



**U.S. Army Corps of Engineers
Walla Walla District**

Two-Dimensional Hydrodynamic, Water Quality, and Fish Exposure Modeling of the Columbia and Snake Rivers.

Part 3: Little Goose Reservoir

FINAL REPORT

February 1999

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Abstract

One of the major goals for the U.S. Army Corps of Engineers Dissolved Gas Abatement Study is to identify measures that could reduce levels of dissolved gas supersaturation in the Columbia and Snake Rivers caused by spillway discharges. Attaining this goal could contribute significantly to meeting water quality criteria and lowering gas bubble trauma in resident and migrating fish in these rivers. To achieve this goal, the Corps of Engineers is studying various operational and structural alternatives using field investigations and computational modeling tools to simulate the transport of dissolved gas in the river system.

Part 3 of the report series summarizes the development and application of a two-dimensional depth-averaged hydrodynamic and water quality model (MASS2) to the Little Goose Reservoir of the Lower Snake River system.

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Two-Dimensional Hydrodynamic, Water Quality, and Fish Exposure Modeling of the Columbia and Snake Rivers. Part 3: Little Goose Reservoir

Under Biological Services Contract DACW68-96-D-0002, Delivery Order No. 8, Battelle, Pacific Northwest Division is developing and applying a two-dimensional hydrodynamic, transport model, and fish exposure model to the Lower Columbia and Snake River systems. This work is an element of the U.S. Army Corps of Engineers Dissolved Gas Abatement Program (DGAS).

Part 3 of the report series describes the application of the model to the Little Goose Pool of the Snake River. The modeled domain encompasses the following region:

- Little Goose Dam, at Snake rivermile (RM) 70
- Lower Granite Dam, at Snake rivermile (RM) 107

1 Application of the Hydrodynamics and Water Quality Models to Little Goose Pool

A two-dimensional-depth averaged hydrodynamics and transport model has been developed and applied to the part of the Snake River that forms the Little Goose Dam pool. The model simulates time-varying distributions of the depth-averaged velocities, water temperature, and total dissolved gas. Further details concerning the model including the governing equations and solutions procedures are provided in Part 1 of the report series (Richmond, Perkins, and Scheibe, 1998).

The section discusses the general aspects of the application of the models to Little Goose Pool. The data used to assign the bathymetry and boundary conditions are described in Appendix A. Summaries of the field data in the calibration and verification simulations are provided in Appendix B and Appendix C.

Hydrodynamics were verified using Spring and Summer 1997 Acoustic Doppler Current Profiler (ADCP) data. Dissolved gas and temperature verification used the Spring and Summer 1997 pool study data.

1.1 Model Grid

The computational grid was generated using the Gridgen 9.1 code. Gridgen 9.1 is software for the generation of 3D, multiple block, structured grids. The code was developed for NASA Ames Research Center (Steinbrenner and Chawner, 1995).

To create the grid, a data file containing discrete geographical locations that outline the river shoreline was imported to Gridgen. In Gridgen, curves containing the data points were created and joined to enclose 2-dimensional flow regions. Grid spacing was set in

each flow region and the grids were smoothed using the Gridgen elliptic solver. The elliptic solver was used to minimize grid twist and skew. The flow regions were then joined end to end in the downstream direction to make up the entire flow domain and the entire 2-dimensional grid was written to file. Once the grid was created bottom elevations in each cell were assigned using the bathymetric data and procedure described in Appendix A.

The model grid for Little Goose pool is shown in Figure 1. Larger scale maps of the model grid near the Lower Granite dam and Little Goose dam boundaries are shown in Figure 2. Note that several small islands were not included in the model and these were replaced with bottom elevation approximately 2 ft below the low water surface elevation (the water is about 2 ft deep where the islands are).

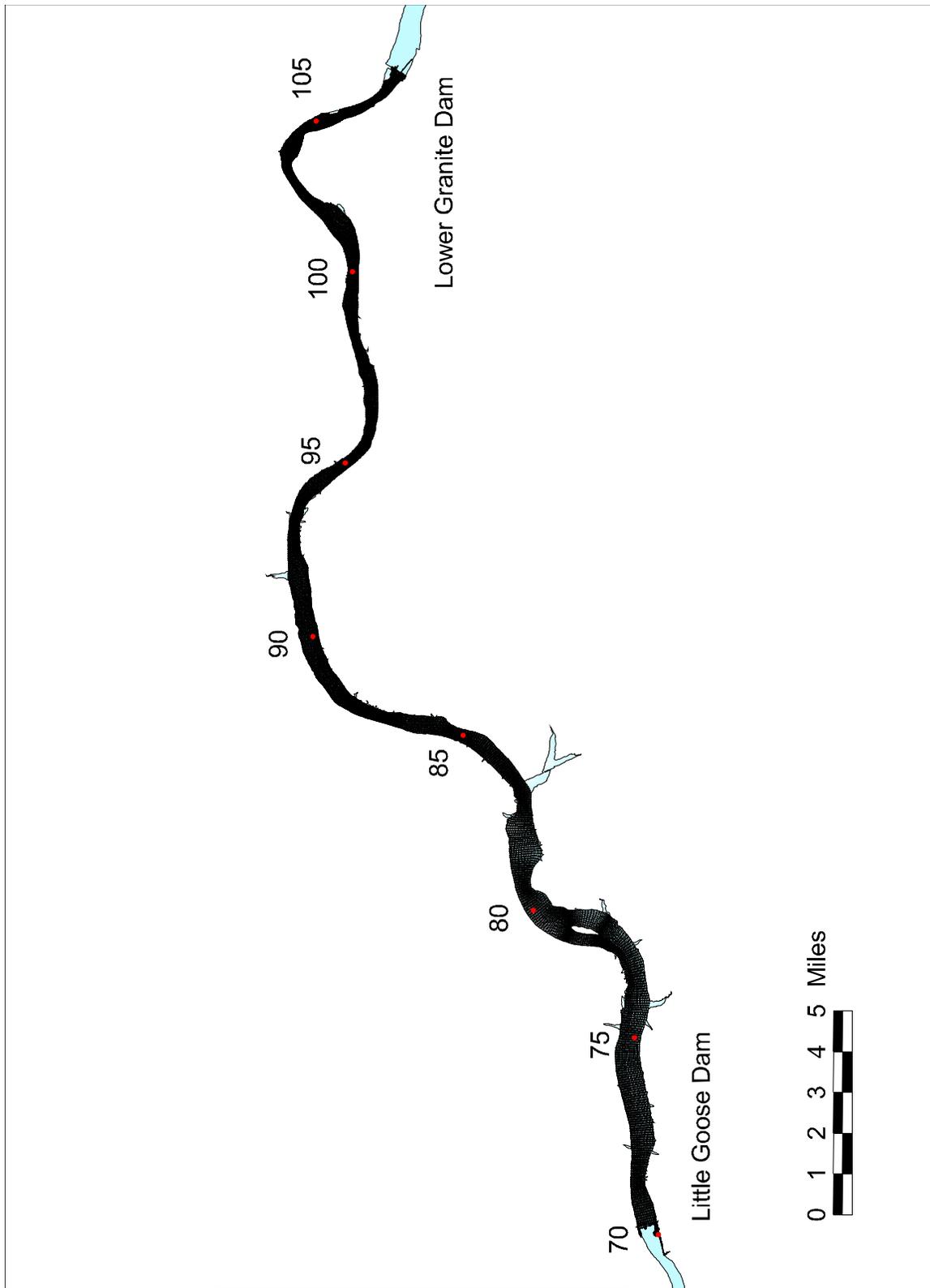


Figure 1. Model grid for Little Goose pool.

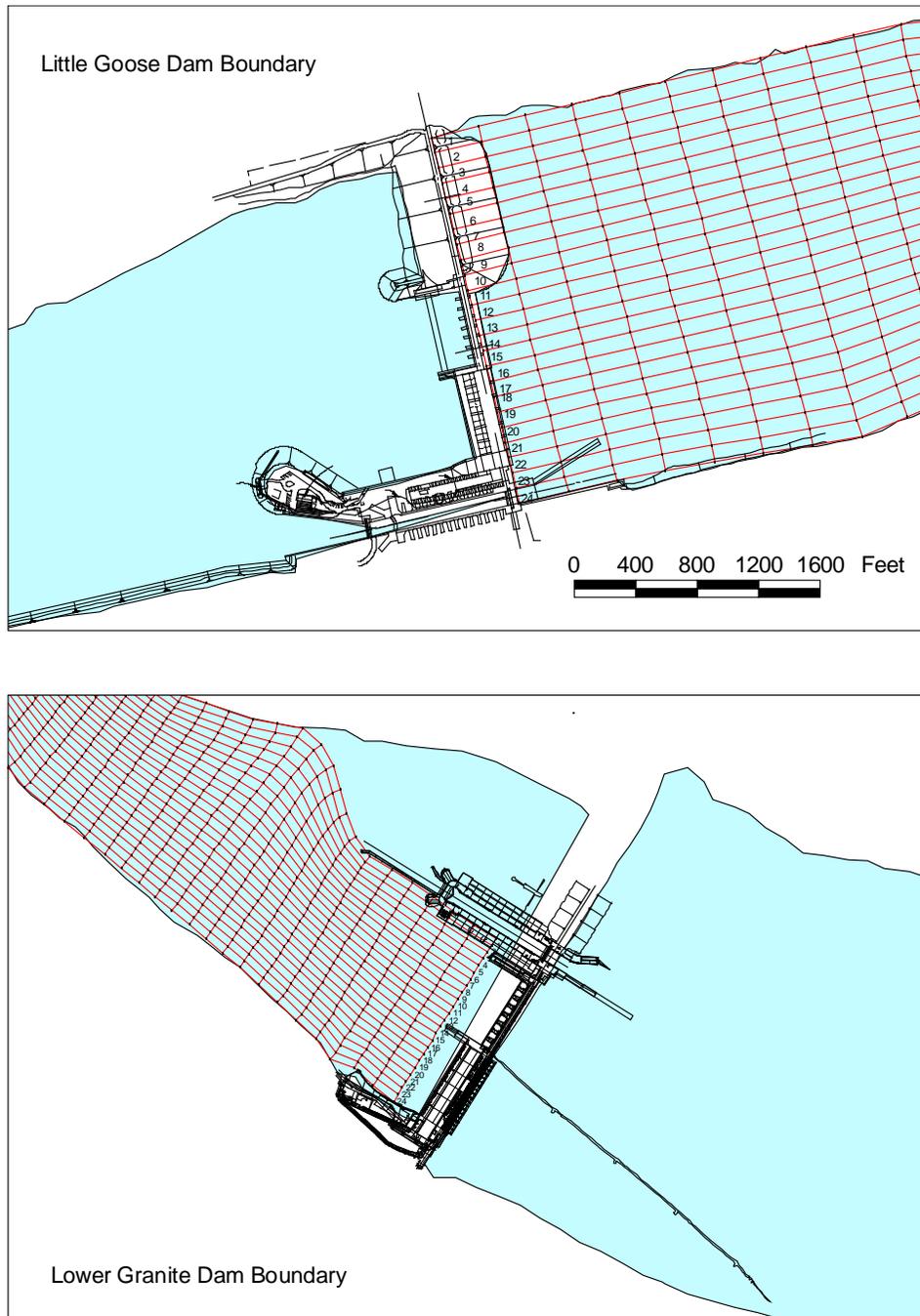


Figure 2. Model grid boundaries near Little Goose and Lower Granite dams.

1.2 Boundary Conditions

1.2.1 Lower Granite Dam Sourcing Function

Spillway TDG concentrations were estimated using the Lower Granite dam TDG sourcing function presented by Schnieder and Wilhelms (1997):

$$S_s = 138.0 - 38.5 \exp(-1.00 \times 10^{-4} q_s) \quad (1)$$

where

S_s = TDG saturation of spillway flow, percent; and

q_s = spillway flow per bay, cfs.

Lower Granite dam has 8 spill bays. When model boundary conditions were prepared, it was assumed that all spill bays were in operation. Forebay temperatures and barometric pressures were used to compute concentration from the saturation estimated using equation (1).

1.3 Hydrodynamics Calibration and Verification

The model hydrodynamics were calibrated primarily using the Lower Granite dam tailwater elevation gage. ADCP velocity measurements were available for both Little Goose pool study periods. Due to instrumentation problems the coordinates of the ADCP data were subject to uncertain errors. Therefore, at this time, use of the ADCP data was restricted to qualitative comparisons with the model simulations.

In all simulations in this report a time step of 50 seconds was used. The simulations also used constant longitudinal and lateral turbulent eddy viscosities of 0.2 ft²/s.

1.3.1 Lower Granite Tailwater

The first step in the calibration procedure was to select a spatially uniform value of the Manning roughness coefficient that would yield computed water surface elevations in satisfactory agreement with the Lower Granite dam tailwater gage. The Spring 1997 pool study period was selected for calibration. Simulations were performed using Manning n values in the range of 0.021 to 0.029. Figure 3 compares the model simulation and measured tailwater elevation for a n-value of 0.029 which was chosen as the final parameter value to be used in the remainder of the Little Goose Pool simulations.

The selected n-value was verified for the Summer 1997 study period. The verification results are shown in Figure 4.

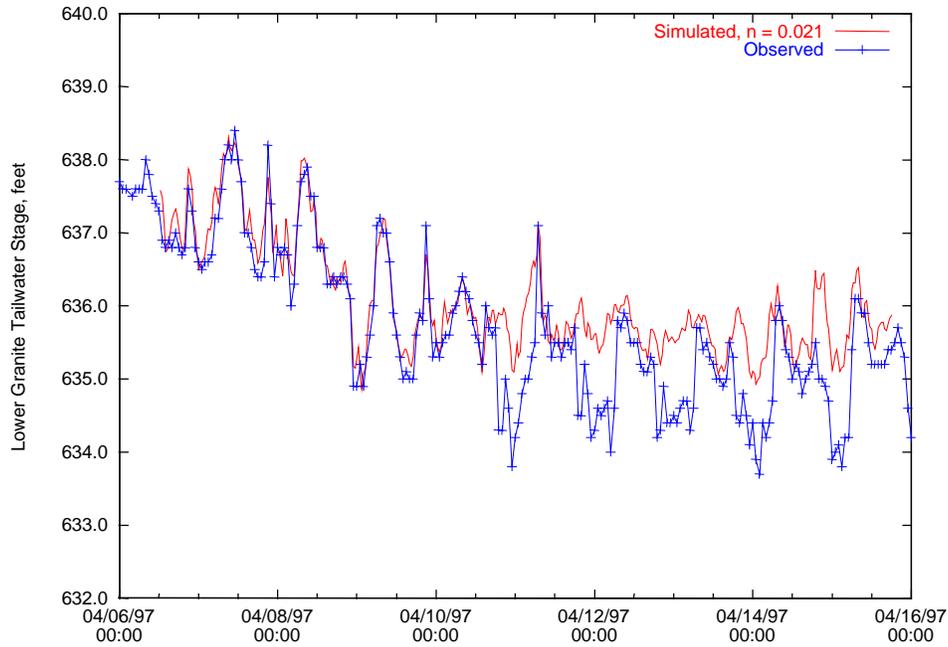


Figure 3. Comparison of simulated (Manning’s $n = 0.021$) and measured water surface elevation at the Lower Granite dam tailwater gage during the Spring 1997 study period

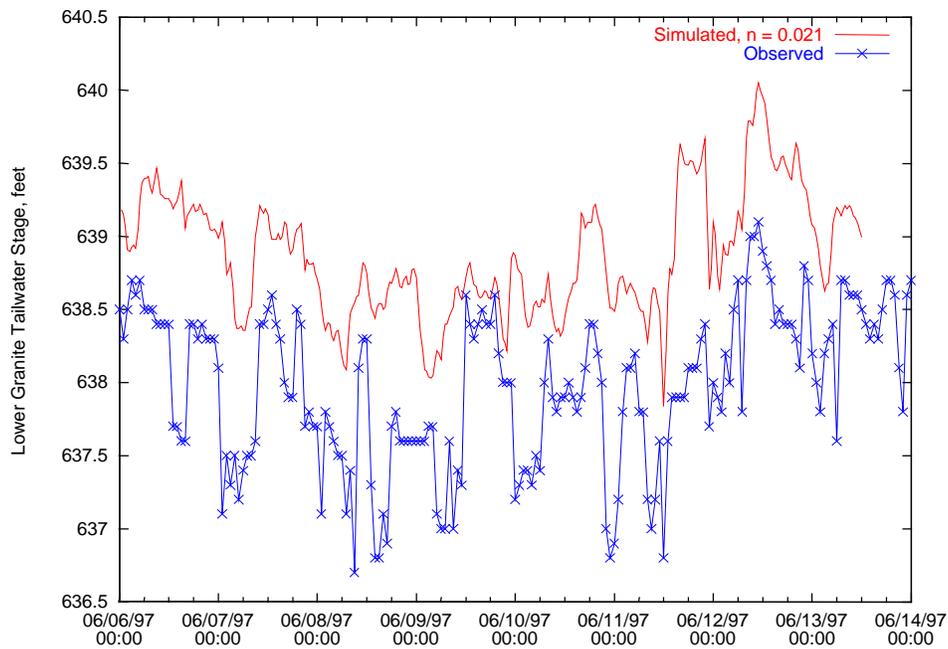


Figure 4. Comparison of simulated (Manning’s $n = 0.021$) and measured water surface elevation at the Lower Granite dam tailwater gage during the Summer 1997 study period

1.3.2 Spring 1997 ADCP Data

Once the Manning n-value was selected, the model was run for the operational conditions that existed when the Spring 1997 ADCP measurements were performed. The Manning n value was not altered from the value of 0.021 selected from the tailwater calibration. Simulated velocities are compared to the depth-averaged ADCP data in Figure 5 through Figure 29.

Two transects are not shown because of obvious data location problems. These transects are labeled “04-08-1997 14:51” and “04-08-1997 14:58” and are shown in Appendix A (Section A.2.2).

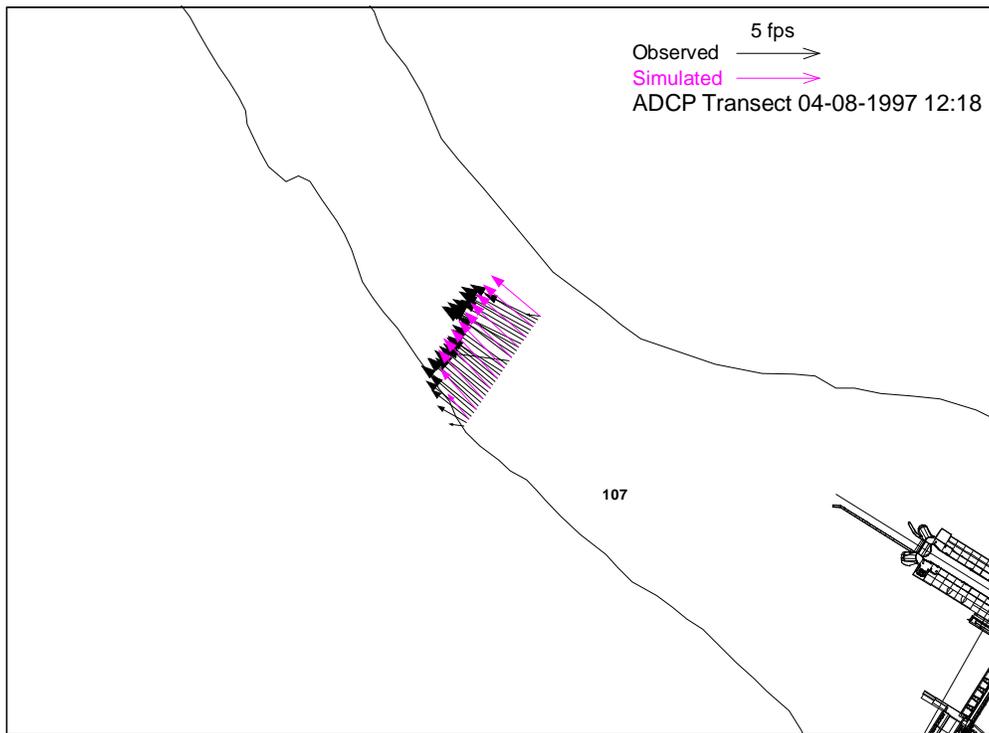


Figure 5. Simulated and observed depth-averaged velocities near Lower Granite dam on April 8, 1997.

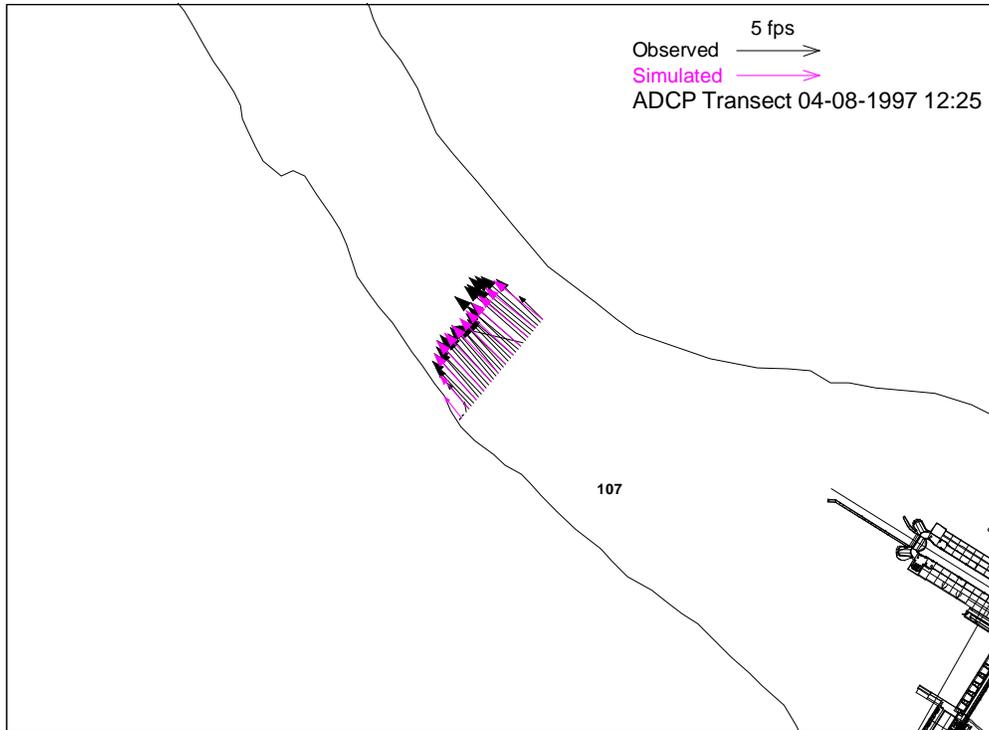


Figure 6. Simulated and observed depth-averaged velocities near Lower Granite dam on April 8, 1997.

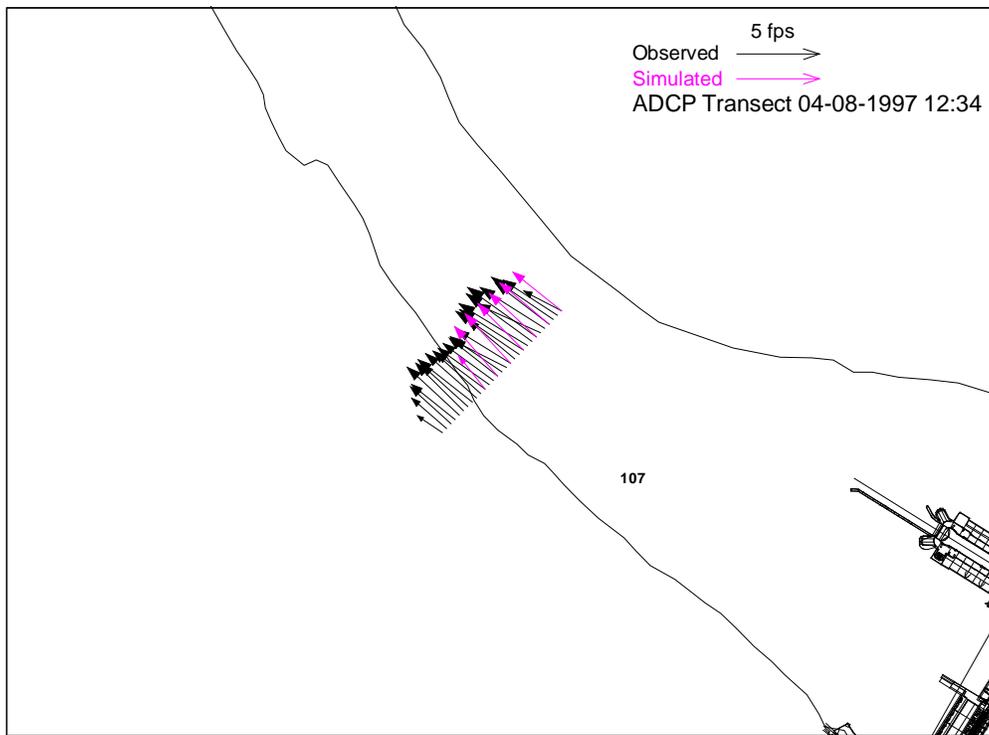


Figure 7. Simulated and observed depth-averaged velocities near Lower Granite dam on April 8, 1997.

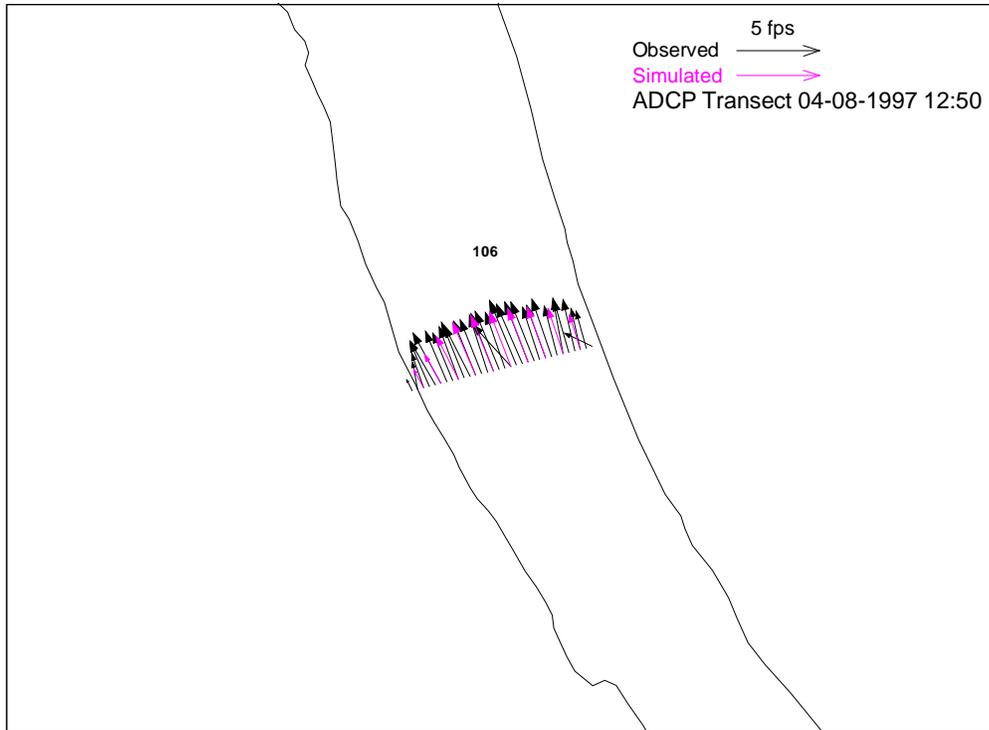


Figure 8. Simulated and observed depth-averaged velocities near river mile 106 on April 8, 1997.

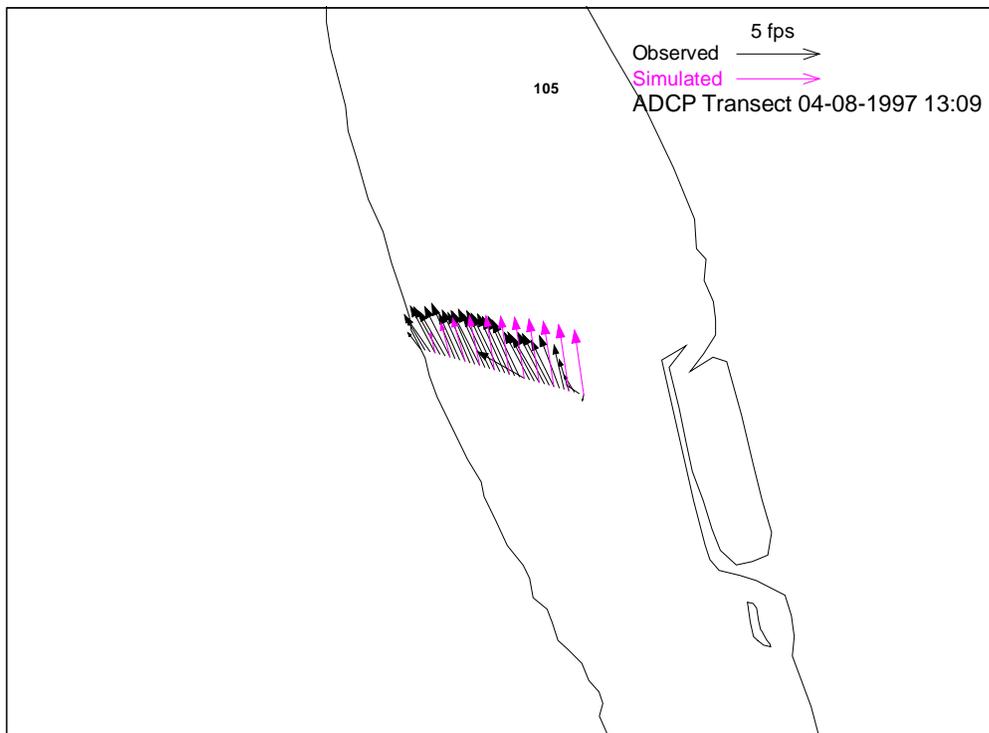


Figure 9. Simulated and observed depth-averaged velocities near river mile 105 on April 8, 1997.

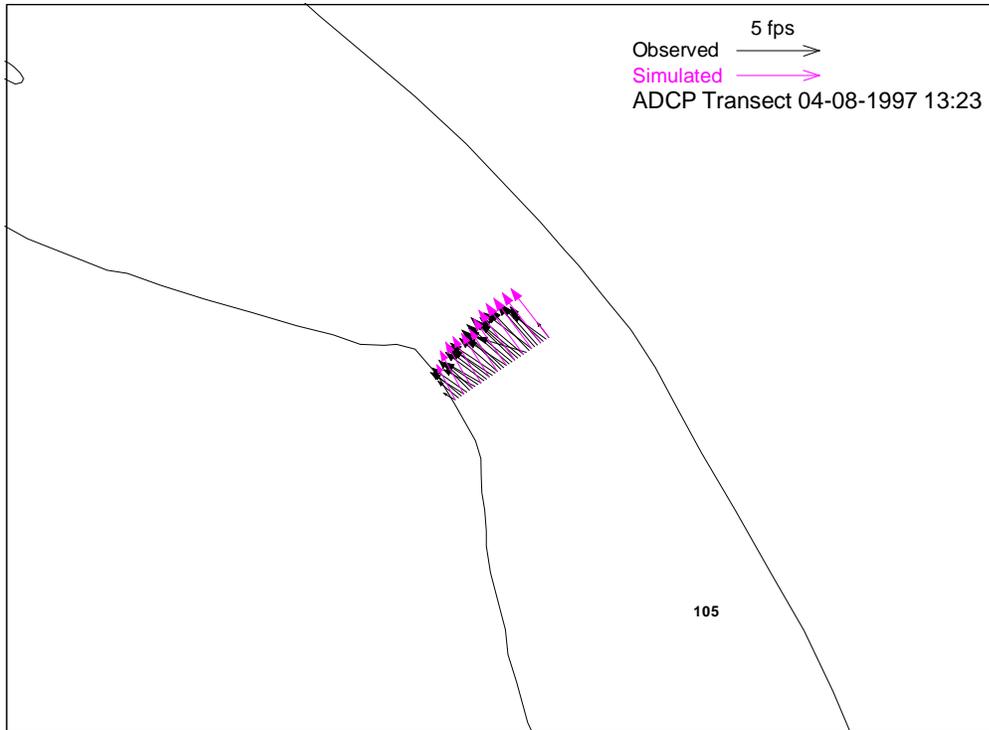


Figure 10. Simulated and observed depth-averaged velocities near river mile 105 on April 8, 1997.

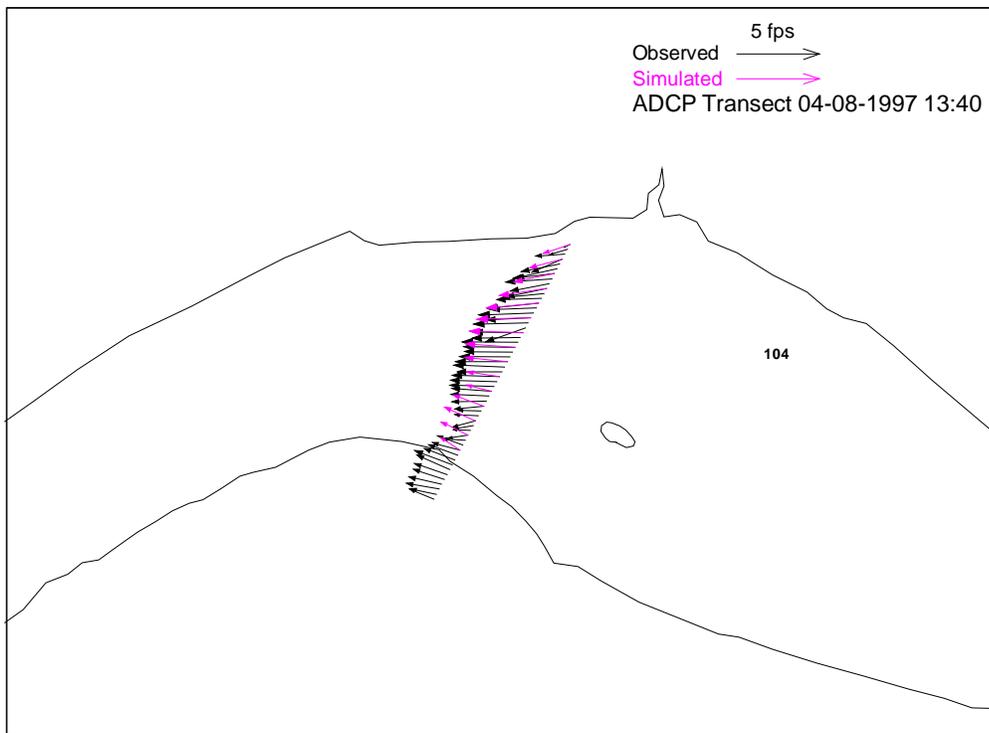


Figure 11. Simulated and observed depth-averaged velocities near river mile 104 on April 8, 1997.

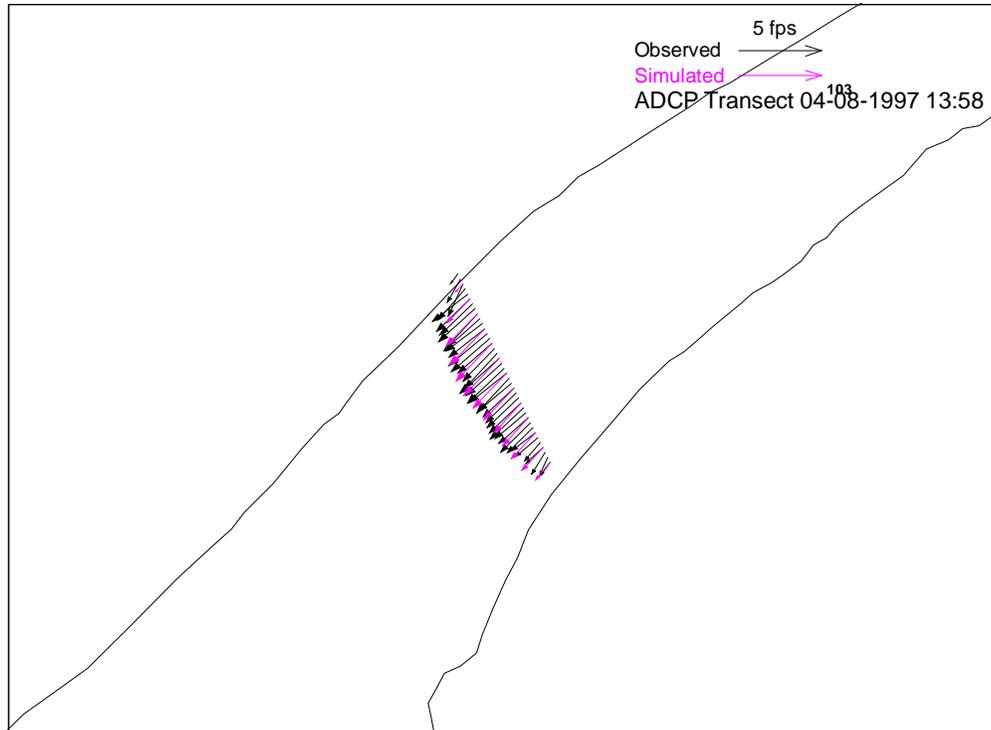


Figure 12. Simulated and observed depth-averaged velocities near river mile 103 on April 8, 1997.

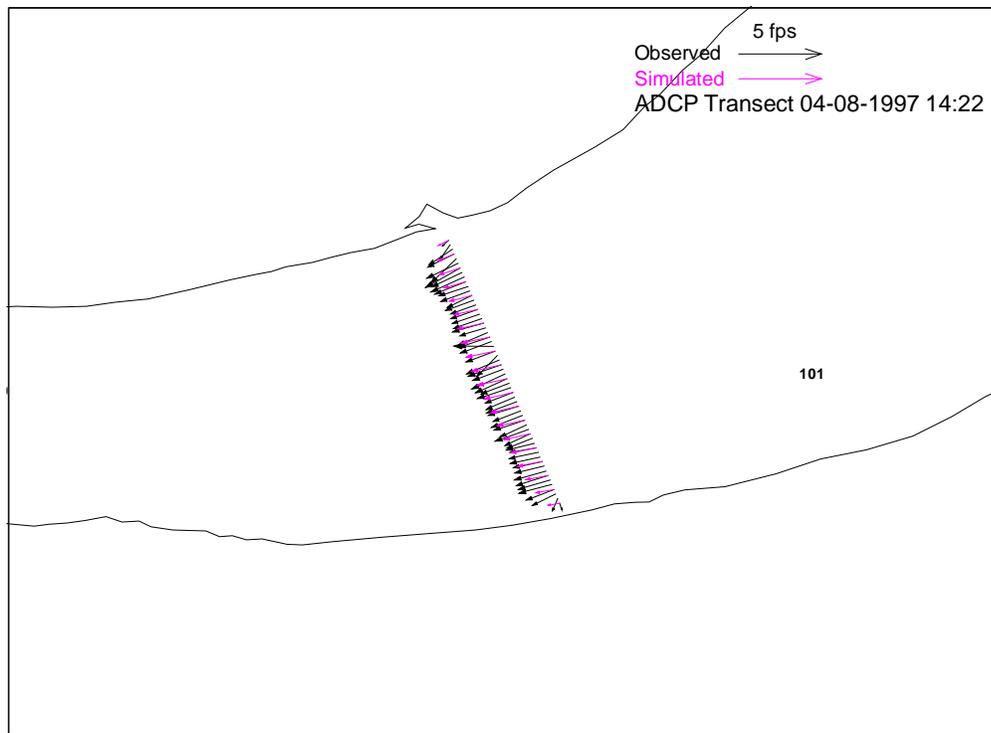


Figure 13. Simulated and observed depth-averaged velocities near river mile 101 on April 8, 1997.

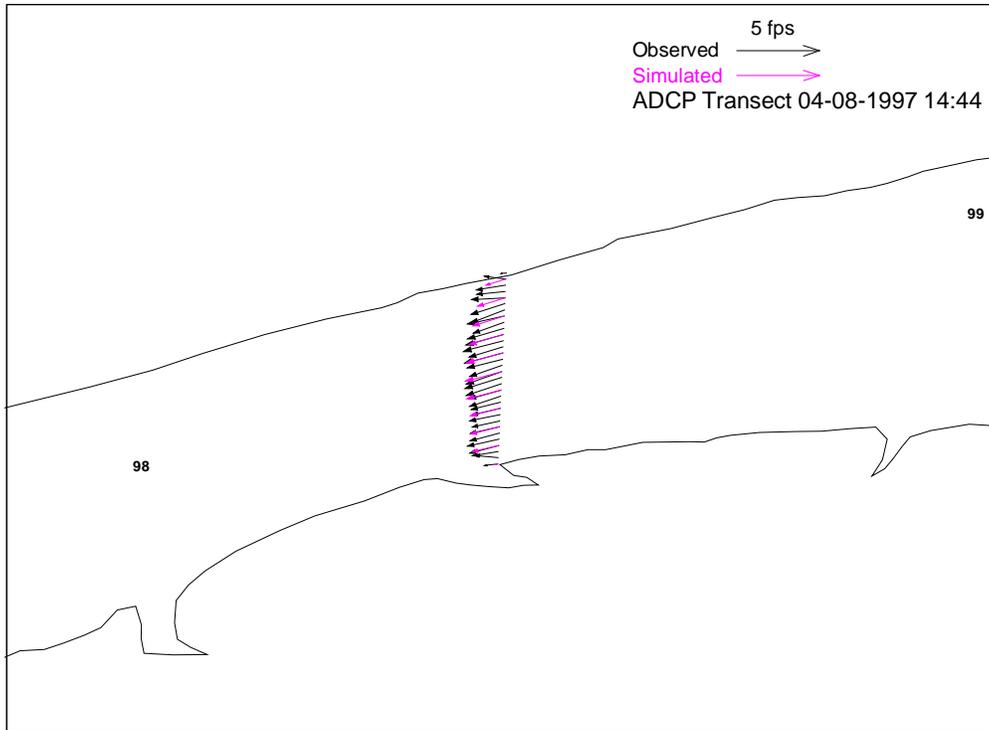


Figure 14. Simulated and observed depth-averaged velocities near river mile 98 on April 8, 1997.

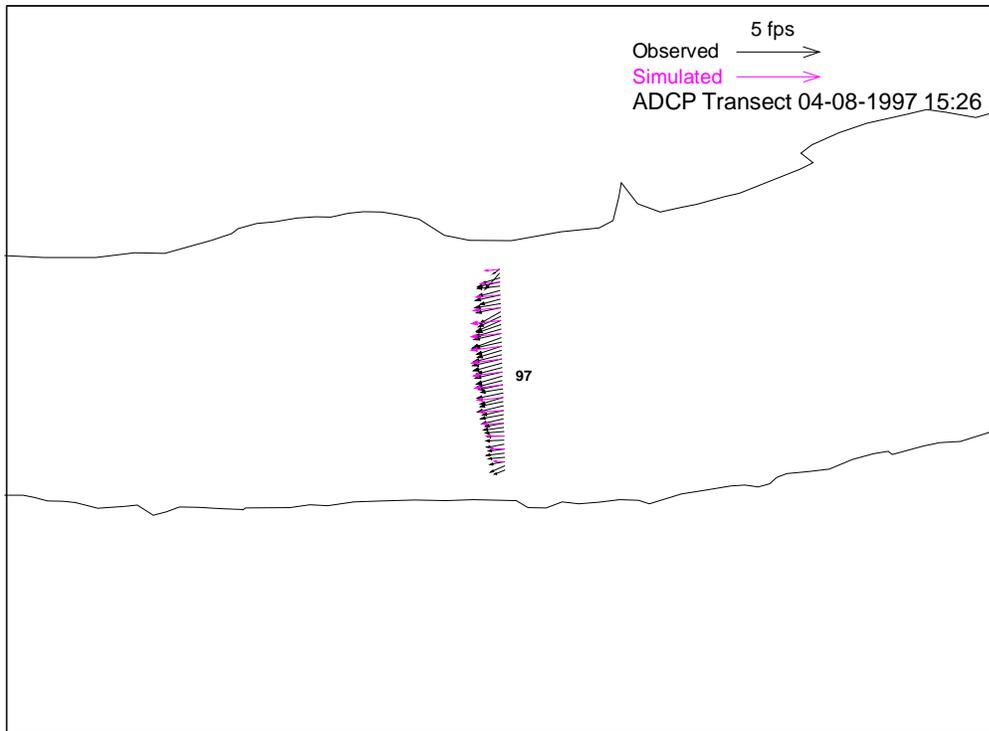


Figure 15. Simulated and observed depth-averaged velocities near river mile 97 on April 8, 1997.

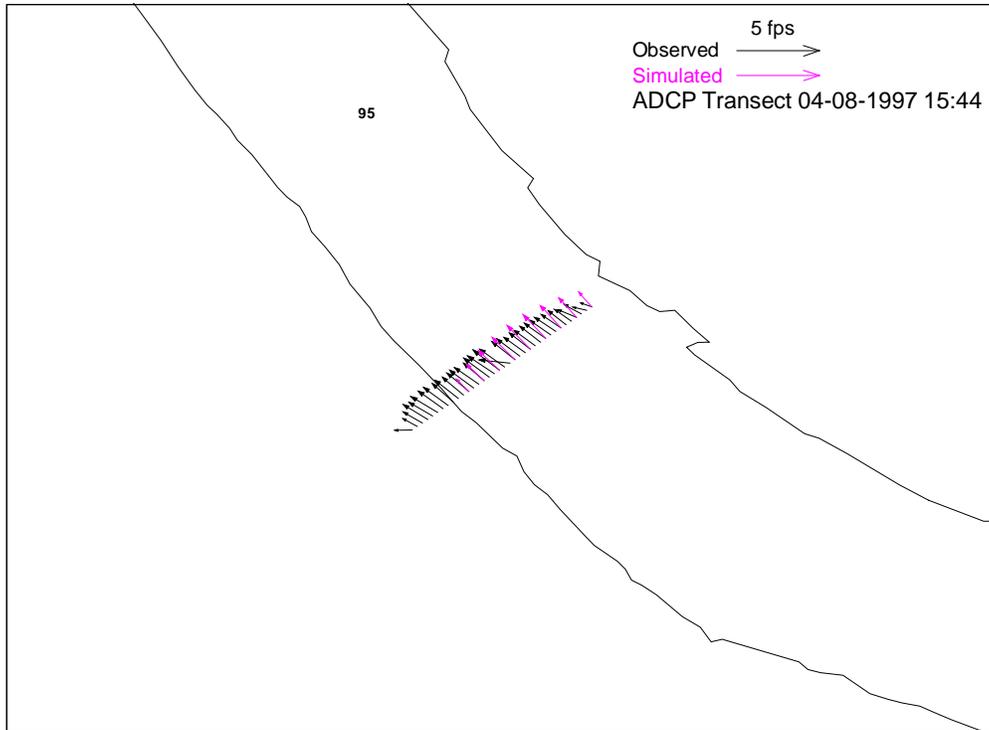


Figure 16. Simulated and observed depth-averaged velocities near river mile 95 on April 8, 1997.

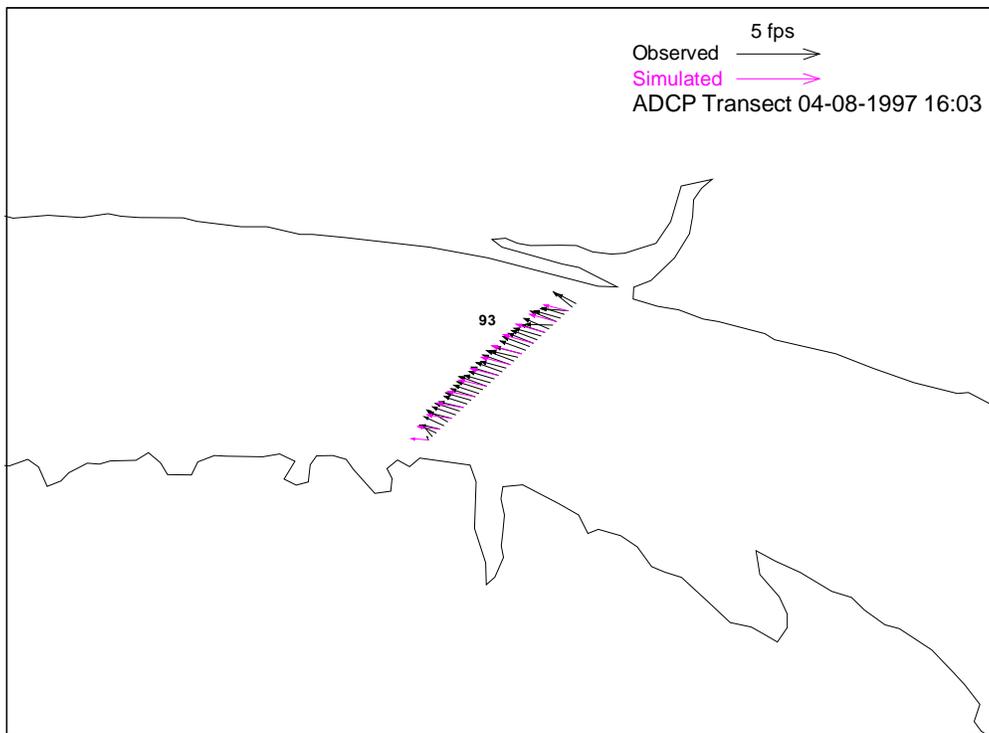


Figure 17. Simulated and observed depth-averaged velocities near river mile 93 on April 8, 1997.

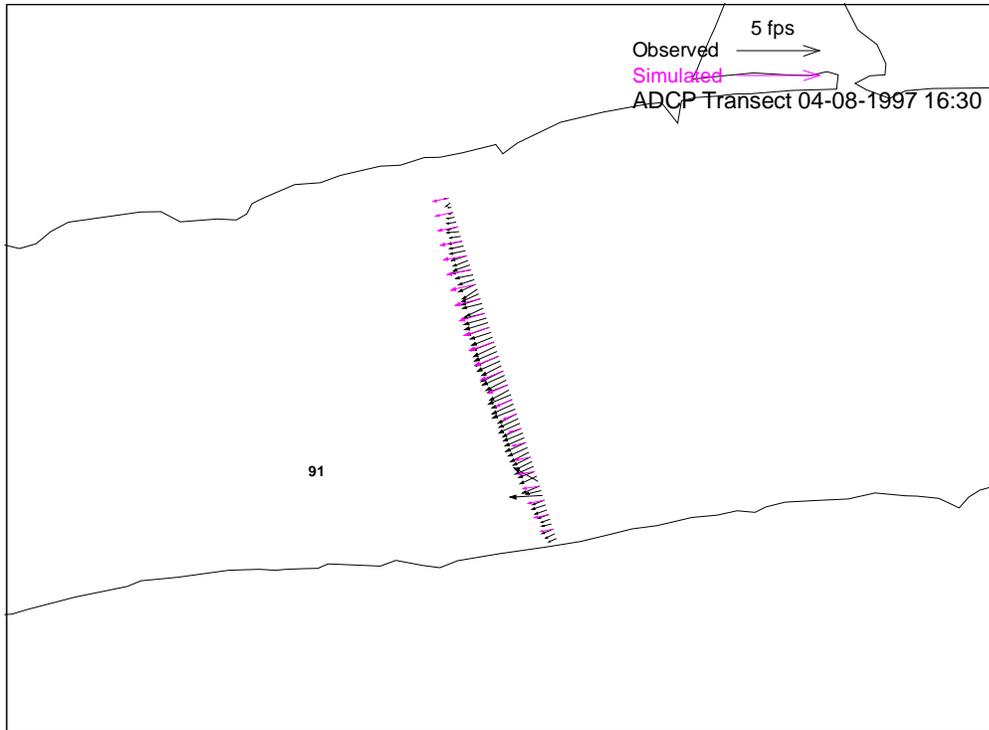


Figure 18. Simulated and observed depth-averaged velocities near river mile 91 on April 8, 1997.

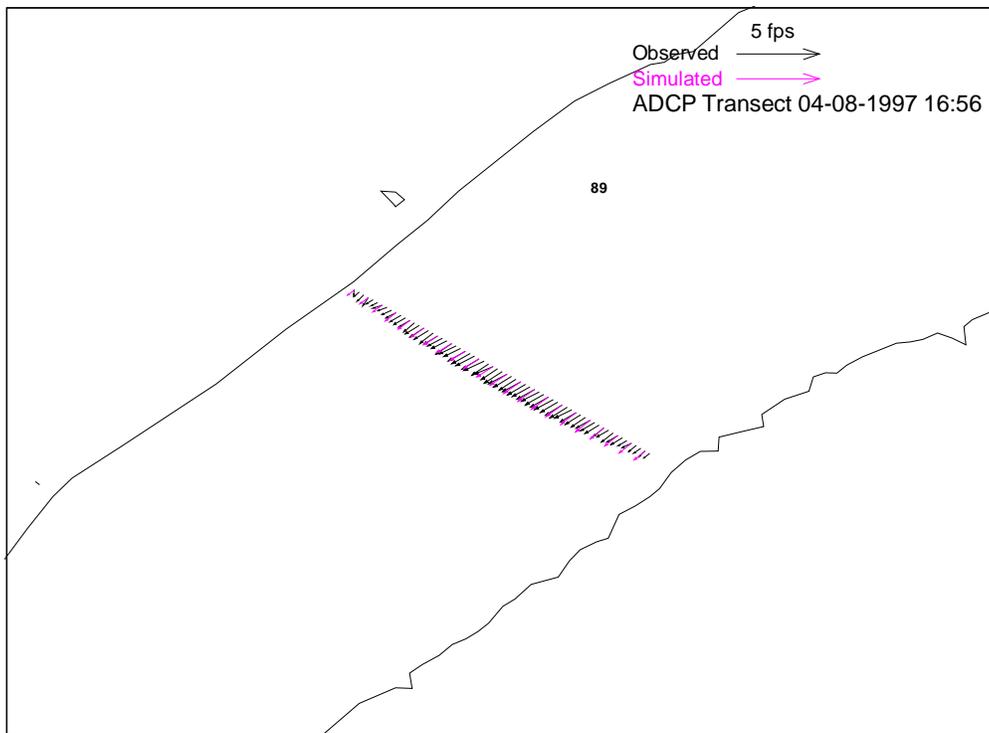


Figure 19. Simulated and observed depth-averaged velocities near river mile 89 on April 8, 1997.

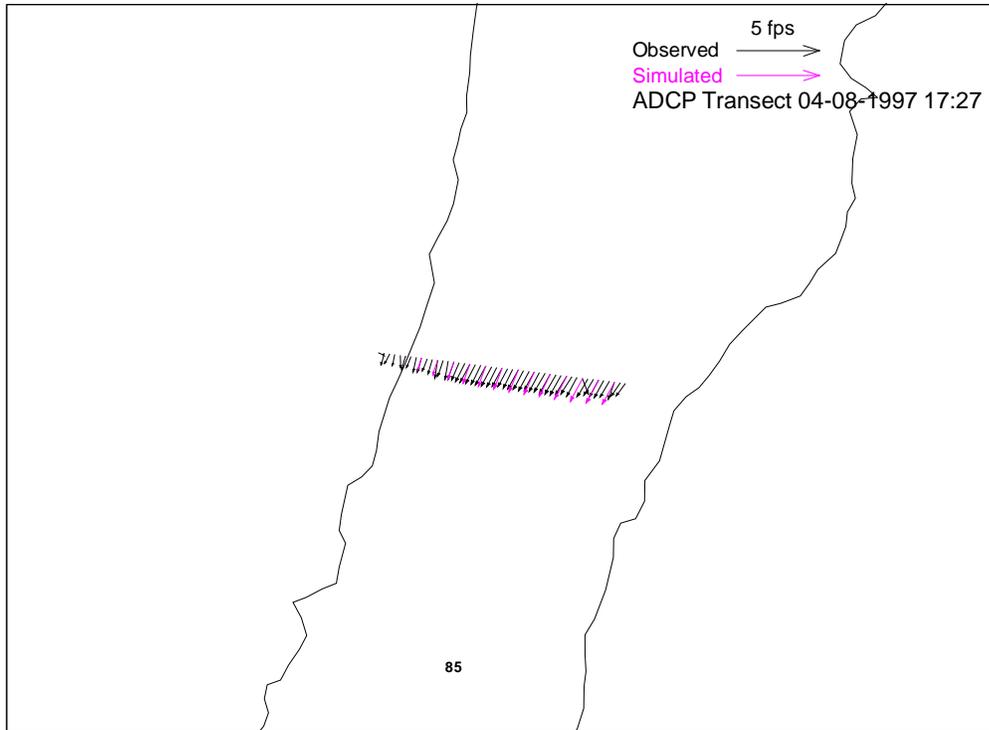


Figure 20. Simulated and observed depth-averaged velocities near river mile 85 on April 8, 1997.

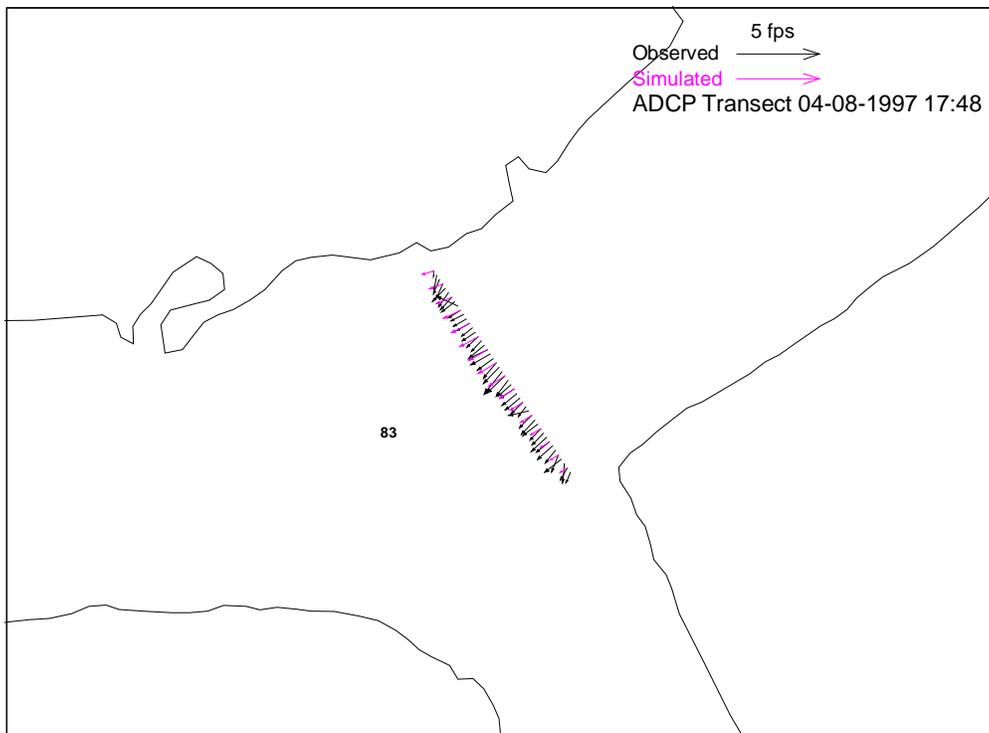


Figure 21. Simulated and observed depth-averaged velocities near river mile 83 on April 8, 1997.

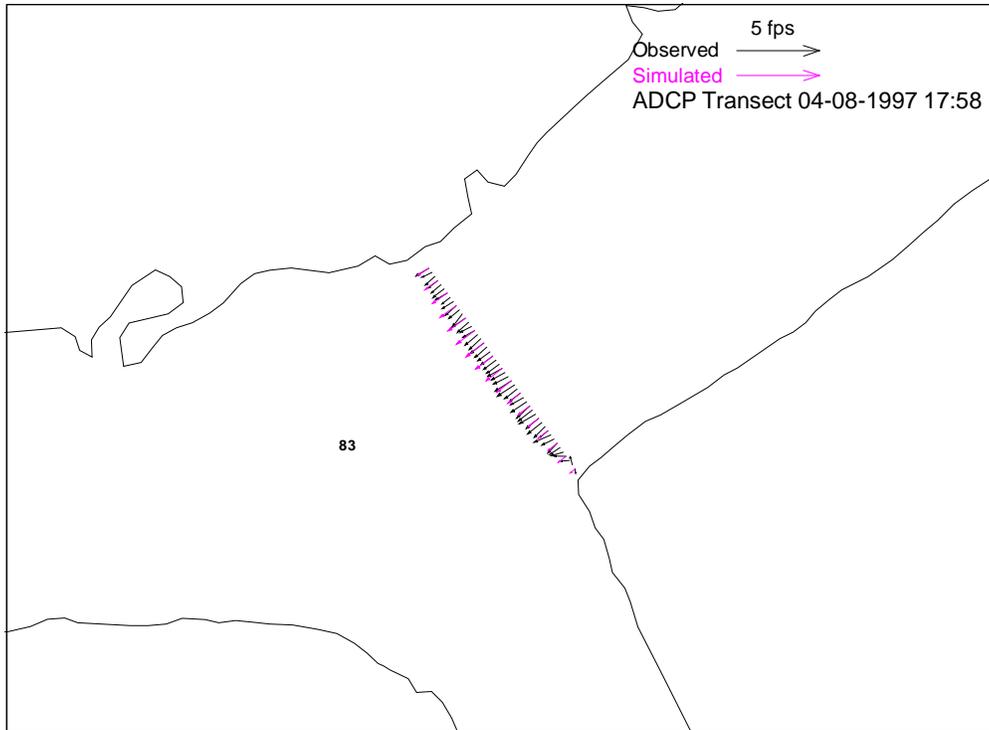


Figure 22. Simulated and observed depth-averaged velocities near river mile 83 on April 8, 1997.

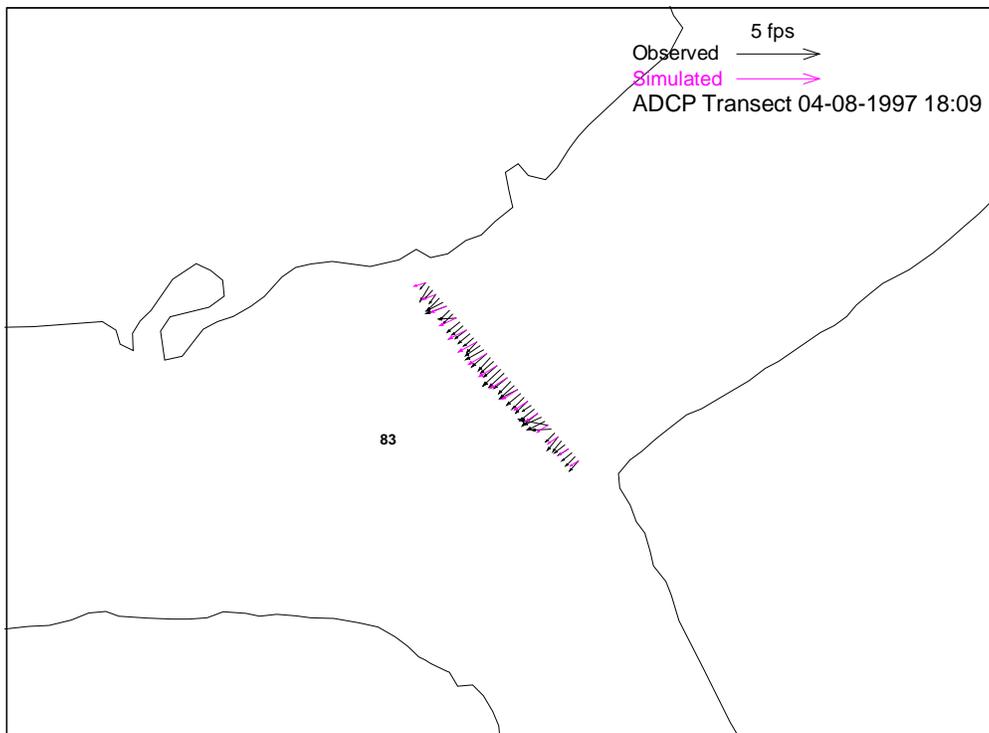


Figure 23. Simulated and observed depth-averaged velocities near river mile 83 on April 8, 1997.



Figure 24. Simulated and observed depth-averaged velocities near river mile 81 on April 9, 1997.

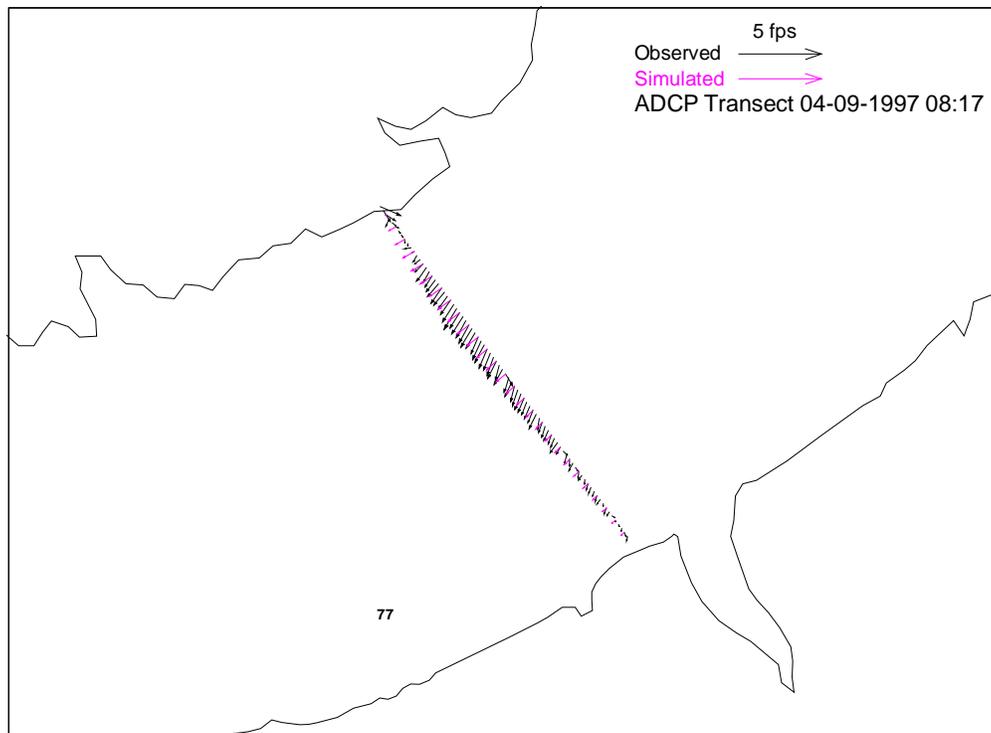


Figure 25. Simulated and observed depth-averaged velocities near river mile 77 on April 9, 1997.

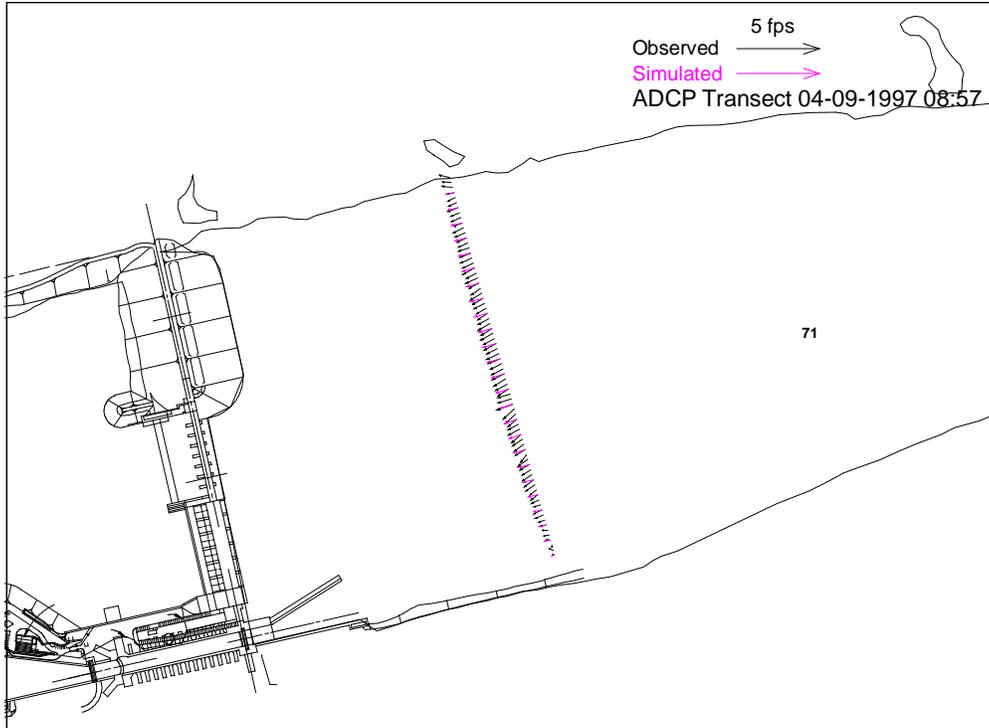


Figure 26. Simulated and observed depth-averaged velocities near Little Goose dam on April 9, 1997.

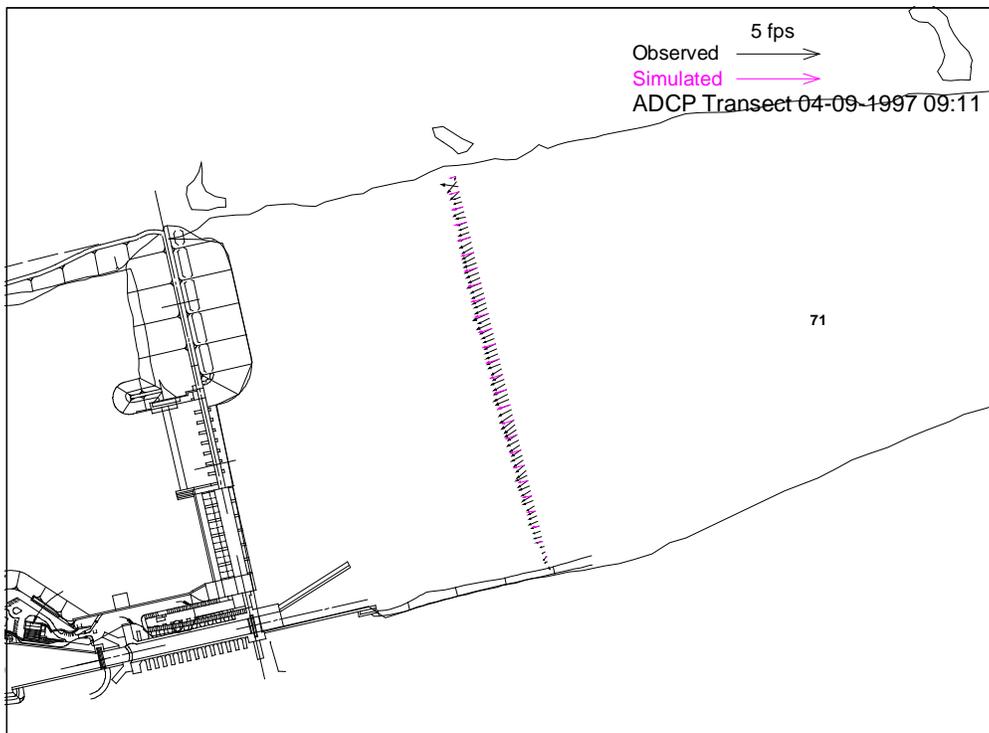


Figure 27. Simulated and observed depth-averaged velocities near Little Goose dam on April 9, 1997.

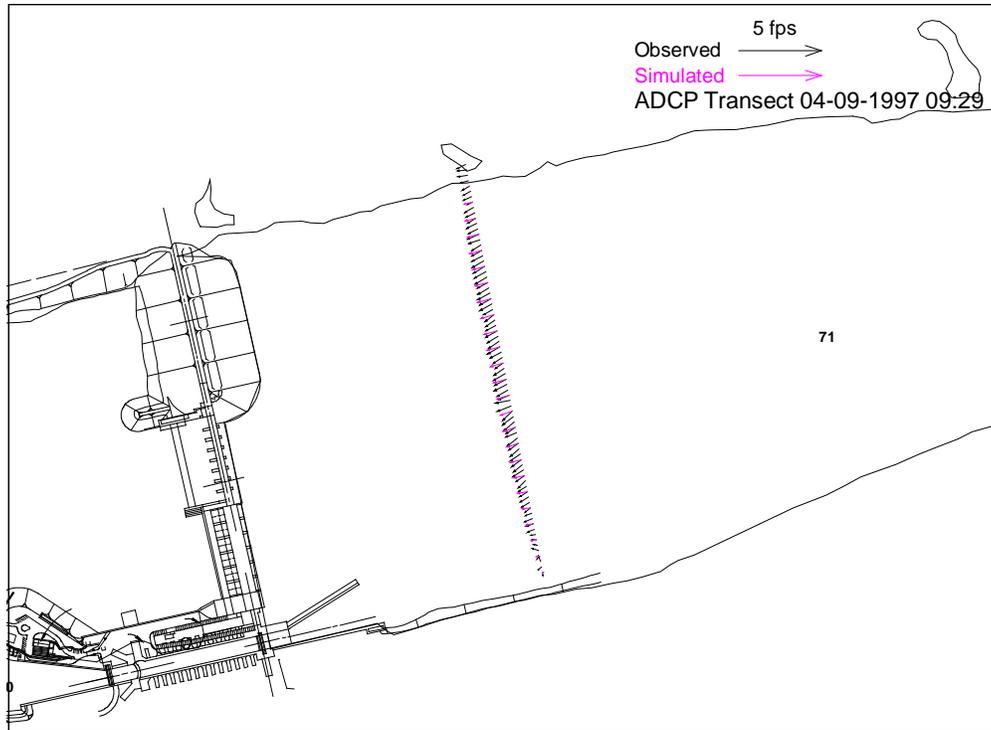


Figure 28. Simulated and observed depth-averaged velocities near Little Goose dam on April 9, 1997.

1.3.3 Summer 1997 ADCP Data

As was the case for the Spring 1997 ADCP case, the model was run using operational conditions that existed when the Summer 1997 ADCP measurements were performed. Again, the Manning n value was not altered from the value of 0.021 selected from the tailwater calibration. Simulated velocities are compared to the depth-averaged ADCP data in Figure 28 through Figure 49.

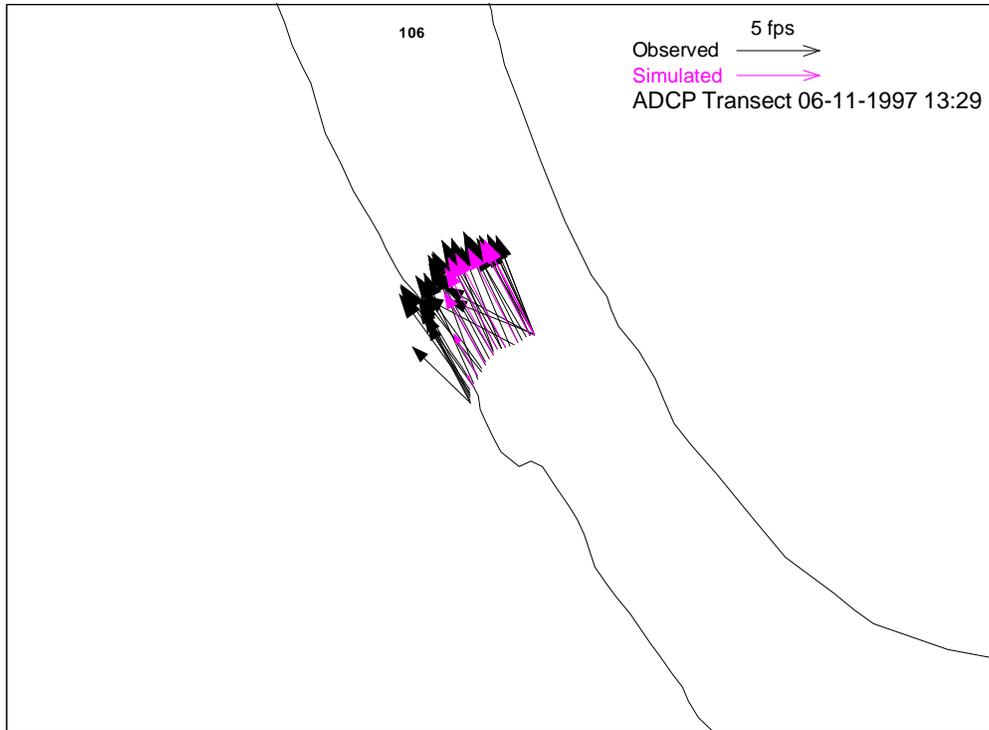


Figure 29. Simulated and observed depth-averaged velocities near river mile 106 on June 12, 1997.

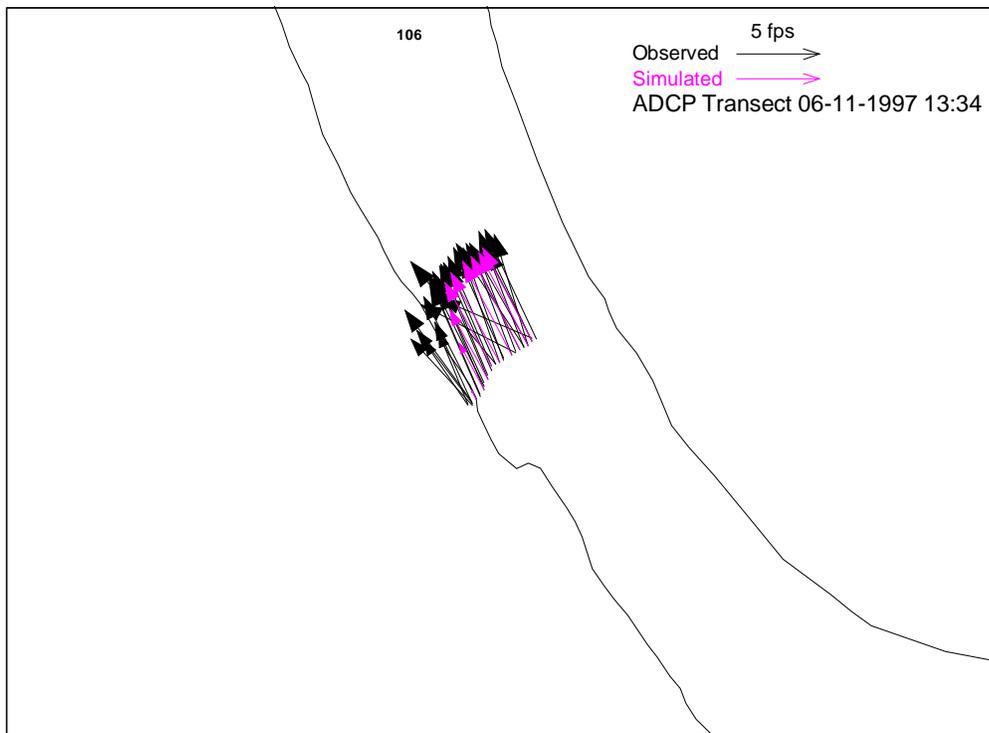


Figure 30. Simulated and observed depth-averaged velocities near river mile 106 on June 12, 1997.

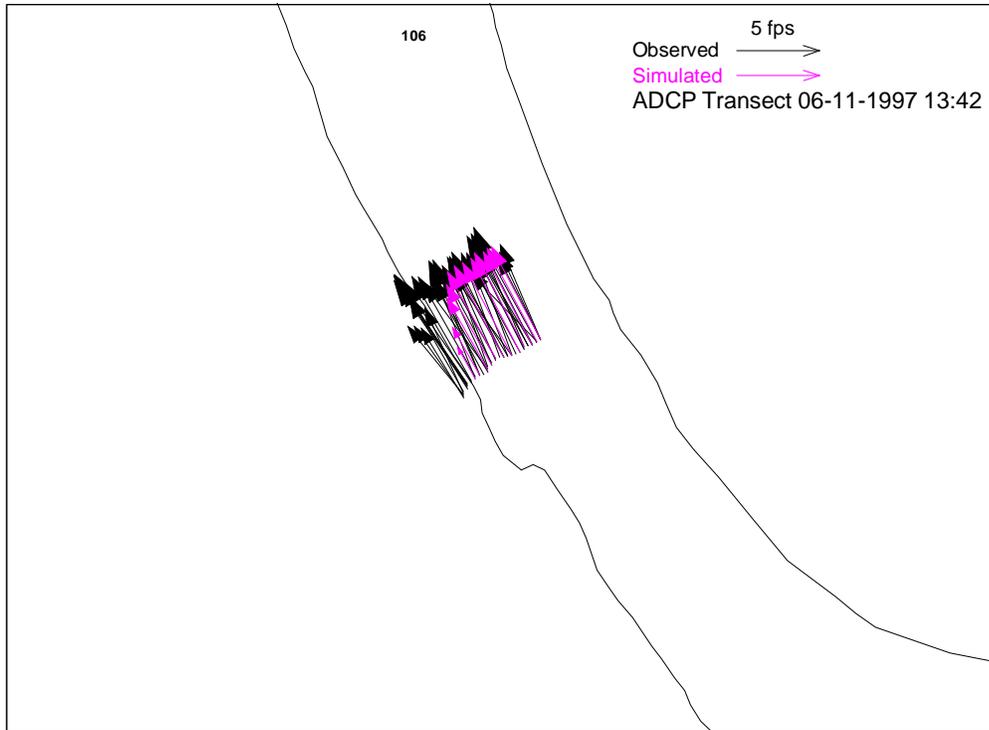


Figure 31. Simulated and observed depth-averaged velocities near river mile 106 on June 11, 1997.

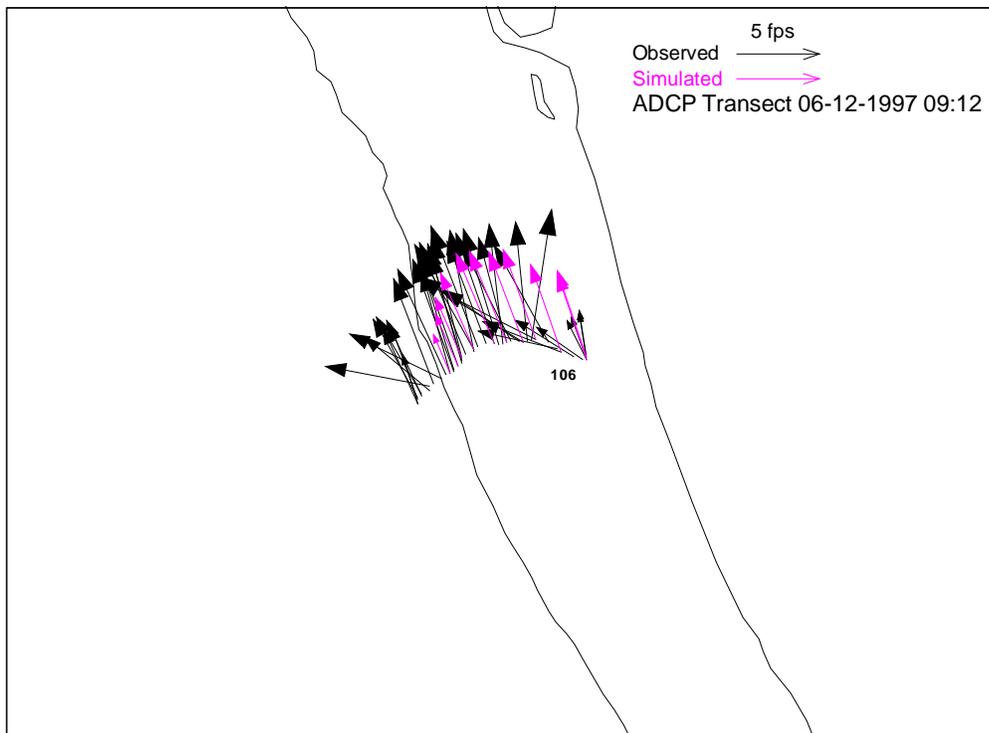


Figure 32. Simulated and observed depth-averaged velocities near river mile 106 on June 12, 1997.

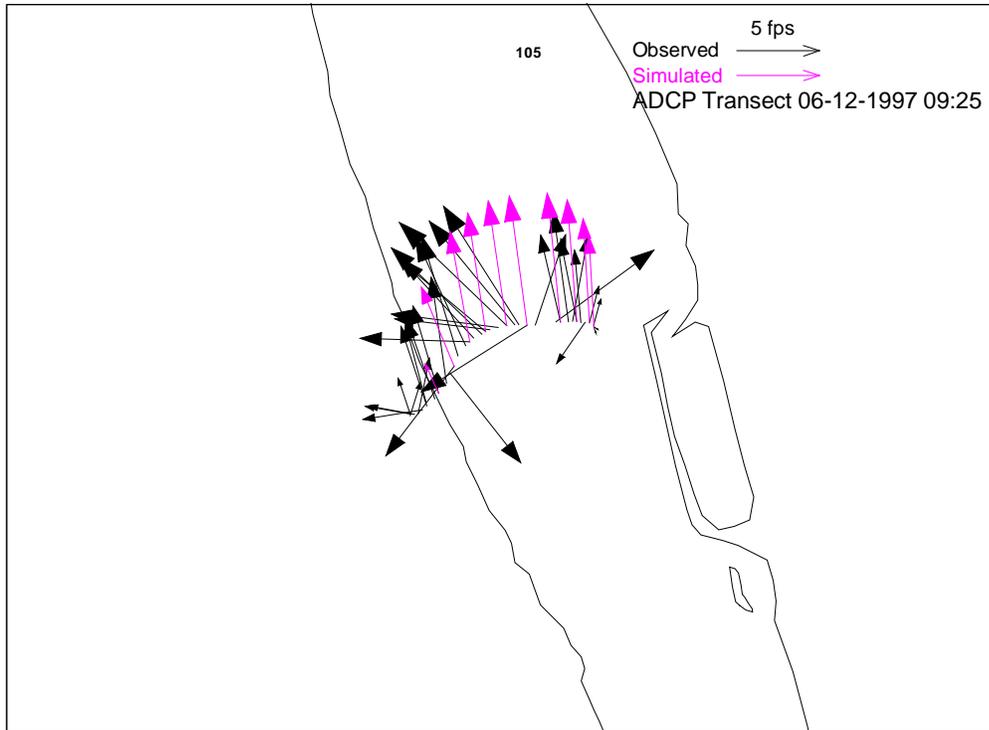


Figure 33. Simulated and observed depth-averaged velocities near river mile 105 on June 12, 1997.

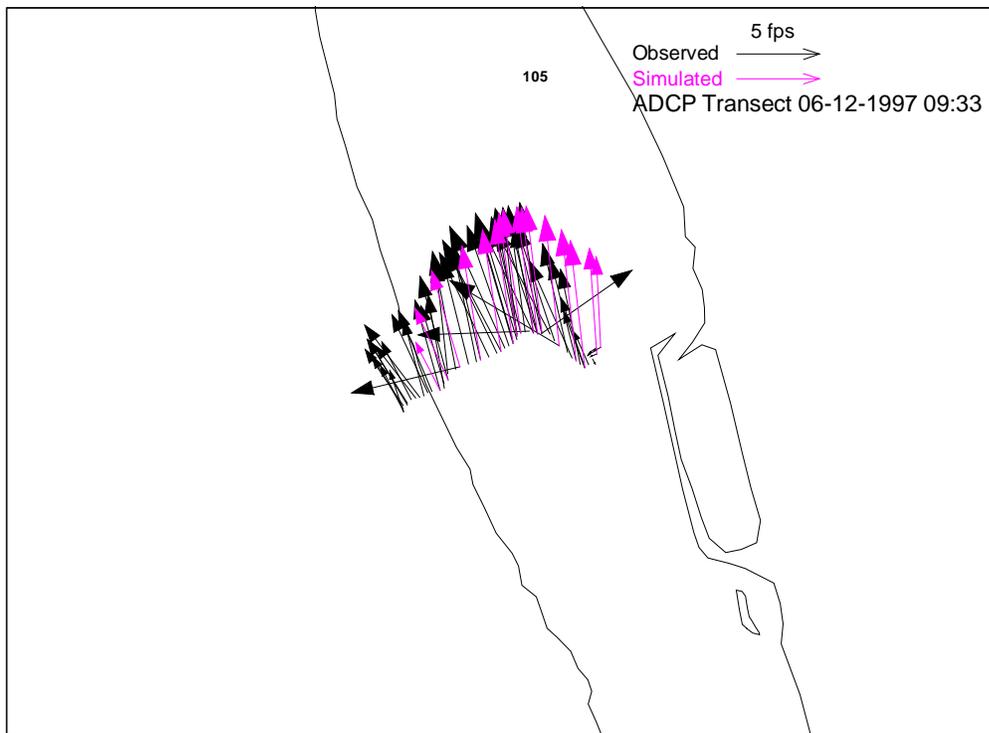


Figure 34. Simulated and observed depth-averaged velocities near river mile 105 on June 12, 1997.

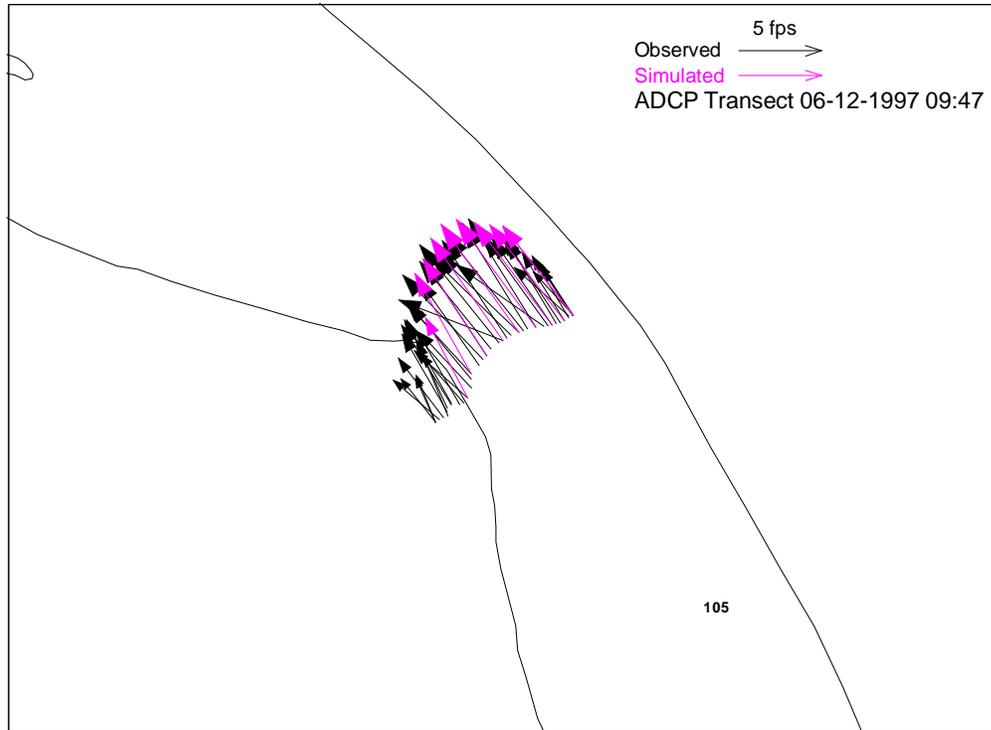


Figure 35. Simulated and observed depth-averaged velocities near river mile 105 on June 12, 1997.

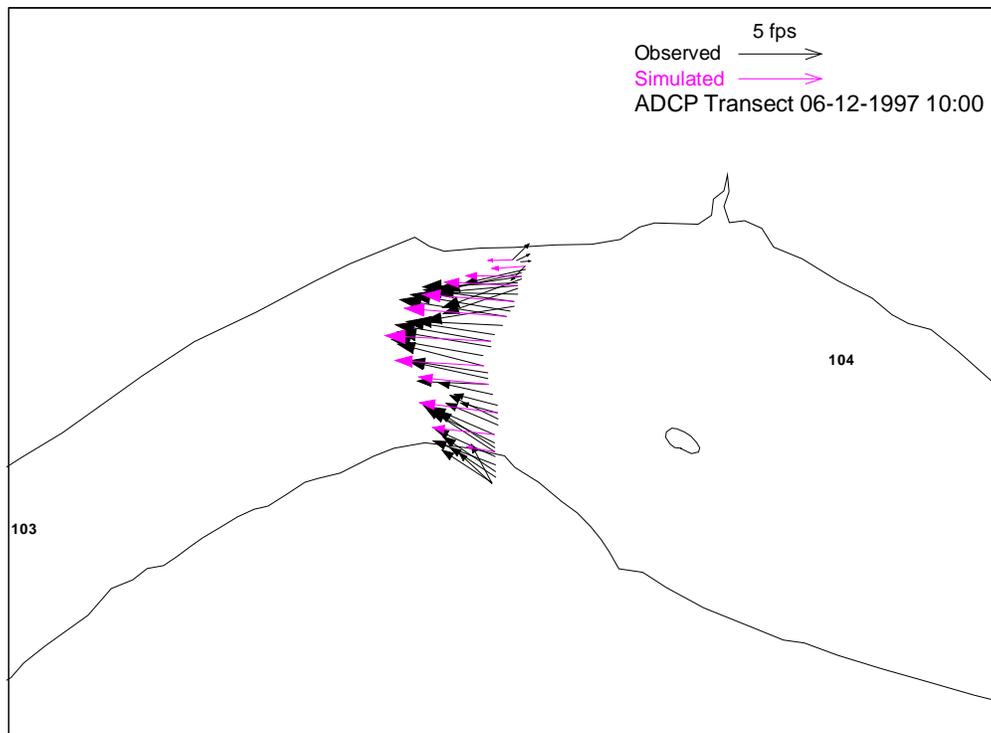


Figure 36. Simulated and observed depth-averaged velocities near river mile 104 on June 12, 1997.

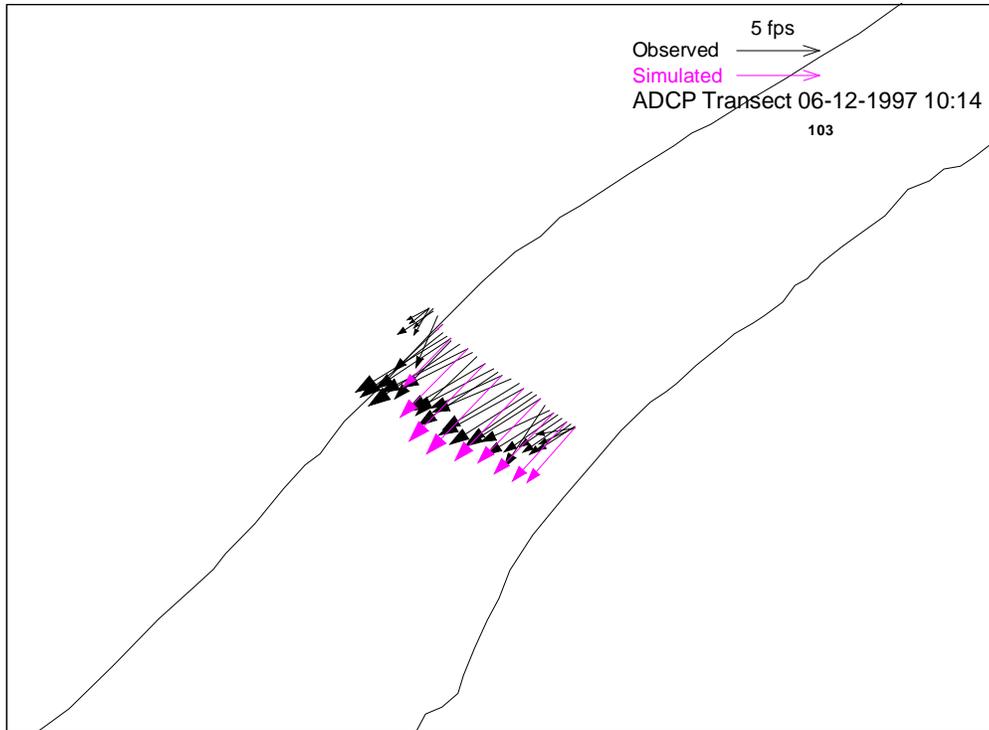


Figure 37. Simulated and observed depth-averaged velocities near river mile 103 on June 12, 1997.

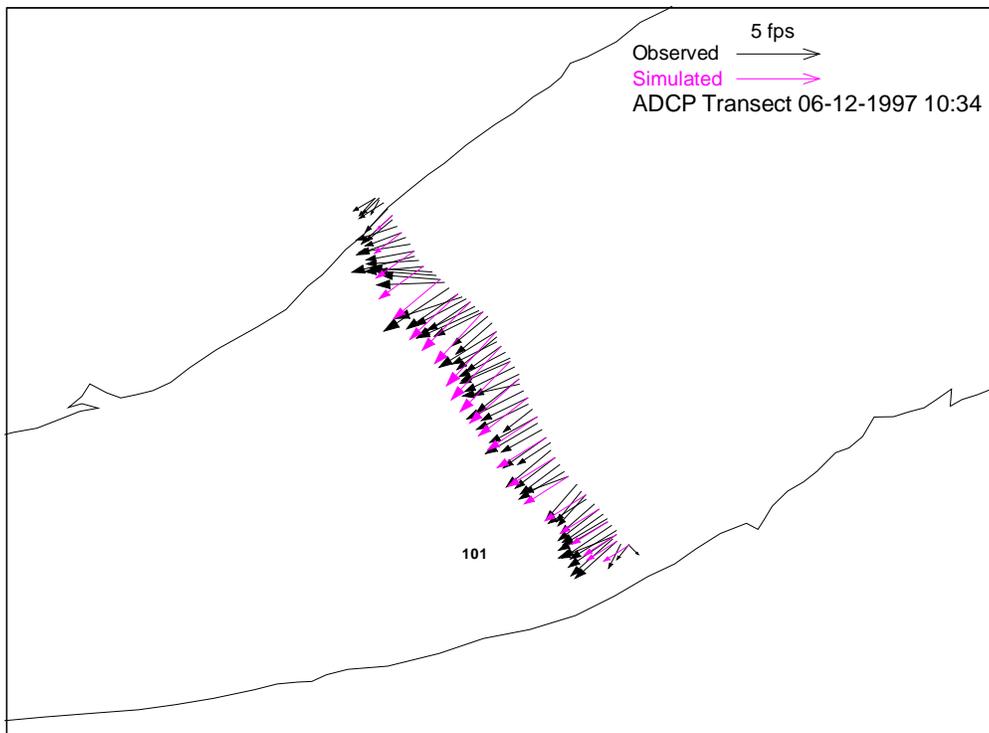


Figure 38. Simulated and observed depth-averaged velocities near river mile 101 on June 12, 1997.

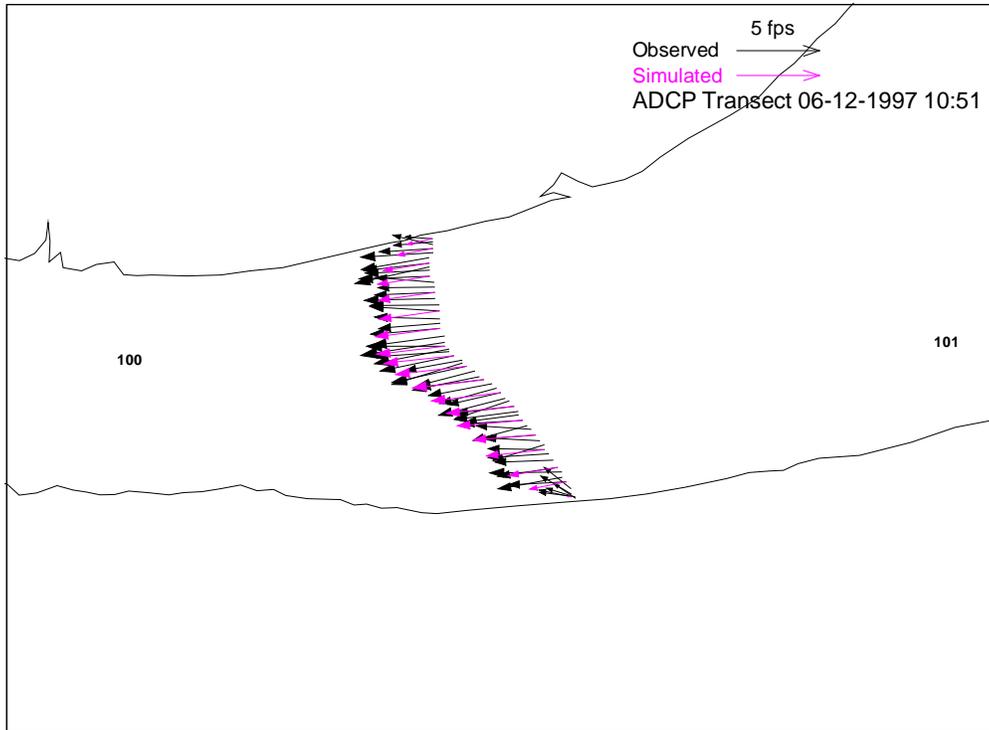


Figure 39. Simulated and observed depth-averaged velocities near river mile 100 on June 12, 1997.

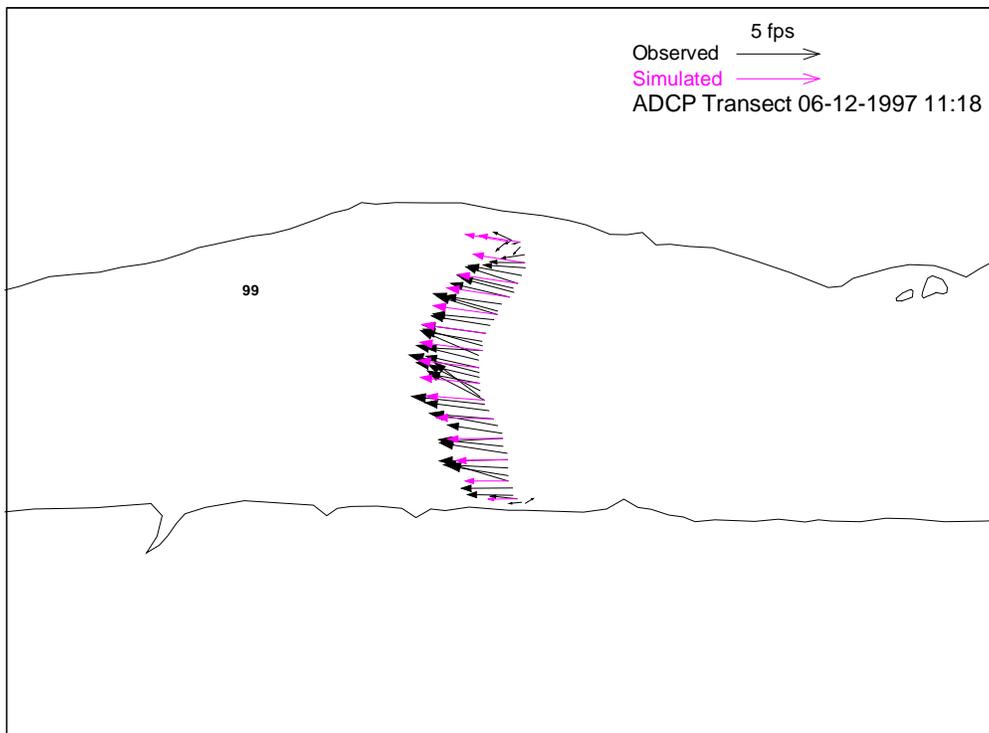


Figure 40. Simulated and observed depth-averaged velocities near river mile 99 on June 12, 1997.

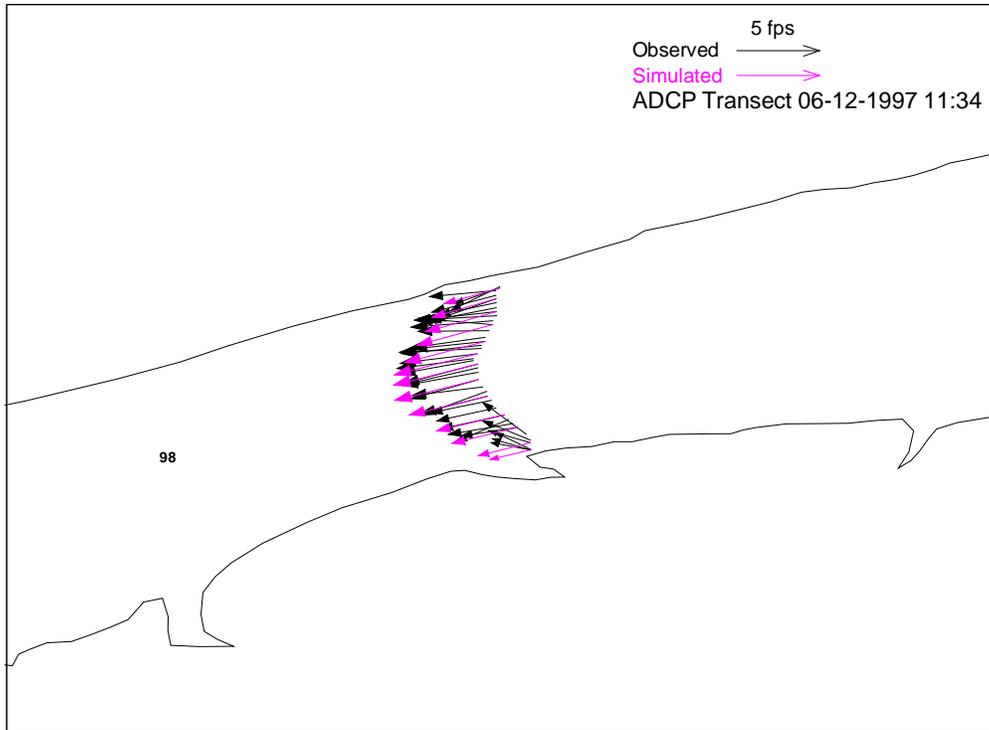


Figure 41. Simulated and observed depth-averaged velocities near river mile 98 on June 12, 1997.

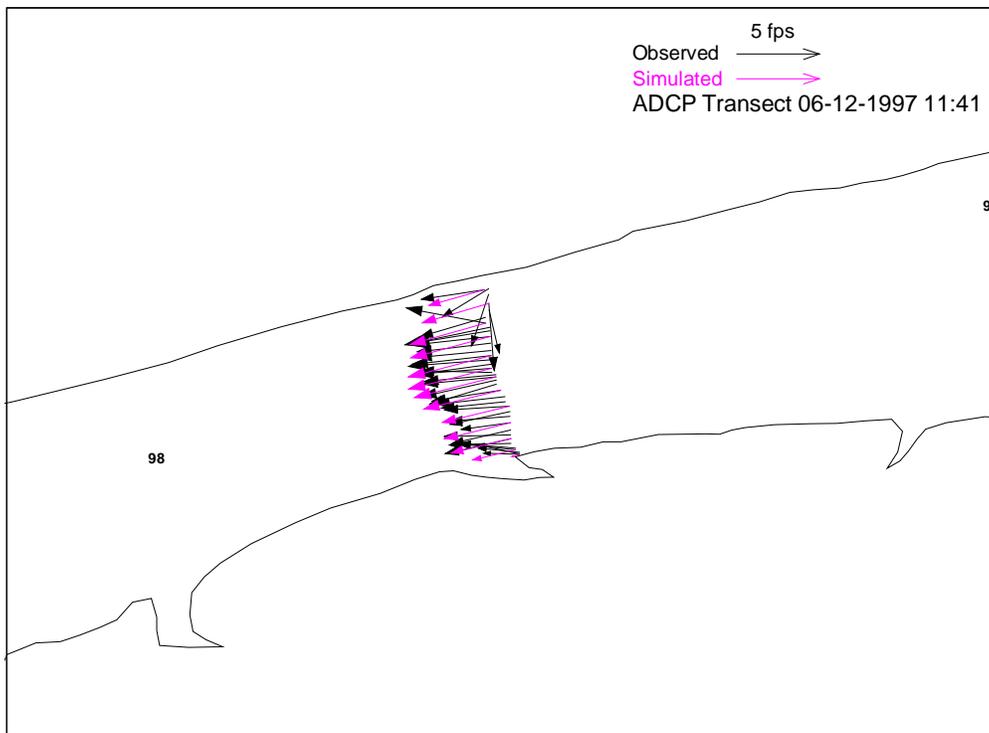


Figure 42. Simulated and observed depth-averaged velocities near river mile 98 on June 12, 1997.



Figure 43. Simulated and observed depth-averaged velocities near river mile 98 on June 12, 1997.

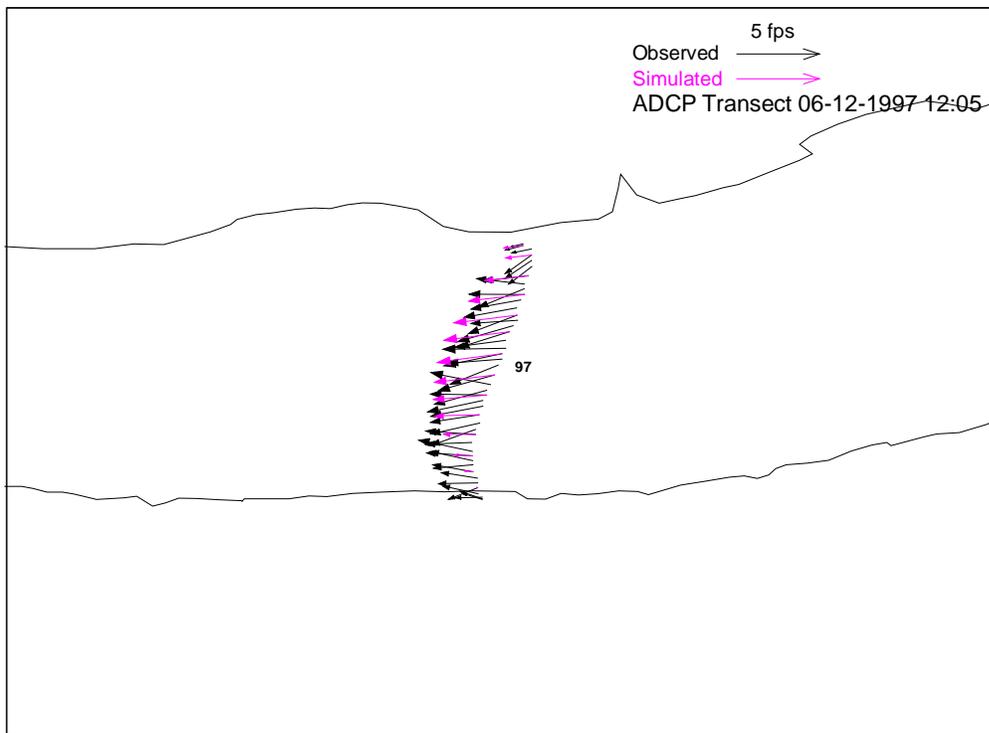


Figure 44. Simulated and observed depth-averaged velocities near river mile 97 on June 12, 1997.

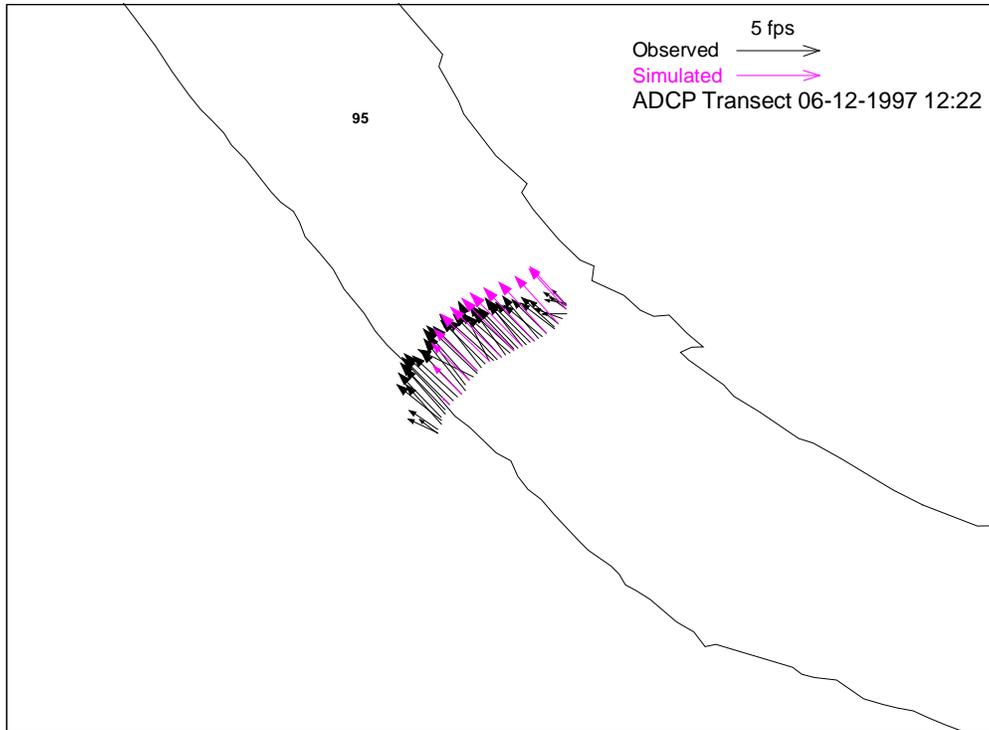


Figure 45. Simulated and observed depth-averaged velocities near river mile 95 on June 12, 1997.

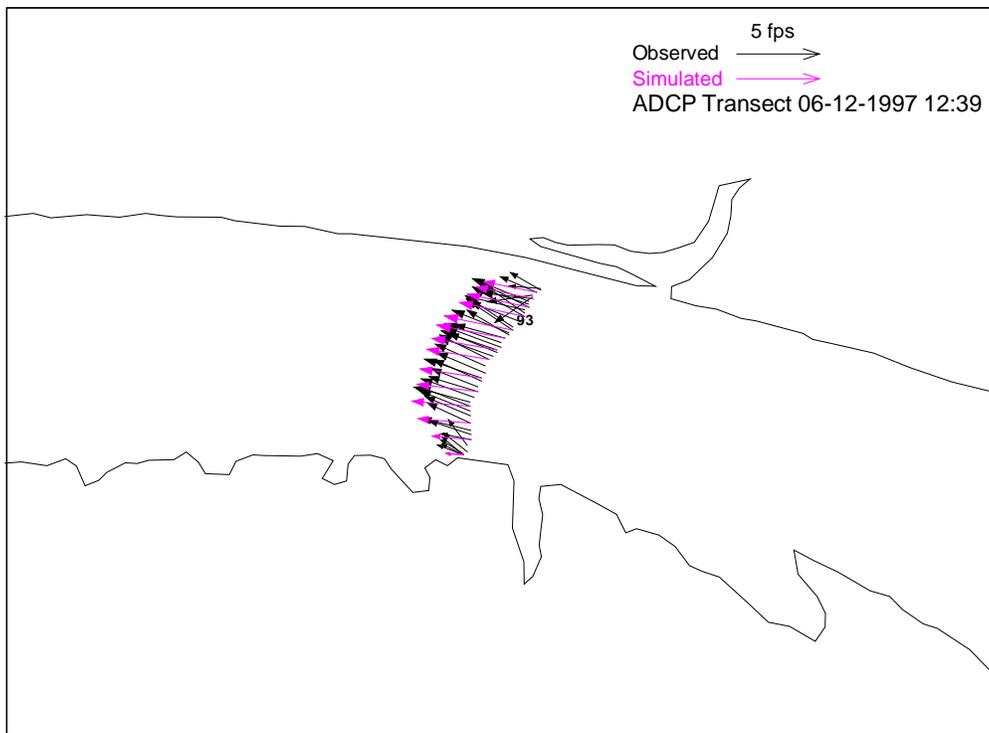


Figure 46. Simulated and observed depth-averaged velocities near river mile 93 on June 12, 1997.

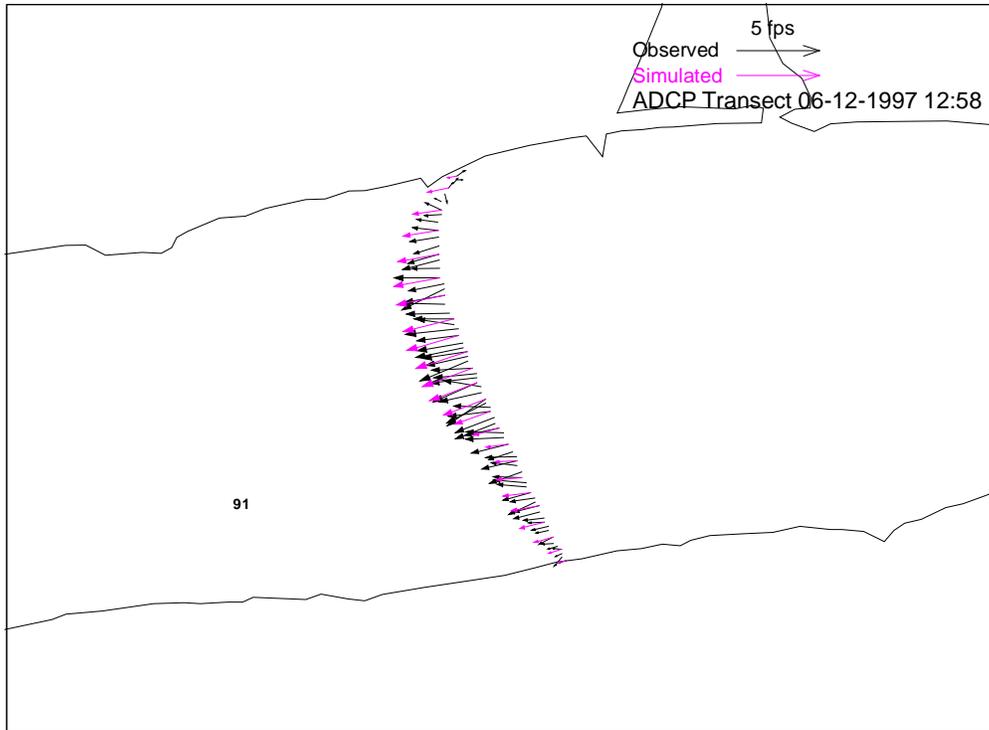


Figure 47. Simulated and observed depth-averaged velocities near river mile 91 on June 12, 1997.

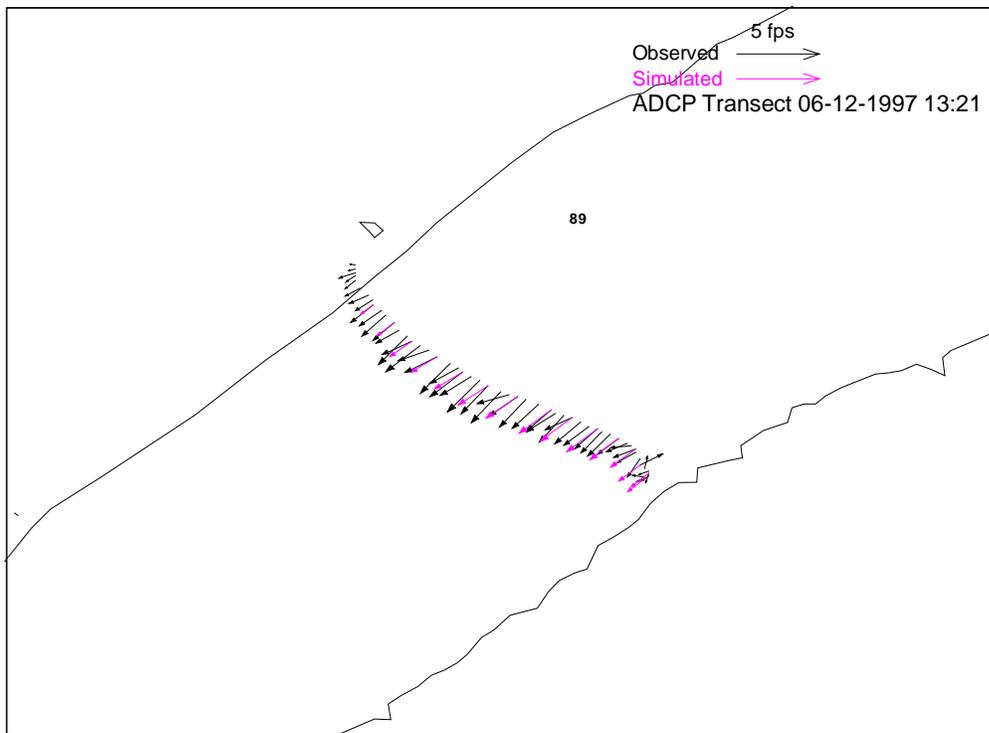


Figure 48. Simulated and observed depth-averaged velocities near river mile 89 on June 12, 1997.

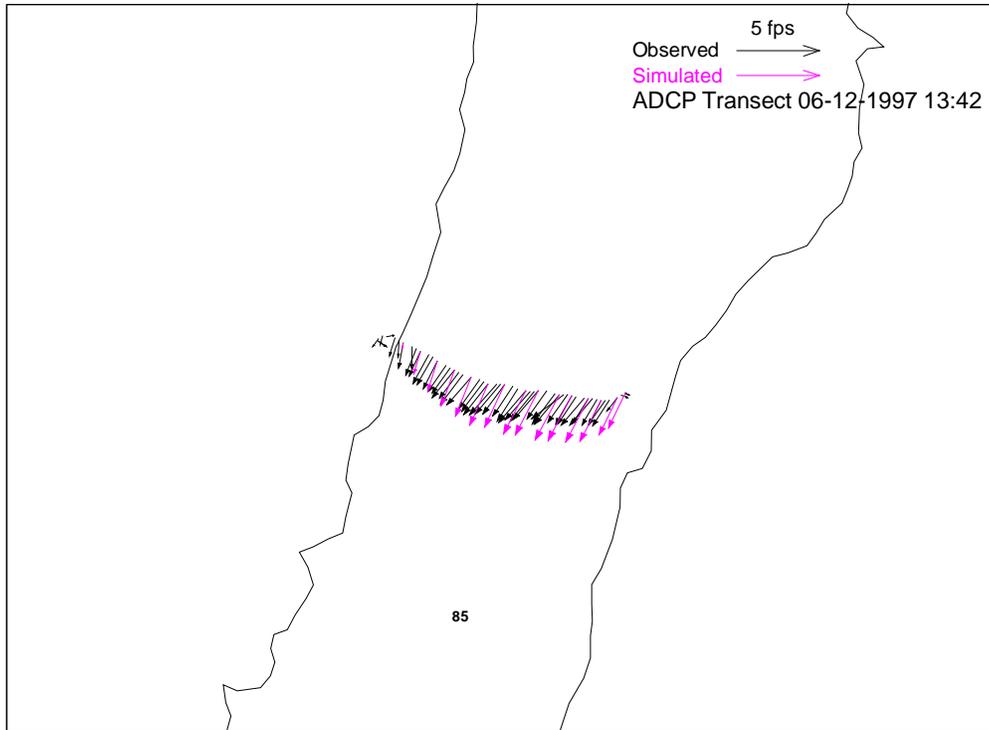


Figure 49. Simulated and observed depth-averaged velocities near river mile 85 on June 12, 1997.

1.3.4 Simulated spatial velocity distribution during the Spring 1997 study.

The following figures show the simulated velocity distributions and these are overlaid on the bathymetry.

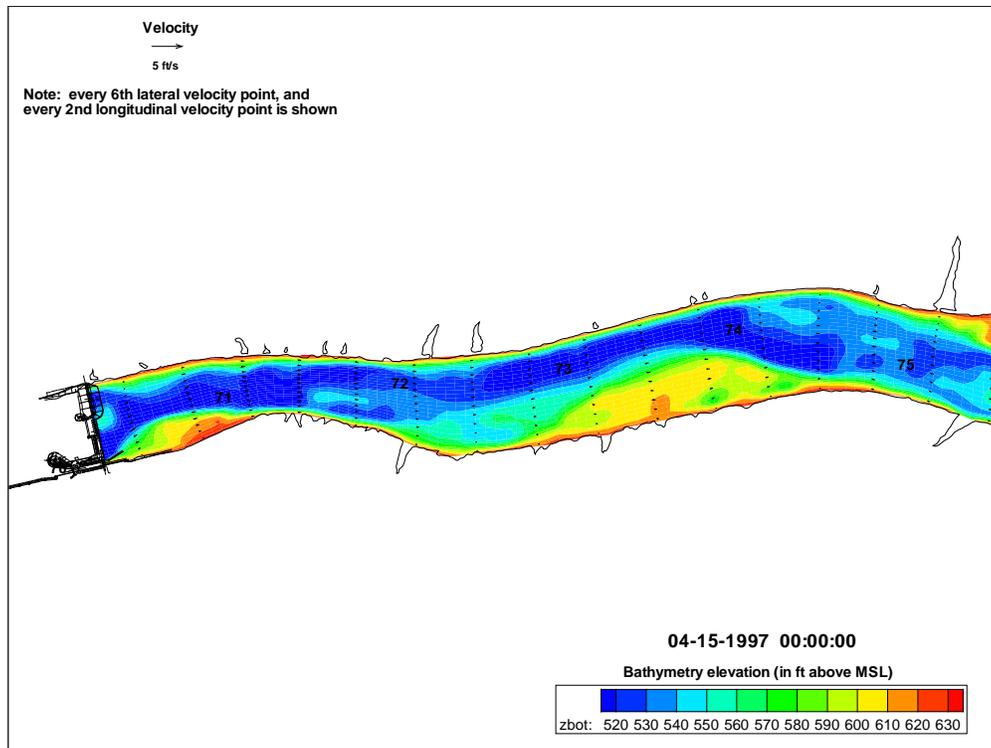


Figure 50 Spatial velocity distribution during the Spring 1997 study.

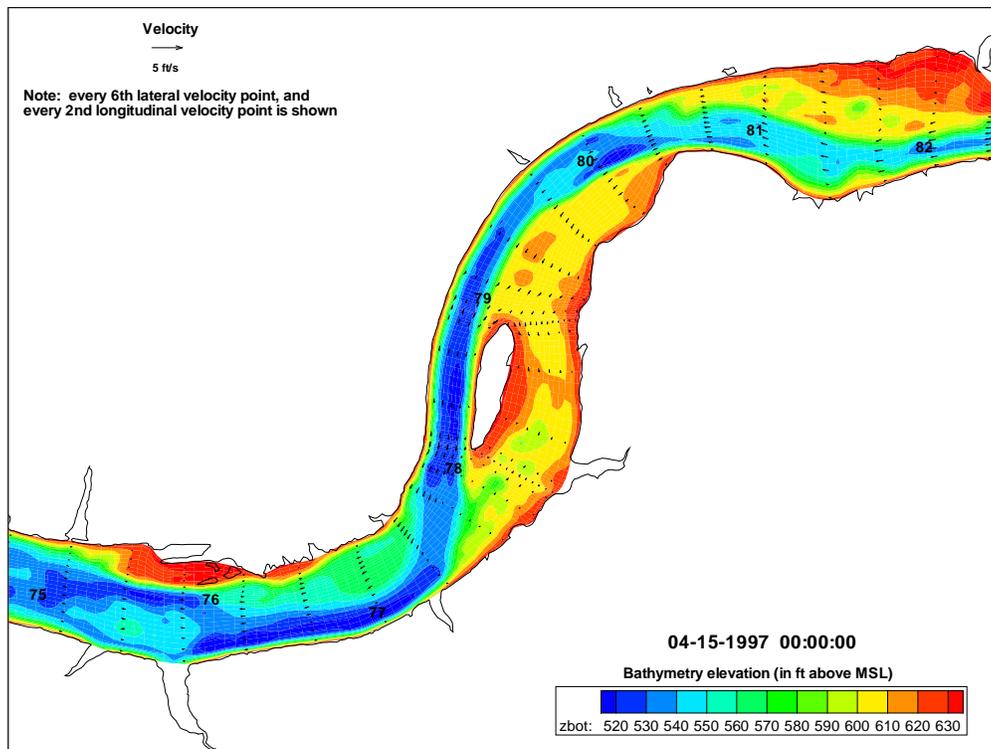


Figure 51. Spatial velocity distribution during the Spring 1997 study.

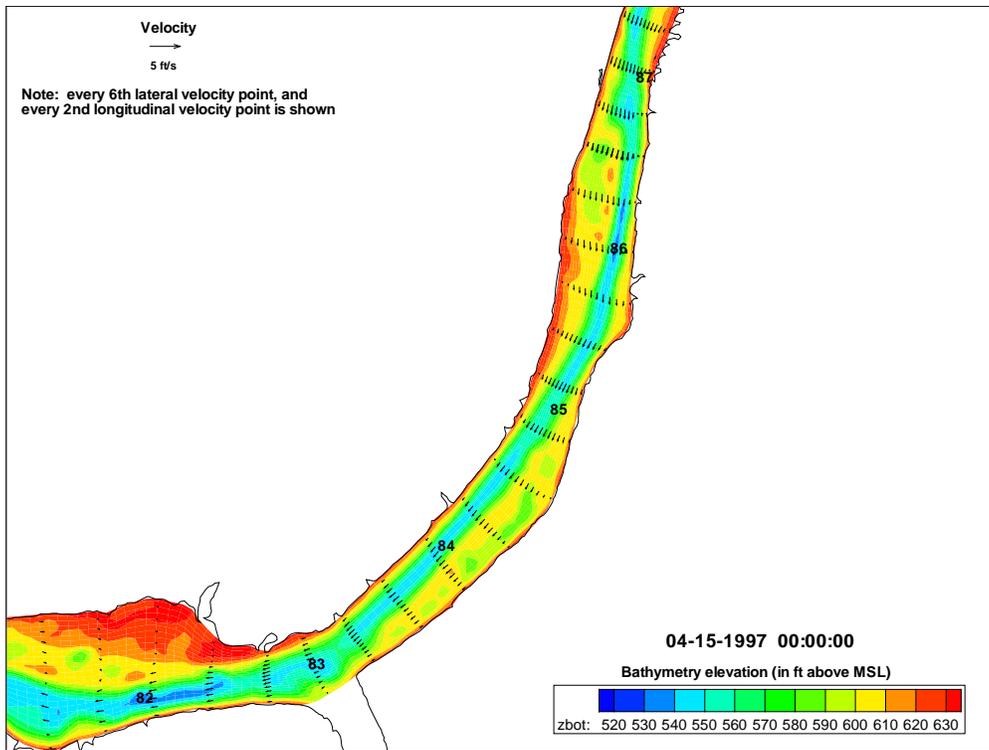


Figure 52. Spatial velocity distribution during the Spring 1997 study.

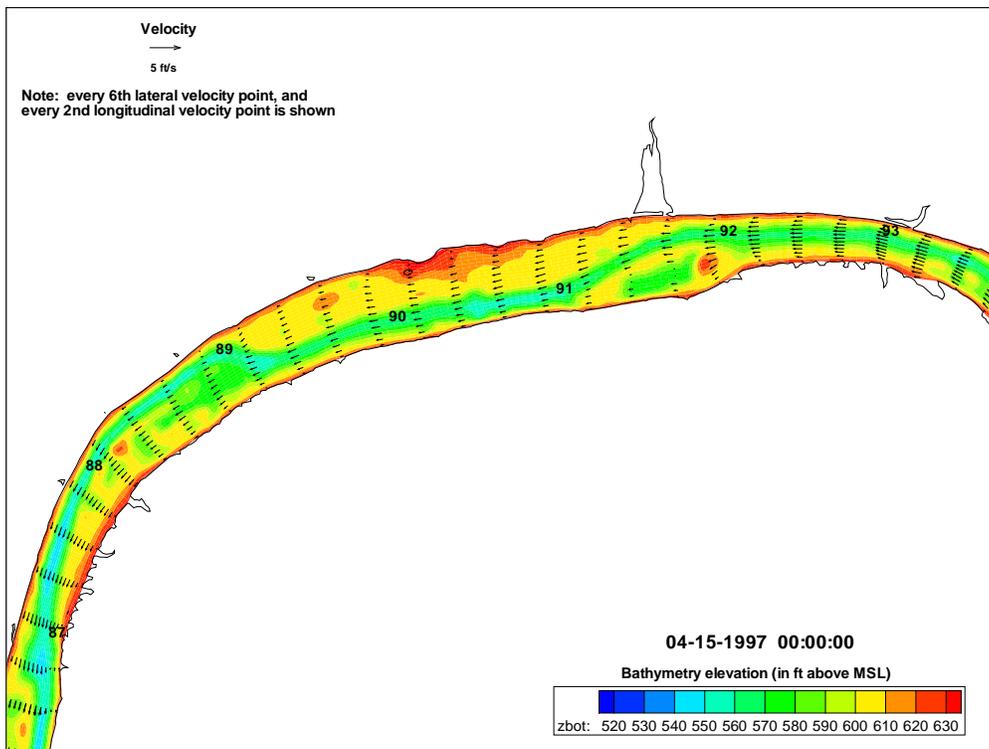


Figure 53. Spatial velocity distribution during the Spring 1997 study.

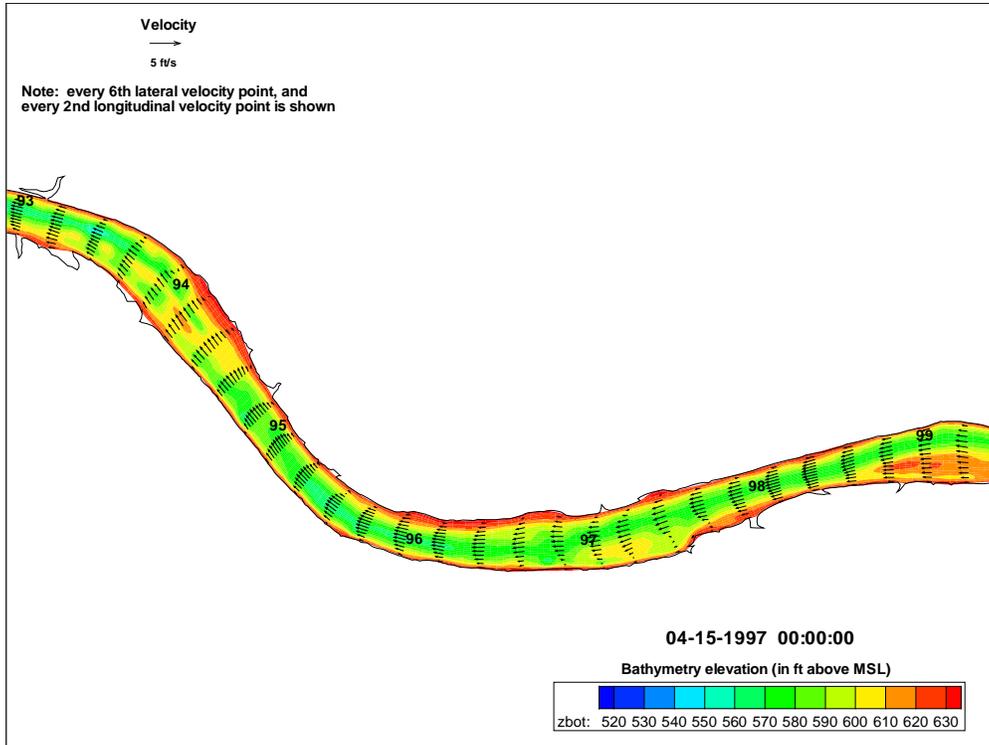


Figure 54. Spatial velocity distribution during the Spring 1997 study.

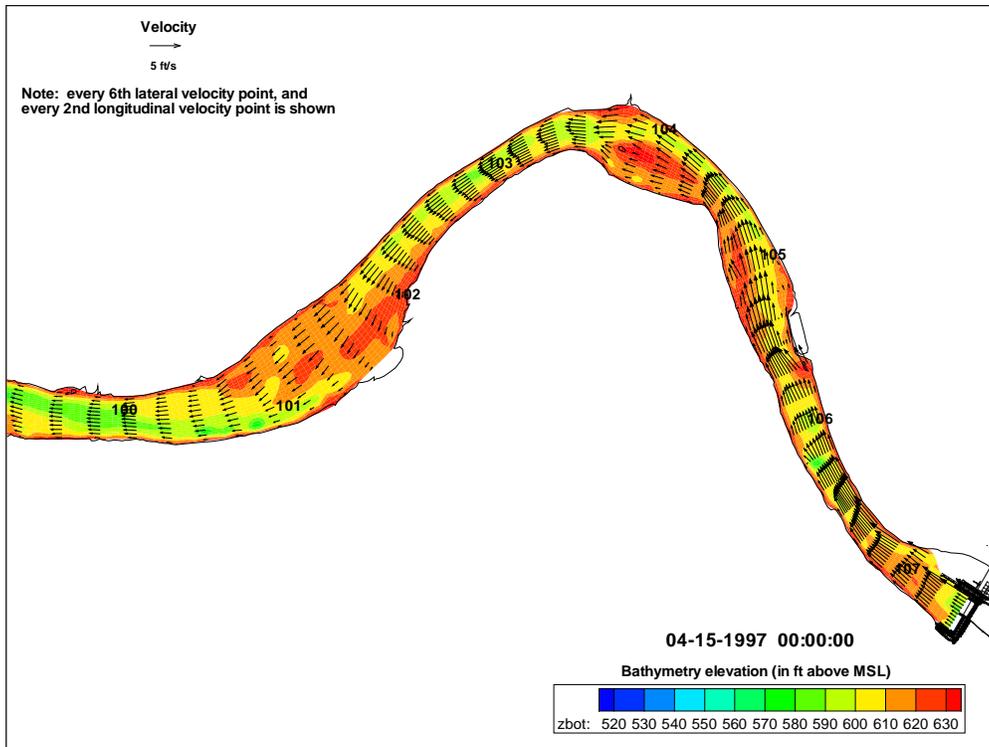


Figure 55. Spatial velocity distribution during the Spring 1997 study.

1.4 Water Quality Calibration and Verification

1.4.1 1997 Spring Simulation

Boundary Conditions using Lower Granite Sourcing Function and Forebay FMS Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from the empirical project gas sourcing function and the forebay FMS are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as FMS-BC in the figure and table captions.

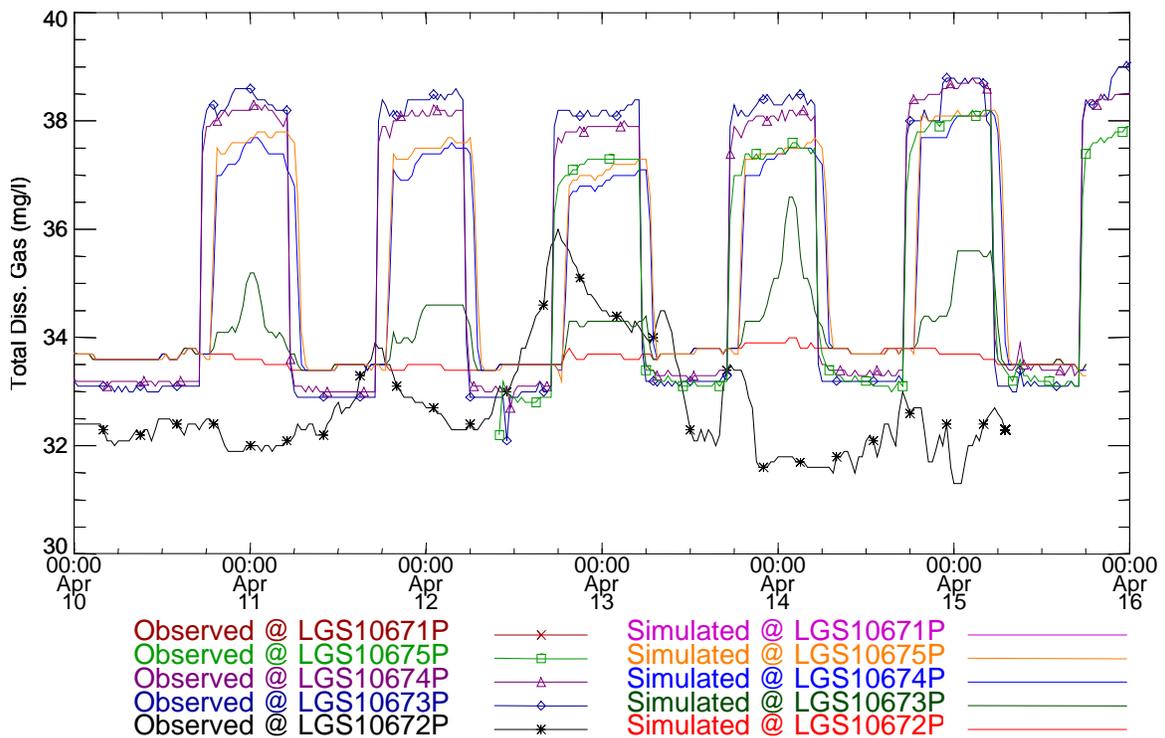
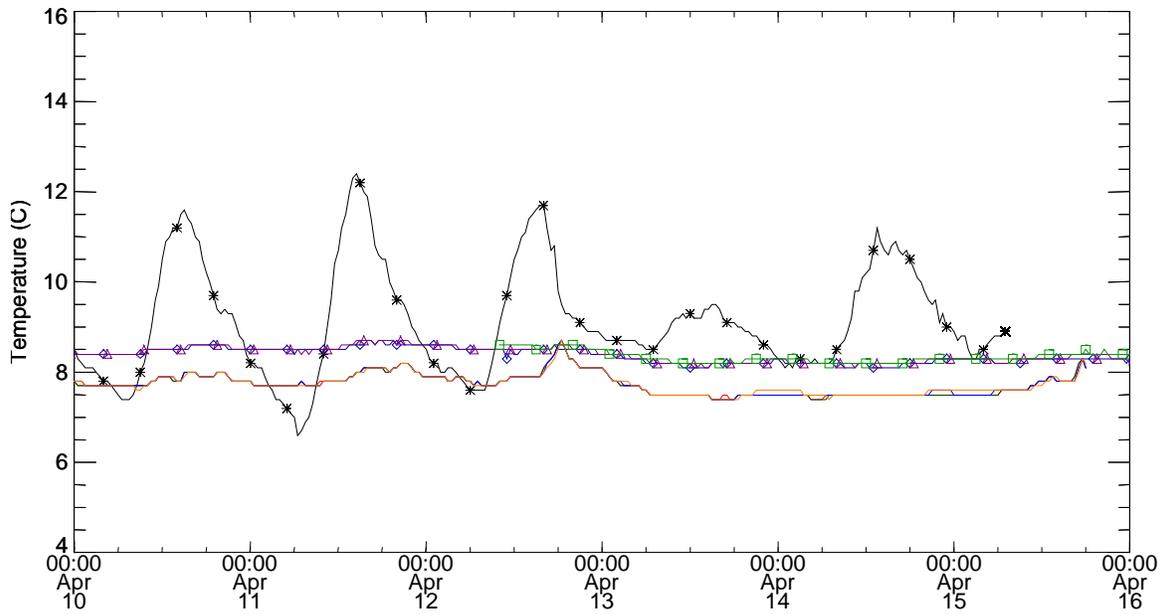


Figure 56. Temperature and total dissolved gas concentration time series near Snake River Mile 106.7 for the Spring 1997 pool study (FMS-BC).

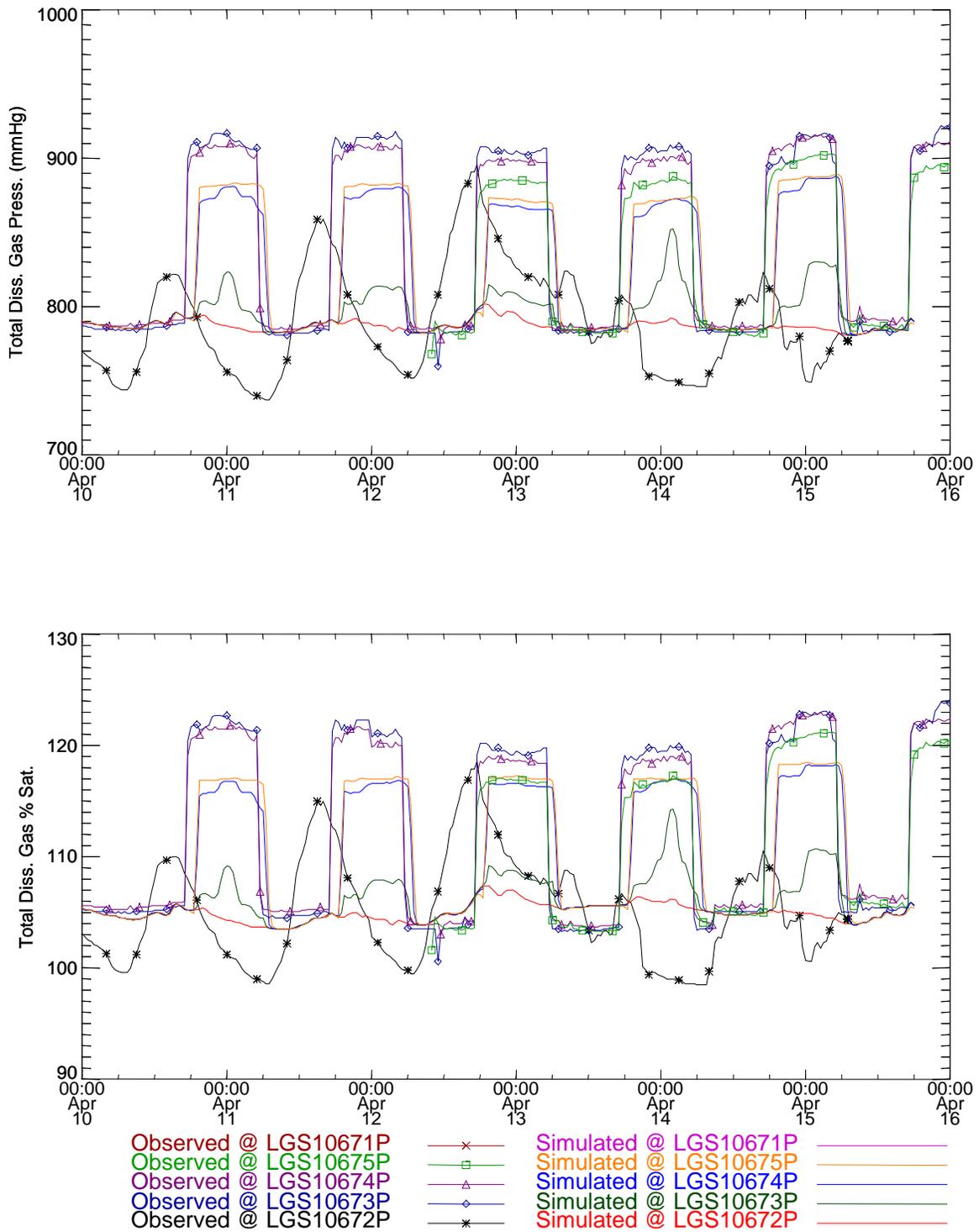


Figure 57. Total dissolved gas pressure and saturation time series near Snake River Mile 106.7 for the Spring 1997 pool study (FMS-BC).

Table 1. Statistical summary of measurements and simulations near Snake River mile 106.7 for the Spring 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS10672P	9.11	7.74	1.17	0.24	1.77
LGS10673P	8.37	7.73	0.16	0.24	0.66
LGS10674P	8.39	7.74	0.16	0.24	0.67
LGS10675P	8.45	7.74	0.16	0.22	0.72
Concentration					
LGS10672P	32.7	33.62	0.97	0.15	1.37
LGS10673P	35.39	34	2.6	0.62	2.62
LGS10674P	35.4	35.16	2.43	1.83	1.48
LGS10675P	33.92	35.29	2.2	1.94	2.52
Gas Pressure					
LGS10672P	788.73	787.23	35.45	3.85	33.76
LGS10673P	838.41	795.86	61.5	13.99	67.14
LGS10674P	838.89	822.82	57.37	42.51	37.25
LGS10675P	805.29	825.71	50.09	45.04	52.92
% Saturation					
LGS10672P	105.1	104.99	4.64	0.82	4.41
LGS10673P	111.72	106.14	8.13	2	8.87
LGS10674P	111.79	109.74	7.6	5.72	5.04
LGS10675P	106.89	110.12	6.84	6.04	7.17

Table 2. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 106.7 for the Spring 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS10672P	44.04	34.3	75.09	79.06
LGS10673P	100	54.15	55.96	55.96
LGS10674P	100	80.51	86.64	78.7
LGS10675P	99.28	48.38	74.01	74.73

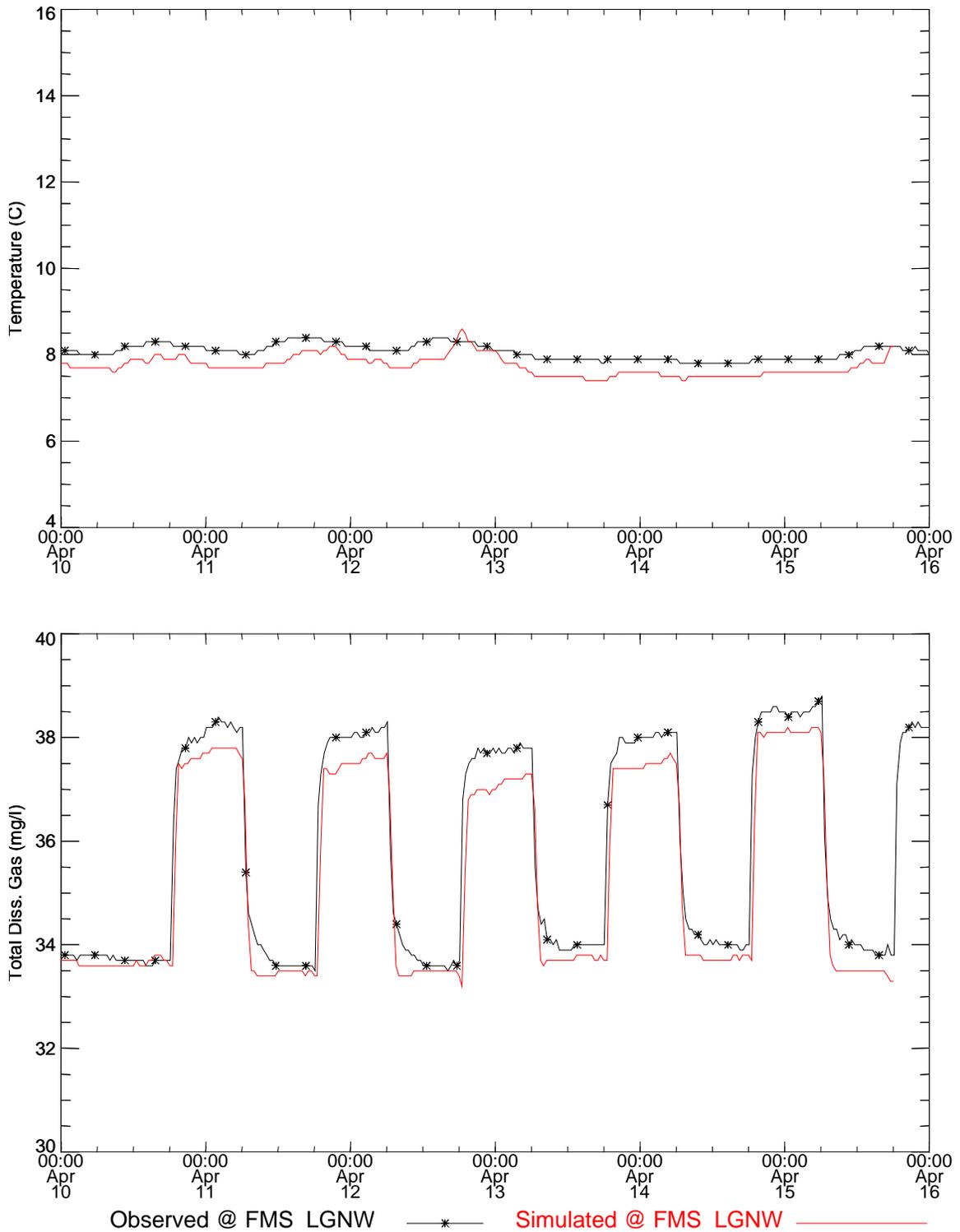


Figure 58. Temperature and total dissolved gas concentration time series near at the LGNW fixed monitor during the Spring 1997 pool study (FMS-BC).

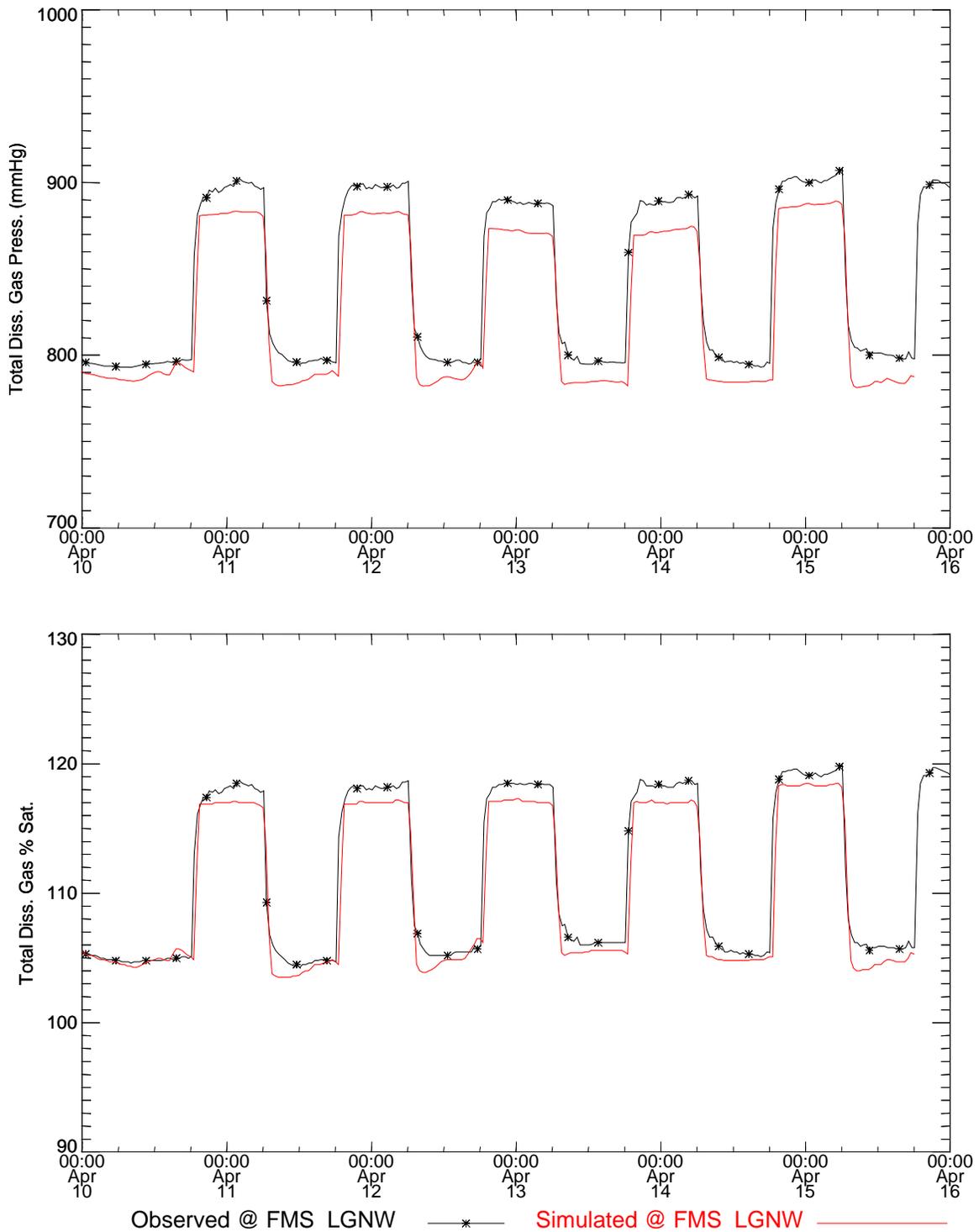


Figure 59. Total dissolved gas pressure and saturation time series near at the LGNW fixed monitor during the Spring 1997 pool study (FMS-BC).

Table 3. Statistical summary of measurements and simulations at fixed monitor LGNW for the Spring 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature FMS_LGNW	8.07	7.74	0.18	0.22	0.34
Concentration FMS_LGNW	35.71	35.3	2.03	1.94	0.59
Gas Pressure FMS_LGNW	839.95	825.94	46.96	45.09	16.88
% Saturation FMS_LGNW	111.14	110.16	6.27	6.05	1.58

Table 4. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGNW for the Spring 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGNW	100	96.39	97.47	98.19

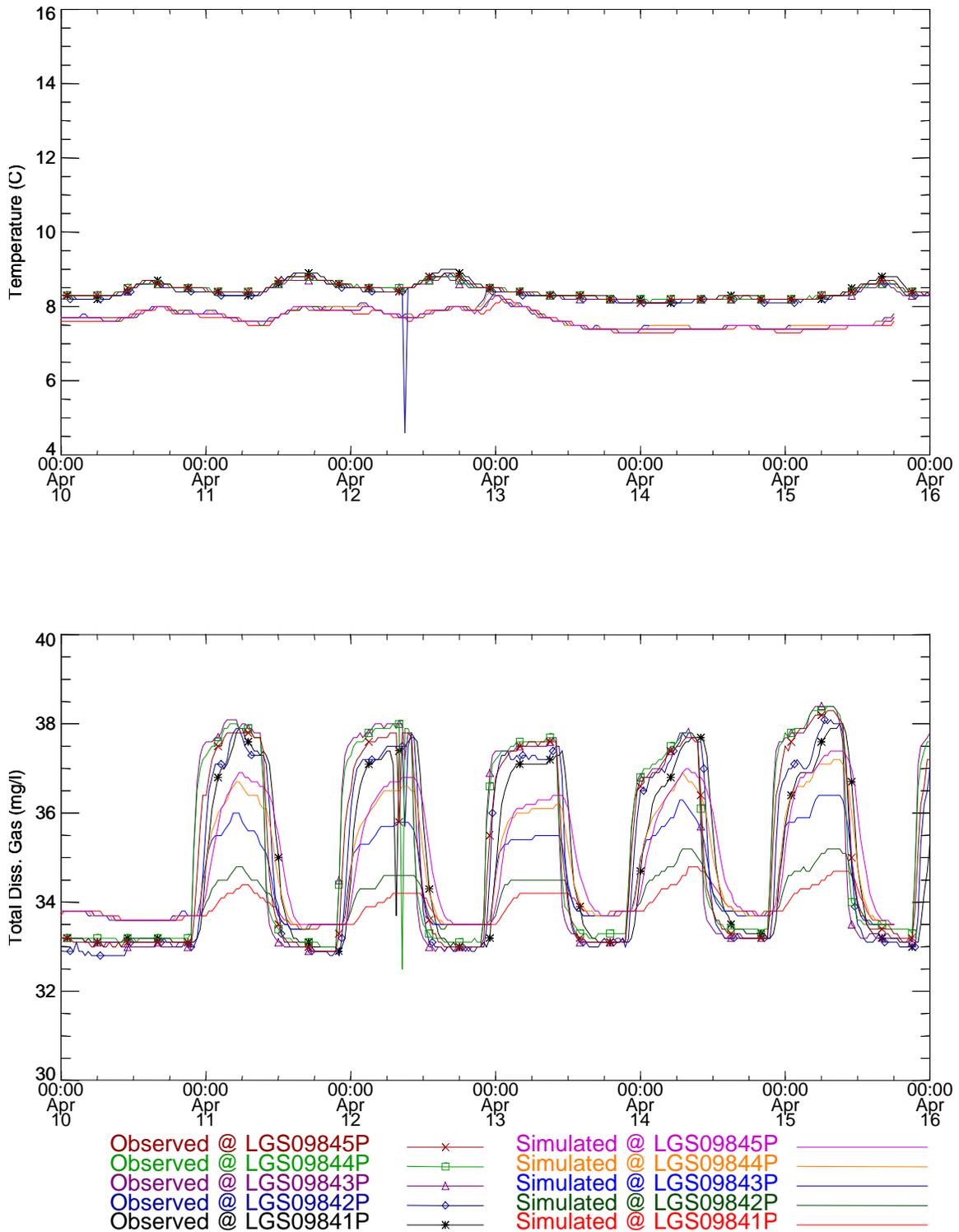


Figure 60. Temperature and total dissolved gas concentration time series near Snake River Mile 98.4 for the Spring 1997 pool study (FMS-BC).

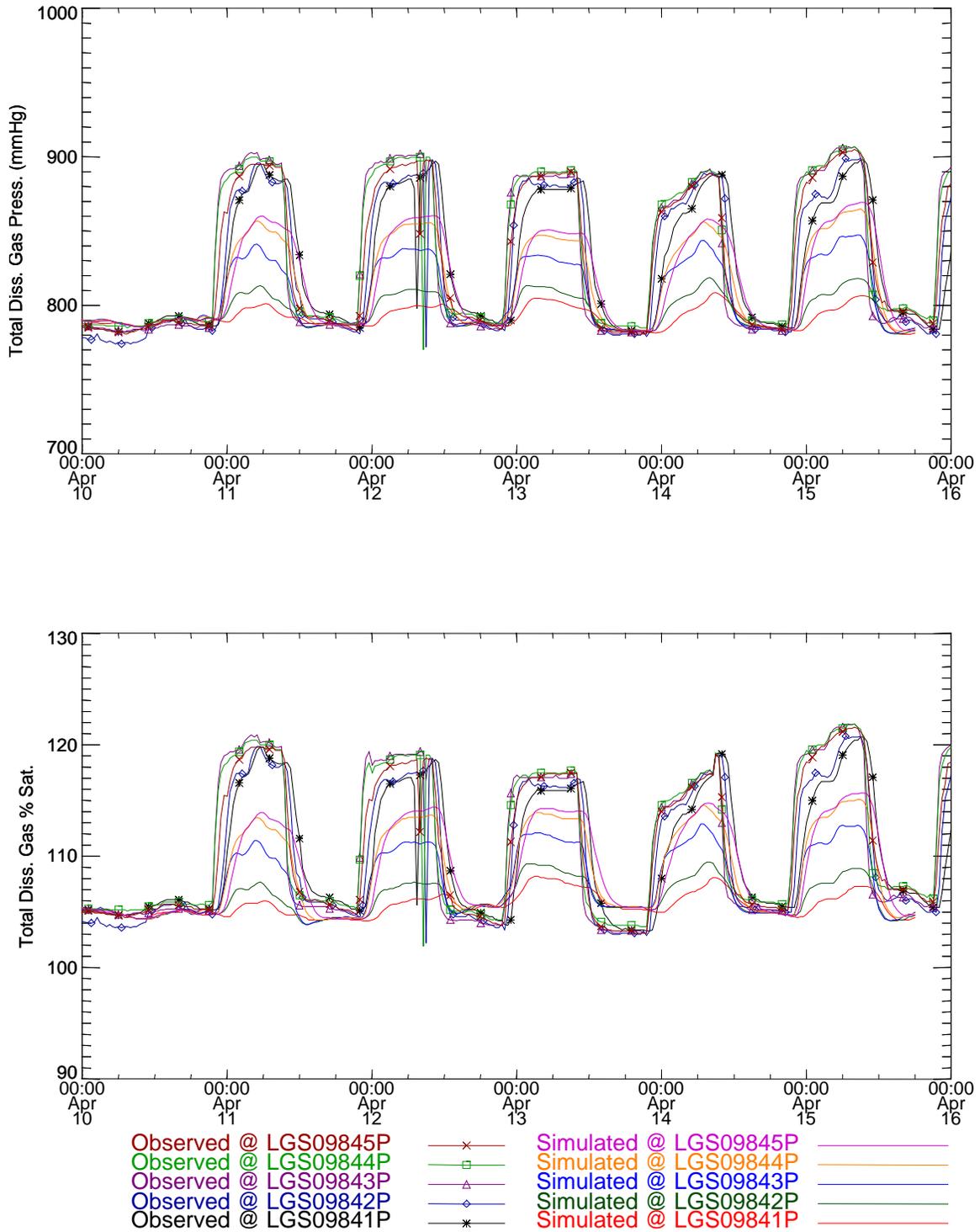


Figure 61. Total dissolved gas pressure and saturation time series near Snake River Mile 98.4 for the Spring 1997 pool study (FMS-BC).

Table 5. Statistical summary of measurements and simulations near Snake River mile 98.4 for the Spring 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS09841P	8.42	7.64	0.23	0.24	0.8
LGS09842P	8.35	7.68	0.31	0.24	0.74
LGS09843P	8.39	7.7	0.18	0.23	0.7
LGS09844P	8.41	7.7	0.18	0.23	0.73
LGS09845P	8.42	7.68	0.2	0.23	0.76
Concentration					
LGS09841P	34.93	33.91	1.88	0.35	1.9
LGS09842P	34.9	34.06	2.03	0.52	1.79
LGS09843P	35.1	34.51	2.21	1	1.52
LGS09844P	35.18	34.83	2.11	1.28	1.29
LGS09845P	35.07	34.95	2.07	1.36	1.24
Gas Pressure					
LGS09841P	828.48	792.01	42.49	7.01	51.75
LGS09842P	826.61	796.17	46.31	11.14	47.45
LGS09843P	831.69	806.92	50.97	22.44	40.62
LGS09844P	834.13	814.3	48.48	28.94	34.3
LGS09845P	831.66	816.56	47.24	30.44	31.58
% Saturation					
LGS09841P	110.4	105.63	5.58	1.06	6.86
LGS09842P	110.14	106.18	6.05	1.56	6.25
LGS09843P	110.82	107.62	6.67	3.01	5.41
LGS09844P	111.15	108.6	6.35	3.86	4.57
LGS09845P	110.82	108.9	6.19	4.04	4.2

Table 6. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 098.4 for the Spring 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS09841P	94.22	55.96	56.32	57.04
LGS09842P	96.39	56.68	57.4	56.68
LGS09843P	99.28	53.07	57.04	63.18
LGS09844P	97.83	53.07	62.09	68.95
LGS09845P	96.03	58.12	73.65	73.29

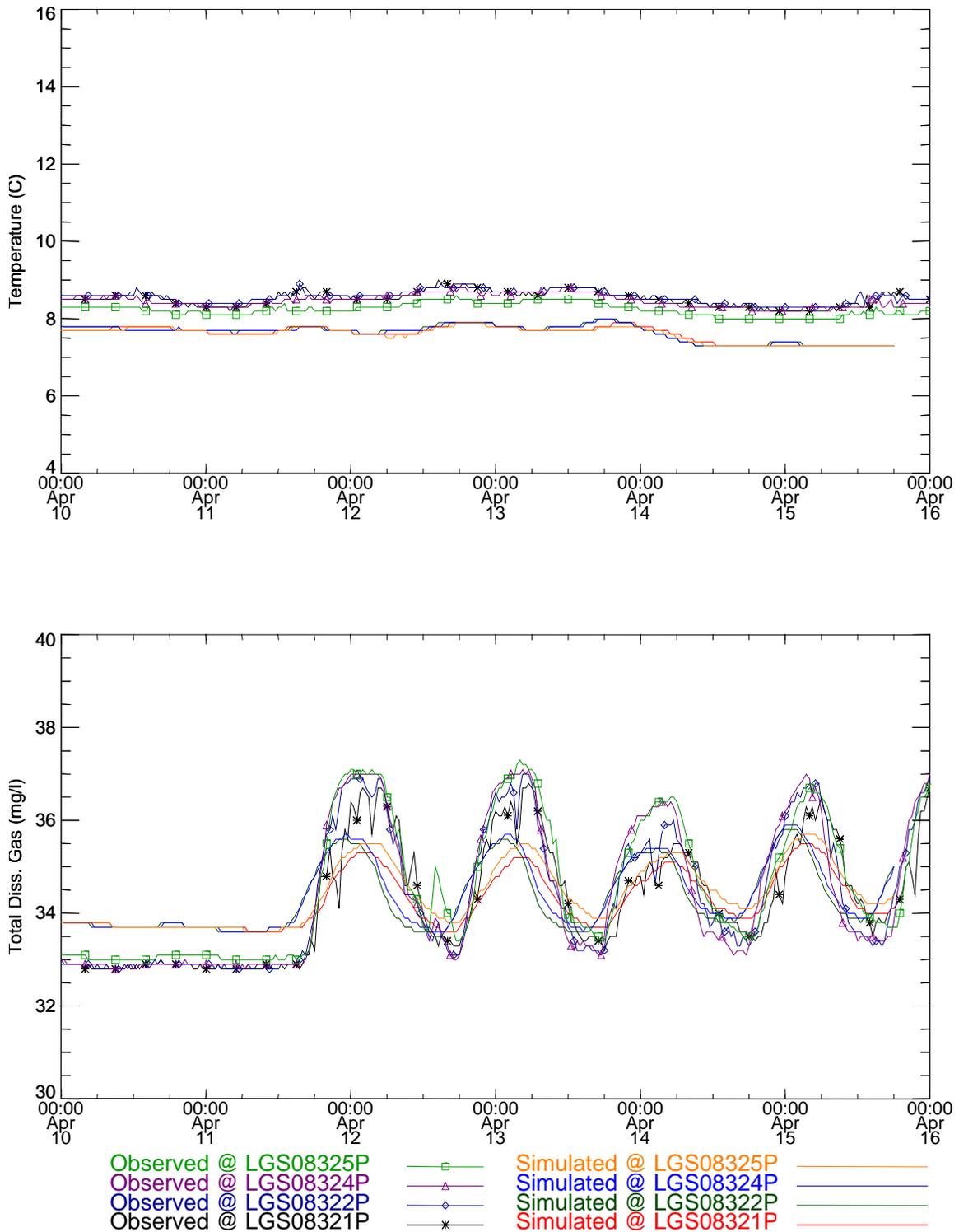


Figure 62. Temperature and total dissolved gas concentration time series near Snake River Mile 83.2 for the Spring 1997 pool study (FMS-BC).

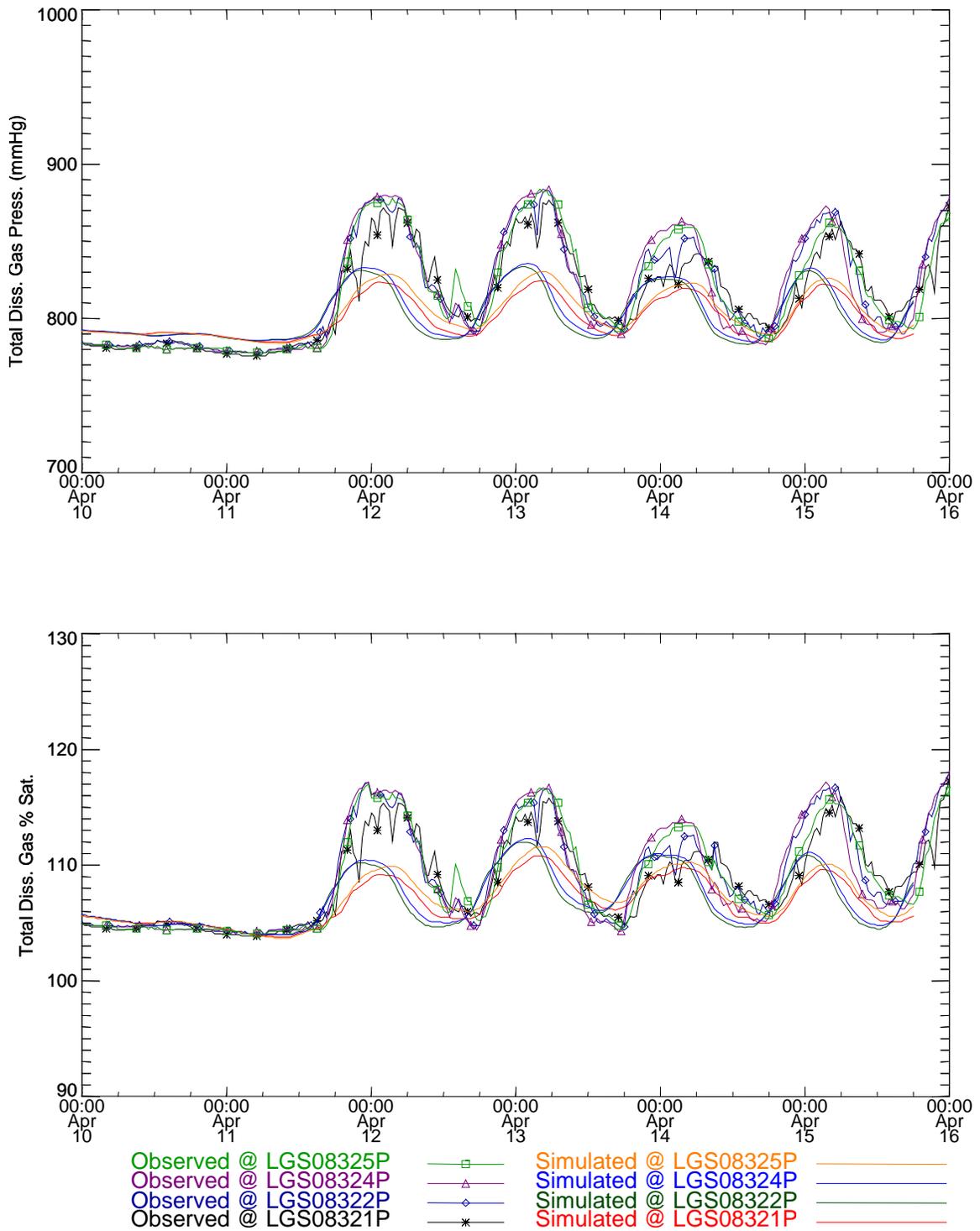


Figure 63. Total dissolved gas pressure and saturation time series near Snake River Mile 83.2 for the Spring 1997 pool study (FMS-BC).

Table 7. Statistical summary of measurements and simulations near Snake River mile 83.2 for the Spring 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS08321P	8.52	7.62	0.19	0.2	0.91
LGS08322P	8.56	7.64	0.16	0.21	0.93
LGS08324P	8.47	7.64	0.16	0.21	0.84
LGS08325P	8.24	7.61	0.16	0.19	0.65
Concentration					
LGS08321P	34.21	34.26	1.24	0.58	0.74
LGS08322P	34.31	34.32	1.4	0.71	0.9
LGS08324P	34.37	34.39	1.51	0.73	0.9
LGS08325P	34.55	34.42	1.43	0.66	0.84
Gas Pressure					
LGS08321P	813.67	799.8	29.22	12.74	23.14
LGS08322P	816.49	801.67	32.92	16.3	26.73
LGS08324P	816.27	803.01	35.81	16.68	25.71
LGS08325P	816.25	802.98	33.75	14.21	24.04
% Saturation					
LGS08321P	108.42	106.67	3.6	1.94	2.8
LGS08322P	108.8	106.92	4.11	2.41	3.33
LGS08324P	108.76	107.1	4.44	2.47	3.06
LGS08325P	108.76	107.09	4.16	2.16	2.85

Table 8. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 083.2 for the Spring 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS08321P	87	88.45	85.92	88.81
LGS08322P	81.95	81.59	81.95	84.12
LGS08324P	97.11	78.34	81.95	85.2
LGS08325P	100	79.78	85.2	88.81

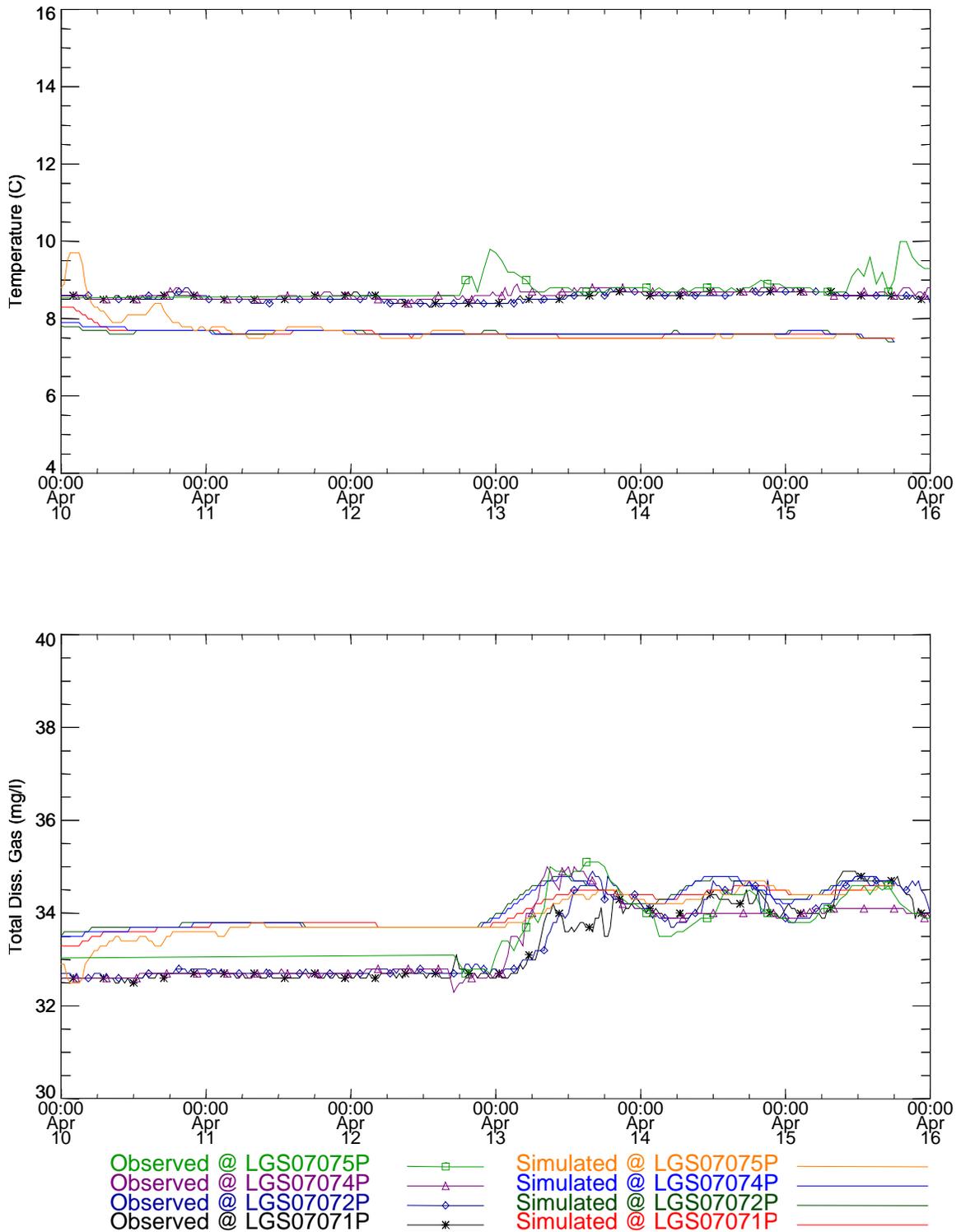


Figure 64. Temperature and total dissolved gas concentration time series near Snake River Mile 70.7 for the Spring 1997 pool study (FMS-BC).

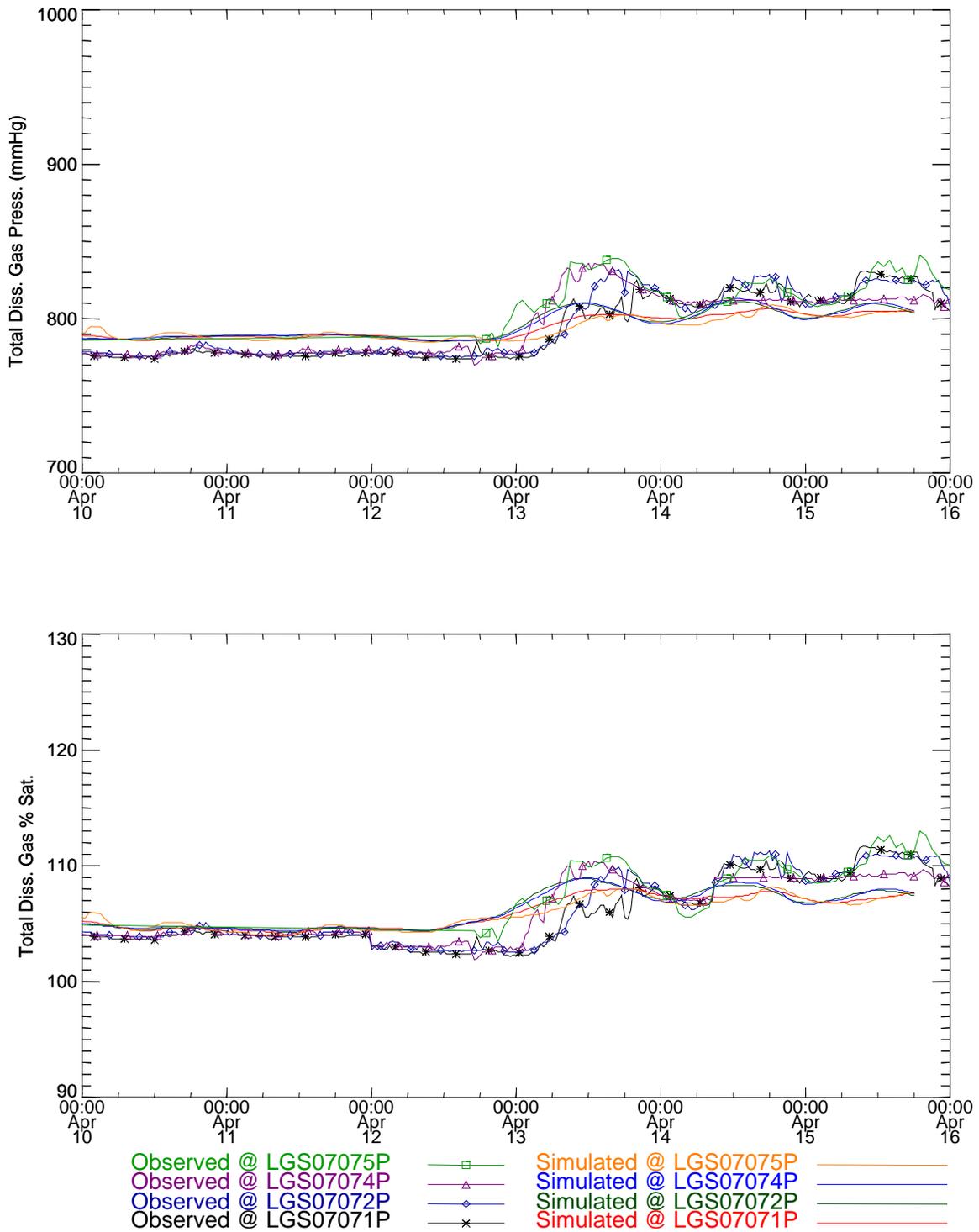


Figure 65. Total dissolved gas pressure and saturation time series near Snake River Mile 70.7 for the Spring 1997 pool study (FMS-BC).

Table 9. Statistical summary of measurements and simulations near Snake River mile 70.7 for the Spring 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS07071P	8.56	7.63	0.1	0.14	0.95
LGS07072P	8.56	7.63	0.11	0.06	0.94
LGS07074P	8.63	7.64	0.1	0.08	0.99
LGS07075P	8.73	7.7	0.23	0.37	1.15
Concentration					
LGS07071P	33.31	34.04	0.78	0.39	0.85
LGS07072P	33.39	34.1	0.8	0.42	0.85
LGS07074P	33.36	34.09	0.76	0.43	0.83
LGS07075P	33.59	33.93	0.66	0.47	0.52
Gas Pressure					
LGS07071P	792.99	794.5	19.64	7.56	12.61
LGS07072P	794.93	796.19	20.27	9.03	13.18
LGS07074P	795.5	796.12	19.35	9.12	11.61
LGS07075P	802.9	793.72	17.52	7.18	15.33
% Saturation					
LGS07071P	105.68	105.96	2.86	1.39	2
LGS07072P	105.94	106.19	2.89	1.6	2.01
LGS07074P	106.01	106.17	2.58	1.6	1.33
LGS07075P	106.78	105.86	2.56	1.3	1.77

Table 10. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 070.7 for the Spring 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS07071P	59.21	69.31	100	100
LGS07072P	63.18	76.53	100	100
LGS07074P	48.38	79.06	100	100
LGS07075P	39.35	100	97.83	98.19

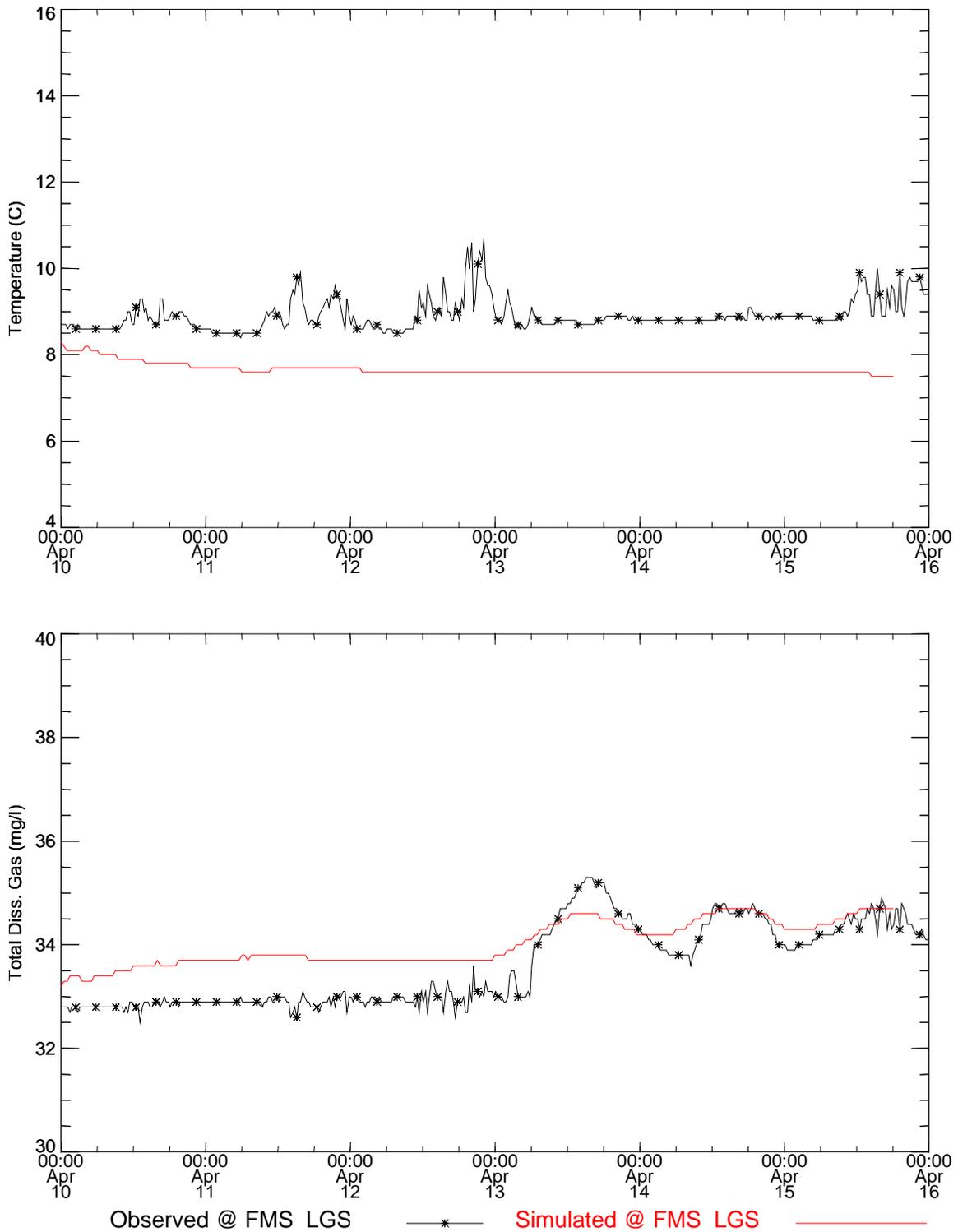


Figure 66. Temperature and total dissolved gas concentration time series near at the LGS fixed monitor during the Spring 1997 pool study (FMS-BC).

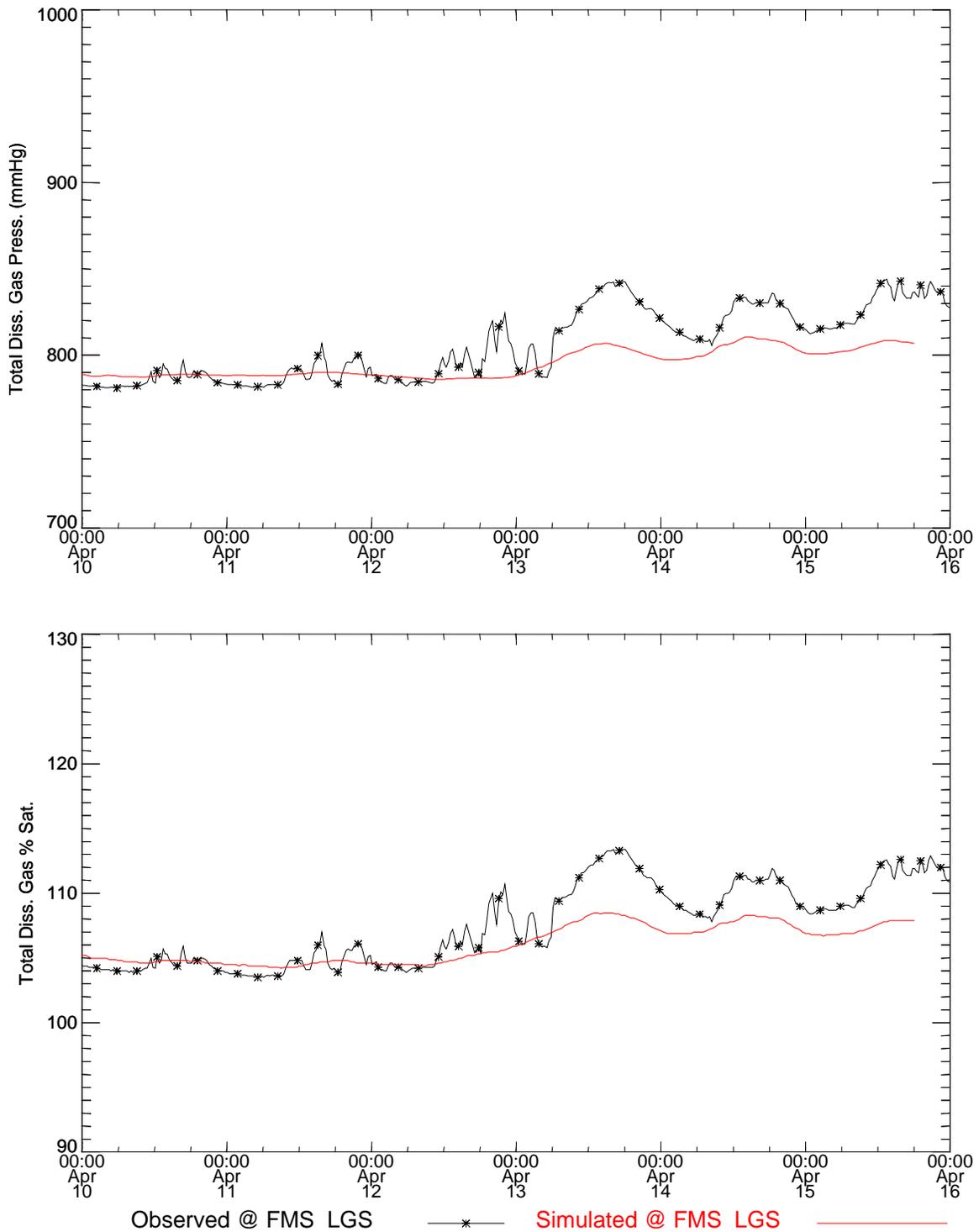


Figure 67. Total dissolved gas pressure and saturation time series near at the LGS fixed monitor during the Spring 1997 pool study (FMS-BC).

Table 11. Statistical summary of measurements and simulations at fixed monitor LGS for the Spring 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_LGS	8.89	7.67	0.34	0.14	1.29
Concentration					
FMS_LGS	33.57	34.02	0.79	0.43	0.62
Gas Pressure					
FMS_LGS	805.19	795.12	19.96	8.15	16.45
% Saturation					
FMS_LGS	107.43	106.04	3.07	1.46	2.23

Table 12. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGS for the Spring 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGS	22.38	97.47	100	99.28

Boundary Conditions using Temporary Monitored Field Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from water temperatures and TDG pressures measured by temporary monitors are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as TM-BC in the figure and table captions.

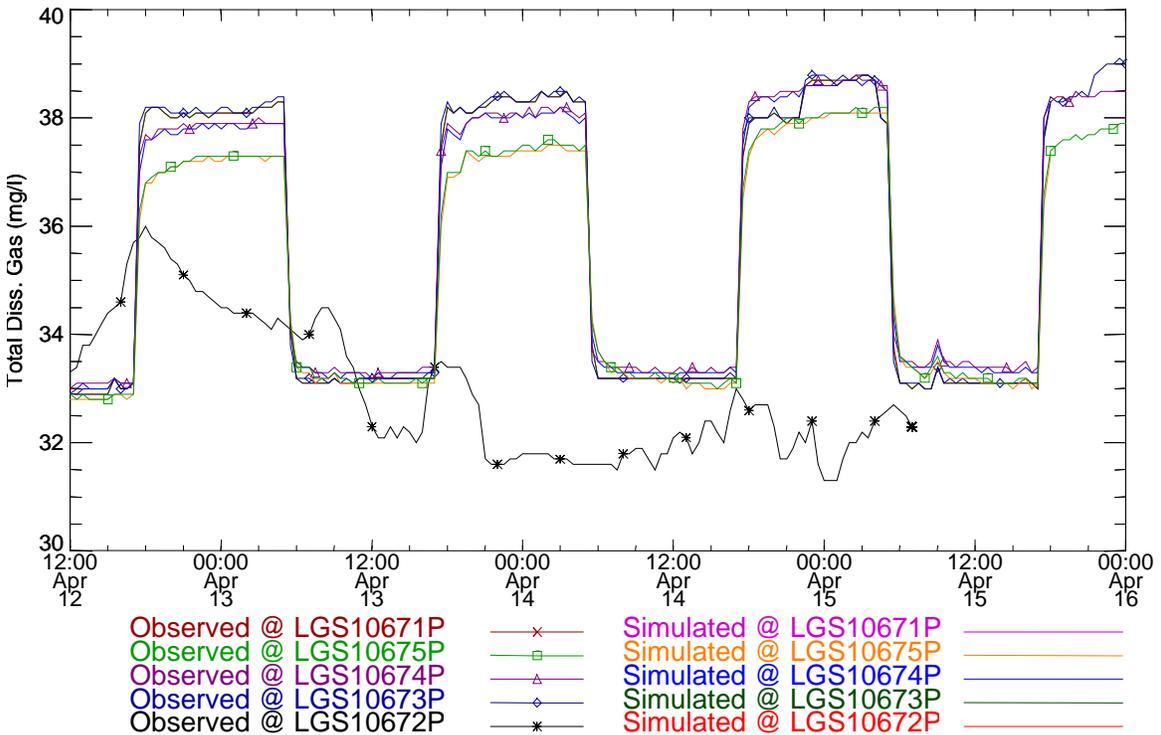
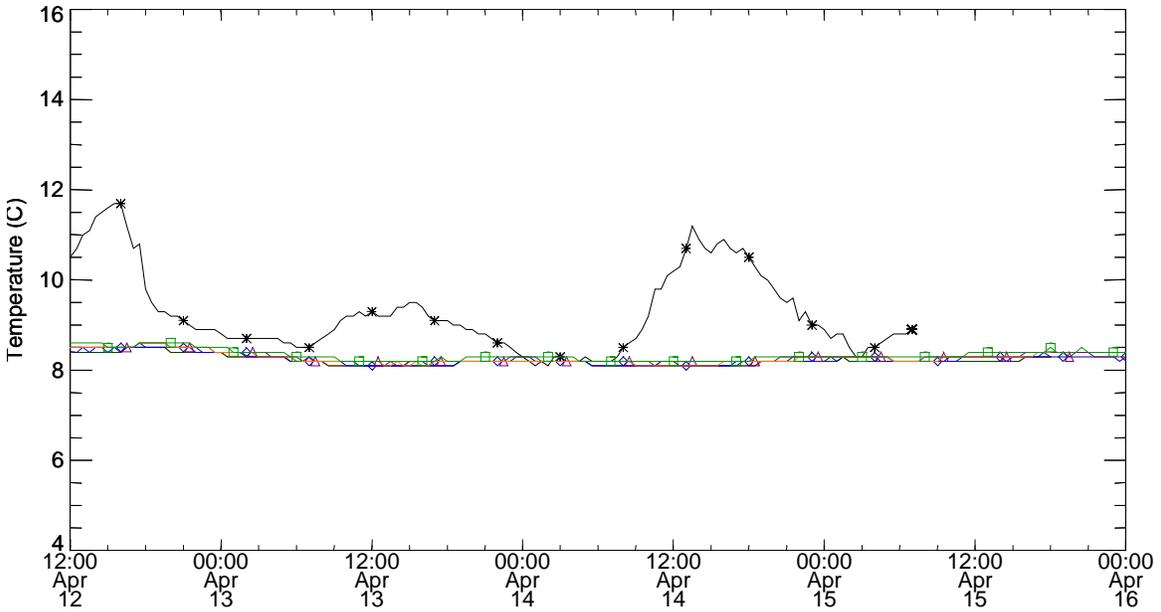


Figure 68. Temperature and total dissolved gas concentration time series near Snake River Mile 106.7 for the Spring 1997 pool study (TM-BC).

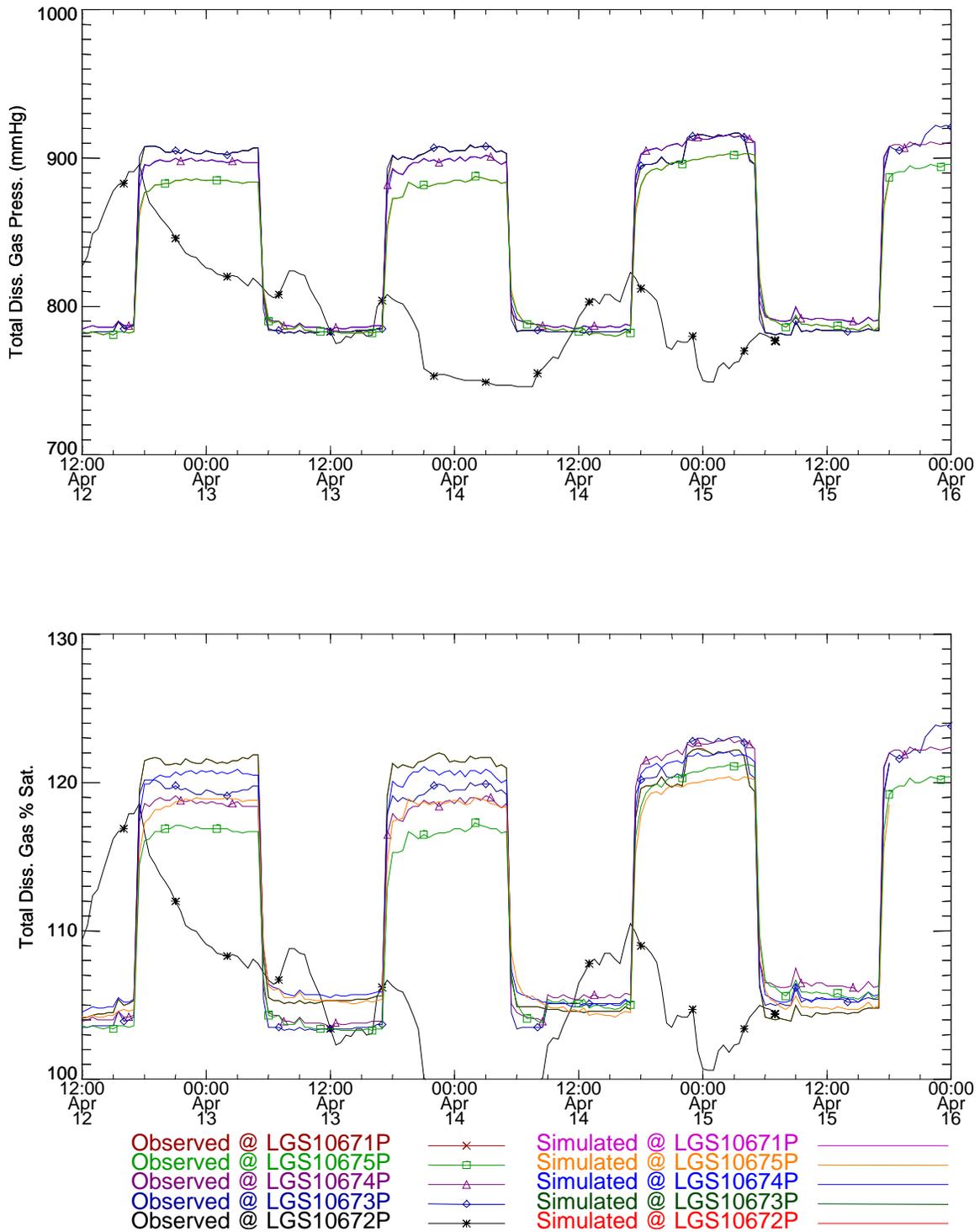


Figure 69. Total dissolved gas pressure and saturation time series near Snake River Mile 106.7 for the Spring 1997 pool study (TM-BC).

Table 13. Statistical summary of measurements and simulations near Snake River mile 106.7 for the Spring 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS10672P	9.21	8.22	0.86	0.11	1.3
LGS10673P	8.26	8.22	0.12	0.11	0.07
LGS10674P	8.29	8.24	0.12	0.13	0.07
LGS10675P	8.33	8.27	0.12	0.13	0.08
Concentration					
LGS10672P	32.86	35.54	1.2	2.54	3.82
LGS10673P	35.58	35.54	2.56	2.54	0.09
LGS10674P	35.61	35.56	2.4	2.39	0.09
LGS10675P	35.22	35.17	2.15	2.15	0.07
Gas Pressure					
LGS10672P	794.58	840.76	36.02	60.26	85.7
LGS10673P	840.87	840.76	60.57	60.26	1.71
LGS10674P	841.91	841.74	56.74	56.42	1.46
LGS10675P	833.43	833.34	50.9	50.76	0.8
% Saturation					
LGS10672P	105.7	112.56	4.62	8.18	11.94
LGS10673P	111.87	112.56	7.96	8.18	1.47
LGS10674P	112.01	112.7	7.5	7.64	1.46
LGS10675P	110.88	111.56	6.74	6.89	1.43

Table 14. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 106.7 for the Spring 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS10672P	66.88	30.57	42.68	42.68
LGS10673P	100	100	100	100
LGS10674P	100	100	100	100
LGS10675P	100	100	100	100

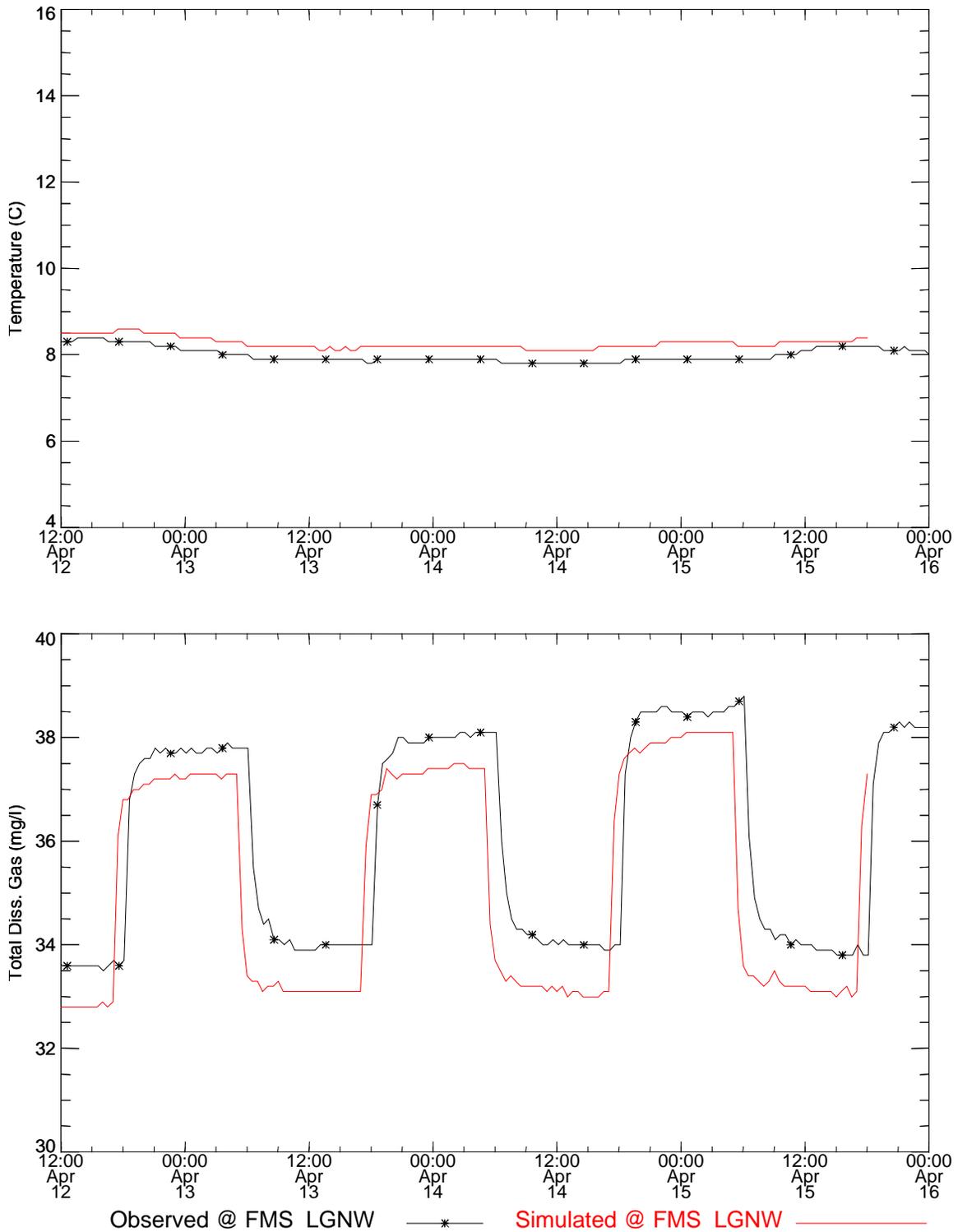


Figure 70. Total dissolved gas pressure and saturation time series near at the LGNW fixed monitor during the Spring 1997 pool study (TM-BC).

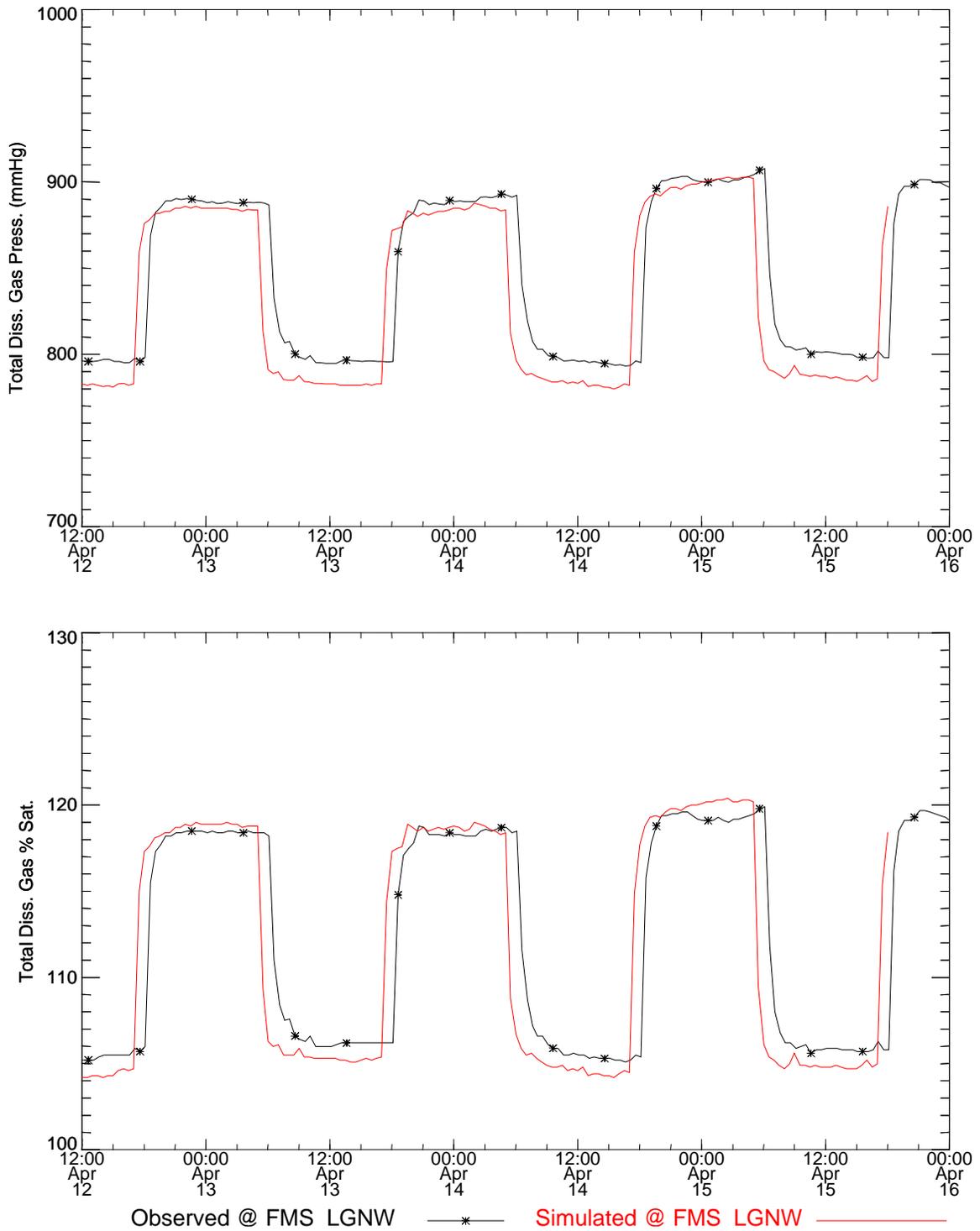


Figure 71. Total dissolved gas pressure and saturation time series near at the LGNW fixed monitor during the Spring 1997 pool study (TM-BC).

Table 15. Statistical summary of measurements and simulations at fixed monitor LGNW for the Spring 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_LGNW	7.98	8.27	0.17	0.13	0.3
Concentration					
FMS_LGNW	35.88	35.17	2	2.15	1.34
Gas Pressure					
FMS_LGNW	842.16	833.31	46.07	50.71	28.13
% Saturation					
FMS_LGNW	111.83	111.56	6.19	6.88	3.58

Table 16. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGNW for the Spring 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGNW	100	81.53	89.17	88.54

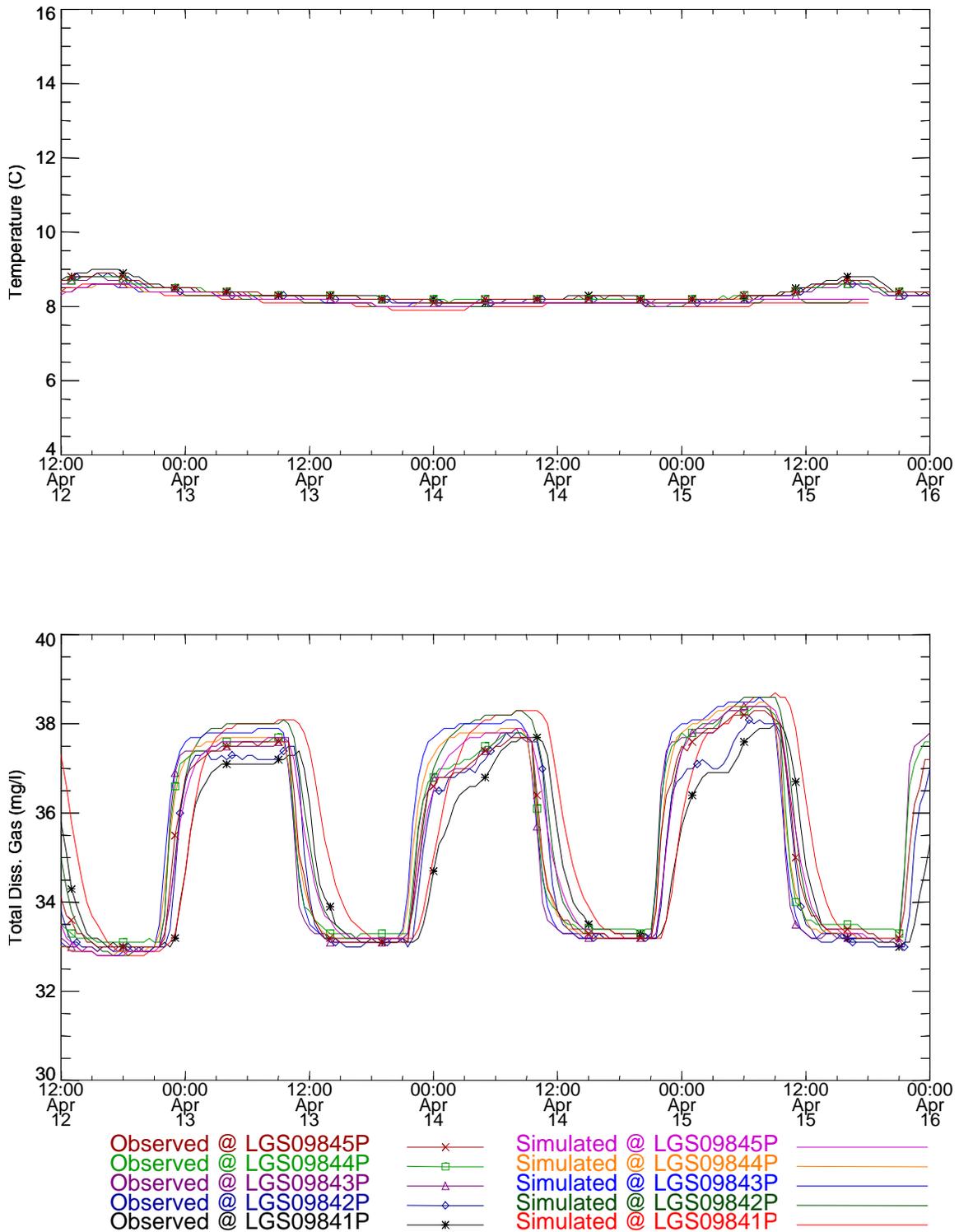


Figure 72. Temperature and total dissolved gas concentration time series near Snake River Mile 98.4 for the Spring 1997 pool study (TM-BC).

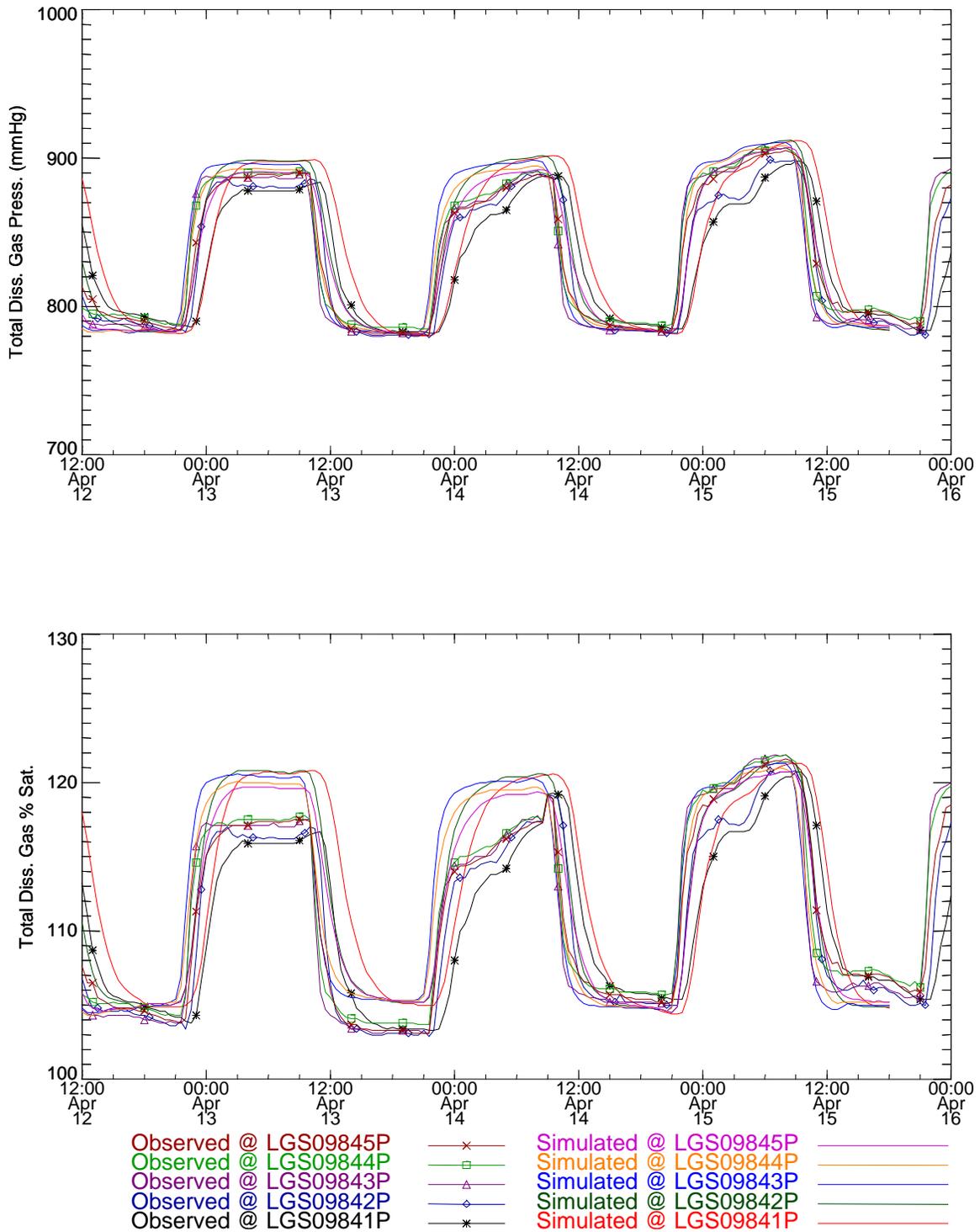


Figure 73. Total dissolved gas pressure and saturation time series near Snake River Mile 98.4 for the Spring 1997 pool study (TM-BC).

Table 17. Statistical summary of measurements and simulations near Snake River mile 98.4 for the Spring 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS09841P	8.38	8.13	0.24	0.18	0.28
LGS09842P	8.31	8.17	0.21	0.16	0.18
LGS09843P	8.31	8.2	0.17	0.14	0.14
LGS09844P	8.35	8.2	0.18	0.15	0.17
LGS09845P	8.35	8.19	0.21	0.16	0.2
Concentration					
LGS09841P	35.11	35.65	1.83	2.15	0.73
LGS09842P	35.1	35.53	2	2.23	0.56
LGS09843P	35.21	35.41	2.15	2.29	0.42
LGS09844P	35.35	35.35	2.07	2.19	0.28
LGS09845P	35.26	35.36	2.04	2.11	0.39
Gas Pressure					
LGS09841P	831.65	841.72	40.8	49.41	15.55
LGS09842P	830.29	839.64	45.36	51.56	13.11
LGS09843P	832.73	837.35	49.42	53.36	10.17
LGS09844P	836.77	836.12	47.08	50.79	7.53
LGS09845P	834.78	835.86	46.36	48.55	9.46
% Saturation					
LGS09841P	110.65	112.68	5.52	6.56	2.9
LGS09842P	110.47	112.41	6.06	6.89	2.7
LGS09843P	110.79	112.1	6.58	7.16	2.45
LGS09844P	111.33	111.93	6.28	6.8	1.96
LGS09845P	111.07	111.89	6.22	6.48	2.04

Table 18. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 098.4 for the Spring 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
LGS09841P	100	85.35	99.36	94.9
LGS09842P	100	95.54	100	94.27
LGS09843P	100	96.18	100	94.9
LGS09844P	100	100	100	100
LGS09845P	100	96.18	100	98.09

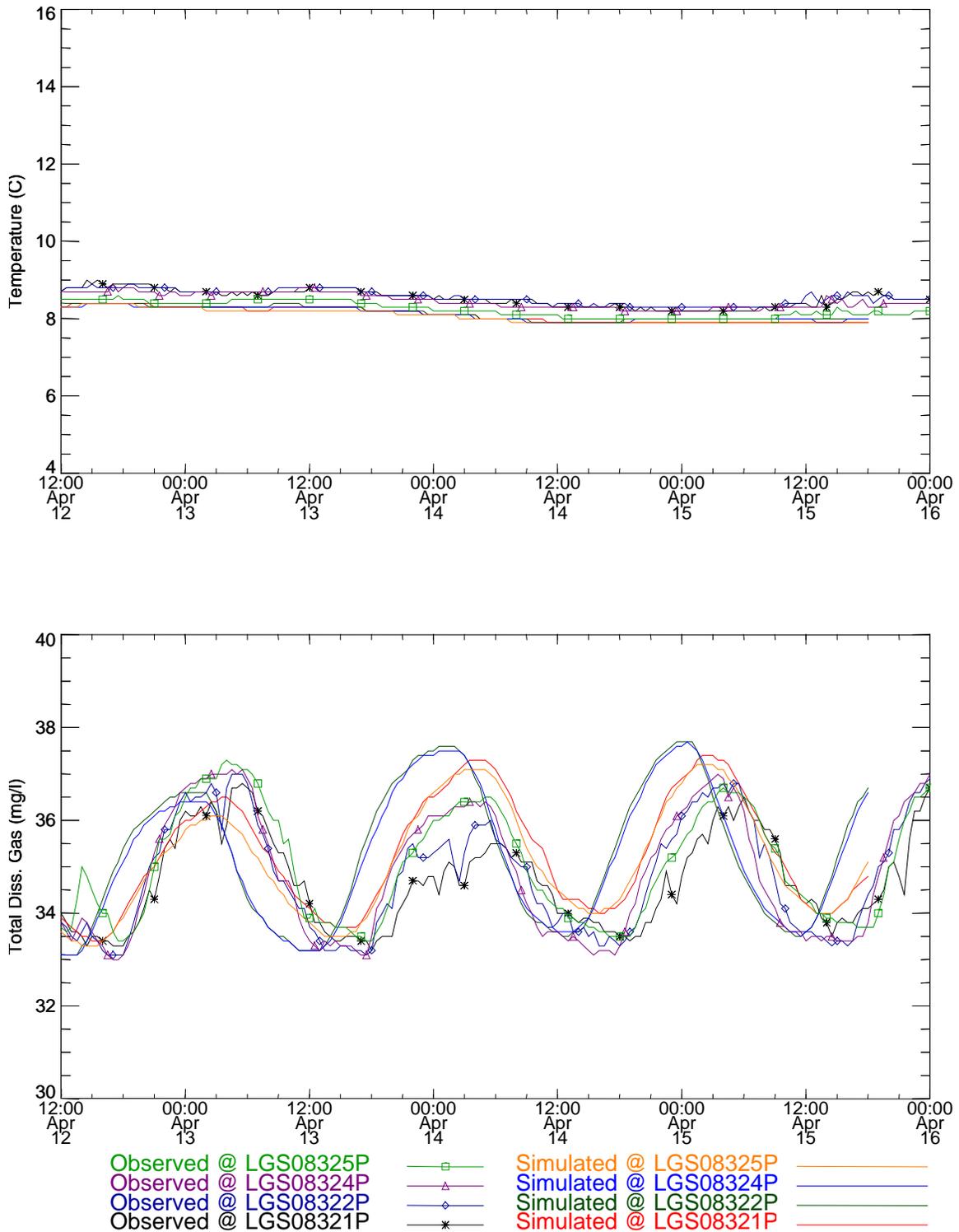


Figure 74. Temperature and total dissolved gas concentration time series near Snake River Mile 83.2 for the Spring 1997 pool study (TM-BC).

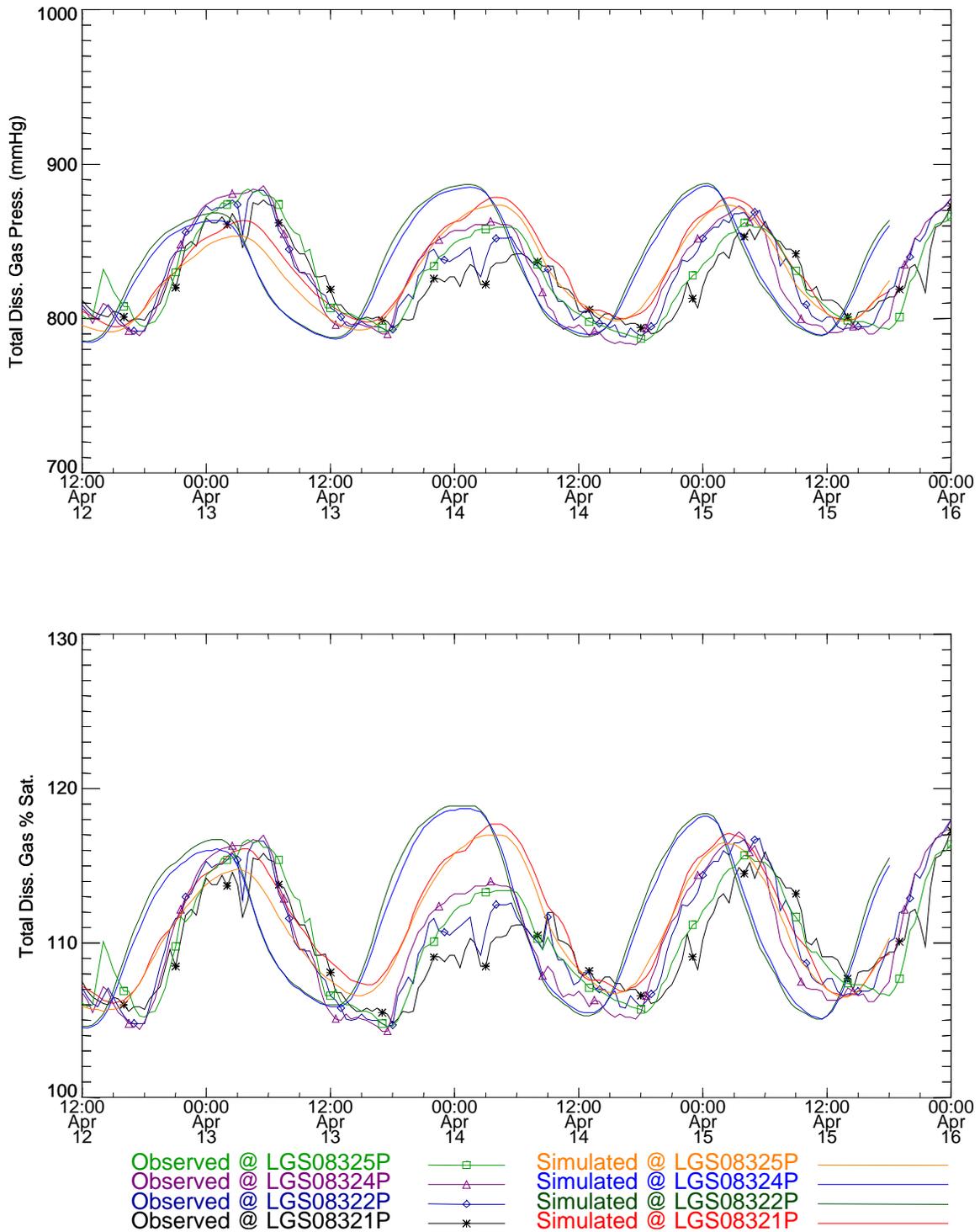


Figure 75. Total dissolved gas pressure and saturation time series near Snake River Mile 83.2 for the Spring 1997 pool study (TM-BC).

Table 19. Statistical summary of measurements and simulations near Snake River mile 83.2 for the Spring 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS08321P	8.53	8.1	0.23	0.19	0.44
LGS08322P	8.56	8.14	0.19	0.17	0.43
LGS08324P	8.47	8.12	0.2	0.17	0.36
LGS08325P	8.24	8.07	0.2	0.17	0.19
Concentration					
LGS08321P	34.64	35.28	1	1.2	1.02
LGS08322P	34.72	35.28	1.21	1.46	1.5
LGS08324P	34.79	35.23	1.36	1.42	1.27
LGS08325P	35.01	35.13	1.2	1.18	0.77
Gas Pressure					
LGS08321P	823.87	832.6	22.81	27.16	20.65
LGS08322P	826.26	833.24	27.81	33.93	33.17
LGS08324P	826.23	831.71	31.97	33.08	28.47
LGS08325P	827.05	828.45	28.2	26.49	18.39
% Saturation					
LGS08321P	109.61	111.46	2.97	3.68	3.28
LGS08322P	109.93	111.55	3.59	4.65	4.79
LGS08324P	109.91	111.35	4.02	4.53	3.97
LGS08325P	110.03	110.91	3.52	3.58	2.42

Table 20. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 083.2 for the Spring 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
LGS08321P	100	71.97	90.45	83.44
LGS08322P	100	47.13	64.97	63.06
LGS08324P	100	50.96	80.25	71.97
LGS08325P	100	78.98	96.82	100

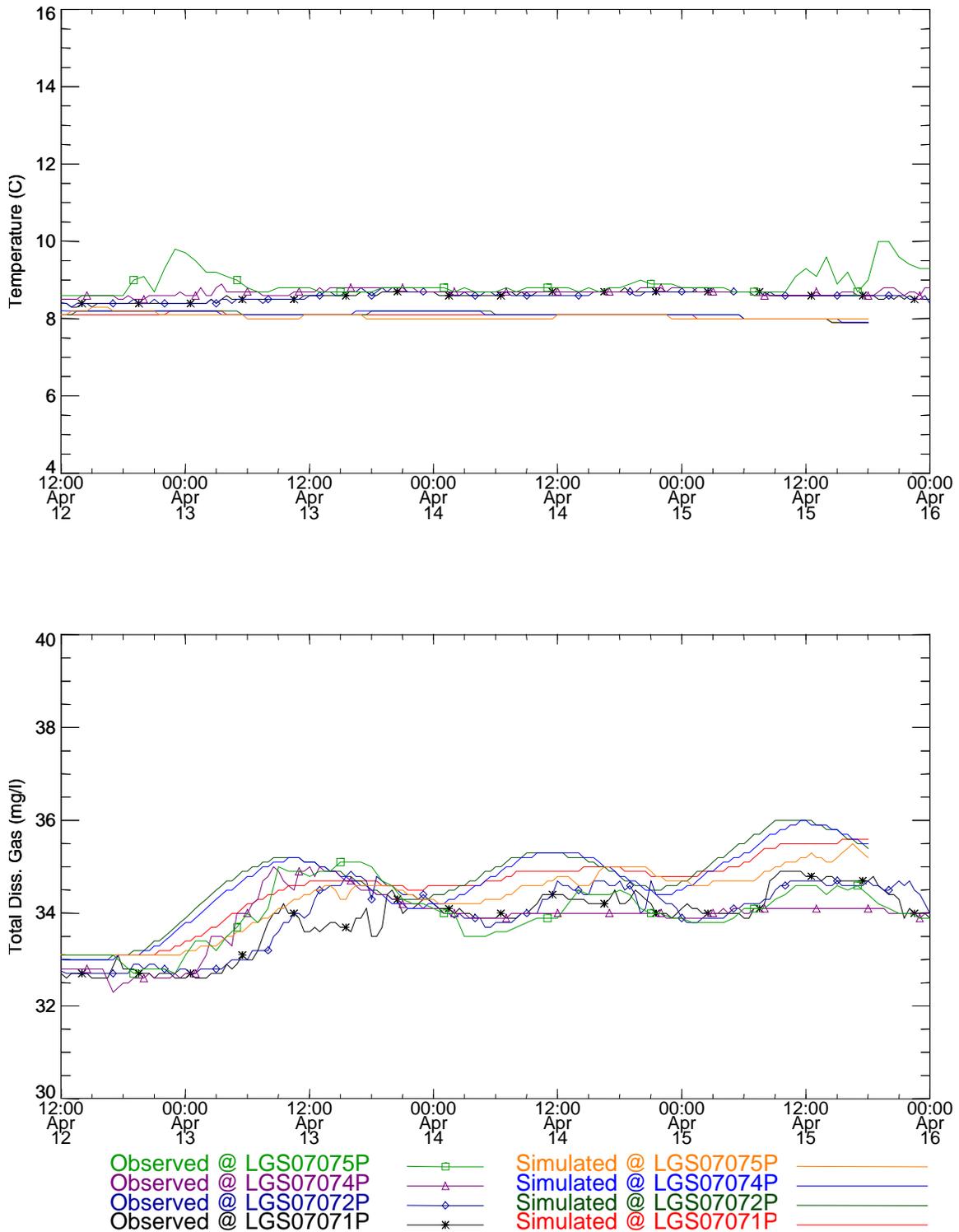


Figure 76. Temperature and total dissolved gas concentration time series near Snake River Mile 70.7 for the Spring 1997 pool study (TM-BC).

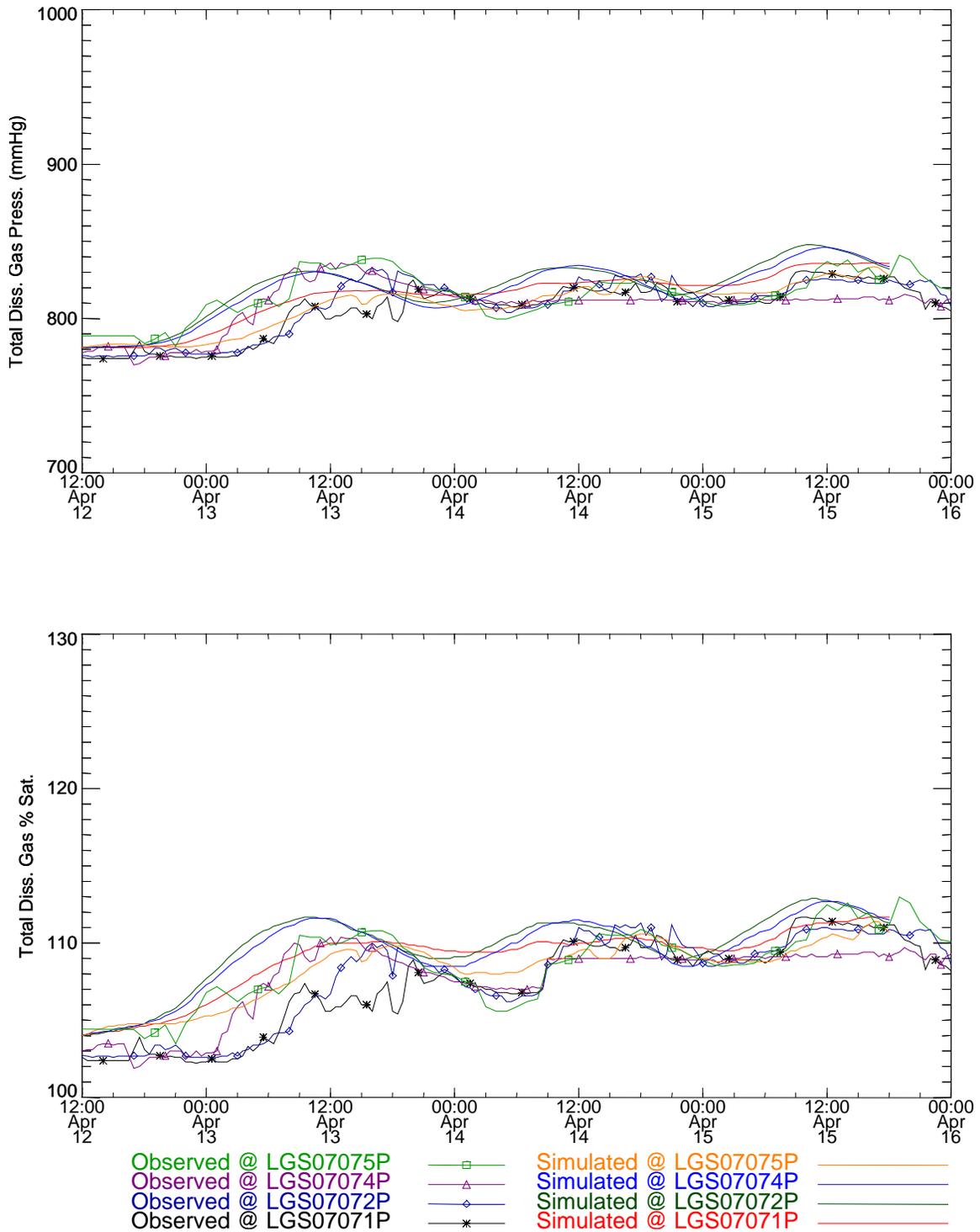


Figure 77. Total dissolved gas pressure and saturation time series near Snake River Mile 70.7 for the Spring 1997 pool study (TM-BC).

Table 21. Statistical summary of measurements and simulations near Snake River mile 70.7 for the Spring 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS07071P	8.59	8.08	0.12	0.06	0.53
LGS07072P	8.59	8.11	0.12	0.08	0.5
LGS07074P	8.68	8.12	0.08	0.08	0.58
LGS07075P	8.86	8.06	0.24	0.07	0.84
Concentration					
LGS07071P	33.82	34.53	0.69	0.74	0.76
LGS07072P	33.91	34.73	0.71	0.8	1
LGS07074P	33.87	34.64	0.64	0.8	0.94
LGS07075P	33.99	34.3	0.63	0.69	0.56
Gas Pressure					
LGS07071P	805.47	814.39	17.86	16.46	10.73
LGS07072P	807.76	819.86	18.51	17.68	18.5
LGS07074P	808.66	818.07	16.07	17.67	15.53
LGS07075P	814.67	808.75	14.88	15.35	12.68
% Saturation					
LGS07071P	107.18	109.02	3.01	2.1	2.4
LGS07072P	107.49	109.75	3	2.29	3.15
LGS07074P	107.59	109.52	2.4	2.29	2.27
LGS07075P	108.4	108.27	2.35	1.94	1.07

Table 22. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 070.7 for the Spring 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS07071P	100	89.81	100	99.36
LGS07072P	100	59.24	94.27	85.35
LGS07074P	100	66.24	100	100
LGS07075P	85.99	100	100	100

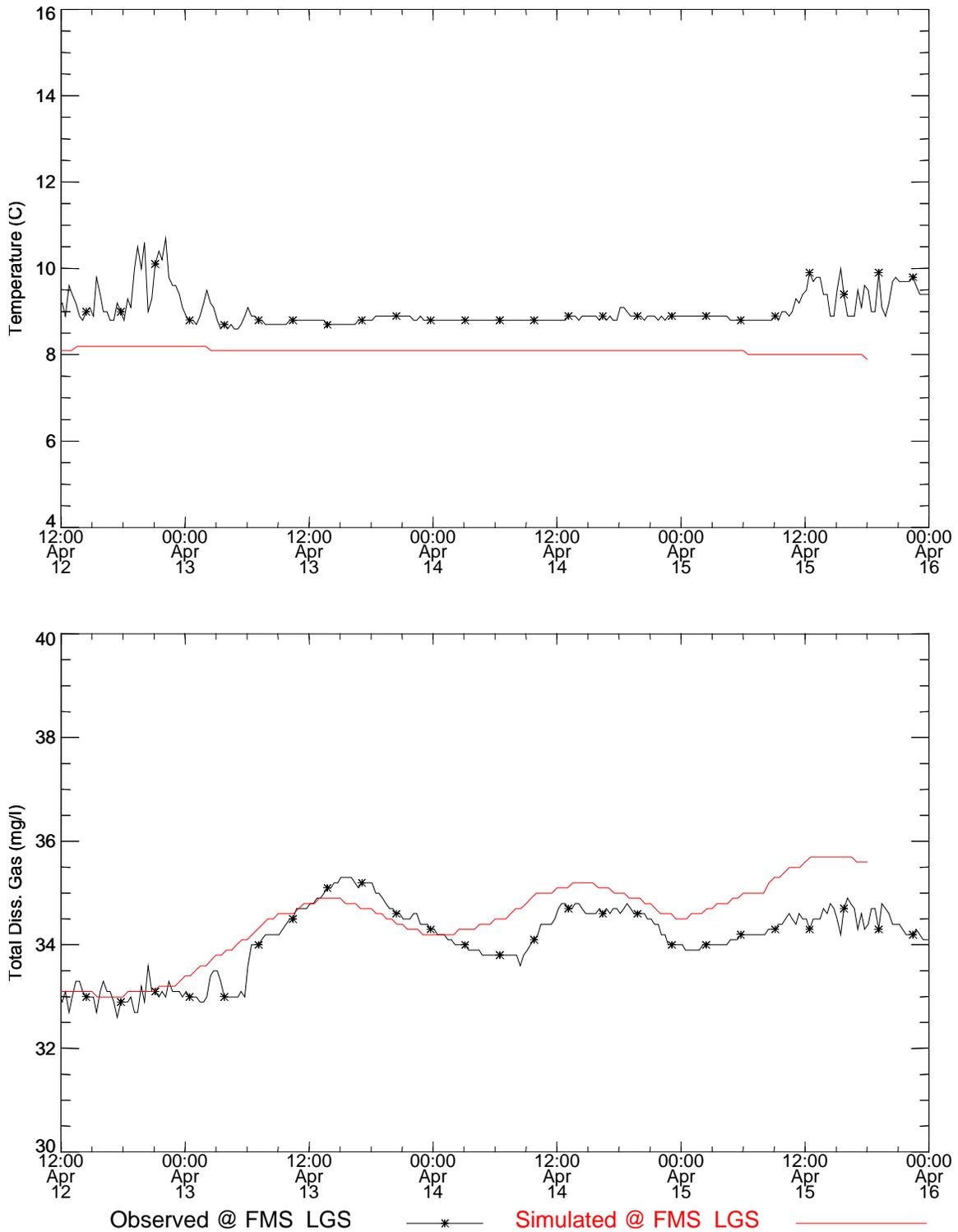


Figure 78. Total dissolved gas pressure and saturation time series near at the LGS fixed monitor during the Spring 1997 pool study (TM-BC).

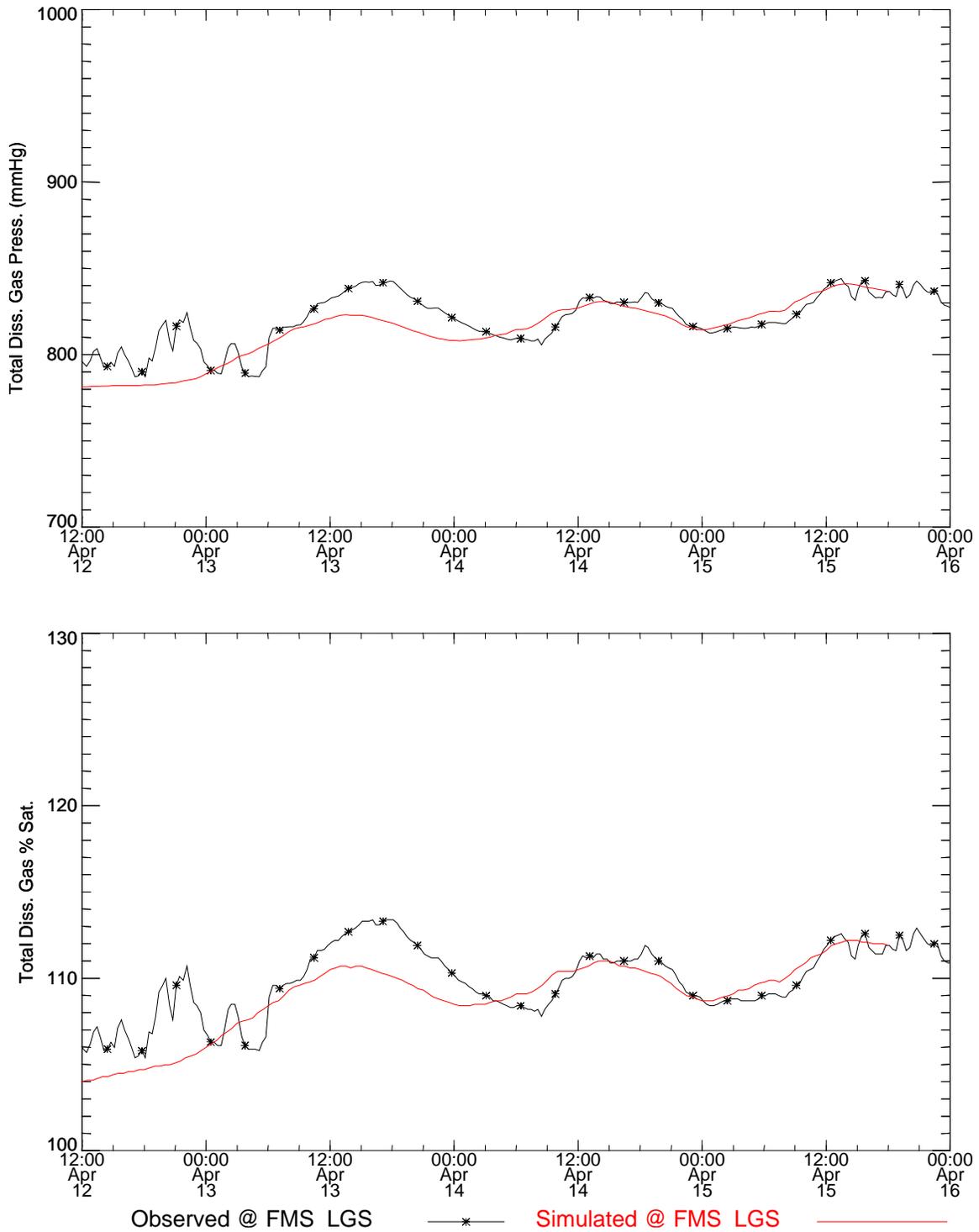


Figure 79. Total dissolved gas pressure and saturation time series near at the LGNW fixed monitor during the Spring 1997 pool study (TM-BC).

Table 23. Statistical summary of measurements and simulations at fixed monitor LGS for the Spring 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_LGS	8.98	8.1	0.35	0.06	0.95
Concentration					
FMS_LGS	34.09	34.49	0.67	0.76	0.59
Gas Pressure					
FMS_LGS	819.31	813.99	14.96	16.83	12.14
% Saturation					
FMS_LGS	109.72	108.97	2.04	2.16	1.65

Table 24. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGS for the Spring 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGS	82.17	91.72	100	99.36

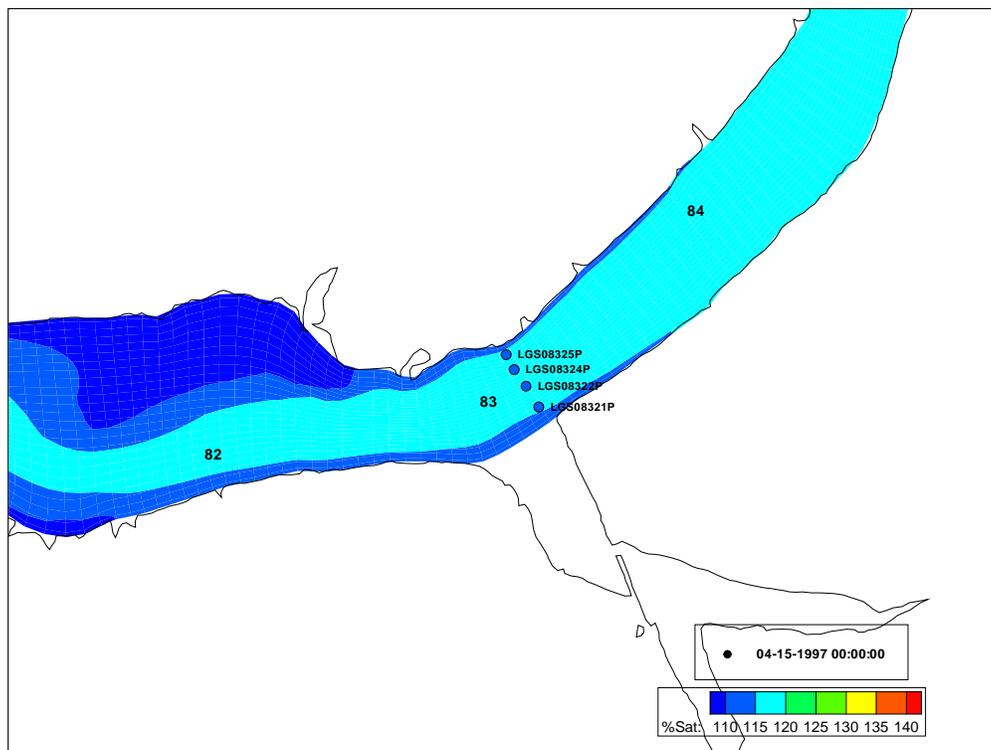


Figure 80. Spatial distribution of dissolved gas near Snake river mile 83 during the Spring 1997 study period.

1.4.2 1997 Summer Simulation

Boundary Conditions using Lower Granite Sourcing Function and Forebay FMS Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from the empirical project gas sourcing function and the forebay FMS are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as FMS-BC in the figure and table captions.

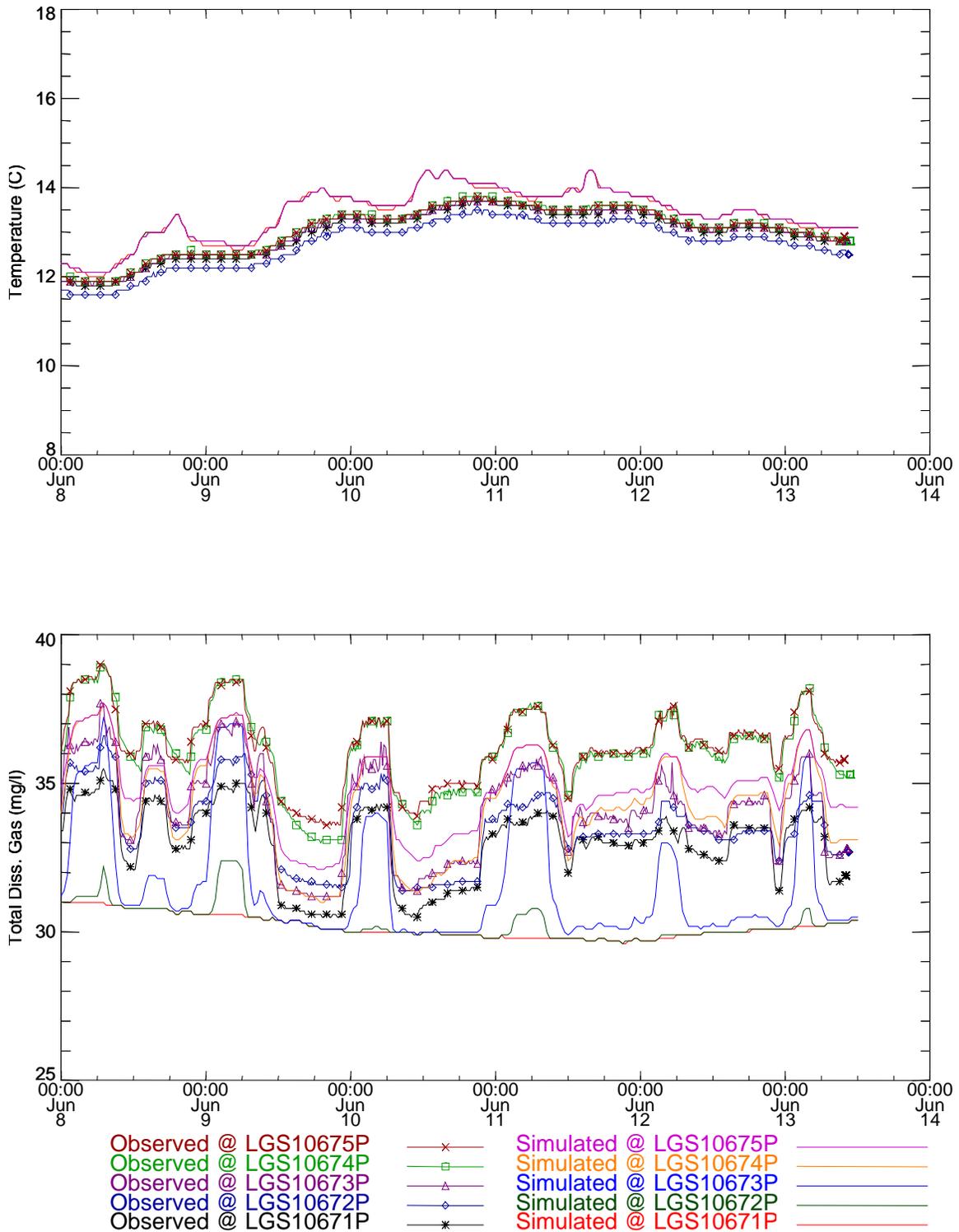


Figure 81. Temperature and total dissolved gas concentration time series near Snake River Mile 106.7 for the Summer 1997 pool study (FMS-BC).

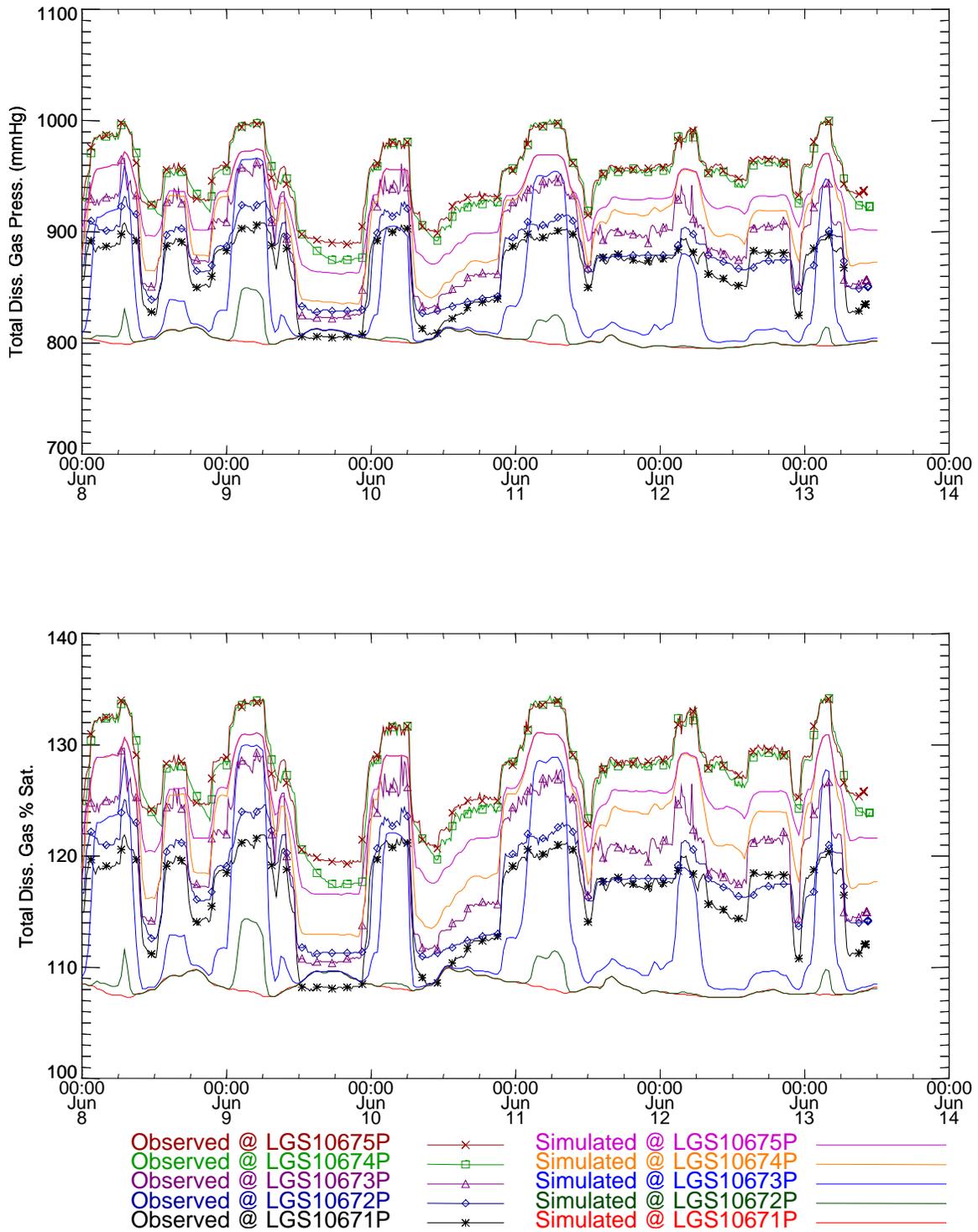


Figure 82. Total dissolved gas pressure and saturation time series near Snake River Mile 106.7 for the Summer 1997 pool study (FMS-BC).

Table 25. Statistical summary of measurements and simulations near Snake River mile 106.7 for the Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS10671P	12.96	13.41	0.54	0.59	0.49
LGS10672P	12.75	13.43	0.54	0.58	0.71
LGS10673P	13.01	13.43	0.53	0.58	0.46
LGS10674P	13.07	13.43	0.54	0.58	0.4
LGS10675P	13.05	13.43	0.54	0.58	0.41
Concentration					
LGS10671P	33	30.18	1.29	0.39	3.07
LGS10672P	33.56	30.31	1.3	0.57	3.42
LGS10673P	34.12	31.65	1.62	2.07	2.8
LGS10674P	36.14	34.32	1.39	1.75	1.89
LGS10675P	36.26	34.84	1.27	1.38	1.44
Gas Pressure					
LGS10671P	865.88	802.5	30.71	5.05	71.68
LGS10672P	876.6	805.87	29.51	9.88	76.39
LGS10673P	895.82	840.72	39.04	49.44	64.85
LGS10674P	949.42	910.54	32.65	40.57	40.61
LGS10675P	952.17	924.17	29.75	30.24	28.54
% Saturation					
LGS10671P	116.24	108.25	4.12	0.73	9.19
LGS10672P	117.68	108.71	3.96	1.31	9.8
LGS10673P	120.26	113.41	5.24	6.62	8.25
LGS10674P	127.45	122.83	4.38	5.44	4.89
LGS10675P	127.82	124.67	3.99	4.04	3.23

Table 26. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 106.7 for the Summer 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS10671P	100	13.24	26.87	27.26
LGS10672P	90.4	0	21.5	21.5
LGS10673P	100	17.66	31.29	35.32
LGS10674P	100	0.77	49.14	61.23
LGS10675P	100	4.99	95.97	99.62

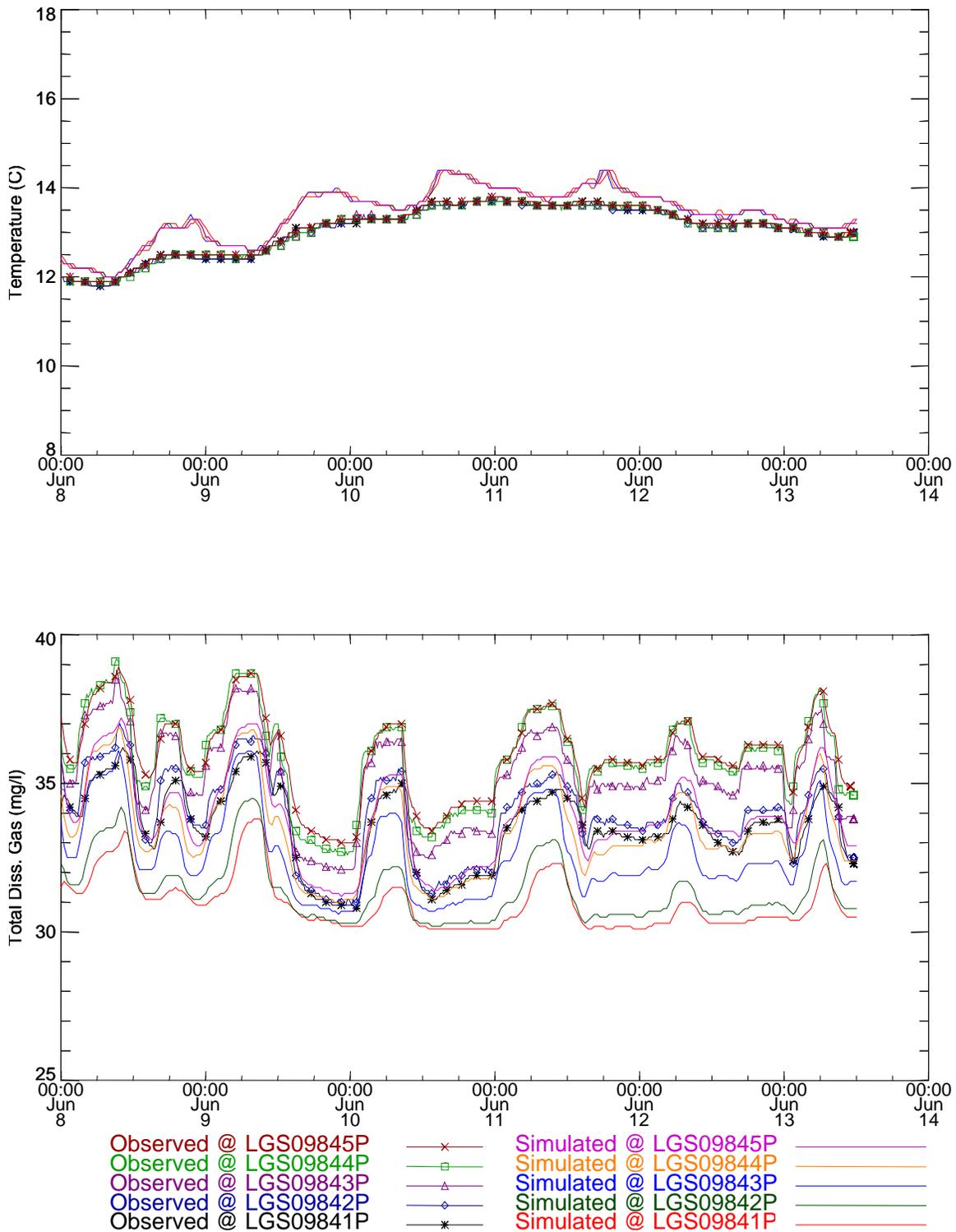


Figure 83. Temperature and total dissolved gas concentration time series near Snake River Mile 098.4 for the Summer 1997 pool study (FMS-BC).

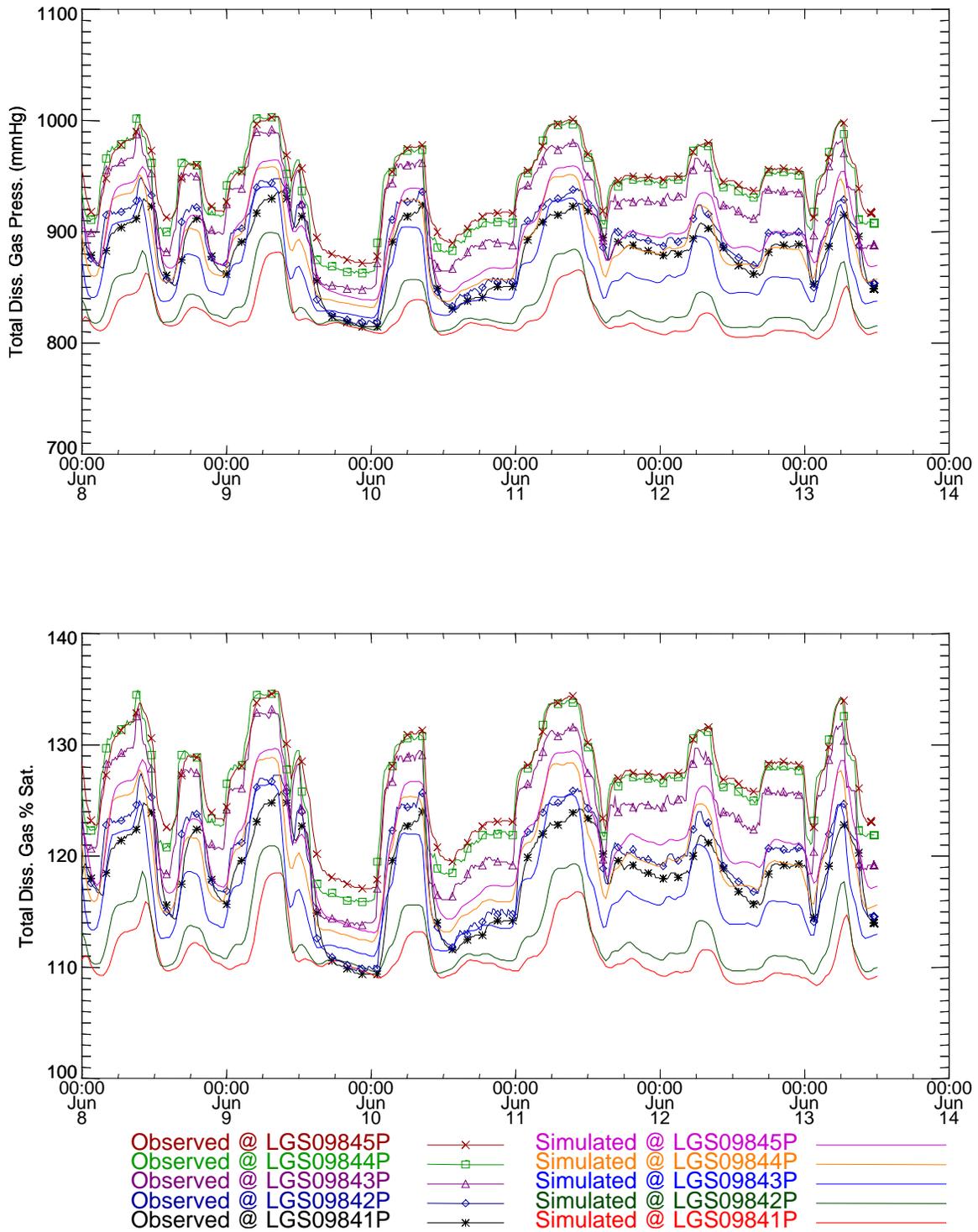


Figure 84. Total dissolved gas pressure and saturation time series near Snake River Mile 098.4 for the Summer 1997 pool study (FMS-BC).

Table 27. Statistical summary of measurements and simulations near Snake River mile 098.4 for the Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS09841P	13.06	13.42	0.55	0.59	0.41
LGS09842P	13.04	13.41	0.55	0.6	0.42
LGS09843P	13.07	13.4	0.55	0.6	0.39
LGS09844P	13.05	13.4	0.54	0.6	0.4
LGS09845P	13.09	13.41	0.55	0.6	0.37
Concentration					
LGS09841P	33.55	30.97	1.34	0.9	2.71
LGS09842P	33.92	31.39	1.48	1.05	2.65
LGS09843P	35.19	32.63	1.59	1.42	2.62
LGS09844P	35.82	33.44	1.56	1.51	2.41
LGS09845P	35.95	33.88	1.43	1.51	2.09
Gas Pressure					
LGS09841P	882.28	823.32	30.76	17.44	63.05
LGS09842P	891.1	834.02	34.37	21.69	61.1
LGS09843P	924.72	866.28	37.87	31.37	60.41
LGS09844P	940.65	887.57	37.2	33.85	54.38
LGS09845P	944.78	899.05	33.55	33.43	46.44
% Saturation					
LGS09841P	118.44	111.06	4.13	2.25	7.99
LGS09842P	119.63	112.5	4.61	2.83	7.72
LGS09843P	124.14	116.85	5.08	4.14	7.57
LGS09844P	126.28	119.73	4.99	4.47	6.73
LGS09845P	126.83	121.27	4.5	4.41	5.65

Table 28. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 098.4 for the Summer 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS09841P	100	7.78	17.46	20.3
LGS09842P	100	6.83	18.79	22.01
LGS09843P	100	0	9.11	13.09
LGS09844P	100	0.19	10.63	12.9
LGS09845P	100	0.38	20.3	29.22

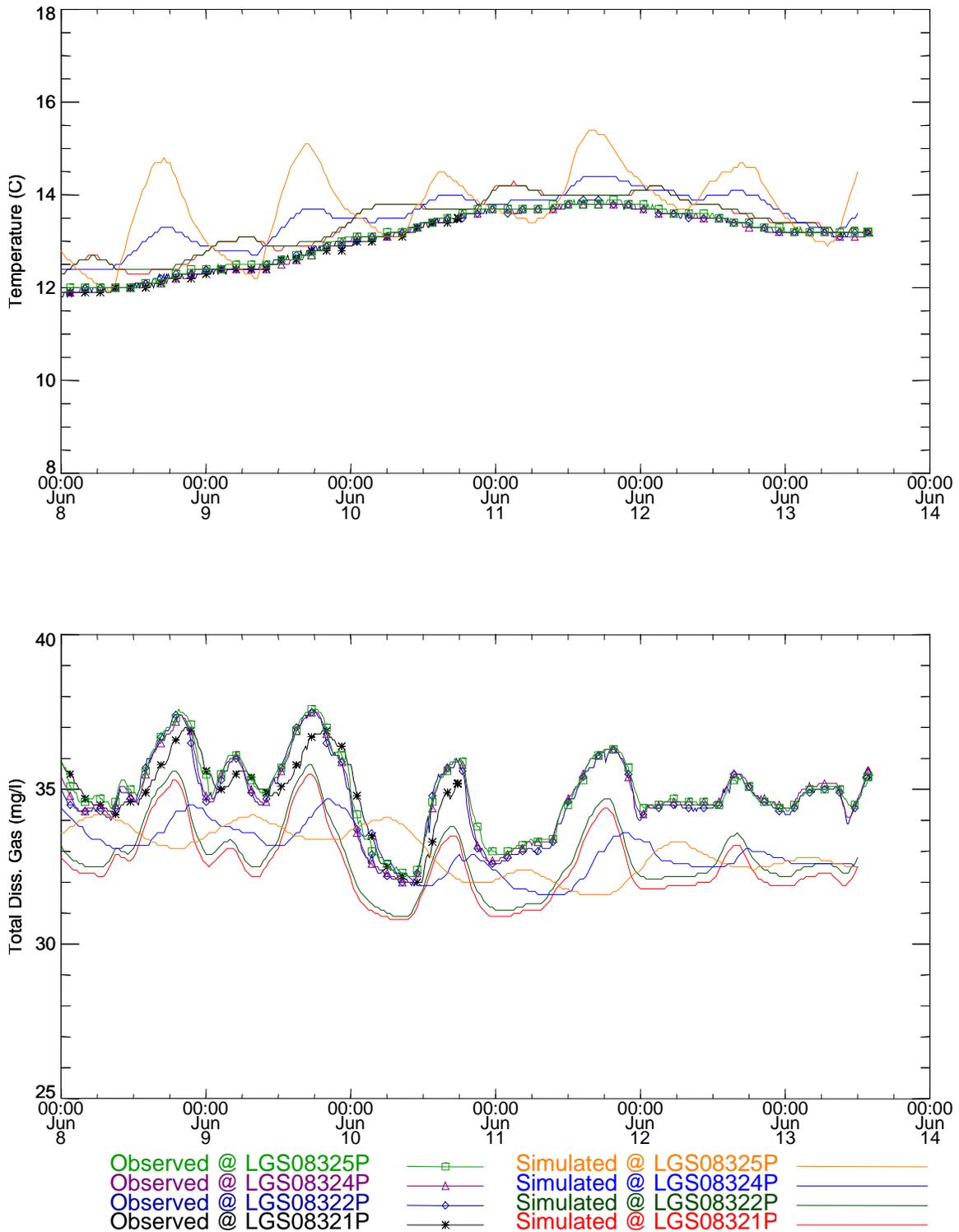


Figure 85. Temperature and total dissolved gas concentration time series near Snake River Mile 083.2 for the Summer 1997 pool study (FMS-BC).

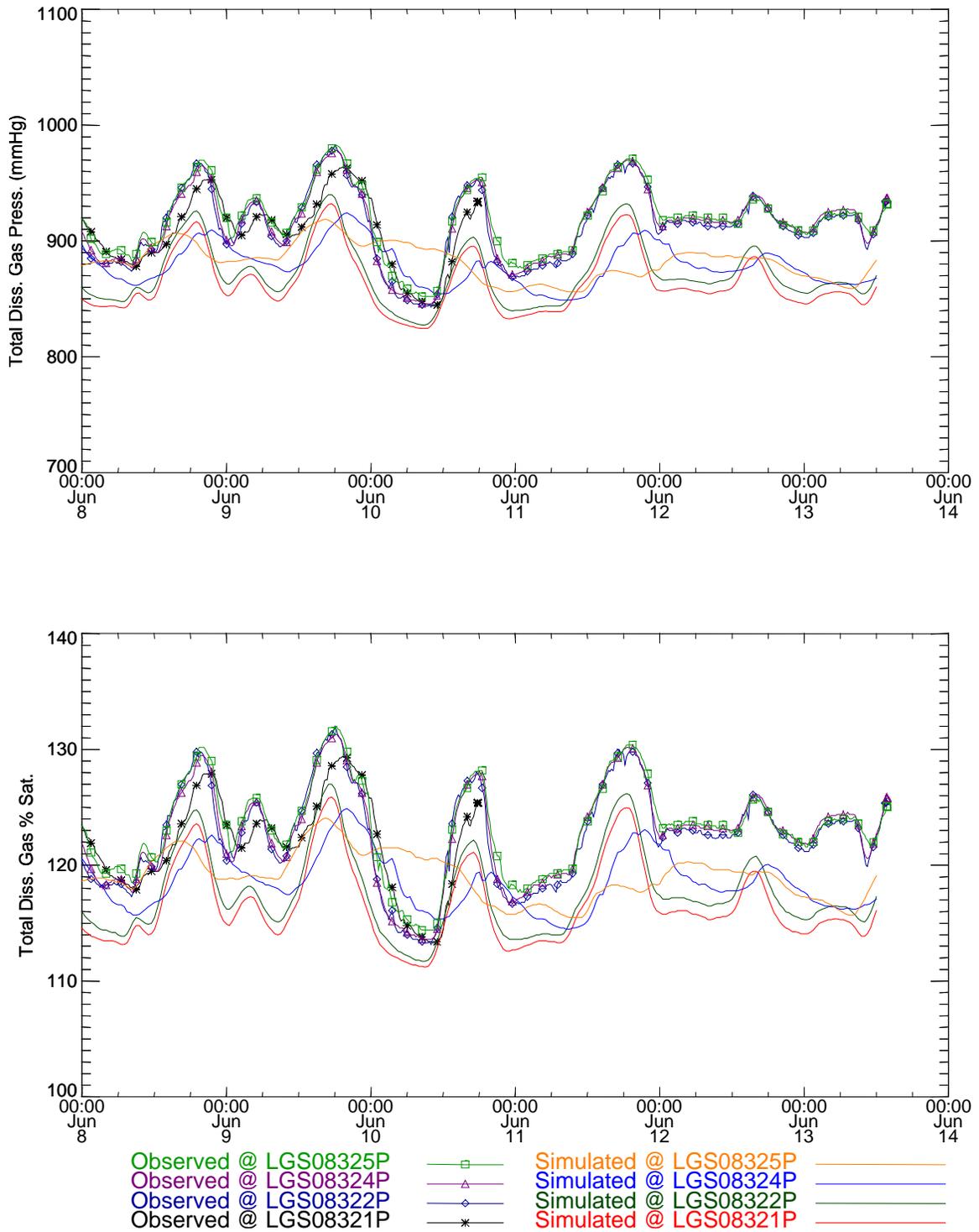


Figure 86. Total dissolved gas pressure and saturation time series near Snake River Mile 083.2 for the Summer 1997 pool study (FMS-BC).

Table 29. Statistical summary of measurements and simulations near Snake River mile 083.2 for the Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS08321P	12.55	13.01	0.49	0.51	0.49
LGS08322P	12.6	13.02	0.49	0.5	0.46
LGS08324P	12.58	13.17	0.49	0.48	0.64
LGS08325P	12.62	13.47	0.49	0.88	1.19
Concentration					
LGS08321P	34.93	32.92	1.32	1.26	2.18
LGS08322P	35	33.18	1.51	1.3	1.87
LGS08324P	35.03	33.46	1.49	0.73	1.97
LGS08325P	35.25	33.6	1.44	0.46	2.34
Gas Pressure					
LGS08321P	907.98	866.55	31.47	28.55	46.3
LGS08322P	910.93	873.86	37.51	29.55	38.91
LGS08324P	911.14	883.95	36.36	18.4	38.92
LGS08325P	917.51	893.2	34.85	11.24	41.23
% Saturation					
LGS08321P	121.89	116.78	4.23	3.93	5.83
LGS08322P	122.29	117.77	5.04	4.05	4.79
LGS08324P	122.32	119.13	4.88	2.56	4.91
LGS08325P	123.17	120.38	4.68	1.59	5.25

Table 30. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 083.2 for the Summer 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS08321P	100	14.77	47.35	49.62
LGS08322P	100	1.89	53.03	59.85
LGS08324P	93.18	30.68	60.61	60.23
LGS08325P	67.8	21.59	53.41	53.03

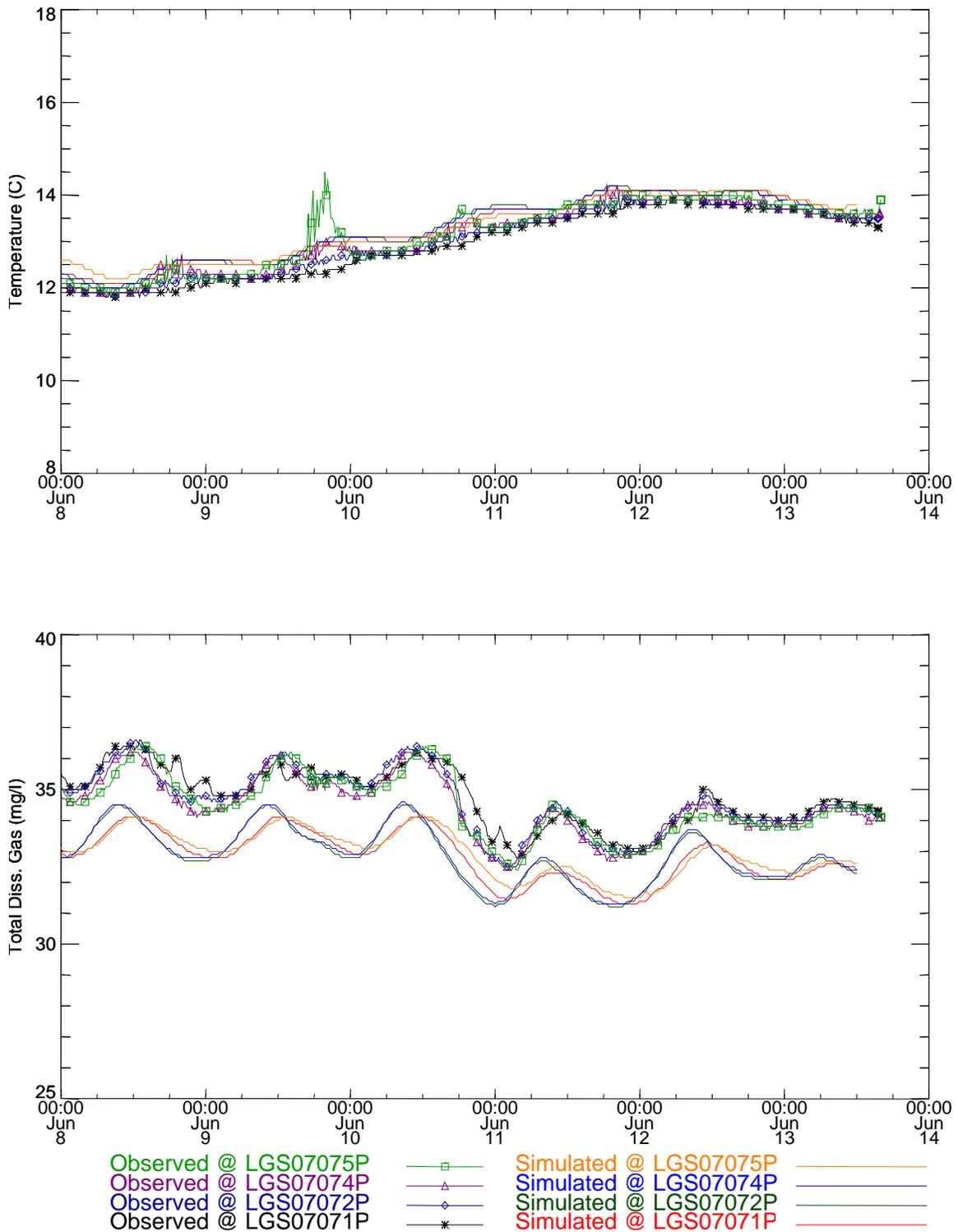


Figure 87. Temperature and total dissolved gas concentration time series near Snake River Mile 070.7 for the Summer 1997 pool study (FMS-BC).

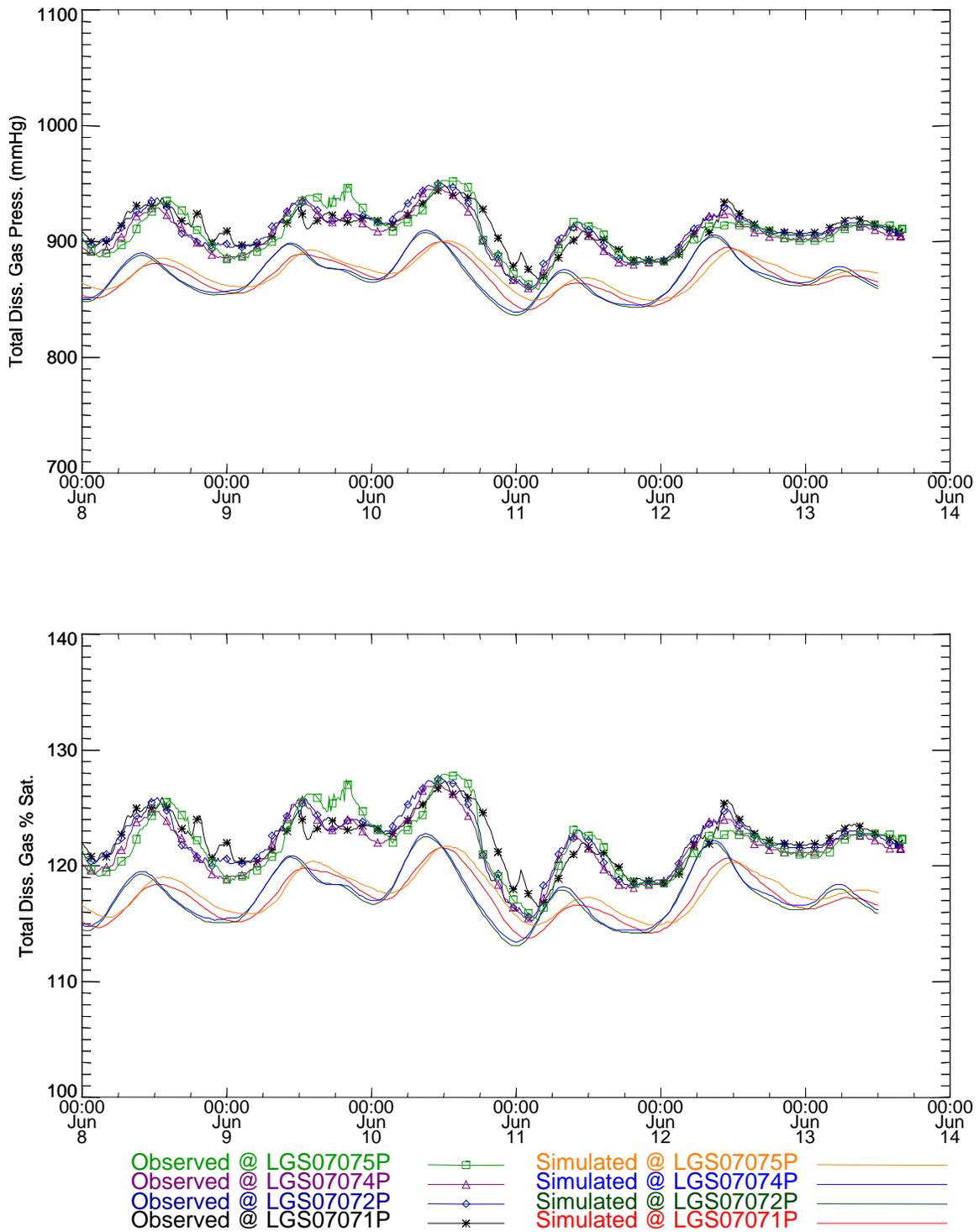


Figure 88. Total dissolved gas pressure and saturation time series near Snake River Mile 070.7 for the Summer 1997 pool study (FMS-BC).

Table 31. Statistical summary of measurements and simulations near Snake River mile 070.7 for the Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS07071P	12.94	13.28	0.71	0.67	0.36
LGS07072P	13.02	13.29	0.7	0.69	0.3
LGS07074P	13.09	13.28	0.69	0.68	0.21
LGS07075P	13.15	13.29	0.71	0.64	0.27
Concentration					
LGS07071P	34.75	32.81	0.96	0.8	1.97
LGS07072P	34.65	32.84	1.01	0.9	1.86
LGS07074P	34.45	32.9	0.97	0.89	1.59
LGS07075P	34.49	32.94	1	0.73	1.6
Gas Pressure					
LGS07071P	910.78	869	16.62	14.48	42.51
LGS07072P	909.71	869.62	18.81	17.1	41.39
LGS07074P	906.05	871.25	18.43	16.85	36.02
LGS07075P	908.1	872.46	20.36	12.97	37.16
% Saturation					
LGS07071P	122.27	117.22	2.23	1.91	5.17
LGS07072P	122.13	117.31	2.52	2.23	5.02
LGS07074P	121.64	117.53	2.48	2.19	4.3
LGS07075P	121.91	117.69	2.73	1.72	4.46

Table 32. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 070.7 for the Summer 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS07071P	100	0.18	30.94	46.78
LGS07072P	100	3.5	35.36	53.04
LGS07074P	100	7.73	61.88	72.74
LGS07075P	99.26	11.23	57.46	71.27

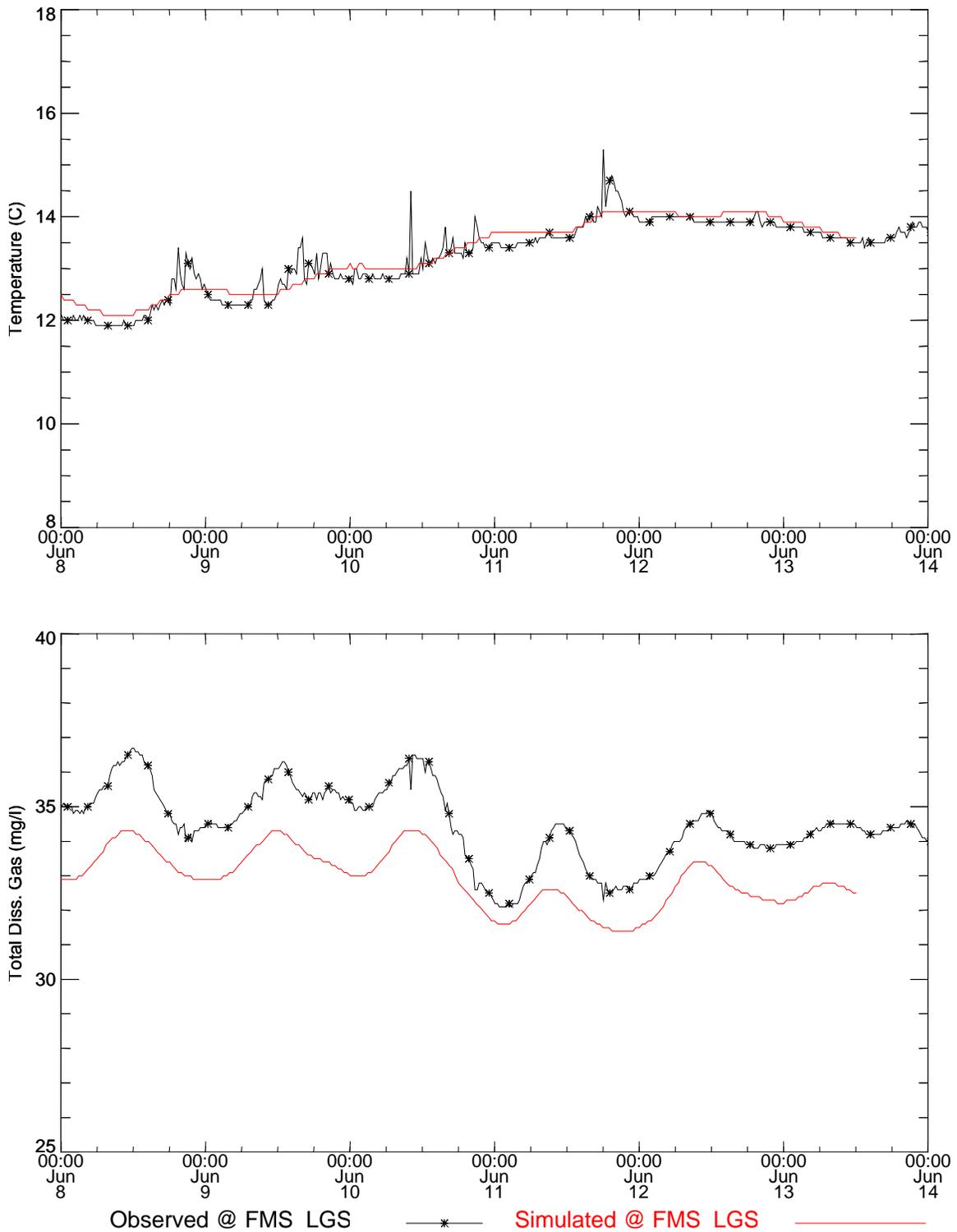


Figure 89. Temperature and total dissolved gas concentration time series near fixed monitor LGS for the Summer 1997 pool study (FMS-BC).

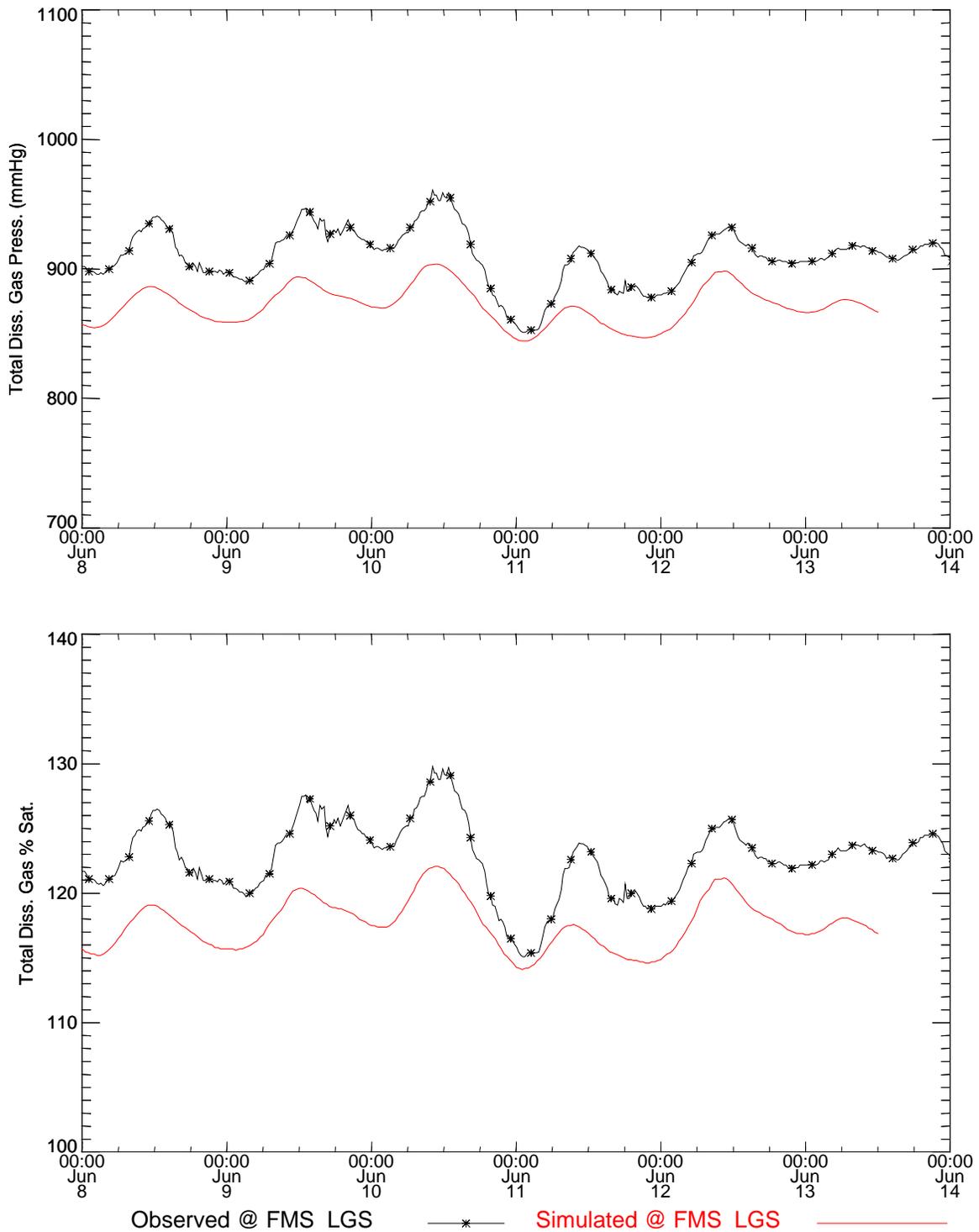


Figure 90. Total dissolved gas pressure and saturation time series near fixed monitor LGS for the Summer 1997 pool study (FMS-BC).

Table 33. Statistical summary of measurements and simulations near fixed monitor LGS for the Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_LGS	13.21	13.27	0.71	0.67	0.22
Concentration					
FMS_LGS	34.48	32.93	1.12	0.81	1.61
Gas Pressure					
FMS_LGS	909.13	871.7	22.56	14.67	38.96
% Saturation					
FMS_LGS	122.68	117.59	2.97	1.92	5.29

Table 34. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGS for the Summer 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGS	99.62	9.43	48.3	44.53

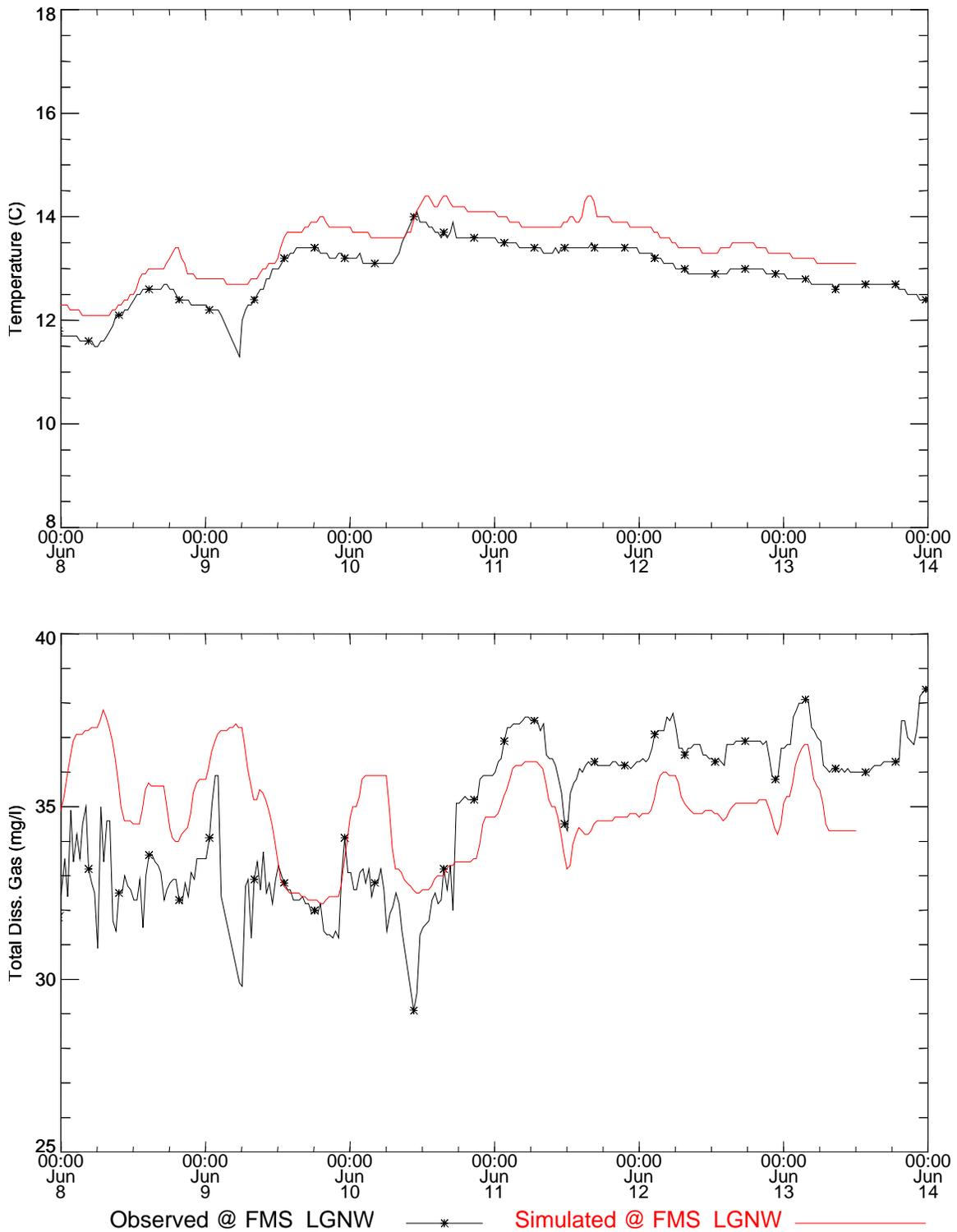


Figure 91. Temperature and total dissolved gas concentration time series near fixed monitor LGNW for the Summer 1997 pool study (FMS-BC).

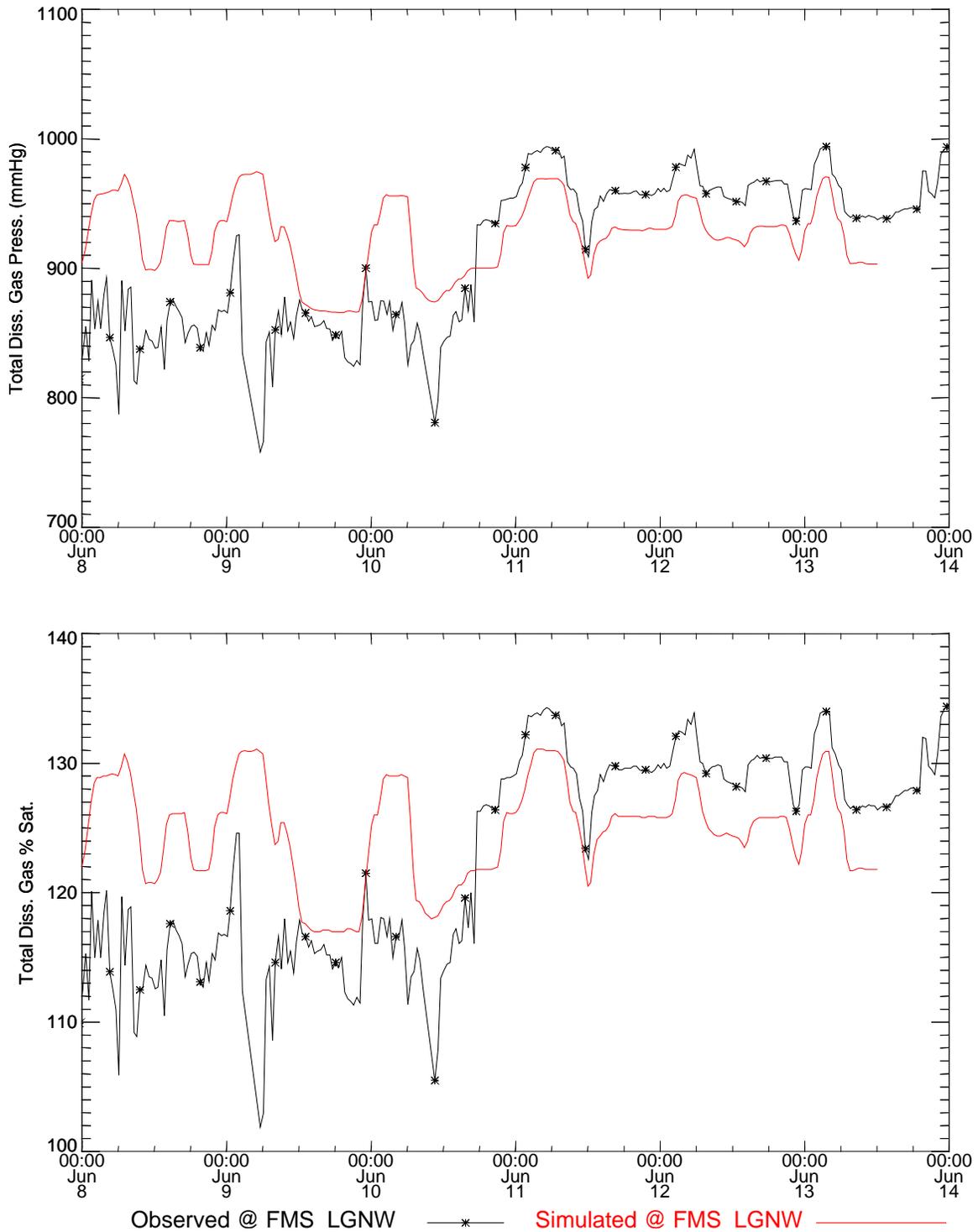


Figure 92. Total dissolved gas pressure and saturation time series near fixed monitor LGNW for the Summer 1997 pool study (FMS-BC).

Table 35. Statistical summary of measurements and simulations near fixed monitor LGNW for the Summer 1997 pool study (FMS-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_LGNW	12.94	13.42	0.59	0.58	0.51
Concentration					
FMS_LGNW	34.54	34.86	2.18	1.34	2.23
Gas Pressure					
FMS_LGNW	906.08	924.63	59.72	29.23	60.21
% Saturation					
FMS_LGNW	122.2	124.73	8.16	3.91	8.1

Table 36. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGNW for the Summer 1997 pool study (FMS-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGNW	98.87	12.08	60.38	60

Boundary Conditions using Temporary Monitored Field Data

Comparisons between the measurements and simulations using an upstream boundary condition developed from water temperatures and TDG pressures measured by temporary monitors are shown in the figures below. Statistics on comparisons between measured and simulated temperatures and total dissolved gas are also presented. The case is denoted as TM-BC in the figure and table captions.

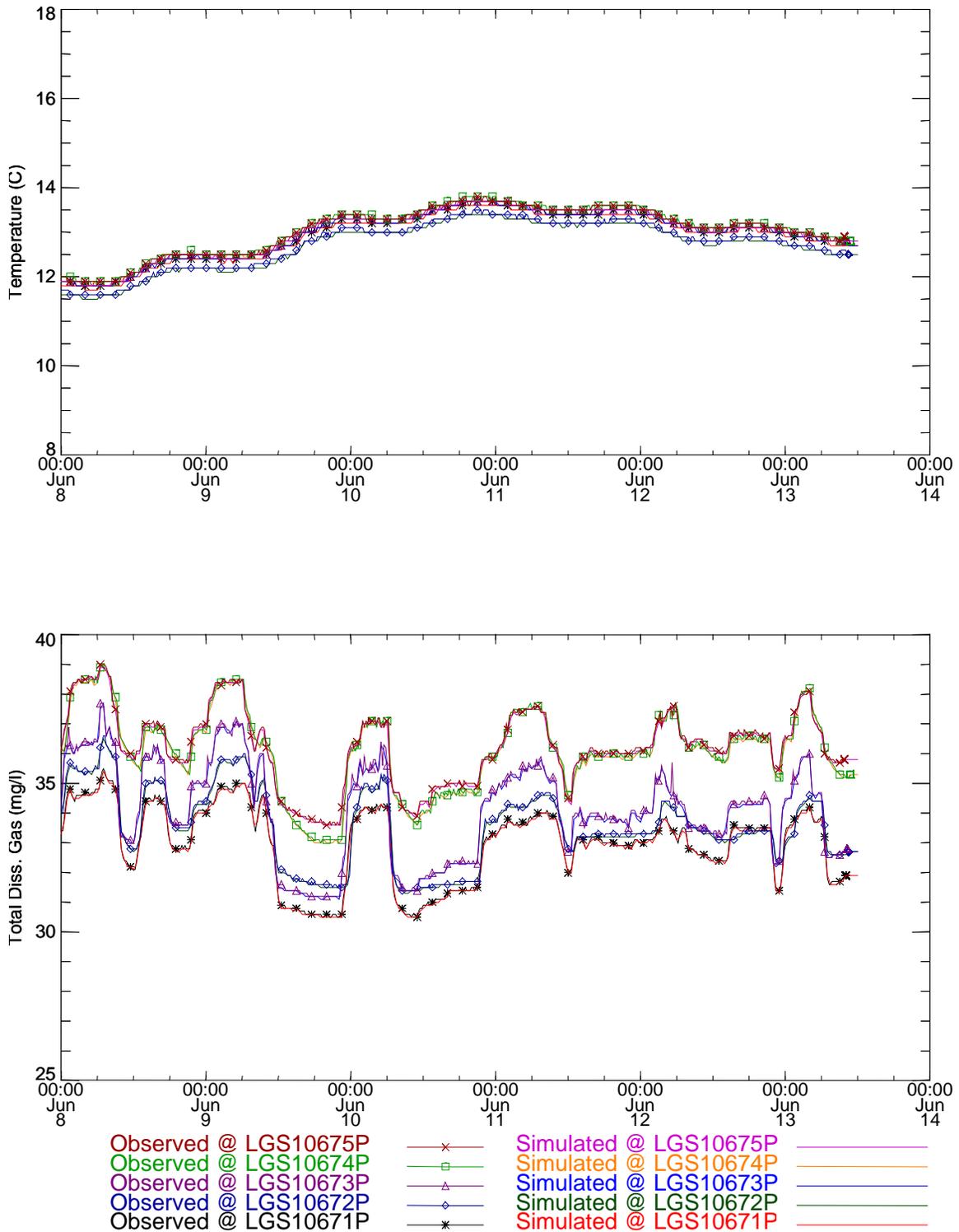


Figure 93. Temperature and total dissolved gas concentration time series near Snake River Mile 106.7 for the Summer 1997 pool study (TM-BC).

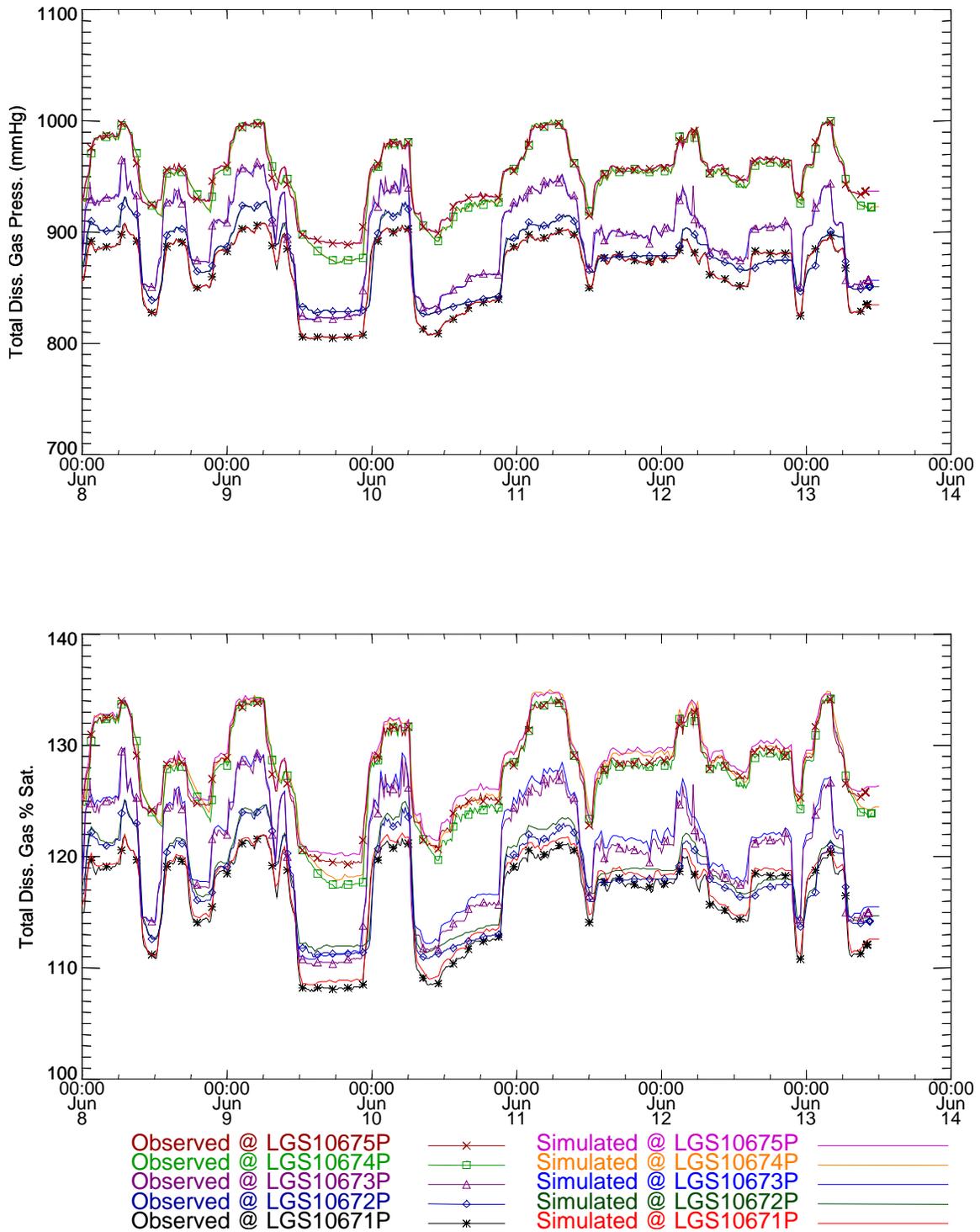


Figure 94. Total dissolved gas pressure and saturation time series near Snake River Mile 106.7 for the Summer 1997 pool study (TM-BC).

Table 37. Statistical summary of measurements and simulations near Snake River mile 106.7 for the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS10671P	12.96	12.91	0.54	0.53	0.07
LGS10672P	12.74	12.7	0.53	0.53	0.07
LGS10673P	13.01	12.96	0.53	0.54	0.07
LGS10674P	13.06	13.01	0.54	0.53	0.07
LGS10675P	13.05	13	0.54	0.54	0.07
Concentration					
LGS10671P	32.98	32.93	1.29	1.29	0.07
LGS10672P	33.55	33.5	1.29	1.29	0.07
LGS10673P	34.1	34.05	1.62	1.62	0.08
LGS10674P	36.13	36.08	1.38	1.37	0.07
LGS10675P	36.24	36.2	1.26	1.26	0.07
Gas Pressure					
LGS10671P	865.41	865.37	30.67	30.62	0.72
LGS10672P	876.21	876.14	29.43	29.39	0.55
LGS10673P	895.22	895.1	39.19	39.04	0.99
LGS10674P	948.92	948.88	32.46	32.43	0.56
LGS10675P	951.72	951.71	29.53	29.48	0.46
% Saturation					
LGS10671P	116.18	116.74	4.12	4.1	0.61
LGS10672P	117.63	118.19	3.95	3.91	0.61
LGS10673P	120.18	120.74	5.26	5.23	0.63
LGS10674P	127.39	128	4.36	4.35	0.67
LGS10675P	127.76	128.39	3.96	3.96	0.68

Table 38. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 106.7 for the Summer 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat
LGS10671P	100	100	100	100
LGS10672P	100	100	100	100
LGS10673P	100	100	100	100
LGS10674P	100	100	100	100
LGS10675P	100	100	100	100

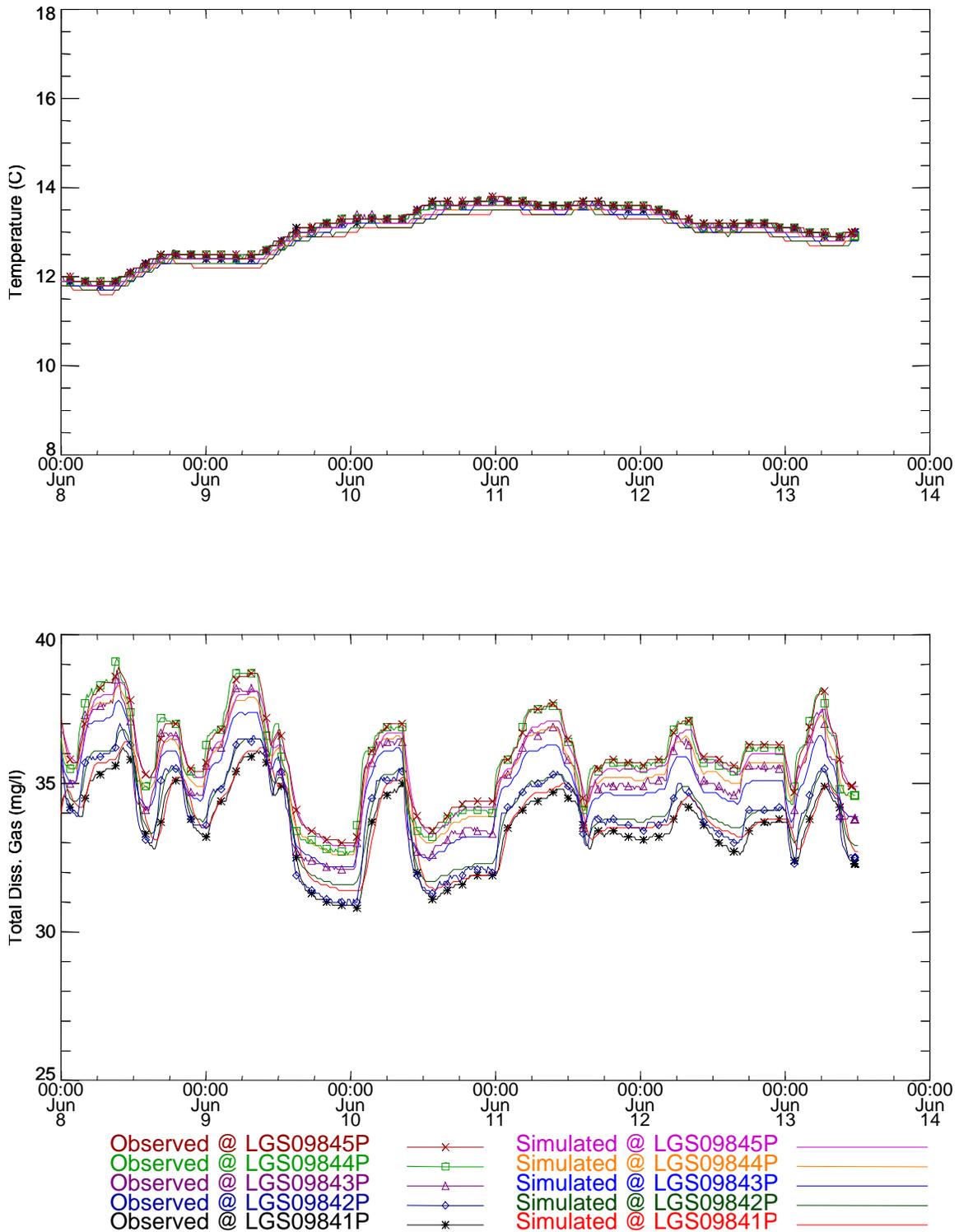


Figure 95. Temperature and total dissolved gas concentration time series near Snake River Mile 098.4 for the Summer 1997 pool study (TM-BC).

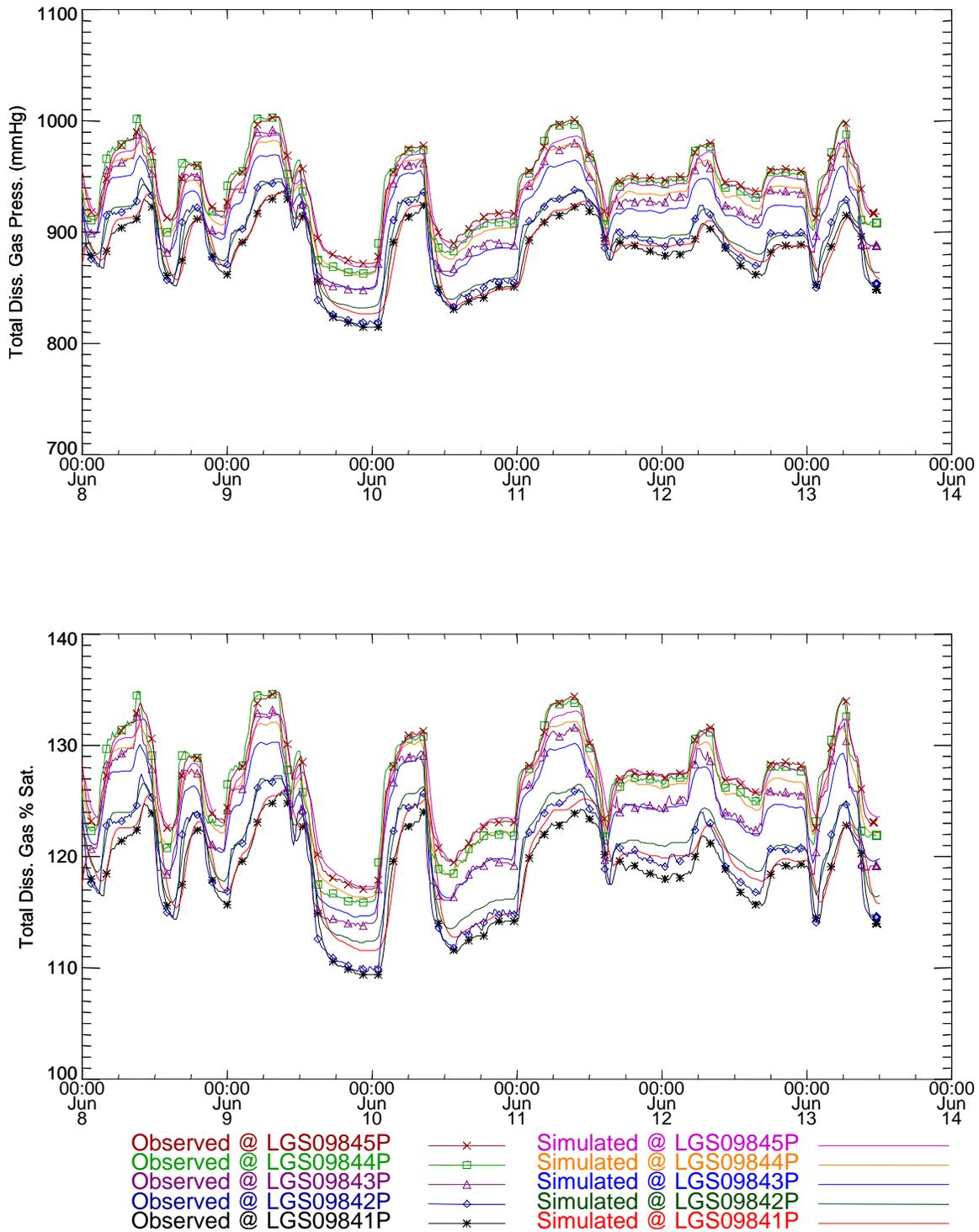


Figure 96. Total dissolved gas pressure and saturation time series near Snake River Mile 098.4 for the Summer 1997 pool study (TM-BC).

Table 39. Statistical summary of measurements and simulations near Snake River mile 098.4 for the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS09841P	13.06	12.84	0.55	0.54	0.22
LGS09842P	13.04	12.86	0.55	0.54	0.18
LGS09843P	13.06	12.92	0.55	0.54	0.15
LGS09844P	13.05	12.96	0.54	0.54	0.1
LGS09845P	13.08	12.99	0.55	0.54	0.11
Concentration					
LGS09841P	33.55	33.8	1.34	1.3	0.37
LGS09842P	33.91	34.08	1.47	1.33	0.33
LGS09843P	35.19	34.89	1.58	1.38	0.43
LGS09844P	35.81	35.42	1.57	1.36	0.51
LGS09845P	35.94	35.69	1.43	1.33	0.33
Gas Pressure					
LGS09841P	882.09	886.55	30.75	29.39	8.18
LGS09842P	890.96	893.89	34.38	30.45	7.76
LGS09843P	924.61	916.33	37.82	32.13	11.67
LGS09844P	940.54	930.79	37.2	31.66	12.74
LGS09845P	944.64	938.42	33.51	30.56	8.37
% Saturation					
LGS09841P	118.41	119.59	4.13	3.86	1.5
LGS09842P	119.61	120.58	4.62	4.01	1.4
LGS09843P	124.12	123.61	5.08	4.25	1.26
LGS09844P	126.26	125.56	4.99	4.18	1.34
LGS09845P	126.81	126.59	4.5	4.03	0.82

Table 40. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 098.4 for the Summer 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS09841P	100	99.25	100	100
LGS09842P	100	100	100	100
LGS09843P	100	100	100	100
LGS09844P	100	99.25	100	100
LGS09845P	100	100	100	100

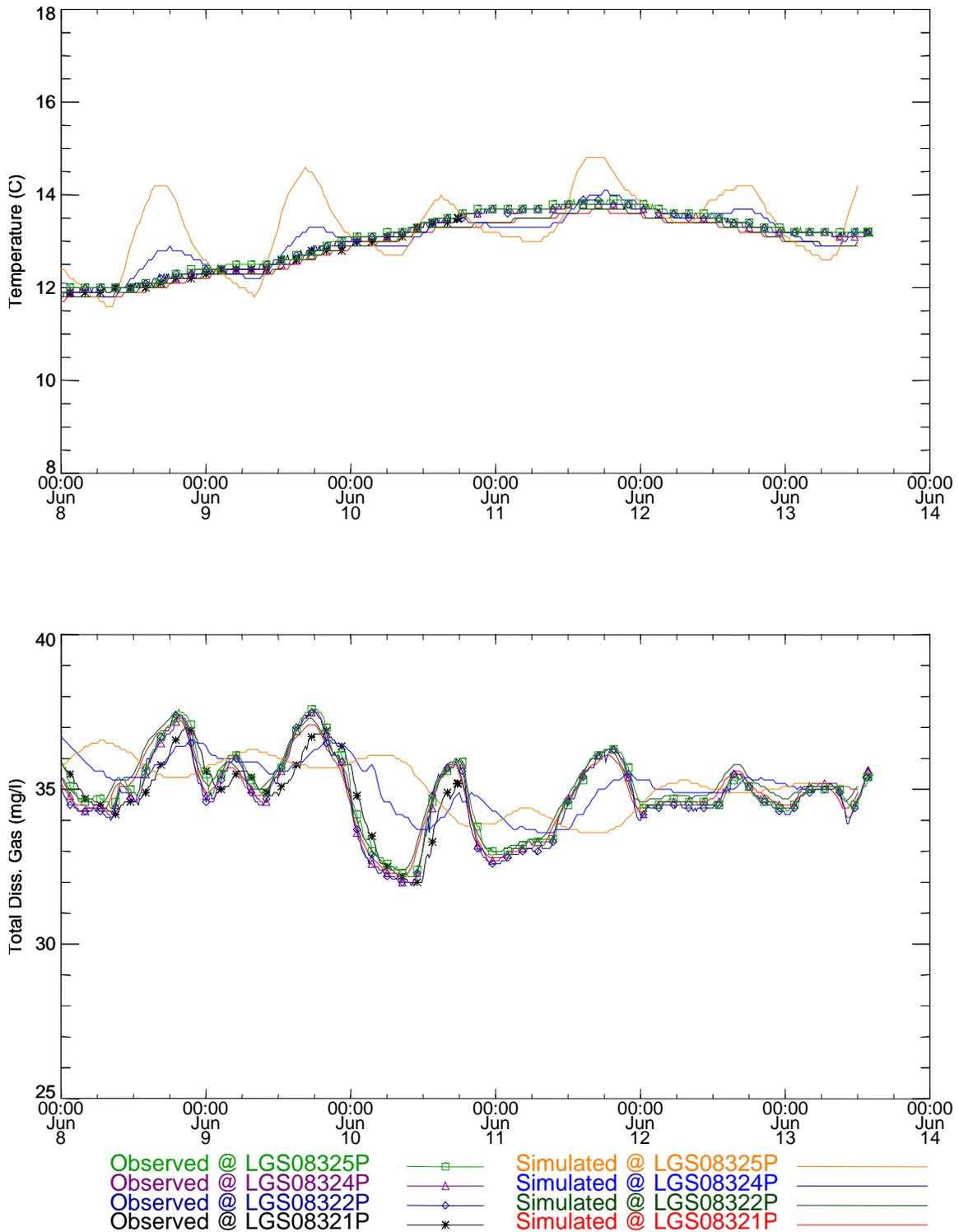


Figure 97. Temperature and total dissolved gas concentration time series near Snake River Mile 083.2 for the Summer 1997 pool study (TM-BC).

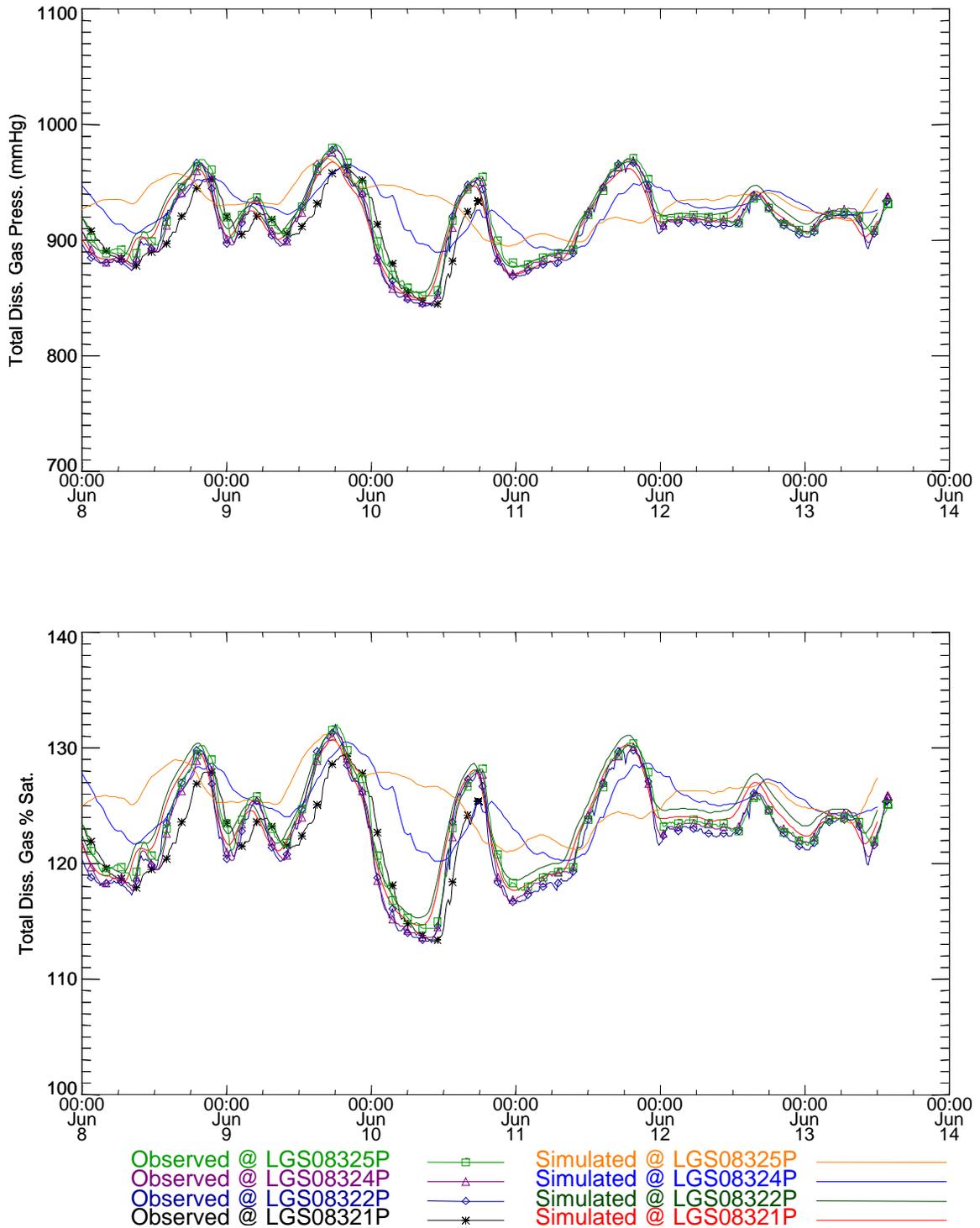


Figure 98. Total dissolved gas pressure and saturation time series near Snake River Mile 083.2 for the Summer 1997 pool study (TM-BC).

Table 41. Statistical summary of measurements and simulations near Snake River mile 083.2 for the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS08321P	13.03	12.89	0.59	0.59	0.22
LGS08322P	13.06	12.91	0.6	0.59	0.16
LGS08324P	13.06	13.07	0.61	0.57	0.27
LGS08325P	13.09	13.31	0.61	0.76	0.72
Concentration					
LGS08321P	35.07	34.82	0.94	1.17	0.93
LGS08322P	34.72	35.02	1.29	1.15	0.41
LGS08324P	34.79	35.17	1.26	0.81	1.08
LGS08325P	34.92	35.18	1.23	0.83	1.43
Gas Pressure					
LGS08321P	921.03	913.82	25.73	28.07	24.74
LGS08322P	912.54	919.42	31.81	27.93	9.9
LGS08324P	914.31	926.65	31	18.68	27.06
LGS08325P	918.38	931.28	29.48	17.55	33.36
% Saturation					
LGS08321P	123.65	123.28	3.46	3.83	3.18
LGS08322P	122.51	124.03	4.27	3.81	1.77
LGS08324P	122.74	125	4.16	2.54	3.9
LGS08325P	123.29	125.62	3.96	2.27	4.66

Table 42. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 093.2 for the Summer 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS08321P	100	80.38	89.43	88.68
LGS08322P	100	100	100	100
LGS08324P	100	65.28	84.91	81.89
LGS08325P	88.3	56.6	75.85	77.74

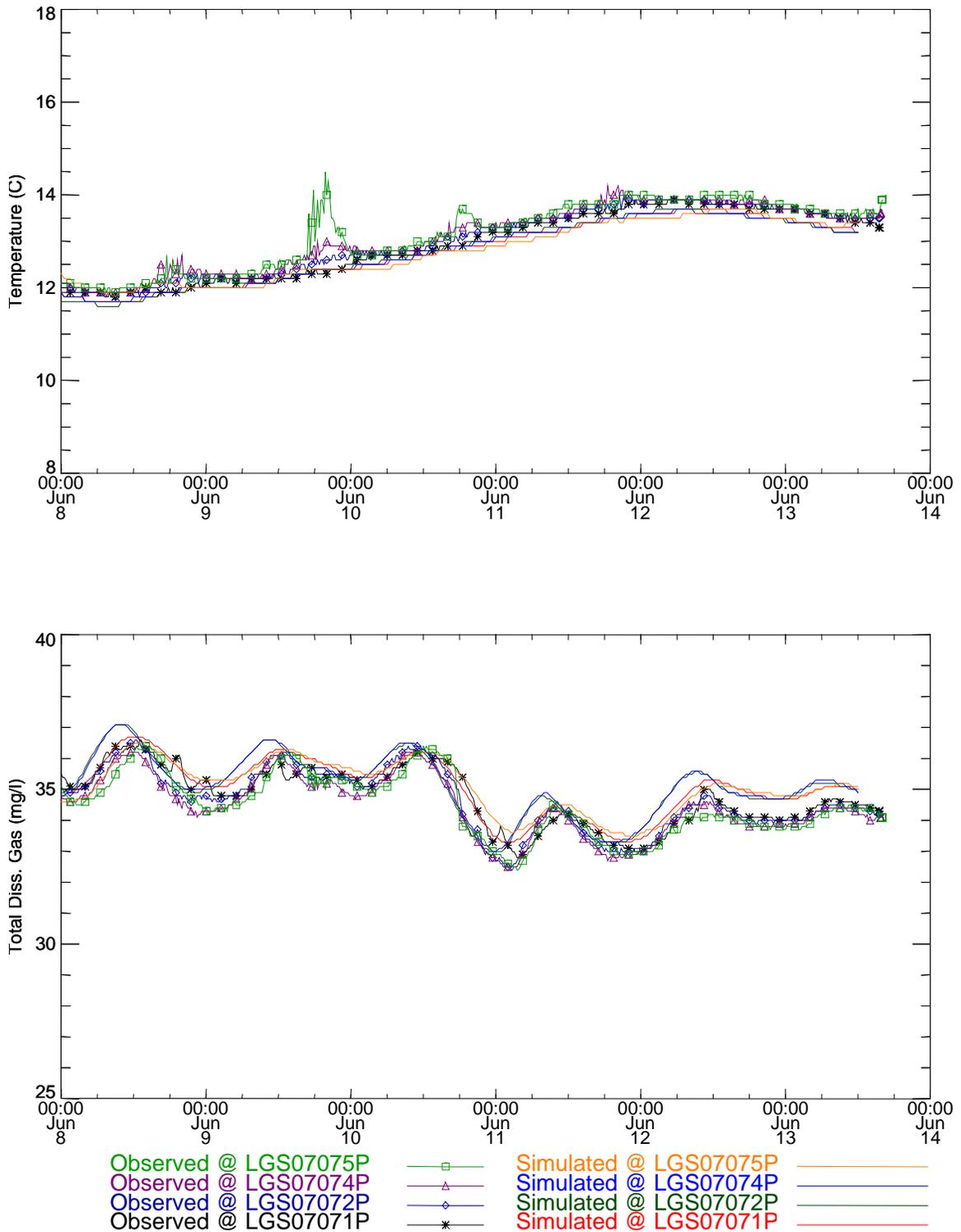


Figure 99. Temperature and total dissolved gas concentration time series near Snake River Mile 070.7 for the Summer 1997 pool study (TM-BC).

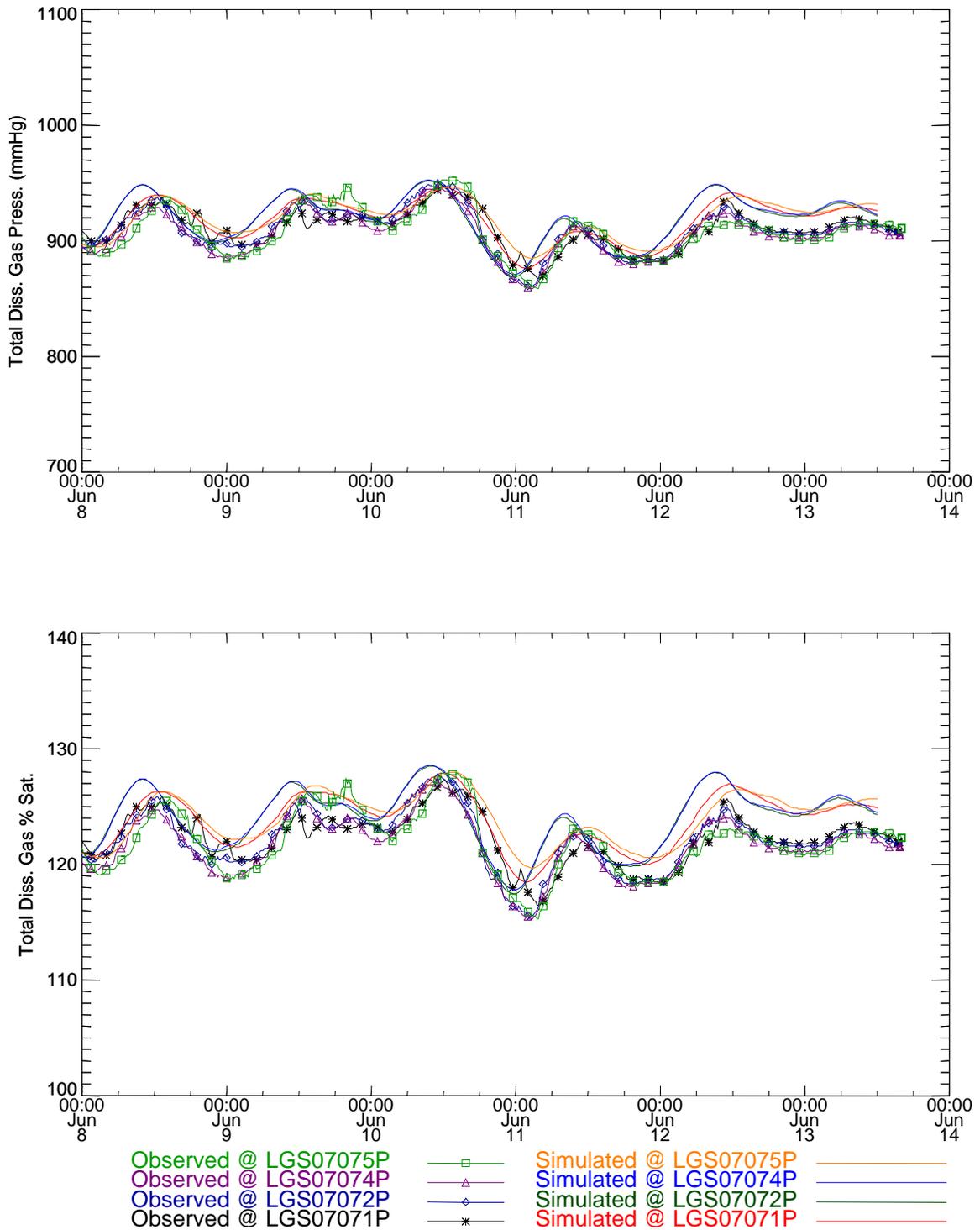


Figure 100. Total dissolved gas pressure and saturation time series near Snake River Mile 070.7 for the Summer 1997 pool study (TM-BC).

Table 43. Statistical summary of measurements and simulations near Snake River mile 070.7 for the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
LGS07071P	12.92	12.78	0.72	0.68	0.17
LGS07072P	13.01	12.78	0.71	0.69	0.24
LGS07074P	13.08	12.78	0.69	0.67	0.32
LGS07075P	13.14	12.8	0.71	0.62	0.42
Concentration					
LGS07071P	34.76	35.07	0.97	0.91	0.43
LGS07072P	34.66	35.1	1.02	1	0.59
LGS07074P	34.46	35.13	0.97	0.99	0.75
LGS07075P	34.5	35.11	1.01	0.82	0.72
Gas Pressure					
LGS07071P	910.76	918.05	16.81	17.86	10.54
LGS07072P	909.74	918.91	19.05	20.32	13.71
LGS07074P	906.05	919.72	18.63	20.08	16.7
LGS07075P	907.94	919.39	20.57	16.45	15.12
% Saturation					
LGS07071P	122.26	123.84	2.26	2.32	1.87
LGS07072P	122.13	123.96	2.55	2.62	2.25
LGS07074P	121.64	124.07	2.5	2.58	2.71
LGS07075P	121.89	124.03	2.76	2.16	2.51

Table 44. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at Snake River Mile 070.7 for the Summer 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
LGS07071P	100	100	100	100
LGS07072P	100	98.11	100	100
LGS07074P	100	86.42	100	100
LGS07075P	97.36	88.3	100	100

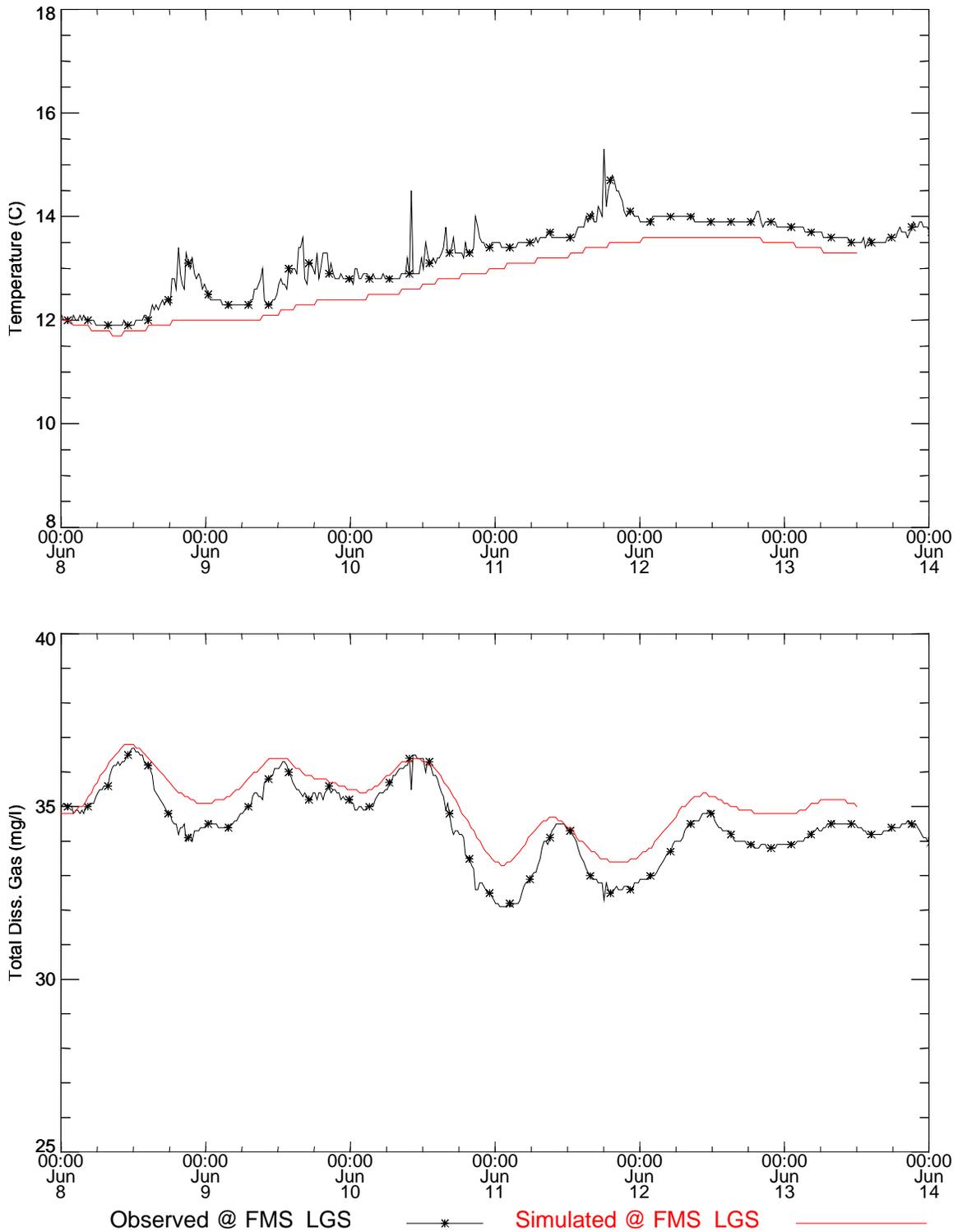


Figure 101. Temperature and total dissolved gas concentration time series near fixed monitor LGS for the Summer 1997 pool study (TM-BC).

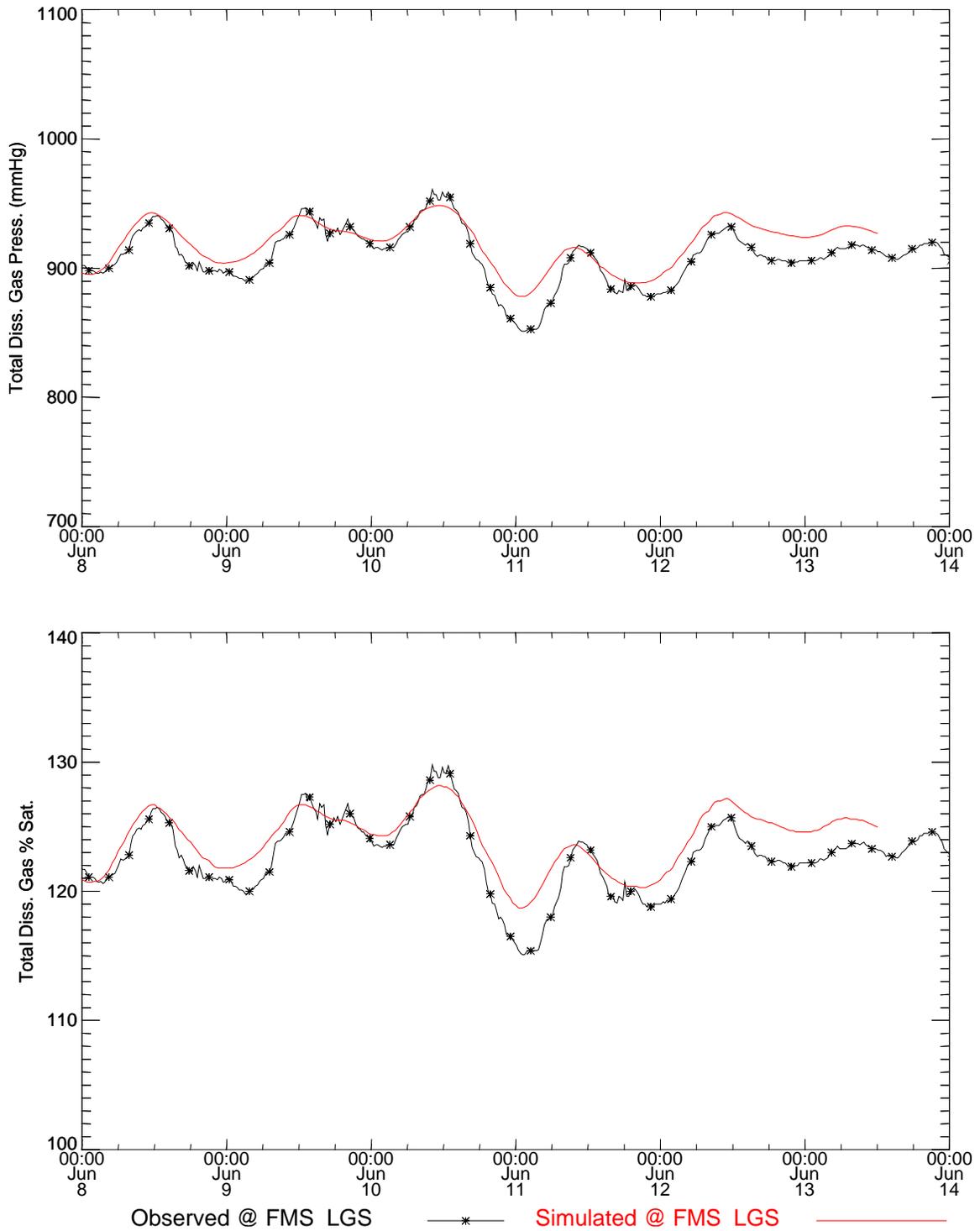


Figure 102. Total dissolved gas pressure and saturation time series near fixed monitor LGS for the Summer 1997 pool study (TM-BC).

Table 45. Statistical summary of measurements and simulations near fixed monitor LGS for the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_LGS	13.21	12.78	0.71	0.65	0.49
Concentration					
FMS_LGS	34.48	35.12	1.12	0.89	0.73
Gas Pressure					
FMS_LGS	909.13	919.43	22.56	17.79	13.69
% Saturation					
FMS_LGS	122.68	124.03	2.97	2.3	1.82

Table 46. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGS for the Summer 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGS	96.23	88.68	100	100

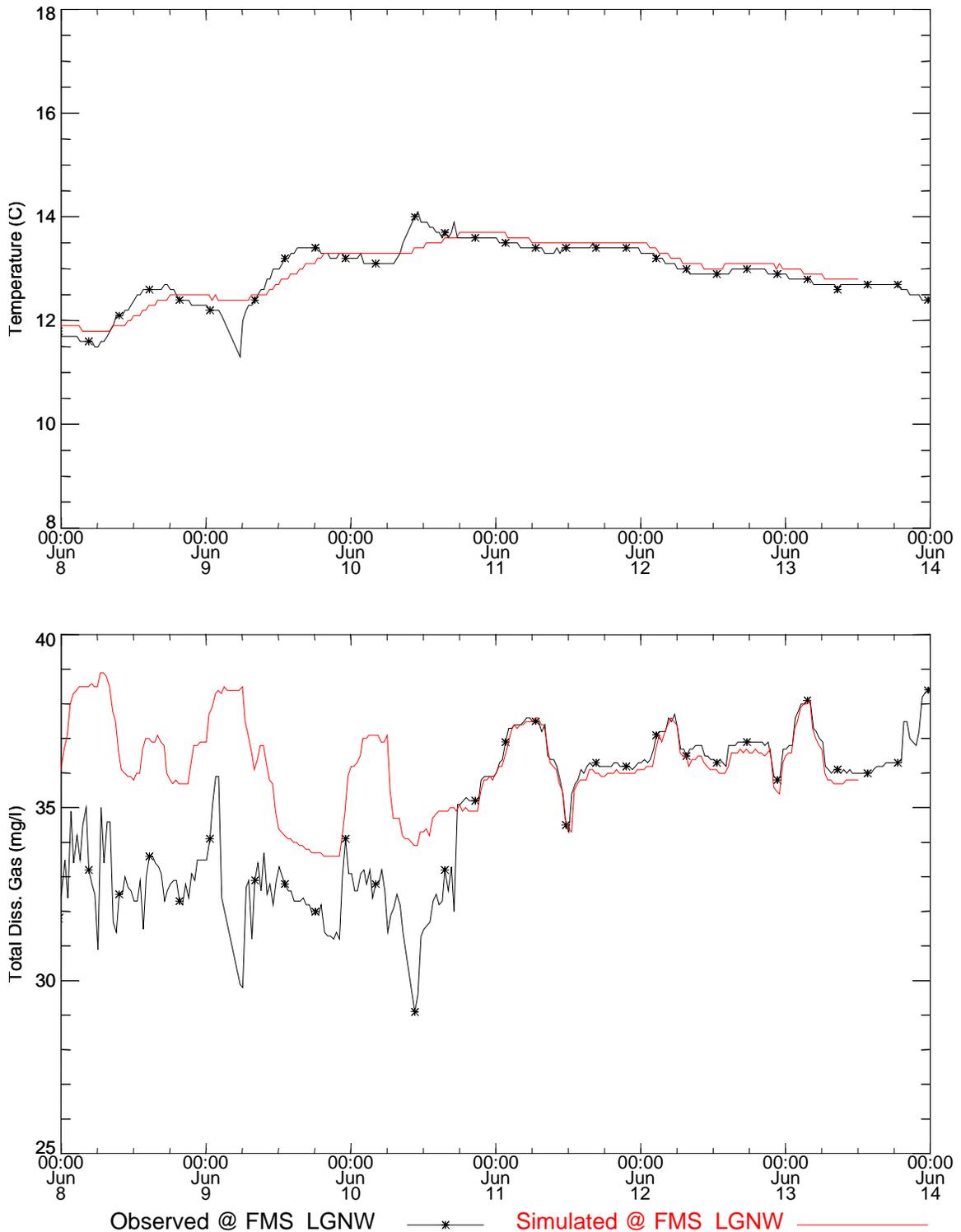


Figure 103. Temperature and total dissolved gas concentration time series near fixed monitor LGNW for the Summer 1997 pool study (TM-BC).

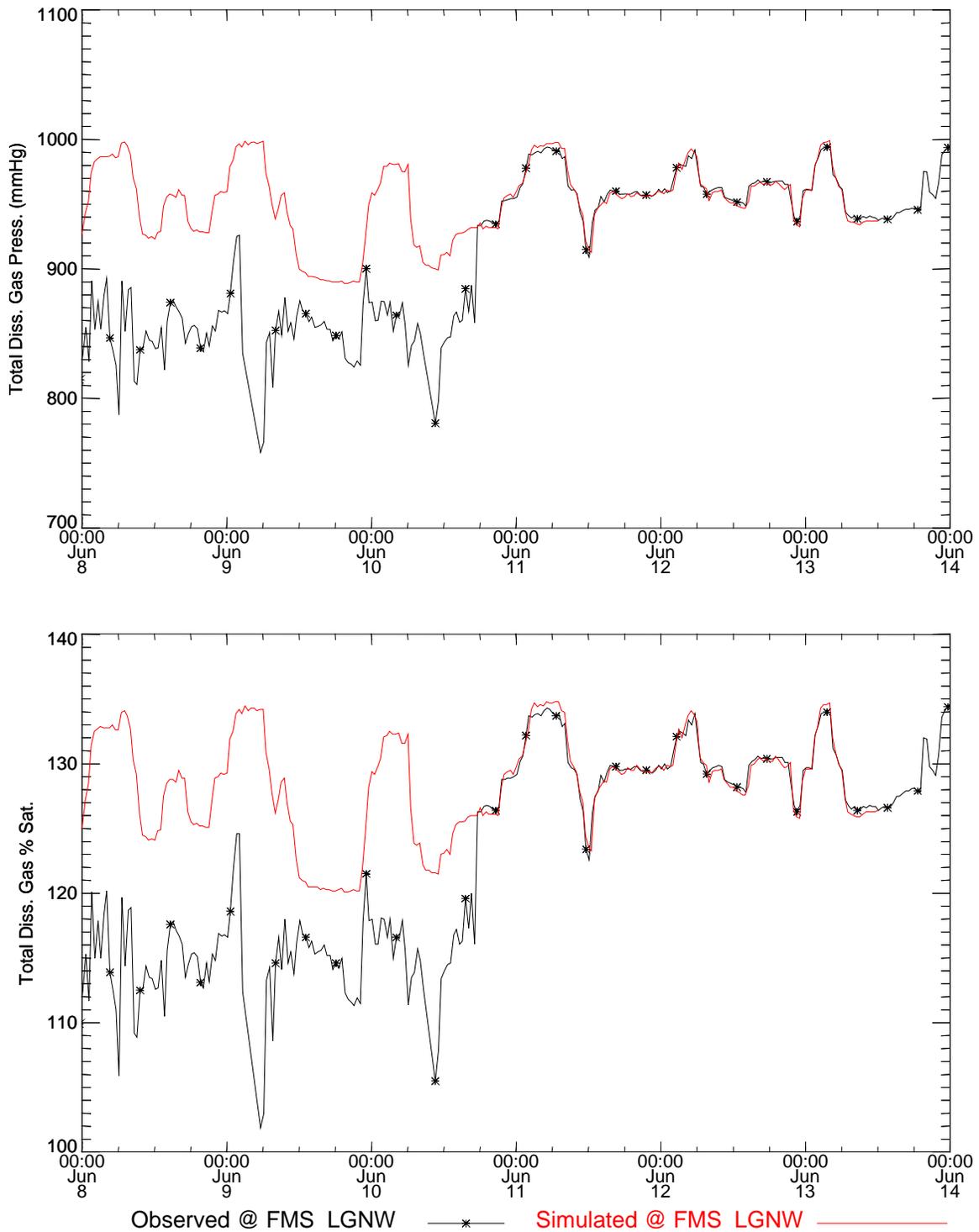


Figure 104. Total dissolved gas pressure and saturation time series near fixed monitor LGNW for the Summer 1997 pool study (TM-BC).

Table 47. Statistical summary of measurements and simulations near fixed monitor LGNW for the Summer 1997 pool study (TM-BC).

Station	Measured Ave.	Simulated Ave.	Measured Std.Dev	Simulated Std.Dev.	RMS Error
Temperature					
FMS_LGNW	12.94	13	0.59	0.54	0.23
Concentration					
FMS_LGNW	34.54	36.2	2.18	1.26	2.71
Gas Pressure					
FMS_LGNW	906.08	951.72	59.72	29.48	71.64
% Saturation					
FMS_LGNW	122.2	128.39	8.16	3.96	9.66

Table 48. Percentage of time during the simulation where the computed value is within the given variance compared to the measurements at fixed monitor LGNW for the Summer 1997 pool study (TM-BC).

Station	1.00 C	1.00 mg/l	38.00 mmHg	5.00% Sat.
FMS_LGNW	99.62	50.57	55.09	54.34

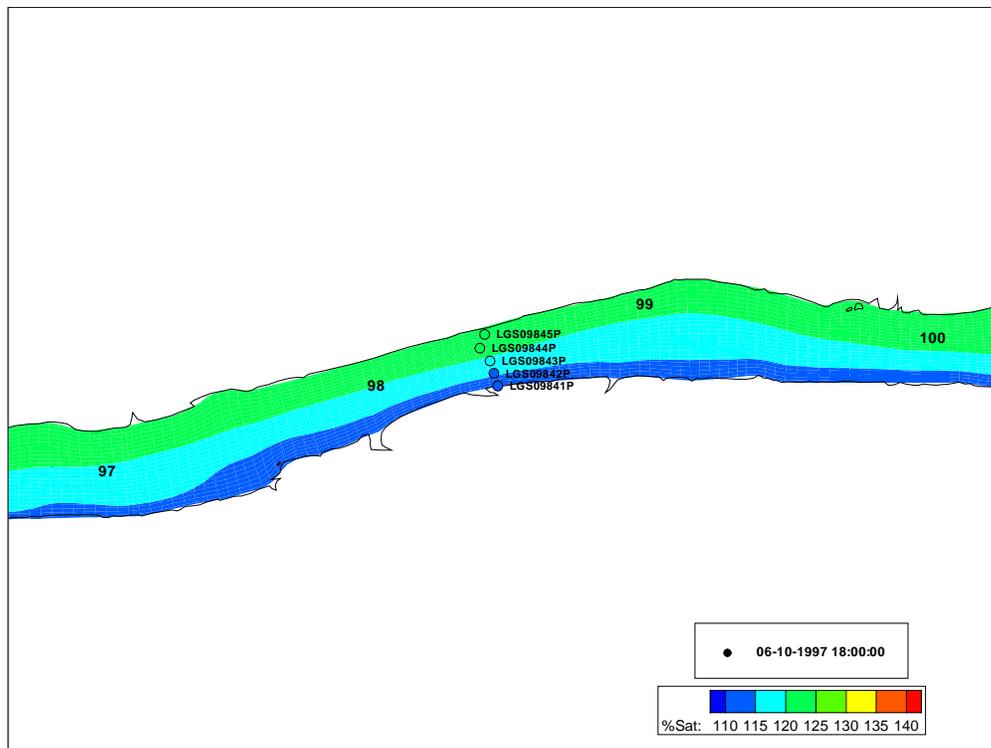


Figure 105. Spatial distribution of dissolved gas near Snake river mile 98 during the Summer 1997 study period.

2 References

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Appendix A. Little Goose Pool Data Sources

A.1 Bathymetry

Bathymetric data for the Snake River was gathered from the various sources shown in Table 49. The primary data source was digitized NOAA navigation charts (NOAA, 1990a, 1990b), which are rather coarse. These were supplemented with surveys in the Lower Granite and Little Goose tailraces. USGS “1-degree” digital elevation data (USGS, 1995) was used to determine elevations on islands and along the shore. Using the Arc/Info® GIS software system, the data was converted to a consistent coordinate system and datum, and combined to build a triangular irregular network (TIN), which represented the river bottom and shore as a three-dimensional surface. The resulting surface for Little Goose pool is shown in Figure 106. Once the surface was produced, it was “sampled” at the necessary grid locations to produce the bathymetry required by the hydrodynamic model grid

Table 49. Columbia River bathymetry data sets used to create the Little Goose pool bathymetric surface. Listed Figure numbers refers to the map which shows the survey location(s).

Bathymetric Data Set	Source	Survey Date	Approximate Rivermile	
			Start	End
Lower Granite Dam Tailrace (Figure 107)	Julie Davin (Walla Walla)	1992	106.4	107.5
Lower Granite Dam Sedimentation Ranges (Figure 107)	Les Cunningham (Walla Walla)	1987	101.8	107.2
Little Goose Dam Tailrace (Figure 108)	Julie Davin (Walla Walla)	1992	69.2	70.2
NOAA Navigation Charts (Figure 107 and Figure 108)	Battelle	unknown	0.0	147.0

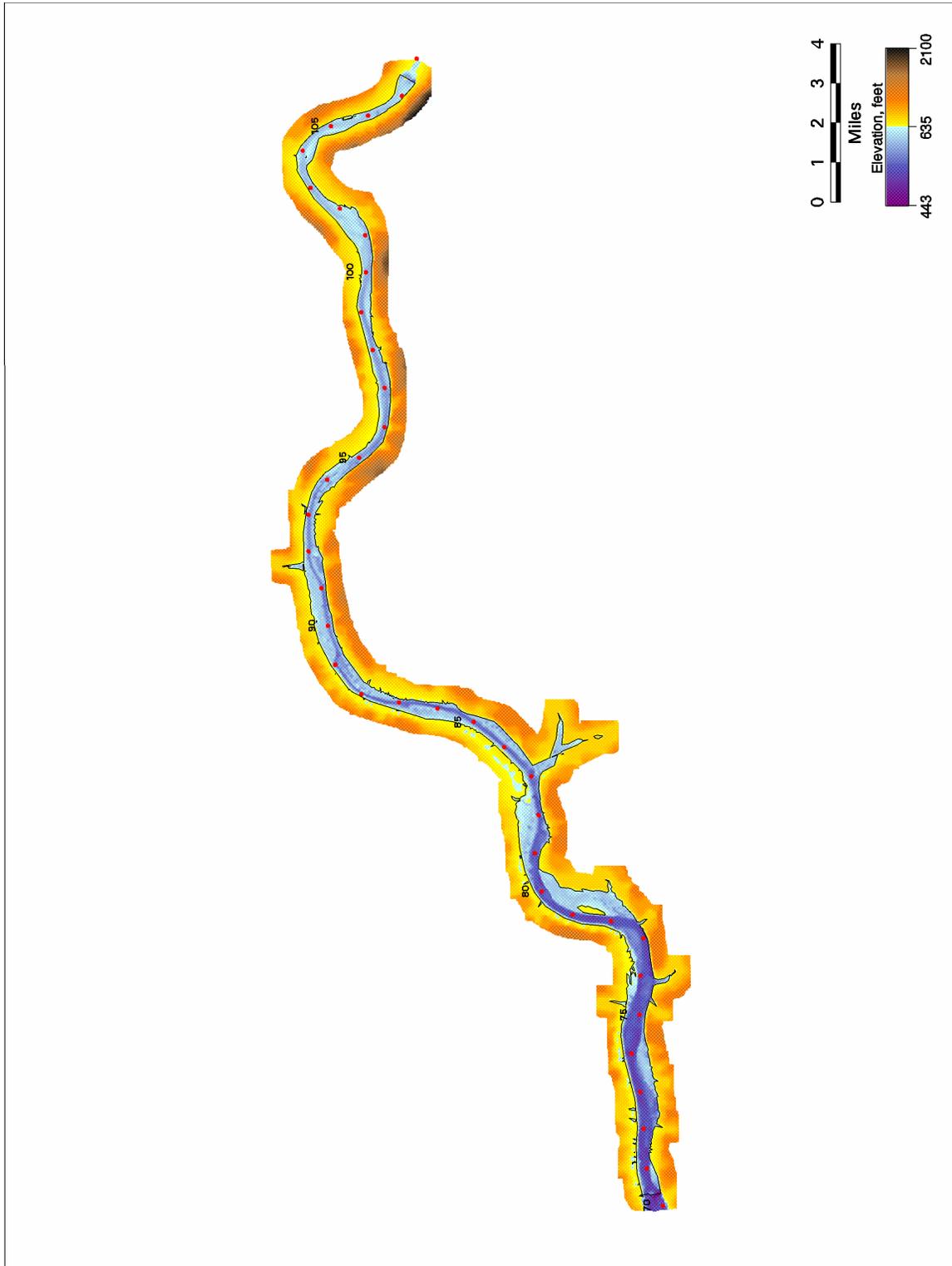


Figure 106. Color representation of Little Goose pool bathymetric surface.

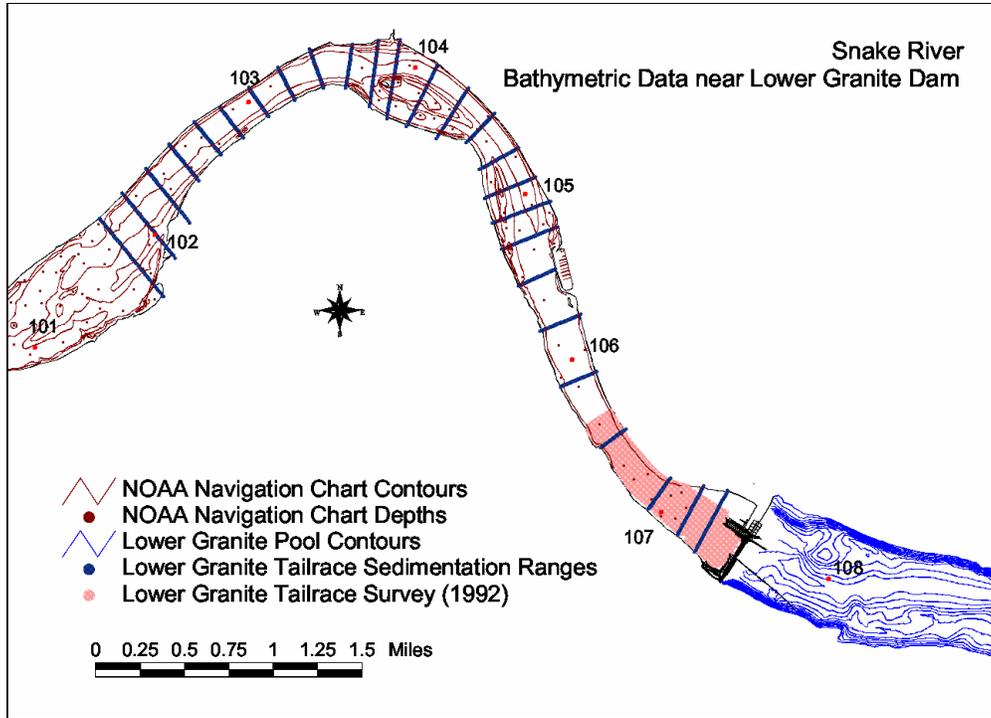


Figure 107. Bathymetric data near Lower Granite Dam.

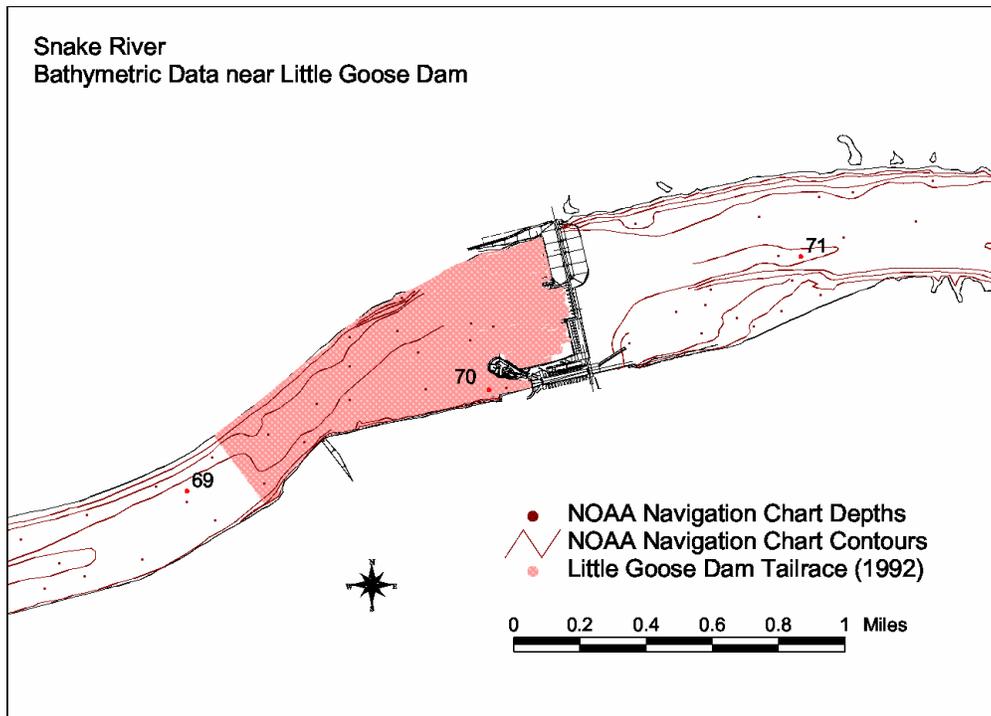


Figure 108. Bathymetric data near Little Goose dam.

A.2 Calibration/Verification Data Sources

A.2.1 Dissolved Gas Measurements

Dissolved gas measurements were available from two sources: permanent fixed monitors and dissolved gas pool studies which used temporary monitors. Fixed monitor stations (FMS) in Little Goose pool area are shown in Figure 109. The water quality data recorded by the FMS included total dissolved gas (TDG) pressure, barometric pressure, and temperature, and was obtained from the DGAS team ftp server, `limnos.wes.army.mil`, in the file `/data3/dgas/database/FMS_data/FMS_data.zip`, dated August 25, 1998. Fixed monitor data was used to establish temperature and TDG concentration in powerhouse flow at the Lower Granite dam model boundary.

The dissolved gas pool studies performed in Little Goose Pool to date are shown in Table 50 and their durations are shown graphically in Figure 110. During these studies water temperature and TDG pressures were measured at several locations within Little Goose pool. These periods were used for model calibration and verification and are discussed individually below. The water quality data gathered during these studies was obtained from the DGAS team ftp server, `limnos.wes.army.mil`, in the file `/data3/dgas/database/field_data/field_data.zip`, dated August 25, 1998.

Table 50. Dates of dissolved gas field studies in Little Goose pool.

STUDY SET	Start	End
LWG LGS LMN SPR 97	4/2/97 11:00:00 AM	4/16/97 11:00:00 AM
LMN LGS SUM 97	6/4/97 8:03:00 AM	6/17/97 3:19:00 PM

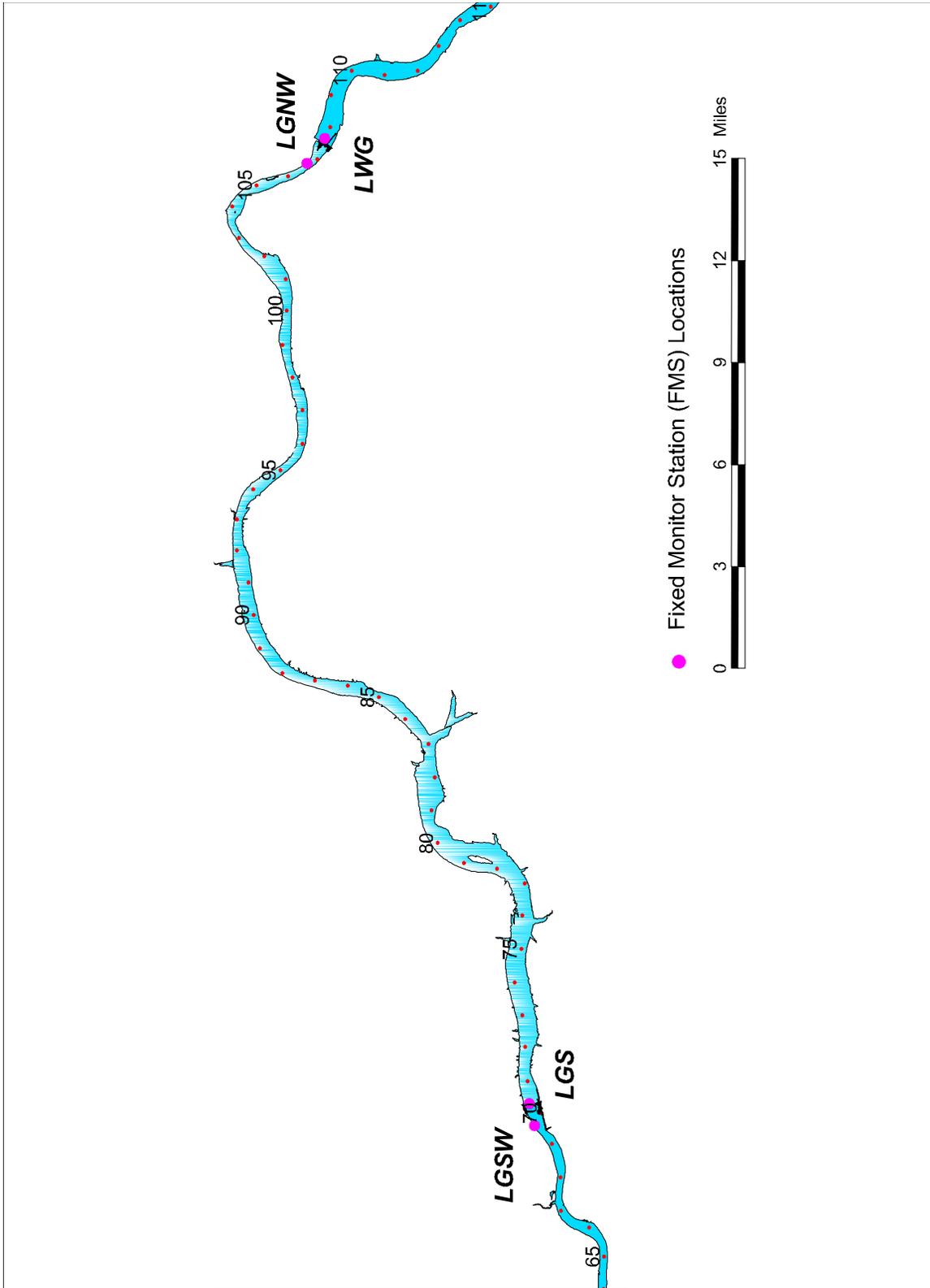


Figure 109. FMS locations in and around Little Goose pool.

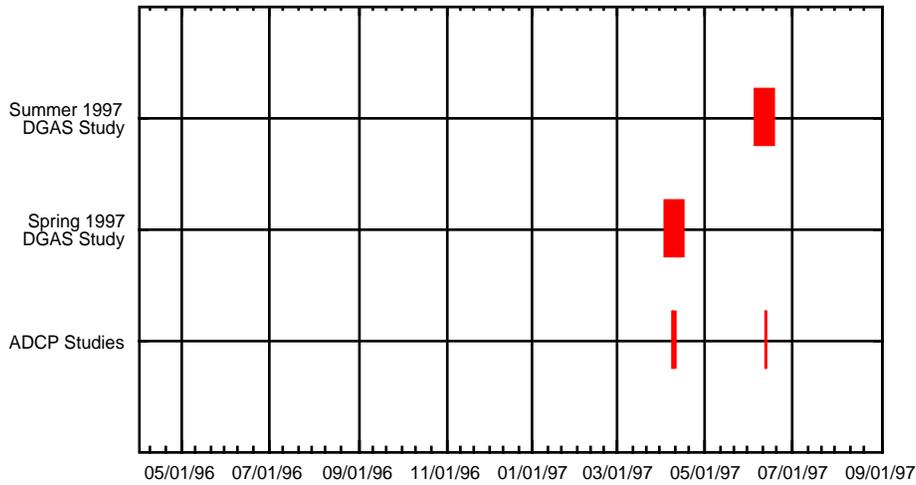


Figure 110. Dates and durations of dissolved gas and ADCP velocity studies in Little Goose Pool

A.2.2 ADCP Velocity Measurements

As shown in Figure 110, velocity measurements were taken using ADCP (Acoustic Doppler Current Profiler) instruments during both dissolved gas pool studies: Spring 1997 and Summer 1997. The ADCP data was obtained from the DGAS team FTP server, `limnos.wes.army.mil`, in the files `/data3/dgas/database/ADCP data/96ADCP.zip` and `/data3/dgas/database/ADCP data/97ADCP.zip`, dated April 10, 1998 and July 15, 1998, respectively. Figure 111 through Figure 119 show the measurements made as small arrows. The measurements were thinned for clarity in those figures: only one arrow in three was drawn.

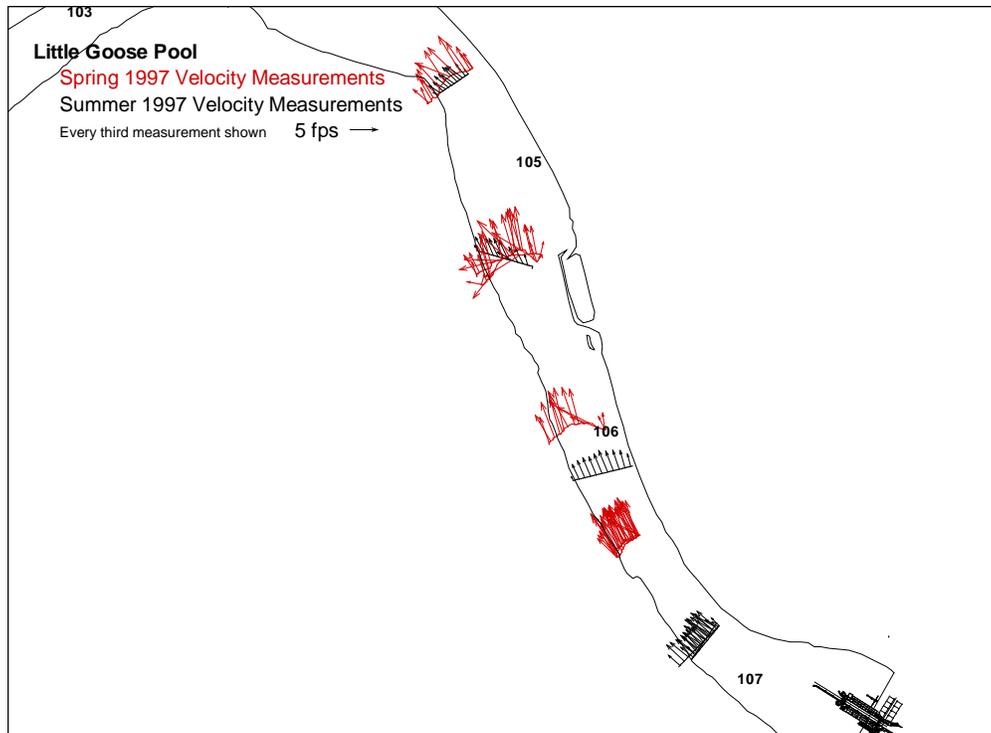


Figure 111. Little Goose pool ADCP velocity measurements near Lower Granite Dam.

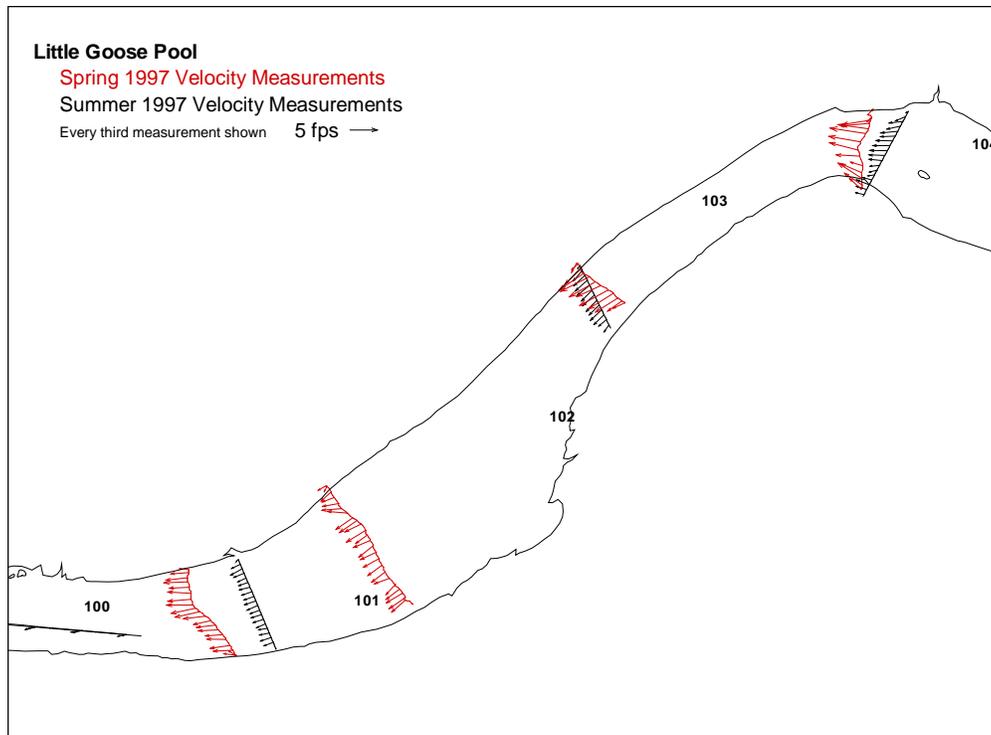


Figure 112. Little Goose pool ADCP velocity measurements below Lower Granite dam .

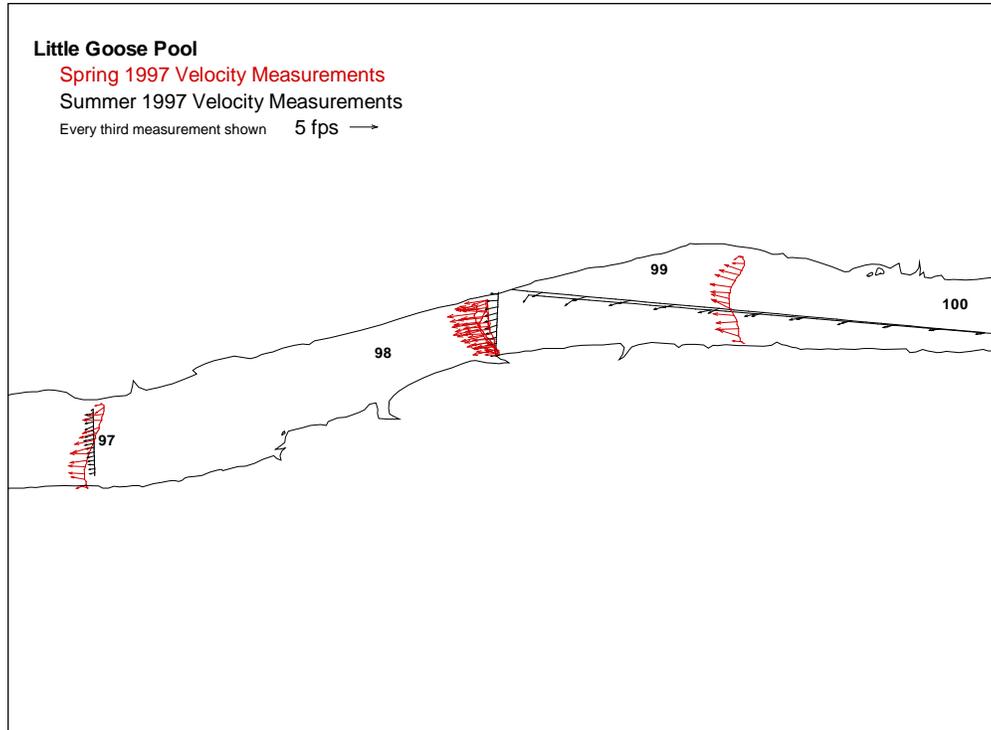


Figure 113. Little Goose pool ADCP velocity measurements near river mile 98.

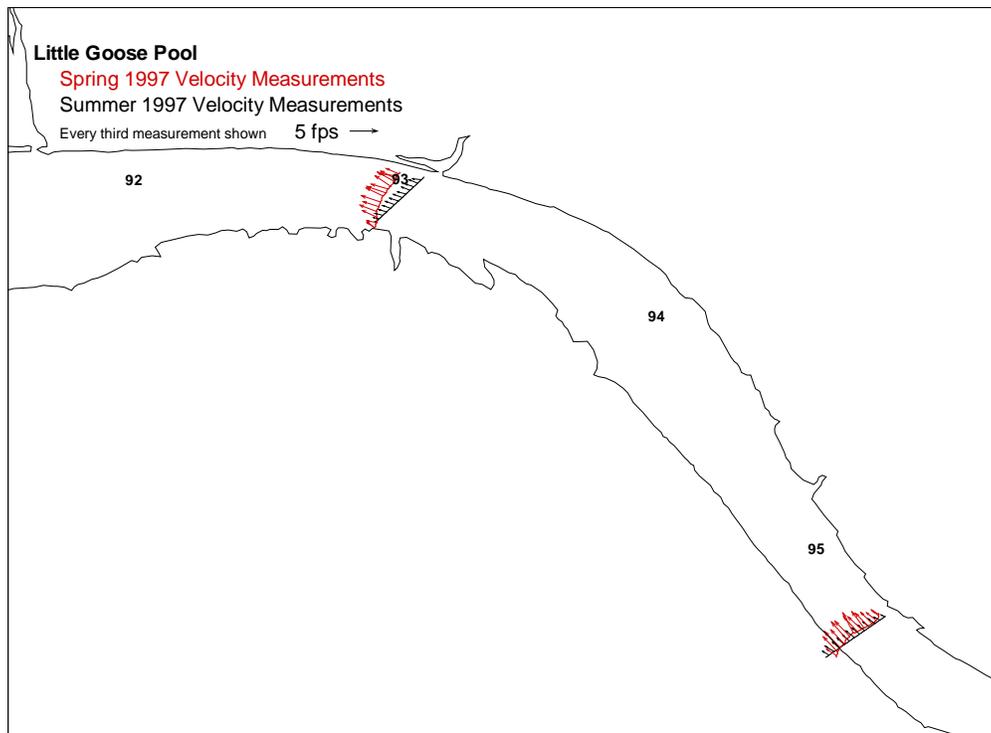


Figure 114. Little Goose pool ADCP velocity measurements near river mile 94.

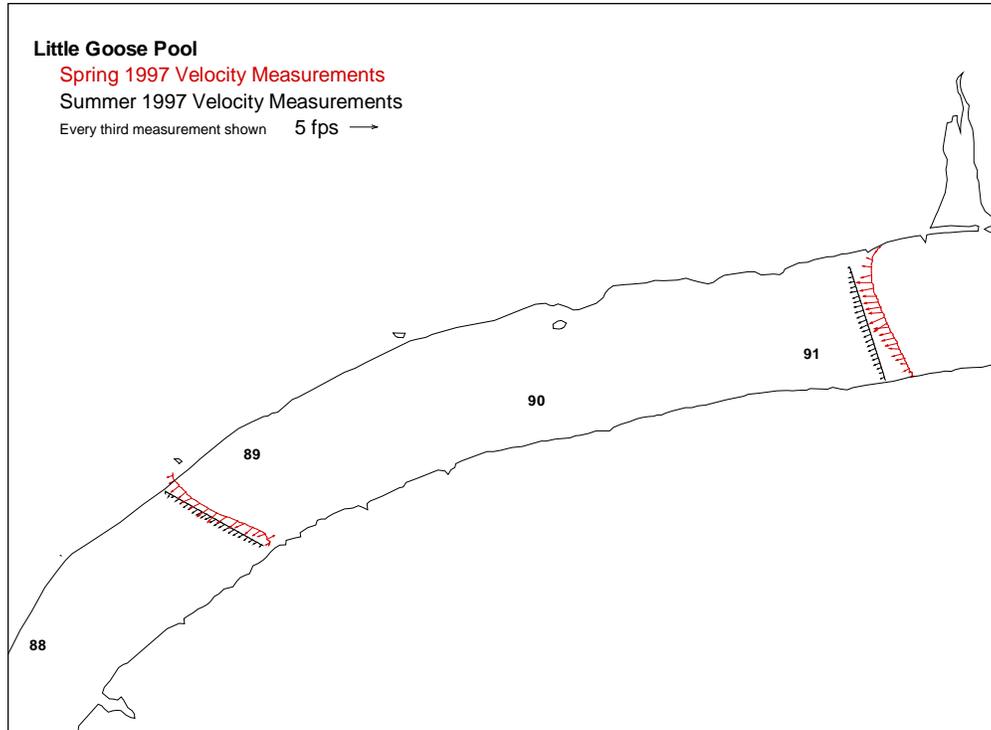


Figure 115. Little Goose pool ADCP velocity measurements near river mile 90.

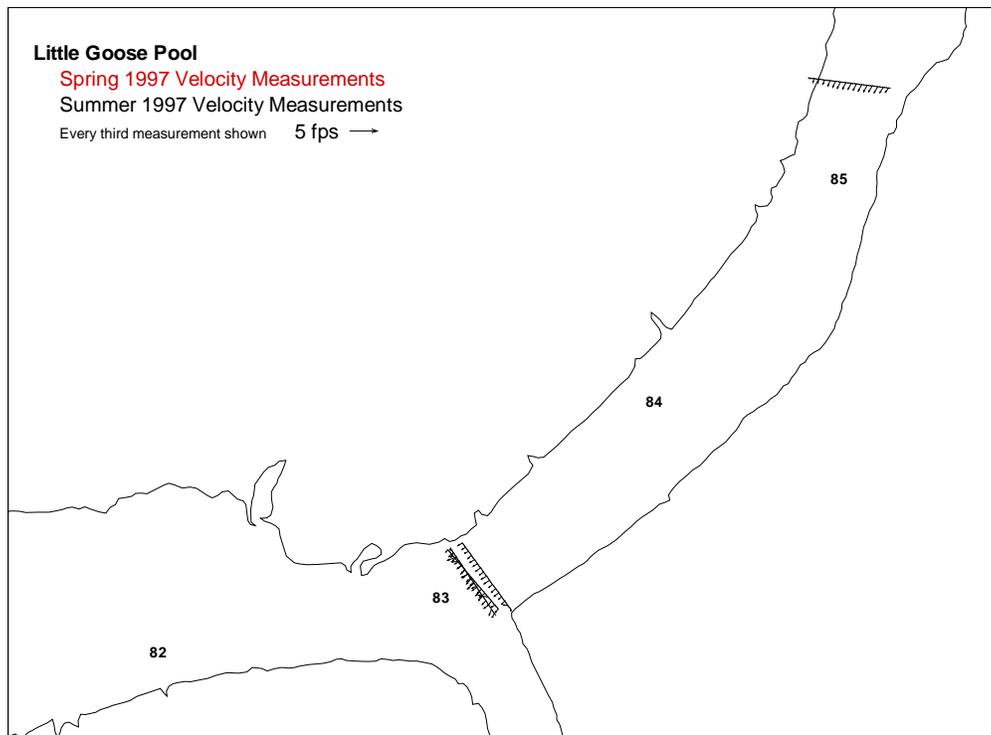


Figure 116. Little Goose pool ADCP velocity measurements near river mile 84.

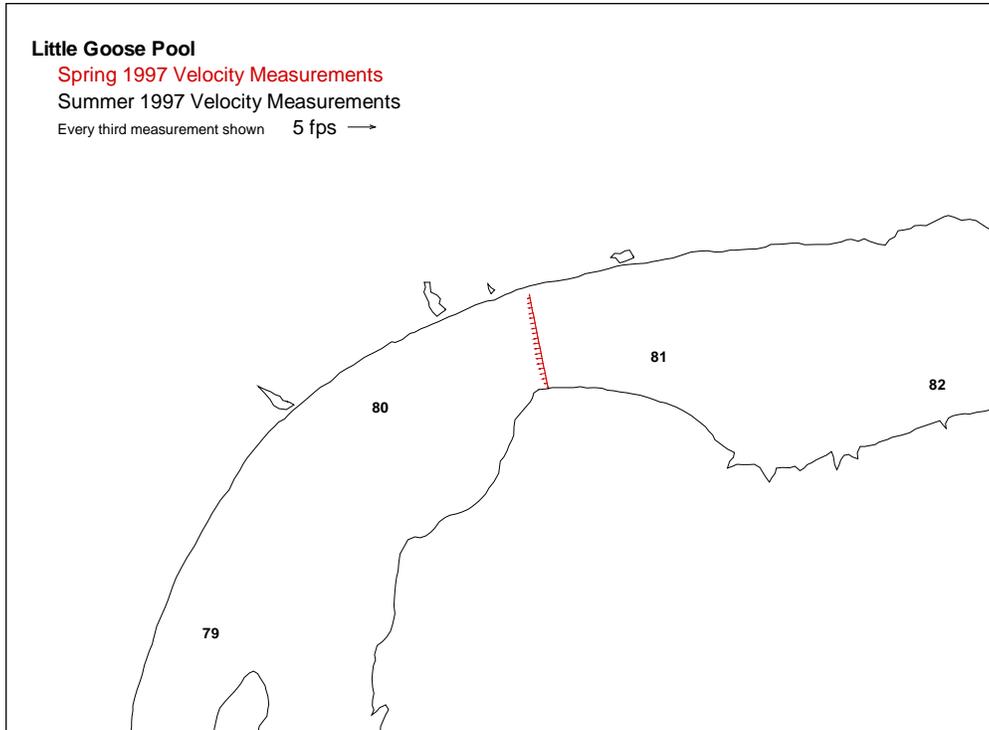


Figure 117. Little Goose pool ADCP velocity measurements near river mile 80.

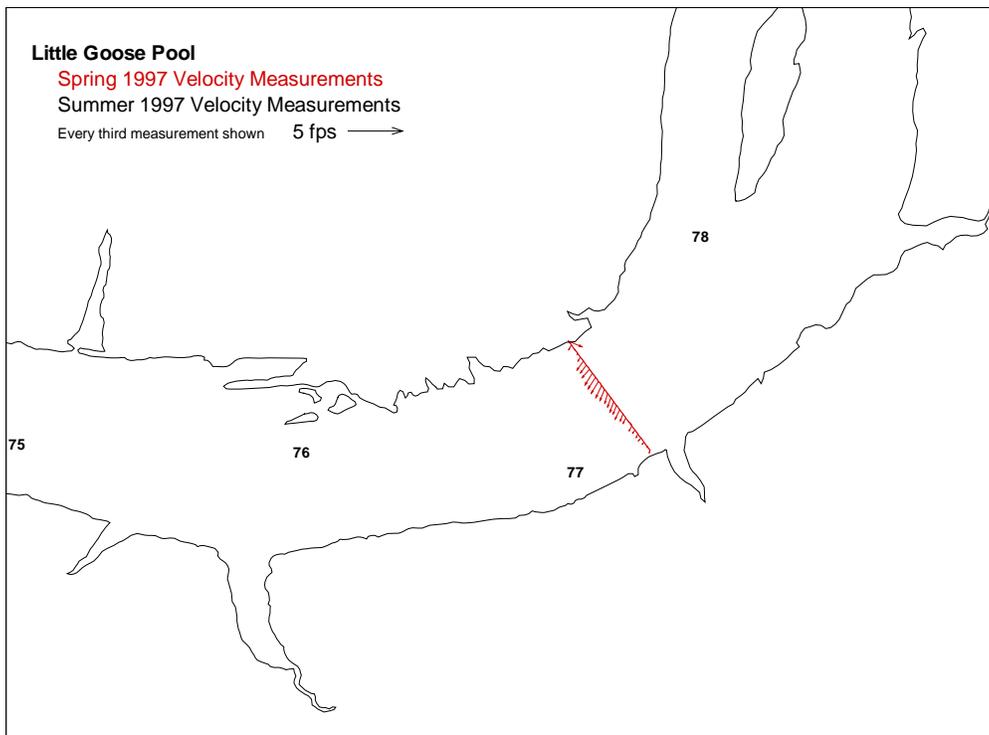


Figure 118. Little Goose pool ADCP velocity measurements near New York Island.

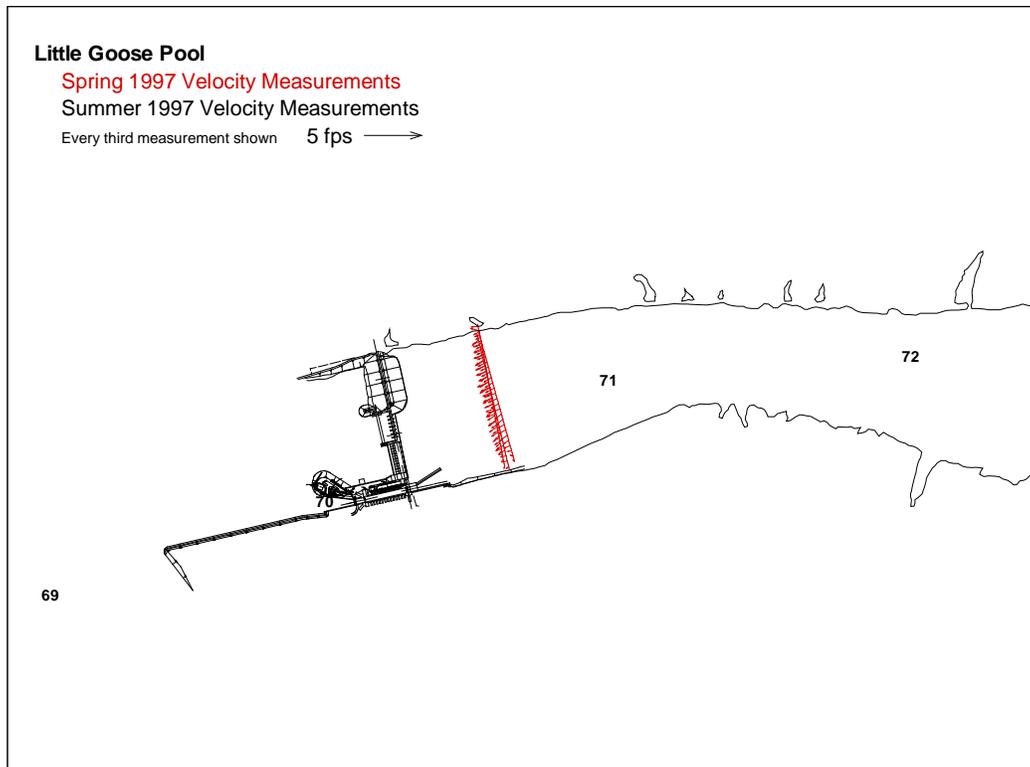


Figure 119. Little Goose pool ADCP velocity measurements near Little Goose dam.

A.2.3 Dam Operations Data

Dam operations data was used to establish model boundary conditions. Hourly CHROMS data was obtained from the DGAS team FTP server, limnos.wes.army.mil, in the file `/data3/dgas/database/ops_data/ops_data.zip`, dated August 25, 1998. The CHROMS operations data provided hourly aggregate spill and powerhouse flows and forebay and tailwater stages.

A.2.4 Weather Data

Weather data was obtained from two DGAS team databases: one containing data from National Weather Service (NWS) stations, the other from WeatherPak instrumentation used for short periods during the pool studies. Both NWS and WeatherPak data was obtained from the DGAS team FTP server, limnos.wes.army.mil, in the file `/data3/dgas/database/weather_data/weather_data.zip`, dated June 11, 1998.

Appendix B. Spring 1997 Little Goose Pool Study

B.1 Dissolved Gas Data

The Spring 1997 Little Goose pool dissolved gas study started on April 2 and ended on April 16. A total of 18 water quality monitors were used. These stations, and their records, are listed in Table 51. Station locations are shown in Figure 120. TDG pressure was not recorded by station LGS10671P during the study period.

Table 51. Dissolved gas monitor stations, and their records, used during the Spring 1997 study period.

Station	Start Time	End Time	Temperature Records	Pressure Records
LGS08325P	4/2/97 11:00:00 AM	4/16/97 9:00:00 AM	669	669
LGS08321P	4/2/97 11:00:00 AM	4/16/97 9:00:00 AM	669	669
LGS08322P	4/2/97 11:00:00 AM	4/16/97 9:00:00 AM	667	667
LGS08324P	4/2/97 11:00:00 AM	4/16/97 9:00:00 AM	668	668
LGS10673P	4/2/97 4:00:00 PM	4/16/97 10:00:00 AM	661	661
LGS10672P	4/2/97 4:00:00 PM	4/15/97 7:00:00 AM	607	607
LGS10671P	4/2/97 4:00:00 PM	4/16/97 10:00:00 AM	661	0
LGS10674P	4/2/97 4:30:00 PM	4/16/97 10:00:00 AM	660	660
LGS09841P	4/2/97 6:00:00 PM	4/16/97 11:00:00 AM	659	659
LGS09843P	4/2/97 6:00:00 PM	4/16/97 11:00:00 AM	659	659
LGS09844P	4/2/97 6:00:00 PM	4/16/97 11:00:00 AM	659	659
LGS09845P	4/2/97 6:00:00 PM	4/16/97 11:00:00 AM	659	659
LGS09842P	4/2/97 6:30:00 PM	4/16/97 11:00:00 AM	658	658
LGS07071P	4/3/97 10:00:00 AM	4/16/97 8:00:00 AM	620	620
LGS07074P	4/3/97 10:30:00 AM	4/16/97 8:30:00 AM	620	620
LGS07075P	4/3/97 12:00:00 PM	4/16/97 8:00:00 AM	216	216
LGS07072P	4/3/97 12:00:00 PM	4/16/97 10:00:00 AM	619	619
LGS10675P	4/12/97 10:00:00 AM	4/16/97 10:00:00 AM	193	193

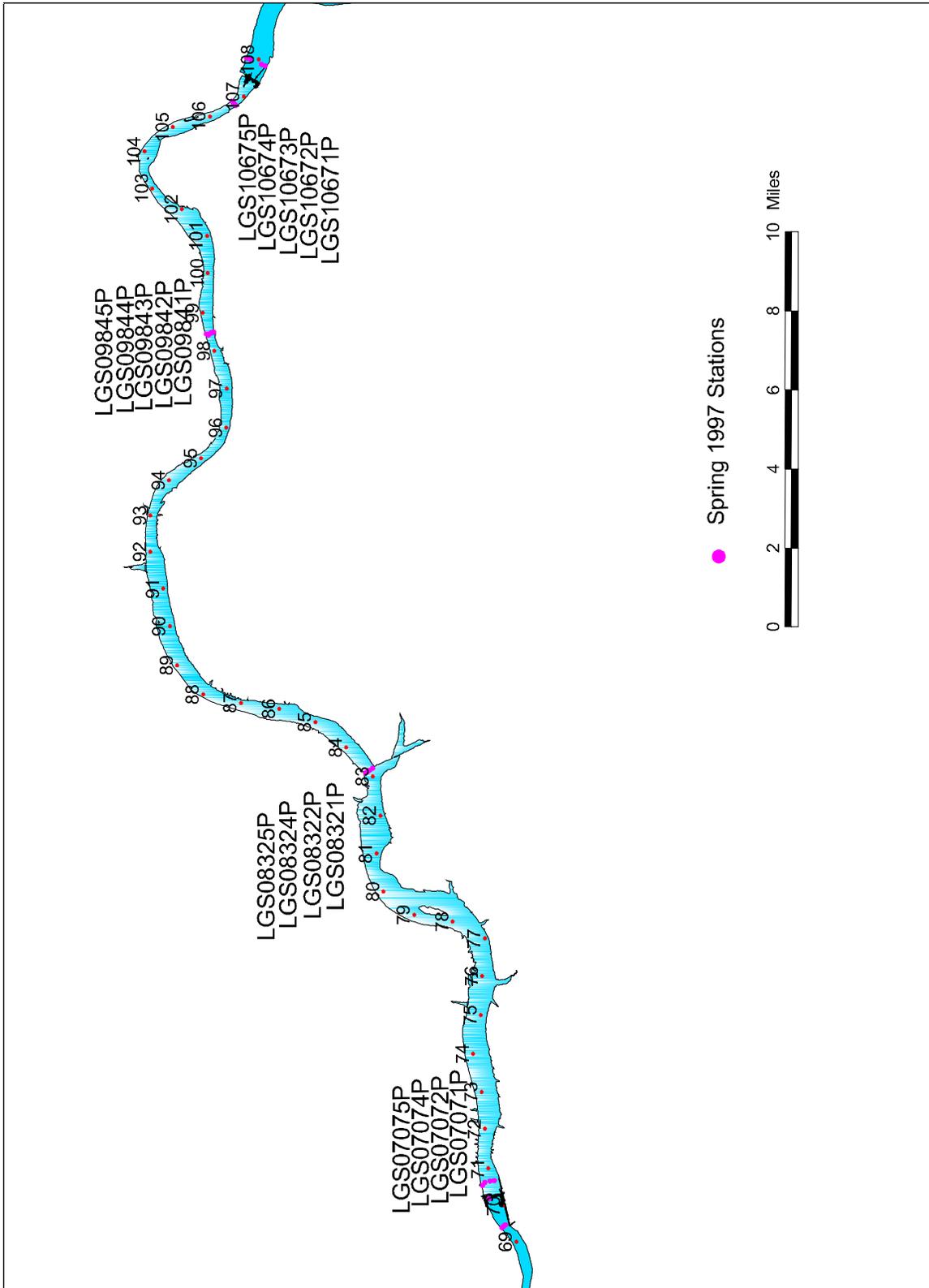


Figure 120. Dissolved gas monitor locations during the Spring 1997 study.

B.2 Velocity Data

Velocity measurements were made along a total of 26 transects in Little Goose pool during the Spring 1997 study period. The transects are summarized in Table 52. Supplied measurement locations are shown in Figure 121.

Table 52. Summary of ADCP transects made during the Spring 1997 study period.

Date Label	Average		Number of Measurements
	Velocity	Depth	
04-08-1997 12:18:00	3.9	24.3	33
04-08-1997 12:25:00	3.6	24.0	34
04-08-1997 12:34:00	3.9	25.2	29
04-08-1997 12:50:00	3.2	27.3	32
04-08-1997 13:09:00	3.1	24.4	34
04-08-1997 13:23:00	2.8	30.6	34
04-08-1997 13:40:00	2.3	26.9	53
04-08-1997 13:58:00	2.4	33.8	39
04-08-1997 14:22:00	1.8	29.2	58
04-08-1997 14:44:00	1.9	46.4	32
04-08-1997 14:51:00	2.0	47.5	32
04-08-1997 14:58:00	1.9	44.9	33
04-08-1997 15:26:00	1.4	42.7	48
04-08-1997 15:44:00	1.6	49.3	36
04-08-1997 16:03:00	1.5	54.6	39
04-08-1997 16:30:00	1.1	38.6	72
04-08-1997 16:56:00	0.9	55.4	65
04-08-1997 17:27:00	1.1	64.3	47
04-08-1997 17:48:00	1.1	60.1	47
04-08-1997 17:58:00	0.9	65.2	49
04-08-1997 18:09:00	1.0	59.7	46
04-09-1997 07:46:00	0.7	77.9	57
04-09-1997 08:17:00	0.7	82.7	82
04-09-1997 08:57:00	0.6	74.4	76
04-09-1997 09:11:00	0.7	74.5	78
04-09-1997 09:29:00	0.7	73.9	77

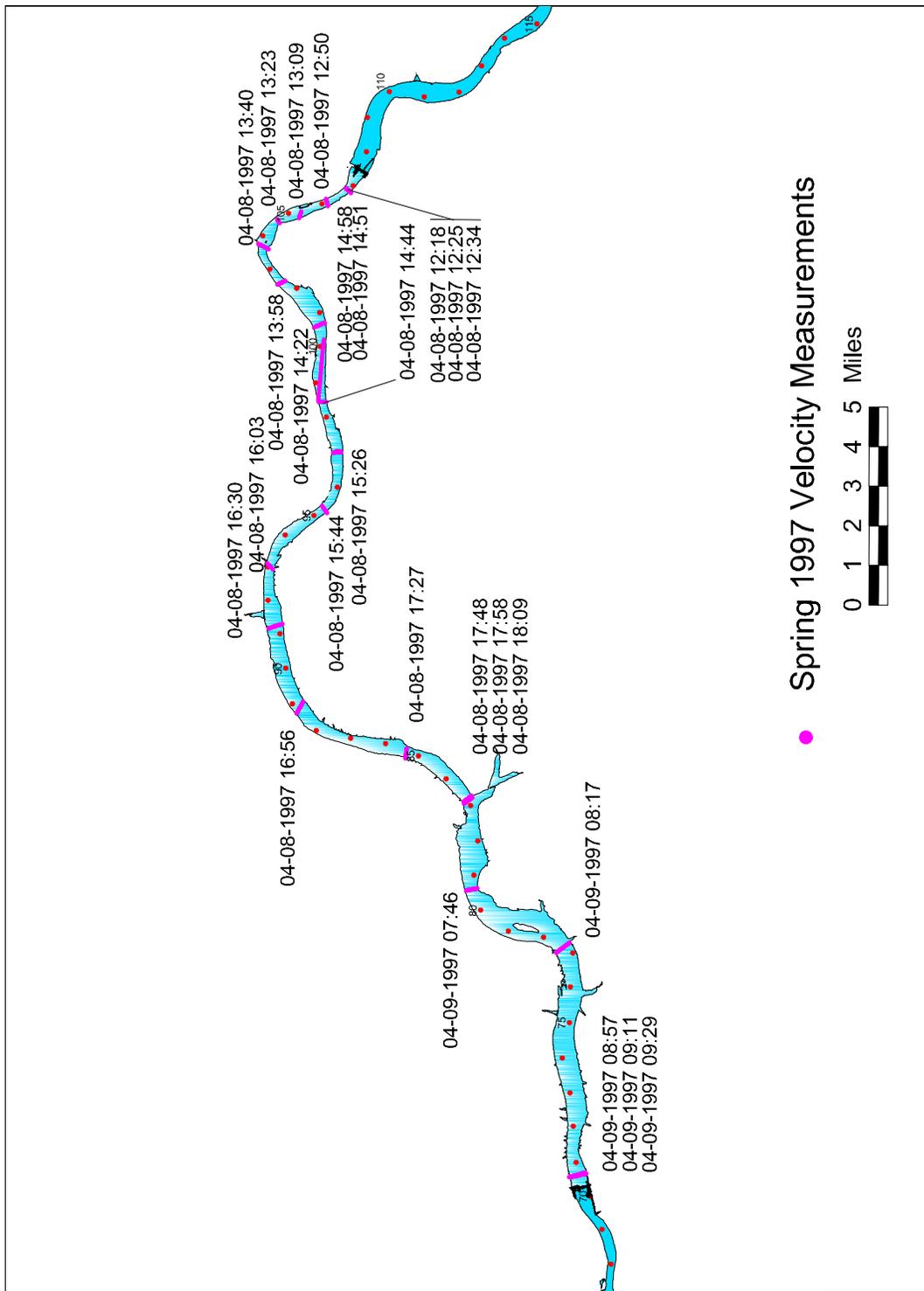


Figure 121. Locations of ADCP velocity measurements during the Spring 1997 study period.

B.3 Lower Granite Dam Model Boundary

B.3.1 Dam Operations

CHROMS operations data was used to establish the flow at the Lower Granite dam model boundary and stage at the Little Goose dam model boundary. This data provided hourly spillway flow and powerhouse flow. Hourly total spill and powerhouse flows for the Spring 1997 study period are shown in Figure 122. These flows were uniformly distributed across the corresponding part of the model grid.

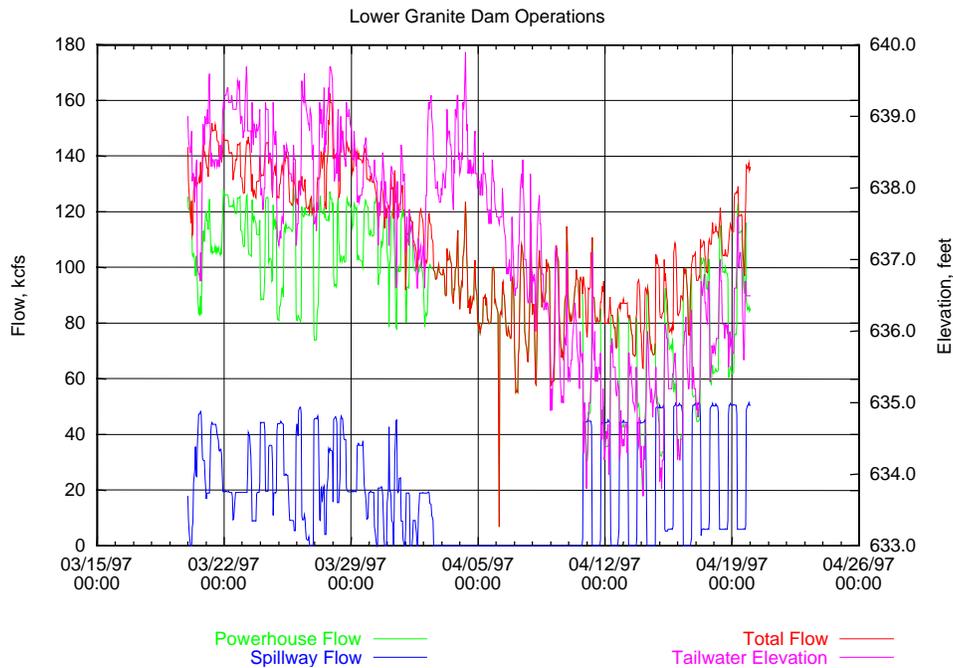


Figure 122. Lower Granite dam operations during the Spring 1997 study.

B.3.2 Water Quality

Initially, data from the permanent fixed monitor located in the Lower Granite dam forebay (station name "LWG") was used to establish temperature at the Lower Granite dam boundary. Station data was taken from the FMS database. Temperature measured by the station (Figure 123) was used for both spillway and power house flow. TDG pressures measured by the station (Figure 124) was used to compute TDG concentrations (Figure 125) for the power house flow. Spillway TDG gas pressures and concentrations (also shown in Figure 124 and Figure 125, respectively) were estimated using the TDG sourcing function for the Lower Granite dam.

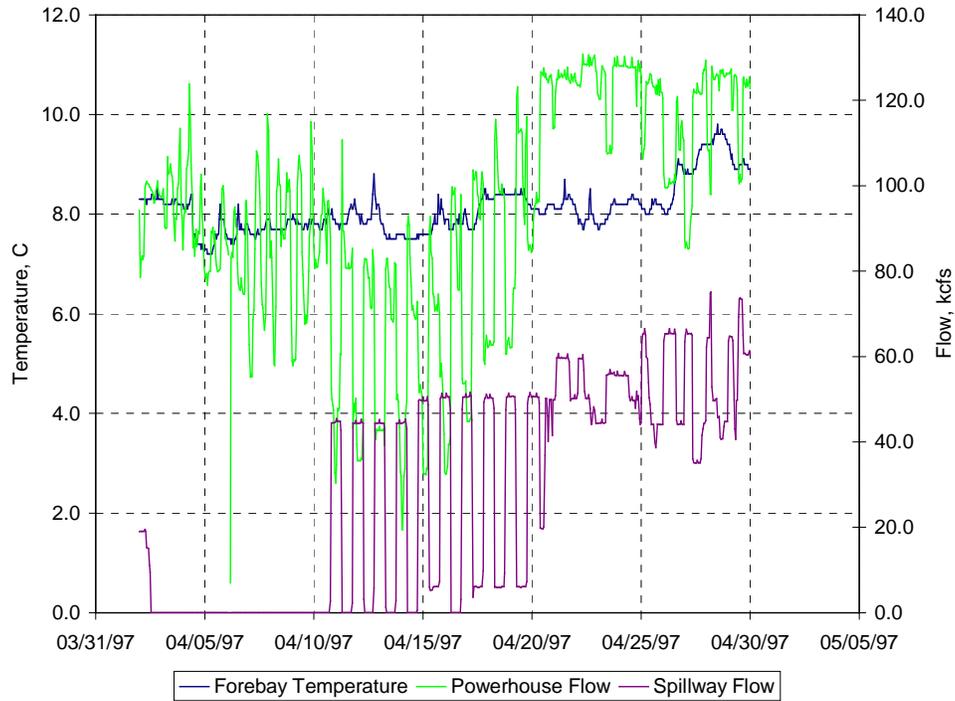


Figure 123. Lower Granite forebay water temperature during the Spring 1997 study period.

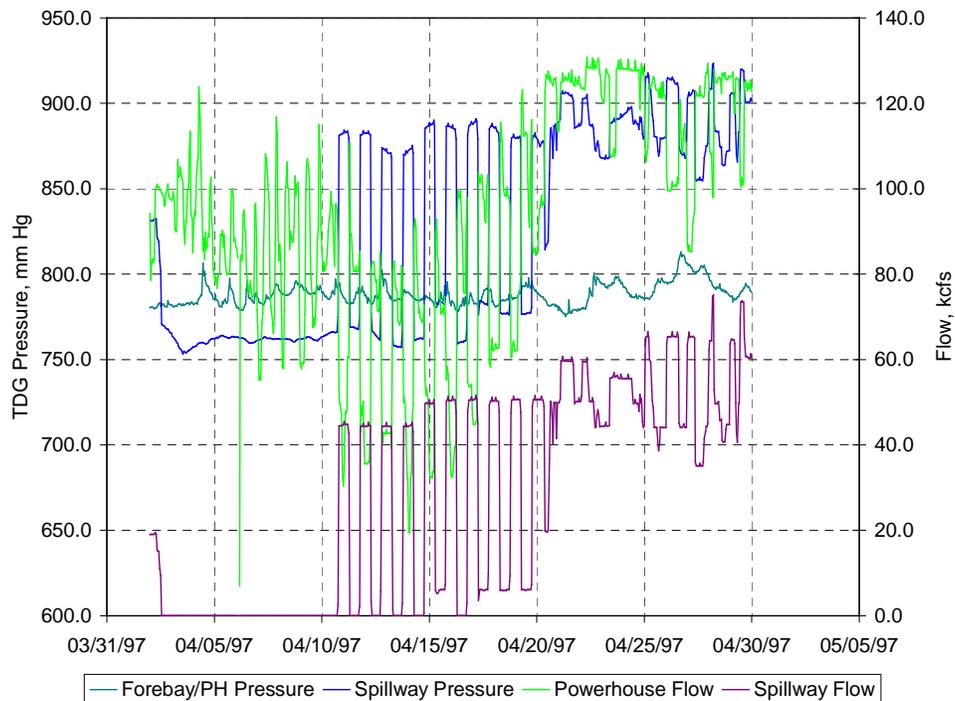


Figure 124. Lower Granite forebay TDG pressure during the Spring 1997 study.

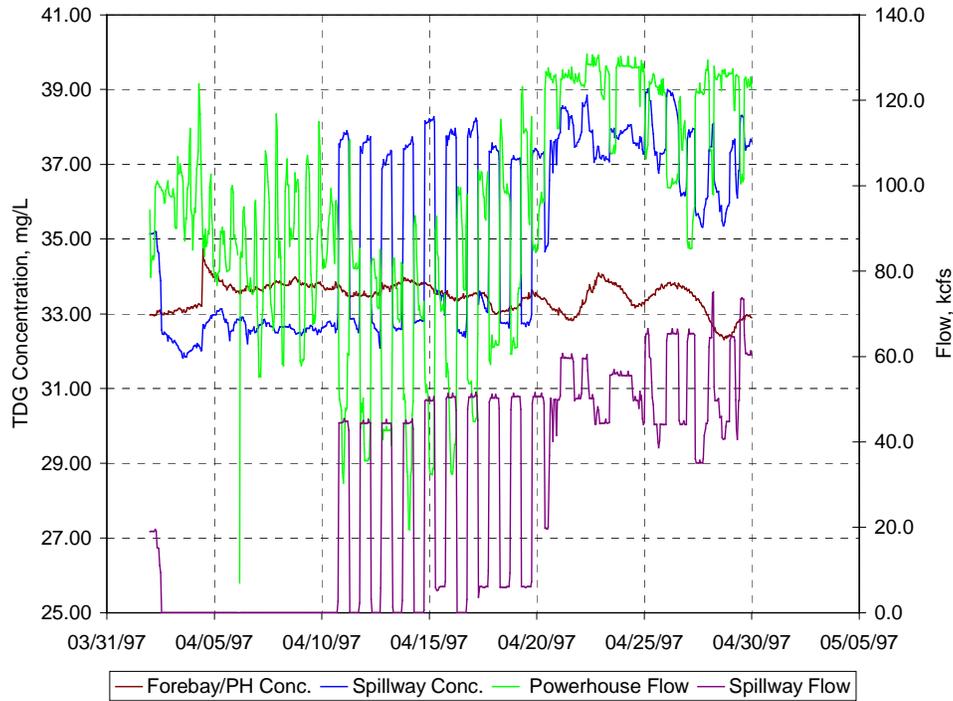


Figure 125. Computed TDG concentration in the Lower Granite forebay during the Spring 1997 study period.

Model boundary temperature and dissolved gas concentrations were also established at the Lower Granite dam boundary using the temporary pool study monitors. Five temporary monitors were located in the Little Goose tailrace during Spring 1996 study period, as shown in Figure 126. The temperatures and TDG pressures recorded by these monitors are shown in Figure 127 and Figure 128, respectively. TDG concentrations computed from the measured TDG pressures and temperatures are shown in Figure 129. The transport simulation boundary was established at grid row 24 of block 1 (shown in red in Figure 126). Temporary monitor TDG concentrations and temperatures as follows along the model grid:

- LGS10675P: columns 1 to 6;
- LGS10674P: columns 7 to 11; and
- LGS10673P: columns 12 to 24.

Station LGS10671P was not used since no TDG pressure measurements were made. Station LGS10672P was not used since its temperature measurements were erratic.

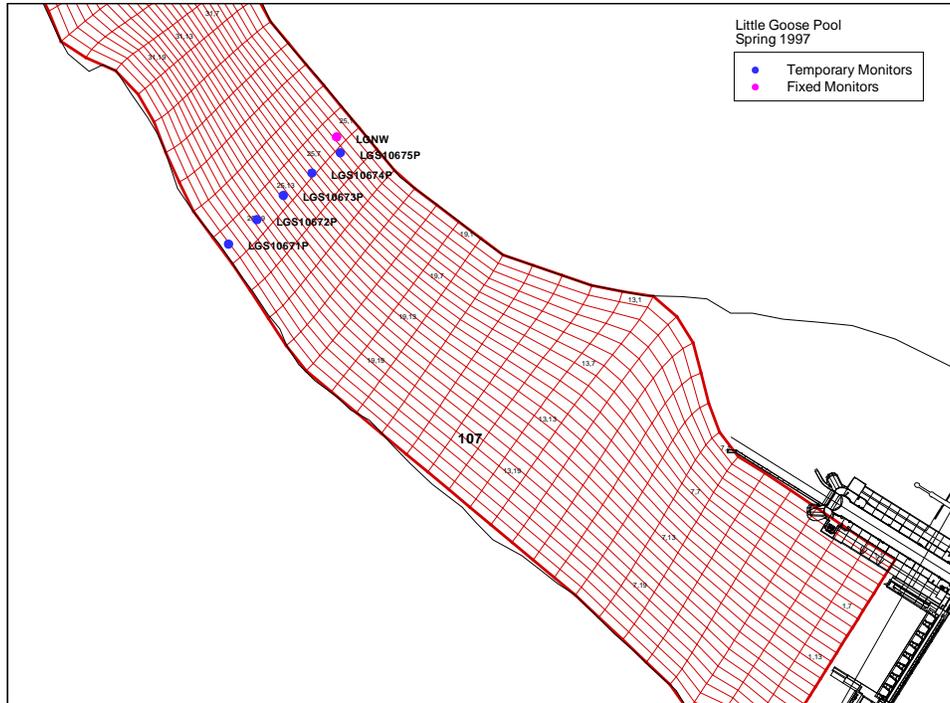


Figure 126. Locations, relative to the model grid, of upstream temporary monitors during the Spring 1997 study period.

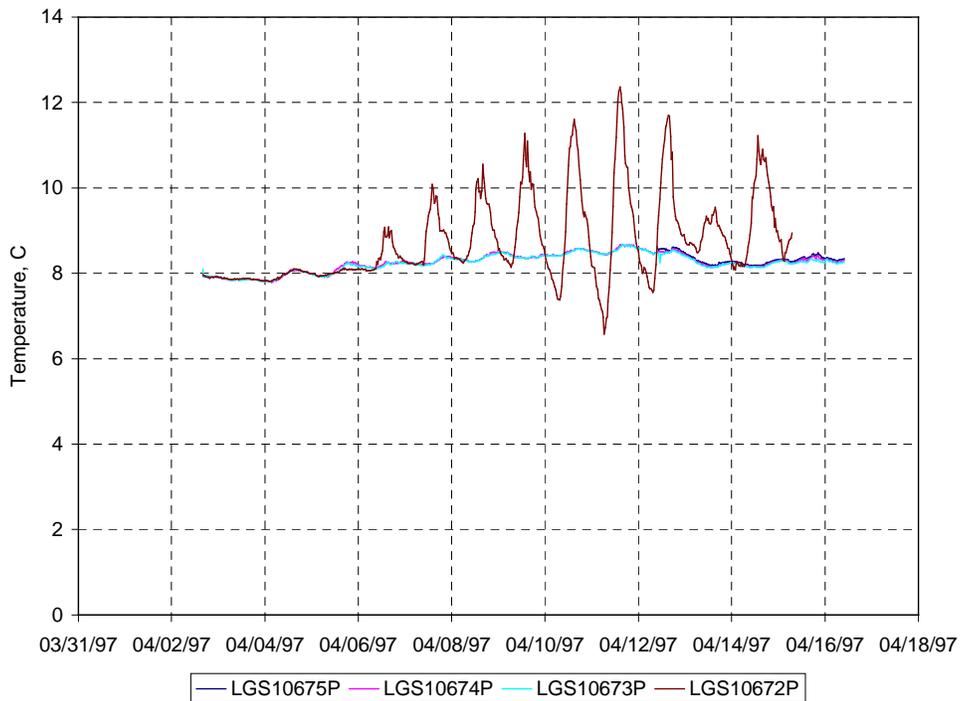


Figure 127. Temperatures measured by temporary monitors near Lower Granite dam during the Spring 1997 study period.

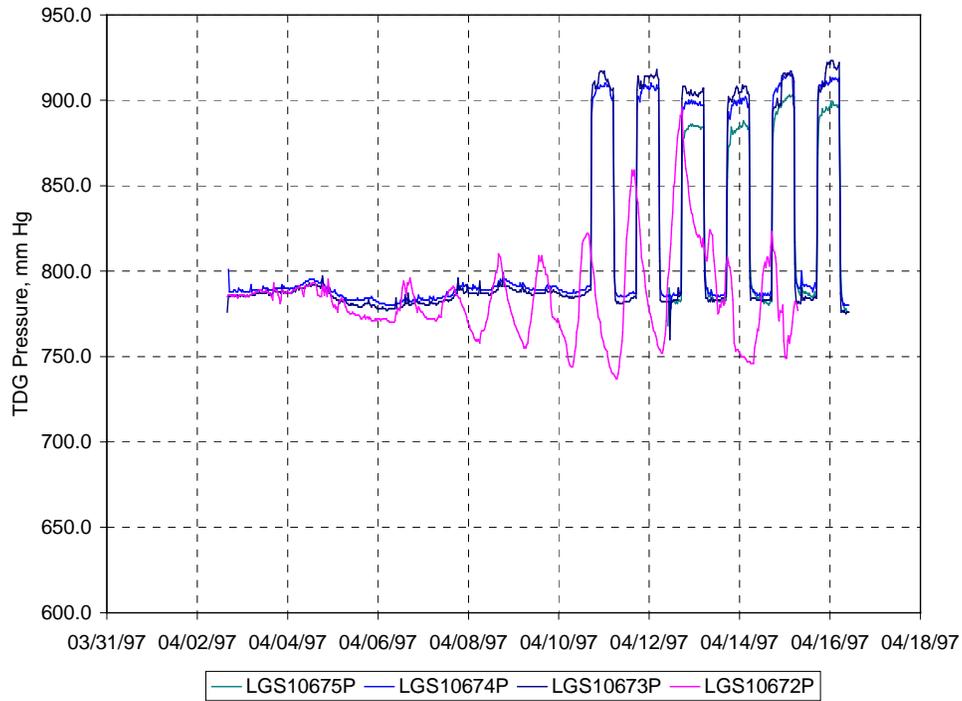


Figure 128. TDG pressures measured by temporary monitors near Lower Granite dam during the Spring 1997 study period.

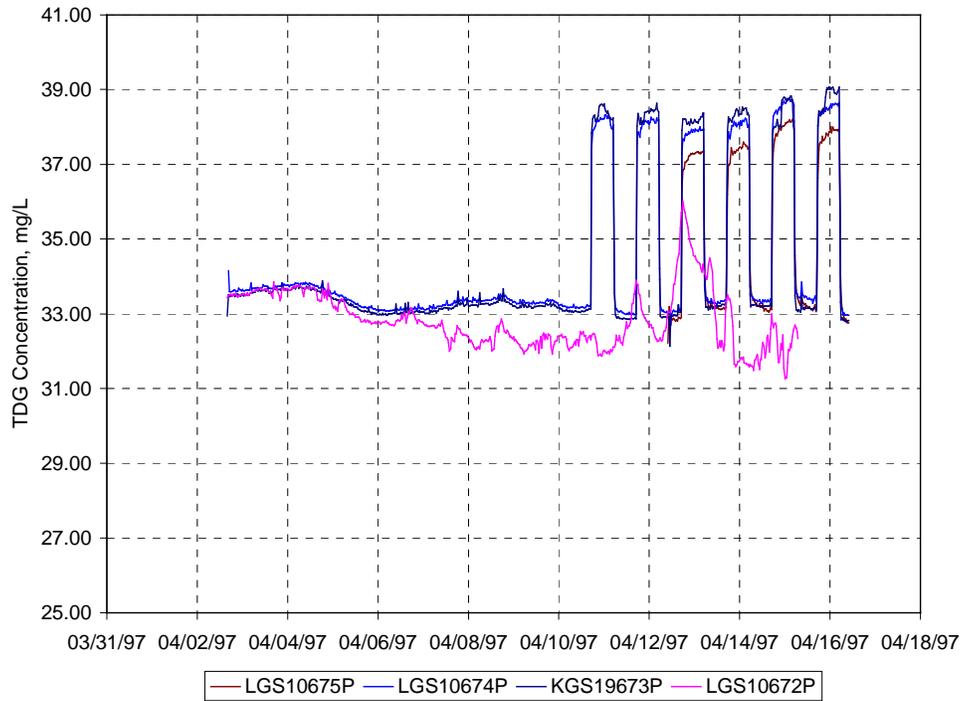


Figure 129. TDG concentrations computed from temporary monitor data near Lower Granite dam during the Spring 1997 study period.

B.4 Little Goose Dam Boundary Operations

Forebay stage for Little Goose dam was obtained from hourly CHROMS operations data and is shown in Figure 130.

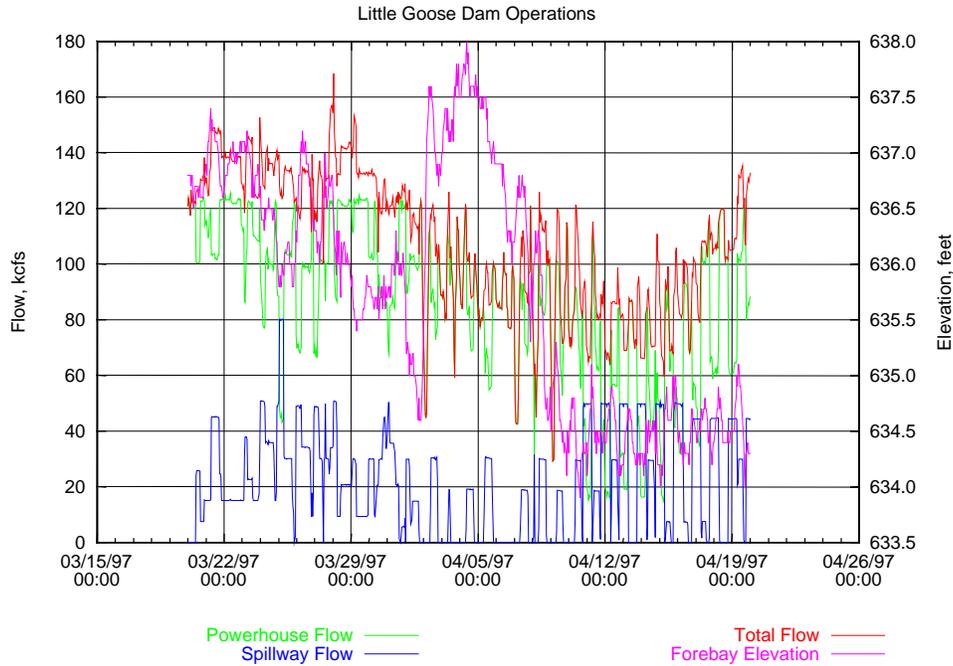


Figure 130. Little Goose dam operations during the Spring 1997 study.

B.5 Weather

Atmospheric conditions were considered constant over the entire pool. Lewiston, Idaho, air and dew point temperature (Figure 131) and wind speed (Figure 132) were used from the NWS weather database. Barometric pressure (also shown in Figure 131), measured at the LGO FMS, was considered to apply over the entire modeled area. Measured short-wave radiation was available from the WeatherPak database for a short time during the Summer 1997 study. That record was extended by estimating total incoming radiation using NWS Lewiston dew point and cloud cover data. Cloud cover was assumed to be zero (clear skies) if cloud cover data was missing from the Lewiston record. Net incoming solar radiation based both on the estimated total solar radiation is shown in Figure 133.

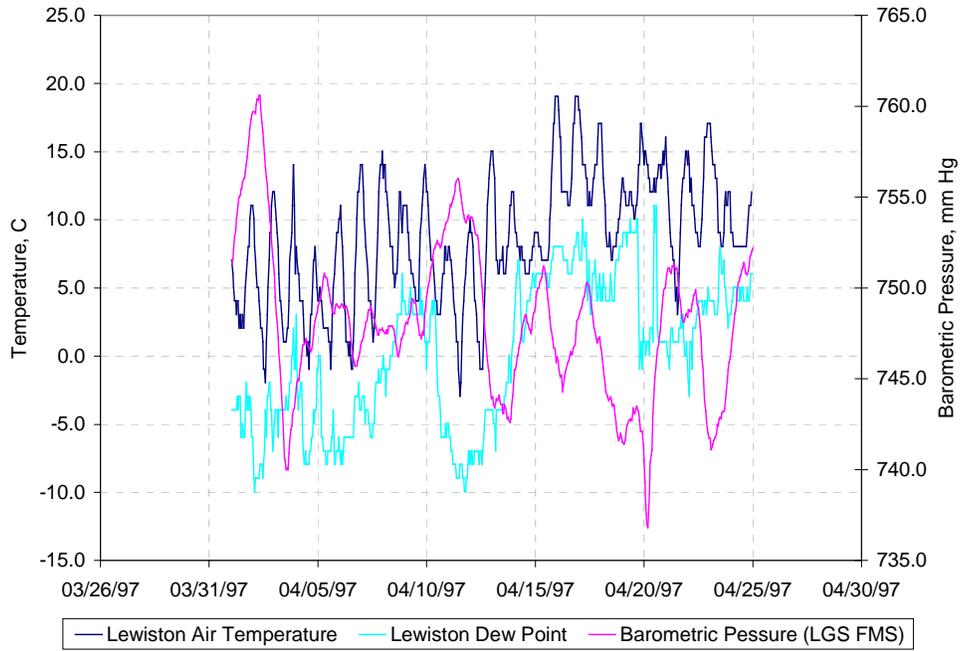


Figure 131 Air temperature, dew point, and barometric pressure used during the Spring 1997 study period.

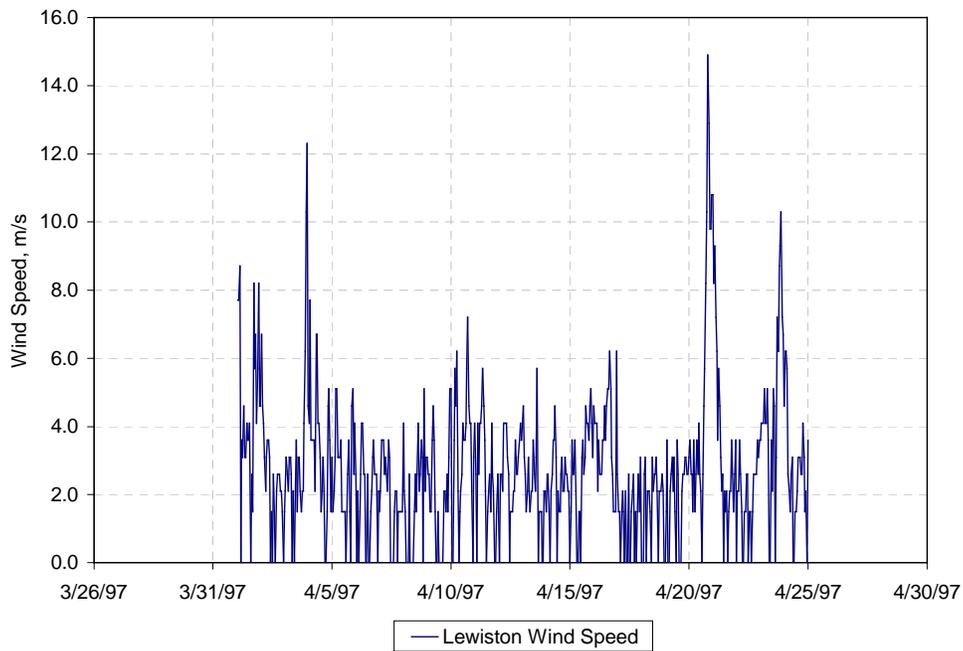


Figure 132. Wind speed used during the Spring 1997 study period.

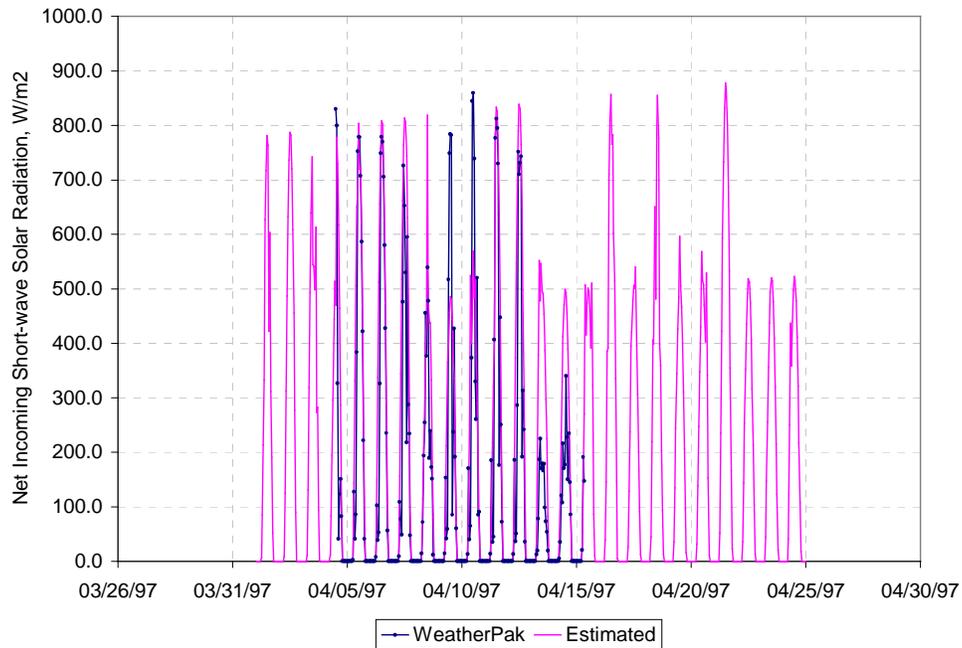


Figure 133. Measured and estimated net incoming short-wave solar radiation used during the Spring 1997 study period.

Appendix C. Summer 1997 Little Goose Pool Study

C.1 Dissolved Gas Data

The Summer 1997 Little Goose pool dissolved gas study started on June 6 and ended on June 13. A total of 18 water quality monitors were used. These stations, and their records, are listed in Table 53. Station locations are shown in Figure 120.

Table 53. Dissolved gas monitor stations, and their records, used during the Summer 1997 study period.

Station	Start Time	End Time	Temperature Records	Pressure Records
LGS09842P	6/6/97 12:00:00 PM	6/13/97 11:30:00 AM	671	671
LGS07072P	6/6/97 12:00:00 PM	6/13/97 3:30:00 PM	687	687
LGS07074P	6/6/97 12:00:00 PM	6/13/97 3:45:00 PM	688	688
LGS07075P	6/6/97 12:00:00 PM	6/13/97 4:00:00 PM	689	689
LGS08321P	6/6/97 12:00:00 PM	6/10/97 5:45:00 PM	408	408
LGS08322P	6/6/97 12:00:00 PM	6/13/97 1:30:00 PM	679	679
LGS08324P	6/6/97 12:00:00 PM	6/13/97 1:45:00 PM	680	680
LGS07071P	6/6/97 12:00:00 PM	6/13/97 3:30:00 PM	687	687
LGS09841P	6/6/97 12:00:00 PM	6/13/97 11:30:00 AM	671	671
LGS10675P	6/6/97 12:00:00 PM	6/13/97 9:45:00 AM	664	664
LGS09843P	6/6/97 12:00:00 PM	6/13/97 11:30:00 AM	671	671
LGS09844P	6/6/97 12:00:00 PM	6/13/97 11:30:00 AM	671	671
LGS09845P	6/6/97 12:00:00 PM	6/13/97 11:00:00 AM	669	669
LGS10671P	6/6/97 12:00:00 PM	6/13/97 10:00:00 AM	665	665
LGS10672P	6/6/97 12:00:00 PM	6/13/97 10:30:00 AM	667	667
LGS10673P	6/6/97 12:00:00 PM	6/13/97 10:15:00 AM	666	666
LGS10674P	6/6/97 12:00:00 PM	6/13/97 10:45:00 AM	668	668
LGS08325P	6/6/97 12:00:00 PM	6/13/97 1:45:00 PM	680	680

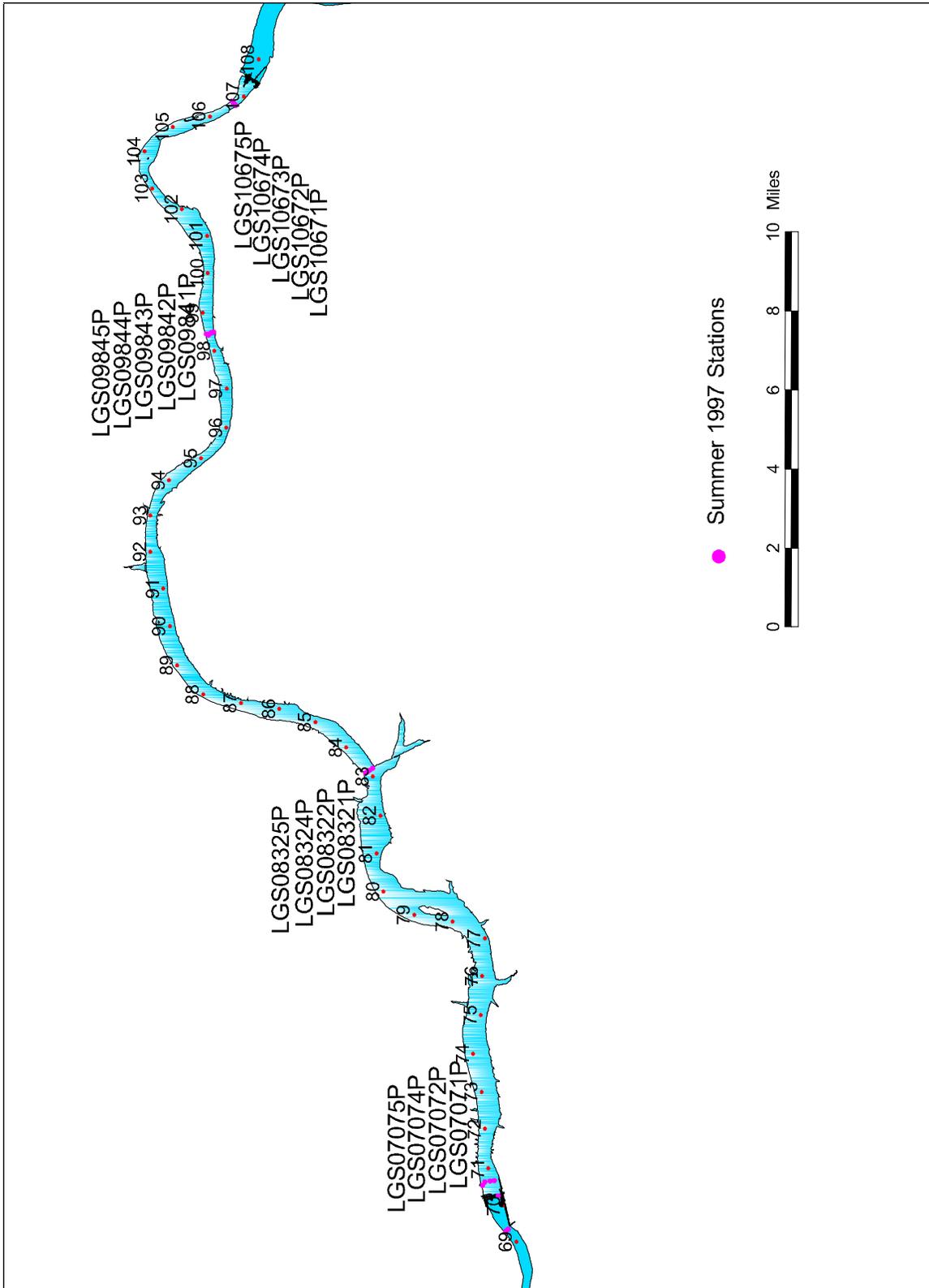


Figure 134. Dissolved gas monitor locations during the Summer 1997 study.

C.2 Velocity Data

Velocity measurements were made along a total of 20 transects in Little Goose pool during the Spring 1997 study period. The transects are summarized in Table 52. Supplied measurement locations are shown in Figure 121.

Table 54. Summary of ADCP transects made during the Summer 1997 study period.

Date Label	Average		Number of Measurements
	Velocity	Depth	
06-11-1997 13:29:00	6.6	34.8	38
06-11-1997 13:34:00	6.8	36.0	33
06-11-1997 13:42:00	6.8	35.2	46
06-12-1997 09:12:00	6.0	28.5	42
06-12-1997 09:25:00	5.2	24.5	37
06-12-1997 09:33:00	5.7	25.4	58
06-12-1997 09:47:00	5.5	28.6	40
06-12-1997 10:00:00	4.2	31.1	41
06-12-1997 10:14:00	4.3	30.6	35
06-12-1997 10:34:00	3.0	24.9	73
06-12-1997 10:51:00	3.6	29.2	58
06-12-1997 11:18:00	3.1	32.8	48
06-12-1997 11:34:00	4.0	43.2	38
06-12-1997 11:41:00	4.0	44.1	37
06-12-1997 11:47:00	3.8	45.3	35
06-12-1997 12:05:00	2.7	41.8	44
06-12-1997 12:22:00	3.1	46.7	45
06-12-1997 12:39:00	2.9	50.9	45
06-12-1997 12:58:00	1.8	37.0	70
06-12-1997 13:21:00	1.6	48.2	51
06-12-1997 13:42:00	1.7	61.9	50

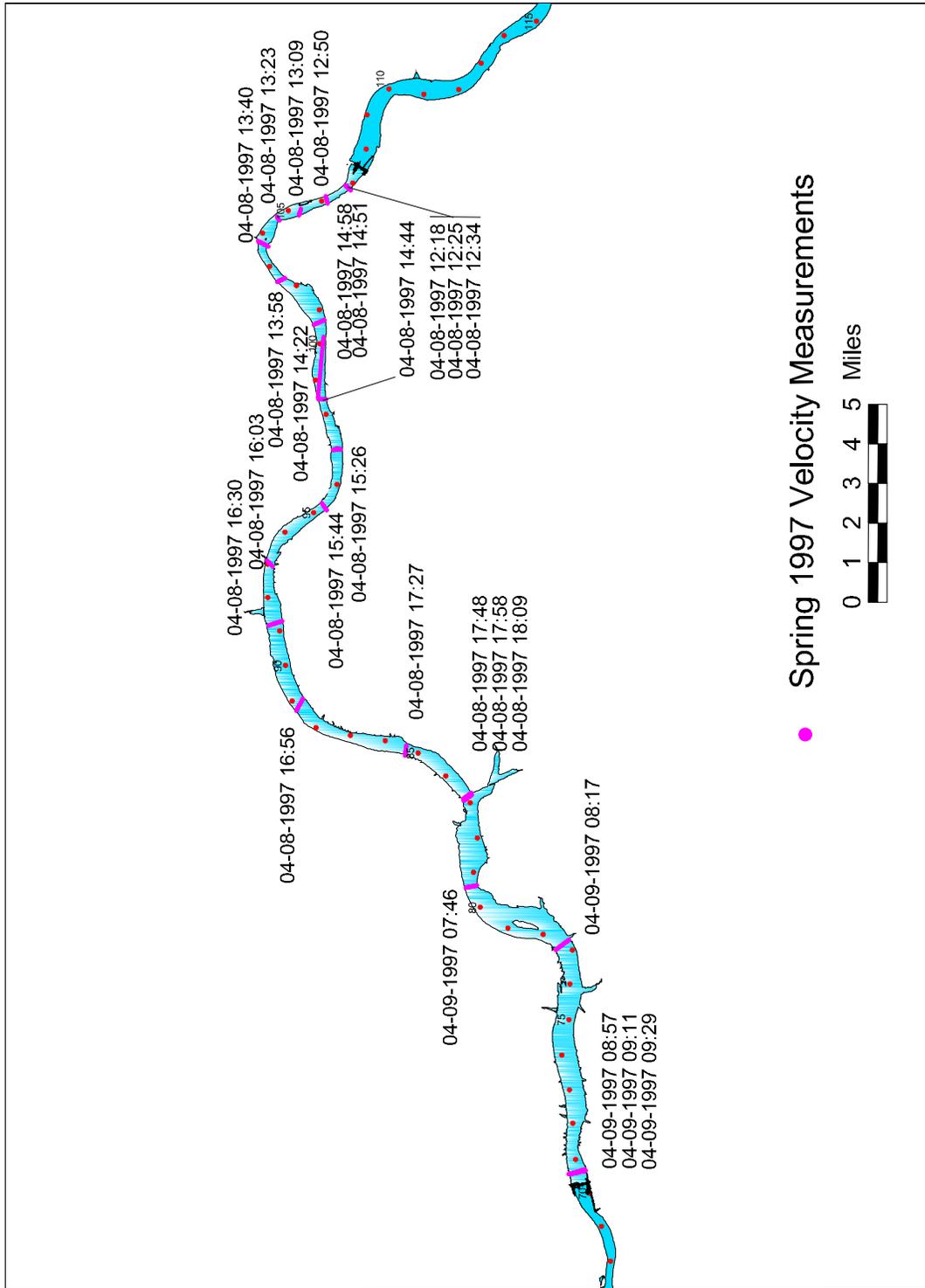


Figure 135. Locations of ADCP velocity measurements during the Summer 1997 study period.

C.3 Lower Granite Dam Model Boundary

C.3.1 Dam Operations

CHROMS operations data was used to establish the flow at the Lower Granite dam model boundary and stage at the Little Goose dam model boundary. This data provided hourly spillway flow and powerhouse flow. Hourly total spill and powerhouse flows for the Summer 1997 study period are shown in Figure 136. These flows were uniformly distributed across the corresponding part of the model grid.

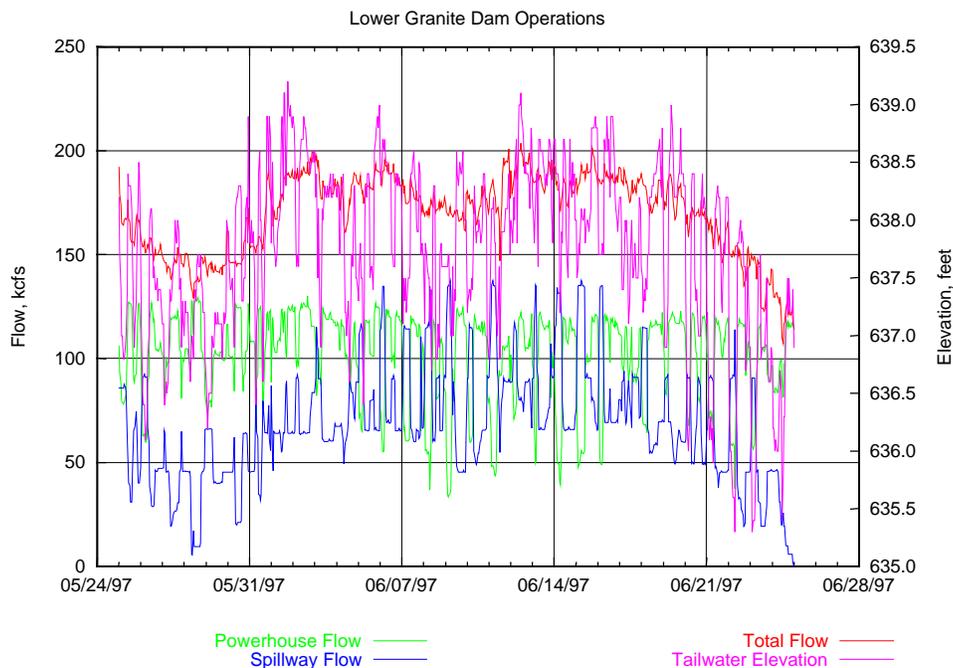


Figure 136. Lower Granite dam operations during the Summer 1997 study.

C.3.2 Water Quality

Initially, data from the permanent fixed monitor located in the Lower Granite dam forebay (station name "JDA") was used to establish temperature at the John Day dam boundary. Station data was taken from the FMS database. Temperature measured by the station (Figure 137) was used for both spillway and powerhouse flow. TDG pressures measured by the station (Figure 138) were used to compute TDG concentrations (Figure 139) for the power house flow. Spillway TDG gas pressures and concentrations (also shown in Figure 138 and Figure 139, respectively) were estimated using the TDG sourcing function for John Day dam.

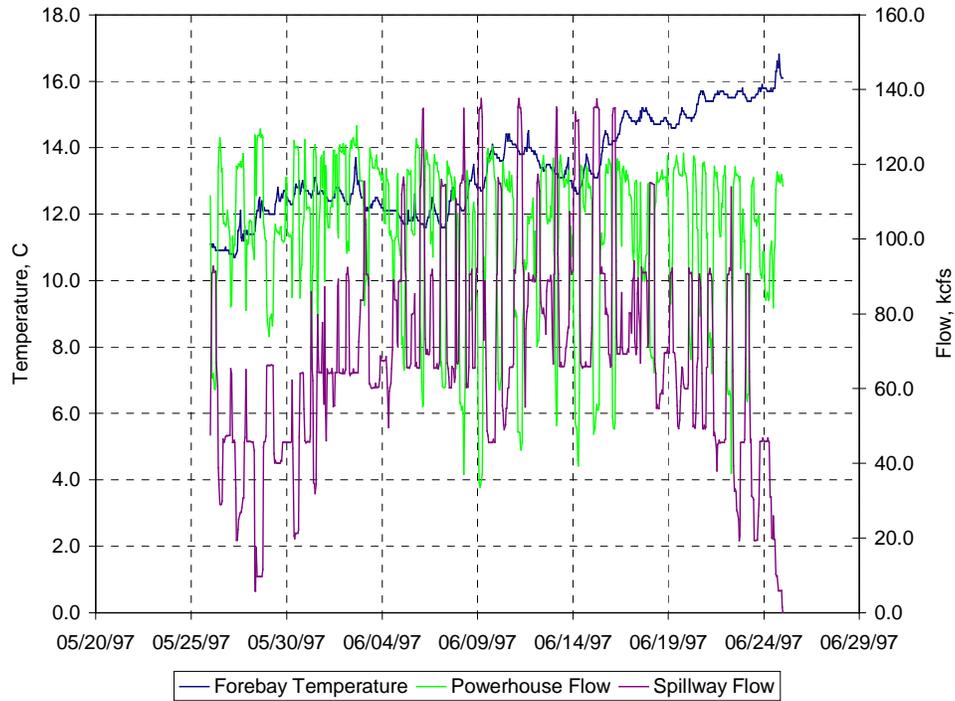


Figure 137. Water temperature at Lower Granite dam during the Summer 1997 study.

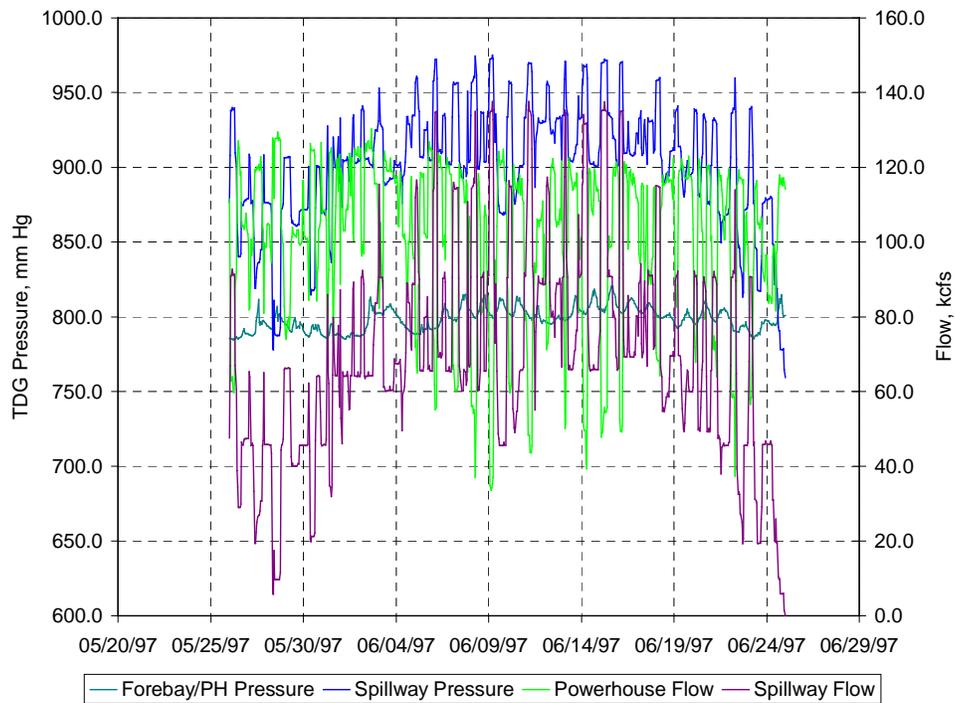


Figure 138. TDG pressure at Lower Granite dam during the Summer 1997 study period.

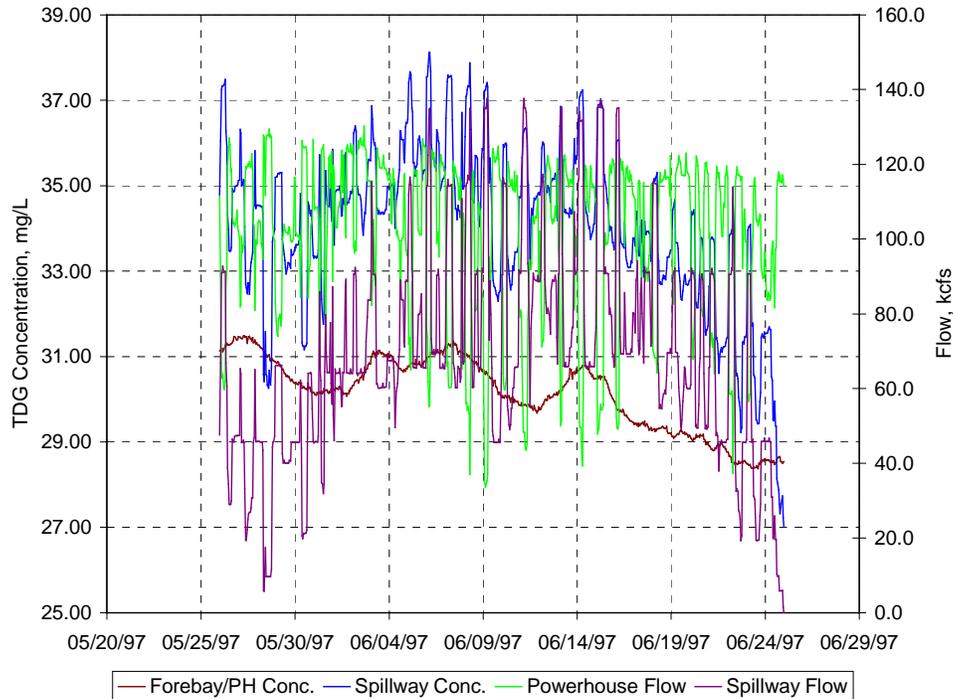


Figure 139. Computed TDG concentration at Lower Granite during the Summer 1997 study.

Model boundary temperature and dissolved gas concentrations were also established at the Lower Granite dam boundary using the temporary pool study monitors. Five temporary monitors were located in the Little Goose tailrace during Spring 1996 study period, as shown in Figure 140. The temperatures and TDG pressures recorded by these monitors are shown in Figure 141 and Figure 142, respectively. TDG concentrations computed from the measured TDG pressures and temperatures are shown in Figure 143. The transport simulation boundary was established at grid row 24 of block 1 (shown in red in Figure 140). Temporary monitor TDG concentrations and temperatures as follows along the model grid:

- LGS10675P: columns 1 to 6;
- LGS10674P: columns 7 to 11;
- LGS10673P: columns 12 to 16;
- LGS10674P: columns 17 to 21; and
- LGS10673P: columns 22 to 24.

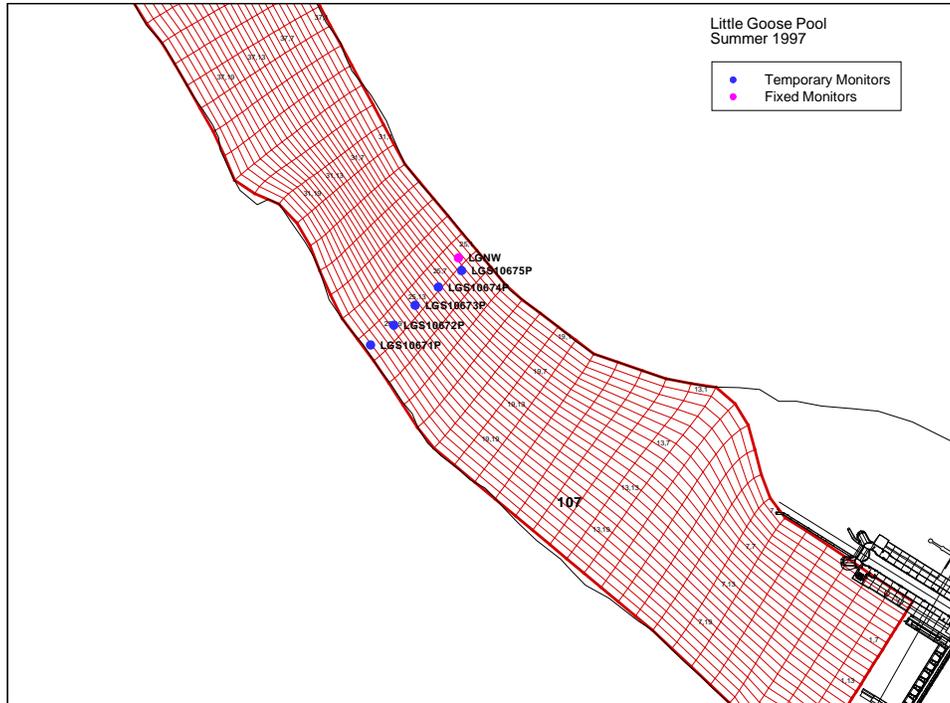


Figure 140. Locations, relative to the model grid, of temporary monitors during the Summer 1997 study period.

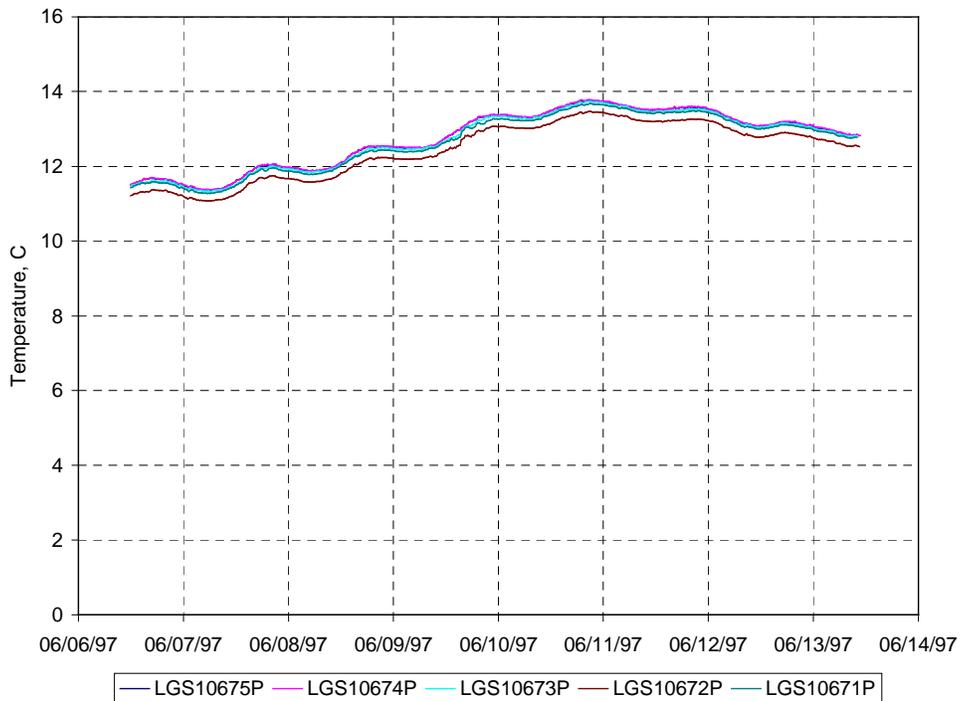


Figure 141. Temperature measured by temporary monitors below Lower Granite dam during the Summer 1997 study period.

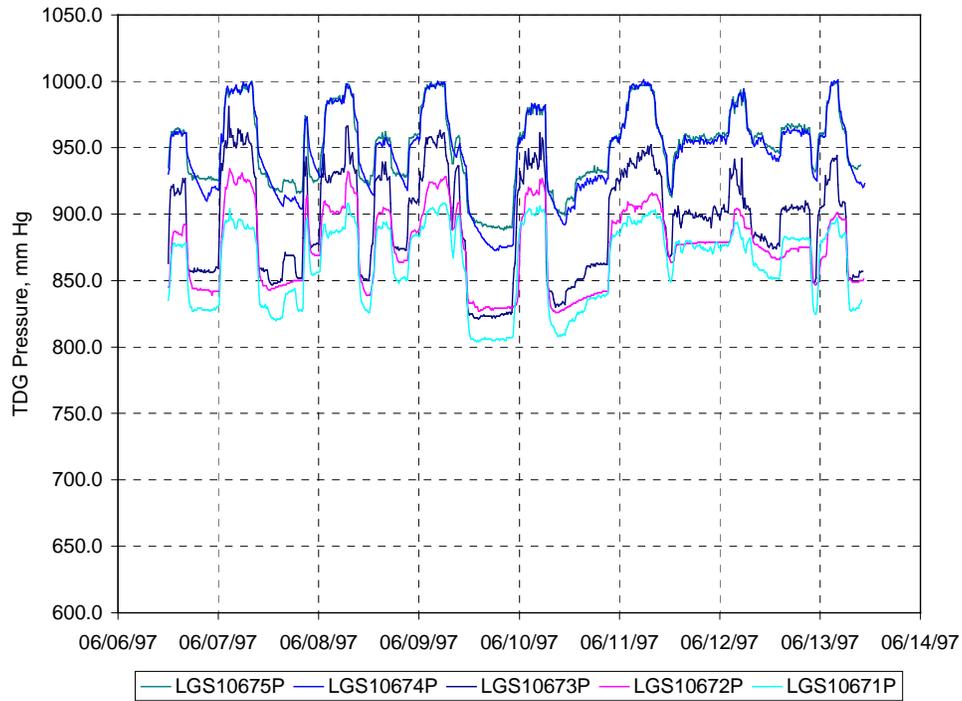


Figure 142. TDG pressure measured by temporary monitors below Lower Granite dam during the Summer 1997 study period.

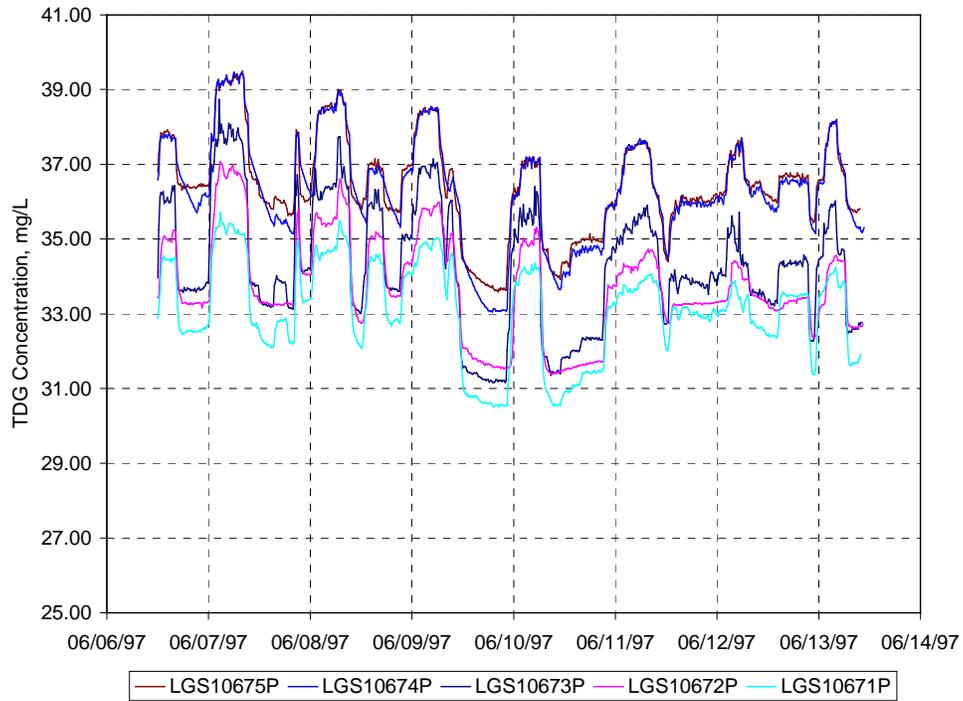


Figure 143. TDG concentration computed using temperature and pressure measured by temporary monitors below Lower Granite during the Summer 1997 study.

C.4 Little Goose Dam Boundary Operations

Forebay stage for Little Goose dam was obtained from hourly CHROMS operations data and is shown in Figure 144.

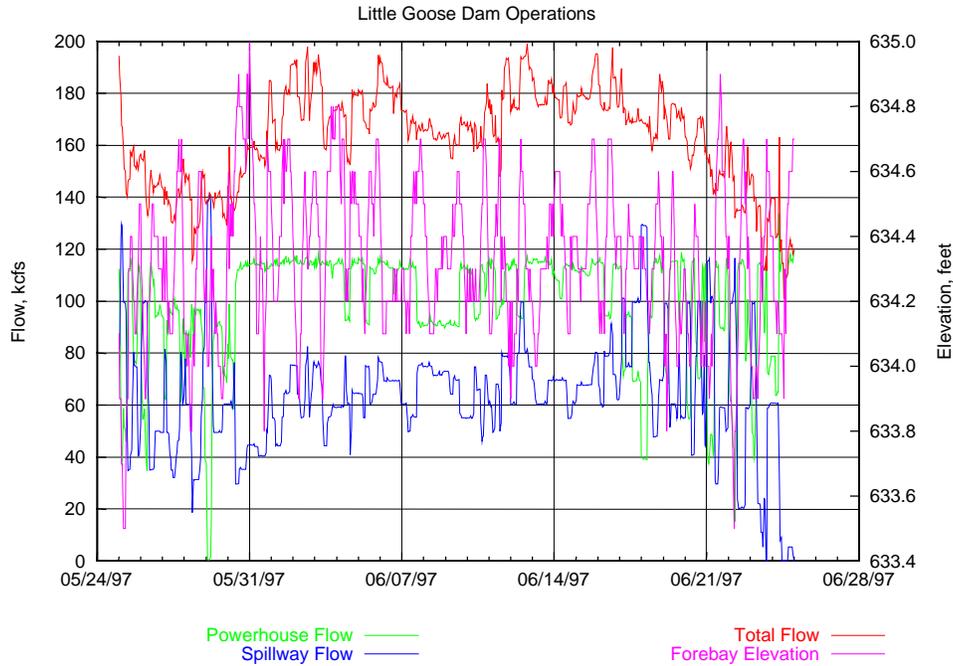


Figure 144. Little Goose dam operations during the Summer 1997 study.

C.5 Weather

Atmospheric conditions were considered constant over the entire pool. Lewiston, Idaho, air and dew point temperature (Figure 145) and wind speed (Figure 146) were used from the NWS weather database. Barometric pressure (also shown in Figure 145), measured at the LGO FMS, was considered to apply over the entire modeled area. Measured short-wave radiation was available from the WeatherPak database for a short time during the Summer 1997 study. That record was extended by estimating total incoming radiation using NWS Lewiston dew point and cloud cover data. Cloud cover was assumed to be zero (clear skies) if cloud cover data was missing from the Lewiston record. Net incoming solar radiation based both on the estimated total solar radiation is shown in Figure 147.

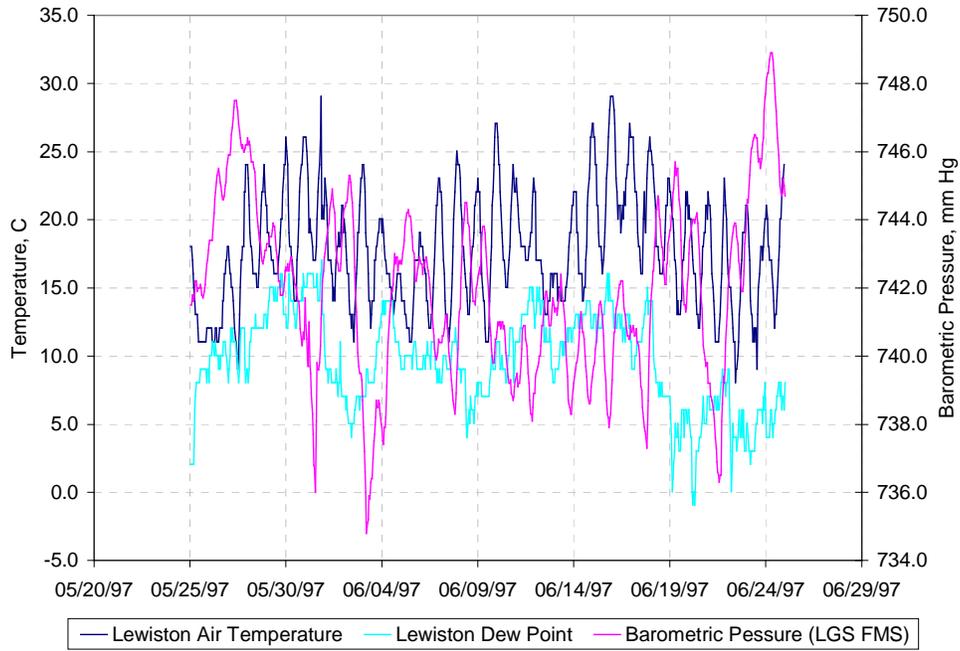


Figure 145 Air temperature, dew point, and barometric pressure used during the Summer 1997 study period.

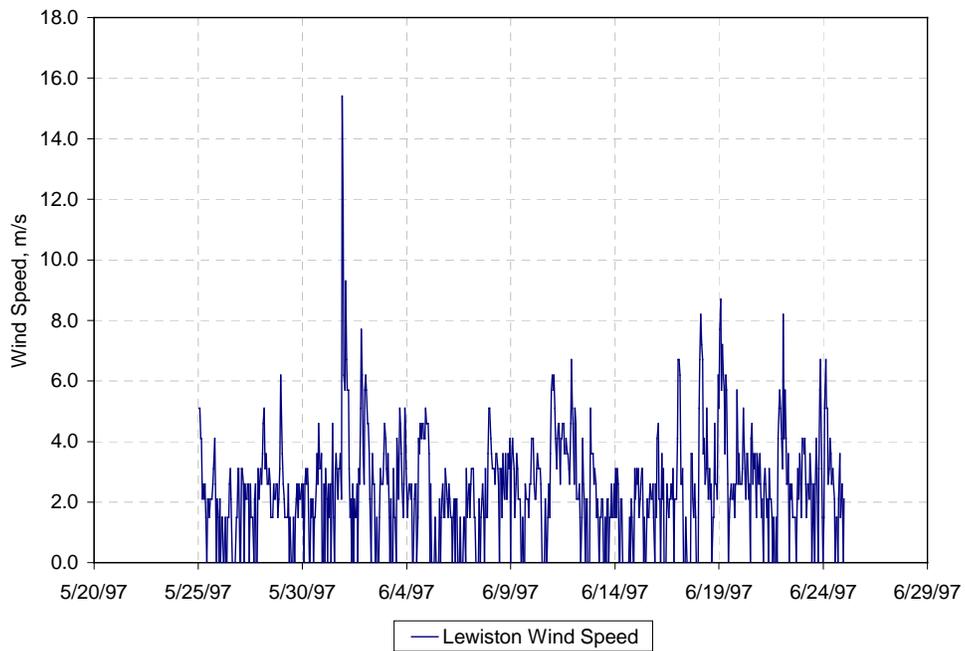


Figure 146. Wind speed used during the Summer 1997 study period.

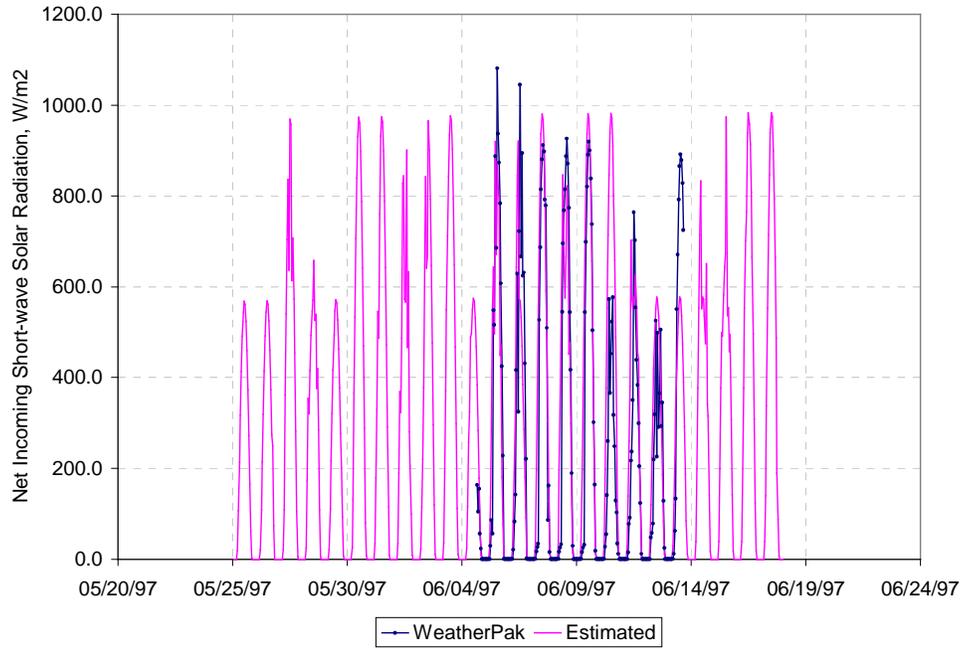


Figure 147. Measured and estimated net incoming short-wave solar radiation used during the Summer 1997 study period.