Bear River Tri-State Water Quality Monitoring

2006-2011 Data Summary

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Summary

Water quality of the Bear River has been regularly monitored at 21 locations from 2006-2011 through a cooperative effort between the States of Idaho, Utah, and Wyoming. Water chemistry monitoring was conducted during defined hydrologic intervals. Sediment and nutrient transport tend to be seasonal, guiding the timing of sampling. In addition to water chemistry, *Escherichia coli* was monitored at each site over a two year period. This monitoring detected only one exceedance of the Primary Contact Recreation (PCR) criterion of 406 colonies/100ml at one monitoring location in Idaho and three exceedances of the Wyoming criteria of 126 colonies/100m/ at two sites in Wyoming and at the Idaho/Wyoming border site.

Table 1. Bear River water quality monitoring locations.

Monitoring Location	Name	Description	Location		
			Latitude	Longitude	Elevation
BR-01	Above Evanston	Above Evanston West of Hwy 150 where Hwy crosses Mill Creek	N 41.04542°	W -110.93326°	7438
BR-02	Evanston	Above Woodruff Narrows below Evanston at Hwy 89 Rd Crossing	N 41.371056 °	W -111.017765 °	6540
BR-03	Below Narrows	Below Woodruff Narrows near UT-WY border	N 41.520477°	W -111.060125°	6344
BR-04	Randolph	East of Randolph	N 41.669000°	W -111.139235°	6245
BR-05	B-Q Dam	Above Pixley Dam	N 41.862987°	W -111.009724°	6205
BR-06	Idaho-Wyoming Border	USGS gage station down river of border	N 42.211197°	W -111.053299°	6064
BR-07	Rainbow Canal	Rainbow Canal below Stewart Dam	N 42.250329°	W -111.288589°	5948
BR-08	Bear Lake Inlet	East of outlet near North Beach State Park	N 42.120264°	W -111.299034°	5934
BR-09	Bear Lake Outlet	Bear Lake outlet at Lifton pump station	N 42.122784°	W -111.315097°	5934
BR-10	Paris Dike	Outlet Canal beneath Mud Lake	N 42.208155°	W -111.339871°	5932
BR-11	Pescadero	USGS gage 10068500	N 42.400874°	W -111.354877°	5918
BR-12	Above Alexander Reservoir	Road crossing above Alexander Reservoir	N 42.649355°	W -111.617240°	5730
BR-13	Below Grace Dam	Below Hwy 34 bridge	N 42.586013°	W -111.730310°	5530
BR-14	Below Cove Power Plant	Road crossing below Cove power plant at River Rd bridge	N 42.494955°	W -111.791969°	4929
BR-15	Above Oneida Reservoir	Hwy 34 crossing above Oneida Narrows	N 42.346769°	W -111.713442°	4906
BR-16	Below Oneida Reservoir	Road crossing below Oneida station	N 42.263672°	W -111.752952°	4764
BR-17	Idaho-Utah Border	Road crossing near border, 3900 S Rd in Idaho	N 42.029571 °	W -111.921775°	4450
BR-18	Below Cub River	Below Cub River Confluence, on Rd Crossing in Amalga, UT	N 41.836256°	W -111.893468°	4416
BR-19	Above Cutler Dam	Road Crossing up river of Benson, above Cutler Reservoir	N 41.800930°	W -111.909844°	4415
BR-20	Below Cutler Dam	Flow Gage below Cutler Dam	N 41.832747°	W -112.059065°	4288
BR-21	Corinne	USGS Real-time gage 10126000 up river from Corinne, Utah	N 41.545613°	W -112.095774°	4228

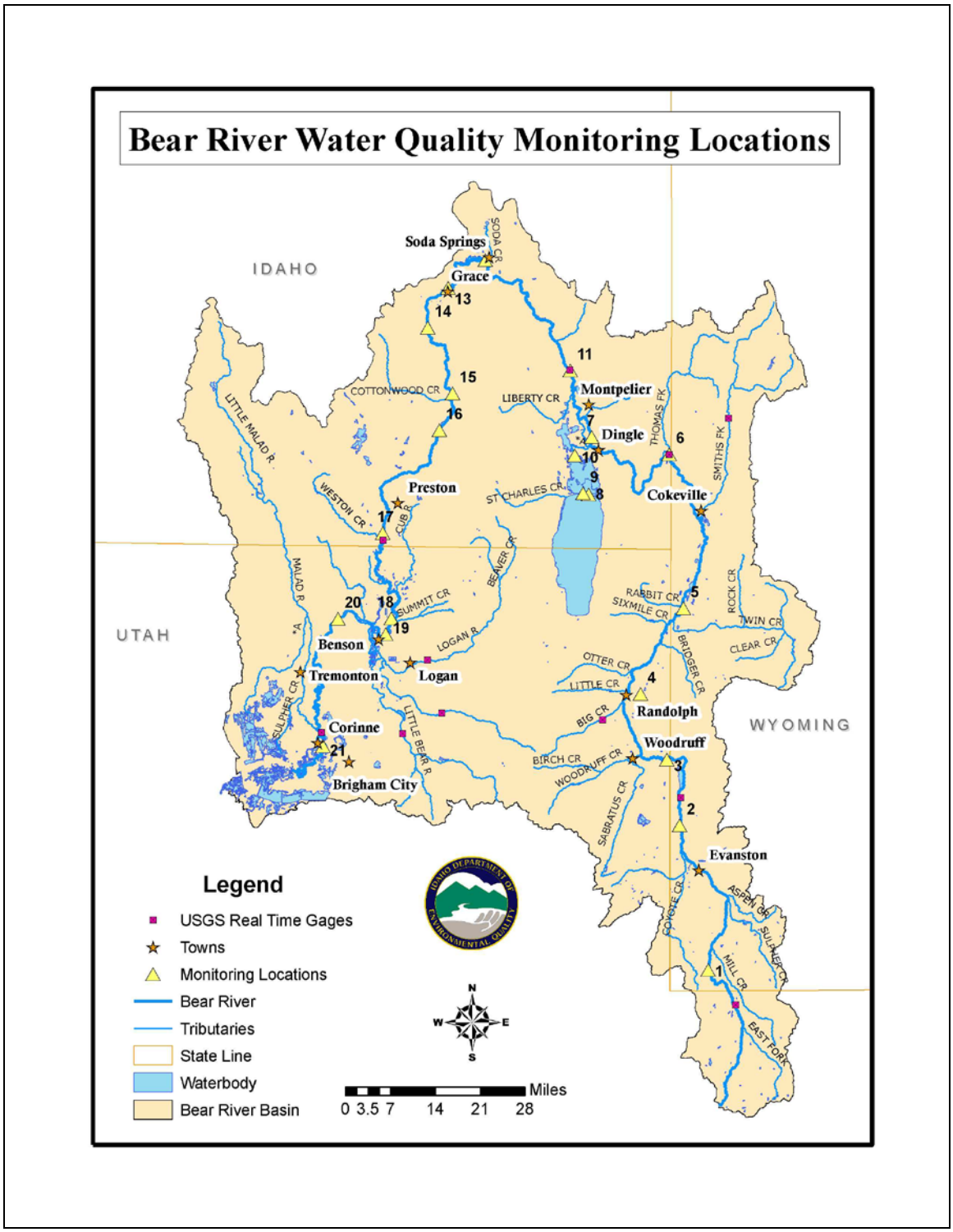

Figure 1. Bear River water quality monitoring locations.

Methods

Twenty-one (21) sites were monitored along the Bear River (Figure 1); 11 in Idaho, 7 in Utah, and 3 in Wyoming, a total of four times a year. Sediment and nutrient transport tend to be both seasonal and flow dependent, therefore water chemistry monitoring coincided with the following hydrologic events: summer base flow, winter base flow, lower basin run-off and upper basin run-off.

The Bear River Tri-State Water Quality Monitoring Plan prescribes depth-integrated sampling across the river channel, however time and resource constraints limit sampling to a grab sample. One discreet bucket sample was collected from the bridge in the centroid of the stream to allow for the most representative sample. Each sample was then transferred from the splitting-churn into sample containers. All water chemistry samples were preserved as necessary, stored at 4°C in coolers and shipped under chain of custody to Energy Laboratories (Billings, MT). Sampling equipment was rinsed three times with local ambient water prior to use and rinsed three times with deionized water after use.

A YSI multi-parameter monitoring system (model 6920 sonde, model 650 MDS display, Yellow Springs Instruments, OH) was used to acquire in-situ readings of dissolved oxygen, temperature, turbidity, specific conductivity, and pH concurrent with water sampling. Readings were taken at up to three locations across the river (middle, left third, right third).

E. coli was sampled at all 21 locations twice over two years (29-30 June 2006, 5-6 July 2007). Bacteria sampling involved either a direct grab or bucket grab depending on location. Each *E. coli* sample was analyzed in the field utilizing Utah DEQ's mobile bacterial testing unit.

Concentration and load results are shown as box and whisker plots. A box plot is a convenient way to visualize datasets. The median value for the dataset, from which the box plot was constructed, is shown as a solid black line. The mean is shown as a dotted line; it is often influenced by extremely high or low values. The box then comprises 50% of the dataset with the top being the upper quartile and the bottom being the lower quartile. The whiskers extend to the 5^{th} and 95^{th} percentiles and are only shown when the sample set has at least nine data points. Data points falling outside of the 10^{th} and 90^{th} percentiles are considered outliers and are shown as dots. Some extreme outliers are not included in the figures and the range of the y-axis was limited, in some cases, to preserve the explanatory value of the graph. Sites below reservoirs are shown in blue.

For the purposes of statistical and load analyses, chemical analyses falling below the limit of detection were assigned a value of one-half of the detection limit. Table 2 lists the detection limit for the applicable constituents.

Table 2. Water chemistry detection limits.

CONSTITUENT	DETECTION LIMIT (mg/L)
Total Suspended Sediment	10
Total Dissolved Solids	10
Alkalinity	2
Chloride	1
Sulfate	1
Ammonia	0.05
Nitrate+Nitrite	0.05
Total Kjeldahl Nitrogen	0.1
Orthophosphate	0.004
Total Phosphorus	0.004

Results

Chemical Constituents

Concentration of total suspended sediment (TSS) in the Bear River ranged from below the detection limit to a high of 454 mg/L. Figure 2 reflects a general upward trend with distance downstream. Median TSS concentrations (Figure 2) were also under the detection limit at several locations and ranged up to 71 mg/L at BR-21. Median loads (Figure 3) ranged from 3065 lb/day at BR-02 (based upon an assumed concentration of one-half of the detection limit) to 282796 lb/day at BR-21.

Total dissolved solids (TDS) were relatively constant through the middle portion of the Bear River with rising concentrations in the far upper and lower reaches (Figure 4). It ranged from a low of 48 mg/L to a high of 3190 mg/L. Median concentrations ranged from 111 mg/L at BR-01 to 603 mg/L at BR-21.

Total phosphorus (TP) was analyzed at all 21 sites along the Bear River and varied from non-detectable to a high concentration of 0.5 mg/L at BR-17. Median concentrations of total phosphorus (Figure 5) ranged from a low of 0.013 mg/L at BR-01 upward to 0.210 mg/L at BR-21. Median loads for total phosphorus (Figure 6) trended from 7 lb/day at BR-01 to 797 lb/day at BR-21.

Total phosphorus generally trended upward downstream in the Bear River. Bear Lake and other reservoirs resulted in lowering total phosphorus downstream of their respective dams. Increases in total phosphorus were typically observed at the next monitoring location downstream of the respective reservoir.

Orthophosphate varied in the watershed from non-detectable levels at several locations to a high of 0.124 mg/L at BR-03(Figure 7). Median orthophosphate concentrations (Figure

7) ranged from 0.006 mg/L to 0.034 mg/L at BR-20. Median orthophosphate loads (Figure 8) ranged from 5 lb/day (based on estimated concentrations of one-half of the detection limit) to 103 lb/day at BR-21. As in the case of TP, orthophosphate concentrations decreased immediately below reservoirs and had a general upward trend through the system.

Ammonia concentrations were below detectable levels at most of the 21 sites for much of the sampling period. All of the 21 sites had levels that were below detection for at least one sampling event. BR-16 had reportable concentrations of ammonia in 13 of 20 samples with a maximum concentration of 0.11 mg/L. The median concentration at that site, which lies directly below Oneida Reservoir, was 0.065. All other sites had median concentrations that were below the detection limit. Ammonia concentrations are shown in Figure 9.

Total Kjeldahl nitrogen (TKN) ranged in concentration from below the detection limit at numerous sites to a high concentration of 3.0 mg/L at BR-21. Median concentrations ranged from 0.2 mg/L at BR-01 to 0.9 mg/L at BR-21.

Nitrate + nitrite concentrations ranged from below the detection limit to a high of 1.25 mg/L at BR-21 and the highest median concentration was 0.36 mg/L at BR-15.

Total nitrogen (NO_3+NO_2 and ammonia) concentration generally increased downstream from a low of 0.08 mg/L at BR-01 to 3.29 mg/L at BR-21(Figure 10). Median values ranged from 0.32 to 1.16 mg/L at the same locations. Figure 11 illustrates the increase of total nitrogen loads with distance downstream, from a minimum of 15 lb/day at BR-03 to 47080 lb/day at BR-21. Median values ranged from 235 to 5874 lb/day (BR-01 to BR-21).

Physicochemical Measurements

In a pattern very similar to that of TDS, specific conductivity generally trended upward downstream, ranging from a low of 0.073 mS/cm at BR-01 to a high of 5.803 mS/cm at BR-21. Figure 12 illustrates increasing specific conductivity in the Bear River.

Turbidity exhibited considerable variation throughout the river (Figure 13). While there was a general increase downstream, several locations exhibited lower readings than upstream sites. The minimum turbidity value observed was 0.0 NTU at BR-01, the highest turbidity measured was 237.5 NTU at BR-17. Median values ranged from 4.2 NTU below Oneida Reservoir to 56 NTU at BR-21.

Median pH followed an interesting pattern through the Bear River as shown in Figure 14. pH increased steeply through the first three sites, then dropped at BR-04. The values rise slowly before beginning a slow descent to the lowest values below Oneida Reservoir. The lowest median value was 7.84 at BR-16, the highest median value was 8.66 at BR-03.

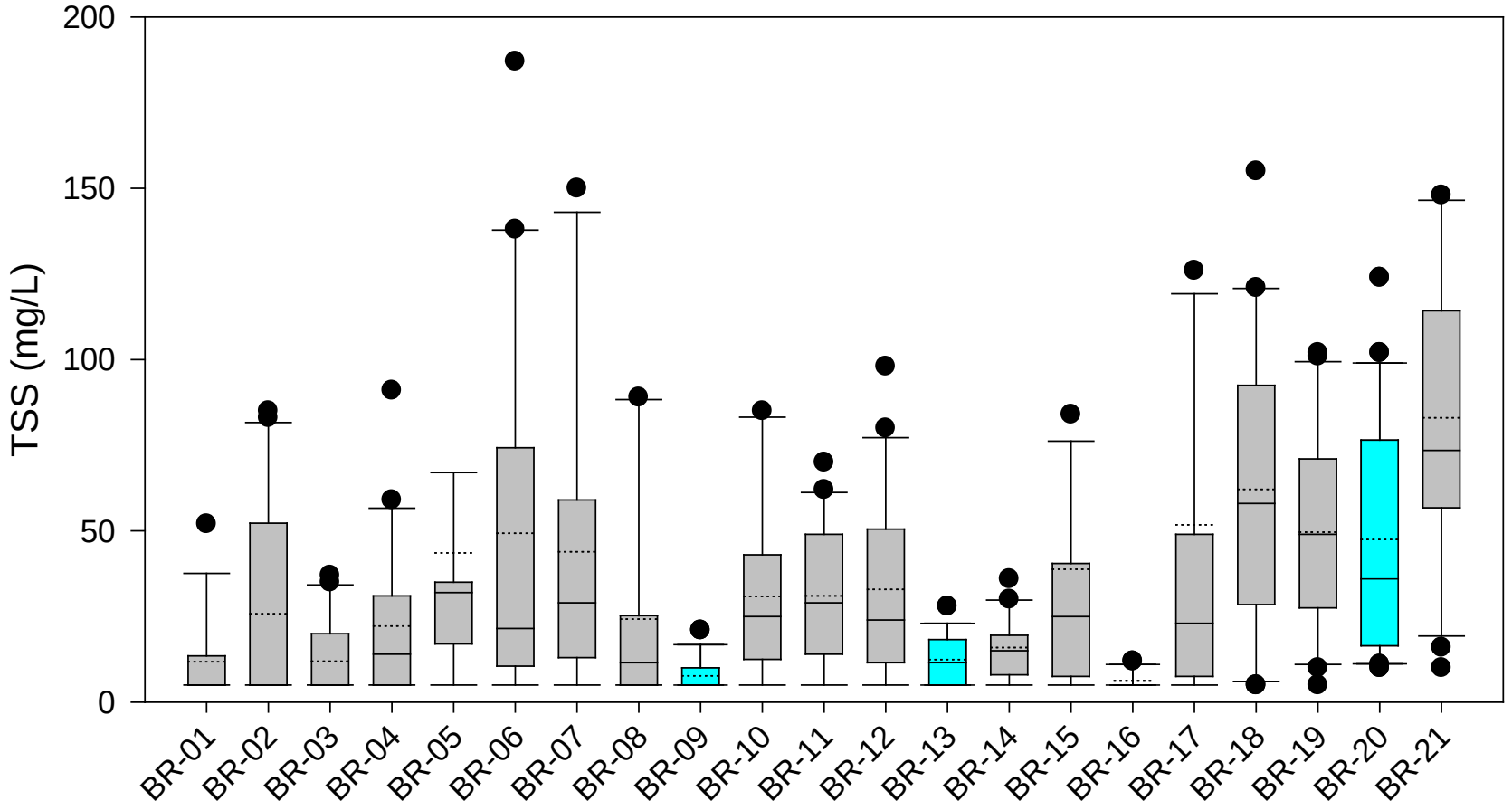

Figure 2. TSS concentrations for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

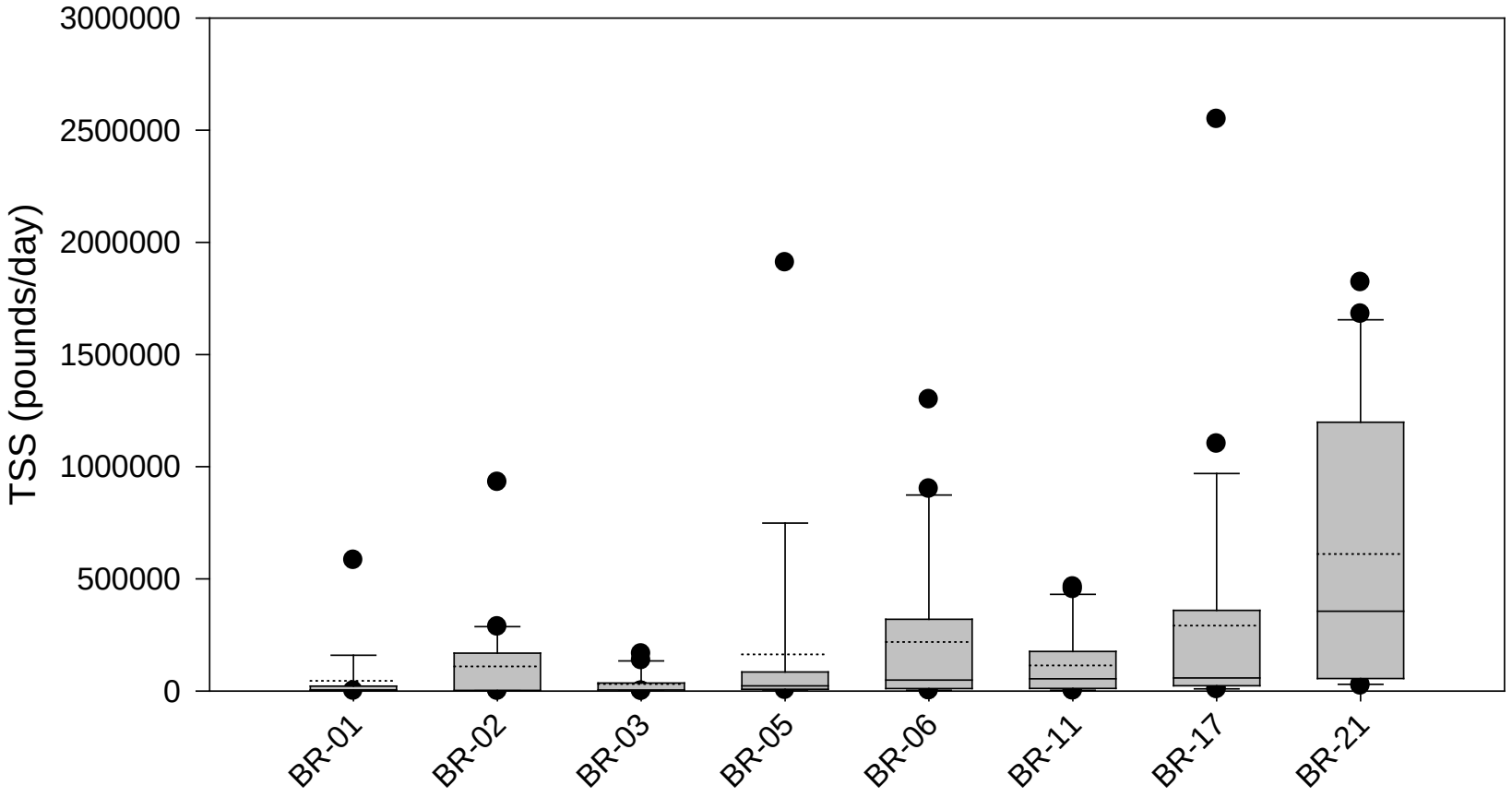

Figure 3. TSS loads for selected monitoring sites (2006-2011). The median is represented as a solid black line; the mean is represented by a dotted line.

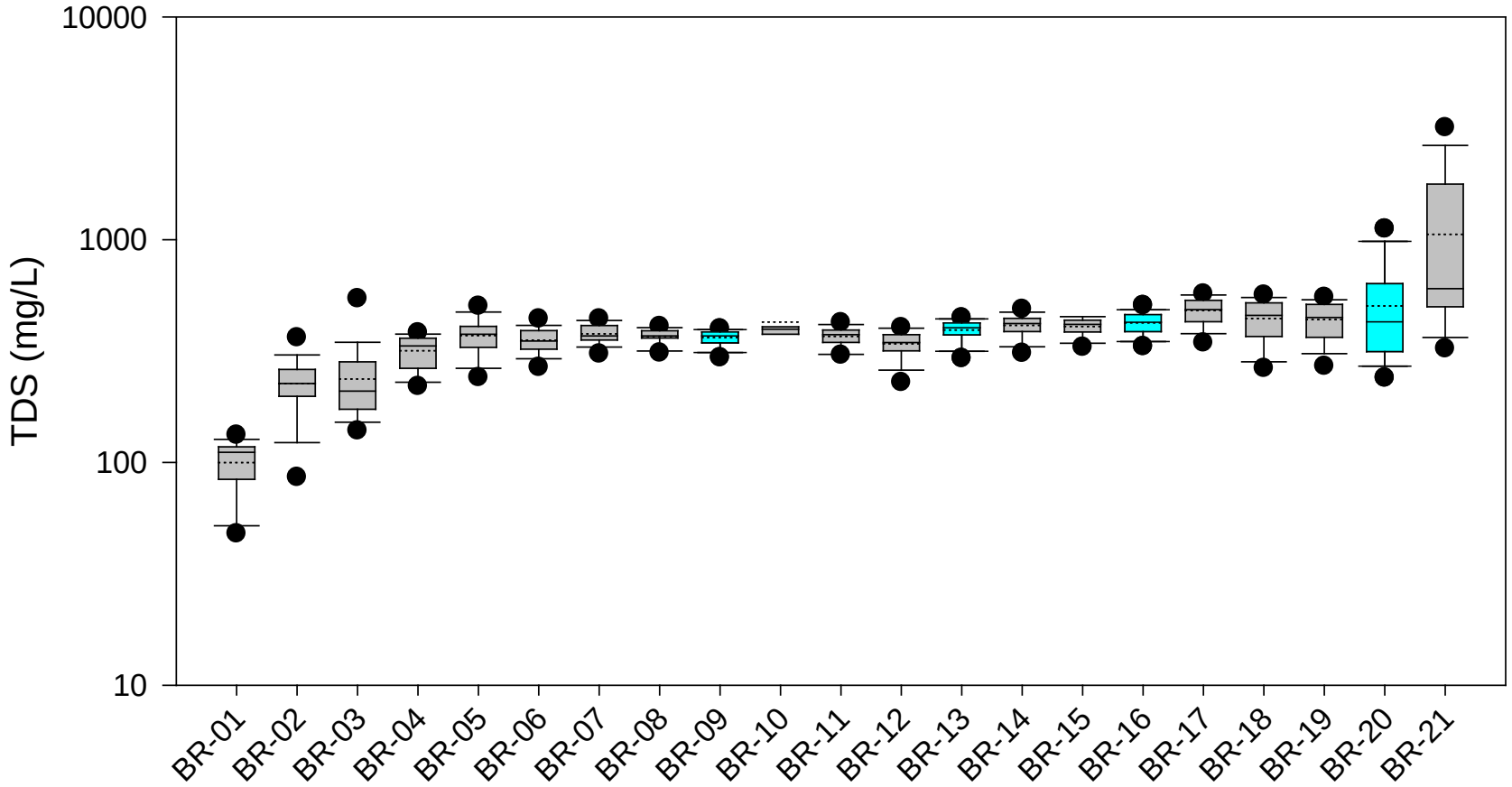

Figure 4. TDS concentrations for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

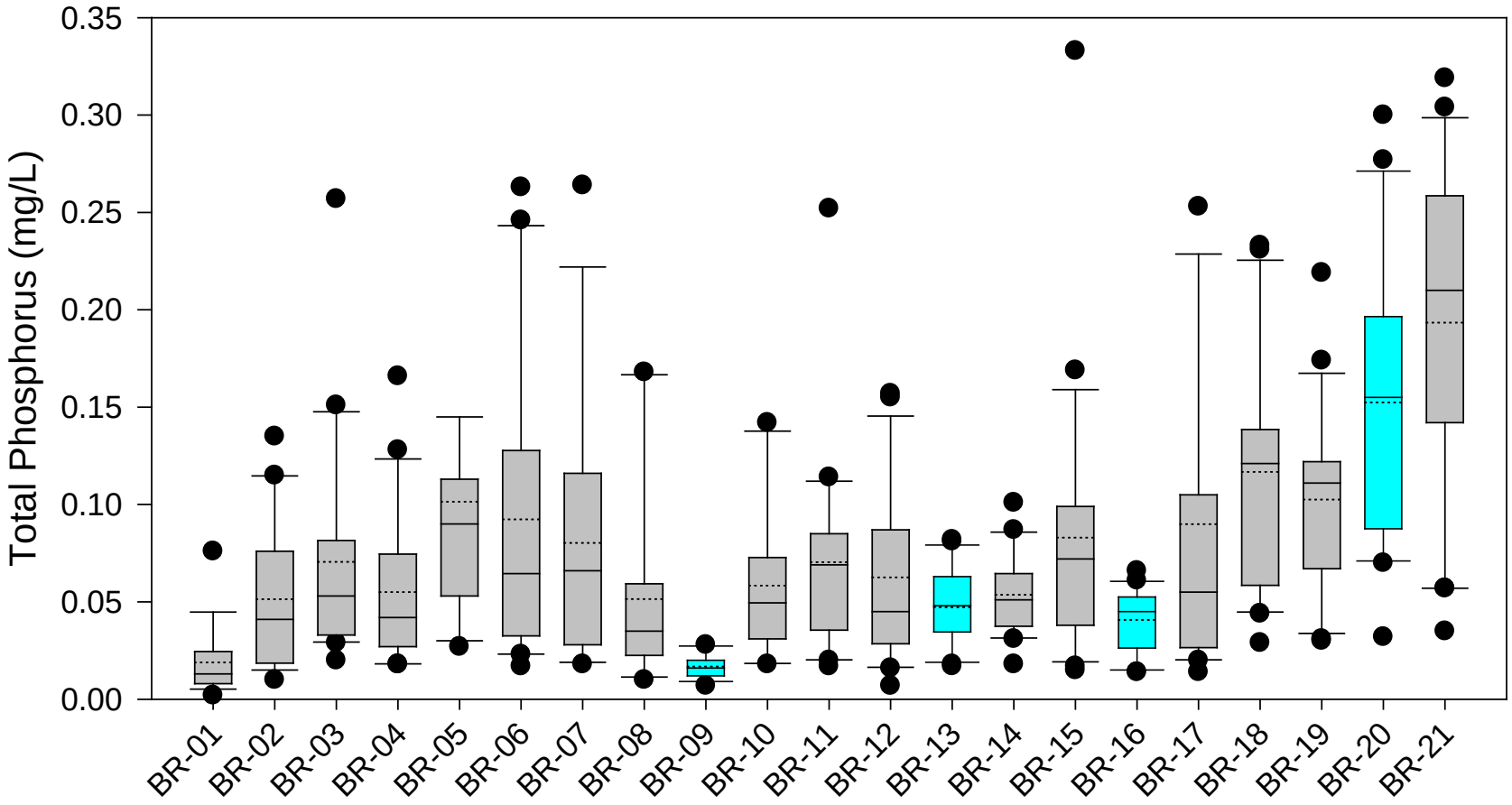

Figure 5. Total phosphorus concentrations for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

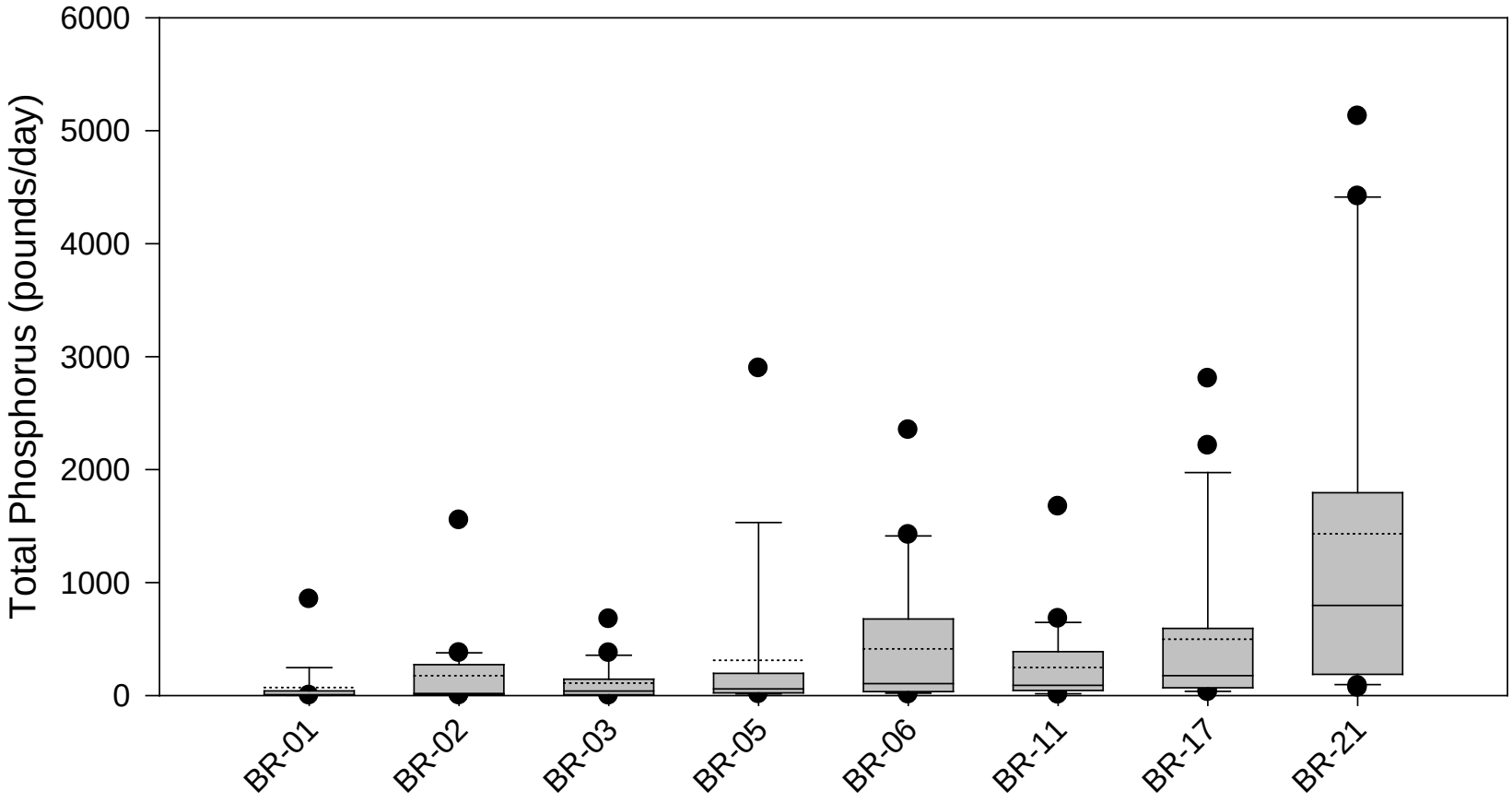

Figure 6. Total phosphorus loads for selected monitoring sites (2006-2011). The median is represented as a solid black line; the mean is represented by a dotted line.

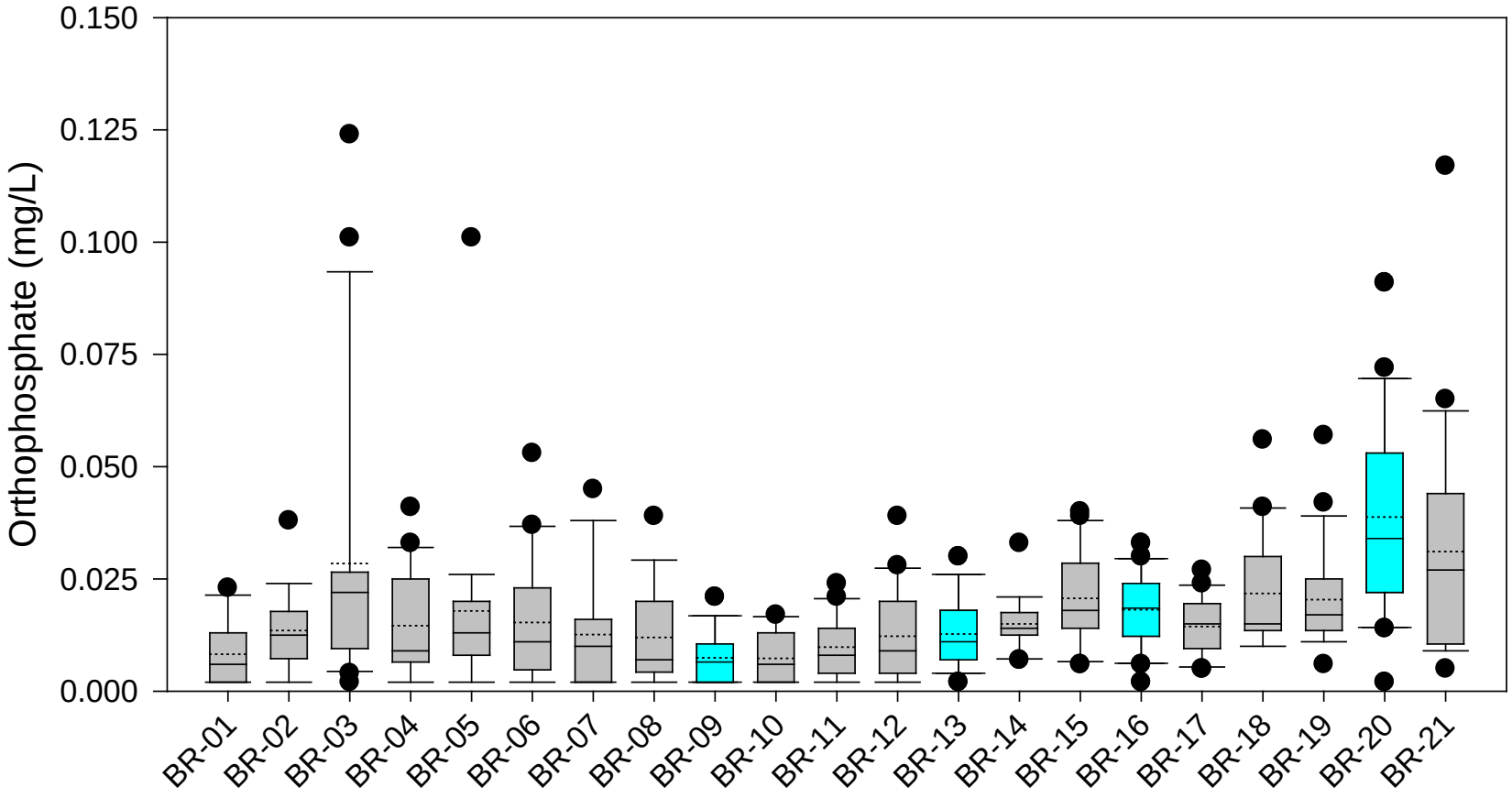

Figure 7. Orthophosphate concentrations for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

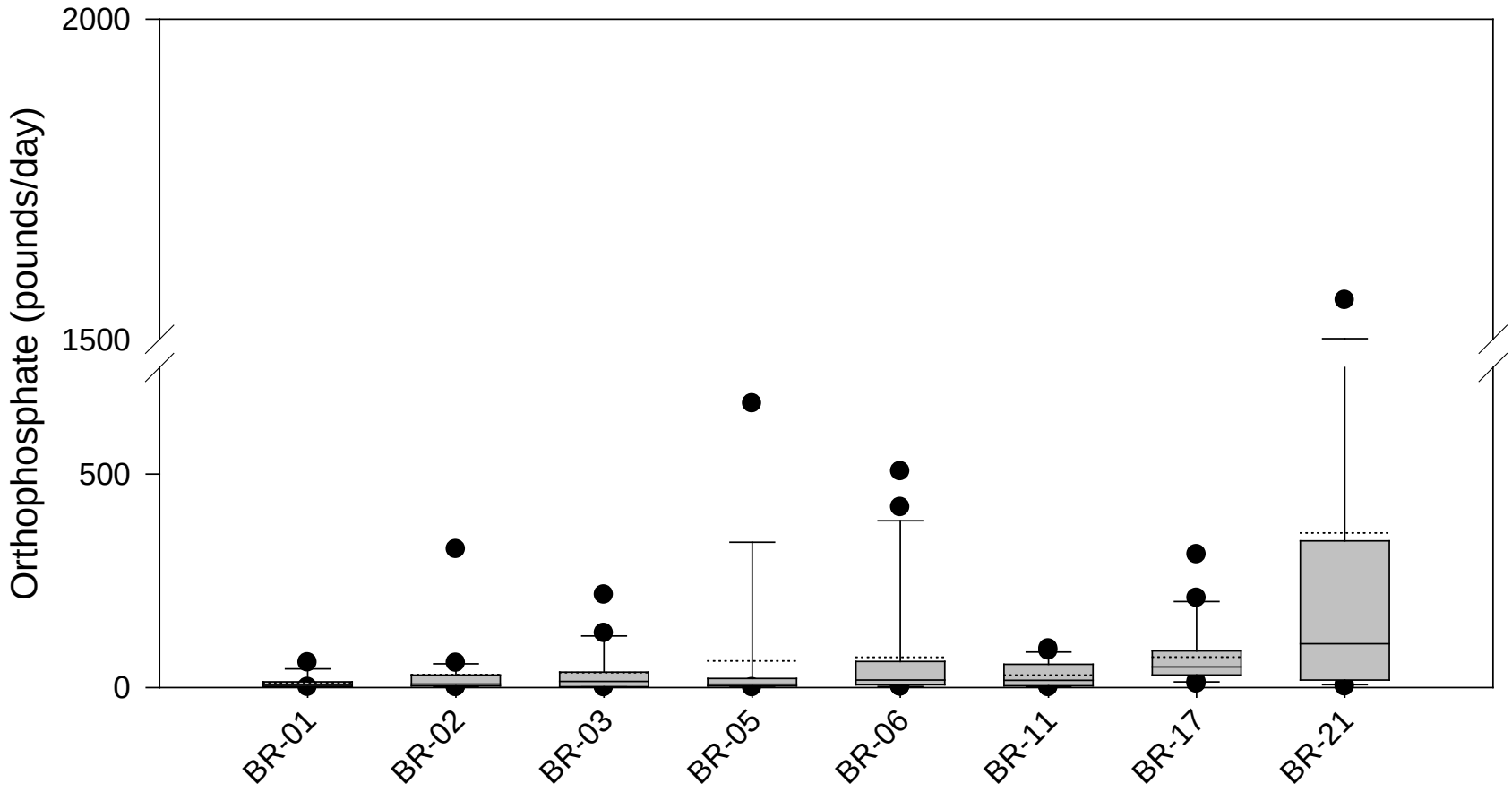

Figure 8. Orthophosphate loads for selected monitoring sites (2006-2011). The median is represented as a solid black line; the mean is represented by a dotted line

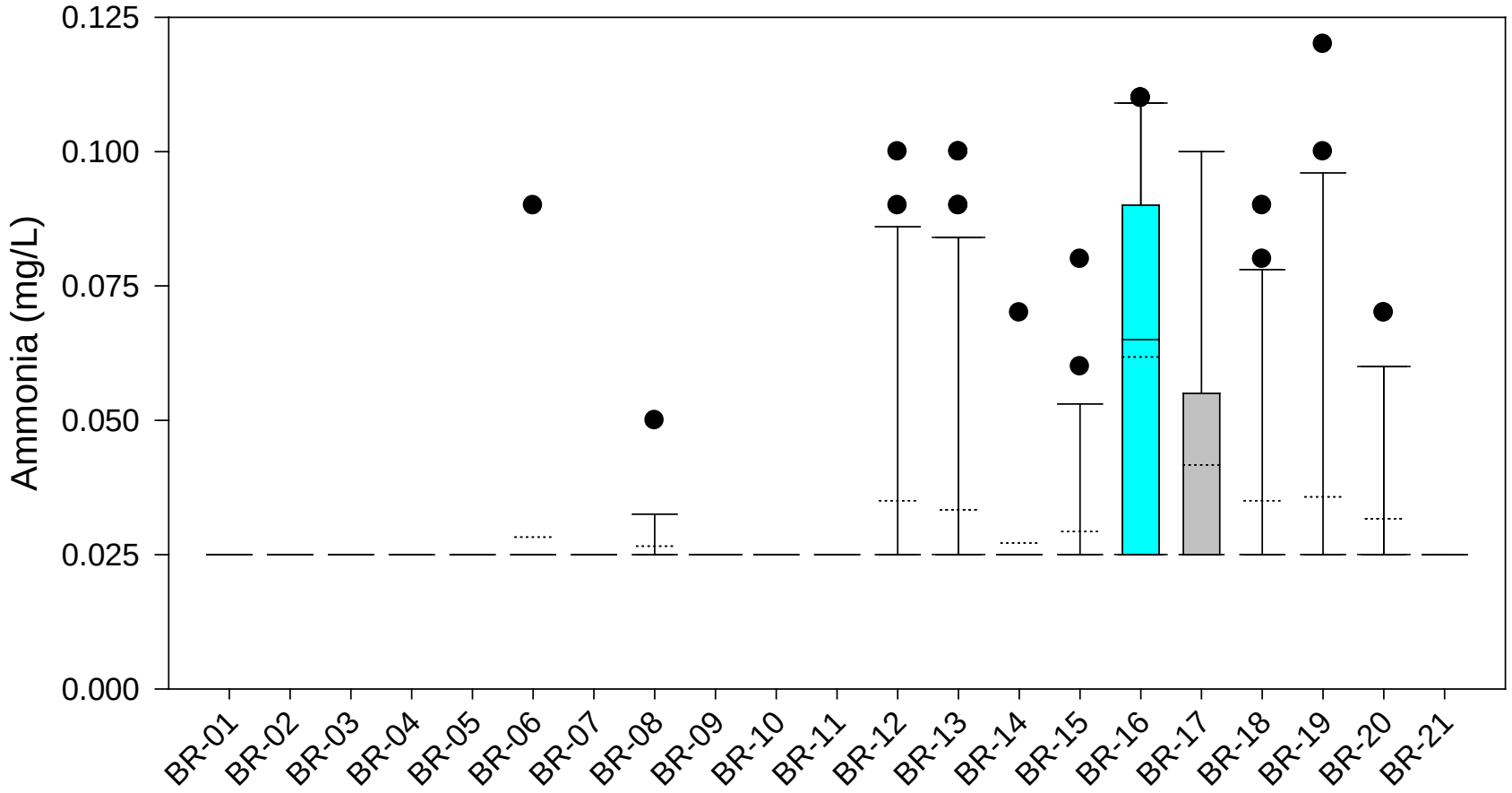

Figure 9. Ammonia concentrations for all monitoring sites (2006-2011). The site in blue is below Oneida reservoir. The median is represented as a solid black line; the mean is represented by a dotted line.

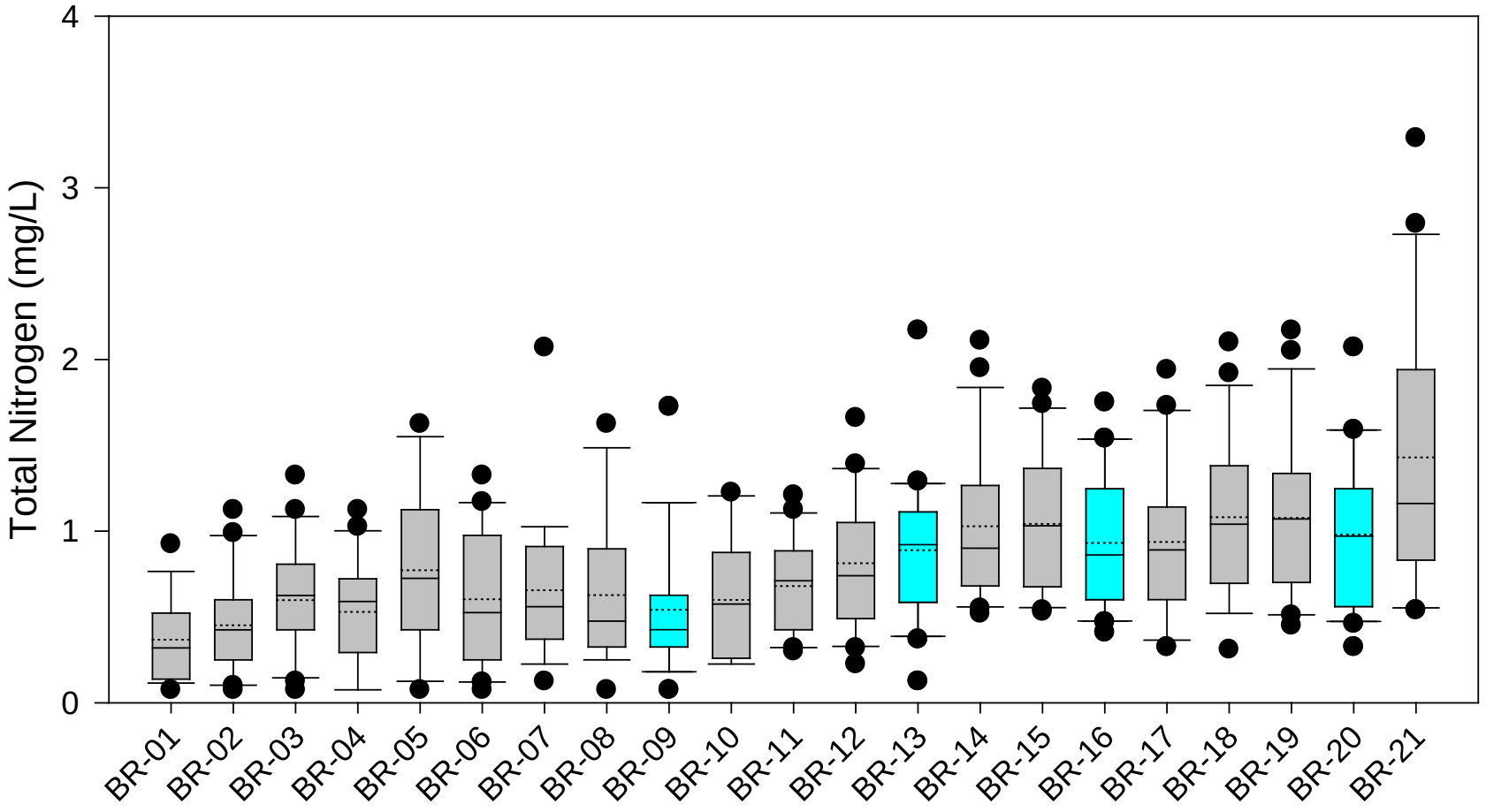

Figure 10. Total nitrogen concentrations (NO_3+NO_2 and ammonia) for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

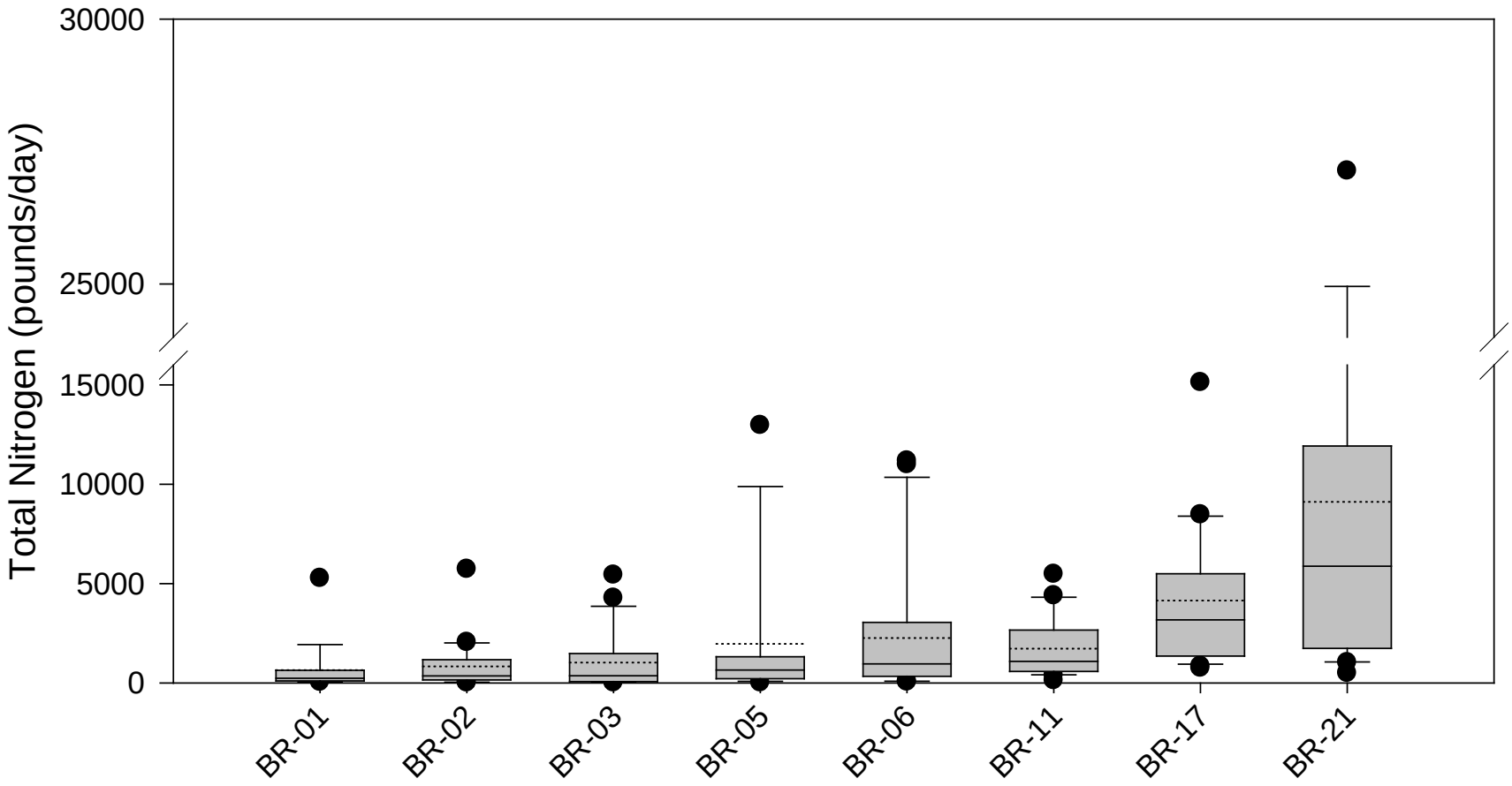

Figure 11. Total nitrogen loads for selected monitoring sites (2006-2011). The median is represented as a solid black line; the mean is represented by a dotted line.

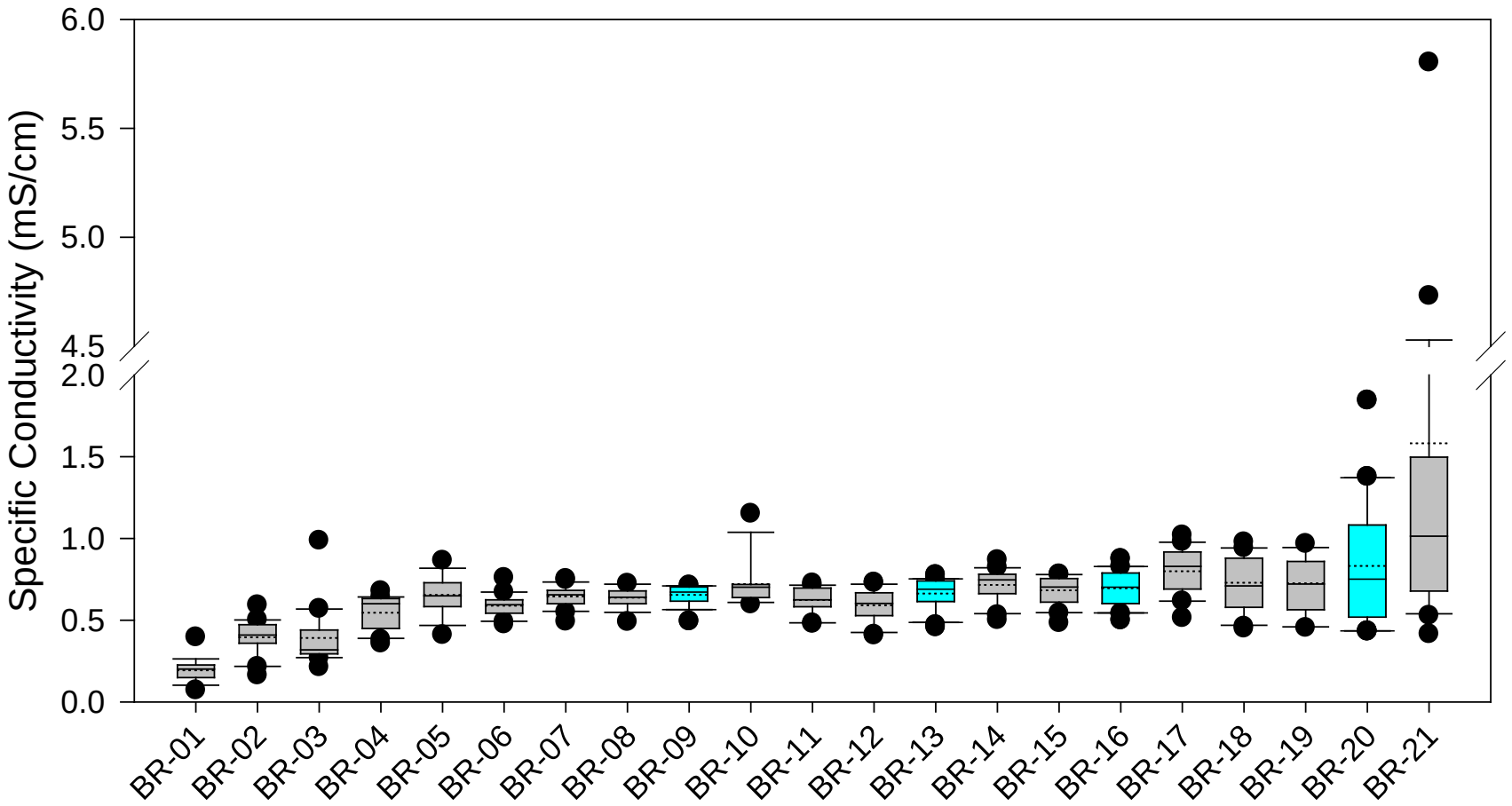

Figure 12. Specific conductivity for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

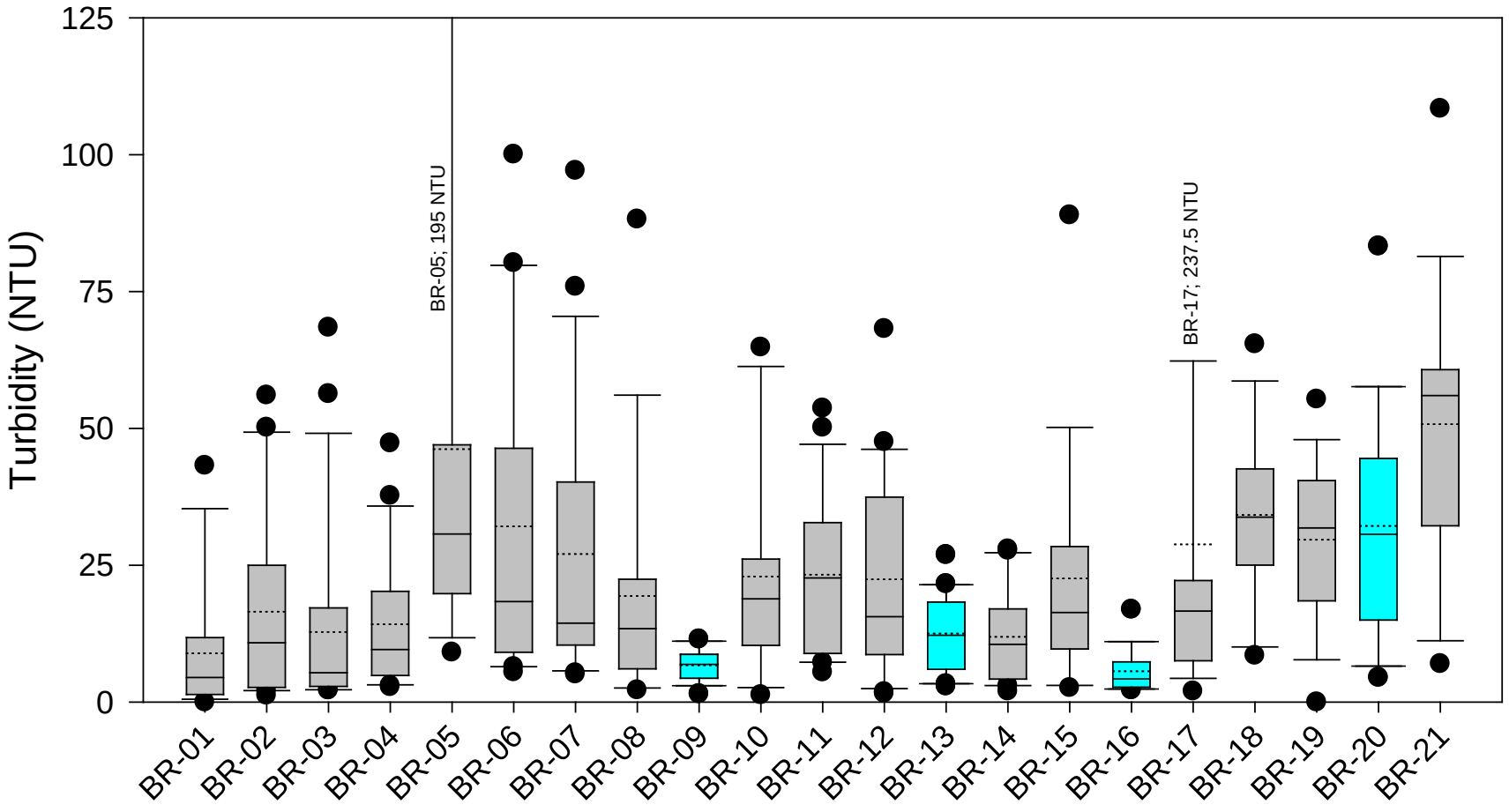

Figure 13. Turbidity for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

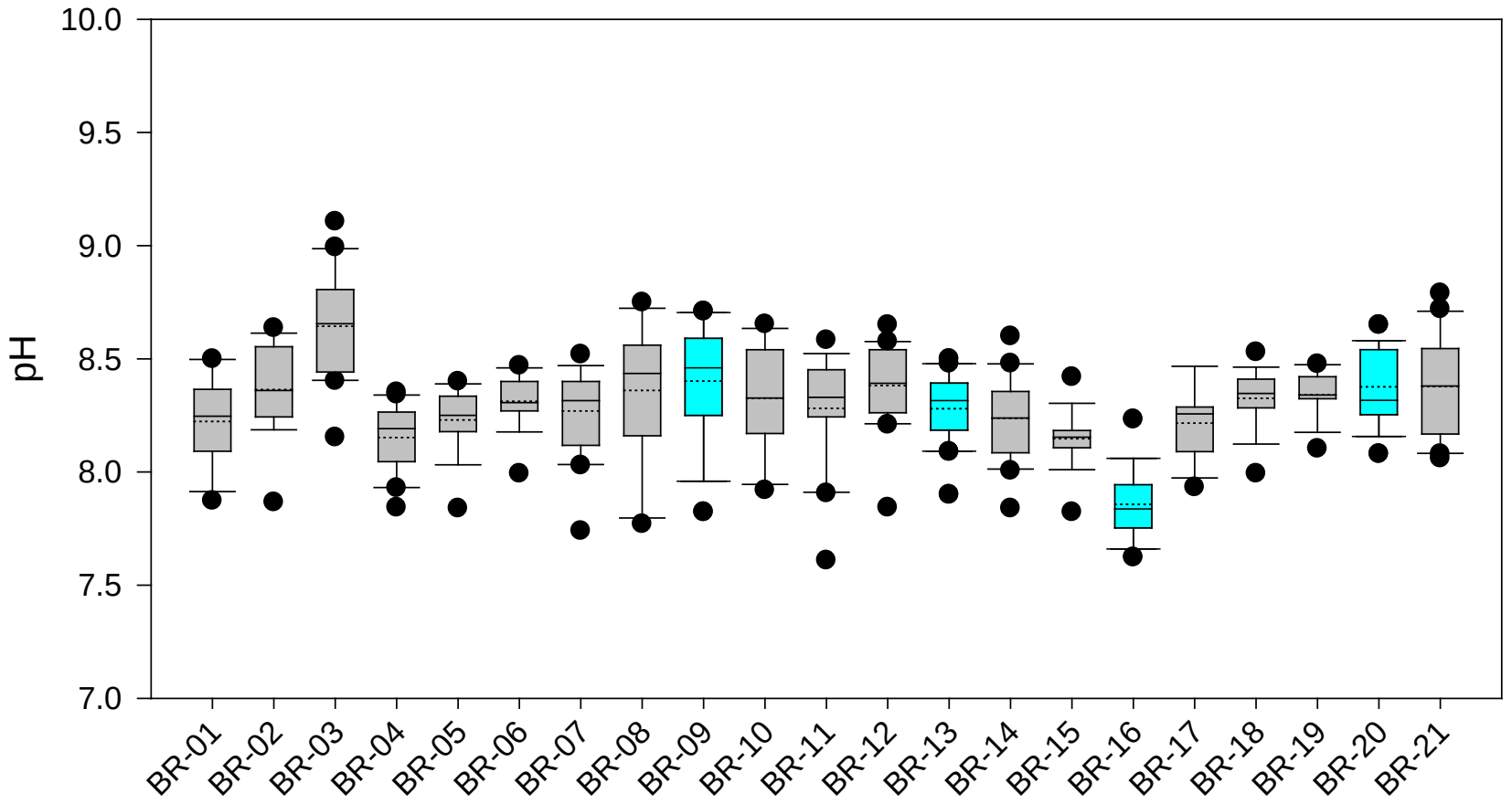

Figure 14. pH for all monitoring sites (2006-2011). Sites in blue are Bear Lake outlet, Below Grace Dam, Below Oneida and Below Cutler. The median is represented as a solid black line; the mean is represented by a dotted line.

Bacteria

In June 2006, *Escherichia coli* counts ranged from four colony forming units (cfu) per 100 mL below Cutler Dam (BR-20) to 326 cfu/100 mL at BR-15 (above Oneida Reservoir). The mean for all sites on that date was 93 cfu/100 mL. In July 2007, *E. coli* ranged from zero mpn (most probable number)/100 mL at BR-09 (Bear Lake Outlet) to 461 mpn/100 mL at Stewart Dam (BR-07). The mean for all sites on that date was 85 mpn/100 mL. Bacterial monitoring results are presented in Table 3 and Figure 15. *E. coli* water quality standards vary amongst the three states. The primary contact instantaneous maximum is 406 cfu/100 mL in Idaho and 576 cfu/100 mL in Utah. During the recreation season (May 1 - September 30) the State of Wyoming has the primary contact recreation criteria for *E. coli* of 126 organisms per 100 ml. The Bear River is a primary contact recreation stream in Wyoming and did exceed the criteria with the 5-Jul-07 sample at BR-01 (204.6) and the 30-Jun-06 sample at BR-05 (186). At the ID/WY border sampling site (BR-06, just below the Wyoming border in Idaho) the sample exceeded the criteria (133.3). There was only one exceedance of the Idaho criteria in July 2007 at Stewart Dam (BR-07) with a measurement of 461 cfu/100 mL.

Table 3. *Escherichia coli* monitoring results.

		Jun-06	**Jul-07**
Site #	**Description**	***E. coli* cfu/100 ml**	***E. coli* MPN/100 ml**
BR-01	Above Evanston at UT/WY border	13.1	204.6
BR-02	Below Evanston	39.3	93.3
BR-03	Below Woodruff Narrows Reservoir	12.2	20.3
BR-04	East of Randolph	131.3	30.5
BR-05	B-Q Dam	186	43.5
BR-06	ID/WY Border	133.3	74.4
BR-07	Rainbow Canal above Stewart Dam	201.4	461.1
BR-08	Bear Lake Inlet	27.8	7.4
BR-09	Bear Lake Outlet	25.9	0
BR-10	Outlet Canal @ Paris Dike	176.9	51.2
BR-11	Pescadero	178.9	105
BR-12	Above Alexander	86.2	38.8
BR-13	Grace	28.8	19.7
BR-14	Below Black Canyon	160.7	61.1
BR-15	Above Oneida Reservoir	325.5	307.6
BR-16	Below Oneida Reservoir	15.5	18.7
BR-17	ID/UT Border - 3900 S. road crossing	82.1	60.2
BR-18	Below Cub River inlet in Amalga	69.5	62
BR-19	Above Cutler	37.9	34.1
BR-20	Below Cutler	4.1	3.1
BR-21	Corrine	10.8	95.9

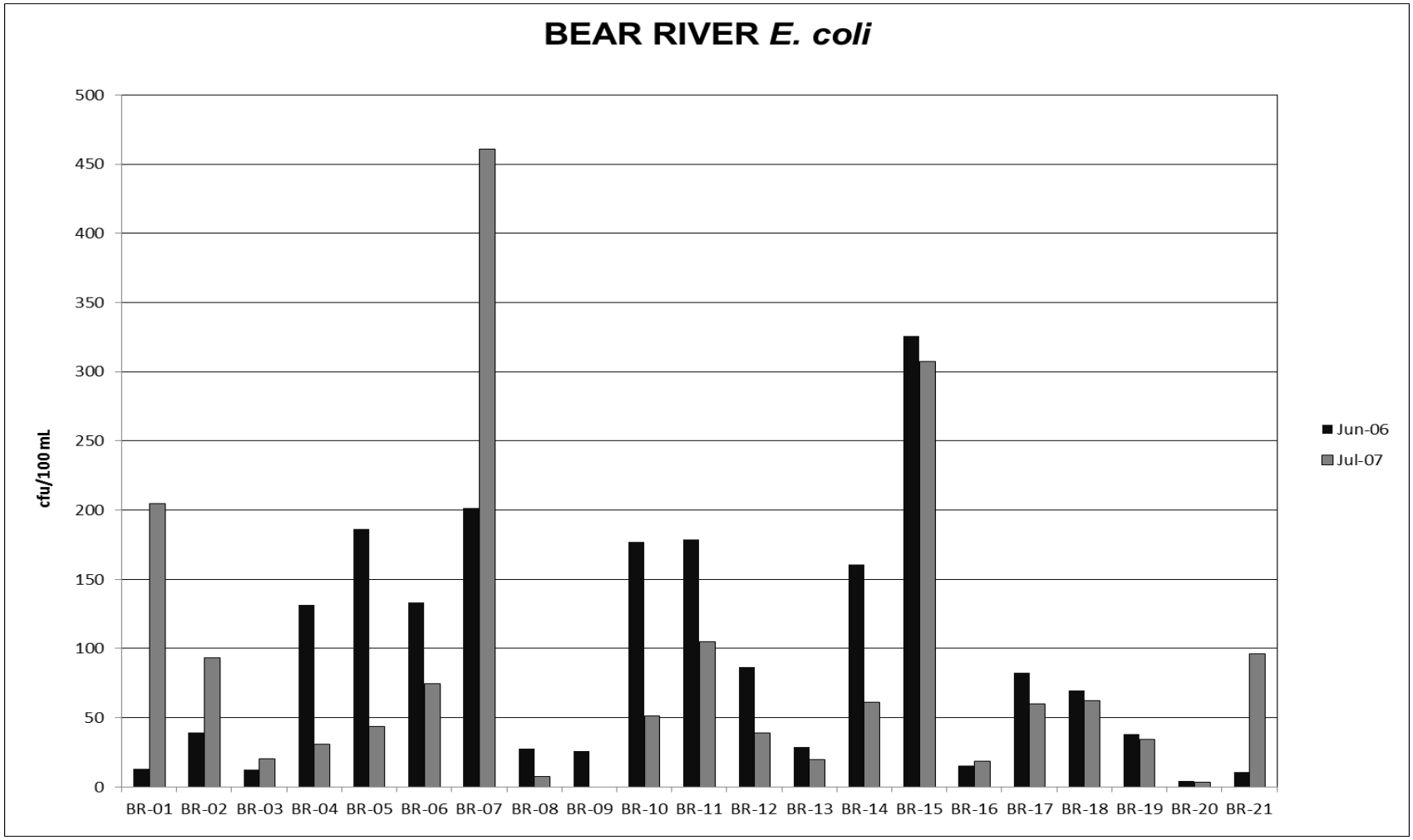

Figure 15. *E. coli* monitoring results for the Bear River (2006-2007).