Off-Channel Habitat Inventory and Assessment for the Upper Skagit River Basin

Report to

Non-Flow Coordinating Committee
Skagit River Hydroelectric Project (FERC No. 553)

by

Devin Smith, Skagit River System Cooperative

March 26, 2005

Table of Contents

Table of Figures

Table of Tables

Introduction

Off-channel habitat includes overflow channels, sloughs, wetlands, and small streams found within the floodplains of larger river channels. These habitat features are created and maintained by channel migration and avulsion of larger river channels during peak flow events. Off-channel habitat has been a focus of habitat protection and restoration efforts because it provides important spawning and winter rearing habitat for a variety of salmon species (Beechie et al. 1994).

The operation of the Skagit Hydroelectric Project has significantly altered the flow regime in the Skagit River and has reduced the frequency and magnitude of peak flows during large flood events (Beamer et al. 1999). Off-channel habitat is often formed during large flood events, so it is widely believed that over time flow regulation has reduced the amount of off-channel habitat in the upper reach of the Skagit River. For this reason, mitigation efforts have focused on protecting existing off-channel habitat and replacing lost habitat by constructing artificial groundwater channels (Seattle City Light 1991).

The purpose of this study was to compile existing data on off-channel habitat for the upper Skagit basin, which includes the Sauk, Whitechuck, Suiattle, and Cascade rivers and the Skagit River upstream of Rockport. The intent was to document the location and characteristics of off-channel habitat in the study area and to compare natural and constructed habitat in the upper reach of the Skagit River with other river reaches that are not affected by flow regulation. This information will be useful for evaluating the effectiveness of off-channel habitat restoration efforts to date and in planning future habitat protection and restoration actions.

Study Area

The study area included the upper reach of the Skagit River (town of Newhalem downstream to the Sauk River confluence), the lower portion of Bacon Creek, and the Whitechuck, Cascade, Suiattle, and Sauk Rivers as described in Table 1 and illustrated in Figure 1. River reaches needed to have a channel large enough to form floodplain habitats and have data available from existing sources.

River Reach	River Mile	Description
Bacon Creek	0 – 0.9	Includes only approximately 1600 m upstream from the mouth.
Cascade River	0 – 19	Mouth to confluence with the North Fork and including approximately 400 m upstream on the South Fork.
Sauk River	0 – 40 and 0 – 3.5 on South Fork Sauk River	Mouth to approximately 150 m downstream of Elliot Creek on the South Fork, and not including the North Fork
Upper Skagit River	66 – 93	Confluence with the Sauk River upstream to Goodell Creek.
Suiattle River	0 – 29	Mouth to approximately 150 m upstream of Milk Creek.
Whitechuck River	0 – 13.5	Mouth to approximately 400 m upstream of Pumice Creek.

Table 1. River reaches included in the study

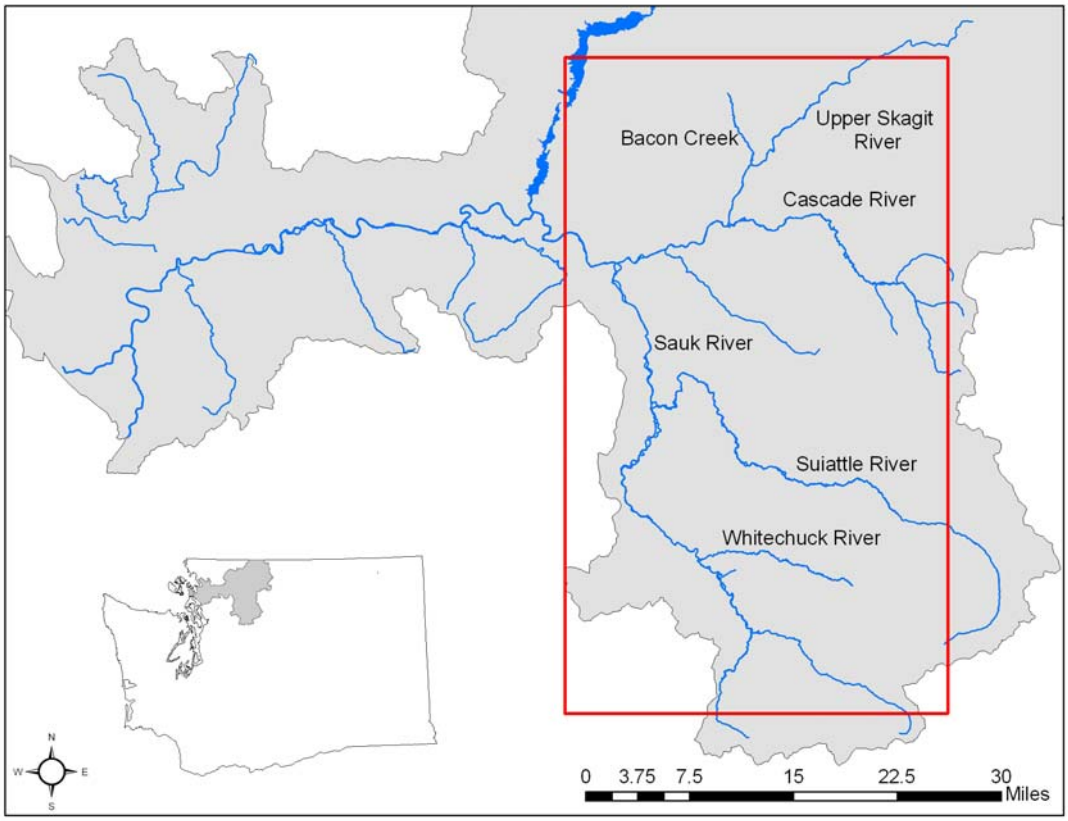


Figure 1. Map of Skagit River basin and study reaches

Methods and Information Sources

Most of the data used in this study were taken from existing sources. The Washington Department of Fish and Wildlife (WDFW) has collected habitat, flow, and location information for much of the off-channel habitat in the Skagit River basin. This includes habitat data that were collected in the 1980s to develop coho escapement estimates (Johnson 1986) and ongoing efforts of WDFW to document additional coho habitat that was not included in previous surveys. In addition, for the purpose of this study, some limited field work was conducted in the summer of 2003 to capture some sites that were not already inventoried.

The WDFW inventories only included sites that were expected to be relatively stable over time and were not likely to be flooded during a flood event with a two-year recurrence interval or less. Active or regularly flooded side channels provide important habitat for fish, but were not included in the WDFW inventories because they change frequently and would be difficult to accurately inventory over time. As a result, the data used for this study likely underestimates the total amount of off-channel habitat in the study area that may be used by fish.

For the most part, methods followed WDFW protocols, although a simplified set of information on each habitat feature was used for this study so that data from different sources could be used together to populate a new database. The off-channel habitat types used are described in Table 2.

Habitat Type	Description
Surface water tributary	Streams flowing onto the floodplain from a terrace or hillslope where the dominant source of water is surface flow. These channels generally have gravel substrate and a higher gradient than other types. Examples include Harriet Creek and Sibley Creek.
Groundwater tributary	Streams flowing in the floodplain where the dominant source of water is groundwater. This can be from springs, hillslope groundwater, or river groundwater. Examples include False All Creek and Cub Creek.
Slough/pond	Channels, ponds, and wetlands that exist in relic river channels generally fed by river groundwater. These very low-gradient habitats are usually deep, slow-moving, and almost entirely pools with no gravel. Examples include Sauk Slough and Lucas Slough.
Overflow channel	Channels that receive surface flow from the river approximately once every 2 to 10 years. These habitats generally have evidence of scour and abundant gravel. Examples include Lower Diobsud Slough and Marblegate Slough.
Constructed pond	Floodplain ponds that have been constructed specifically to provide habitat for fish, such as Newhalem Ponds.
Constructed channel	Floodplain channels that have been constructed specifically to provide habitat for fish. Examples include Illabot Channel and Taylor Channel.

Table 2. Types of off-channel habitat

For each habitat type, the following information was collected:

Site information (site ID, ownership, county, local name, stream number, river basin, river mile, tributary, comments, etc.)
Source and **date** of information
Habitat type: Surface water tributary, groundwater tributary, slough/pond, overflow channel, constructed pond, constructed channel
Channel width, **winter wetted width**, and **channel length:** Measured in the field with hip chain and tape measure or in a few cases were taken from aerial photographs. Channel width was not available for all habitat units in the original data, so was not included for all habitat features
Channel area: Estimated by multiplying the width and length of habitat units along the entire length of the channel and summing those estimates for each habitat feature.
Flow type: intermittent or year-round flow
Spawning habitat area: Estimated by taking length and width measurements for spawning gravel present in each habitat feature and summing those estimates for each habitat feature
Dominant water source: Hillslope groundwater, hillslope surface water, or river groundwater
Beaver activity: Presence, absence, or dominant

Larger habitat features were delineated into smaller segments at tributary junctions, a change in habitat type, or significant change in width of the feature. Data were entered into a database for each habitat segment and the approximate locations were digitized into a Geographic Information System (GIS) using aerial photography, field maps, and in some cases a mapping grade Trimble Global Positioning System (GPS) unit.

River Reaches

Floodplain information in the study area was used to locate habitat features in specific floodplain reaches and to interpret off-channel habitat conditions in the context of floodplain characteristics. Floodplain data were based on an existing GIS layer delineating the active floodplain for the larger streams and rivers in Skagit Basin (Beamer 1999). Floodplains were broken into reaches based on gradient, floodplain width, and flow. Using 1998 DNR digital orthophotographs and 10-meter digital elevation data in a GIS, the following information was measured for each floodplain reach: floodplain length, average floodplain width, floodplain gradient, contributing drainage area, active channel width, channel gradient, channel length, and total area of the floodplain.

Bank armoring structures, major roads and other significant structures that restrict channel migration can limit off-channel habitat creation and function. For this reason, these structures were digitized into a GIS and portions of the floodplain that were isolated from the river channel were subtracted from the total floodplain area. This information was used to calculate the “effective” floodplain area and “effective” floodplain width where floodplain habitat formation is most likely to occur. These provide metrics for

comparing the quantity of habitat in reaches that have been heavily modified with those that have more naturally functioning floodplains.

Results from the floodplain reach assessment are summarized for each river reach in Table 3. The upper Skagit River reach was divided into two reaches: the "Skagit Barnaby Reach," which is located just upstream from the confluence with the Sauk River and is approximately 12,000 m long, and "Skagit Above Barnaby" which includes the rest of the upper Skagit River reach. This was done because the Skagit Barnaby Reach has a much wider floodplain than the rest of the upper Skagit reach and for this reason has more off-channel habitat than any other reach in the study. There have also been a large number of habitat projects constructed in this reach. It was expected that treating these reaches separately would yield much more meaningful results than by averaging the Barnaby reach in with the rest of the upper Skagit reach.

	Bacon	Cascade	Sauk	Skagit Barnaby Reach	Skagit Above Barnaby	Upper Skagit Combined	Suiattle	White-chuck
Mainstem channel length (m)	1,587	30,622	68,933	12,226	33,487	45,713	48,925	22,699
Contributing drainage area (sq km)	131	477.5	1,894	4,265	4,265	4,265	889	222
Floodplain area (ha)	35	718	3,611	1,685	1,202	2,887	1,597	211
Effective floodplain area (ha)	19	586	2,886	794	881	1,675	1,503	208
% Effective Floodplain Area	55%	82%	80%	47%	73%	58%	94%	98%
Average floodplain width (m)	292	280	610	1,536	381	680	369	100
Average effective floodplain width (m)	159	230	487	724	280	394	361	100
Average channel width (m)	47.5	36.9	106.3	123.1	85.2	90.6	60.8	34.3
Average channel gradient	0.6%	1.0%	0.6%	0.2%	0.2%	0.2%	0.9%	2.2%

Table 3. Charactersitics of river reaches used in the study

Inventory Results

The habitat inventory provides useful information on the location and characteristics of off-channel habitat in the study area, including habitat formed naturally by the river and also channels that were specifically constructed for habitat restoration purposes. These results are summarized in the following tables. Table 4 provides a summary of the length and wetted surface area of constructed habitat by river reach. Two large channels in the Skagit Barnaby Reach -- Harrison Pond and Barnaby Slough -- were historically natural sloughs, but were categorized as constructed habitat because they were artificially impounded and enlarged to provide rearing ponds for hatchery steelhead. The original surface area of the natural sloughs was estimated from 1944 aerial photographs. In order to improve the results of the assessment, this historic area measurement was considered to be natural "slough/pond" habitat and only the additional surface area created by the impoundments was classified as "constructed pond" habitat.

River Reach	Site ID	Floodplain Reach	Local Name	Tributary to	Channel Length (m)	Wetted Area (m^2)	pre-Project Area (m^2)**
Cascade	CA1RB3	CA010	Cascade Pond	Cascade R	241	7,332	
Cascade	CA3LB1	CA040C	Grouse Marsh	Cascade R	140	10,500	
Cascade Subtotal:					**381**	**17,832**	
Sauk	SA10LB1	SA070	Skinny Sauk	Sauk R	340	2,844	
Sauk	SA6LB2	SA050	Boyd Pond	Sauk R	218	3,768	
Sauk	SA7LB2	SA060A		Sauk R	1,090	7,261	
Sauk	SA7RB6	SA060B	Tiny Kisutch	Sauk R	253	4,048	
Sauk	SA7RB7	SA060B	Hyachuck Cr	Sauk R	529	7,262	
Sauk	SA8LB3	SA060B	Constant Channel	Sauk R	520	2,860	
Sauk Subtotal:					**2,950**	**28,043**	
Sk Barnaby Reach	SK13LB7	SK100A	Barnaby Slough	Lower Barnaby Sl	1,786	72,833	57,306
Sk Barnaby Reach	SK13LB8	SK100A	Harrison Pond	Lucas Sl	2,458	154,036	60,543
Sk Barnaby Reach	SK14LB3	SK100A	Illabot Channel	3.1348	308	2,156	
Sk Barnaby Reach	SK14LB5	SK100A	Illabot Channel #2	Illabot Ch	402	3,807	
Sk Barnaby Reach	SK15LB2	SK100A	Powerline Channel	Skagit R	250	2,550	
Skagit Barnaby Reach Subtotal:					**5,204**	**235,382**	**117,849**
Sk above Barnaby	SK16LB1	SK110	Taylor Channel	Skagit R	884	5,693	
Sk above Barnaby	SK18RB1	SK130B	Newhalem Ponds	Skagit R	1,881	79,595	
Sk above Barnaby	SK18RB2	SK130B	Co.Line Ponds 2	Skagit R	1,798	22,253	
Sk above Barnaby	SK18RB3	SK130B	Co Line Ponds	Skagit R	598	24,688	
Sk above Barnaby	SK19LB1	SK130B	Park Slough I	Skagit R	605	3,001	
Sk above Barnaby	SK19LB2	SK130B	Park Slough II	Park Slough I	605	3,001	
Sk above Barnaby	SK19RB1	SK130B		Thornton Cr	698	2,078	
Skagit above Barnaby Subtotal:					**7,069**	**140,308**	
Suiattle	SU6LB2	SU040A	Pedestal Ponds	Suiattle R	310	1,017	
Suiattle Subtotal:					**310**	**1,017**	
Grand Total:					**15,914**	**422,582**	**117,849**
Grand Total minus pre-Project Area:						**304,733**	

** Wetted area for Barnaby Slough and Harrison Pond includes total current habitat area, pre-project area includes natural habitat area that existed before these were artificially impounded as measured from 1944 aerial photographs

Table 4. Summary of constructed habitat characteristics

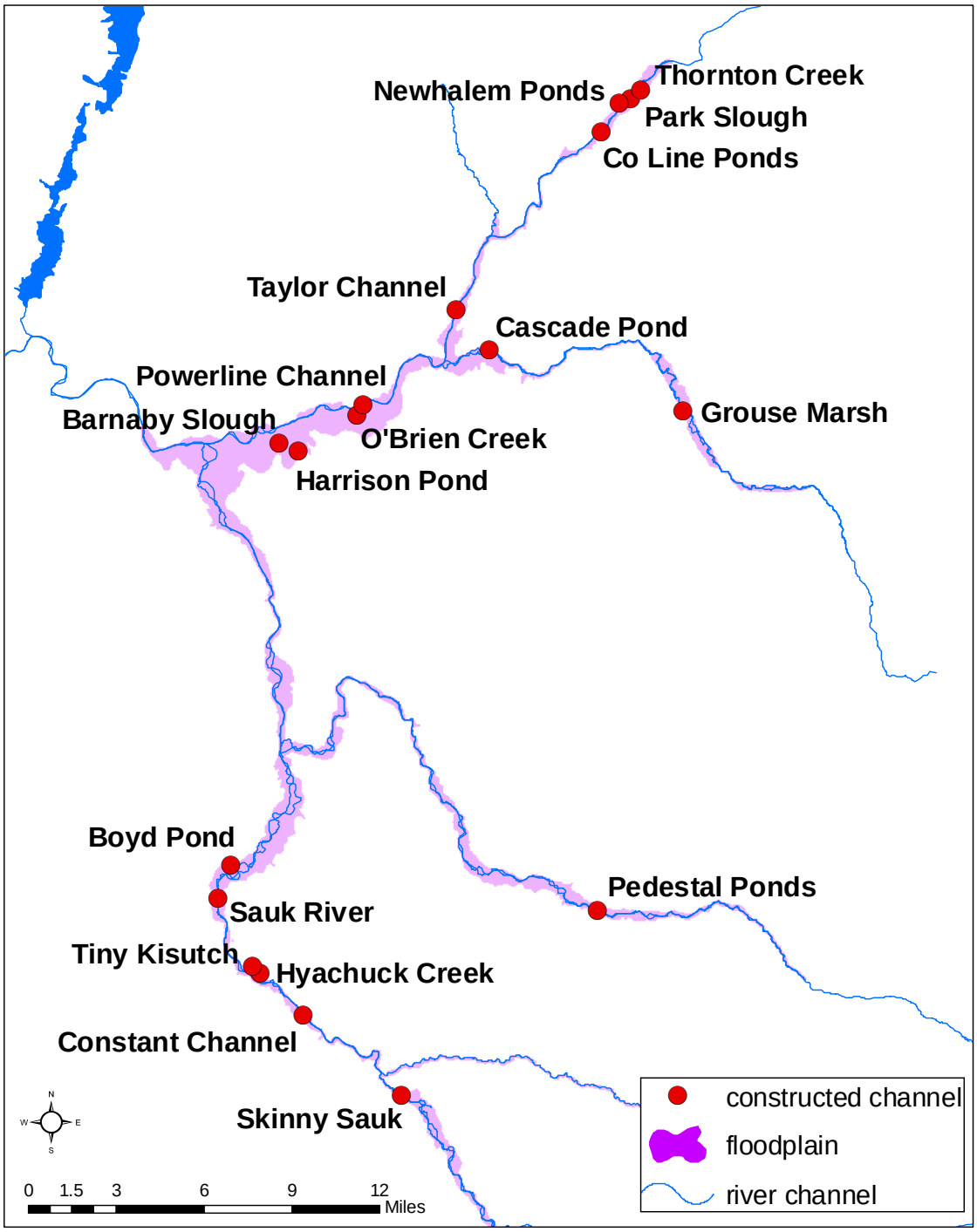


Figure 2. Location of constructed habitat in Skagit River basin

Table 5 provides an overall summary of the length and wetted surface area of natural and constructed off-channel habitat included in this study. These habitat parameters were also normalized so that comparisons could be made between river reaches with different sizes and floodplain areas, and different levels of floodplain impairment. Off-channel habitat length was normalized with length of mainstem river channel, and wetted surface area was normalized with total floodplain area and effective floodplain area.

Figure 3 shows the surface area of off-channel habitat by floodplain reach and habitat type. For each river reach, the smaller floodplain reaches are shown in order from downstream-to-upstream as they are presented left-to-right in the figure. Clearly the total amount of habitat is not evenly distributed throughout each river reach. Figure 4 shows several graphs that provide summary statistics of habitat area and length for each river reach in the study.

	Bacon	Cascade	Sauk	Skagit Barnaby Reach	Skagit Above Barnaby	Upper Skagit Combined	Suiattle	Whitechuck
Constructed Habitat								
total winter wetted area (m^2)	**0**	**17,832**	**28,043**	**117,533**	**140,308**	**257,841**	**1,017**	**0**
area per floodplain area (m^2/ha)	0	25	8	70	117	89	1	0
area per effective floodplain area (m^2/ha)	0	30	10	148	159	154	1	0
total channel length (m)	**0**	**381**	**2,950**	**5,204**	**7,069**	**12,273**	**310**	**0**
length per mainstem length (m/m)	0.00	0.01	0.04	0.43	0.21	0.27	0.01	0.00
Natural Habitat								
total winter wetted area (m^2)	**2,080**	**110,317**	**558,916**	**706,656**	**63,116**	**769,772**	**229,643**	**9,160**
area per floodplain area (m^2/ha)	59	154	155	419	52	267	144	43
area per effective floodplain area (m^2/ha)	109	188	194	890	72	459	153	44
total channel length (m)	**710**	**19,314**	**40,999**	**16,982**	**6,892**	**23,874**	**40,569**	**4,440**
length per mainstem length (m/m)	0.45	0.63	0.59	1.39	0.21	0.52	0.83	0.20
Total Habitat								
total winter wetted area (m^2)	**2,080**	**128,149**	**586,958**	**824,190**	**203,424**	**1,027,614**	**230,660**	**9,160**
area per floodplain area (m^2/ha)	59	178	163	489	169	356	144	43
area per effective floodplain area (m^2/ha)	109	219	203	1,038	231	613	153	44
total channel length (m)	**710**	**19,695**	**43,949**	**22,186**	**13,961**	**36,147**	**40,879**	**4,440**
length per mainstem length (m/m)	0.45	0.64	0.64	1.81	0.42	0.79	0.84	0.20
% constructed habitat by area	**0%**	**14%**	**5%**	**14%**	**69%**	**25%**	**0%**	**0%**

Table 5. Off-channel habitat totals

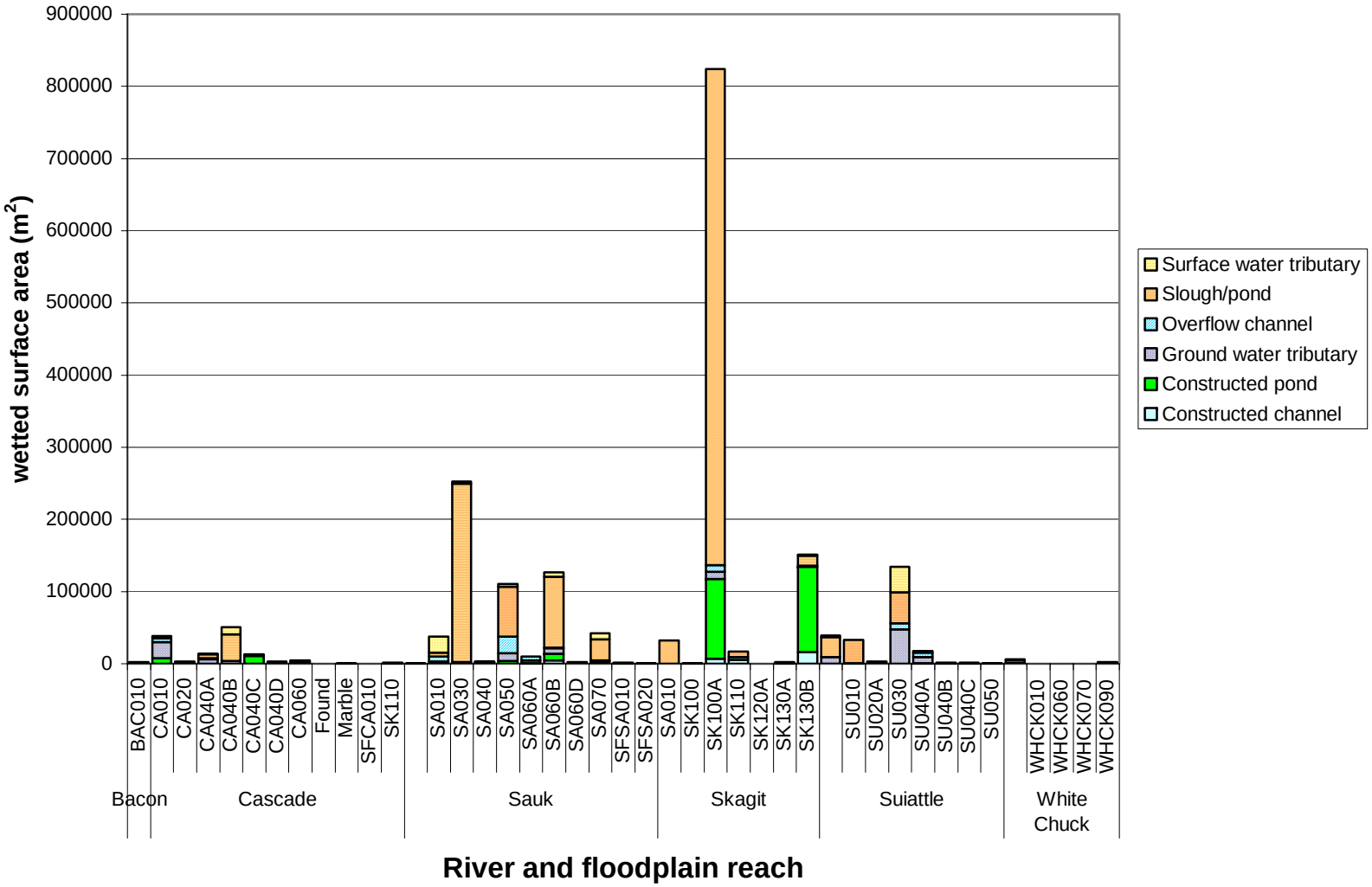
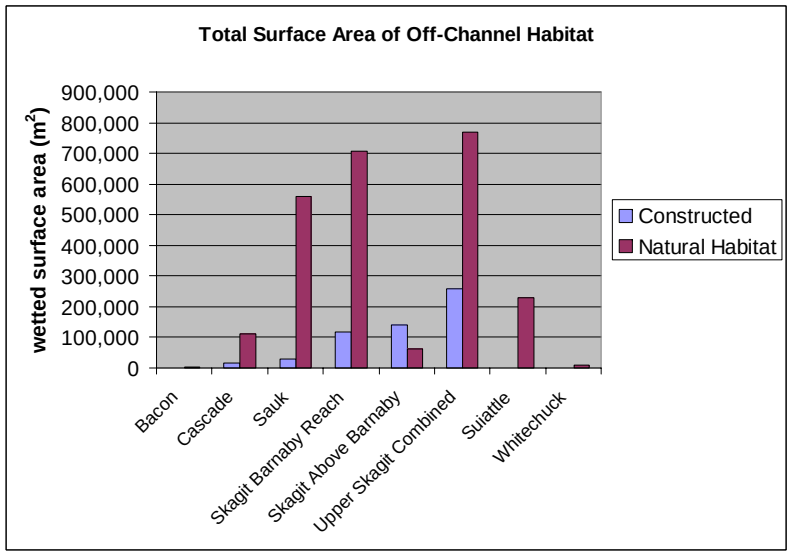
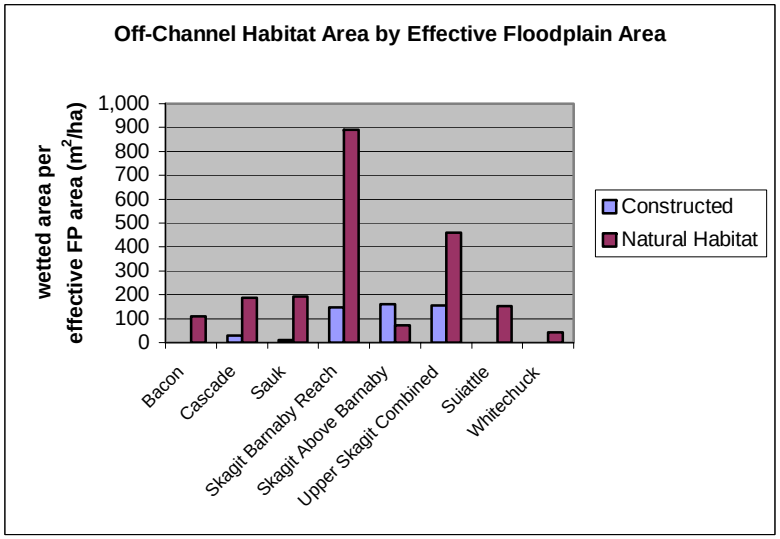
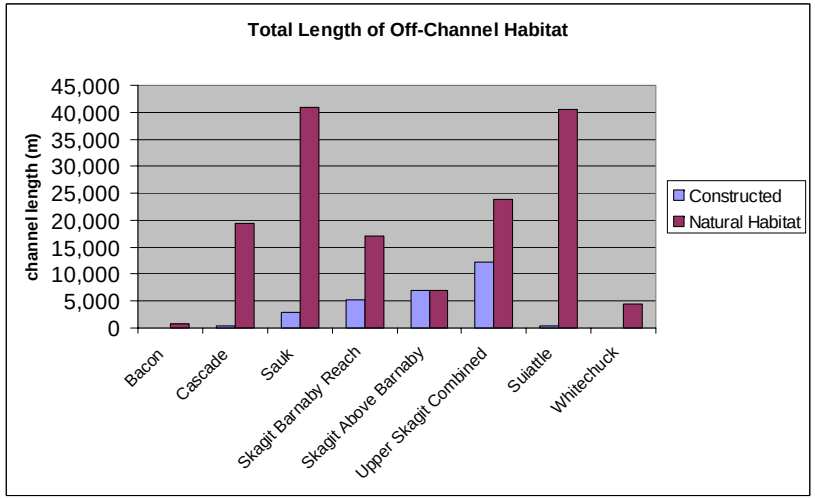


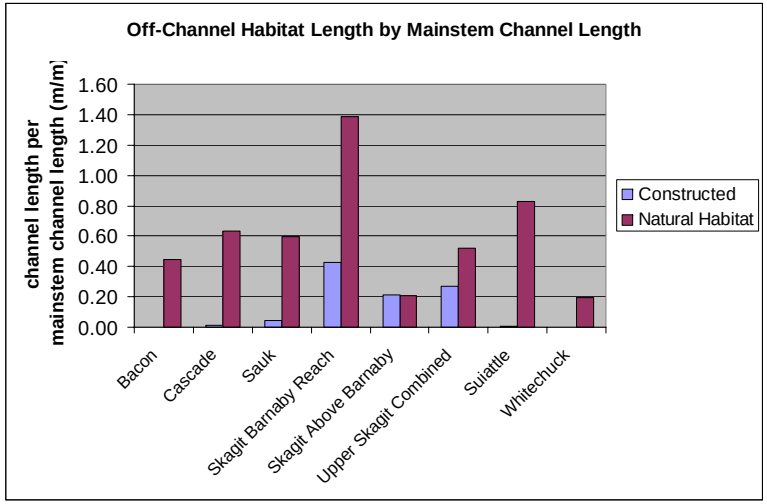
Figure 3. Off-channel habitat area summarized by river reach and habitat type

Figure 4. Summary statistics for off-channel habitat









Analysis Results

One of the primary objectives of the study was to evaluate the progress and effectiveness of constructed channels in mitigating for the loss of off-channel habitat as a result of flow regulation in the Skagit River. In order to accomplish this, the Skagit River reaches affected by flow regulation were compared with unregulated river reaches. Surface area of off-channel habitat was used because it is a better overall measure of habitat quantity. Total surface area for each reach was normalized with effective floodplain area in order to compare habitat between reaches that were different in size. Effective floodplain area was used to improve the comparison of habitat quantity between reaches with different levels of floodplain impairment.

Total habitat density (habitat area per unit of effective floodplain area) for each of the five unregulated river reaches was plotted against the average effective floodplain width for that reach because it was expected that river reaches with larger floodplains were likely to have a higher density of habitat. The parameters were log-transformed and a regression analysis was conducted (Figure 5).

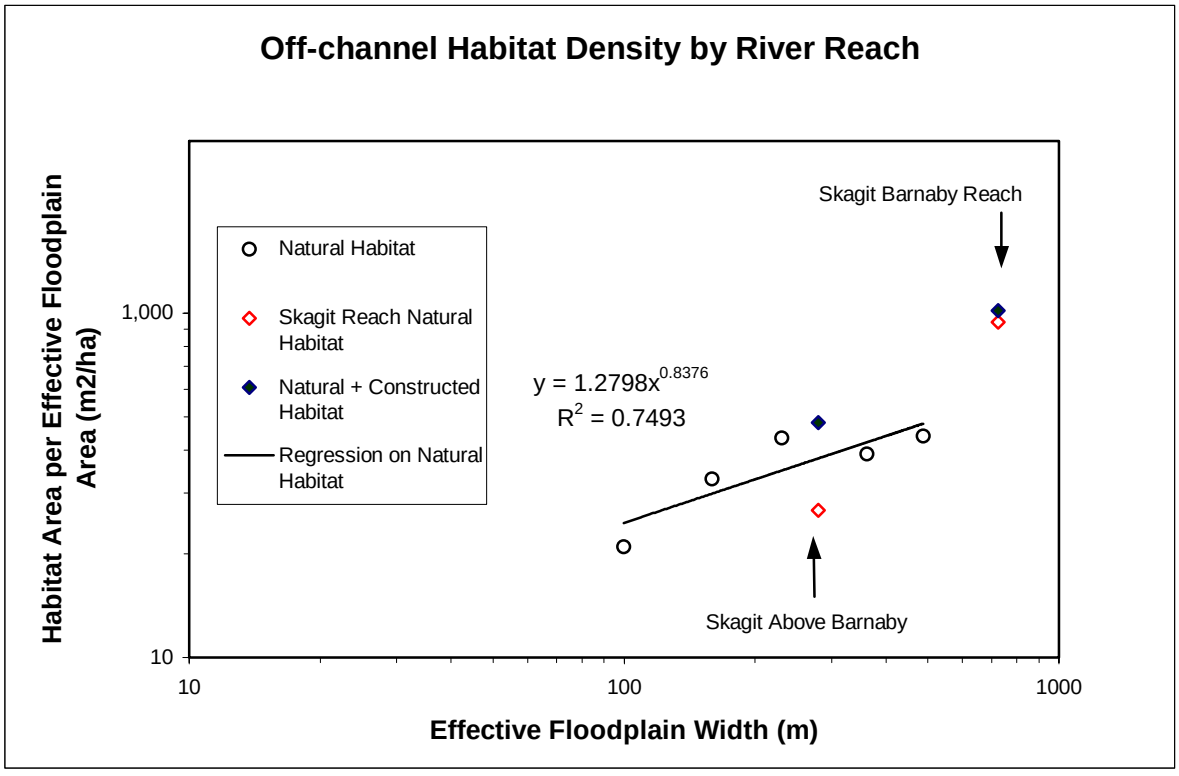


Figure 5. Regression analysis for unregulated river reaches

The regression analysis showed a positive relationship between average effective floodplain width of the river reach and off-channel habitat density with an r^2 of 0.75 and

significance level (p-value) of 0.058. This regression equation predicts the habitat density that would be expected for a range of effective floodplain widths in unregulated reaches, so can be used to estimate the habitat density that might be expected in the Skagit River in the absence of flow regulation.

The next step was to plot the measured habitat density for the regulated reaches in the Skagit River and compare them with the values predicted by the regression. Both natural habitat density and the total habitat density (which includes both natural habitat and habitat that has been constructed for restoration purposes) were compared with the regression to evaluate the extent that habitat has been increased by restoration activities.

This analysis shows that the density of natural off-channel habitat in the Skagit Above Barnaby reach is well below the regression prediction for habitat density in unregulated river reaches. This is likely a result of flow regulation in the Skagit River reducing the creation and maintenance of natural off-channel habitat over time in this reach. Habitat construction activities in the past decade have resulted in a measurable increase in the total amount of habitat and brought the current total habitat density in this reach to a level greater than would be predicted by the regression equation. This suggests that construction efforts have been successful at mitigating for impacts from flow regulation and may not need to be continued in the future.

In the Barnaby reach, the analysis indicates that natural off-channel habitat is well above the value that would be predicted by the regression for natural habitat in unregulated reaches and is likely a very important reach for fish production in the basin. However, this result is uncertain because the effective floodplain width of the Barnaby Reach is much greater than any of the reaches that were used to develop the regression equation. In any case, while construction efforts have resulted in a substantial total area of new habitat, they have had a much smaller relative effect on the density of habitat in the reach. This is due to the large amount of natural habitat present in the reach and the very large floodplain. Both of these factors make it difficult to increase the density of habitat through construction activities on a per-unit-area of floodplain basis. This suggests that future restoration activities in this reach should emphasize protection of the existing habitat value of this important reach.

Conclusion and Recommendations

The results of this study should be viewed with caution for two important reasons. First, as discussed earlier, the existing data that were used in the analysis did not include habitat that would likely be flooded in a peak flow event with a recurrence interval of two years or less. For this reason the inventory underestimates the amount of natural off-channel habitat that might be used by fish and overestimates the contribution of constructed habitat to the total amount of floodplain habitat by an unknown amount. Second, the regression equation used in the analysis was based on only five reaches and is not significant at a 95% confidence level (p=0.058).

Even with these limitations the analysis still provides meaningful results and represents the best available information on off-channel habitat conditions in the upper Skagit basin. Until more detailed information can be collected to improve the results, the following recommendations are provided:

Habitat construction activities may no longer be needed in the upper reach of the Skagit River. The analysis suggests that while off-channel habitat may have been reduced in this reach as a result of flow regulation, habitat construction efforts have substantially offset that loss. It may no longer be necessary to construct new habitat through construction efforts in the Skagit River upstream from the confluence with the Sauk River.

Habitat in the floodplain of the Barnaby Reach should be protected. The analysis shows that this reach has a very high density of habitat and more total habitat area than any other reach in the study. This reach clearly provides significant benefits to salmon species and should be protected from future impacts.

Future restoration activities should emphasize increasing effective floodplain area by removing or relocating infrastructure. Roads, bank protection structures, and other infrastructure can limit the creation and maintenance of off-channel habitat. The analysis only considered the effective floodplain area for river reaches in the study in order to improve the comparison of habitat density between reaches with differing levels of floodplain impairment. However, removing or relocating floodplain impairments would likely increase the total amount of off-channel habitat available to fish.

The limited analysis of floodplain impairment presented here suggests that the Sauk River and Skagit Barnaby Reach likely have the highest level of floodplain impairment. The Cascade and Suiattle rivers also have floodplain impairments to a smaller degree, but there are likely a few specific reaches where these impairments are concentrated. The lower portion of Bacon Creek shows a substantial loss of effective floodplain area, although this has already been partially addressed through restoration efforts undertaken since these data were collected. It is also very likely that the Skagit River downstream from the Sauk River confluence has suffered from a significant floodplain impairment, although this reach was not included in this study.

Additional Studies

A more detailed study should be completed to identify specific floodplain reaches where floodplain impairments have had the greatest impact on off-channel habitat and where good opportunities may exist to remove or relocate infrastructure that could impair floodplain function. This study may also identify other important areas like the Barnaby Reach that have a very high density of existing habitat that should be protected from future development This kind of study should include the reaches identified here as well as the middle and lower portions of the Skagit River.

The analysis presented here could be improved with an inventory of side channels and regularly flooded off-channel habitat that were not included in the available data sources used in this study. It is difficult to include all of these habitats in a field inventory because they often change from year to year, and it would be challenging to field inventory them in a single field season. A method is needed to estimate the amount of these habitats using aerial photographs or other remote sensing methods, which would increase the certainty of the conclusions from this study.

Acknowledgments

Much appreciation to Mike Olis for collecting field data and dilligently organizing all of the existing off-channel habitat information. Without his hard work, this project would not have been possible.

Chris Detrick and Brett Barkdull provided assistance in accessing and interpreting a variety of data sources from the Washington Department of Fish and Wildlife.

Eric Beamer, Chris Detrick, and Dave Pflug all provided useful comments that greatly improved the quality of this report.

Kate Ramsden provided valuable assistance with GIS and maps.

References

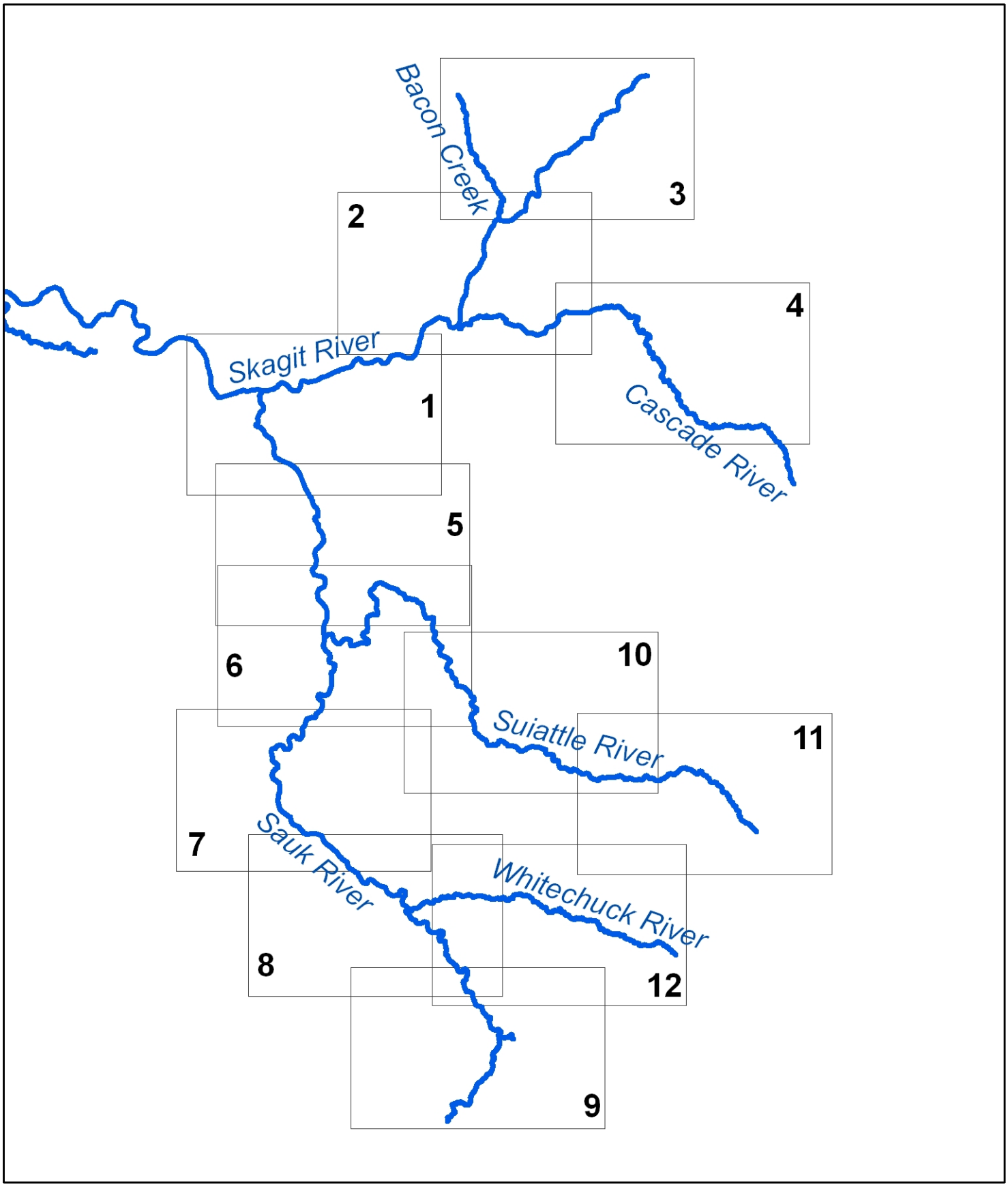
Beamer, E., T. Beechie, B. Perkowski, J. Klochak. 1999. Application of the Skagit Watershed Council Strategy. Skagit Watershed Council, Mount Vernon.

Beechie, T., E. Beamer, L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. No. American Journal of Fisheries Management **14**:797-811.

Johnson, Rich. 1986. Assessment of the Skagit River System's coho rearing potential. Technical Report No. 95. State of Washington, Department of Fisheries, Olympia.

Seattle City Light. 1991. Skagit River Hydroelectric Project (FERC No. 553) Fisheries Settlement Agreement.

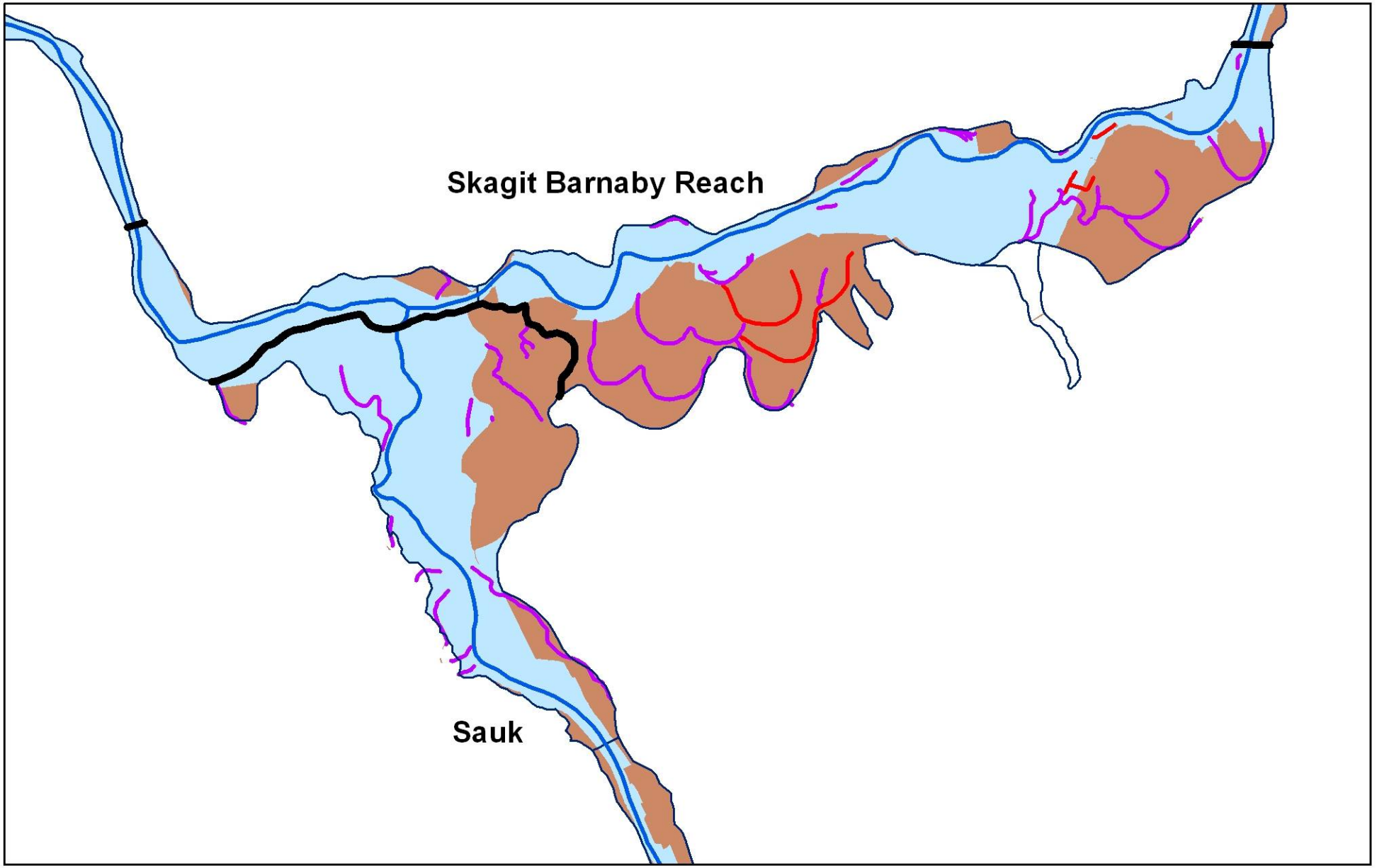
Appendix A: Off-channel Habitat Maps



Index for Off-Channel Habitat Maps

0 2.5 5 10 15 20 Miles

N
W E
S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

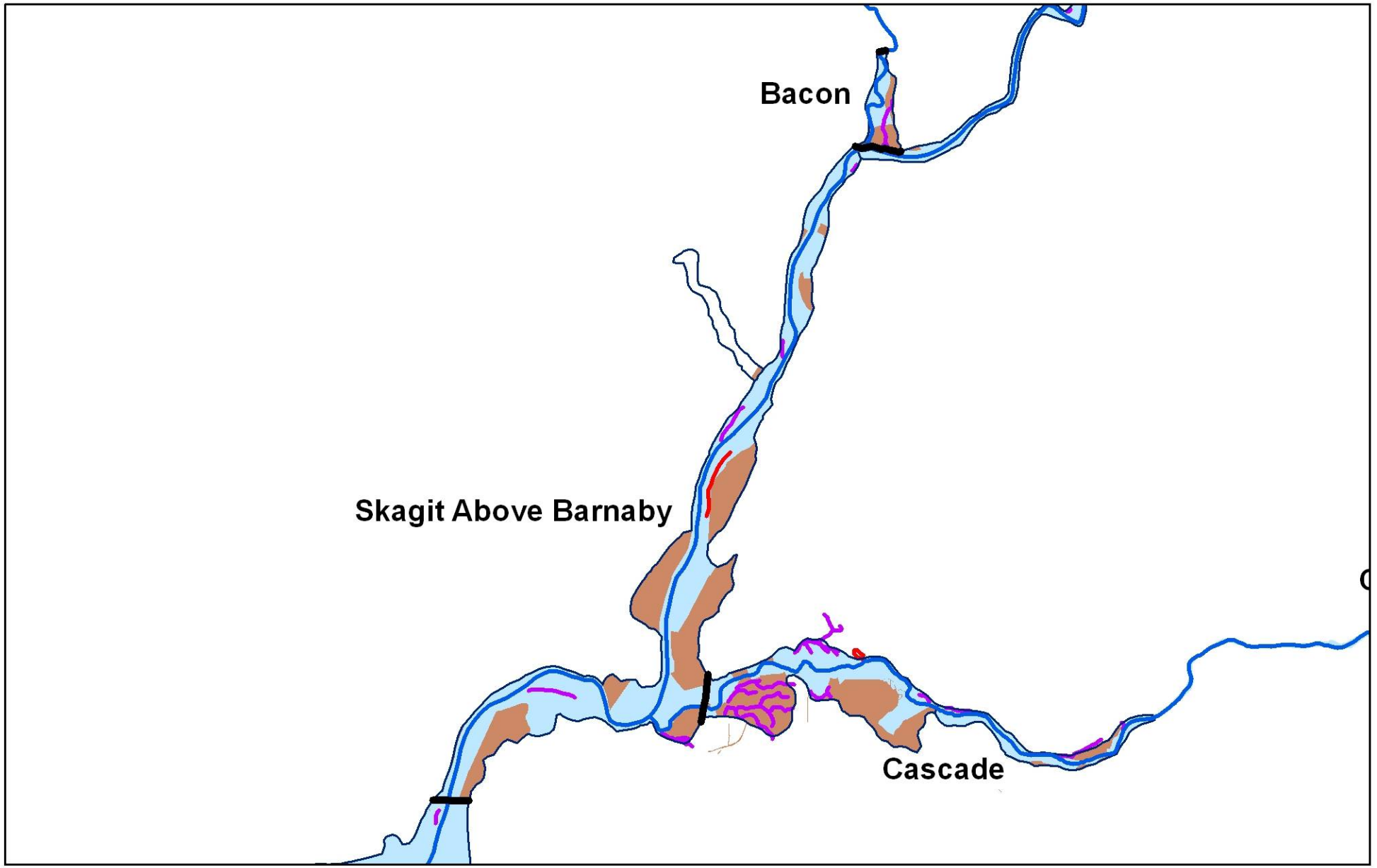
Off Channel Habitat

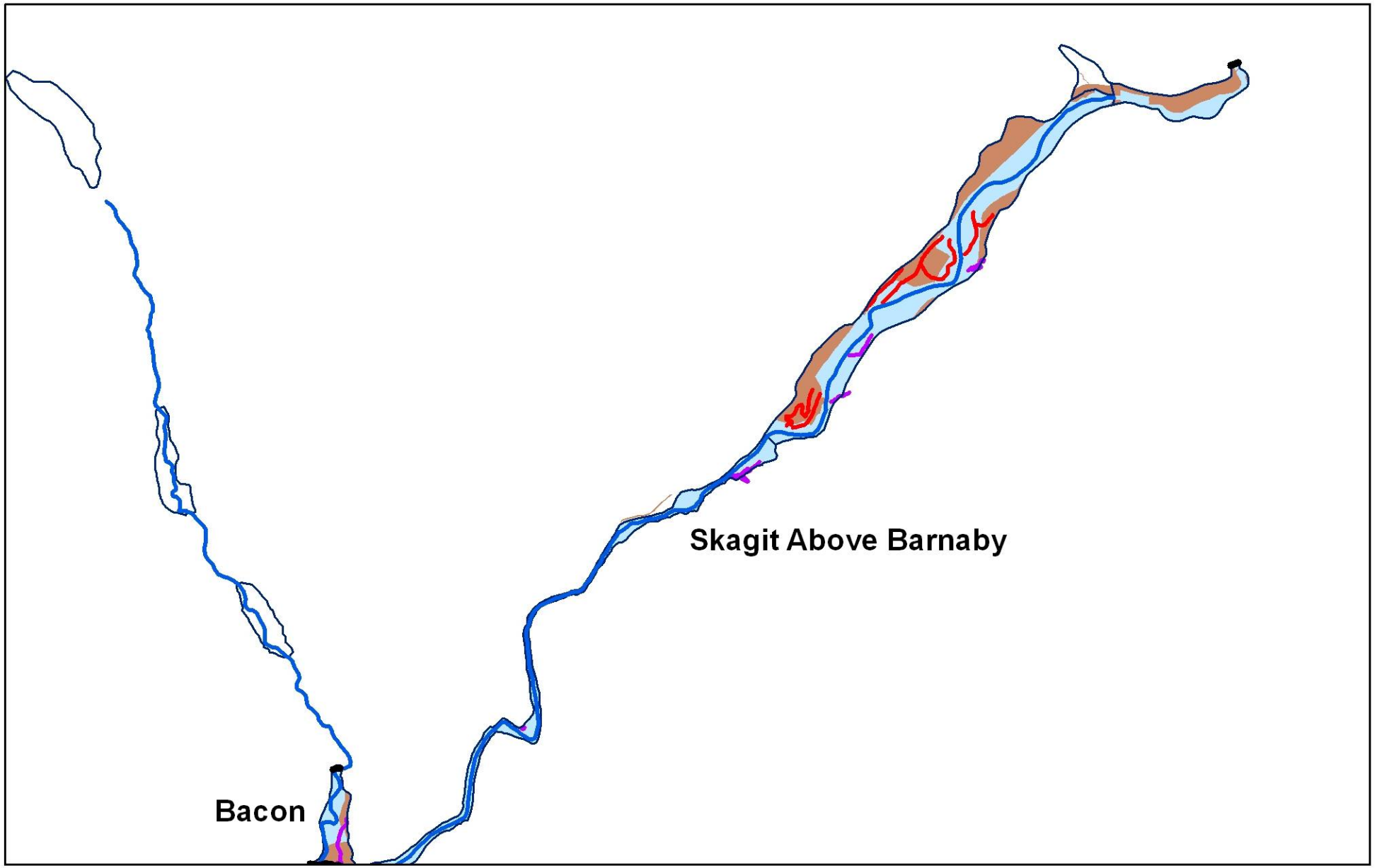
- natural
- constructed

Map 1 of 12

0 0.5 1 2 3 4 Miles

N W E S


Bacon
Skagit Above Barnaby
Cascade
Floodplain Area
effective
isolated or impaired
main channel
floodplain reach
river reach boundary
Off Channel Habitat
natural
constructed
Map 2 of 12
0 0.5 1 2 3 4
Miles
N
W
E
S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

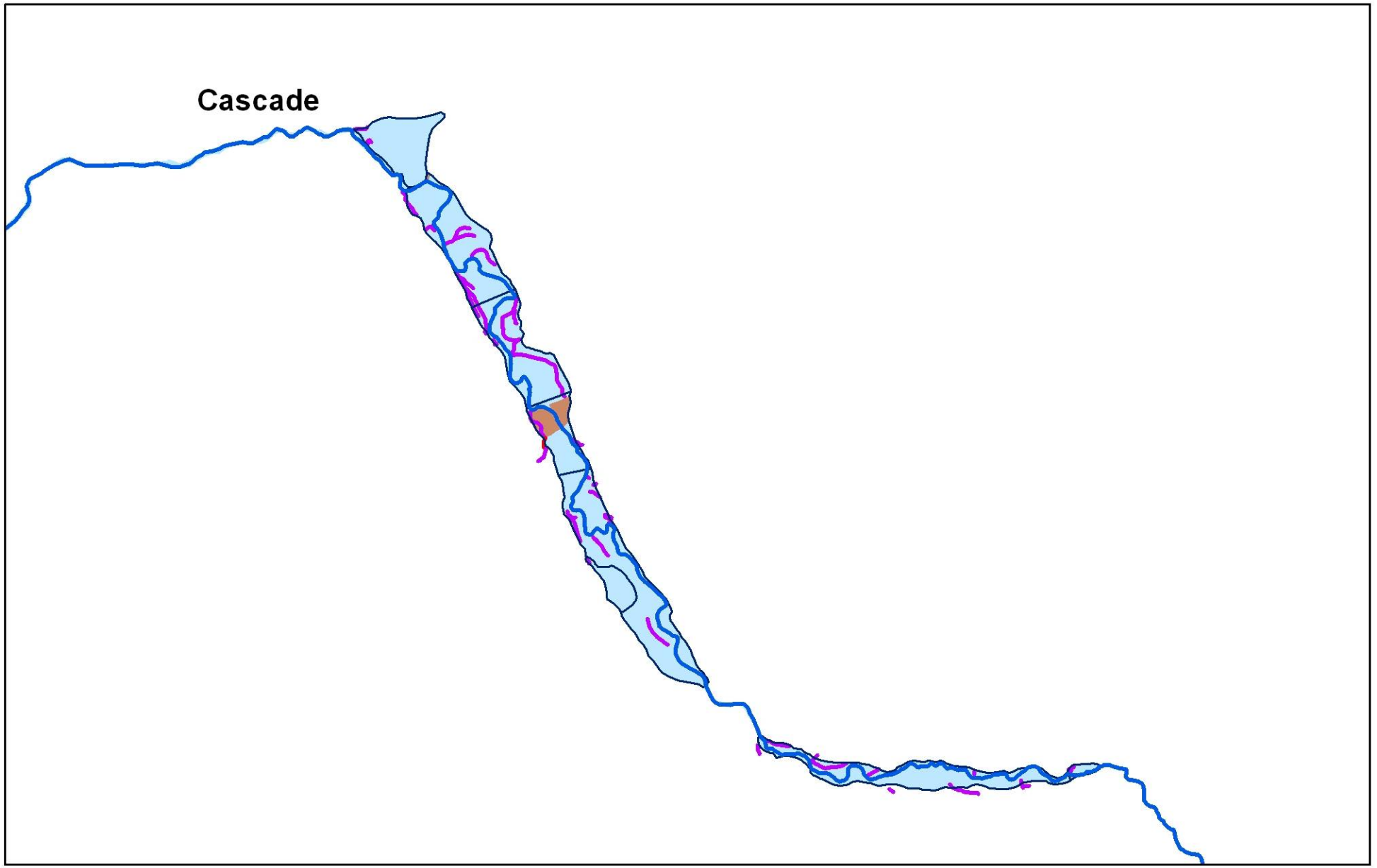
Off Channel Habitat

- natural
- constructed

Map 3 of 12

0 0.5 1 2 3 4 Miles

N W E S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

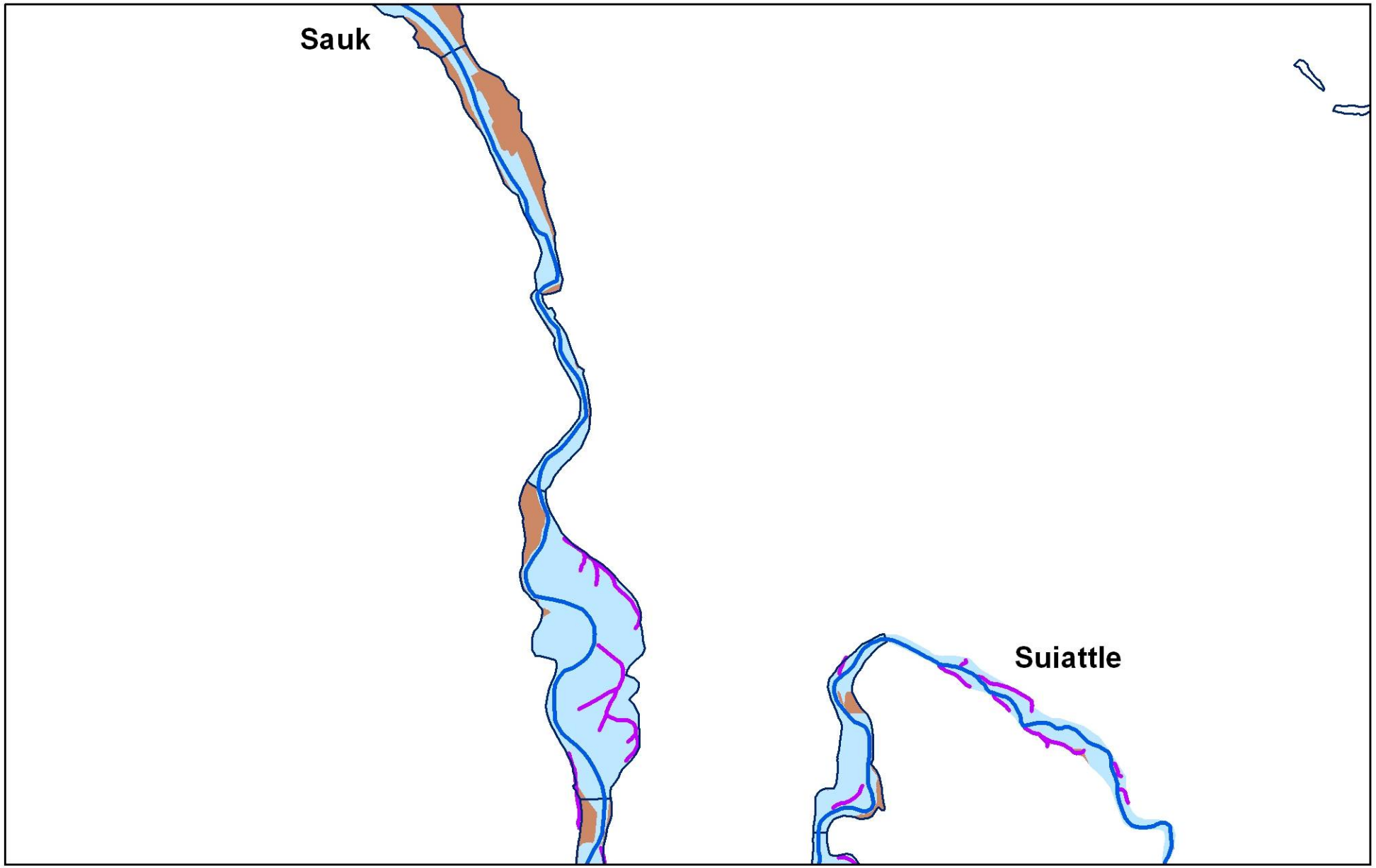
Off Channel Habitat

- natural
- constructed

Map 4 of 12

0 0.5 1 2 3 4 Miles

N W E S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

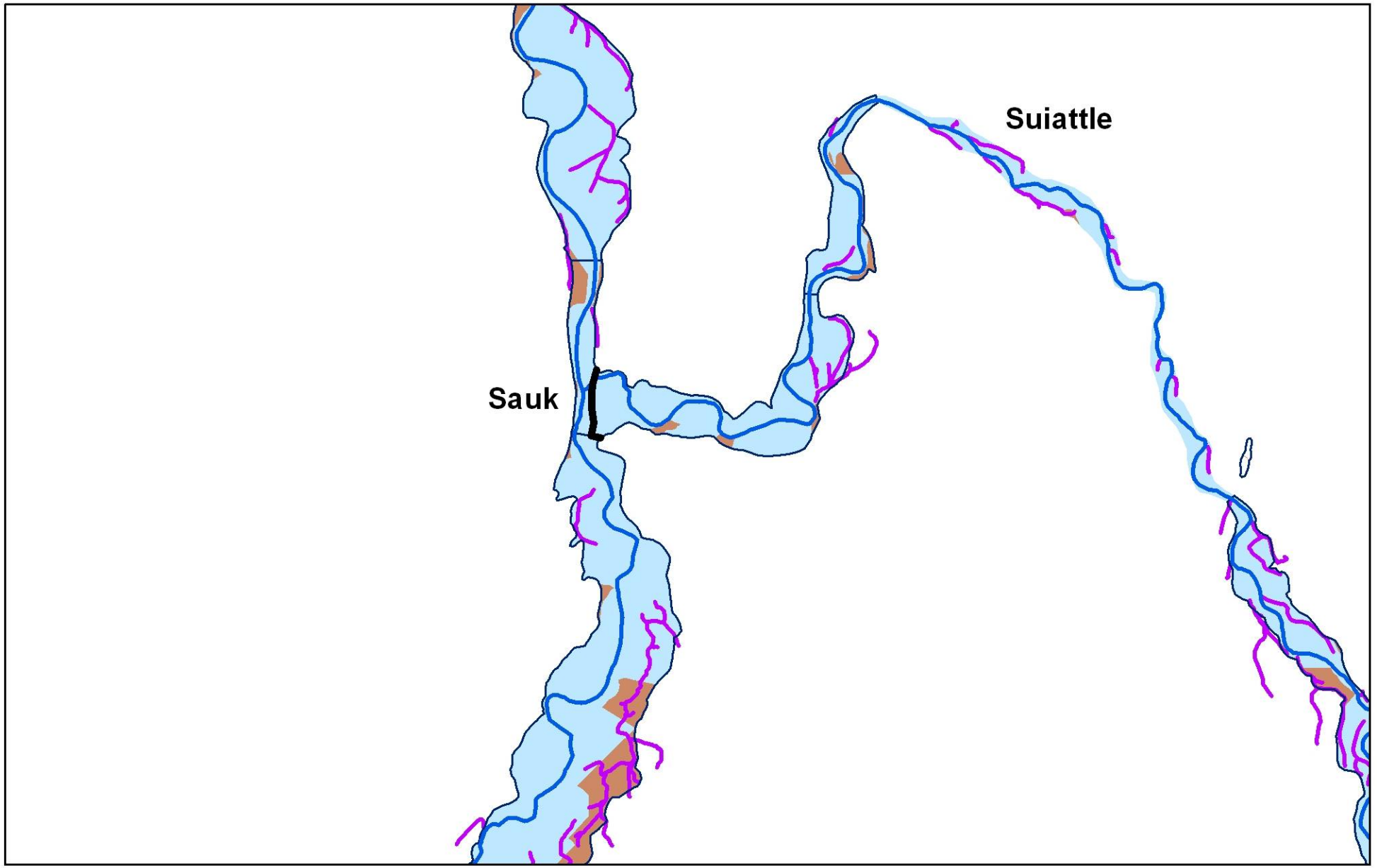
Off Channel Habitat

- natural
- constructed

Map 5 of 12

0 0.5 1 2 3 4 Miles

N
W E
S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

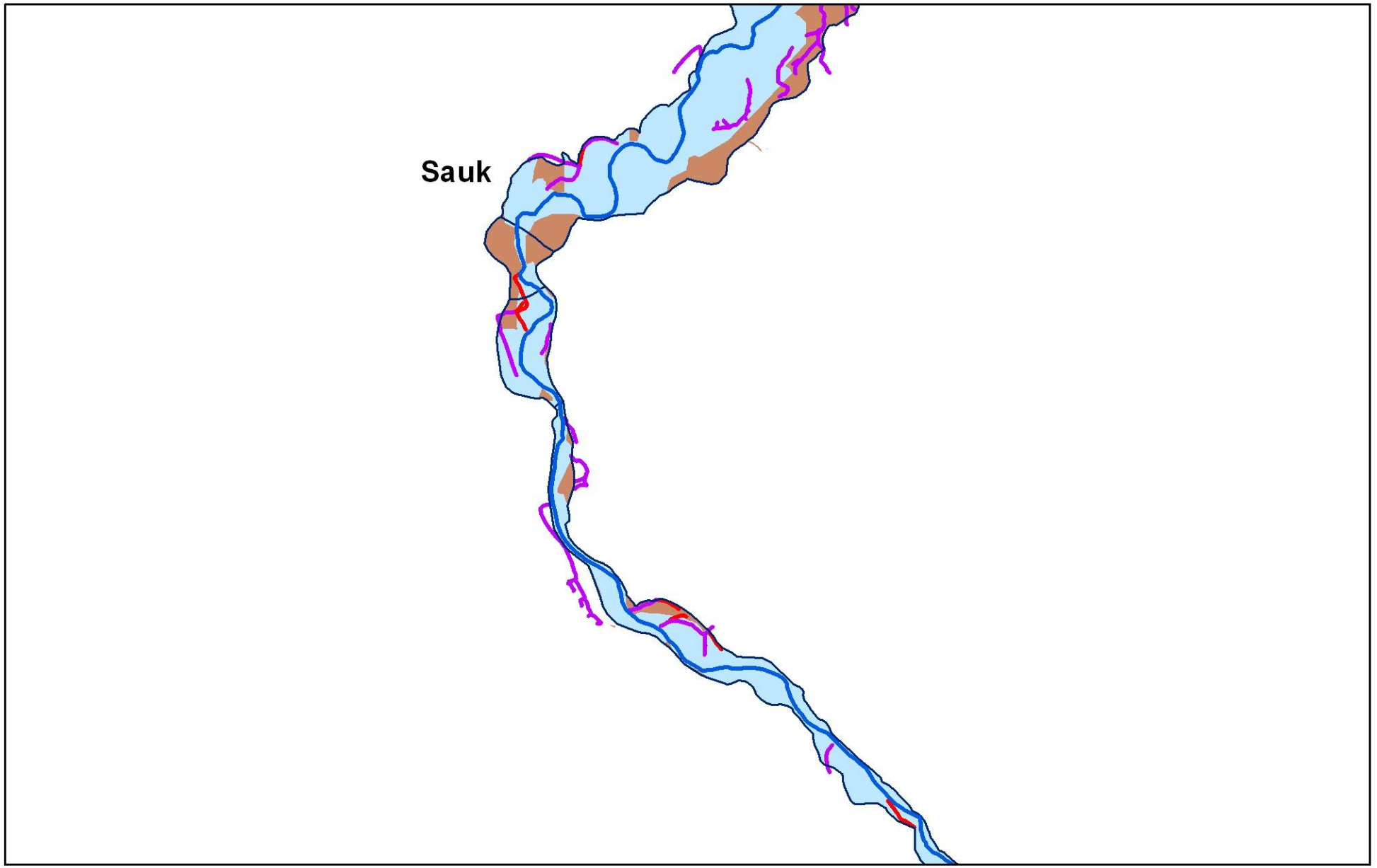
Off Channel Habitat

- natural
- constructed

Map 6 of 12

0 0.5 1 2 3 4 Miles

N W E S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

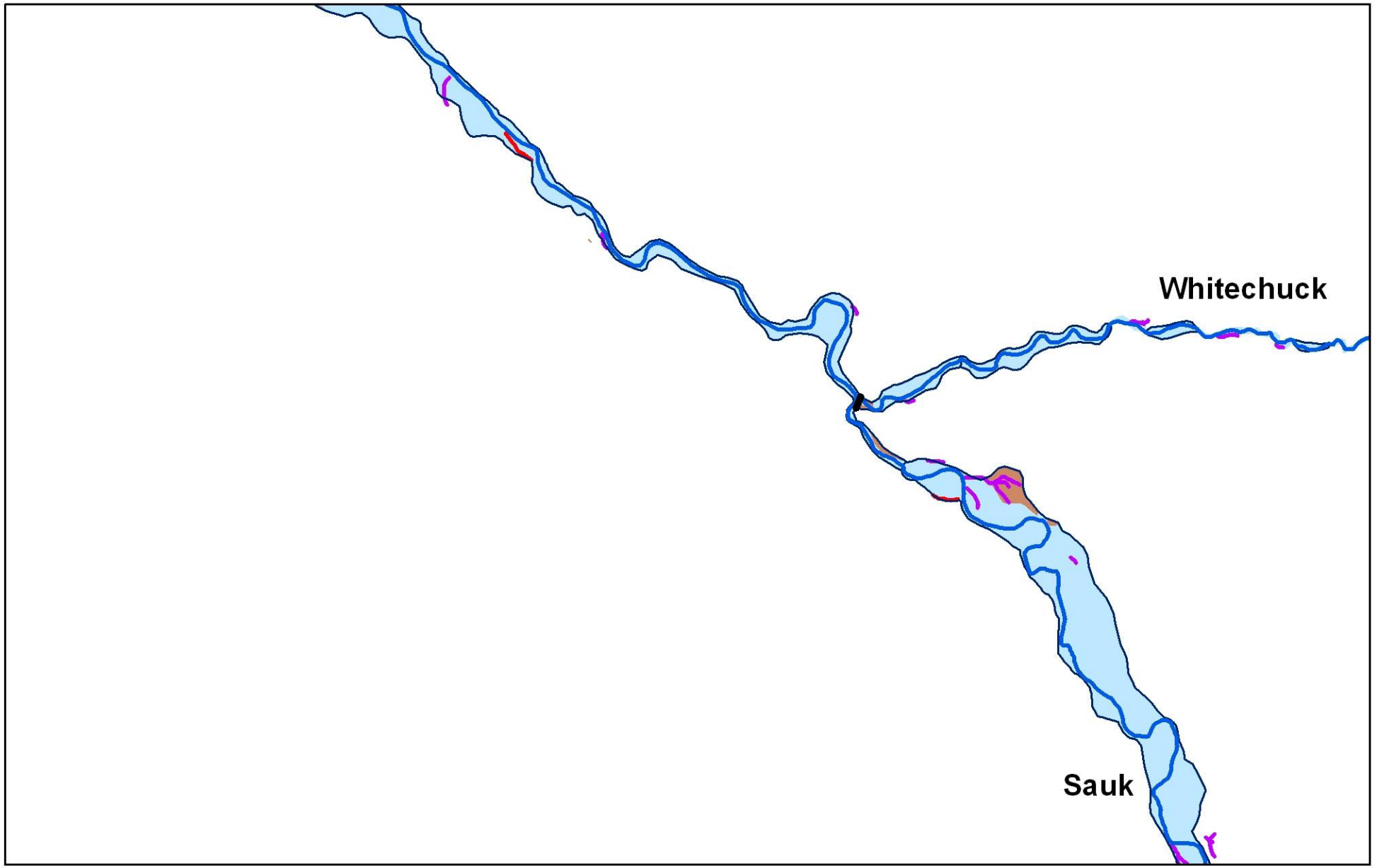
Off Channel Habitat

- natural
- constructed

Map 7 of 12

0 0.5 1 2 3 4 Miles

N W E S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

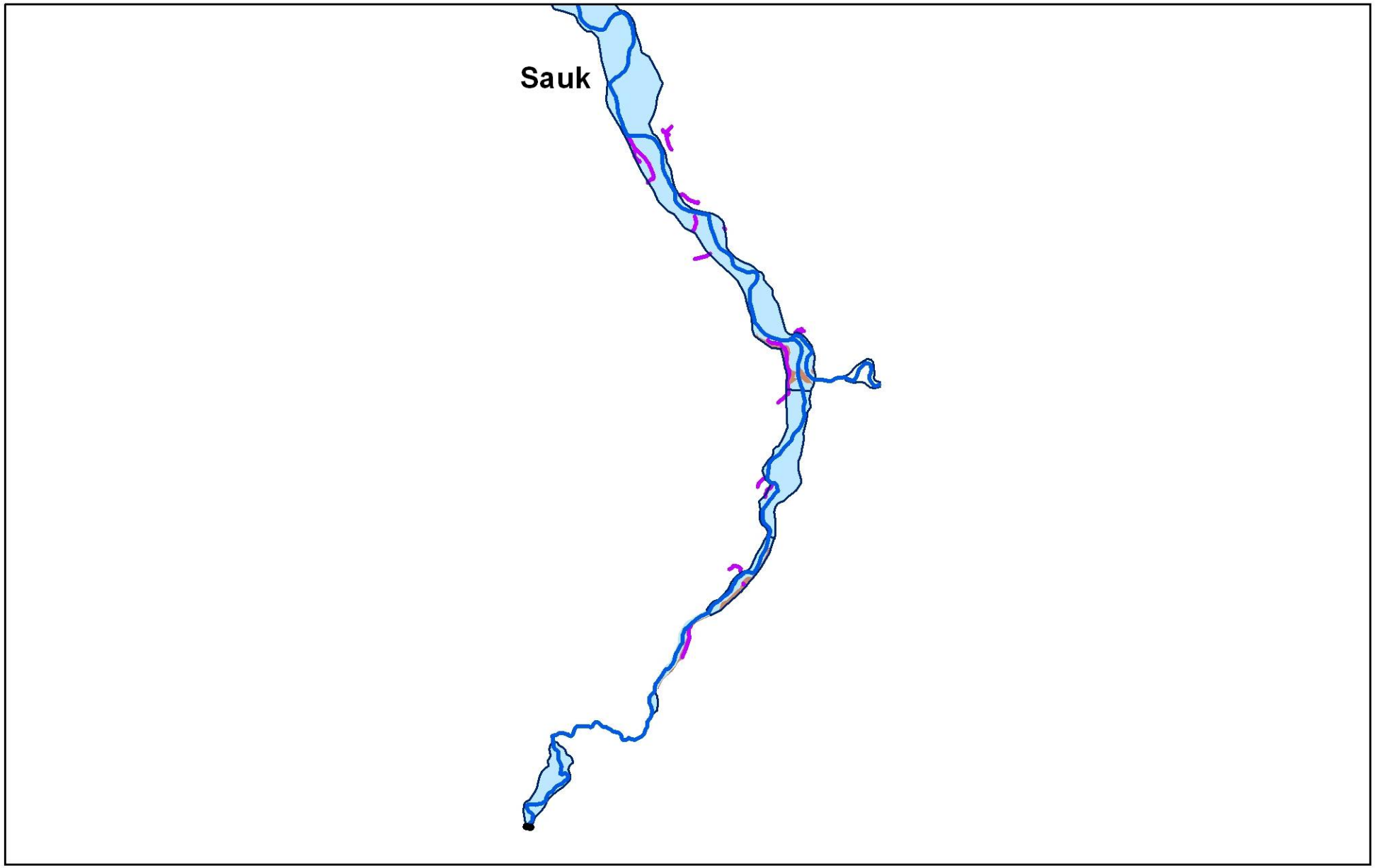
Off Channel Habitat

- natural
- constructed

Map 8 of 12

0 0.5 1 2 3 4 Miles

N
W E
S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

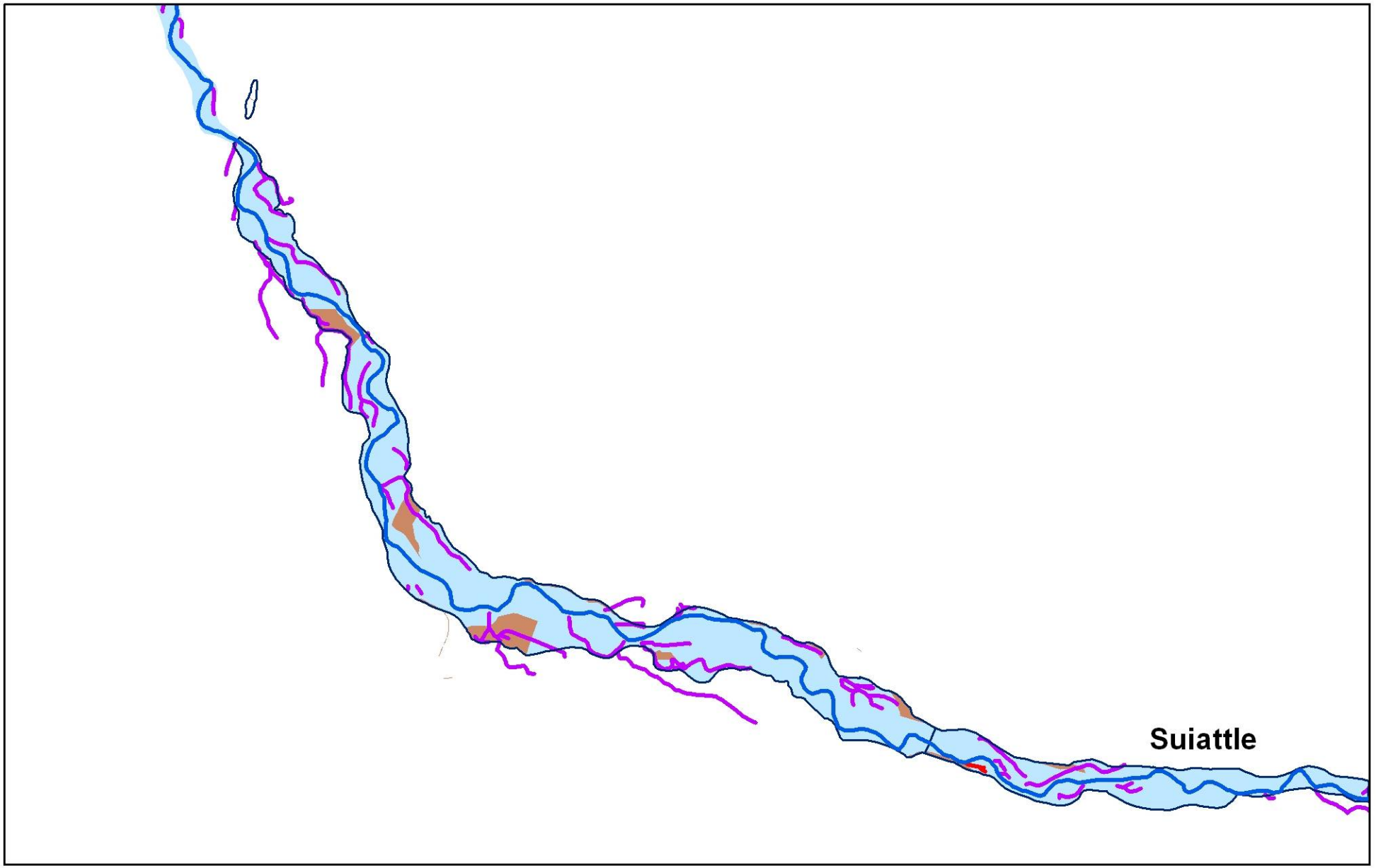
Off Channel Habitat

- natural
- constructed

Map 9 of 12

0 0.5 1 2 3 4 Miles

N W E S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

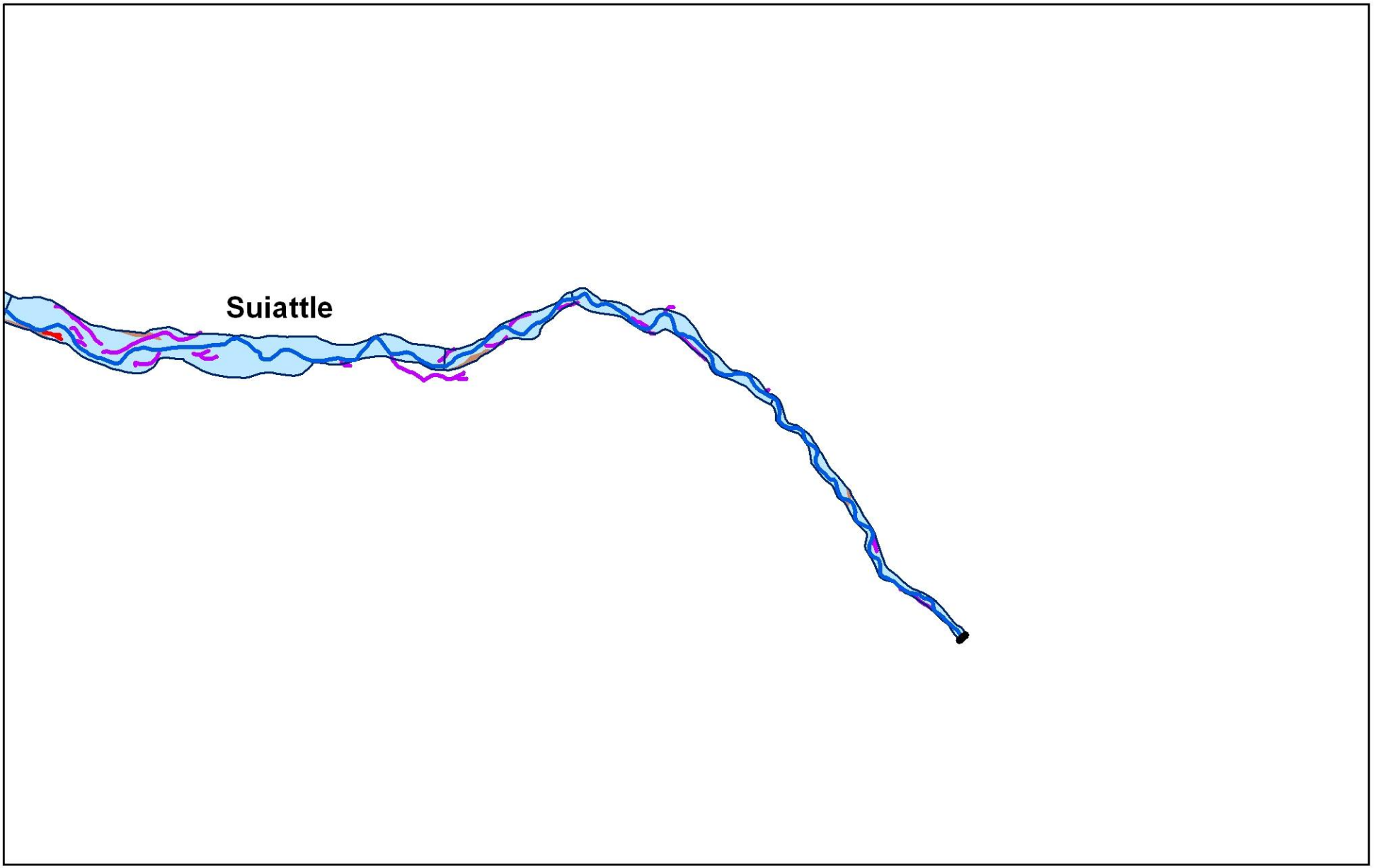
Off Channel Habitat

- natural
- constructed

Map 10 of 12

0 0.5 1 2 3 4 Miles

N W E S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

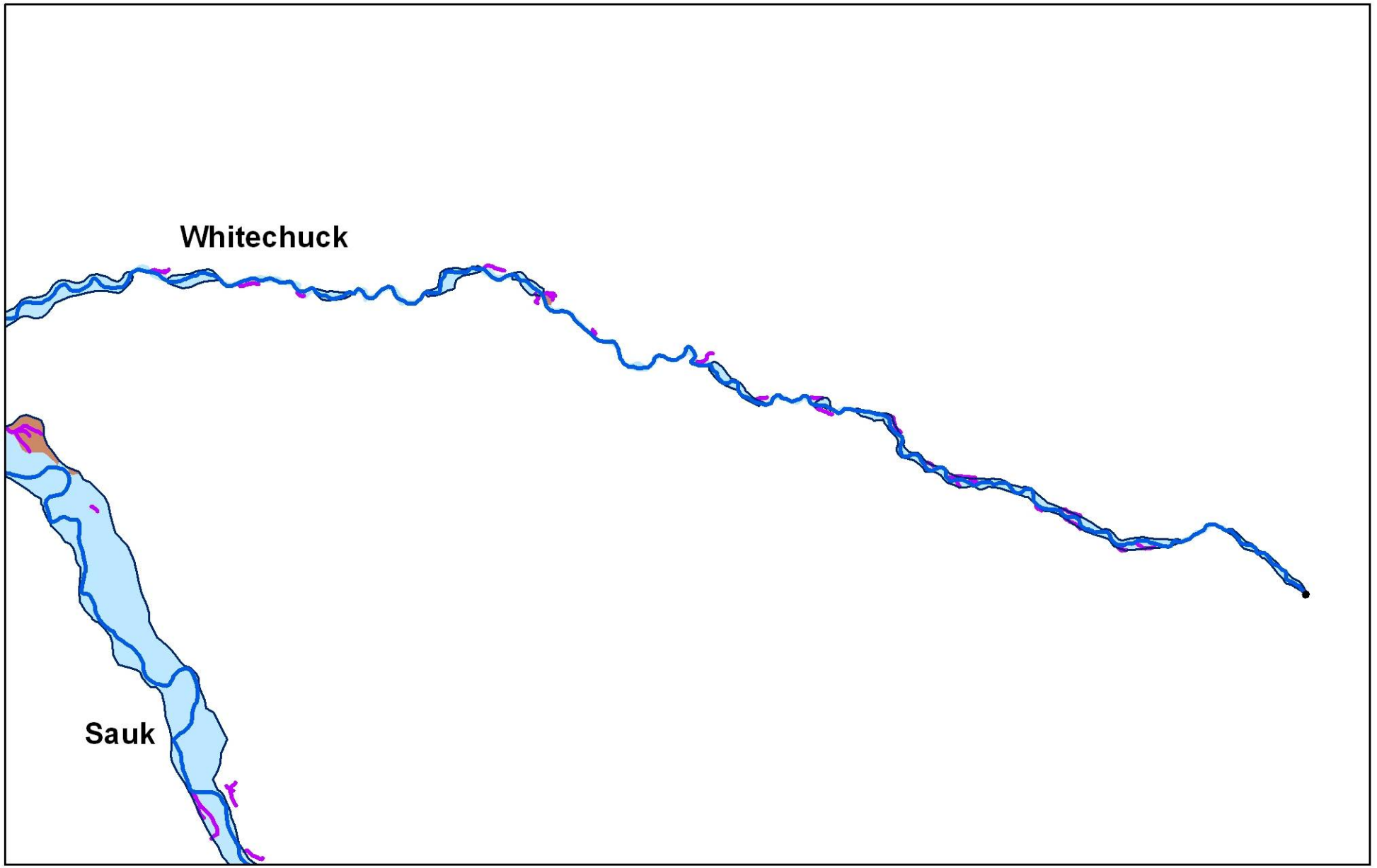
Off Channel Habitat

- natural
- constructed

Map 11 of 12

0 0.5 1 2 3 4 Miles

N W E S



Floodplain Area

- effective
- isolated or impaired
- main channel
- floodplain reach
- river reach boundary

Off Channel Habitat

- natural
- constructed

Map 12 of 12

0 0.5 1 2 3 4 Miles

N
W E
S