Millstone River Habitat Survey – 2016

On behalf of

The Regional District of Nanaimo

Drinking Water & Watershed Protection

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Introduction

The Regional District of Nanaimo Drinking Water & Watershed Protection (DWWP) program works with local stewards, scientists and residents to gain a better understanding of watershed health in the region. Through the RDN Community Watershed Monitoring Network, the DWWP program partners with volunteer groups and the Ministry of Environment to monitor water quality in numerous local streams, including the Millstone River since 2012. In June 2016, the DWWP program organized a training session and stream survey on the Millstone, to further interpret the water quality results and trends that have been observed. The data collected in this survey is intended to serve as a reference to help inform the interpretation of water quality data collected by the stewards as part of the RDN Community Watershed Monitoring Network and possibly guide restoration, remedial actions and/or further monitoring activities.

The objectives were;

- Survey the stream habitat and physical characteristics of the Millstone River.
- Train and educate community stewards and local property owners.
- Identify Millstone Watershed water quality conditions and remediation actions.
- Compare and rank fish habitat conditions and identify restoration actions.

Methods

The Urban Salmon Habitat Program (USHP) survey[1] was utilized. This method of survey was initiated in 1997 by the Ministry of Environment in concert with Vancouver Island stewardship groups. The Urban Salmon survey methodology has now been used by the majority of stewardship groups on Vancouver Island and the lower mainland.

The data collection objective of the Millstone River survey was to measure ten habitat units (pools or rifles) within each reach segment (each reach has a contiguous gradient, width and riparian cover) of the watershed. Two days of field collection were allocated with two teams each day. The survey was conducted on June 8 and 9, 2016 with volunteers from the Island Waters Fly Fishers. We surveyed Reach 1, 2, 4, 5, 7, 8 and Metral Creek, a tributary to Brannen Lake. On July 27, 2016, Reach 6 was surveyed by the Island Waters Fly Fishers Club members, utilizing their training from the June survey dates.

The USHP survey method involves instream and riparian assessments as well as field water quality. The USHP survey method collects up to 40 data points on each habitat unit (pool or riffle) encountered. It is compared to fish habitat assessment standards (Johnston & Slaney 1996[2]). The USHP habitat data was measured using staffs, tapes, chains and clinometers and then entered on an Apple iPad or iPhone using a custom file (pdf schema) written by D.R. Clough Consulting. The data was collected using a software

[1] Michalski, T.A., G.E. Reid, G.E. Stewart, 1997. Urban Salmon Habitat Program, Assessment and Mapping Procedures for Vancouver Island. Ministry of Environment, Lands and Parks, Fisheries Section. Nanaimo B.C.

[2] Johnston, N.T. and P.A. Slaney, 1996, Fish habitat Assessment Procedures, Watershed Restoration Circular No. 8, Ministry of Environment Lands and Parks and Ministry of Forests.

program (Avenza PDF Map) that was installed on an Apple iPhone and iPad dedicated to each survey team. The stream habitat data, locations and photo points were then exported as KML and CSV files for display on Google Earth and a spreadsheet program. The data was summarized and then results compared to the Watershed Restoration Program[3] standards for instream and riparian health.

The participants in the survey were; Julie Pisani of the RDN as well as Island Waters Fly fisher members (Paul Inscho, Dan Hooper, Jim McEwan, Bernie Heinrichs, Ant Elsdale and Ton Plijnaar). We also contacted several property owners on the survey reaches whom gave us access on their property. The survey was conducted by David Clough RPBio with assistance by Braden Judson, Fisheries Technician.

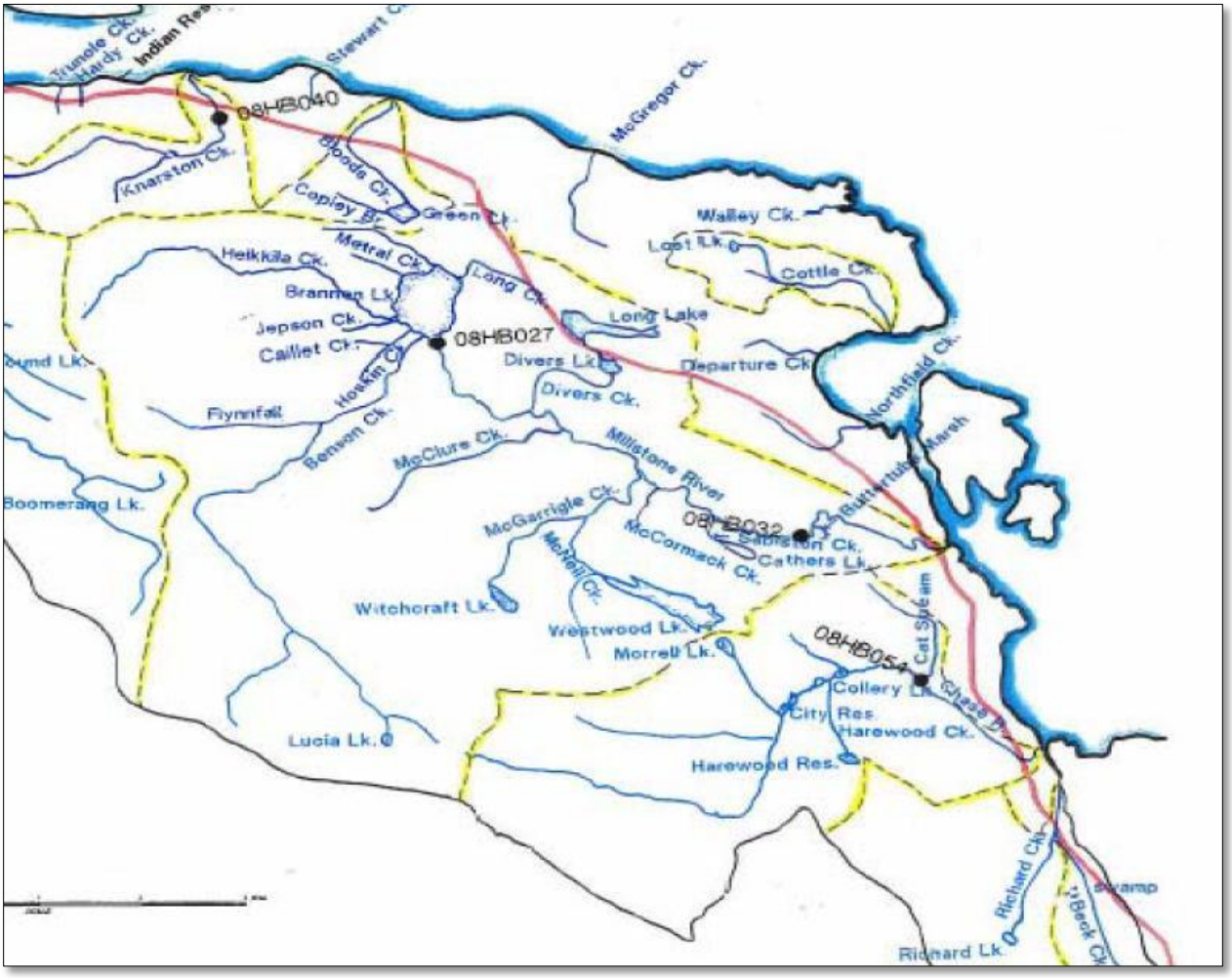
Watershed Area

The Millstone River is a moderately sized watershed of 93.2 km^2 area in the Regional District of Nanaimo. The watershed drains from Lucid Lake on the side of Mount Benson at 617m elevation. It then flows approximately 27km to the ocean. The headwaters are privately managed forestlands, the middle reaches are agricultural areas and the lower reaches are urban/residential areas. The Millstone Watershed includes many tributaries and several lakes. The largest lake is Brannen Lake followed by Westwood Lake, Divers Lake, Long Lake and Cathers Lake. The named (BC Env 1994[4]) tributaries include Sabiston, McGarrigle, McClure, Benson, Caillet, Jepson, Heikkila, Metral, Long and Beaver Creeks (Figure 1).

[3] N.T. Johnston and P.A. Slaney, 1996, Fish Habitat Assessment Procedures, Watershed Restoration Technical Circular No. 8. Ministry of Environment, Lands and Parks and Ministry of Forests

[4] Cook, Bob & John Baldwin, 1994, Water Allocation Plan, Chase to Nanoose. Ministry of Environment, Nanaimo B.C.

Figure 1: Millstone River Watershed (BC Env 1994).



Survey Area:

The Millstone River was split into reaches for the survey design. To accommodate the volunteer stewards two day schedule, we surveyed only mainstem reaches and one of the many tributaries that make up the watershed. Each reach was determined as a contiguous section of riparian vegetation, channel characteristics (confinement/sinuosity, depth) or gradient. They are briefly described below;

Reach 1: This reach goes from Swyalana Lagoon in the City Harbour, upstream past commercial, residential, park and recreational areas as well as under Highway 17 and Wall Street through the City. It ends at the Millstone River falls in Bowen Park. It is approximately 1.77 km long and ends at 30m elevation. This was the historic end of salmon access before the fishways were built.

Reach 2: This is a 500m long bedrock canyon through Bowen Park terminating at 52m elevation. It begins at the main falls and ends at the top of the steep gradient canyon. It has a 6m waterfall as well as long bedrock chutes that have blocked upstream fish access. This reach was not surveyed.

Bowen Park Fish Bypass Channel: This channel was constructed in 2007 to offer an 800m long fish bypass around the barrier falls. It runs parallel to Reach 2. This area was not surveyed.

Reach 3: In Bowen Park from the top of the falls 850m through a meandering riffle/pool complex to end at Bowen Road on 56m elevation.

Reach 4: A deep water meandering channel that begins at Bowen Road and after 3.23km ends at East Wellington Road at 60m elevation. This reach is sinuous and deep and drains Buttertubs Wetland.

Reach 5: A 2.14km long reach that follows farm land in a shallower, sinuous channel with exposed gravel bars from east Wellington Road upstream to Newfield Road at 70m elevation.

Reach 6: A 4.0 km long reach through farmland across Jinglepot Road that had a narrow riparian width with deep and sinuous channel ending at 76m elevation.

Reach 7: Above Jingle Pot Road 1.87km up past Biggs Road to end at Brannen Lake at an elevation of 77m. The reach is shallower with exposed gravel bars and limited riparian area.

Reach 8: Named Benson Creek, it begins at Brannen Lake, it is 3.11km up to Ammonite Falls over a confined, shallow, pool/riffle complex that ends at 207m elevation. Ammonite Falls is the current end of salmon access at the approximate 10m bedrock drop.

Reach 9: The headwater reach from Ammonite Falls 9.3 km climbing the west side of Mount Benson upstream to Lucid Lake at 617m elevation. This reach was not surveyed but is known to have resident trout.

Metral Creek: A short tributary from a small wetland (0.84 ha) near Metral Road 1.22km downstream to Brannen Lake. This tributary was selected to represent one of the many less known urban tributaries of the watershed.

Figure 2: Survey Area

Results and Discussion –Habitat Survey

The habitat data was summarized for surveyed reach. As noted in Methods, the survey dates were June 8 and 9, and July 27, 2016. Reaches 1, 3, 4, 5, 6, 7, 8 and Metral Creek were surveyed. Note field water quality sampling was not included in the report as it was not done in enough locations to compare data.

In the reach summaries below, only the 12 most important habitat parameters are summarized, rated and scored. Scoring is based on the USHP rating system where a Good result is scored as a 1, a Fair result scored as a 3 and a Poor result scored as a 5. The lower the score, the better the habitat. The appendices show the raw data as well as the sums and averages of all the detailed parameters.

Reach 1:

This reach goes from Swyalana Lagoon in the City Harbour, upstream past commercial, residential, park and recreational areas as well as under Highway 17 and Wall Street through the City. It ends at the Millstone River falls in Bowen Park. It is approximately 1.77 km long and ends at 30m elevation. This was the historic end of salmon access before the fishways were built.

The reach was surveyed in two segments, above and below the railway tunnel ending in Bowen Park. We measured five pools and five riffles over 242m. The average channel width was 16.9 m, and wetted width of 5.3 on a 2.6% average channel gradient. The results are shown in Table 1 below.

Reach 1 Habitat Results

Habitat Parameter	R1	Ratings	Result
% Pool Area	75	1	Good
Large Woody Debris/Bankfull Channel Width	0	5	Poor
% Cover in Pools	8	3	Fair
Average% Boulder Cover	8	5	Poor
Average % Fines	9	1	Good
Average % Gravel	3	not rated	Poor
% of Reach Eroded	3	1	Fair
Obstructions	0	0	Good
% of Reach Altered	0	1	Good
% Wetted Area	31	5	Poor
Totals		**22**	**Fair**

The Riparian features of Reach 1 are shown in the table below taken from the USHP summary tables.

Reach 1 Riparian Results

Riparian Ratings	R1	Ratings	Result
Land Use	38	3	Fair
Riparian Slope	32	3	Fair
Bank Stability	106	9	Fair
% Crown Cover	68	3	Fair
% of Reach Accessed	10	3	Fair

Riparian Ratings	R1	Ratings	Result
Average Vegetation Depth	31	3	Fair
Totals		**24**	**Fair**

Reach 1 is an urban/parkland reach that is protected by being in a confined area or parkland for most of its length. The instream fish habitat characteristics that were good are;

- Lack of man-made barriers, the reach from the ocean to the falls passes under a bridge and two culverts. These structures offer fish passage with no significant impairment.
- Lack of garbage (some minor material only)
- Lack of stream bank alterations (hardened banks).
- Lack of significant bank erosion
- Fair to Good Riparian depth (average 31m)
- Lack of significant invasive plants

The instream habitat characteristics that were poor are;

- Lack of wood cover (LWD). This material was washed out or removed over time.
- Lack of spawning gravel. This material was likely washed out over time.
- Lack of conifer riparian trees, much was young or deciduous.

Reach 2

As noted above in methods, this reach was not surveyed. It represents a 467m long bedrock run that includes bedrock waterfalls that historically stopped salmon access. There is now a bypass around the falls that offers both access and habitat for Coho Salmon and anadromous trout.

Reach 3

This reach is located at the top of the fishway and above the falls to Bowen Road (850m). Thirteen pools and riffles along 612m were measured June 8, 2016. The survey crew found out it had a few narrow deep sections that were not capable of wading through. It had a channel width of 14.6m with a wetted width of 9.9 m. Mean depth was 0.66m with observations over 1.5m in some sites.

Reach 3 Habitat Results

Habitat Parameter	R3	Ratings	Result
% Pool Area	103	1	Good
Large Woody Debris/Bankfull Channel Width	0.2	5	Poor
% Cover in Pools	56	1	Good
Average% Boulder Cover	0	5	Poor
Average % Fines	28	5	Poor
Average % Gravel	12	not rated	Fair
% of Reach Eroded	6	3	Fair
Obstructions	0	0	Good

Habitat Parameter	R3	Ratings	Result
% of Reach Altered	0	1	Good
% Wetted Area	68	5	Poor
Totals		**25**	**Fair**

The Riparian features of Reach 3 are shown below taken from the USHP summary tables.

Reach 3 Riparian Results

Riparian Ratings	R3	Ratings	Result
Land Use	94	4	Fair
Riparian Slope	26	1	Good
Bank Stability	74	3	Fair
% Crown Cover	61	3	Fair
% of Reach Accessed	14	3	Fair
Average Vegetation Depth	10	5	Poor
Totals		**18**	Fair

Reach 3 is adjacent a residential area on the river left bank and the upper Bowen park clearings on the right bank. It has a steep left bank and a shallow right bank. The instream fish habitat characteristics that were good were;

- Excellent instream cover with undercut banks and depth
- Lack of fish barriers
- Lack of garbage (some minor material only)
- Lack of stream bank alterations (hardened banks).
- Lack of significant invasive plants

The instream habitat characteristics that are poor were;

- Lack of wood cover (LWD). This material was washed out or removed over time.
- Erosion was observed on the steep left bank; a treed slide spanning the creek was reported to the City of Nanaimo to inspect for its immediate concern.
- Fine substrates were high indicating sediment inputs. They may be from a storm drain off Bowen that enters into the top of this reach. It also had the most significant bank failure and single sediment source observed in the survey.
- The thin riparian average width of 10m resulted in a canopy closure of only 61%.
- Lack of conifer riparian trees, most were young trees and/or deciduous trees with poorer canopy and root structure.

Reach 4

A deep water meandering channel that begins at Bowen Road and goes upstream past Buttertubs Marsh to end after 3.23km in a parkland area below East Wellington Road at 60m elevation. This reach is

sinuous and deep and drains Buttertubs Wetland. We surveyed 923m and found it to be very low gradient. The channel with was 11.7m with a wetted width of 8.6m. The average depth was just over 1.0m.

Reach 4 Habitat Results

Habitat Parameter	R4	Ratings	Result
% Pool Area	99	1	Good
Large Woody Debris/Bankfull Channel Width	0	5	Poor
% Cover in Pools	10	3	Fair
Average% Boulder Cover	0	5	Poor
Average % Fines	31	5	Poor
Average % Gravel	57	not rated	Good
% of Reach Eroded	17	5	Poor
Obstructions	0	0	Good
% of Reach Altered	0	1	Good
% Wetted Area	74	3	Fair
Totals		**28**	**Fair**

The Riparian features of Reach 4 are shown below taken from the USHP summary tables.

Reach 4 Riparian Results

Riparian Ratings	R4	Ratings	Result
Land Use	68	3	Fair
Riparian Slope	22	1	Good
Bank Stability	106	5	Poor
% Crown Cover	45	5	Poor
% of Reach Accessed	5	1	Good
Average Vegetation Depth	5	5	Poor
Totals		**20**	**Fair**

Reach 4 flows along a golf course and farm land in the upper area. The Island Highway crosses over its mid-section. The habitat characteristics of this reach reflect historic land use practices of land clearing and drainage. The reach is meandering and routinely floods over its banks in winter. The instream fish habitat characteristics that were good are;

- Lack of fish barriers,
- Large deep pools that offer cover and space for fish.
- No bank hardening (shoring, piles or placed rock)
- Gravel is present in this reach donates to the reaches downstream but spawning areas are lacking. A significant spawning gravel bar was located in the reach near the confluence of Sabiston Creek out of Cathers Lake.

The instream habitat characteristics that were poor are;

- Lack of wood cover (LWD). This material was all removed when the first farmers cleared and drained the land.
- Erosion was evident along most of this reach, primarily due to the steep gravel/sand banks with no embedded tree roots. The reach had soil blocks calving off the sides of the bank.
- Fine substrates were high confirming the sediment inputs from erosion.
- The thin riparian average width of 5m resulted in a canopy closure of only 45%.
- Lack of riparian trees and shrubs is the most significant impairment, much of the erosion and sediment could be minimized with a healthy riparian community.

Reach 5

This reach is 2.14km long and follows east Wellington Road upstream to Newfield Road at 70m elevation. It was inspected in the mid-section with a shorter survey of 138m length. The channel and wetted width were 10.0 m wide and the mean depth was 0.5m.

Reach 5 Habitat Results

Habitat Parameter	R5	Ratings	Result
% Pool Area	88	1	Good
Large Woody Debris/Bankfull Channel Width	0	5	Poor
% Cover in Pools	33	1	Good
Average% Boulder Cover	0	5	Poor
Average % Fines	50	5	Poor
Average % Gravel	17	not rated	Good
% of Reach Eroded	49	5	Poor
Obstructions	0	0	Good
% of Reach Altered	0	1	Good
% Wetted Area	100	1	Good
Totals		**24**	**Fair**

The Riparian features are shown in the table below taken from the USHP summary tables.

Reach 5 Riparian Results

Riparian Ratings	R5	Ratings	Result
Land Use	18	3	Fair
Riparian Slope	6	1	Good
Bank Stability	18	3	Fair
% Crown Cover	53	3	Fair
% of Reach Accessed	91	5	Poor
Average Vegetation Depth	5	5	Poor
Totals		**20**	**Fair**

Reach 5 flows along farm land and rural residences adjacent East Wellington Road. The instream fish habitat characteristics that were good are;

- Lack of fish barriers,
- Deep pools that offer cover and space for fish.
- No bank hardening (shoring, piles or placed rock)
- Gravel is present and there are spawning sites in shallow areas such as the road crossing bridges.

The instream habitat characteristics that were poor are;

- Lack of instream wood cover (LWD). This material was all removed when the first farmers cleared and drained the land.
- Erosion was evident but less than Reach 4 as the banks were lower and slightly better riparian strength.
- Fine substrates were high confirming the sediment inputs from erosion.
- The thin riparian average width of 5m resulted in a canopy closure of only 53%.
- Lack of riparian trees and shrubs is the most significant impairment, much of the erosion and sediment could be minimized with a healthy riparian community.

Reach 6

A 4.0 km long sinuous reach from East Wellington through farmland that had a narrow riparian width with deep and sinuous channel ending above Jingle Pot Road. This reach was surveyed a month later by the Island Waters Fly Fishers Club that recorded the data on field paper. The detailed record of the survey experience by Bernie Heinrichs is below in italics;

About 230 metres of the Millstone River was assessed with detailed notes out of over 2500 metres of river between Jingle Pot Bridge and Bigg's Road Bridge. There are sections of exceptional fish rearing habitat in assessed area with only one small unstable bank. Ray Gullison, the farmer along that portion, is an enthusiastic stream keeper who was very interested in our survey and very helpful in providing information during his guided walk. He has been planting trees close to the river. Some of them just last year and some many years ago.

Mark Fortin, Island Valley Farms, has a strong desire to repair the three eroded banks on his property.

Even including the quick views of portions of the river, we waded through less than 15% of the over 2.5 km of river between the two bridges. It definitely has great potential and should be assessed in more sections. Participants; Ant Elsdale, Bruce Murray, Dan Hooper and Bernie Heinrichs (250 658 6658) all with Island Waters Fly Fishers.

Water testing at Bigg's Bridge on the Millstone River and downstream at Jingle Pot Bridge revealed that there was a considerably greater flow at Jingle Pot Bridge than at Bigg's Bridge and considerably higher specific conductance indicating ground water. There are no inflow streams in this section of the

river. We also wanted to see if there were any beaver dams, the type and quality of fish habitat and any unstable banks.

Other Highlights of Ray Gullison's Land Along the River;
After our detailed assessment of the river, Ray showed us some more highlights. These included:
A culvert that drained run off and possibly some ground water
the location of where a beaver dam had been located but is now only a short riffle
Another beaver dam which has been inactive for over one year but was mainly intact with water flowing through it. Some trees that he had planted- some of them getting over 15 metres high. He also has some trails throughout the bush and trees.

Island Valley Farms Section;
We only waded in a few sections of the river on Island Valley Farms section but did meet the manager, Mark Fortin. He was looking for solutions to fixing three areas with eroded banks. He does have access to an excavator. I suggested that eventually a consultant such as Dave Clough could provide a design and work plan and the farm could do the work. We could only find one eroded bank which was getting close to the farm's road. It was about 3 metres high and had a log and some signs of remediation work done on it. We found another fairly long riffle near an unused cattle crossing section of the river. The other beaver dam that I had observed over 6 years ago was also not located but likely still there. The section of the river on the land leased by the Correction Center was not accessed either.

Historically, stream habitat restoration was undertaken in Reach 6 (?) from 2006 to 2010 with local property owners and DFO Community Programs (LWD on banks). Below are the results tables of the survey.

Reach 6 Habitat Results

Habitat Parameter	R6	Ratings	Result
% Pool Area	82	1	Good
Large Woody Debris/Bankfull Channel Width	0.4	5	Poor
% Cover in Pools	5	1	Poor
Average% Boulder Cover	1	5	Poor
Average % Fines	50	5	Poor
Average % Gravel	32	not rated	Good
% of Reach Eroded	0	1	Good
Obstructions	0	0	Good
% of Reach Altered	20	5	Poor
% Wetted Area	35	5	Poor
Totals		**24**	**Fair**

Reach 6 habitat and riparian is a mixed overall condition with the historic farm land clearing practices sweeping away much of the rooted bank cover and removing the riparian depth (both scoring poorly). Fortunately the thin riparian area has regenerated a thick brush canopy that makes up for some losses. The farms were maintaining a setback from the creek and there were no intrusions observed by machinery or livestock. There still remain some longer term issues with high sediment loads affecting

spawning habitat and lack of cover for fish. The continued recovery of the riparian area as well as possible solutions such as sediment traps and spawning gravel replacement may improve the fish values.

Reach 6 Riparian Results

Riparian Ratings	R6	Ratings	Result
Land Use	58	4	Poor
Riparian Slope	14	1	Good
Bank Stability	18	1	Good
% Crown Cover	71	1	Good
% of Reach Accessed	0	0	Good
Average Vegetation Depth	5	5	Poor
Totals		**15**	**Fair**

Reach 7

Above Jingle Pot Road 1.87km up past Biggs Road to end at Brannen Lake at an elevation of 77m. The reach is shallower with exposed gravel bars and limited riparian area. Seven pools and riffles along 172m were measured on June 9, 2016. The survey site was located just below Biggs Road adjacent the Wheat Family Farm. The channel width was 11.3 m wide and the wetted width was 6.1m. The mean depth was 0.51m. This reach had an average gradient of 1%. The survey ended in the deep channel draining Brannen Lake next to the Correctional Centre.

Reach 7 Habitat Results

Habitat Parameter	R7	Ratings	Result
% Pool Area	75	1	Good
Large Woody Debris/Bankfull Channel Width	0	5	Poor
% Cover in Pools	25	1	Good
Average% Boulder Cover	0	5	Poor
Average % Fines	69	5	Poor
Average % Gravel	24	not rated	Good
% of Reach Eroded	26	5	Poor
Obstructions	0	0	Good
% of Reach Altered	0	1	Good
% Wetted Area	54	5	Poor
Totals		**28**	**Fair**

The Riparian features are shown in the Table below taken from the USHP summary tables.

Reach 7 Riparian Results

Riparian Ratings	R7	Ratings	Result
Land Use	42	3	Fair
Riparian Slope	14	1	Good
Bank Stability	42	3	Fair

% Crown Cover	44	3	Fair
% of Reach Accessed	0	0	Good
Average Vegetation Depth	12	5	Poor
Totals		**15**	**Fair**

Reach 7 flows along farm land and rural residences adjacent East Wellington Road. The instream fish habitat characteristics that were good are;

- Lack of fish barriers
- Good cover (25%) despite the limited depth (0.5m)
- No bank hardening (shoring, piles or placed rock)
- Spawning habitat is the best of all reaches surveyed below the lake. There is a high amount of gravel substrates and several broad gravel riffles.

The instream habitat characteristics that were poor are;

- Lack of wood cover (LWD). This material was all removed when the first farmers cleared and drained the land. The lower banks allow easier potential placement.
- Erosion was less prevalent everywhere there was thick bank shrubbery. A large right bank erosion occurs at the Biggs Road Bridge pool. This site could be addressed with LWD placement.
- Fine substrates were high from sources such as the erosion below Biggs Road.
- The thin riparian average width of 12m resulted in a canopy closure of only 44%.
- Lack of tall riparian trees and shrubs is the most significant impairment. There may have been historic cattle erosion of the banks, but no active livestock damage was observed in this reach or any of the others surveyed.

Reach 8 (Benson Creek)

Above Biggs Road, Benson Creek goes 3.11km up to Ammonite Falls over a confined, shallow, pool/riffle complex that ends at 207m elevation. Ammonite Falls is the current end of salmon access at the approximate 10m bedrock drop. Twenty three pools and riffles were surveyed from the Scout Camp upstream 491m. The average channel width was 13.1m with a wetted of 4.4m. The average depth was 0.3m and 0.5% channel gradient. This was the last mainstem survey reach.

Reach 8 Habitat Results

Habitat Parameter	R8	Ratings	Result
% Pool Area	69	1	Good
Large Woody Debris/Bankfull Channel Width	1	5	Poor
% Cover in Pools	45	1	Good
Average% Boulder Cover	0	5	Poor
Average % Fines	37	5	Poor
Average % Gravel	22	not rated	Good
% of Reach Eroded	9	3	Fair
Obstructions	0	0	Good

Habitat Parameter	R8	Ratings	Result
% of Reach Altered	4	1	Good
% Wetted Area	34	5	Poor
Totals		**26**	**Fair**

The Riparian features are shown in the Table below taken from the USHP summary tables.

Reach 8 Riparian Results

Riparian Ratings	R8	Ratings	Result
Land Use	92	2	Good
Riparian Slope	48	1	Good
Bank Stability	122	3	Fair
% Crown Cover	71	1	Good
% of Reach Accessed	0	0	Good
Average Vegetation Depth	19	3	Fair
Totals		**10**	**Fair/Good**

Reach 8 flows past the Scout Camp and drains forested land, farms and rural residences. There are three gravel quarry operations adjacent to this reach. All are set back from the creek by over 30m. There are no public road crossings above Biggs Road. This reach is closest to forestry operations and has some debris jams in corners. The fish habitat characteristics that were good were;

- Lack of fish barriers
- Good instream cover (45%) despite the limited depth (0.3m)
- No bank hardening (shoring, piles or placed rock).
- Gravel is abundant and many pool crests offer spawning habitat. This is likely the highest value spawning area in the entire watershed.
- LWD was present in the highest amounts found (still low). It also offers LWD placement opportunities.
- There are more tall trees in this reach than most of the river. They are second growth but there is a good mix of conifer and shrubbery. The riparian width of 19m is a big increase from lower reaches. The canopy closure is 71%. Riparian conifer under-planting in this reach would still be recommended to fill in gaps.
- Erosion was lower than all the reaches except R1/R2. The trees and riparian depth are helping considerably.
- Brannen Lake is downstream offering perennial wetted habitat for fry rearing after emergence from spawning gravel in this reach.

The instream habitat characteristics that were poor are;

- Lack of wood cover (LWD). This material was all removed by logging in this area. As noted above while low it is higher amount than any other reach. More is needed.

- Fine substrate composition remains high, the legacy of historic logging of the banks. Smaller erosion sites such as mobile sticks and log chunk jams were observed in upper reaches.
- Summer drying has historically occurred in the lower reaches with fish trapped in shallow pools on their way to the lake.

Metral Creek

A short tributary from a small wetland (0.84 ha) near Metral Road 1.22km downstream to Brannen Lake. This tributary was selected to represent one of the many lesser known urban tributaries of the watershed. Nine pools and riffles were surveyed from just above Brannen Lake past Garside Road to 96m. The average channel width was 3.6m with a wetted of 1.85m. The average depth was 0.14m and 1.7 % channel gradient. This was the only tributary surveyed.

Metral Creek Habitat Results

Habitat Parameter	M1	Ratings	Result
% Pool Area	25	5	Poor
Large Woody Debris/Bankfull Channel Width	0	5	Poor
% Cover in Pools	30	1	Good
Average% Boulder Cover	20	3	Fair
Average % Fines	40	5	Poor
Average % Gravel	33	not rated	Good
% of Reach Eroded	22	5	Poor
Obstructions	0	0	Good
% of Reach Altered	19	5	Poor
% Wetted Area	51	5	Poor
Totals		**34**	**Fair**

The Riparian features are shown in the Table below taken from the USHP summary tables.

Metral Creek Riparian Results

Riparian Ratings	M1	Ratings	Result
Land Use	12	1	Good
Riparian Slope	20	1	Good
Bank Stability	38	2	Fair
% Crown Cover	85	1	Good
% of Reach Accessed	16	3	Fair
Average Vegetation Depth	6	5	Poor
Totals		**11**	**Fair**

The survey segment of Metral Creek flows through a residential subdivision. It passes through at least three road culverts and receives road runoff. The fish habitat characteristics that were good were;

- Lack of fish barriers (3 culverts are passable)
- Good instream cover (30%) despite the limited depth (0.14m)
- Gravel is abundant but lacks pool crests for stable spawning habitat. This could be improved with addition of rock crests.
- Brannen Lake is downstream offering perennial wetted habitat for fry rearing after emergence from spawning gravel in this reach.

The instream habitat characteristics that are poor were;

- Altered stream banks with hardening (bricks) and removal of all riparian plants along several house lots near the lake.
- Lack of wood cover (LWD). This material is being removed by property owners keeping the creek 'clean". Need some information and education in this area.
- Fine substrate composition remains high, the current sources appear to be the roads. Storm water management is needed.

Summary & Recommendations for Water Quality Improvement

Reach	Water Quality Impact	Recommended Remedial Action	Comments
1	Storm water runoff affecting turbidity and water chemistry.	Identify all storm water drainage entry locations and determine remediation (sumps, rain gardens, diversion)	Wall Street runoff is likely the highest concern
2	Not surveyed	In Bowen Park	
3	Erosion and turbidity (land slide)	Repair the slide in the creek that resulted in a full spanning tree blocking flow.	City has been notified.
4	Erosion and turbidity (general bank erosion)	Work with property owners whom have begun tree planting. Fast growing shrubbery cuttings likely the best start to address weak banks, followed by trees.	Willow and Red Osier planting needed.
4	Storm water runoff resulting in erosion, turbidity, and pollution.	There are several highway drainages that lead to the creek that require monitoring and should have remediation structures if not present.	Traffic accident runoff could kill the creek if no detention is available.
5	Erosion and Turbidity	Work with property owners. Fast growing shrubbery cuttings likely the best start to address weak banks, followed by trees.	Willow and Red Osier planting needed.
6	Erosion and Turbidity	Add LWD to corners to improve fish habitat and reduce erosion	Completed 2006 to 2010, more requested by property owners.
7	Erosion and Turbidity	Address Biggs Road Bridge erosion. Add LWD as well as improve spawning/rearing habitat	Higher priority as it is active erosion. Stan Wheat is property owner to contact.
8	Erosion and Turbidity	Address small wood jams by repositioning to offer habitat and bank protection, plant riparian areas.	Willing property owners at gravel quarries and Scouts.
Metral	Erosion and Turbidity	Repair altered stream banks with crumbling bricks below Garside Rd.	Work with property owners
Metral	Storm water Runoff	Garside Road runoff goes to this creek – a bioswales should be considered for protection.	At the road culvert location

Conclusions

The Millstone River habitat survey completed several objectives;

1.) We educated and trained stewards in fish habitat assessment as well as gave them an understanding of the value of this habitat
2.) We gathered the most complete habitat survey that has ever been done of the Millstone watershed.
3.) We identified water quality and fish habitat opportunities
4.) We met many watershed property owners whom also wish to participate in future monitoring or restoration activities by the RDN or local stewards

The Millstone River is home to Coho, Chum and Pink Salmon as well as Cutthroat and Rainbow Trout. It is not the most productive stream in the RDN but it may be the most well known as more people live near this waterway than any other. The Millstone is an urban stream. Identifying the anthropogenic impacts, monitoring them, and repairing them are essential for its existence. As many as 50 urban streams in Vancouver and Victoria have been eliminated by urbanization. The RDN Drinking Water Protection Program is generating essential information that is being used to protect the Millstone from ending up like Cecelia Creek in Victoria. This habitat survey will help, but the DWWP monitoring program and the invaluable partnership with stewards to form an evolving knowledge base of the watershed is the real success. It was a pleasure to work with such an interested and unselfish group of people whom proved their care and concern of the environment.

Yours Truly,

David R. Clough RPBio

Figure 3: Millstone Reach 1 Photo Page

Figure 4: Millstone Reach 3 Photo Page

Reach 3 - large pools

reach 3 - steep treed eft bank

Reach 3 - Slide site

Reach 3 - Outfall into creek

Figure 5: Millstone Reach 4 Photo Page

Reach 4 - with shrub riparian

Reach 4 - with deep pools

Reach 4 - eroding soil blocks

Reach 4 - the only gravel riffle

Figure 6: Millstone Reach 5 Photo Page

See reach 8 photo insert

Figure 7: Millstone Reach 7 Photo Page

Reach 7 - Pool start

Reach 7 - erosion at bridge outlet

R7 - Sediment across stream channel

R7-beaver dam above Biggs Rd bridge

Figure 8: Millstone Reach 8 Photo Page

Reach 5 - Erosion site

reach 8 - small loose wood debris

Reach 8 at Biggs Bridge

Reach 8 - shallow site

Figure 9: Millstone Metral Photo Page

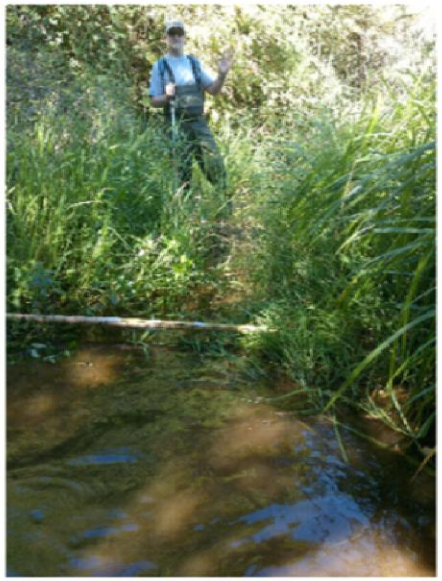
Metral M1- cleared right bank

Metral M1 - Garside Rd Culvert

Metral M1 - altered bank and drains

Metral M1- erosion from storm water

Figure 10: Reach 6 Photos



1.) Deep pool in brushy area.

3.) washout on Island Valley Farm

2.) Inactive beaver dam

Appendix 1 –Reach 1 Habitat Data

Stream Name	Millstone River	Watershed Code	920-395400	Date	June 8/9	Reach Name	1.00			Discharge Depth #1		Velocity
Water Quality Information				Field Crew		BJJ						T1
Dissolved Oxygen	.	pH		Total Dissolved Solids		Temp C	17.30	Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	242.00	Discharge Depth #3		T3

Site Length

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate Percent					Percent Instream Cover					Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)	Land Use		Vegetation Type		Riparian Slope		Stability		Vegetation Depth		Livestock Access		Photos	Comments
												Bed	Bld	Cob	Grv	Fine	Bold	LWD	Cutbk	Veg	Other										Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left		
Pool	0.00	37.00	37.00	11.20	414.40	414.40		0.30	0.00	15.60		0	5	45	5	45	5					70.00	0		3	0	0				FG	RS	Mix	Br	5	30	Med	Med	0	40	5			
Riffle	37.00	52.00		7.00	0.00	105.00		0.10	7.00	15.00		0	70	20	5	5	10					80.00	0		0	0	0				FG	RS	Gr	Mix	5	40	Med	Med	10	40	5			
Pool	52.00	131.00	79.00	7.00	553.00	553.00		0.80	0.00	15.00		80	15	0	0	5	10					50.00	0		5	0	0				Nat	RS	Gr	Mix	5	40	High	Med	0	40	0			
Riffle	131.00	161.00		6.00	0.00	180.00		0.20	10.00	19.00		90	10	0	0	0	10					50.00	0		0	0	0				FG	RS	Br	Mix	10	45	High	High	0	30	0			
Pool	161.00	207.00	46.00	4.00	184.00	184.00		0.30	0.00	19.00		80	10	5	0	5	5					65.00	0		0	0	0				FG	RS	Br	Mix	10	60	High	High	5	40	0			
Pool	242.00	253.00	11.00	4.00	44.00	44.00		0.20	0.00	19.00		60	15	15	0	10	5					75.00	0		0	0	0				Nat	Nat	Mix	Mix	10	60	High	High	10	60	0			
Riffle	253.00	268.00		2.50	0.00	37.50		0.20	2.00	16.50		10	30	60	0	0	10					80.00	0		0	0	0				Nat	Nat	Mix	Mix	5	60	High	High	50	50	0			
Pool	268.00	272.00	4.00	7.50	30.00	30.00		0.30	0.00	16.50		10	30	60	0	0	10					70.00	0		0	0	0				Nat	Nat	Mix	Mix	5	50	High	High	50	50	0			
Riffle	272.00	283.00		2.00	0.00	22.00		0.10	4.00	17.00		0	50	20	20	10	5					75.00	0		0	0	0				Nat	Nat	Mix	Mix	10	40	High	High	50	60	0			
Riffle	207.00	242.00		2.00	0.00	70.00		0.10	3.00	17.00		80	10	5	0	5	5					60.00	0		0	0	0				Nat	Nat	Mix	Mix	10	55	High	High	0	40	0			
Reach Totals and Averages		242.00	242.00	5.32	1225.40	1639.90	74.72	0.26	2.60	16.96	31.37	41	25	23	3	9	8					67.50	0	0.00	3	0	0	0			18	20			10	22	14	16	17.50	45.00	4	0		

Appendix 2 –Reach 3 Habitat Data

Stream Name	Millstone	Watershed Code	920-000	Date	Jun 8/16	Reach Name	3			Discharge Depth #1		Velocity	
Water Quality Information					Field Crew		BJ,Ton,					T1	Site Length
Dissolved Oxygen	.	pH		Total Dissolved Solids		Temp C		Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2	
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	612.00	Discharge Depth #3		T3	

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate Percent Bed	Bld	Cob	Grv	Fine	Percent Instream Cover Bold	LWD	Cutbk	Veg	Other	Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)	Land Use Right	Left	Vegetation Type Right	Left	Riparian Slope Right	Left	Stability Right	Left	Vegetation Depth Right	Left	Livestock Access Right	Left	Photos	Comments
Pool	0.00	83.00	83.00	9.00	747.00			0.80	0.00	12.80		0	5	40	0	55			15			50.00	2		30						R	R	Mix	Mix	10	42	Med	Med	5	15				pool 1
Riffle	83.00	89.00		4.00	0.00			0.10	1.00	12.00		0	5	40	0	55				15		100.00	0								R	R	Mix	Mix	12	30	Med	Med	5	15				
Pool	89.00	99.00	10.00	8.00	80.00			0.40		9.00			5	50	15	30			20												R	R	Sh	Mix			Med	Low	5	15	5	30		
Riffle	99.00	114.00		5.00	0.00			0.10		10.00				80	10	10															R	R	Sh	Mix	5	30	Med	Med	5	15				
Pool	114.00	137.00	23.00	11.70	269.10			1.00	0.00	14.00			5	70		25			10			60.00	0		4						R	R	Sh	Mix	5	30	Med	Low	5	15				
Pool	137.00	170.00	33.00	21.00	693.00			1.20	0.00	25.00		40			30	30			25			20.00	2								Nat	Nat	Mix	Mix	2	25	Med	Med	20	10				
Riffle	170.00	182.00		20.00	0.00			0.01		21.00		100																			Nat	Nat	Mix	Mix	2	25	Med	Med	15	5				
Pool	182.00	194.00	12.00	11.00	132.00			1.50	0.00	19.00		40	20			40						55.00	2								Nat	Nat	Mix	Mix	2	2	High	High	15	5				
Riffle	194.00	211.00		2.00	0.00			0.10	2.00	18.00		90				10					30	100.00	1								R	R	Mix	Br	2	10	High	High	10	5				
Pool	211.00	331.00	120.00	12.00	1440.00			1.40		14.00		40	20		15	25															C	R	Mix	Br	2	2	Med	Med	2	10				
Pool	331.00	548.00	217.00	12.00	2604.00			1.40	0.00	14.00		40	20		15	25					20	35.00	0								C	R	Mix	Mix	12	18	Med	Med	2	10				
Riffle	548.00	582.00		3.50	0.00			0.20	1.00	9.50		40		50		10					25	65.00	0								Nat	R	Mix	Mix	1	1	Med	Med	5	5				
Pool	582.00	612.00	30.00	10.00	300.00			0.40	0.00	11.00		30	10	40		20					20	60.00	0								Nat	R	Mix	Mix	1	1	Med	Med	20	10				
																															0	0	0	0			0	0						
																															0	0	0	0			0	0						
Reach Totals and Averages		612.00	528.00	9.94	6265.10	6082.34	103.00	0.66	0.44	14.56	68.25	42	11	53	12	28	0		18	15	24	60.56	7	0.17	6	0	0	0			41	53			12	14	35	39	8.77	10.38	1	5		

Appendix 3 – Reach 4 Habitat Data

Stream Name	Millstone River	Watershed Code	920-395400	Date	June 8/9	Reach Name	4			Discharge Depth #1		Velocity																														
Water Quality Information					Field Crew		DRC					T1		Site Length																														
Dissolved Oxygen	.	pH		Total Dissolved Solids		Temp C		Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2																																		
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	923.00	Discharge Depth #3		T3																																		

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate Percent						Percent Instream Cover						Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)	Land Use		Vegetation Type		Riparian Slope		Stability		Vegetation Depth		Livestock Access		Photos	Comments
												Bed	Bld	Cob	Grv	Fine		Bold	LWD	Cutbk	Veg	Other											Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left		
Pool	0.0	184.0	184.00	9.00	1656.00	1656.00		0.90	0.00	12.00		0.0	0.0	0.0	0.0	100					10.0			25.0	3		0	0	0				FG	FG	Sh	Br	5	5	Low	Low	2	5				
Pool	184.0	246.0	62.00	9.00	558.00	558.00		1.50	0.00	13.00		0.0	0.0	0.0	90.0	10.0					10.0			50.0	1		70	0	0				FG	FG	Mix	Mix	5	5	Med	Low	5	10				
Pool	184.0	246.0	62.00	9.00	558.00	558.00		1.50	0.00	13.00		0.0	0.0	0.0	90.0	10.0					10.0			50.0	1		70	0	0				FG	FG	Mix	Mix	5	5	Med	Low	5	10				
Pool	246.0	328.0	82.00	11.00	902.00	902.00		1.40	0.00	12.00		0.0	0.0	0.0	10.0	90.0					10.0			50.0	0		0	0	0				FG	FG	Mix	Mix	5	5	Low	Low	5	10				
Pool	328.0	413.0	85.00	7.00	595.00	595.00		0.70	0.00	10.00		0.0	0.0	10.0	70.0	20.0					10.0			50.0	1		0	0	0				FG	FG	Mix	Mix	2	5	Low	Low	5	5				
Pool	413.0	482.0	69.00	5.00	345.00	345.00		0.80	0.00	8.00		0.0	0.0	70.0	20.0	10.0					10.0			50.0	0		0	0	0				FG	FG	Mix	Mix	2	5	Low	Low	5	5				
Pool	482.0	658.0	176.00	11.00	1936.00	1936.00		0.90	0.00	12.00		0.0	0.0	10.0	70.0	20.0					10.0			50.0	0		0	0	0				FC	FG	Mix	Mix	2	5	Low	Low	5	5				
Pool	658.0	785.0	127.00	11.00	1397.00	1397.00		0.90	0.00	12.00		0.0	0.0	10.0	70.0	20.0					10.0			50.0	0		0	0	0				FG	FG	Mix	Mix	2	5	Low	Low	5	5				
Pool	785.0	831.0	46.00	11.00	506.00	506.00		0.90	0.00	12.00		0.0	0.0	10.0	70.0	20.0					10.0			50.0	0		0	0	0				FG	FG	Mix	Mix	2	5	Low	Low	5	5				
Pool	831.0	892.0	61.00	11.00	671.00	671.00		0.90	0.00	12.00		0.0	0.0	10.0	70.0	20.0					10.0			50.0	0		0	0	0				FG	FG	Mix	Mix	5	5	Low	Low	2	5				
Riffle	892.0	923.0	31.00	1.50		46.50		0.80	0.00	13.00		0.0	0.0	10.0	70.0	20.0								25.0	1		20	0	0				FG	FG	Mix	Mix	5	5	Low	Low	2	5		20		
Reach Totals and Averages		923.00	0.00	8.68	9124.00	9170.50	99.49	1.02	0.00	11.73	74.03	0.0	0.0	11.8	57.3	30.9	0				10.0			45.5	7.0	0.1	17.3	0.0	0.0	0.0			35.0	33.0			11.0	11.0	51.0	55.0	4.2	6.4	0.0	2.2		

Appendix 4 – Reach 5 Habitat Data

Stream Name	Millstone River	Watershed Code	920-395400	Date	June 8/9	Reach Name	5.00			Discharge Depth #1		Velocity		
Water Quality Information					Field Crew		DRC					T1		Site Length
Dissolved Oxygen	9.00	pH	8.05	Total Dissolved Solids	81.00	Temp C		Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2		
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	138.00	Discharge Depth #3		T3		

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate Percent					Percent Instream Cover				
												Bed	Bld	Cob	Grv	Fine	Bold	LWD	Cutbk	Veg	Other
Pool	0.00	50.00	50.00	11.00	550.00	550.0		0.60	0.00	11.00		0	10	30	30	30					30
Riffle	50.00	68.00		10.00	0.00	180.0		0.40	0.00	10.00		0	5	25	10	60					40
Pool	68.00	138.00	70.00	10.00	700.00	700.0		0.40	0.00	10.00		0	5	25	10	60					30
Reach Totals and Averages		138		10	1250	1426.0	88	0.5	0.0	10	100	0	7	27	17	50	0				33

Habitat Type	Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)	Land Use		Vegetation Type		Riparian Slope		Stability		Vegetation Depth		Livestock Access		Photos	Comments
										Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left		
Pool	50	1		0	0	0				RS	RS	Mix	Mix	34	26	Med	Med	5	5		50		
Riffle	50	1		18	0	0				RS	RS	Mix	Mix	34	26	Med	Med	5	5				
Pool	60	0		50	0	0				RS	RS	Mix	Mix	34	26	Med	Med	5	5				
										0	0	0	0			0	0						
										0	0	0	0			0	0						
Reach Totals and Averages	53	2	0.15	49	0	0	0			9	9			3	3	9	9	5.0	5.0	0	36		

Appendix 5 – Reach 6 Habitat Data

Stream Name	Millstone R6	Watershed Code	1234	Date	27-Jul-16	Reach Name	R6			Discharge Depth #1		Velocity		
Water Quality Information					Field Crew		IWFF					T1		Site Length
Dissolved Oxygen	.	pH		Total Dissolved Solids		Temp C		Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2		
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	230.00	Discharge Depth #3		T3		

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	e Percent Wetted Area	Substrate Percent					Percent Instream Cover				
												Bed	Bld	Cob	Grv	Fine	Bold	LWD	Cutbk	Veg	Other
Riffle	0.00	22.00	22.00	4.00		88.00		0.10	1.00	10.00		0	20	20	30	30	5	0	5	0	0
Pool	22.00	87.00	65.00	5.00	325.00	325.00		0.80	0.00	10.00		0	20	30	30	20	5	5	5		
Pool	87.00	137.00	50.00	4.00	200.00	200.00		0.40	0.00	10.00		0	5	30	35	30	0	0	10	0	0
Riffle	137.00	139.00	2.00	2.00		4.00		0.10	1.00	10.00		0	0	0	50	50	0	0	0	0	0
Pool	139.00	188.00	49.00	6.00	294.00	294.00		0.40	0.00	10.00		0	0	0	30	70	0	0	0	0	0
Riffle	188.00	191.00	3.00	2.00		6.00		0.10	1.00	10.00		0	0	0	25	75	0	0	0	0	0
Riffle	191.00	230.00	39.00	2.00		78.00		0.10	1.00	10.00		0	0	0	25	75	0	0	0	0	0
Reach Totals and Averages		230.00	230.00	3.57	819.00	995.00	82.31	0.29	0.57	10.00	35.71	0	6	11	32	50	1	1	3	0	0

Habitat Type	Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Land Use		Vegetation Type		Riparian Slope		Stability		Vegetation Depth		Livestock Access		Photos	Comments
								Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left		
Riffle	90.00	0		0	0	0	0	FG	FG	Mix	Mix	0	0	High	High	5	5				Bridge site
Pool	60.00	3		0	50	0	0	FG	FG	Mix	Mix	0	0	High	High	5	5				rt bank
Pool	90.00	2		0	0	0	0	FG	FG	Mix	Mix	5	5	High	High	5	5				brushy site
Riffle	45.00	0		0	0	0	0	FC	FC	Mix	Mix	5	5	High	High	5	5	0	0		
Pool	55.00	3		0	0	0	0	FC	FC	Mix	Mix	5	5	High	High	5	5				
Riffle	90.00	1		0	0	0	0	FC	FC	Mix	Mix	5	5	Med	Med	5	5				
Riffle	70.00	0		0	0	0	0	FC	FC	Mix	Mix	5	5	High	High	5	5				
								0	0	0	0			0	0						
								0	0	0	0			0	0						
Reach Totals and Averages	71.43	9	0.39	0	22	0	0	29	29			7	7	9	9	5.00	5.00	0	0		

Appendix 6 – Reach 7 Habitat Data

Stream Name	Millstone River	Watershed Code	920-395400	Date	June 8/9	Reach Name	7.00			Discharge Depth #1		Velocity		
Water Quality Information					Field Crew		BJJ					T1		Site Length
Dissolved Oxygen	.	pH		Total Dissolved Solids		Temp C		Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2		
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	172.00	Discharge Depth #3		T3		

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate Percent Bed	Bld	Cob	Grv	Fine	Percent Instream Cover Bold	LWD	Cutbk	Veg	Other
Pool	0.00	50.00	50.00	9.00	450.00	450.0		0.60	0.00	12.00		0	0	0	20	80					20
Riffle	50.00	53.00		2.50	0.00	7.5		0.05	5.00	13.00		0	0	0	60	40				5	
Pool	53.00	68.00	15.00	5.00	75.00	75.0		0.50	0.00	9.00		0	0	0	30	70				5	
Riffle	68.00	77.00		1.00	0.00	9.0		0.05	1.00	11.00		0	5	45	30	20					
Pool	77.00	110.00	33.00	9.00	297.00	297.0		0.90	0.00	12.00		0	0	0	10	90					20
Riffle	110.00	149.00		8.00	0.00	312.0		0.50	2.00	11.00		0	0	0	10	90					
Pool	149.00	172.00	23.00	8.00	184.00	184.0		1.00	0.00	11.00		0	0	0	5	95				5	
Reach Totals and Averages		172.00	121.00	6.07	1006.0	1334.5	75.4	0.51	1.14	11.29	53.80	0	1	6	24	69	0			5	20

Habitat Type	Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)	Land Use Right	Land Use Left	Vegetation Type Right	Vegetation Type Left	Riparian Slope Right	Riparian Slope Left	Stability Right	Stability Left	Vegetation Depth Right	Vegetation Depth Left	Livestock Access Right	Livestock Access Left	Photos	Comments
Pool	65.00	5		0	0	0				FG	FG	Sh	Mix	10	1	Med	Med	5	30				
Riffle	40.00	0		0	0	0				FG	FG	Br	Br	10	1	Med	Med	5	30				
Pool	40.00	0		5	0	0				FG	FG	Br	Br	5	5	Med	Med	5	30				
Riffle	65.00	0		15	0	0				FG	FG	Br	Br	5	5	Med	Med	5	10				
Pool	15.00	1		25	0	0				FG	FG	Br	Br	5	5	Med	Med	5	10				
Riffle	60.00	0		0	0					FG	FG	Br	Br	5	5	Med	Med	5	10				
Pool	25.00	1		0	0	0				FG	FG	Sh	Gr	5	5	Med	Med	5	15				
Reach Totals and Averages	44.3	7	0.46	26	0	0	0			21	21			7	7	21	21	5.00	19.29	0	0		

Appendix 7 – Reach 8 Habitat Data

Stream Name	Millstone River	Watershed Code	920-395400	Date	June 8/9	Reach Name	8.00			Discharge Depth #1		Velocity	
Water Quality Information					Field Crew		BJJ					T1	Site Length
Dissolved Oxygen	.	pH		Total Dissolved Solids		Temp C		Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2	
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	491.00	Discharge Depth #3		T3	

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area
Pool	0.00	20.00	20.00	5.00	100.00	100.0		0.70	0.00	7.50	
Riffle	20.00	26.00		5.00	0.00	30.0		0.20	2.00	8.00	
Pool	26.00	36.00	10.00	4.50	45.00	45.0		0.50	0.00	8.00	
Riffle	36.00	64.00		2.50	0.00	70.0		0.10	2.00	9.00	
Pool	64.00	86.00	22.00	6.00	132.00	132.0		0.20	0.00	8.00	
Riffle	86.00	95.00		3.00	0.00	27.0		0.10	2.00	11.00	
Pool	95.00	111.00	16.00	4.00	64.00	64.0		0.20	0.00	11.00	
Riffle	111.00	191.00		3.00	0.00	240.0		0.10	1.00	12.00	
Pool	191.00	219.00	28.00	6.00	168.00	168.0		0.20	0.00	11.00	
Riffle	219.00	228.00		5.50	0.00	49.5		0.10	1.00	12.00	
Pool	228.00	244.00	16.00	5.00	80.00	80.0		0.40	0.00	9.00	
Riffle	244.00	256.00		5.00	0.00	60.0		0.10	1.00	10.00	
Pool	256.00	275.00	19.00	6.00	114.00	114.0		0.60	0.00	11.00	
Pool	275.00	288.00	13.00	5.00	65.00	65.0		0.70	0.00	21.00	
Pool	288.00	313.00	25.00	3.00	75.00	75.0		0.30	0.00	18.00	
Riffle	313.00	324.00		5.00	0.00	55.0		0.20	1.00	24.00	
Pool	324.00	333.00	9.00	5.00	45.00	45.0		0.70	0.00	23.00	
Riffle	333.00	347.00		1.00	0.00	14.0		0.10	1.00	16.00	
Pool	347.00	392.00	45.00	6.00	270.00	270.0		0.70	0.00	24.00	
Pool	392.00	412.00	20.00	5.00	100.00	100.0		0.30	0.00	13.00	
Riffle	412.00	420.00		2.00	0.00	16.0		0.10	1.00	11.50	
Pool	420.00	439.00	19.00	5.00	95.00	95.0		0.40	0.00	11.00	
Riffle	439.00	463.00		5.00	0.00	120.0		0.10	1.00	13.00	
Pool	463.00	491.00	28.00	5.00	140.00	140.0		0.10	0.00	13.00	
Reach Totals and Averages		491.00	290.00	4.48	1493.00	2174.50	68.7	0.30	0.54	13.13	34.13

Habitat Type	Substrate Percent Bed	Bld	Cob	Grv	Fine	Percent Instream Cover Bold	LWD	Cutbk	Veg	Other	Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)
Pool	0	30	20	30	20					20	30.00	0		4	0	0			
Riffle	0	0	50	30	20						85.00	0		0	0	0			
Pool	0	10	20	35	35			10			90.00	0		0	0	0			
Riffle	0	5	45	35	15					5	75.00	0		0	0	0			
Pool	0	0	30	20	50					25	70.00	0		0	0	0			
Riffle	0	0	60	20	20						60.00	0		2	0	0			
Pool	0	0	40	10	50					25	75.00	1		0	0	0			
Riffle	0	0	40	10	50						75.00	0		0	0	0			
Pool	0	0	30	30	40					40	70.00	2		0	20	0			
Riffle	0	5	60	10	25						70.00	0		0	0	0			
Pool	0	0	40	30	30			20			100.00	2		0	0	0			
Riffle	0	0	40	30	30						70.00	0		0	0	0			
Pool	0	5	40	15	40					25	70.00	0		0	0	0			
Pool	0	0	30	20	50					15	60.00	2		11	0	0			
Pool	0	0	50	30	20					25	70.00	1		0	0	0			
Riffle	0	0	50	20	30						60.00	3		0	0	0			
Pool	0	0	30	5	65			25			70.00	1		7	0	0			
Riffle	0	0	30	5	65			25			70.00	0		0	0	0			
Pool	0	0	35	5	60			30			60.00	8		11	0	0	20	2	R
Pool	0	0	20	40	40						60.00	0		2	0	0			
Riffle	0	0	30	30	40						60.00	0		0	0	0			
Pool	0	0	40	30	30						95.00	1		8	0	0			
Riffle	0	10	60	15	15						75.00	0		0	0	0			
Pool	0	0	35	15	50						90.00	0		0	0	0			
Reach Totals and Averages	0	3	39	22	37	0		22		23	71.25	21	0.56	9	4	0	4		

Habitat Type	Land Use Right			Left			Vegetation Type Right	Left	Riparian Slope Right			Left	Stability Right			Left			Vegetation Depth Right	Left	Livestock Access Right	Left	Photos	Comments
Pool	RS	11	3	1	2	Nat	Gr	Gr	26	1	1	22	High	2	1	3	3	Med	10	5				
Riffle	RS	11	3	1	2	Nat	Br	Mix	22	1	1	4	High	2	1	3	3	Med	3	15				
Pool	RS	11	3	3	11	RS	Mix	Mix	22	1	1	4	Med	3	3	3	3	Med	3	15				
Riffle	RS	11	3	3	11	RS	Mix	Mix	8	1	1	4	Med	3	3	3	3	Med	5	20				
Pool	RS	11	3	3	11	RS	Mix	Mix	12	1	1	6	Med	3	3	3	3	Med	10	5				
Riffle	RS	11	3	3	11	RS	Mix	Mix	4	1	1	6	Med	3	3	3	3	Med	1	5				
Pool	RS	11	3	3	11	RS	Mix	Mix	2	1	1	6	High	2	1	3	3	Med	1	20				
Riffle	RS	11	3	3	11	RS	Mix	Mix	4	1	1	6	Med	3	3	3	3	Med	2	5				
Pool	RS	11	3	3	11	RS	Mix	Mix	13	1	1	16	High	2	1	1	2	High	10	30				
Riffle	Nat	2	1	3	11	RS	Mix	Mix	5	1	1	25	High	2	1	3	3	Med	10	30				
Pool	Nat	2	1	1	2	Nat	Mix	Mix	5	1	1	25	High	2	1	1	2	High	30	30				
Riffle	Nat	2	1	1	2	Nat	Mix	Mix	5	1	1	25	High	2	1	1	2	High	30	30				
Pool	Nat	2	1	3	11	RS	Mix	Mix	12	1	1	27	High	2	1	3	3	Med	30	5				
Pool	Nat	2	1	3	11	RS	Mix	Mix	11	1	1	27	Low	4	5	3	3	Med	30	5				
Pool	Nat	2	1	3	11	RS	Mix	Mix	5	1	1	4	Med	3	3	3	3	Med	30	20				
Riffle	Nat	2	1	3	11	RS	Mix	Mix	12	1	1	15	High	2	1	1	2	High	30	20				
Pool	Nat	2	1	1	2	Nat	Mix	Mix	32	1	1	8	Low	4	5	1	2	High	30	30				
Riffle	Nat	2	1	1	2	Nat	Mix	Mix	32	1	1	8	Low	4	5	3	3	Med	30	30				
Pool	Nat	2	1	3	11	RS	Mix	Mix	12	1	1	32	Med	3	3	3	3	Med	30	10				
Pool	Nat	2	1	1	2	Nat	Mix	Mix	13	1	1	18	Med	3	3	3	3	Med	30	30				
Riffle	Nat	2	1	1	2	Nat	Mix	Mix	16	1	1	12	Med	3	3	3	3	Med	10	30				
Pool	Nat	2	1	1	2	Nat	Mix	Mix	9	1	1	14	Med	3	3	3	3	Med	30	15				
Riffle	Nat	2	1	1	2	Nat	Mix	Mix	28	1	1	7	Med	3	3	3	3	Med	30	15				
Pool	Nat	2	1	1	2	Nat	Mix	Mix	26	1	1	11	Med	3	3	3	3	Med	30	30				
Reach Totals and Averages	42					50			24			24	60					62	18.96	18.75	0	0		

Appendix 8 – Metral Creek Habitat Data

Stream Name	Millstone Trib	Watershed Code	920-395400	Date	June 8/9	Reach Name	Metral			Discharge Depth #1		Velocity	
Water Quality Information					Field Crew		DRC					T1	Site Length
Dissolved Oxygen	9.50	pH	7.00	Total Dissolved Solids	76.00	Temp C	13.00	Chainage at Beginning of Reach	0.00	Discharge Depth #2		T2	
Velocity (m/s)	.	Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m3/s)		Chainage at End of Reach	96.00	Discharge Depth #3		T3	

Habitat Information (All Pool and Cross Section Data)

Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate Percent Bed	Bld	Cob	Grv	Fine
Pool	0.00	4.00	4.0	2.00	8.00	8.0		0.20	0.00	6.00		0	0	40	0	60
Riffle	4.00	15.00	11.0	2.00		22.0		0.01	1.00	4.00		5	0	85	0	10
Pool	15.00	18.00	3.0	2.00	6.00	6.0		0.15	0.00	4.00		0	0	0	40	60
Riffle	18.00	27.00	9.0	2.00		18.0		0.01	5.00	3.00		10	0	70	0	20
Pool	27.00	31.00	4.0	2.00	8.00	8.0		0.30	0.00	3.00		0	0	30	30	40
Riffle	31.00	42.00	11.0	2.00		22.0		0.10	5.00	3.00		0	5	15	40	40
Riffle	42.00	68.00	26.0	1.50		39.0		0.01	4.00	4.00		0	5	15	40	40
Pool	68.00	73.00	5.0	1.00	5.00	5.0		0.20	0.00	2.00		0	0	0	85	15
Riffle	73.00	88.00	15.0	2.00		30.0		0.01	2.00	3.50		0	0	0	80	20
Pool	88.00	96.00	8.0	2.00	16.00	16.0		0.40	0.00	3.50		0	0	0	10	90
Reach Totals and Averages		96.00	96.0	1.85	43.0	174.0	24.7	0.14	1.70	3.60	51.39	2	1	26	33	40

Habitat Type	Percent Instream Cover Bold	LWD	Cutbk	Veg	Other	Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)
Pool	20					55.00	0		4	4	0			
Riffle			10			80.00	2		0	11	0			
Pool						100.00	0		0	3	0			
Riffle						95.00	0		9	0	0			
Pool						80.00	0		0	0	0			
Riffle						85.00	0		0	0	0			
Riffle						85.00	0		0	0	0			
Pool						85.00	0		0	0	0			
Riffle						90.00	0		0	0	0			
Pool						90.00	0		8	0	0			
Reach Totals and Averages	20		10			84.50	2	0.08	22	19	0	0		

Habitat Type	Land Use Right					Left	Vegetation Type Right	Left	Riparian Slope Right	Left	Stability Right	Left	Vegetation Depth Right	Left	Livestock Access Right	Left	Photos	Comments
Pool	RS	2	1	1	2	RS			5	5			0	0				
Riffle	RS	2	1	1	2	RS			5	5			0	0				
Pool	RS	2	1	1	2	RS			5	5			0	0	3	3		
Riffle	RS	2	1	1	2	RS			5	5			10	10				
Pool	RS	2	1	1	2	RS			5	5			15	15				
Riffle	RS	2	1	1	2	RS			5	5			8	8				
Riffle	RS	1	0	0	1	RS			5	5			10	10				
Pool	RS	1	0	0	1	RS			5	25			10	10				
Riffle	RS	1	0	0	1	RS			5	25			10	10				
Pool	RS	1	0	0	1	RS			5	10			0	0				
Reach Totals and Averages	6					6			10	10	14	24	6.30	6.30	3	3		

Appendix 9 –Millstone June 2016 Habitat Summary

Stream Name	Millstone River			Watershed Code	920-395400								
Reach Habitat Parameter	1	**Ratings**	**4**	**Ratings**	**5**	**Ratings**	**7**	**Ratings**	**Metral**	**Ratings**	**8**	**Ratings**	**Total**
% Pool Area	75	1	99	1	88	1	75	1	25	5	69	1	**10**
Large Woody Debris/Bankfull Channel Width	0	5	0	5	0	5	0	5	0	5	1	5	**30**
% Cover in Pools	8	3	10	3	33	1	25	1	30	1	45	1	**10**
Average% Boulder Cover	8	5	0	5	0	5	0	5	20	3	0	5	**28**
Average % Fines	9	1	31	5	50	5	69	5	40	5	37	5	**26**
Average % Gravel	3	not rated	57	not rated	17	not rated	24	not rated	33	not rated	22	not rated	**--**
% of Reach Eroded	3	1	17	5	49	5	26	5	22	5	9	3	**24**
Obstructions	0	0	0	0	0	0	0	0	0	0	0	0	**0**
% of Reach Altered	0	1	0	1	0	1	0	1	19	5	4	1	**10**
% Wetted Area	31	5	74	3	100	1	54	5	51	5	34	5	**24**
Dissolved Oxygen	.	1	.	1	9	1	.	1	10	1	.	1	**6**
pH		5		5	8	5		5	7	1		5	**26**
Totals		**28**		**34**		**30**		**34**		**36**		**32**	**194**
Off-Channel Habitat as % of Reach	0	5	0	5	0	5	0	5	0	5	4	5	**30**
Reach Lengths	**13712**	not rated	923	not rated	138	not rated	172	not rated	96	not rated	491	not rated	**15531.5**

Fish Data													
Reach	**1**	**Ratings**	**4**	**Ratings**	**5**	**Ratings**	**7**	**Ratings**	**Metral**	**Ratings**	**8**	**Ratings**	**Total**
Fry Capacity	**1931**	**--**	**12020**	**--**	**2139**	**--**	**1566**	**--**	**266**	**--**	**3299**	**--**	**21222**
Actual Pop.	0.00		0.00		0.00		0.00		0.00		0.00		**0**

Riparian Ratings													
Reach	**1**	**Ave. Ratings**	**4**	**Ave. Ratings**	**5**	**Ave. Ratings**	**7**	**Ave. Ratings**	**Metral**	**Ave. Ratings**	**8**	**Ave. Ratings**	**Total**
Land Use	38	2	68	3	18	3	42	3	12	1	92	2	**13**
Riparian Slope	32	0	22	1	6	1	14	1	20	1	48	1	**5**
Bank Stability	30	0	106	5	18	3	42	3	38	2	122	3	**16**
% Crown Cover	68	3	45	5	53	3	44	3	85	1	71	1	**16**
% Livestock Access	10	3	5	1	91	5	0	0	16	3	0	0	**12**
Riparian Depth	31	3	5	5	5	5	12	5	6	5	19	5	**28**
Totals		**12**		**20**		**20**		**15**		**13**		**11**	**90**