SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

HYDROLOGY, GEOMORPHOLOGY AND HABITAT STUDIES

2005 FINAL REPORT

prepared by

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CHAPTER 1: INTRODUCTION

Hydrology, geomorphology and habitat studies of the San Juan River began in 1992 as a part of the San Juan River Basin Recovery Implementation Program (SJRIP). The activities changed from research to monitoring beginning in 1999. Water quality sampling was terminated in 2004, as was backwater characterization. Geomorphology monitoring changed in 2005 at the direction of the SJRIP Biology Committee. River cross-section measurement changed from pre- and post-runoff to post-runoff every 5 years with the next measurements in 2009. Cobble bar monitoring was terminated and monitoring of two detailed reaches was initiated. The changes will be covered in the appropriate chapters.

This report summarizes data collected in 2005 as a part of the long-term monitoring program and compares this data to that collected since 1992. Data collected in the following areas are summarized here:

- Hydrology
- Detailed Reach Selection
- Aquatic Habitat Mapping from the confluence of the San Juan and Animas Rivers (RM180) to the Clay Hills Crossing (RM 2)
- Water Temperature
- Razorback Sucker Spawning Bar Characterization

All data sets are from the 2005 field season except habitat mapping. Due to the long data analysis time after the late fall data collection, there is a one-year lag in the habitat data.

Methods for each data set are covered in the Long-Term Monitoring Plan and are not described in detail in this annual progress report, except for the methods for detailed reach selection and analysis and Razorback sucker spawning bar characterization. The report concentrates on data reporting with a minimum of data analysis, particularly between data sets.

SAN JUAN RIVER STUDY AREA

The seven-year research program defined 8 geomorphically distinct reaches in the San Juan River (Bliesner and Lamara, 1999). Figure 1.1 shows these reach locations. The bulk of the studies reported here occur within Reaches 1-6, as this encompasses the critical habitat for the endangered Colorado pikeminnow and razorback sucker. Some studies extend outside this range where necessary to define processes that affect the critical habitat. The study area for each data set is described with the summary of that data set.

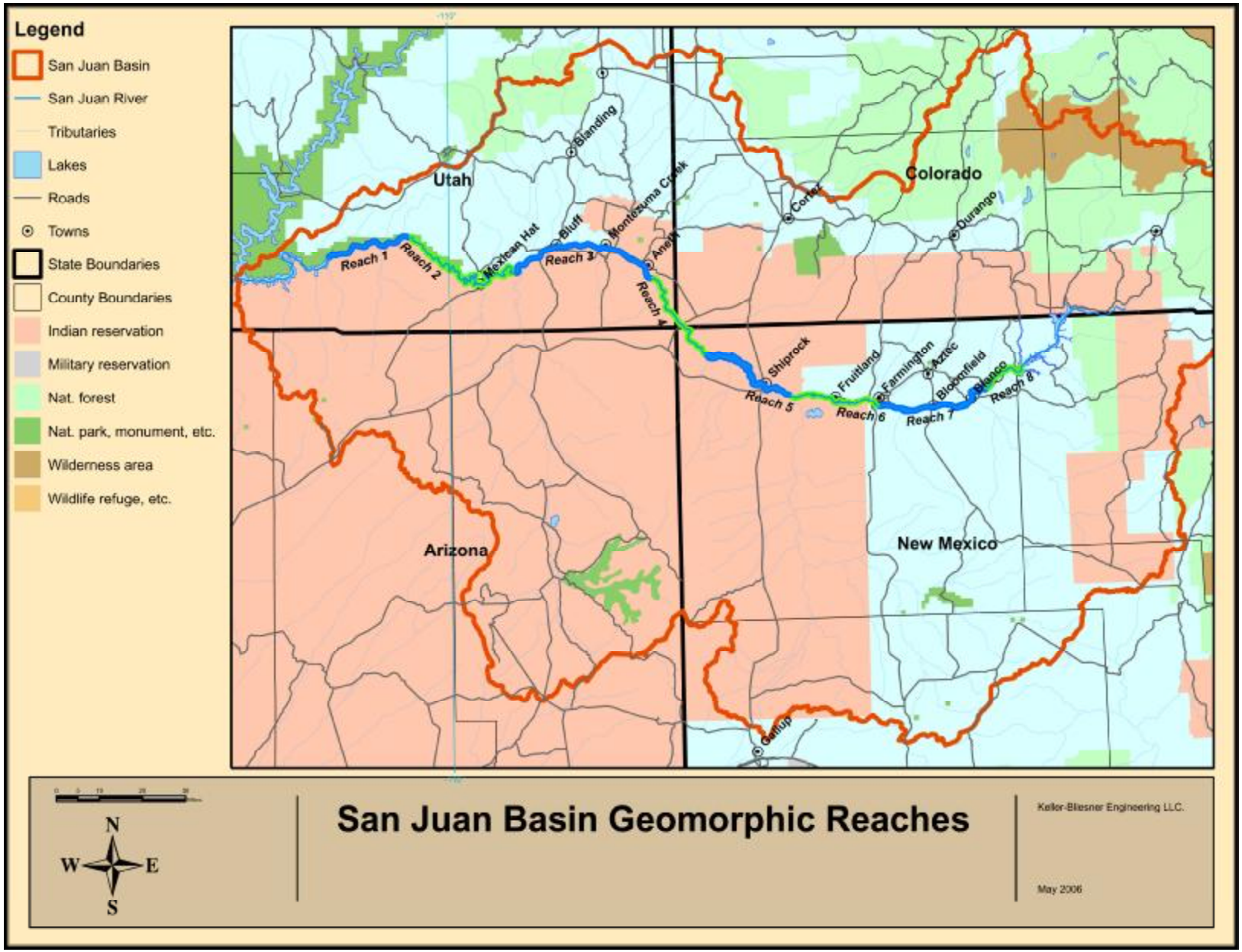

Figure 1.1. San Juan Basin Location Map Showing Geomorphic Reaches

CHAPTER 2: HYDROLOGY

BACKGROUND

United States Geological Survey (USGS) flow records for the San Juan River begin in 1911, but are not consistent or complete until about 1929. By this time substantial irrigation development had occurred. While the pre-Navajo Dam hydrology is natural in shape, it is depleted in volume by about 16 percent from natural conditions due to this irrigation development, with most of the depletion coming during the summer months. Since the depletion prior to Navajo Dam was relatively small and the flow was not regulated by major storage reservoirs, the conditions during the pre-dam period (1929-1961) are used to judge effects of later development and the value of future modification of the hydrology for the benefit of the endangered fishes.

Daily flow data recorded by the USGS from 1929 through the present are available for the key points on the San Juan River. These data have been used to analyze the 2005 hydrology and compare the statistics to other years. The foundation of comparison is the flow statistics in the SJRIP Flow Recommendation Report (Holden, 1999).

METHODS

Beginning in 1999, the operating rules recommended in the Flow Recommendation Report have been employed by Reclamation as far as restrictions would allow. USGS gage records were used to assess the resulting hydrograph at Archuleta, Farmington, Shiprock, Four Corners and Bluff.

For each release year, the operating rules are evaluated utilizing the anticipated water supply and the release criteria set. The design release pattern and the actual releases are compared. The statistics of each year are computed and the flow recommendation conditions that were met indicated.

RESULTS

Research releases from Navajo Dam were made every year from 1992 through 1998 (1991 was a control year with no modification to the release) to augment the unregulated flows from the Animas River and provide peak spring runoff flows mimicking a natural hydrograph in the San Juan River below Farmington, NM. Beginning in 1999, the operating rules presented in the Flow Recommendation Report were implemented. There was no fish release in 2000. A release of 166,000 acre-feet (based on a 600 cfs base flow) over 27 days was called for in early Spring 2001 per the Navajo Fish Release Decision Tree. Higher forecasted inflows and the need to complete dam maintenance caused Reclamation to increase the planned release to 300,000 acre-feet to reach a pool elevation of 6,074 feet by the end of September.

One of the 72-inch Hollow Jet Valves experienced hydraulic control problems and was shut down on May 30th. At that time flows were reduced to about 4,300 cfs. Not all of the forecast inflows materialized and hence there was an over-release, resulting in the reservoir being about 10 ft lower than planned, even though the release was terminated early in response to the smaller runoff volume. The release was about 130,000 acre-feet greater than needed to achieve the desired reservoir elevation.

If water year 2002 had been a normal runoff year the over-release in 2001 would not have been a source for much concern. However, 2002 was a record-breaking dry year. There is a continuous gage record for the San Juan near Bluff starting in 1927. Sporadic records exist back as far as 1915. The March to July runoff at Bluff for each year were summed and ranked for years 1927 to 2004 for a total of 78 years. The driest year on record, which is 2002, receives a rank of 1. As measured at the Bluff gage, the 2002 March through July runoff was only 92% of 1977, the previous driest year on record and now ranked number 2.

Without extra releases from Navajo Reservoir to maintain flows for the endangered fish, the flow at Bluff would have been even lower. The inflow to Navajo Reservoir was only 52% of the driest year, having a 2.5% recurrence frequency over the period of record.

Water year 2003 was another extremely dry year. The Bluff March through July runoff was 274,000 ac-ft and ranking as the fourth driest year on record. Water year 2004 brought yet another dry year but not as bad as 2002 and 2003. The March through July runoff at Bluff was 427,000 ac-ft and is ranked at number 14. No releases were called for by implementing the flow recommendation in 2002, 2003 or 2004.

Water year 2005 turned out to be wetter than average (104%), filling the reservoir and allowing for a full release under the flow recommendation rules (4-week ramp-up, 3-week peak and 2-week ramp-down). The resulting March through July runoff at Bluff was 1,168,400 ac-ft, with only about 1/3 of the years between 1929 and 2005 exceeding this amount. The 2005 water year total was exceeded in 40% of the years, indicating the impact of the release on the peak runoff. For comparison purposes the wettest year on record was 1941 and had a March through July runoff of nearly 3.4 million acre feet (rank = 78). The average is approximately 1.1 million acre feet.

Table 2.1 describes the nature of the release each year since 1991. The volume of water released in excess of an assumed base release of 600 cfs, the typical minimum historical release. In 2000, 2002, 2003 and 2004 there was not sufficient water to make a fish release.

Table 2.2 compares the flow statistics from 2005 to those of the 1994-2004 period for each non-base flow category identified in the Flow Recommendation Report. Also indicated are the desired conditions that were met. Table 2.3 shows a summary of the base flow conditions for 2005. The last line presents the statistics from implementing the 3-gage rule for computation of base flow compliance with the flow recommendations using the latest recommendation of the Biology and Hydrology Committees. The statistics for 2005 are within this recommendation with the exception of 2 days when flows were below 500 cfs.

The 2005 hydrographs for the San Juan River at Archuleta (release hydrograph), Four Corners, Bluff and the Animas River at Farmington are presented in Figure 2.1. Figure 2.2 shows the hydrographs for the San Juan River at Four Corners for 2002 – 2005 for comparison of this year to the previous drought years. Figure 2.3 compares the high-flow year hydrographs at Four Corners since the Program started. The flow statistics that apply to these hydrographs appear in Table 2.4. The Four Corners gage is considered the most representative gage for the habitat range and is used in all correlations reported here.

Table 2.1. Summary of Navajo Dam Release Hydrograph Characteristics since the Beginning of the Research Period, 1992 to 2005

YEAR	ASCENDING LIMB	PEAK	DESCENDING LIMB	MATCHED ANIMAS RIVER PEAK	VOLUME ABOVE 600 CFS BASE - AF
1992	6 weeks starting April 13	2 weeks at 4,500 cfs	4 weeks ending July 15	Yes	409,740
1993	Starting March 1, rapid increase to 4,500 (compare with 1987)	split peak, 45 days at 4,500 cfs, 7 days at 4,500 cfs	4 weeks ending July 13	No	773,820
1994	4 weeks starting April 23	3 weeks at 4,500 cfs	6 weeks ending July 28	Yes	486,620
1995	3 weeks at 2,000 cfs in March, ramp to 4,500 over 6 weeks starting April 1	3 weeks at 5,000 cfs	4 weeks ending July 14 (summer flow increased by 200 cfs)	Yes	675,810
1996	1 week starting May 27	3 weeks at 2,500 cfs	1 week ending June 29	No	100,320
1997	3 weeks at 2,000 cfs in March, return to 600-cfs base for 31 days, 10 days starting May 12	2 weeks at 5,000 cfs	6 weeks ending July 16	Yes	433,580
1998	30 days starting April 23	3 weeks at 5,000 cfs	1 week ending June 18	Yes	340,850
1999	9 days starting May 24	8 days at 5000 cfs	9 days ending June 18	No	166,189
2000	8 days starting May 30	1 day at 4580	7 days ending June 13	No	61,484
2001	10 days starting May 15	26 days at 4300-5300 cfs	10 days ending June 28	No	265,527
2002	none	none	none	N/A	-
2003	none	none	none	N/A	-
2004	none	none	none	N/A	-
2005	April 28 – May 19	28 days at 4300-4670 cfs	9 days ending June 24	Yes	325,369

Table 2.2. Flow Statistics Met in Each Year

Condition	Std	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
10,000 cfs or more	5	1	0	**11**	0	**10**	0	0	0	0	0	0	0	**8**
8,000 cfs or more	10	**16**	**13**	**27**	0	**33**	2	0	0	0	0	0	0	**16**
5,000 cfs or more	21	**109**	**49**	**72**	0	**50**	**34**	**29**	3	**33**	0	0	1	**48**
2,500 cfs or more	10	**126**	**67**	**135**	**36**	**100**	**65**	**70**	**37**	**55**	0	**13**	**23**	**82**
Yrs w/o meeting 10,000cfs	10	7	8	0	1	0	1	2	3	4	5	6	7	0
Yrs w/o meeting 8,000 cfs	6	0	0	0	1	0	1	2	3	4	5	6	7	0
Yrs w/o meeting 5,000 cfs	4	0	0	0	1	0	0	0	1	0	1	2	3	0
Yrs w/o meeting 2,500 cfs	2	0	0	0	0	0	0	0	0	0	1	0	0	0

Note: Values in **Bold** are those that meet or exceed the minimum standard

Table 2.3. 2005 Base Flow Statistics Using a 7-day Running Average

Gage	Minimum 7-Day Average Flow	Days below Given Flow Rate		
		500 cfs	400 cfs	300 cfs
Farmington	596	0	0	0
Shiprock	376	22	3	0
Four Corners	542	0	0	0
Bluff	453	9	0	0
3-gage	484	2	0	0

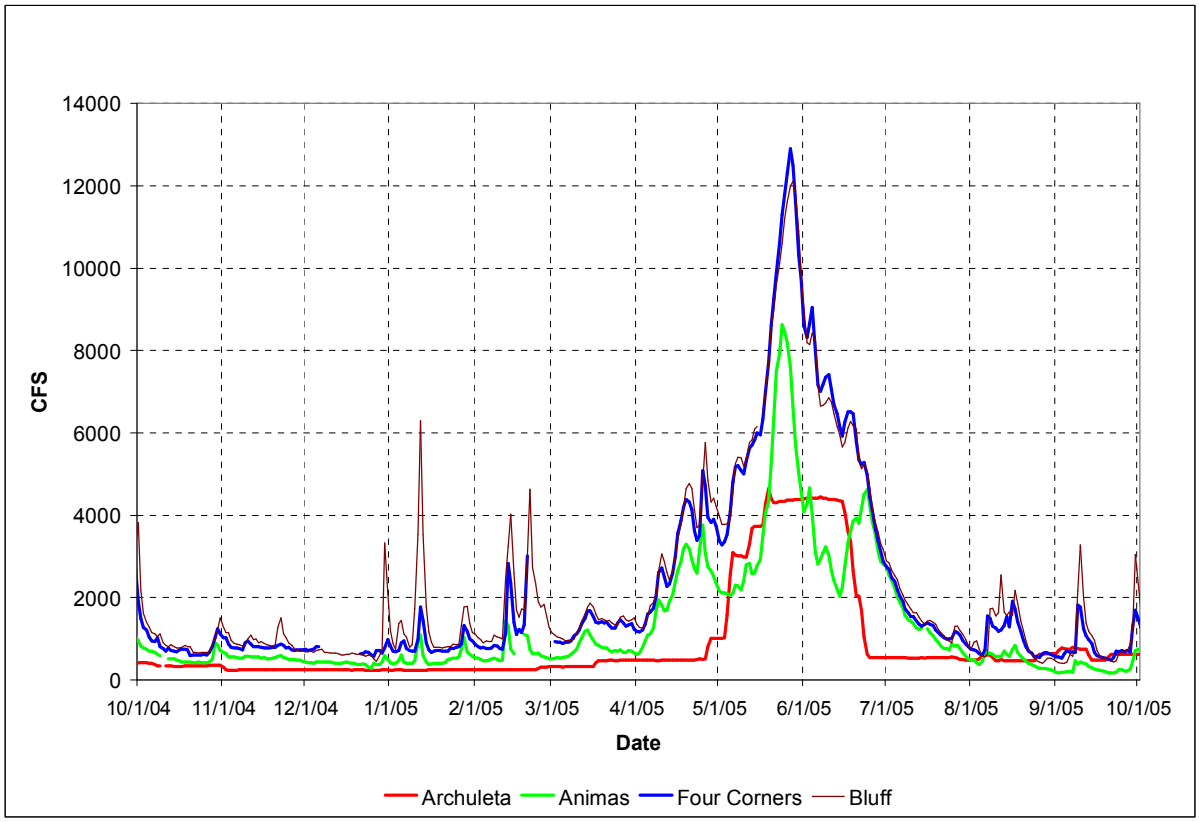

Figure 2.1. San Juan River near Archuleta, Four Corners and Bluff and Animas near Farmington, 2005

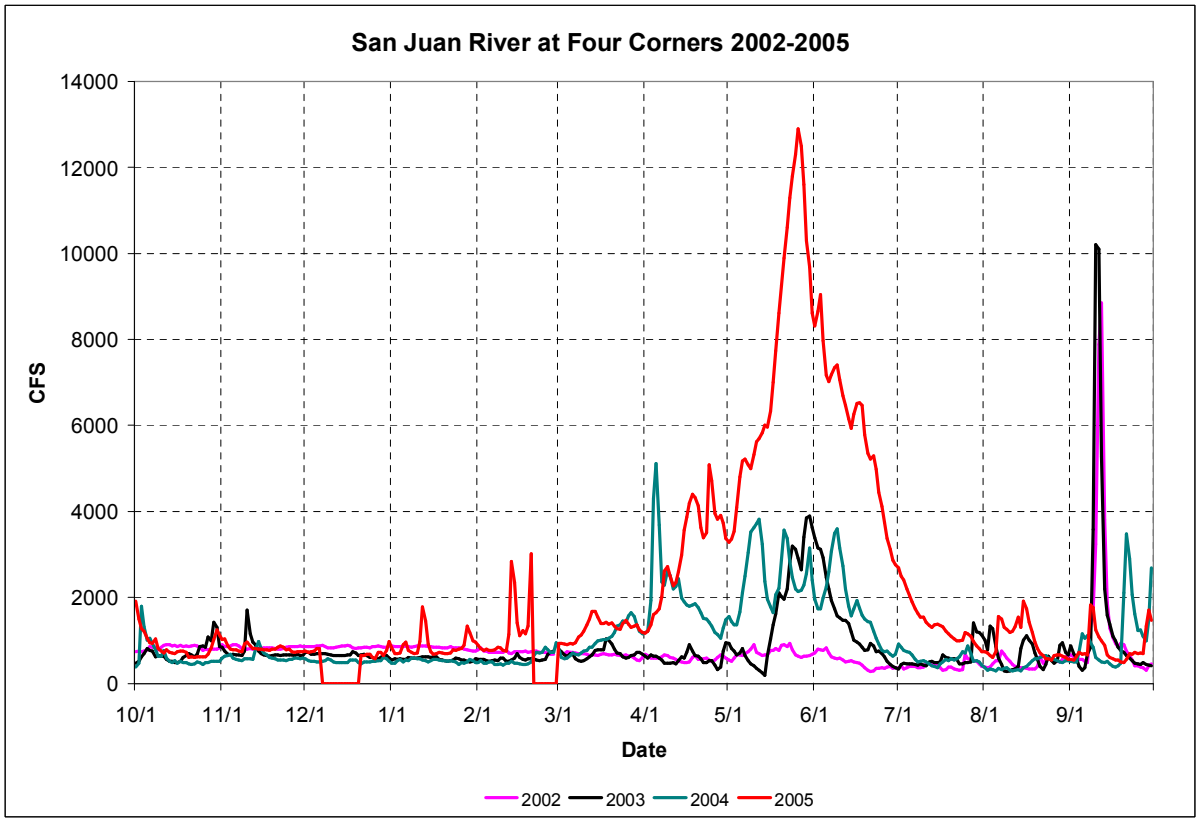

Figure 2.2. San Juan River at Four Corners, 2002-2005

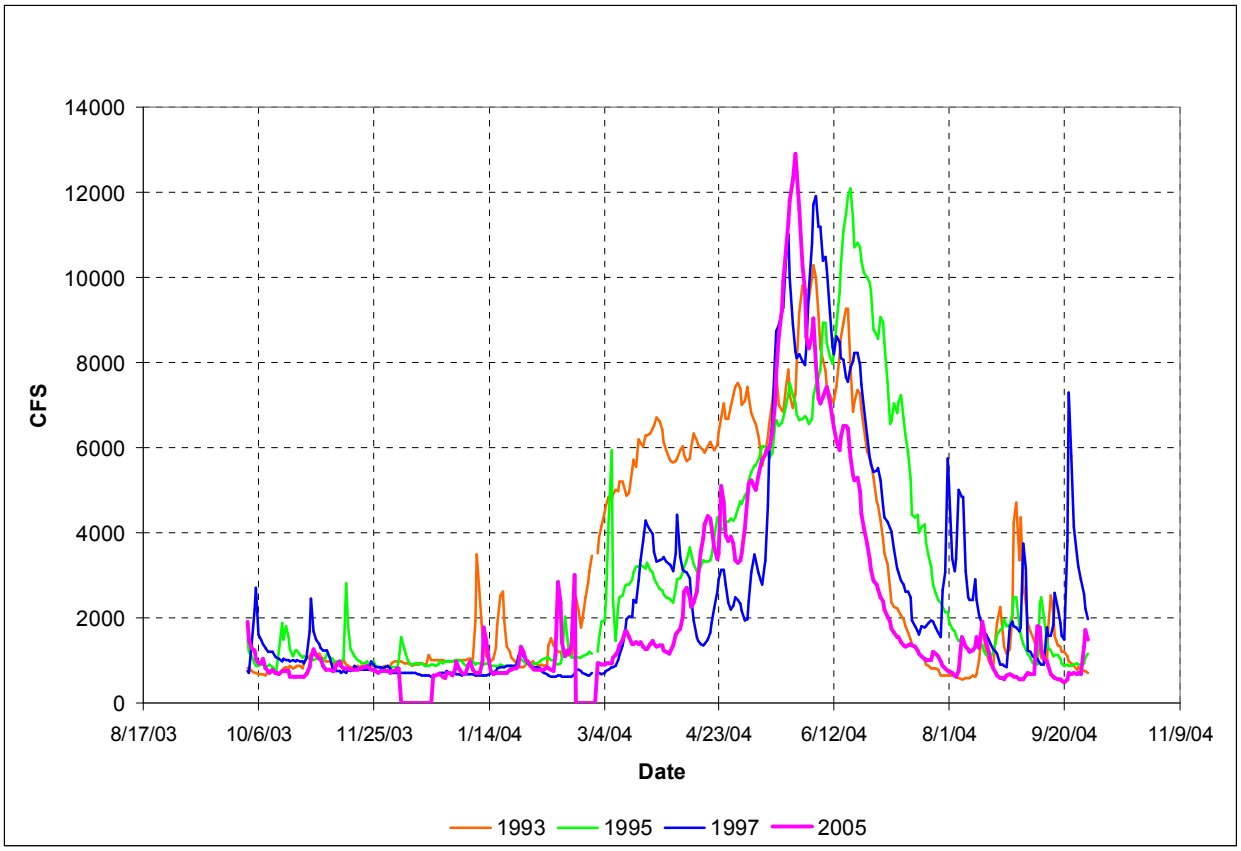

Figure 2.3. San Juan River at Four Corners High Flow Year Hydrographs Since 1992

Table 2.4. Summary of Flows for the Research (1992-1998) and Monitoring (1999-2005) Periods, San Juan River at Four Corners, New Mexico

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Peak Runoff-cfs	5,160	8,900	10,300	9,090	12,100	3,540	11,900	8,580	7,970	5,210	8,340	926	3,900	5,110	12,900
Runoff - af (Mar - Jul)	600,510	1,076,680	1,717,333	1,004,047	1,627,775	432,670	1,340,886	931,107	876,847	548,424	848,626	174,282	294,401	475,970	1,168,401
Runoff - af (total annual)	1,086,676	1,512,795	2,216,820	1,410,706	2,102,229	815,796	1,884,020	1,401,536	1,901,804	928,808	1,288,346	534,643	627,396	739,950	1,507,200
Peak Date	16-May	29-May	3-Jun	5-Jun	19-Jun	18-May	4-Jun	4-Jun	3-Jun	6-Jun	29-May	23-May	30-May	5-Apr	26-May
Days >10,000	0	0	1	0	11	0	10	0	0	0	0	0	0	0	8
Days >.8,000	0	3	16	9	27	0	33	2	0	0	1	0	0	0	16
Days >5,000	2	54	109	49	72	0	51	34	29	3	33	0	0	1	48
Days >2,500	46	81	126	68	135	36	103	65	72	37	55	0	13	23	82
Average daily flow for month															
Oct	1,447	767	826	919	1,107	1,089	1,273	1,404	1,533	1,141	1,273	829	720	633	875
Nov	1,125	1,354	909	1,202	1,076	1,137	881	1,175	1,494	910	1,154	836	744	612	813
Dec	1,078	1,086	955	1,129	958	1,087	700	1,154	1,031	940	966	848	657	517	395
Jan	1,171	858	1,356	1,056	916	783	788	1,208	947	935	915	835	569	524	867
Feb	1,299	1,263	1,522	852	1,084	874	695	1,239	976	931	1,039	732	574	578	868
Mar	994	1,171	5,454	948	2,777	765	2,251	1,267	969	1,186	1,329	663	698	1,016	1,263
Apr	1,807	3,716	6,178	984	3,472	606	2,524	1,910	1,174	2,263	1,680	582	580	2,020	3,079
May	3,733	6,622	7,285	5,255	6,108	2,146	5,990	5,831	3,439	2,995	5,146	713	1,619	2,485	7,560
Jun	2,575	4,835	7,688	7,212	9,351	2,920	8,499	4,542	5,986	2,293	4,984	501	1,371	1,754	5,975
Jul	799	1,442	1,773	2,195	5,178	714	2,899	1,802	2,925	330	877	411	583	586	1,418
Aug	555	925	1,346	534	1,561	491	2,306	1,073	6,135	708	1,315	482	672	440	982
Sep	1,441	997	1,432	1,078	1,193	891	2,361	574	4,852	733	646	1,443	1,611	1,100	847
Uniqueness	Control	Early Ave.	Early ascent	Late ave.	Late Peak	dry	Narrow runoff	Early Ave.	large summer Release	dry	Early Ave.	record dry	very dry	dry	Classic Hydro-graph
		Storm @ spawn					Storm @ Spawn	Storm @ Spawn	Storm @ Spawn				Sept Peak >10,000		

CHAPTER 3: DETAILED REACH SELECTION AND ANALYSIS

BACKGROUND

In the process of integrating and evaluating the standardized monitoring data, the Biology Committee determined that the information gained from semi-annual (pre- and post-runoff) surveys of the standard cross-sections in the river was not sufficient to warrant such regular survey. Further, it was determined that a more detailed look at the geomorphology and habitat of shorter reaches that contained elements important to native and endangered fish was warranted. The change was made to better understand the mechanisms at work that maintain backwater and other low velocity habitats and channel complexity and to assess habitat in more detail related to actual captures of endangered fish. Described here are the methods to be employed in the identification of detailed reaches and the results of that selection process. In addition, the first set of survey data are presented for these reaches. Two-dimensional modeling of the flow in these reaches is underway and the results will be reported in the 2006 annual report.

OBJECTIVES

The objectives of the detailed reach studies stated in the work plan are:

1. Detailed Reach Selection. Identify 2 complex river reaches that have been important for endangered fish, exhibit channel and habitat complexity, include backwater habitat area, are representative of other complex reaches and are accessible for efficient survey.
2. Channel Morphology Monitoring of Detailed Reaches. Annually survey multiple cross-sections in each detailed reach at sufficient density to allow two-dimensional modeling of the hydrologic processes involved in forming and maintaining the reach.
3. Map Habitat in the Detailed Reaches. Map Habitat in the detailed reaches annually at a level of detail adequate to represent yoy fish sampling.
4. Identify Habitat Use of YOY Endangered Fish and Correlate to Detailed Mapping. Map sampled habitat during YOY fish surveys in these reaches to identify characteristics and scale of habitats important to these life stages. Utilize this information to refine scale of mapping in the detailed reach and allow better interpretation of the larger scale mapping of the entire river.
5. Develop Two-Dimensional Steady State Model of Detailed Reaches. Based on the survey data collected under Objective 3, select a modeling platform and develop a two-dimensional, steady state model of each detailed reach.
6. Analyze Response of Channel Morphology and Habitat to Hydrology. The data collected will be used to better define the relationships between hydrology and habitat, both with stage and in response to antecedent conditions.

METHODS

Reach Selection

The following criteria for reach selection were identified as a result of the data integration process. Two river reaches of from ½ to ¾ mile in length were to be identified. They were to be chosen from geomorphic reaches 3, 4, 5 or 6 as shown in Figure 1.1. The reaches were required to include slackwater, riffle, and island habitat during all fall low-flow habitat mapping data sets (1993-2004), and have backwater habitat in 75% or more of the data sets. Having backwater habitats that have come and gone along with more stable backwaters was desirable if possible. In addition, the reaches were to have a history of multiple captures of both razorback sucker and Colorado pikeminnow. In as much as both habitat richness (number of habitat types per river mile) and channel complexity have been associated with endangered fish capture, the habitat types described above were used to identify complex reaches. Finally, to allow flow modeling, the reaches had to be hydrologically contained. In other words, any secondary channels had to begin and end in the reach and there could be no tributary inflow.

Table 3.1 lists the habitat data sets used in the analysis along with the flow at mapping. The following fish capture data sets were used:

- Razorback Sucker Stocking Evaluation (FWS, Grand Junction)
- Pikeminnow Augmentation Evaluation (Bio-West)
- Adult Monitoring (FWS, Grand Junction)
- Larval Razorback Study (UNM)
- Non-Native Removal (FWS, ABQ)

To accomplish the screening the fish capture data sets were added to the GIS system containing the habitat data. One-half mile long reaches were identified every 0.1 miles from RM 180 to RM 76. The number of years that all the habitat conditions were met was identified for each reach. The reaches that met the conditions at least 75% of the time were then intersected with the fish capture data and the list of potential reaches identified. The GIS coverages were then scanned visually to select the candidate reaches that were hydrologically contained. These candidate reaches were field investigated to select the two final reaches that best met the selection criteria.

Table 3.1. Habitat Mapping Data Sets Used in Detailed Reach Selection Analysis

Mapping Date	Flow-cfs	Mapping Date	Flow-cfs
Oct93	945	Nov99	835
Nov94	1,146	Oct00	946
Sep95	1,036	Nov01	770
Oct96	1,081	Jul02	459
Nov97	1,097	Oct03	446
Nov98	1,008	Nov04	806

Reach Analysis

Once selected, each reach was surveyed with a combination of sub-centimeter GPS and total station equipment. Total station equipment was used only to fill in survey data when tree cover was too dense or access was inadequate for GPS equipment. Cross-sections were surveyed with an average point density of 10 ft every 75 ft, on average. In addition, break lines and waters edge were surveyed. Islands and bank-full river's edge were surveyed to sufficient density to allow identification of the topology for modeling high flows.

Survey data were used to develop the topology of the channel and floodplain in each reach for use in hydrodynamic modeling. The model chosen for analysis is River2D[1]. River2D is a two dimensional depth averaged finite element hydrodynamic model that has been customized for fish habitat evaluation studies. Three of the four modules that are a part of the River2D model suite were used: R2D_Bed, R2D_Mesh and River2D.

The modules were used in succession. A preliminary bed topography file (text) was developed from the field survey data, then edited and refined using R2D_Bed. The resulting bed topography file is used in R2D_Mesh to develop a computational discretization as input to River2D. River2D is then used to solve for the water depths and velocities throughout the discretization. Finally, River2D is used to visualize and interpret the results and can be used to perform PHABSIM type fish habitat analyses. In the San Juan River, habitat mapping data will be compared to velocity and depth information generated by the model for interpretation at calibration points and extrapolation to other flow conditions. This is an iterative approach at various stages, including modification of the bed topography, for refinement and calibration of the model of the two reaches.

The model is initially calibrated to measured water surface elevations at the time of survey. The roughness is adjusted to calibrate to water surface elevation. The model refinement and calibration is an extensive process whereby the field data points are supplemented with the placement of break lines to best describe the topology and input of roughness height that is judged by the attributes of the bed (fines, gravel, cobble, or vegetation type) collected during survey. Additional calibration is accomplished by measurement of water surface elevation (water's edge) at higher stage flows during spring runoff.

Habitat mapping for the detailed reaches was completed in the fall close to the time of the standardized mapping. Each reach is included in the standardized mapping and then each was mapped in conjunction with an endangered species survey in close proximity. Standard habitat mapping is completed at approximately 1" = 150 ft scale. Detailed mapping for the reaches is completed at 1" = 75 ft scale. The two data sets are then compared to determine differences in mapping detail.

Endangered fish survey information for the detailed reaches from the fall surveys is included in the analysis to compare habitat utilization with availability. Fish capture locations are included

[1] Developed by the University of Alberta. www.river2d.ualberta.ca

in the GIS analysis and the habitat descriptions recorded by the surveyors compared to the habitat mapped.

RESULTS

Reach Selection

Figure 3.1 shows the number of years the required habitat conditions were met in each ½ mile reach. There are only 5 reaches in two river miles (RM 137 and 139) that met the required habitat conditions every year of the analysis. Thirty-four reaches in 14 miles met the required conditions at least 75% of the time. These half-mile reaches fall either in Reach 3 or Reach 5. The predominant characteristic for the reaches determining inclusion or exclusion was the presence or absence of backwater type habitats. Riffles and slackwater were always present in the reaches that had islands and 73% of the reaches met all the required conditions at least once in 12 years. The reduced abundance of backwaters since 1997 means that there has been a diminishing portion of the river meeting the selection criteria as time has passed.

The 34 reaches identified as qualifying from the habitat analysis were further screened by analyzing the endangered fish capture data. Only the small bodied monitoring, razorback sucker larval monitoring and Colorado pikeminnow stocking monitoring data sets have actual capture locations. The adult monitoring, razorback sucker augmentation monitoring and non-native removal studies typically record the RM or survey reach that the fish were captured in, but not the specific location. Therefore, these latter data sets were included for any reach within the river mile or range specified. The non-native removal study results were not used because of their limited range.

Table 3.2 lists the studies that have identified usage of the 34 candidate reaches by endangered fish. All of the reaches have demonstrated usage by both Colorado pikeminnow and razorback sucker in at least one study. Some reaches have as many as five species/study combinations documenting use. While these reaches do not necessarily have the highest capture rate within the river, all have documented use and therefore qualify for selection.

The next step in selection was to use the screened reach data and visually inspect each qualified reach in the GIS using the most recent aerial photos and the habitat mapping data. In this screening system it was found that many of the reaches met all the criteria but were not hydraulically contained. Typically, the reach would end in the middle of an island with outflow on both sides of the island or would have a long secondary bypassing the reach. This screening process identified the reach length required to achieve hydraulic containment as well as meet the required conditions. The results of this step are shown in Table 3.3.

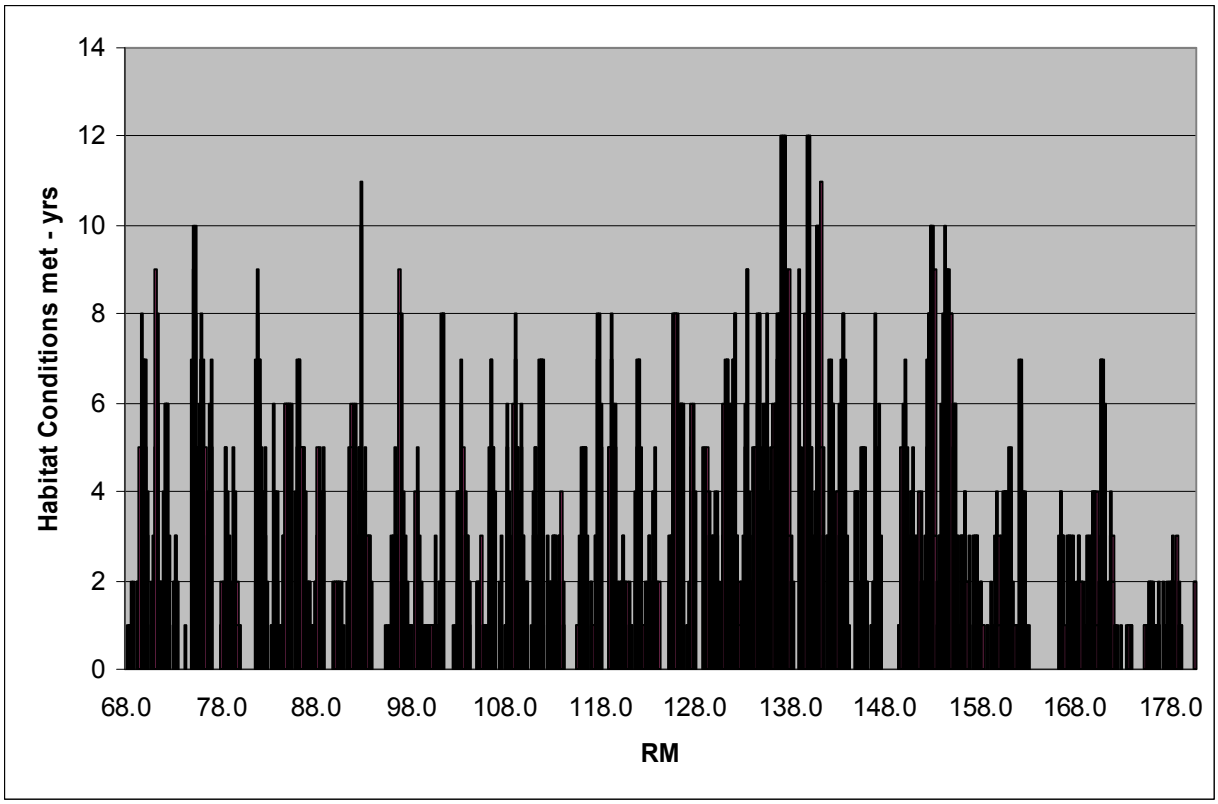

Figure 3.1. Number of Years each ½ mile Reach Met the Required Habitat Conditions for Reach Selection

The six reaches described in Table 3.3 were inspected on the ground and adjusted to allow full survey. Reaches 82.1 (the longest listed) and 137.4 were selected as the best candidates to represent the range of conditions needed. They both have substantial utilization by endangered fish over a range of years, they are currently being used by both species and they are hydraulically contained. Reach 82.1 has a backwater area that comes and goes to allow monitoring of those mechanisms. Reach 137.4 has had consistent backwater area during low flow since surveys began. Both reaches are considerably longer than ½ mile, requiring more surveying than anticipated, but the length was necessary to have them hydraulically contained and allow model closure.

Table 3.2. Endangered Fish Studies Showing Utilization of Reaches Qualified for Selection by Habitat Availability

RM	Years w/req'd Habitat	Small Bodied Monitor PTYLUC	XYRTEX Augment Monitor PTYLUC	XYRTEX Augment Monitor XYRTEX	Adult Monitor XYRTEX	Adult Monitor PTYLUC	PTYLUC Stocking Monitor	Larval XYRTEX Monitor	Studies Showing T&E Fish Usage
154.6	9			x	x	x	NS	NS	3
154.5	9			x	x	x	NS	NS	3
154.4	9			x	x	x	NS	NS	3
154.2	10			x	x	x	NS	NS	3
153.2	9			x		x	NS	NS	2
153.1	9			x		x	NS	NS	2
153.0	10			x		x	NS	NS	2
152.9	10			x	x	x	NS	NS	3
152.8	10			x	x	x	NS	NS	3
141.2	11			x		x		x	3
141.1	10			x		x	x	x	4
141.0	10			x		x		x	3
140.9	10			x	x	x	x	x	5
140.8	10			x	x	x		x	4
139.9	12		x		x	x	NS	x	4
139.8	12		x		x	x	NS	x	4
139.0	9		x		x	x	NS		3
137.8	9	x	x	x	x	x	NS		5
137.7	9		x	x	x	x	NS		4
137.5	10		x	x	x	x	NS	x	5
137.4	12		x	x	x	x	NS		4
137.3	11		x	x	x	x	NS		4
137.2	12		x	x	x	x	NS	x	5
137.1	12		x	x	x	x	NS	x	5
133.5	9				x	x	NS		2
133.4	9				x	x	NS		2
96.8	9			x	x	x	x	x	5
92.9	11		x	x	x	x	NS	x	5
92.8	10		x		x		NS		2
81.8	9		x		x	x	x	x	5
75.3	10				x	x	NS	x	3
75.2	10				x	x	NS	x	3
75.1	9				x	x	x	x	4
71.2	9				x	x	NS	x	3

Note: NS = not sampled

Table 3.3. Summary of Reaches Selected for Field Investigation

Reach	RM Start	RM Stop	Survey length ft	Years w/req'd Habitat	Years in which fish were caught in Reach: Adult Monitor XYRTEX	Adult Monitor PTYLUC	PTYLUC Stocking Monitor	XYRTEX Stocking Monitor PTYLUC	XYRTEX Stocking Monitor XYRTEX	Larval XYRTEX Monitor	Comments
82.1	82.35	81.9	2750	7	95, 04	98, 03,04	03, 04, 05	99	none	99, 00, 04	At high flow, some loss from the main channel on RR. Need some survey in this area
82.1	82.4	81.7	4600	9	95, 04	98, 03, 04	03, 04, 05	99	none	99, 00, 04	Long, but meets all conditions
126.4	126.7	126.25	2370	8	95	98	04	none	03	98, 03, 04	Input channel on river right for some conditions, including 2003, make modeling difficult
137.4	137.8	137.15	3765	12	95,97,03, 04	98, 04	Not sampled	00	01, 04	03	very complicated channel
141.2	141.55	140.95	3635	11	04	98	04, 05	none	99, 01, 02	n/a	above larval RZ sampling range
143.5	143.75	143.15	3450	8	96, 02, 04	98, 04	02,03,04, 05	none	04	n/a	two islands end-to-end, above larval RZ sampling range

An aerial view of the detailed reach at RM 82.1 (DR 82) is shown in Figure 3.2. It is characterized by a large central island during low flow, flanked on the right by the main channel and on the left by a much narrower, but somewhat deeper secondary channel. A second large island downstream on the right of the main channel is present at all but very low flows, with a very small secondary channel to the right. Island count increases with increased flow as tertiary channels develop in the larger islands. At high flow much of the downstream island becomes submerged.

The detailed reach at RM 137.4 (DR 137) is shown in Figure 3.3. It also has a large central island, except the secondary channel is on the right and the main channel on the left. There is less distinction between the two channel capacities, especially at low flow. The main channel is wider and shallower than the secondary and is more dynamic. At high flows, tertiary channels develop and a large portion of the main island is submerged.

Both detailed reaches have a high degree of use by endangered fish relative to other areas of the river and the use has extended over most of the period of record (1995-2005). Both are within the range of all endangered fish sampling studies. However, while DR 137 is within the overall range of Colorado pikeminnow stocking monitoring, it is not within one of the sampling reaches. If possible, it would assist data integration to have this area added to this monitoring study.

Reach Analysis

Each reach was surveyed in the fall of 2005 to prepare for modeling and to establish a baseline data set for later channel change comparison. Figures 3.4 and 3.5 show the survey point locations for DR 82 and DR 137, respectively. There are 9,127 points from DR 82 and 6,954 for DR 137. These data points were used to generate the bed elevations for River2D modeling. The survey data were collected in cross-sections to aid in repeatability for channel change analysis. However, this is not the ideal format for collecting survey data for modeling. Those data have been extensively analyzed and longitudinal break lines constructed to provide better bed form for modeling purposes.

Preliminary model runs have been completed for DR 82 using a 2.0 m nominal grid size with refinement in areas where more detail was required to match water surface elevations. Calibration is being completed at 1,020 cfs (November 14, 2005 – San Juan River near Bluff). This was the flow on the date of the detailed habitat mapping. The average flow during the survey was 1,085 cfs, ranging from 956 to 1,330 cfs during the duration of the survey. The preliminary model flow depth and mean column velocities are shown in Figure 3.6.

In Figure 3.7, the modeled velocities are shown with the detailed habitat mapped on November 14, 2005. The agreement of wetted area is quite good although the water surface is still slightly high. Island shapes are also a little off and the edges do not precisely match. These differences will be reduced in the calibration process, but will not entirely be resolved. Very shallow depths are difficult to accurately model because of the small closure error required to catch the small flows involved with such shallow depths.

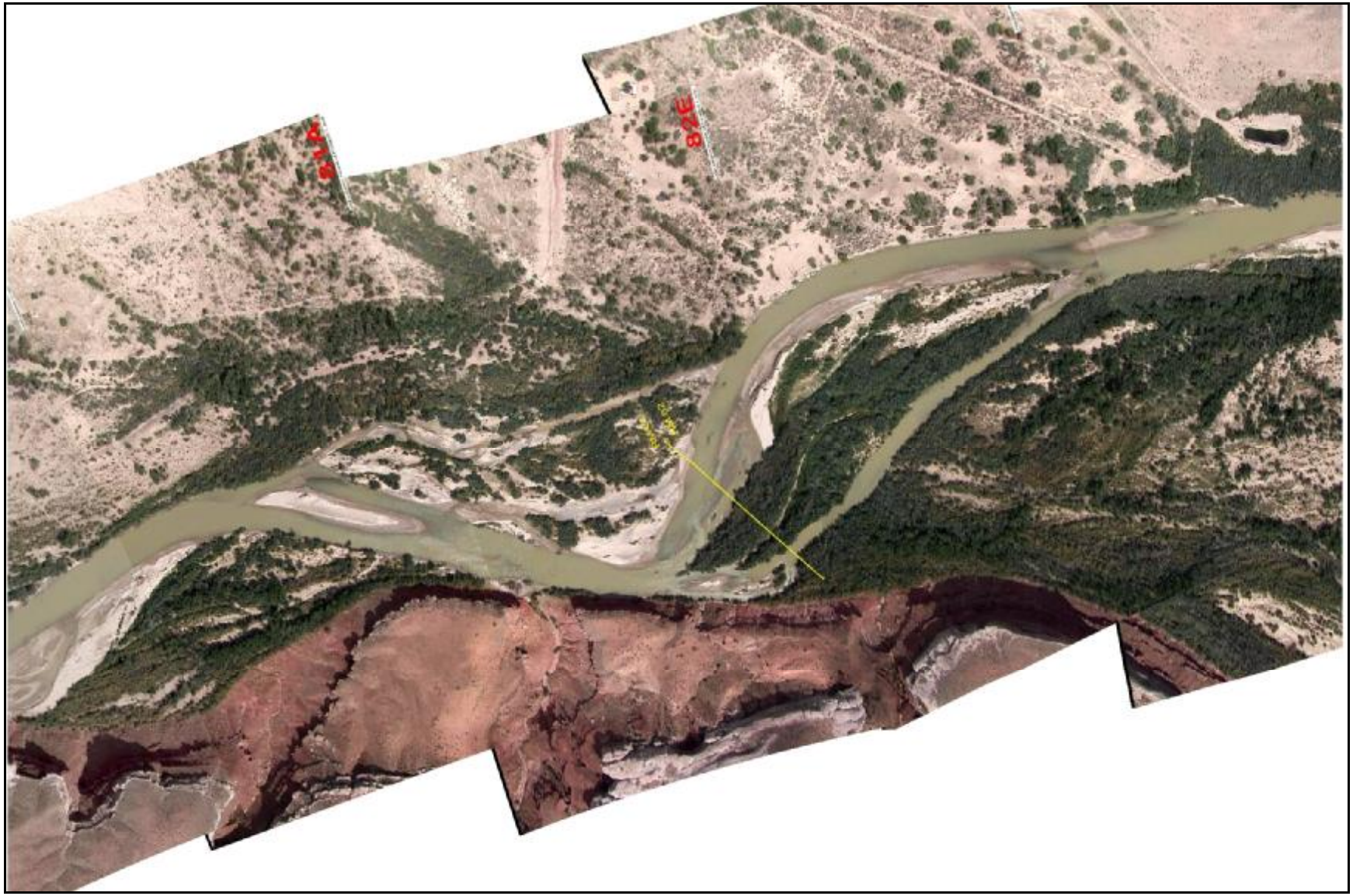

Figure 3.2. Aerial View of Detailed Reach 82

Figure 3.3. Aerial View of Detailed Reach 137

Figure 3.4. Detailed Reach 82 Showing Survey Point Locations for Fall 2005 Survey

Figure 3.5. Detailed Reach 137 Showing Survey Point Locations for Fall 2005 Survey

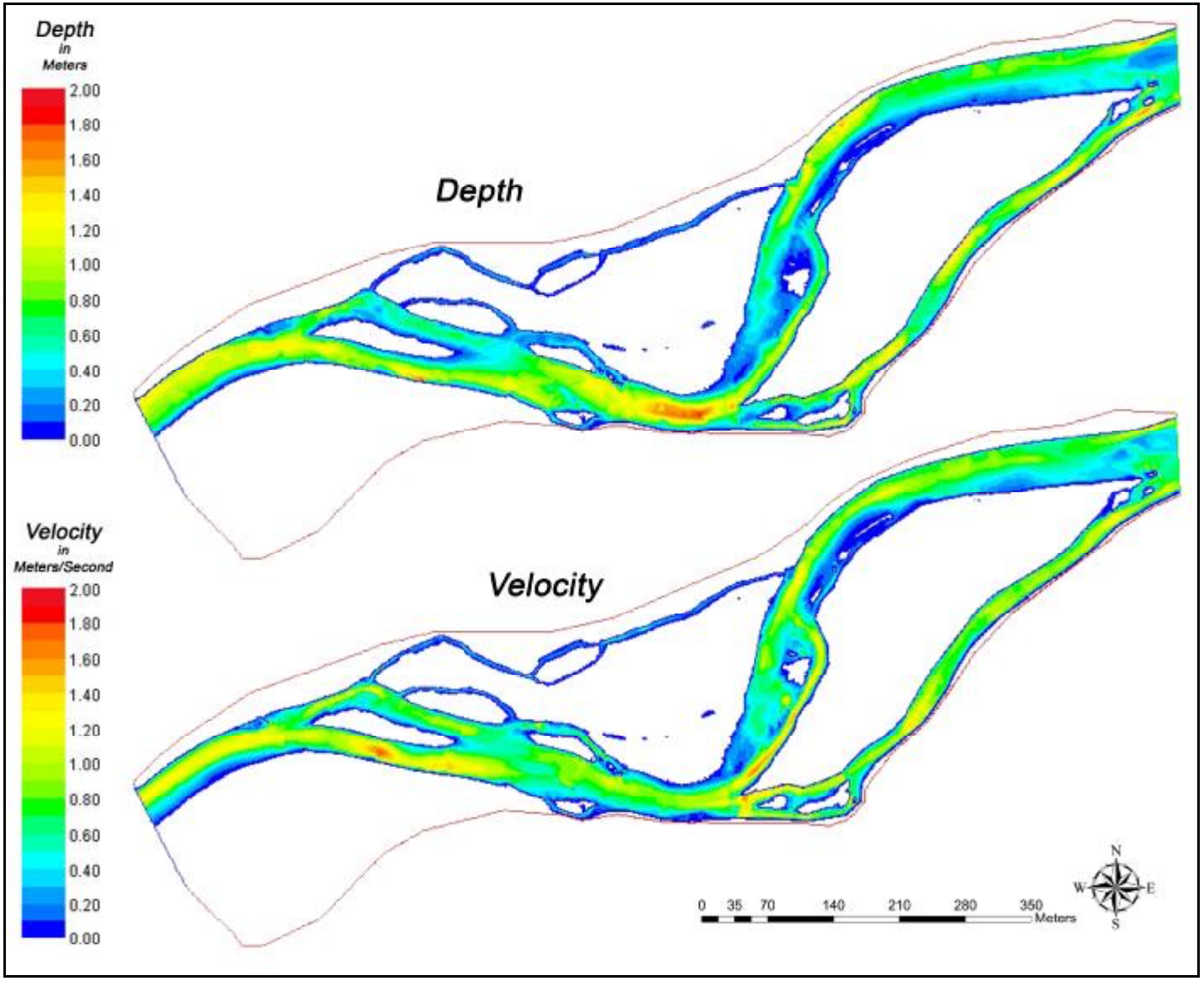

Figure 3.6. Preliminary Model Predictions of Depth and Velocity for DR 82

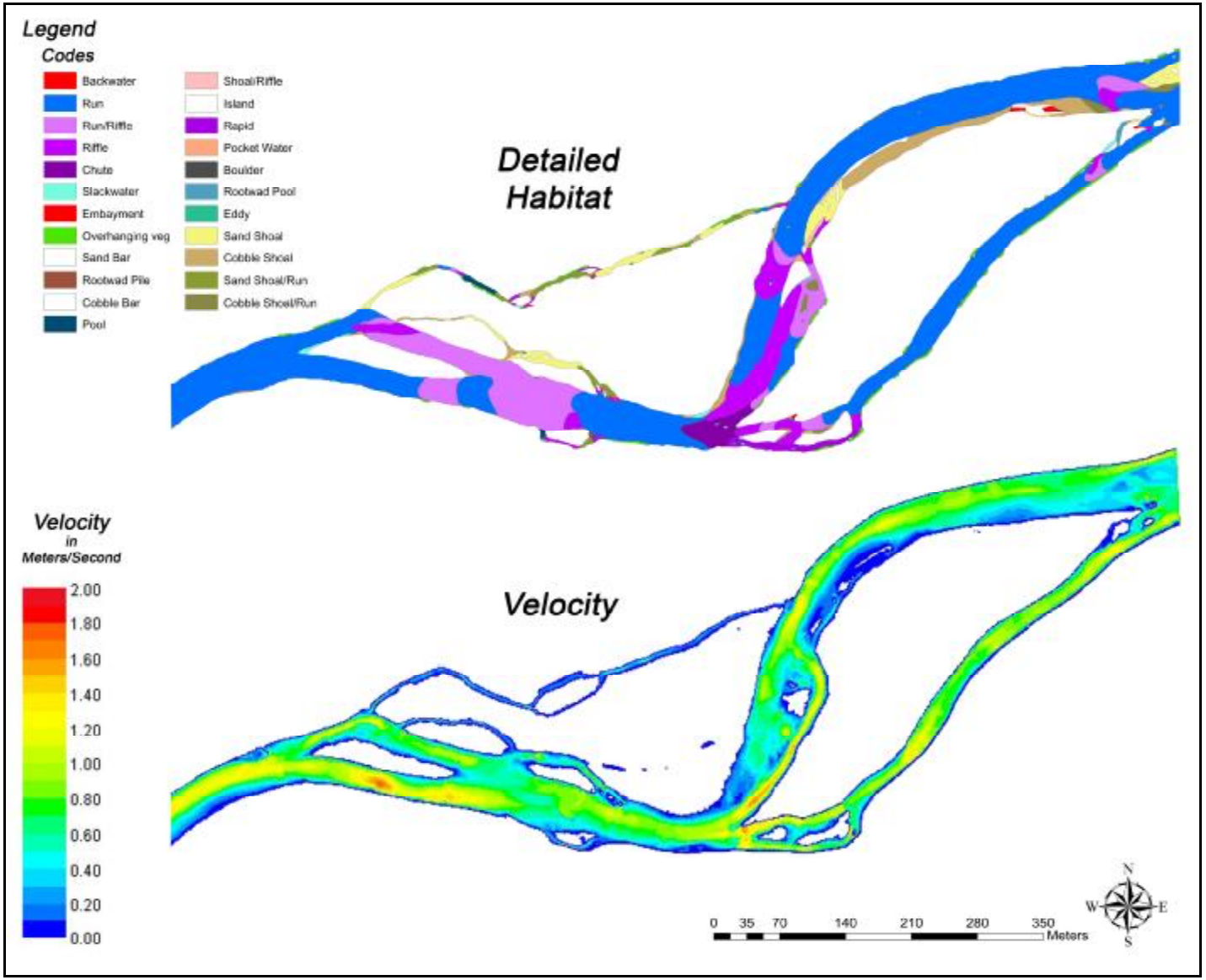

Figure 3.7. Preliminary Modeled Mean Column Velocity Compared to November 14, 2005 Detailed Habitat Mapping Results for DR 82.

Comparing the velocities with habitat characterizations points out some differences that should be resolved, if possible. Further refinement of topology may correct some of these problems, but a correlation between velocity, depth and habitat classification is needed to determine the ability to forecast habitat changes with change in flow. Substantial improvement in model results will be needed for such forecasts to be meaningful. Correlations will be completed upon final model calibration.

Table 3.4 displays the habitat mapping data for DR 82 completed at a scale of 1 inch = 75 feet (detailed mapping) and 1 inch = 150 feet (standard mapping). Figure 3.8 compares the detailed and standard mapping results. While there is a small difference in flow on the two dates (1,020 cfs for detailed mapping compared to 968 cfs for standard mapping), the flow difference is too small to explain much of the difference between the 2 mappings. There are three times as many mapped polygons for the detailed mapping as for the standard mapping, representing the ability to map more detail on the larger scale maps and the improvements with focus on capturing more detail in these short reaches. The extra detail may be important. The detailed survey mapped 5 backwater type habitats and 19 other low velocity types, mostly small pools or eddies associated with debris piles or "root wads". These features are too small to capture at the standard mapping detail, but are very important to young endangered fish as evidenced by the capture locations associated with these habitat types.

DR 137 was not mapped at a detailed level. This work was completed in conjunction with the Colorado pikeminnow stocking surveys and presently DR 137 is not within their survey range. It is recommended that the Colorado pikeminnow stocking survey areas be adjusted to cover this detailed reach in the future to allow a complete data set.

Table 3.5 summarizes the habitat data for the larval Colorado pikeminnow survey on November 14, 2005 conducted at the same time as the detailed mapping. The mapping categories attributed to BioWest are those that were recorded by the ERI mapper while in the field from the BioWest field notes. Even at the more detailed scale, there are nuances of habitat that the mapping does not capture. For example, while the habitat category does not indicate it, the sampling is completed typically in proximity to a debris pile or boulder. Sometimes the sampling location falls within the "rootwad pool" and sometimes outside, yet the samplers call the habitat a "debris pool", even though the habitat mapper indicated that the sample was taken outside the pool limit. The sample locations and those with Colorado pikeminnow captures are shown on Figure 3.9. Overall, only 4 of the 14 samples had habitat descriptions that matched those mapped. Although there were three mapped backwaters and one embayment within the reach, none were sampled.

Table 3.4. Comparison of Detailed and Standard Habitat Mapping for DR 82

	Count		Area – m^2	
Habitat Category	**Detailed**	**Standard**	**Detailed**	**Standard**
Backwater	5	0	171	---
Other Low Velocity	19	1	497	440
Runs	39	13	56,714	67,584
Riffles	30	16	10,350	8,842
Shoals	37	25	8,516	11,494
Slackwater	43	4	522	200
Vegetation	49	0	1,802	---
Total wetted area	***222***	***59***	***78,574***	***88,558***
Islands	7	5	91,813	90,879
Sand Bar	19	10	6,162	7,49
Cobble Bar	29	20	3,947	8,637
Rootwad piles	41	16	271	566
Boulders	10	0	44	---
Total mapped area	***328***	***110***	***180,810***	***196,132***
Flow - cfs			1,020	968
Map Scale ft/inch			75	150

Table 3.5. Larval Colorado Pikeminnow Survey and Habitat Data for DR 82, November 14, 2005

Bio-West Sample ID	ZYRTEX	PTYLUC	Bio-West Habitat	ERI Habitat
256	0	0	shore run / debris pool	sand shoal/run
257	0	0	shore run	sand shoal/run
258	0	0	pool	sand shoal/run
259	0	0	debris pool	sand shoal
260	0	0	pool / run	sand shoal
261	0	0	debris pile pool	sand shoal/run
262	0	0	debris pile pool	rootwad pool
263	0	0	pool	rootwad pool
264	0	0	shore run	run
265	0	0	pool	riffle
266	0	0	debris pool	riffle
267	0	0	run	riffle
268	0	0	slack water	pool
269	0	4	debris pool	sand shoal

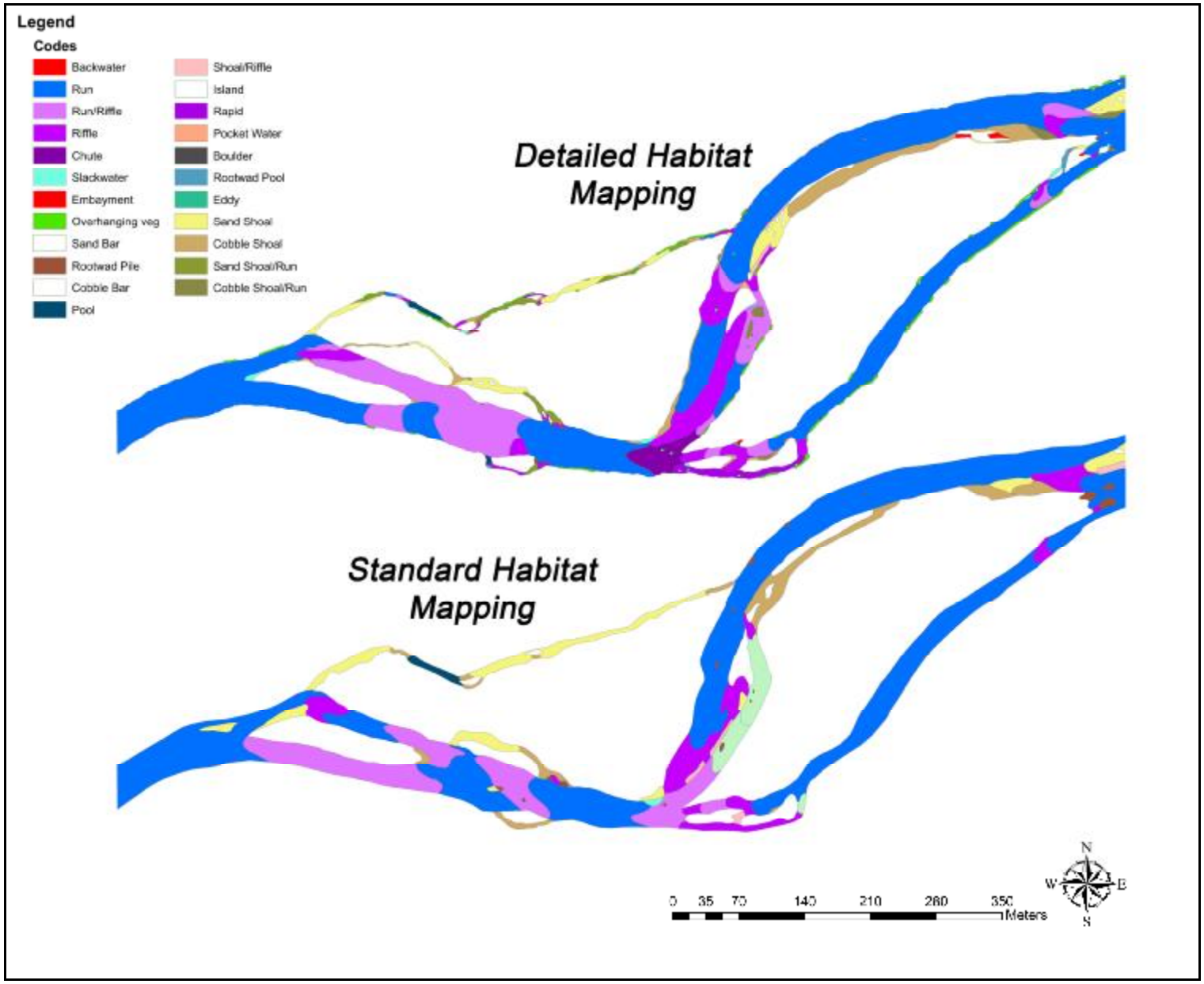

Figure 3.8. Detailed and Standard Mapping Results

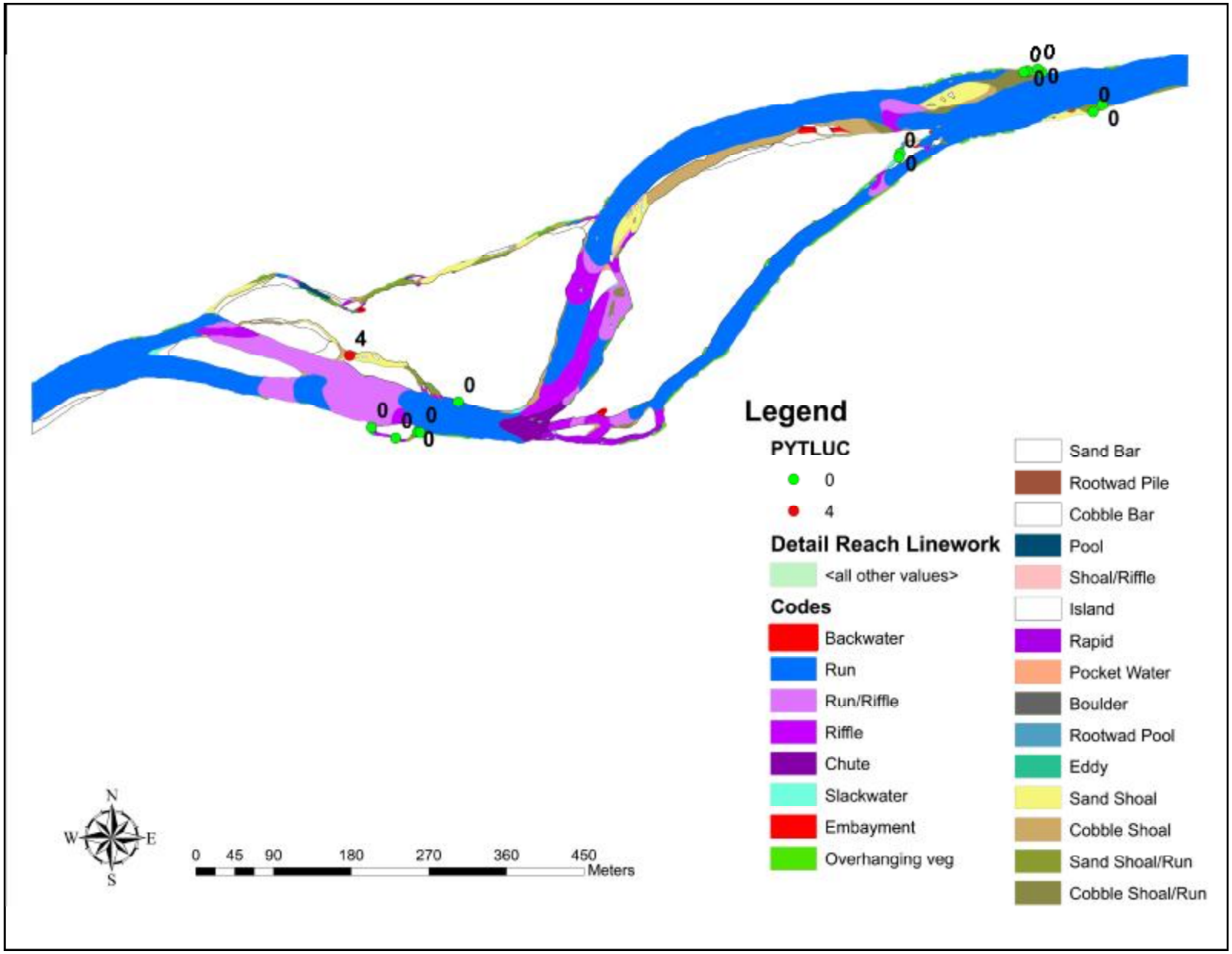

Figure 3.9. Colorado Pikeminnow Sampling Locations in DR 82 Shown with the November 14, 2005 Detailed Habitat

CONCLUSIONS

Reach Selection

The two detailed reaches that were selected adequately meet the selection criteria originally established. They occur in two different geomorphic reaches and demonstrate different stability and characterization for low velocity habitat. To meet all the conditions necessary to model the reaches, the reach length exceeded the anticipated and originally screened length. This increases the time required to conduct annual surveys, but was necessary for hydraulic containment.

These reaches, by design, do not represent the "average" condition in the river, but represent the more complex reaches. Also, there is a relatively small subset of reaches that meet all the requirements, so it could be argued that these reaches may not be representative of the bulk of the more complex reaches. In all conditions except long presence of backwater habitats these reaches are very similar to the other reaches displayed in Figure 3.1 which are ubiquitous in the system. Given that only two reaches could be studied, it was essential to have them exhibit long histories of backwater habitat or one of the very purposes of the study would be negated. Since all other parameters are represented at many locations in the system, it is felt that these two reaches will adequately represent the other reaches as a group.

Reach Analysis

Conclusions are focused on DR 82, as the detailed analysis is not yet completed on DR 137. The following preliminary conclusions are postulated:

- Adjustments are needed in the method of collecting the survey data to better represent longitudinal trends. This will make channel change in response to spring runoff more difficult, but will improve model calibration.
- A process should be added to correlate depth and velocity in the model to habitat characterization.
- Even with survey changes, matching edge habitat conditions may be difficult. Additional correlation between mapped habitat and model output may improve the ability to forecast habitat with change in flow, but it appears that for smaller habitats, particularly on channel margins, the accuracy will not be high.
- Detailed habitat mapping substantially improves the characterization of small low velocity habitats that are being used by the fish.
- Additional correlation between fish sampling crews and habitat mapping is needed (and planned) to make the data sets more compatible.
- Correlation between standard and detailed mapping should be completed when additional data sets are available to extrapolate the detailed reach results to additional similar locations in the river and to evaluate the adequacy of the detailed reaches to characterize habitats important to the endangered fishes.
- Fish sampling locations should be changed to include both detailed reaches if possible.

CHAPTER 4: HABITAT

METHODS

Habitat quantity was determined using airborne videography as previously described by Bliesner and Lamarra (1999) and established as part of the Long Range Monitoring Program. Habitat types mapped can be seen in Table 4.1 with habitat categories summarized into seven general categories.

Trend analysis was completed for the period of record by regressing the backwater habitat area with flow at mapping and then plotting the residuals of this relationship with time after shifting the values to be all positive.

The trend analysis happens to start near the end of the highest consecutive 10 years of flow on record. To examine the possibility that the San Juan River has exhibited other periods of low backwater habitat abundance, aerial photography taken at low flow in 1962 – 1963 was examined to determine backwater habitat availability during this period of time. Ten-year running average flows were also computed to compare the flow conditions for the two periods. No photo coverage was available for Reach 2. Coverage was available for 66% of Reach 3 and 88% of Reach 4. Reaches 5 and 6 had full coverage. For comparative analyses, backwater habitats from comparative river miles for 1992-2004 were used.

RESULTS

The mapping dates and ranges of flow rates for mapping between RM 2 and RM 180 are shown in Table 4.2 for the 2002-2004. In 2004, the sequence of dominant to subdominant habitat types based upon the amount of surface area between RM 2 to RM 180 had the same distribution as the two previous years (Figure 4.1). These distributions can be seen in Figure 4.2 and the results in terms of the percent of total wetted area are summarized in Table 4.2 for 5 of the 7 main habitat categories.

The spatial distribution of these same general categories can be seen in Figures 4.2 and 4.3 for 2002 and 2003. Figure 4.4 shows a more detailed spatial distribution of the subdominant categories in 2004 excluding the run type habitats.

Table 4.1. Seven General Categories of Habitat Types on The San Juan River

LOW VELOCITY TYPES	RUN TYPES	RIFFLE TYPES	BACK-WATER TYPES	SHOAL TYPES	SLACK-WATER TYPES	VEGETATION ASSOCIATED HABITAT TYPES
pool	shoal/run	riffle	backwater	sand shoal	slackwater	overhanging vegetation
debris pool	run	shore riffle	backwater pool	cobble shoal	pocket water	Inundated vegetation
rootwad pool	scour run	riffle chute	embayment			
eddy	shore run	shoal/riffle				
edge pool	undercut run	chute				
riffle eddy	run/riffle	rapid				

Table 4.2. Summary of mapping dates, flows and habitat distribution for 2002-2004

Year	Dates	Flow - cfs	Runs	Riffles	Shoals	Slackwater	Backwater
2002	7/23-8/04	329-704	82%	9%	6.4%	1.6%	0.17%
2003	10/20-24	337-511	80.5%	11%	4.8%	2.3%	0.13%
2004	11/03-08	758-891	78.5%	9%	6.4%	3.8%	0.21%

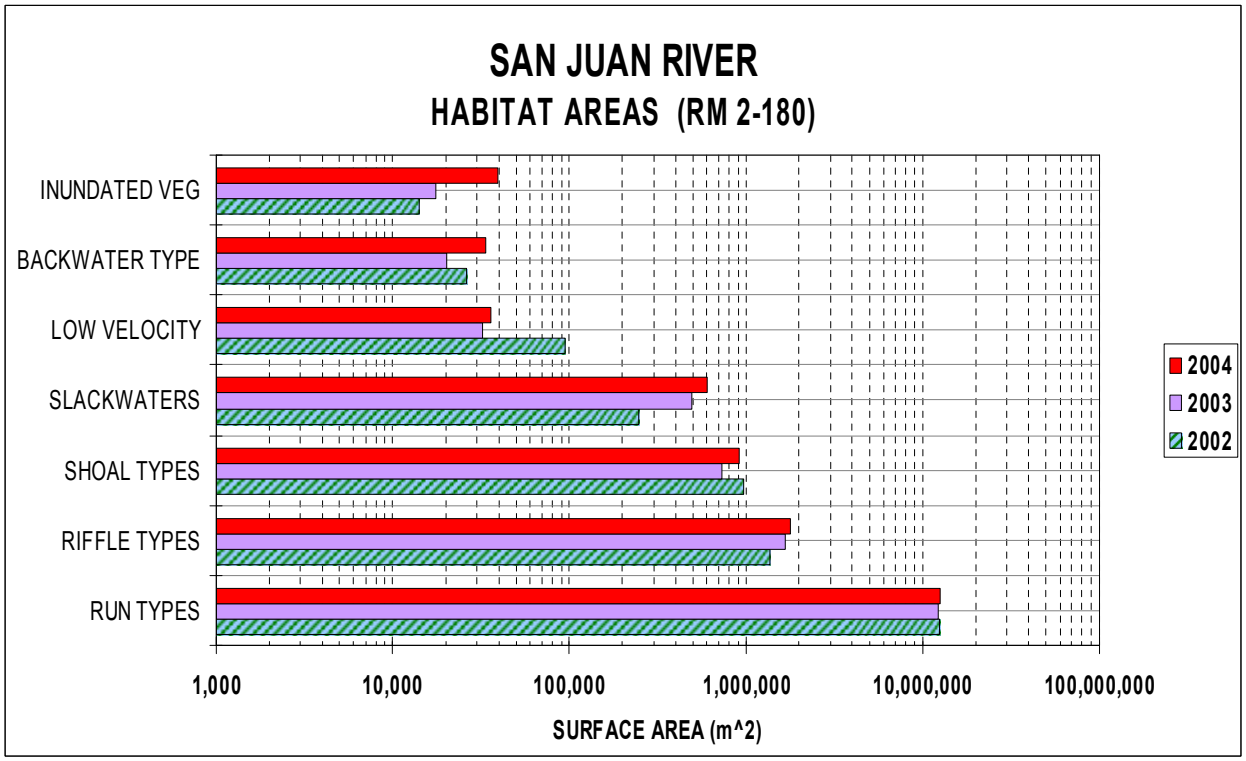

Figure 4.1. A Comparison of the Amount of Surface Areas by General Habitat Type in the San Juan River (RM2 to RM180) for 2002 – 2004

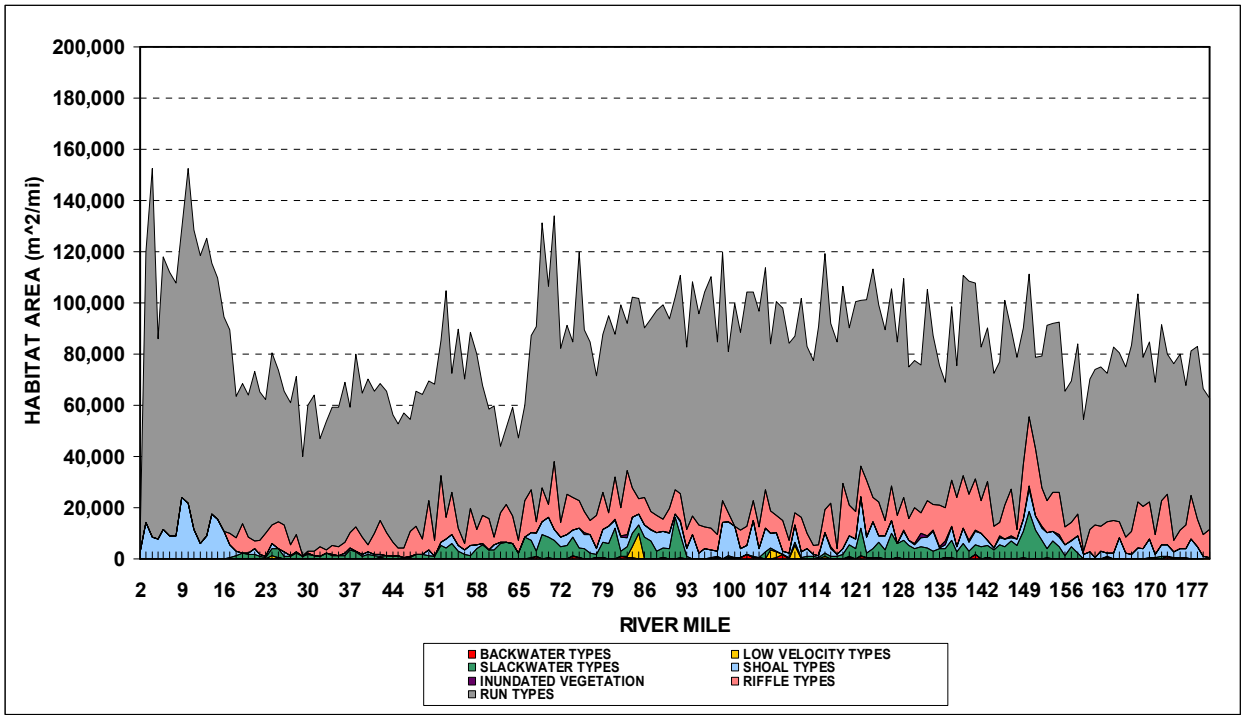

Figure 4.2. The Spatial Distribution of Major Habitat Types in the San Juan River for 2003

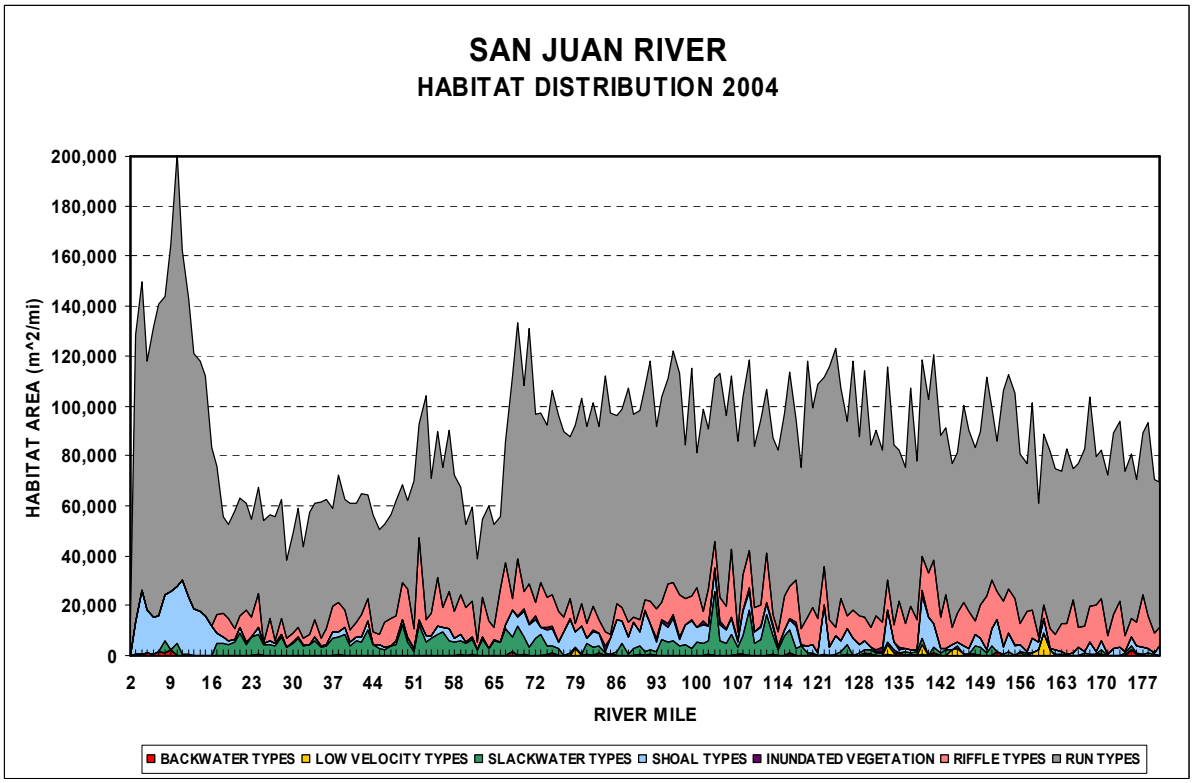

Figure 4.3. The Spatial Distribution of Major Habitat Types in the San Juan River in 2004

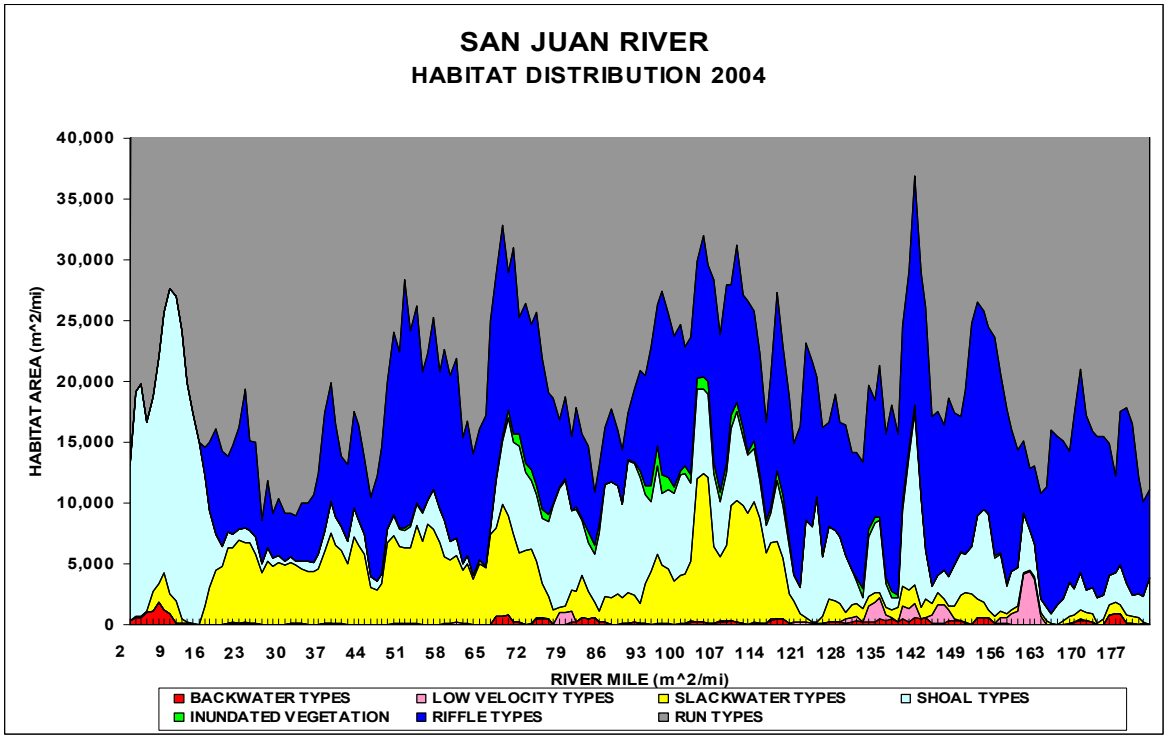

Figure 4.4. The Detailed Spatial Distribution of the Major Habitat Types in the San Juan River During 2004

Riffle habitat is the most dominant habitat in the San Juan River when runs are excluded. This habitat type contains mostly cobble substrate in all river miles except the bottom 14 miles where the river substrate is exclusively sand.

Excluding run habitat, shoals are the second most abundant habitat type and are also found throughout the river system but are a major habitat feature in the lower 19 miles of the San Juan River where it is influenced by the backwater effects of Lake Powell and between RM 70 and 115 where the gradient of the river is low. Slackwater habitats are most abundant between RM 20 and RM 120 and are associated with riffle complexes. Compared to 2003, the slackwater is reduced between RM 120 and RM 160, likely due to the higher flows at mapping. The relative abundance ranking of these major habitat categories has not changed during the period of habitat mapping for low flow conditions.

Backwater and other low velocity habitat increased in 2004 relative to 2003, primarily in response to increased flows at mapping. The increase occurred entirely within reaches 1, 5 and 6, with a slight reduction in backwater habitat and a substantial reduction in other low velocity habitat in Reaches 3 and 4.

Backwater habitats represent an important component of the life cycle of many of the native species found in the San Juan River. Because of this fact, the temporal trend in the magnitude of surface area of this habitat type is used as a monitoring indicator to assess influences of flows on habitat quantity. As noted in previous investigations (Bliesner and Lamarra 1999), the magnitude of backwater habitats are influenced by their location in the river, flow magnitude, and summer storm events. A summary and breakdown by Reach of the total backwater areas for 2004 (33,500 m^2) compared to previous years with similar flows are shown in Figure 4.5 for surface area and in Figure 4.6 for the number of backwaters. The data indicated that after reaching a maximum surface area of 143,000 m^2 (373 backwaters) between RM 2 and RM 180 in 1995, there has been a decrease down to 20,290 m^2 (53 backwaters) in the summer of 2003 with a subsequent increase 33,500 m2 in 2004. Of the 111,000 m^2 lost between 1995 and 2004, 55% was lost in Reach 3. Reaches 1 and 2 have seen the next greatest loss, accounting for 10 and 15% of the total loss, respectively. The total loss represents 280 backwaters.

Even though all these mappings occurred at low flow, there was still a relatively large range in flow at mapping (450 to 1,200 cfs). To better determine the change with time, the values were normalized by regressing habitat area against flow at mapping and then plotting the residuals of this relationship (adjusted to be all positive) with time. Only habitat runs with flows under 1,200 cfs and for which reaches 1-6 were sampled are included. This relationship is shown in Figure 4.7. The relationship is significant with a downward trend, showing loss of habitat with time. When corrected for flow, the trend from October 1996 through November 2004 is nearly flat. Although the actual mapped backwater area increased in 2004, when normalized for flow at mapping, the increase was not significant compared to the previous four years.

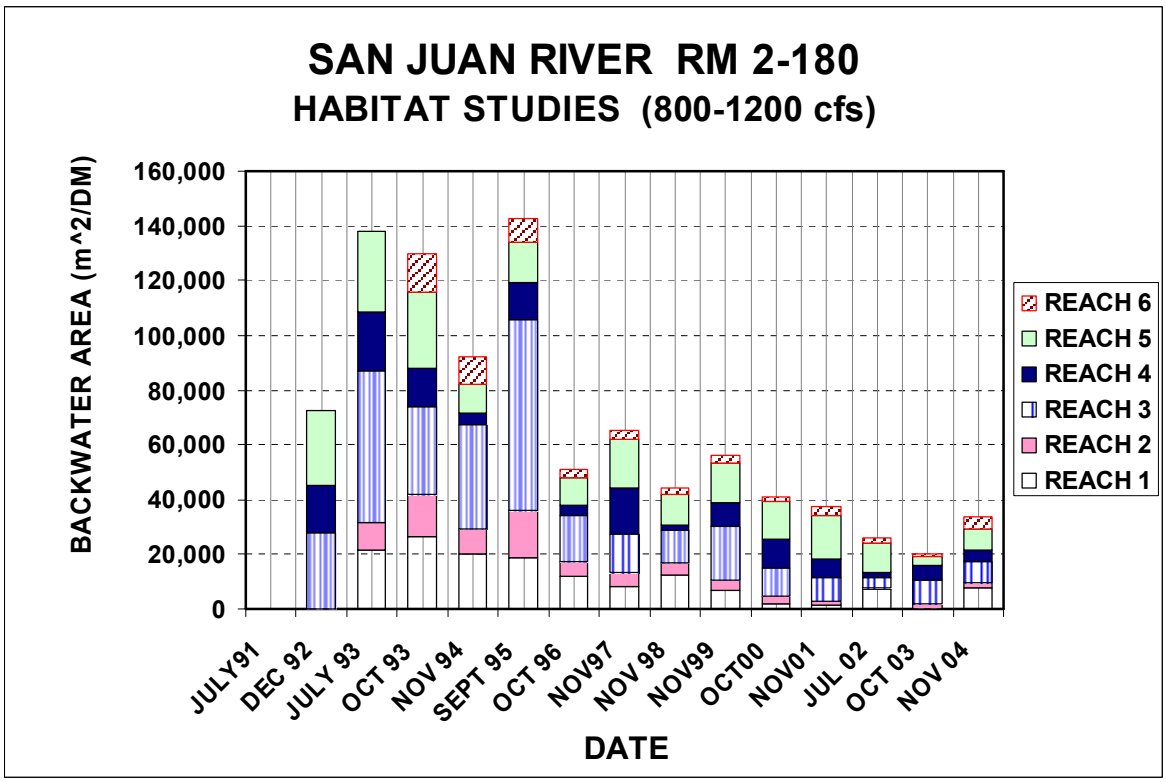

Figure 4.5. **A Comparison of the Backwater Surface Areas Mapped at Approximately the Same Flow in the San Juan River Since 1991 (450-1200 cfs)[2]**

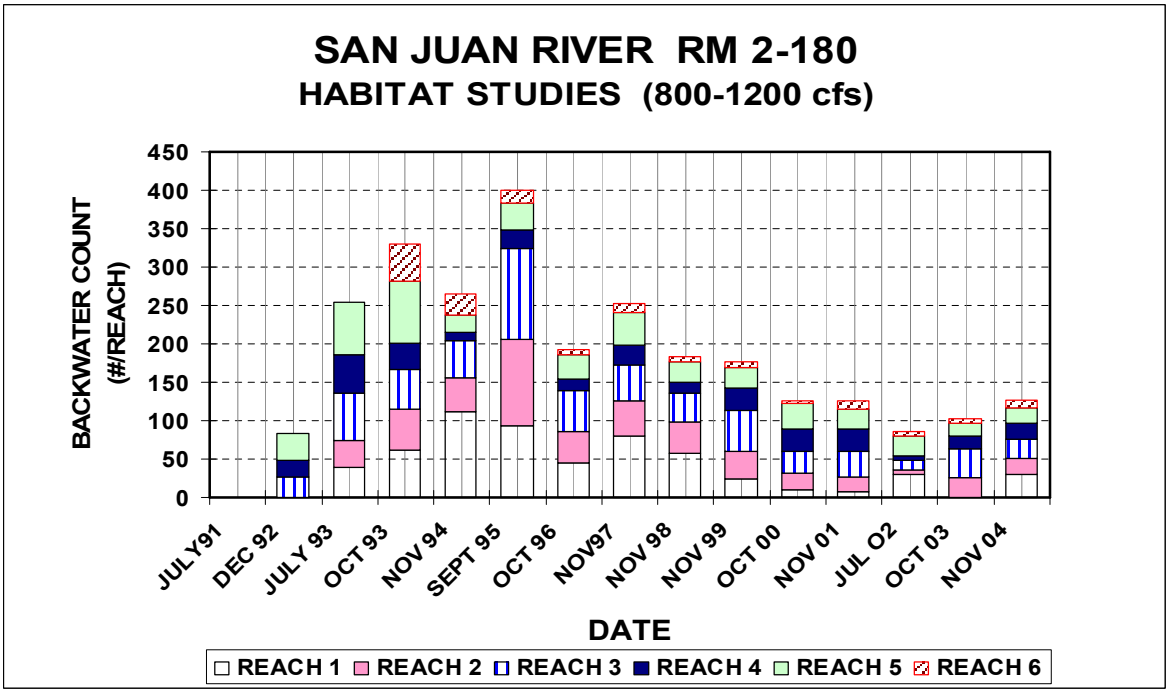

Figure 4.6. **A Comparison of the Number of Backwaters in the San Juan River Mapped at Approximately the Same Flow Since 1991 (450-1200 cfs).[1]**

[2] Reach 1 not surveyed in December 92. Reach 6 not surveyed in December 92 or July 93.

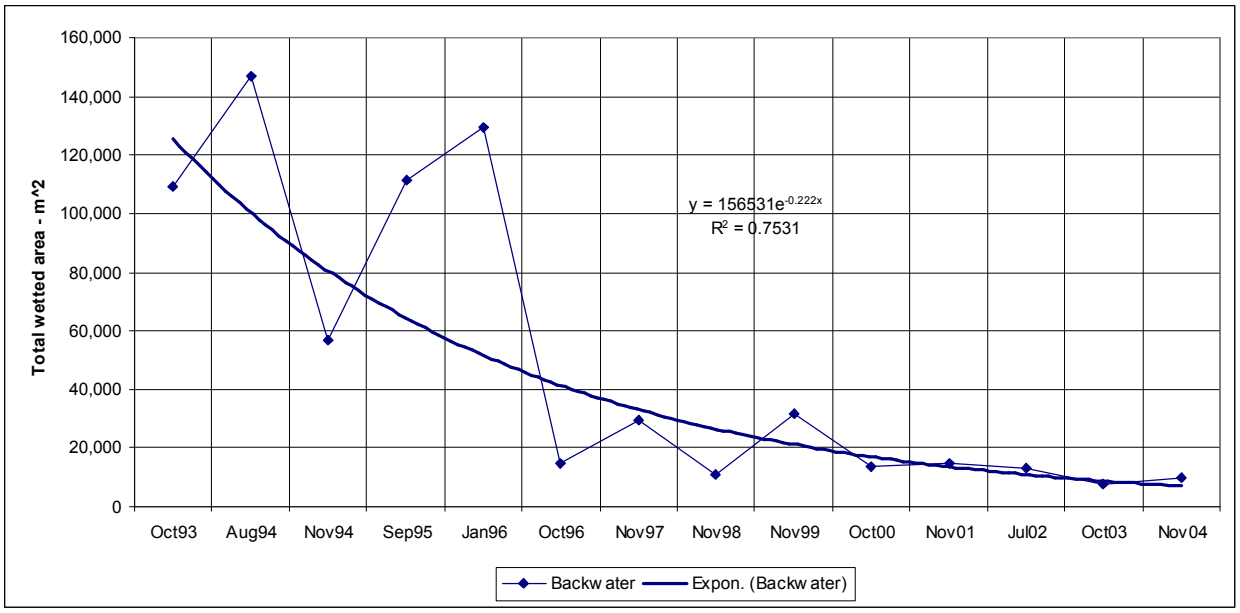

Figure 4.7. Backwater Area Residual (Transposed to Eliminate Negative Values) from Habitat-Flow Regression

Figure 4.8 shows the backwater habitat area for Reaches 3-6 for 1962 and 1992-2004, including just the river miles in Reaches 3 and 4 for which aerial photography was available in 1962. The backwater habitat area for Reaches 3 through 5 is more similar to the 2000 to 2004 period than to the 1993 to 1995 period. However, Reach 6 appears to be consistently lower in backwater habitat area in these later years compared to 1962.

Figure 4.9 shows the backwater habitat area for the various mapping periods for Reaches 3-6 and Reach 6 only plotted with the 10-year running average antecedent runoff volume. The total backwater habitat area for Reaches 3-6 for 1962 are more similar to the 1996-2004 period than to the pre-1996 period and the 10-year antecedent runoff is also similar. Reach 6, however, is significantly lower now than in 1962, indicating a loss of backwater habitat that may not be related to antecedent flow.

Figure 4.10 shows the relationship between backwater habitat area and 10-year antecedent runoff for the available data set. The relationship is significant and the 1962 data point fits will within the range of the later period.

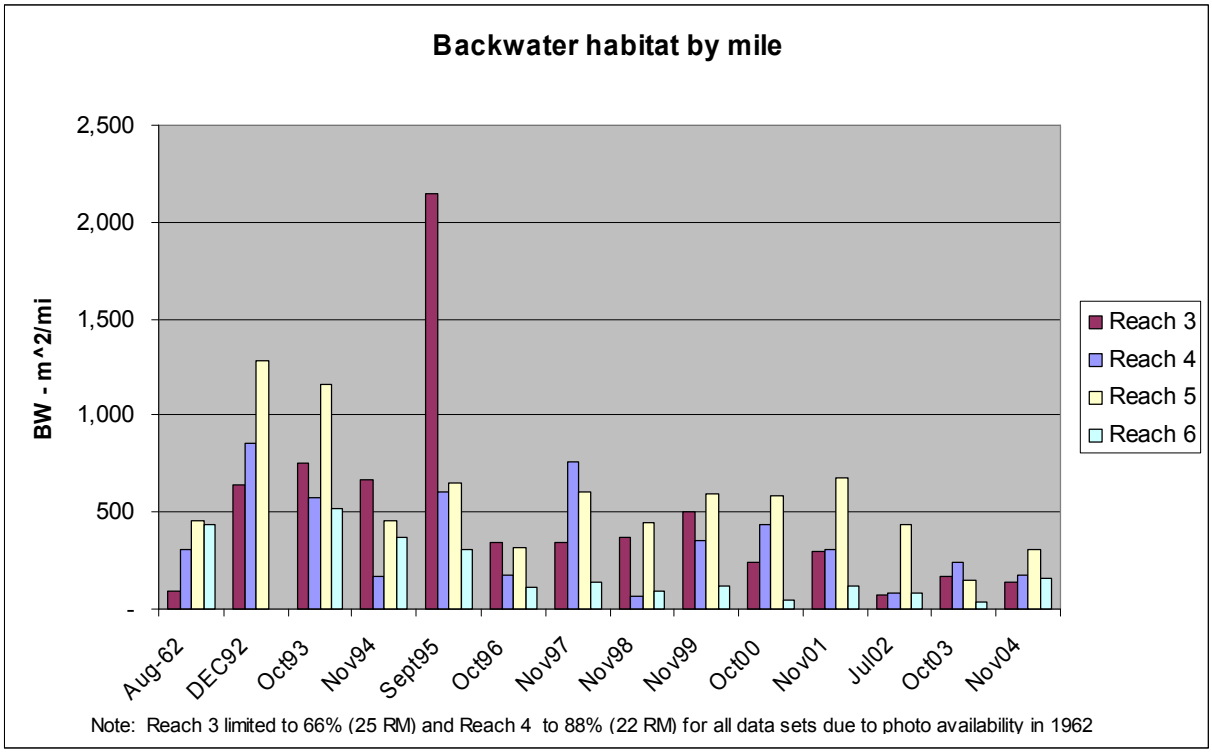

Figure 4.8. Backwater Habitat Area for Reaches 3-6 for 1962 and 1992-2004

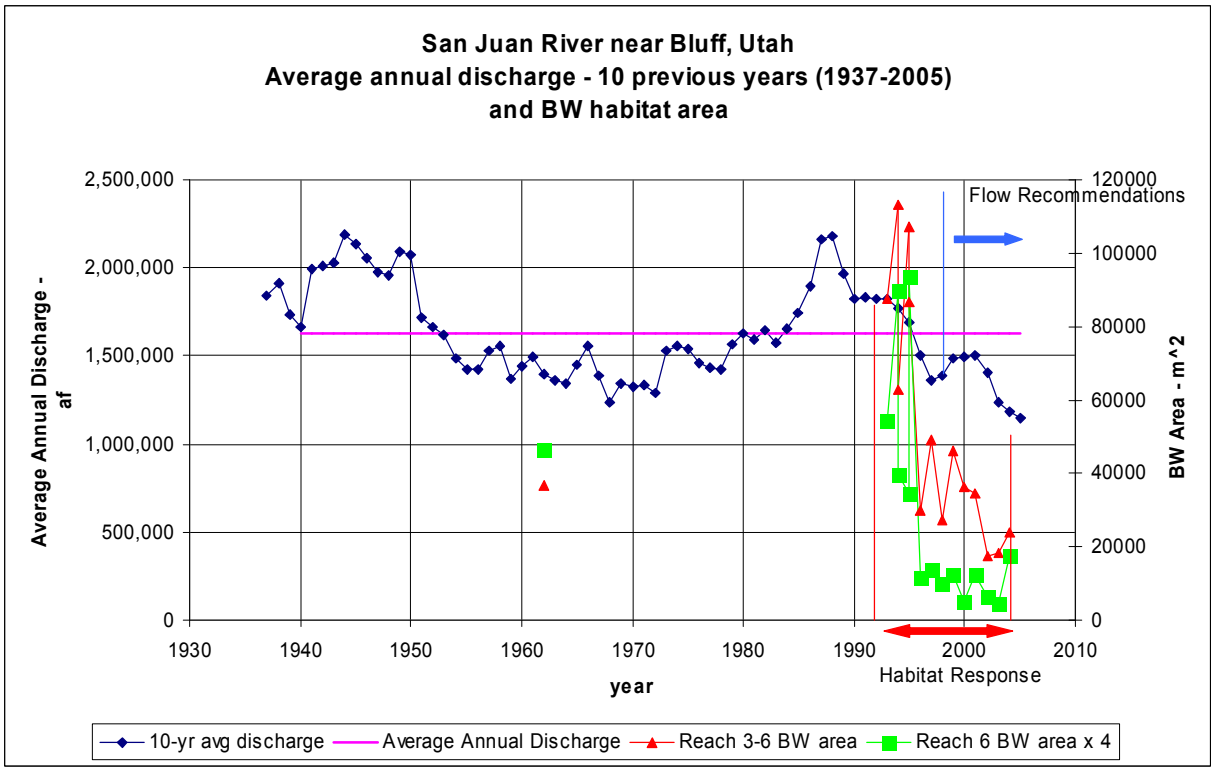

Figure 4.9. Backwater Habitat Area by Reach at Low Flow for 1962 and 1992-2004 Plotted with 10-Year Average Antecedent Runoff

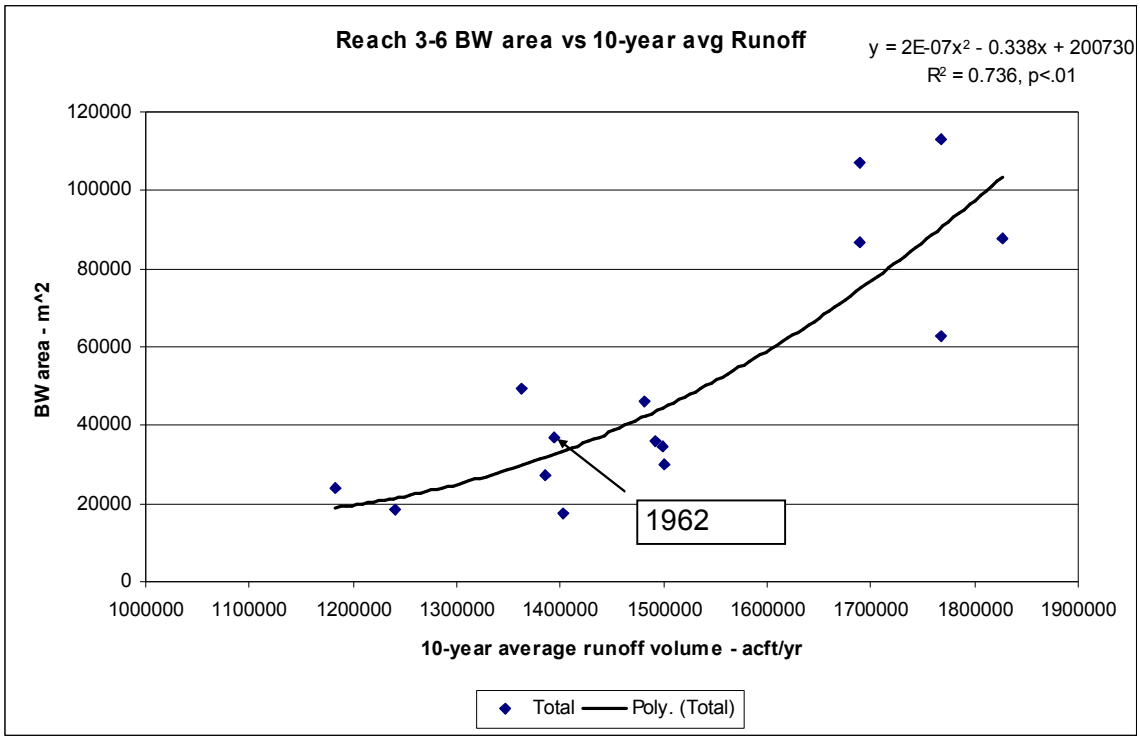

Figure 4.10. Reach 3-6 Backwater Habitat Area Versus 10-year Average Annual Antecedent Runoff

CONCLUSIONS

The following conclusions are drawn from the results of the habitat mapping in 2004:

- The relative abundance of the major habitat types has not changed substantially in 2004 from 2003.
- Since flow at mapping was greater, the area of most habitats increased from the previous year.
- There was a shift in abundance of some habitat types in 2004 relative to 2003. Slackwater abundance declined in Reaches 5 and 6, but increased in the lower reaches. Backwater habitat increased in Reaches 1, 5 and 6 and decreased slightly in Reaches 2-4. Other low velocity area also increased in Reaches 1, 5 and 6 and decreased substantially in Reaches 3 and 4, with no change in Reach 2. Most changes are likely in response to higher flows at mapping.
- When normalized for change in flow, there has been no significant change in backwater habitat abundance since 2000.
- Backwater habitat for Reaches 3-6 in 1962 was more similar to backwater area in the period of 1996 to 2004 than to the earlier period of record.
- Backwater area in Reaches 3-6 is significantly correlated to the 10-year average annual antecedent runoff in the San Juan River.

- Since 1962 had similar backwater area to the more recent drought period and had similar antecedent runoff, there may be normal swings in backwater habitat area relative to longer term wet and dry cycles and a series of wet years may be needed to substantially increase backwater habitat area.
- Reach 6 does not follow the pattern of the other reaches, indicating a net loss in backwater habitat that may not be related to hydrologic cycles.

CHAPTER 5: WATER TEMPERATURE

METHODS

Nine temperature recorders were originally installed in the San Juan and Animas rivers in July and August of 1992 at the locations shown in Table 5.1. Each station consisted of a temperature sensor, lead wires and an OMNIDATA DP-230 data pod. The temperature was sampled every 10 minutes and stored every 24 hours as a maximum, minimum and mean temperature for the day. Table 4.1 also shows the periods of record at each site. The missing data were caused by equipment problems. Due to equipment problems and other maintenance challenges, the temperature recorders were replaced in July 1999 with the Optic StowAway temperature loggers. These are manufactured by Onset Computer Corporation and are factory sealed, submersible units that communicate via an optical interface. The temperature sensor is embedded in the body of the unit, eliminating any external wires. Water temperature is currently recorded every 15-minutes. The "in place" phrase in Table 4.1 indicates that StowAway's are monitoring temperature at the indicated sites.

RESULTS

The plots of the 2005 water temperature data for all monitored sites except Montezuma Creek are shown in Figure 5.1. There was a malfunction in the Archuleta recorder between November 2, 2004 and February 24, 2005. That period of record is missing from Figure 5.1. The Montezuma Creek sensor was stolen some time after April 11, 2005, the last download point. The data are not shown for this sensor as it appears to be in error, possibly due to probe location. The data will be evaluated and removed from the database if it cannot be corrected. The probe was replaced at a new location on October 8, 2005 and appears to be functioning well since that date.

Also shown on Figure 5.1 is the flow at the Four Corners gage. The impact of snowmelt runoff and cold water releases from Navajo Dam are apparent. At high flow, the temperature at Archuleta is suppressed to the dam release temperature and the temperature of the San Juan at Farmington ranges 1 - 5° C cooler than the Animas at Farmington with an average suppression of 2° C. By June 23 when the release is ending, the San Juan and Animas Rivers are about the same temperature at Farmington.

Table 5.1 Water Temperature Monitoring Locations and Period of Record

Location	RM	Period of Record
Near Navajo Dam	225	7/9/1999 to 10/07/05 (in place)
Archuleta - San Juan at USGS Gage Location	218.6	7/23/92 to 10/07/05 (in place)
Blanco - San Juan at US-64 Bridge	207.1	8/7/92 to 2/28/95 (missing 11/21 - 12/9/92)
Bloomfield - San Juan at Highway 44 Bridge	195.6	2/27/93 to 7/17/98
Lee Acres - San Juan at Lee Acres Bridge	188.9	8/8/92 to 12/2/92, 2/26/93 to 4/15/93, 5/27/93 to 9/6/94, 3/9/95 to 10/10/95
Farmington - San Juan at USGS Gage Location	180.1	8/5/92 to 1/16/96, 7/8/99 to 11/4/01, 10/3/02 to 10/10/05 (in place)
Shiprock - San Juan at USGS Gage Location	148.0	7/8/99 to 10/08/05 (in place)
Four Corners - San Juan at USGS Gage Location	119.4	10/7/94 to 3/11/96*, 7/9/99 to 10/08/05 (in place)
Montezuma Creek - San Juan at Montezuma Creek Bridge	93.6	8/9/92 to 1/11/93, 2/25 to 3/14/93, 4/14 to 5/10/93, 5/28/93 to 3/11/05 (sensor stolen. Replace 10/08/05) (in place)
Mexican Hat - San Juan near Bluff Gage Location	52.1	7/9/99 to 3/27/02 , 9/18/02 to 10/08/05 (in place)
Cedar Hill - Animas at USGS Gage nr Cedar Hill	n/a	8/7/92 to 9/22/98
Farmington - Animas at USGS Gage Location	n/a	8/5/92 to 4/14/97, 5/7/97 to 8/26/97, 10/15/97 to 6/4/98, 7/8/99 to 10/08/05 (in place)
USGS Data - San Juan at Archuleta	218.6	10/1/50 - 9/30/68 with some missing data
USGS Data - San Juan at Shiprock	148.0	10/1/51 - 9/30/86,9/7/91 - 3/3/93 with some missing data
USGS Data - Animas	n/a	10/1/52 - 9/30/90 with some missing data

Note: all locations missing October 1992 data
* installed 8/10/92 but bad data were logged until thermistor was changed in October 1994. Prior to this time it was thought sediment accumulation was causing the warmer readings instead of bad thermistor.

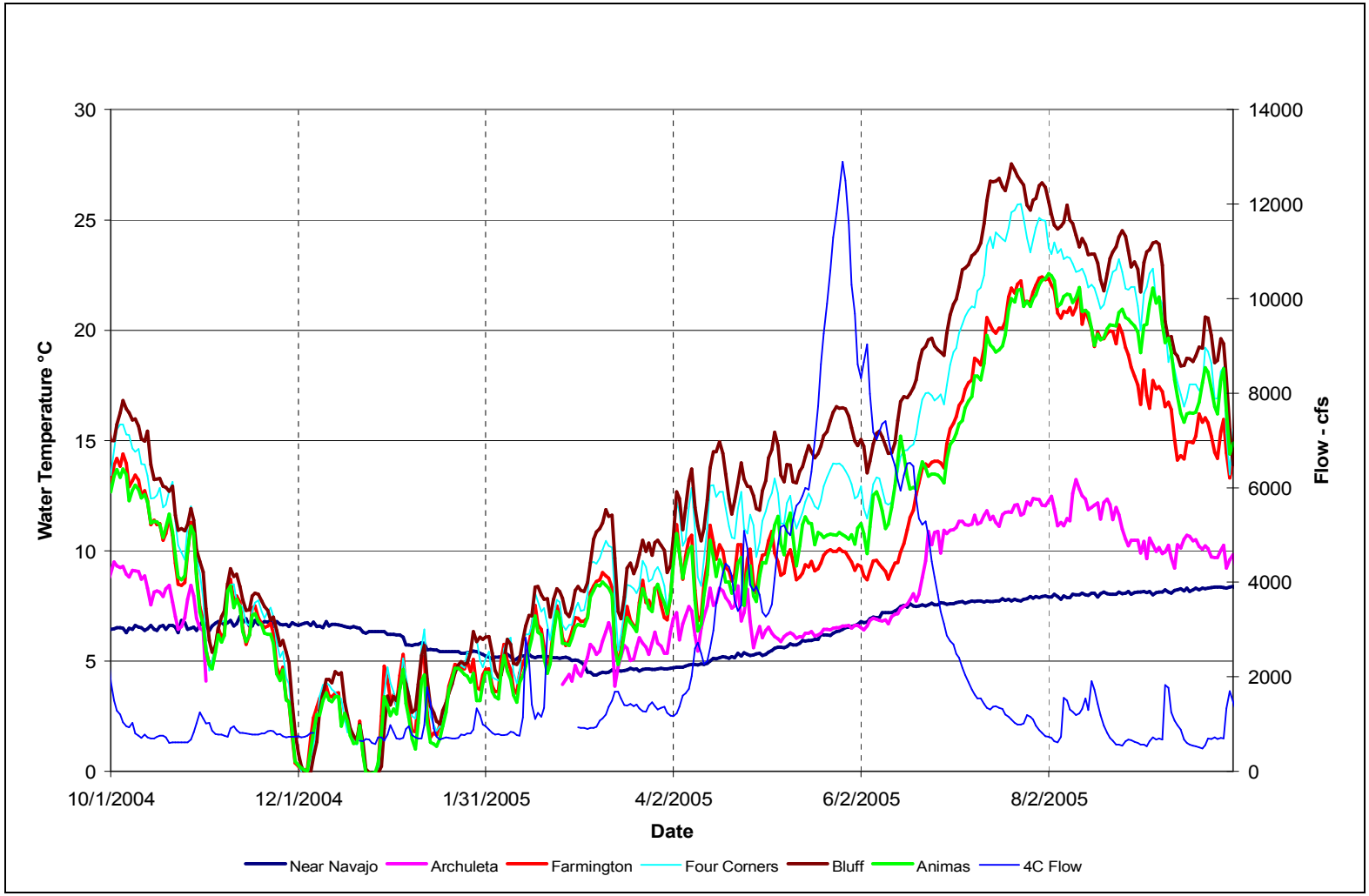

Figure 5.1. San Juan Basin Average Water Temperature Data, 2005

CHAPTER 6: RAZORBACK SUCKER SPAWNING BAR ANALYSIS

BACKGROUND

In 2003 a study was funded to characterize razorback spawning bars, assuming one could be found. The identification of the bar was based upon finding spawning aggregations of razorback sucker. While spawning aggregations were suspected near Aneth, Utah, no spawning habitat could be identified.

In 2004, Dale Ryden of the USFWS discovered a potential spawning site for razorback sucker at RM 154.4 in the San Juan River. This site was studied and reported in 2004 (Bliesner and Lamarra, 2004). The methods of characterization were established and have been used in this study.

METHODS

As reported by Bliesner and Lamarra (2004), in their analysis of pre and post runoff conditions at the 2004 site, conditions on the bars dramatically change over the runoff time period. Razorback suckers have been shown to spawn in the San Juan River on the increasing hydrograph (Brandenberg 2000) with larval fish being captured below RM 130 in April and May. Although difficult to investigate due to rising water elevations, it was felt that only pre runoff data would be collected on any potential spawning areas investigated in 2005.

Once identified, spawning bar characterization consists of site assessment utilizing aerial photography and data provided by fish survey crews on location of razorback sucker aggregations. In the investigation of the new sites, physical substrate measurements and observations were made as close to the observation of fish presence as possible in order to insure common conditions. These measurements included Wolman pebble counts , which characterized course bed particle distribution (Wolman 1954). In addition, replicate depth to the embedded layer (DTE) measurements were collected within the same area where substrate characterizations were made.

Utilizing the data from 2004 on characteristics common to the sites, a synoptic survey was completed on the ascending limb of the hydrograph on April 18-19, 2005 from RM 178.4 to 119.2 to identify other potential locations where those conditions existed. These other site locations were identified and tabulated.

RESULTS

As in 2004, Dale Ryden contacted Bliesner and Lamarra when, during their survey work in April, 2005 he discovered ripe fish near RM 132. Upon being contacted, a field investigation was immediately undertaken on April 26, 2005 to characterize the site. In addition, as in 2004 an area adjacent to the bar was selected as a control riffle where fish were not collected.

In a similar manner Jason Davis from the USFWS also discovered a concentration of razorback suckers at RM 156 during his catfish removal program in May 2005. This area corresponded to

the same location where he had observed congregated fish in previous years during his spring removal efforts (Jason Davis personal communication 2005). This site was also immediately investigated prior to spring runoff (May 10, 2005). In addition to the new sites investigated, the site at RM 154 identified in 2004 was also revisited. This latter site had dramatically changed from 2004 to such an extent that the riffle previously studied did not exist. No samples were taken at RM 154 in 2005.

The location of each pair of sample sites can be seen in Figures 6.1, 6.2 and 6.3 with Figure 6.1 representing the site where data were collected in 2004 but did not exist in 2005. Figures 6.2 and 6.3 represent locations sampled in 2005. A comparison between all locations indicates that there is a similar orientation of the suspected spawning bars. In each case, the sites are located on the upstream nose of an island with cobble/gravel exposed at lower flows (as noted in the Figures 6.1 to 6.3 which were taken at a flow of 450-630 cfs in September 2005).

As noted above, the sample events occurred on April 26, 2005 at a flow of 4,500 cfs for RM 132 and on May 10, 2005 at a flow of 4,700 cfs for RM 156.

The distributions of the substrate particles based upon Wolman pebble counts are shown in Figure 6.4. In each case, the suspected spawning bars had small amounts of large substrate (>7.5 cm) and were dominated by gravel sized materials when compared to adjacent riffle habitats. This is reflected by the D_{50} values for each site (Figure 6.5). In 2004, the site at RM 154 had a D_{50} of 3.5 cm which was similar to the 4.0 cm D_{50} measured at RM 132 in 2005. The D_{50} at RM 156 was 6.0 cm. As a comparison, an adjacent riffle was sampled at each site in a similar manner. In those locations, bed substrate tended to be dominated by larger substrate and an overall larger D_{50}. The depth to the embedded layer was also measured where the substrate conditions were quantified. This depth (measured in centimeters) is shown in Figure 6.6, and the relative depth in Figure 6.7. During 2005, the control sites were more embedded than the suspected spawning locations. There was significantly greater interstial space at the bar locations compared to the adjacent riffles.

The relative depth to embeddedness (DTE/D_{50}) which reflects the depth to the embedded layer as the number of diameters of the D_{50} sized rock showed the same pattern compared to the control sites for all three suspected spawning locations. This value ranged between 1.65 (RM 156) and 3.38 (RM 132) while the control sites were 0.56 to 1.38.

Table 6.1 lists the sites identified in the April synoptic survey that had similar characteristics to those found in 2004. These are sites that could be identified at a flow of around 4,000 cfs. Many more sites could be available but could not be identified because of the depth of flow. Note that neither of the actual sites where fish were found in 2005 were identified in the synoptic survey, indicating the difficulty of identifying the sites based only on observed conditions at other sites.

Figure 6.1. The Location of the 2004 Suspected Spawning Site for Razorback Suckers at RM 156 in the San Juan River

Figure 6.2. The Location of a 2005 Suspected Spawning Site for Razorback Suckers at RM 156 in the San Juan River

Figure 6.3. **The location of a 2005 Suspected Spawning Site for Razorback Suckers at RM 132 in the San Juan River**

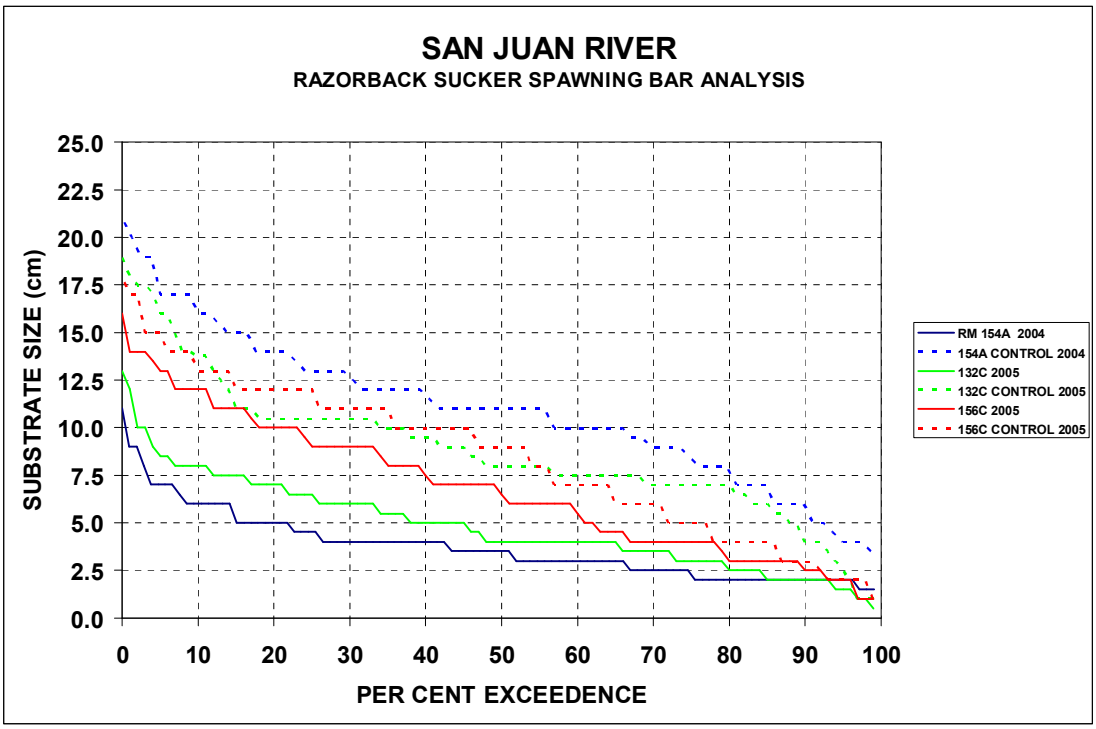

Figure 6.4. **The Substrate Size Distribution at the Three Suspected Razorback Spawning Bars in the San Juan River in 2004 and 2005**

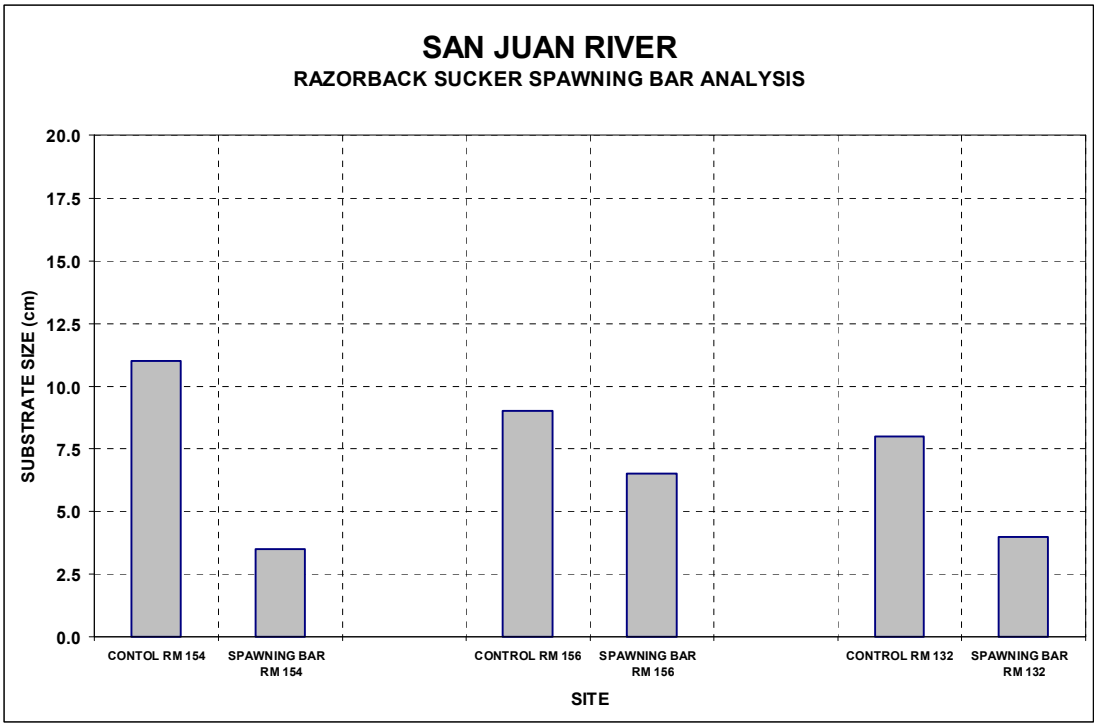

Figure 6.5. The D50 Measurement of Substrate Size at the Suspected Razorback Sucker Spawning Bars in the San Juan in 2004 and 2005

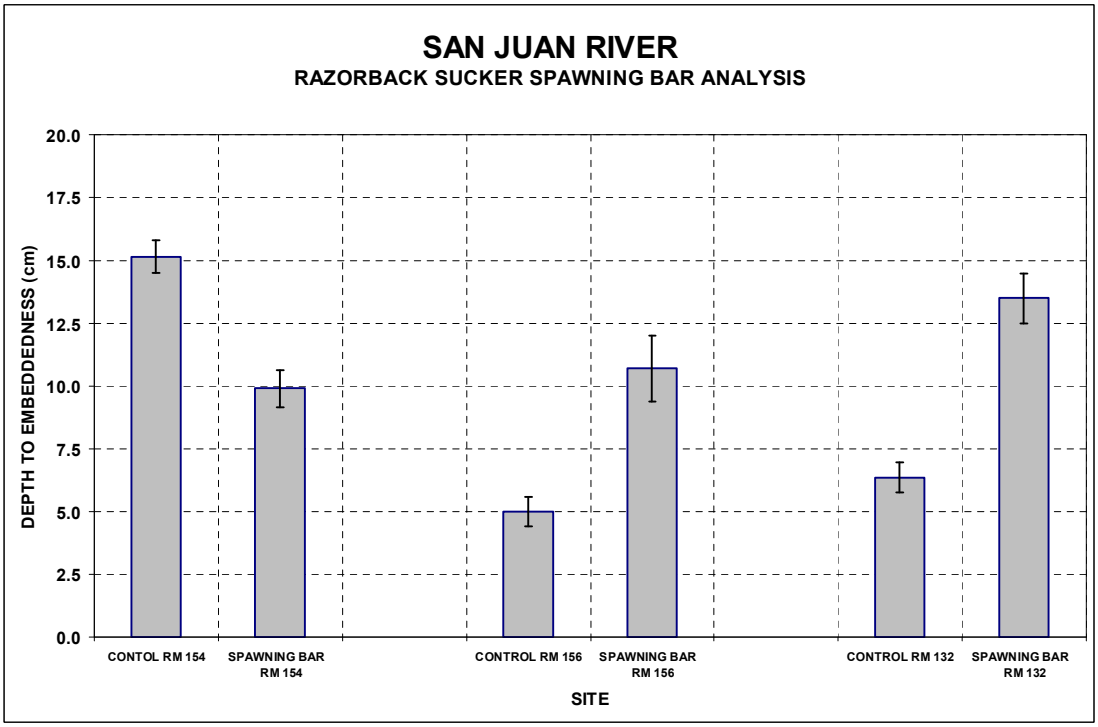

Figure 6.6. The Depth to the Embedded Layer at the Suspected Razorback Sucker Spawning Bars in the San Juan River in 2004 and 2005

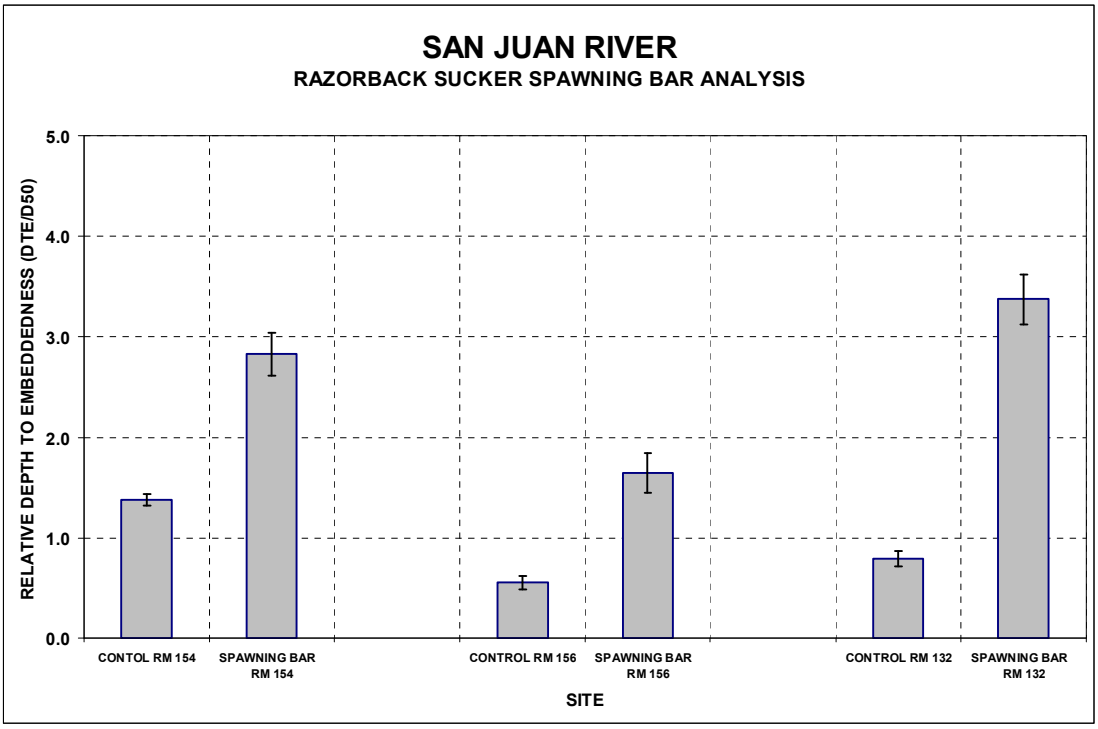

Figure 6.7. The Relative Depth to the Embedded Layer (DTE/D50) for the Suspected Razorback Sucker Spawning Bars in the San Juan River in 2004 and 2005

Table 6.1. Sites in the San Juan River with Conditions Similar to a Suspected Razorback Sucker Spawning Site Characterized in 2004

River Mile	Site Description
152.4	Large bar located river left around an island. Large gravel with some cobble. DTE >1.0. Water approximately 18" deep at 4,000 cfs.
149.6	Clean gravel developing on cross-island chutes. Small areas of DTE/D_{50} - 1.5 – 2.0
130.8	Small bar developing with clean gravel
126.6	Mid-channel bar with 5-6 cm gravel. TDE/D_{50} - 1.5 – 2.5
123.9	Potential right side of small island. D_{50} ≈8-9 cm, DTE/D_{50} – 1.0 – 1.5, marginal
121.7	River left, left side of Island. D_{50} ≈8-9 cm, DTE/D_{50} – 1.0 – 1.5, marginal

CONCLUSIONS

The three suspected spawning sites for razorback suckers sampled in the San Juan River in 2004 and 2005 had similar geomorphic positions in the river channel. The island complexes are upstream of the locations where larval razorback sucker specimens have been annually collected since 1998. In addition the distribution of substrate material was dominated by gravels and interspersed with larger cobbles. This was in marked contrast to adjacent riffles which were dominated by cobble sized material. In addition, at each site, the interstial space as inferred from the relative depth to the embedded layer was always greater than 1.65 D_{50} diameters.

As evidenced by the loss of the 2004 site by 2005, these sites are not stable. They may exist for only one season, but ample other locations seem to be available regardless of antecedent flow conditions for successful spawning of razorback sucker to occur. Both the synoptic survey and the successful spawning of razorback sucker since at least 1998 verify suitable spawning areas exist in the San Juan River. It is recommended that this study not be extended.

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