APPENDIX J:
TRIBUTARY PHYSICAL ASSESSMENT FOR TMDL DEVELOPMENT SUPPORT

J.1 Stream Assessment Methodology

Physical assessments on the 2002 303(d)-listed tributaries (Goat, Piper, Elk, and Jim Creeks) of the Swan River were conducted according to a two-part methodology. In the first part of the assessment, DEQ personnel conducted an aerial photo analysis of the listed streams (reference Appendix I and Section 5.11). Streams were divided, into assessment reaches according to ownership boundaries, change in slope or valley type, change in riparian vegetation, and county lines. Reaches were numbered beginning with 1 at the mouth of each creek. A suite of parameters was evaluated in each reach to evaluate riparian and streambank conditions.

In the second part of the assessment, several reaches from each stream were selected for evaluation on the ground. Based on the preliminary aerial assessment results, these reaches were classified as either indications of human impact or not having indications of human impacts, so that the effect of human impacts could be evaluated by comparing results from the two reach types. However, because the Swan Lake Watershed has been heavily logged in these drainages, few true lower elevation reference reaches could be found. Instead, non-impacted reaches were defined as those that contained few impervious surfaces or riparian structures and that appeared in the air photos to contain channels that remained in a relatively natural condition: i.e., the channel was bordered by a wide vegetated buffer strip, the banks appeared to be stable, and no evidence of excessive sediment deposition or channel adjustments were observed.

Field crews visited the selected reaches and evaluated their physical condition using a modified version of the Environmental Protection Agencies EMAP protocols (EPA, 1999b). Assessment reaches were either 1000 or 800 feet in length depending on conditions identified in the aerial photo assessment. Within each reach, three transects were established, at 250, 500, and 750 feet in the 1,000-foot reaches, and at 200, 400 and 600 feet in the 800-foot reaches. At each transect, field crews determined bank full width and average bankfull depth, maximum bankfull depth, and flood prone width (the width of the flood prone area at twice the maximum bankfull depth) using a measuring tape and staff gage. This approach did not allow for very accurate flood prone width measurements in most cases. These data were used to calculate width-to-depth ratios based on the bankfull width divided by the average bankfull depth, and entrenchment ratios based on the flood prone width divided by the maximum bankfull depth. Width to depth and entrenchment ratios from the three transects were averaged to provide a single measurement for each reach. At the tail-out of the pool closest to the 250 and 750-foot transects (or the 200 and 600-foot transects), Wolman pebble counts (Wolman, 1954) were conducted on a minimum of 100 particles (with one exception).

Along the entire length of each assessment reach, field crews took measurements of number and depth of pools, pieces of large woody debris, riparian plant coverage and reproduction, eroding bank locations and length, and indicators of human impacts to the streams. For each reach, crews also calculated a stability rating designed to help evaluate whether the channel was aggrading,

stable, or degrading. Example field forms are provided as attachments to this appendix. In general, this method was intended to identify areas of anthropogenic habitat alteration and/or sediment delivery, which were the primary causes of the impairment listings in the Swan Lake Watershed. Another major goal was to characterize a wide range of sediment and habitat indicators that could be used to help validate impairment conditions and develop sediment and habitat related TMDL targets.

In several reaches, modified assessments were conducted and there was some minor follow-up field reconnaissance work in 2003. In these assessments, field crews simply walked the reaches, making notes on the conditions they encountered and looking for evidence of instability and/or human impacts to the streams. Where significant degradation was found, the full assessment was conducted. If no sign of degradation was found, then no additional assessment took place. In this way, crews were able to evaluate a greater length of each stream than if they had conducted full source assessments in streams with little to no evidence of significant anthropogenic impacts.

J.2 Assessment Results

J.2.1 Goat Creek

Goat Creek was divided into 24 reaches for the aerial photo analysis and 6 of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 6 reaches are presented in Table J-1. In general, the aerial photo analysis indicated that although some level of timber harvest had occurred in the vicinity of most reaches, Goat Creek appeared to be in relatively stable condition, with wide riparian vegetation buffers, streambanks in seemingly natural condition, and few areas of active channel adjustment. Notable exceptions to this were found in Reach 7 where the riparian buffer on the right bank was only 25 feet wide and the bank condition was rated as “reduced” (indicating vegetation was reduced or absent and that erosion and/or channel widening were evident), and Reach 10, where the vegetation buffer on the right bank was only 50 feet and some channel bar formation was noted, which can be an indicator of instability. These reaches appeared to be among the most heavily impacted and were included in the field assessment to help evaluate the effects of anthropogenic activities in the watershed.

Reaches 2, 3, 9, and 16 appeared to be among the least impacted in Goat Creek, characterized by relatively wide riparian buffer zones, streambanks in apparent stable condition, and few significant human impacts to the stream channel. These reaches were selected as potential reference conditions against which to compare conditions in the more heavily impacted reaches.

Table J-1. Select Aerial Photo Analysis Results for Assessed Goat Reaches.

Location	Stream Type (Rosgen)	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 2	C	300	60	250	70	No
Reach 3	C	300	70l	300	60	No*
Reach 7	B	100	70	25	10	Yes
Reach 9	C	300	30	300	40	No
Reach 10	B	100	30	50	10	Yes
Reach 16	B	250	70	250	70	No*

*Results of the field assessment did find evidence of limited human impacts to the riparian area (Table J-2).

Selected results of the field stream assessments are provided in Table J-2. In Reaches 3, 7, 9, and 16, the full field assessment was conducted; in Reaches 2 and 10, the modified assessment was conducted. Observed human impacts ranged from limited riparian harvest probably consistent with state SMZ law, to significant riparian harvest that apparently occurred prior to implementation of the SMZ law. All of the reaches of Goat Creek that were assessed in the field appeared to be in stable condition, with sediment inputs and stream energy near equilibrium. Most reaches were only slightly entrenched, as indicated by entrenchment ratios consistently greater than 2.2. Reach 16 was moderately entrenched, with an entrenchment ratio of 1.5, consistent with the Rosgen "B" stream type (Rosgen, 1996). In fact, the entrenchment ratio for Reach 7 indicates that the assessed portion of this stream may be more indicative of a "C" vs. "B" stream type, although potential variations in flood prone width and other measurements may also account for this inconsistency. The width-to-depth ratio for Reach 7, the most impacted reach with a full assessment, was consistent with the ratios in less impacted reaches.

Table J-2. Goat Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth ratio	Entrenchment Ratio	Observed Human Impacts
Reach 2	Stable	NC	NC	None
Reach 3	Stable	18	>2.2	Limited Riparian Harvest
Reach 7	Stable	12	>2.2	Significant Riparian Harvest
Reach 9	Stable	12	>2.2	Limited Riparian Harvest
Reach 10	Stable	NC	NC	Significant Riparian Harvest
Reach 16	Stable	14	1.5	Limited Riparian Harvest

Table J-3 presents additional results of the Goat Creek assessment. No actively eroding banks were observed in any of the reaches evaluated in Goat Creek. Woody debris, both single pieces and aggregates, was common throughout most of the reaches; with a total woody debris count that was slightly lower in Reaches 7 and 2, possibly due to historic riparian harvest and reduced woody debris inputs, although the somewhat mobile nature of woody debris, once in a stream channel, must be taken into account when evaluating woody debris numbers and trying to link these numbers to local riparian impacts. Pools were also common throughout all of the reaches; with deeper pools over 3 feet in depth (bankfull depth) comprising 50 to 74 percent of the total number of pools.

Particle size distributions were determined by Wolman pebble counts at two locations in each reach. Particle size distributions refer to the percentage of the bed materials of the bankfull channel that are finer than a designated size. For example, at Reach 3, the D_{15} indicates that 15 percent of the particles are 0.25 mm or smaller at the lower cross section, and 15 percent are 16 mm or smaller at the upper cross section. The results of these pebble counts revealed tremendous variability in the particle distributions throughout Goat Creek; however, it does not appear that there were significantly more fines at the most impacted reach (Reach 7) than in the other, non-impacted reaches. It is worth noting that given sediment transport and depositional characteristics, percent fines may not represent a good methodology for identifying impacts from localized impairment indicators such as riparian removal.

Although field crews found evidence of significant riparian harvest along the banks of some reaches of Goat Creek, they consistently commented that the stream channel appeared to have recovered, or was in the process of recovering, from impacts that might have occurred from this riparian harvest. When visited on the ground, reaches that were identified in the aerial photo analysis as impacted by human activities did not appear to differ significantly from reaches that were identified as least impacted, with the possible exception of a reduction in woody debris in Reach 7. If Reach 7 is used as an example reach for other reaches with evidence of riparian harvest (see aerial assessment comments and canopy density results in Appendix I for Reaches 5, 9, 10, 20 and 21), then it would appear that as much as 25% of the lower 8 miles of Goat Creek may have some level of reduced woody debris, and the lower portion of the stream as a whole may have reduced numbers of large woody debris due to the mobile nature of woody debris.

No obvious anthropogenic sediment sources or other major indicators of water quality problems were located within these reaches (note that road crossings were excluded from the assessed reaches). In the qualitative assessment of Reach 2, the field crew found no evidence of the bank erosion and logging debris that were mentioned in the 1989 DEQ assessment (Appendix B) as a sign of impairment. Additional field reconnaissance work in 2003 was done for a longer stretch of this particular reach, and one significant LWD aggregate with some minor levels of localized bank erosion and stream widening was noted further down. This aggregate did not appear to include significant amounts of logging debris and was likely providing positive habitat in the form of pools and cover and was, therefore, not considered an indicator of impairment conditions. Overall, any significant levels of logging debris have probably been washed downstream and out of Goat Creek and any significant levels of bank erosion have healed naturally similar to other areas of historical impact.

Additional 2003 field reconnaissance work was also done along a portion of Goat Creek located in Section 7. Impacts along this portion of Goat Creek provided some of the rationale for originally listing Goat Creek for siltation and other habitat alterations based on evidence of elevated sediment, equipment crossings, and other indicators associated with timber harvest (reference Appendix B). The portion visited corresponds to Reach 21 of the aerial assessment, with evidence of riparian harvest and canopy densities of 20% and 30%. As was the case in other areas of historical harvest, a healthy riparian with essentially no eroding banks was observed and at least one old stream crossings was distinguishable with minimal remaining impact. The stream appeared stable with good pool numbers, although the LWD and pool cover values seemed

depressed, and the riparian trees greater than one foot in diameter were essentially non-existent. Nearby timber harvest waste consisting of tree sections of possibly more than 3 feet in diameter, and the lack of such trees along the riparian and within the stream provide evidence of the long-term types of potential impacts that removal of riparian trees can have. It could be several decades or more before this section of the stream can produce LWD and related habitat and shade to the degree that it was once capable of.

The aerial assessment work was also performed for Squeezer Creek, which is a tributary stream that enters Goat Creek at the upstream end of Goat Creek Reach 4. Although determined to be fully supporting of aquatic life based on the 2000 303(d) list, it is worth noting that the lower 2.5 miles have of Squeezer Creek have low canopy density numbers providing evidence of potential riparian harvest (Appendix I). The upper 4 to 5 miles analyzed have significantly higher canopy density numbers and less evidence of potential riparian harvest. Right and Left Bank Buffer values in Squeezer Creek are consistently high and there are few other indications of human impacts, similar to Goat Creek and other streams assessed.

Table J-3. Goat Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 2	NC	NC	NC	NC	NC	NC	NC	0
Reach 3	20	7	9	56	0.25/16	32/27	144/49	0
Reach 7*	20	11	18	71	7/7	26/30	52/56	0
Reach 9	49	13	15	50	7/0.2	26/28	61/79	0
Reach 10*	NC	NC	NC	NC	NC	NC	NC	0
Reach 16	32	23	19	74	11/0.24	39/140	81/464	0

*Reaches with significant (historical) riparian harvest.

J.2.2 Piper Creek

Piper Creek was divided into 16 reaches for the aerial photo analysis and 6 of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 6 reaches are presented in Table J-4. In general, the aerial photo analysis indicated that although some level of timber harvest had occurred in the vicinity of most reaches, Piper Creek appeared to be in stable condition, with relatively wide riparian vegetation buffers, streambanks in seemingly natural condition, and few areas of active channel adjustment. Notable exceptions to this were found in reaches 2 and 10, where the riparian buffers on the right banks were only 25 feet wide and the bank condition was rated as “reduced” (indicating that vegetation was reduced or absent and that erosion and/or channel widening were evident), and in Reaches 3 and 5 where the riparian canopy density appeared to have been reduced by timber harvest. These reaches appeared to be among the most heavily impacted and were included in the field assessment to help evaluate the effects of anthropogenic activities in the watershed.

Reaches 6 and 14 appeared to be among the least impacted in Piper Creek, characterized by relatively wide riparian buffer zones, streambanks in apparently stable condition, and few significant human impacts to the stream channel. These reaches were selected as potential reference conditions against which to compare conditions in the more heavily impacted reaches.

Table J-4. Select aerial photo analysis results for Assessed Piper Creek Reaches.

Location	Stream Type (Rosgen)	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 2	B	300	40	25	20	Yes
Reach 3	B	300	50	300	40	Yes
Reach 5	B	150	50	150	50	Yes
Reach 6	A	300	70	300	70	No
Reach 10	B	100	50	25	20	Yes
Reach 14	A*	300	60	300	60	No

*Field assessment and map reconnaissance indicate that this stream classification, at least in a significant portion of the area assessed, is likely in error.

Selected results of the field stream assessment in Piper Creek are shown in Table J-5. In Reaches 2, 5, 6, 10, and 14, the full field assessment was conducted; in Reach 3 the modified assessment was conducted. All of the reaches of Piper Creek that were assessed in the field appeared to be in stable condition, with little if any evidence of active channel aggradation or degradation, with the exception of Reach 14 where aggradation and multiple channels existed. This condition was not linked to human disturbances and appears to be a naturally occurring condition. None of the reaches were entrenched, as indicated by entrenchment ratios consistently near or exceeding 2.2, indicating that possible variations in the Rosgen stream types noted in Table J-4, at least in the areas assessed. This is especially true for part of Reach 14. Width to depth ratios did not provide evidence of significant channel widening in the reaches with observed human impacts.

Table J-5. Piper Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth Ratio	Entrenchment Ratio	Observed Human Impacts
Reach 2	Stable	16	>2.2	Private Home Development Encroachment, Bridge
Reach 3	Stable	NC	NC	Limited Private Lot Development
Reach 5	Stable	8	>2.2	Limited Riparian Harvest; Recent Harvest Near Streambanks; Small campsite
Reach 6	Stable	16	2.1	None
Reach 10	Stable	12	>2.2	Significant Riparian Harvest
Reach 14	Aggrading	16	>2.2	Timber Harvest in Vicinity, Good Buffer

As is shown in Table J-6, eroding banks were observed in Reaches 2 and 5. One of the eroding banks in Reach 2 was a high terrace. The erosion at this site appeared to be natural; although a bridge that crosses the creek approximately 50 yards upstream could be exacerbating the erosion. The other two banks were clearly unstable as a result of human activities. One was a steep bank adjacent to a house on the banks of Piper Creek. The bank had been partially armored with rock, but some erosion was still occurring. The other bank had been partially cleared of vegetation to accommodate a small pump house for irrigation water. The total length of the 3 eroding banks was approximately 60 feet, out of a total bank length in the reach of 2,000 feet. The eroding bank in Reach 5 was located at an informal campsite where campers accessing the creek have cleared the vegetation. The length of eroding bank was 20 feet; total bank length in the reach was 2000 feet. No other eroding banks were observed in any of the reaches visited in the Piper Creek field assessment. Overall these eroding bank numbers represent a very low overall percentage of the total bank lengths.

Large woody debris, both single pieces and aggregates, was common throughout most of the surveyed reaches of Piper Creek. Woody debris numbers appeared to be slightly reduced in Reaches 2 and 5, particularly when compared to the LWD count in Reach 6, immediately upstream of Reach 5. Pools were also common throughout all reaches, but like LWD, appeared to be slightly less common in Reaches 2 and 5 – reaches showing potential obvious impacts from human activities. Particle size distributions revealed highly variable conditions, but provided no evidence of increased fine sediment deposition in the impacted reaches. Only the upper transect of Reach 5 stands out as having a noticeably high proportion of fines (D_{15} = 0.41mm). This transect is located approximately 125 feet upstream of a bridge over Piper Creek, which could be the source of the additional fines. The fines may also be the result of natural forces, as the slope of Piper Creek decreases noticeably between the upper and lower ends of Reach 5, which could result in the deposition of fine materials.

Table J-6. Piper Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 2*	30	5	15	53	16/15	47/46	87/90	3
Reach 3*	NC	NC	NC	NC	NC	NC	NC	0
Reach 5*	32	12	11	64	25/0.41	70/11	129/41	1
Reach 6	115	26	16	46	11/12	38/57	68/123	0
Reach 10*	139	33	23	72	6/12	32/30	56/58	0
Reach 14	70	19	28	41	9/19	47/45	142/86	0

*Verified evidence of potentially significant human impacts from field assessment, although relatively minor for the Reach 3 section evaluated.

In general, field crews found evidence of historic logging activity in several reaches of Piper Creek, but consistently commented that the stream appeared to either have recovered or be

recovering from many of the impacts that might have occurred as a result of timber harvest. Even Reach 10, which perhaps had the greatest indicators of riparian harvest, had good numbers of woody debris, although as previously mentioned the mobile nature of woody debris must always be considered when making these types of analyses. In Reach 2, several instances of human bank alteration were noted; however these impacts were localized, comprising a small fraction of the total reach length, and no systemic degradation of the stream was observed. Reach 6, and perhaps portions of Reach 3, were noted as the most likely potential reference conditions for the assessed portions of Piper Creek.

Although there was significant focus on some of the stream reaches with evidence of human impacts, the assessment results do not reveal significant indicators of problem conditions. A few reaches with evidence of clearcuts on the stream banks (Reaches 11, 12, and 13) were not assessed although their total length in comparison the whole stream length is relatively low and the opposite banks have good canopy density numbers. Based on the results of the aerial and stream assessment, it would seem that a significantly high percentage of Piper Creek would have field assessment results consistent with the results documented in Tables J-5 and J-6.

J.2.3 Elk Creek

Elk Creek was divided into 24 reaches for the aerial photo analysis and 4 of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 4 reaches are presented in Table J-7. In general, the aerial photo analysis indicated that although some level of timber harvest was evident in the vicinity of most reaches, Elk Creek appeared to be in stable condition, with relatively wide riparian vegetation buffers, streambanks in seemingly natural condition, and few areas of active channel adjustment. Exceptions to this were found in Reach 6, which showed signs of recent timber harvest and where the condition of both banks was rated as “reduced” (indicating that vegetation was reduced or absent and that erosion and/or channel widening were evident). This reach appeared to be among the most heavily impacted and was included in the field assessment to evaluate the effects of anthropogenic activities in the watershed.

Reaches 2, 3, and 13 appeared to be among the least impacted in Elk Creek, characterized by relatively wide riparian buffer zones, streambanks in apparent stable condition, and few apparent human impacts to the stream channel. These reaches were selected as potential reference conditions against which to compare conditions in the more heavily impacted reaches, although subsequent field assessment determined that low levels of canopy density in Reaches 2 and 3 were due to riparian harvest versus natural conditions. Conversely, the section of Reach 6 assessed in the field showed little to no obvious human impacts and was identified as a potential reference reach. Reach 13 is the lower part of the segment of Elk Creek that has been identified as fully supporting aquatic life and cold water fish (reference Table J-1), and ultimately represents the best potential reference reach not only for Elk Creek, but also for the other three assessed streams.

Table J-7. Select Aerial Photo Analysis Results for Assessed Elk Creek Reaches.

Location	Stream Type (Rosgen)	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 2	C	100	20	200	70	No*
Reach 3	C	100	20	100	40	No*
Reach 6	C	50	20	300	50	Yes**
Reach 13	C	300	60	300	80	No

*Results of the field assessment revealed potentially significant impacts associated with riparian harvest. This area of riparian harvest was initially determined to be a natural riparian mosaic conditions via the aerial assessment.
** Results of the field assessment revealed very little indication of potentially significant impacts associated with human activities in the assessed section of this reach.

Selected results of the field stream assessments are provided in Table J-8. In Reaches 3, 6, and 13, the full field assessment was conducted; in Reach 2 the modified assessment was conducted. All of the reaches of Elk Creek that were assessed in the field appeared to be in stable condition, with little if any evidence of active channel aggradation or degradation. None of the reaches were entrenched, as indicated by entrenchment ratios consistently greater than 2.2. The width-to-depth ratios were consistent for most reaches, although slightly higher in Reach 3, the most obviously impacted reach, suggesting the possibility of some channel widening as a result of human impacts.

Table J-8. Elk Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth ratio	Entrenchment Ratio	Observed Human Impacts
Reach 2	Stable	NC	NC	Significant Riparian Harvest
Reach 3	Stable	21	>2.2	Significant Riparian Harvest
Reach 6	Stable	17.3	>2.2	None
Reach 13	Stable	14.6	>2.2	None

Additional stream assessment results are shown in Table J-9**.** Only one actively eroding bank was observed in the assessment of Elk Creek. In Reach 3, a bank 15 feet in length was rated as moderately unstable due to erosive forces created by a log jam on a bank that may have had additional protection if the riparian harvest had not occurred. None of the logs showed evidence of having been cut. Large woody debris, both single pieces and aggregates, was common throughout all of the reaches. Similar results were noted for pools.

Particle size distributions revealed a high diversity of substrate materials, but provided no evidence of fines accumulation in the impacted reaches. The D_{15} in Reach 13 appears to be significantly smaller than in the other reaches. Fifteen percent of the particles were smaller than 0.11 mm at the lower transect and smaller than 0.19 mm at the upper transect. The source of

these fine materials is likely to be natural, as minimal human activity has taken place in the watershed upstream of this site.

Table J-9. Elk Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 2*	NC	NC	NC	NC	NC	NC	NC	0
Reach 3*	19	10	11	100	24/10	51/35	102/77	1
Reach 6	96	19	17	65	23/37	56/76	138/108	0
Reach 13	21	10	14	79	.11/.19	84/41	285/104	0

*****Verified evidence of potentially significant human impacts from field assessment.

In general, field crews found evidence of historic logging activity in much of Elk Creek, but consistently commented that the stream appeared to have recovered, or was in the process of recovering, from any impacts that may have occurred. Field crews noted old riparian harvests that probably occurred prior to implementation of the SMZ law in several reaches, but no significant signs of channel degradation in these reaches were observed. No significant in-stream anthropogenic sediment sources were located. Elk Creek was placed on the 303(d) list in part because cut logs, bridge parts, and potential cattle impacts identified during a 1989 DEQ assessment; no such impairment conditions were observed in the assessment described here and no evidence of grazing were noted.

The Elk Creek reaches where field assessment work was done appear to be a good representation of conditions in the portion of Elk Creek that had been identified as being impaired. No indications of problems were noted, with the possible exception of a minor increase in width-to-depth ratio in the section where there were obvious indicators of riparian harvest. It is worth noting that there is good pool development in this lower reach area (Reach 3), with all pool indicators comparing favorably against the Reach 13 potential reference condition (Table J-9).

J.2.4 Jim Creek

Jim Creek was divided into 31 reaches for the aerial photo analysis and four of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 4 reaches are presented in Table J-10. Reach 24 was selected to represent a section of Jim Creek where potentially significant human impacts were evident in the aerial photos. In Reach 24, the bank condition was rated as reduced, indicating that vegetation was reduced or absent and that erosion and/or channel widening were evident. Similar conditions were identified in the air photo assessment in Reaches 22, 25, 27, and 30. Reach 11 was selected because of the riparian

meadows and mosaic conditions which indicated an area of potential human impacts from riparian harvest.

Reaches 4 and 5 were initially both selected for assessment, but a map review and GPS data indicate that the lower part of Reach 5 was actually assessed versus Reach 4, in addition to assessment that was done on the upper part of Reach 5. Reach 5 has indicators of limited residential development via the aerial assessment work, with perhaps some indication of past logging activities. Subsequent field assessment work revealed limited riparian harvest and limited private home development impacts in the assessed portions of Reach 5 (denoted as Reach 5U for the upper assessed reach and Reach 5L for the lower assessed reach), and significant riparian harvest along Reach 24 that occurred prior to implementation of the SMZ law. There was no evidence of riparian harvest along Reach 11.

Table J-10. Select Aerial Photo Analysis Results for Assessed Jim Creek Reaches.

Location	Stream Type	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 5L	B	150	40	300	60	No**
Reach 5U	B	150	40	300	60	No**
Reach 11	A*	300	20	300	20	No
Reach 24	A	100	20	100	20	Yes

*Field assessment and map reconnaissance indicates the assessed section may be more representative of an E or other stream type.
** Field assessment identified limited riparian impacts from human activities.

Selected results of the field assessment are provided in Table J-11. In Reaches 5L, 11, and 24, the full assessment was conducted; in Reach 5U the modified assessment was conducted. All of the reaches of Jim Creek that were assessed in the field appeared to be in stable condition, with little if any evidence of either aggradation or degradation. Reaches 5L and 11 were not entrenched, as indicated by the entrenchment ratios greater than 2.2, whereas Reach 24 was entrenched with a ratio of 1.2. The width-to-depth ratio for Reach 5L appears to be within the range of width to depth ratios found within the three other streams evaluated, and the entrenchment ratio and field observations indicated that this assessed portion of Reach 5 may be more of a “C” vs. “B” stream type. The low width to depth ratios for Reaches 11 and 24 are indications of E and A channel types (Rosgen, 1996), with the entrenchment ration values indicating an E type channel for Reach 11, and an A type channel in Reach 24.

Table J-11. Jim Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth ratio	Entrenchment Ratio	Observed Human Impacts
Reach 5L	Stable	12	>2.2	Limited Riparian Removals, Older Nearby Harvest
Reach 5U	Stable	NC	NC	Limited Riparian Removals
Reach 11	Stable	9	>2.2	None
Reach 24*	Stable	8	1.2	Significant Riparian Harvest

Additional stream assessment results are presented in Table J-11. No eroding banks were observed in any of the reaches evaluated in Jim Creek. Woody debris was common in Reaches 5L and 11, but relatively scarce in Reach 24. Field crews noted that in Reach 24, woody debris recruitment appeared to be reduced by heavy riparian logging. Pools followed a similar pattern, and field crews noted that few pools in Reach 24 had significant fish cover, probably a result of the relative scarcity of LWD. Even though Reach 24 was dry, pool measurements were obtained given the approach of using bankfull conditions for determining pool measures.

Particle size distributions revealed a great deal of diversity in substrate composition. Fine material was least common at the upstream site (Reach 24), increased in proportion at the middle site (Reach 11), and further increased in proportion at Reach 5L, the lowest surveyed site in the watershed. Woody debris helps establish streambed stability, dissipates energy, and directly influences sediment storage (Rosgen, 1996). The relatively large particle size distribution in Reach 24 is an indicator of a lack of sediment storage and increased transport of fine material. In fact, the D_{15} values in Jim Creek Reach 24 are consistently higher in comparison to the values for all other A or B stream types in Piper and Goat Creeks (Elk Creek had only C stream types evaluated). The location of a lake upstream of Reach 24 is a possible confounding factor that should also be considered when evaluating some of the data for this reach, although additional 2003 field reconnaissance over a longer portion of this reach verifies that significant storage of finer materials is only occurring in areas where the relatively scarce large woody debris aggregates exist.

Table J-12. Jim Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 5L	96	6	19	100	NC/0.23	NC/17	NC/39	0
Reach 5U	78	23	NC	NC	NC	NC	NC	0
Reach 11	186	129	30	88	10/4	26/28	40/48	0
Reach 24*	13	0	20	0	35/32	68/81	118/167	0

*****Verified evidence of potentially significant human impacts from field assessment.

Field crews found some evidence of historic logging activity in Reaches 5L and 5U. Although it appeared as though the creek had recovered from most impacts that may have occurred from this logging and was not significantly impacted by private development in the assessed sections. No impacts were noted in Reach 11. In Reach 24, however, riparian harvest appeared to be more extensive and more recent than in the other reaches, and, as described above, this harvest appears to have impacted the channel by reducing LWD recruitment and perhaps pool development, particularly regarding the development of potential spawning gravels at the downstream ends of these pools. Similar conditions were identified on aerial photographs for other nearby reaches such as Reaches 22 through 31. This essentially represents an upstream portion of Jim Creek

where there has been significant reduction of stream side trees and woody debris over a length of as much as 2.5 miles (about 25% of the stream length that underwent aerial assessment), in addition to significant reduction of trees along the lake shore of Jim Lake and the small lake downstream from Jim Lake.

J.2.5 Comparison of Field Results to Aerial Assessment Results

There was good match between the aerial assessment canopy density determinations and field observations. Reaches where the aerial assessment showed low canopy density (less than or equal to 30%) were subsequently found to have low canopy density in the field. As noted above, the field evaluations were important in providing final verification at most reaches concerning whether the low canopy density was due to natural conditions versus riparian harvest or other human impacts. Also, areas with very high canopy density (greater than or equal to 70%) via aerial assessment also were found in the field to have high canopy density with high quality riparian cover and shade. Reaches were the canopy density varied from about 40 to 60% also matched field observations but with greater variability likely due to the fact that the physical assessment reach canopy information was typically averaged over a much shorter length than the length of stream reach for determining canopy density via aerial assessment.

A comparison of field width data with aerial assessment width data showed good correlation. Table J-13 is a representative comparison of the field reach width average measures with the aerial assessment width measures. Given the photo scale (1:15840), the fact that all but one measure is within 15 feet and many are less than 10 feet indicates good correlation. The one measure that was off by 62 feet is likely due to a miscommunication of where the photo estimate was taken relative to where the field assessment was performed or due to a significant channel change between the date when the aerial photo was taken and performance of the field assessment.

Table J-13. Comparison Between Aerial and Field Width Measures.

Aerial Assessment Reach Width Measure	Field Assessment Width Measure	Difference
20	21	(1)
25	24	1
25	24	1
25	24	1
25	20	5
25	18	7
30	23	7
30	19	11
30	19	11
40	30	10
40	35	5
40	36	4
60	45	15
100	38	62

Swan River Tributaries TMDL Development
Phase II Physical Assessment
Modified EMAP Field Parameters (X Section)

Date: ________

Stream: ______________________________ Observers: ______________

Reach ________ Units:(circle one) English (feet) Metric (meters) ______________

____

____

River Miles: ______________

Transect	Bankfull Width	Bankfull Depth	Bar Width	Wet Width	Flood Prone Width	Channel Unit Type	Canopy Cov.	Comments*

WOLMAN PEBBLE COUNT

Stream:	**Channel Elevation:**
Reach:	**Channel Type:**
Survey Date:	**Surveyors:**

	Size Class (mm)	Dot Tally	Total #	Total %	Cum %	Description
	<0.062					Silt/Clay
	0.062 - 0.125					V. Fine Sand
	0.125 - 0.25					Fine Sand
	0.25 - 0.5					Med. Sand
	0.5 - 1					Coarse Sand
1)	1 - 2					V. Coarse Sand
2)	2 - 4					V. Fine Gravel
3)	4 - 6					Fine Gravel
4)	6 - 8					Fine Gravel
5)	8 -12					Med. Gravel
6)	12 - 16					Med. Gravel
7)	16 - 24					Coarse Gravel
8)	24 - 32					Coarse Gravel
9)	32 - 48					V. Coarse Gravel
10)	48 - 64					V. Coarse Gravel
11)	64 - 96					Small Cobble
12)	96 - 128					Small Cobble
13)	128 - 192					Large Cobble
14)	192 - 256					Large Cobble
15)	256 - 384					Small Boulder
16)	384 - 512					Small Boulder
17)	512 - 1024					Med. Boulder
18)	1024 - 2048					Large Boulder
19)	2048 - 4096					2048.0 - 4096.0
		TOTAL # =				

Conduct pebble count at lower and upper transects in tailout of nearest pool.
Min 100 particles

Swan River Tributaries TMDL Development
Phase II Physical Assessment
Pool Information

Date: _____

Stream: _____ Observers: _____

Reach _____ Units: (circle one) English (feet) Metric (meters)

Tansect Sub-reach	Pool Number	Length of Pool	Cover (Yes or No)	Max. Bankfull depth of pools		Comments		

NOTES:
Pools are defined as areas with defined increase in thalwag depth and very low gradient
Cover is defined as LWD or undercut banks that can provide refugia for fish

Comments:

Swan River Tributaries TMDL Development
Phase II Physical Assessment
LWD Tally

Date: _____

Stream: _____ Observers: _____

Reach _____

River Miles: _____

LARGE WOODY DEBRIS (≥ 4 inch small end diameter; ≥ 5 ft length)

Transect A-B							
Diameter	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
Large End	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

Transect B-C							
Diameter	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
Large End	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

Transect C-D							
Diameter	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
Large End	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

Transect E-D Diameter Large End	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

NOTE:
Aggregates are defined as two or more LWD pieces contributing to one habitat/pool feature; if LWD pieces overlap at angles and contribute to unique cover, then they can be counted as individual LWD pieces vs. as an aggregate

Swan River Tributaries TMDL Development
Phase II Physical Assessments
Modified EMAP Visual Riparian Estimates

Date: _____

Stream: _____ Observers: _____ Page: _____ of _____

Reach _____

EMAP Site Reference (eg BR22-1) River Miles:

Codes: 0=absent (0%), 1= sparse (<10%), 2=mod (10-40%), 3=heavy (40-75%), 4=very heavy (> 75%)

		Canopy (> 5 m high)		Understory (0.5 to 5		Ground Cover (< 0.5 m high)			
Reach	Bank	BIG trees (trunk > 1' dbh)	SMALL trees (trunk < 1' dbh)	Woody shrubs and saplings	non-woody herbs, grasses and forbs	woody shrubs and seedlings	non-woody herbs, grasses, and forbs	barren, bare dirt, or duff	Comments (Observations such as riparian community composition, health and vigor, trend, human influence, livestock and wildlife influence). Also provide estimate of condition: PFC, FAR, NF
A-B									
	right 10m								
	right total								
	left 10m								
	left total								
B-C									
	right 10m								
	right total								
	left 10m								
	left total								
C-D									
	right 10m								
	right total								
	left 10m								
	left total								
E-F									
	right 10m								
	right total								
	left 10m								
	left total								

Stream
Reach #
Transects: A-B, B-C etc.

Swan River Tributaries Physical Assessment

Bank Erosion Inventory (modified from Zaroban and Sharp, 2001)

Bank Stability Rating Sheet

Site:	
Bank Stability	
0 = no erosion	
1 = erosion evident	
2 = erosion/cracking	
3 = slumps/block failure	
Bank Condition	
0 = some bare, no overhang	
1 = moderate overhang	
2 = overhang/exposed roots	
3 = bare, rills, overhang, falling trees	
Vegetation/Bank Cover	
0= Perennials/rocks	
1= annuals/perennials/40% bare	
2= annuals/70% bare	
3= predominanatly bare	
Bank/Channel Shape	
0= v-shaped, sloped banks	
1= steep V- near vertical banks	
2= Vertical banks-U-shaped	
3= u-shaped, undercut bks	
Channel Bottom	
0= noneroding bedrock	
1= soil, grvl, cbbls; minor erosion	
2= Silt bottom, active downcutting	
Deposition	
0= Recent deposits, silt bars	
1= no evidence recent dpstn	
Cumulative Rating	
0-4 = Slight	
5-8 = Moderate	
9+ = Severe	

Swan River Tributaries TMDL Development
Phase II Physical Assessment
bank description

Stream: ______________________ **Observers:** ______________

____

Reach: ________ ______________

River Miles: ________ **Date:** ______________

Erosion Site (BR23-EI1)	Bank (TRB or TLB)	Length of Eroding Bank (ft)	Average Bank Height (ft)	Rating condition (slight, moderate, severe)	Do human activities appear to imapact the site	If yes, how?

Swan River Tributaries TMDL Development
Phase II Physical Assessment
Human Influence

Date: __________

Stream: ______________________________ Observers: ____________________

____

Reach __________ ____________________

____

River Miles: ____________________

Codes: 0 = not present, P = > 30 feet, C = within 30 feet, B = on bank

Beginning distance from transect	Ending distance from transect	Wall/Dike/Revetment/Riprap/dam	buildings	pavement	road/ railroad	pipes (inlet/ outlet	landfill/ trash	park/lawn	row crops	pasture/ range/hayfield	logging operations	weeds	mining activity	Other

Swan River Tributaries Physical Assessment

applies to the entire 1000 ft (or less) reach

Channel Stability Indicators (Johnson, et.al., Rosgen, Thorne)

Stream: _____ **Observers:** _____

Reach _____

River Miles: _____ **Date:** _____

Reach Stability: circle appropriate indicator	***1-2: Degrading***	***3: Stable***	***4-5: Aggrading***
Substrate Consolidation	Strong Gravels	Strong Gravels	Weak Gravels/Sands
Bank Failure Mechanism	High banks; gravitational collapse; variable channel width	Localized surficial erosion constant width	Low banks; overflows; surficial erosion
Bar Development	Poorly formed	Narrow; Vegetated	Wide (>1/2 Channel width); unvegetated
Bank Erosion Extent	Extensive both banks	Local erosion @ pools	Extensive bar pressure
Width:Depth Ratio	Low <6	Average (6-20)	High (>20)
Channel Pattern	Single thread	Single thread	Multiple threads
Average Bank Slope	<3:1	>3:1	n/a
Vegetative Bank Protection	Poor	Extensive	Poor

Field Stability Rating (circle one) ***1 2 3 4 5***

Boundary Conditions

Confinement (circle one) ***High*** (canyon) ***Moderate*** ***Low*** (broad floodplain)

Channel Perimeter (approximate % of total bankline) ***Bedrock*** ***Alluvium*** ***Revetment***

Channel Classification _____ **Aerial Assessment**

_____ **Field Assessment** (Add Substrate Value)

Sediment Source or Sink: ***source*** ***sink*** ***neither***

PFC trend (if possible) ***upward*** ***downward*** ***n/a***

Swan River Tributaries Physical Assessment

Impairments/Solutions/Reference Reach Potential/ Photo Log

Date: _____

Stream: _____ Observers: _____

_____

Reach _____ _____

_____ River Miles: _____

Identified human influence (notes)

Potential Remedies	(e.g. off-channel watering, culvert replacement, grazing BMP's, erosion control, channel reconfiguration, revegetation)

Does this reach have potential reference sites? Where? Why?

Photo Log

Photo Number	View	Notes