**FINAL**

# 2011 Water Quality Monitoring Mill River

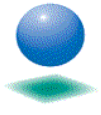
## Hamden and New Haven, CT

**APRIL 2012**

*Prepared for*

**Regional Water Authority**

*Prepared by*



CH2MHILL

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# 2011 Mill River Water Quality Monitoring

## Introduction

This report presents the results of continuing studies by the Regional Water Authority (RWA) to document dissolved oxygen (DO) and salinity concentrations in the Mill River downstream of the Lake Whitney water supply reservoir. The objective of these studies, which began in 1998, is to monitor DO and salinity in the Mill River as they relate to potential impacts from reactivating Lake Whitney as a public water supply. The lake served as a water supply from 1862 until 1991, when its use was temporarily discontinued. The RWA resumed water withdrawals from the reservoir during the summer of 2005, concurrent with completion of the new Lake Whitney Water Treatment Plant (WTP).

As part of a comprehensive environmental assessment of the WTP project, studies of DO and salinity patterns in the lower Mill River were conducted in 1998 and then annually since 2000. DO and salinity were both recognized as important parameters to be considered in developing an environmental management plan for the Lake Whitney water withdrawals (Lake Whitney WTP Environmental Evaluation Team, 1999).

Based on the analysis of data collected from 1998 to 2003, 7.0 milligrams per liter (mg/L) was selected as a reasonable DO target level for the plunge pool in the Mill River immediately below the Lake Whitney Dam (CH2M HILL, 2003). That data indicated that, under most circumstances, this level will result in surface water DO concentration above 5.0 mg/L at the Orange Street Bridge during dry weather conditions. However, DO concentrations slightly below 5.0 mg/L were occasionally observed before water withdrawals from the lake resumed in 2005.

Past monitoring has identified negative effects on Orange Street Bridge DO concentrations during wet weather. These negative effects are believed to be from input of organic matter from urban stormwater runoff and combined sewer overflows (CSOs). To evaluate the effects of lake withdrawals more directly, DO and salinity have been regularly monitored farther upstream, at the footbridge in East Rock Park, since the summer of 2003. At this location, the influence of stormwater runoff, CSOs, and tidal flows are presumed to be lesser factors.

DO and salinity sampling were performed every week at dawn between July 1 and September 23, 2011, as part of the continuing monitoring and assessment effort.

Daily precipitation at Lake Whitney for 2011 is shown in Figure 1. As shown in the figure, 2011 saw slightly above normal rainfall through July, followed by record setting rainfall in August, and wet conditions prevailing through September. The recorded precipitation from June to September of 2011 was 25.5 inches at the Lake Whitney rain gauge. The total rainfall amount from June to September 2011 was much greater in 2011 compared to 2010 (14.3 inches). The average precipitation from June to September over the sampling period since the WTP has been in operation is 18.8 inches.

Figure 2 presents the rainfall amounts in the 72 hours preceding each sampling event. When analyzing the DO data, it is important to note influences from stormwater runoff. Based on data collected in prior years related to storm event water quality effects on downstream Mill River DO (CH2MHILL 2002), rainfall accumulation greater than 0.12 inch is considered as a wet- weather measurement event. Rainfall of less than or equal to 0.12 inch is considered a dry-weather event (in the 72 hours preceding each sampling event). Wet-weather measurements were taken on July 1, July 29, August 12, August 26, and September 9, with rainfall ranging from 0.16 to 4.2 inches. The remaining sampling events had no rainfall (July 8, July 15, July 22, August 5, August 19, September 2, September 16, and September 23).

The WTP was first operational in April 2005 and continued operation through 2011. Starting in October 2008, , the plant has mainly operated one day a week due to declining customer water demands. Figure 3 shows average Lake Whitney WTP withdrawals for 2011.

Figure 4 presents estimated Lake Whitney Dam downstream flows to the Mill River from January 2011 to November 2011.

Figure 5 presents the estimated flow in the Mill River for each of the sampling dates in 2011. Sampling date flows, as estimated by water levels relative to the Lake Whitney spillway elevation, ranged from 40 million gallons per day (MGD) on July 15 to 348 MGD on September 9.

The 2011 sampling is the seventh annual DO and salinity monitoring and assessment effort at Mill River since the new WTP has gone on line. This report discusses a historical review of DO data, which was undertaken to establish a relationship between flow conditions and DO at the Footbridge and Orange Street stations.

# Monitoring Methods

From July 1 to September 23, 2011, the RWA conducted weekly DO and salinity monitoring at and below the Lake Whitney dam (i.e., the spillway, plunge pool, the footbridge, the Orange Street Bridge, and both sides of the tidegates) (Figure 6). The measurements were conducted at dawn to reflect the diurnal oxygen sag that typically occurs in a lake or stream because of overnight respiration and lack of oxygen, producing photosynthesis. Table 1 presents a summary of the 2011 Mill River measurements.

As in the previous several years, the weekly data were collected using a Hydrolab Quanta multi-parameter meter that was calibrated before each set of water quality measurements. Measurements were collected at one depth at the spillway and plunge pool. At the footbridge, Orange Street Bridge, and the tidegates, measurements were taken near the surface (0.1- to 0.2-meter depth) and near the bottom to account for the possible presence of distinct water layers caused by salinity intrusion from Long Island Sound. All weekly monitoring data are presented in the Attachment.

**TABLE 1**
Mill River Monitoring Data Collected in 2011

| Frequency/Dates | Locations | Parameters |
|---|---|---|
| Weekly – July 1 through September 23 (early morning) | Spillway<br>Plunge Pool<br>Footbridge<br>Orange St.<br>Tidegates (North and South) | Temperature, DO, salinity, pH, estimated flow |

# Monitoring Results

## Salinity

The weekly salinity monitoring data are presented in Figure 7 (surface layer) and Figure 8 (bottom layer). In general, increasing salinity at tidally influenced monitoring stations (footbridge and downstream) occurs during periods of lower freshwater flow from Lake Whitney. The highest salinity measurements were observed at North tidegate and South tidegate on July 8, July 22, and August 5 at both the surface and bottom layers. Salinity levels were elevated at the tide gates, with concentrations ranging from 0.07 to 21.6 parts per thousand (ppt) in the bottom waters and from 0.07 to 15.6 ppt at the surface.

Figure 9 presents surface salinities at Orange Street and the footbridge, with river flow as measured at Lake Whitney Dam (spillway overflow). The salinity at Orange Street increased as the flow gradually decreased and the salinity at Orange Street decreased as the flow increased during the sampling period.

## Dissolved Oxygen

Weekly surface layer DO measurements from Mill River at the spillway, the plunge pool, the footbridge, Orange Street Bridge, and the tide gates are shown in Figure 10. Bottom layer measurements are shown in Figure 11. Table 2 summarizes all of the 2011 DO concentrations at the spillway, plunge pool, footbridge, Orange Street Bridge, and tidegates, including average, minimum, and maximum DO concentrations. Average DO readings for all weekly monitoring from 2001 to 2011 are presented in Table 3.

**TABLE 2**
Weekly Dissolved Oxygen Concentrations from July 1, 2011 through September 23, 2011

| Date | Spillway | Plunge Pool | Footbridge Surface | Footbridge Bottom | Orange Street Surface | Orange Street Bottom | North Tidegate Surface | North Tidegate Bottom | South Tidegate Surface | South Tidegate Bottom |
|---|---|---|---|---|---|---|---|---|---|---|
| 7/1/2011 | 8.61 | 7.86 | 6.92 | 6.78 | 6.15 | 6.07 | 6.01 | 5.78 | 6.58 | 6.36 |
| 7/8/2011 | 7.16 | 7.21 | 6.26 | 5.88 | 5.96 | 5.52 | 5.88 | 5.35 | 5.41 | **4.64** |
| 7/15/2011 | 6.63 | 7.47 | 6.36 | 6.23 | 5.84 | 5.49 | 5.95 | 5.73 | 6.61 | 6.65 |
| 7/22/2011 | 7.19 | 6.91 | **4.53** | **3.98** | 6.10 | 6.08 | **4.80** | **4.41** | **4.64** | **4.18** |
| 7/29/2011 | 8.31 | 7.28 | 5.53 | 5.17 | 6.00 | 5.67 | 5.78 | 5.35 | 6.31 | 5.84 |
| 8/5/2011 | 8.38 | 7.54 | 5.64 | 5.23 | 6.54 | 5.55 | **4.99** | **4.04** | **4.03** | **3.34** |
| 8/12/2011 | 6.64 | 7.72 | 6.95 | 6.83 | 6.16 | 6.12 | 5.98 | 5.77 | 6.83 | 6.28 |
| 8/19/2011 | 6.58 | 7.93 | 7.46 | 7.30 | 6.90 | 6.75 | 6.66 | 6.65 | 6.77 | 6.63 |
| 8/26/2011 | 7.43 | 8.07 | 7.16 | 7.04 | 6.54 | 6.34 | 6.45 | 6.34 | 6.32 | 6.29 |
| 9/2/2011 | 6.83 | 8.19 | 7.81 | 7.77 | 7.40 | 7.37 | 7.01 | 6.86 | 7.49 | 7.14 |
| 9/9/2011 | 7.44 | 8.75 | 8.53 | 8.55 | 8.53 | 8.43 | 8.03 | 8.00 | 8.02 | 8.04 |
| 9/16/2011 | 8.09 | 8.71 | 8.22 | 8.18 | 7.83 | 7.77 | 7.47 | 7.41 | 7.98 | 7.70 |
| 9/23/2011 | 8.40 | 8.75 | 7.64 | 7.66 | 7.51 | 7.25 | 6.78 | 6.47 | 7.49 | 6.52 |
| Average | 7.51 | 7.88 | 6.85 | 6.66 | 6.73 | 6.49 | 6.29 | 6.01 | 6.50 | 6.12 |
| Min | 6.58 | 6.91 | **4.53** | **3.98** | 5.84 | 5.49 | **4.80** | **4.04** | **4.03** | **3.34** |
| Max | 8.61 | 8.75 | 8.53 | 8.55 | 8.53 | 8.43 | 8.03 | 8.00 | 8.02 | 8.04 |

Notes:

**Bold** represents DO concentrations less than the Connecticut Department of Environmental Protection water quality standard of 5.0 mg/L.

**TABLE 3**
Average Mill River Surface Dissolved Oxygen, 2001 – 2011 Weekly Measurements

| Station | 2001 | 2002 | 2003 | 2004* | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spillway | 8.0 | 8.0 | 8.0 | 8.2 | 7.6 | 8.4 | 7.3 | 8.8 | 7.81 | 7.78 | 7.51 |
| Plunge Pool | 7.7 | 7.9 | 7.9 | 4.1 | 7.5 | 7.7 | 7.4 | 7.6 | 7.59 | 7.13 | 7.88 |
| Footbridge | NA | NA | 6.5 | 6.0 | 5.2 | 5.5 | 5.0 | 5.5 | 6.40 | 4.70 | 6.85 |
| Orange St. Bridge | 5.9 | 6.2 | 6.4 | 6.8 | 5.3 | 6.7 | 5.9 | 5.7 | 6.69 | 5.21 | 6.73 |
| Tide Gates Upstream | NA | NA | 6.2 | 6.2 | 5.1 | 6.1 | 5.5 | 5.0 | 5.78 | 5.13 | 6.29 |
| Tide Gates Downstream | NA | NA | 6.6 | 6.1 | 5.6 | 5.8 | 5.6 | 5.1 | 6.00 | 5.17 | 6.50 |

Notes:

- *Flow bypassed around plunge pool July 6 - August 27, 2004 for Lake Drawdown.
- Average represents only weeks sampled during the summer—not the entire year. The number of weeks per year varied depending on weather patterns.

NA = No data available

Figure 12 presents the DO concentrations at the plunge pool, Orange Street (surface and bottom), and the footbridge (surface and bottom), along with the flow in the river as measured at the Lake Whitney spillway. DO measurements at the plunge pool typically were 6.9 mg/L or greater during the sampling period. Minimum surface water and bottom DO concentrations at the footbridge were observed on July 22, 2011, with a bottom DO concentration of 4.0 mg/L and a surface DO concentration of 4.5 mg/L. Estimated flow during this sampling was 52 mgd. This was a deviation from the overall tendency of DO readings at the footbridge to be greater than 5 mg/L when flow was greater than 30 MGD, so it is likely that other factors, perhaps runoff or increased primary productivity affecting water quality, were playing a greater role than flow in determining DO concentrations. Re-aeration was evident downstream at the Orange Street bridge, with DO measurements exceeding 6 mg/L on this date. All other 2011 DO readings at the footbridge were greater than 5 mg/L.

Prior to 2010, the historical data showed that, between the beginning of July and end of September, occurrences of surface DO lower than 5.0 mg/L at the footbridge dropped off substantially when the flow over the spillway was greater than 30 mgd, which corresponds to a lake level of 0.17 feet. DO data collected in 2010 were not consistent with this relationship. This was likely due to the infrequent occurrence of substantial rain events in summer 2010 that helped to flush quiescent stretches of the Mill River. With the exception of one sampling date, DO readings at the footbridge in 2011 were consistent the aforementioned DO/flow relationship.

# Conclusions

This report summarizes the information obtained from the seventh year of data collection during since the new Lake Whitney WTP was activated. 2011 saw slightly above normal

rainfall through July, followed by record setting rainfall in August, and wet conditions prevailing through September. The DO concentrations measured in 2011 at Orange Street and the footbridge are generally comparable to other years with substantial river flow. Surface and bottom DO concentrations at the Orange Street bridge were always above 5 mg/L. DO was below 5.0 mg/L at the footbridge on only one sampling date, and DO readings at the spillway and plunge pool were always above 6 mg/L. The pattern of footbridge station DO readings being greater than or equal to 5 mg/L when Mill River flows were above 30 MGD generally continued in 2011, as it had been in all previous years except 2010. Due to the minimal operation of the Whitney WTP, summer 2010 was essentially a baseline monitoring period, i.e., approximating "natural" conditions without water withdrawals. In this case, the lower DOs observed appeared more related to the lack of peak flushing flows as opposed to average or baseline flows.

DO and salinity data collected from 1998-2004 and 2009-2011 established a general range of baseline variability ,both during pre-operation and when the treatment plant was generally operated at minimal flow rates once a week. DO data during operating conditions was collected from 2005-2008, including two years (2005 and 2007) that were representative of seasonal low flows during operating conditions. At this point no discernible impacts attributed to water withdrawals have been detected and this appears unlikely to occur under the water withdrawal restrictions and mitigation measures specified in the Management Plan.

Based on the overall findings from the monitoring program to date, we believe that reductions in the frequency of DO and salinity monitoring are warranted. Specifically, it is recommended that the RWA focus its resources on collecting additional DO and salinity data when seasonal river flows are most critical and in areas of the Mill River that are most likely to be affected by flows from Lake Whitney. Based on the statistical relationships observed since monitoring began, targeting DO measurements during periods when prevailing river flows based on a running average or similar statistic are less than 40 MGD (lake level of 0.20 feet over spillway elevation) would be a reasonable approach going forward until a better overall understanding is achieved of Management Plan performance relative to DO. The spillway, the plunge pool, and footbridge stations are most reflective of freshwater flow and water quality influence from Lake Whitney and thus appropriate for future monitoring. This level of effort should be sufficient for continued assessment of downstream DO and salinity patterns under baseline seasonal low flow conditions, and for evaluating the efficacy of the Management Plan to maintain adequate conditions for aquatic life in the Mill River during future operating conditions.

# Literature Cited

Lake Whitney WTP Environmental Evaluation Team. 1999. *Lake Whitney Water Treatment Plant Environmental Evaluation, Vol. 1: Environmental Evaluation Team Final Report.* Report prepared for the South Central Connecticut Regional Water Authority, New Haven, CT.

CH2MHILL 2002. *2002 Water Quality Monitoring Mill River Hamden and New Haven CT*. Report prepared for the South Central Connecticut Regional Water Authority, New Haven, CT

CH2M HILL. 2003. *1998– 2003 Comprehensive Dissolved Oxygen Monitoring in the Lower Mill River, Hamden and New Haven, CT*. Report prepared for the South Central Connecticut Regional Water Authority, New Haven, CT.

# Figures

**Figure 1 - Precipitation at Lake Whitney**
**January - October 2011**

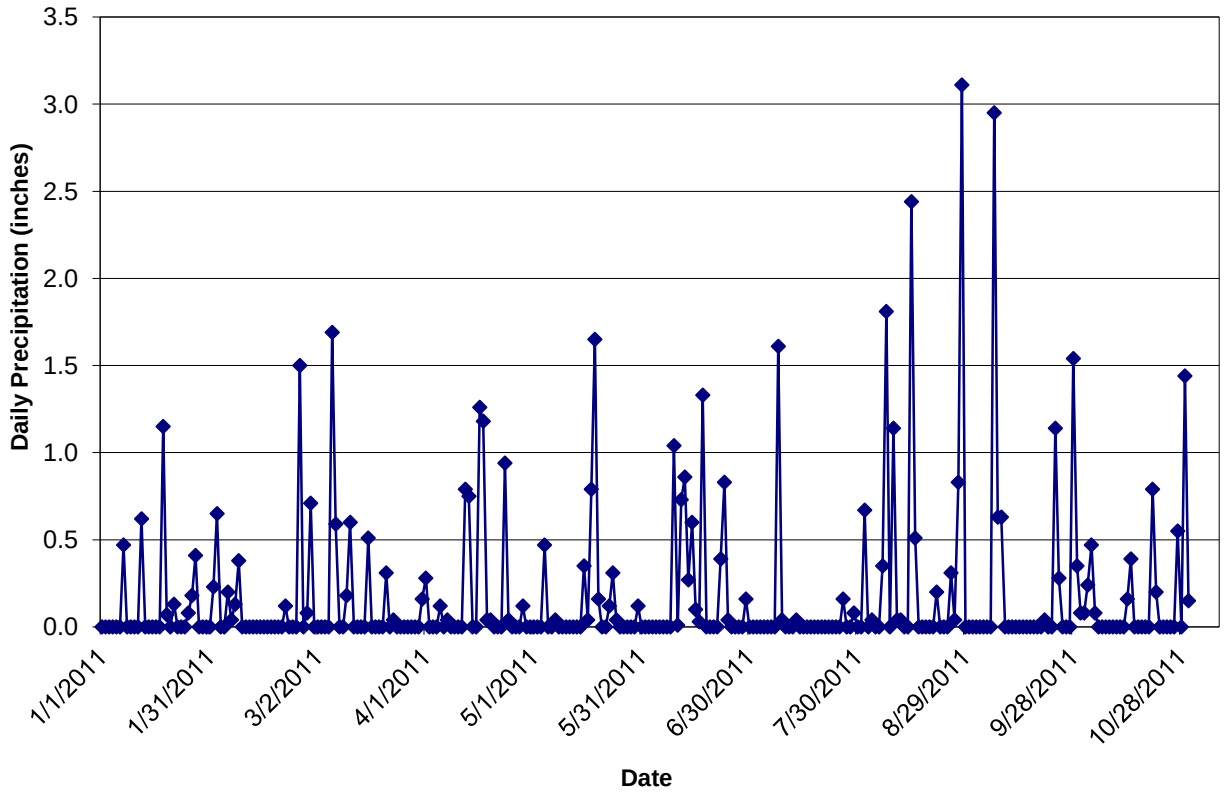


**Figure 2: 2011 Sampling Event Precipitation**
**(72 hours Prior to each Sampling Event)**

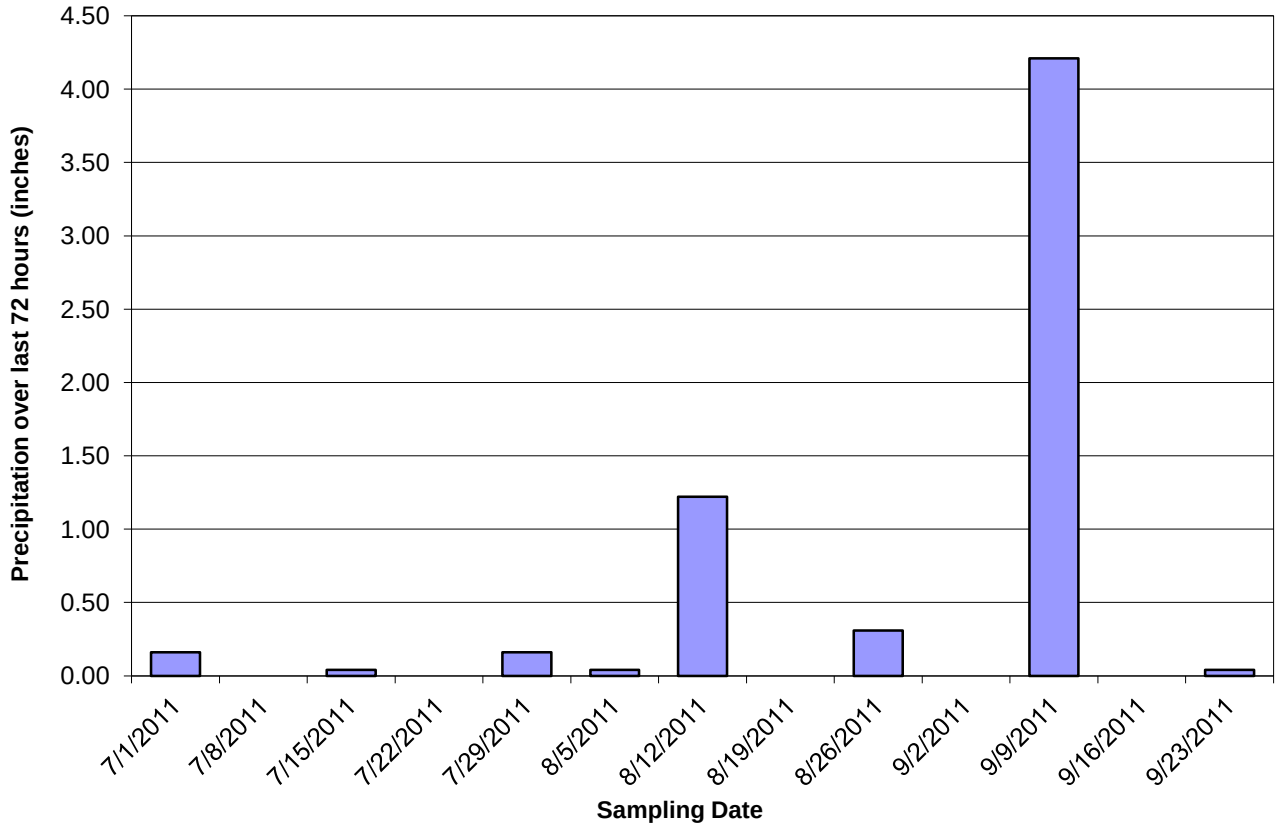


**Figure 3: Lake Whitney Water Treatment Plant Withdrawals**

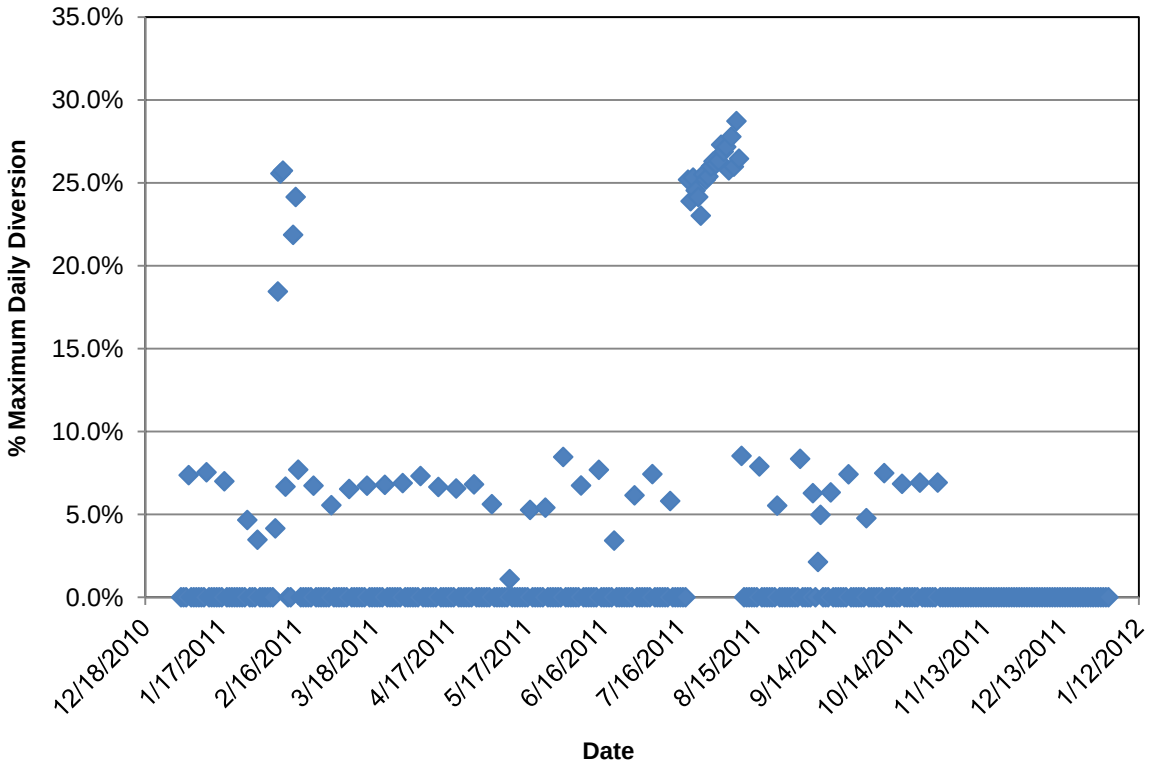


**Figure 4: 2011 Lake Whitney Dam Downstream Flow**

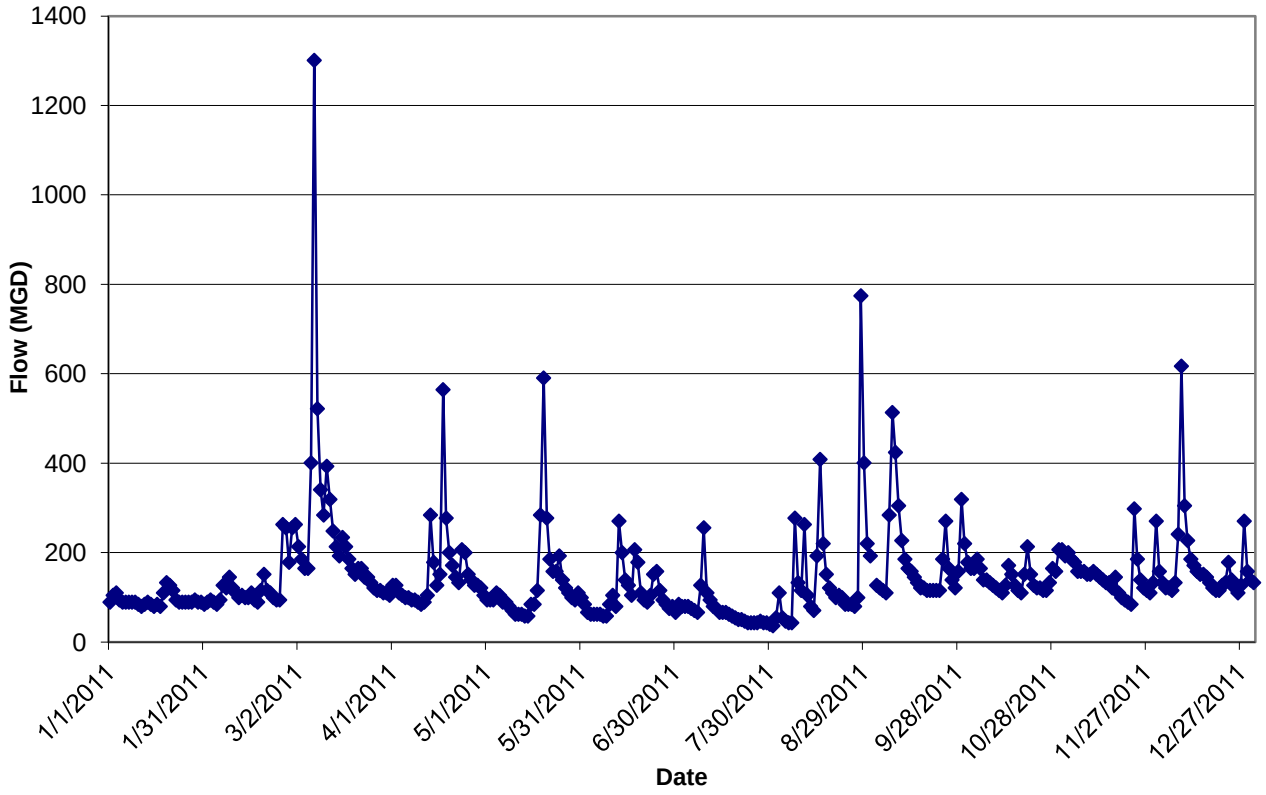


**Figure 5: 2011 Mill River Sampling Event Instantaneous Flow**

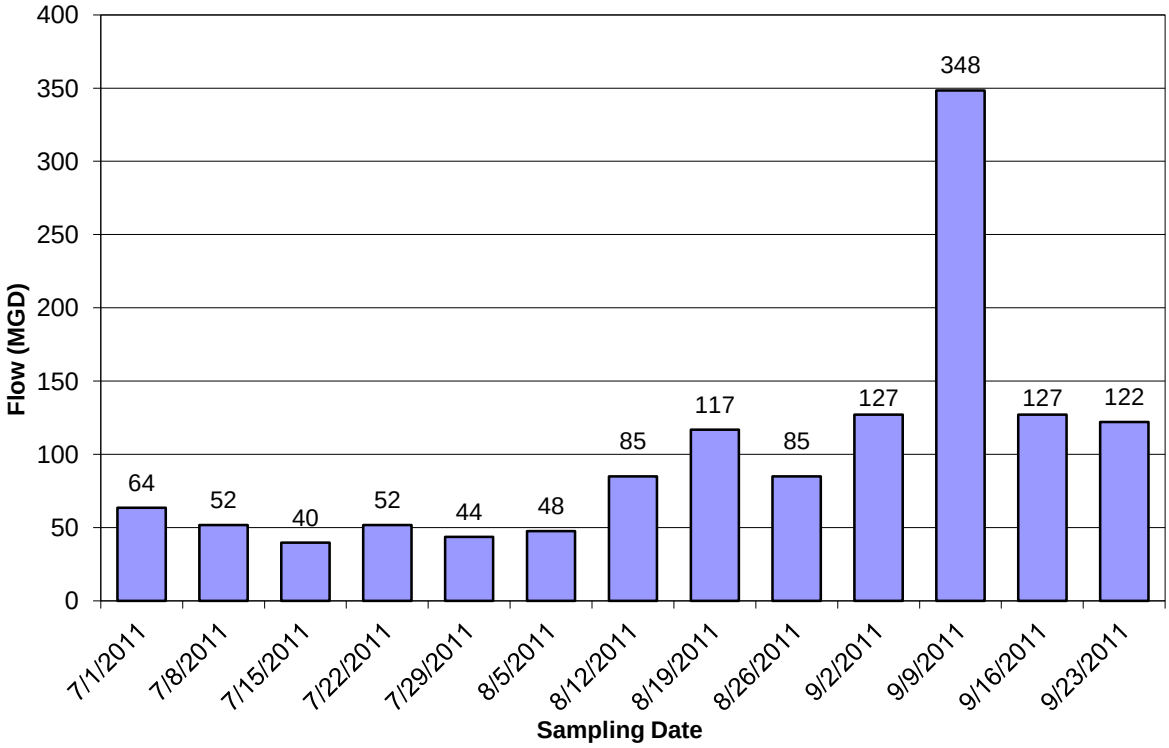


**FIGURE 6**
Locations Sampled During Mill River Monitoring

## Figure 7: 2011 Mill River Surface Salinity

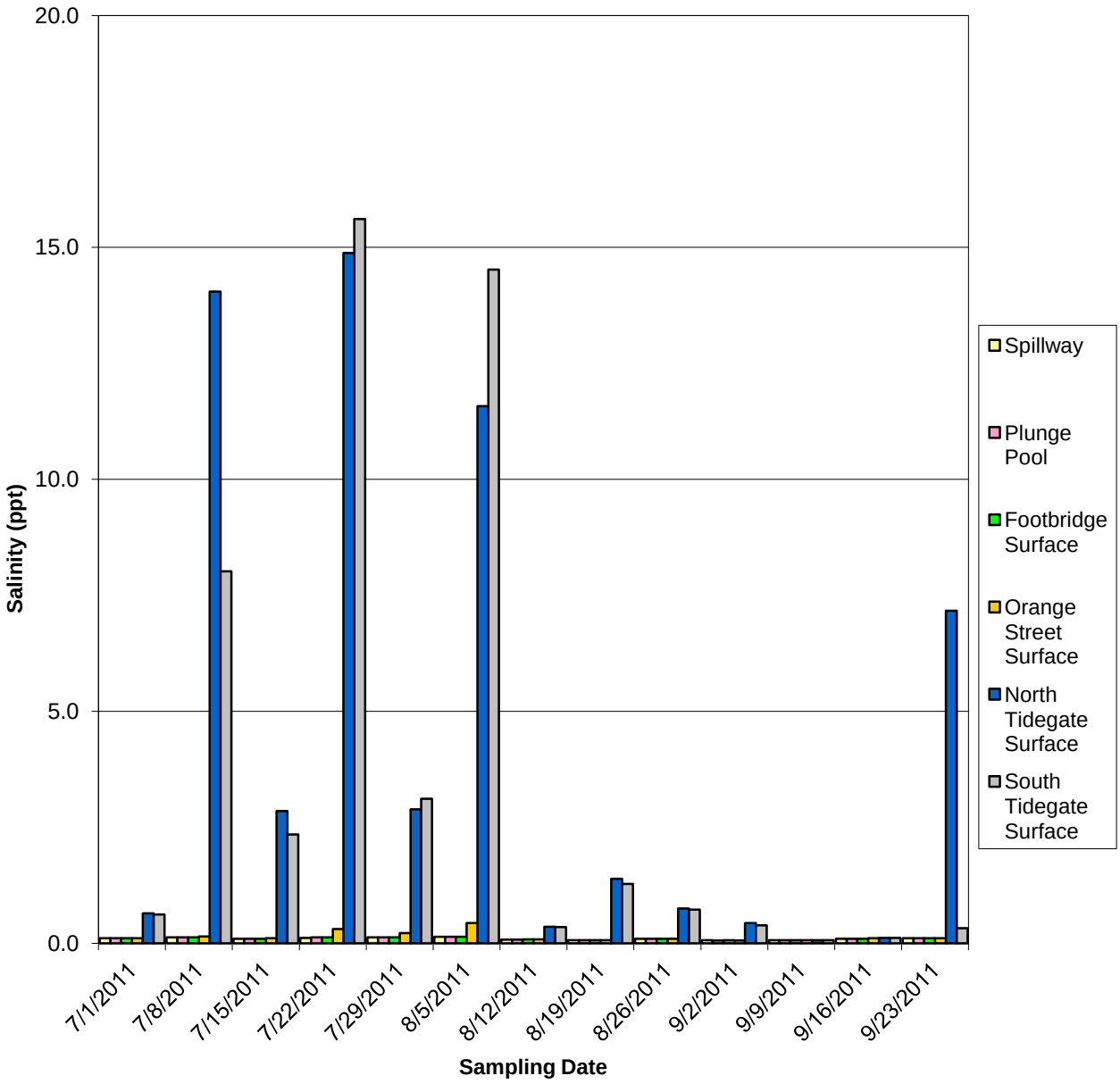


**Figure 8: 2011 Mill River Bottom Salinity**

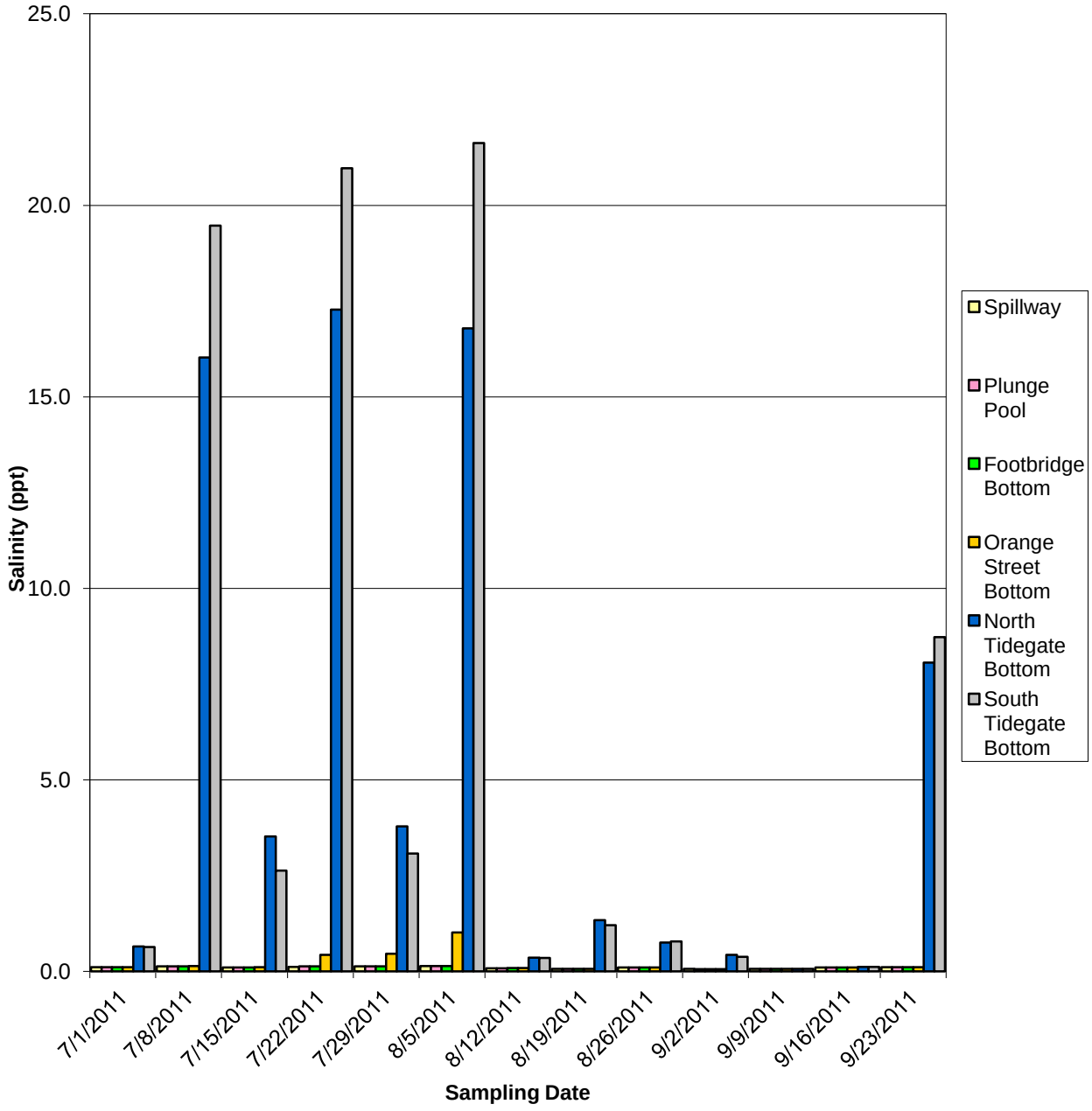


**Figure 9: 2011 Mill River Downstream Surface Salinity with Flow**

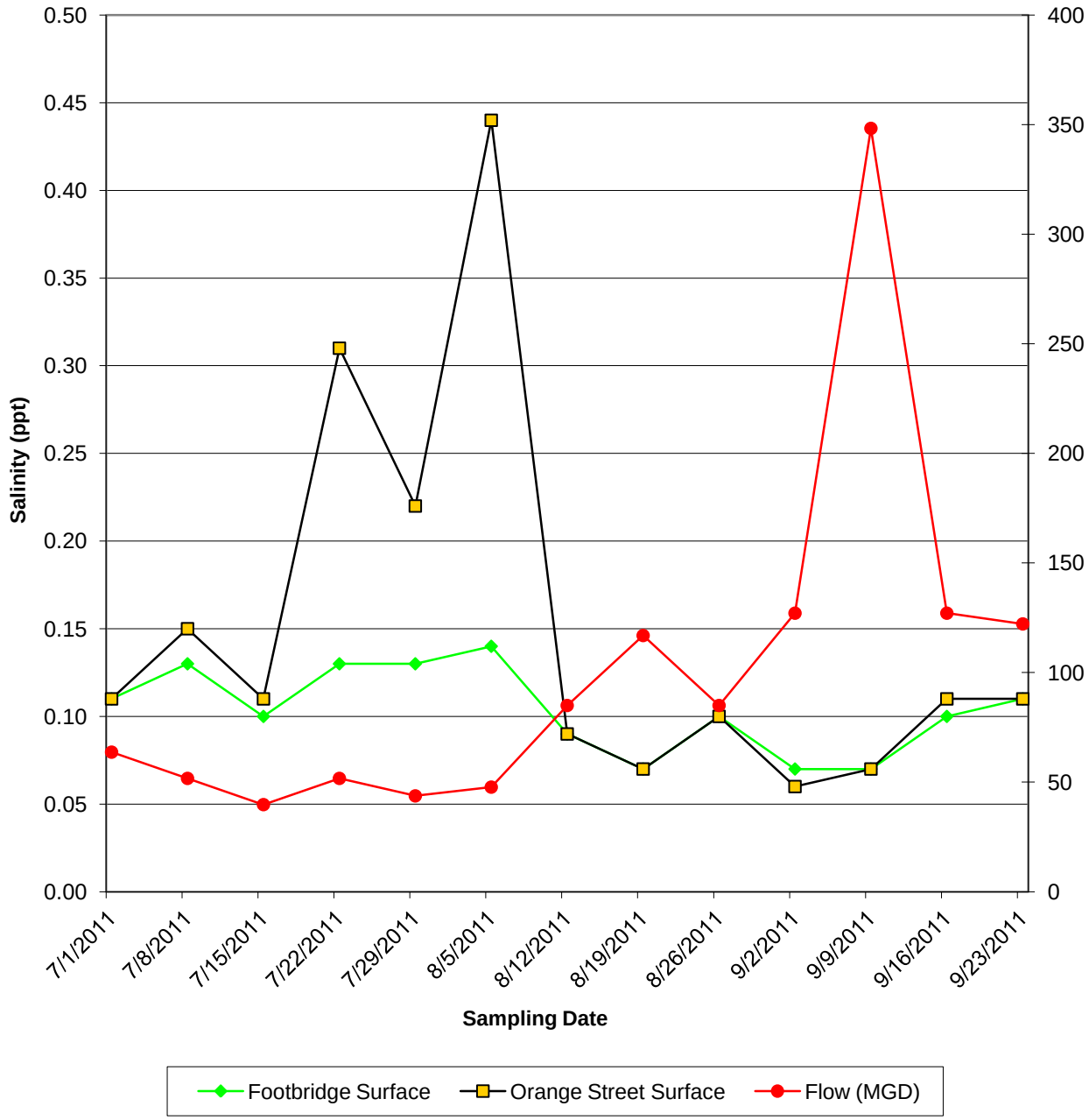


**Figure 10: 2011 Mill River Surface Dissolved Oxygen**

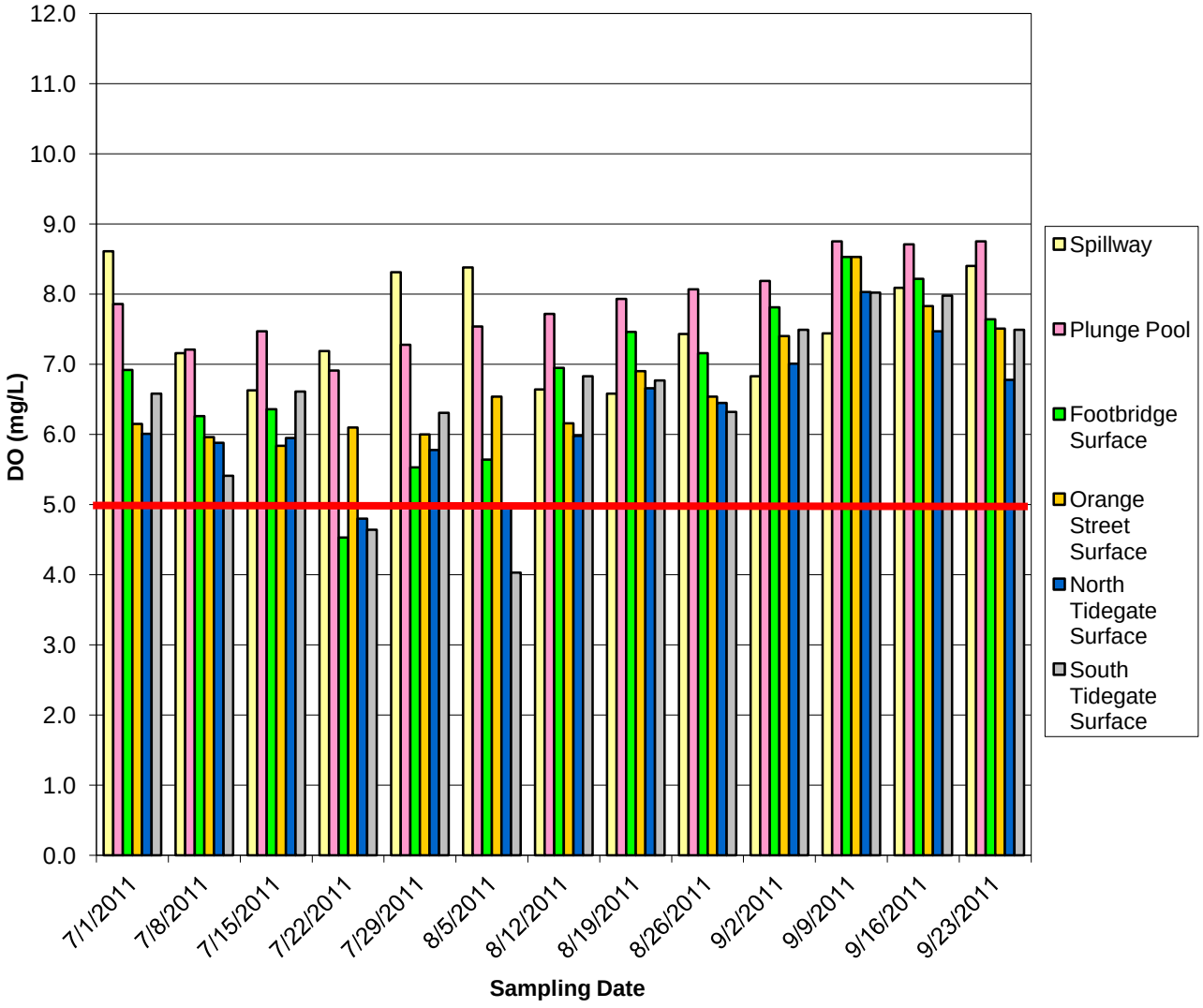


**Figure 11: 2011 Mill River Bottom Dissolved Oxygen**

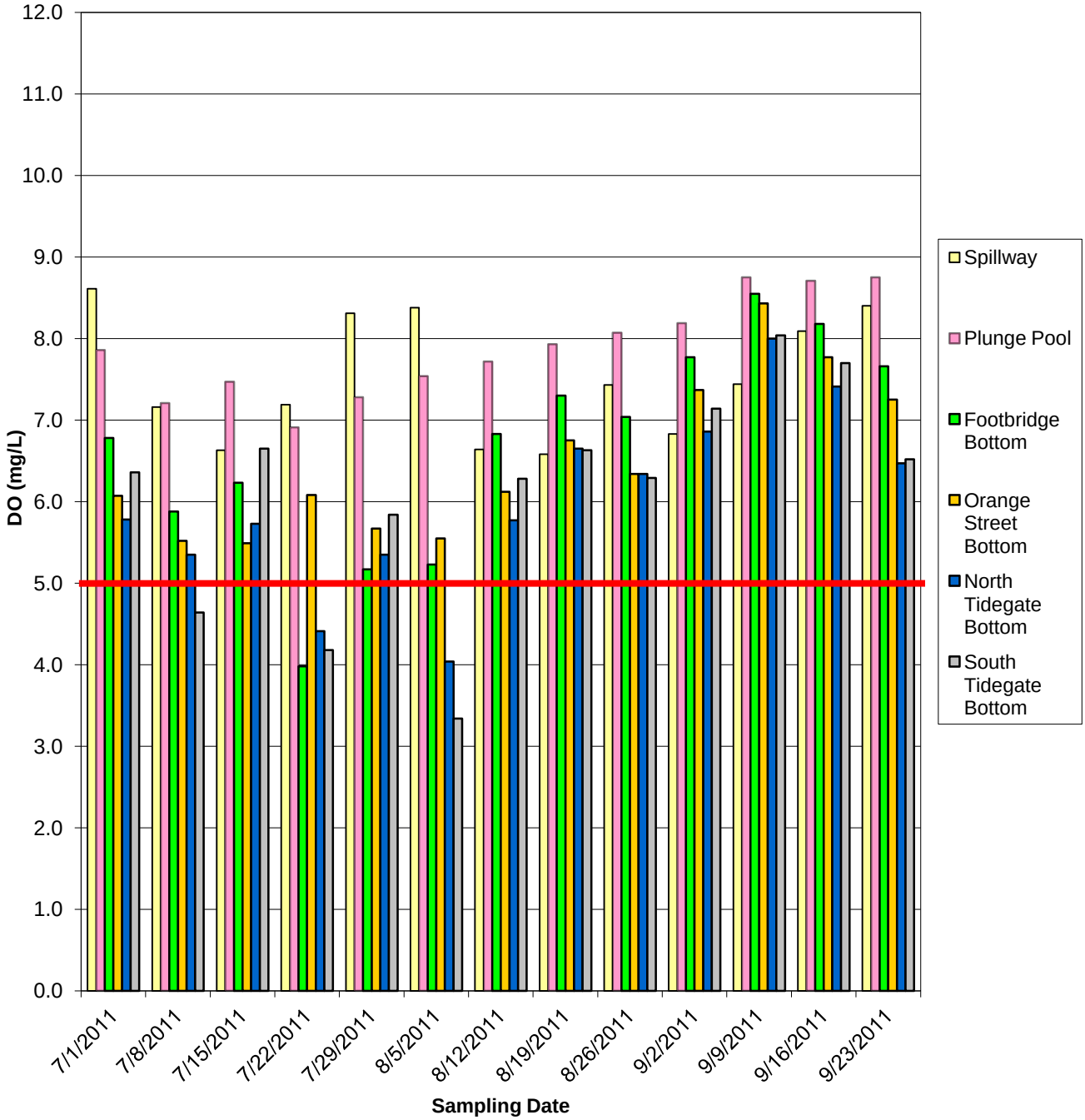
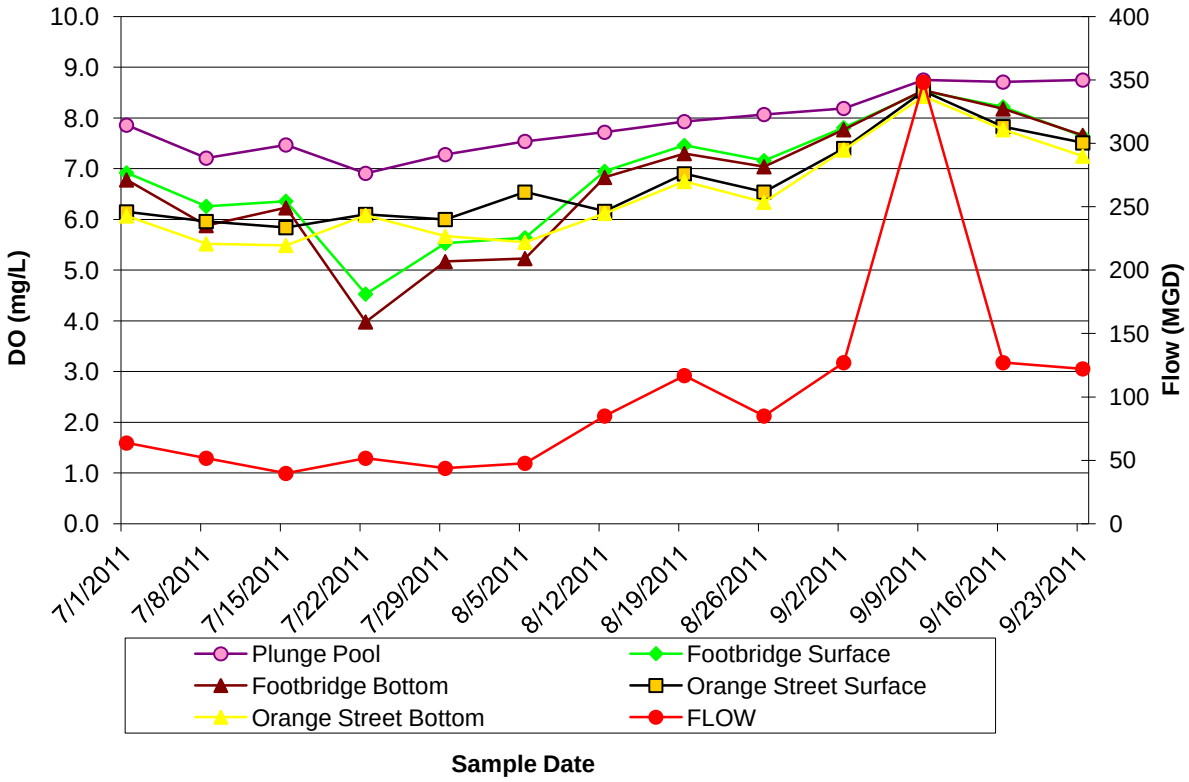


**Figure 12: 2011 Mill River Downstream DO With Flow**



# Attachment

# 2011 Weekly Monitoring Data

| Date | Station | Time | Depth (m) | Temp (C) | Salinity (ppt) | DO (mg/L) | DO (%) | pH | Estimated flow (mgd) | Dry or Wet | Tide Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/1/2011 | 0 | 5:55 | 0.30 | 23.29 | 0.11 | 8.61 | 101.00 | 8.18 | 63.70 | Wet | Low |
| 7/1/2011 | 1 | 6:05 | 0.30 | 22.72 | 0.11 | 7.86 | 91.30 | 8.21 | 63.70 | Wet | Low |
| 7/1/2011 | 4 | 5:35 | 0.20 | 22.49 | 0.11 | 6.92 | 79.90 | 7.66 | 63.70 | Wet | Low |
| 7/1/2011 | 4 | 5:45 | 0.90 | 22.54 | 0.11 | 6.78 | 78.40 | 7.70 | 63.70 | Wet | Low |
| 7/1/2011 | 6 | 5:18 | 1.10 | 22.78 | 0.11 | 6.15 | 71.50 | 7.38 | 63.70 | Wet | Low |
| 7/1/2011 | 6 | 5:25 | 0.20 | 22.75 | 0.11 | 6.07 | 70.50 | 7.44 | 63.70 | Wet | Low |
| 7/1/2011 | 7 | 6:15 | 0.20 | 23.47 | 0.65 | 6.01 | 70.90 | 7.71 | 63.70 | Wet | Low |
| 7/1/2011 | 7 | 6:25 | 0.80 | 23.49 | 0.65 | 5.78 | 68.40 | 7.64 | 63.70 | Wet | Low |
| 7/1/2011 | 8 | 6:30 | 0.20 | 23.47 | 0.62 | 6.58 | 77.80 | 7.64 | 63.70 | Wet | Low |
| 7/1/2011 | 8 | 6:35 | 0.70 | 23.46 | 0.64 | 6.36 | 75.20 | 7.62 | 63.70 | Wet | Low |
| 7/8/2011 | 0 | 6:00 | 0.40 | 25.68 | 0.13 | 7.16 | 87.90 | 7.80 | 51.72 | Dry | High |
| 7/8/2011 | 1 | 6:08 | 0.40 | 25.17 | 0.13 | 7.21 | 87.60 | 8.00 | 51.72 | Dry | High |
| 7/8/2011 | 4 | 5:48 | 0.20 | 25.04 | 0.13 | 6.26 | 75.90 | 7.62 | 51.72 | Dry | High |
| 7/8/2011 | 4 | 5:53 | 1.20 | 25.01 | 0.13 | 5.88 | 71.30 | 7.63 | 51.72 | Dry | High |
| 7/8/2011 | 6 | 5:30 | 0.30 | 25.17 | 0.15 | 5.96 | 72.40 | 7.40 | 51.72 | Dry | High |
| 7/8/2011 | 6 | 5:40 | 0.90 | 25.16 | 0.14 | 5.52 | 67.00 | 7.44 | 51.72 | Dry | High |
| 7/8/2011 | 7 | 6:15 | 0.20 | 23.65 | 14.05 | 5.88 | 75.70 | 7.42 | 51.72 | Dry | High |
| 7/8/2011 | 7 | 6:25 | 1.10 | 23.35 | 16.03 | 5.35 | 69.30 | 7.41 | 51.72 | Dry | High |
| 7/8/2011 | 8 | 6:30 | 0.20 | 24.56 | 8.02 | 5.41 | 68.30 | 7.41 | 51.72 | Dry | High |
| 7/8/2011 | 8 | 6:35 | 1.40 | 22.83 | 19.47 | 4.64 | 60.90 | 7.35 | 51.72 | Dry | High |
| 7/15/2011 | 0 | 5:55 | 0.30 | 24.59 | 0.10 | 6.63 | 79.70 | 7.54 | 39.75 | Dry | Low |
| 7/15/2011 | 1 | 6:00 | 0.30 | 24.00 | 0.10 | 7.47 | 88.90 | 7.74 | 39.75 | Dry | Low |
| 7/15/2011 | 4 | 5:36 | 0.20 | 23.65 | 0.10 | 6.36 | 75.10 | 7.45 | 39.75 | Dry | Low |
| 7/15/2011 | 4 | 5:44 | 0.80 | 23.64 | 0.10 | 6.23 | 73.60 | 7.54 | 39.75 | Dry | Low |
| 7/15/2011 | 6 | 5:20 | 0.20 | 23.63 | 0.11 | 5.84 | 69.00 | 7.30 | 39.75 | Dry | Low |
| 7/15/2011 | 6 | 5:30 | 0.90 | 23.64 | 0.11 | 5.49 | 64.80 | 7.41 | 39.75 | Dry | Low |
| 7/15/2011 | 7 | 6:10 | 0.30 | 24.29 | 2.85 | 5.95 | 72.40 | 7.40 | 39.75 | Dry | Low |
| 7/15/2011 | 7 | 6:15 | 0.70 | 24.33 | 3.52 | 5.73 | 70.20 | 7.35 | 39.75 | Dry | Low |
| 7/15/2011 | 8 | 6:20 | 0.20 | 24.26 | 2.35 | 6.61 | 80.10 | 7.40 | 39.75 | Dry | Low |
| 7/15/2011 | 8 | 6:25 | 0.40 | 24.24 | 2.63 | 6.65 | 80.80 | 7.40 | 39.75 | Dry | Low |
| 7/22/2011 | 0 | 5:55 | 0.20 | 26.87 | 0.12 | 7.19 | 90.10 | 7.87 | 51.72 | Dry | High |

| Date | Station | Time | Depth (m) | Temp (C) | Salinity (ppt) | DO (mg/L) | DO (%) | pH | Estimated flow (mgd) | Dry or Wet | Tide Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/22/2011 | 1 | 6:05 | 0.20 | 26.52 | 0.13 | 6.91 | 86.10 | 8.01 | 51.72 | Dry | High |
| 7/22/2011 | 4 | 5:40 | 0.20 | 26.05 | 0.13 | 4.53 | 55.90 | 7.55 | 51.72 | Dry | High |
| 7/22/2011 | 4 | 5:45 | 0.90 | 25.92 | 0.13 | 3.98 | 49.10 | 7.43 | 51.72 | Dry | High |
| 7/22/2011 | 6 | 5:22 | 0.20 | 27.40 | 0.31 | 6.10 | 77.20 | 7.59 | 51.72 | Dry | High |
| 7/22/2011 | 6 | 5:30 | 0.90 | 27.49 | 0.43 | 6.08 | 77.20 | 7.57 | 51.72 | Dry | High |
| 7/22/2011 | 7 | 6:15 | 0.20 | 25.53 | 14.88 | 4.80 | 64.40 | 7.35 | 51.72 | Dry | High |
| 7/22/2011 | 7 | 6:20 | 0.90 | 25.35 | 17.28 | 4.41 | 59.70 | 7.29 | 51.72 | Dry | High |
| 7/22/2011 | 8 | 6:25 | 0.20 | 25.53 | 15.61 | 4.64 | 62.50 | 7.31 | 51.72 | Dry | High |
| 7/22/2011 | 8 | 6:30 | 0.90 | 25.03 | 20.97 | 4.18 | 57.60 | 7.26 | 51.72 | Dry | High |
| 7/29/2011 | 0 | 6:05 | 0.20 | 26.24 | 0.13 | 8.31 | 103.00 | 8.55 | 43.74 | Wet | Low |
| 7/29/2011 | 1 | 6:15 | 0.20 | 25.79 | 0.13 | 7.28 | 89.50 | 8.50 | 43.74 | Wet | Low |
| 7/29/2011 | 4 | 5:55 | 0.20 | 25.18 | 0.13 | 5.53 | 67.20 | 7.67 | 43.74 | Wet | Low |
| 7/29/2011 | 4 | 5:58 | 0.70 | 25.12 | 0.13 | 5.17 | 62.80 | 7.64 | 43.74 | Wet | Low |
| 7/29/2011 | 6 | 5:35 | 0.20 | 25.62 | 0.22 | 6.00 | 73.50 | 7.67 | 43.74 | Wet | Low |
| 7/29/2011 | 6 | 5:45 | 0.80 | 25.66 | 0.46 | 5.67 | 69.70 | 7.63 | 43.74 | Wet | Low |
| 7/29/2011 | 7 | 6:25 | 0.20 | 25.56 | 2.89 | 5.78 | 72.10 | 7.63 | 43.74 | Wet | Low |
| 7/29/2011 | 7 | 6:30 | 0.70 | 25.51 | 3.79 | 5.35 | 67.10 | 7.50 | 43.74 | Wet | Low |
| 7/29/2011 | 8 | 6:40 | 0.20 | 25.51 | 3.12 | 6.31 | 78.70 | 7.48 | 43.74 | Wet | Low |
| 7/29/2011 | 8 | 6:45 | 0.60 | 25.52 | 3.08 | 5.84 | 72.70 | 7.47 | 43.74 | Wet | Low |
| 8/5/2011 | 0 | 6:05 | 0.20 | 25.15 | 0.14 | 8.38 | 101.90 | 8.69 | 47.73 | Dry | High |
| 8/5/2011 | 1 | 6:15 | 0.30 | 24.62 | 0.14 | 7.54 | 90.70 | 8.63 | 47.73 | Dry | High |
| 8/5/2011 | 4 | 5:50 | 0.20 | 24.17 | 0.14 | 5.64 | 67.30 | 7.77 | 47.73 | Dry | High |
| 8/5/2011 | 4 | 5:58 | 1.20 | 24.10 | 0.14 | 5.23 | 62.30 | 7.79 | 47.73 | Dry | High |
| 8/5/2011 | 6 | 5:35 | 0.20 | 25.41 | 0.44 | 6.54 | 79.90 | 8.04 | 47.73 | Dry | High |
| 8/5/2011 | 6 | 5:40 | 0.80 | 25.59 | 1.02 | 5.55 | 68.40 | 7.78 | 47.73 | Dry | High |
| 8/5/2011 | 7 | 6:25 | 0.20 | 24.33 | 11.58 | 4.99 | 64.10 | 7.61 | 47.73 | Dry | High |
| 8/5/2011 | 7 | 6:35 | 1.00 | 24.18 | 16.79 | 4.04 | 53.40 | 7.36 | 47.73 | Dry | High |
| 8/5/2011 | 8 | 6:40 | 0.20 | 24.43 | 14.52 | 4.03 | 52.80 | 7.34 | 47.73 | Dry | High |
| 8/5/2011 | 8 | 6:45 | 0.80 | 24.00 | 21.63 | 3.34 | 45.30 | 7.24 | 47.73 | Dry | High |
| 8/12/2011 | 0 | 6:10 | 0.20 | 24.02 | 0.08 | 6.64 | 79.00 | 7.51 | 84.98 | Wet | Low |
| 8/12/2011 | 1 | 6:20 | 0.20 | 23.56 | 0.08 | 7.72 | 91.00 | 7.64 | 84.98 | Wet | Low |

| Date | Station | Time | Depth (m) | Temp (C) | Salinity (ppt) | DO (mg/L) | DO (%) | pH | Estimated flow (mgd) | Dry or Wet | Tide Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/12/2011 | 4 | 5:55 | 0.20 | 23.34 | 0.09 | 6.95 | 81.50 | 7.60 | 84.98 | Wet | Low |
| 8/12/2011 | 4 | 6:00 | 0.70 | 23.29 | 0.09 | 6.83 | 80.10 | 7.53 | 84.98 | Wet | Low |
| 8/12/2011 | 6 | 5:40 | 0.20 | 23.45 | 0.09 | 6.16 | 72.50 | 7.73 | 84.98 | Wet | Low |
| 8/12/2011 | 6 | 5:45 | 0.70 | 23.45 | 0.09 | 6.12 | 71.80 | 7.62 | 84.98 | Wet | Low |
| 8/12/2011 | 7 | 6:30 | 0.20 | 24.10 | 0.36 | 5.98 | 71.30 | 7.43 | 84.98 | Wet | Low |
| 8/12/2011 | 7 | 6:40 | 0.80 | 24.10 | 0.36 | 5.77 | 68.80 | 7.35 | 84.98 | Wet | Low |
| 8/12/2011 | 8 | 6:45 | 0.20 | 24.07 | 0.35 | 6.83 | 81.50 | 7.33 | 84.98 | Wet | Low |
| 8/12/2011 | 8 | 6:50 | 0.70 | 24.06 | 0.35 | 6.28 | 74.70 | 7.33 | 84.98 | Wet | Low |
| 8/19/2011 | 0 | 6:10 | 0.30 | 22.21 | 0.07 | 6.58 | 75.50 | 7.38 | 116.90 | Dry | High |
| 8/19/2011 | 1 | 6:25 | 0.20 | 22.02 | 0.07 | 7.93 | 90.80 | 7.45 | 116.90 | Dry | High |
| 8/19/2011 | 4 | 6:00 | 0.20 | 21.99 | 0.07 | 7.46 | 85.30 | 7.51 | 116.90 | Dry | High |
| 8/19/2011 | 4 | 6:05 | 1.30 | 22.00 | 0.07 | 7.30 | 83.50 | 7.48 | 116.90 | Dry | High |
| 8/19/2011 | 6 | 5:40 | 0.20 | 20.90 | 0.07 | 6.90 | 77.20 | 7.66 | 116.90 | Dry | High |
| 8/19/2011 | 6 | 5:50 | 0.90 | 20.91 | 0.07 | 6.75 | 75.60 | 7.55 | 116.90 | Dry | High |
| 8/19/2011 | 7 | 6:35 | 0.10 | 21.79 | 1.39 | 6.66 | 76.60 | 7.35 | 116.90 | Dry | High |
| 8/19/2011 | 7 | 6:40 | 0.50 | 21.77 | 1.34 | 6.65 | 76.50 | 7.33 | 116.90 | Dry | High |
| 8/19/2011 | 8 | 6:45 | 0.20 | 21.75 | 1.28 | 6.77 | 77.80 | 7.32 | 116.90 | Dry | High |
| 8/19/2011 | 8 | 6:50 | 0.80 | 21.73 | 1.21 | 6.63 | 76.10 | 7.31 | 116.90 | Dry | High |
| 8/26/2011 | 0 | 6:30 | 0.20 | 22.66 | 0.10 | 7.43 | 86.70 | 7.57 | 84.98 | Wet | Low |
| 8/26/2011 | 1 | 6:40 | 0.20 | 22.51 | 0.10 | 8.07 | 93.30 | 7.67 | 84.98 | Wet | Low |
| 8/26/2011 | 4 | 6:15 | 0.20 | 22.36 | 0.10 | 7.16 | 82.60 | 7.54 | 84.98 | Wet | Low |
| 8/26/2011 | 4 | 6:20 | 0.70 | 22.36 | 0.10 | 7.04 | 81.10 | 7.52 | 84.98 | Wet | Low |
| 8/26/2011 | 6 | 5:50 | 0.20 | 22.29 | 0.10 | 6.54 | 75.30 | 7.58 | 84.98 | Wet | Low |
| 8/26/2011 | 6 | 6:05 | 0.80 | 22.29 | 0.10 | 6.34 | 72.90 | 7.51 | 84.98 | Wet | Low |
| 8/26/2011 | 7 | 6:50 | 0.20 | 22.42 | 0.75 | 6.45 | 74.70 | 7.39 | 84.98 | Wet | Low |
| 8/26/2011 | 7 | 6:55 | 0.90 | 22.42 | 0.75 | 6.34 | 73.40 | 7.38 | 84.98 | Wet | Low |
| 8/26/2011 | 8 | 7:00 | 0.20 | 22.41 | 0.73 | 6.32 | 73.30 | 7.35 | 84.98 | Wet | Low |
| 8/26/2011 | 8 | 7:05 | 0.90 | 22.43 | 0.78 | 6.29 | 73.00 | 7.32 | 84.98 | Wet | Low |
| 9/2/2011 | 0 | 6:25 | 0.20 | 21.12 | 0.07 | 6.83 | 76.80 | 7.27 | 127.10 | Dry | High |
| 9/2/2011 | 1 | 6:35 | 0.30 | 20.70 | 0.06 | 8.19 | 91.40 | 7.31 | 127.10 | Dry | High |
| 9/2/2011 | 4 | 6:10 | 0.20 | 20.65 | 0.07 | 7.81 | 87.00 | 7.36 | 127.10 | Dry | High |

| Date | Station | Time | Depth (m) | Temp (C) | Salinity (ppt) | DO (mg/L) | DO (%) | pH | Estimated flow (mgd) | Dry or Wet | Tide Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/2/2011 | 4 | 6:15 | 1.40 | 20.66 | 0.06 | 7.77 | 86.60 | 7.29 | 127.10 | Dry | High |
| 9/2/2011 | 6 | 5:55 | 0.20 | 20.46 | 0.06 | 7.40 | 82.10 | 7.33 | 127.10 | Dry | High |
| 9/2/2011 | 6 | 6:05 | 0.80 | 20.45 | 0.06 | 7.37 | 81.80 | 7.31 | 127.10 | Dry | High |
| 9/2/2011 | 7 | 6:45 | 0.20 | 20.16 | 0.44 | 7.01 | 77.60 | 7.28 | 127.10 | Dry | High |
| 9/2/2011 | 7 | 6:50 | 1.30 | 20.16 | 0.43 | 6.86 | 75.90 | 7.26 | 127.10 | Dry | High |
| 9/2/2011 | 8 | 7:00 | 0.20 | 20.15 | 0.39 | 7.49 | 82.90 | 7.21 | 127.10 | Dry | High |
| 9/2/2011 | 8 | 7:05 | 1.10 | 20.14 | 0.38 | 7.14 | 79.00 | 7.21 | 127.10 | Dry | High |
| 9/9/2011 | 0 | 6:35 | 0.20 | 18.55 | 0.07 | 7.44 | 79.50 | 7.32 | 348.30 | Wet | Low |
| 9/9/2011 | 1 | 6:45 | 0.20 | 18.33 | 0.07 | 8.75 | 93.00 | 7.35 | 348.30 | Wet | Low |
| 9/9/2011 | 4 | 6:20 | 0.20 | 18.37 | 0.07 | 8.53 | 90.80 | 7.42 | 348.30 | Wet | Low |
| 9/9/2011 | 4 | 6:28 | 1.10 | 18.38 | 0.07 | 8.55 | 91.10 | 7.43 | 348.30 | Wet | Low |
| 9/9/2011 | 6 | 6:00 | 0.30 | 18.33 | 0.07 | 8.53 | 90.80 | 7.45 | 348.30 | Wet | Low |
| 9/9/2011 | 6 | 6:15 | 0.60 | 18.33 | 0.07 | 8.43 | 89.70 | 7.43 | 348.30 | Wet | Low |
| 9/9/2011 | 7 | 6:57 | 0.20 | 18.34 | 0.07 | 8.03 | 85.50 | 7.43 | 348.30 | Wet | Low |
| 9/9/2011 | 7 | 7:00 | 1.20 | 18.34 | 0.07 | 8.00 | 85.10 | 7.41 | 348.30 | Wet | Low |
| 9/9/2011 | 8 | 7:05 | 0.20 | 18.35 | 0.07 | 8.02 | 85.40 | 7.39 | 348.30 | Wet | Low |
| 9/9/2011 | 8 | 7:12 | 1.00 | 18.35 | 0.07 | 8.04 | 85.60 | 7.35 | 348.30 | Wet | Low |
| 9/16/2011 | 0 | 6:40 | 0.20 | 20.21 | 0.10 | 8.09 | 89.40 | 7.58 | 127.10 | Dry | Mid |
| 9/16/2011 | 1 | 6:45 | 0.20 | 19.77 | 0.10 | 8.71 | 95.50 | 7.69 | 127.10 | Dry | Mid |
| 9/16/2011 | 4 | 6:20 | 0.20 | 19.50 | 0.10 | 8.22 | 89.60 | 7.63 | 127.10 | Dry | Mid |
| 9/16/2011 | 4 | 6:30 | 1.00 | 19.56 | 0.10 | 8.18 | 89.30 | 7.60 | 127.10 | Dry | Mid |
| 9/16/2011 | 6 | 6:05 | 0.20 | 19.18 | 0.11 | 7.83 | 84.80 | 7.65 | 127.10 | Dry | Mid |
| 9/16/2011 | 6 | 6:15 | 0.80 | 19.18 | 0.10 | 7.77 | 84.10 | 7.60 | 127.10 | Dry | Mid |
| 9/16/2011 | 7 | 6:55 | 0.10 | 19.20 | 0.12 | 7.47 | 80.90 | 7.54 | 127.10 | Dry | Mid |
| 9/16/2011 | 7 | 7:00 | 0.80 | 19.20 | 0.12 | 7.41 | 80.20 | 7.47 | 127.10 | Dry | Mid |
| 9/16/2011 | 8 | 7:05 | 0.20 | 19.18 | 0.12 | 7.98 | 86.40 | 7.48 | 127.10 | Dry | Mid |
| 9/16/2011 | 8 | 7:10 | 0.80 | 19.18 | 0.12 | 7.70 | 83.30 | 7.45 | 127.10 | Dry | Mid |
| 9/23/2011 | 0 | 6:50 | 0.20 | 20.09 | 0.11 | 8.40 | 92.60 | 7.64 | 122.20 | Dry | Mid |
| 9/23/2011 | 1 | 7:00 | 0.20 | 19.96 | 0.11 | 8.75 | 96.20 | 7.76 | 122.20 | Dry | Mid |
| 9/23/2011 | 4 | 6:30 | 0.20 | 19.72 | 0.11 | 7.64 | 83.60 | 7.59 | 122.20 | Dry | Mid |
| 9/23/2011 | 4 | 6:43 | 1.10 | 19.72 | 0.11 | 7.66 | 83.90 | 7.58 | 122.20 | Dry | Mid |

| Date | Station | Time | Depth (m) | Temp (C) | Salinity (ppt) | DO (mg/L) | DO (%) | pH | Estimated flow (mgd) | Dry or Wet | Tide Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/23/2011 | 6 | 6:15 | 0.30 | 19.24 | 0.11 | 7.51 | 81.40 | 7.54 | 122.20 | Dry | Mid |
| 9/23/2011 | 6 | 6:25 | 0.80 | 19.20 | 0.11 | 7.25 | 78.50 | 7.48 | 122.20 | Dry | Mid |
| 9/23/2011 | 7 | 7:10 | 0.20 | 19.99 | 7.17 | 6.78 | 78.10 | 7.34 | 122.20 | Dry | Mid |
| 9/23/2011 | 7 | 7:20 | 1.10 | 20.04 | 8.06 | 6.47 | 75.10 | 7.32 | 122.20 | Dry | Mid |
| 9/23/2011 | 8 | 7:25 | 0.20 | 19.58 | 0.33 | 7.49 | 81.90 | 7.77 | 122.20 | Dry | Mid |
| 9/23/2011 | 8 | 7:30 | 1.20 | 20.09 | 8.73 | 6.52 | 75.90 | 7.21 | 122.20 | Dry | Mid |