CHAPTER 4: HABITAT STUDIES

The quantity of aquatic habitat utilized by upper trophic levels is an important factor that must be considered regarding the recovery of endangered fishes in the San Juan River. In the following section of this report, the spatial and temporal distribution of habitats are described in detail. Factors which regulate the formation and persistence of these habitats are also discussed in the context of various hydrologic conditions.

INTRODUCTION

The distribution and abundance of habitat types commonly found in riverine systems are modified by both the magnitude-duration of spring runoff and the amount of base flows during the summer/fall period. The intent of this investigation was to evaluate aquatic habitat in the San Juan River with the specific objective to:

> ***Characterize the distribution and abundance of habitat in the San Juan River and measure the response of habitat to experimental flows.***

During certain times of the year, the rare fishes in the San Juan River utilize specific habitat types. It is therefore important to understand the mechanisms of formation of these habitat types (i.e. backwaters) as well as the factors which regulate their quantity during the critical periods that these habitats are needed by the target species.

METHODS

From 1992 to 1997, aquatic habitat in the San Juan River was mapped thirteen times. Table 4.1 describes the mapping periods, flow ranges and river miles mapped as part of this study. Although mapping occurred over the entire 224 miles from Lake Powell to Navajo Dam, the most intensively mapped reaches were between RM 154 and RM 2 (Reaches 1 to 5). Table 4.2 describes the 36 specific habitats mapped, along with the eight general categories used to group the habitats for statistical analysis.

Mapping occurred in the field using hard copies of aerial videography as base maps. While floating down the river, habitats were drawn as polygons and identified using unique codes. Upon returning to the laboratory, maps were entered into a GIS system for analysis. Processing the data in GIS produced coded polygons (habitats) by which the surface areas were computed and sorted individually. The data was then retrieved and analyzed by cross tabulation (summarized by habitat type by river mile).

Table of Contents

Table 4.1. The Hydrologic Characteristics of Each Mapping Run by Geomorphic Reach

		GEOMORPHIC REACH							
MAPPING DATE	**FLOW CATEGORY**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Nov. 16-20, 1992 Dec, 1-5, 1993	low	NM	NM	949	849	952	878	NM	NM
June 4-10, 1993	high	NM	7781	7781	8279	6971	7437	NM	NM
July 19-23, 1993	medium	1078	1078	1078	1010	868	1308	NM	NM
Oct. 28-Nov. 3, 1993	medium	992	992	933	899	931	945	NM	NM
June 13-28, 1994	high	5780	5790	5790	7235	6490	7100	3730	3740
Aug. 19-24, 1994	low	578	626	642	792	845	605	633	633
Nov. 15-18, 1994	medium	1383	1397	1335	1129	1041	1045	NM	NM
Apr. 11-16, 1995	medium	3055	3215	3300	3045	3300	3135	2550	2550
Sept. 4-7, 1995 Oct. 4-16, 1995	medium	1430	1205	1029	1080	961	1265	815	796
Jan. 22-26, 1996	low	589	584	582	639	524	608	252	252
June 4-10, 1996	medium	3230	3210	3105	3440	3230	3445	NM	NM
Oct. 23-26, 1996	medium	1130	1123	1125	1010	1060	1225	NM	NM
Nov. 17-Dec. 2, 1997	medium	1168	1134	1137	1155	931	905	NM	NM

NM=not mapped

previous next
return to Main Menu

Table 4.2. The Detailed Habitat Types and the Eight General Categories on the San Juan River

HABITAT CATEGORY	HABITAT TYPE
Low Velocity	pool debris pool rootwad pool eddy edge pool riffle eddy
Run	shoal/run run scour run shore run undercut run run/riffle
Riffle	riffle shore riffle riffle chute shoal/ riffle chute rapid
Backwater	backwater backwater pool embayment
Shoal	sand shoal cobble shoal
Slackwater	slackwater pocket water
Vegetation Associated	overhanging vegetation inundated vegetation
Other	isolated pool cobble bar rootwad pile abandoned channel (dry) sand bar tributary island irrigation return boulders

Table of Contents

RESULTS

The thirty-six habitat types were mapped thirteen times on a river-wide basis. In order to demonstrate the major differences in habitat quantity, the data were summarized first by river mile for major habitats. These data for a high (greater than 7000 cfs), medium (3000 cfs), and low (less than 700 cfs) flow mapping run can be seen in Figures 4.1 and 4.2. Figure 4.1 clearly shows that run habitats dominate the total surface area of habitats. On a broad scale, the canyon reaches (Reaches 1 and 2) had comparable total wetted areas when compared to the upper river reaches (Reaches 6, 7, and 8). However, the middle geomorphic reaches (Reaches 3, 4, and 5) had significantly greater total available habitat areas (Figure 4.3). In addition, the total wetted areas (TWA) for these reaches had significant linear relationships with flow, with TWA increasing as flow increased.

On a river-wide basis (Reaches 1-6), inspection of the habitat types presented in Figures 4.1 and 4.2 shows that both runs and inundated vegetation increase dramatically from low to high flow mapping runs (Figure 4.4). This is verified by plotting the density of run and inundated vegetation habitats (m^2 from Reaches 1 through 6). As can be seen in Figure 4.5, both habitats have positive linear or curve linear relationships with flow. Shoal and riffle habitats have the opposite trend with increasing surface areas with decreasing flows. Shoals show a strongly decreasing pattern even through the highest flow mapped (Figure 4.6). Riffles had a similar decreasing pattern except they increased slightly at higher flow (greater than 7,000 cfs).

Low velocity habitat types had two component habitats that responded differently to increasing flows (Figure 4.7). Pool habitats decreased significantly with flow, while eddies had a significant linear increase (r^2=0.90). Slackwaters, although changing locations in the river with flows, did not change in magnitude and did not have a relationship with flow (Figure 4.8).

Backwaters, which are an extremely rare habitat type when expressed as surface area, are critical for the rare and native fishes in the San Juan River. Their distribution and magnitude was found to be highly variable. Their relationship with flow varied by geomorphic reach, as well as the location within the channel. For example, in Reaches 1 and 2, backwaters were found to be associated with main channel sandbars or side canyon mouths, both of which had different relationships with flow (Figure 4.9). In the non-canyon reaches where there are multiple channels, Reaches 3, 4 and 5 have very complex relationships with flow (Figure 4.10). These relationships, although having the same basic form, vary by reach. In these three reaches, at very low flows, backwater surface areas decrease. At flows between 700-1000 cfs, the areas are at a maximum. With increasing flows, these backwaters decrease in area, reaching minimum values when flows were between 2000 and 3000 cfs, depending upon the reach. At flows greater than 3500 cfs, backwater area again increases. It is believed that these relationships reflect the gain and/or loss of main channel bar, and secondary channel associated backwaters as flows increase.

return to Main Menu
previous
next

Table of Contents

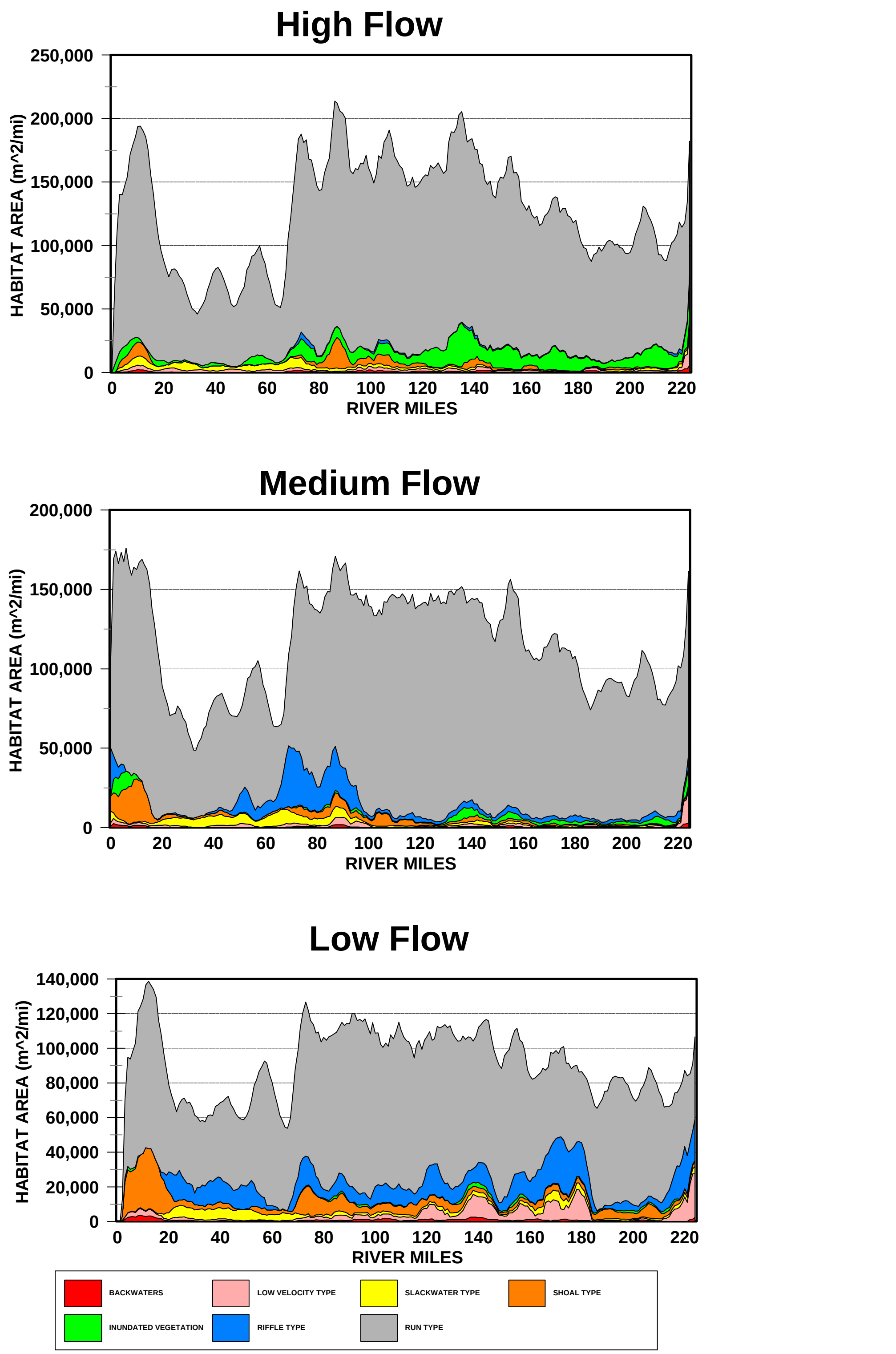


Figure 4.1. The Spatial Distribution of the Seven Major Habitat Types (Excluding "Other") in the San Juan River for Three Flow Regimes

previous
next
return to Main Menu

Table of Contents

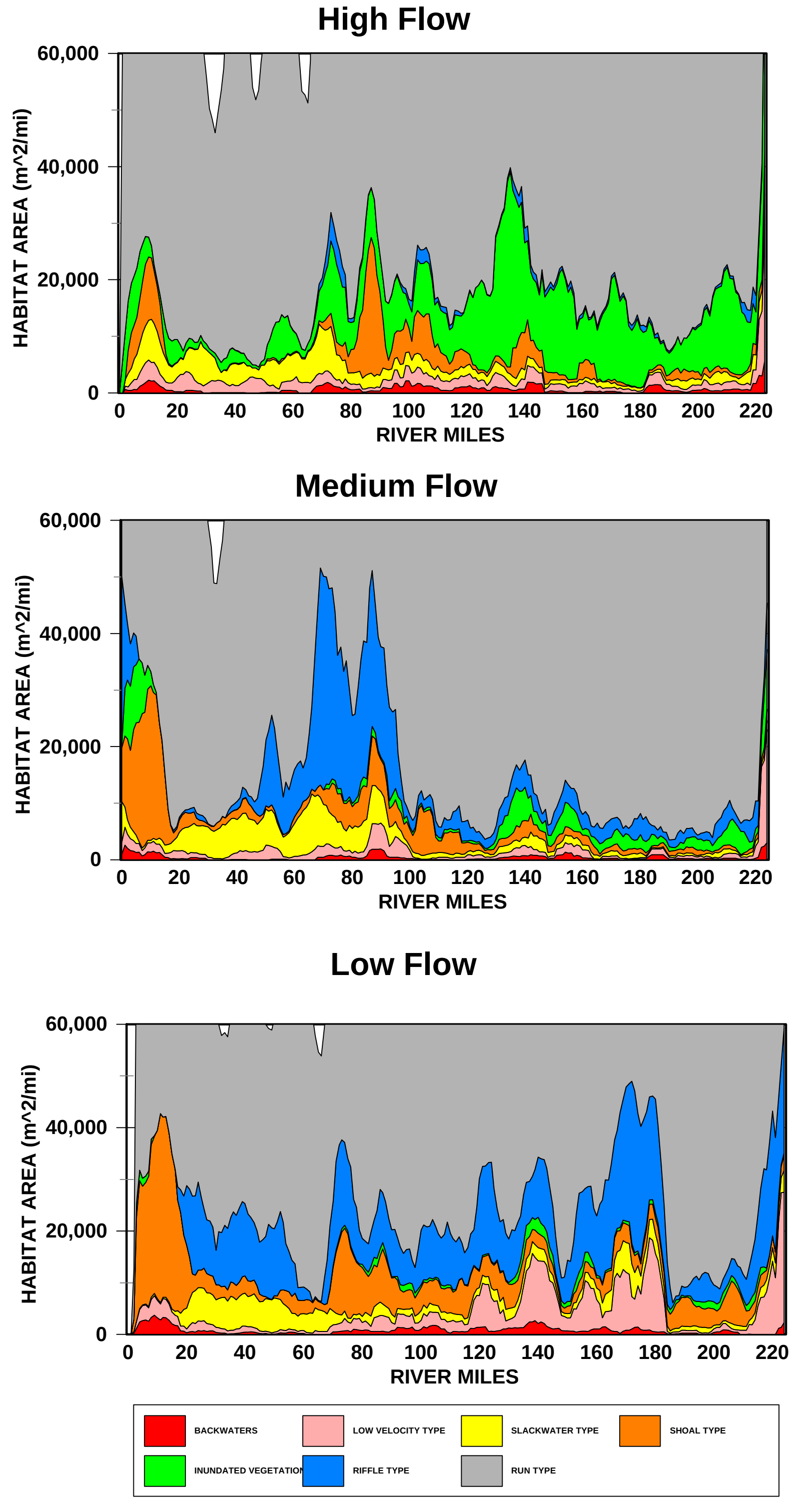


Figure 4.2. The Spatial Distribution of Seven Habitat Categories in the San Juan River with Expanded Scales to Allow Viewing Minor Categories

previous next
return to Main Menu

Table of
Contents

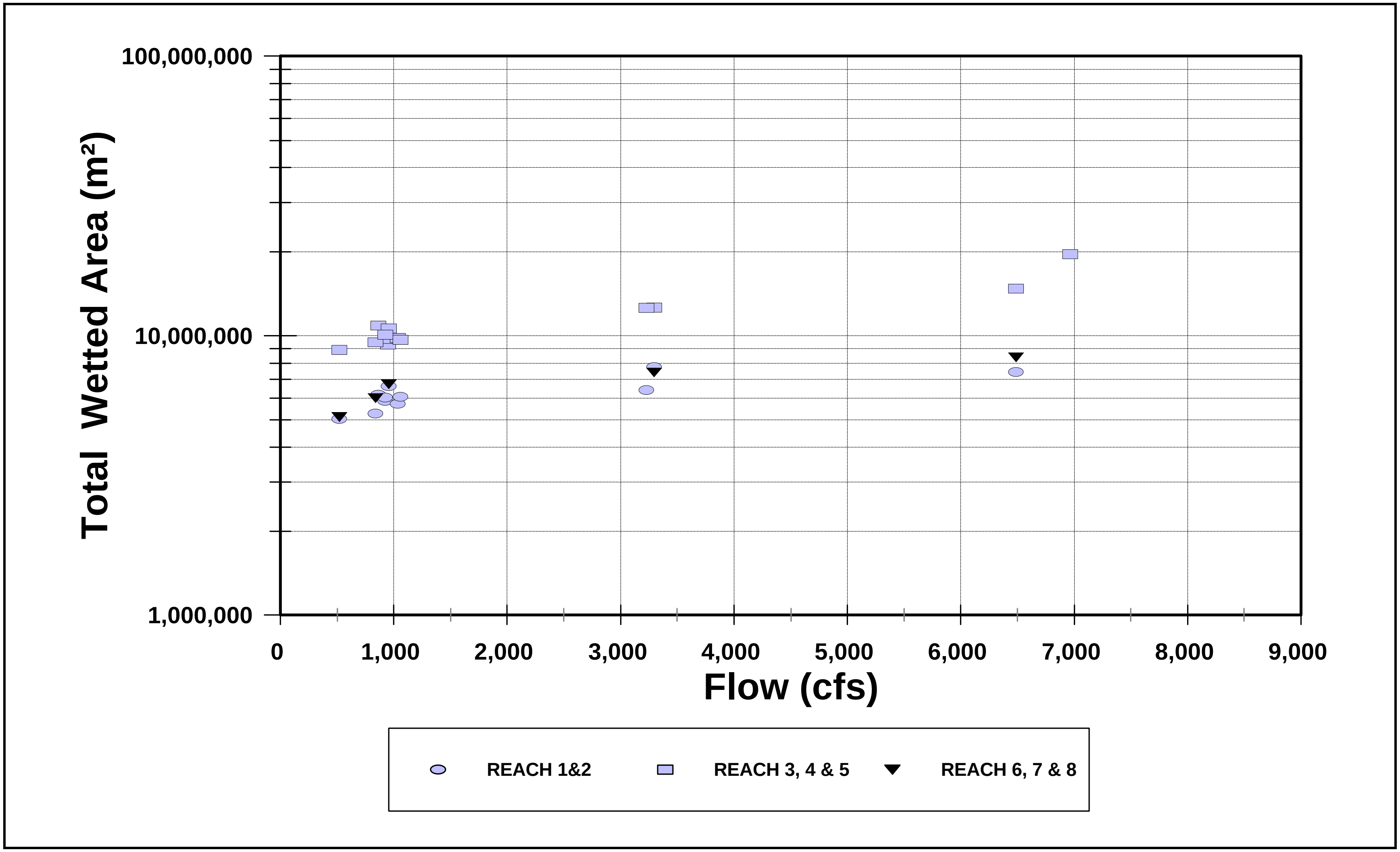


Figure 4.3. The Total Wetted Area vs. Flow Relationships for the Three Combinations of Geomorphic Reaches

previous
next
return to
Main Menu

Table of Contents

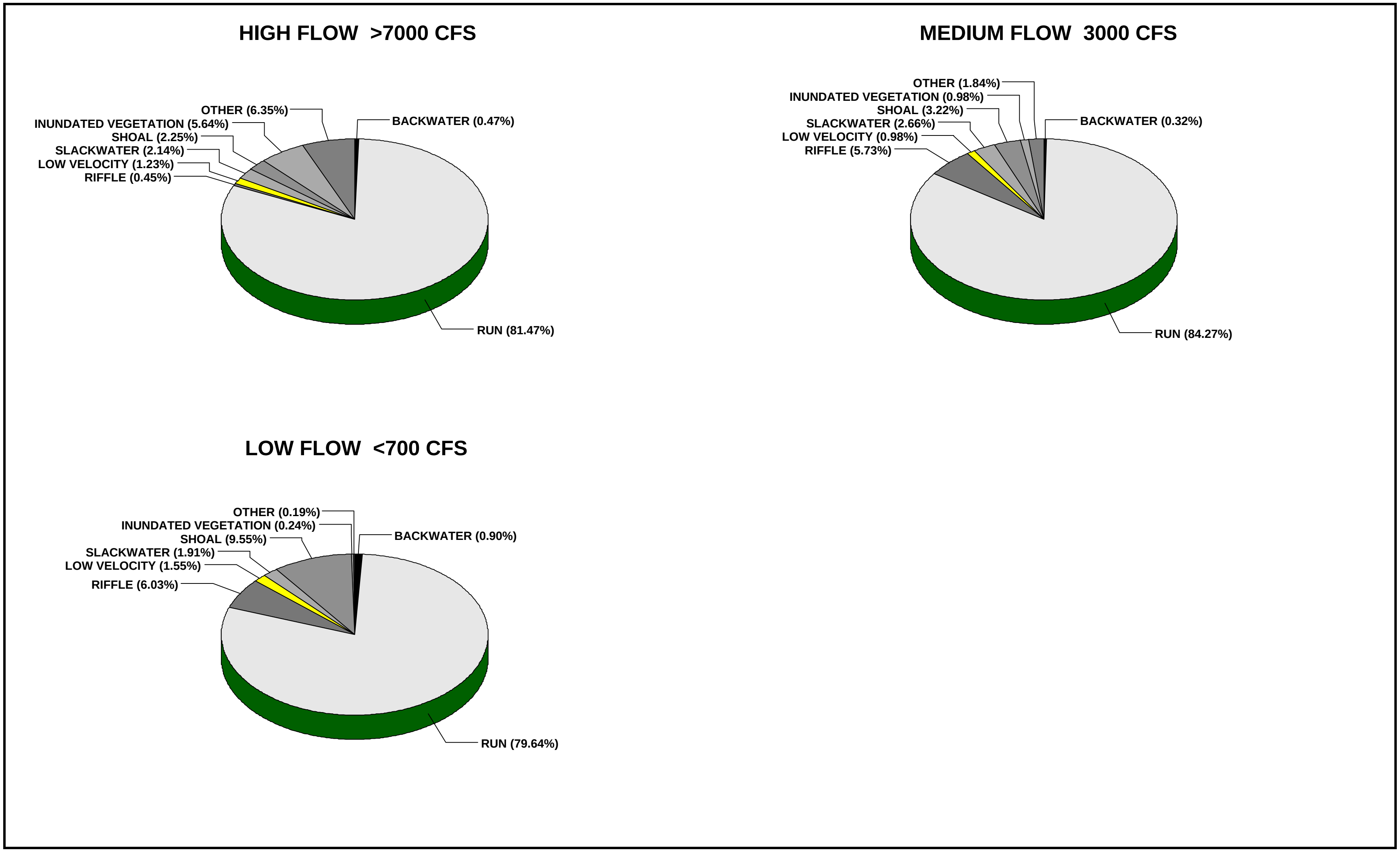


Figure 4.4. A Summary of the Major Habitat Categories as a Percent of Total Wetted Area for a High, Medium and Low Flow Period

previous next
return to Main Menu

Table of
Contents

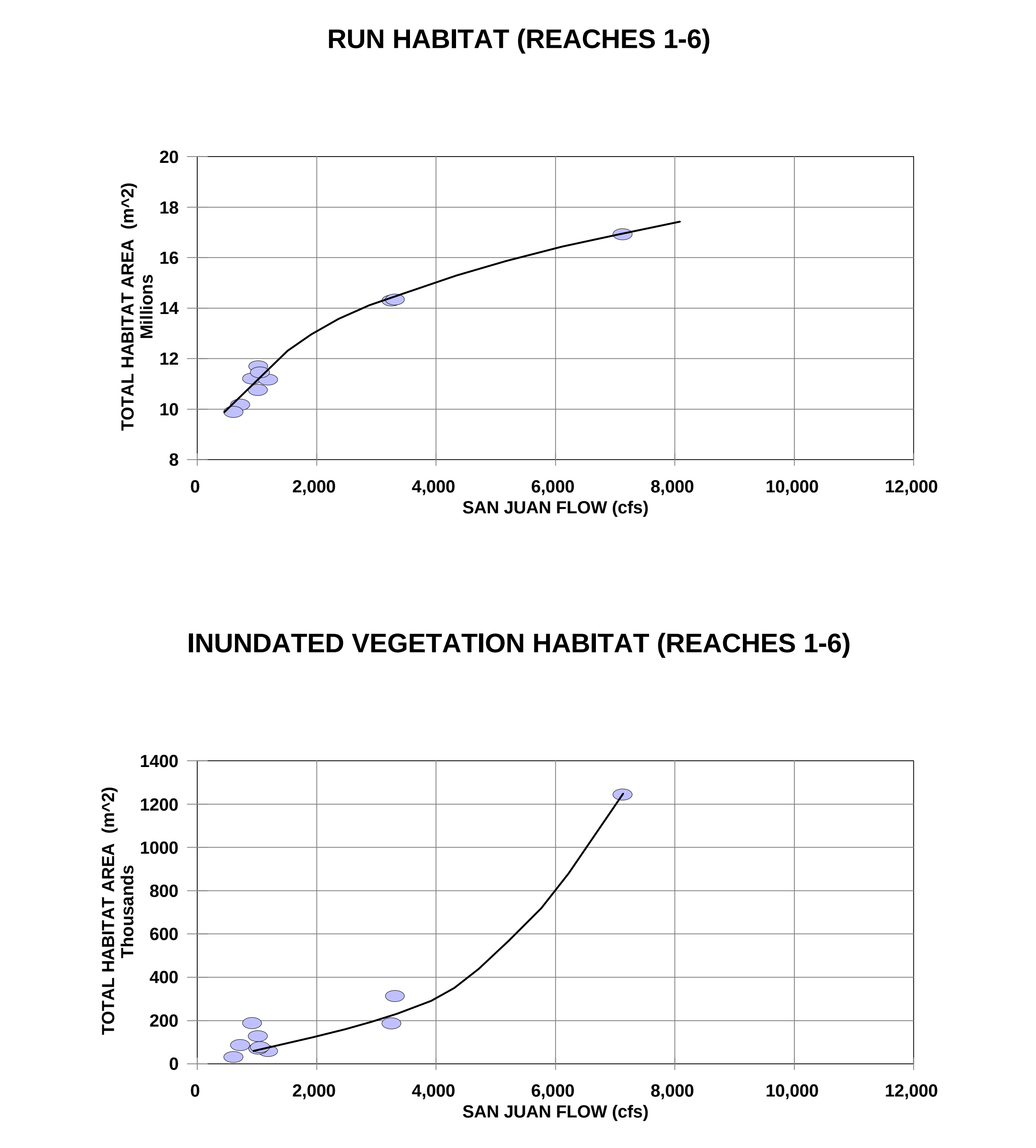
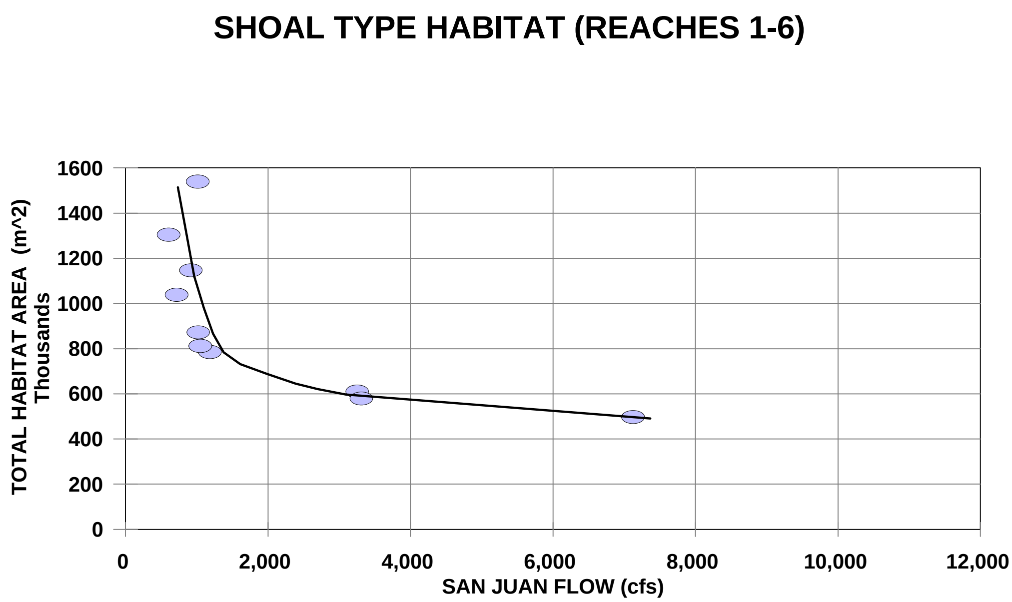


Figure 4.5 The Comparison Between Habitat Area (M2) and Mapping Flow for the Sum of Reaches 1 Through 6 in the San Juan River for Runs (above) and Inundated Vegetation (below)

previous
next
return to
Main Menu

Table of Contents



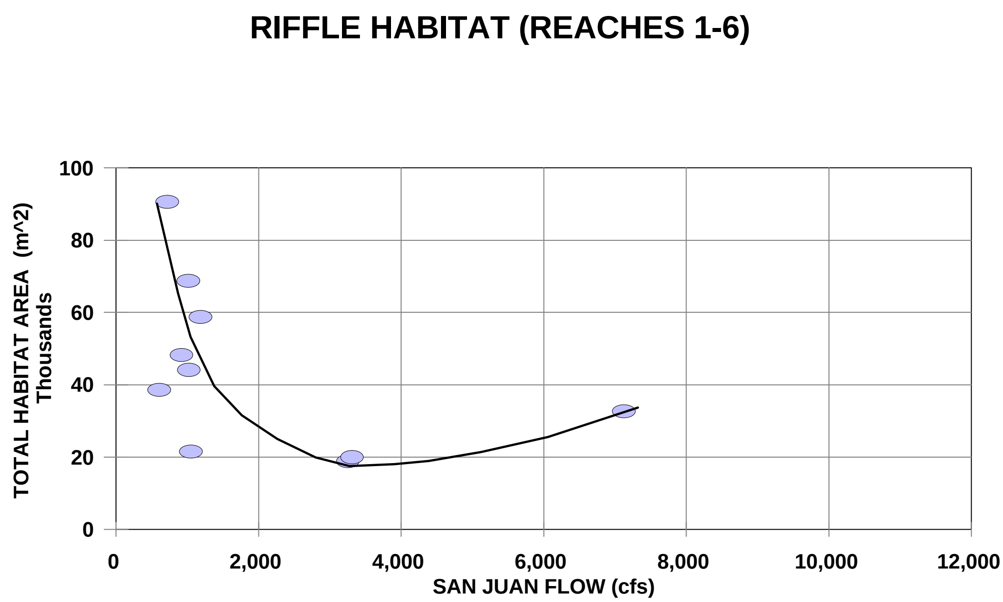


Figure 4.6. The Comparison Between Habitat Area (m2) and Mapping Flow for the Sum of Reaches 1 Through 6 in the San Juan River for Shoal Types (above) and Riffles (below)

previous
next
return to Main Menu

Table of
Contents

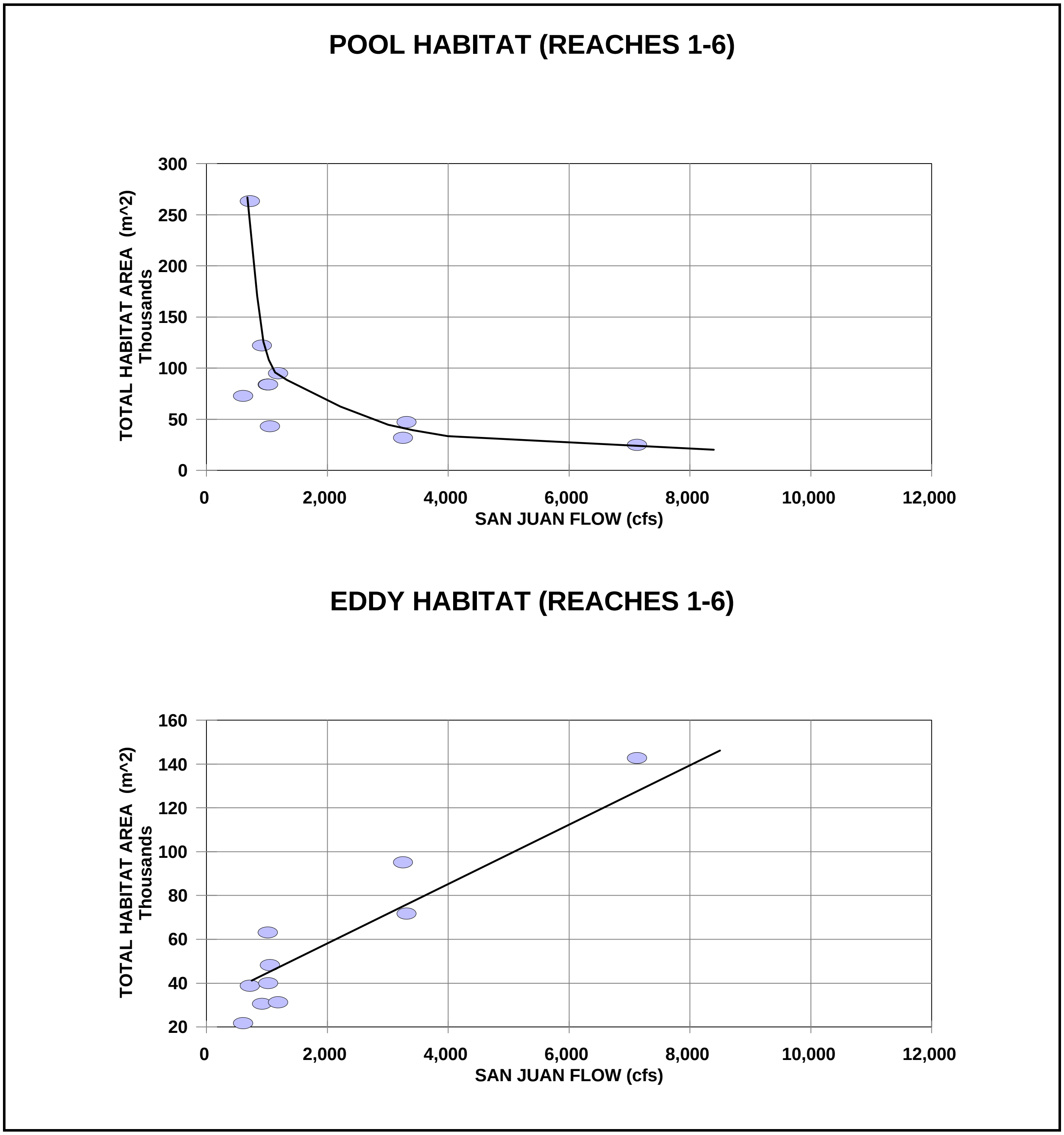


Figure 4.7. **The Comparison Between Habitat Area (m2) and Mapping Flow for the Sum of Reaches 1 Through 6 in the San Juan River for Pools (above) and Eddies (below)**

previous
next
return to
Main Menu

Table of
Contents

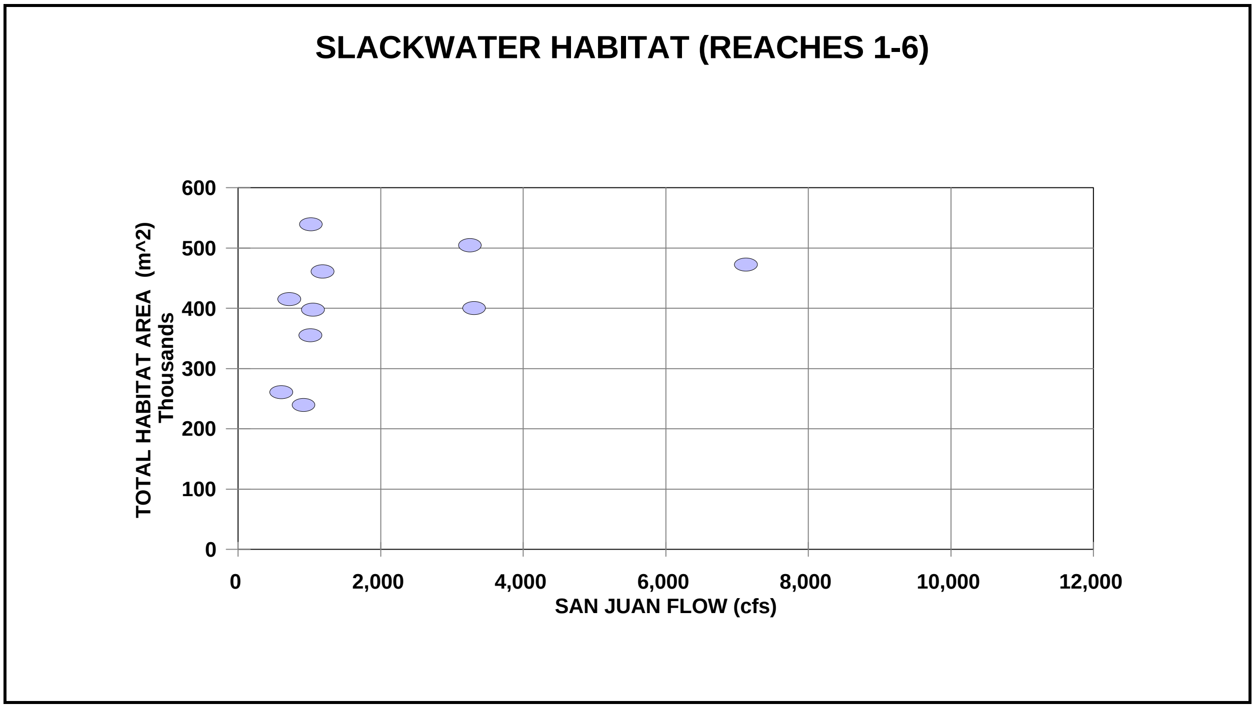


Figure 4.8. **The Comparison Between Habitat Area (m2) and Mapping Flow for the Sum of Reaches 1 Through 6 in the San Juan River for Slackwaters**

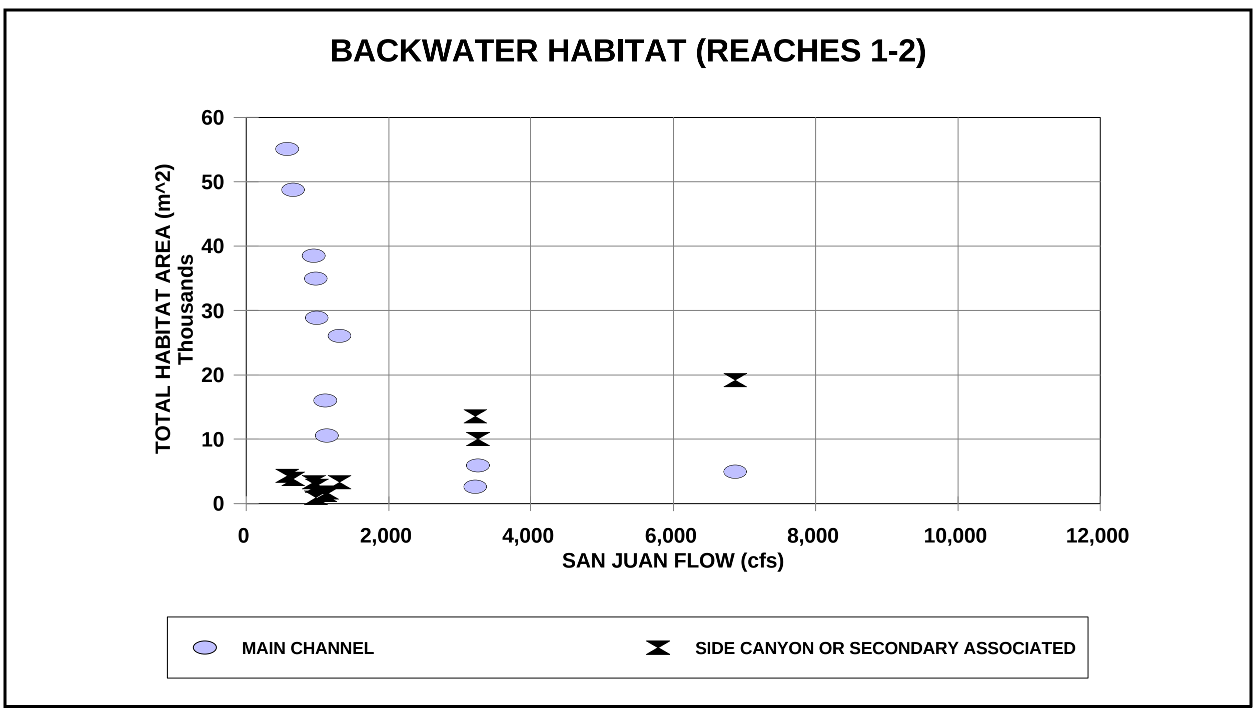


Figure 4.9. **The Relationship Between Backwater Surface Area and Flow for Reaches 1 and 2 Based upon Location Within the Channel**

previous
next
return to
Main Menu

Table of Contents

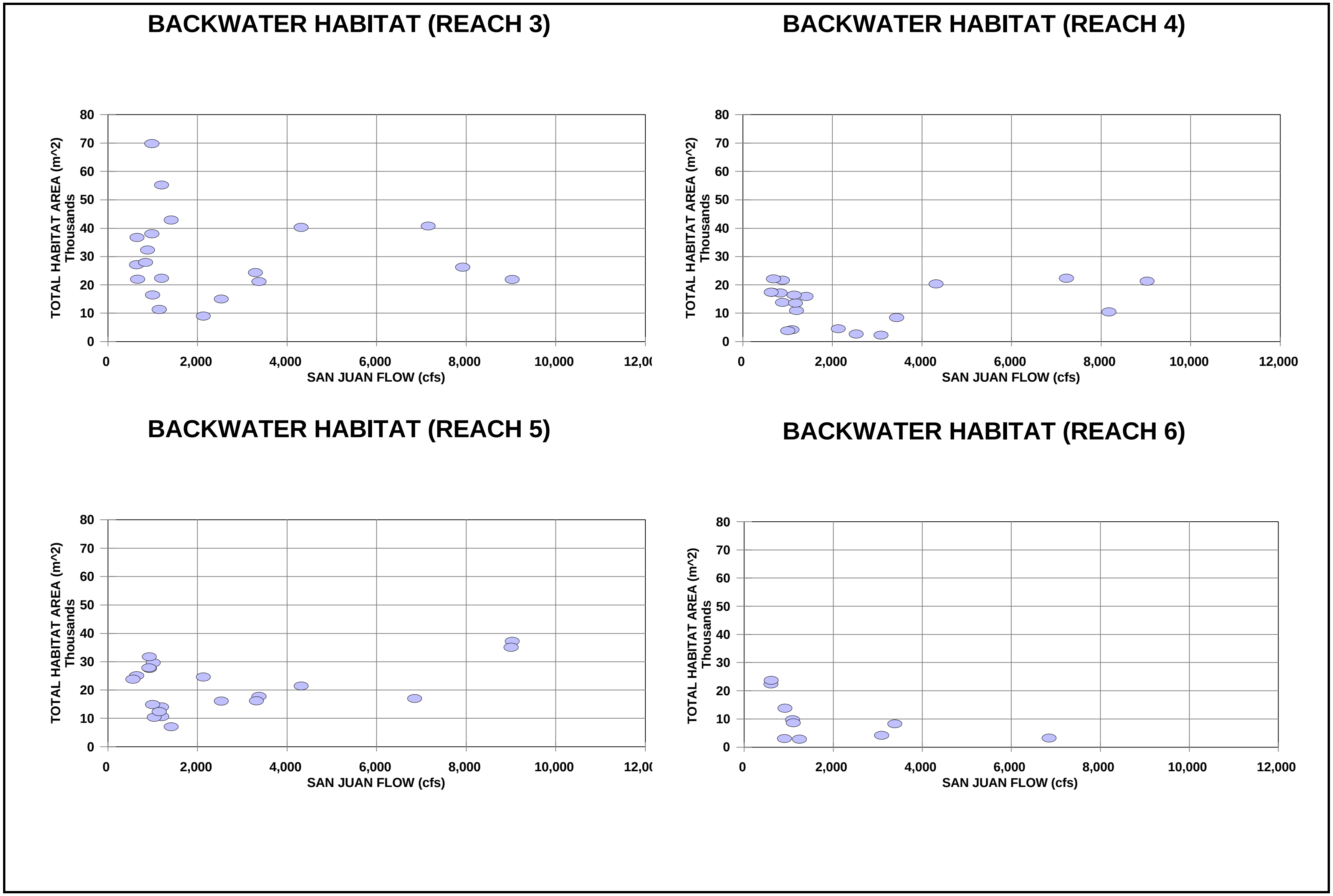


Figure 4.10. The Relationship Between Backwater Surface Area and Flow for Reaches 3, 4, 5 and 6 in the San Juan River

return to Main Menu
previous
next

Table of Contents

In Reach 6, backwater decreased with flows similar to the main channel backwaters in Reaches 1 and 2. This is consistent with the largely single channel (or channelized) form in this reach, which makes it similar to the canyon bound Reaches 1 and 2.

As noted previously, run type habitats were the most common for all San Juan River flow levels. These habitat types were 81.5%, 84.3%, and 79.6% of the TWA for the high-,medium-, and low-flow mapping runs, respectively (Figure 4.4).

Riffle and shoal habitat types represented the second most abundant habitat types found in the San Juan River at medium and low flows. Riffle habitats were found to be 5.7% at medium flows and 6.0% at low flows, while shoals were 3.2% and 9.5% for medium and low flows. At high flows, riffles and shoals were only 0.5% and 2.3% of the TWA, respectively. However, inundated vegetation was 5.6% of the TWA at high flows, the only flows where this habitat type was greater than 1% of the TWA.

Slackwaters and low-velocity habitats (embayments, eddies, pools, etc.) together made up 3.4% of high-flow habitats, 3.6% of medium flows, and 3.5% of low flows. Backwater types had the lowest overall percent of TWAs with 0.5%, 0.3%, and 0.9% for high, medium, and low flows, respectively.

Many of the habitats that are relatively rare in the San Juan River are used to a large degree by the native fish species. Though they are rare, the quantity of many of these habitats varies with flow. As noted in Figure 4.4, low-velocity habitat quantity makes up a larger amount of the available habitat at low flows (1.55% of habitat), and is lowest at intermediate flows (0.98% of habitat). Backwaters, as a percent of total habitat, nearly double (0.47% to 0.90% of habitat) from high flows (greater than 7,000 cfs) to low flows (less than 700 cfs). The percent of shoal area also dramatically increases at low flows (2.25% to 9.55% of habitat) compared with high flows.

In summary, habitat quantity varies in the San Juan River with both flow level and location in the river. Run habitats dominate, and many of the other habitats important to the native fish community are relatively rare in the system.

DISCUSSION

The analysis of the habitat surface area and flows described above indicates that the surface areas of habitats used by Colorado pikeminnow and razorback sucker, as well as other native species, varied significantly with the flows measured at the time of habitat mapping. In addition, the quantity of habitat from year to year was believed to be dependent upon the hydrologic conditions necessary to form and maintain the habitat.

For backwater habitat, a critical habitat for YOY pikeminnow, the flow/habitat area relationship was also found to vary between geomorphic reaches of the river. In order to evaluate the physical response and mechanism of formation of these habitat types to total area, each habitat type was normalized to 1,000 cfs and compared with runoff conditions immediately preceding each respective mapping period.

previous
next
return to Main Menu

The normalization process utilized the following procedure: for each runoff cycle (baseflow-runoff-baseflow) sequential mapping dates were plotted as hysterysis loops. Because backwater habitat area was very sensitive to flow, for each year post runoff backwater habitat area was interpolated to 1000 cfs along the hysterysis loop.

In November 1992 and 1993, mapping occurred near 1000 cfs, therefore, normalization of these data were minimal.

The hydrologic characteristics (Figure 2.5) for each year from 1991 to 1997 were analyzed relative to their impact on backwater habitat surface areas (Table 4.3). At least one mapping session was conducted after each spring runoff period, and four years (1992, 1993, 1994, and 1996) included replicate data. Although an attempt was made to investigate unique features of these hydrographs, initial analysis indicated substantial auto-correlations among several characteristics. In total, 71% of the parameter pairs were auto correlated. These analyses suggest strongly that both the duration and magnitude of the runoff are important for providing backwater habitat in the subsequent summer/fall session.

As noted in the previous section, analysis of backwater habitat areas indicated that the flow/habitat area relationships in geomorphic Reaches 1, 2 and 6 (Figure 1.1) were similar, while Reaches 3, 4, and 5 were different. Further analysis indicated that within Reaches 1 and 2, the type of backwater (i.e. main channel or side canyon associated) was also an important factor in the flow/habitat relationship.

Table 4.3. A Comparison of Significant Correlations (P#0.05) Between the Hydrologic Parameters Investigated for Antecedent Conditions Relative to Backwater Surface Areas

PARAMETER	% AUTO-CORRELATED
Total Days [a] >3000 cfs	89
Days Pre-peak >3000 cfs	67
Total Days >5000 cfs	78
Days Pre-peak >5000 cfs	55
Total Days >8000 cfs	78
Days Pre-peak >8000 cfs	67
Total Days >10,000 cfs	33
Peak (cfs)	89
Total Run-off volume (ac-ft)	89
Duration	89
TOTAL	**71**

(a) Total days and days pre-peak are summarized between April 1 and July 31.

Within Reaches 3, 4, and 5, backwater locations were associated with two different geomorphic processes categorized broadly into main or secondary channel processes. Backwaters were formed through shoreline scour of sand bars, recirculation in main channel processes, or backwaters formed at the entrance or exit of ephemeral secondary channels. These two backwater types (main channel vs. secondary channel) were analyzed separately in Reaches 3, 4, and 5.

The coefficients of determination (r^2) for backwater habitats normalized to 1,000 cfs compared with antecedent runoff conditions at the time of mapping (Figure 2.5) are summarized in Table 4.4.

A statistical analysis of the relationship between backwater quantity and hydrologic characteristics (Table 4.4) indicated that within Reaches 1 and 2, total backwater area was not related to hydrologic characteristics regardless of backwater type. Although significant relationships were not found, trends in the data were evident (Figure 4.9). In Reaches 3, 4, and 5, main channel backwaters were not related to hydrologic conditions; however, secondary channel associated backwaters in these reaches were significantly related to all days above 3,000 and 8,000 cfs, as well as total runoff volume. For all backwaters (Reaches 3, 4, and 5) all hydrologic factors were bound to be significant(coefficients of determination 0.95 to 0.91).

In summary, the significant relationships shown in Table 4.4 indicate that hydrologic conditions significantly impact the amount of backwater habitats formed through secondary channel processes; however, because of the auto-correlations between hydrologic parameters, it is difficult to determine if one characteristic has a greater influence than any other. Because the backwaters associated with secondary channels are the dominant component of the regressions in Table 4.4, those factors that affect secondary channel modification may also drive backwater habitat area. For example, results from channel morphology studies on secondary channels indicate that flows exceeding 5,000 cfs initiate secondary channel flushing. Consequently, days above 5,000 cfs may be a driving factor for backwater quantity.

Backwater habitats demonstrated a high degree of variability at low flows. The degree of this variability was different for each geomorphic reach with Reaches 3 and 4 being highly variable. Inspection of the GIS database indicated that specific backwaters would vary in size dependant upon the number of summer storms. In order to further investigate this mechanism, an analysis of storm impacts was undertaken. Part of that effort was to develop a perturbation model for San Juan River backwaters.

Table of Contents

Table 4.4. the Coefficient of Determination Expressed as r^2 and Their Associated p Values for Backwater Habitat Area Normalized to 1000 Cfs Compared to Various Antecedent Hydrologic Conditions

Reach	Location	HYDROLOGIC CONDITIONS [a]					
		Days > 3000 cfs	Days > 5000 cfs	Days > 8000 cfs	Peak Flow (cfs)	Total Runoff Volume ($ac\text{-}ft^2$)	Duration (Days)
1-2	Main Channel	0.58 (0.15)	0.15 (0.99)	0.64 (0.56)	0.60 (0.35)	0.63 (0.12)	0.44 (0.22)
1-2	Abandoned Secondary Associated	0.47 (0.28)	0.47 (0.21)	0.52 (0.38)	0.49 (0.80)	0.43 (0.35)	0.38 (0.85)
1-2	All Backwaters	0.60 (0.13)	0.16 (0.89)	0.63 (0.68)	0.61 (0.98)	0.64 (0.12)	0.39 (0.26)
3-5	Main Channel	0.34 (0.15)	0.12 (0.89)	0.36 (0.52)	0.23 (0.41)	0.38 (0.11)	0.04 (0.67)
3-5	Abandoned Secondary Associated	0.95 (0.002)	0.85 (0.07)	0.91 (0.005)	0.88 (0.22)	0.92 (0.009)	0.76 (0.14)
3-5	All Backwaters	0.95 (0.04)	0.89 (0.02)	0.85 (0.006)	0.91 (0.03)	0.93 (0.05)	0.81 (0.003)
1-4	Main Channel	0.28 (0.42)	0.22 (0.60)	0.39 (0.50)	0.43 (0.32)	0.33 (0.37)	0.55 (0.17)
1-4	Abandoned Secondary Associated	0.92 (0.05)	0.87 (0.19)	0.91 (0.16)	0.89 (0.52)	0.85 (0.16)	0.89 (0.10)
1-4	All Backwaters	0.85 (0.13)	0.73 (0.63)	0.83 (0.63)	0.82 (0.17)	0.87 (0.13)	0.84 (0.07)
1-5	Main Channel	0.54 (0.24)	0.31 (0.93)	0.57 (0.55)	0.68 (0.24)	0.59 (0.21)	0.61 (0.21)
1-5	Abandoned Secondary Associated	0.93 (0.04)	0.77 (0.82)	0.93 (0.18)	0.84 (0.47)	0.93 (0.06)	0.84 (0.13)
1-5	All Backwaters	0.90 (0.05)	0.73 (0.42)	0.89 (0.43)	0.86 (0.21)	0.92 (0.05)	0.81 (0.10)

(a) Between April 1 and July 31.

return to Main Menu
previous
next

As a first step, flow/habitat relationships for backwaters were developed for each of Reaches 1 to 6. Because Reaches 3 and 4 were easily filled with sediment by summer/fall storm events, two relationships were developed. The first relationship was developed using data for which no perturbating storms occurred between the end of runoff and mapping. The second relationship was developed from a perturbation model relating the number of storm-event days to the amount of habitat area lost.

A storm-event day was defined as a day when the daily gain in flow between Farmington, New Mexico, and Bluff, Utah, and the daily flow at Bluff, Utah, were each more than 150 cfs greater than the preceding 5-day average. A storm-event day was given a weight of 2 if the gain in flow was 3,000 cfs or more. These two parameters were selected based on calibration against known storm events in the last 3 years, optimizing for the number of storm events accurately predicted. There were 19 storm events with sediment concentration measurements during the 7-year research period of which 16, or 84%, were predicted with the model. The three storm events that were not predicted had elevated sediment concentrations with a very small change in flow. There was no statistically significant relationship between sediment concentration and flow for these 19 storm events.

Based on this model, the perturbating storm events were predicted for each month for the period August through December, measured by the weighted storm event days. For each habitat mapping, the number of storm-event days was computed between the end of runoff and the time of mapping. Habitat-mapping data were grouped into three categories: (1) nonperturbated and flushed (runoff adequate to clean backwaters), (2) nonperturbated and not flushed, and (3) perturbated. A flow/habitat relationship was developed for each reach utilizing the nonperturbated measurements. A second curve was developed for Reaches 3 and 4 for nonflushed conditions. The average perturbation (loss of habitat area) per weighted event day was computed for Reaches 3 and 4 by comparing the measured habitat area with the prediction of the flow/habitat model for nonperturbated conditions and dividing the average loss by the average number of weighted event days for that reach. By this process, it was found that Reach 3 lost 6% of the habitat area for every weighted event day, and Reach 4 lost 5%. The other reaches did not show a consistent trend, indicating that the variability of data from the model is random rather than associated with perturbation. Figure 4.11 shows the individual data points and model curves for Reach 3. Figure 4.12 presents the combined model curves for Reaches 1 to 4 (flushed and nonflushed) and Reaches 1 to 5 (flushed and nonflushed).

In application, if runoff flows exceeded 5,000 cfs for 21 days or more, then the flushed model was used, and the average habitat available for the month was predicted to be that available at the mean monthly flow, less the perturbations to date. If the runoff flows were over 5,000 cfs for 1 day but less than 21 days, the post-runoff maximum was linearly interpolated between the nonflushed and flushed curves and then perturbated as above. If runoff flows did not exceed 5,000 cfs, then the previous December value was used as the new base from which to perturbate. In all cases, the minimum habitat area computed was 322,800 ft^2 for Reaches 1 to 4 and 430,400 ft^2 for Reaches 1 through 5. A linear regression of the modeled backwater area against the actual area for the available data utilizing this model yielded an r^2 of 0.89 ($p<.01$, $n=78$) for the combination of Reaches 1 through 5. This model was applied to each year of the historical hydrograph and each year of each modeled condition to determine the impact to backwater habitat area for each level of development analyzed.

Table of
Contents

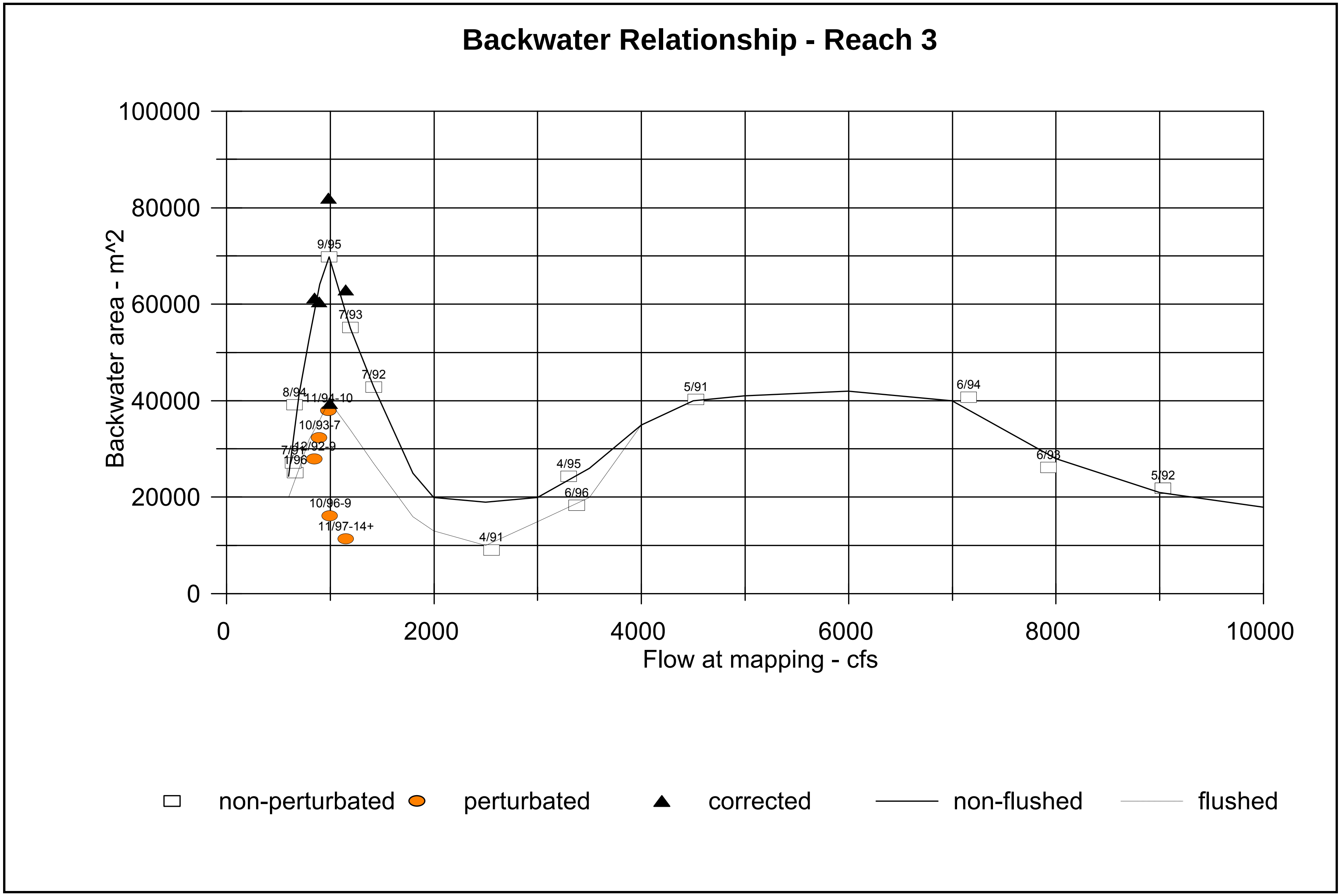


Figure 4.11. Flow/backwater Habitat Area Relationships for Reach 3

previous
next
return to
Main Menu

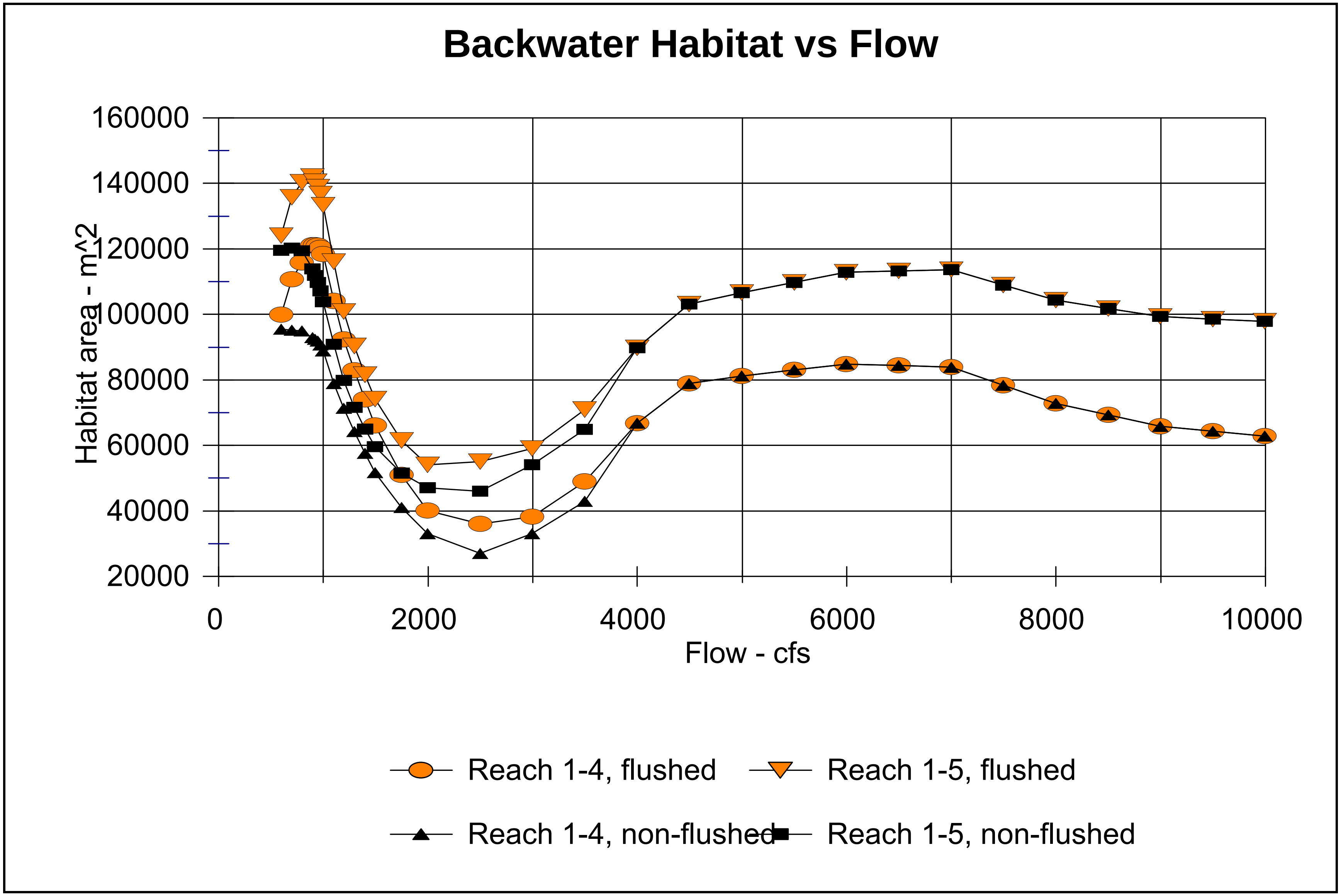


Figure 4.12. Flow/backwater Habitat Model for Reaches 1 to 4 and 1 to 5 Based on Flushed and Nonflushed Conditions

SUMMARY AND CONCLUSIONS

Habitat surface areas in the San Juan River were mapped thirteen separate times with flows ranging from 525 to 8,000 cfs. Some habitat types displayed strong relations with mapping flows (runs, eddies, inundated vegetation and shoal) while other habitats displayed high variability (slackwaters) with no relationship with flow.

Backwater habitats, although variable, demonstrated a systematic pattern related to the inundation of the mouths of secondary channels and the subsequent loss via flow through these channels at higher flows. Backwater habitats were also found to be diminished due to summer silt-laden storm events.