7%	0%	–2.1%	–25%	29%	0%	NA	–13%
	No Action	100	14.4	8.0	235	.004	.007	.017	<.001	.30
2002	Joint Use Pipeline North	100	14.3	8.1	238	.003	.008	.018	<.001	.26
	Percent change		–.7%	1.3%	1.3%	–25%	14%	5.9%	NA	–13%
	No Action	100	14.4	8.0	235	.004	.007	.017	<.001	.30
	Master Contract Only	100	14.2	8.1	228	.003	.009	.017	<.001	.22
	Percent change		–1.4%	1.3%	–3.0%	–25%	29%	0%	NA	–27%
					Hypolimnion					
	No Action	100	9.6	7.8	235	.006	.005	.018	<.001	.07
	Comanche South	100	9.0	8.1	230	.006	.005	.017	<.001	.07
	Percent change		–6.3%	3.8%	–2.1%	0%	0%	–5.6%	NA	0%
	No Action	100	9.6	7.8	235	.006	.005	.018	<.001	.07
2002	Joint Use Pipeline North	100	9.8	7.9	237	.006	.006	.018	<.001	.06
	Percent change		2.1%	1.3%	.9%	0%	20%	0%	NA	–14%
	No Action	100	9.6	7.8	235	.006	.005	.018	<.001	.07
	Master Contract Only	100	11.3	7.4	228	.006	.005	.018	<.001	.07
	Percent change		18%	–5.1%	–3.0%	0%	0%	0%	NA	0%

Table 7. Percent change between annual median values for selected constituents in the epilimnion and hypolimnion at site 3B for direct-effects analyses for the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios as compared to the No Action scenario.

[N, nitrogen; P, phosphorus; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; NA, not applicable; <, less than]

Water year	Simulation scenario	Percent of annual results available	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved solids (mg/L)	Dissolved ammonia as N (mg/L)	Dissolved nitrate as N (mg/L)	Total phosphorus as P (mg/L)	Total iron (mg/L)	Chlorophyll-a (µg/L)
	Epilimnion									
2000	No Action	100	14.0	7.9	282	<0.001	0.005	0.015	0.010	0.91
	Comanche South	100	14.0	7.9	284	<.001	.004	.015	.009	.90
	Percent change		0%	0%	.7%	0%	–20%	0%	–10%	–1.1%
	No Action	100	14.0	7.9	282	<.001	.005	.015	.010	.91
	Joint Use Pipeline North	100	14.0	7.9	284	<.001	.005	.015	.011	1.02
	Percent change		0%	0%	.7%	NA	0%	0%	10%	12%
	No Action	100	14.0	7.9	282	<.001	.005	.015	.010	.91
	Master Contract Only	100	14.0	7.8	282	<.001	.004	.015	.007	.87
	Percent change		0%	–1.3%	0%	NA	–20%	0%	–30%	–4.4%
	Hypolimnion									
2000	No Action	100	12.0	7.8	282	.002	.012	.016	.031	.70
	Comanche South	100	12.1	7.8	283	.002	.012	.016	.031	.69
	Percent change		.8%	0%	.4%	0%	0%	0%	0%	–1.4%
	No Action	100	12.0	7.8	282	.002	.012	.016	.031	.70
	Joint Use Pipeline North	100	12.0	7.8	283	.002	.012	.016	.034	.72
	Percent change		0%	0%	.4%	0%	0%	0%	9.7%	2.9%
	No Action	100	12.0	7.8	282	.002	.012	.016	.031	.70
	Master Contract Only	100	12.1	7.8	281	.002	.011	.016	.030	.71
	Percent change		.8%	0%	–.4%	0%	–8.3%	0%	–3.2%	1.4%
	Epilimnion									
2001	No Action	100	13.9	7.8	235	.002	.017	.018	.009	.75
	Comanche South	100	13.8	7.7	230	.002	.014	.017	.006	.71
	Percent change		–.7%	–1.3%	–2.1%	0%	–18%	–5.6%	–33%	–5.3%
	No Action	100	13.9	7.8	235	.002	.017	.018		.75
	Joint Use Pipeline North	100	13.4	8.0	239	.003	.026	.019	.014	.64
	Percent change		–3.6%	2.6%	1.7%	50%	53%	5.6%	56%	–15%
	No Action	100	13.9	7.8	235	.002	.017	.018	.009	.75
	Master Contract Only	100	13.9	7.7	227	.002	.016	.017	.006	.73
	Percent change		0%	–1.3%	–3.4%	0%	–5.9%	–5.6%	–33%	–2.7%
	Hypolimnion									
2001	No Action	100	11.2	7.6	239	.003	.033	.019	.027	.51
	Comanche South	100	10.9	7.7	235	.003	.027	.018	.027	.53
	Percent change		–2.7%	1.3%	–1.7%	0%	–18%	–5.3%	0%	3.9%
	No Action	100	11.2	7.6	239	.003	.033	.019	.027	.51
	Joint Use Pipeline North	100	11.1	7.9	242	.004	.035	.019	.035	.52
	Percent change		–.9%	3.9%	1.3%	33%	6.1%	0%	30%	2%
	No Action	100	11.2	7.6	239	.003	.033	.019	.027	.51
	Master Contract Only	100	11.0	7.6	233	.003	.029	.018	.024	.50
	Percent change		–1.8%	0%	–2.5%	0%	–12%	–5.3%	–11%	–2.0%
	Epilimnion									
2002	No Action	100	13.4	7.9	260	.003	.008	.023	.014	1.29
	Comanche South	100	14.3	7.9	258	.003	.009	.022	.010	1.19
	Percent change		6.7%	0%	-.8%	0%	12%	–4.3%	–29%	–7.8%
	No Action	100	13.4	7.9	260	.003	.008	.023	.014	1.29
	Joint Use Pipeline North	100	12.2	8.1	282	.009	.037	.024	.032	.64
	Percent change		–9.0%	2.5%	8.5%	200%	362%	4.3%	129%	–50%
	No Action	100	13.4	7.9	260	.003	.008	.023	.014	1.29
	Master Contract Only	100	14.5	8.0	255	.003	.010	.022	.008	1.14
	Percent change		8.2%	1.3%	-1.9%	0%	25%	–4.3%	–43%	–12%
	Hypolimnion									
2002	No Action	100	12.3	7.8	260	.003	.009	.022	.022	1.31
	Comanche South	100	12.4	7.7	254	.003	.010	.021	.017	1.12
	Percent change		.8%	–1.3%	–2.3%	0%	11%	–4.5%	–23%	–15%
	No Action	100	12.3	7.8	260	.003	.009	.022	.022	1.31
	Joint Use Pipeline North	83[1]	11.4	9.2	261	.006	.034	.024	.033	.62
	Percent change		–7.3%	18%	.4%	100%	278%	9.1%	50%	–53%
	No Action	100	12.3	7.8	260	.003	.009	.022	.022	1.31
	Master Contract Only	100	12.1	7.6	249	.003	.010	.021	.015	.91
	Percent change		–1.6%	–2.6%	–4.2%	0%	11%	–4.5%	–32%	–31%

[1]Computational cells in the model “dry up” for this scenario due to drought conditions observed in 2002. Percent change calculated on less than 100 percent of the daily values for this water year.

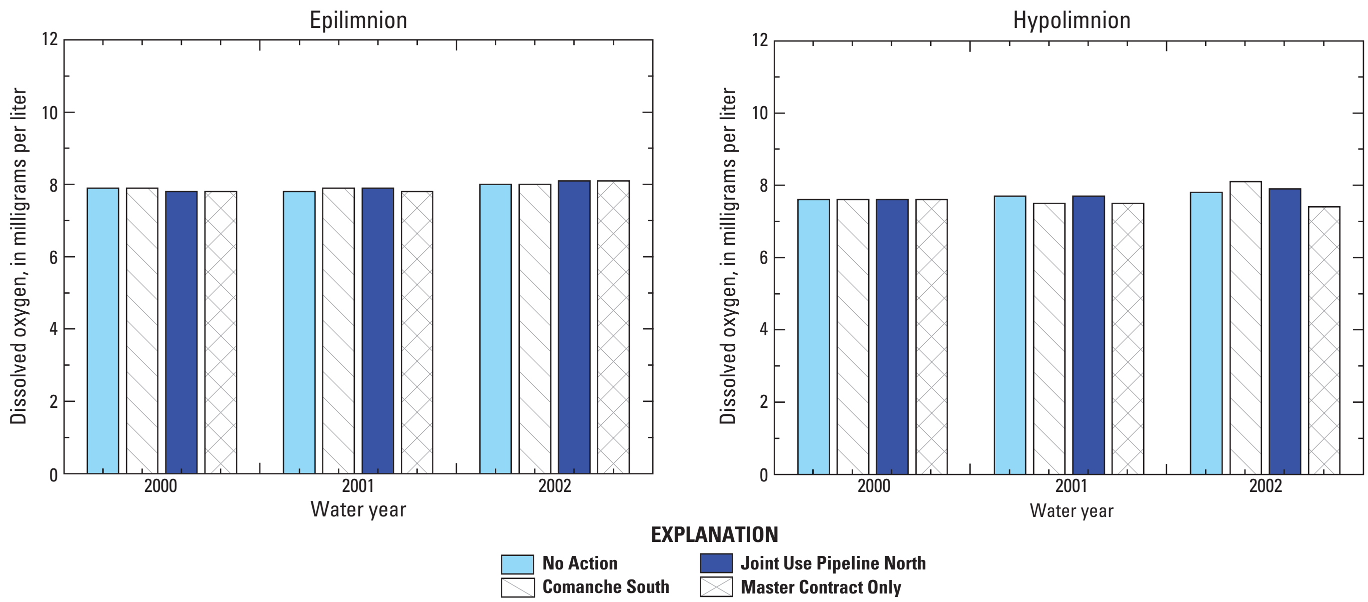

Figure 23. Annual median dissolved oxygen concentrations in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

Major Nutrients

Nutrients are essential for plant growth. The main nutrients of concern in lakes and streams are nitrogen and phosphorus, which can be found in various forms. Factors such as water temperature, pH, dissolved oxygen concentrations, and biological activity influence the concentrations of nitrogen and phosphorus forms found in lakes and streams. Natural sources of nitrogen and phosphorus include precipitation and biogeochemical processes in the watershed. Anthropogenic sources of nutrients include but are not limited to urban runoff, domestic effluent, livestock waste, and erosion caused by development (Gaffey and others, 1996).

Dissolved Ammonia

The annual median dissolved ammonia (as nitrogen (N)) concentrations in the epilimnion and hypolimnion of Pueblo Reservoir at site 7B were similar between the No Action scenario and either the Comanche South, Joint Use Pipeline North, or Master Contract Only scenarios (fig. 25). Annual median simulated ammonia concentrations at either depth for the No Action scenario were within 0.001 mg/L of any of the other simulated scenarios (table 6). Annual median simulated ammonia concentrations in the epilimnion at site 7B were less than annual median simulated concentrations in the hypolimnion.

Similar results were observed in the epilimnion and hypolimnion at site 3B in the upstream riverine section of the reservoir with the exception of comparisons to the Joint Use Pipeline North scenario in WY 2002 (table 7). Typically, differences from the No Action scenario did not exceed more than 0.001 mg/L for these comparisons. Larger differences in concentration, however, were observed between the No Action scenario and the Joint Use Pipeline North scenario at either of the two simulated depths; the differences were as large as 0.006 mg/L.

Dissolved Nitrate

The annual median dissolved nitrate concentrations in the epilimnion of Pueblo Reservoir at site 7B generally were similar between the No Action scenario and any of the three simulated scenarios (fig. 26). Percent differences from the No Action scenario compared to the three simulated scenarios did not exceed 33 percent for these comparisons (table 6). Because of the relatively small concentrations of nitrate in Pueblo Reservoir, a change of 33 percent equated to an overall difference of only 0.003 mg/L as N between the annual median concentrations. Similar results were observed in the hypolimnion at site 7B (table 6).

Overall, observed results in the epilimnion and hypolimnion at site 3B were more variable with regard to the percent change in concentrations when compared to the No Action scenario (table 7). Whereas, concentrations varied by only 0.003 mg/L as N at site 7B, concentrations at site 3B varied from the No Action results by as much as 0.029 mg/L as N (Joint Use Pipeline North in WY 2002). Annual median nitrate concentrations at this upstream site also were larger than concentrations observed at site 7B near the dam. Denitrification processes and consumption from algal growth likely resulted in the decrease in concentration in the lower portion of the reservoir. A maximum annual median concentration of 0.037 (Joint Use Pipeline North in WY 2002) was still small in terms of nitrate concentrations with public health implications. The water-quality standard for dissolved nitrate is 10 mg/L

Table 8. Percent change between annual 85th percentile values for selected constituents and comparisons of the annual 15th percentile values for dissolved oxygen concentrations in the epilimnion and hypolimnion at site 7B for direct-effects analyses for the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios as compared to the No Action scenario.

[N, nitrogen; P, phosphorus; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; NA, not applicable; <, less than]

Water year	Simulation scenario	Percent of annual results available	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved solids (mg/L)	Dissolved ammonia as N (mg/L)	Dissolved nitrate as N (mg/L)	Total phosphorus as P (mg/L)	Total iron (mg/L)	Chlorophyll-a (µg/L)
				Epilimnion						
2000	No Action	100	25.2	5.7	289	0.006	0.017	0.016	0.005	1.11
	Comanche South	100	25.2	5.7	290	.006	.017	.016	.005	1.08
	Percent change		0%	0%	0.3%	0%	0%	0%	0%	–2.7%
	No Action	100	25.2	5.7	289	.006	.017	.016	.005	1.11
	Joint Use Pipeline North	100	25.2	5.7	290	.006	.011	.016	.008	1.13
	Percent change		0%	0%	.3%	0%	–35%	0%	60%	1.8%
	No Action	100	25.2	5.7	289	.006	.017	.016	.005	1.11
	Master Contract Only	100	25.2	5.7	288	.006	.017	.016	.005	1.07
	Percent change		0%	0%	–.3%	0%	0%	0%	0%	–3.6%
				Hypolimnion						
2000	No Action	100	17.7	<.1	290	.015	.009	.019	5.87	.80
	Comanche South	100	17.6	<.1	291	.015	.009	.019	6.71	.80
	Percent change		–.6%	NA	.3%	0%	0%	0%	14%	0%
	No Action	100	17.7	<.1	290	.015	.009	.019	5.87	.80
	Joint Use Pipeline North	100	18.3	<.1	292	.015	.009	.020	6.86	80
	Percent change		3.4%	NA	.7%	0%	0%	5.3%	17%	0%
	No Action	100	17.7	<.1	290	.015	.009	.019	5.87	.80
	Master Contract Only	100	17.3	<.1	289	.015	.009	.019	6.40	.79
	Percent change		–2.3%	NA	–.3%	0%	0%	0%	9.0%	–1.3%
				Epilimnion						
2001	No Action	100	24.6	5.0	238	.006	.016	.017	.006	.97
	Comanche South	100	24.7	4.9	233	.007	.016	.017	.006	.90
	Percent change		.4%	–2.0%	–2.1%	17%	0%	0%	0%	–7.2%
	No Action	100	24.6	5.0	238	.006	.016	.017	.006	.97
	Joint Use Pipeline North	100	24.8	5.0	241	.007	.015	.017	.003	.93
	Percent change		.8%	0%	1.3%	17%	–6.3%	0%	–50%	–4.1%
	No Action	100	24.6	5.0	238	.006	.016	.017	.006	.97
	Master Contract Only	100	24.7	5.0	231	.007	.020	.017	.006	.89
	Percent change		.4%	0%	–2.9%	17%	25%	0%	0%	–8.2%
				Hypolimnion						
2001	No Action	100	18.9	<.1	238	.015	.014	.022	6.98	.13
	Comanche South	100	18.7	<.1	234	.014	.014	.022	6.10	.13
	Percent change		–1.1%	NA	–1.7%	–6.7%	0%	0%	–13%	0%
	No Action	100	18.9	<.1	238	.015	.014	.022	6.98	.13
	Joint Use Pipeline North	100	19.3	<.1	240	.014	.012	.021	2.76	.17
	Percent change		2.1%	NA	.8%	–6.7%	–14%	–4.5%	–60%	31%
	No Action	100	18.9	<.1	238	.015	.014	.022	6.98	.13
	Master Contract Only	100	18.5	<.1	233	.014	.016	.022	6.35	.10
	Percent change		–2.1%	NA	–2.1%	–6.7%	14%	0%	–9.0%	–23%
				Epilimnion						
2002	No Action	100	24.6	5.5	280	.013	.030	.019	<.001	.97
	Comanche South	100	24.5	5.5	277	.014	.034	.018	.002	.90
	Percent change		–.4%	0%	–1.1%	7.7%	13%	–5.3%	NA	–7.2%
	No Action	100	24.6	5.5	280	.013	.030	.019	<.001	.97
	Joint Use Pipeline North	100	24.6	5.5	282	.010	.013	.020	<.001	1.11
	Percent change		0%	0%	.7%	–23%	–57%	5.3%	NA	14%
	No Action	100	24.6	5.5	280	.013	.030	.019	<.001	.97
	Master Contract Only	100	24.5	5.5	271	.013	.034	.018	<.001	.92
	Percent change		–.4%	0%	–3.2%	0%	13%	–5.3%	NA	–5.2%
				Hypolimnion						
2002	No Action	100	14.8	.6	247	.010	.007	.022	.605	.25
	Comanche South	100	14.5	1.6	243	.009	.008	.021	.209	.23
	Percent change		–2.0%	167%	–1.6%	–10%	14%	–4.5%	–66%	–8%
	No Action	100	14.8	.6	247	.010	.007	.022	.605	.25
	Joint Use Pipeline North	100	17.0	<.1	255	.014	.009	.024	2.38	.18
	Percent change		15%	NA	3.2%	40%	29%	9.1%	293%	–28%
	No Action	100	14.8	.6	247	.010	.007	.022	.605	.25
	Master Contract Only	100	15.0	.2	242	.010	.008	.022	1.48	.18
	Percent change		1.4%	–67%	–2.0%	0%	14%	0%	144%	–28%

Table 9. Percent change between annual 85th percentile values for selected constituents and comparisons of the annual 15th percentile values for dissolved oxygen concentrations in the epilimnion and hypolimnion at site 3B for direct-effects analyses for the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios as compared to the No Action scenario.

[N, nitrogen; P, phosphorus; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; NA, not applicable; <, less than]

Water year	Simulation scenario	Percent of annual results available	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved solids (mg/L)	Dissolved ammonia as N (mg/L)	Dissolved nitrate as N (mg/L)	Total phosphorus as P (mg/L)	Total iron (mg/L)	Chlorophyll-*a* (µg/L)
					Epilimnion					
	No action	100	24.0	6.1	291	0.003	0.030	0.016	0.070	1.87
	Comanche South	100	24.3	6.1	292	.003	.029	.016	.062	1.79
	Percent change		1.3%	0%	.3%	0%	–3.3%	0%	–11%	–4.3%
	No action	100	24.0	6.1	291	.003	.030	.016	.070	1.87
2000	Joint Use Pipeline North	100	23.8	6.1	292	.002	.030	.017	.083	1.82
	Percent change		–.8%	0%	.3%	–33%	0%	6.2%	19%	–2.7%
	No action	100	24.0	6.1	291	.003	.030	.016	.070	1.87
	Master Contract only	100	24.4	6.1	289	.003	.030	.016	.061	1.84
	Percent change		1.7%	0%	–.7%	0%	0%	0%	–13%	–1.6%
					Hypolimnion					
	No action	100	23.3	4.7	294	.004	.031	.017	.445	1.40
	Comanche South	100	23.2	4.7	295	.004	.030	.017	.493	1.36
	Percent change		–.4%	0%	.3%	0%	–3.2%	0%	11%	–2.9%
	No action	100	23.3	4.7	294	.004	.031	.017	.445	1.40
2000	Joint Use Pipeline North	100	22.7	4.8	296	.005	.035	.018	.541	1.60
	Percent change		–2.6%	2.1%	.7%	25%	13%	5.9%	22%	14%
	No action	100	23.3	4.7	294	.004	.031	.017	.445	1.40
	Master Contract only	100	23.2	4.6	294	.004	.029	.017	.469	1.38
	Percent change		–.4%	–2.1%	0%	0%	–6.5%	0%	5.4%	–1.4%
					Epilimnion					
	No action	100	23.2	5.9	247	.006	.064	.021	.187	1.34
	Comanche South	100	23.6	6.0	242	.005	.056	.020	.092	1.21
	Percent change		1.7%	1.7%	–2.0%	–17%	–12%	–4.8%	–51%	–9.7%
	No action	100	23.2	5.9	247	.006	.064	.021	.187	1.34
2001	Joint Use Pipeline North	100	22.4	5.5	258	.009	.073	.022	.373	1.15
	Percent change		–3.4%	–6.8%	4.5%	50%	14%	4.8%	99%	–14%
	No action	100	23.2	5.9	247	.006	.064	.021	.187	1.34
	Master Contract only	100	23.7	6.0	239	.006	.049	.020	.069	1.18
	Percent change		2.2 %	1.7%	–3.2%	0%	–23%	–4.8%	–63%	–12%
					Hypolimnion					
	No action	100	22.4	5.0	252	.006	.058	.020	.733	1.16
	Comanche South	100	22.8	4.8	247	.005	.051	.020	.462	1.09
	Percent change		1.8%	–4.0%	–2.0%	–17%	–12%	0%	–37%	–6.0%
	No action	100	22.4	5.0	252	.006	.058	.020	.733	1.16
2001	Joint Use Pipeline North	100	22.0	5.1	263	.008	.068	.021	.791	.80
	Percent change		–1.8%	2.0%	4.4%	33%	17%	5.0%	7.9%	–31%
	No Action	100	22.4	5.0	252	.006	.058	.020	.733	1.16
	Master Contract only	100	22.8	4.8	244	.005	.051	.020	.498	1.03
	Percent change		1.8%	–4.0%	–3.2%	–17%	–12%	0%	–32%	–11%
					Epilimnion					
	No Action	100	23.1	5.8	329	.009	.060	.027	.047	4.43
	Comanche South	100	23.2	6.1	324	.009	.048	.026	.042	5.46
	Percent change		.4%	5.2%	–1.5%	0%	–20%	–3.7%	–11%	23%
	No Action	100	23.1	5.8	329	.009	.060	.027	.047	4.43
2002	Joint Use Pipeline North	100	22.5	5.4	336	.016	.073	.032	.175	1.94
	Percent change		–2.6%	–6.9%	2.1%	78%	22%	18%	272%	–56%
	No Action	100	23.1	5.8	329	.009	.060	.027	.047	4.43
	Master Contract Only	100	23.3	6.1	313	.009	.041	.024	.034	4.14
	Percent change		.9 %	5.2%	–4.9%	0%	–32%	–11%	–28%	–6.5%
					Hypolimnion					
	No Action	100	22.8	5.6	330	.008	.047	.028	.054	3.85
	Comanche South	100	23.0	5.9	324	.008	.033	.026	.054	5.24
	Percent change		.9%	5.4%	–1.8%	0%	–30%	–7.1%	0%	36%
	No Action	100	22.8	5.6	330	.008	.047	.028	.054	3.85
2002	Joint Use Pipeline North	83	22.1	5.6	313	.014	.067	.027	.139	2.04
	Percent change		–3.1%	0%	–5.2%	75%	43%	–3.6%	157%	–47%
	No action	100	22.8	5.6	330	.008	.047	.028	.054	3.85
	Master Contract only	100	23.1	5.6	315	.008	.035	.024	.035	4.02
	Percent change		1.3%	0%	–4.5%	0%	–26%	–14%	–35%	4.4%

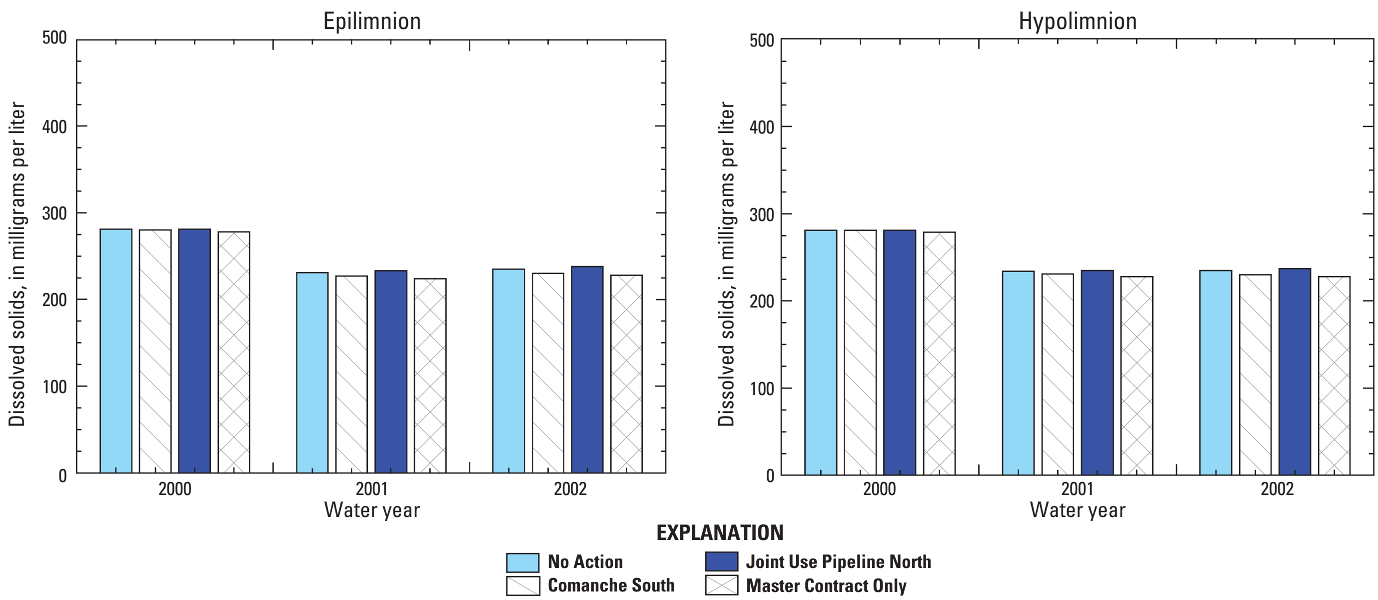

Figure 24. Annual median dissolved solids concentrations in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

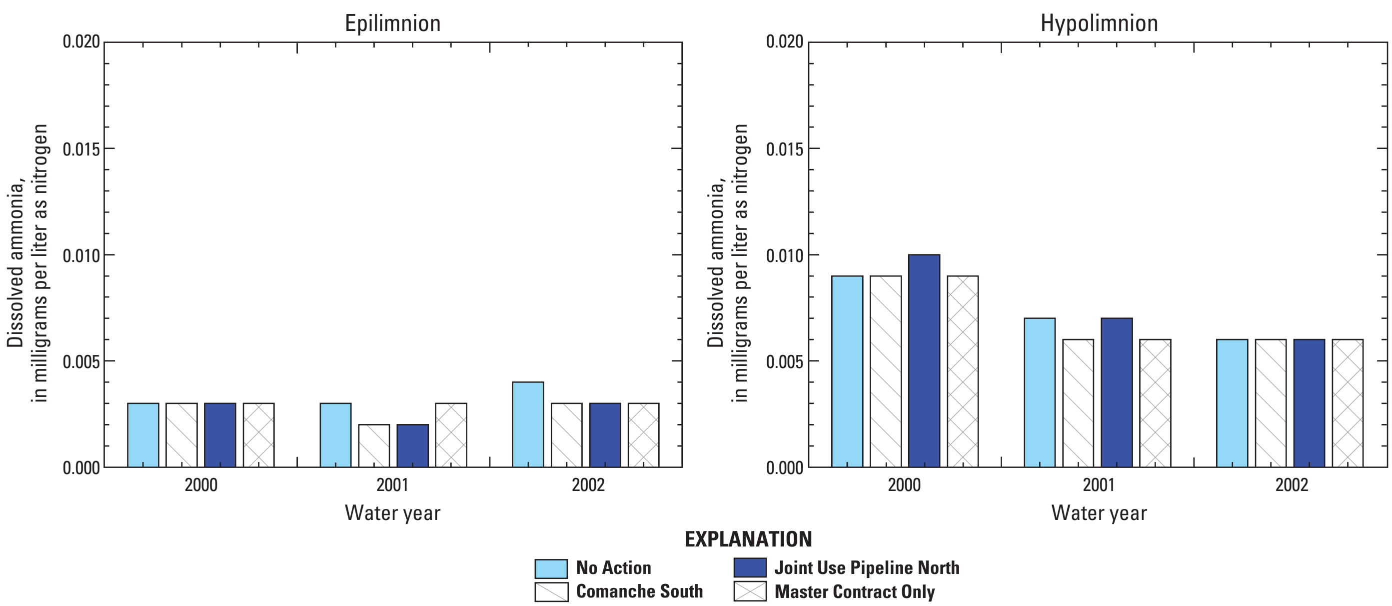

Figure 25. Annual median dissolved ammonia concentrations in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

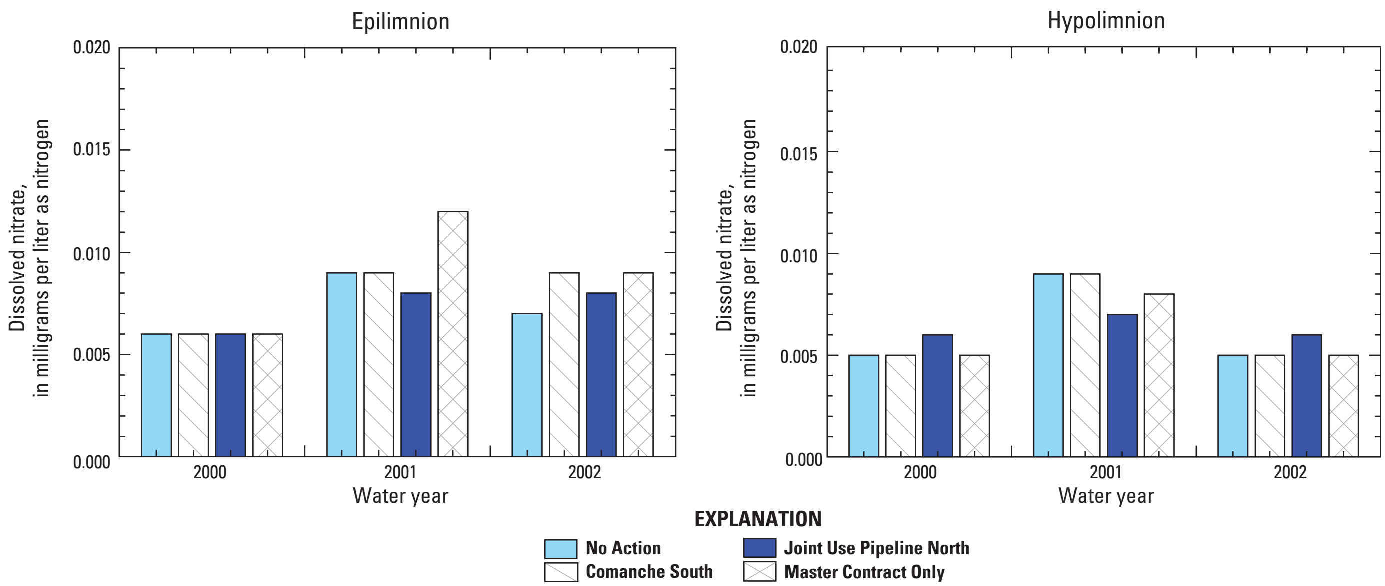

Figure 26. Annual median dissolved nitrate concentrations in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

(Colorado Department of Public Health and Environment, 2007). The standard was not exceeded by any of the annual 85th percentile values for any simulated scenario for any simulated year at either site (tables 8 and 9).

Total Phosphorus

Comparisons among scenarios for annual median total phosphorus concentrations at site 7B were similar to the comparisons of dissolved nitrate concentrations. The annual median concentrations in the epilimnion at site 7B generally were the same between the No Action scenario and either the Comanche South, Joint Use Pipeline North, or Master Contract Only scenarios (fig. 27). The largest percent difference from the No Action scenario did not exceed 6 percent; an increase of this magnitude equated to a difference of only 0.001 mg/L. Similar results were observed in the hypolimnion at site 7B (table 6).

Similar comparisons were made between the No Action scenario and the other simulation scenarios at site 3B (table 7). Annual median total phosphorus concentrations at site 3B were similar in magnitude to concentrations observed in the epilimnion and hypolimnion at site 7B. No specific water-quality standards were applicable for comparison to the simulated results.

Total Iron

The annual median total iron concentrations were small in the epilimnion at site 7B for the No Action scenario and the three other simulation scenarios (fig. 28). Simulation results for these various scenarios indicated that concentrations were less than or equal to 0.001 mg/L during much of the year. Annual median total iron concentrations in the hypolimnion at site 7B were larger than in the epilimnion but still were relatively small. However, a seasonal analysis of total iron concentrations in the hypolimnion at this site showed periods of increased concentrations (fig. 29). The seasonal periods occurred at similar times when anoxic conditions in the reservoir were observed (fig. 6). It is likely that iron was released from the reservoir bottom during these times. These relatively short episodes of high iron concentrations were reflected in the annual 85th percentile concentrations shown in table 8.

Concentrations generally were similar between the No Action scenario and each of the three other simulation scenarios at site 3B. Differences in concentration from the No Action scenario were no more than 0.01 mg/L for any comparison to the Comanche South or Master Contract Only scenarios (table 7). Comparisons of simulated iron concentrations between the No Action scenario and the Joint Use Pipeline North scenario were more variable, particularly in WY 2002 when the difference in the epilimnion was 0.018 mg/L. Larger annual median total iron concentrations were observed near the upstream end of Pueblo Reservoir (site 3B) than those near the surface at site 7B (tables 6 and 7). Total iron concentrations would be expected to be larger in response to suspension of particulate matter at the upstream site.

The chronic surface-water water-quality standard for total iron in Pueblo Reservoir is 1 mg/L (Colorado Department of Public Health and Environment, 2007). The impacts of iron on aquatic life are uncertain, and the benefit of iron as a water-quality standard is more an indicator of sediment loading (Colorado Department of Public Health and Environment, 2005). No calculated annual median value at sites 7B or 3B exceeded this standard value at any reservoir depth for any of the four simulation scenarios (tables 6 and 7). Caution should be used when applying the

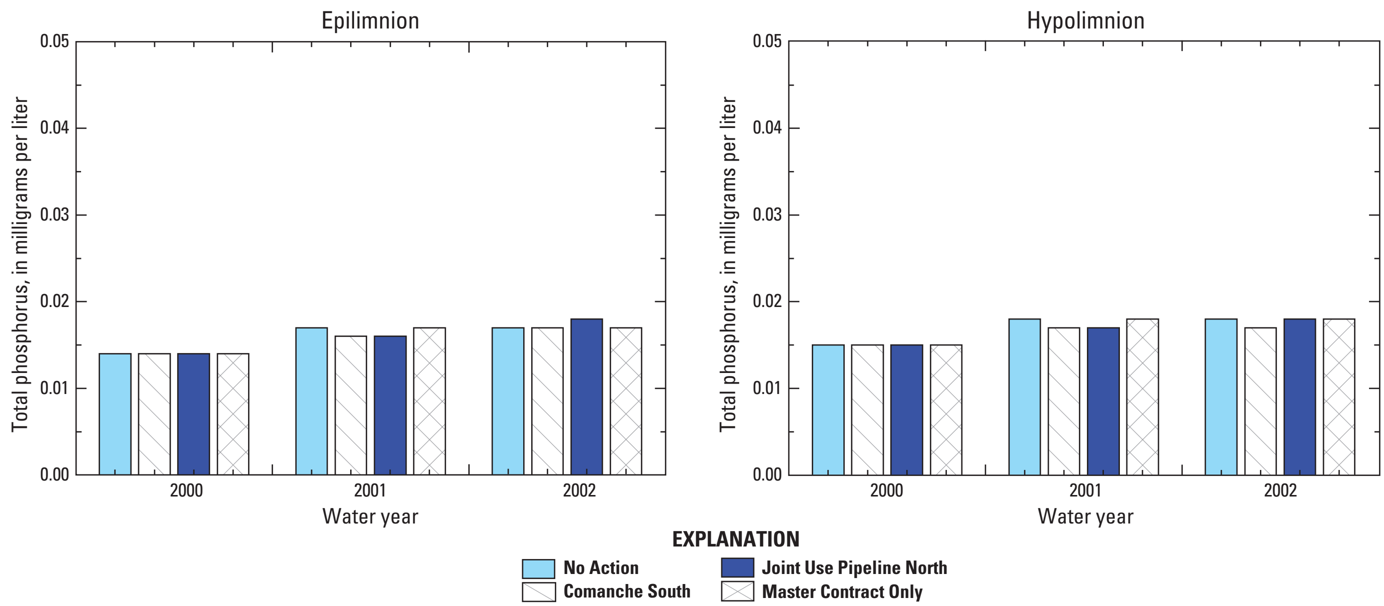

Figure 27. Annual median total phosphorus concentrations in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

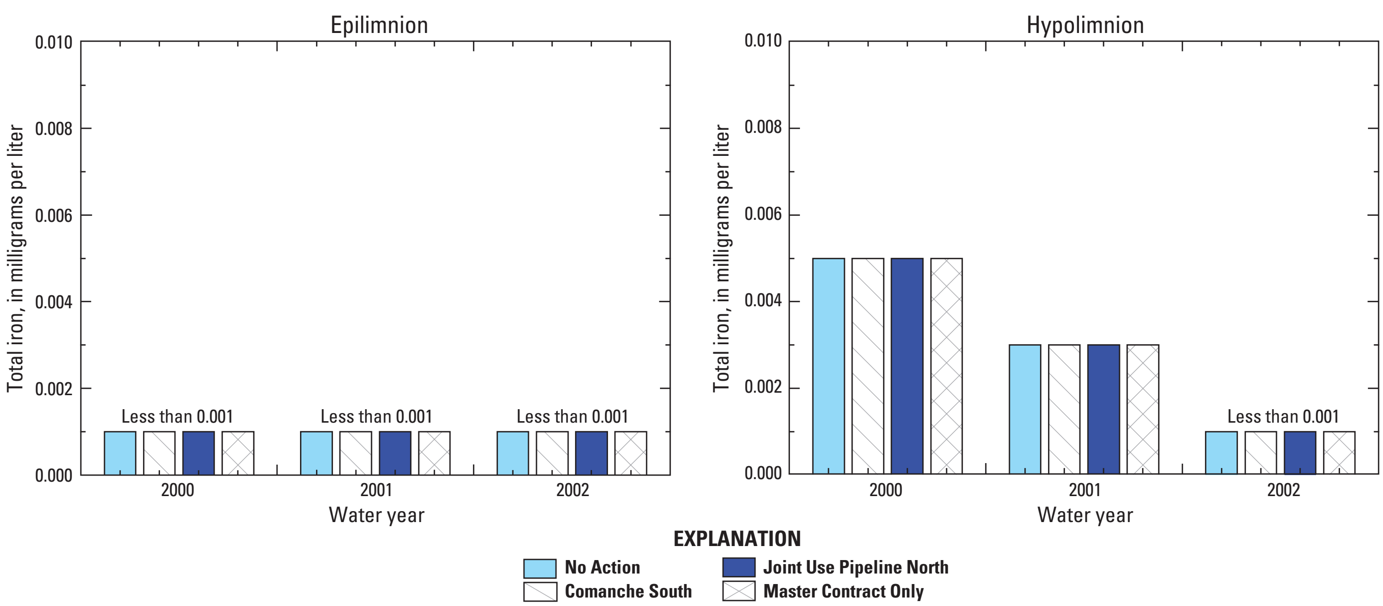

Figure 28. Annual median total iron concentrations in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

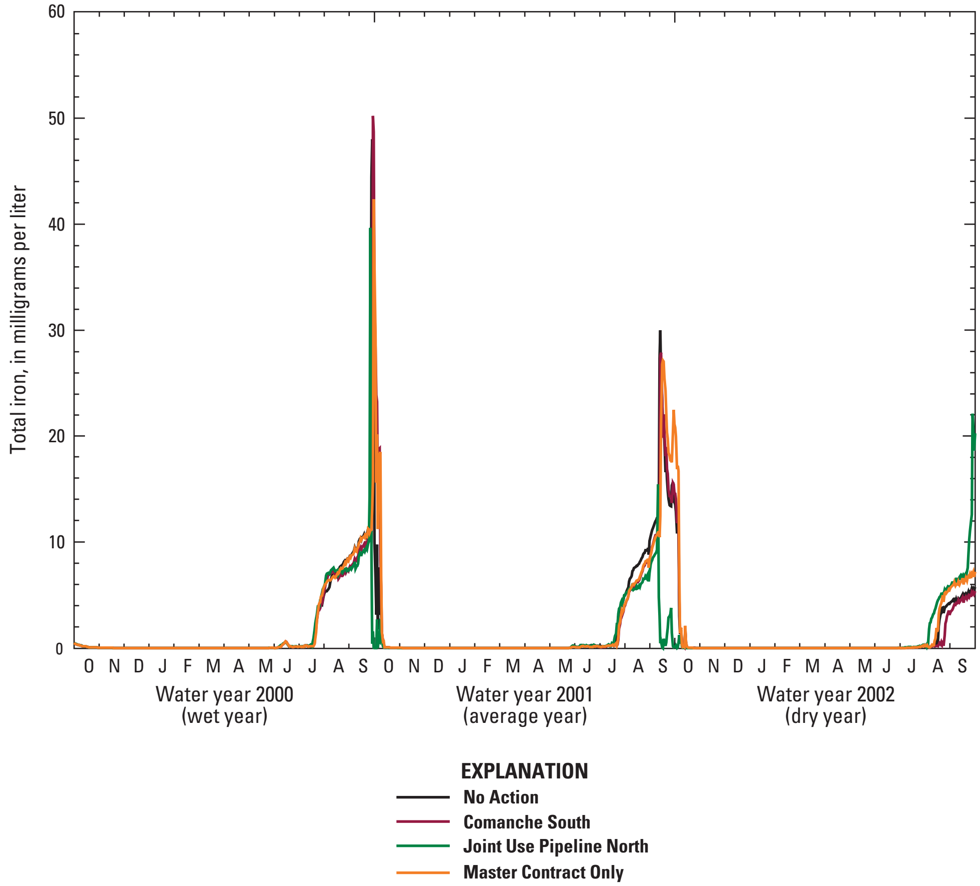

Figure 29. Comparison of total iron concentrations in the hypolimnion at site 7B in Pueblo Reservoir for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

simulated total iron concentrations to water-quality standards since the absolute mean error reported for the calibrated Pueblo Reservoir model was 1.48 mg/L (Galloway and others, 2008).

Algal Groups and Chlorophyll-*a*

The simulated distribution of algal populations was highly variable in Pueblo Reservoir from WY 2000 through WY 2002 (fig. 30). The largest algal biomass at site 7B generally occurred from May through September when blue-green and green algae were the dominant algal groups; blue-green algae increased sharply during the summer months. Generally, simulated algae biomass concentrations in the epilimnion at site 7B were similar for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios and typically were less than 1 mg/L for any group (fig. 30).

Algae biomass concentrations in the epilimnion at site 3B were more variable than in the epilimnion at site 7B, but the general relation between the biomass concentrations for the simulated scenarios remained similar to those observed at site 7B (fig. 30). The diatoms and flagellates were the dominant algal group at this upstream site in the reservoir in WY 2000 and WY 2001; biomass concentrations for the scenarios were less than 1 mg/L for all the algal groups. The blue-green algae were the dominant algal group in WY 2002 and biomass concentrations were less than 2 mg/L.

Harmful algal blooms in freshwater, particularly from blue-green algae, can occur when water use is impaired due to excessive accumulations of nutrients. Simulated algae biomass concentrations associated with No Action, Comanche South, Joint Use Pipeline North, or Master Contract Only scenarios would not be expected to pose a health issue or produce taste-and-odor problems in Pueblo Reservoir (Graham, 2006).

Annual median chlorophyll-*a* concentrations in the epilimnion at site 7B generally were similar between the No Action scenario and the Comanche South, Joint Use Pipeline North, and the Master Contract Only scenario (fig. 31). Specifically, the difference between the median chlorophyll-*a* concentrations and each of these scenarios did not exceed 0.08 µg/L in the epilimnion (table 6). Similar relations were observed in the hypolimnion, but concentrations were consistently smaller than concentrations in the epilimnion and the difference between the median chlorophyll-*a* did not exceed 0.01 µg/L.

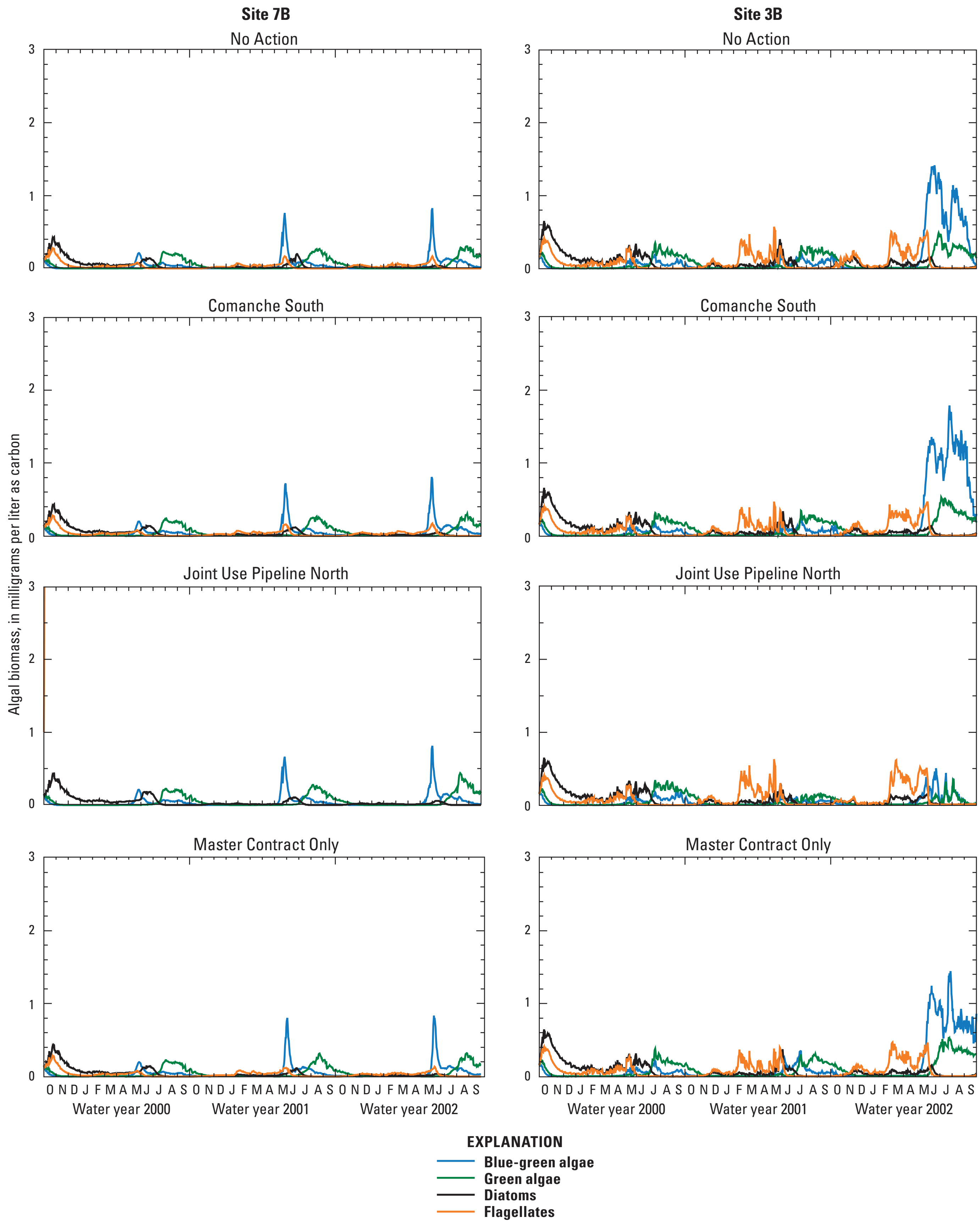

Figure 30. Relation between various algal groups in the epilimnion at sites 7B and 3B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

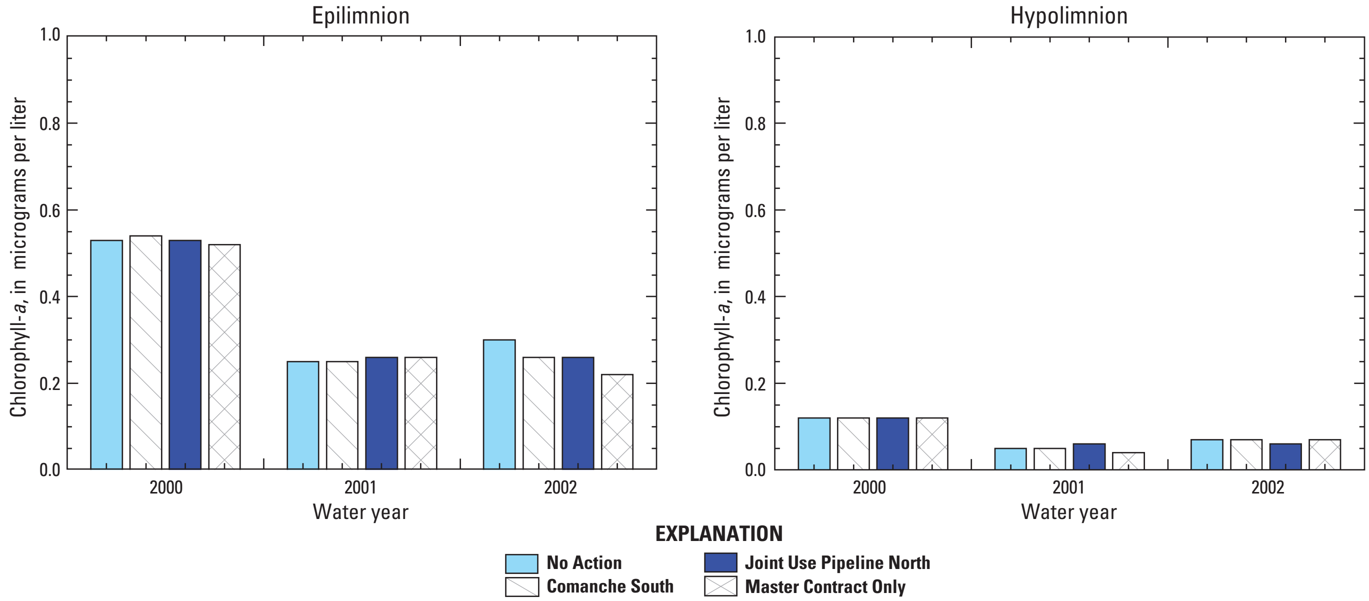

Figure 31. Annual median chlorophyll–*a* concentrations in the epilimnion and hypolimnion at site 7B for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios (direct-effects analyses).

Summary and Conclusions

The Fryingpan-Arkansas Project (Project) is a multipurpose transmountain, transbasin water diversion and delivery project that annually diverts surplus water from the western slope of the Rocky Mountains to the Arkansas River Basin. As part of the Public Law 87-590 which authorized the Project, authorization was included to construct a municipal water-supply pipeline to provide communities downstream from Pueblo Reservoir with a source of high-quality water. In 2009, Congress authorized appropriations and cost-sharing language to proceed with project planning and implementation of the Arkansas Valley Conduit (AVC). The purpose of the AVC is to deliver water for municipal and industrial use within the boundaries of the Southeastern Colorado Water Conservancy District. Water supplied through the AVC would serve two needs: (1) to supplement or replace existing poor-quality water to communities downstream from Pueblo Reservoir; and (2) to meet a portion of the AVC participants' projected water demands through 2070. The Bureau of Reclamation (Reclamation) initiated an Environmental Impact Statement (EIS) to address the potential environmental consequences associated with constructing and operating the proposed AVC, entering into a conveyance contract for the Pueblo Dam north-south outlet works interconnect (Interconnect), and entering into a long-term excess capacity master contract (Master Contract). Reclamation chose to evaluate the environmental effects of these three independent proposed actions in the same EIS because of overlap in area, timing, and participants. A complete description of the Arkansas Valley Conduit Draft Environmental Impact Statement can be found at *http://www.usbr.gov/avceis*. To that end, six action alternatives and one no action alternative were evaluated in the EIS to meet the purpose and needs of the AVC, Interconnect, and Master Contract. Reclamation understands that there may be water-based issues (surface-water hydrology, water quality, aquatic species, groundwater, wetlands, and recreation) associated with each of the proposed alternatives.

Operational changes, as a result of implementation of these alternatives, could change the hydrodynamics and water-quality conditions in Pueblo Reservoir. The reservoir, located west of Pueblo, Colo., is the primary source of water for the conduit and is one of southeastern Colorado's most valuable water resources. It provides irrigation, municipal, and industrial water to various entities throughout the region as well as providing flood control, recreational activities, sport fishing, and wildlife enhancements to the region. The hydrodynamics and water quality of Pueblo Reservoir were modeled previously (2008), and the results of the modeling were documented by the USGS.

Discussions with Reclamation and the U.S. Geological Survey (USGS) led to an interagency agreement between the two Federal agencies to simulate the hydrodynamics and water quality of Pueblo Reservoir and to make comparisons of simulated hydrodynamics and water quality for projected demands associated with four of the seven proposed EIS alternatives. Scenario simulations were done using the documented USGS Pueblo Reservoir model developed from the U.S. Army Corps of Engineers CE-QUAL-W2 model (version 3.2). Comparisons of the simulated results were conducted to determine if substantial differences were observed between selected scenarios.

The four alternatives submitted to the USGS for scenario simulation included various combinations (action or no action) of the proposed AVC, Master Contract, and Interconnect options. The four scenario simulations were the No Action (AVC and Interconnect, no action; Master Contract, no action), the Comanche South (AVC and Interconnect, proposed action; Master Contract, proposed action), the Joint Use Pipeline North (AVC and Interconnect, proposed action; Master Contract, no action), and the Master Contract Only (AVC and Interconnect, no action; Master Contract, proposed action). Each of the scenarios was simulated for three contiguous water years (WY) representing a wet, average, and dry annual hydrologic cycle. Streamflow, diversion, reservoir storage, and return-flow quantity data for projected demands in 2070 were provided to the USGS by contractors for Reclamation. Water-quality data for this effort was originally provided to the USGS (2009) by contractors for Reclamation as described for the Existing Conditions simulation scenario documented by the USGS in a previous report.

Additionally, each selected simulation scenario was evaluated for differences in direct/indirect effects (herein referred to as "direct effects") and cumulative effects on a particular scenario. Direct effects are intended to isolate the future effects of the scenarios. Cumulative effects are intended to evaluate the effects of the scenarios in conjunction with all reasonably foreseeable future activities in the study area. The primary difference between the two sets of simulations was that the direct-effects simulations include existing levels of demand by nonparticipants in the AVC/Master Contract project, whereas the cumulative-effects simulations include projected demands in 2070 by the nonparticipants in the AVC/Master Contract project.

Finally, scenario simulations were done that represented existing conditions in Pueblo Reservoir. The results of the Existing Conditions scenario were compared to the No Action scenario to assess changes in water quality from current demands (2006) to projected demands in 2070. All simulations used an external nutrient-decay model to simulate degradation and assimilation of selected nutrients along the riverine reach upstream from Pueblo Reservoir as described in previous USGS simulation reports on Pueblo Reservoir.

Various tools were used to simulate results for comparison between the different simulation scenarios. Reservoir simulations were done using a two-dimensional water-quality model. Lake hydrodynamics, water temperature, dissolved oxygen, dissolved solids, dissolved ammonia, dissolved nitrate, total phosphorus, total iron, algal groups, and algae biomass (measured as chlorophyll-*a*) were simulated. The model accurately captured the most important seasonal and spatial influences on the reservoir water quality. Input data to the reservoir model that represented the projected demands in 2070 were modeled externally and provided to the USGS by Reclamation's consultant. Nutrient decay along the riverine reach upstream from Pueblo Reservoir was simulated to account for the degradation and assimilation of selected constituents in the Arkansas River.

Two sites were selected for comparison in this report. Results of scenario simulations at site 3B were characteristic of a riverine environment in the reservoir, whereas results at site 7B (near the dam) were characteristic of the main body of the reservoir. Simulated results for the epilimnion and hypolimnion at these two sites were evaluated and compared. The results in the hypolimnion at site 7B were indicative of the quality of the water leaving the reservoir.

A general comparison of results for site 7B (near the dam) between all simulation scenarios was conducted for water-surface elevations, water temperatures, dissolved oxygen, dissolved solids, and ammonia concentrations. Similarities and differences between the direct- and cumulative-effects analyses also were compared.

Simulated water-surface elevations in Pueblo Reservoir were variable between the simulation scenarios, between the different effects analyses, and between the simulated hydrologic conditions. Generally, there was a substantial temporal decrease in water-surface elevations between the wet, average, and dry years. Water-surface elevations associated with the direct-effects analyses were larger than the water-surface elevations for the corresponding cumulative-effects analyses, and the differences between the effects analyses, for any scenario, increased temporally from wet to dry year. During the dry year (WY 2002), the lowest water-surface elevations for either the direct-effects or cumulative-effects analysis were associated with the No Action and Joint Use Pipeline North scenarios; these two scenarios do not include an excess capacity storage component as part of the proposed EIS alternative. Simulated water-surface elevations for the direct-effects analysis of any simulation scenario during WY 2000 (wet year) and WY 2001 (average year) were similar to the water-surface elevations for the Existing Conditions scenario. Water-surface elevations during WY 2002 (dry year) remained similar to those of the Existing Conditions scenario with the exception of the Joint Use Pipeline North scenario.

Water temperatures in Pueblo Reservoir have been shown to stratify during the summer (June-August) prior to mixing in September. Results from the various simulation scenarios showed a similar pattern. In general, the reservoir has been shown to be isothermal during the winter and water temperatures were coldest from December to April. Thermal stratification is apparent by May. Maximum water temperatures were observed in August prior to when Pueblo Reservoir typically mixed in September at the deeper locations. In general, the water temperatures in Pueblo Reservoir were similar for all the simulation scenarios for the 3-year simulation period regardless of the effects analysis.

Results of the scenario simulations for dissolved oxygen showed the typical stratification patterns that occur in Pueblo Reservoir. This included anoxic conditions near the bottom of the reservoir during the summer before the reservoir turned over and mixed. Dissolved oxygen concentrations in the epilimnion and hypolimnion of the reservoir near the dam were similar to the Existing Conditions scenario for all the simulation scenarios regardless of the effects analysis.

Typically, simulated dissolved solids concentrations for the Existing Conditions scenario were similar to concentrations for all the direct-effects simulation scenarios. Concentrations for the cumulative-effects simulation scenarios were slightly larger than concentrations for the Existing Conditions scenario. Typically, the percent differences were less than 5 percent but could be as much as 10 percent during the winter months. Concentrations for the cumulative-effects simulation scenarios were similar among themselves. These results would be expected given that the reservoir storage for the cumulative-effects analyses was less than that for the direct-effect analyses and water-quality inputs were identical.

Comparisons were made between the Existing Conditions scenario and the No Action scenario to determine what differences, if any, were observed between existing conditions in Pueblo Reservoir (demand conditions for 2006) and the most likely conditions in 2070 assuming the absence of a major Reclamation action, such as the AVC or a storage contract. Analysis of the results for the direct- and cumulative-effects analyses indicated that, in general, the results were similar for most of the scenarios. As such, comparisons between the Existing Conditions and No Action scenarios focused on the results from the direct-effects analysis for each modeled scenario. Overall, comparisons of the results between the Existing Conditions and the No Action scenarios for water-surface elevations, water temperature, dissolved oxygen, dissolved solids, dissolved ammonia, dissolved nitrate, total phosphorus, and total iron concentrations indicated that the annual median values generally were similar for all three simulated years. Additionally, algal groups and chlorophyll-*a* concentrations (algal biomass) were similar for the Existing Conditions and the No Action scenarios at site 7B in the epilimnion for the simulated period (WY 2000 through WY 2002).

The No Action scenario also was compared individually to the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios. Comparisons were made to describe changes in the annual median, 85th percentile, or 15th percentile concentration between the No Action scenario and each of the other three simulation scenarios.

Simulated water-surface elevations in Pueblo Reservoir generally were similar between the No Action scenario and each of the other three simulation scenarios. Overall, differences in reservoir water-surface elevation increased each year and there was a temporal decrease in water-surface elevations from WY 2000 through WY 2002 for all the simulated scenarios.

Comparisons of the results between the No Action scenario and each of the other three simulation scenarios for water temperature indicated that the simulated scenarios generally provided similar results. At site 7B, the percent change from the No Action scenario in the epilimnion was less than 5 percent for all simulated years.

Comparisons of simulated DO concentrations between the No Action scenario and the three other scenarios indicated that the annual median values in the epilimnion at site 7B generally were similar to results for the No Action scenario. Typically, the percent change from the No Action scenario was within 2 percent for the simulated scenarios for any simulated year. The percent change from the No Action scenario in the hypolimnion was less than 6 percent for the simulated scenarios for any simulated year.

Comparisons of simulated dissolved solids concentrations indicated that the annual medians were relatively similar between the No Action and the Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios in the epilimnion and hypolimnion at site 7B. Simulated results for the No Action scenario were 3 percent or less of the annual medians for the other three scenarios during WY 2000 through WY 2002. The results were similar for both the epilimnion and the hypolimnion. For the most part, similar results also were observed in the epilimnion and hypolimnion at site 3B.

The annual median dissolved ammonia (as nitrogen) and dissolved nitrate concentrations in the epilimnion and hypolimnion of Pueblo Reservoir at site 7B were similar between the No Action scenario and either the Comanche South, Joint Use Pipeline North, or Master Contract Only scenarios.

The annual median total iron concentrations were small in the epilimnion at site 7B for the No Action scenario and the three other simulation scenarios. Simulation results for these various scenarios indicated that concentrations were less than or equal to 0.001 mg/L during much of the year. Iron concentrations at site 3B generally were similar between the No Action scenario and the each of the three other simulation scenarios. Differences in concentration from the No Action scenario were no more than 0.01 mg/L for any comparison to the Comanche South or Master Contract Only scenarios. Comparisons of simulated iron concentrations between the No Action scenario and the Joint Use Pipeline North scenario were more variable, particularly in WY 2002.

Generally, simulated algae biomass concentrations in the epilimnion at site 7B were similar for the No Action, Comanche South, Joint Use Pipeline North, and Master Contract Only scenarios and concentrations typically were less than 1 mg/L. Annual median chlorophyll-*a* concentrations in the epilimnion at site 7B generally were similar between the No Action scenario and the Comanche South, Joint Use Pipeline North, and the Master Contract Only scenario. Specifically, the difference between the median chlorophyll-*a* concentrations and each of these scenarios did not exceed 0.08 µg/L.

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