

**Agency of Natural Resources
Department of Environmental Conservation
Watershed Management Division
1 National Life Drive, Davis 3**

MEMORANDUM

To: 2024 Listing File

From: Biomonitoring and Aquatic Studies Section; River Science Section, Rivers Program

Cc: Tim Clear, Chip Gianfagna (TMDLs, Assessment, Standards and Compliance Program),
Jeff Crocker (River Science Section, Rivers Program)

Date: January 5, 2024

Subject: Aquatic Biota Impairment of Holmes Creek (Charlotte, VT)

Background

Holmes Creek is a small stream located entirely within the town of Charlotte, VT, and is a direct tributary of Lake Champlain (Figure 1). Holmes Creek has three tributaries large enough in size to be perennial during years with average precipitation and/or flow, including one named tributary, Pringle Brook. The elevation of Holmes Creek at its confluence with Lake Champlain is approximately 100 feet above sea level. The mainstem and tributary #1 monitoring sites generally range from 105-115 feet above sea level, though the low to moderate gradient throughout the stream's lower reaches make it difficult to accurately determine each site's precise elevation. The elevation of the monitoring station on tributary #3 is approximately 180 feet above sea level.

The stream's 14.5 km² watershed is dominated by agricultural land use (approximately 64%, primarily hay and pasture), with significant forested land cover (19%) and smaller amounts of wetland and developed land (Table 1). An analysis of land use within the 30-meter buffer of the stream network upstream of the monitoring station at river mile (RM) 0.2 shows similar percentages of forest and development compared to the overall watershed, with substantial but slightly less agriculture (54%) and more riparian wetland cover (24%).

Water quality monitoring was performed at two stations on Holmes Creek by the [LaRosa Partnership Program](#) (LPP) between 2010 and 2013; RM 0.2 (on the mainstem just above the confluence with Trib #1), and Trib #1 RM 0.1 (just above the confluence with the mainstem). LPP monitoring during this time included total and dissolved phosphorus, total nitrogen, nitrate/nitrite, total suspended solids, turbidity, and a small number of chloride samples.

The Biomonitoring and Aquatic Studies Section (BASS) in the Watershed Management Division of the Department of Environmental Conservation (DEC) first collected water quality and macroinvertebrate data in this watershed at Trib #3 RM 0.1 in 2011 as part of its [Ambient Monitoring Network](#) (ABN)

program. This was followed by the collection of water quality, habitat and macroinvertebrate data at RM 0.2 in 2021, and at RM 0.2 and RM 0.5 in 2023. Additional water quality collections were done at RM 0.1, RM 0.5 and Trib #1 RM 0.5 during summer 2023 to supplement the biological data. Biological collections were not feasible at RM 0.1 (non-wadeable) or Trib #1 RM 0.5 (inadequate flow for biological sampling) in 2023. Imagery and field observations suggest that a majority of reaches in the watershed would be characterized as low gradient stream types (slow low gradient (SLG) or hybrid low gradient (HLG)). However, riffle habitat at RM 0.2 indicates that this reach should be designated as a warm-water moderate gradient (WWMG) stream type.

Water Chemistry and Habitat

The LPP turbidity, phosphorus and nitrogen data were aggregated and summarized (Figure 2). Chloride, nitrate/nitrite and total suspended solids (TSS) data were also collected by the LPP but are not shown in Figure 2. There were only five chloride samples collected over this period, one at Trib #1 RM 0.1 (13 mg/l) and four at RM 0.2 (ranging from 19-23 mg/l). These concentrations are below levels that cause chronic effects on macroinvertebrate communities. Nitrate/nitrite concentrations were also very low, with 13 of 25 observations at or below the 0.05 mg/l detection limit, and only two samples exceeding 0.09 mg/l. TSS ranged from 6-52 mg/l at the Trib #1 RM 0.1 station and from 9-55 mg/l at the RM 0.2 station. TSS values are correlated with turbidity, and the latter is shown in Figure 2 as a representation of sediment and siltation stress.

The LPP data are not associated with flow types (e.g. baseflow vs. freshet flow), which limits the interpretation of water chemistry data. While the inclusion of both baseflow and freshet flow data increases data variability, concentrations of turbidity and nutrient parameters are generally very high (Figure 2) and well above what would be expected under reference conditions. All total phosphorus samples at both stations exceeded the 27 µg/l Vermont Water Quality Standards (VWQS) baseflow nutrient criteria for WWMG streams (applied at low median monthly flow during June through October), and a majority of turbidity readings exceeded the VWQS baseflow criteria of 25 NTU.

ABN water quality data taken at Trib #3 RM 0.1 in 2011 and at Trib #1 RM 0.5 and mainstem sites RM 0.1, RM 0.2 and RM 0.5 in 2021 and 2023 show similar patterns (Table 2). Except for the RM 0.2 sampling event in 2021, all samples were collected under baseflow conditions. Alkalinity and pH are elevated above expected background levels. Turbidity is variable, with results both above and below the VWQS criteria of 25 NTU depending on the site and sampling date, however, all results were notably higher than the near-zero expected turbidity for an undisturbed stream at baseflow. Total aluminum and total iron are also high, likely due to fine sediments and suspended solids indicated by the high turbidity values. Iron and aluminum have been used to illustrate this pattern, though other earth metal parameters were similarly elevated.

Total nitrogen, total phosphorus and dissolved phosphorus are all very high at baseflow, with all phosphorus results significantly exceeding the 27 µg/l VWQS criteria for WWMG streams (directly applicable at only the RM 0.2 station). The highest concentrations of nitrogen and phosphorus were found in Trib #1, however concentrations throughout the watershed were at levels expected to act as a primary stressor on aquatic ecosystems. Ammonia and nitrate/nitrite concentrations were also sampled during this period but were found to be at or below the 0.05 mg/l detection limit.

Conductivity and chloride values were also elevated above expected background levels. Chloride was highest at the mainstem sites, with the highest values approaching levels that could be a secondary stressor to sensitive macroinvertebrate populations. Conductivity is likely elevated by both chloride concentrations as well as suspended clay and fine sediments.

Riffle habitat and substrate observations at RM 0.2 in 2021 and 2023 showed low embeddedness, but very high silt ratings (5 out of 5). Fine sediment percentages in the pebble count were low (6% and 0% respectively). These data suggest that habitat is being affected by a general coating of clay and silt from suspended sediment, rather than heavy deposition of fine sediments that would lead to high embeddedness. Despite high nutrient concentrations, algae productivity in the pebble count and in general site observations were noted as low to moderate. Primary productivity is likely being limited by shading from the canopy at RM 0.2.

Biological Assessments

Macroinvertebrate assessments from 2011, 2021 and 2023 are shown in Table 2. The 2011 assessment at Trib #3 received an automatic failing Index of Biotic Integrity (IBI) score as a result of both richness metrics failing to meet individual B(2) thresholds, and five out of 10 metrics failing overall. While the richness of sensitive taxa was low, the relative abundance of organic and nutrient enrichment sensitive species was higher than seen at downstream mainstem sites. This is likely correlated with the elevated but somewhat lower percentage of watershed agriculture and nutrient concentrations compared to downstream monitoring stations.

Macroinvertebrate monitoring at RM 0.2 in 2021 showed a highly degraded community assessed with the lowest possible rating of 'Poor'. Richness metrics were very low, particularly richness within the generally sensitive Ephemeroptera, Plecoptera and Trichoptera (EPT) orders. Biotic index (BI) was very high, suggesting a community dominated by pollution tolerant taxa. Only two taxa collected had individual BI values less than six, representing less than 5% of the total community. Biotic index is a zero (highly sensitive) through 10 (highly tolerant) scale measuring the community's tolerance to nutrient enrichment and organic pollution and can be correlated with thermal stress in some taxa.

A second sample taken at RM 0.2 in 2023 demonstrated a similar assessment and level of biological degradation, though with slightly different metric patterns. Richness values remain low (particularly EPT richness), though values were somewhat higher than seen in 2021. The community was dominated by black fly larvae (*Simulium sp.*, >65%). The dominance of this genus indicates a decline in biological condition and led to both the PMA-O and PPCS-F metrics failing to meet B(2) thresholds. The two most common black fly taxa (*Simulium jenningsi* and *S. tuberosum*) have a moderate BI value of four. While this led to a lower overall BI value that met B(2) criteria compared to the 2021 community, only three of 29 unique taxa found in the community had individual BI values less than five. This suggests a high degree of pollution and enrichment tolerance within the macroinvertebrate community.

The low gradient community sample taken at RM 0.5 in 2023 corroborates the highly degraded biological condition and suspected stressors seen in the RM 0.2 samples. Eight of 10 metrics failed to meet individual B(2) thresholds, resulting in an assessment of 'Poor'. While Ephemeroptera, Odonata, and Trichoptera (EOT) richness just met the minimum number of taxa (eight), richness of sensitive taxa was very low. The community was dominated by a high relative abundance of tolerant species, with 23 of 30 unique taxa having a BI value of 6-10. The dominant taxon in the community was the amphipod

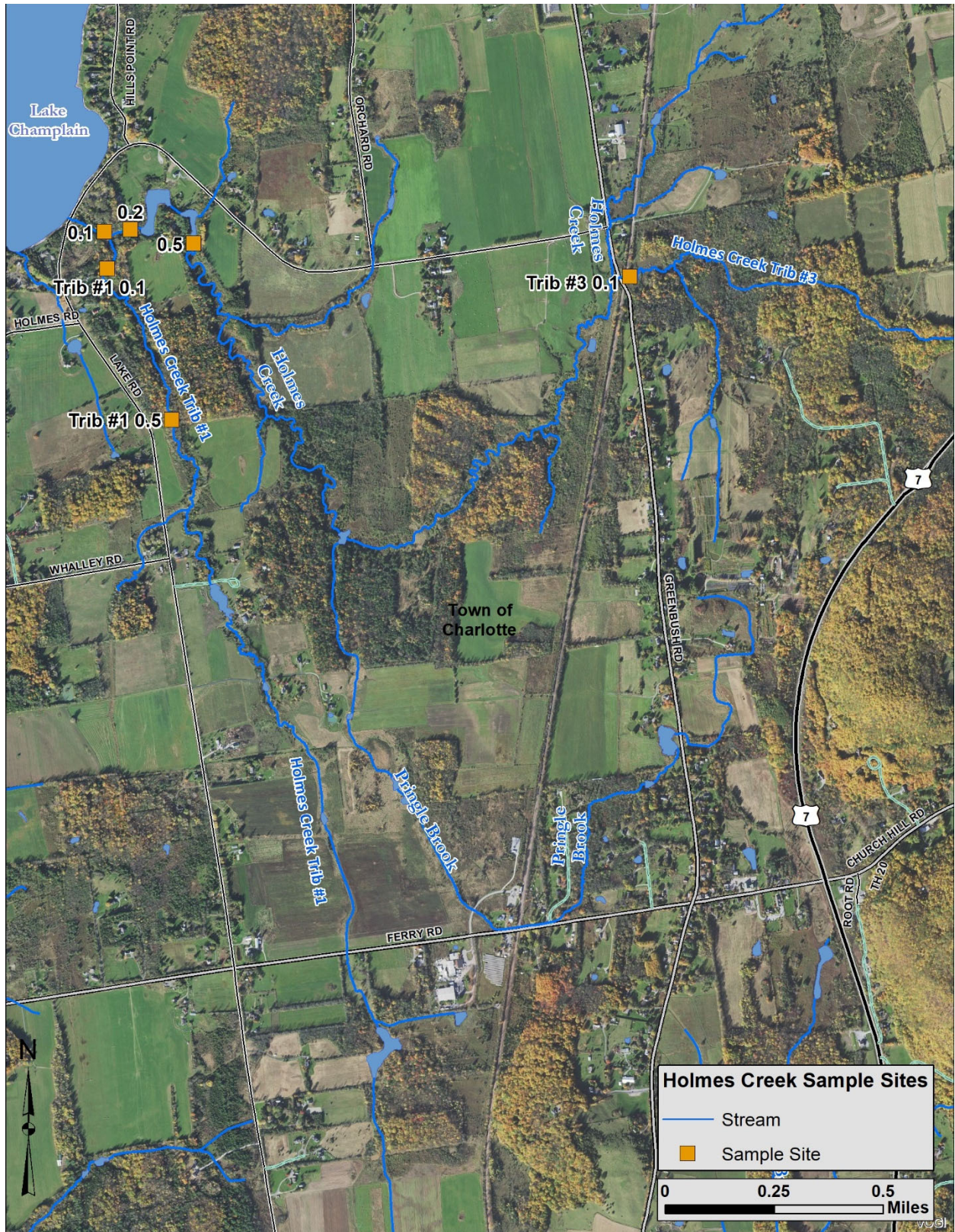
Crangonyx sp (43%). A high relative abundance of amphipods and isopods in low gradient stream communities is generally viewed as an indicator of nutrient enrichment.

Summary

The watershed of Holmes Creek is dominated by agricultural land use. Dozens of water quality samples collected by the ABN and LPP over the last 10 years at multiple stations have shown highly elevated nutrient concentrations with total phosphorus exceeding the WWMG nutrient criteria of 27 µg/l in every instance. Riparian encroachment and surface water runoff are likely exacerbating nutrient pollution by increasing turbidity and sediment stress, as well as increasing chloride and water temperature.

All three recent macroinvertebrate samples collected at two sites on the Holmes Creek mainstem (as well as a 2011 sample on Tributary #3) failed to meet minimum VWQS biological criteria for their respective stream types. Individual metrics suggest organic matter pollution and nutrient enrichment as the primary causes of biological degradation.

Based on the results of these extensive monitoring efforts, BASS is recommending that Holmes Creek be placed on the State's 303(d) List of Impaired Waters due to an aquatic biota use impairment. The primary pollutant is believed to be nutrients and sediment/siltation, with the listed problem being runoff from agricultural lands. Based on the non-point source nature of the stressors, as well as water quality monitoring results and land use patterns on multiple tributaries, we recommend listing the entire stream (and its tributaries) from its confluence with Lake Champlain.



Lake Champlain

HILLS POINT RD

ORCHARD RD

0.1 0.2 0.5

Trib #1 0.1

Trib #1 0.5

HOLMES RD

LAKE RD

Holmes Creek Trib #1

Holmes Creek

Trib #3 0.1

Holmes Creek

Holmes Creek Trib #3

Town of Charlotte

WHALLEY RD

Holmes Creek Trib #1

FERRY RD

Pringle Brook

Pringle Brook

GREENBUSH RD

7

CHURCH HILL RD

TH20

ROOT RD



vs76

Figure 1. Map showing the majority of the Holmes Creek watershed, including major tributaries. Numbers associated with monitoring stations are river miles (RM) measured from the confluence with Lake Champlain.

Table 1. Geographic information, watershed land use data, and macroinvertebrate stream type designations (where applicable) for monitoring stations on Holmes Creek and its tributaries.

Stream	River Mile	Stream Type	Latitude	Longitude	Drainage Area (km ²)	% Agriculture	% Developed	% Wetland	% Forest
Holmes Creek	0.1	-	44.33261	-73.28071	14.4	64	5	11	19
	0.2	WWMG	44.33270	-73.27950	9.9	62	5	9	23
	0.4	-	44.33338	-73.27741	9.9	62	5	9	23
	0.5	SLG	44.33225	-73.27657	9.0	62	5	8	25
Holmes Creek Trib #1	0.1	-	44.33139	-73.28056	4.4	68	6	16	10
	0.5	-	44.32641	-73.27750	4.1	71	5	14	10
Holmes Creek Trib #3	0.1	HLG	44.33129	-73.25637	2.1	41	5	5	47

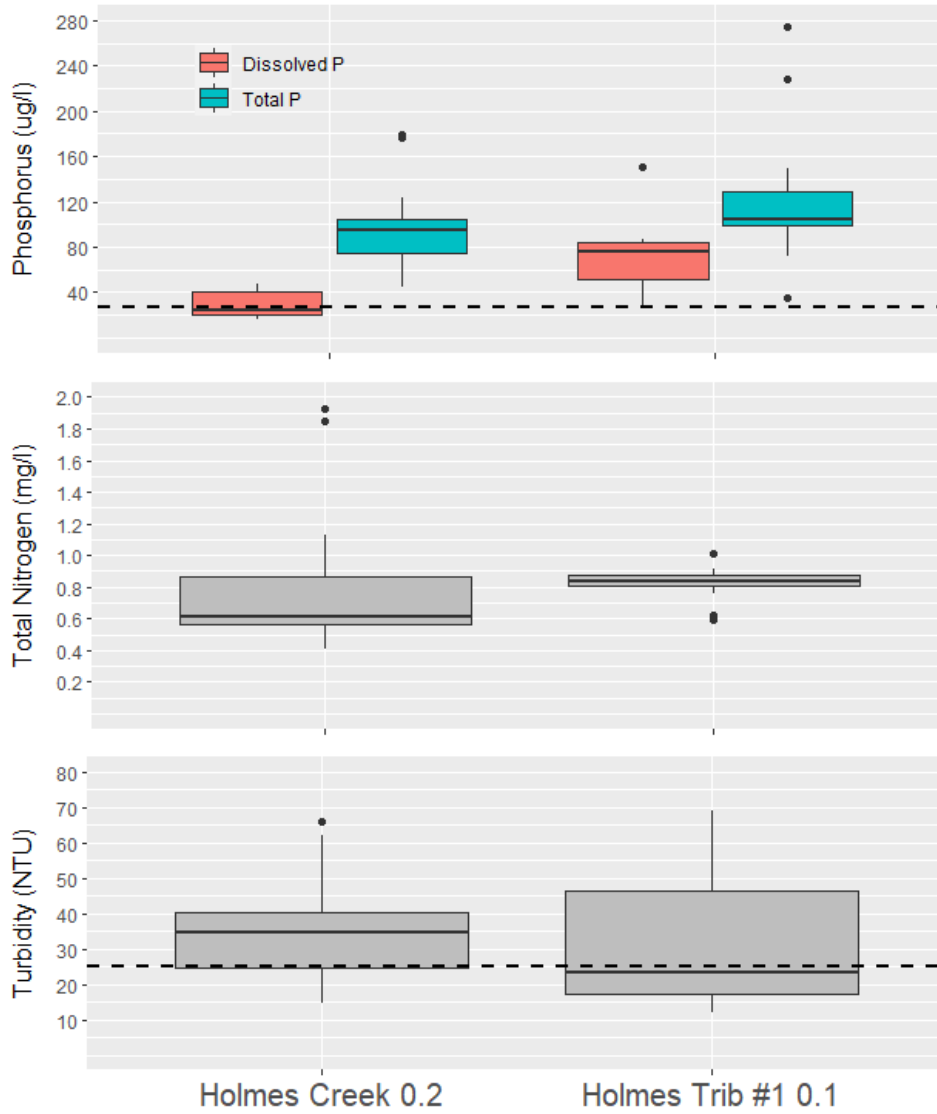


Figure 2. LaRosa Partnership Program water quality data collected from 2010-2013 at two sites on Holmes Creek. Plots represent an aggregation of base and freshet flow data. Dashed lines represent baseflow criteria in the Vermont Water Quality Standards.

Table 2. Relevant water quality data collected by the Biomonitoring and Aquatic Studies Section of DEC. Additional water quality data for these sites can be found in the Vermont Integrated Watershed Information System (IWIS; anrweb.vt.gov/DEC/IWIS).

Stream	River Mile	Date	Flow Level	Flow Type	Dissolved Oxygen (mg/l)	Dissolved Oxygen Saturation (%)	Alkalinity (mg/l)	pH (None)	Conductivity (umho/cm)	Chloride (mg/l)	Dissolved Phosphorus (ug/l)	Total Phosphorus (ug/l)	Total Nitrogen (mg/l)	Total Aluminum (ug/l)	Total Iron (ug/l)	Turbidity (NTU)
Holmes Creek	0.1	2023-06-22	Low	Base	7.7	83.2	210	7.54	571	42.6	34.2	70.6	0.6	547	861	16
		2023-07-20	Low	Base	5.57	62.8	203	7.5	455.4	23.9	75.1	109	0.71	567	879	20.9
		2023-09-07	Low	Base	4.23	49.6	266	7.46	598.9	28.8		92.4	0.68	224	478	9.6
	0.2	2021-10-05	Moderate	Freshet	7.46	72.6	250	7.67	879.1	68.7	83.7	81.8	0.75	610	1040	18
		2023-09-07	Low	Base	4.64	55.2	325	7.52	733.4	35.1	44	84.7	0.58	465	806	15
	0.5	2023-07-20	Low	Base	7.04	80.1	236	7.69	549.1	35.2	46.4	81.9	0.57	854	1320	20.7
		2023-08-24	Low	Base	6.66	74.9	297	7.75	652.4	30.7	31.1	72.2	0.53	617	1110	23
2023-09-07		Moderate	Base	4.5	54.8	323	7.68	720.7	33.6	28	89.2	0.66	77	271	38	
Holmes Creek Trib #1	0.5	2023-07-20	Moderate	Base	7.61	85.9	162	7.63	344.1	11.1	163	177	1.07	248	626	5.5
		2023-08-24	Low	Base	7.98	86.4	244	7.78	490	11.6	91.9	120	1.09	202	428	7.1
		2023-09-07	Low	Base	3.4	38.2	275	7.63	599.2	20.1	77.3	142	1.51	1600	2010	50
Holmes Creek Trib #3	0.1	2011-09-22	Low	Base			254	8.06	583	17.8		34.9				

Table 3. Macroinvertebrate community assessments for biological sampling events at Mud Hollow Brook. Individual metric values are colored to correspond to biological criteria thresholds in the Vermont Water Quality Standards (VWQS). For more information on the calculation of individual metrics and how assessments are determined, refer to Appendix G of the VWQS (dec.vermont.gov/watershed/map/assessment/waterqualitystandards).

Holmes Creek 0.1	Stream Type: Warm-water Moderate Gradient												
	Date	Density	Richness	EPT Richness	PMA-O	Biotic Index	Oligo.	EPT/EPT + Chiro	PPCS-F	Community Assessment			
	2021-10-05	631	18.0	2.0	47.6	6.95	0.35	0.99	0.51	Poor			
	2023-09-07	5260	29.0	7.0	35.9	4.72	4.03	0.80	0.28	Poor/Fair			
	Full Support	≥ 300	≥ 30	≥ 16	≥ 45	≤ 5.4	≤ 12	≥ 0.45	≥ 0.4				
	Indeterminate	≥ 250	≥ 28	≥ 15	≥ 40	≤ 5.65	≤ 14.5	≥ 0.43	≥ 0.35				
Non-Support	< 250	< 28	< 15	< 40	> 5.65	> 14.5	< 0.43	< 0.35					
Holmes Creek 0.5	Stream Type: Slow Low Gradient												
	Date	Density	EOT Richness	BCG Intolerant Richness	PMA-O	Biotic Index	Amphipod + Isopod - Hyallela	EOT/EOT+C	PPCS-F	Sensitive COTE%	EOT Density	IBI Score	Community Assessment
	2023-09-07	2124	8.0	2.0	29.3	7.63	44.4	0.215	0.192	0.377	68.0	18	Poor
	IBI 5	≥ 500	≥ 15	≥ 10	≥ 65	≤ 5.5	0	≥ 0.5	≥ 0.5	≥ 20	≥ 500		
	IBI 4	≥ 400	≥ 11	≥ 7	≥ 57	≤ 6	≤ 1	≥ 0.36	≥ 0.42	≥ 14	≥ 350		
	IBI 3	≥ 300	≥ 8	≥ 5	≥ 50	≤ 6.5	≤ 5	≥ 0.23	≥ 0.34	≥ 9	≥ 200		
	IBI 2	≥ 200	≥ 5	≥ 2	≥ 40	≤ 7	≤ 25	≥ 0.11	≥ 0.29	≥ 3	≥ 100		
IBI 1	≥ 0	≥ 0	≥ 0	≥ 0	>7	>25	≥ 0	≥ 0	≥ 0	≥ 0			
Holmes Creek 2.7	Stream Type: Hybrid Low Gradient												
	Date	Density	EOT Richness	BCG Intolerant Richness	PMA-O	Biotic Index	Amphipod + Isopod - Hyallela	EOT/EOT+C	PPCS-F	Sensitive COTE%	Shredders / Collector	IBI Score	Community Assessment
	2011-09-22	618	8.0	5.0	48.9	5.55	0.0	0.035	0.408	43.042	0.500	28	Fair
	IBI 5	≥ 500	≥ 15	≥ 14	≥ 75	≤ 4	0	≥ 0.5	≥ 0.57	≥ 28	≥ 0.5		
	IBI 4	≥ 400	≥ 13	≥ 11	≥ 65	≤ 5	≤ 1	≥ 0.38	≥ 0.49	≥ 20	≥ 0.35		
	IBI 3	≥ 300	≥ 11	≥ 9	≥ 55	≤ 6	≤ 5	≥ 0.26	≥ 0.41	≥ 13	≥ 0.2		
	IBI 2	≥ 200	≥ 7	≥ 5	≥ 45	≤ 6.5	≤ 25	≥ 0.13	≥ 0.36	≥ 5	≥ 0.1		
IBI 1	≥ 0	≥ 0	≥ 0	≥ 0	>6.5	>25	≥ 0	≥ 0	≥ 0	≥ 0			