WASHINGTON STATE DEPARTMENT OF ECOLOGY

Summary of Streamflow Conditions, September 2000: Fisher Creek and Carpenter Creek Basin

Abstract

To develop a baseline record of late-summer flow conditions for future water-quality and water-quantity investigations, a reconnaissance study was undertaken in the Fisher Creek/Carpenter Creek subbasin of the lower Skagit watershed. A synoptic flow survey (also known as a seepage run) was conducted on September 21, 2000, concentrating on 11 stations within the lower elevation portions of the drainage basin. Total discharge for the drainage area on the day of measurement was estimated to be less than 3 cubic feet per second. The bulk of the discharge measured during this period is assumed to be derived from groundwater baseflow contributions. The limited late-summer baseflows are consistent with the low permeability character of the basin's subsurface geology. Due to the low-flow conditions encountered during the survey period, the discharge estimates calculated for the individual stations have a large error range, preventing defensible conclusions regarding seepage gains or losses along the Carpenter Creek mainstem.

Acknowledgements

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Introduction and Study Purpose

The subbasins of the lower Skagit River watershed face a number of significant water resource and water quality issues of concern. However, the basic environmental monitoring data necessary for decision-making are largely absent. As a result, Ecology's Northwest Regional Office (NWRO) requested that Ecology's Environmental Assessment Program (EAP) evaluate existing water quality and streamflow conditions within the Fisher Creek/Carpenter Creek basin (Figures 1 and 2). This report addresses the NWRO request for an improved understanding of basin flow conditions.

In response to this request, EAP staff conducted a reconnaissance visit to the basin in late July 2000. This visit revealed that summertime streamflow rates were very low throughout the drainage area. Many of the basin tributaries were flowing at a rate low enough to require specialized effort to measure accurately (e.g., construction of temporary weirs).

On the basis of this information, and because of the limited resources available for the project, it was determined that a full-scale monitoring study of streamflow under summer conditions was not justified. As an alternative, EAP staff conducted a one-day, synoptic flow study on September 21, 2000. This flow study concentrated on the lower elevation portion of the basin. The purpose of this monitoring effort was to conduct a reconnaissance of streamflow within the basin during low-flow conditions.

This effort will serve as a benchmark for future flow monitoring within the basin. If resources allow, a second, more extensive synoptic flow monitoring effort will be undertaken by EAP in the spring of 2001, during higher flow conditions.

Objectives

The main objective of the study was to develop a map that summarizes streamflow in the basin during late summer, low-flow conditions. Depending on the estimated accuracy of the flow measurements, a second objective was to develop a preliminary understanding of the streamflow gains and loses along the mainstem of Carpenter Creek (also known as Hill Ditch).

Basin Description

Topography and Drainage

The Fisher Creek and Carpenter Creek drainages occupy a subbasin of the lower Skagit River watershed. The majority of the basin is located in southern Skagit County, southeast of the city of Mt. Vernon, with a small portion covering northern Snohomish County (Figure 1). The basin topography ranges from a flat-lying alluvial plain (Skagit plain) in the westernmost portion of the basin, low rolling hills to the south (lowland), and rugged upland foothills to the east and

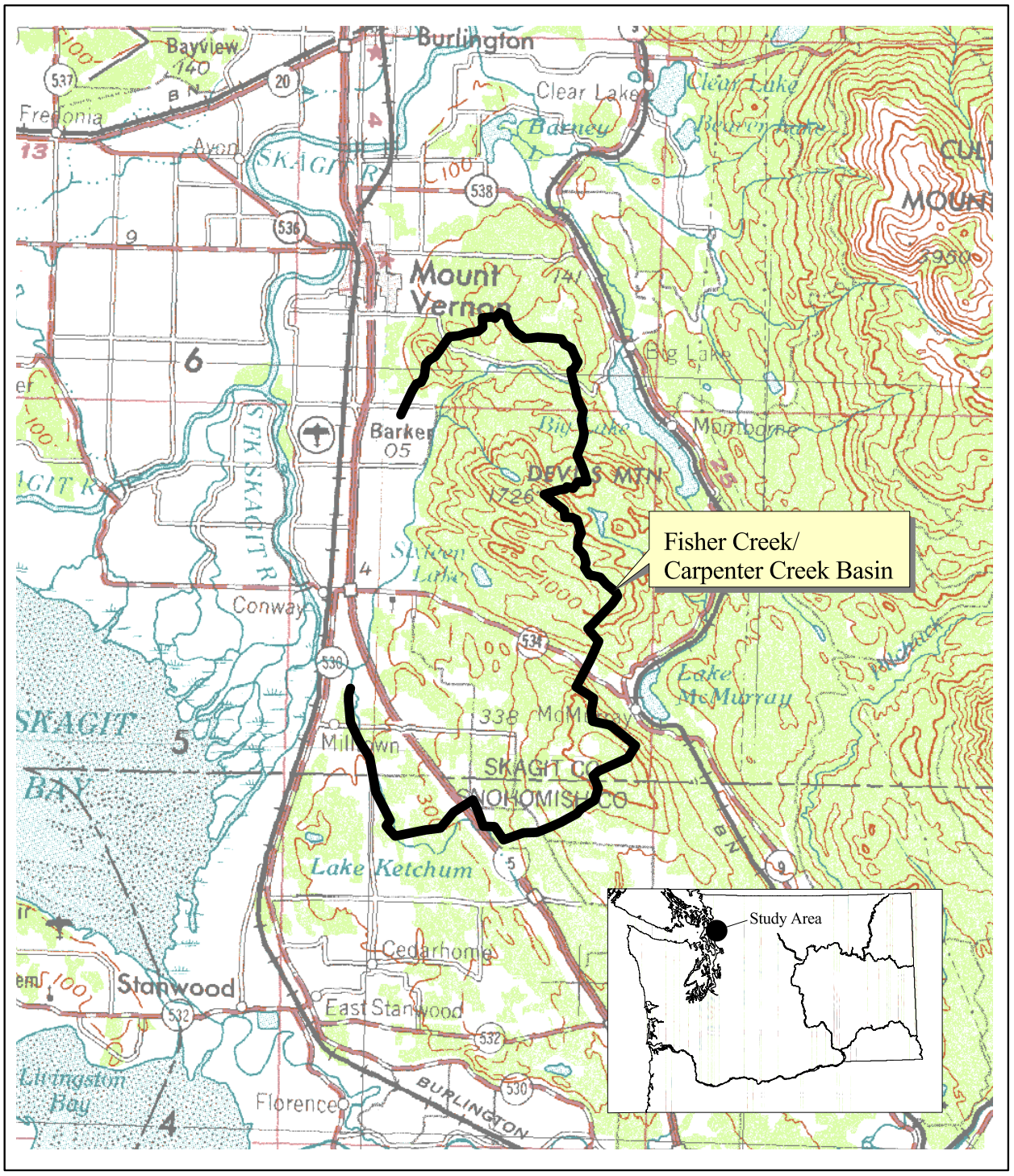


Figure 1 -
Study Area Map
Fisher Creek/
Carpenter Creek Basin
Washington

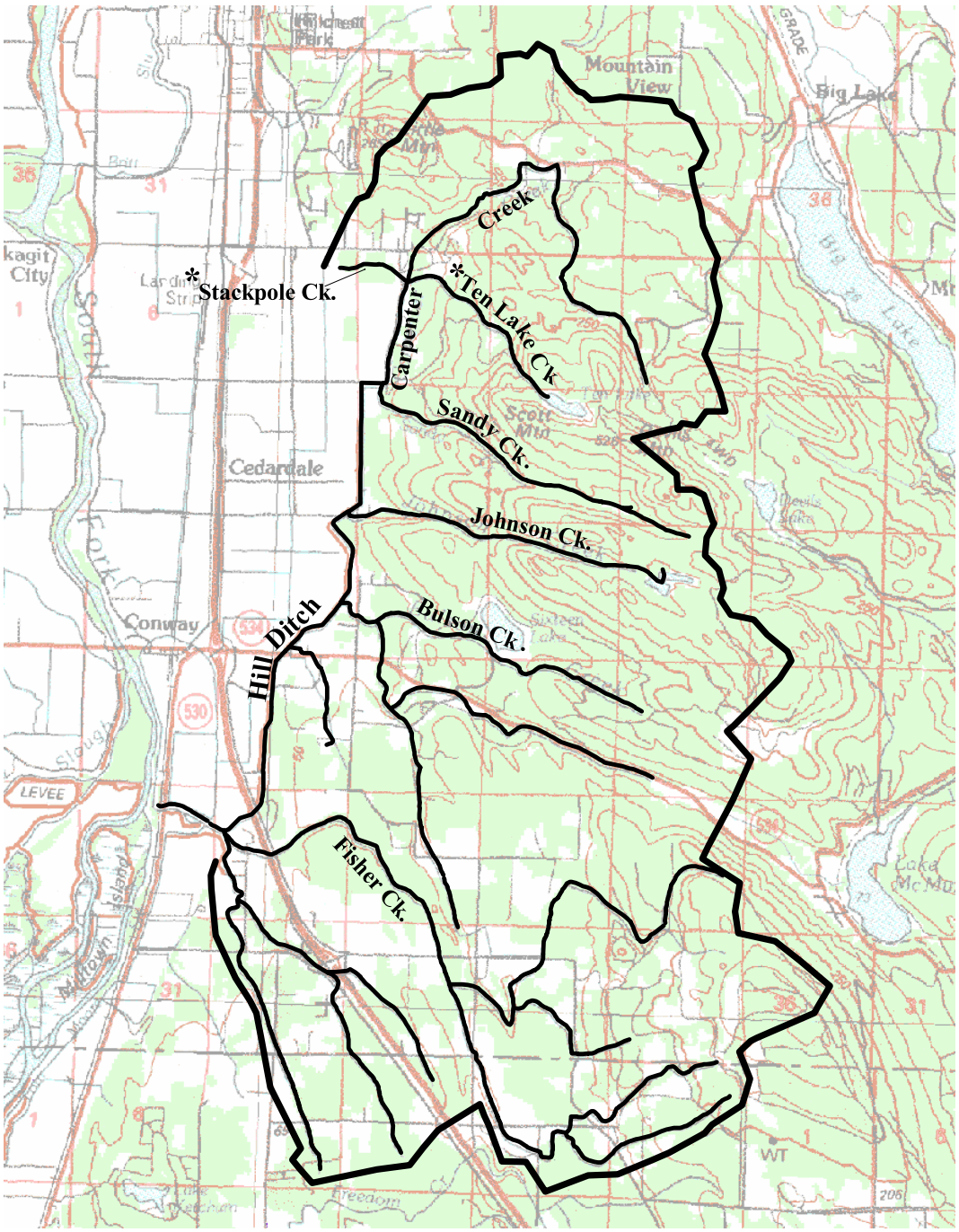


Figure 2 -
Basin Map
Fisher Creek/Carpenter Creek Basin

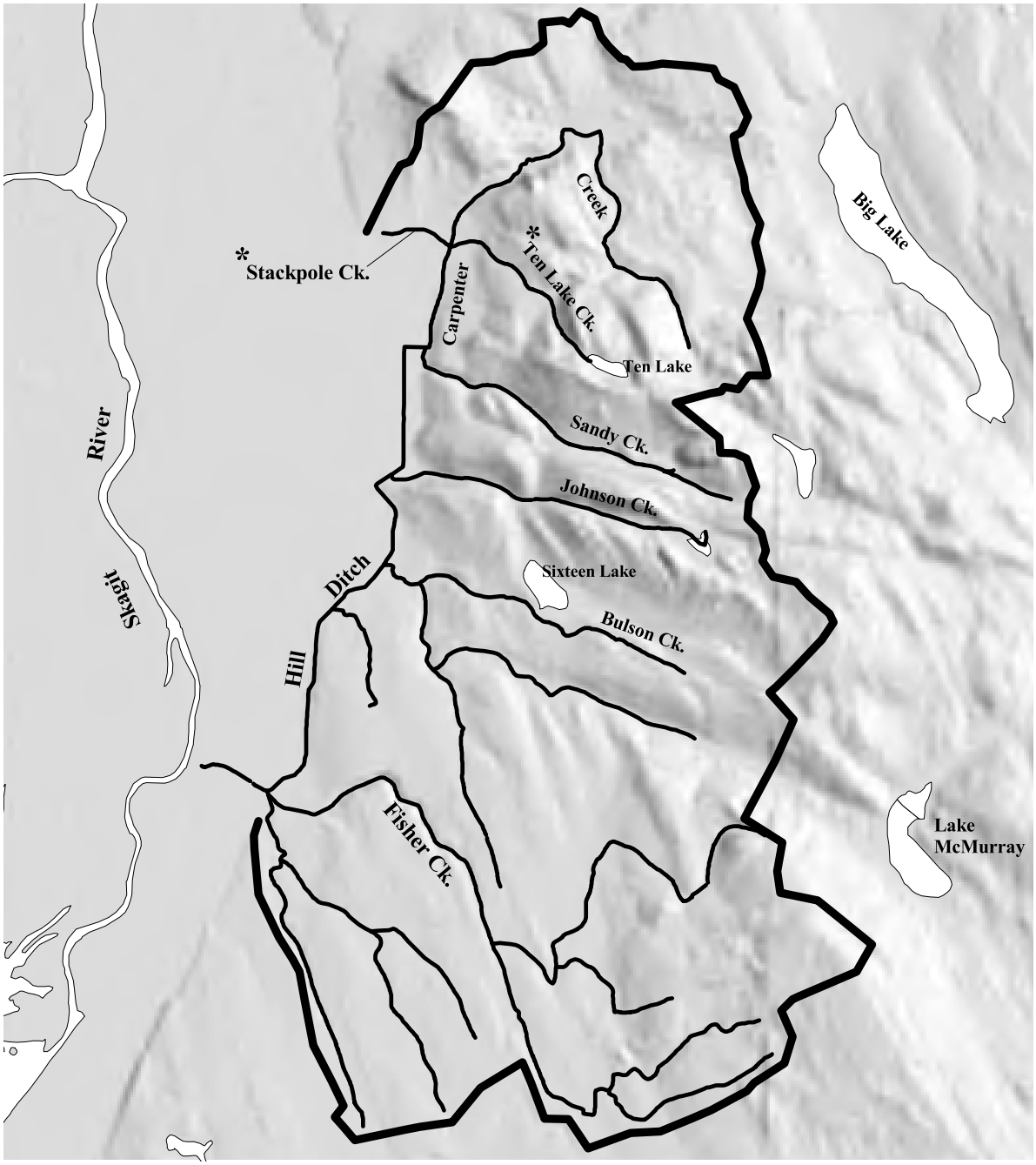


Figure 3 -
Basin Topography
Fisher Creek/
Carpenter Creek Basin

northeast (uplands) (Figures 2 and 3). Basin surface elevations range between approximately 5 and 1700 feet above mean sea level (AMSL).

The Carpenter Creek mainstem occupies the northern half of the basin, draining towards the south (Figure 2). The portion of the Carpenter Creek mainstem that flows across the Skagit plain has been diked and channeled adjacent to the base of the uplands, and is also known as Hill Ditch. Tributaries feeding the Carpenter mainstem drain largely from the east out of the uplands.

The Fisher Creek mainstem drains towards the northwest. The Fisher mainstem and its tributaries largely drain the lower elevation hills of the southern and southeastern lowland.

The confluence of Fisher and Carpenter creeks is located approximately one-half mile east of the South Fork of the Skagit River (Figure 2). The combined drainage area for the two creek systems is approximately 25 square miles (mi^2). Those portions of the drainage area with an elevation less than the local mean higher high water (MHHW) mark may be routinely influenced by the tide. The MHHW elevation at the Swinomish Channel Station is reported as 10.34 feet. This elevation lies upstream of Sandy Creek on Carpenter Creek, and downstream of the I-5 bridge over Fisher Creek. The upstream extent of tidal backwater effects on streamflow is unknown.

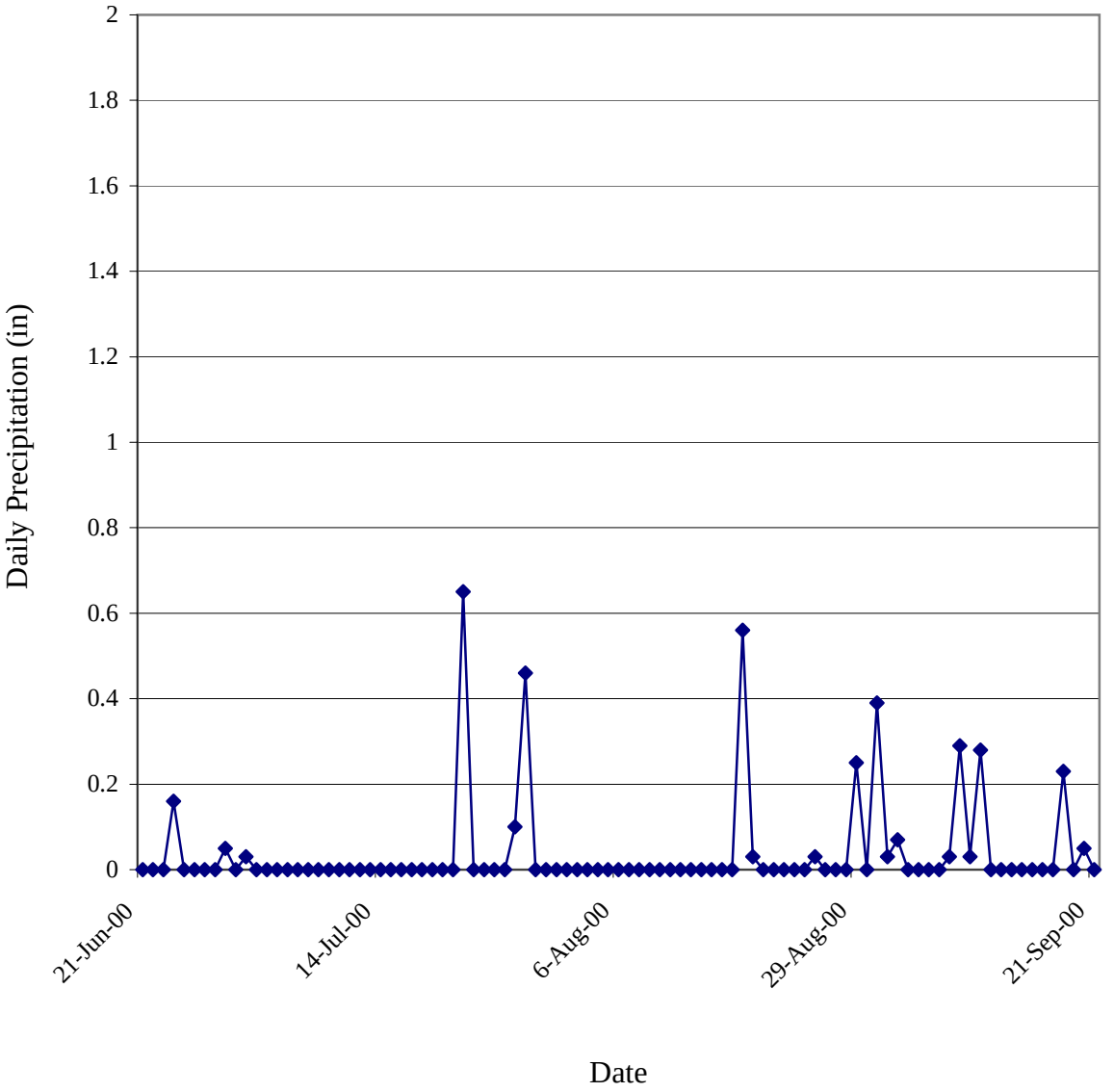
There are several small lakes located within the basin, most notably Ten Lake which drains to an unnamed tributary to Carpenter Creek unofficially referred to in this report as Ten Lake Creek. A second unnamed tributary that joins Carpenter Creek from the west immediately upstream of Ten Lake Creek is unofficially referred to in this report as Stackpole Creek (Figures 2 and 3).

Climate

The lower Skagit River watershed has a mild marine climate with cool, dry summers and mild, wet winters. The mean annual precipitation across the Fisher Creek/Carpenter Creek basin ranges from 28 to 42 inches per year, increasing from west to east (NOAA, 1973). The majority of the annual precipitation occurs between October and March. Figure 4 shows daily precipitation prior to the synoptic monitoring event, as recorded by the Washington State University Mt. Vernon Research and Extension Unit weather station. The total precipitation for the 90-day period prior to the synoptic survey was 3.72 inches. No precipitation or evidence of overland runoff was noted on the day of this survey, September 21, 2000.

Land Use

Rural residential development and small farms dominate the lowland portion of the basin. Agricultural land use dominates the flat-lying Skagit plain to the west, largely supporting cropland and pasture. The eastern uplands are predominantly forestland, with some recent residential development, particularly in the Ten Lake Creek drainage.



Source: WSU Mt. Vernon Research and Extension Unit

Figure 4
Fisher Creek/Carpenter Creek Flow Study
Daily Precipitation

Basin Hydrogeology

Figure 5 shows the surficial geologic units exposed within the Fisher Creek/Carpenter Creek basin and outlying area. The basin straddles a major regional structure, the Mount Vernon Fault (not shown on Figure 5) that defines the boundary between the Puget Sound Lowland and the Cascade Range (Jones, 1999; Cheney, 1987). The bedrock units occurring on the eastern side of this boundary are upthrown with respect to those occurring to the west, and are now exposed at the surface in the eastern half of the basin. Younger, unconsolidated deposits now cover the bedrock units on the downthrown side of the fault.

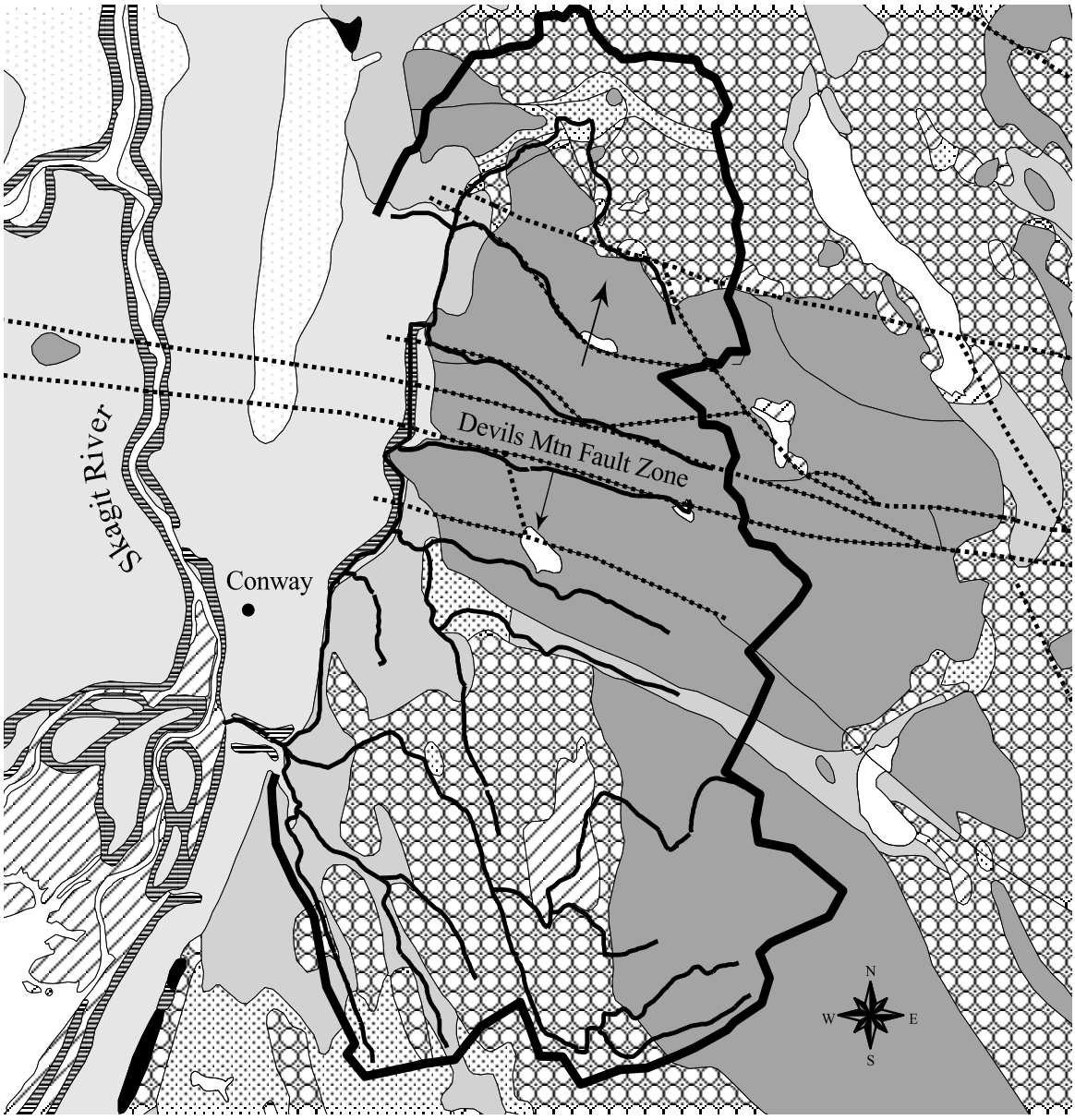
The terrain of the eastern foothills of the basin is composed of a complex assemblage of bedrock. This area includes the late Cretaceous melange of the Haystack Terrane, and the Tertiary-age sedimentary and volcanic rocks of the Bulson Creek Unit and the Chuckanut Formation (Whetten et al., 1988; Sceva, 1950). The contacts between the various bedrock units are defined by the high angle faults of a west-northwest/east-southeast trending fault zone known as the Devils Mountain Fault Zone. Several of the key tributary streams to Carpenter Creek/Hill Ditch follow these contact faults (Sandy Creek, Johnson Creek, Ten Lake Creek; Figure 5). Considering the very low permeability of the bedrock, this suggests that baseflow to tributary streams originating within the uplands may be significantly controlled by fracture flow. This is supported by similar observations in other areas of the Skagit basin (Drost and Lombard, 1978; Grimstad, 1971). A review of available well logs and water supply data indicates that few water-supply wells have been installed in the bedrock foothills (Frank, 1980).

In the southern, lowland portion of the basin the bedrock units are overlain by a stratified sequence of unconsolidated, Pleistocene-age glacial sediments, ranging from less than 10 to greater than 300 feet thick (Pessl et al., 1989; Jones, 1999; Sceva, 1950; Drost and Lombard, 1978). These sediments were deposited during the Vashon Stade of the Fraser glaciation approximately 13,000 to 18,000 years ago.

The oldest sediments of this sequence exposed in the study area are glaciofluvial advance outwash sands and gravels, with finer-grained interbeds of silt and clay. A limited surface exposure of these deposits is found just southwest of the basin (Figure 5). Well logs reported from the study area do, however, indicate that the advance outwash deposits extend laterally beneath the younger glacial deposits of the basin (Pessl et al., 1989; Drost and Lombard, 1978; Sceva, 1950).

The advance outwash deposits reportedly range between 2 and 200 feet thick, averaging between 30 and 65 feet (Pessl, 1989). The coarser-grained layers of this unit serve as the primary drinking water aquifer for local residents, with well yields reportedly averaging between 15 and 20 gallons per minute (Drost and Lombard, 1978). Recharge to this aquifer is assumed to occur from downward leakage of precipitation, and possible upward leakage from bedrock fractures.

Overlying the advance outwash sediments is the Vashon Till. The till unit is exposed at the surface throughout much of the lowland portion of the basin (Figure 5), and is composed of



Source: WDNR Div. of Geology/Earth Resources, 1998

Fault
Stream
Water

Geological Unit

Fill/Diking
Peat and bog deposits
Alluvium - silts/clays
Alluvium - snd/grvl
Recessional slt/cly
Recessional snd/grvl
Vashon Till
Advance outwash
Bedrock

Figure 5 -
Surficial Geology of
the Fisher Creek/
Carpenter Creek Basin

5000 0 5000 10000 Feet

predominantly fine-grained, highly compacted, unsorted and poorly stratified glacial sediments (Pessl et al., 1989; Miller and Pessl, 1986). The estimated thickness of the till in the area ranges between 3 and 130 feet, averaging between 10 and 50 feet (Pessl et al., 1989; Drost and Lombard, 1978). The till, often referred to in driller's logs as "hardpan", is typically interpreted as a lower permeability semi-confining unit that separates the older advance outwash aquifer from younger overlying recessional sediments. A significant portion of the Fisher Creek drainage flows over the till surface; the low summertime baseflows observed in Fisher Creek suggest that groundwater discharge from the till unit to the stream is relatively limited during this period.

The Vashon recessional outwash deposits that overlie the till sediments within the basin are discontinuously exposed at the surface along the eastern edge of the lowland. The estimated thickness of these deposits varies between 3 and 60 feet. Previous investigators have mapped these deposits as two distinct subunits: coarser-grained sand and gravel fraction, and a finer-grained silt/clay fraction (Miller and Pessl, 1986; Pessl, et al, 1989; Jones, 1999). Only limited surface exposures of the coarser-grained subunit are found in the basin (e.g., south of the Bulson Creek drainage, Figure 5); the majority of the recessional deposits are fine-grained and are not thought to yield significant quantities of groundwater.

Extensive deposits of recent alluvium laid down by the Skagit River and its tributaries occupy the Skagit plain in the westernmost portion of the basin. Well logs examined from this area record an interbedded sequence of silts, clays, sands, and gravels. There is some limited water supply development from wells installed in the coarser-grained sediments of the alluvial plain, with moderate well yields.

Methods

Streamflow measurements were collected from eleven stations over a 9-hour period on September 21, 2000 (Figure 6). Stations that were potentially tidally influenced (FC-1, 2, 3, and 5) were measured in the first half of the day during a flood tide, following the daily lower-low tide (Figure 7). No visual signs of tidal influence were noted during the study, no measurable change of stage occurred at the tidally influenced stations during the period of measurement, and all stations were above the tidal elevation when measured.

Measurements of temperature in degrees centigrade (^{o}C) and conductivity in umhos/cm @ 25^{o}C were recorded for the majority of the stations. Both parameters were measured using a YSI brand field meter.

The majority of the streamflows for this study were estimated using standard USGS wading rod and current meter midsection methods (Rantz et al., 1982). A Swoffer Model 2100 current meter was used to record flow velocities. Pre-selected measurement locations were chosen on the basis of position within the drainage, quality of the measurement section, and access considerations. Approximately half of the stations were rated fair to poor for measurement purposes. The accuracy of the flow-rate estimate for all of the stations was adversely affected to varying

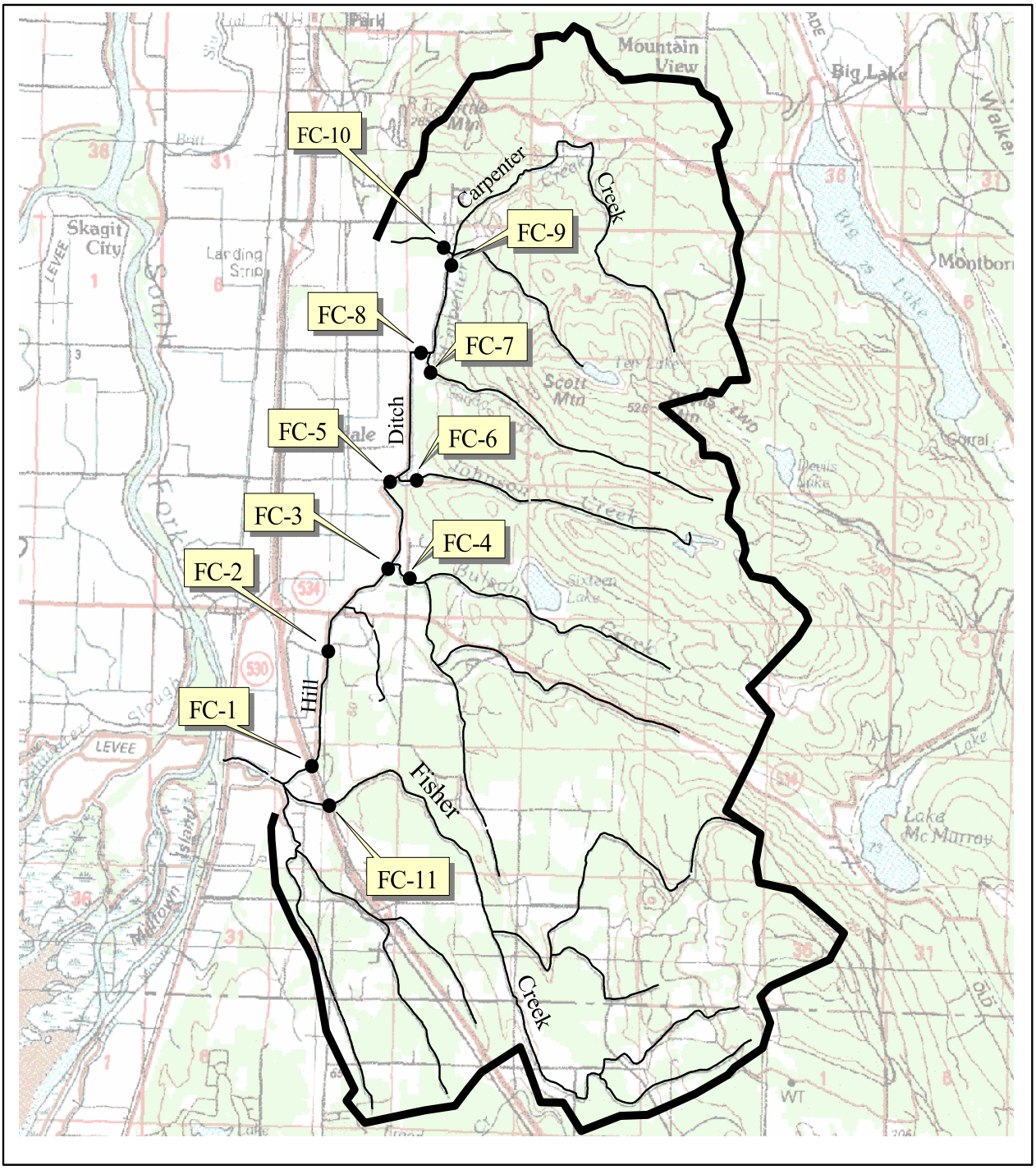


Figure 6 -
Flow Monitoring Stations
Fisher Creek/
Carpenter Creek Basin

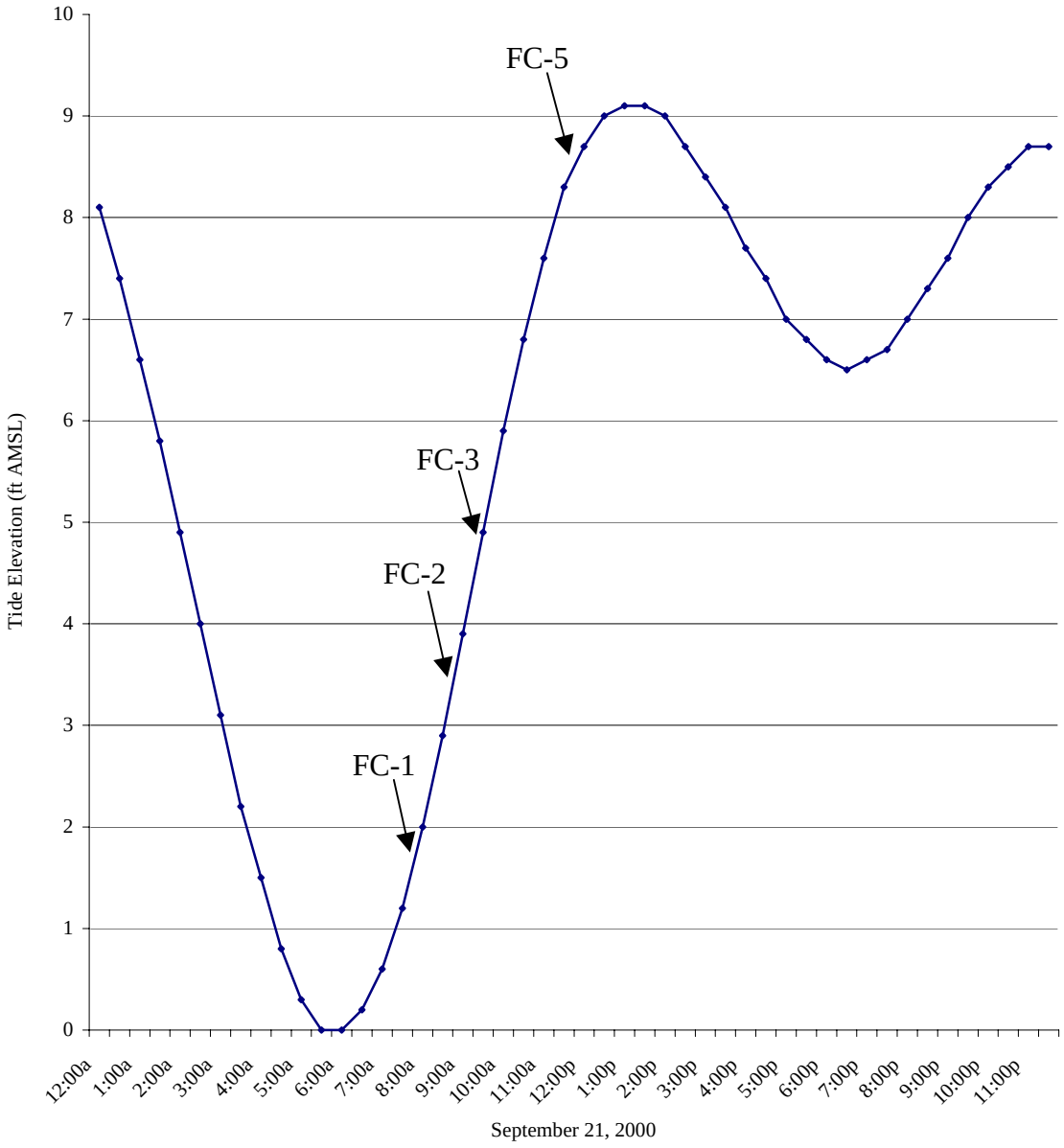


Figure 7
Fisher Creek/Carpenter Creek Basin
Streamflow Measurements vs Tides
La Conner, Swinomish Channel Station

degrees by the shallow depths, backwater effects, narrow channels, and/or sluggish conditions of the flow. Comments about the flow-section conditions are provided for each station in Appendix A. No effort was made to identify or measure human-caused water inputs or withdrawals from the streams between measurement stations.

Each station was measured for width from water edge to water edge, and then subdivided into 15 to 20 sections. Depth of water and water velocity were recorded for each section. The channel was modified for four of the measurement stations where flow was extremely shallow (FC-6, 7, 9, and 10) in order to facilitate measurement. Stations where the channel was especially narrow (FC-6, 7, and 11) were measured for velocity at fewer locations across the profile. To help determine the precision of the field measurements, a replicate measurement was conducted at station FC-4.

The water velocity at station FC-8 was below the minimum measurement capability of the current meter (published vendor limit: 0.1 ft/sec). To develop an approximation of the flow rate at this station, water velocities across the stream profile were assumed to be 0.05 ft/sec, or one-half of the measurement limit, for each section showing visible flow.

Station FC-11 was located in the fish ladder on Fisher Creek. The fish ladder is composed of a series of weir-shaped steps having a rectangular profile. The dimensions of the profile were measured, and measurements of water depth and velocity were collected at several points across the opening.

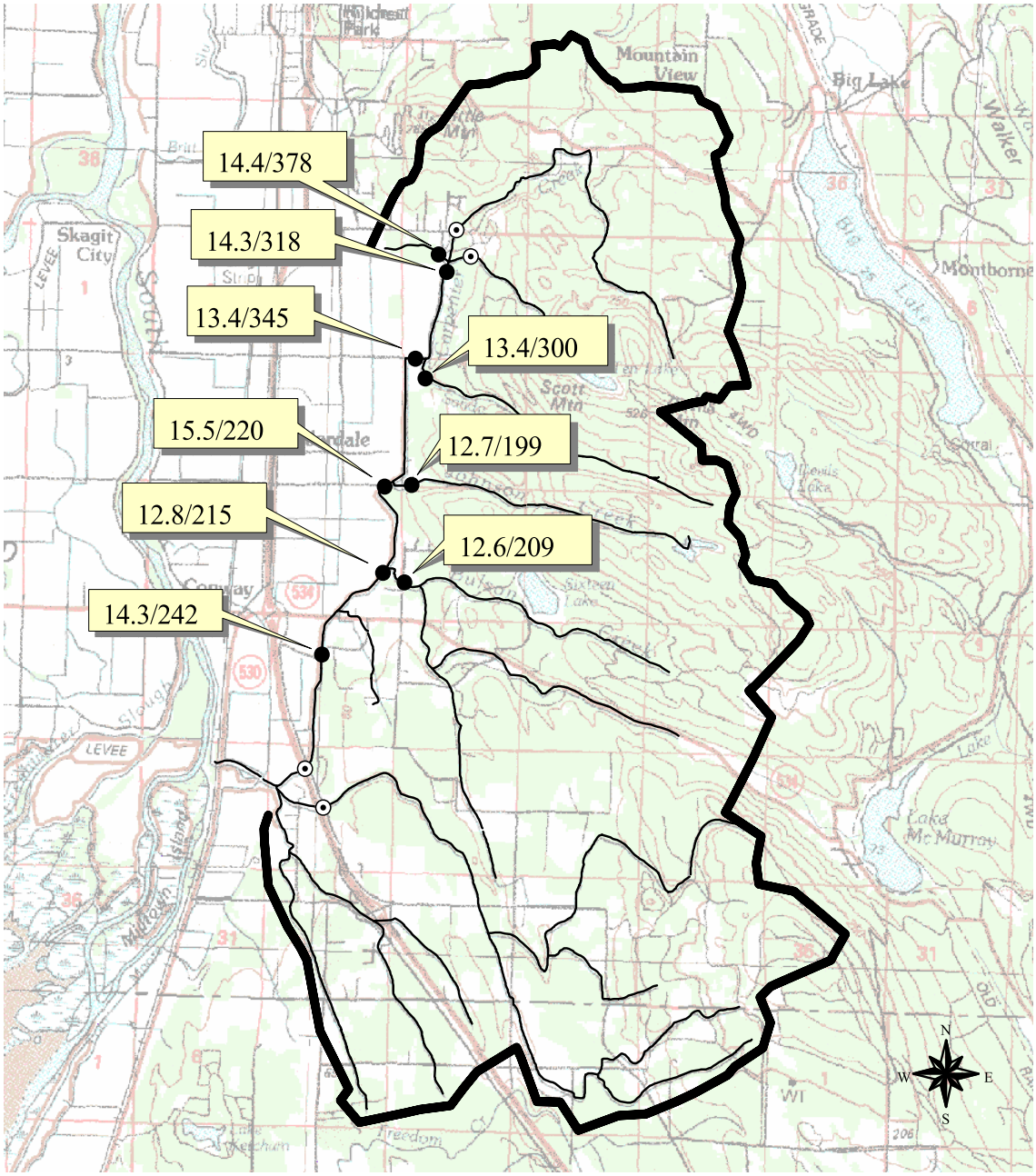
Measured or estimated water depth and velocity values for each station were input into an EAP flowrate software program called QWIN. The QWIN program calculates the total stream discharge rate based on the USGS midsection method (Rantz et al., 1982), and reports the results in cubic feet per second (cfs) for each station.

Results

Recorded temperature and conductivity measurements are shown on Figure 8. Due to the fact that temperature measurements were collected over a nine-hour period, no conclusive remarks can be made regarding temperature variations within the basin. Figure 8 does suggest that there is a general increase in conductivity moving upstream on Hill Ditch/Carpenter Creek, but the cause of this increase is unknown.

Appendix A includes the data printout sheets from the QWIN program for each of the stations measured. Table 1 summarizes the estimated streamflow for each of the stations. These results are graphically presented in Figure 9.

The streamflow estimate for Ten Lake Creek is based on field observations; access to the creek for measurement was not available. The estimated streamflow for Carpenter Creek above Stackpole Creek was derived by difference. The estimate of discharge rate below the confluence of Hill Ditch and Fisher Creek was derived by summing the combined flows of these drainages.



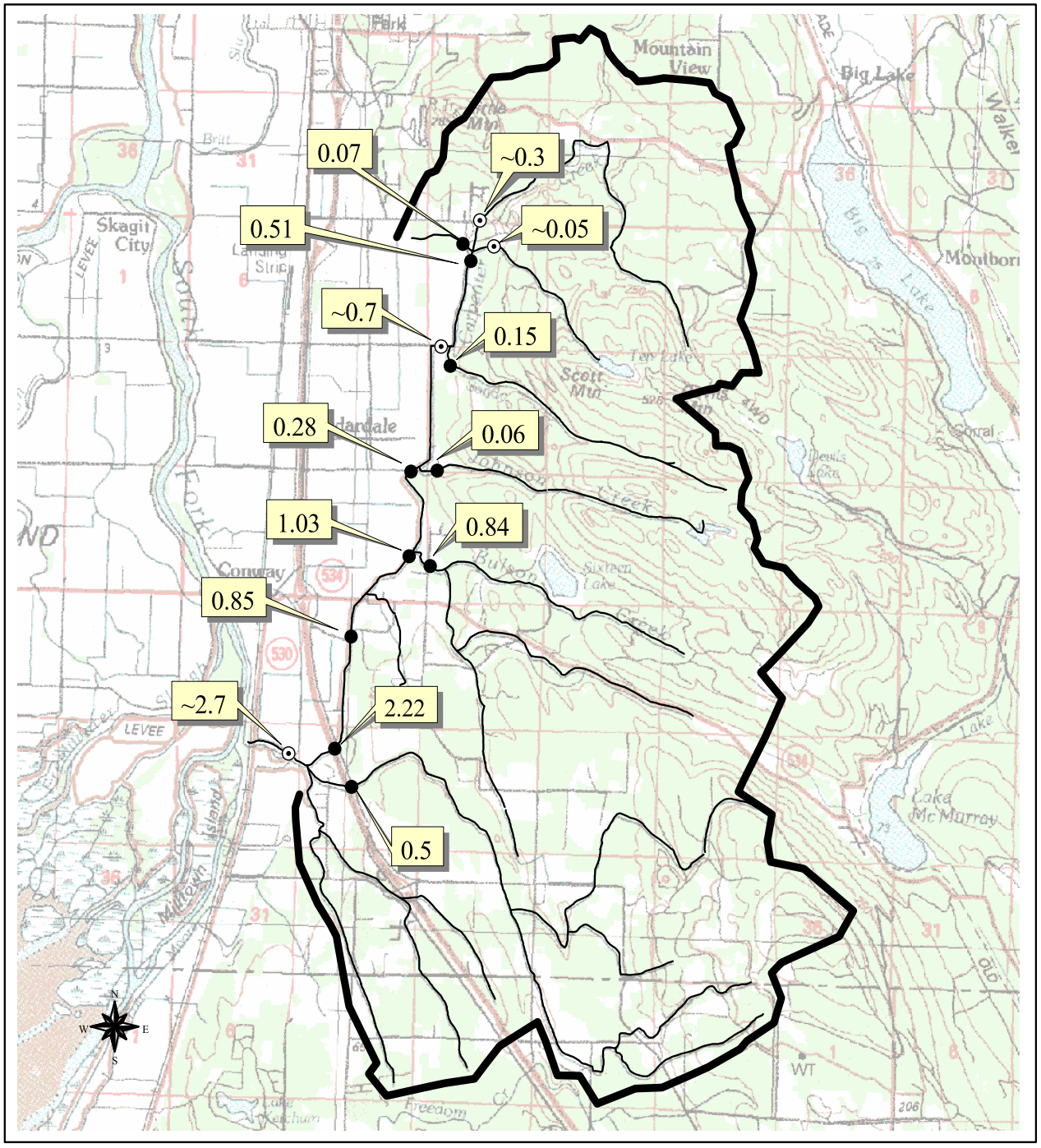
Legend

14.3/242 - Temp. in ^{o}C/
Cond. in umhos/cm @25

⊙ - not measured

Figure 8 -
Water Temperature and
Conductivity
Sept. 21, 2000

5000 0 5000 10000 Feet



Legend

● Measured Streamflow

⊙ Estimated Streamflow

Figure 9 -
September 21, 2000
Streamflow Estimates (cfs)
Fisher Creek/
Carpenter Creek Basin

5000 0 5000 10000 Feet

Table 1. Estimated Streamflows, Fisher Creek/Carpenter Creek Basin, Sept. 21, 2000

Station #	Station Name	Measurement Time	Estimated Streamflow (cfs)
FC-1	Hill Ditch under northbound I-5 bridge	0745	2.22
FC-2	Hill Ditch under Conway Hill Road bridge	0845	0.85
FC-3	Hill Ditch below Bulson Creek	0950	1.03
FC-4	Bulson Creek below Bulson Road	1045	0.84
FC-4	Bulson Creek below Bulson Road	1055	0.86
FC-5	Hill Ditch below Johnson Creek	1145	0.28
FC-6	Johnson Creek	1215	0.06
FC-7	Sandy Creek	1335	0.15
FC-8	Carpenter Creek below Sandy Creek.	1400	~0.7
FC-9	Carpenter Creek below Ten Lake Creek	1525	0.51
FC-10	Stackpole Creek	1545	0.07
FC-11	Fisher Creek. at fish ladder	1700	0.50
-	Ten Lake Creek	-	~0.05
-	Carpenter Creek above Stackpole Creek	-	~0.3
-	Fisher Ck./Carpenter Ck. below confluence	-	~2.7

Discussion

The streamflow estimates presented in Table 1 should be considered approximations. The field methods that were used to estimate streamflow are not well suited to the conditions encountered during the measurement event. The discharge rate estimated by the replicate measurement at station FC-4 was within 3% of the initial measurement, suggesting that the measurement values had good repeatability. This value, however, does not necessarily indicate that the study results accurately represent the true flowrate.

To quantify the uncertainty in the reported values, and evaluate the significance of that uncertainty to the report results, a simple sensitivity analysis was conducted. To conduct this analysis all of the measured input values for water depth and velocity for three representative stations (FC-1, 4, and 7) were modified by adding or subtracting the estimated measurement error to the appropriate field measurement. A measurement error of ±0.05 feet was assumed for water depth; a measurement error of ±0.1 ft/sec was assumed for water velocity. Once each field measurement was modified, the station flowrate was recalculated in the QWIN program. Table 2 summarizes the results of this analysis, and indicates the probable uncertainty ranges for the results. The associated QWIN datasheets can be found in Appendix B.

Table 2. Probable Uncertainty Ranges, Sept. 21, 2000 Streamflow Results

Station	Minimum Probable Flow (cfs)	Maximum Probable Flow (cfs)	Error Percent From Table 1 Estimate
FC-1	1.56	3.04	-30%/+37%
FC-4	0.58	1.15	-31%/+37%
FC-7	0.09	0.24	-40%/60%

The results presented in Table 2 suggest that while there may be a high degree of relative error in the station flowrate estimates, in absolute terms the values still indicate that the basin has limited streamflow during the late-summer season. The analysis does indicate that the relative error in the estimates increases with decreasing streamflow.

On the basis of the precipitation record prior to the measurement date, and field observations at the time of measurement, it is assumed that increases in streamflow between measurement stations, other than those assigned to tributary inputs, were not the result of overland runoff. It is assumed that the bulk of the stream discharge recorded at this time of the year is derived from groundwater baseflow contributions. The limited magnitude of the late-summer baseflow is consistent with the low permeability character of the basin's subsurface geologic units.

Figure 10 summarizes the estimated gain or loss in flow rate between selected stations along the Carpenter Creek/Hill Ditch mainstem that is not attributable to tributary inputs. The station FC-8 flow rate estimate was not used in the gain/loss calculations because it was not a measured value. It is unknown if the loses or gains estimated are attributable to measurement error, seepage to or from the channel bed, bank storage effects, or undocumented withdrawals or inputs. Because of the low flow values reported, the interpretation of gain or loss between stations is sensitive to even small-scale measurement errors or undocumented inputs or diversions.

Conclusions

Streamflow rates for the Fisher Creek/Carpenter Creek basin are very low during late summer, dry-season conditions. The discharge rate for the combined drainage area of approximately 25 square miles is estimated to be less than 3 cfs ($< 0.12 cfs/mi^2$). The low flow rates are consistent with the fact that a significant percentage of the drainage area is located over a low permeability geologic setting, suggesting dry-season groundwater baseflow contributions to streams will be limited in scale. Tributary contributions to the Carpenter Creek/Hill Ditch mainstem are likely controlled in large part by groundwater fracture flow within the upland bedrock.

The estimated error of the flowrate results is too high to make defensible conclusions regarding seepage losses or gains along the Carpenter Creek/Hill Ditch mainstem. Estimation of seepage

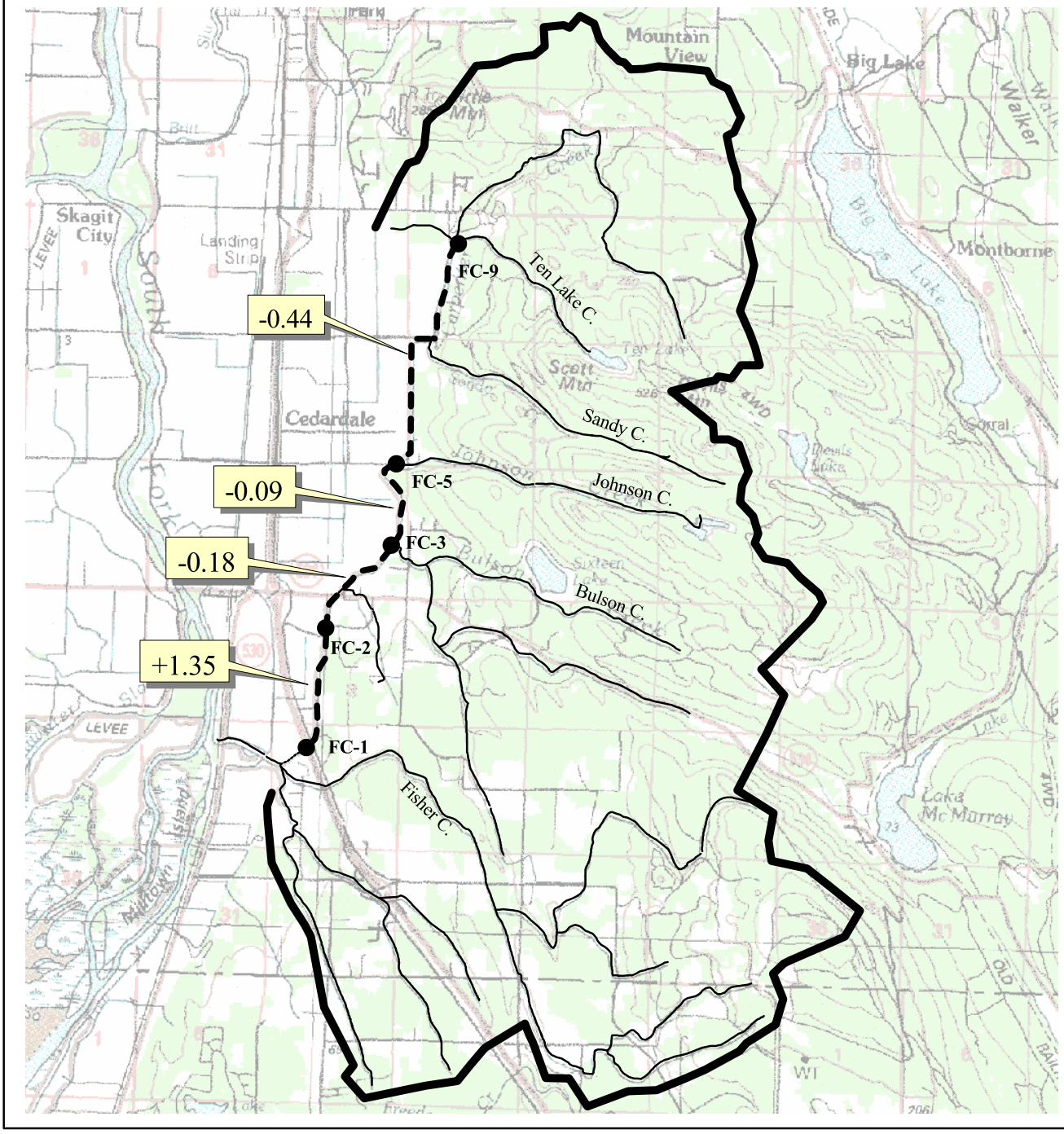


Figure 10 -
Streamflow Gain/Loss Map (cfs)
Hill Ditch
September 21, 2000

along the mainstem is also not possible without detailed knowledge of human-derived inputs or withdrawals occurring between measurement stations. The mainstem reach of Hill Ditch between Ten Lake Creek and Johnson Creek had the highest estimated streamflow loss on the day of measurement. On the date of measurement, September 21, 2000, Bulson Creek was the tributary estimated to contribute the greatest amount of flow to the Carpenter Creek/Hill Ditch mainstem.

Recommendations

The flow values reported for this study represent a discrete point in time, and do not necessarily characterize average conditions for the basin. It is recommended that a long-term flow-monitoring program be established for the basin, including the collection of measurements under a range of flow-rate conditions. Collection of flow measurements under higher flow conditions may improve the ability to evaluate groundwater contributions to basin streamflow, if coupled with accurate surveys of human-derived water inputs and withdrawals. It is also recommended that future flow monitoring efforts consider the addition of more stations in the upstream portions of the Fisher Creek drainage, including monitoring along the south fork of Fisher Creek and at key tributary confluences.

Additional information would be required to improve the understanding of seepage to and from the channel of Hill Ditch/Carpenter Creek. Again, a detailed survey of human-derived water inputs and withdrawals occurring along the reach (or reaches) of interest would be required to determine where true groundwater/surface water interchange was occurring. If seepage losses or gains are smaller than the flow measurement error, alternative techniques such as the installation of small-diameter well points (piezometers) and collection of water table measurements beneath and adjacent to the stream channel would be required.

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Appendix A

QWIN Data Reports -
Stream Discharge Calculations

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Site ID: FC-1

Site Name: Hill Ditch under N-bound I-5 bridge

Stage (ft): 15.27

Date: 09/21/200 Time: 07:45

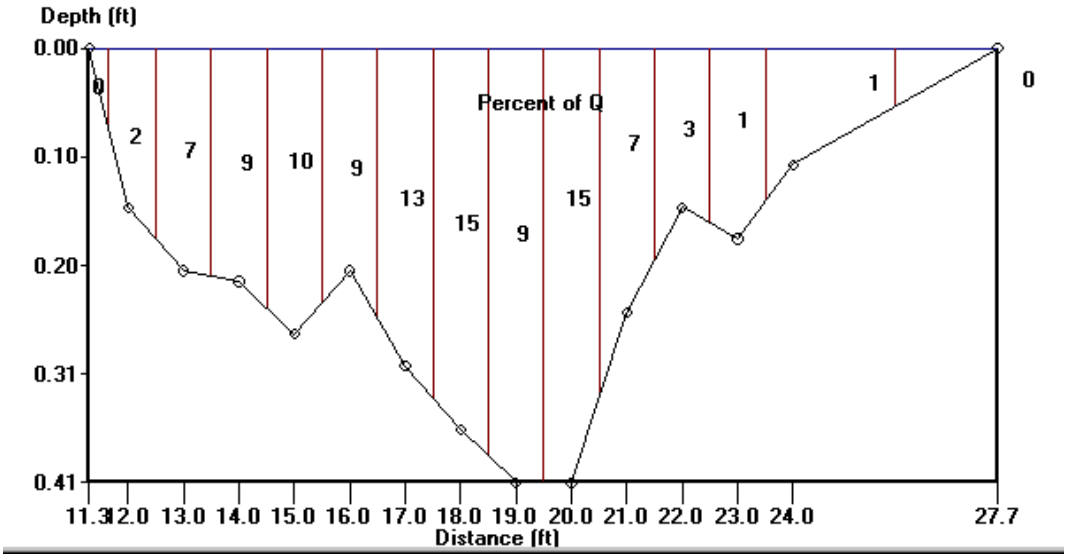
Comment: Reference point (RP) measured from established RP on Cedardale Road bridge after flow measurement complete at 08:27. No RP measurement made before flow measurement. Flow-measurement site rated as good (+/- 5% error).

Discharge Result

Total Area = 3.36 sq. ft.
Average Velocity = 0.66 ft./sec.

Total Discharge = 2.22 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	11.30	0.00	0.00		0.00	0.00
2	12.00	0.15	0.28		0.13	0.04
3	13.00	0.21	0.76		0.21	0.16
4	14.00	0.22	0.87		0.22	0.19
5	15.00	0.27	0.80		0.27	0.22
6	16.00	0.21	0.96		0.21	0.20
7	17.00	0.30	0.96		0.30	0.29
8	18.00	0.36	0.93		0.36	0.33
9	19.00	0.41	0.47		0.41	0.19
10	20.00	0.41	0.84		0.41	0.34
11	21.00	0.25	0.61		0.25	0.15
12	22.00	0.15	0.49		0.15	0.07
13	23.00	0.18	0.11		0.18	0.02
14	24.00	0.11	0.05		0.26	0.01
15	27.70	0.00	0.00		0.00	0.00



Site ID: FC #2

Site Name: Hill Ditch under Conway Hill Road bridge

Stage (ft):

Date: 9/21/2000 Time: 0845

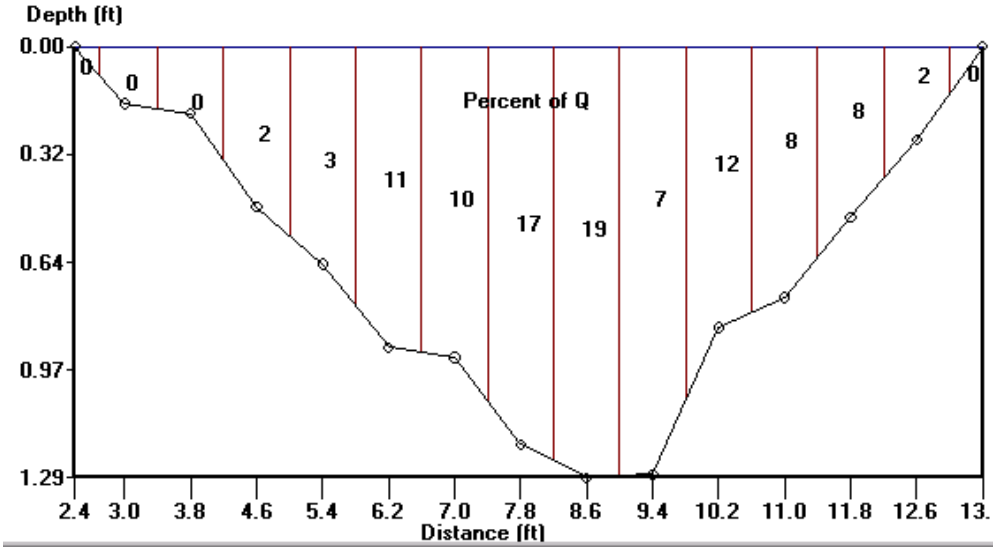
Comment: RP went down .01 ft. during measurement. Dam about 40 ft. down stream of flow site. Heavy, rocky bottom - flow too slugish for accurate measurement. SW flow from left bank into creek just downstream of measuring site - could not determine source and volume. Measurement site rated as very poor (+/- over 8% error) based on field observations.

Discharge Result

Total Area = 7.56 sq. ft.
Average Velocity = 0.11 ft./sec.

Total Discharge = 0.85 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	2.40	0.00	0.00		0.00	0.00
2	3.00	0.17	0.00		0.12	0.00
3	3.80	0.20	0.00		0.16	0.00
4	4.60	0.48	0.05		0.38	0.02
5	5.40	0.65	0.05		0.52	0.03
6	6.20	0.90	0.13		0.72	0.09
7	7.00	0.93	0.11		0.74	0.08
8	7.80	1.19	0.15		0.95	0.14
9	8.60	1.29	0.16		1.03	0.17
10	9.40	1.28	0.06		1.02	0.06
11	10.20	0.84	0.15		0.67	0.10
12	11.00	0.75	0.12		0.60	0.07
13	11.80	0.51	0.17		0.41	0.07
14	12.60	0.28	0.09		0.22	0.02
15	13.40	0.00	0.00		0.00	0.00



Site ID: FC-3

Site Name: Hill Ditch below Bulson Creek

Stage (ft):

Date: 9/21/2000 Time: 09:50

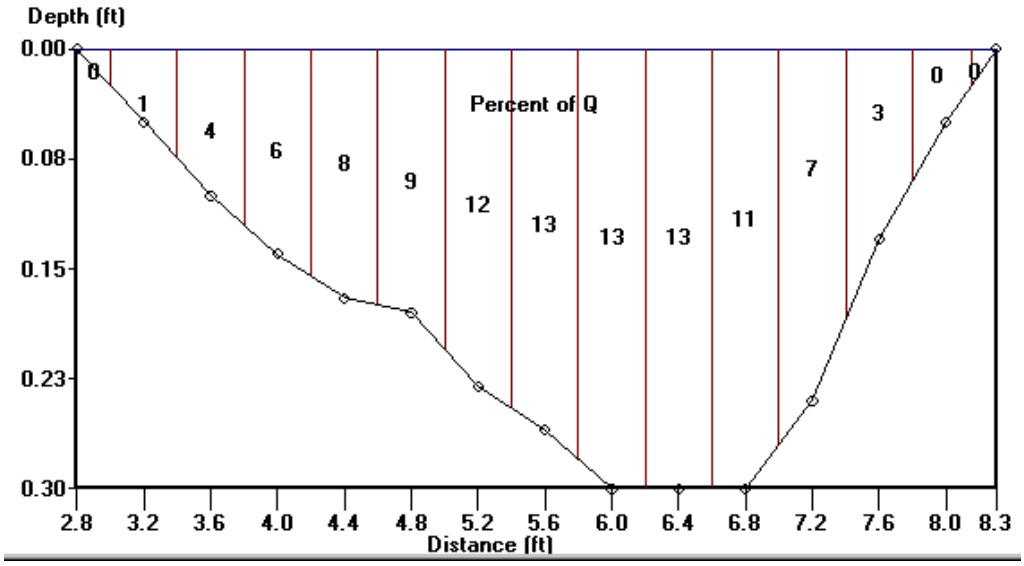
Comment: No change in RP during measurement. Good, even bottom, with laminar flow. Section rated as good (+/- 5% error)

Discharge Result

Total Area = 0.98 sq. ft.
Average Velocity = 1.06 ft./sec.

Total Discharge = 1.03 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	2.80	0.00	0.00		0.00	0.00
2	3.20	0.05	0.50		0.02	0.01
3	3.60	0.10	1.01		0.04	0.04
4	4.00	0.14	1.09		0.06	0.06
5	4.40	0.17	1.26		0.07	0.09
6	4.80	0.18	1.23		0.07	0.09
7	5.20	0.23	1.32		0.09	0.12
8	5.60	0.26	1.30		0.10	0.14
9	6.00	0.30	1.13		0.12	0.14
10	6.40	0.30	1.09		0.12	0.13
11	6.80	0.30	0.97		0.12	0.12
12	7.20	0.24	0.77		0.10	0.07
13	7.60	0.13	0.56		0.05	0.03
14	8.00	0.05	0.20		0.02	0.00
15	8.30	0.00	0.00		0.00	0.00



Site ID: FC-4

Site Name: Bulson Creek below Bulson Road

Stage (ft):

Date: 09/21/200 Time: 10:45

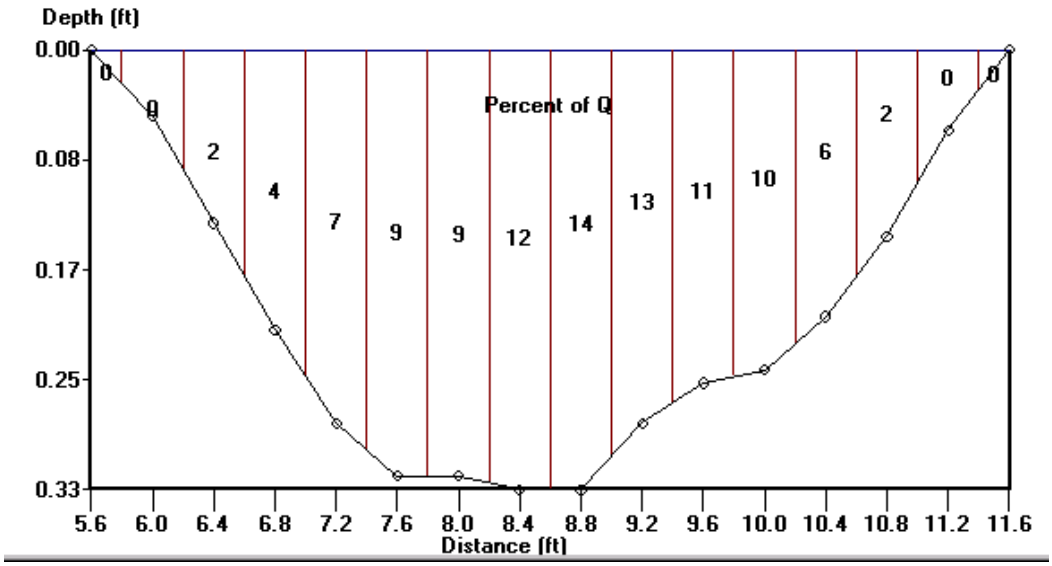
Comment: No stage change during measurement. Good even bottom, fairly laminar flow. Section rated good (+/- 5% error) based on field observations.

Discharge Result

Total Area = 1.26 sq. ft.
Average Velocity = 0.67 ft./sec.

Total Discharge = 0.84 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	5.60	0.00	0.00		0.00	0.00
2	6.00	0.05	0.05		0.02	0.00
3	6.40	0.13	0.28		0.05	0.01
4	6.80	0.21	0.41		0.08	0.03
5	7.20	0.28	0.55		0.11	0.06
6	7.60	0.32	0.62		0.13	0.08
7	8.00	0.32	0.57		0.13	0.07
8	8.40	0.33	0.74		0.13	0.10
9	8.80	0.33	0.89		0.13	0.12
10	9.20	0.28	0.98		0.11	0.11
11	9.60	0.25	0.91		0.10	0.09
12	10.00	0.24	0.86		0.10	0.08
13	10.40	0.20	0.67		0.08	0.05
14	10.80	0.14	0.33		0.06	0.02
15	11.20	0.06	0.10		0.02	0.00
16	11.60	0.00	0.00		0.00	0.00



Site ID: FC-5

Site Name: Hill Ditch below Johnson Creek

Stage (ft):

Date: 9/21/2000 Time: 11.:45

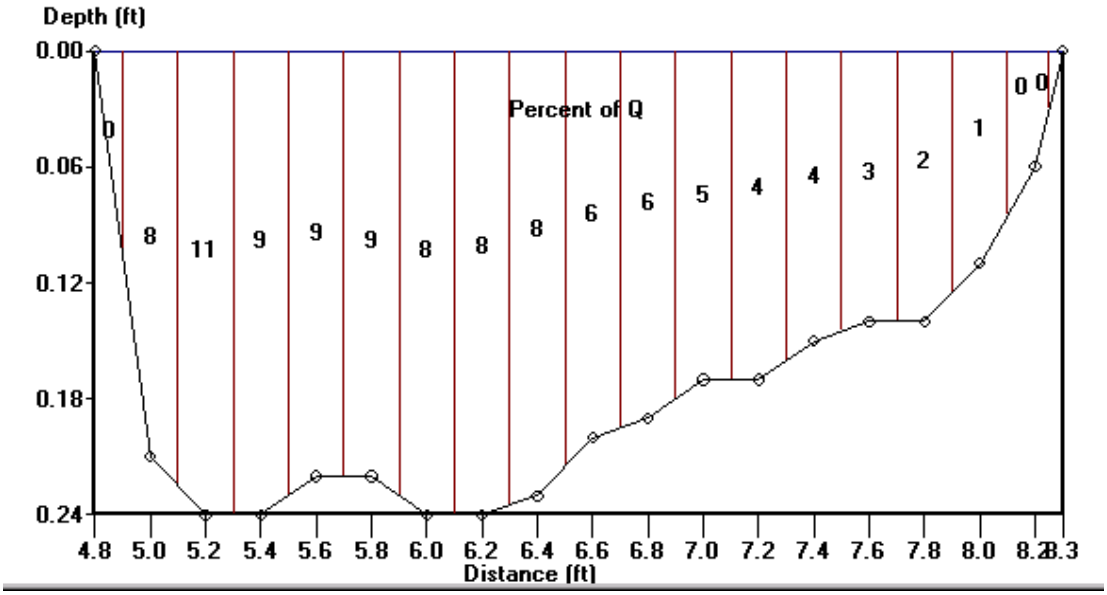
Comment: No stage change. Muddy bottom, fairly sluggish flow, shallow. Section rated as fair (+/- 8% error) based on field observations.

Discharge Result

Total Area = 0.63 sq. ft.
Average Velocity = 0.44 ft./sec.

Total Discharge = 0.28 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	4.80	0.00	0.00		0.00	0.00
2	5.00	0.21	0.54		0.04	0.02
3	5.20	0.24	0.62		0.05	0.03
4	5.40	0.24	0.50		0.05	0.02
5	5.60	0.22	0.56		0.04	0.02
6	5.80	0.22	0.54		0.04	0.02
7	6.00	0.24	0.48		0.05	0.02
8	6.20	0.24	0.47		0.05	0.02
9	6.40	0.23	0.46		0.05	0.02
10	6.60	0.20	0.44		0.04	0.02
11	6.80	0.19	0.42		0.04	0.02
12	7.00	0.17	0.41		0.03	0.01
13	7.20	0.17	0.36		0.03	0.01
14	7.40	0.15	0.36		0.03	0.01
15	7.60	0.14	0.31		0.03	0.01
16	7.80	0.14	0.18		0.03	0.01
17	8.00	0.11	0.10		0.02	0.00
18	8.20	0.06	0.05		0.01	0.00
19	8.30	0.00	0.00		0.00	0.00



Site ID: FC-6

Site Name: Johnson Creek

Stage (ft):

Date: 9/21/2000 Time: 12:15

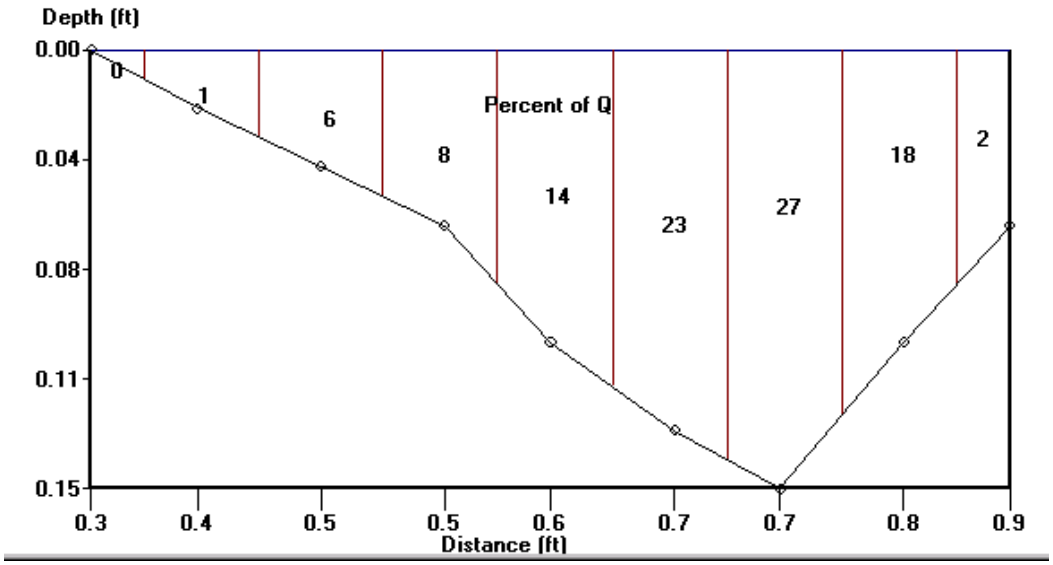
Comment: Due to extremely small cross section and flow, could only measure velocity at station numbers 4 and 7, all other velocity values are estimated. Small natural bedrock weir, had to dam edges to channel water through. Section rated as poor (over 8% error) based on field observations.

Discharge Result

Total Area = 0.04 sq. ft.
Average Velocity = 1.46 ft./sec.

Total Discharge = 0.06 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	0.33	0.00	0.00		0.00	0.00
2	0.39	0.02	0.60		0.00	0.00
3	0.46	0.04	1.27		0.00	0.00
4	0.53	0.06	1.27		0.00	0.00
5	0.59	0.10	1.27		0.01	0.01
6	0.66	0.13	1.66		0.01	0.01
7	0.72	0.15	1.66		0.01	0.02
8	0.79	0.10	1.66		0.01	0.01
9	0.85	0.06	0.80		0.00	0.00



Site ID: FC-7

Site Name: Sandy Creek

Stage (ft):

Date: 09/21//20 Time: 13:35

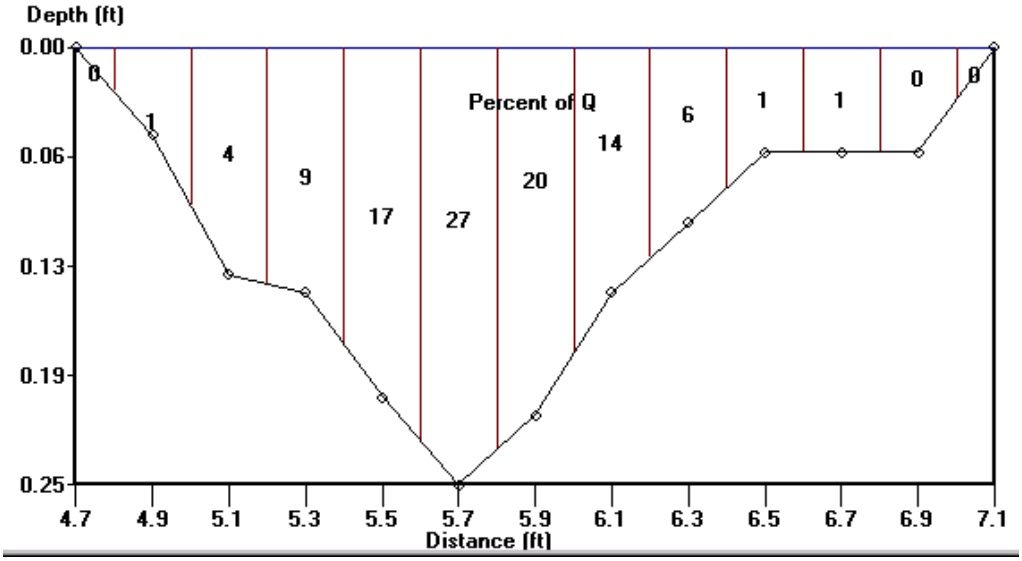
Comment: Location about 15 ft. above confluence w/ Carpenter Creek. Moderately smooth, even bottom, very shallow. Sectoin rated as good to fair (+/- 5% to 8% error) based on field observations.

Discharge Result

Total Area = 0.28 sq. ft.
Average Velocity = 0.55 ft./sec.

Total Discharge = 0.15 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	4.70	0.00	0.00		0.00	0.00
2	4.90	0.05	0.10		0.01	0.00
3	5.10	0.13	0.25		0.03	0.01
4	5.30	0.14	0.47		0.03	0.01
5	5.50	0.20	0.65		0.04	0.03
6	5.70	0.25	0.83		0.05	0.04
7	5.90	0.21	0.73		0.04	0.03
8	6.10	0.14	0.75		0.03	0.02
9	6.30	0.10	0.48		0.02	0.01
10	6.50	0.06	0.16		0.01	0.00
11	6.70	0.06	0.10		0.01	0.00
12	6.90	0.06	0.05		0.01	0.00
13	7.10	0.00	0.00		0.00	0.00



Site ID: FC-8

Site Name: Carpenter Creek below Sandy Creek

Stage (ft):

Date: 9/21/2000 Time: 14:00

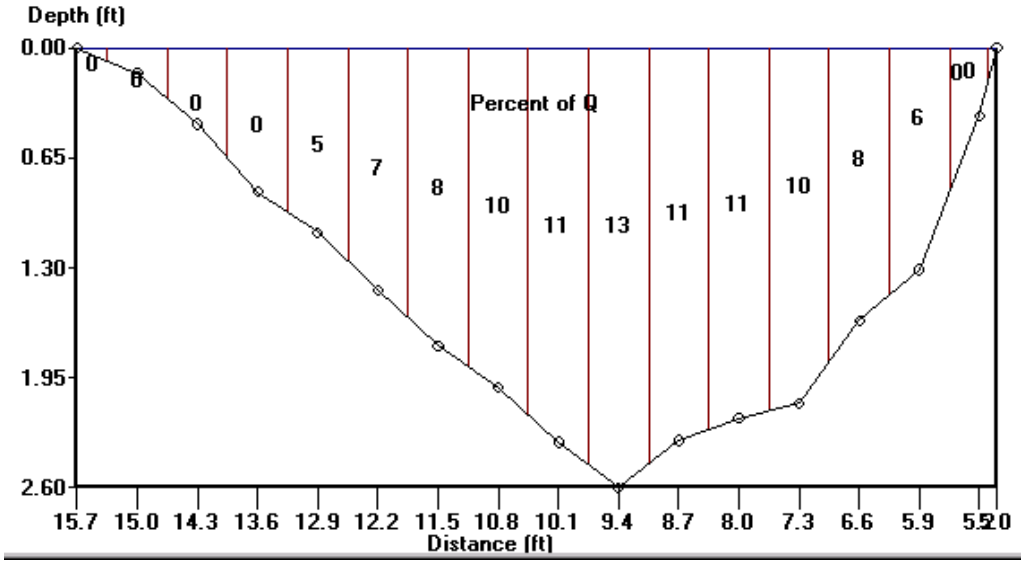
Comment: Extremely poor section - Deep pool, very muddy bottom, no measureable flow, all velocity measurements are estimates. Very inaccurate, probably wrong by 50% or much more.

Discharge Result

Total Area = 15.72 sq. ft.
Average Velocity = 0.05 ft./sec.

Total Discharge = 0.73 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	15.70	0.00	0.00		0.00	0.00
2	15.00	0.15	0.00		0.10	0.00
3	14.30	0.45	0.00		0.31	0.00
4	13.60	0.85	0.00		0.60	0.00
5	12.90	1.09	0.05		0.76	0.04
6	12.20	1.43	0.05		1.00	0.05
7	11.50	1.76	0.05		1.23	0.06
8	10.80	2.01	0.05		1.41	0.07
9	10.10	2.33	0.05		1.63	0.08
10	9.40	2.60	0.05		1.82	0.09
11	8.70	2.32	0.05		1.62	0.08
12	8.00	2.19	0.05		1.53	0.08
13	7.30	2.10	0.05		1.47	0.07
14	6.60	1.61	0.05		1.13	0.06
15	5.90	1.31	0.05		0.92	0.05
16	5.20	0.40	0.00		0.18	0.00
17	5.00	0.00	0.00		0.00	0.00



Site ID: FC-9

Site Name: Carpenter Creek below Ten-Lake Creek

Stage (ft):

Date: 9/21/2000 Time: 15:25

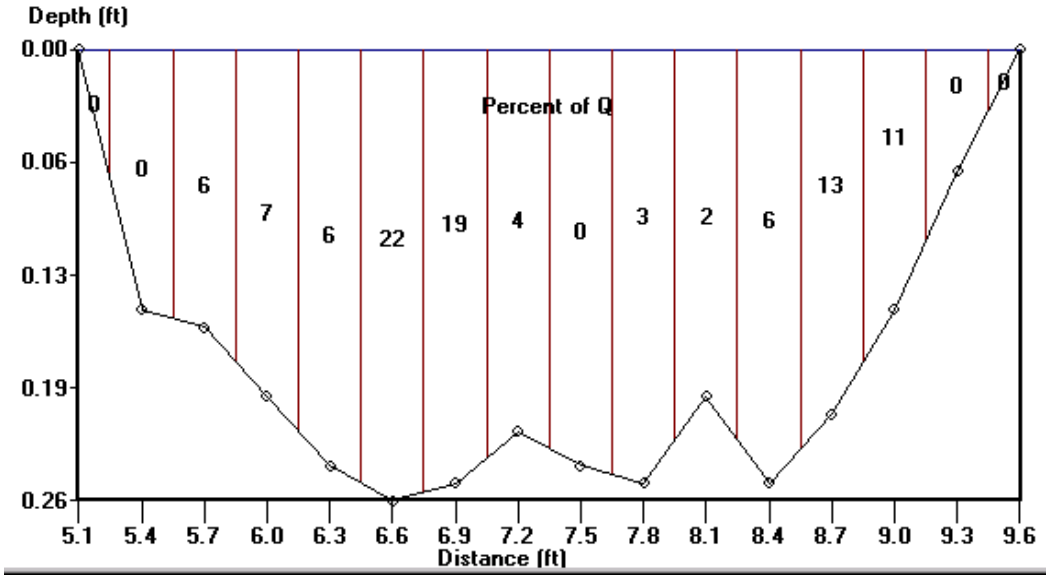
Comment: Very shallow, gravelly cross section. Had to dam up sides to narrow section a bit to create enough depth to measure and to get course gravel out of cross section area. Section rated as poor (+/- over 8% error) based on field observations.

Discharge Result

Total Area = 0.86 sq. ft.
Average Velocity = 0.59 ft./sec.

Total Discharge = 0.51 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	5.10	0.00	0.00		0.00	0.00
2	5.40	0.15	0.05		0.04	0.00
3	5.70	0.16	0.62		0.05	0.03
4	6.00	0.20	0.59		0.06	0.04
5	6.30	0.24	0.45		0.07	0.03
6	6.60	0.26	1.45		0.08	0.11
7	6.90	0.25	1.28		0.07	0.10
8	7.20	0.22	0.31		0.07	0.02
9	7.50	0.24	0.00		0.07	0.00
10	7.80	0.25	0.19		0.08	0.01
11	8.10	0.20	0.16		0.06	0.01
12	8.40	0.25	0.44		0.07	0.03
13	8.70	0.21	1.04		0.06	0.07
14	9.00	0.15	1.24		0.05	0.06
15	9.30	0.07	0.05		0.02	0.00
16	9.60	0.00	0.00		0.00	0.00



Site ID: FC-10

Site Name: "Stackpole Creek" - Trib. to Carpenter Creek abv. Ten Lake Creek

Stage (ft):

Date: 9/21/00 Time: 15:45

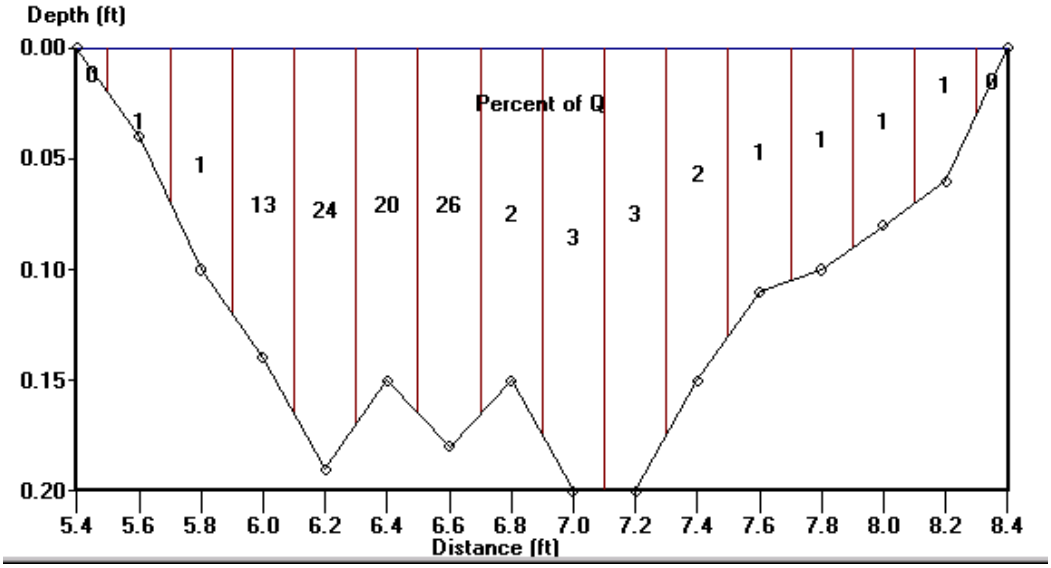
Comment: Very shallow cross section. Dammed up sides to narrow section to create enough depth to measure and to get coarse gravel out of cross section area. Where flow velocity is shown as 0.5, values are estimates- flow was observable but not measurable at these points. Section rated poor (+/- over 8% error) based on field observations.

Discharge Result

Total Area = 0.37 sq. ft.
Average Velocity = 0.20 ft./sec.

Total Discharge = 0.07 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	5.40	0.00	0.00		0.00	0.00
2	5.60	0.04	0.05		0.01	0.00
3	5.80	0.10	0.05		0.02	0.00
4	6.00	0.14	0.34		0.03	0.01
5	6.20	0.19	0.48		0.04	0.02
6	6.40	0.15	0.50		0.03	0.02
7	6.60	0.18	0.55		0.04	0.02
8	6.80	0.15	0.06		0.03	0.00
9	7.00	0.20	0.05		0.04	0.00
10	7.20	0.20	0.05		0.04	0.00
11	7.40	0.15	0.05		0.03	0.00
12	7.60	0.11	0.05		0.02	0.00
13	7.80	0.10	0.05		0.02	0.00
14	8.00	0.08	0.05		0.02	0.00
15	8.20	0.06	0.05		0.01	0.00
16	8.40	0.00	0.00		0.00	0.00



Site ID: FC-11

Site Name: Fisher Creek at fish ladder

Stage (ft):

Date: 9/21/2000 Time: 1700

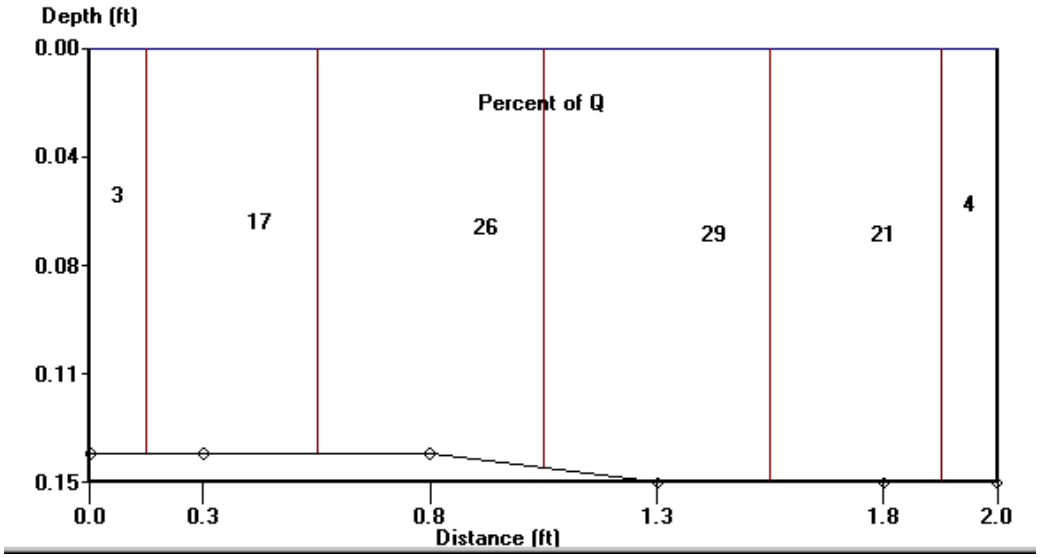
Comment: Measured flow in fish ladder weir notch second from bottom of ladder. Flow through weir even and laminar, but shallow. Flow rated as good (+/- 5% error) based on field observations.

Discharge Result

Total Area = 0.29 sq. ft.
Average Velocity = 1.73 ft./sec.

Total Discharge = 0.50 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	0.00	0.14	0.83		0.02	0.01
2	0.25	0.14	1.65		0.05	0.09
3	0.75	0.14	1.90		0.07	0.13
4	1.25	0.15	1.92		0.08	0.14
5	1.75	0.15	1.89		0.06	0.11
6	2.00	0.15	0.95		0.02	0.02



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Appendix B

QWIN Data Reports –
Minimum/Maximum Flow Estimates

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Site ID: FC-1 MIN

Site Name: Hill Ditch under N-bound I-5 bridge

Stage (ft): 15.27

Date: 09/21/200 Time: 07:45

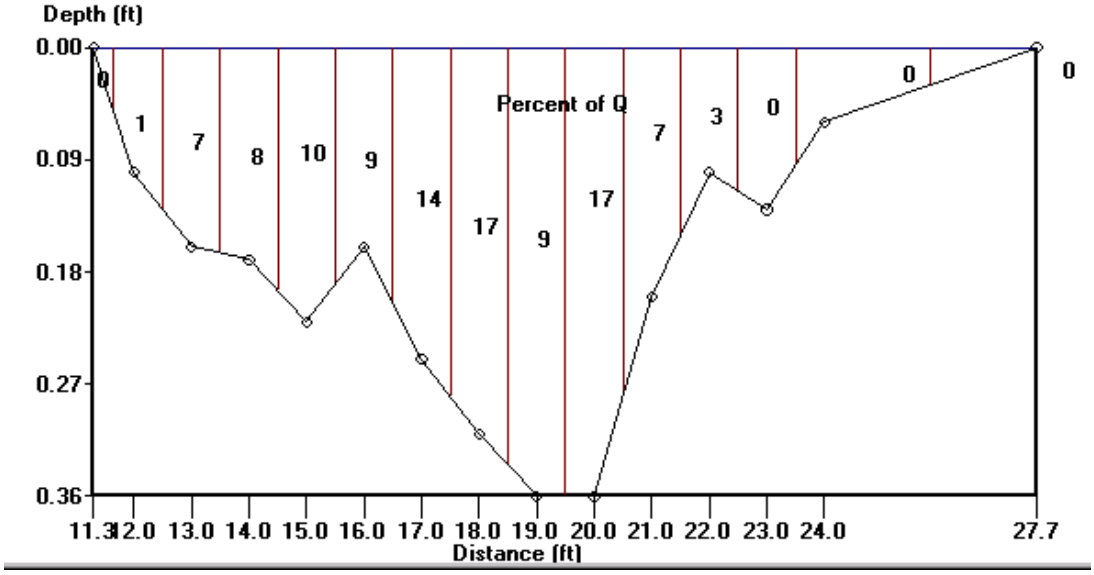
Discharge Result

Total Area = 2.65 sq. ft.
Average Velocity = 0.59 ft./sec.

Total Discharge = 1.56 cfs

Comment: Reference point (RP) measured from established RP on Cedardale Road bridge after flow measurement complete at 08:27. No RP measurement made before flow measurement. Flow-measurement site rated as good (+/- 5% error).

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	11.30	0.00	0.00		0.00	0.00
2	12.00	0.10	0.18		0.08	0.02
3	13.00	0.16	0.66		0.16	0.11
4	14.00	0.17	0.77		0.17	0.13
5	15.00	0.22	0.70		0.22	0.15
6	16.00	0.16	0.86		0.16	0.14
7	17.00	0.25	0.86		0.25	0.22
8	18.00	0.31	0.83		0.31	0.26
9	19.00	0.36	0.37		0.36	0.13
10	20.00	0.36	0.74		0.36	0.27
11	21.00	0.20	0.51		0.20	0.10
12	22.00	0.10	0.39		0.10	0.04
13	23.00	0.13	0.01		0.13	0.00
14	24.00	0.06	0.00		0.14	0.00
15	27.70	0.00	0.00		0.00	0.00



Site ID: FC-1MAX

Site Name: Hill Ditch under N-bound I-5 bridge

Stage (ft): 15.27

Date: 09/21/200 Time: 07:45

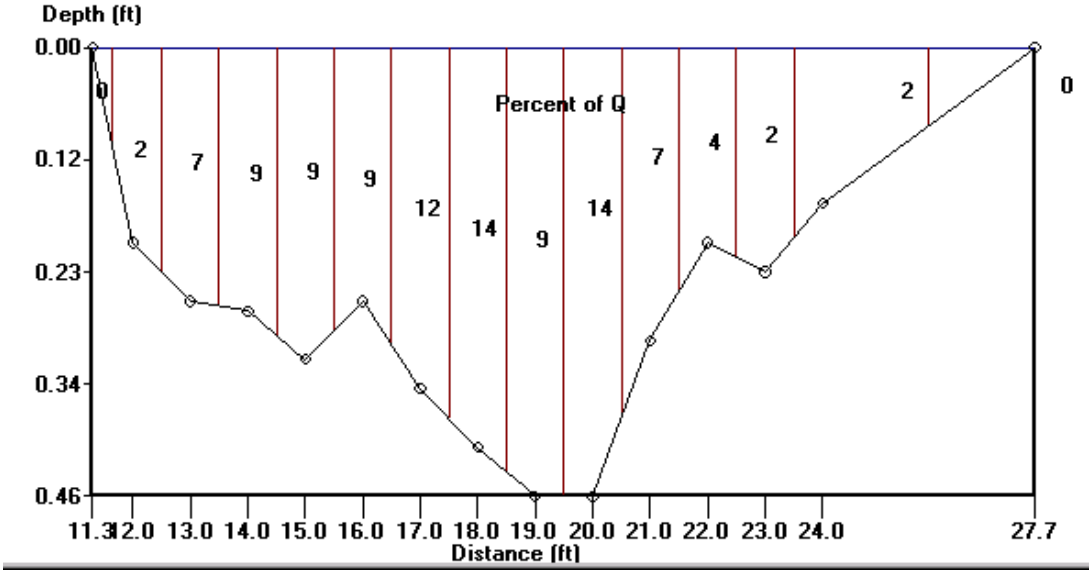
Discharge Result

Total Area = 4.07 sq. ft.
Average Velocity = 0.75 ft./sec.

Total Discharge = 3.04 cfs

Comment: Reference point (RP) measured from established RP on Cedardale Road bridge after flow measurement complete at 08:27. No RP measurement made before flow measurement. Flow-measurement site rated as good (+/- 5% error).

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	11.30	0.00	0.00		0.00	0.00
2	12.00	0.20	0.38		0.17	0.06
3	13.00	0.26	0.86		0.26	0.22
4	14.00	0.27	0.97		0.27	0.26
5	15.00	0.32	0.90		0.32	0.29
6	16.00	0.26	1.06		0.26	0.28
7	17.00	0.35	1.06		0.35	0.37
8	18.00	0.41	1.03		0.41	0.42
9	19.00	0.46	0.57		0.46	0.26
10	20.00	0.46	0.94		0.46	0.43
11	21.00	0.30	0.71		0.30	0.21
12	22.00	0.20	0.59		0.20	0.12
13	23.00	0.23	0.21		0.23	0.05
14	24.00	0.16	0.15		0.38	0.06
15	27.70	0.00	0.00		0.00	0.00



Site ID: FC-4MIN

Site Name: Bulson Creek below Bulson Road

Stage (ft):

Date: 09/21/200 Time: 10:45

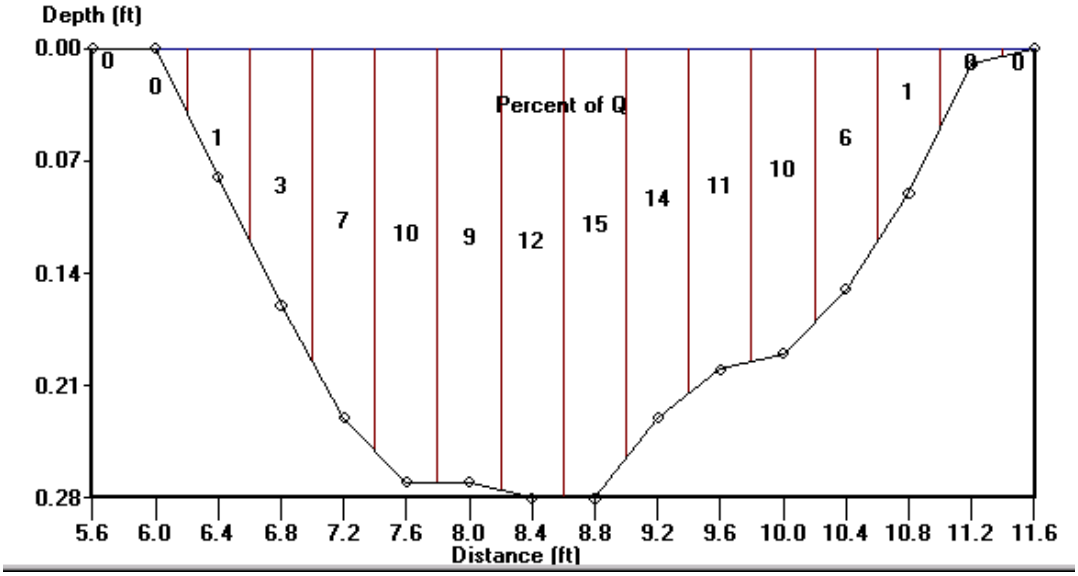
Discharge Result

Total Area = 0.98 sq. ft.
Average Velocity = 0.59 ft./sec.

Total Discharge = 0.58 cfs

Comment: No stage change during measurement. Good even bottom, fairly laminar flow. Section rated good (+/- 5% error) based on field observations.

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	5.60	0.00	0.00		0.00	0.00
2	6.00	0.00	0.00		0.00	0.00
3	6.40	0.08	0.18		0.03	0.01
4	6.80	0.16	0.31		0.06	0.02
5	7.20	0.23	0.45		0.09	0.04
6	7.60	0.27	0.52		0.11	0.06
7	8.00	0.27	0.47		0.11	0.05
8	8.40	0.28	0.64		0.11	0.07
9	8.80	0.28	0.79		0.11	0.09
10	9.20	0.23	0.88		0.09	0.08
11	9.60	0.20	0.81		0.08	0.06
12	10.00	0.19	0.76		0.08	0.06
13	10.40	0.15	0.57		0.06	0.03
14	10.80	0.09	0.23		0.04	0.01
15	11.20	0.01	0.00		0.00	0.00
16	11.60	0.00	0.00		0.00	0.00



Site ID: FC-4MAX

Site Name: Bulson Creek below Bulson Road

Stage (ft):

Date: 09/21/200 Time: 10:45

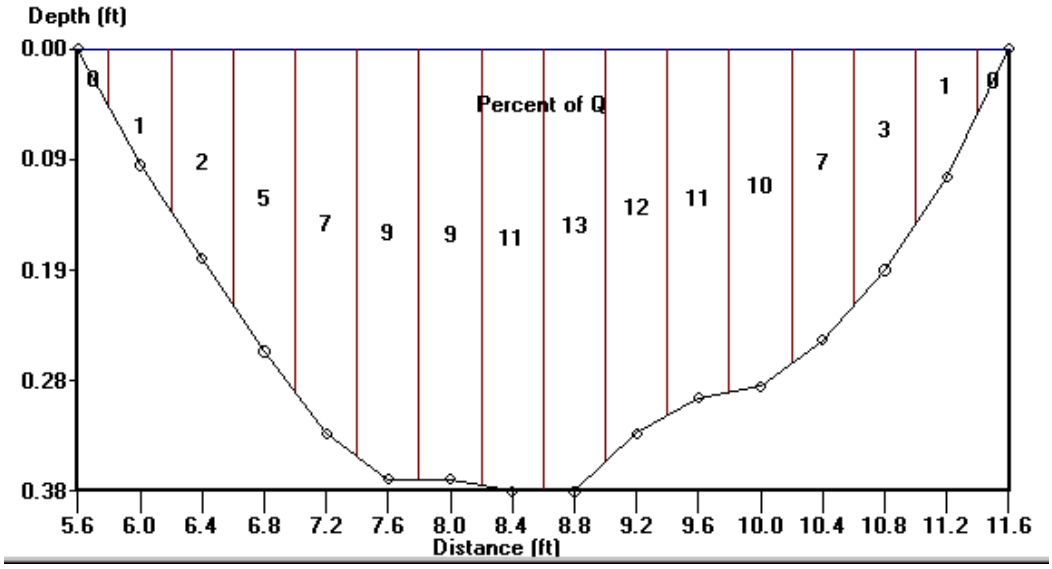
Discharge Result

Total Area = 1.54 sq. ft.
Average Velocity = 0.75 ft./sec.

Total Discharge = 1.15 cfs

Comment: No stage change during measurement. Good even bottom, fairly laminar flow. Section rated good (+/- 5% error) based on field observations.

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	5.60	0.00	0.00		0.00	0.00
2	6.00	0.10	0.15		0.04	0.01
3	6.40	0.18	0.38		0.07	0.03
4	6.80	0.26	0.51		0.10	0.05
5	7.20	0.33	0.65		0.13	0.09
6	7.60	0.37	0.72		0.15	0.11
7	8.00	0.37	0.67		0.15	0.10
8	8.40	0.38	0.84		0.15	0.13
9	8.80	0.38	0.99		0.15	0.15
10	9.20	0.33	1.08		0.13	0.14
11	9.60	0.30	1.01		0.12	0.12
12	10.00	0.29	0.96		0.12	0.11
13	10.40	0.25	0.77		0.10	0.08
14	10.80	0.19	0.43		0.08	0.03
15	11.20	0.11	0.20		0.04	0.01
16	11.60	0.00	0.00		0.00	0.00



Site ID: FC-7 MIN

Site Name: Sandy Creek

Stage (ft):

Date: 09/21//20 Time: 13:35

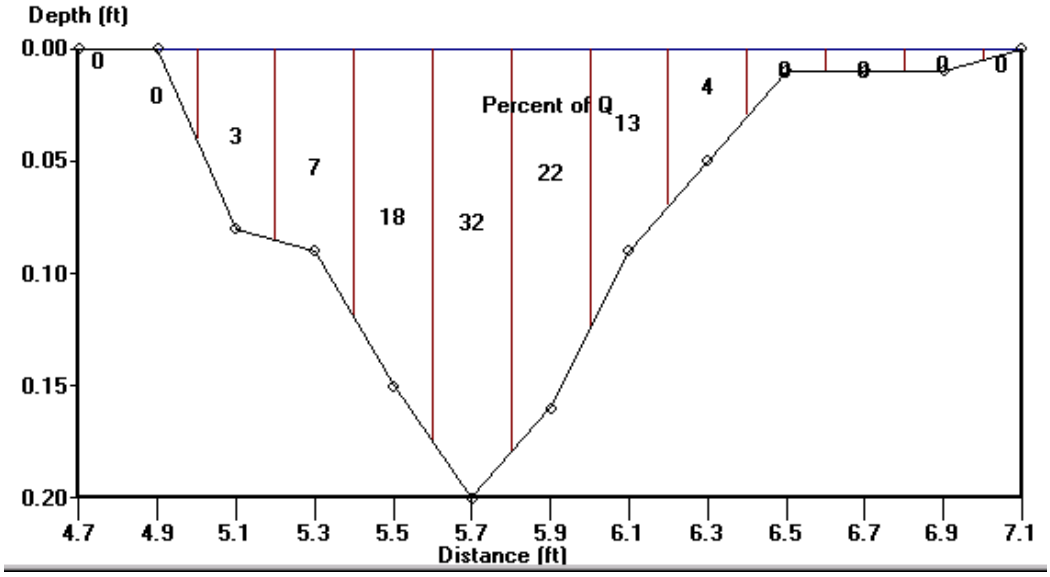
Discharge Result

Total Area = 0.17 sq. ft.
Average Velocity = 0.53 ft./sec.

Total Discharge = 0.09 cfs

Comment: Location about 15 ft. above confluence w/ Carpenter Creek. Moderately smooth, even bottom, very shallow. Sectoin rated as good to fair (+/- 5% to 8% error) based on field observations.

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	4.70	0.00	0.00		0.00	0.00
2	4.90	0.00	0.00		0.00	0.00
3	5.10	0.08	0.15		0.02	0.00
4	5.30	0.09	0.37		0.02	0.01
5	5.50	0.15	0.55		0.03	0.02
6	5.70	0.20	0.73		0.04	0.03
7	5.90	0.16	0.63		0.03	0.02
8	6.10	0.09	0.65		0.02	0.01
9	6.30	0.05	0.38		0.01	0.00
10	6.50	0.01	0.06		0.00	0.00
11	6.70	0.01	0.00		0.00	0.00
12	6.90	0.01	0.00		0.00	0.00
13	7.10	0.00	0.00		0.00	0.00



Site ID: FC-7 MAX

Site Name: Sandy Creek

Stage (ft):

Date: 09/21//20 Time: 13:35

Comment: Location about 15 ft. above confluence w/ Carpenter Creek. Moderately smooth, even bottom, very shallow. Sectoin rated as good to fair (+/- 5% to 8% error) based on field observations.

Discharge Result

Total Area = 0.40 sq. ft.
Average Velocity = 0.60 ft./sec.

Total Discharge = 0.24 cfs

Station	Distance	Depth	Velocity1	Velocity2	Area	Q
1	4.70	0.00	0.00		0.00	0.00
2	4.90	0.15	0.20		0.03	0.01
3	5.10	0.18	0.35		0.04	0.01
4	5.30	0.19	0.57		0.04	0.02
5	5.50	0.25	0.75		0.05	0.04
6	5.70	0.30	0.93		0.06	0.06
7	5.90	0.26	0.83		0.05	0.04
8	6.10	0.19	0.85		0.04	0.03
9	6.30	0.15	0.58		0.03	0.02
10	6.50	0.11	0.26		0.02	0.01
11	6.70	0.11	0.20		0.02	0.00
12	6.90	0.11	0.15		0.02	0.00
13	7.10	0.00	0.00		0.00	0.00