



# **Bear Creek Environmental**

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**Stowe Mountain Resort  
SMR 2000 Community Plan  
Water Quality Management Plan**

## **2015 Monitoring Report**

June 9, 2016

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## **Stowe Mountain Resort SMR 2000 Community Plan Water Quality Management Plan**

### **2015 Monitoring Report**

June 9, 2016

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# **Stowe Mountain Resort SMR 2000 Community Plan Water Quality Management Plan**

## **2015 Monitoring Report**

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# **Stowe Mountain Resort SMR 2000 Community Plan Water Quality Management Plan**

## **2015 Monitoring Report**

### **EXECUTIVE SUMMARY**

- Bear Creek Environmental, LLC (BCE) was retained by Stowe Mountain Resort (SMR) to conduct water quality monitoring and sediment assessments in the West Branch of the Little River watershed as part of the SMR Community 2000 Master Development Plan (MDP). The purpose of the water quality monitoring program is to provide information and guidance for water quality protection during construction and development at Spruce Peak.
- BCE monitored water quality at seventeen stream stations during the 2015 monitoring period (June 2015 through May 2016). The monitoring stations are within the vicinity of Spruce Peak and are located within the West Branch of the Little River watershed and Pinnacle Brook watershed. Fourteen years of water quality monitoring have taken place at Stowe Mountain Resort.
- SMR conducted monitoring at all the stations specified in the Settlement Agreement during 2015-2016, and at many supplemental water quality stations. Additionally, samples were collected during runoff events from the outlets of five sediment basins.
- For the 2015-2016 monitoring season, there were five event-based sampling rounds during storm or melt events that resulted in significant runoff. Event-based samples were analyzed for pH, turbidity, conductivity, and temperature. Chloride was also analyzed for samples collected during a March 2016 rain and melt event.
- Turbidity values reported in 2015-2016 were generally low, with the exception of the March 10, 2016 rain and melt event. The highest stream turbidities were measured on the Spruce side of the resort.
- SMR implemented a plan during the 2012-2013 monitoring period to improve water quality in the West Branch in the vicinity of the Mansfield Base Area. Based on observations during storm events in 2015-2016, these improvements are helping to reduce sediment reaching surface waters. In particular, the small stormwater basins and drainage networks that are treating stormwater onsite are working well. These areas include: 1. Snowplow Workroad Improvements; 2. Midway Lot Stormwater Management System; 3. Workroad Improvements near Barnes Camp Stream Crossing.
- The performance of the larger basins at the resort was generally very good during the 2015-2016 monitoring year. Samples collected at the Snowmaking Pond outflow,



Mansfield Exit Basin, and Big Spruce Basin had consistently low turbidity for each event during the 2015-2016 monitoring year. Elevated turbidity was observed only at the Mansfield Basin outlet on March 10, 2016. This elevated turbidity was likely a result of sediment from melting snow on the Mansfield parking lot running off into the basin. This event took place prior to the spring cleanup of sand from roads and parking lots, which is conducted annually by the Resort. The Upper Barnes Camp Basin continues to perform well with the outflow of the basin dissipating into the forest duff rather than discharging directly to the West Branch. The Lower Barnes Camp Basin also performs well, with no discharge to surface waters being reported for four of the five events sampled.

- Little Spruce Brook typically had the highest turbidities of the stream stations during the 2015-2016 monitoring year. The source of this turbidity has not been determined but may be related to construction activities at Spruce Peak.
- Macroinvertebrate sampling to assess the biological integrity of streams within the vicinity of Stowe Mountain Resort took place at nine monitoring stations during fall 2015. The control station, located at the picnic area in Smuggler's Notch, upstream of the Resort on the West Branch, was found to have good biological integrity. This upper station is likely impacted by acid precipitation. Kick net samples were collected at the West Branch station located immediately upstream of the Mansfield basin, and results indicate the biological integrity was fair to good. The West Branch station below the Mansfield parking lot exit and the station located upstream of the Pinnacle Brook confluence was also found to have fair to good biological integrity. Both West Branch stations within the report had suppressed densities, with the other seven metrics meeting Class B biocriteria. The most downstream West Branch station was found to have good biological integrity in 2015, while Pinnacle Brook, the reference stream, had very good to excellent biological integrity.
- Two biomonitoring stations on Big Spruce Brook were added in 2015 to better understand the impact of heavy iron seeps on the aquatic biota. The upstream monitoring station, located upstream of Spruce Peak Road, had good biological integrity. The DEC sampled Big Spruce within a heavy iron seep, downstream of Spruce Peak Road. This station had poor biological integrity. Both lower Big Spruce stations had low density and EPT Richness and did not meet the Class B2-3 biocriteria.
- A field reconnaissance of Big Spruce Brook occurred in May 2015 to identify potential conditions and impacts that may be adversely affecting the macroinvertebrate community in the brook. River scientists observed nineteen iron seeps along the brook between the Spruce Peak Road crossing and the mouth of the brook. This reconnaissance is detailed in the 2015 annual water quality report. Field observations suggest that water chemistry is likely the most important factor influencing the biological community in Big Spruce Brook. Excessive iron in the brook appears to be degrading water quality and the macroinvertebrate community. These iron seeps do not appear to be related to construction activities at Spruce Peak and likely date back many years. The seeps are

located near the bottom of steep, inaccessible, heavily vegetated slopes. The numerous naturally occurring iron seeps and lack of access (e.g. steep slopes and fragile adjacent environments) make iron seep remediation implausible.

- The USGS Stream gauge on the West Branch of the Little River was discontinued at the end of February 2016.
- A meeting is scheduled with the VDEC on June 13, 2016 to discuss the listing of the West Branch and Big Spruce Brook in Part B of the 2016 preliminary list of priority waters. This upcoming meeting will likely include discussions regarding modifying the current monitoring program.



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## **Stowe Mountain Resort**

### **SMR 2000 Community Plan Water Quality Management Plan**

### **2015 Monitoring Report**

#### **1.0 INTRODUCTION**

Bear Creek Environmental, LLC (BCE) was retained by Stowe Mountain Resort (SMR) to conduct water quality monitoring and sediment assessments in the West Branch of the Little River watershed. This report summarizes the monitoring activities associated with the Water Quality Management Plan (WQMP) from spring 2015 through spring 2016 as part of the SMR Community 2000 Master Development Plan (MDP).

The purpose of the WQMP is to provide information and guidance for water quality protection during construction and development at Spruce Peak. SMR began the implementation of this plan in 1999. One primary objective of the WQMP is to document water quality conditions throughout the implementation of the MDP. Another objective is to show that the MDP will not result in any undue water pollution to the waters of Vermont according to Criterion 1 of Act 250. As part of the MDP, Spruce Peak construction started in 2003. The data collected in summer 2015 through spring 2016 represents the thirteenth year of monitoring during construction. Monitoring data has been collected annually from the Big Spruce Brook watershed and the West Branch Little River Watershed.

### Big Spruce

Big Spruce Brook was placed on the Part C of the 2008 Vermont List of Priority Waters by the Agency of Natural Resources (ANR) as in need of further assessment to determine compliance with the Vermont Water Quality Standards (VWQS). In 2010, Big Spruce Brook was moved to Part B of the Vermont Priority Water List, based on monitoring data from the past four years. Waters listed on Part B are considered impaired, but do not require the development of a Total Maximum Daily Load (TMDL). Rather, the development of a water quality remediation plan is required so that the VWQS are attained. The Agency of Natural Resources issued a 1272 order on May 6, 2010 to serve as a water quality remediation plan to address sources of iron and sediment identified in Big Spruce Brook (Refer to Appendix 2 of 2010 Monitoring Report; Nealon, 2011).

Following the issuance of the 1272 order, improvements were completed by SMR to remediate a local iron seep adjacent to the Club House and to improve stormwater management to reduce sediment impacts. Despite these remediation efforts, both Big Spruce monitoring stations have shown little improvement. In May 2015 extensive iron seeps were documented that are contributing to impairment of the macroinvertebrate community. These iron seeps do not appear to be related to construction activities at Spruce Peak, and have likely existed for many years. Bear Creek Environmental conducted a stream reconnaissance with Steve Fiske during September 2015 and noted iron seeps are strong, extensive in length, and are in steep locations that are not accessible. The Big Spruce Brook is listed on the 2016 Draft Part B List of Priority Surface Waters due to iron seeps and sediment impacts (VDEC 2016). In this recent listing, the impaired reach has been extended to river mile (RM) 0.8.

Spruce Peak Realty is continuing to work with consultants and the VDEC for solutions to bring Big Spruce Brook in compliance with VWQS; however, the remediation of these iron seeps does not appear to be feasible given the location and extent. The seeps are located at the bottom of steep, heavily vegetated slopes where access is impractical. In 2015, The Mount Mansfield Company initiated an additional evaluation with VHB, Civil Engineering Associates and Bear Creek Environmental to explore options to reduce sedimentation in the Big Spruce

watershed in the vicinity of the Sensation Lot, Spruce Peak Road, and from in-channel and bank erosion within the Ski Club drainage. The Ski Club drainage is located primarily on privately owned land. Although adjustments along the Ski Club drainage have been identified as a potential sediment source, no remediation work can occur on the brook without the consent, cooperation, and financial participation of the private landowner.

#### West Branch of Little River

The West Branch from RM 7.5 to 8.0 was placed on the 2012 list of impaired waters by the ANR. Based on a meeting held between ANR and SMR on March 15, 2012, and written comments dated April 11, 2012, the West Branch was moved to Part B of the Vermont Priority Waters List. A 1272 order was issued by Pete LaFlamme of the ANR on May 3, 2012 to provide steps to be implemented to improve water quality of the West Branch (Refer to Appendix 2 of 2012 Monitoring Report; Nealon and Kinghorn, 2013). SMR developed and implemented measures during 2012 to reduce hydrologic and sediment impacts in the West Branch by improving stormwater management and infrastructure. Turbidity results from the past few years indicate the stormwater infrastructure is working to reduce sediment inputs; however, the macroinvertebrate metrics for the West Branch in the vicinity of the resort are not consistently meeting Class B water quality standards. Further investigation is needed to determine the relationship between the flashy upland streams that feed into the West Branch within the resort as well as the hydrologic characteristics of the West Branch watershed. Biologic and physical results indicate that the West Branch within the resort has a tendency to settle out sands where the slope drops, yet is still susceptible to scour during large flow events. The proximity of Vermont Route 108 and the winter maintenance practices for this state managed road are likely factors contributing to sedimentation of the West Branch. This state route is outside the control of Stowe Mountain Resort.

Minor construction activities will occur during 2016 and 2017 at Stowe Mountain Resort as part of the SMR 2000 Master Development Plan. According to Rob Apple of Spruce Peak Realty, construction will continue at the Spruce Adventure Center. This work will mostly encompass interior work, some trim/exterior, and final landscaping.

## **2.0 STUDY AREA AND METHODOLOGY**

BCE monitored water quality at seventeen stream stations (see page I of Appendix I) during the 2015 monitoring period. Seven of these monitoring stations were previously selected by Pioneer Environmental Associates, LLC (Pioneer) based on their proximity to construction activities. The rationale for station selection is reported in Pioneer's Quality Assurance Project Plan (QAPP) dated February 2002. Two additional monitoring stations were voluntarily added by Stowe Mountain Resort during the 2006 monitoring period to provide data for the West Branch and Big Spruce Brook. Based on a recommendation from Bear Creek Environmental, turbidity monitoring of the outflow of three sediment basins was added during 2007. A new monitoring station on Big Spruce Brook at river mile 0.7 was added in 2009 to offer background turbidity data immediately upstream of the Big Spruce Basin. In 2010, two stations on the Ski Club drainage were added to monitor sediment sources to the Big Spruce sediment basin. A station on the West Branch at river mile 8.8 was added in 2011 to provide a reference/control biomonitoring station upstream of the resort. Stations near the mouth of Gondola Brook and Long Trail Brook and the Mansfield Exit Basin outlet were added to the turbidity monitoring during spring 2012 to better understand sediment sources to the West Branch.

A revised monitoring plan, including recommendations from Steve Fiske (DEC), was submitted to VANR in December 2012. The Revised Monitoring Plan added three baseflow monitoring stations (Long Trail Tributary 0.1, Gondola Brook 0.1, and Little Spruce Brook 0.1), removed the total dissolved phosphorus parameter from baseflow samples, and added the chloride parameter to event-based surface water quality sampling. (Refer to Appendix 2 of 2012 Monitoring Report; Nealon and Kinghorn, 2013).

During 2015, two additional biomonitoring stations were sampled on Big Spruce Brook. The upper station at RM 0.9 is located downstream of the Big Spruce ski trails, but upstream of the iron seeps that begin below the culvert crossing on Spruce Peak Road. A station at RM 0.8, located downstream of the culvert within the iron seep impacted area, was sampled by VDEC.

The monitoring stations at Stowe Mountain Resort are located within the West Branch of the Little River watershed and Pinnacle Brook watershed. The drainage areas of the subwatersheds are included in Table I.

<b>Table I. Drainage Areas of Subwatersheds in the Vicinity of SMR</b>		
<b>Subwatershed</b>	<b>Description</b>	<b>Drainage Area (Sq. miles)</b>
West Branch	Above confluence with Pinnacle Brook	4.81
Pinnacle Brook	Tributary to West Branch	2.31
Big Spruce Brook	Tributary to West Branch	0.78
Little Spruce Brook	Tributary to Big Spruce Brook	0.12
Ski Club Drainage	Tributary to Big Spruce Brook	0.02
Gondola Brook	Tributary to Long Trail Tributary	0.90
Long Trail Tributary	Tributary to West Branch	1.44

The station numbering of the monitoring stations was revised in 2006 to provide a spatial reference to the stations and to be consistent with the methodology that the Vermont Department of Environmental Conservation (DEC) uses for numbering its stations. The first two letters of the station name is short for the surface water: West Branch of Little River (WB), Big Spruce Brook (BS), Little Spruce Brook (LS), Pinnacle Brook (PB), Ski Club drainage (SC), Gondola Brook (GB), and Long Trail Brook (LT). The number in the station name represents the river mile and is the distance from the mouth. The six sediment basin outflow sampling locations are identified as outlets. A brief description of the stations and the rationale for sampling is provided below.

**West Branch of Little River above Stowe Mountain Resort - WB8.8:** Located behind the picnic area off Route 108 in Smugglers Notch, this upper monitoring station was added in 2011 to provide a local control station upstream of Stowe Mountain Resort.

**West Branch of Little River at Barnes Camp - WB8.2:** Located upstream of the resort near Barnes Camp, this station offers a background turbidity monitoring station upstream of

the Mansfield Basin and development at the Mansfield Base area. This station was added in 2011 to better understand sources of turbidity to station WB8.0.

**West Branch of Little River below Long Trail Tributary - WB8.0 (MS-16B):** This station on the West Branch is located directly downstream of the intermountain connector lift and upstream of the discharge from the sedimentation basin that treats the stormwater from the Mt. Mansfield parking lot. It was added in 2006, per the recommendation of Steve Fiske, to bracket the Mt. Mansfield sedimentation basin.

**West Branch of Little River above Big Spruce Brook - WB7.5 (MS-8):** This station is located on the West Branch above the Big Spruce confluence. The station extends from the bridge at the entrance of the resort downstream to the first section of rock riprap. The purpose of sampling WB7.5 is to evaluate the water quality and biological community upstream of the Spruce Hamlet project and the golf course, yet downstream of the Mansfield Basin. Per the Settlement Agreement, sampling at WB7.5 is required annually until the year after completion of build out.

**West Branch of Little River below Snowmaking Pond Outlet - WB6.9:** This station is located on the West Branch downstream of the snowmaking pond outlet. The station is representative of water quality at the downstream end of the resort.

**West Branch of Little River above Pinnacle Brook Confluence - WB6.5 (MS-14):** This station on the West Branch is located immediately above the confluence of Pinnacle Brook. The lower West Branch station is located below the Spruce Hamlet development and much of the drainage from the golf course. The Stowe Mountain Resort Settlement Agreement dated June 13, 2000 specifies that monitoring at WB6.5 be conducted every other year until the year after completion of build-out. SMR has gone beyond this agreement and has sampled WB6.5 annually.

**Gondola Brook – GB0.1:** The Gondola Brook station is located at the mouth of Gondola Brook, just downstream of the crossing that enters the Mansfield Basin Parking Lot. The



station was added in 2012 to better track sources of turbidity. Per the request of the DEC, baseflow water chemistry monitoring was added in 2013 at the mouths of Gondola Brook and Long Trail Brook.

**Long Trail Brook – LT0.1:** The Long Trail Brook station is located at the mouth of Long Trail Brook, just upstream of the crossing that enters the northernmost parking lot at the resort. The station was added in 2012 to better track sources of turbidity.

**Big Spruce Brook below Ski Trails – BS0.9 (MS-9):** This station is located on Big Spruce Brook above the golf course limits. BS0.9 acts as the background water chemistry station for the golf course, and is located below the ski and lift construction and existing ski trails. Per the Stowe Mountain Resort Settlement Agreement dated June 13, 2000, no sampling is required at this station during the construction phase.

**Big Spruce Brook below Ski Trails – BS0.8:** This station is located on Big Spruce Brook downstream of the culvert on Big Spruce Road where the stream is impacted by heavy iron seeps. This station was sampled in 2015 by VDEC.

**Big Spruce Brook above basin – BS0.7:** Located on Big Spruce above the outlet of the Big Spruce Basin, this station was added voluntarily in 2009 by SMR to provide turbidity data upstream of the basin.

**Big Spruce upstream of Club House – BS0.3 (MS-10A):** This station on Big Spruce Brook is located immediately downstream of the new golf course bridge and upstream of the confluence with Little Spruce Brook. This station was added voluntarily by Stowe Mountain Resort following a site visit with Steve Fiske (DEC) in July 2006.

**Big Spruce at Mouth – BS0.2 (MS-10):** Located on Big Spruce Brook above the confluence of the West Branch, BS0.2 covers the area between the bridge crossing at the ski hostel and the bedrock outcrop, which is below the confluence of Little Spruce Brook. BS0.2 serves as the downstream monitoring station for the golf course. The Stowe Mountain Resort

Settlement Agreement dated June 13, 2000 calls for annual monitoring at this station until the year after completion of build-out.

**Little Spruce Brook – LS0.1 (MS-11):** Located on Little Spruce Brook below the Spruce Hamlet Development, LS0.1 serves as a monitoring station downstream of the Spruce Hamlet Development. Sampling at this station during construction is not required by the Settlement Agreement. Stowe Mountain Resort (SMR) has conducted voluntary monitoring on Little Spruce throughout the construction phase.

**Pinnacle Brook Lower– PB0.1 (MS-13):** PB0.1 serves as the local/reference site. Below the upper monitoring station, a very small portion of the golf course (holes 7 and 8) drains toward Pinnacle Brook. The stump dump and the gravel pit also are located between the two Pinnacle Brook stations. The stump dump was covered and seeded in August 2006 and the gravel pit was closed off and seeded in August 2006 as well. Although no monitoring of Pinnacle Brook is required by the Stowe Mountain Resort Settlement Agreement dated June 13, 2000 during the construction phase, SMR has voluntarily sampled PB0.1 throughout the construction phase.

**Ski Club Drainage – SC0.2:** The upper Ski Club drainage monitoring station is located near the Ski Club, where a couple of small drainages come together. The station was added in 2010 to provide turbidity data above a steep section of the Spruce Peak Access Road, where road runoff has been a concern.

**Ski Club Drainage – SC0.1:** The lower Ski Club drainage monitoring station is located at the mouth of the Ski Club drainage, just upstream of the culvert that passes under the Spruce Peak Access Road to the Big Spruce Basin. The station was added in 2010 to provide turbidity data to better understand the sediment contribution to the basin.

**Mt. Mansfield Basin Outlet (OUTLET 1):** Outlet 1 drains from the Mansfield sedimentation basin into the West Branch between stations WB8.0 and WB7.5. A mountain

tributary that is piped into the West Branch at this station is also voluntarily monitored during selected events.

**Snowmaking Pond Outlet (OUTLET 2):** Stormwater is collected from the golf course and other developed areas of the resort and piped to the former snowmaking pond. Outlet 2 drains into the West Branch downstream of the confluence of Big Spruce Brook.

**Big Spruce Basin (OUTLET 3):** Outlet 3 drains into Big Spruce Brook immediately downstream of BS0.7.

**Mount Mansfield Exit Basin (OUTLET 4):** Outlet 4 drains from the Mansfield Exit Basin into the West Branch immediately downstream of the access road bridge. The station was added in spring 2012 to better track sources of turbidity. A tributary that is piped into the West Branch at this station is also voluntarily monitored during select events.

**Upper Barnes Camp Basin Outlet (OUTLET 5):** Outlet 5 drains from the Upper Barnes Camp Basin and is only sampled when there is a discharge to the West Branch. Generally, outflow from the basin dissipates in a drainage swale prior to discharge to the West Branch.

**Lower Barnes Camp Basin Outlet (OUTLET 6):** Outlet 6 drains from the Lower Barnes Camp Basin and is only sampled when there is a discharge to the West Branch. Generally, outflow from the basin dissipates in the forest duff and only reaches the West Branch during significant precipitation events or under wet conditions.

Table 2 provides a list of monitoring parameters evaluated at the 2015-2016 monitoring stations. Table 3 shows the drainage and approximate elevation of the seven biomonitoring stations.

<b>Table 2. 2015-2016 Water Quality Monitoring Stations at Stowe Mountain Resort</b>					
<b>Station</b>	<b>Location</b>	<b>Monitoring Parameter</b>			
		<b>Baseflow</b>	<b>Turbidity</b>	<b>Sediment</b>	<b>Biomonitoring</b>
WB8.8	West Branch at picnic area above SMR	+		+	+
WB8.2	West Branch above Barnes Camp		+		
WB8.0 (MS-16B)	West Branch below Barnes Camp	+	+	+	+
WB7.5 (MS-8)	West Branch above Big Spruce	✓	✓	✓	✓
WB6.9	West Branch below snowmaking pond		✓		
WB6.5 (MS-14)	West Branch above Pinnacle Brook confluence	✓		✓	✓
LT0.1	Long Trail Tributary at Mansfield Entrance	X	+		
GB0.1	Gondola Brook at Mansfield Entrance	X	+		
BS0.9 (MS-9)	Big Spruce Brook below ski trails		+		Sampled in 2015 by SMR
BS0.8	Big Spruce Brook below Spruce Peak Road Culvert				Sampled in 2015 by VDEC
BS0.7	Big Spruce above Big Spruce Basin		+		
BS0.3 (MS-10A)	Big Spruce upstream of Club House	+	+	+	+
BS0.2 (MS-10)	Big Spruce Brook at mouth	✓	✓	✓	✓
LS0.1 (MS-11)	Little Spruce Brook	X	+		
PB0.1 (MS-13)	Lower Pinnacle Brook	+		+	+
SC0.2	Upper Ski Club Drainage		+		
SC0.1	Lower Ski Club Drainage		+		
Outlet 1	Mansfield Basin		+		
Outlet 2	Snowmaking Pond		+		
Outlet 3	Big Spruce Basin		+		
Outlet 4	Mansfield Exit Basin		+		
Outlet 5 <sup>1</sup>	Upper Barnes Camp Basin		+		
Outlet 6 <sup>1</sup>	Lower Barnes Camp Basin		+		
+ - additional voluntary monitoring by Stowe Mountain Resort not required in Settlement Agreement X - Station added per request of Steve Fiske (email of October 1, 2012) <sup>1</sup> Basin outlet sampled only if there is a discharge to waters of the state.					

<b>Table 3. Drainage and Elevation of Biomonitoring Stations</b>			
<b>Station</b>	<b>Location</b>	<b>Drainage Area (sq. mi.)</b>	<b>Elevation (feet)</b>
<b>BS0.3</b>	Big Spruce Brook near Golf Cottage, above Little Spruce Brook	0.73	1470
<b>BS0.2</b>	Big Spruce Brook near Hostel, below Little Spruce Brook	0.76	1420
<b>WB8.8</b>	West Branch at picnic area upstream of resort	1.18	1605
<b>WB8.0</b>	West Branch upstream of Mansfield Basin	2.92	1480
<b>WB7.5</b>	West Branch downstream of Mansfield Basin	3.56	1410
<b>WB 6.5</b>	West Branch above confluence with Pinnacle Brook	4.81	1250
<b>PB0.1</b>	Pinnacle Brook at mouth	2.31	1255

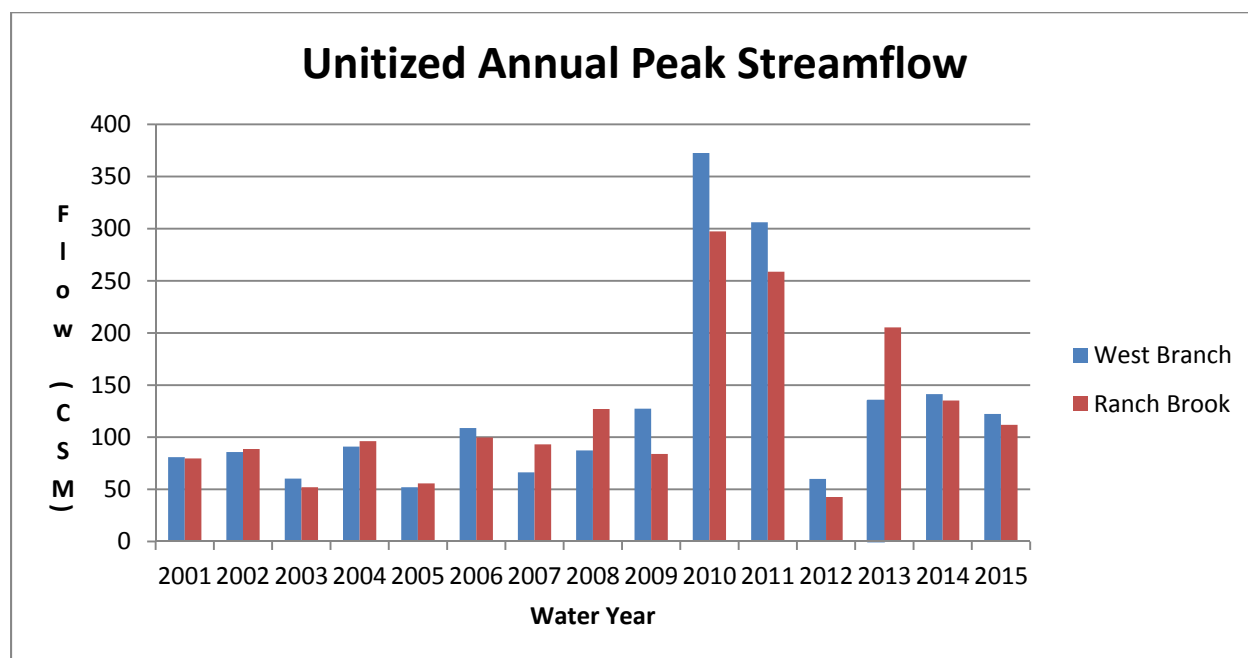
### 3.0 MOUNT MANSFIELD CLIMATE

The West Branch watershed lies exclusively within the Northern Green Mountains biophysical region. This region is characterized by Thompson and Sorenson (2005) as having high elevations and cool summers. The Green Mountains have a strong influence on the weather, resulting in an abundance of precipitation in the form of both rain and snow. Precipitation within the West Branch watershed averages 53 inches annually (USGS, Scott Olson, pers. comm., 2004). On the top of Mount Mansfield annual precipitation averages over 78 inches. For the 2015 calendar year, 67.4 inches of precipitation was reported at the Mount Mansfield weather station operated by WCAX. Precipitation increases with elevation, at about an inch per 1000 feet of elevation (Wemple, 2002). Mount Mansfield receives more precipitation than most areas of the State. An orographic effect often occurs on Mount Mansfield.

### 4.0 WEATHER AND FLOW DURING THE 2015-2016 MONITORING PERIOD

Unitized annual peak stream flow values for the period of record from the West Branch and Ranch Brook are presented below in Table 4 and graphed in Figure 1. The unitized peak flows for the West Branch and Ranch Brook in 2015 were slightly lower than the peak flows in 2014.

<b>Table 4. Annual Peak Flows West Branch and Ranch Brook USGS Gaging Stations</b>				
Water Year	West Branch		Ranch Brook	
	Date	Unitized Peak Flow (cfs/sq. mi.)	Date	Unitized Peak Flow (cfs/sq. mi.)
2001	Aug. 31, 2001	81.0	Apr. 24, 2001	79.7
2002	May 17, 2002	85.8	Apr. 14, 2002	88.7
2003	Jun. 14, 2003	60.4	Mar. 29, 2003	52.1
2004	Nov. 20, 2003	91.0	Nov. 19, 2003	96.3
2005	Aug. 31, 2005	52.0	Aug. 31, 2005	55.8
2006	May 19, 2006	108.8	May 19, 2006	99.7
2007	Oct. 28, 2006	66.4	Oct. 28, 2006	93.2
2008	Jul. 24, 2008	87.4	Jul. 20, 2008	127.1
2009	May 10, 2009	127.4	May 10, 2009	83.9
<b>2010</b>	<b>Aug. 04, 2010</b>	<b>372.6</b>	Aug. 04, 2010	95.0
2010	Sep. 30, 2010	233.4	<b>Sep. 30, 2010</b>	<b>297.4</b>
<b>2011</b>	<b>Apr. 27, 2011</b>	<b>306.2</b>	<b>Apr. 27, 2011</b>	<b>258.7</b>
2011	Aug. 28, 2011	204.9	Aug. 28, 2011	121.3
2012	June 27, 2012	60.0	March 08, 2012	42.6
2013	May 23, 2013	135.1	July 4, 2013	205.3
2014	April 15, 2014	141.3*	April 15, 2014	135.3*
2015	June 9, 2015	122.3	June 9, 2015	111.8
Median		91.0		96.3
Mean		126.5		121.8
Maximum	Aug. 04, 2010	372.6	Sep. 30, 2010	297.4
<b>Extreme Peak flow events (&gt;250 cfs/square mi.) in bold font</b> * Discharge is an estimate				



**Figure 1. Annual unitized peak stream flow values for the West Branch and Ranch Brook**

Based on data from U.S.G.S., the rain event that began on June 8, 2015 resulted in the peak stream flow values for the year on June 9<sup>th</sup> for both the West Branch and Ranch Brook. The total precipitation for the event was 5.07 inches on top of Mt. Mansfield and 3.21 inches in the vicinity of the resort. The peak flow in the West Branch watershed was 571 cfs (122.3 cfs/sq. mile) compared with 425 cfs (111.8 cfs/sq. mile) in the Ranch Brook watershed based on data from the USGS. The peak flows for the West Branch and Ranch Brook for the 2015 water year were close to the mean peak flows for the period of record (2001 through 2015).

## 5.0 WATER QUALITY STANDARDS

The Vermont Water Quality Standards (VWQS) (State of Vermont Water Resources Board, effective October 30, 2014) were used to evaluate water quality parameters. Table 5 shows the water quality standards used for comparison in this study. There are no established standards for conductivity or total suspended solids in surface water. Therefore, there are no comparisons against standards for these analytes in the tables and text. According to the VWQS, in general total phosphorus loads should be limited so as not to “contribute to the

acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.”

<b>Table 5. Vermont Water Quality Standards for Class B Waters</b>	
<b>Parameter</b>	<b>Standard</b>
pH	6.5 to 8.5 s.u.
Chloride	230 mg/L
Iron	1.0 mg/L
Nitrate-nitrogen	5.0 mg/L
Total Phosphorus	0.012 mg/L <sup>1</sup>
Turbidity	10 NTU <sup>2</sup>
Notes: 1. Standard for small, high gradient stream 2. Standard for cold water fish habitat	

### 5.1 Baseflow Sampling Results

Baseflow chemistry monitoring occurred at each macroinvertebrate assessment site during fall 2015. Monitoring parameters included: Alkalinity, pH, chloride, conductivity, nitrate, total Kjeldahl nitrogen (TKN), total phosphorus, conductivity, and water temperature. The results of baseflow water chemistry from 2000 through 2015 are found on pages 2 through 12 of Appendix I. During 2015, baseflow sampling took place on September 24<sup>th</sup>, the day before the annual biomonitoring.

#### Alkalinity

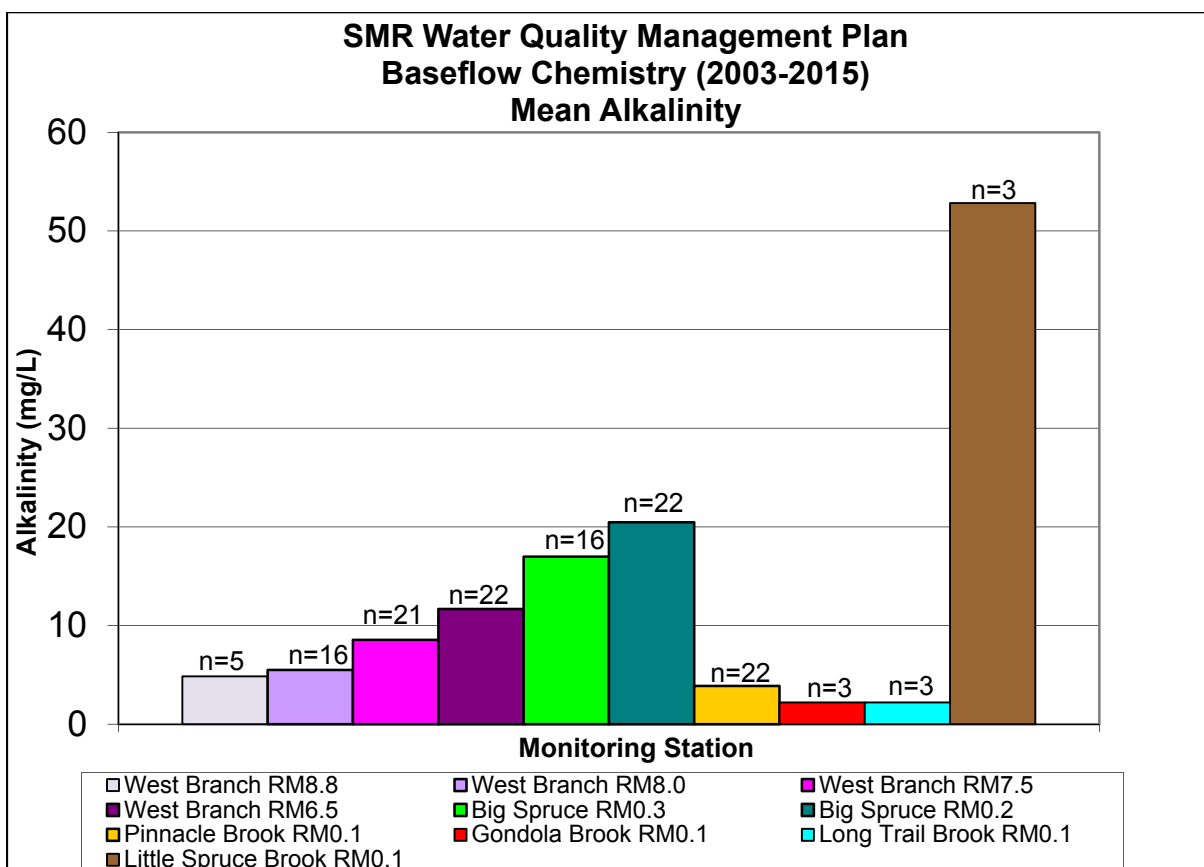
Alkalinity indicates the buffering capacity of water. Aquatic life requires buffering capacity to minimize the impact of acid precipitation. Low alkalinity values, especially those below 4 mg/L as CaCO<sub>3</sub>, suggest that a stream is critically acidified and the macroinvertebrate community would be likely impacted.

Figure 2 shows the mean alkalinity values for the biomonitoring stations for fall 2003 through fall 2015. Three new stations were added for the 2013 baseflow monitoring year, Gondola Brook, Long Trail Brook, and Little Spruce Brook. All stations had mean alkalinity values of less than 25 mg/L as CaCO<sub>3</sub>, with the exception Little Spruce RM 0.1, as shown in



Figure 3. Alkalinity was high at station LS 0.1 in 2015, measuring a reported 145 mg/L as CaCO<sub>3</sub>. This is the highest alkalinity value recorded for any station throughout the history of the project. Alkalinity was much lower at LS 0.1 for the two other samples collected in 2013 and 2014 (6.8 mg/L and 6.7 mg/L, respectively). The high value in 2015 skews the average over the three years to above 50 mg/L CaCO<sub>3</sub>. It is possible that limestone added to prevent iron seeps as part of the construction of the Adventure Center, contributed to increased alkalinity levels in 2015.

The Big Spruce stations have had the highest alkalinity historically; while Pinnacle Brook, Long Trail Brook, Gondola Brook, and the upper West Branch stations have the lowest. For past years, alkalinity has shown an increasing trend from upstream to downstream on the West Branch. For the September 2015 sampling round, Little Spruce Brook at RM 0.1 had the highest alkalinity by far, as mentioned above. Big Spruce Brook was next highest at RM 0.2 (54 mg/L CaCO<sub>3</sub>), followed by Big Spruce at RM 0.3 (35 mg/L). The lowest alkalinity values were observed for the stations on Gondola Brook and Pinnacle Brook, both at 2.2 mg/L CaCO<sub>3</sub>. The alkalinity values at the upper West Branch stations, RM 8.8 and 8.0, were also very low at 2.5 mg/L as CaCO<sub>3</sub>, as were the alkalinities on Long Trail Brook and Big Spruce RM 0.9 (2.6 and 2.9 mg/L CaCO<sub>3</sub>, respectively). These low alkalinity values suggest that some of the streams at and surrounding Stowe Mountain Resort have a very low buffering capacity and are susceptible to the impacts from acid precipitation.



**Figure 2. Mean alkalinity for biomonitoring stations**

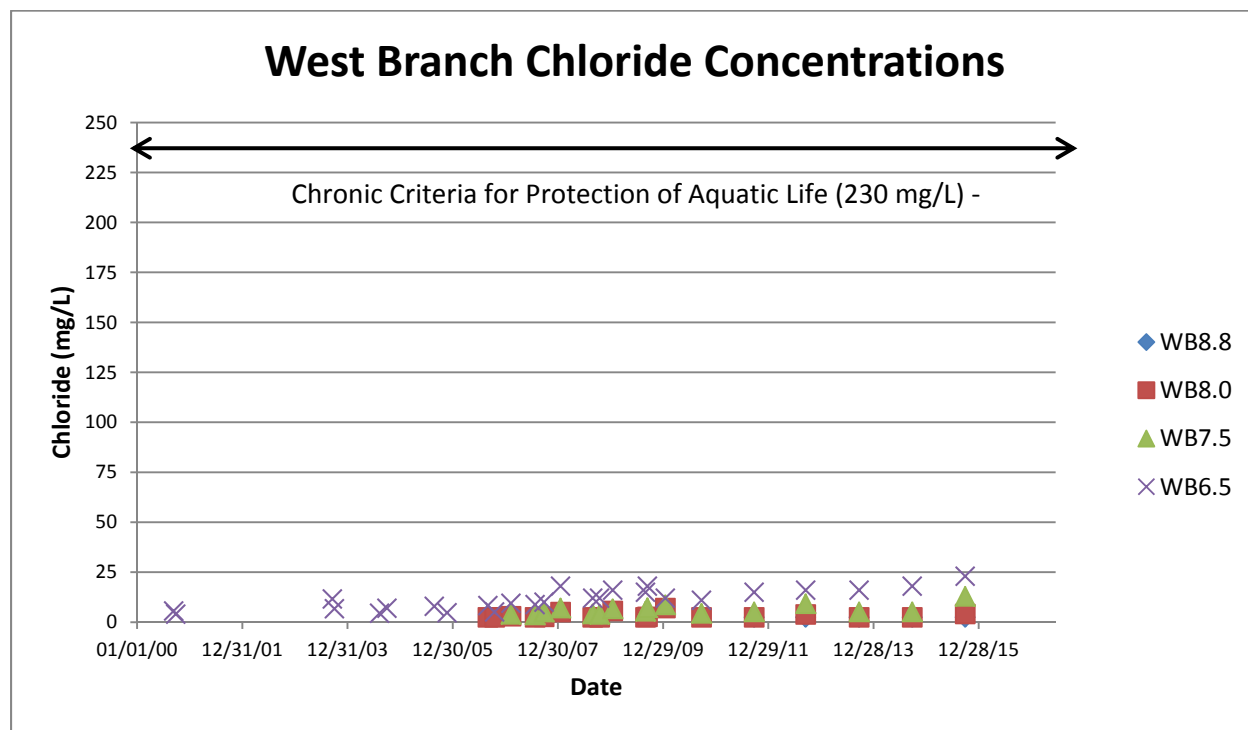
### pH

The pH values for all baseflow samples collected on September 24, 2015 were within the water quality standard limits of 6.5 to 8.5 s.u.

### Chloride

Chloride concentrations for the West Branch watershed and the Spruce Peak watershed over time are plotted below in Figures 3 and 4. As shown in Figure 3, the chloride concentrations at all the stations West Branch stations under baseflow conditions have been less than 25 mg/L. These concentrations are well below the chronic criteria for protection of aquatic life, which is listed as 230,000 µg/L (230 mg/L) in the Vermont Water Quality Standards (State of Vermont, 2014). As expected, the most downstream West Branch station sampled (WB6.5) had slightly higher chloride concentrations than the upstream stations. The average concentration for the 24 samples at WB6.5 is 11.4 mg/L.

Chloride concentrations were lowest at the most upstream station, WB 8.8 and were less than the detection limit of 2.5 mg/L for the annual sampling that was conducted in September 2011 through 2015. Water quality samples collected at Gondola Brook and Long Trail Brook, which enter upstream of WB8.0, were also less than the detection limit in 2013-2015.



**Figure 3. Chloride concentrations from 2000 through 2015 for West Branch of Little River**

Baseflow sampling in the Spruce Peak watershed has been conducted for different lengths of time at the monitoring stations. BS0.2, the most downstream station at Big Spruce Brook has the longest period of record (2000, 2003-2015). Chloride concentrations at this most downstream station suggest an upward trend over time. Baseflow sampling has been conducted at BS0.3 since 2006. In general, chloride concentrations at BS0.3 have been slightly lower than BS0.2. The most upstream Big Spruce station (BS0.9) has been sampled 16 times over the years with chloride concentrations being recorded less than the detection limit of 2.5 mg/L each time. The highest chloride concentrations recorded have been at the Little Spruce station, near the mouth of the brook. Baseflow sampling has been conducted at LS0.1 annually during the past

three years. Chloride concentrations at LS0.1 have ranged between 5.2 mg/L in 2014 to 170 mg/L in 2015. The most recent chloride value is elevated, but still below the chronic criteria for chloride listed in the VWQS.

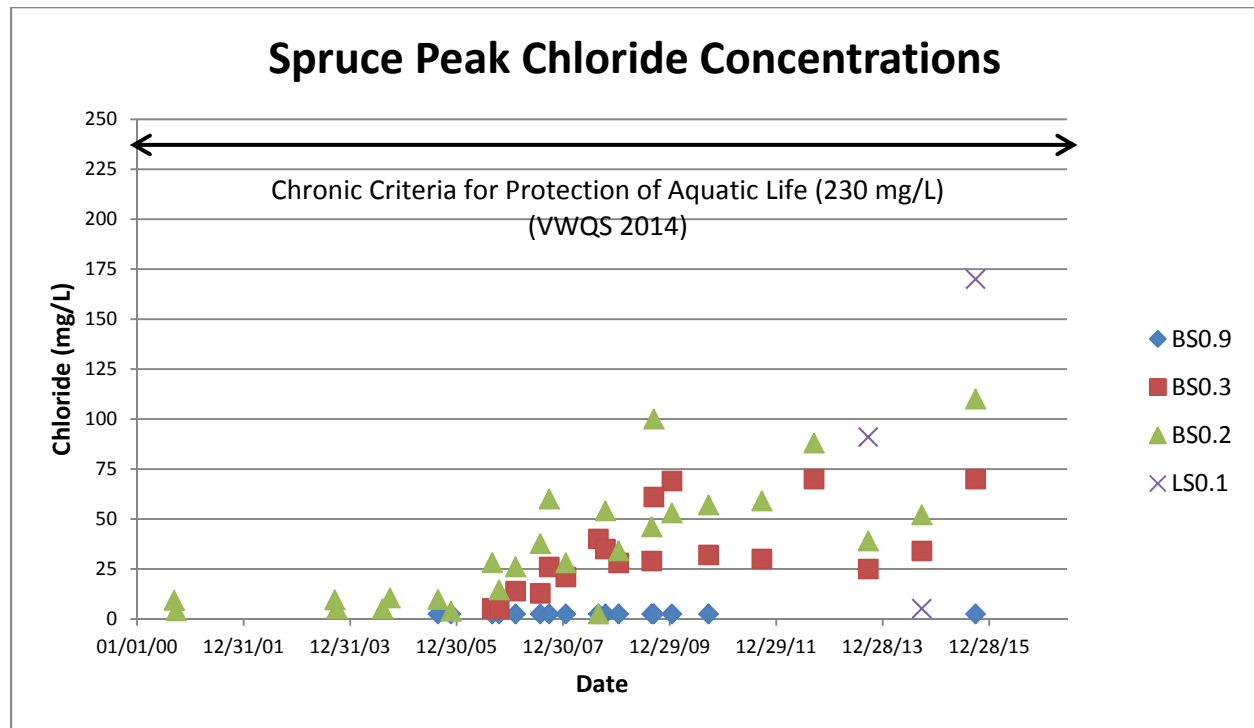
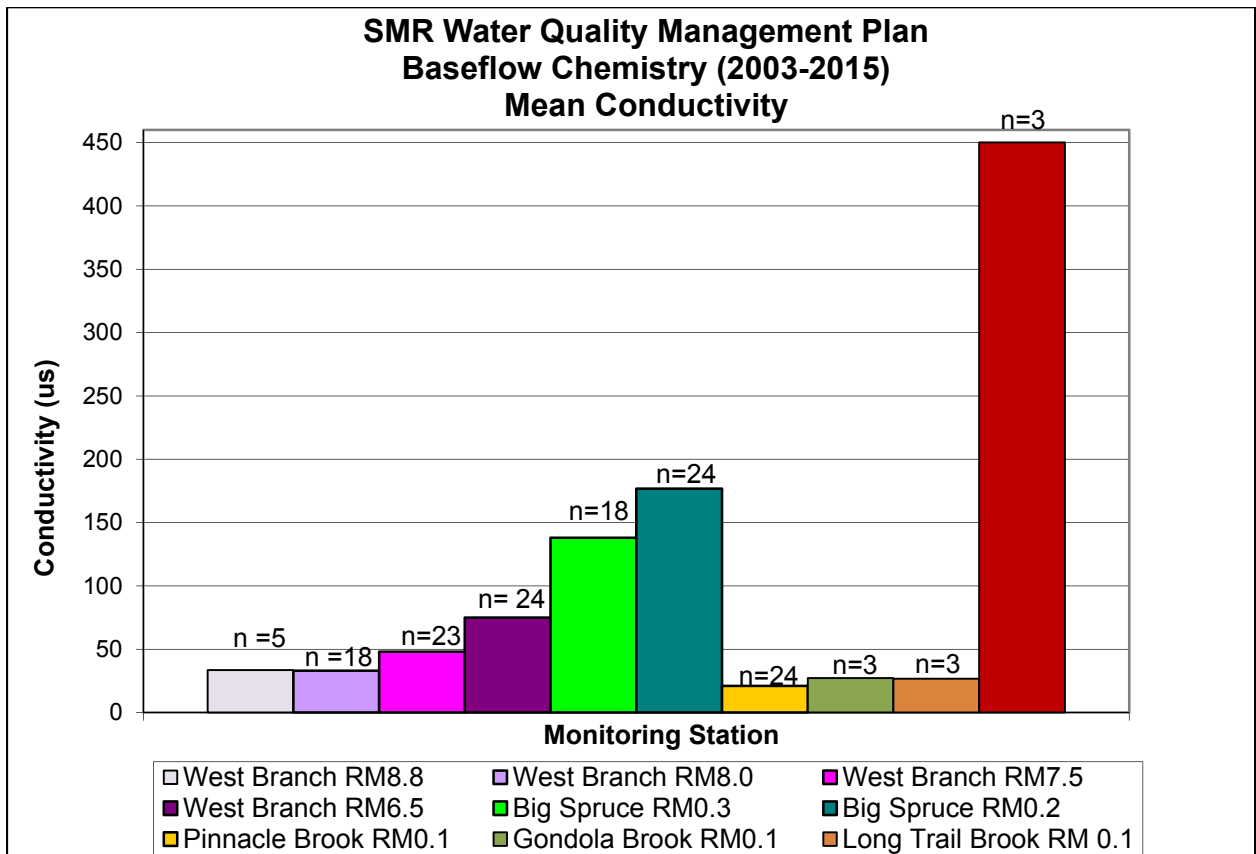


Figure 4. Chloride concentrations from 2000 through 2015 for Spruce Peak

### Conductivity

Mean conductivity levels were highest on Little Spruce (only three monitoring years) and at the lower Big Spruce stations. The lowest mean conductivity has been measured on Pinnacle Brook, which is a reflection of its undeveloped watershed. Road salt, dissolved solids, and elevated metals are likely reasons for the higher conductivity values reported for Little Spruce and Big Spruce Brooks. There is a trend of increasing conductivity on the West Branch and Big Spruce Brook from upstream to downstream. In 2015, a historic high conductivity for the project was recorded at Little Spruce RM 0.1 (951  $\mu$ S). Additional water quality sampling is recommended during summer 2016 to investigate the sources of elevated chloride, conductivity and alkalinity on Little Spruce and Big Spruce Brooks.



**Figure 5. Mean conductivity for biomonitoring stations**

### Total Phosphorus

The nine biomonitoring stations, along with the three separate baseflow stations, were monitored for total phosphorus in 2015. Total phosphorus concentrations in samples taken in September 24, 2015 were very low overall.

### Nitrate-Nitrogen

The results of the monitoring indicate that nitrate-nitrogen concentrations were well below the water quality standard of 5 mg/L at all stations. The highest nitrate concentration reported on September 24, 2015 was 0.52 mg/L at the picnic area in the notch on the upper West Branch (RM8.8), above the Resort.

### Iron

Iron seeps in the vicinity of station Big Spruce RM 0.3 have been observed for several years. A remediation of one seep near the station occurred in 2010. This iron seep was located in the vicinity of the resort golf club house, just south of the bridge connecting to the golf course on the east side of the brook. Baseflow monitoring of total iron at the station has occurred each year since the remediation in 2010. The total iron concentration in the baseflow sample at BS 0.3 was highest for 2014 and 2015 sampling at 0.21 mg/L, followed by 2013 at 0.17 mg/L, 0.071 mg/L in 2010, and 0.054 mg/L in 2011 and 2012. A field reconnaissance of Big Spruce Brook occurred in May 2015, during which nineteen separate iron seeps were identified along the brook between the Spruce Peak Road crossing above the golf course and the confluence of Big Spruce Brook with the West Branch of the Little River. Five of these nineteen iron seeps were identified to be major sources of iron to the brook. Remediation of iron seeps may not be feasible due to their extent and inaccessible locations.

## **5.2 Event-based Sampling Results**

For the 2015-2016 monitoring season, Bear Creek Environmental, LLC conducted five event-based monitoring rounds. Two of these sampling rounds involved sampling at a subset of stations rather than all of the monitoring stations (June 23, 2015 and March 10, 2016).

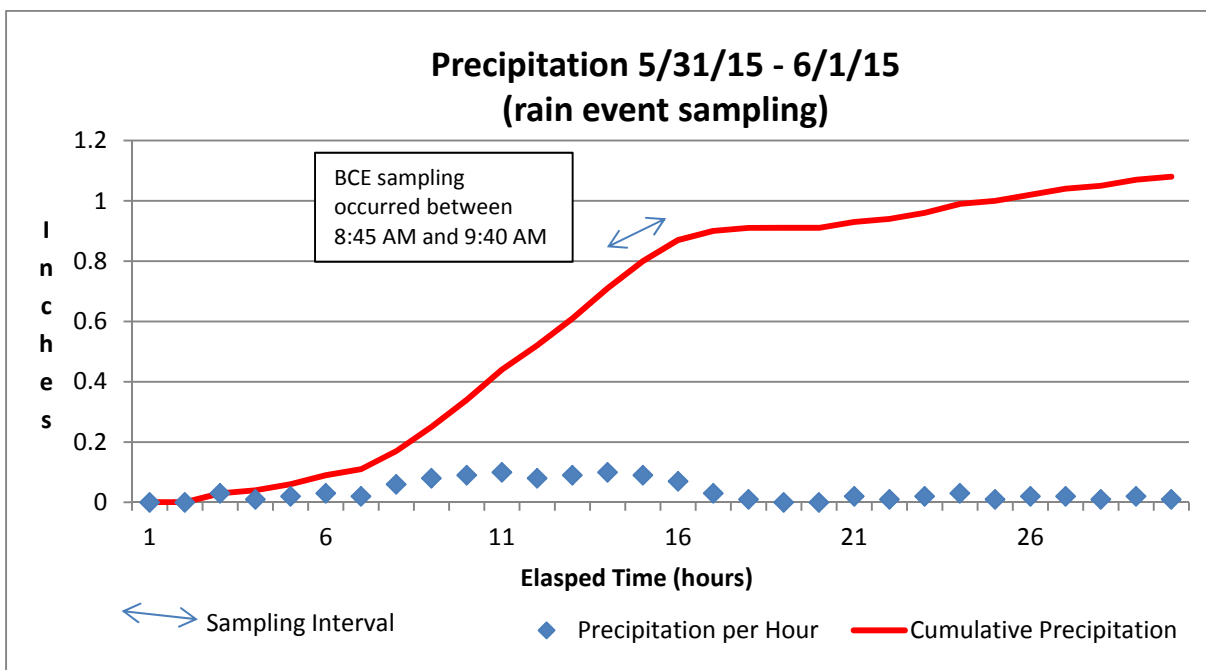
Event-based samples were collected during storm events that resulted in significant runoff (approximately greater than 0.5 inches of rain in 24 hours). In the case of the winter/spring events, sampling coincided with warm temperatures and/or rain that caused a significant snowmelt. Each event-based sample was analyzed for pH, turbidity, conductivity, and temperature. In addition, chloride was analyzed for one of the spring thaw events.

The first two of the five BCE event-based sampling rounds for the 2015-2016 monitoring period were completed in early summer of 2015. BCE also sampled during early and late fall 2015, as well as late winter 2016. The results of event-based water chemistry sampling from

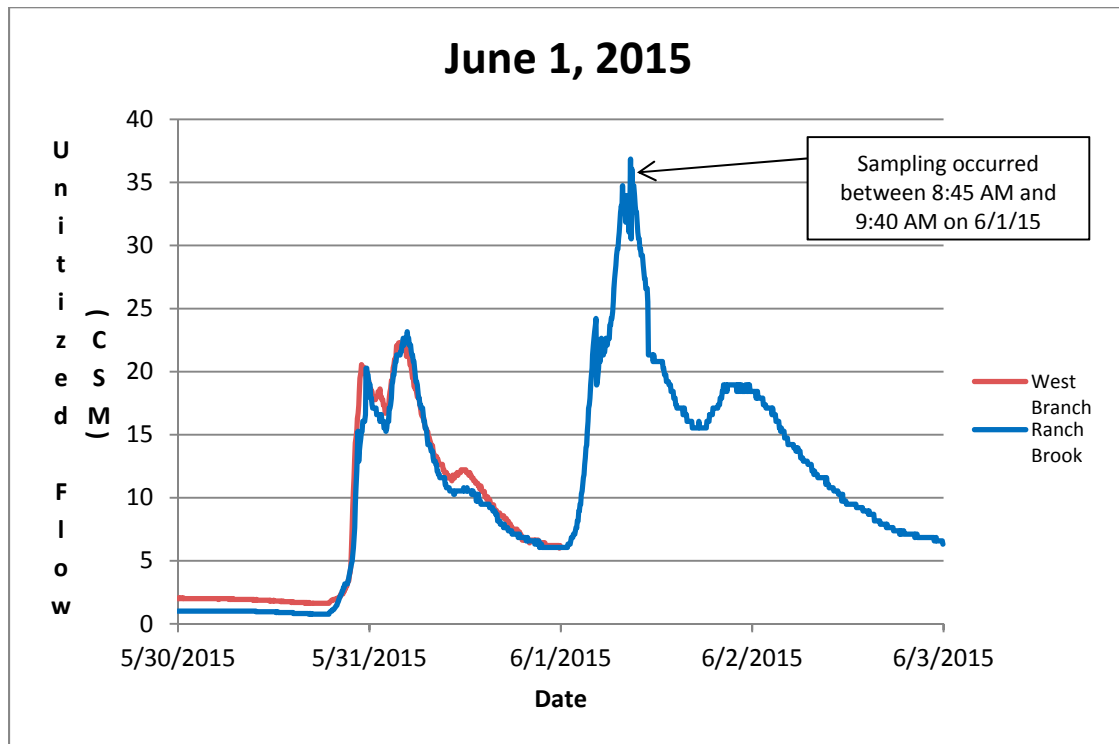
2000 through 2016 are found on pages 13 through 42 of Appendix I. Hourly precipitation data are available from the weather station at the turf care center for all of the events during the 2015-2016 monitoring period.

#### June 1, 2015

Bear Creek Environmental, LLC conducted the first round of event-based monitoring on June 1, 2015. The rain started around 8:00 PM in Stowe on May 31<sup>st</sup> and was heaviest around 7:00 AM on June 1<sup>st</sup>. Sampling occurred between 8:45 AM and 9:40 AM on June 1<sup>st</sup>, during which time the rain was light. As shown in Figure 6, the total rainfall at the time of sampling was 0.87 inches. The peak flow recorded in the Ranch Brook watershed was 140 cfs (36.8 cfs/sq. mile). There is a gap in flow data for the West Branch gauge on June 1, 2015, which Rick Kiah of the USGS attributed to likely being caused by equipment malfunction (personal communication). Figure 7 shows the hydrographs for the West Branch from May 30, 2015 to June 1, 2015 and Ranch Brook from May 30, 2015 to June 3, 2015.



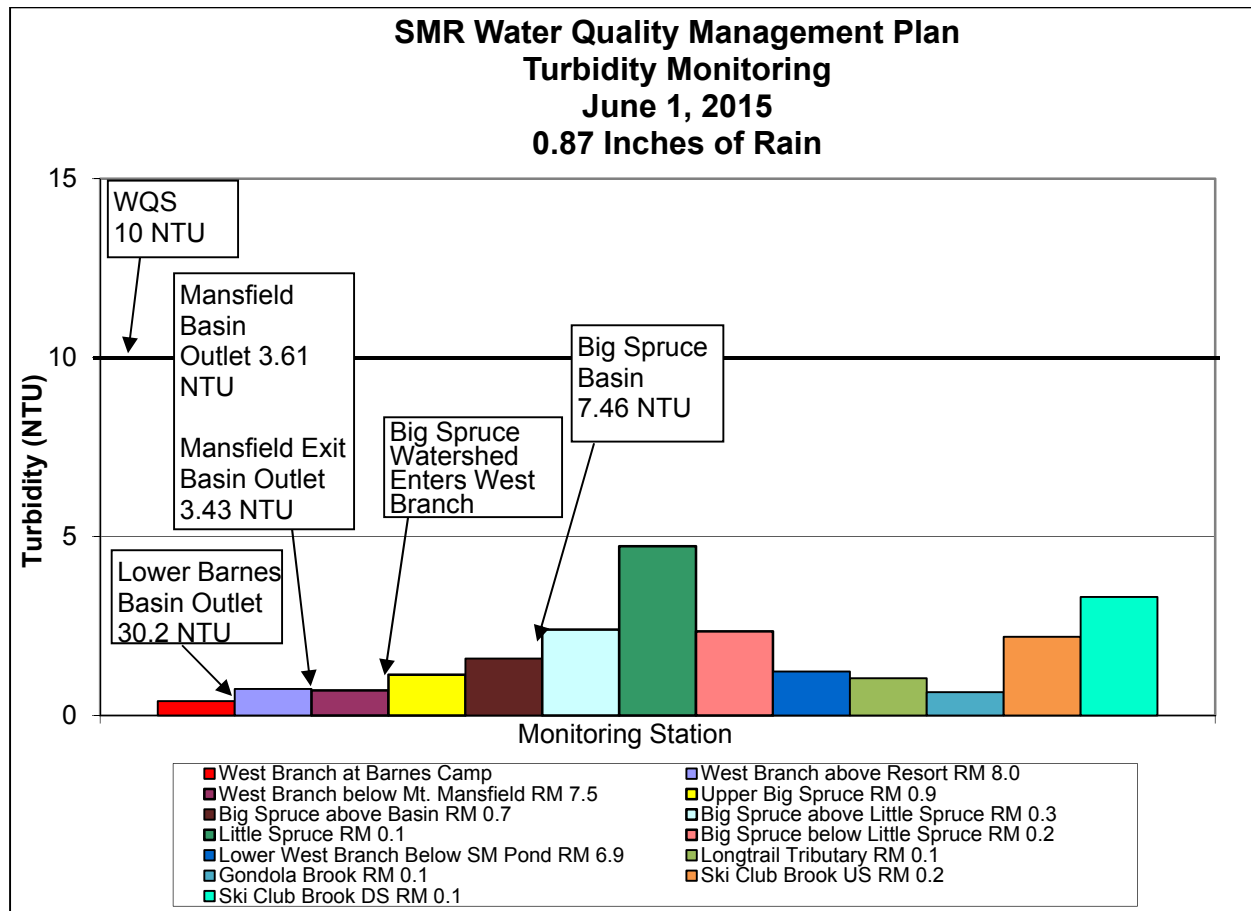
**Figure 6. Precipitation for June 1, 2015 event**



**Figure 7. West Branch and Ranch Brook hydrographs for June 1, 2015 sampling event**

As shown in Figure 8, turbidity values were below the water quality standard of 10 NTU at all surface water stations on June 1, 2015. The highest turbidity result was on Little Spruce Brook at RM 0.1 (4.73 NTU), which was well below the VWQS. The stream station with the lowest turbidity value was the West Branch at Barnes Camp (RM 8.2). All sediment basin outlets were below 50 NTU as presented in Figure 7. Overall, instream turbidity values were quite low, indicating that erosion and sediment control measures implemented and maintained by the Resort are working effectively.





**Figure 8. Turbidity results from June 1, 2015**

The highest turbidity value observed at a sediment basin was 30.2 NTU at the Lower Barnes Basin outlet, followed by the Big Spruce Basin outlet at 7.46 NTU. The range of turbidity values by station for this event is shown on the map (Figure 9).

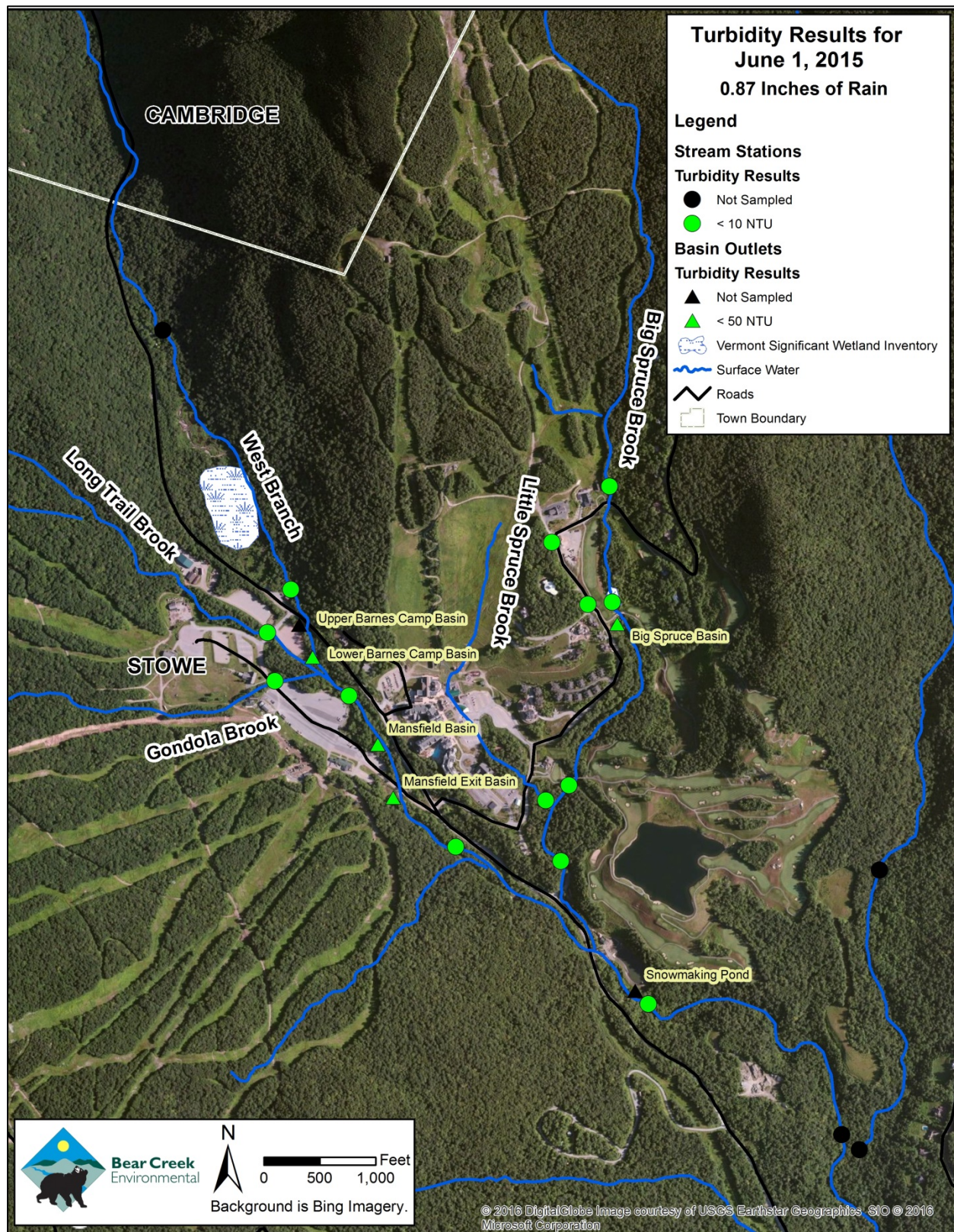
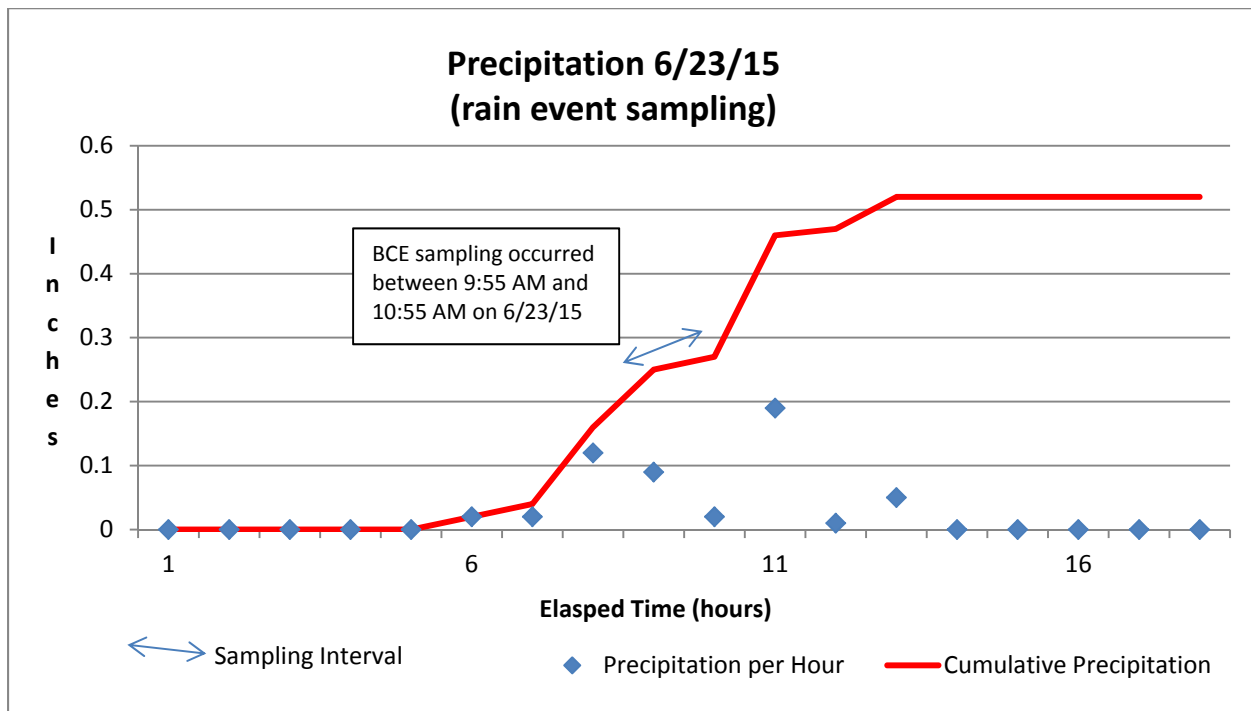


Figure 9. Turbidity Results for June 1, 2015

June 23, 2015

The second round of event based sampling took place on June 23<sup>rd</sup> between 9:55 AM and 10:55 AM. The resort received 0.46 inches of rain over the course of that morning, as shown in Figure 10. Accepted data from the USGS indicate that the West Branch of the Little River peaked at 91 cfs (19.5 cfs/sq. mile). Sampling occurred at the peak of the hydrograph (Figure 11). This was a partial sampling round, with twelve samples collected and analyzed for turbidity.



**Figure 10. Precipitation at Stowe Mountain Resort on June 23, 2015**



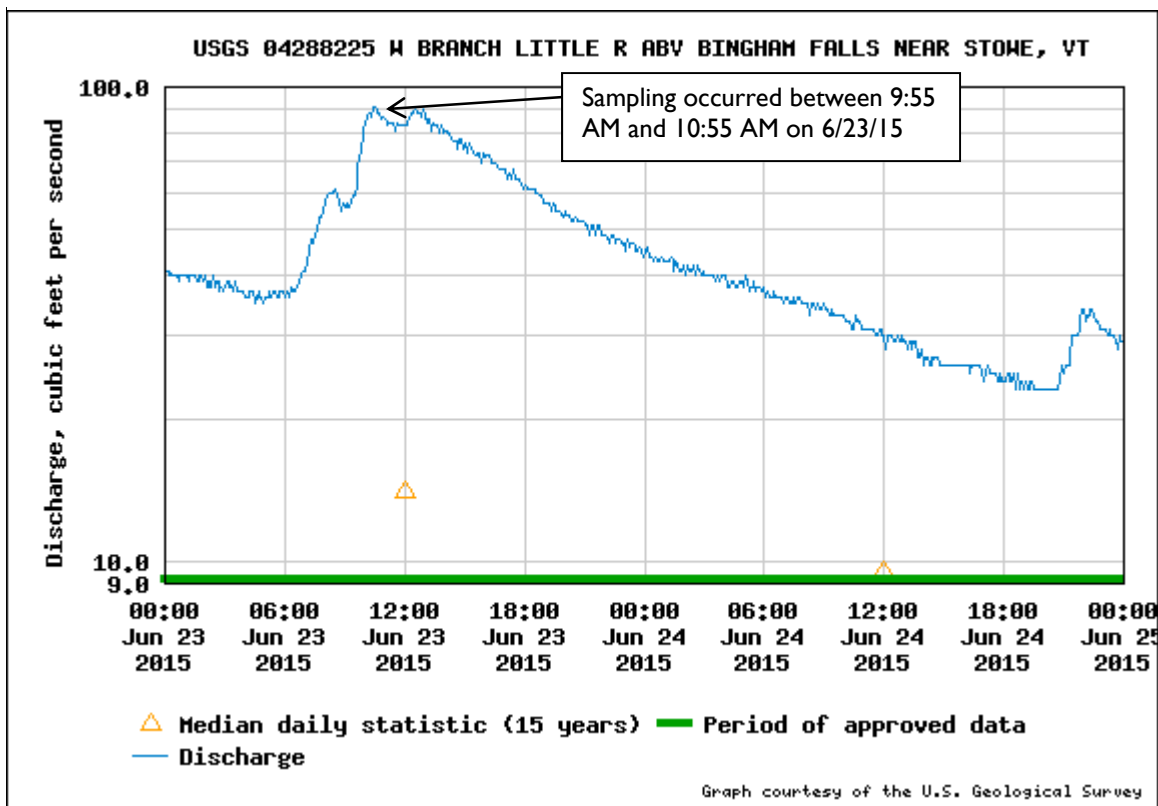
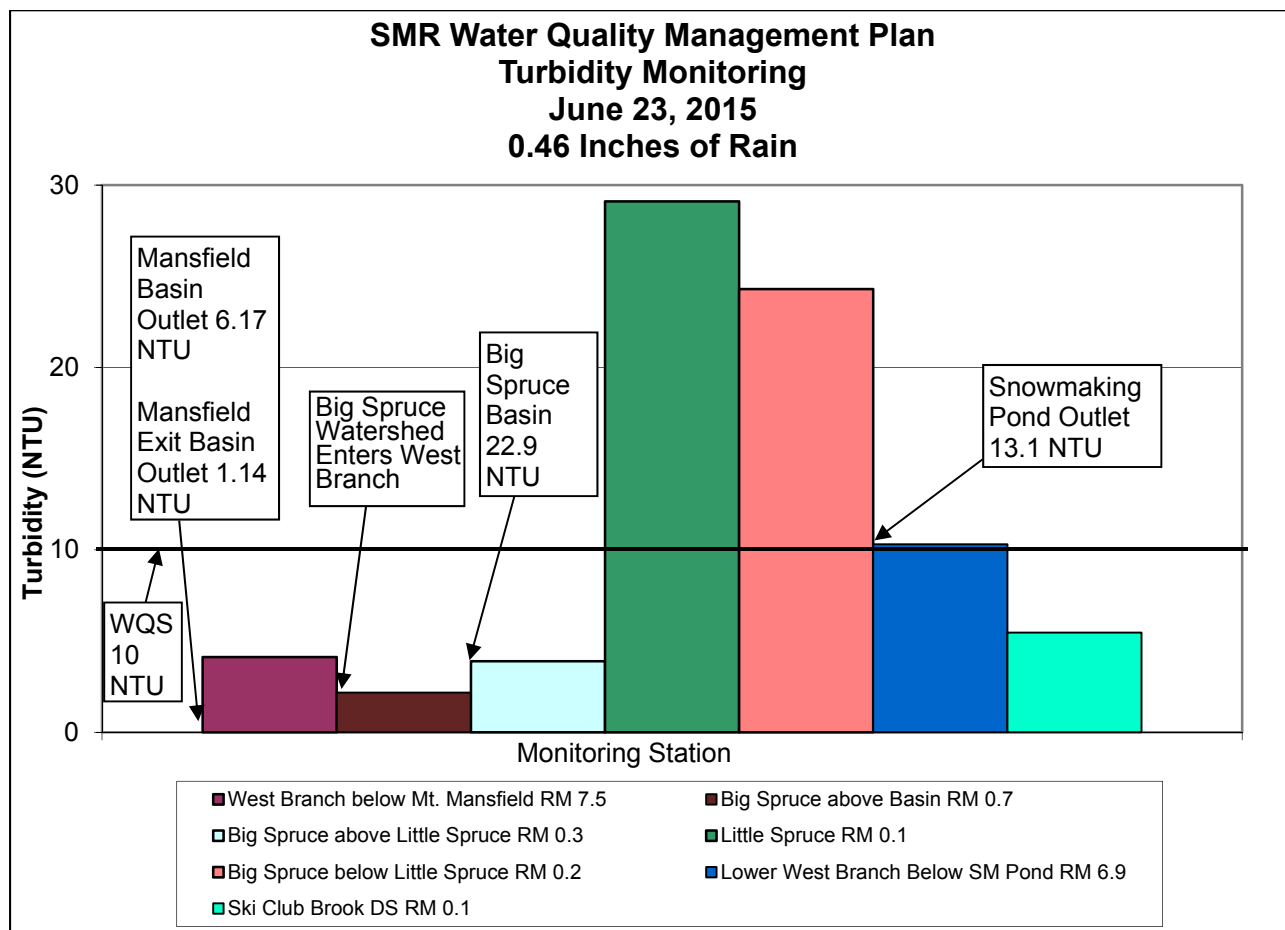


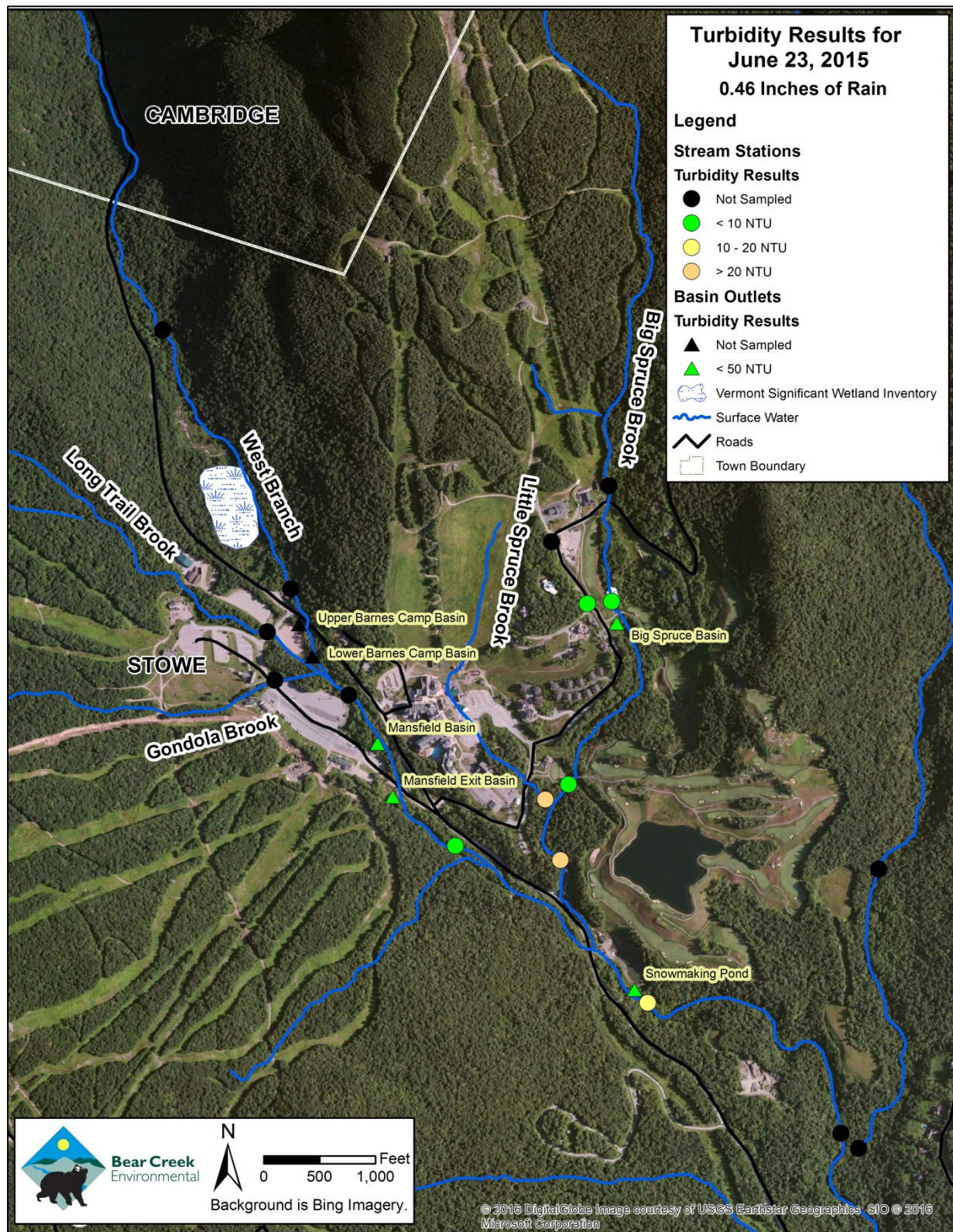
Figure 11. West Branch hydrograph for the June 23, 2015 sampling round

As shown below in Figure 12, turbidity exceeded Vermont Water Quality Standards at three stations on June 23, 2015. The station on Little Spruce Brook (RM 0.1) had the highest turbidity of any surface water station at 29.1 NTU, followed by Big Spruce RM 0.2 (24.3 NTU), and the West Branch RM 6.9 (10.3 NTU). The lowest turbidities of the samples collected were observed at Big Spruce RM 0.7 and West Branch 7.5.



**Figure 12. Turbidity results from June 23, 2015**

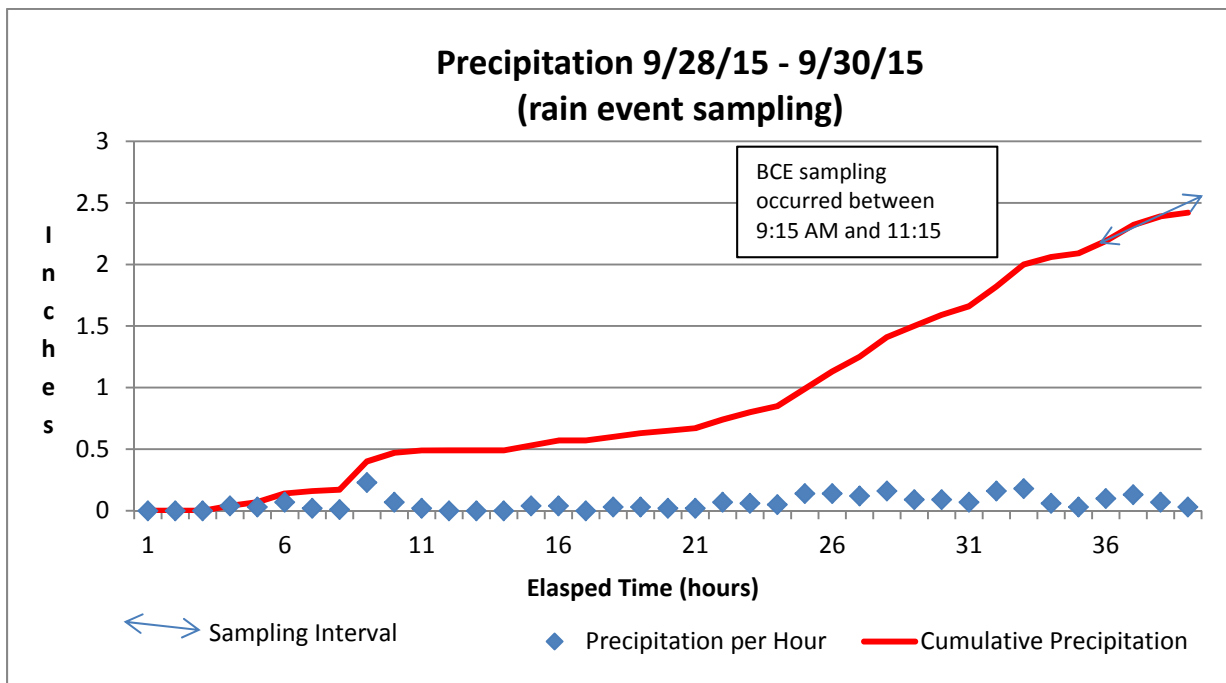
Turbidity values at the resort's sediment basins were low for samples collected on June 23<sup>rd</sup>. The highest turbidity was observed at the Big Spruce Basin outlet, measuring 22.9 NTU, followed by the Snowmaking Pond at 13.1 NTU. Figure 13 displays turbidity values observed at each surface water and basin station on June 23<sup>rd</sup>.



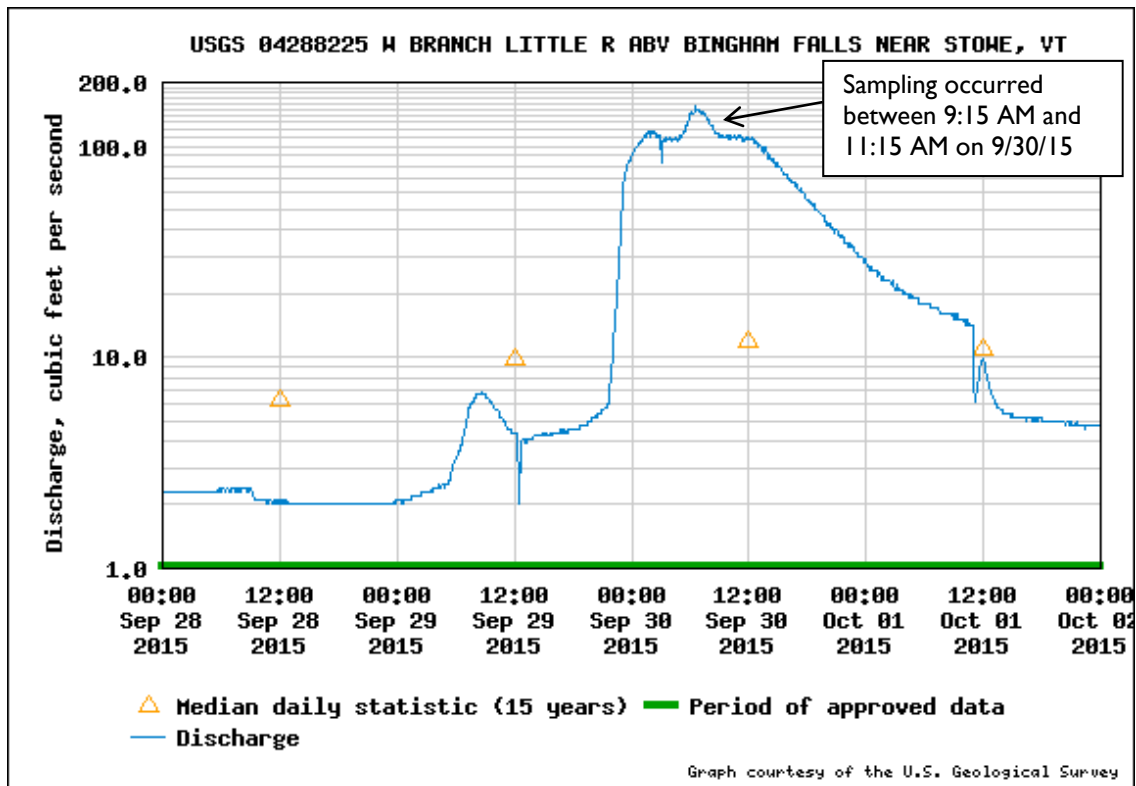


### September 30, 2015

Steady rainfall over the course of the day on September 29, 2015 and overnight into the 30<sup>th</sup> resulted in high flows on the West Branch of the Little River. A total of 2.42 inches of rain fell over 23 hours during this event (Figure 14). According to accepted data from the USGS, the West Branch peaked at 154 cfs (33 cfs/sq. mile) at 6:30 AM on September 30<sup>th</sup>, immediately before sampling began (Figure 15). Bear Creek Environmental collected a full sampling round between 9:15 AM and 11:15 AM on the 30<sup>th</sup>, which were sent to Endyne, Inc. for turbidity analysis. The results from the sampling are reported below.



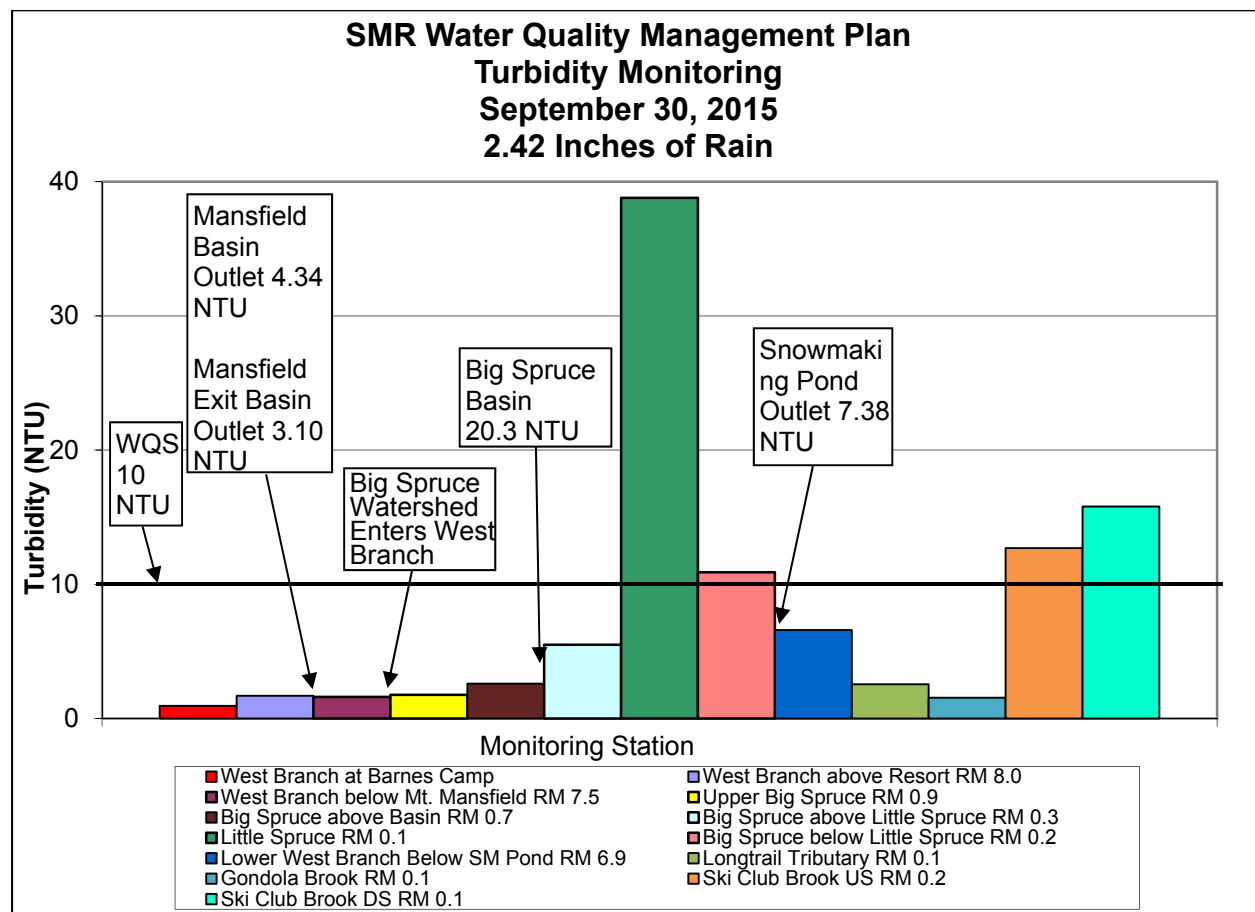
**Figure 14. Precipitation data for September 29<sup>th</sup> and 30<sup>th</sup>**



**Figure 15. Hydrograph of the West Branch for September 30, 2015 event**

BCE turbidity results for September 30, 2015 were good overall. Four stations exceeded the VWQS – Little Spruce Rm 0.1 at 38.8 NTU, Ski Club drainage Downstream at 15.8 NTU, Ski Club drainage Upstream at 12.7 NTU, and Big Spruce RM 0.2 at 10.9 NTU. The remaining stream stations were below 10 NTU. The West Branch at Barnes Camp RM 8.2 and Gondola Brook had the lowest turbidities, 0.94 NTU and 1.54 NTU, respectively. The basin outlet samples had very low turbidities, the highest of which being the Big Spruce Basin outlet, which measured 20.3 NTU. Figures 16 and 17 show the BCE turbidity results for this rain event.





**Figure 16. Turbidity results for sampling conducted on September 30, 2015.**

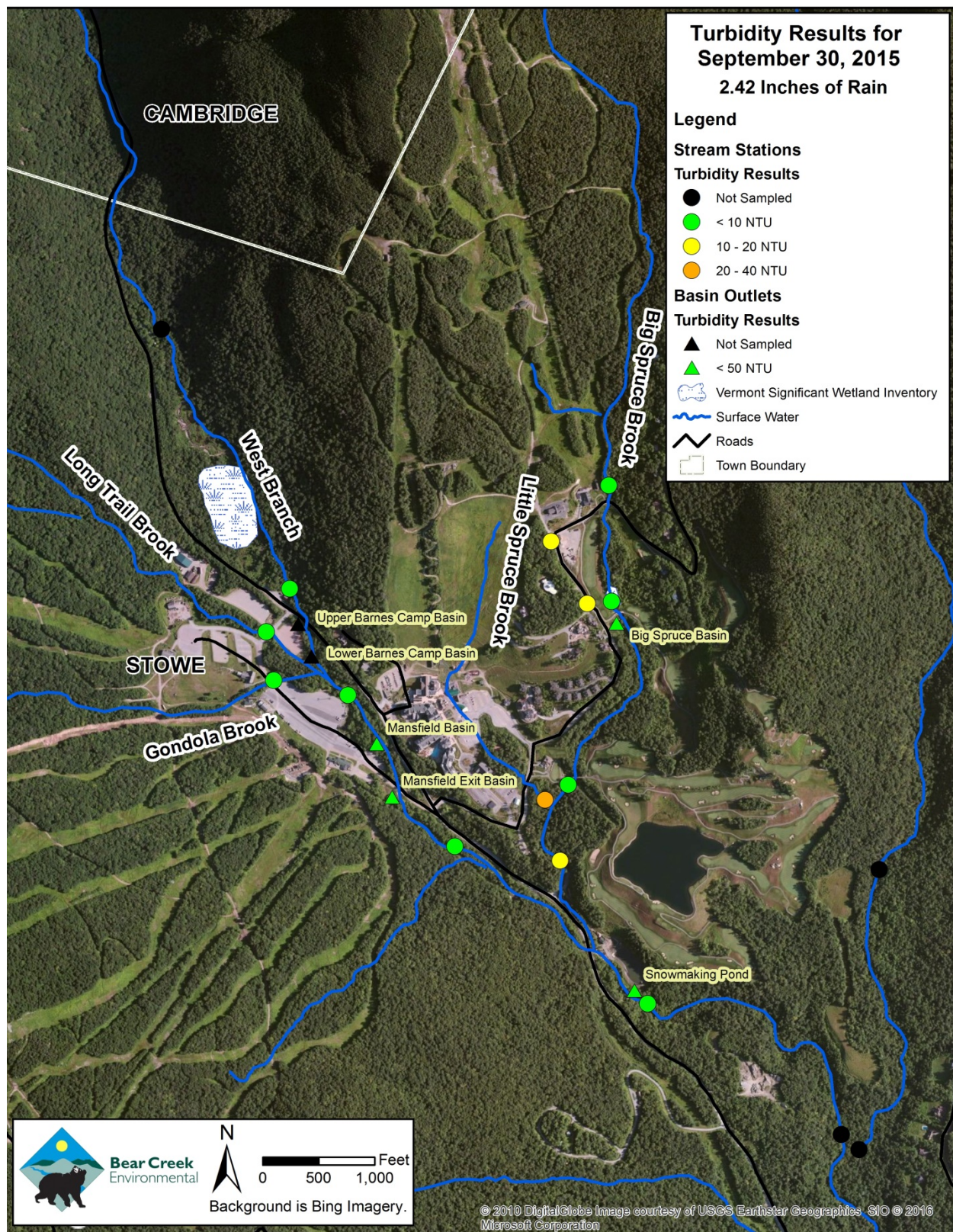
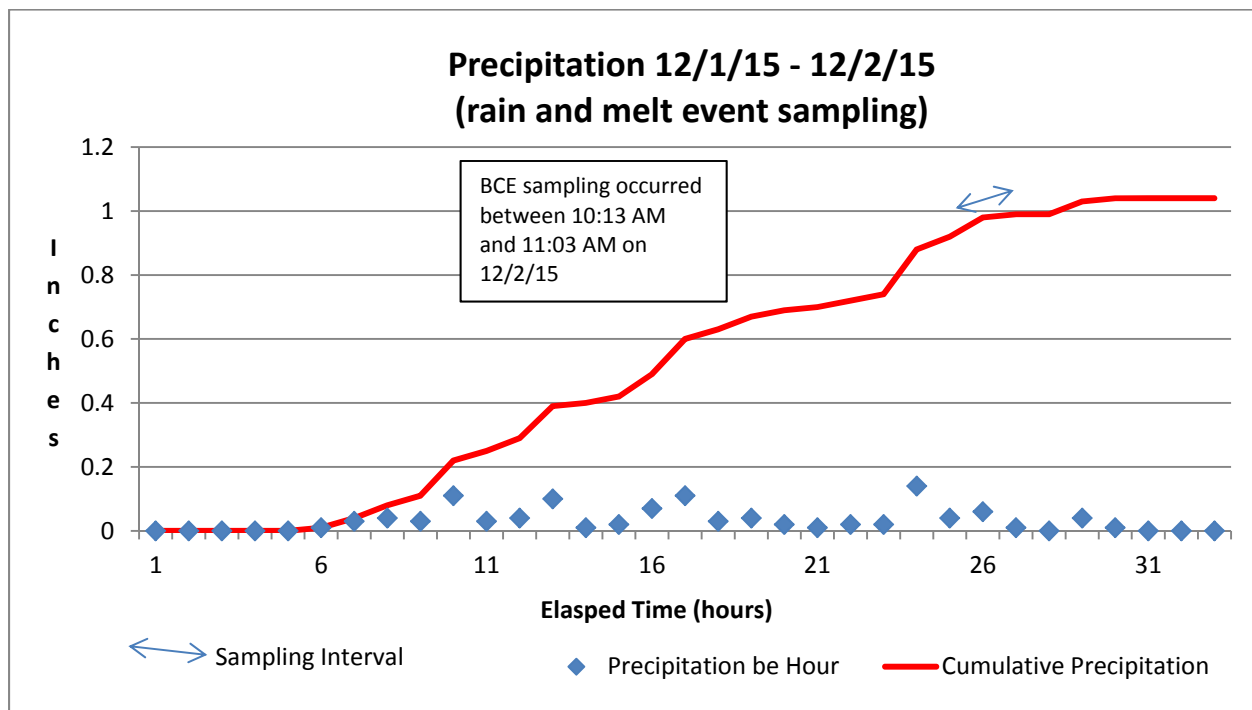


Figure 17. Map of BCE turbidity results for sampling round on September 30, 2015.

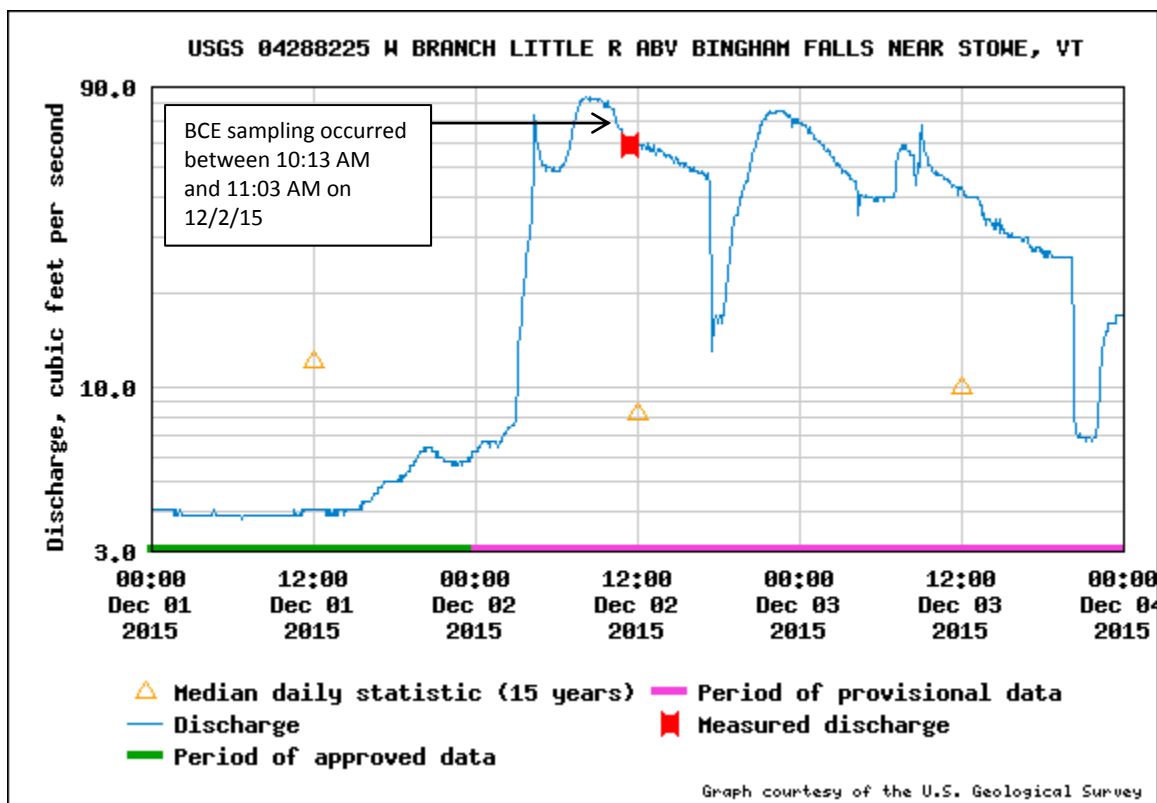
### December 2, 2015

On December 1<sup>st</sup> and 2<sup>nd</sup>, 2015, 0.99 inches of rain fell at Stowe Mountain Resort preceding an event-based sampling round. Due to a warm November, there was no snow on the ground at the base of the mountain, but there was snow on the trails that likely contributed some melt runoff during this event. The pattern of rain during the two days is shown below in Figure 18. The West Branch Little River peaked at 84 cfs between 8:00 AM and 8:30 AM on December 2<sup>nd</sup>. Sampling occurred later that morning (Figure 19).



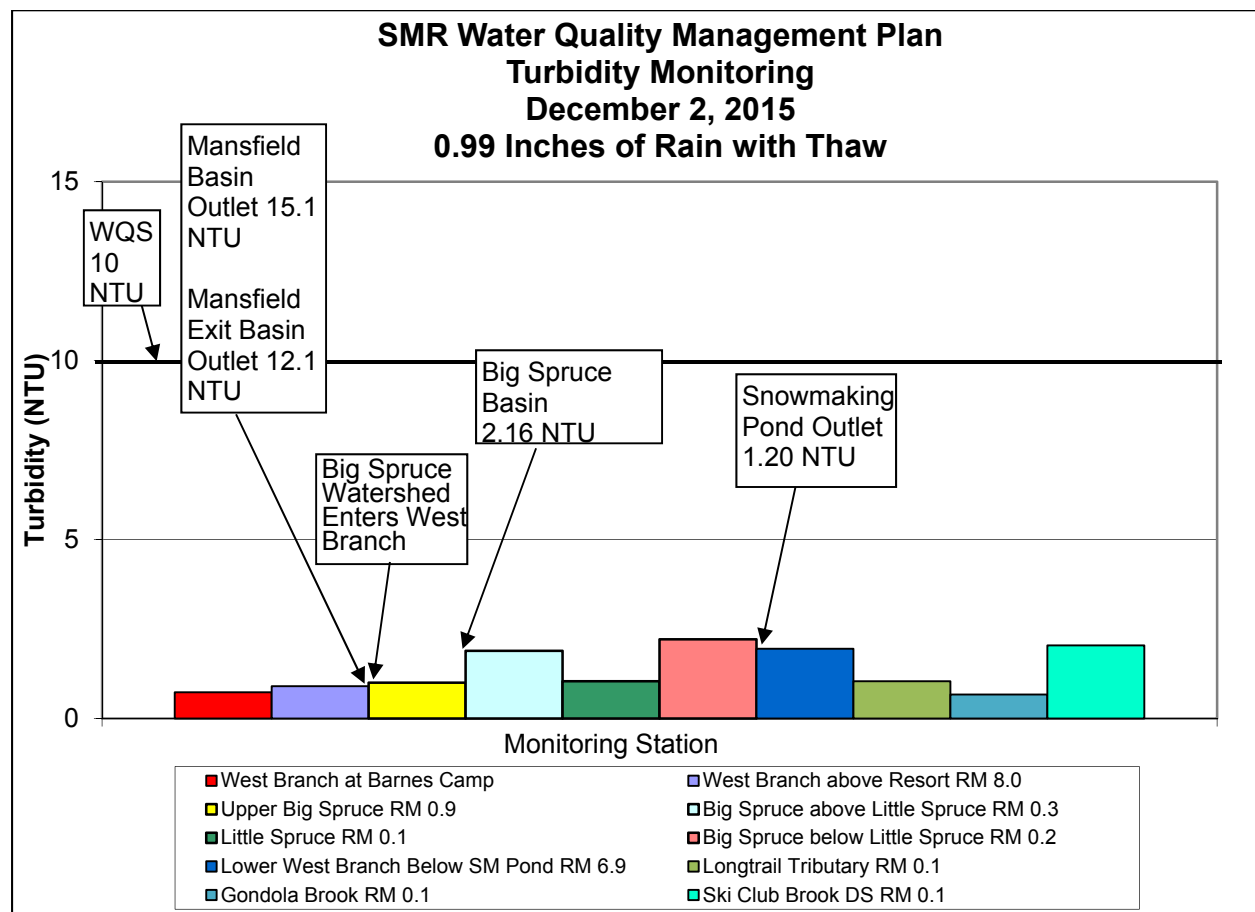
**Figure 18. Precipitation data for December 1<sup>st</sup> and 2<sup>nd</sup>, 2015**





**Figure 19. Hydrograph of the West Branch for the December 2, 2015 event**

Turbidity results were very low for all stream and basin stations sampled during the December 2, 2015 rain/melt event. The highest stream turbidity was observed at Big Spruce RM 0.2 (2.21 NTU), which was well below the VWQS of 10 NTU. The lowest stream turbidity was recorded for Gondola Brook RM 0.1 at 0.67 NTU. The highest basin outlet turbidity measured was 15.1 NTU at the Mansfield Basin outlet, while the lowest, 1.20 NTU, was measured at the Snowmaking Pond outlet. Turbidity results for this event are shown below in Figures 20 and 21.



**Figure 20. Turbidity results for sampling conducted on December 2, 2015.**

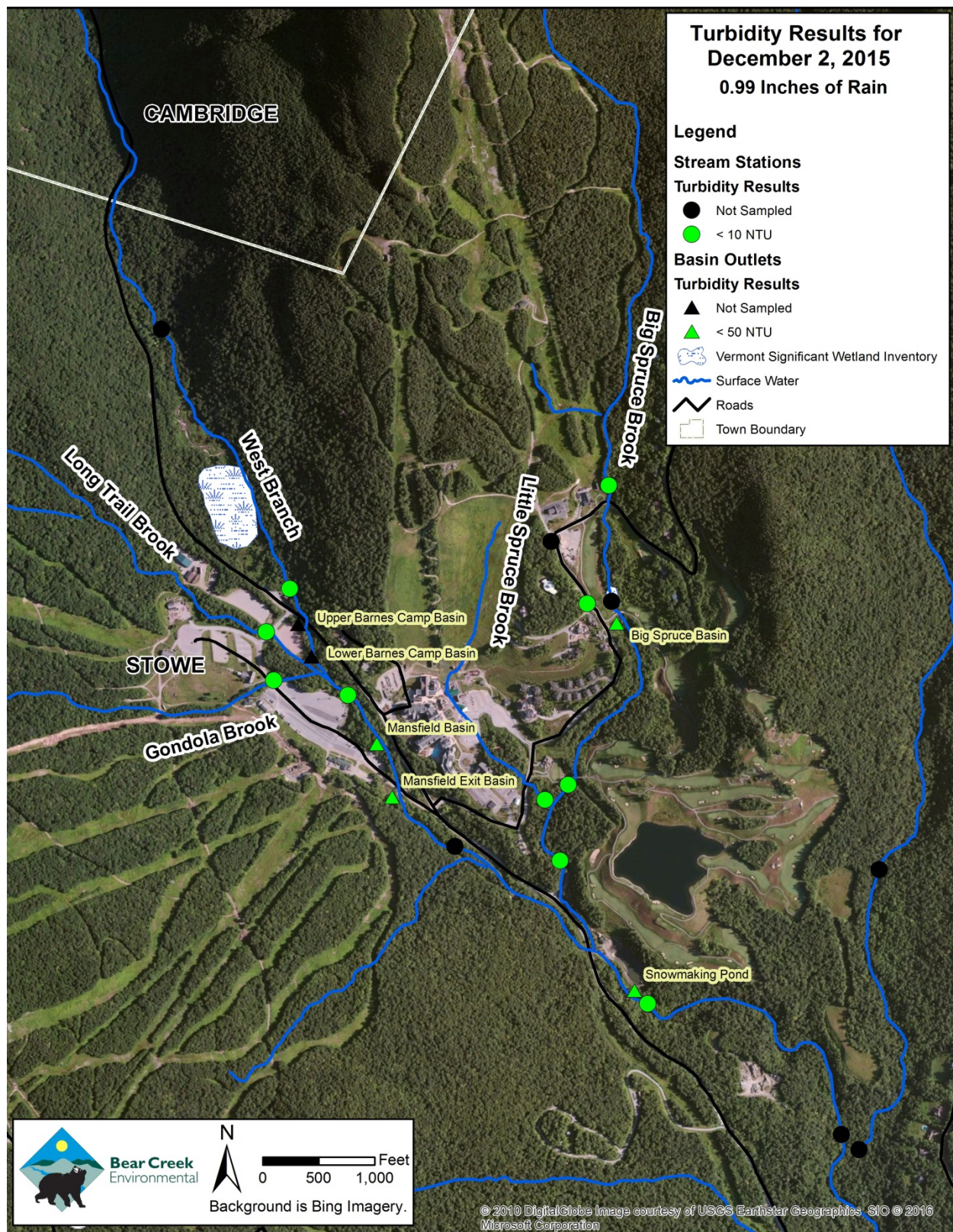
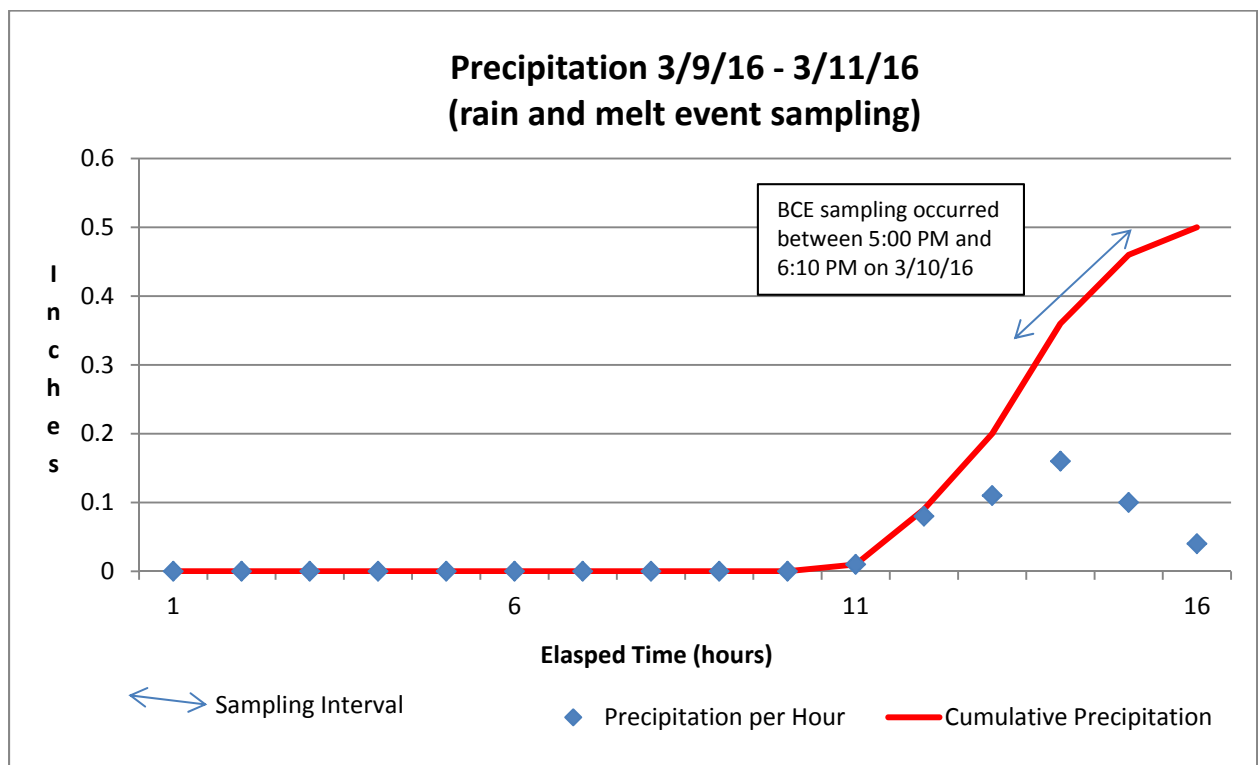


Figure 21. Map showing the turbidity results from the December 2, 2015 sampling event.

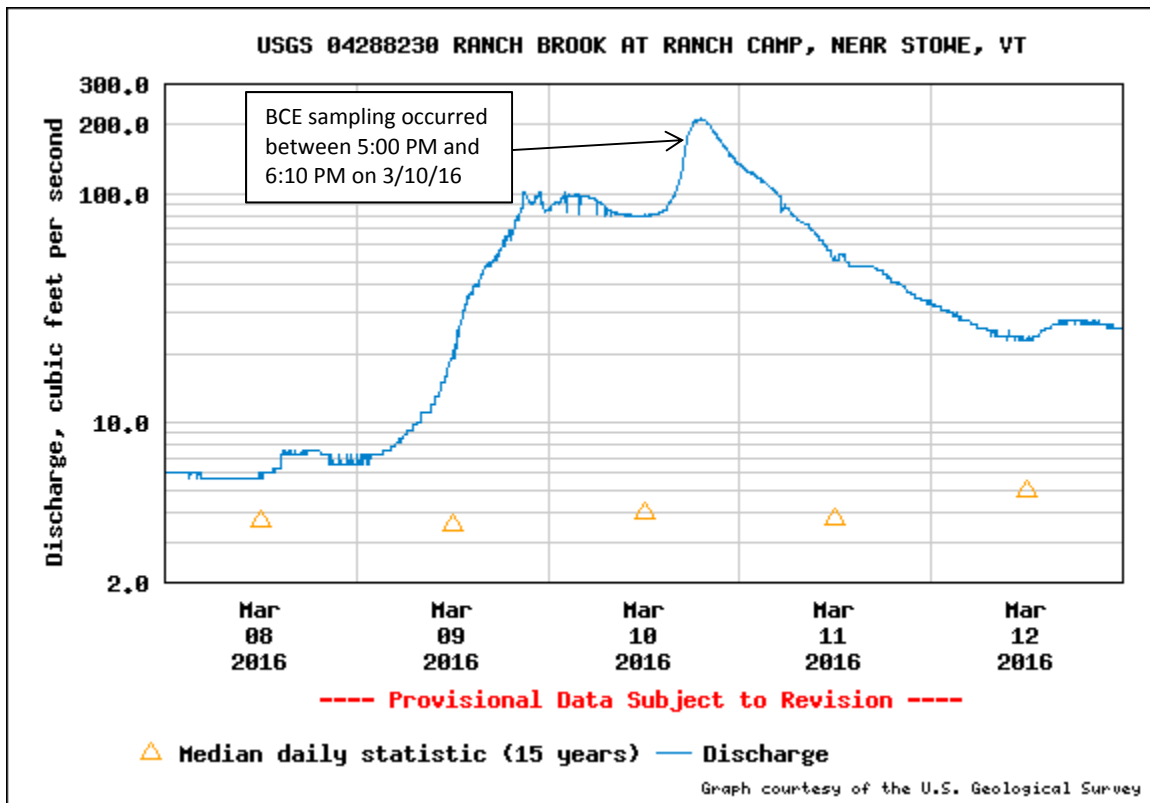


### March 10, 2016

The final event-based sampling round that occurred at Stowe Mountain Resort for the 2015-2016 monitoring year took place on March 10, 2016. Warm temperatures and 0.50 inches of rain sparked increased runoff from snowmelt and elevated flows in the West Branch watershed. Figure 22 below shows the pattern of rain that occurred at the resort leading up to sampling on the 10<sup>th</sup>. The peak flow in the Ranch Brook watershed was 214 cfs (56.3 cfs/sq. mile) at approximately 7:00 PM on the 10<sup>th</sup>. Flow gauging was discontinued on the West Branch Little River on February 29, 2016, so data for the West Branch during this event are not available. Figure 23 shows the hydrograph, including the ascending and descending limbs, for Ranch Brook from March 8 through March 12, 2016.



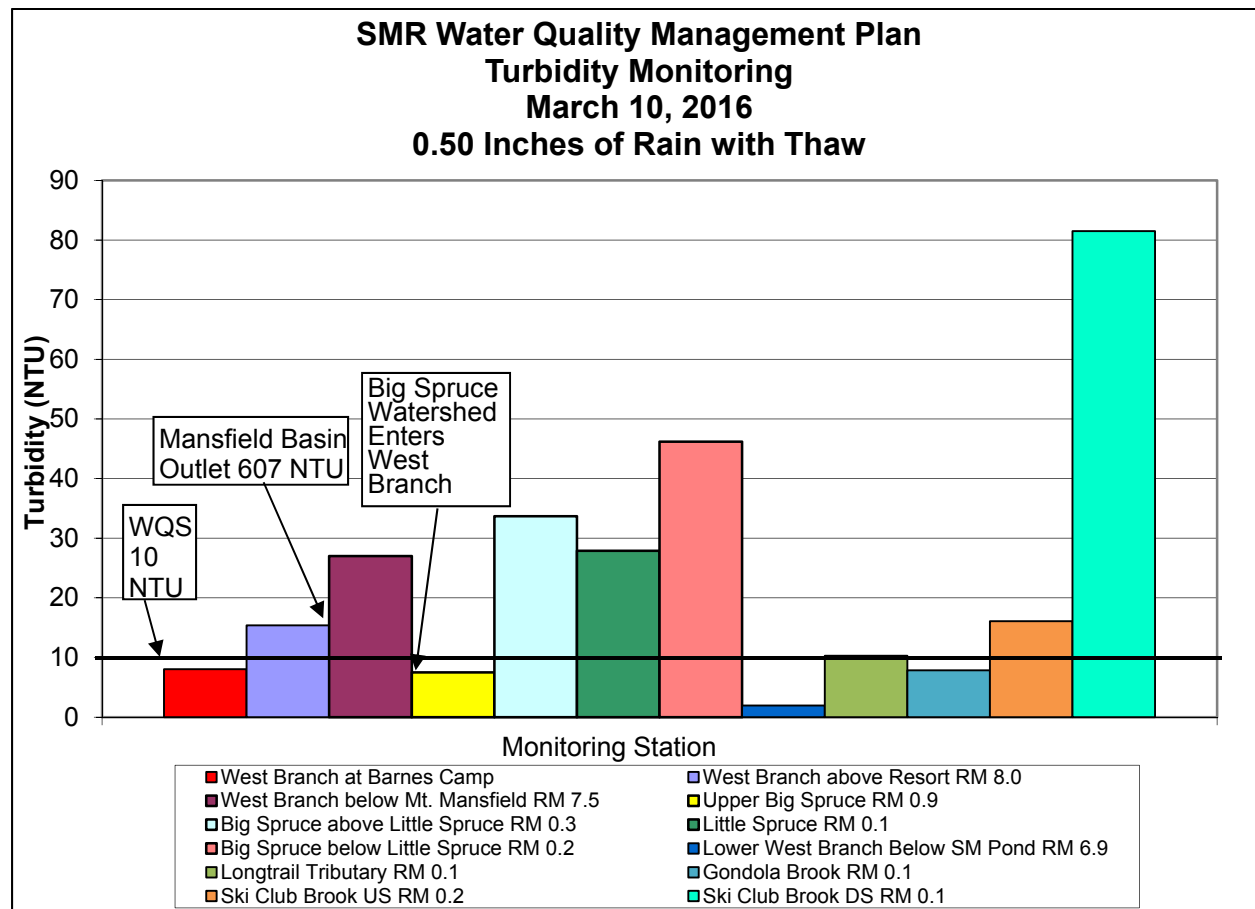
**Figure 22. Precipitation data for the March 10, 2016 sampling event.**



**Figure 23. Hydrograph for Ranch Brook for the March 10, 2016 sampling event**

Stream turbidities were generally elevated during sampling on March 10, 2016. Eight of the eleven stream stations that were sampled had turbidities that were above the VWQS of 10 NTU (Figures 24 and 25). The highest stream turbidity measured was at Ski Club drainage Downstream (81.5 NTU), followed by Big Spruce RM 0.2 (46.2 NTU), and Big Spruce RM 0.3 (33.7 NTU). The lowest turbidity for the stream samples on March 10<sup>th</sup> was at Big Spruce RM 0.9 (7.51 NTU), followed by Gondola Brook (7.85 NTU) and the West Branch Rm 8.2 (8.03 NTU). Only one sediment basin was sampled during the event, the Mansfield Basin outlet. The turbidity of the sample from the basin outlet was very turbid, measuring 607 NTU. This event occurred before the resort conducted its annual spring sand cleanup of the parking lots.





**Figure 24. Turbidity results for sampling conducted on March 10, 2016.**

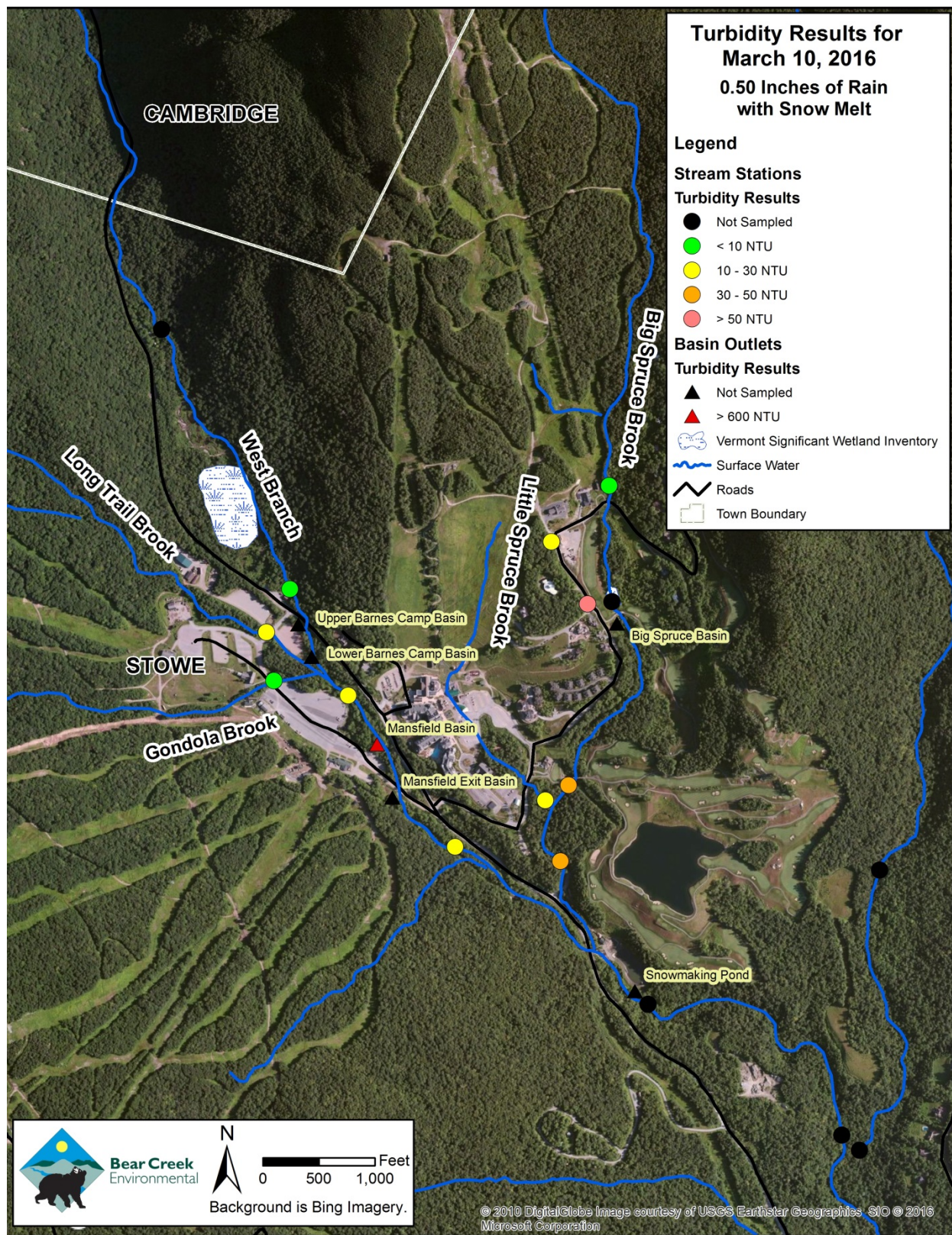


Figure 25. Map of turbidity results from the March 10, 2016 sampling round.

The event-based chemistry results for 2000 to 2015 are summarized in Appendix I. A mean value, maximum value, and the sample size are presented for the construction monitoring that has occurred between fall 2003 and spring 2016.

#### pH

The following mean pH values were reported for the period (2003-2016):

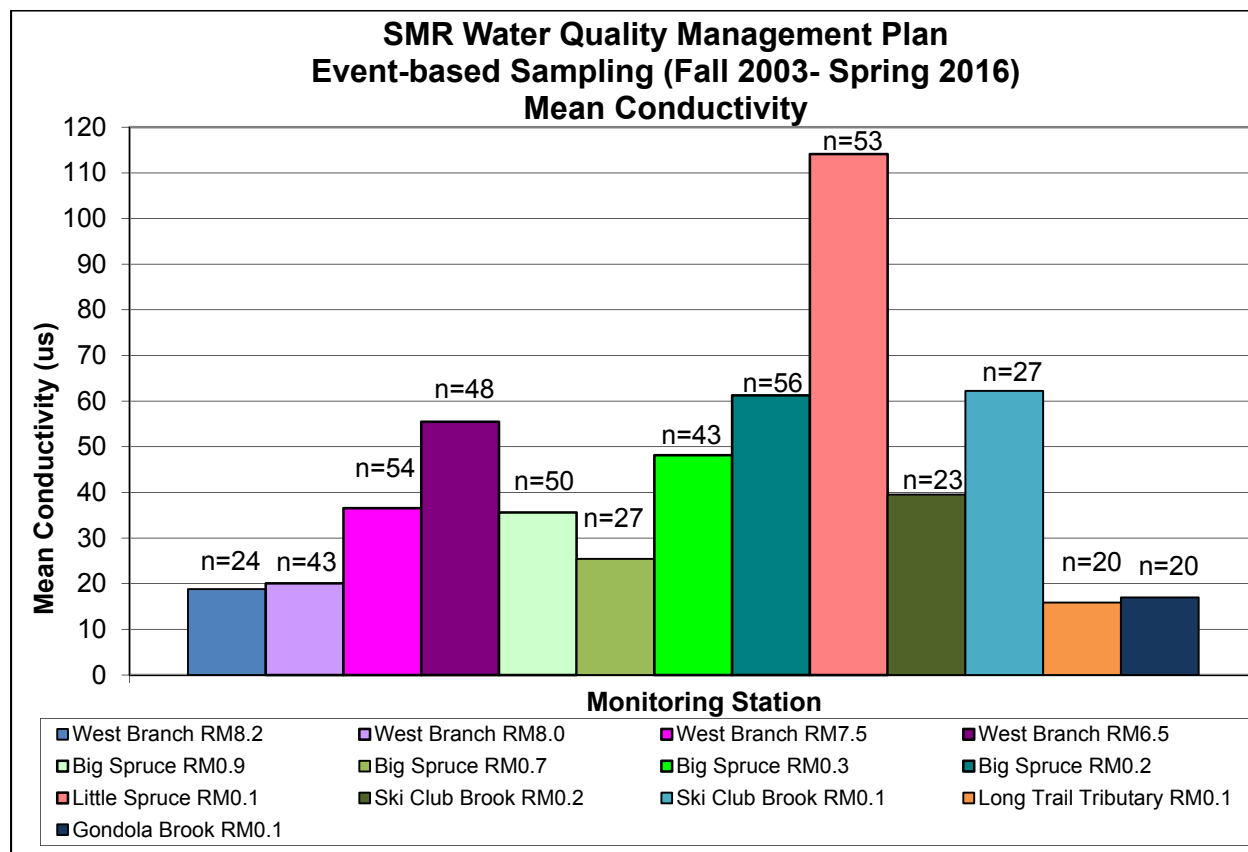
- WB8.2 (West Branch above Barnes Camp, 2010-2016) – 6.49 s.u.
- WB8.0 (West Branch below Barnes Camp, 2006-2016) – 5.79 s.u.
- WB7.5 (West Branch above Big Spruce Brook) – 6.50 s.u.
- WB6.5 (Lower West Branch) – 6.25 s.u.
- BS0.9 (Upper Big Spruce) – 5.06 s.u.
- BS0.7 (Big Spruce above basin, 2009-2016) – 6.06 s.u.
- BS0.3 (Big Spruce above Little Spruce, 2006-2016) – 6.24 s.u.
- BS0.2 (Lower Big Spruce) – 6.34 s.u.
- LS0.1 (Little Spruce Brook) – 6.48 s.u.
- SC0.2 (Upper Ski Club drainage, 2010-2016) – 6.19 s.u.
- SC0.1 (Lower Ski Club drainage, 2010-2016) – 6.28 s.u.
- LT0.1 (Lower Long Trail Brook, 2012-2016) – 5.36 s.u.
- GB0.1 (Lower Gondola Brook, 2012-2016) – 5.49 s.u.

Event-based sampling reveals that streams in the vicinity of Stowe Mountain Resort are critically acidified. In particular, the high elevation streams and undeveloped watersheds appeared to be severely acid stressed. The West Branch below Barnes Camp, Upper Big Spruce Brook, Long Trail Brook and Gondola Brook have mean pH values of less than 6.0 s.u.

#### Conductivity

In general, conductivity levels were highest on Little Spruce Brook and lowest on upper West Branch, Long Trail Brook, and Gondola Brook. The mean conductivity for the period of fall 2003 through spring 2015 for each of the monitoring stations is provided below in Figure 26.





**Figure 26. Mean conductivity reported for event-based sampling for fall 2003 through spring 2016.**

## 6.0 EPSC PROGRAM AND MONITORING

Event based monitoring is used by the Resort to sample turbidity and target areas for improvement. As discussed in Section 5.2, five precipitation/snow melt events were sampled during the spring 2015 to spring 2016 monitoring period. BCE sampled on June 1, 2015, June 23, 2015, September 30, 2015, December 2, 2015, and March 10, 2016.

Table 6 below summarizes the turbidity results for each event sampled during the 2015-2016 monitoring period. The final column of Table 6 shows the station's average turbidity for the monitoring period. In general, turbidity levels were low during the June 1, 2015 and December 2, 2015 events. Turbidity levels were low on the Mansfield side of the resort but slightly elevated on the Spruce side of the resort on September 30, 2015. Turbidity levels were elevated at most stations in March 10, 2016.

## **West Branch Subwatershed**

### West Branch

For most of the events that were sampled during the 2015-2016 monitoring year, turbidity results for the West Branch were low. Three turbidities were observed that were above the Vermont Water Quality Standard of 10 NTU, at RM 8.0 and RM 7.5 on March 10, 2016 and at RM 6.9 on June 23, 2015. Turbidity was very low on Gondola Brook and Long Trail Brook, with the exception of during the event on March 10, 2016 when turbidity slightly exceeded the VWQS at Long Trail Brook RM 0.1 (10.3 NTU). Stations on the West Branch at RM 8.0 and 7.5 are in very close proximity to the Mansfield parking area and its stormwater basin outlets. Turbidity values measured during the 2015-2016 events were consistently low at these two stations, except during the March event. This suggests that resort runoff is being well managed in this area.

The sediment basins in the West Branch subwatershed at Stowe had very low turbidity during the 2015-2016 sampling year, with one exception. The Mansfield Basin had elevated turbidity during one sampling event in the spring of 2016 (March 10, 2016). This sampling round occurred before the resort conducted its annual spring parking lot cleanup of sediment left behind by melted snow. The high turbidity can likely be attributed to sediment in snowmelt running off the parking lot and into the basin. Samples taken at the outlet of the Mansfield Exit Basin and the snowmaking pond had consistently low turbidities during sampling in 2015 and 2016.

## **Big Spruce Subwatershed**

### Big Spruce Brook

The turbidity values at the Big Spruce upper stations (RM 0.9 and RM 0.7) were typically low. The water quality trends for the downstream stations (RM 0.3 and RM 0.2) suggest that turbidity increases between the upstream and downstream stations. On one occasion during the monitoring year, measured turbidity was higher than the VWQS at RM 0.3 (March 10, 2016). Big Spruce at RM 0.2 was above the VWQS for three of five sampling rounds (June 23<sup>rd</sup>, September 30<sup>th</sup>, and March 10<sup>th</sup>).

### Little Spruce Brook

Construction activities occurred throughout 2015 and 2016 at Spruce Peak within the Little Spruce Brook drainage. Turbidity values observed during event based sampling in 2015 and 2016 were typically higher than the other surface water quality monitoring stations and ranged between 1.04 and 38.8 NTU on sampling dates. These slightly elevated turbidity values may be linked to construction activities at Spruce Peak.

### Ski Club Drainage

This drainage located upstream of the Big Spruce basin is intermittent and is typically dry during the summer. While not required by ANR, two stations were sampled on this drainage to get a better understanding of potential sediment sources to Big Spruce Brook. Elevated turbidity values were observed on Ski Club drainage on two of five sampling dates during the 2015 to 2016 monitoring year. The source of this turbidity is likely attributable to channel and bank erosion within the drainage. Stormwater improvements made at the Sensation Lot have helped reduce sediment reaching the Big Spruce Basin.

**Table 6. Event-Based Sampling Turbidity Results Spring 2015-Spring 2016  
Stowe Mountain Resort**

<b>Station</b>	<b>June 1, 2015</b>	<b>June 23, 2015</b>	<b>Sept. 30, 2015</b>	<b>Dec. 2, 2015</b>	<b>March 10, 2016</b>	<b>Average</b>
<b>WB8.2 (above SMR)</b>	0.40	Not sampled	0.94	0.73	8.03	<b>2.53</b>
<b>WB8.0</b>	0.74	Not sampled	1.69	0.90	15.4	<b>4.68</b>
<b>WB7.5</b>	0.70	4.12	1.60	Not sampled	27.0	<b>8.36</b>
<b>WB6.9</b>	1.23	10.3	6.59	1.95	Not sampled	<b>5.02</b>
<b>LT0.1</b>	1.04	Not sampled	2.55	1.04	10.3	<b>3.73</b>
<b>GB0.1</b>	0.65	Not sampled	1.54	0.67	7.85	<b>2.68</b>
<b>BS0.9</b>	1.14	Not sampled	1.76	1.00	7.51	<b>2.85</b>
<b>BS0.7</b>	1.59	2.17	2.60	Not sampled		<b>2.12</b>

**Table 6. Event-Based Sampling Turbidity Results Spring 2015-Spring 2016  
Stowe Mountain Resort**

Station	June 1, 2015	June 23, 2015	Sept. 30, 2015	Dec. 2, 2015	March 10, 2016	Average
<b>BS0.3</b>	2.40	3.89	5.49	1.89	33.7	9.47
<b>BS0.2</b>	2.35	24.3	10.9	2.21	46.2	17.19
<b>LS0.1</b>	4.73	29.1	38.8	1.04	27.9	20.31
<b>SC0.2</b>	2.2	Not sampled	12.7	Not sampled	16.1	10.3
<b>SC0.1</b>	3.31	5.46	15.8	2.04	81.5	21.62
<b>Outlet 1 (Mansfield Basin)</b>	3.61	6.17	4.34	15.1	607	127.24
<b>Outlet 2 (Snowmaking Pond)</b>	Not discharging	13.1	7.38	1.20	Not sampled	7.23
<b>Outlet 3 (Big Spruce Basin)</b>	3.31	22.9	20.3	2.16	Not sampled	13.21
<b>Outlet 4 (Mansfield Exit Basin)</b>	3.43	1.14	3.10	12.7	Not sampled	5.09
<b>Outlet 5 (Upper Barnes Camp Basin)</b>	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	N/A
<b>Outlet 6 (Lower Barnes Camp Basin)</b>	30.2	Not sampled	Not sampled	Not sampled	Not sampled	30.2
<b>Precipitation</b>	0.87"	0.46"	2.42"	0.99" with melt	0.50" with melt	
<b>Streamflow (cfs) at time of sampling</b>	Not available <sup>1</sup>	81 to 91	108 to 113	62 to 77	Not available <sup>2</sup>	

Stream station turbidity exceeds 10 NTU

Sediment basin outflow with elevated turbidity (> 100 NTU)

1. Flow data unavailable for the West Branch due to gauge malfunction. Ranch Brook flow was 59 to 61 cfs during sampling.
2. Flow data unavailable for the West Branch. Gauge was discontinued on February 29, 2016. Ranch Brook flow was 142 to 203 cfs.

Stowe Mountain Resort expanded its program during the 2007 construction season to promote erosion prevention and sediment control across the resort. This program has been continued over the past several years. A report prepared by Stowe Mountain Resort describing the erosion prevention/sediment control (EPSC) improvement projects is provided in Appendix 2. During spring 2015 and 2016, as part of routine maintenance at the resort, accumulated sand from the winter was removed from parking lots, roads, culvert inlets, swales, water bars, stone check dams and sediment basins to prevent sediment reaching surface waters. Stormwater improvements made to the Resort in 2012 in response to the 1272 order issued on May 3, 2012 are summarized in Nealon and Kinghorn (2013). EPSC activities on the Spruce side of the resort are reported in the 2016 EPSC Annual Monitoring report, which is included in Appendix 2 of this report.

Highlights for the EPSC are provided below. All disturbed areas were seeded and mulched.

- Waterbar repair, sediment basin maintenance, and bridge cleaning were conducted on the Cat road from Mansfield to Spruce;
- Waterbars enlarged, new waterbars installed, armor placed at the Meadows base;
- Stabilization of the geothermal well on the Inspiration ski trail via waterbar repair, sediment basin enlargement, and base area conveyance armoring;
- Base area of Spruce repaired from previous disturbance and closed for spring and early summer to facilitate vegetated stabilization;
- Spruce Catwalk rebuilt, diversion berm enlarged, waterbars repaired;
- Snowplant bridge and fueling station was regraded and waterbars were rebuilt;
- Snowplant road was rebuilt and waterbars enlarged;
- Lower Barnes parking lot was graded and accumulated sand removed, perimeter ditch restored and stone dams enlarged, forebay cleaned of sediment;
- East Run and Sterling intersection workroad was narrowed and waterbars repaired;
- Permit Lot at Mansfield perimeter swale enlarged and sediment trap restored;
- Mansfield Exit conveyances realigned, ditches armored, sediment removed;
- Bus lot graded and sand removed, perimeter ditch cleaned and check dam reestablished, basin cleaned of sediment;



- Mansfield base road armored, new conveyances installed, waterbars improved;
- Switchback work road waterbars repaired, perimeter ditches enlarged, damaged culvert replaced;
- Cliff Trail waterbars enlarged and additional ones added, diversion ditches enlarged, culvert replaced;
- Triple base driving surface armored, conveyances armored, sediment traps built;
- Sensation parking lot conveyances realigned and sediment basin doubled in size;
- Swale along Big Spruce Road cleaned and basins enlarged;
- Big Spruce Basin cleaned of accumulated sediment;
- Snowmaking (stormwater) Pond cleaned of accumulated sediment
- Sterling workroad waterbars reestablished, ditches aligned, sediment traps cleaned.

## **7.0 SEDIMENT ASSESSMENT**

BCE conducted pebble counts at specified sediment monitoring stations to evaluate channel materials. A substrate summary table of the pebble counts is included in Appendix 3 on pages 1 and 2. The results of each pebble count are shown on pages 3 through 18 of Appendix 3.

### Embeddedness:

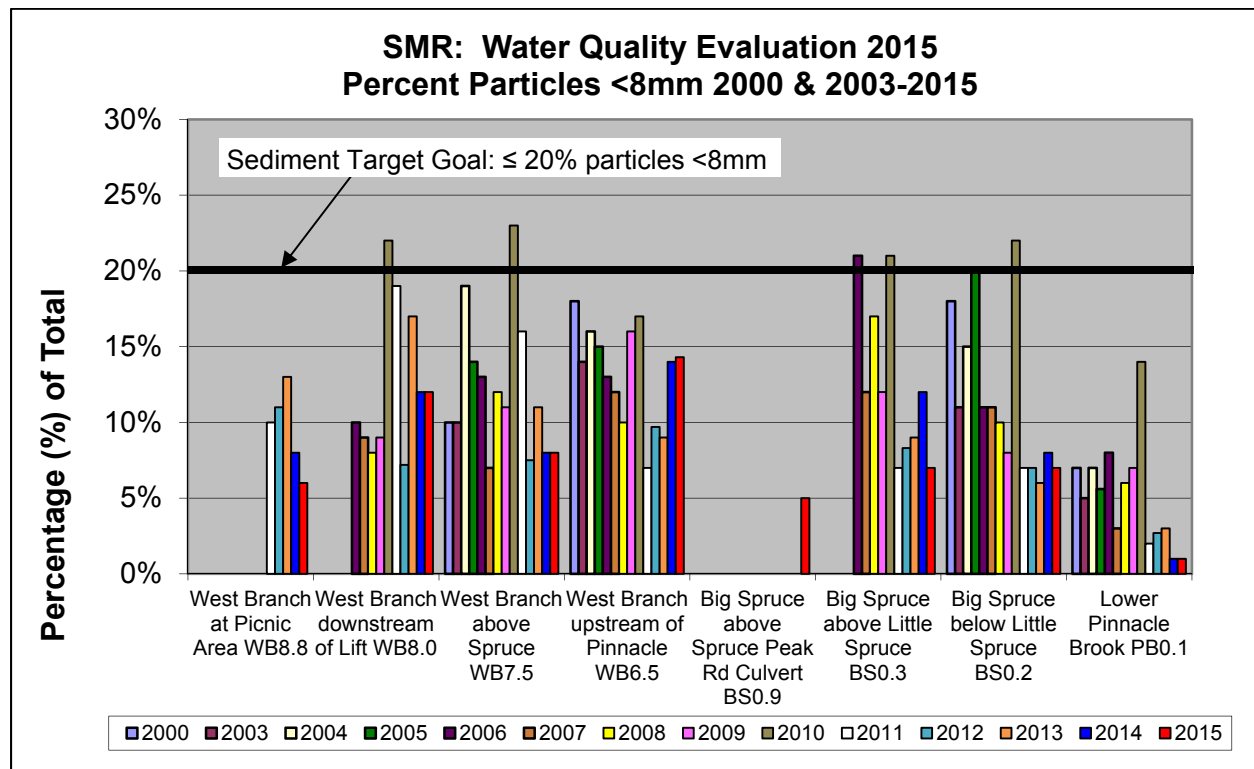
Embeddedness was assessed at the eight biomonitoring stations. Half of the stations sampled had embeddedness estimates of 0-25% (very good) in 2015 and met the target goals. Stations West Branch RM 8.0, Big Spruce RM 0.9, Big Spruce RM 0.3, and Big Spruce RM 0.2 had embeddedness estimates of 25-50% in 2015.

### Channel Materials:

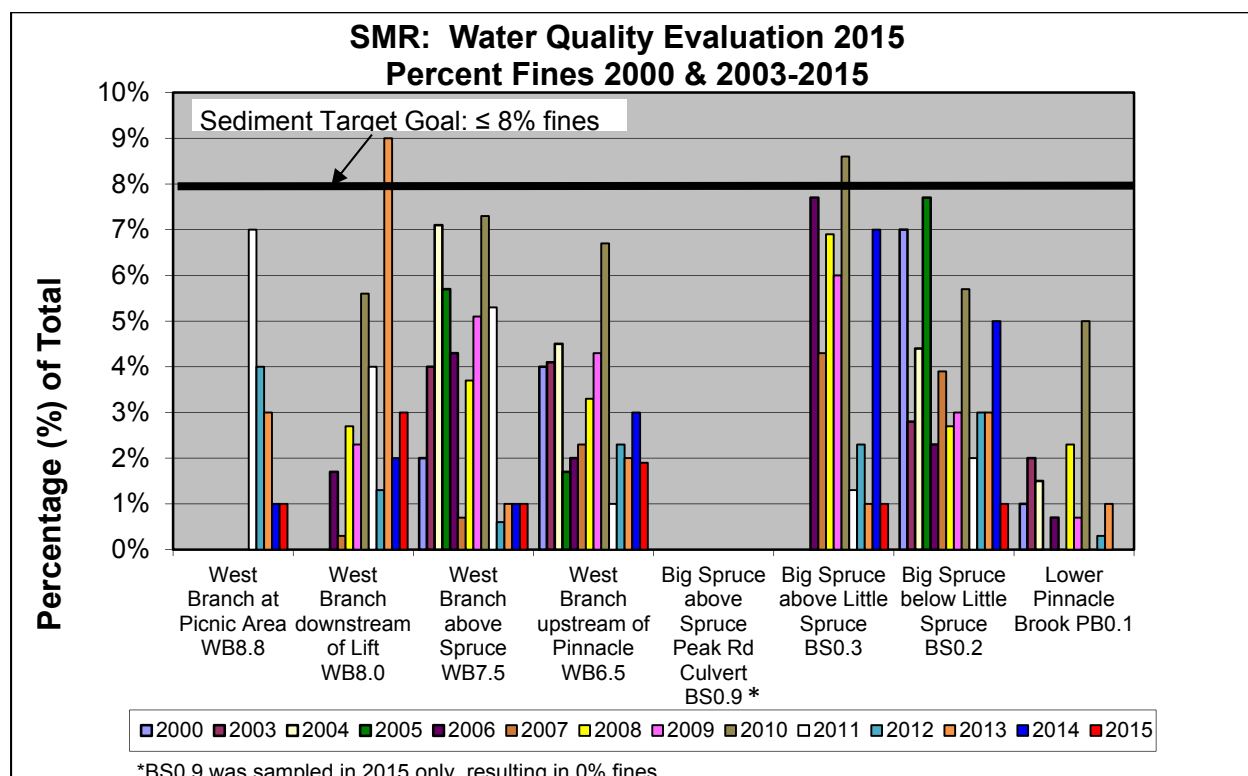
The pebble count data serve as an important tool for understanding improvement in habitat from remediation efforts as well as impacts from catastrophic flood events. As shown below in Figure 27, the percentage of particles less than 8 mm met the target threshold of less than or equal to 20 percent of the substrate composition at all monitoring stations in 2015. Both the graph of the percentage of particles less than 8 mm and the percent fines (Figure 28), indicate

there was a shift toward smaller particle sizes in 2010. A high flow event in August 2010 was the primary cause and the percentage of fines has generally decreased since 2010 as the sediment works its way through the study area. This shift can be seen for each station on the graphs in Appendix 3.

All the monitoring stations in 2015 also met the target for percent fines. Four of eight monitoring stations met all three target goals for sediment in 2015 – West Branch RM 8.8, West Branch RM 7.5, West Branch RM 6.5, and Pinnacle Brook RM 0.1. The remaining four stations met two of three target goals for sediment (all but embeddedness) – West Branch RM 8.0, Big Spruce RM 0.9, Big Spruce RM 0.3, and Big Spruce RM 0.2. Streams in the vicinity of SMR will continue to be monitored for changes in channel substrate condition as the MDP continues to be implemented.



**Figure 27. Substrate Assessment – Percent particles less than 8 mm.**



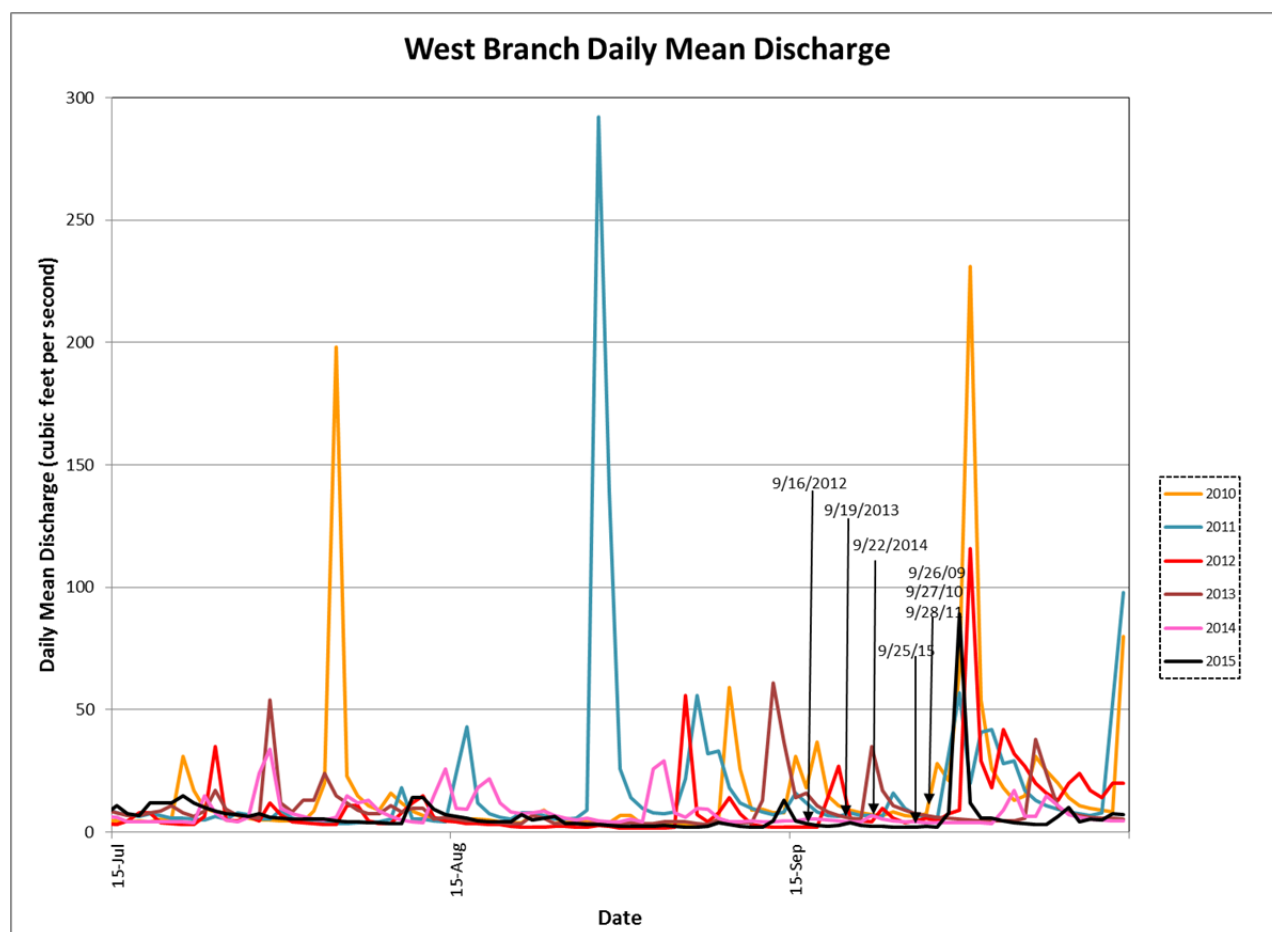
**Figure 28. Substrate Assessment – Percent fines.**

## 8.0 BIOMONITORING AND HABITAT ASSESSMENT

Macroinvertebrate kick net sampling and habitat assessments were conducted by Catherine Szal on September 25, 2015. Biomonitoring and habitat assessments were completed by Ms. Szal on the four West Branch stations, two Big Spruce Brook stations, and one Pinnacle Brook station that were sampled in 2014. In addition, Catherine collected a kick net sample at BS RM 0.9. Water chemistry samples have been collected at BS RM 0.9 in the past, but this is the first year biomonitoring and habitat assessments have been conducted in that location. BS RM 0.9 is located upstream of the section of stream that is heavily impacted by iron seeps. In an effort to assess the impact of the heavy iron seeps on the macroinvertebrate community, Steve Fiske of the VDEC sampled at BS RM 0.8.

The sampling took place under low flow conditions. Two replicate kick net samples were collected at each station with the exception of Big Spruce RM 0.9, RM 0.8 and RM 0.3, where riffle habitat is limited. Figure 29 shows the flow conditions in the West Branch for the past five

monitoring years. During the 2010 field season, a large flood event occurred in early August, causing major damage at the resort and changes to the channel morphology and extreme scouring of the streambed. A second flood event took place about a week after the kick net samples were collected on September 26, 2010. During 2011, the daily mean stream flow exceeded 250 cfs as a result of Tropical Storm Irene. The 2012, 2013, and 2014 monitoring seasons are characterized as having low to moderate flows during the monitoring period. In 2015, flows were typically low from mid-July to late September. On the September 25, 2015 sampling date, the flow was only 2.1 cfs.



**Figure 29. Daily mean discharge on West Branch between mid-July and mid-October for monitoring years 2010 through 2015.**

## 8.1 Habitat Assessment

Qualitative habitat assessments were made at the nine biomonitoring stations on September 25, 2015. Field sheets and observations from these habitat assessments conducted by BCE are provided on pages 1 through 16 of Appendix 4. Silt ratings and substrate embeddedness ratings for each station are provided below in Table 7. The silt is rated from 0 to 5 by the biologist. A rating of 0 indicates silt is absent, while a rating of 5 reflects considerable silt as evidenced by a chocolate brown color. Silt can impair aquatic insects by clogging gills. Both Embeddedness ratings were estimated to the nearest quartile by the biologist collecting the kick net samples. Bear Creek scientists also calculated the percent embeddedness by measuring the percentage of substrate covered by fine sediment for ten random cobbles. Embeddedness is an important habitat parameters as it provides a qualitative measure of the interstitial spaces available for colonization by aquatic insects.

<b>Table 7. Substrate Embeddedness and Silt Ratings</b>				
Stream	RM	Silt Rating (0-5)	Pebble Count Embeddedness (Percentage)	Biomonitoring Embeddedness (Percentage)
West Branch	8.8	3	20	5-25
	8.0	2	27	25-50
	7.5	2-3	14	5-25
	6.5	3	26	5-25
Big Spruce Brook	0.9	4	28.5	25-50
	0.8	NA	NA	NA
	0.3	4	27.5	5-25
	0.2	5	37	25-50
Pinnacle Brook	0.1	2	9	5-25
Silt rating (0 – none; 5- chocolate)				
NA – not available – sampled by VDEC				

**West Branch of Little River – RM 8.8:**

West Branch RM 8.8 has a surrounding land use of forest and is located off the Notch Road about a half mile upstream of Barnes Camp. Riffle embeddedness was estimated to be within the range of 5-25% and the silt rating was “3”. Abundant coarse particulate organic material (CPOM) was present at this station. Diatom coverage on the gravel dominated substrate was estimated to be 80 percent. Stream bank stability was good (50-75% stable).

**West Branch of Little River – RM 8.0:**

West Branch RM 8.0 is located downstream of the transfer lift crossing. Small iron seeps were present along the stream margins. Embeddedness was in the range of 25-50% in the riffle and was more embedded in pool habitat (Figure 30). Bank stability was good (50-75% stable). Canopy cover was estimated to be partly open, creating a cover of about 60 percent. The diatom cover was 70 percent.

**West Branch of Little River RM 7.5:**

West Branch RM 7.5 is located downstream of the exit to the Mansfield parking lot, below the outlets of both the Mansfield Basin and the Mansfield Exit Basin. Diatoms were the dominant periphytic cover. Embeddedness was estimated to be 5-25%, and light iron staining was noted. The leaves were mainly on providing a canopy cover of 80 percent, as shown in Figure 31.

**West Branch of Little River (RM 6.5):**

The lowest station on the West Branch is at RM 6.5, and is located immediately upstream of the confluence with Pinnacle Brook. Bank stability in 2015 was rated as good at WB 6.5, and substrate embeddedness was rated as 5-25 percent. The diatom coverage was approximately 90 percent. Canopy cover was partly open and was estimated to be 70 percent, as shown in Figure 32.





**Figure 30. West Branch RM 8.0 (9/25/15)**



**Figure 31. West Branch RM7.5 (9/25/2015)**





**Figure 32. West Branch RM 6.5 above the confluence with Pinnacle Brook (9/25/15)**

**Big Spruce RM 0.9:**

Biomonitoring was conducted for the first time at Big Spruce RM 0.9, located below the Spruce Peak ski trails and upstream of the Spruce Peak Road culvert crossing. Some isolated iron seeps were present. The silt rating was 4, reflecting heavy silt and fine particulate material (FPOM). Bank stability was poor with only 0 to 25% of the bank stable. The station offered limited areas for kick net sampling (Figure 33). The canopy was partly open and was estimated to be 60%.

**Big Spruce RM 0.8:**

Biomonitoring was also conducted for the first time at Big Spruce RM 0.8, located in an area with heavy iron seeps downstream of the Spruce Peak Road crossing. Kick net sampling was conducted by Steve Fiske of the VDEC within a strong seep (Figure 34). Based on field notes from the VDEC, the substrate was 100% covered with iron floc and precipitate. The water column iron was also elevated, and was reported to be 838 µg/L or just below water quality criteria for the protection of aquatic biota. This average allowable concentration (chronic criteria) to protect aquatic life is 1,000 micrograms per liter.





**Figure 33. Big Spruce Brook RM 0.9 (9/25/15)**



**Figure 34. Big Spruce Brook RM 0.8 (9/25/15)**

**Big Spruce RM 0.3:**

This upper biomonitoring station on Big Spruce Brook at river mile 0.3 is located downstream of the Golf Cottage and upstream of the confluence with Little Spruce Brook. Big Spruce station RM0.3 has historically had several iron seeps. One major iron seep was remediated in fall 2010 using limestone to intercept and treat the groundwater. Iron seeps were noted to be heavier in 2015 than recent years. Kick net sampling was conducted in an area with less iron. The station was 5-25 percent embedded and had a silt rating of 4. Bank stability was rated as good and canopy cover was 80 percent at the time of sampling (Figure 35).

**Big Spruce - RM0.2:**

Big Spruce RM 0.2 is located downstream of the Little Spruce Brook confluence. Bank stability at RM0.2 was rated as poor in September 2015. Significant bank erosion occurred during the August 4, 2010 flood event, and the channel and banks are still undergoing an adjustment process in response to this large flood event. Embeddedness in 2015 was rated as 25-50 percent. Heavy organic rich silt was noted, and a silt rating of 5 (chocolate) was given based on field observations. The substrate was hard to kick net due to the shallow riffles and wide channel (Figure 36). A small iron seep and iron staining were noted within the reach. Percent canopy cover averaged 70 percent.





**Figure 35. Big Spruce Brook RM 0.3 (9/25/15)**



**Figure 36. Looking upstream at Big Spruce RM0.2 (9/25/15)**



**Pinnacle Brook – RM0.1:**

The reference/control station for biomonitoring is located at the mouth of Pinnacle Brook. In 2015, bank stability was rated as excellent (75-100% stable). Based on habitat observations, the silt rating was low and embeddedness was very good (5 to 25 percent). Canopy cover was approximately 70 percent and leaves were still on the trees. There was 80% diatom cover and a 2% cover of blue-green algae. A small iron seep was noted along the right bank. Figure 37 shows the Pinnacle Brook monitoring station.



**Figure 37. Pinnacle Brook monitoring station (9/25/15)**

**8.2 Macroinvertebrate Results**

The macroinvertebrate taxa were identified and recorded for the duplicate kick net samples collected during fall 2015. The macroinvertebrate kick net samples were processed and identified by Catherine Szal. Bear Creek Environmental, LLC calculated the biometrics for the samples, which underwent a quality control review by DEC aquatic biologist, Steve

Fiske. These biometrics included percent composition of the orders and percent composition of the functional feeding groups for each station.

All biomonitoring stations sampled during 2015 in the vicinity of SMR are located below 2,500 feet in elevation. All seven sampling stations fall into the stream type “small-size high gradient” (SHG). For this reason, the Class B (2-3) scoring guidelines for SHG were applied. The outcomes of the scoring guidelines are summarized in Tables 8 through 14 below. The Class B2-3 threshold values are provided at the bottom of each table. Sampling dates where the biological integrity is good or better and the samples meet Class B biocriteria are highlighted in green.

**West Branch of Little River – RM 8.8:** Station RM8.8 is located at the picnic area in Smugglers Notch off of Route 108. This is the fifth year the West Branch upstream of Stowe Mountain Resort has been sampled by Stowe Mountain Resort. Steve Fiske of the Vermont DEC also sampled the West Branch above the resort in the vicinity of RM8.8 in early September 2007 and 2011. The biometrics for September 2015 indicate West Branch station RM8.8 has good biological integrity. This background/control station passed the Class B2-3 biocriteria in 2015 with EPT Richness meeting the threshold criteria of 16. The mean EPT Richness has been below the threshold value of 16 for four of the seven sampling dates. The low EPT Richness values may be attributed to impacts from acid precipitation. Alkalinity over the past five years of baseflow sampling has averaged only 4.8 mg/L, indicating a poor buffering capacity.

<b>Table 8. Macroinvertebrate Results West Branch of Little River RM 8.8 Picnic Area off of Route 108 in the Notch</b>									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/7/2007 DEC	1124.5	30	14	77.4	2.37	0.3	0.75	0.63	Class B2-3 Not Supported: Fair
9/9/2011 <sup>1</sup> DEC	379.2	36	19	63.8	2.18	1.6	0.77	0.38	Class B2-3 Supported: Good
9/28/2011 <sup>1</sup> BCE	275.5	23.5	15.5	54	1.12	0.0	0.91	0.35	Class B2-3 Not Supported: Fair

<b>Table 8. Macroinvertebrate Results West Branch of Little River RM 8.8 Picnic Area off of Route 108 in the Notch</b>									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/16/12 BCE	427.2	<b>24.5</b>	<b>15.5</b>	61.3	1.19	0.2	0.88	0.46	Class B2-3 Not Supported: Fair to Good
9/19/13 BCE	369.4	27.0	<b>15.5</b>	63.5	1.98	0.0	0.88	0.43	Indeterminate (+) for Class B2-3: Good to Fair
9/22/14 BCE	501.8	27.5	17.5	66.0	1.90	0.50	0.79	0.47	Class B2-3 Supported: Good
9/25/15	410.6	29.0	17.0	49.7	1.23	0.5	0.85	0.44	Class B2-3 Supported: Good
<b>Annual Mean 2007-2015</b>	526.8	28.0	16.2	62.8	1.72	0.4	0.83	0.47	
Class B2-3	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
<b>Bold</b> denotes value does not meet the proposed macroinvertebrate biocriteria threshold <sup>1</sup> Large flood event in August 2011 Note: DEC and BCE station locations are not exact, but are within the same reach									

**West Branch of Little River – RM 8.0:** The upper West Branch station was added in 2006 to provide a control station on the West Branch that is located above the discharge from the Mount Mansfield sedimentation basin. Density in the kick net samples was suppressed in 2015, resulting in an outcome of fair to good biological integrity. The other seven biometrics met Class B water quality standards, indicating the macroinvertebrate structure and composition is well rounded.

The iron seeps, embedded substrate, and lack of CPOM at this station are possible reasons for the low densities in the kick net samples. Substrate embeddedness was 25-50% in riffle habitat, indicating the interstitial spaces were partially filled with sediment. Water quality sensitive EPT organisms depend upon clean spaces between gravel and cobbles to colonize. The Resort is diligent about erosion prevention and sediment control, but does not have full control over sedimentation, as the VT Route 108 is maintained by the town of Stowe.

Both the lack of CPOM and the low densities suggest scour may occur during high flow events. A review of the historic biomonitoring data indicates the percentage of *Baetis tricaudatus* was elevated (>20% of the sample) in 6 of the past 10 years of biomonitoring. This species of mayfly tends to colonize immediately following freshet events. WB8.0 is located immediately below the location where the West Branch, Gondola Brook and Long Trail Brook converge. These brooks are high gradient and flashy and the timing of the peak runoff as these brook meet, may contribute to elevated flows and velocities at WB8.0. The amount of CPOM at WB8.0 has been noted to be in low abundance. It is speculated that CPOM is scoured from the substrate when velocities are high.

Another stressor at WB8.0 is the low buffering capacity. The alkalinity at West Branch RM 8.0 has averaged only 5.7 mg/L as CaCO<sub>3</sub>, suggesting the station is acid stressed. Water chemistry data samples collected within the past five years have shown pH values in the 4 to 6 s.u. range on multiple occasions, showing this West Branch in this location is affected by acidic pulses. The tributaries (Gondola Brook and Long Trail Brook) that merge just upstream of WB8.0 have very low alkalinities, in the range of 2.0 to 2.6 mg/L CaCO<sub>3</sub>. The low buffering capacity of these tributaries likely impacts the macroinvertebrate carrying capacity, thereby reducing the drift upstream of WB8.0.

**Table 9. Macroinvertebrate Results  
West Branch of Little River RM 8.0 (MS-16b)  
Above Discharge from Mount Mansfield Parking Area**

Year	Density	Richness	EPT	PMA -O	BI	% Oligo.	EPT/ EPT+C	PPCS -FG	Outcome
10/10/2006 BCE	199.5	26	13.5	65	2.19	10.0	0.89	0.61	Class B2-3 Not Supported: Fair
9/7/2007 BCE	682	26	15.0	60	3.01	13.0	0.93	0.42	Indeterminate for Class B2-3: Fair
9/7/2007 ANR	1204	33	14.0	63	3.50	8.0	0.87	0.36	Class B2-3 Not Supported: Fair
9/12/2008 BCE	184.5	24.0	13.5	65	3.38	9.3	0.93	0.34	Class B2-3 Not Supported: Fair
9/10/2009 BCE	567	23.5	14.5	69	3.29	1.5	0.94	0.55	Class B2-3 Not Supported: Fair

**Table 9. Macroinvertebrate Results  
West Branch of Little River RM 8.0 (MS-16b)  
Above Discharge from Mount Mansfield Parking Area**

Year	Density	Richness	EPT	PMA -O	BI	% Oligo.	EPT/ EPT+C	PPCS -FG	Outcome
9/27/2010 <sup>1</sup> BCE	<b>77</b>	<b>15.5</b>	<b>9.0</b>	59.5	2.13	0.8	0.90	<b>0.35</b>	Class B2-3 Not Supported: Poor
9/28/2011 <sup>1</sup> BCE	<b>89.5</b>	<b>20.0</b>	<b>13.5</b>	67	2.13	6.1	0.91	0.52	Class B2-3 Not Supported: Poor
9/16/2012 BCE	399.5	29.5	17.5	78.3	2.49	2.7	0.89	0.46	Class B2-3 Supported: Good
10/24/12 <sup>2</sup> DEC	837.0	30.0	17.0	68.1	2.58	8.2	0.69	<b>0.34</b>	Class B2-3 Not Supported: Fair to Good
9/19/2013 BCE	<b>160.5</b>	<b>24.5</b>	<b>14.0</b>	67.2	2.98	3.8	0.87	<b>0.32</b>	Class B2-3 Not Supported: Fair
9/22/14 DEC <sup>3</sup>	434.7	35.0	16.0	56.9	3.78	<b>17.5</b>	0.93	0.40	Class B2-3 Not Supported: Fair
9/22/14 BCE	469.7	30.0	19.0	60.3	3.71	11.2	0.95	0.45	Class B2-3 Supported: Good
9/25/15	<b>223.5</b>	31.0	19.0	65.1	1.99	6.8	0.84	0.48	Class B2-3 Not Supported: Fair to Good
<b>Annual Mean (2006-2015)</b>	329.5	<b>25.6</b>	<b>14.7</b>	65.7	2.76	6.6	0.90	0.44	
Class B2-3	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
<b>Bold</b> denotes value does not meet the proposed macroinvertebrate biocriteria threshold <sup>1</sup> Large flood events in August 2010 and August 2011 <sup>2</sup> Sampled five days following a freshet event. <sup>3</sup> One replicate only									

**West Branch of Little River RM 7.5:** The middle West Branch station is located below the discharge from the Mt. Mansfield sedimentation basin. The September 2015 kick net results were found to meet the Class B biocriteria for all metrics with the exception of density.



<b>Table 10. Macroinvertebrate Results West Branch of Little River RM7.5 (MS-8) Below Lower Entrance to Mount Mansfield (Above Big Spruce Brook Confluence)</b>									
<b>Year</b>	<b>Density</b>	<b>Richness</b>	<b>EPT</b>	<b>PMA-O</b>	<b>BI</b>	<b>% Oligo.</b>	<b>EPT/EPT+C</b>	<b>PPCS-FG</b>	<b>Outcome</b>
Sept. 2000 PEA	<b>118</b>	<b>24.5</b>	<b>13</b>	55	2.08	1.9	0.76	0.40	Class B2-3 Not Supported: Fair
Sept. 2000 VANR	605	<b>22</b>	<b>12</b>	55	3.13	0.0	0.70	<b>0.39</b>	Class B2-3 Not Supported: Fair
Sept. 2001 VANR	<b>130</b>	<b>25.5</b>	<b>15</b>	72	2.68	0.40	0.80	0.47	Class B2-3 Not Supported: Fair
Oct. 2003 PEA <sup>1</sup>	<b>123.5</b>	<b>18.5</b>	<b>8.5</b>	49	3.56	<b>44.0</b>	0.57	0.41	Class B2-3 Not Supported: Poor
Nov. 2004 PEA	<b>165.5</b>	<b>25</b>	<b>14</b>	58	1.45	<b>14.1</b>	0.90	0.54	Class B2-3 Not Supported: Fair
Sept. 2005 BCE	<b>179</b>	34	<b>15</b>	73	2.19	<b>23</b>	0.80	0.47	Class B2-3 Not Supported: Fair
10/10/2006 BCE	<b>185.5</b>	<b>26</b>	17	64	1.76	5.9	0.91	0.60	Class B2-3 Not Supported: Fair
9/7/2007 BCE	629	28.5	17.5	65	2.28	3.3	0.93	0.44	Class B2-3 Supported: Good
9/12/2008 BCE	<b>213.5</b>	<b>26.5</b>	16.0	67	2.89	2.5	0.91	0.48	Class B2-3 Not Supported: Fair
9/10/2009 BCE	477.5	28	16.5	71	2.45	1.8	0.86	0.44	Class B2-3 Supported: Good
9/26/2009 BCE	350.0	28.5	19.0	70	1.95	1.7	0.90	0.50	Class B2-3 Supported: Good
9/27/2010 <sup>2</sup> BCE	<b>88</b>	<b>23</b>	<b>14.5</b>	65	2.63	7.3	0.92	0.49	Class B2-3 Not Supported: Poor
9/28/2011 <sup>2</sup> BCE	<b>99.5</b>	<b>19.5</b>	<b>13</b>	68	2.23	1.5	0.88	0.51	Class B2-3 Not Supported: Poor
9/16/12 BCE	417.3	30.0	18.0	69.4	2.83	0.6	0.91	0.43	Class B2-3 Supported: Good
9/19/2013 BCE	<b>260.5</b>	33.0	19.0	66.8	2.39	<b>12.5</b>	0.88	0.41	Indeterminate for Class B2-3 (Fair to Good)
9/22/14 BCE	344.2	29.5	18.5	68.0	2.19	8.4	0.91	<b>0.36</b>	Class B2-3 Supported: Good
9/25/15 BCE	<b>237.5</b>	32.5	21.0	68.5	2.09	7.1	0.83	0.49	Class B2-3 Not Supported: Fair to Good

<b>Table 10. Macroinvertebrate Results</b> <b>West Branch of Little River RM7.5 (MS-8)</b> <b>Below Lower Entrance to Mount Mansfield (Above Big Spruce Brook Confluence)</b>									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Annual Mean (2006-2015)	288.9	27.7	17.2	67.2	2.35	5.1	0.90	0.47	
Annual Mean (2000-2015)	256.6	26.9	15.8	65.3	2.40	8.9	0.85	0.46	
Class B2-3	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
<b>Bold</b> denotes value does not meet the proposed macroinvertebrate biocriteria threshold <sup>1</sup> Petroleum spill in 2003 <sup>2</sup> Large flood event in August 2010									

**West Branch of Little River (RM 6.5):** This is the fourth consecutive year, since the extreme high flow events in 2010 and 2011 that the metrics for RM6.5 passed the biocriteria. All eight metrics exceeded the threshold values, and the macroinvertebrate community was found to be of good biological integrity.

<b>Table 11. Macroinvertebrate Results</b> <b>West Branch of Little River RM 6.5 (MS-14)</b> <b>Above Pinnacle Brook</b>									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Sept. 2000 PEA	420	38	21	70	3.35	0.4	0.69	0.44	Class B1 Supported: V.Good
Oct. 2003 <sup>1</sup> PEA	135	24.5	14	58	3.62	19.5	0.64	0.56	Class B2-3 Not Supported: Fair
Nov. 2004 PEA	364	38	23.5	65	3.01	14.1	0.90	0.65	Indeterminate
Sept. 2005 BCE & DEC	352	43	24	80	1.91	9.2	0.83	0.52	Class B2-3 Supported: Good
10/10/2006 BCE	212	30.5	20.5	70	1.86	1.8	0.90	0.67	Class B2-3 Not Supported: Fair
9/7/2007 BCE	626	27	16.0	81	2.06	1.8	0.91	0.59	Class B2-3 Supported: Good
9/12/2008 BCE	272	25	15.0	64	3.40	2.7	0.95	0.52	Class B2-3 Not Supported: Fair

**Table II. Macroinvertebrate Results  
West Branch of Little River RM 6.5 (MS-14)  
Above Pinnacle Brook**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/12/2008 DEC	302	35	20	73.7	2.90	1.7	0.91	0.60	Class B2-3 Supported: Good
9/10/2009 BCE	593	30	18.5	74.7	2.47	0	0.90	0.52	Class B2-3 Supported: VG to Good
9/11/2009 DEC	694.5	44	26	76.7	2.86	1.7	0.87	0.59	Class B1 Supported: VG to Exc.
9/27/2010 <sup>2</sup> BCE	<b>158.5</b>	31.5	21.5	64	2.67	2.0	0.95	0.53	Class B2-3 Not Supported: Fair
9/9/2011 <sup>2</sup> DEC	<b>266</b>	43	23	69.7	3.45	1.9	0.92	0.62	Class B2-3 Not Supported: Fair
9/28/2011 <sup>2</sup> BCE	<b>207.5</b>	<b>25.5</b>	18	53	3.98	0.6	0.96	0.41	Class B2-3 Not Supported: Fair
8/30/2012 DEC	936.0	39.7	23.7	71.5	2.67	1.0	0.84	0.49	Class B1 Supported: V.Good
9/16/2012 BCE	340.9	34.5	22.0	73.0	2.47	1.2	0.83	0.45	Class B2-3 Supported: Good
10/24/12 <sup>3</sup> DEC	589.5	42.0	29.0	60.5	1.64	3.6	0.93	<b>0.29</b>	Class B2-3 Not Supported: Fair to good
9/19/13 <sup>4</sup> BCE	350.2	35.0	22.5	69.5	2.67	3.1	0.89	<b>0.39</b>	Class B2-3 Supported: Good
9/22/14 BCE	354.3	33.0	21.5	65.1	3.17	2.4	0.93	0.49	Class B2-3 Supported: Good
9/25/15 BCE	374.8	41.5	24.5	65.5	2.46	1.5	0.69	0.47	Class B2-3 Supported: Good
<b>Annual Mean (2006-2015)</b>	388.2	33.7	21.0	69.3	2.70	1.8	0.89	0.52	
<b>Annual Mean (2000-2015)</b>	368.1	34.3	20.9	69.0	2.78	4.4	0.85	0.53	
Class B2-3	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	

**Bold** denotes value does not meet the proposed macroinvertebrate biocriteria threshold

<sup>1</sup> Petroleum spill in 2003

<sup>2</sup> Large flood event in August 2010 and 2011

<sup>3</sup> Sampled five days after a freshet event

<sup>4</sup>PPCS slightly under threshold value of 0.40 with very good EPT and Richness numbers.

**Table 12. Macroinvertebrate Results  
Big Spruce Brook RM0.9  
Below Ski Trails**

**Bold** denotes value does not meet the proposed macroinvertebrate biocriteria threshold

**Table 13. Macroinvertebrate Results  
Big Spruce Brook RM0.8  
Below Big Spruce Access Road Bridge**

**Bold** denotes value does not meet the proposed macroinvertebrate biocriteria threshold

**Big Spruce RM 0.3:** A biomonitoring station was added on Big Spruce Brook during 2006 to provide a second set of data to evaluate compliance with Class B2-3 biocriteria and to bracket Little Spruce Brook. Similar to 2014, four of the eight metrics fell below the threshold value for Class B2-3 biocriteria at Big Spruce RM 0.3 in 2015. Although, the density was higher at BS0.3 than BS0.8 (within a heavy iron seep), richness and EPT richness values were quite similar. The multiple heavy iron seeps in the reach between the Spruce Peak culvert and station BS0.3 is greatly impacting the macroinvertebrate community.

**Table 14. Macroinvertebrate Results  
Big Spruce Brook RM 0.3 (MS10-a)  
Upstream of Club House**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
10/10/2006 BCE	<b>207</b>	29.5	17.5	72	2.77	0.5	0.89	0.46	Class B2-3 Not Supported: Fair
9/7/2007 BCE	314.5	36.5	20.5	84	2.04	0.1	0.78	0.64	Class B2-3 Supported: Good
9/12/2008 BCE	<b>125</b>	<b>25.5</b>	<b>12.0</b>	72	1.59	1.5	0.87	0.44	Class B2-3 Not Supported: Fair
9/10/2009 BCE	358.5	<b>25.5</b>	<b>13.0</b>	79	2.38	0.3	0.68	0.50	Class B2-3 Not Supported: Fair
9/27/2010 <sup>1</sup> BCE	<b>64</b>	<b>20.0</b>	<b>13.0</b>	66	2.44	3.1	0.77	0.53	Class B2-3 Not Supported: Poor
9/28/2011 <sup>1</sup> BCE <sup>1</sup>	<b>99</b>	<b>22.0</b>	<b>13.0</b>	74	2.50	3.0	0.90	0.41	Class B2-3 Not Supported: Poor
9/16/2012 BCE	346.0	38.0	20.0	56.3	3.17	1.2	0.45	0.48	Class B2-3 Supported: Good
9/19/2013 BCE	<b>116</b>	30.0	16.0	68.4	2.10	0.0	0.84	0.44	Class B2-3 Not Supported: Poor to Fair
9/22/14 BCE	<b>132</b>	<b>25.0</b>	<b>11.0</b>	47.8	1.71	5.3	0.66	<b>0.38</b>	Class B2-3 Not Supported: Fair to Poor
9/25/15 BCE	<b>241</b>	<b>22.0</b>	<b>9.0</b>	45.1	1.99	4.6	0.70	<b>0.35</b>	Class B2-3 Not Supported: Fair to Poor
<b>Annual Mean (2006-2015)</b>	<b>200.3</b>	27.4	<b>14.5</b>	66.5	2.27	2.0	0.75	0.46	
Class B2-3	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	

**Bold** denotes value does not meet the proposed macroinvertebrate biocriteria threshold; <sup>1</sup>Large flood event in August 2010

**Big Spruce - RM0.2:** The geomorphic stability and habitat of Big Spruce at RM0.2 was greatly impacted by extreme high flow events that took place during 2010 and 2011. Channel adjustment processes in response to those events have been noted (Nealon, 2012). The results of the kick net sampling indicate the macroinvertebrate community at Big Spruce RM0.2 has not rebounded since the extreme high events of 2010 and 2011. Similar to 2013 and 2014, the Density and EPT Richness values fell below the Class B2-3 threshold value in 2015. Strong iron seeps in the reach above the golf cottage, are suspected of suppressing density and EPT Richness at this station.

**Table 15. Macroinvertebrate Results  
Big Spruce Brook RM0.2 (MS-10)  
At Mouth**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Sept. 2000 PEA	<b>207</b>	39.5	20.5	71	3.45	2.7	0.66	0.62	Class B2-3 Not Supported: Fair
Oct. 2003 PEA	<b>261</b>	35	21	60	1.76	1.5	0.76	0.45	Class B2-3 Not Supported: Good to Fair
Nov. 2004 PEA	1224	35	<b>14</b>	<b>44</b>	4.24	2.0	<b>0.26</b>	0.48	Class B2-3 Not Supported: Fair
Sept. 2005 BCE	<b>209</b>	44	19	67	2.45	<b>12.6</b>	0.70	0.56	Class B2-3 Not Supported: Fair
10/10/2006 BCE	<b>181.5</b>	<b>24</b>	<b>14.5</b>	69	2.74	0.3	0.84	0.45	Class B2-3 Not Supported: Fair
9/7/2007 BCE	500.5	29.5	18.0	77	2.37	0	0.67	0.48	Class B2-3 Supported: Good
9/12/2008 BCE	<b>225</b>	29.5	17.0	83	2.27	0.2	0.87	0.56	Class B2-3 Not Supported: Fair to good
9/10/2009 BCE	474.5	29.0	17.5	83	2.93	0.8	0.71	0.52	Class B2-3 Supported: Good
9/26/2009 BCE	322.5	35.5	22.0	80	1.87	0.5	0.88	0.62	Class B2-3 Supported: Good
9/27/2010 <sup>1</sup> BCE	<b>105</b>	<b>25.5</b>	<b>14.5</b>	70	3.44	0.5	0.65	0.65	Class B2-3 Not Supported: Fair to Poor



**Table 15. Macroinvertebrate Results  
Big Spruce Brook RM0.2 (MS-10)  
At Mouth**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/28/2011 <sup>1</sup> BCE	<b>166.5</b>	36	19.5	73	2.84	3.6	0.70	0.52	Class B2-3 Not Supported: Fair
9/16/2012 BCE	<b>187.0</b>	32.5	17.5	63.5	2.49	0.9	0.66	0.44	Class B2-3 Not Supported: Fair
9/19/2013 BCE	<b>176.0</b>	32	<b>15.5</b>	64.6	2.62	2.8	0.75	0.44	Class B2-3 Not Supported: Fair
9/22/14 BCE	<b>153.5</b>	28.5	<b>14.5</b>	61.7	1.98	3.0	0.76	0.42	Class B2-3 Not Supported: Fair
9/25/15 BCE	<b>192.5</b>	27.0	<b>12.0</b>	47.5	1.42	2.4	0.79	0.43	Class B2-3 Not Supported: Fair
<b>Annual Mean (2006-2015)</b>	<b>228.6</b>	29.7	16.3	69.1	2.46	1.4	0.75	0.50	
<b>Annual Mean (2000-2015)</b>	<b>299.1</b>	32.2	16.9	66.6	2.61	2.4	0.70	0.50	
Class B2-3	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
<b>Bold</b> denotes value does not meet the proposed macroinvertebrate biocriteria threshold									
<sup>1</sup> Large flood event in August 2010 and August 2011									

**Pinnacle Brook – RM0.1:** Pinnacle Brook acts as a local control/reference station for the other biomonitoring stations at Stowe Mountain Resort. The 2015 macroinvertebrate results from the lower Pinnacle Brook station indicate the biological integrity was very good as summarized in Table 16.

**Table 16. Macroinvertebrate Results  
Pinnacle Brook MS-13 At Mouth**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Sept. 2000 PEA	714	35.5	21.5	72	2.05	0.0	0.68	0.56	Class A1 Supported: Exc.
Oct. 2003 PEA	1098	28	16.5	65	1.20	0.4	0.91	0.40	Class B2-3 Supported: Good
Nov. 2004 PEA	499	32.5	17.5	58	2.17	3.1	0.76	0.53	Class B2-3 Supported: Good

**Table 16. Macroinvertebrate Results  
Pinnacle Brook MS-13 At Mouth**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Sept. 2005 BCE	601	53	22	67	2.43	14.0 <sup>1</sup>	0.64	0.47	Class B2-3 Supported: Very Good to good
10/10/2006 BCE	499	30	18	70	1.61	0	0.90	0.65	Class B2-3 Supported: Good
9/7/2007 BCE	791.5	28	18	79	2.00	0	0.79	0.58	Class B2-3 Supported: Good
9/12/2008 BCE	411.5	33.5	17.5	61	2.58	1.5	0.64	<b>0.39</b> <sup>2</sup>	Class B2-3: Good
9/10/2009 BCE	649.5	30	18	74	3.17	0.2	0.68	0.68	Class B2-3 Supported: Good to very good
9/27/2010 BCE	439	30.5	19	80	1.94	0.6	0.75	0.56	Class B2-3 Supported: Good to very good
9/28/2011 <sup>3</sup> BCE	320.5	28.5	17.5	69	2.01	0.4	0.83	0.45	Class B2-3 Supported: Good
9/16/2012 BCE	607.7	37.5	21.5	77.1	1.97	0	0.74	0.54	Class A1 Supported: Exc.
9/19/13 BCE	412.0	40.5	24.5	77.6	2.56	0.3	0.79	0.45	Class B1 Supported: Very Good
9/22/14 BCE	426.3	35.5	21.0	64.9	2.15	1.0	0.70	0.48	Class B1 Supported: Very Good
9/25/15 BCE	462.5	38.0	23.5	67.4	1.85	0.0	0.74	0.57	Class B1 Supported: Very Good
<b>Annual Mean (2006-2015)</b>	502.0	33.2	19.9	72.0	2.18	0.4	0.76	0.54	
<b>Annual Mean (2000-2015)</b>	566.5	34.3	19.7	70.1	2.12	1.5	0.75	0.52	
Class B2-3	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	

<sup>1</sup>high percentage of Oligochaeta in 2005 not associated with deposition (Naididae)

<sup>2</sup>Functional feeding group metric is dissimilar to the reference Class B2-3 community because it is critically acidified. Overall biological integrity is good.

<sup>3</sup>Flood event in late. August 2011 (Tropical Storm Irene)

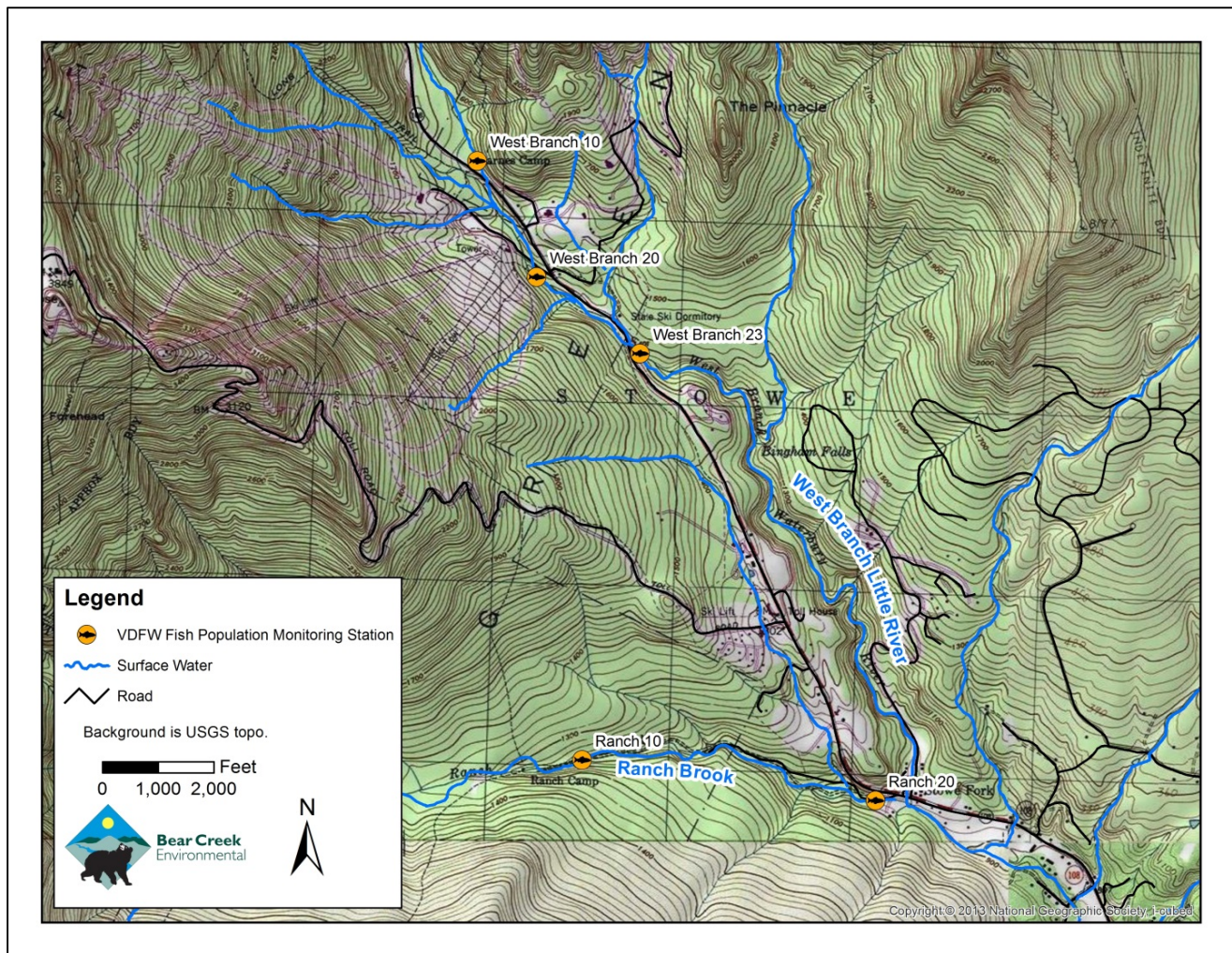
**Bold** denotes value does not meet the proposed macroinvertebrate biocriteria threshold

### 8.3 Fish Population Monitoring

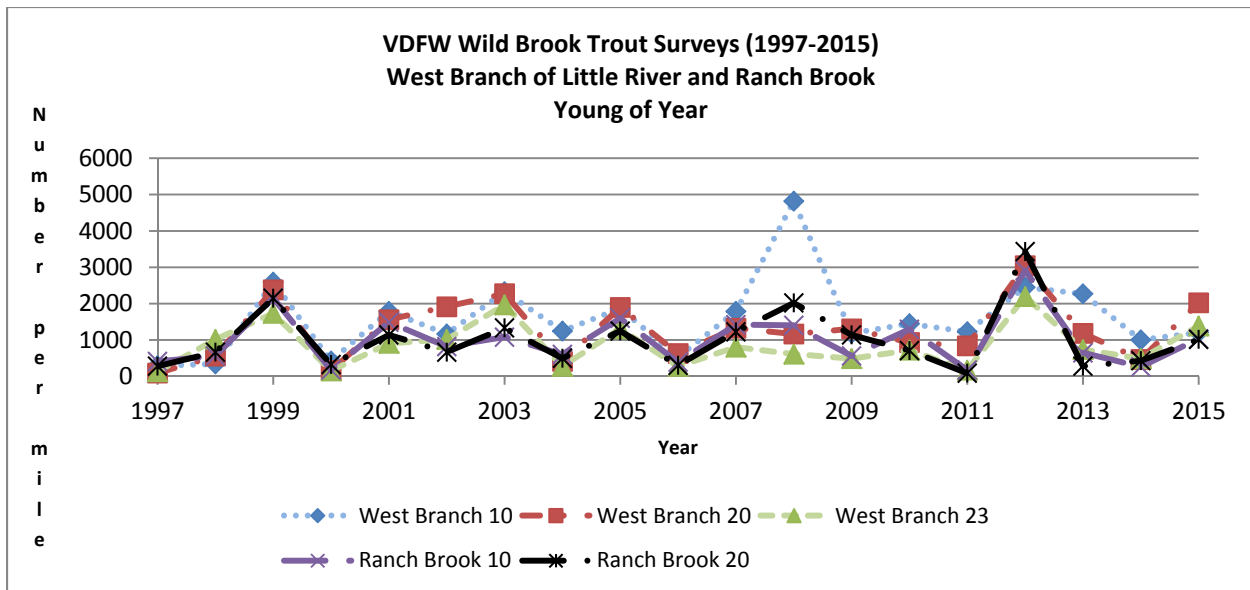
The Vermont Department of Fish and Wildlife (VDFW) has been monitoring wild brook trout populations annually since 1994 at three stations on the West Branch in the vicinity of Stowe Mountain Resort and two stations on Ranch Brook (Figure 38). Monitoring stations are summarized in the following Table 17. Trout densities per mile have been provided courtesy of Rich Kirn, Fisheries Biologist with the VDFW, and are included in Appendix 4 on pages 17 and 18. The mean number of young-of-the-year brook trout per mile from 1997 through 2015 is highest on West Branch 10 (1576) and West Branch 20 (1271). The other three stations (Ranch 10, Ranch 20 and West Branch 23) have similar average densities of young-of-the-year trout in the range of 860 to 1000 fish per mile. Mean densities of yearling and older trout for 1997 through 2015 are in the range of 700 to 1100 trout per mile. Graphs showing the number of young-of-the-year and yearling and older wild brook trout are provided below in figures 39 and 40, respectively. The results indicate there is a healthy wild brook trout population in the West Branch in the vicinity of Stowe Mountain Resort.

**Table 17. Vermont Fish and Wildlife Department  
Annual Brook Trout Monitoring Stations**

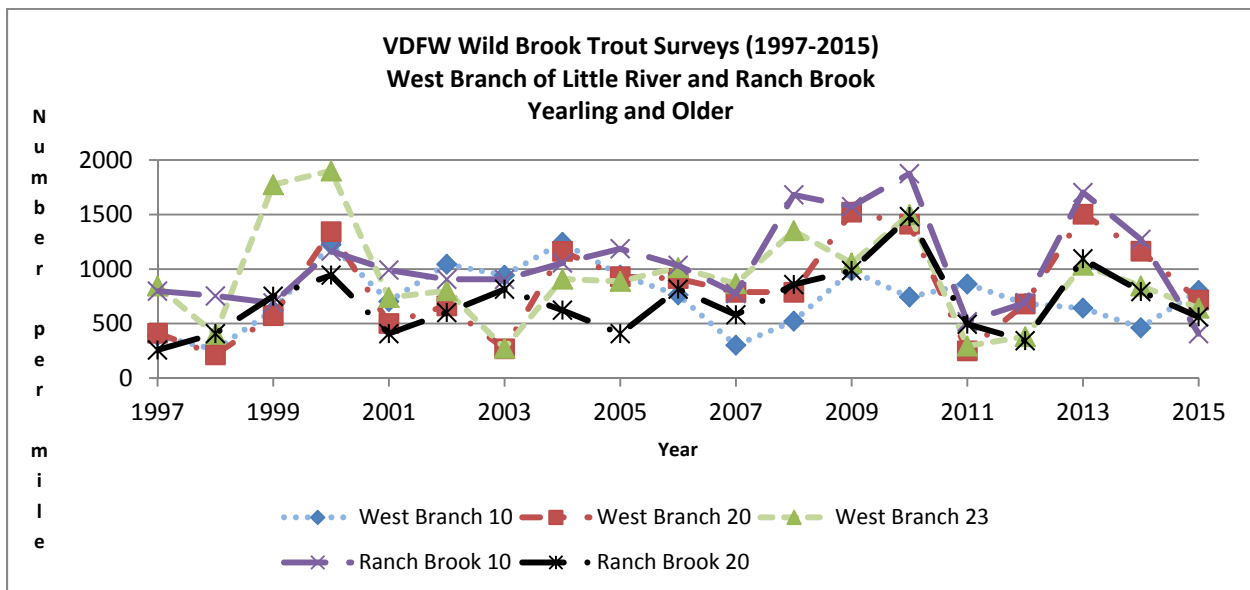
<b>Station</b>	<b>Elevation (feet)</b>	<b>Location</b>
West Branch 10	1550	Near Barnes Camp
West Branch 20	1440	Mansfield Parking Lot Exit
West Branch 23	1410	At Stowe Mountain Resort pump house
Ranch Brook 10	1200	Near Ranch Camp
Ranch Brook 20	960	Above confluence with West Branch



**Figure 38. Vermont Fish and Wildlife Department Brook Trout Monitoring Stations**



**Figure 39. Vermont Fish and Wildlife Department brook trout young-of-year data.**



**Figure 40. Vermont Fish and Wildlife Department brook trout yearling and older data.**

## **9.0 WATER QUALITY SUMMARY**

This section presents a water quality summary of the assessment streams based on field observations, biomonitoring data and water chemistry data.

### **9.1 West Branch of the Little River**

The water quality summary for the three West Branch monitoring stations is provided in Table 18. In about half of the years sampled, the upper West Branch above Stowe Mountain Resort at river mile 8.8 has met aquatic life support (ALS). Richness and EPT have been lower than the Class B threshold in some of the years, and is likely attributed to the very low alkalinity at this station.

Three years of monitoring have been completed since Stowe Mountain Resort implemented significant stormwater improvements associated with the parking lots at Mount Mansfield. Biomonitoring results from VVB8.0 indicate sedimentation is an issue. The substrate information show sediment targets were met in only one of three years. In 2013 and 2015 the kick net samples did not meet Class B biocriteria. In 2014 the results were mixed with one sample collected by BCE meeting ALS and the other collected by VDEC not meeting ALS. Both samples had high percentages of Oligochaeta (worms) supporting a sedimentation problem. It appears that scour in some years is reducing densities and richness. The low alkalinity at this station is also likely playing a role in biological integrity of the macroinvertebrate community.

Station WB7.5, located below the exit to the Mansfield parking lot, has been teetering on meeting Class B water quality standards since stormwater improvements were completed in 2012, thereby being indeterminate in 2013 for ALS, meeting ALS in 2014, and being not support in 2015. A pattern of sedimentation and scour in addition to low alkalinity may also explain the biomonitoring results at this station.



The lowest monitoring station on the West Branch (RM6.5) has meet Class B water quality standards in all three years following the completion of the stormwater improvements.

Other than low alkalinity, there are no apparent water quality or habitat concerns at this station.

**Table 18. West Branch of Little River Water Quality Summary (2015)**

Station	Location	Category				Water Quality Concerns
		Physical Habitat	Water Chemistry	Sediment Targets	Aquatic Life Support (Class B Biocriteria)	
WB8.8	Above SMR in picnic area	Good habitat	Low alkalinity	Meets all three targets	Class B supported – “Good”	None
WB8.0 (MS-16B)	Above Mount Mansfield sedimentation basin	Fair habitat quality, hydrologic regime – possible scour (stormwater improvements in 2012)	Low alkalinity	Meets two of three targets	Class B not supported – “Fair to good”	Small iron seeps, sand
WB7.5 (MS-8)	Above Big Spruce Confluence	Hydrologic regime (stormwater improvements in 2012)	Low alkalinity	Meets all three targets	Class B not supported – “Fair to good”	Light iron staining
WB6.5 (MS-14)	Above Pinnacle Brook Confluence	Hydrologic regime (stormwater improvements in 2012)	Low alkalinity	Meets all three targets	Class B supported – “Good”	None

## 9.2 Big Spruce Brook

Recent field observations, water chemistry data, and biomonitoring data from 2015 and 2016 indicate the heavy iron seeps in Big Spruce Brook are impacting the macroinvertebrate community. An iron seep, located at Big Spruce Brook RM 0.3 was remediated in fall 2010 by SMR to improve a localized seep. Heavy iron seeps between river mile 0.8 and 0.3 are located in areas where access is poor and banks are steep, making possible remediation of these banks infeasible.

**Table 19. Big Spruce Watershed Water Quality Summary (2015)**

Station	Location	Category				Water Quality Concerns
		Physical Habitat	Water Chemistry	Sediment Targets	Aquatic Life Support (Class B Biocriteria)	
BS0.9 (MS-9)	Big Spruce above Spruce Peak Rd Culvert	Incised channel	Low alkalinity	Meets two of three targets	Class B supported	Small iron seeps
BS0.8	Big Spruce below Spruce Peak Rd Culvert	Substrate covered with iron floc and precipitate	Elevated iron in water column	Not available	Class B not supported	Heavy iron seeps
BS0.3 (MS-10A)	Big Spruce upstream of Little Spruce		Moderate alkalinity; Big Spruce Basin outflow	Meets two of three targets	Class B not supported	Iron seeps
BS0.2 (MS-10)	Big Spruce at mouth	Eroding stream banks	Moderate alkalinity	Meets two of three targets	Class B not supported	Iron seeps

### 9.3 Pinnacle Brook

Other than having a low buffering capacity, there have been no water quality concerns at the lower Pinnacle Brook station. This station has met the Class Biocriteria in all years sampled, dating back to 2000.

**Table 20. Pinnacle Brook Watershed Water Quality Summary (2015)**

Station	Location	Category				Water Quality Concerns
		Physical	Water Chemistry	Sediment Targets	Aquatic Life Support (Class B Biocriteria)	
PB0.I (MS-13)	Lower Pinnacle Brook	Stable banks, good riparian corridor	Low alkalinity	Meets all three targets	Class B2-3 supported	Critically acidified

## 10.0 PROPOSED 2016-2017 MONITORING

SMR has been working with the Vermont DEC to develop and implement water quality improvements in both the Big Spruce and West Branch watersheds, and continues to operate an expensive erosion prevention/sediment control program. Even with this work, streams within the vicinity of the resort are not meeting Class B biocriteria. A meeting with the VDEC to go over the water quality results and the draft part B list of priority surface waters is scheduled for June 13, 2016. At this time, it is also expected that discussions will take place to consider modifications to the monitoring. Following this meeting a schedule of tasks for the 2016-2017 monitoring season will be developed.

## REFERENCES

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