Appendix A. Water-Column Properties for all Conductivity, Temperature, and Depth Profiles and the Quality Assurance Data, Lynch Cove, Western Washington, July—October 2004

The estimate of transport in the lower layer of the estuarine circulation requires that the boundary between the upper layer and lower layer be defined. The water column properties in the Sisters Point region were determined in July (figs. A1–A3), August (figs. A4–A13), September (figs. A14–A23), and October (figs. A24–A33) not only to provide the physical context of the DIN data, but to define the boundary between the upper and lower layer. Before sampling for discrete water samples at each station, a profile of the water column was obtained with a Seabird 19+ CTD (conductivity, temperature, and depth) sensor equipped with a Seatech (OBS-3) optical backscatter sensor. A newly calibrated Seabird Electronics, Inc. model 43 dissolved-oxygen sensor was installed on the CTD instrumentation for the September sampling. The accuracy of the CTD salinity and oxygen sensor was assessed by comparing the sensor data with the results of the analyses of discrete samples. The comparison of the continuous profile of salinity from the CTD sensor with determinations of salinity from discrete samples is shown in figures A1-A33. Between July and October the median deviation between salinity results from the deep samples at L13, L14, and L19 was 0.025, except for a deviation 0.233 in L19 in September (table A1). The median deviation between results from the sensor DO data and Winkler titrations for September and October was 0.19 mg/L. The maximum deviation of the 7-point temperature calibration before and after the field exercise was 0.0012°C.

Salinity and temperature are the main factors controlling the density of water in estuarine systems. Therefore, the vertical distribution of salinity and temperature define the stability of the water column. The highest surface temperatures at station L13 (about 18°C) were recorded in July (fig. A1). From 2 to 6 m, temperature decreased from 17.5°C to 11.7°C and salinity increased from 26.95 to 29.41. The increasing salinity and decreasing temperature with depth resulted in a zone of rapidly increasing density, which is called the pycnocline. Temperature and salinity decreases less rapidly between 6 and 11 m, and then decreases slowly to a temperature of 10.1°C and salinity of 29.95 near the bottom of the water column.

Although the temperature in the upper layer was slightly cooler in August, light winds in August had allowed a thin (about 2 m) well-mixed surface layer with slightly higher salinities to form (fig. A4). The strong decrease in temperature and increase in salinity were observed at about 2 m, with more moderate changes to about 5 m. Wind and rain events prior to sampling in September resulted in cooler, fresher upper layer. Although the bottom of the thermocline deepened only slightly, mixing of fresher, warmer water from the upper layer to depth of about 9 m was apparent (fig. A14). By October, cooling of the upper layer and downward mixing decreased the temperature difference between the upper and lower layers to less than 1°C (fig. A24). Fresher upper layer water also mixed down weakening the thermocline and decreased salinities between 3 and 7 m. Although the temperature of the lower layer was fairly constant between July and August, the lower layer began to warm slightly in September and increased significantly in October. The lower water also became saltier with salinity rising to 30.51 in October relative to 30.16 in September. Because the salinity in the lower layer landward of L13 was fresher (for example, salinity of 30.09 at L14 in September; fig. A15), this more saline water must have been advected to L13 from the seaward direction. The CTD mounted on the mooring at site B near L13 indicated that a front of salty and warm water passed site B on September 15 (fig. 9).

At the constriction at Sisters Point (L14), the vertical distributions of salinity and temperature between August and October 2004 underwent similar temporal changes to those of L13. In August (fig. A5), the upper mixed layer was about 6 m thick, below which the temperature decreased and salinity increased sharply for 4 m before decreasing more slowly. By September (fig. A15), the upper layer had cooled and thinned to about 1 m. Rain and wind had weakened that pycnocline, which allowed salt to mix upward. The front of the warm salty lower water, which had passed site B on September 15, passed site A seven days later on September 22 (fig. 9). Further cooling in the upper layer occurred through October and continued to weaken the pycnocline (fig. A25).

At L19 landward of Sisters Point, the upper mixed layer was less than 1 m. The pycnocline was weak in August and extended to 10 m (fig. A10). Through September, rain and wind cooled the upper 5 m of the water column and fresher water had mixed down to about 6 m (fig. A20). Although the top 7 m of the water column continued to cool through October, the weak salinity gradient of September was maintained through October (fig. A30).

Table A1. Comparison of sensor data with results of analysis of deep discrete samples at L13, L14, and L19.

[**Abbreviations:** CTD, conductivity-temperature-depth probe; DO, dissolved oxygen; m, meter; mg/L, milligram per liter; Δ, difference; n, number of observations; –, not available]

Month	CTD			Discrete sample			ΔSalinity	ΔDO
	Depth (m)	Salinity	DO (mg/L)	Depth (m)	Salinity	DO (mg/L)		
				L13				
July	37.1	29.949	–	37.1	29.908	1.23	0.041	
August	38.1	29.992	–	39.6	29.956	.46	.036	
September	38.9	3.169	1.05	39.6	3.164	–	.005	
October	4.4	3.512	2.16	44.2	3.537	2.40	.025	0.24
				L14				
August	37.5	29.932	–	45.7	29.931	0.43	0.001	
September	41.369	3.092	0.61	48.7	3.187	1.08	.095	0.47
October	53.379	3.462	1.98	53.3	3.447	2.00	.015	.02
				L19				
August	35.6	29.925	–	36.6	29.929	0.46	0.004	
September	34.58	3.019	0.17	36.0	29.786	.14	(.233)	0.03
October	34.83	3.384	1.44	38.1	3.425	1.63	.041	.19
					Mean		.029	.19
					Standard deviation		.029	.18
					Median		.025	.19
					n		10	5

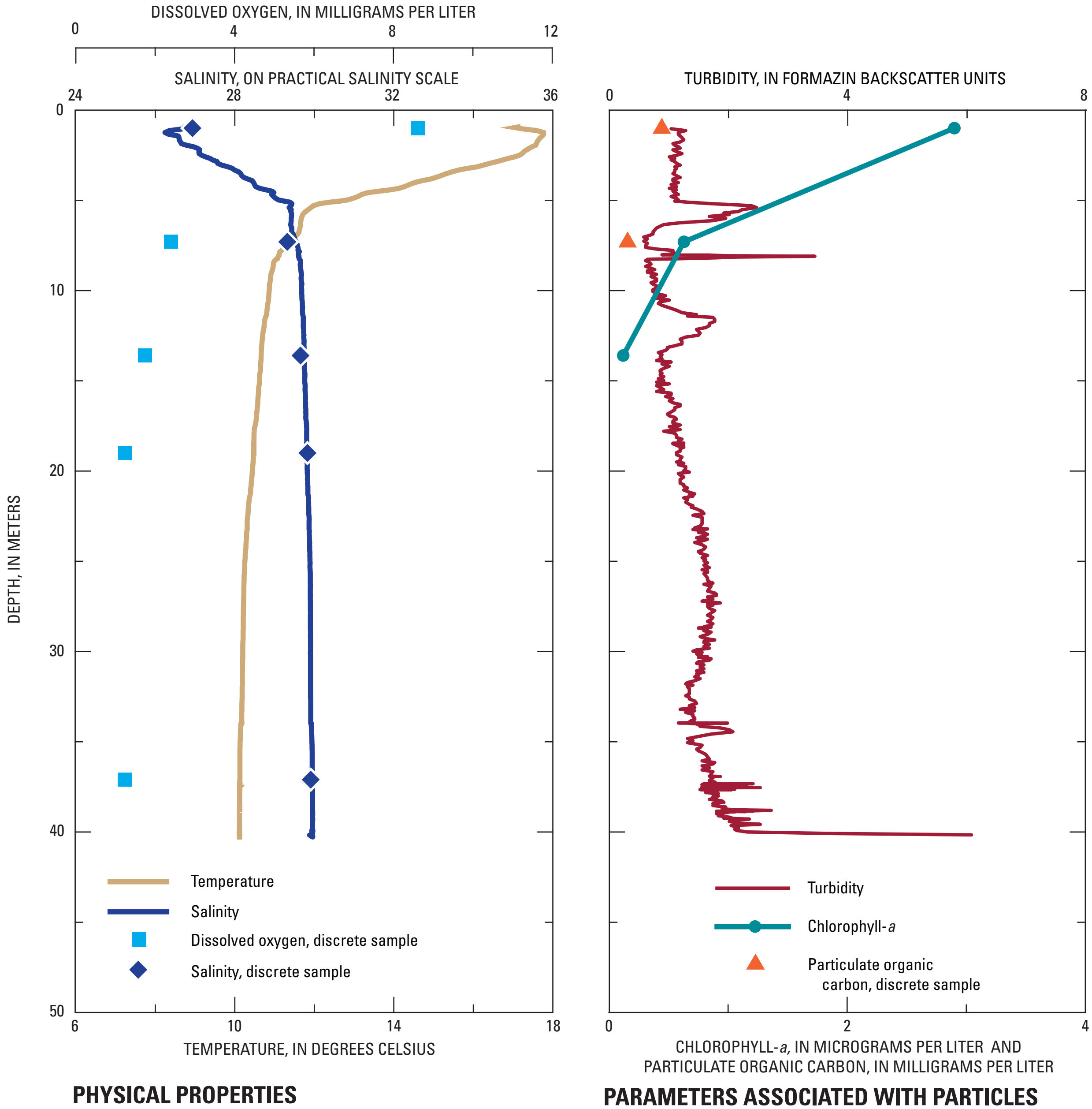


Figure A1. Water properties for site L13, July 2004.

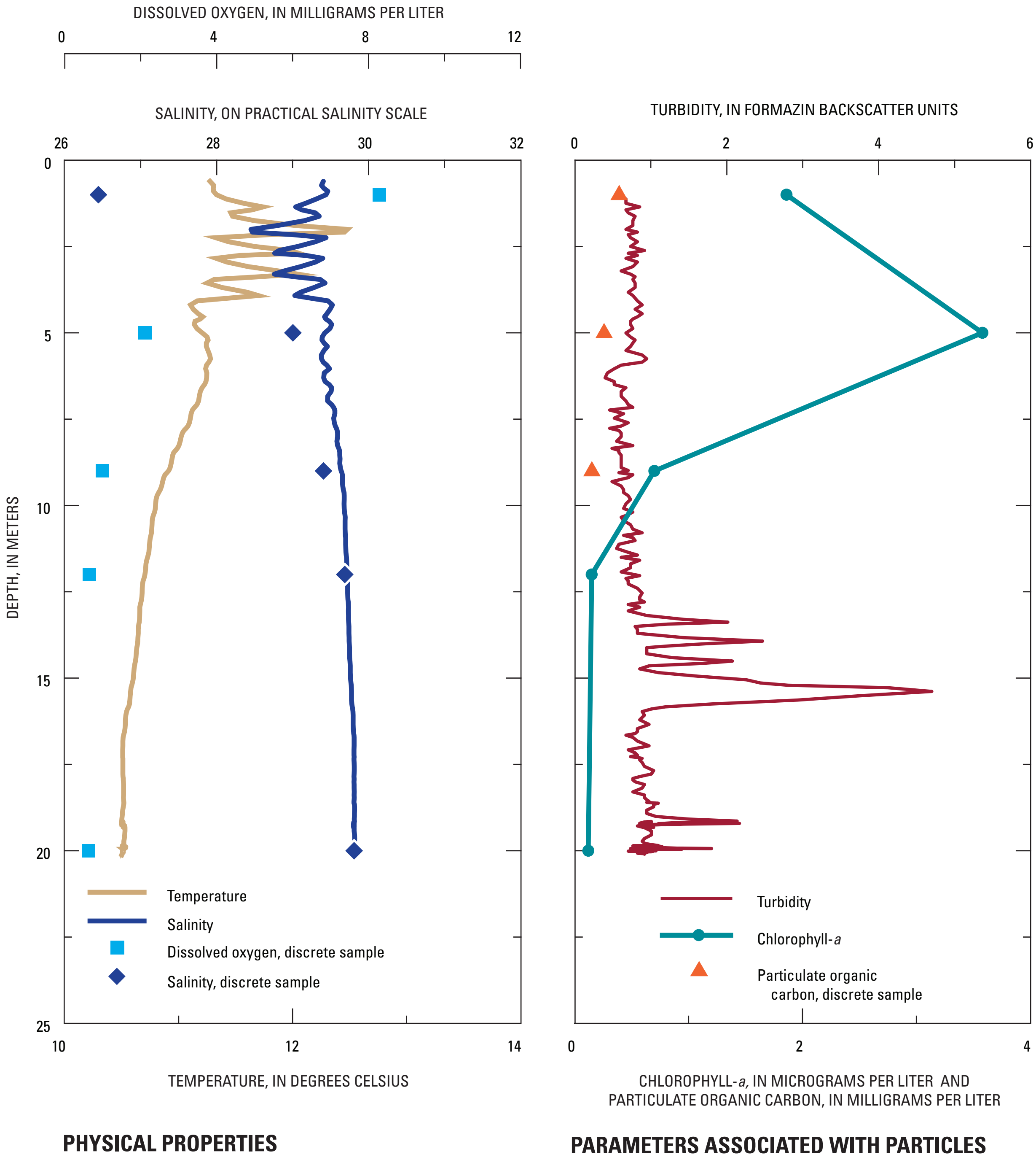


Figure A2. Water properties for site L16, July 2004.

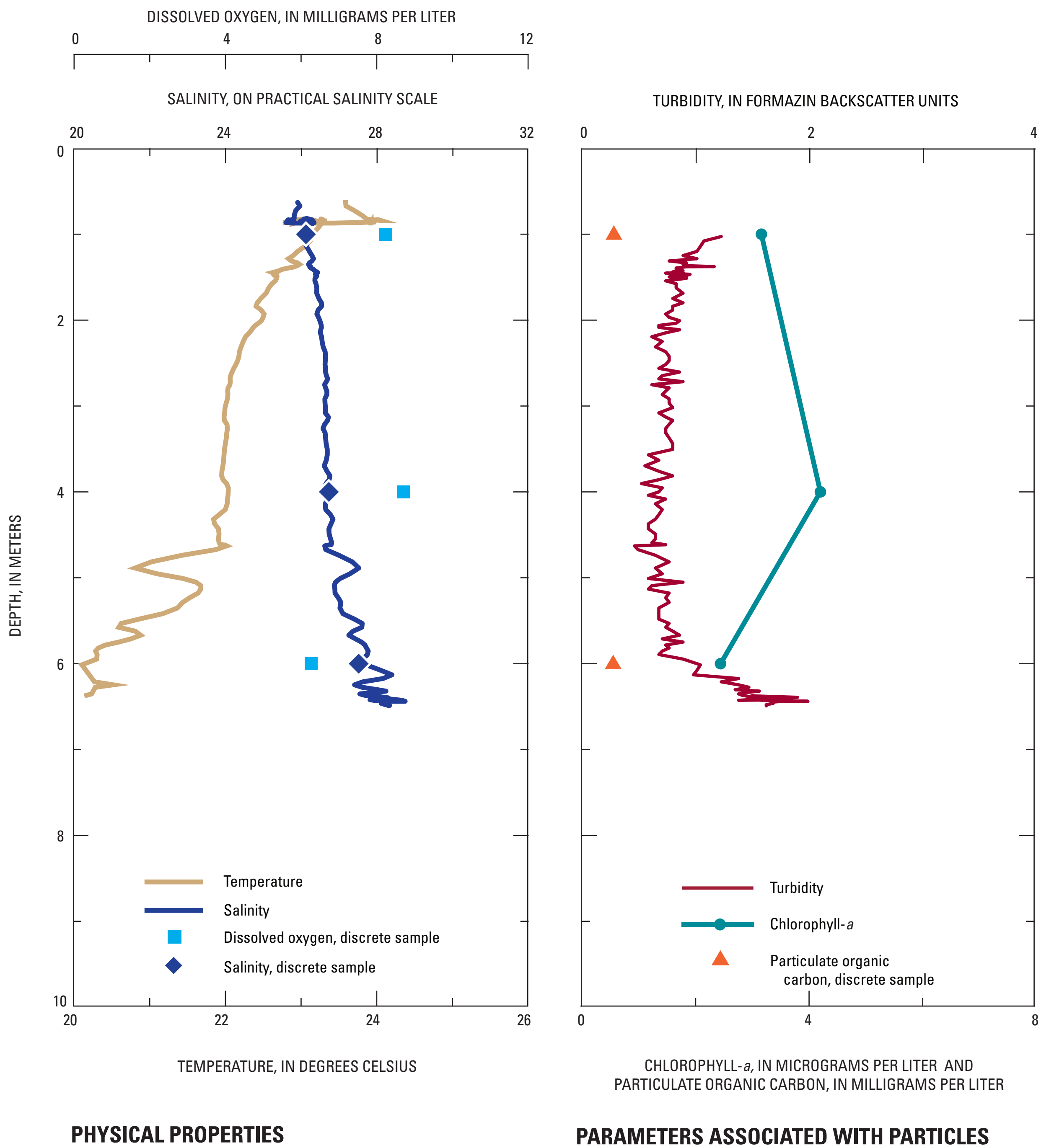


Figure A3. Water properties for site L18, July 2004.

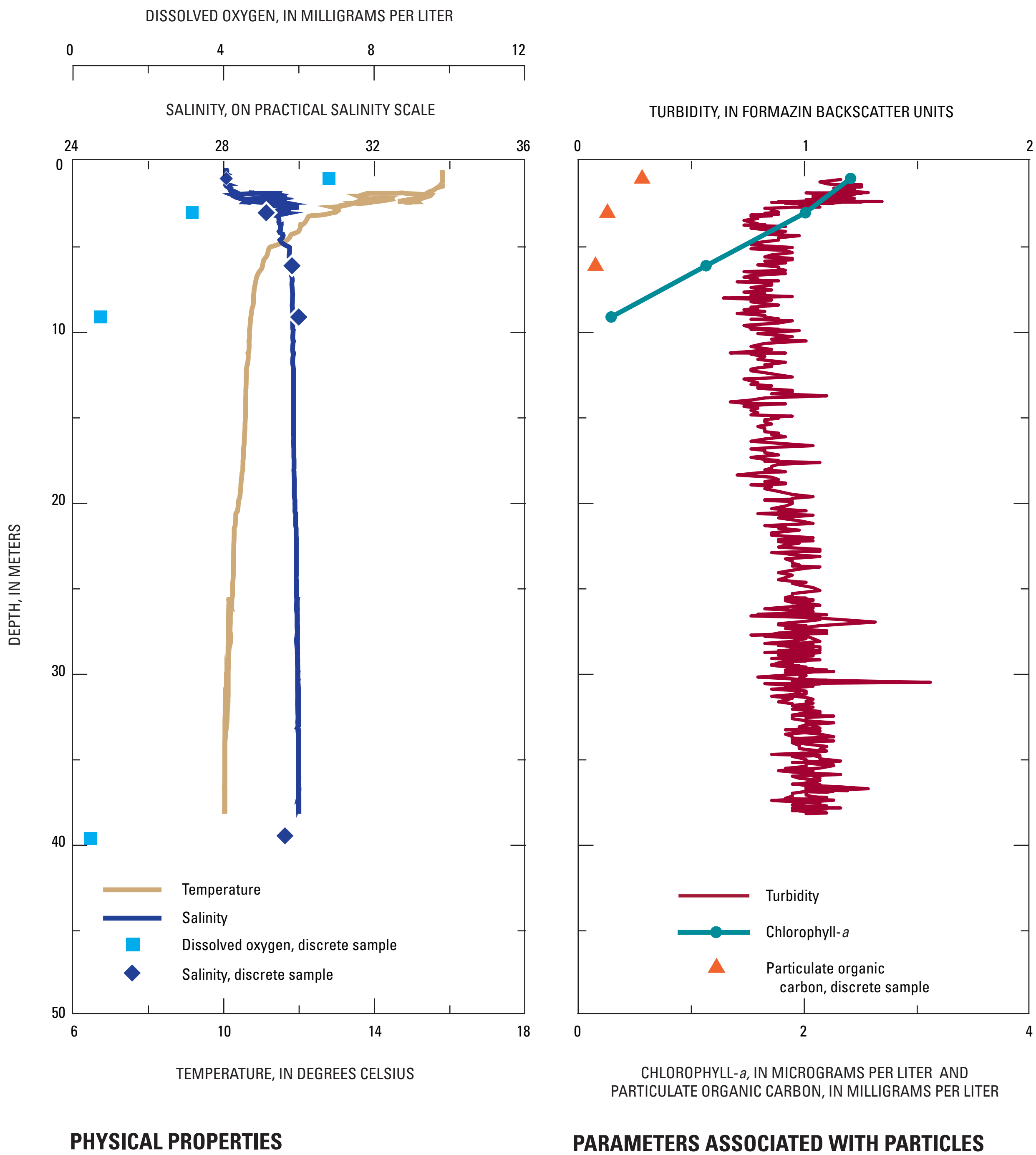


Figure A4. Water properties for site L13, August 2004.

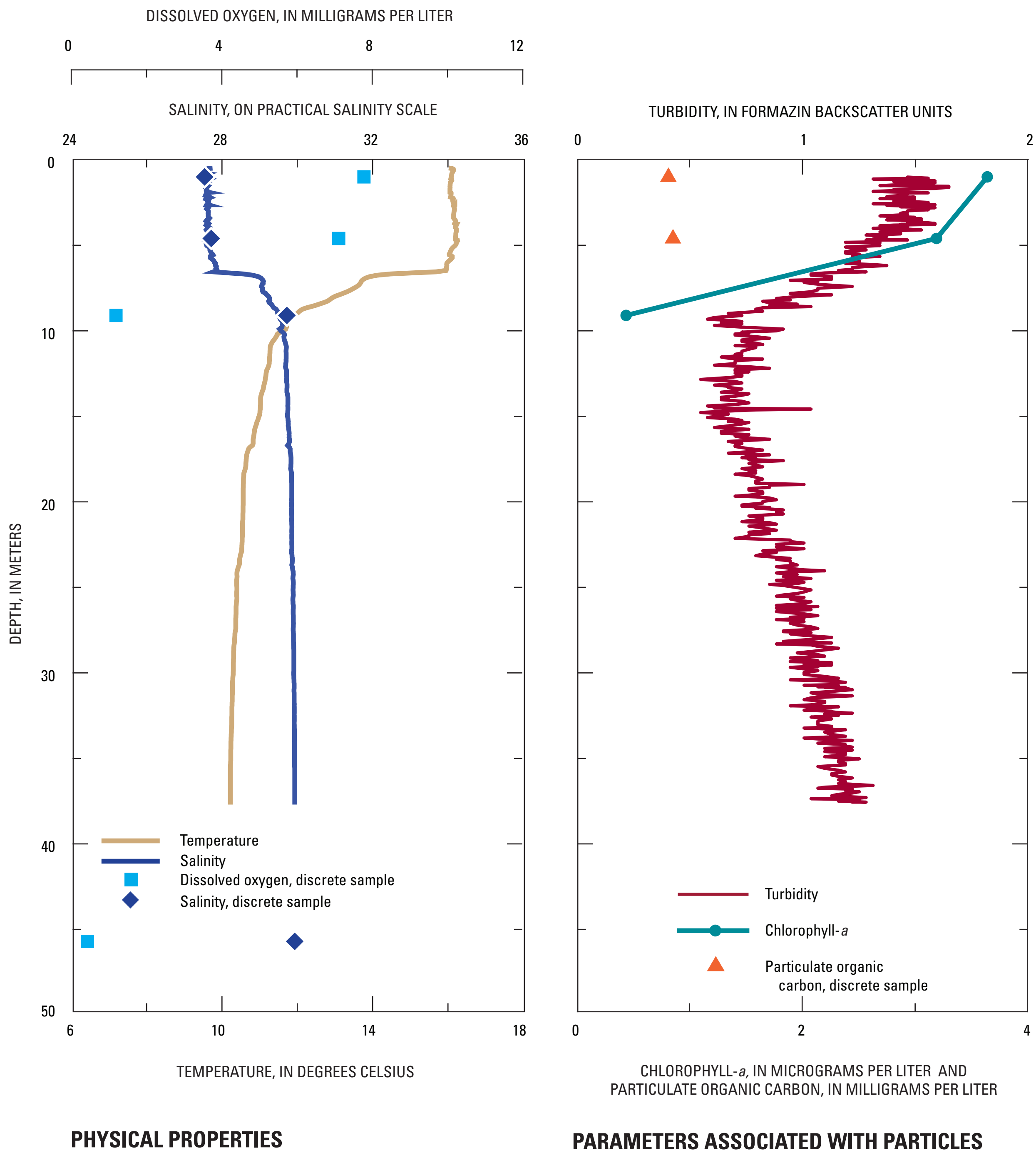


Figure A5. Water properties for site L14, August 2004.

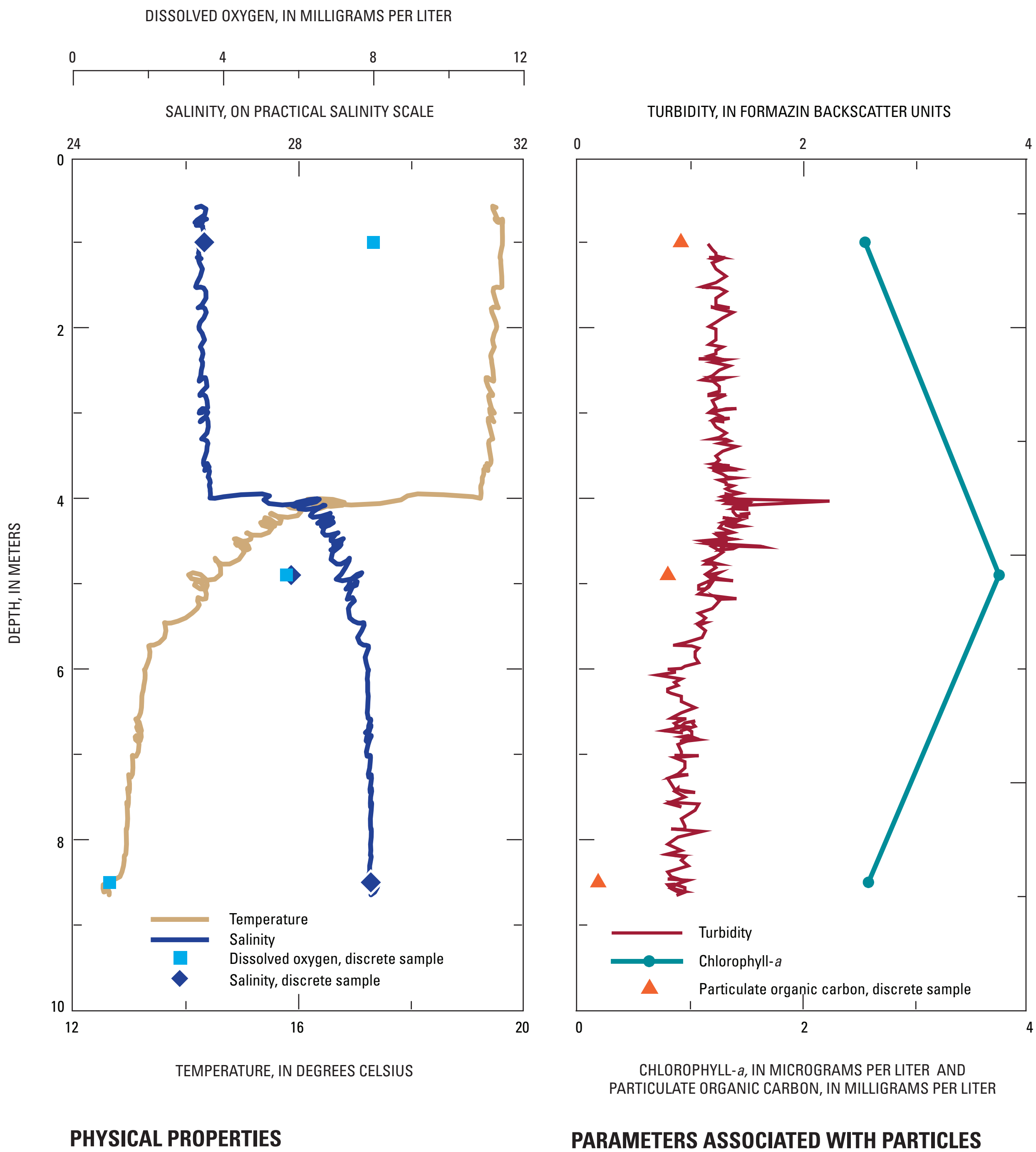


Figure A6. Water properties for site L15, August 2004.

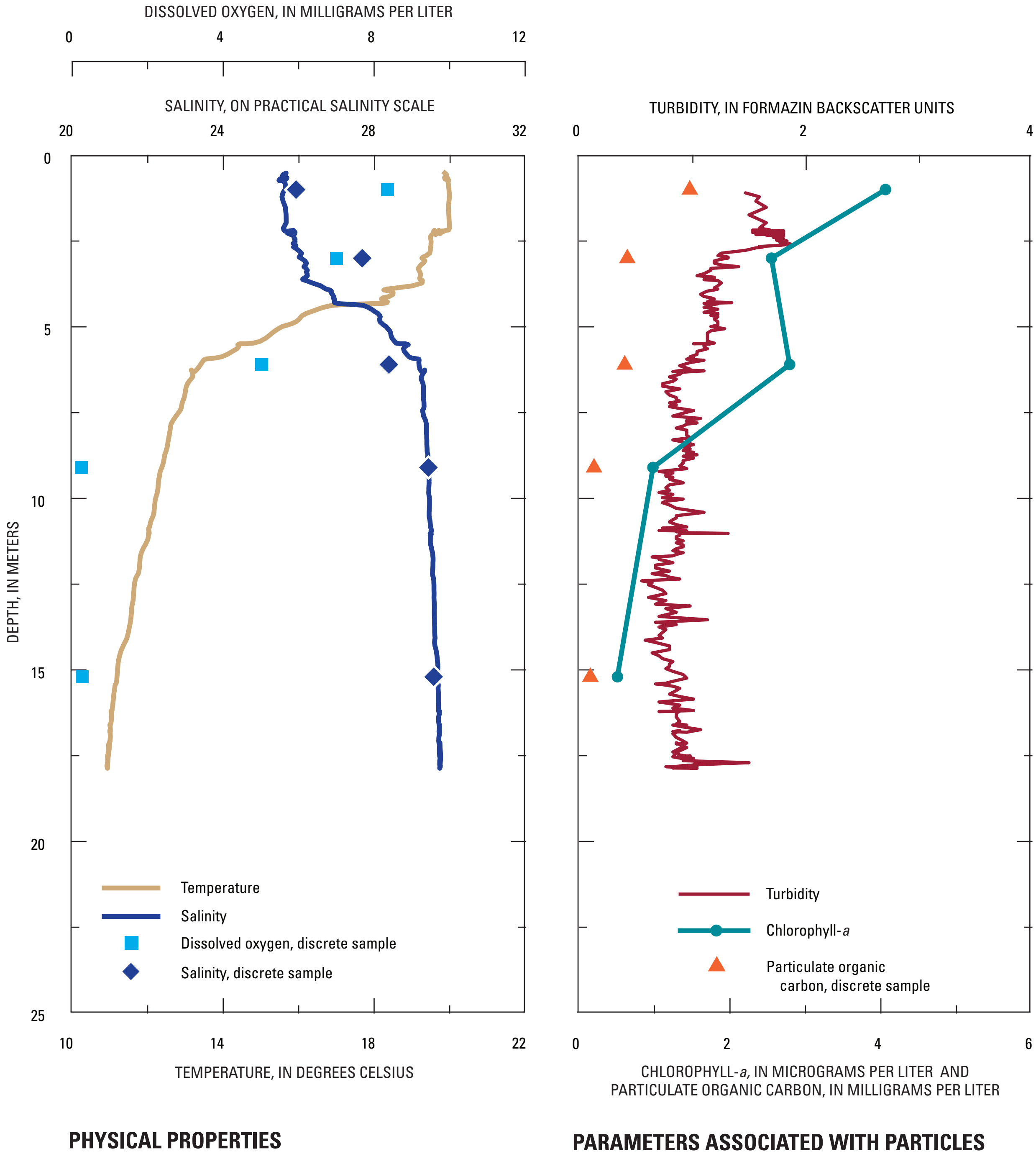


Figure A7. Water properties for site L16, August 2004.

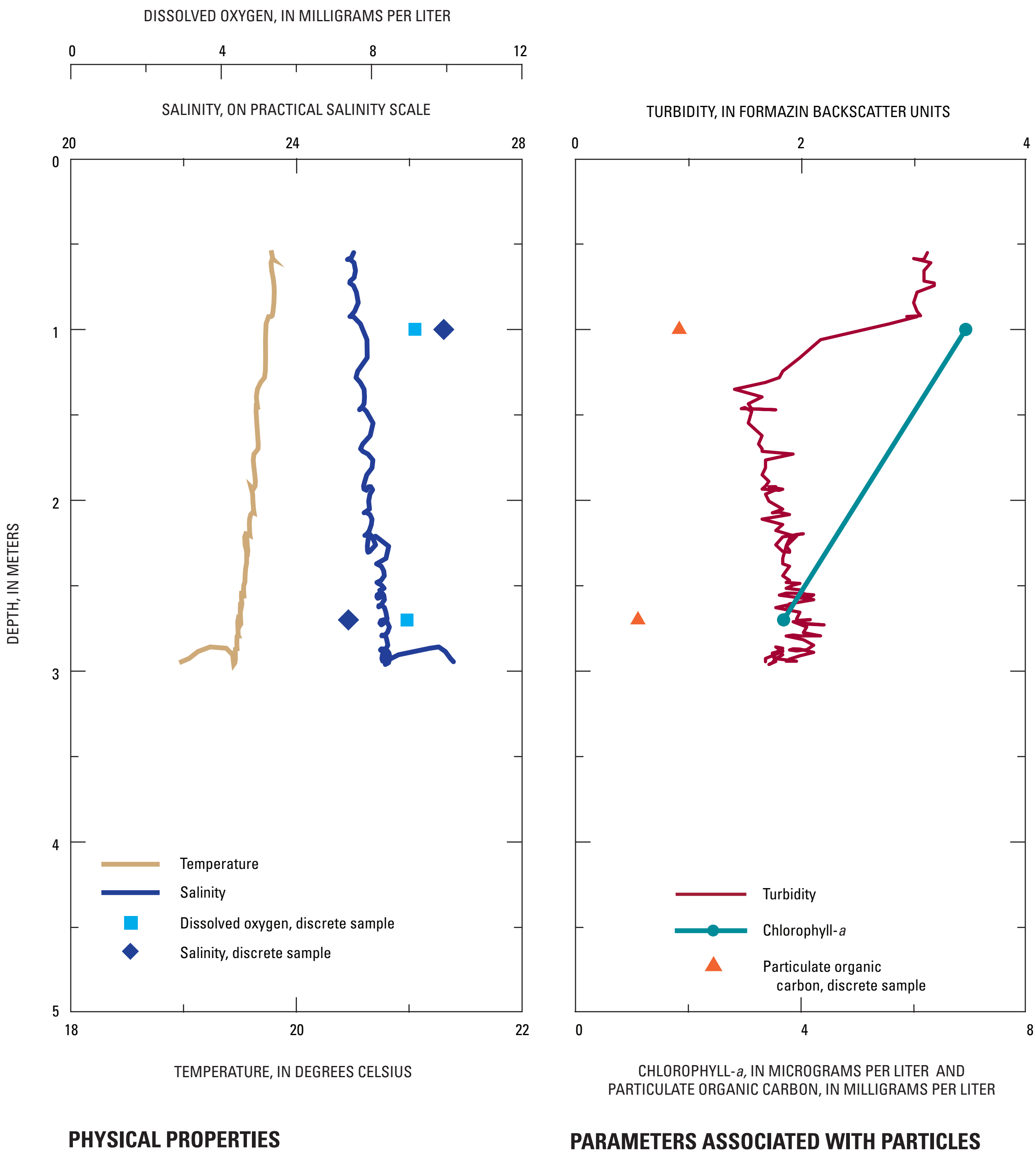


Figure A8. Water properties for site L17, August 2004.

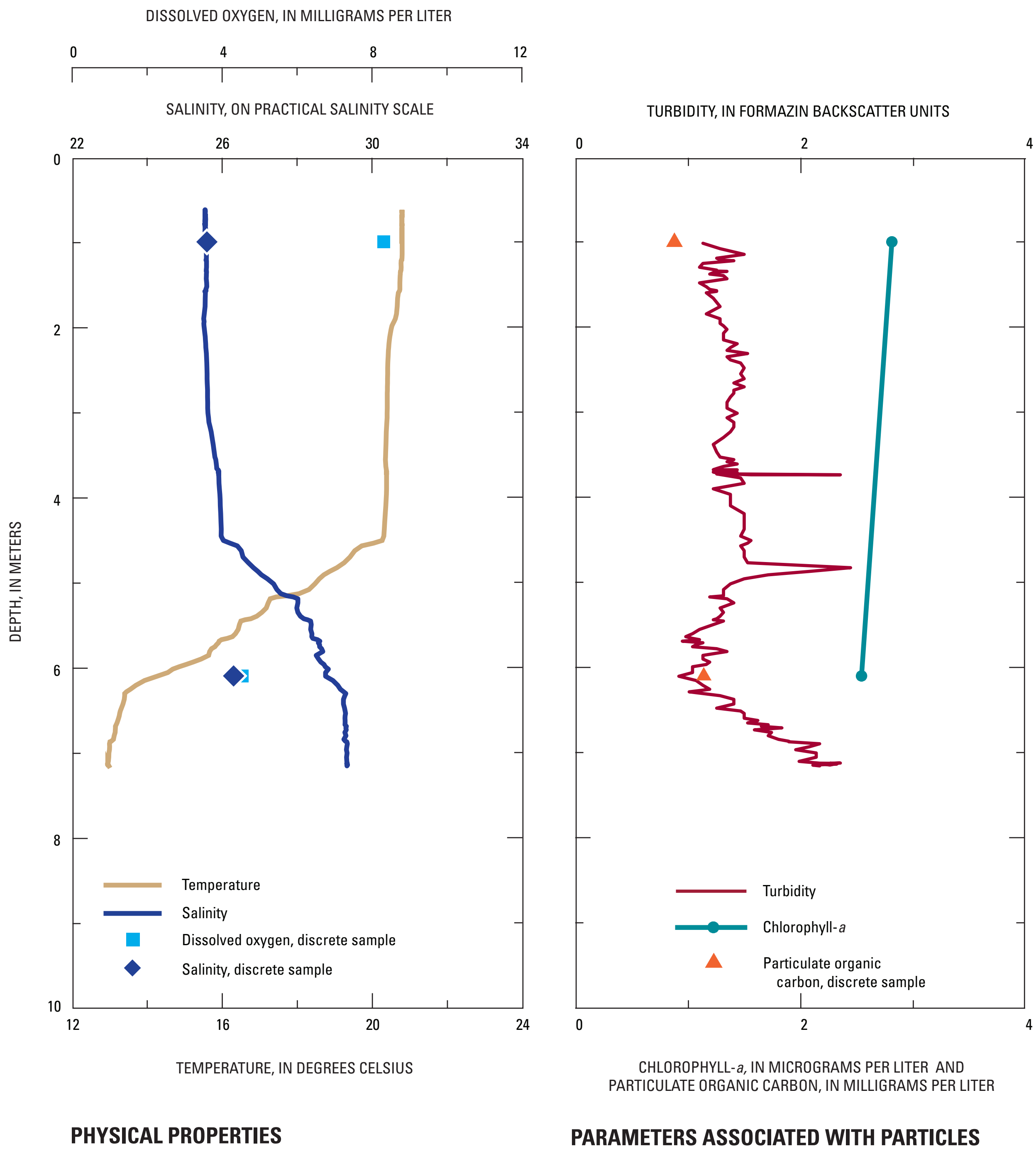


Figure A9. Water properties for site L18, August 2004.

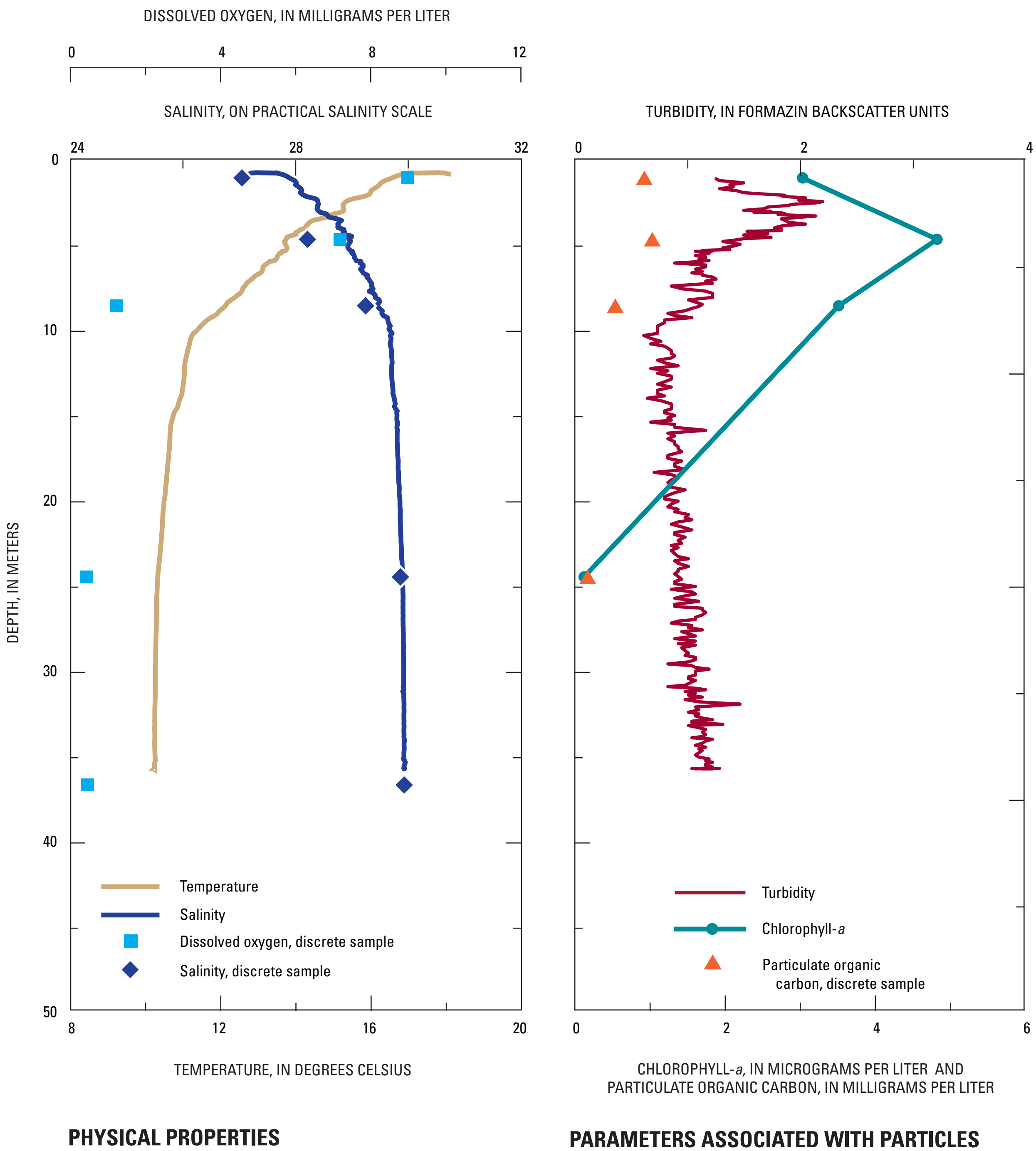


Figure A10. Water properties for site L19, August 2004.

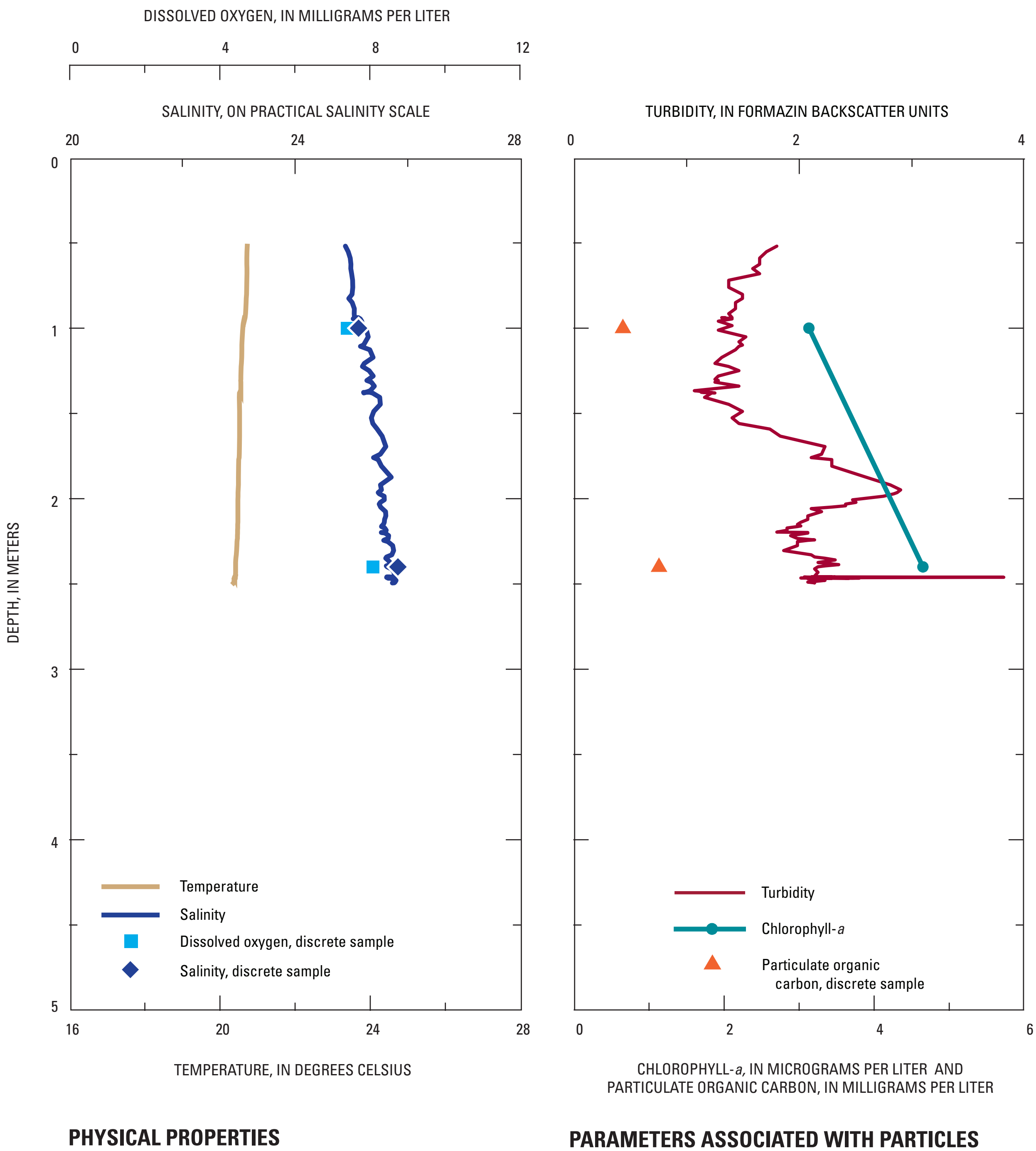


Figure A11. Water properties for site L20, August 2004.

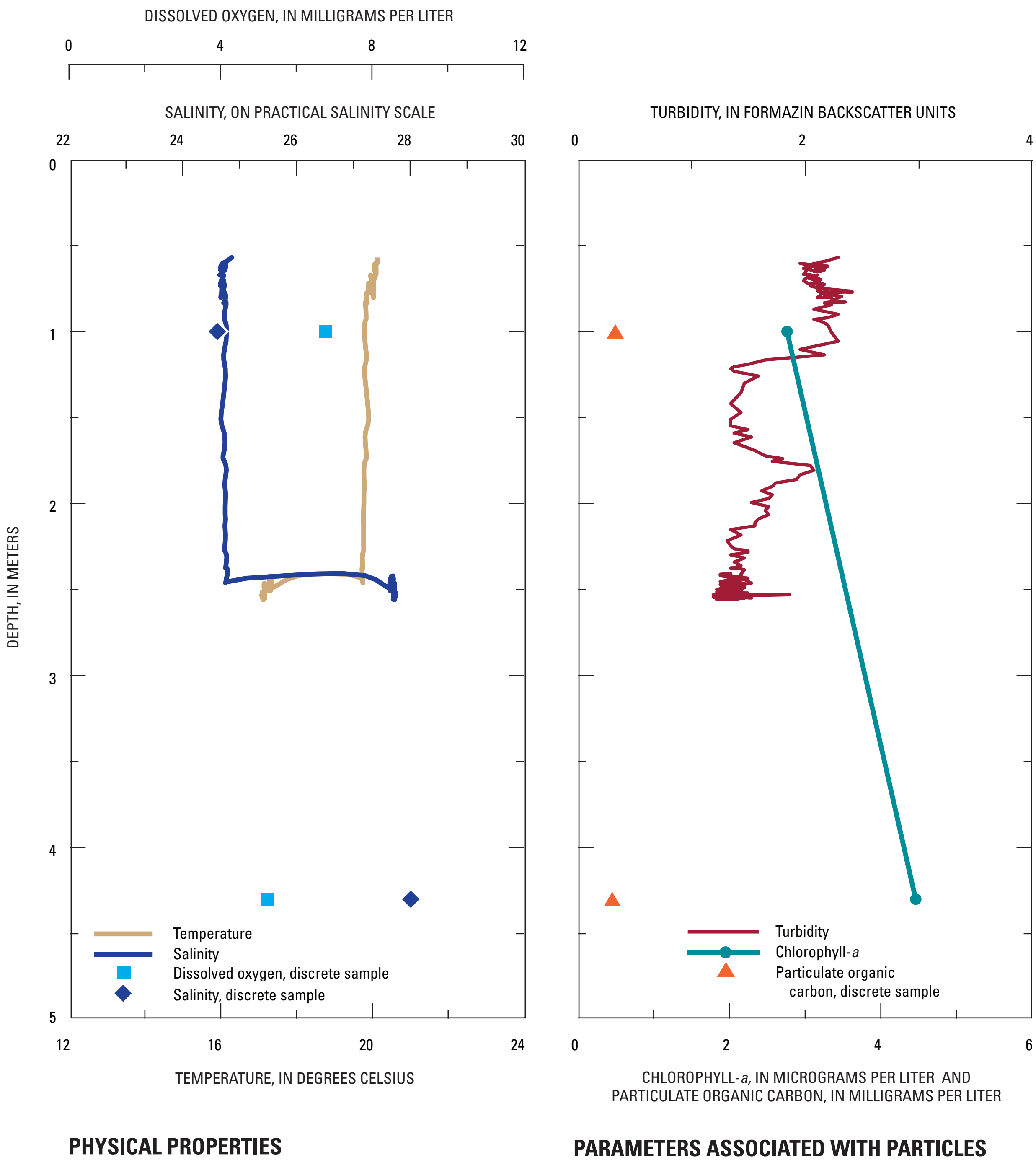


Figure A12. Water properties for site L21, August 2004.

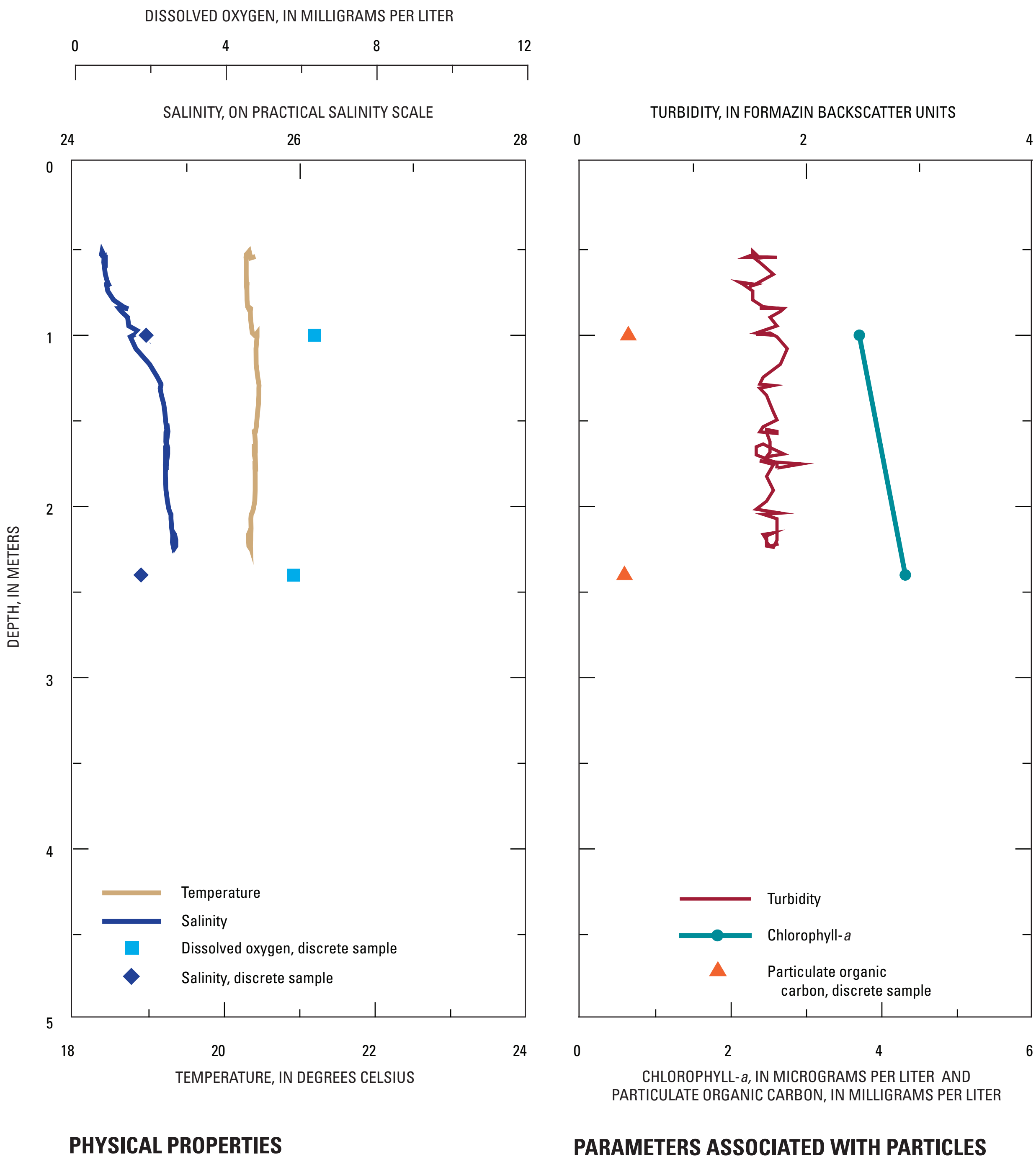


Figure A13. Water properties for site L22, August 2004.

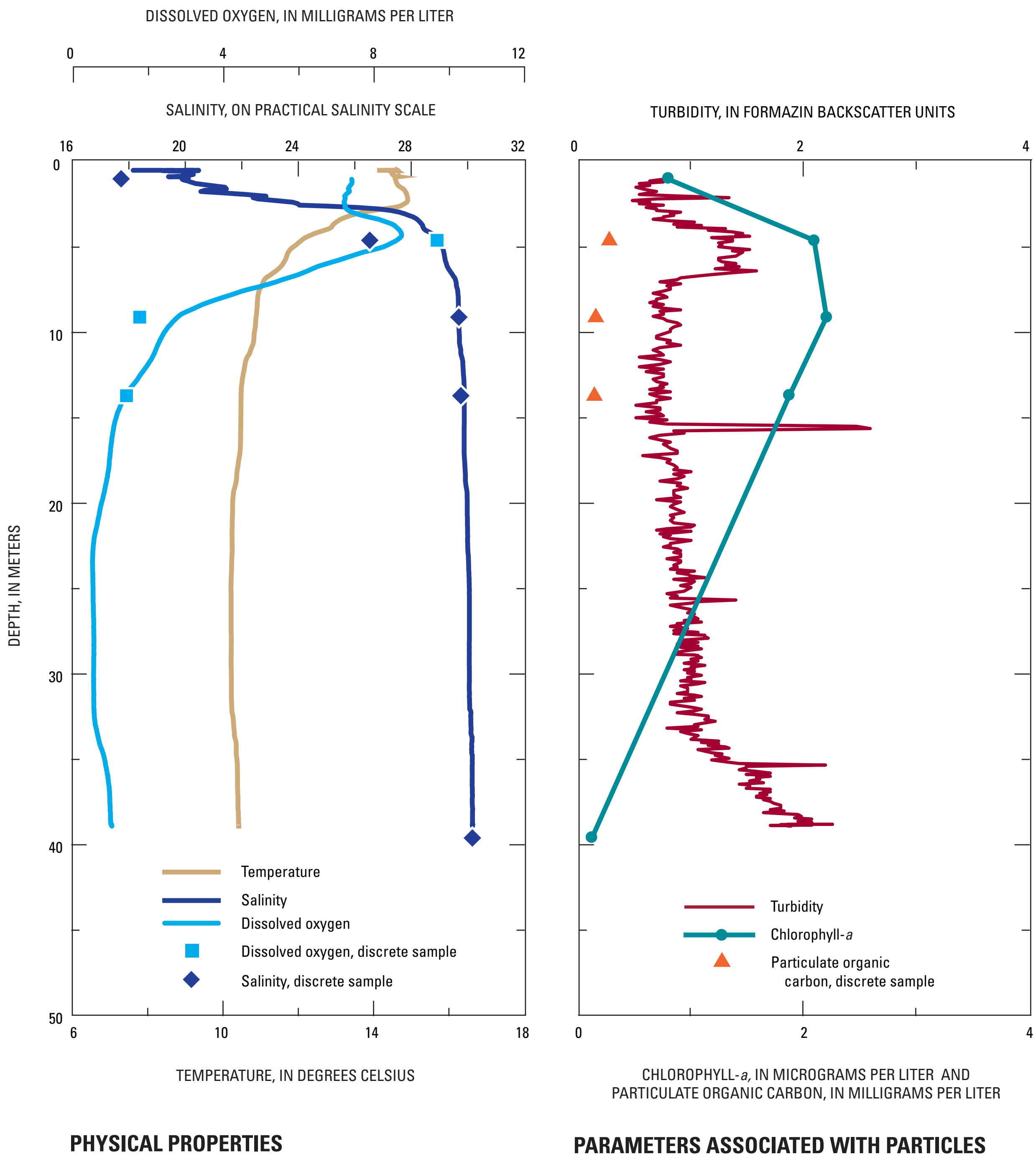


Figure A14. Water properties for site L13, September 2004.

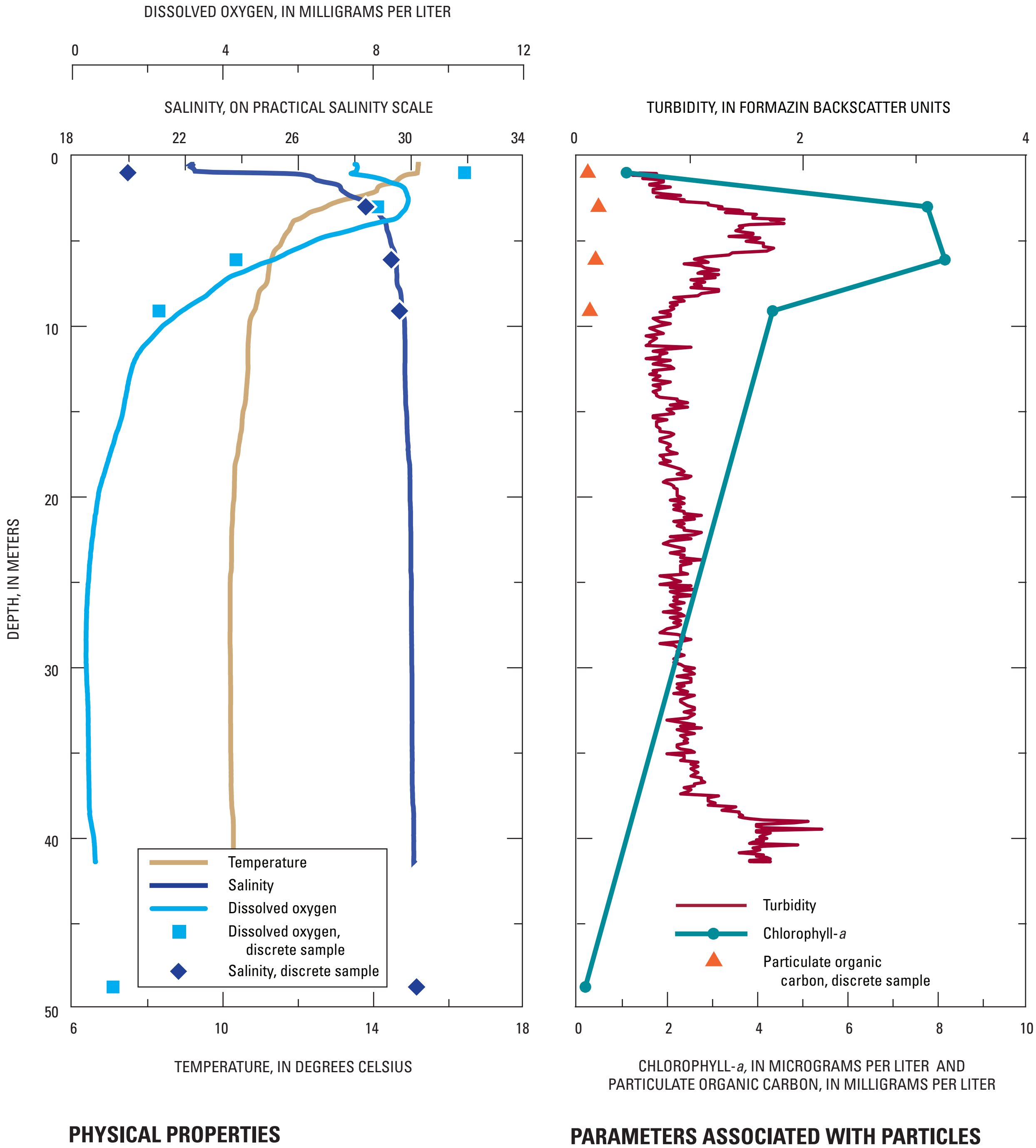
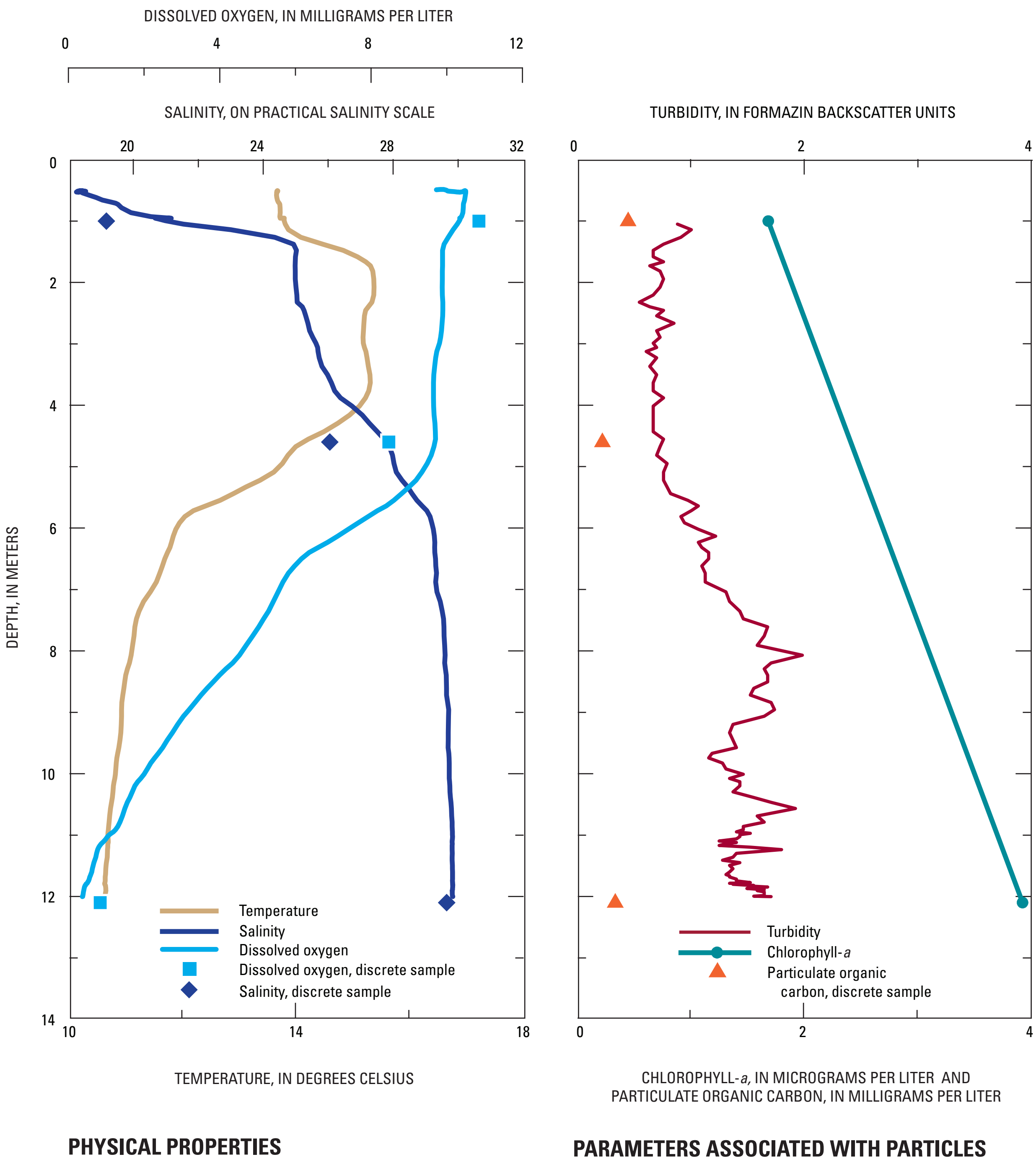


Figure A15. Water properties for site L14, September 2004.



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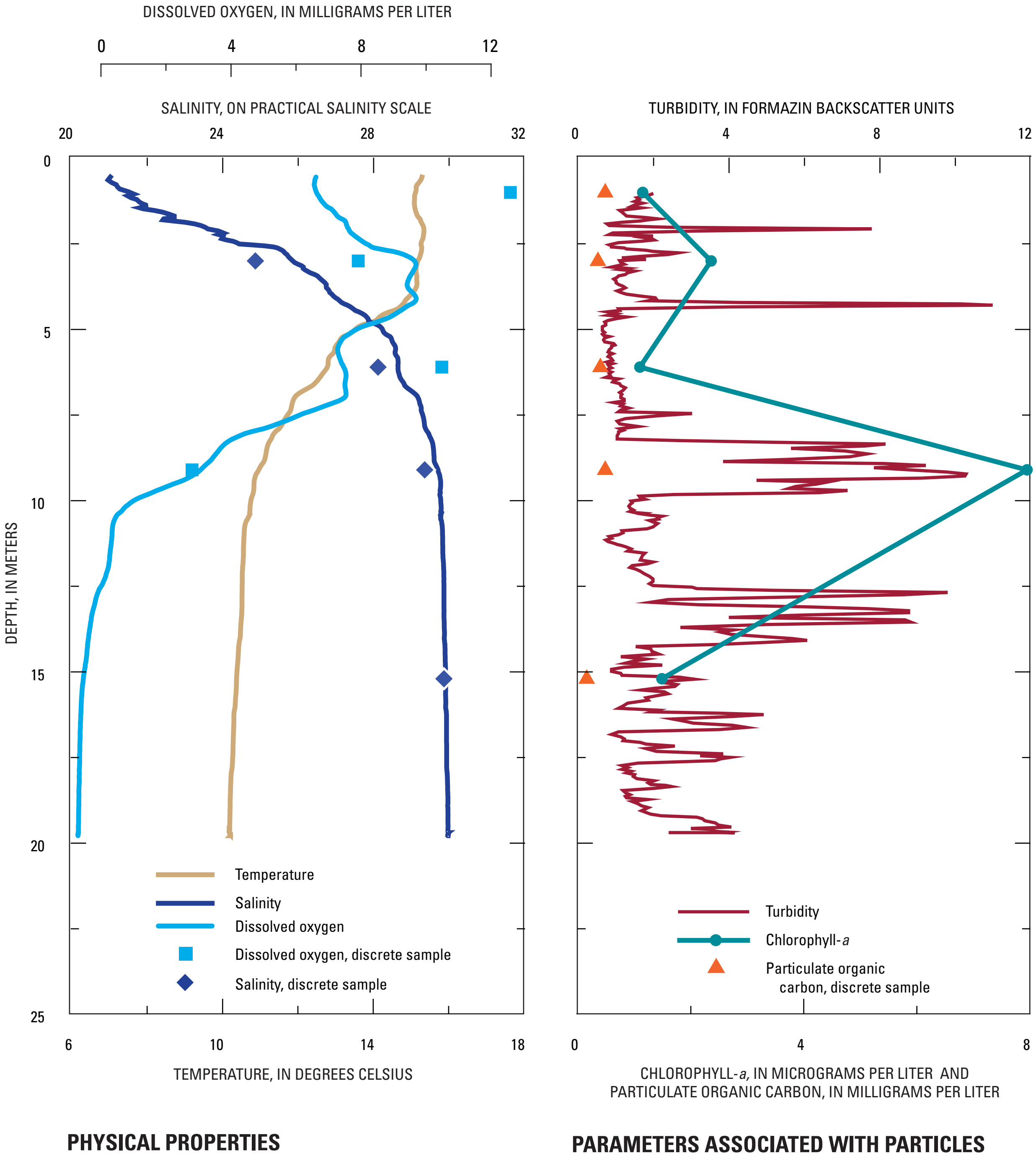

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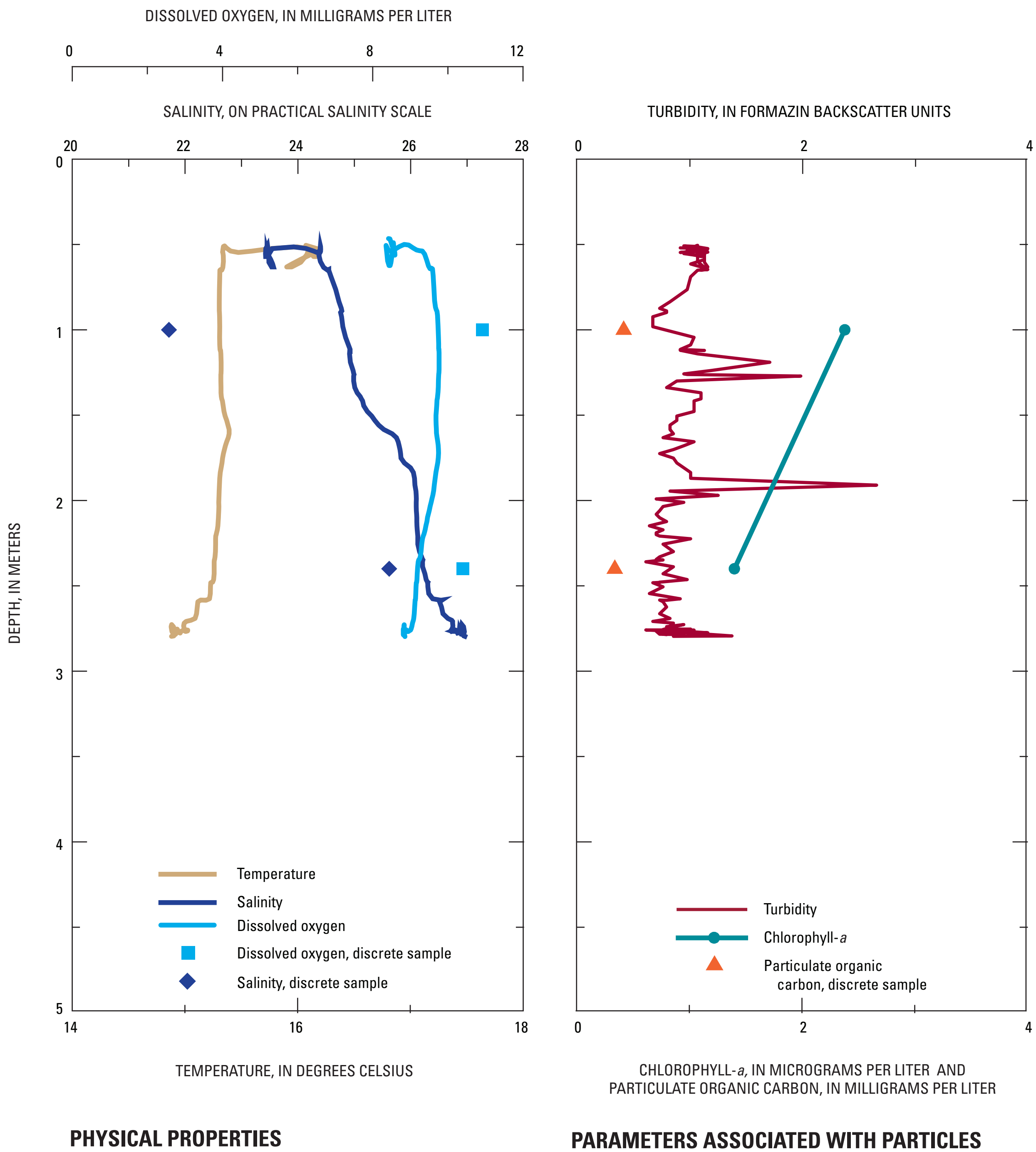

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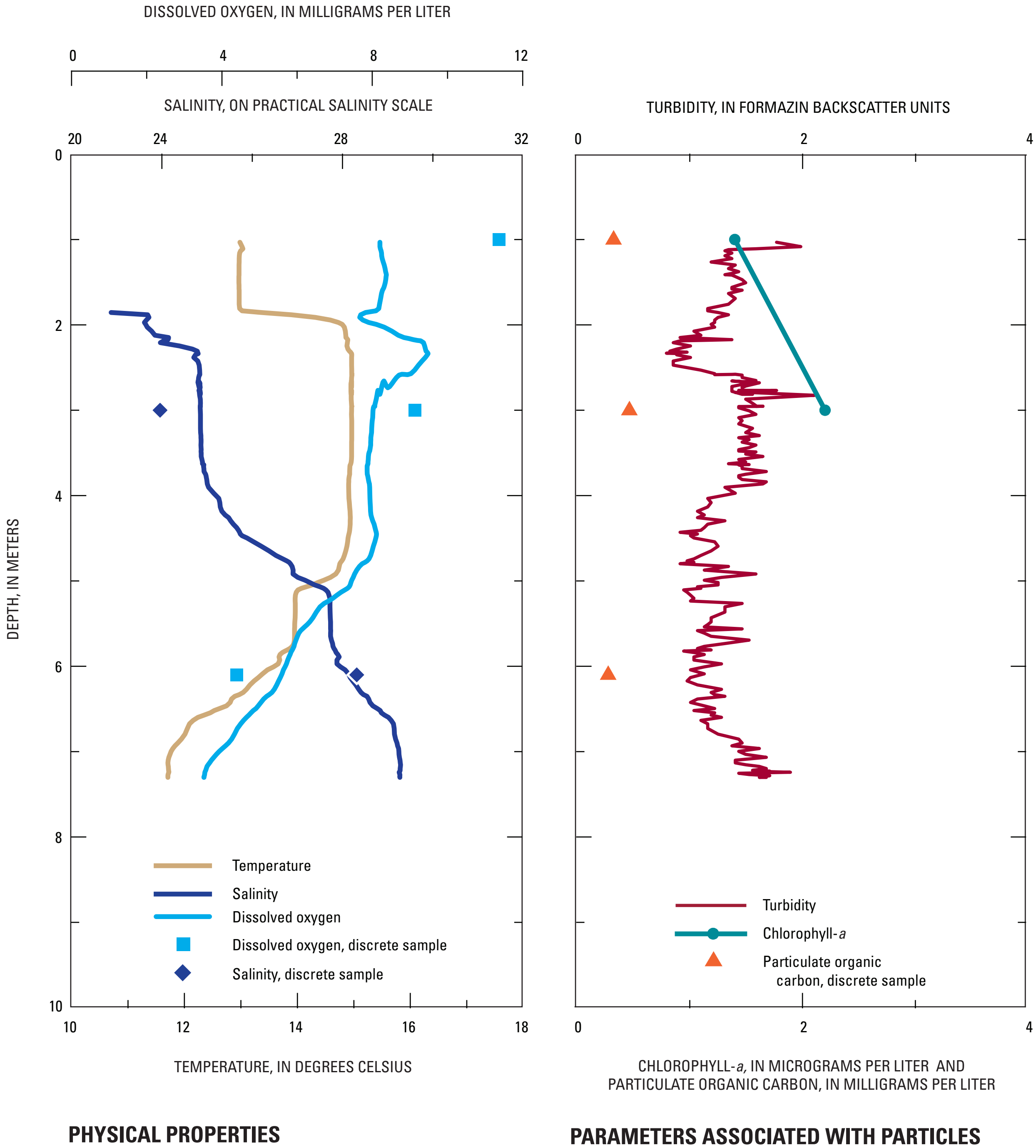


Figure A19. Water properties for site L18, September 2004.

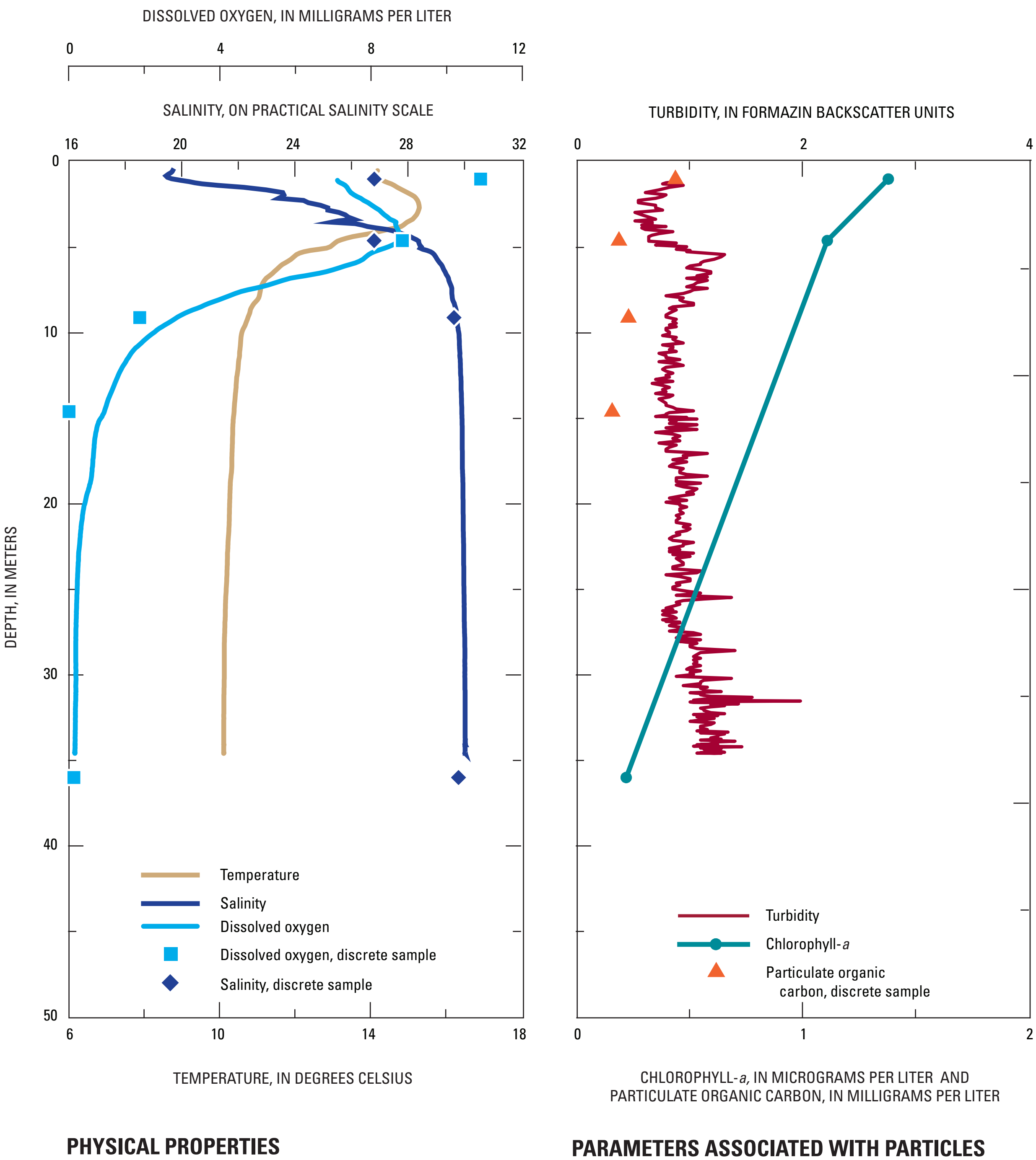
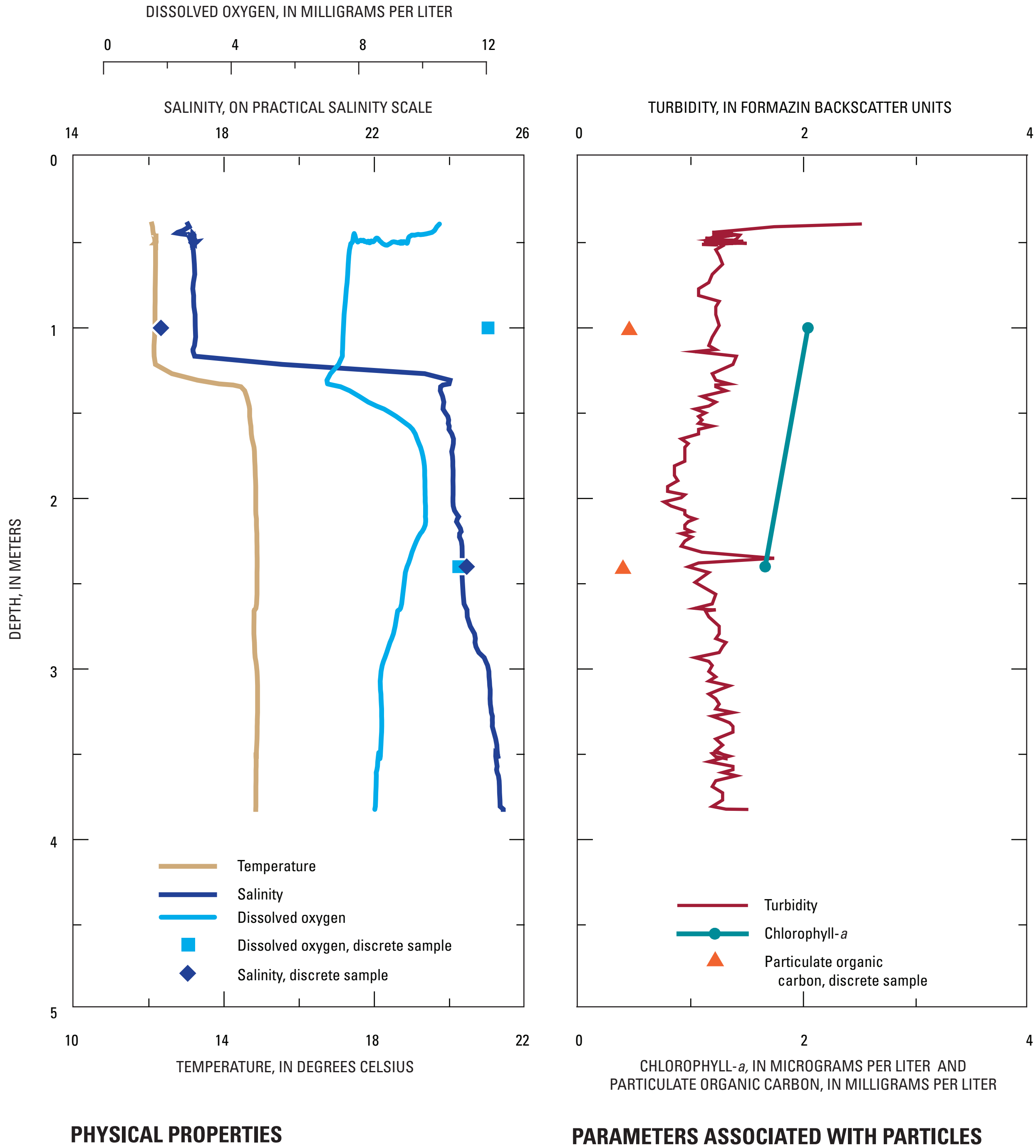


Figure A20. Water properties for site L19, September 2004.



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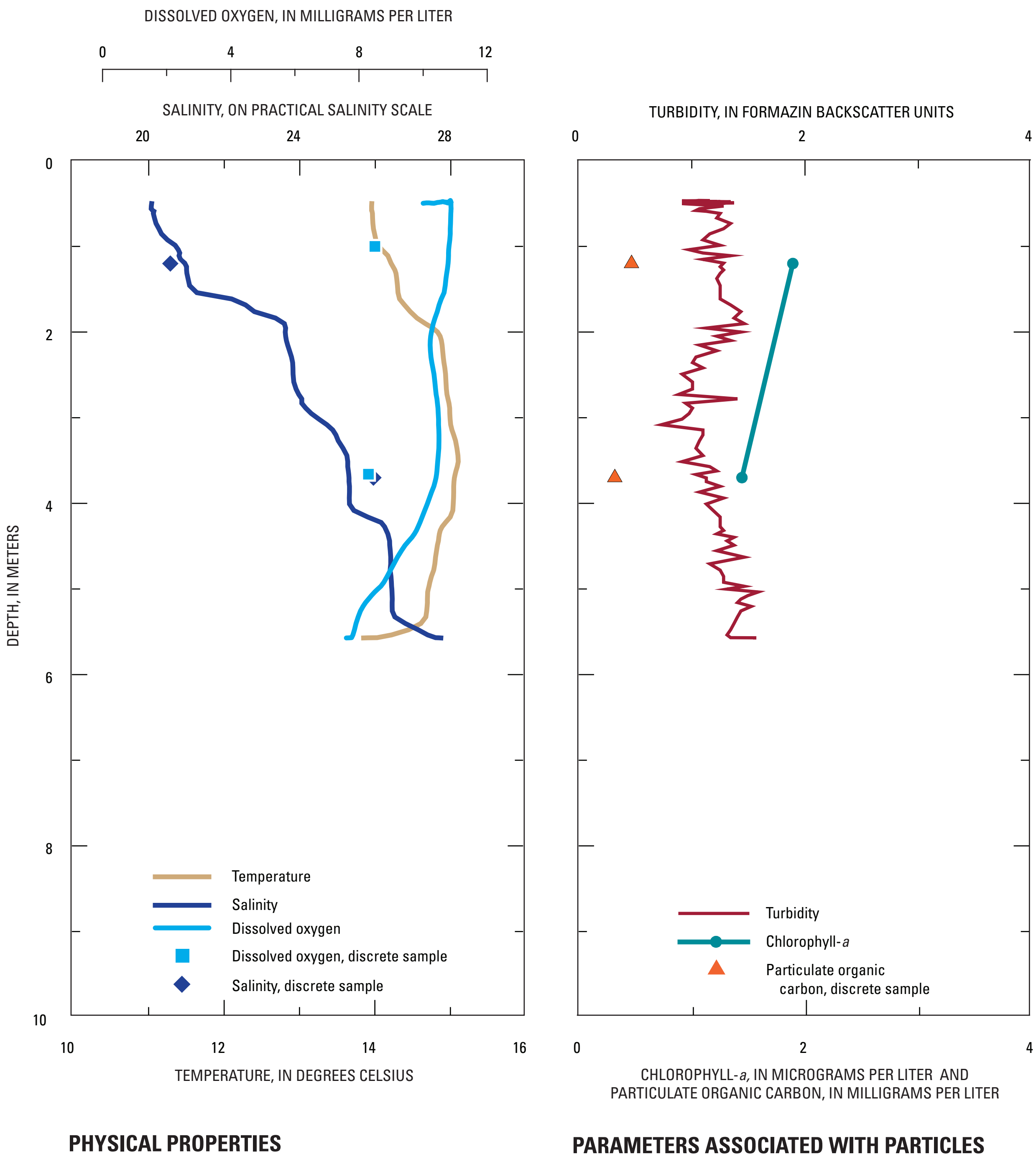

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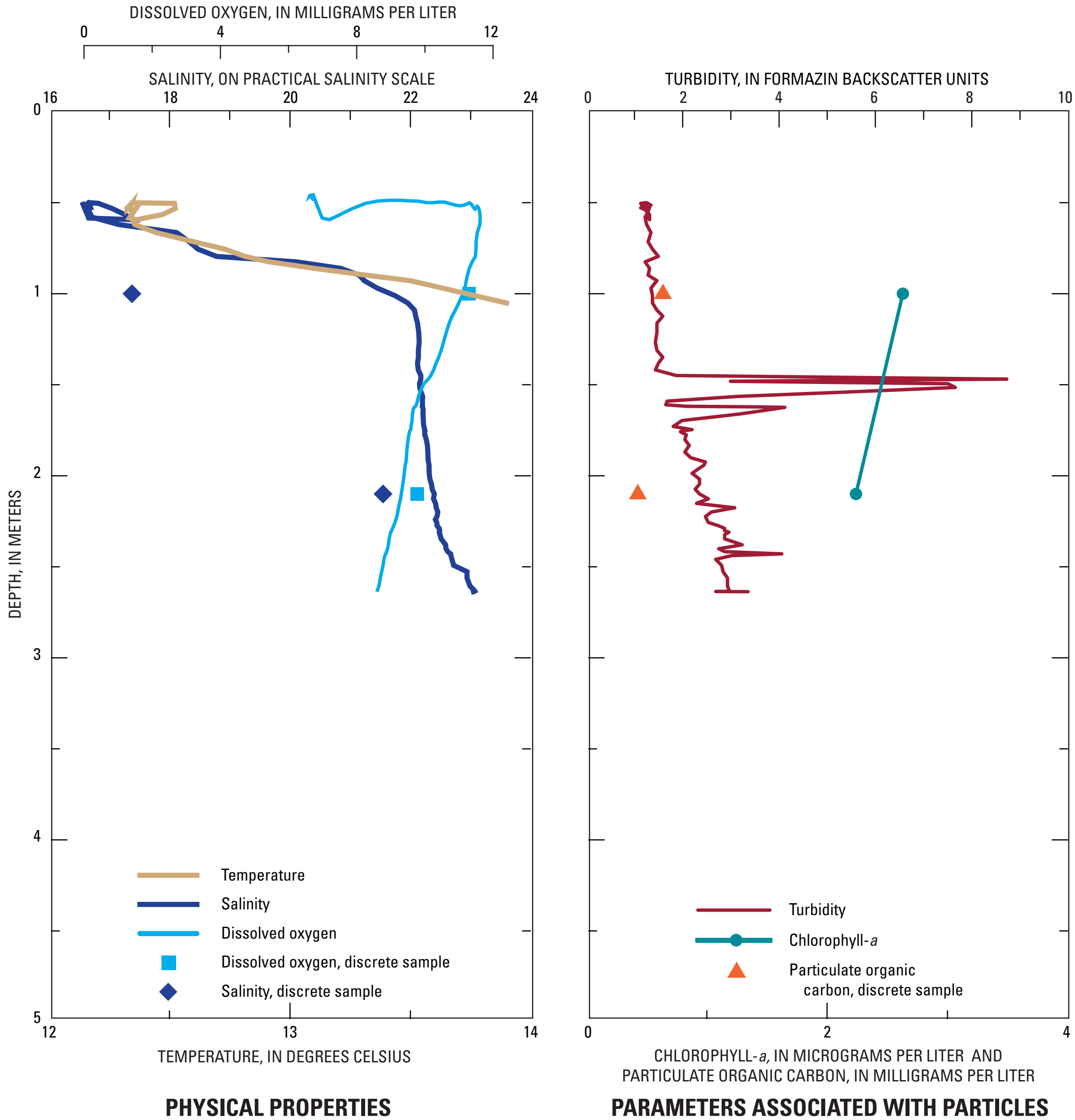

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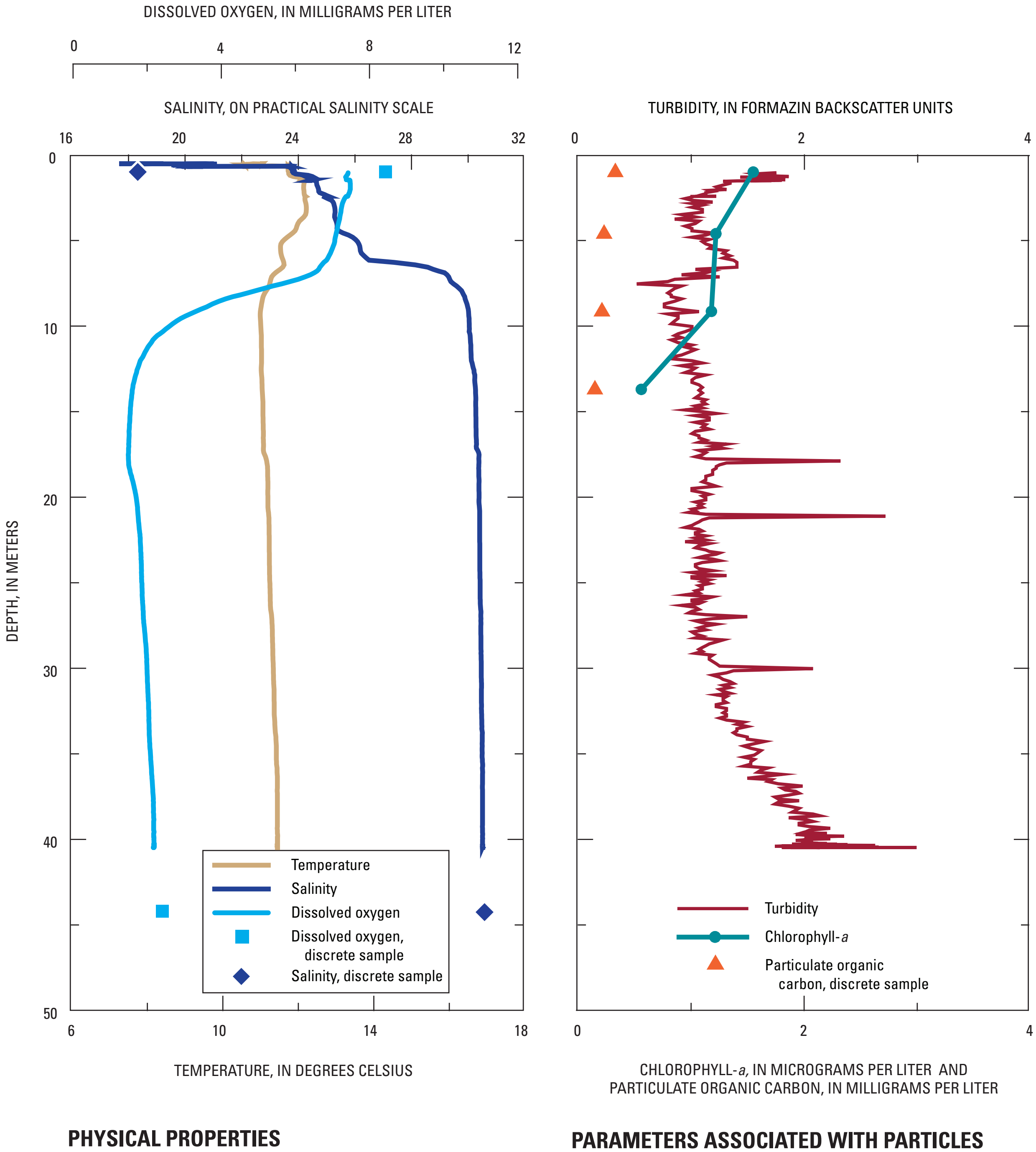

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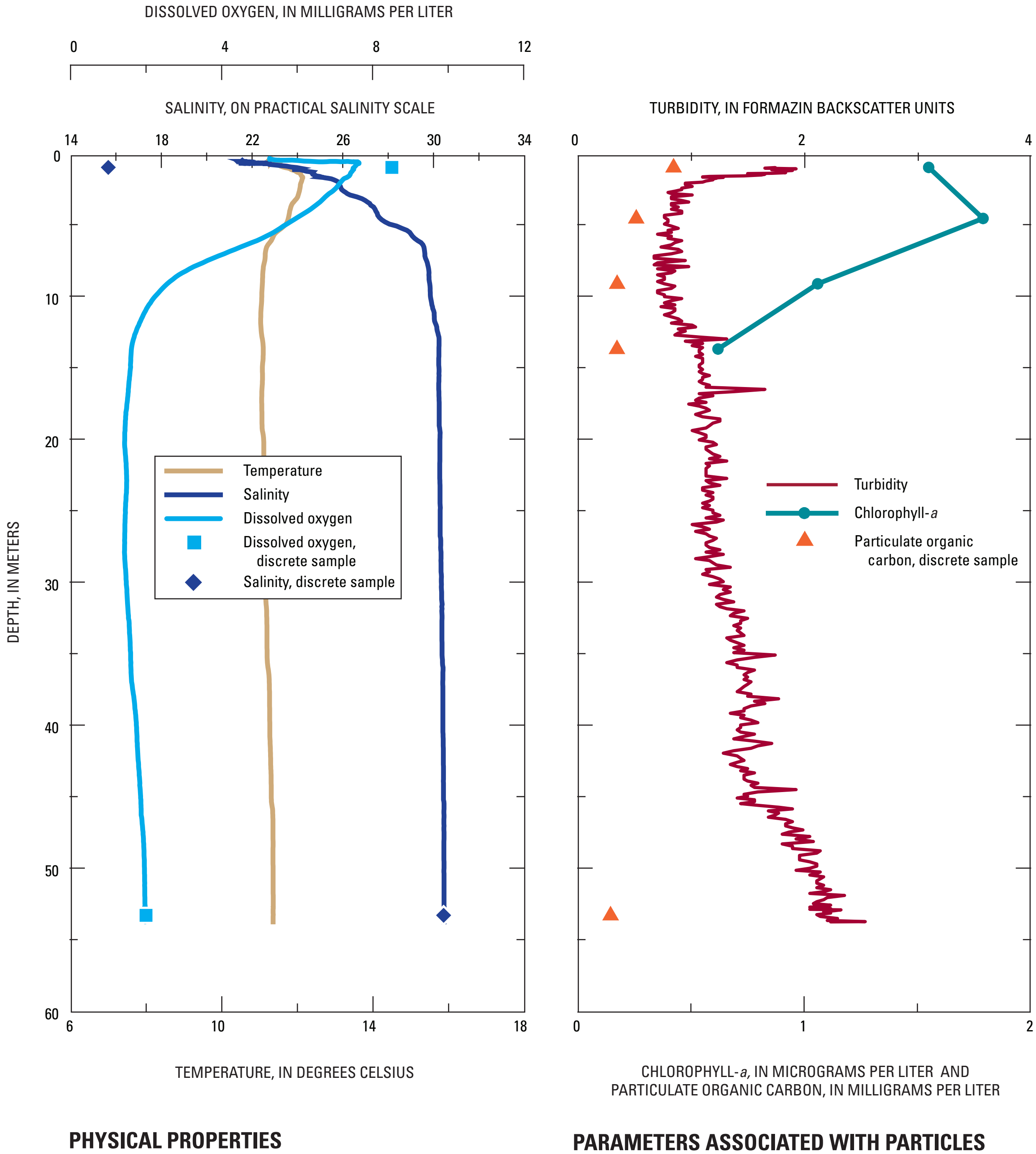
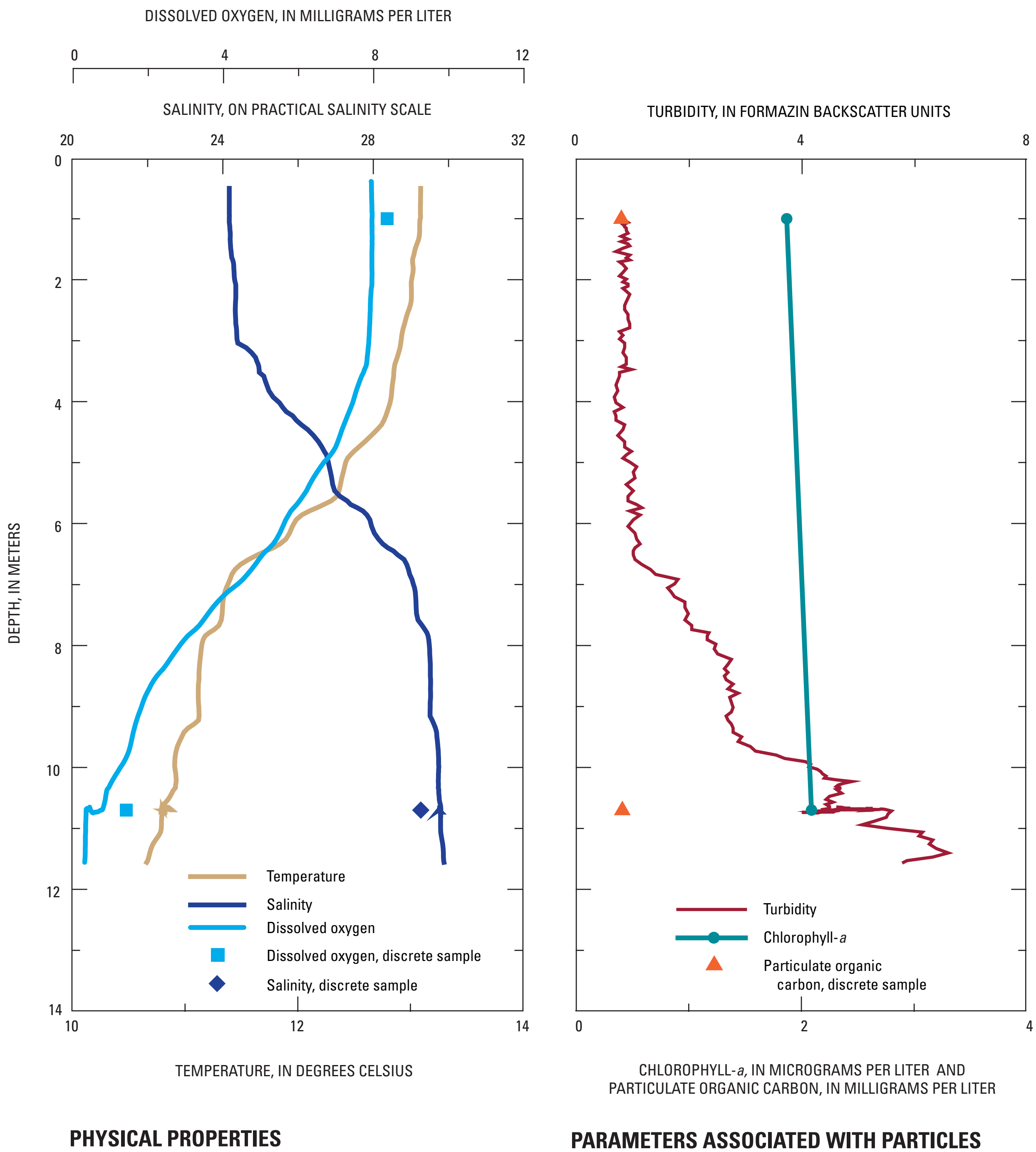


Figure A25. Water properties for site L14, October 2004.



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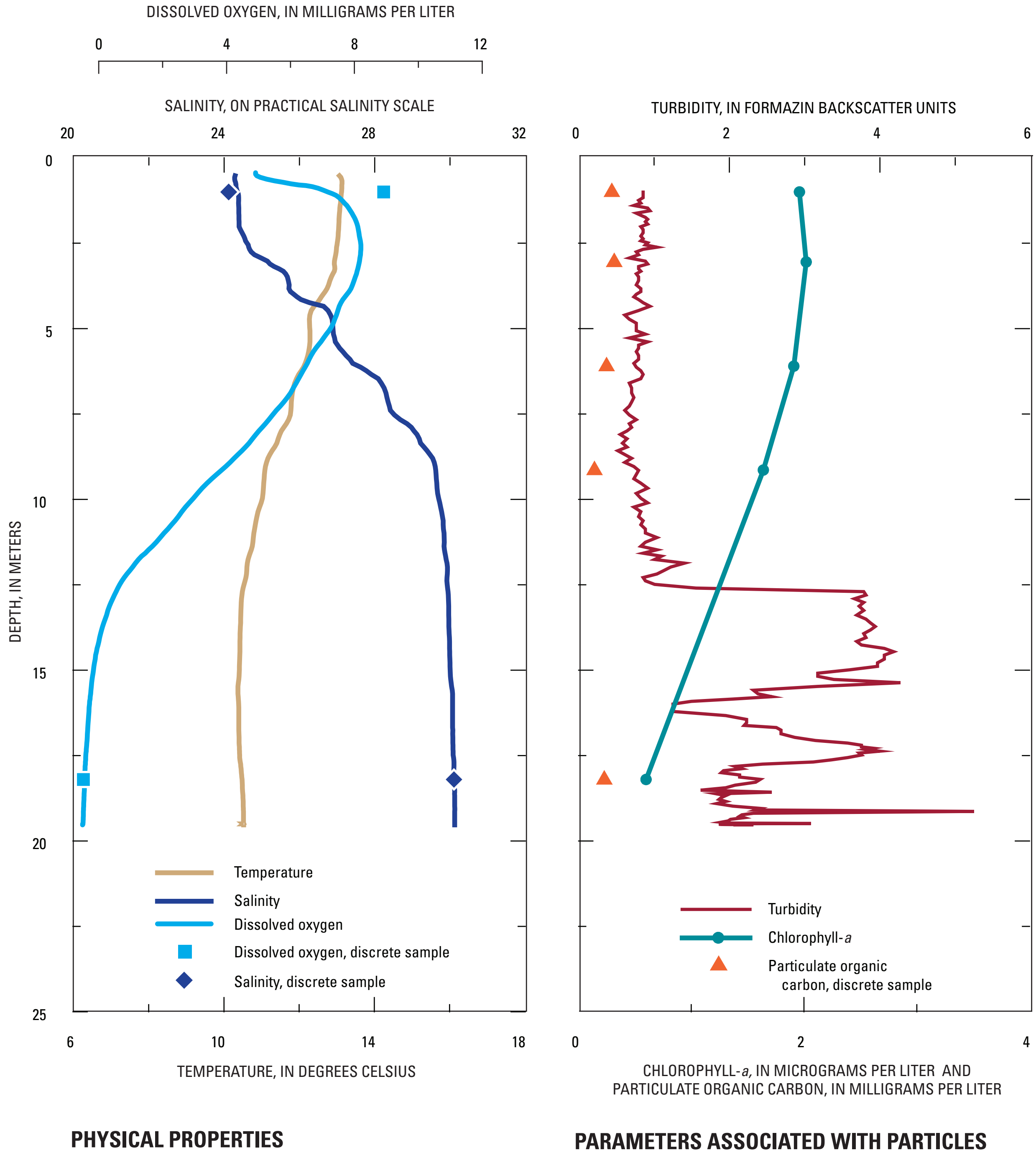

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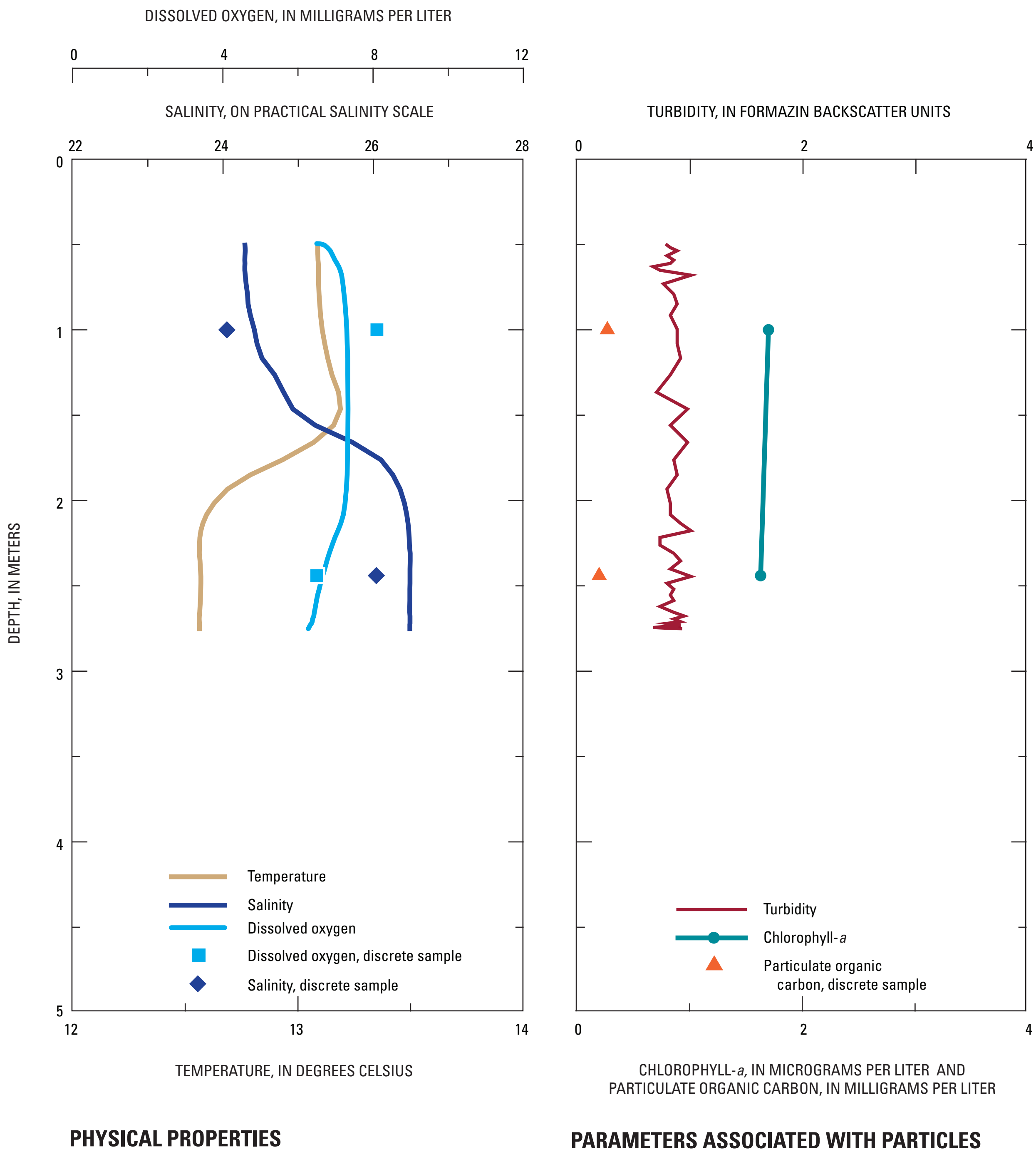

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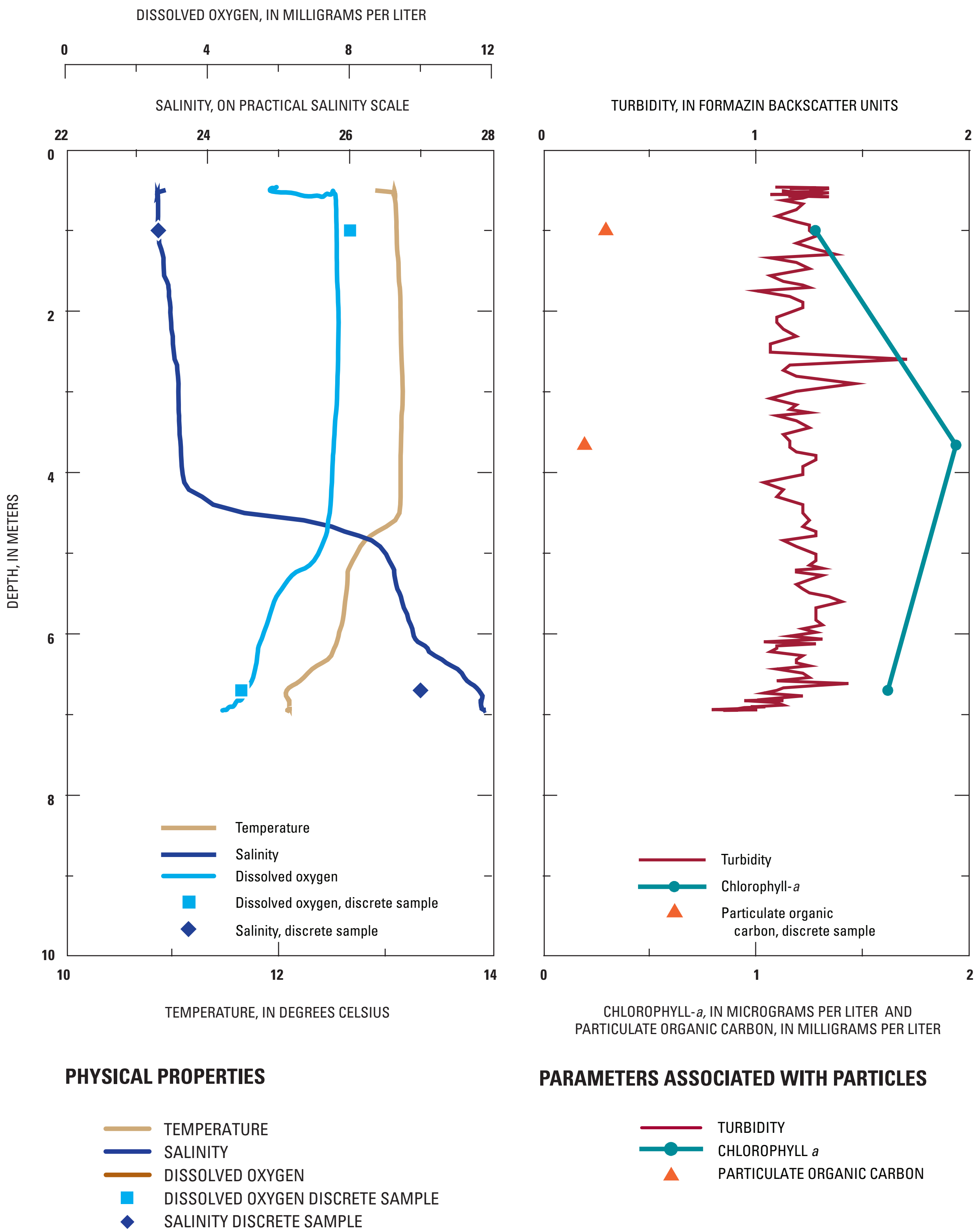

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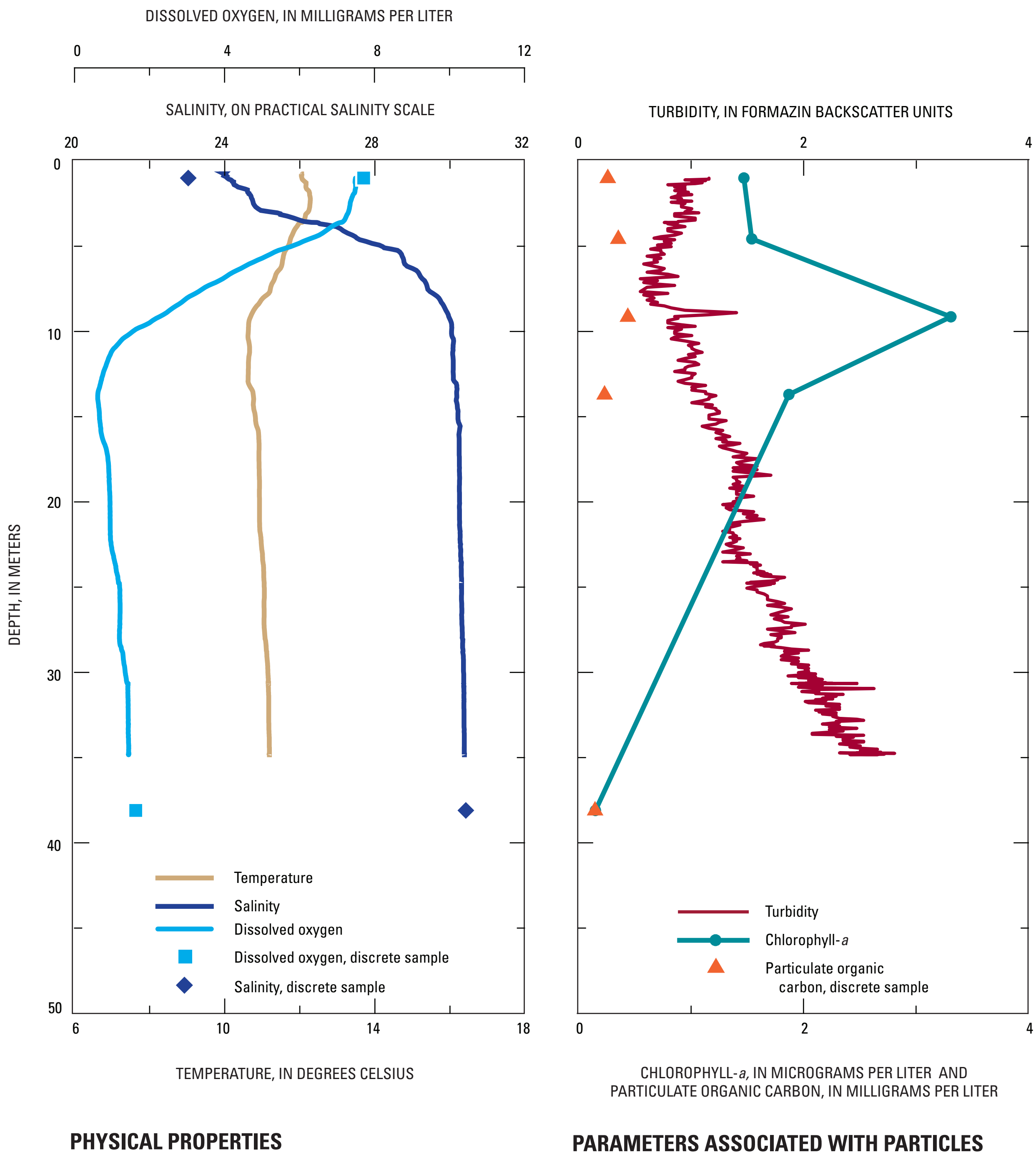
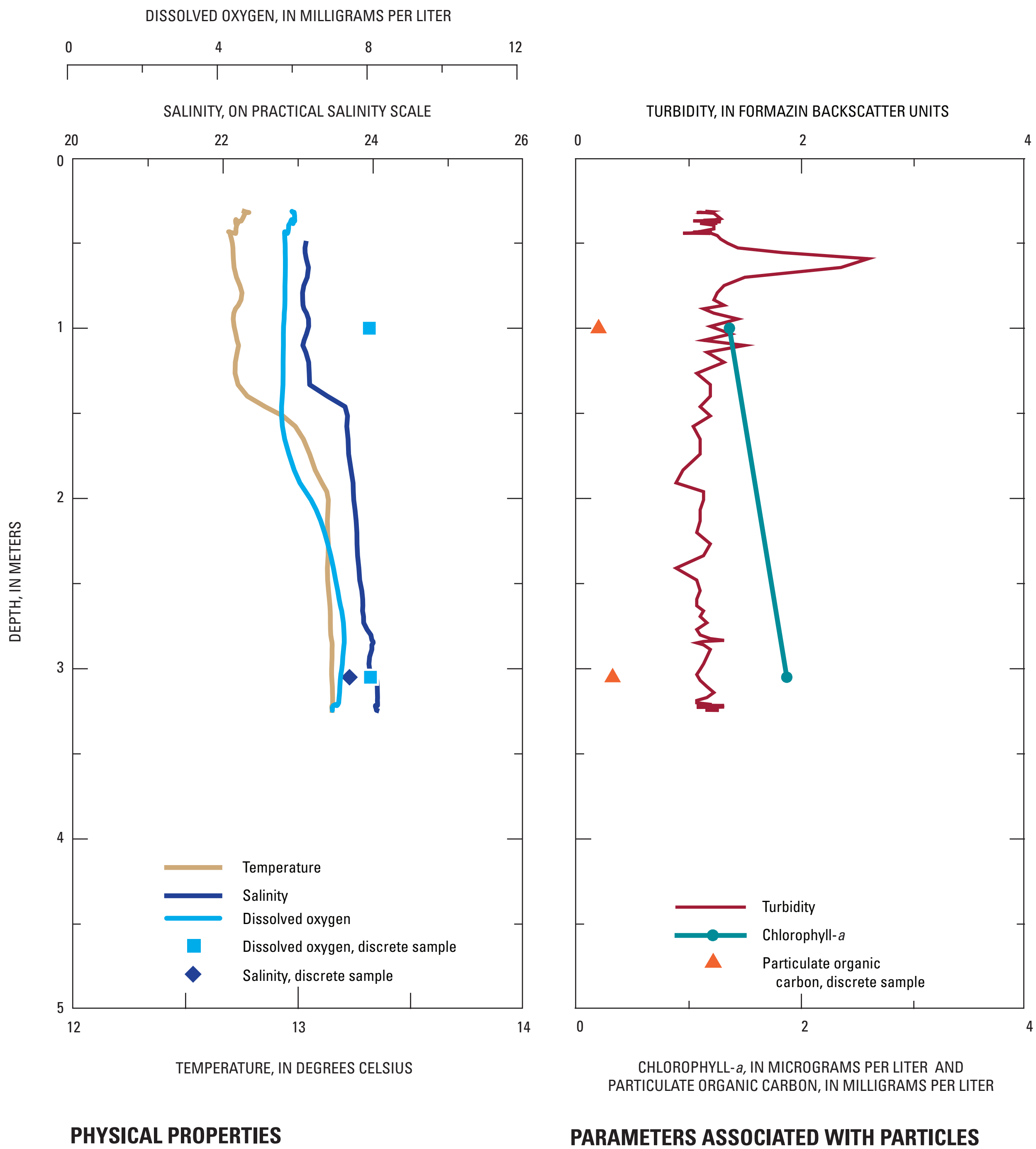


Figure A30. Water properties for site L19, October 2004.



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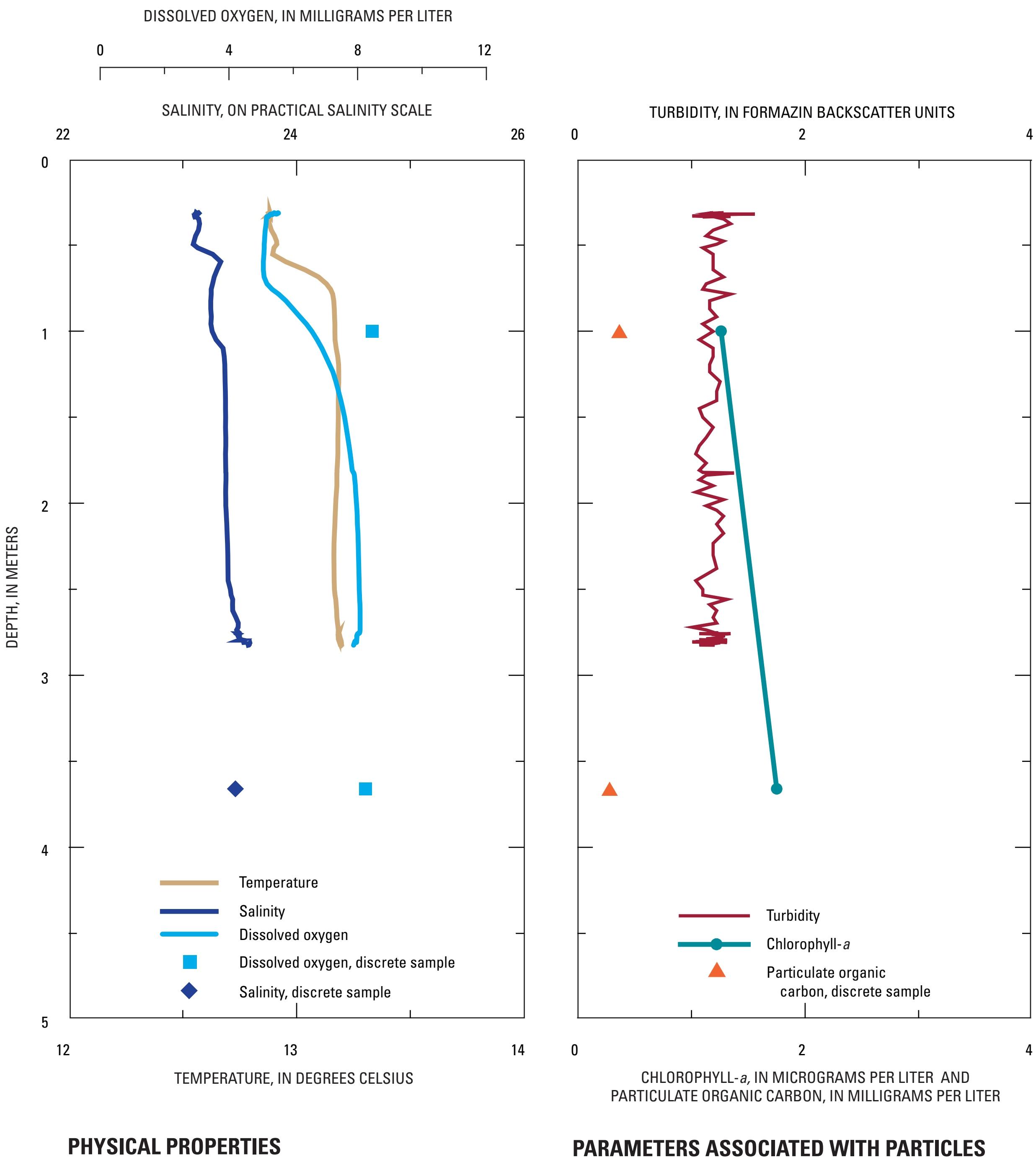

Figure A32. Water properties for site L21, October 2004.

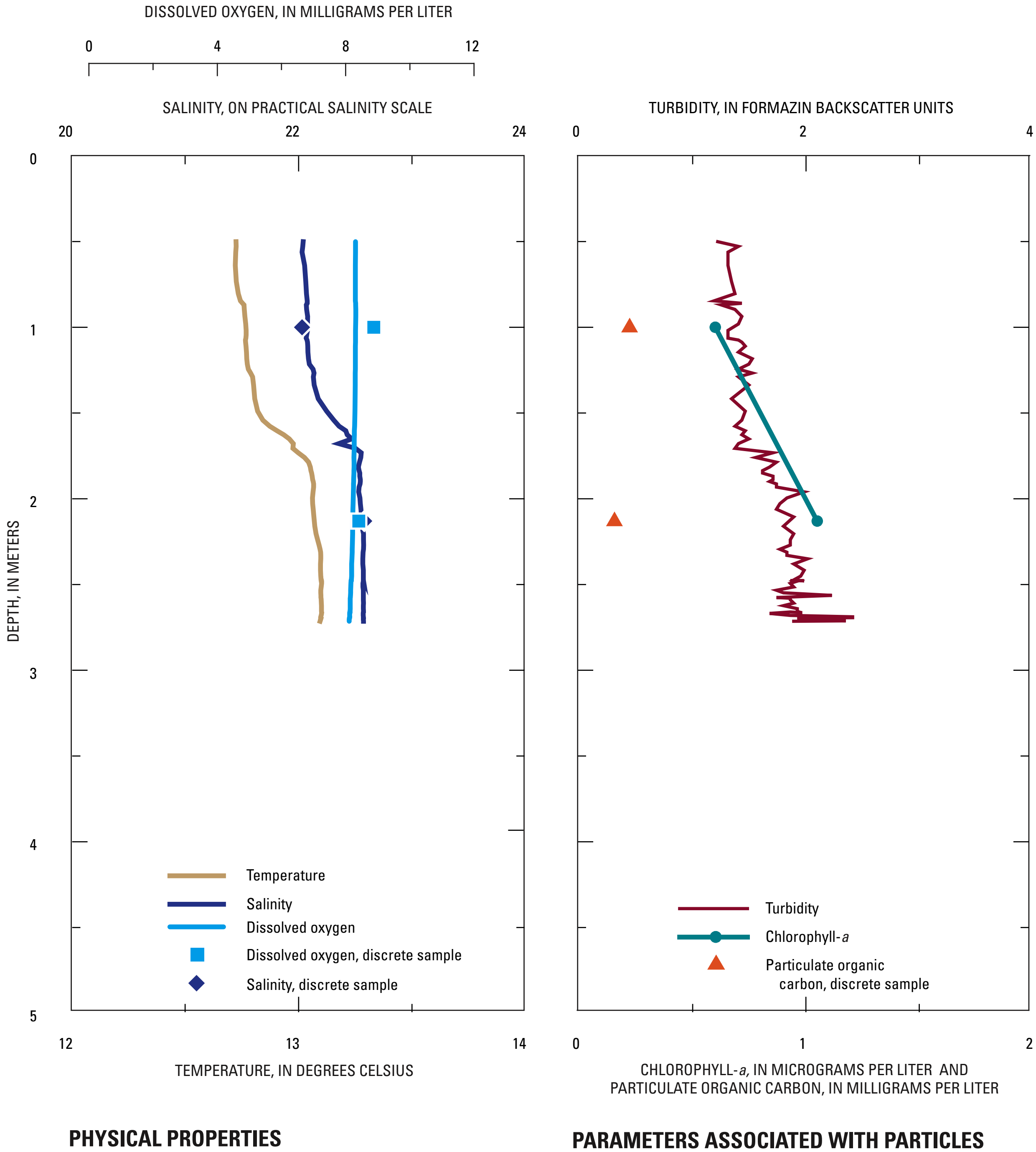

Figure A33. Water properties for site L22, October 2004.

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