EFFECTS OF A BEACH/HABITAT-BUILDING FLOW ON CAMPSITES IN THE GRAND CANYON

FINAL REPORT

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ABSTRACT

Large riverside sand deposits located above daily river fluctuations are used as campsites in Grand Canyon National Park. Since completion of Glen Canyon Dam in 1965, these deposits have degraded while campsite use has increased. Concern on Glen Canyon Dam's effects on campsites and other resources in the Grand Canyon precipitated an effort to reintroduce flooding, an integral component of the pre-dam river. In March 1996, an experimental "flood" consisting of a week-long discharge well above normal dam operations was released from the dam as part of a research experiment primarily designed to restore high elevation sand deposits in the Grand Canyon. Preliminary studies had indicated that this flood would help move sediment to higher elevations thus expanding campsite availability. The present study evaluates the effects of the experimental flood on campsite number, size, and longevity.

Campsites were evaluated in three ways. First, we quickly assessed flood-induced changes to 92% (200/218) of all established campsites. Second, we documented and when feasible measured new flood-created sites two weeks and six months after the flood. Third, we mapped campsite area for 53 established campsites two weeks before, two weeks after, and six months after the flood. The rapid assessment data show that half (50%) of the campsites increased substantially in size, 39% remained the same, and 11% became smaller. The test flow created 82 and destroyed 3 campsites. More than twice as many campsites per mile were created above the Little Colorado River (LCR), a major tributary that flows into the mainstem, than below it and in wide "non-critical reaches" versus narrow "critical reaches." Six months after the flood, 45% (37/82) of the new deposits were no longer useable as campsites. New campsite loss was primarily attributed to erosion of the newly deposited sediment but also to inaccessibility of otherwise sufficiently large sediment deposits due to their steep slopes along the river. The remaining new sites were on average half their 2-week post-flood size. The 53 established sites that were mapped increased in area on average by 57% two weeks after the flood. After six months most had decreased in size so that all measured sites were on average 22% larger than they were prior to the flood.

INTRODUCTION

Sediment deposits along the Colorado River in the Grand Canyon serve as campsites for river runners, as habitat for vegetation and wildlife, and are part of the dynamics of sand movement and storage in the system. While river use has increased in the past 30 years to approximately 22,000 people per year, the number and size of campsites has markedly decreased (Kearsley et al. 1994). As a result, campsites in narrow stretches of the river are extremely limited, causing severe competition and excessive use.

These decreases to campsite area are a result of changes to the river caused by Glen Canyon Dam and its operations (Beus et al. 1985; Schmidt and Graf 1990; unpublished consensus of long-term river guides). Glen Canyon Dam, completed in 1963, greatly reduced the river's sediment load and its flooding capability. The dam traps essentially all upstream sediment so that all downstream sediment is contributed by flash flooding events and downstream tributaries, primarily the Paria River and the LCR. These sources, however, contribute only a fraction of the pre-dam sediment load. The dam has also limited flooding. Mean annual flooding during the 40 years preceding Glen Canyon Dam was 77,000 cubic feet per second (cfs) (Kieffer et al. 1989). Currently, maximum discharge is restricted to 25,000 cfs; however, unplanned flooding events have occurred when Lake Powell has been full and inflow has been high.

Concern over Glen Canyon Dam's effects on downstream resources in Grand Canyon has prompted political action during the past decade. The Bureau of Reclamation's Glen Canyon Environmental Studies (GCES) program was initiated in 1982 (National Research Council 1987), which lead to an environmental impact statement (EIS), released in 1995 (Bureau of Reclamation 1995), to resolve management of these resources. The EIS initiated a plethora of resource-related studies in the Grand Canyon, many of which focused on sediment. Also, in 1992, US Congress passed the Grand Canyon Protection Act which required that dam operations protect and mitigate adverse impacts to natural resources in Grand Canyon.

Aerial photograph analysis and campsite inventories show a 30-year trend of diminishing campsites punctuated by infrequent flood-induced increases. Between 1965 and 1973, nearly 1/3 of all campsites ceased to exist or decreased substantially in size due to erosion (Kearsley et al. 1994). The first campsite inventory provided a baseline campsite number, documenting 333 campsites in 1973 (Weeden et al. 1975). The second inventory, immediately following flood level flows of 92,000 cfs, documented 438 campsites in 1983, a 34% increase in number. The increased number of campsites since 1973 were primarily attributed to the pprevious year's flood releases (Brian and Thomas 1984). Aerial photograph analysis showed that these flood-induced increases were short-lived. One year after the inventory most of these new and larger campsites had substantially eroded (Kearsley et al. 1994). The most recent inventory documented 226 campsites in 1991, a 32% reduction in campsite number since 1973, and a 48% reduction since 1983 (Kearsley and Warren, 1993).

Flood-induced changes, however, vary in response to sediment storage in the river bed. Discharges in 1984-1986, while not as high as those in 1983, were well above the normal high discharge with peak flows between 48,000 and 58,000 cfs. However, most sites eroded during these years. While high erosion rates following flooding events account for much of the erosion that occurred (Beus et al. 1985; Schmidt and Graf, 1990), a principal mechanism is likely the small amount of sediment remaining on the river bed after 1983, causing the high flows to be more erosive (Bureau of Reclamation 1995). In contrast, between 1965 and 1983, a great deal of sediment from tributaries had accumulated on the river bed, so was available for deposition by the 1983 high flows (Randle et al. 1993).

Continued monitoring of campsites found more moderate decreases in campsite size as well as flood-induced increases. For part of the EIS and subsequent monitoring, 93 campsites were measured annually from 1991 to 1994 by on-site mapping using aerial photographs. The measured campsites lost on average 9% of their total area during this time primarily due to erosion but also due to vegetation growth. In 1993, a natural flood event from the Little Colorado River raised the mainstem's discharge below the Little Colorado River to 33,000 cfs (U.S. Geological Survey 1994). Half of all measured campsites increased in size, primarily below the Little Colorado River. A year later most of this increased area eroded; however, some campsites remained larger in 1994 than they were in their initial 1991 measurements (Kearsley 1995).

As a result of these and other flood-related findings, the EIS incorporated a beach/habitat-building flow within its preferred alternative. This high flow would consist of a 45,000 cfs discharge for 1-2 weeks every five years in part to rebuild high elevation sandbars. In order to determine whether its impacts would adhere to researchers' predictions, the EIS proposed conducting a test beach/habitat-building flow before incorporating it into the final alternative. This test flow of 45,000 cfs was conducted from March 26-April 2, 1996 (Figure 1). The present study evaluates its effects on campsite number and size, and the 6-month longevity of these changes.

Changes in the dam's discharge regime surrounding the EIS process have led to different maximum discharge levels. Consequently, discharge levels defining the lower boundaries of campsite area have changed. From dam closure to the beginning of the EIS, maximum discharge from Glen Canyon Dam was 31,500 cfs. However, maximum discharge usually did not exceed 25,000 cfs, and a drift and vegetation line could be seen at this level. Campsite area above and at various discharge levels below 25,000 cfs were measured in 1991 for the EIS (Kearsley and Warren 1993) and in 1992-1994 for a monitoring study subsequent to the EIS (Kearsley 1995) in order to directly compare measurements. From August 1991 to October 1996 maximum discharge was further restricted to 20,000 cfs in order to mitigate damages to resources. Both the test flood and the present study were conducted during this period, so campsite area above 20,000 cfs was of issue during the study. In October 1996 the Record of Decision changed the maximum discharge from 20,000 to 25,000 cfs but also stated that discharges above 20,000 cfs would be rare (Bureau of Reclamation 1996). 20,000 cfs is the lower boundary for measuring campable area in this study, and, barring any further changes in the discharge regime, should

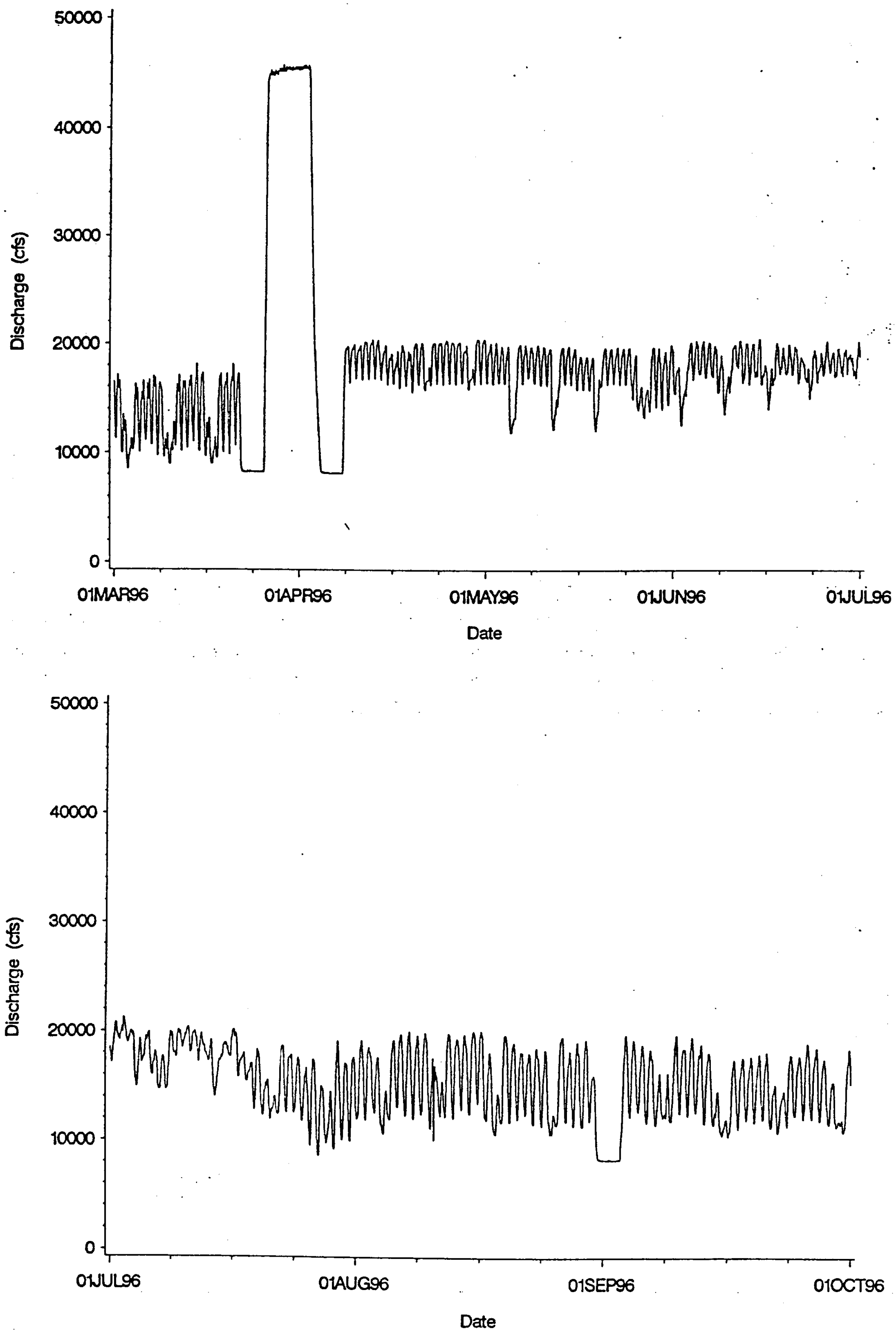

Figure 1. Colorado River discharge at Lees Ferry during the study period.

remain the lower boundary for future studies. Because of these changes in the lower boundaries of campsite area, campsite area changes between 1991-1994, can be compared to changes during the 1996 test flow, but changes between 1994 and 1996 cannot equitably be compared.

STUDY AREA

Campsites were measured along the Colorado River in the Grand Canyon between Lees Ferry and Diamond Creek (river mile 0-226) (Figure 2). Lees Ferry, located 15 miles downstream from Glen Canyon Dam, is the launch point for Grand Canyon river trips, and Diamond Creek is the first road access from which boats can depart. The study area is subdivided into reaches based on the number of campsites available in relation to recreational demand. "Critical reaches" of the river have a limited number of available campsites, and competition for sites is greater than for sites on other stretches of the river (Kearsley and Warren, 1993). Critical reaches are located 11-40.8, 75.6-116, and 131-164 miles downstream from Lees Ferry. Non-critical reaches are river mile 0-11, 40.8-75.6, 116-131, and 164-226. Critical and non-critical reaches, based on recreational considerations, correspond closely to Schmidt and Graf's (1990) narrow and wide reach designations, based on river geomorphology.

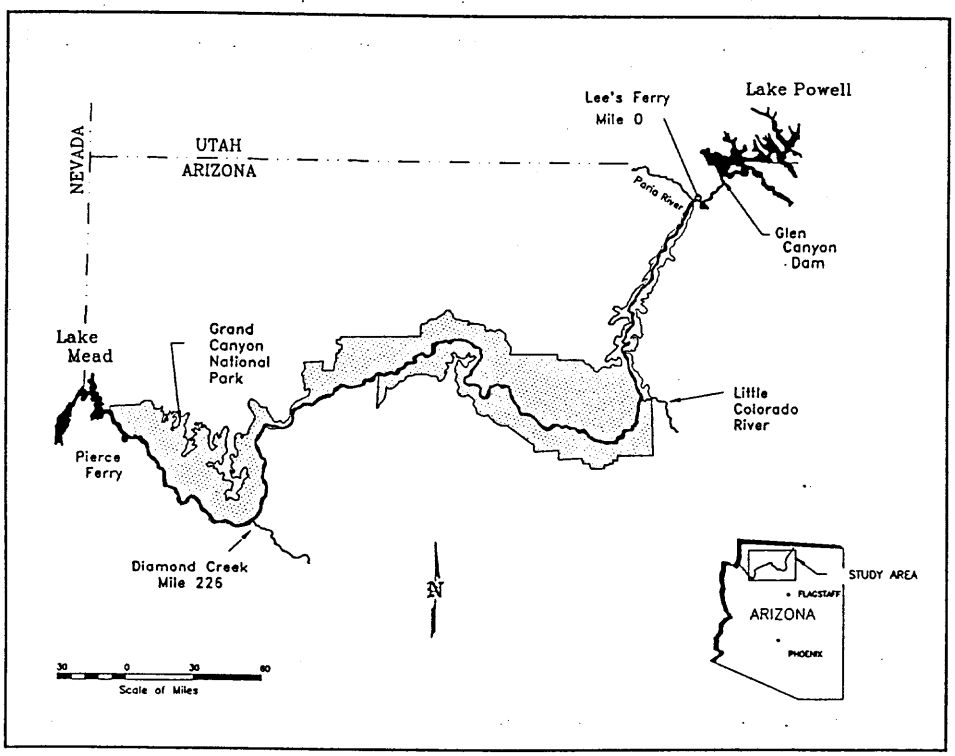

Figure 1. Map of study area

METHODS

Our most comprehensive evaluation involved quickly assessing flood-induced changes to nearly all campsites in the Grand Canyon. Two weeks after the experimental flood, we performed float-by assessments for 200 (92%) of the 218 sandbar campsites that existed before the flood. Documentation and location of the 218 established camps was based on the 1991 campsite inventory (Kearsley and Warren 1993) and adjusted during our two-week pre-flood trip to exclude campsites exclusively on bedrock ledges and to account for site degradation subsequent to the 1991 inventory. Post-flood assessments of these sites consisted of evaluating campsites on-river and deciding, based on our knowledge of the campsites' pre-flood condition, whether the sites appeared to have gained or lost at least ten percent of their pre-flood campsite area, or whether they appeared the same.

We also documented all, and measured many, of the new campsites created by the flood during our two-week and six-month post-flood trips. To attain "new campsite" status, the site must have been accessible, have had sufficient space for a kitchen and 10 or more people, and not be overgrown with vegetation (Kearsley and Warren 1993). We stopped at prospective new campsites, estimated the site's capacity for people and a kitchen while walking on the site, and, when time allowed, mapped campsite area.

Our more in-depth evaluation involved mapping campsite area of 53 of the 218 established campsites two weeks before, two weeks after, and six months after the flood. These 53 established sites were randomly selected within each reach from the original 93 campsites that were measured annually from 1991-1994. We mapped campable area above 20,000 cfs for each site. Areas below 20,000 cfs were not mapped because these areas are often not available under the current dam operations. Mapping consisted of the following steps: Laser xerox copies of the 1:4800 spring 1995 aerial photographs enlarged 400% were used as base maps for the pre-flood measurements, and copies of the spring 1996 post-flood photographs were used for both post-flood measurements. Because of high dam discharges at or close to 20,000 cfs throughout the study period (Figure 1), current water levels and cutbanks were sufficient to determine where the 20,000 cfs water line was at each campsite. We also took pre-flood photographs of the 20,000 cfs line to ensure accurate relocation for the subsequent measurements. While visiting each site, we outlined the perimeter of campable area above 20,000 cfs onto a mylar overlay of the basemap. Campable area is a smooth substrate (almost always sand) with no more than an eight degree slope that has little to no vegetation; basically, area that you could easily sleep or put a kitchen on. Bushes, trees, and boulders seen on the basemap were used as references for campsite area delineations onto the maps. Where campable-area perimeters were not near visual references, we measured distances from the perimeter to visual landmarks in order to later check and sometimes adjust our line placement. While the areas of the larger polygons were later calculated using Geographic Information System (GIS), the length and width of smaller outlying sleep spots, usually less than 15 meters squared (m^2), were measured on-site. Some of the measured sites are within GCES GISlong-term monitoring sites, sites which have high accuracy geodetic survey control points established. We entered campsite area for these sites into the GCES GIS, using rocks and bushes visible on both the campsite basemap and the GIS reach orthophoto as tic marks to transform the coverage into Arizona state plane coordinates. For the sites outside of the GIS sites, we measured distances between rocks or bushes visible on the basemap while visiting each site. After digitizing the maps into GIS, we used the digitized distance to calculate a conversion factor to convert campsite area from digitizer inches to square meters. In addition to mapping the sites, we photographed nearly all the 53 measured established sites and many of the new sites during these time periods.

The new campsites were mapped in a similar fashion. However, since we did not have prior knowledge of the new campsites' locations, we did not have a basemap from which to map campsite area, so drew maps on a blank sheet of paper and took length by width measurements of campsite areas. After the post-flood aerial photographs became available, we transferred our maps onto the enlarged laser xeroxes of the photographs when our drawn maps correlated well with the xeroxes of the actual sites. For sites that did not transfer well, we used only the length by width measurements of the site. These different assessment methods resulted in documentation and a capacity estimate of all new sites, maps of many of the sites, and length by width measurements of a few of the sites two weeks and six months after the flood.

Horizontal mapping accuracy in GIS is estimated at +/-3m for the 53 established sites that were measured. Field mapping has an error of +/-1m while the Arizona State plane orthophotos have an error of +/-2m. Mapping of new campsites is less accurate because areas were originally drawn without a basemap.

RESULTS

Overall Assessment

Our assessments of 92% of all campsites showed a pronounced system-wide increase in campsite area. Half (100/200) of the sites were at least ten percent larger, 39% (77/200) were the same, and 12% (23/200) were smaller than they had been prior to the flood (Appendix A). It is important to note that sand deposition at a site did not always correlate with increased size of the site. Many sites experienced sand deposition on top of campable area already above 20,000 cfs, resulting in higher elevation sand with no increase in campable area. Some sites actually became narrower or gained a mound of sand upon previously campable area, so that sand deposition increased the volume of the sand at the site but decreased the area upon which people could camp. Evaluations of the amount of sand at each site irrespective of how it affected campsite area showed an even sharper increase. There was a substantial increase in sand at 72% (144/200), little to no change at 23%, and a decrease at 5% of the sites. It must be emphasized that these are quick, rough assessments; however, what they lack in actual measurements, they make up for by documenting the experimental flood's effect on nearly every sandbar suitable for camping in the Grand Canyon. In order to check the accuracy of these assessments, we compared the assessments of the 200 sites with the size changes in the 53 measured sites and found the assessments to be less sensitive to change than the measured sites ($X^2_{(2)} = 9.88$, $p<.05$) but not biased towards an increase or decrease in area. Sixty-two percent (33) of the measured sites increased >10% area, 17% (9) were the same size, and 21% (11) decreased in area.

New Campsites

The test flood created 82 and destroyed 3 campsites (Appendix B) and 3 sites were destroyed by the test flood. These sites are new in the sense that they could not accommodate 10 or more people plus a kitchen directly prior to the flood. However, 33 of these sites were large enough in previous years to be included in the 1973, 1983, and/or the 1991 campsite inventories but had since degraded so that they were not suitable as campsites by 1996 (Appendix B). These sites accommodated on average 21 people per site; however, campsite capacity estimates are fairly subjective so should serve solely as a rough approximation of how many people these sites can accommodate. Many of the new sites consisted of deposition upon previously existing low elevation sand bars that were not exposed above 20,000 cfs. These types of sites usually consisted of exposed bars jutting out into the river, offering no protection from sun or wind, and generally are not popular campsites. A few sites were created by deposition of sand on top of a high elevation bar that was overgrown with vegetation. The new sand covered up most of the vegetation, creating ample camping space. The 3 campsites destroyed by the flood, river miles 61.7R ("below LCR island"), 164.8L ("below Tuckup") and 196.5L ("below Frogy Fault"), experienced sand scouring which obliterated most of their campsite area.

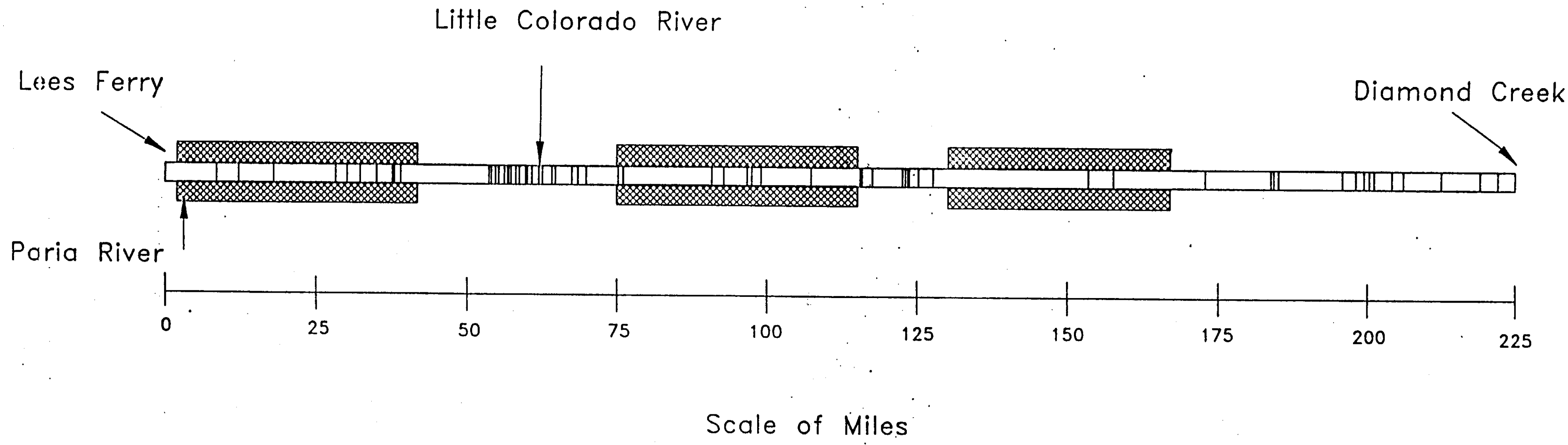

Figure 3. Schematic showing distribution of new campsites. Horizontal bar depicts Colorado River. Lines crossing bar show locations of new campsites. Hatched areas represent critical reaches.

These new campsites were not uniformly distributed by river mile or by reach type. Forty percent of the new sites were created in a 25-mile section between river miles 40-65, with an average of 1.3 new sites/mile (Figure 3). More than twice as many campsites were created per mile above the LCR versus below the LCR so that on average, one new site occurred every 1.6 miles above the LCR and every 3.7 miles below the LCR. Also, more than twice as many campsites were created per mile in non-critical reaches, which averaged one every 2 miles, than in critical reaches, which averaged one every 4.5 miles.

While the high number of new flood-created sites was substantial, it was also short-lived. Six months after the flood only 55% (45/82) of the new sites could still be considered suitable as campsites. These new sites changed total campsite number between Lees Ferry and Diamond Creek from 218 directly before the flood to 297 two weeks after the flood to 262 six months after the flood. Total number of 1996 campsites divided into critical versus non-critical reaches shows that the increase and subsequent decrease in campsite number during the test flood primarily occurred in non-critical reaches (Figure 4). Despite the disproportionately high numbers of new sites above the LCR and in non-critical reaches, new campsite loss above versus below the LCR and in critical versus non-critical reaches was not significantly different (Chi squared test, X^2=0.08 and 1.9 respectively).

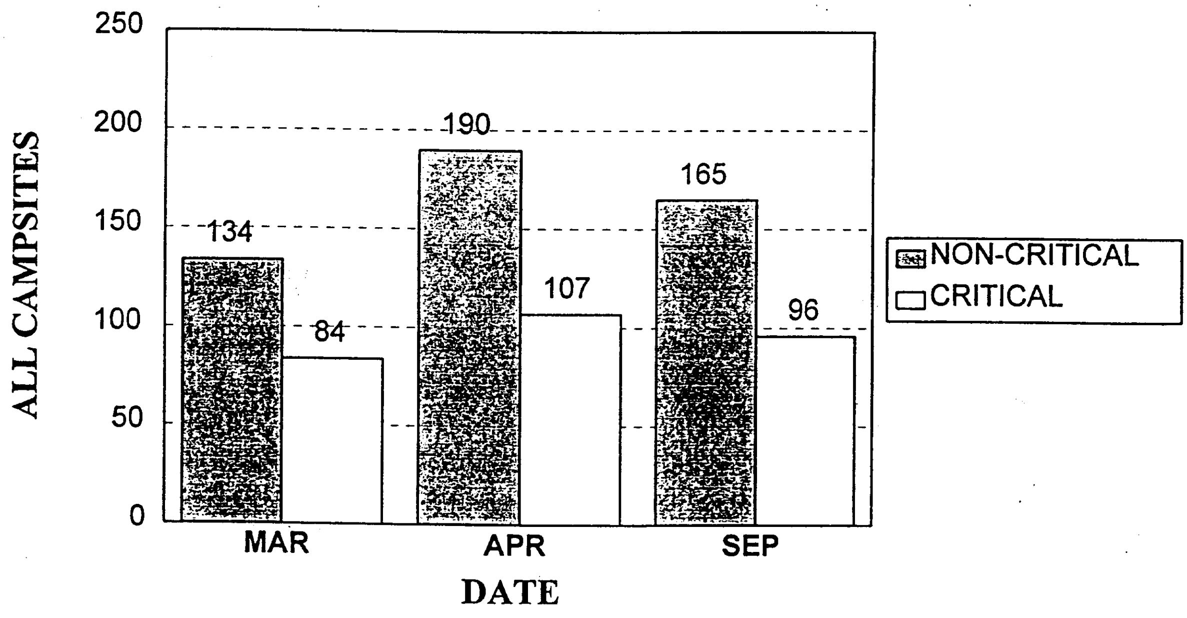

Figure 4. Number of campsites divided into critical and non-critical reaches two weeks prior to the test flood, two weeks after the test flood, and six months after the test flood.

Several factors were attributed to the cause of new campsite loss. Of the 37 sites that lost their campsite status by September, 70% (26) had eroded either completely above 20,000 cfs or to a size too small for camping, 24% (9) were still of adequate size but had such steep slopes along the river that they were inaccessible, and 5% (2) were too vegetated to use (Figure 5) (Appendix B). Vegetation that had been covered by sand at the new sites grew robustly during the summer, possibly benefitting from aspects of the flood or the high summer flows. One of the 26 eroded sites (RM 35.2R) eroded due to a flash flood.

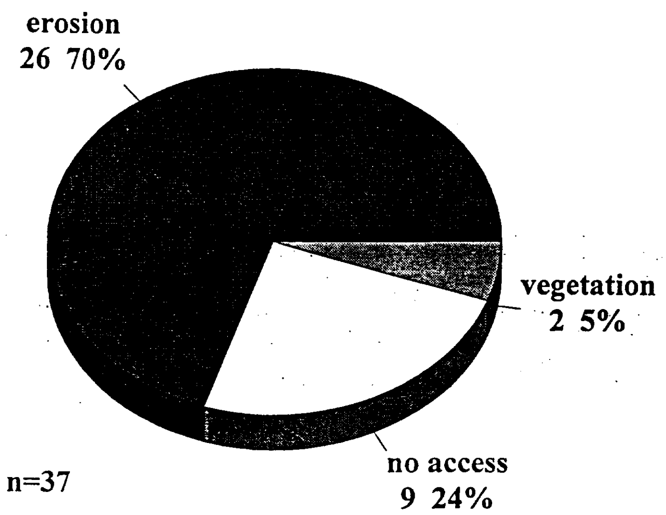

Figure 5. Reasons for loss of 37 flood-created campsites six months after the flood.

We measured 33 new campsites: 20 were mapped and 13 were roughly measured by recording length by width of campable area. Campsite areas also changed dramatically six months after the flood. Two weeks after the flood, the mean area of the 33 sites was 474 m^2, about half the mean area of the 53 established sites measured after the flood. Six months later, the measured sites that remained decreased to a mean of 199 m^2 so that they were on average 45% of their original post-flood size (Appendix B).

Measured Established Campsites

The 53 measured established campsites had a net increase in area two weeks after the flood followed by a net decrease six months after the flood, which resulted in a moderate net increase in size during the six-month time span. Two weeks after the flood the sites increased in area by a mean of 144m^2 from a pre-flood mean area of 700m^2, increasing on average by 57% (Appendix C). Of those that increased in size, campsite area increased on average by 202%. Of those that decreased in size, campsite area decreased on average by 59%. Measured campsites in critical reaches increased on average by 75% of their pre-flood area, while those in non-critical reaches increased by 31%. These differences between critical and non-critical reaches were significant (Mann-Whitney U-test, $u=12$, $p=.05$). Campsites above versus below the LCR behaved similarly, with all measured sites above the LCR increasing in area by 47% of their original area, and sites below the LCR increasing by 60%. By September most sites had decreased in size so that when compared to their pre-flood size, they increased on average by 22% (Figure 6). A histogram showing the numbers of sites which increased by different percentages for the three time periods is shown in Figure 7. Maps of the measured sites in GIS sites are in Appendix D.

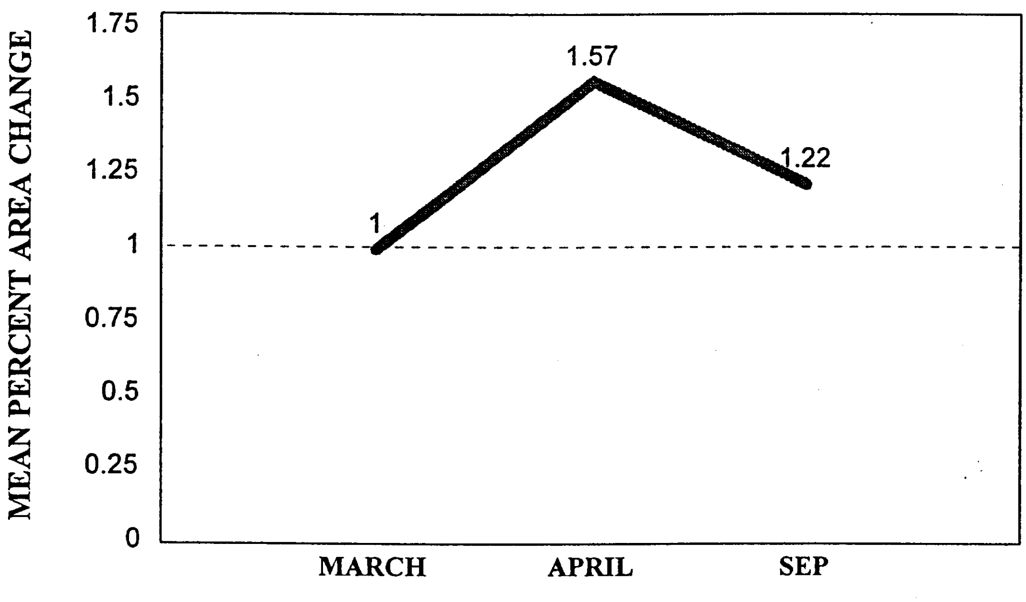

Figure 6. Mean percent area change of the 53 established measured campsites 2 weeks before, 2 weeks after, and 6 months after the test flood.

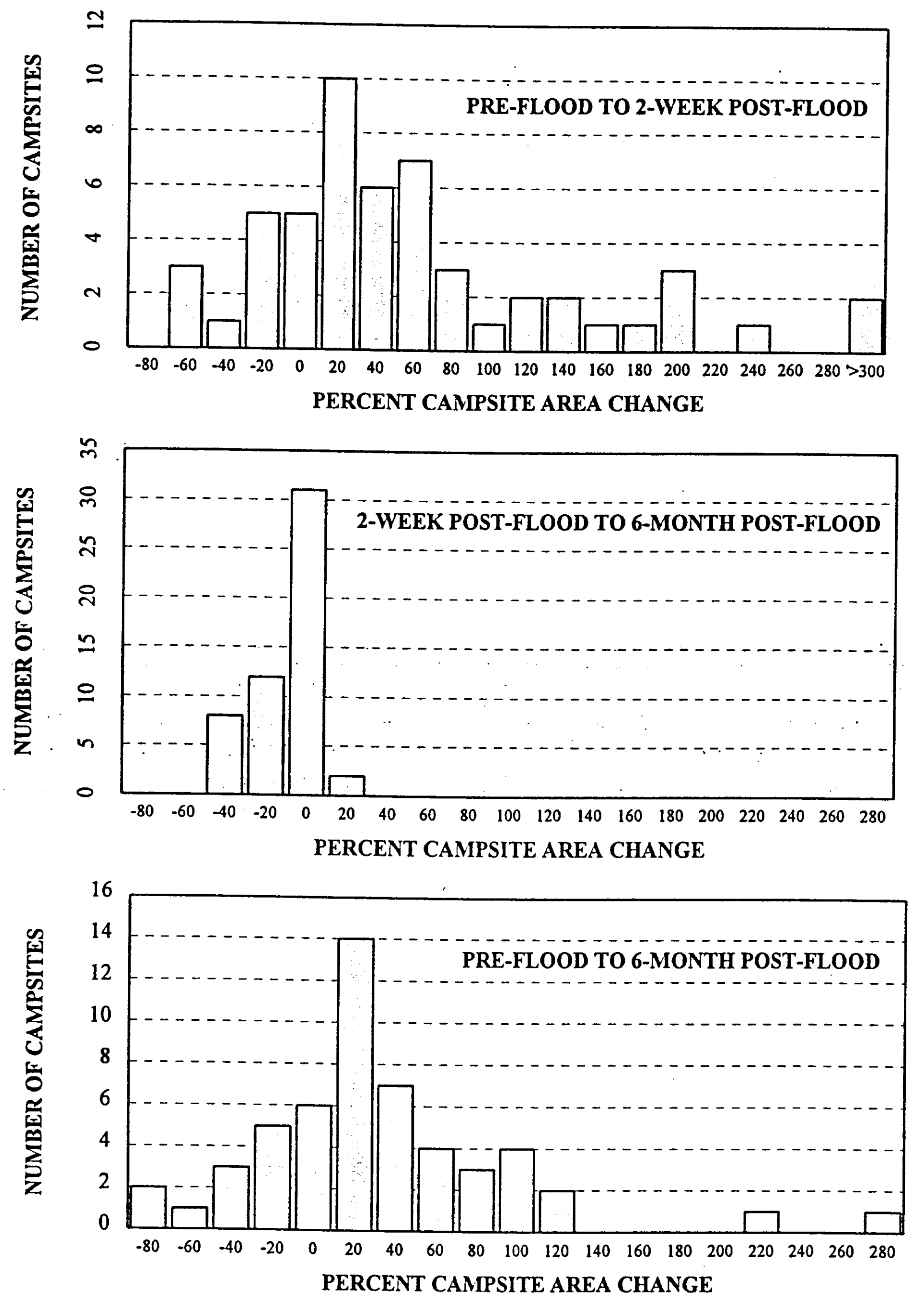

figure 7. Histograms showing percent campsite area change of the 53 established measured campsites for three time periods during the study. Zero on the x-axis represents 0-20% area increase, 20 represents 20-40% increase, -20 represents 0-20% decrease, etc.

DISCUSSION

The test flow has irrefutably increased the number, size, and, consequently, capacity of campsites in the Grand Canyon. Thus, the incorporation of similar flood flows into Glen Canyon Dam's operations would benefit recreational uses of campsites. Under the right conditions, an occasional high flow improves more than four times as many campsites than it degrades, increases camp area on average by over 50%, and creates many new campsites. While new campsites predominated in non-critical reaches, some campsites were created in critical reaches, helping to alleviate the campsite shortage along these river sections. Flooding also reverses the trend of slow degradation that occurs during non-flood years.

When compared to campsite area changes during non-flood years, changes to campsite area due to the test flood were positive and were more pronounced. Campsite area changes consisted of net increases rather than net decreases, were larger, and were more rapid than area changes during the 1991-1994 EIS and monitoring studies. Campsite area above 25,000 cfs of the same sites as those measured during the test flood decreased on average by 16% between 1991 and 1994. As opposed to a 16% area loss over a 3-year time span, measured campsites experienced a 57% and an overall 22% area gain during a 2-week and 6-month post-flood time span, respectively.

The test flow also improved the campsites aesthetically. Particularly in a National Park, river runners prefer to travel through a more natural, dynamic system that is periodically flooded. While steep slopes and cutbanks formed at many of the sites, these higher, steeper sandbars are common along natural river systems in this type of geomorphic setting. Also, in addition to sand deposition, redistribution of sand on campsites cleansed the sites, making them more appealing, particularly in heavily used portable toilet locations (Jeri Ledbetter, pers com.).

While flood-induced benefits to campsites were substantial, degradation of these new deposits occurred fairly quickly. Six months after the flood, nearly half of the new campsites were no longer useable, the remaining new campsites were half their initial size, and most of the increased area on the measured established campsites had eroded. The relatively high near-constant summer flows of 15,000 to 20,000 cfs probably accelerated the erosion process. But even without these high flows, the new deposits appear to last on a much shorter time span than 5 years, which is the planned flooding frequency for future dam management (Bureau of Reclamation 1995). Since various physical, ecological, and legal constraints preclude more frequent flooding, new and larger campsites will subsist for only a portion of the 5-year cycle.

While our measurements consist of only two post-flood time periods, many Grand Canyon river guides photographed and noted campsite changes to many of the sites throughout the summer. Many of these sites appeared to become more stable with a decreased rate of cutbank retreat and smaller cutbanks by July or August. A complete documentation of their repeated photographs and observations will be compiled by the river guides.

One issue of concern was whether the test flood would aggrade or further erode sandbars in Marble Canyon, which begins at Lees Ferry and ends at the LCR. Because the Paria River is the regions's only sizeable sediment source, this limited sediment supply makes Marble Canyon more vulnerable to high elevation sand loss rather than deposition (Randle et al. 1993), and there was uncertainty as to whether the river bed had accumulated enough sediment to aggrade sandbars. However, the high density of new campsites above the LCR, with more than twice the number of new sites per mile than below the LCR, documents that not only did the flood not erode campsites in Marble Canyon, it aggraded sites more than in any other section of the Grand Canyon. This relatively intense deposition may have occurred in part because sites in Marble Canyon were not influenced by the 1993 LCR flood so were in a depleted condition primed for deposition.

A comparison of these inventory number changes with campsite number in previous inventories surrounding floods shows that while the increased number of campsites due to the test flood was substantial, it was not as large as the increase in campsite number due to the 1983 high flows (figure 8). T hose flows, however, were twice as high and occurred after tributary sediment had accumulated on the river channel for approximately 20 years. The new 1983 deposits were also short-lived, with documentation of massive erosion by 1984 (Kearsley et al. 1994). While the 1996 inventory number changes were not as dramatic as they have been in the past, considering the current conditions of more stable existing bars, moderate flood levels, and moderate 5-year river bed sand accumulation, they are nevertheless substantial.

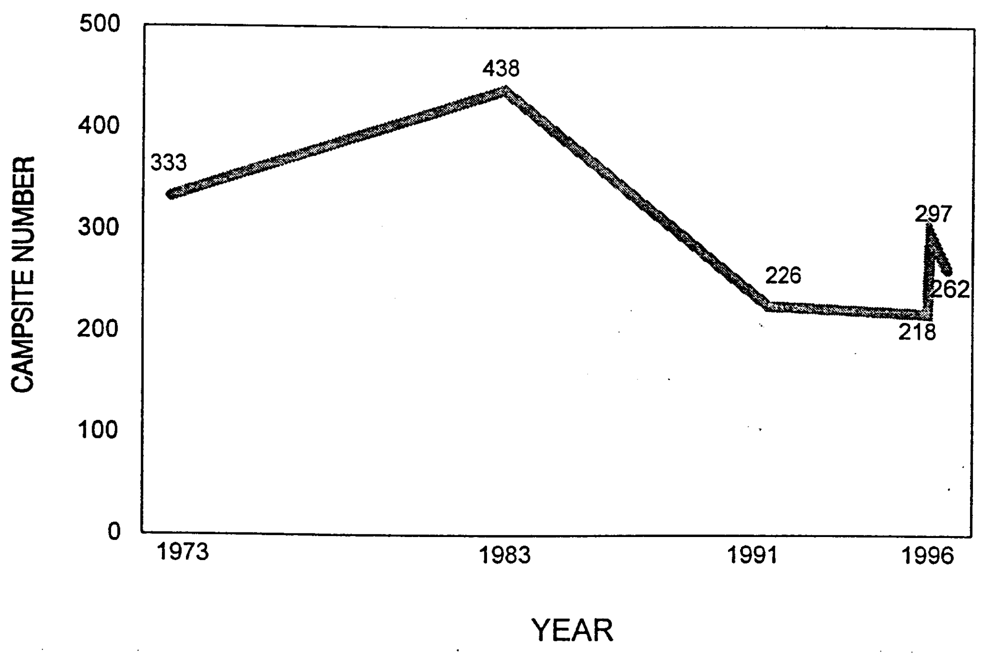

Figure 8. Number of campsites in the Grand Canyon according to the 1973, 1983, 1991, and March, April, and September 1996 campsite inventories.

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APPENDIX A

List of flood-induced changes to all evaluated campsites (n=200) in Grand Canyon. Campsites were evaluated April 1996, two weeks after the flood and were compared to their condition two weeks prior to the flood.

These data are entered on a Lotus 1-2-3 spreadsheet file. Data columns are as follows:

MILE	campsite location according to river mile
SIDE	side of the river while facing downstream
REACH	reach type: **C** = critical reaches (see text for reach definitions and locations) **NC** = non-critical reaches
NAME	campsite name
AREA	post-flood changes to campsite area: **I** = area substantially increased **S** = area remained the same **D** = area substantially decreased
SAND	post-flood changes to the amount of sand at campsite irrespective of changes to campsite area: **I** = amount of sand substantially increased **S** = amount of sand remained the same **D** = amount of sand substantially decreased
NOTES	Pertinent notes about campsite changes. Only notes containing information beyond that found in AREA and SAND columns are included.

MILE	SIDE	REACH	NAME	AREA	SAND	NOTES
8.0	R	NC	BADGER	I	I	
8.0	L	NC	JACKASS	I	I	
11.0	R	C	SOAP CREEK	S	S	
16.4	L	C	HOT NA NA	I	I	
17.0	R	C	HOUSE ROCK	I	I	
19.0	R	C		D	I	LESS AREA, MORE SAND HIGHER UP
19.1	L	C		D	S	US-NEW, STEEP SAND MOUND. DS-SCOURED
19.9	L	C		S	S	MORE AREA BUT DOWNSTREAM SECTION HARD TO REACH
20.4	R	C	UPR NORTH CYN	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
20.5	R	C	LWR NORTH CYN	I	I	
21.5	L	C		I	I	
21.9	R	C		I	I	
23.0	L	C	INDIAN DICK	I	I	
23.7	L	C	LONE CEDAR	S	S	
24.5	L	C	241/2 MILE	S	S	
26.3	L	C	ABOVE TIGER W	I	I	
29.3	L	C	SHINUMO WASH	I	I	
30.4	R	C	FENCE FAULT	I	I	
31.6	R	C	SOUTH CANYON	I	I	JUST OVER 10% LARGER
33.6	L	C	BELOW REDWALL	S	S	
34.0	L	C	LITTLE REDWALL	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
34.8	L	C	NAUTILOID	I	I	
37.7	L	C	TATAHATSO	I	I	
38.3	L	C	MARTHA'S	S	S	
39.0	R	C	REDBUD ALCOVE	D	S	LESS AREA. POORER AESTHETICS
40.9	R	NC	UPR BUCKFARM	S	S	
41.0	R	NC	LWR BUCKFARM	I	I	
43.2	L	NC	ANASAZI BRIDGE	I	I	SAND COVERED WILLOWS, SO MORE AREA
43.3	L	NC	LWR ANASAZI	S	S	
44.2	L	NC	EMINENCE	I	I	
44.6	L	NC		S	S	
44.8	L	NC	WILLIE TAYLOR	I	I	
46.9	L	NC	DUCK N QUACK	S	S	
47.2	R	NC	UPR SADDLE	S	S	
47.3	R	NC	LWR SADDLE	I	I	
50.0	R	NC	DINOSAUR	S	S	
51.2	L	NC		I	I	
51.8	R	NC	LITTLE NANKOWEAP	S	S	
52.6	R	NC	UPR NANKOWEAP	I	I	
53.0	R	NC	NANKOWEAP	S	S	
56.2	R	NC	LWR NANKOWEAP	I	I	
56.7	R	NC		I	I	
57.5	R	NC	MALGOSA	I	I	
57.5	L	NC		I	I	
58.2	R	NC	AWATUBI	S	S	
58.6	L	NC		I	I	
59.0	R	NC		I	I	
59.8	R	NC	60-MILE	S	S	
60.8	R	NC		S	S	
61.0	L	NC		S	S	
61.2	R	NC	ABOVE LCR	I	I	
61.7	R	NC	BELOW LCR	D	D	CAMP DESTROYED BY FLOOD. DOWNSTREAM MAIN AREA GONE
62.6	R	NC	CRASH CYN	S	S	
64.7	R	NC	CARBON	I	I	
65.5	R	NC	LAVA CYN	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
65.7	L	NC	PALISADE CK	S	S	
66.3	L	NC		I	I	
66.8	L	NC	ESPEJO	I	I	
68.4	R	NC	TANNER	I	I	
69.8	R	NC	LWR BASALT	I	I	
71.0	L	NC	CARDENAS	I	I	

MILE	SIDE	REACH	NAME	AREA	SAND	NOTES
71.9	R	NC	UPR UNKAR	S	S	
72.3	L	NC	UNKAR	I	I	
73.6	R	NC	BELOW GRANARY	I	I	
74.1	R	NC	UPR RATTLESNAKE	I	I	
74.3	R	NC	LWR RATTLESNAKE	I	I	
75.6	L	C	NEVILLS	I	I	
75.8	R	C	PAPAGO	S	S	
76.6	L	C	HANCE	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
78.9	L	C	BELOW SOCK	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
81.3	L	C	GRAPEVINE	I	I	
84.0	R	C	CLEAR CK	I	I	
84.4	L	C	ABOVE ZOROASTER	I	I	
87.1	L	C	UPR CREMATION	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
87.2	L	C	LWR CREMATION	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
89.3	R	C	BELOW PIPE CK	I	I	
91.1	R	C	91-MILE CK	I	I	
91.6	R	C	TRINITY CK	I	I	
92.3	L	C	ABOVE SALT CK	S	S	
93.4	L	C	GRANITE	D	S	NEW SAND HIGHER UP, BUT MAIN AREA NARROWER
94.3	R	C		I	I	
94.9	L	C	HERMIT	S	S	
96.0	R	C	UPR SCHIST	I	I	
96.1	L	C	SCHIST	I	I	
98.0	R	C	UPR CRYSTAL	D	D	MAIN AREA SCOURED, UPSTREAM AREAS INACCESSIBLE
102.8	R	C	NEW SHADY GROVE	I	I	
103.8	R	C	EMERALD	I	I	
107.8	L	C	ROSS WHEELER	D	D	SCOURED. DECREASED AREA
108.0	R	C	PARKINS' INSCR	I	I	
108.2	R	C	LWR BASS	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
109.4	R	C	110-MILE	D	D	MUCH SCOURING. DECREASED AREA
114.3	R	C	UPR GARNET	S	I	
118.1	R	NC		I	I	
118.5	L	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
119.0	R	NC	BIG DUNE	I	I	
119.2	R	NC		I	I	
119.5	L	NC	SHADY GROVE	I	I	
119.8	L	NC	120-MILE	S	I	
120.0	R	NC	UPR BLACKTAIL	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
120.1	R	NC	LWR BLACKTAIL	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
120.2	L	NC		D	D	MAIN AND DOWNSTREAM AREAS SCOURED. MUCH SMALLER
120.9	L	NC		S	S	
122.2	R	NC	122-MILE	D	I	
122.7	L	NC	UPR FORSTER	I	I	
125.4	L	NC	BELOW FOSSIL	I	I	
126.5	R	NC	RANDY'S ROCK	D	D	MOST OF LOWER AREA GONE
131.1	R	C	BELOW BEDROCK	D	D	MUCH OF MAIN AREA GONE
131.8	R	C	GALLOWAY	S	S	
132.0	R	C	STONE CK	I	I	
133.0	L	C	TALKING HEADS	I	I	
133.5	R	C	RACETRACK	I	I	
133.8	R	C	TAPEATS	S	S	
133.9	R	C	BELOW TAPEATS	I	I	
134.2	L	C		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
134.6	L	C	OWL EYES	I	I	
136.0	L	C	JUNEBUG	S	S	
136.2	L	C	ACROSS DEER CK	S	S	
136.3	L	C	OC'S	I	I	
136.8	L	C	PONCHO'S KITCHEN	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
136.9	L	C	FOOTBALL FIELD	I	I	
137.0	L	C	BACKEDDY	D	S	HIGH BERM BETWEEN MAIN AREA AND RIVER, DRIFTWOOD
137.9	L	C	DORIS	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE

MILE	SIDE	REACH	NAME	AREA	SAND	NOTES
138.2	L	C		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
138.4	L	C		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
139.0	R	C	FISHTAIL	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
139.8	L	C	KEYHOLE	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
143.3	L	C	ABOVE KANAB	I	I	
143.5	R	C	MOUTH OF KANAB	I	I	
144.2	R	C	BELOW KANAB	S	S	
145.1	L	C	ABOVE OLO	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
145.6	L	C	OLO	I	I	
147.9	R	C	OPP MATKAT	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
148.4	L	C	MATKAT HOTEL	I	I	
148.5	L	C	BELOW MATKAT	D	S	GAIN AND LOSS OF CAMP AREA
150.3	L	C	UPSET HOTEL	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
155.7	R	C	LAST CHANCE	I	I	
157.7	R	C	FIRST CHANCE	I	I	
158.5	R	C	SECOND CHANCE	I	I	
160.0	L	C	160-MILE	D	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
160.7	R	C		I	I	
164.5	R	NC	TUCKUP	I	I	
164.8	L	NC	BELOW TUCKUP	D	D	CAMP DESTROYED BY FLOOD
166.5	L	NC	UPR NATIONAL	D	D	LESS AREA ALONG RIVER
166.6	L	NC	LWR NATIONAL	S	I	
167.0	L	NC	BELOW NATIONAL	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
167.2	L	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
168.0	R	NC	FERN GLEN	I	I	
171.0	R	NC	STAIRWAY CYN	S	S	
171.6	L	NC	MOHAWK	I	I	
172.1	L	NC	172-MILE	I	I	
173.0	R	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
174.3	R	NC	UPR COVE	I	I	
174.4	R	NC	LWR COVE	I	I	
176.0	L	NC	BELOW RED SLIDE	I	I	
177.1	L	NC	HONGA SPRING	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
177.7	L	NC	ABOVE ANVIL	I	I	
178.0	R	NC	VULCAN'S ANVIL	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
179.0	L	NC	ABOVE LAVA	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
179.2	L	NC	JUST ABOVE LAVA	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
179.7	R	NC	BELOW LWR LAVA	S	S	
182.5	R	NC	UPR CHEVRON	I	I	
182.6	R	NC	LWR CHEVRON	I	I	
182.8	R	NC	BELOW CHEVRON	I	I	
182.8	L	NC		I	I	
183.0	L	NC	BELOW OLD HEDIPAD	S	S	
184.5	L	NC		I	I	
185.5	R	NC		S	S	
186.0	L	NC		D	D	MOST OF CAMP AREA ALONG RIVER GONE
188.0	R	NC	WHITMORE WASH	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
188.2	R	NC	LWR WHITMORE	I	I	
189.5	L	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
189.7	L	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
190.3	L	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
191.0	R	NC	UPPER FAT CITY	S	I	
191.8	L	NC	FAT CITY	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
192.2	R	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
192.8	L	NC		S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
194.1	L	NC	HUALAPAI ACRES	I	I	
196.4	L	NC	FROGY FAULT	S	I	NEW SAND HIGHER UP, BUT NO AREA CHANGE
196.5	L	NC	BELOW FROGY	D	D	CAMP DESTROYED. HEAVY GULLY EROSION
198.5	R	NC	PARASHANT	I	I	
202.0	R	NC	202-MILE	D	S	RIVER SIDE OF MAIN AREA GONE. ALSO, NEW SAND HIGHER UP
202.5	R	NC		I	I	

MILE	SIDE	REACH	NAME	AREA	SAND	NOTES
204.5	R	NC	BELOW SPRING CYN	I	I	
206.6	R	NC	INDIAN CYN	I	I	
208.8	L	NC	GRANITE PARK	S	S	
209.5	R	NC		I	I	
210.7	R	NC	BIG CEDAR	I	I	
211.2	L	NC		I	I	
212.9	L	NC	PUMPKIN SPRINGS	I	I	
215.6	R	NC	OPP THREE SPRING	I	I	
216.4	R	NC		D	S	NARROWER, NEW SAND HIGHER UP
219.8	R	NC	UPPER 220-MILE	S	I	
219.9	R	NC	MIDDLE 220-MILE	D	I	MORE SAND BUT LESS AREA
220.0	R	NC	LOWER 220-MILE	D	S	NARROWER. ALSO, NEW SAND HIGHER UP
221.2	R	NC	221-MILE	I	I	
222.0	L	NC	222-MILE	I	S	SAND LOSS AND GAIN. A TRADE-OFF
223.0	R	NC	223-MILE	S	S	
223.4	L	NC	224-MILE	I	I	
224.5	L	NC		I	I	

APPENDIX B

List of new campsites (n = 82) in April 1996 two weeks after the flood, and fate of these campsites in September, 6 months after the flood.

These data are entered on a Lotus 1-2-3 spreadsheet file. Data columns are as follows:

MILE campsite location according to river mile
SIDE side of the river while facing downstream
RCH reach type: **C** = critical reaches (see text for reach definitions and locations)
NC = non-critical reaches
ACAP campsite capacity in April: number of people the site can accommodate
SCAP campsite capacity in September
MAP list of sites that were mapped or measured; a blank cell indicates that neither was done:
MAP = the site was mapped
LXW = the site was measured by taking length by widths of campsite areas
PHOTO list of whether the site was photographed
AAREA campsite area in meters squared for campsites that were either mapped or measured in April 1996
SAREA campsite area in meters squared for campsites that were either mapped or measured in September 1996
AREACHG change in campsite area in meters squared between April and September
% Percent of April campsite area that remained in September
SEPCAMP lists which new campsites were no longer suitable as campsites by September
N = no longer suitable
73INV lists sites which were included in 1973 inventory
83INV lists sites which were included in 1983 inventory
SEPT-COMMENTS pertinent notes about campsite conditions in September that are not covered in previous columns

MILE	SIDE	RCH	ACAP	SCAP	MAP	PHOTO	AAREA	SAREA	AREACHG	%	SEPCAMP	73INV	83INV	SEPT COMMENTS
8.5	L	NC	30	20	MAP		580	190	-390	0.33				
12.2	L	C	18	13	MAP	Y	490	270	-220	0.55			83	
18.0	L	C	12	12	LXW	Y	360	90	-270	0.25		73	83	
28.3	L	C	10	10	MAP		50	50	0	1.00				
30.2	R	C	25	25	MAP		360	280	-80	0.78		73	83	
32.4	L	C	33	16	LXW		420	90	-330	0.21				
35.1	L	C	11		MAP		40	0	-40	0.00	N	73		SOME LOSS DUE TO FLASH FLOOD (10M)
35.2	R	C	12		LXW		180	0	-180	0.00	N			ALL LOSS DUE TO FLASH FLOOD (184M)
37.8	R	C	11		MAP		360	50	-310	0.14	N			
38.1	L	C	15	10	LXW		360	40	-320	0.11				
39.2	R	C	12								N			
43.4	L	NC	17	12								73		
44.3	L	NC	25	17	LXW		1310	170	-1140	0.13				ALL LOSS DUE TO VEG ENCROACHMENT (1140M)
44.9	L	NC	16		LXW		520	0	-520	0.00	N			EPHEMERAL ISLAND
47.4	L	NC	10								N		83	
47.5	L	NC	15								N			
48.4	R	NC	36		LXW		1020				N			TOO STEEP ACCESS
48.5	L	NC	17	17	LXW	Y	280	130	-150	0.46				
49.6	L	NC	11								N		83	TOO STEEP ACCESS
50.1	R	NC	22	22								73	83	DIFFICULT ACCESS
53.4	R	NC	20	20	LXW	Y	720	280	-440	0.39		73	83	
53.8	L	NC	20	20	MAP	Y	510	270	-240	0.53		73	83	
54.2	R	NC	25	25	LXW	Y	510	300	-210	0.59		73	83	SOME AREA LOSS DUE TO VEG (26M)
54.9	R	NC	18	11	MAP		220	100	-120	0.45				ALL AREA LOSS DUE TO VEG (121M)
55.4	L	NC	18	12	MAP	Y	460	280	-180	0.61			83	ALL AREA LOSS DUE TO VEG (180M)
55.5	R	NC	36	36										
56.4	R	NC	25	13	MAP	Y	470	110	-360	0.23				
56.9	L	NC	18	16								73	83	STEEP ACCESS, VEG ENCROACHMENT (EQ)
57.0	R	NC	18								N			TOO STEEP ACCESS
57.1	R	NC	18								N			TOO STEEP ACCESS
57.2	L	NC	25								N		83	NO LONGER A CAMP DUE TO VEG ENCROACHMENT
57.5	L	NC	36	36										
58.3	L	NC	15	12										
58.9	L	NC	12	12										
59.9	L	NC	12	12										
60.2	L	NC	12								N		83	TOO STEEP ACCESS
60.9	R	NC	36								N			
61.0	L	NC	15	11										VEG ENCROACHMENT (SAEX,EQ)
62.0	R	NC	26	22										
62.1	R	NC	26	18										
62.7	R	NC	28								N			
62.8	R	NC	36								N			
64.2	R	NC	28								N			
64.8	R	NC	18	15	LXW	Y	480	250	-230	0.52				
67.5	L	NC	28								N		83	

MILE	SIDE	RCH	ACAP	SCAP	MAP	PHOTO	AAREA	SAREA	AREACHG	%	SEPCAMP	73INV	83INV	SEPT COMMENTS
68.5	L	NC	11		LXW	Y	430	10	-420	0.02	N			ALL AREA LOSS DUE TO VEG (SAEX, ALCA, TESE, 400M)
69.9	L	NC	20	16								73		VEG ENCROACHMENT (ALCA, TESE)
75.1	L	NC	11								N			
76.0	L	C	18	16										SOME VEG ENCROACHMENET (SAEX, ALCA)
76.1	L	C	20		MAP	Y	980				N			NO APPROACH--SHALLOW BAR
90.9	L	C	20	13	MAP		130	70	-60	0.54		73	83	LOSS FROM NON-RIVER EROSION (AEOLIAN, PEOPLE?)
92.9	L	C	11			Y					N			
96.8	L	C	10								N	73	83	
97.6	R	C	12								N			STEEP ACCESS
99.1	L	C	10								N			
99.6	L	C	36	36								73		STEEP ACCESS, BUT WORTH IT
107.4	R	C	30	18	MAP	Y	210	170	-40	0.81		73	83	
115.5	L	C	26	16								73	83	STEEP, ROCKY ACCESS
115.8	R	C	18		LXW	Y	280	0	-280	0.00	N			
117.5	R	NC	25	25		Y								
122.5	L	NC	24	24										
123.0	R	NC	20	16										
123.4	L	NC	18								N	73	83	
123.6	L	NC	30								N			
125.2	R	NC	18								N			NO PULL-IN--SWIFT CURRENT
127.6	R	NC	11								N			
153.5	R	C	15		MAP	Y	210	130	-80	0.62	N		83	
157.7	R	C	24	24	MAP	Y	280	280	0	1.00		73	83	
172.9	R	NC	16		MAP		410				N			
184.0	R	NC	20	16										
184.5	L	NC	36		MAP	Y	1610				N			NO ACCESS-US ARMORING, DS MUDDY AND STEEP
185.3	R	NC	28	20								73	83	
196.0	R	NC	25	22	MAP		570	350	-220	0.61			83	MUDDY ACCESS
198.2	R	NC	20	18										VEG ENCROACHMENT (TAMARISK, TESE)
199.6	R	NC	10								N	73		SOME VEG ENCROACHMENT (TESE, EQ)
200.5	R	NC	30								N			
201.3	R	NC	36	36									83	STEEP, MUDDY ACCESS
204.3	R	NC	10								N		83	SOME AREA LOSS DUE TO FF
206.2	R	NC	25	10	MAP		610	170	-440	0.28				
212.6	R	NC	25	18								73	83	
219.1	R	NC	21	21	MAP	Y	230	440	210	1.91		73		
222.1	L	NC	14								N	73		TOO STEEP ACCESS

APPENDIX C

List of established campsites that were mapped (n = 53). Mapping occurred in March, April, and September 1996, two weeks before, two weeks after, and six months after the flood, respectively.

These data are entered on a Lotus 1-2-3 spreadsheet file. Data columns are as follows:

MILE	campsite location according to river mile
SIDE	side of the river while facing downstream
NAME	campsite name
RCH	reach type: **C** = critical reaches (see text for reach definitions and locations) **NC** = non-critical reaches
MAREA	campsite area in meters squared in March
AAREA	campsite area in meters squared in April
SAREA	campsite area in meters squared in September
MA	how campsite area changed from March to April: **I** = area increased by >10% **S** = area remained the same **D** = area decreased by >10%
MAPER	proportion of March campsite area in April (April area/March area)
MAAREA	change in campsite area in meters squared between March and April
AS	how campsite area changed from April to September: **I** = area increased by >10% **S** = area remained the same **D** = area decreased by >10%
ASPER	proportion of April campsite area in September (Sept area/April area)
ASAREA	change in campsite area in meters squared between April and September
MS	how campsite area changed from March to September: **I** = area increased by >10% **S** = area remained the same **D** = area decreased by >10%
MSPER	proportion of March campsite area in September (Sept area/March area)
MSAREA	change in campsite area in meters squared between March and September

MILE	SIDE	NAME	RCH	MAREA	AAREA	SAREA	MA	MAPER	MAAREA	AS	ASPER	ASAREA	MS	MSPER	MSAREA
8.0	L	Jackass	NC	2380	3370	2850	I	1.42	990	D	0.85	-520	I	1.20	470
19.0	R	upper 19-mile	C	230	180	160	D	0.78	-50	D	0.89	-20	D	0.70	-70
19.9	L	20 mile	C	330	450	420	I	1.36	120	S	0.93	-30	I	1.27	90
20.4	R	upper North Canyon	C	400	410	410	S	1.03	10	S	1.00	0	S	1.03	10
21.5	L	22-mile Wash	C	120	310	260	I	2.58	190	D	0.84	-50	I	2.17	140
21.9	R	22-mile	C	140	470	270	I	3.36	330	D	0.57	-200	I	1.93	130
23.0	L	Indian Dick	C	710	1270	1150	I	1.79	560	S	0.91	-120	I	1.62	440
31.6	R	South Canyon	C	1000	1200	1030	I	1.20	200	D	0.86	-170	S	1.03	30
37.7	L	Tatahatso	C	430	580	550	I	1.35	150	S	0.95	-30	I	1.28	120
39.0	R	Redbud Alcove	C	250	190	160	D	0.76	-60	D	0.84	-30	D	0.64	-90
44.2	L	Eminence	NC	870	1230	1080	I	1.41	360	D	0.88	-150	I	1.24	210
47.3	R	Lower Saddle	NC	1570	1670	920	I	1.06	100	D	0.55	-750	D	0.59	-650
53.0	R	Main Nankoweap	NC	710	730	720	S	1.03	20	S	0.99	-10	S	1.01	10
56.2	R	Kwagunt	NC	1220	1780	1270	I	1.46	560	D	0.71	-510	S	1.04	50
61.7	R	below LCR island	NC	990	200	170	D	0.20	-790	D	0.85	-30	D	0.17	-820
64.7	R	Carbon	NC	300	880	500	I	2.93	580	D	0.57	-380	I	1.67	200
66.8	L	Espejo	NC	160	190	170	I	1.19	30	D	0.89	-20	S	1.06	10
74.3	R	lower Rattlesnake	NC	320	460	360	I	1.44	140	D	0.78	-100	I	1.13	40
75.6	L	Nevills	NC	1990	4030	2880	I	2.03	2040	D	0.71	-1150	I	1.45	890
76.6	L	Hance	C	530	480	470	S	0.91	-50	S	0.98	-10	D	0.89	-60
84.0	R	Clear Creek	C	50	290	160	I	5.80	240	D	0.55	-130	I	3.20	110
84.4	L	above Zoroaster	C	312	830	430	I	2.66	518	D	0.52	-400	I	1.38	118
91.1	R	lower 91-mile	C	320	380	360	I	1.19	60	S	0.95	-20	I	1.13	40
94.3	R	94-mile	C	120	350	220	I	2.92	230	D	0.63	-130	I	1.83	100
96.1	L	Schist	C	190	420	340	I	2.21	230	D	0.81	-80	I	1.79	150
98.0	R	upper Crystal	C	340	300	300	D	0.88	-40	S	1.00	0	D	0.88	-40
103.8	R	Emerald	C	100	510	370	I	5.10	410	D	0.73	-140	I	3.70	270
107.8	L	Ross Wheeler	C	250	140	110	D	0.56	-110	D	0.79	-30	D	0.44	-140
109.4	R	110-mile	C	1280	390	210	D	0.30	-890	D	0.54	-180	D	0.16	-1070
114.3	R	upper Garnet	C	410	450	420	S	1.10	40	S	0.93	-30	S	1.02	10
119.8	L	120-mile	NC	1530	1660	1550	S	1.08	130	S	0.93	-110	S	1.01	20
122.2	R	122-mile	NC	1860	1650	1550	D	0.89	-210	S	0.94	-100	D	0.83	-310
125.4	L	below Fossil	NC	610	810	770	I	1.33	200	S	0.95	-40	I	1.26	160
131.1	R	below Bedrock	C	940	310	300	D	0.33	-630	S	0.97	-10	D	0.32	-640
131.8	R	Galloway	C	200	200	200	S	1.00	0	S	1.00	0	S	1.00	0
132.0	R	Stone Creek	C	1010	1390	1080	I	1.38	380	D	0.78	-310	S	1.07	70
133.0	L	Talking Heads	C	240	470	310	I	1.96	230	D	0.66	-160	I	1.29	70
134.6	L	Owl Eyes	C	1120	1920	960	I	1.71	800	D	0.50	-960	D	0.86	-160
136.0	L	Junebug	C	160	230	160	S	1.44	70	D	0.70	-70	S	1.00	0
137.0	L	Backeddy	C	470	370	370	D	0.79	-100	S	1.00	0	D	0.79	-100
148.5	L	Lower Matkat	C	260	200	110	D	0.77	-60	D	0.55	-90	D	0.42	-150
155.7	R	Last Chance	C	120	210	230	I	1.75	90	I	1.10	20	I	1.92	110

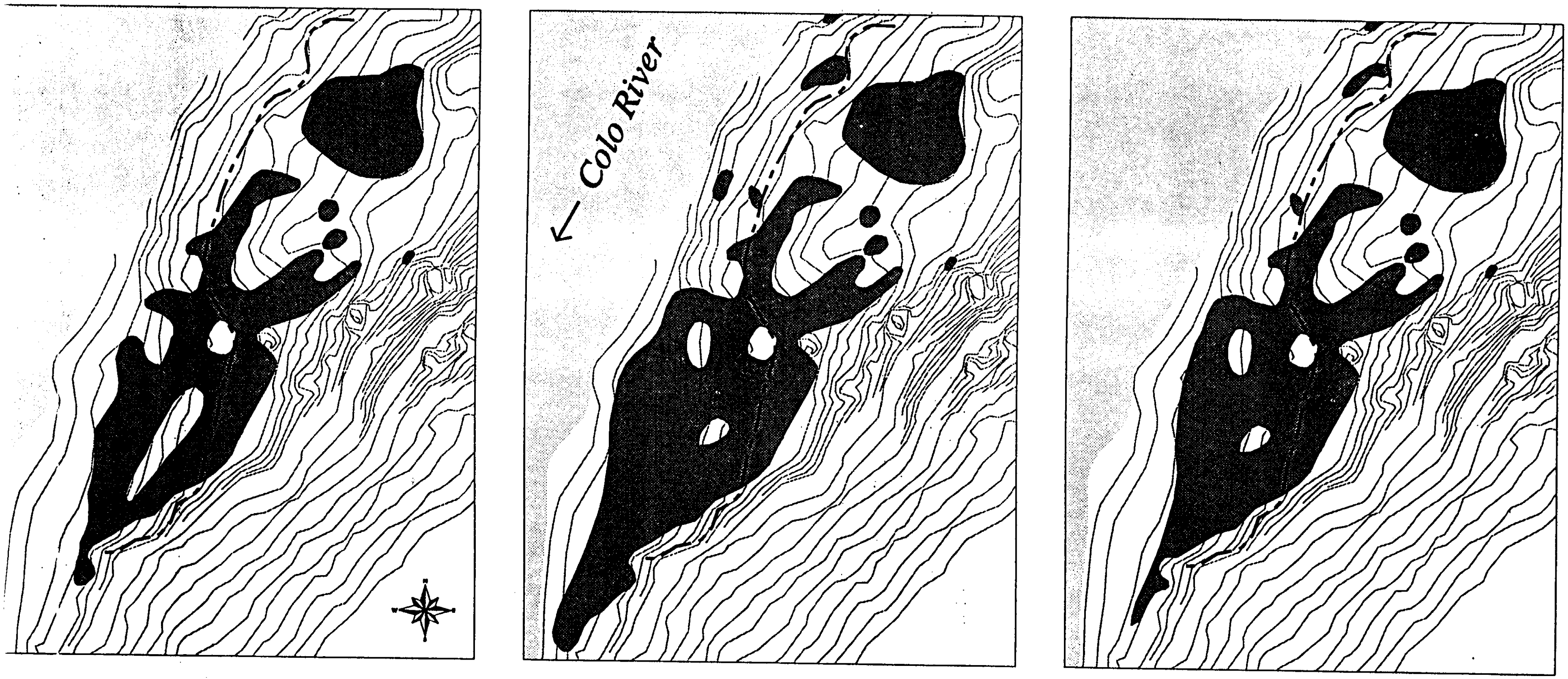
MILE	SIDE	NAME	RCH	MAREA	AAREA	SAREA	MA	MAPER	MAAREA	AS	ASPER	ASAREA	MS	MSPER	MSAREA
158.5	R	Second Chance	C	100	240	210	I	2.40	140	D	0.88	-30	I	2.10	110
160.7	R	161-mile	C	230	660	440	I	2.87	430	D	0.67	-220	I	1.91	210
166.6	L	lower National	NC	1340	1290	950	S	0.96	-50	D	0.74	-340	D	0.71	-390
174.3	R	upper Cove	NC	570	850	850	I	1.49	280	S	1.00	0	I	1.49	280
174.4	R	lower Cove	NC	2040	2240	2180	I	1.10	200	S	0.97	-60	S	1.07	140
177.7	L	above Anvil	NC	320	420	360	I	1.31	100	D	0.86	-60	I	1.13	40
188.2	R	lower Whitmore	NC	520	750	640	I	1.44	230	D	0.85	-110	I	1.23	120
212.9	L	Pumpkin Springs	NC	350	740	520	I	2.11	390	D	0.70	-220	I	1.49	170
219.8	R	upper 220-mile	NC	1300	1390	1320	S	1.07	90	S	0.95	-70	S	1.02	20
219.9	R	middle 220-mile	NC	1930	1290	1290	D	0.67	-640	S	1.00	0	D	0.67	-640
222.0	L	222-mile	NC	490	620	710	I	1.27	130	I	1.15	90	I	1.45	220

APPENDIX D

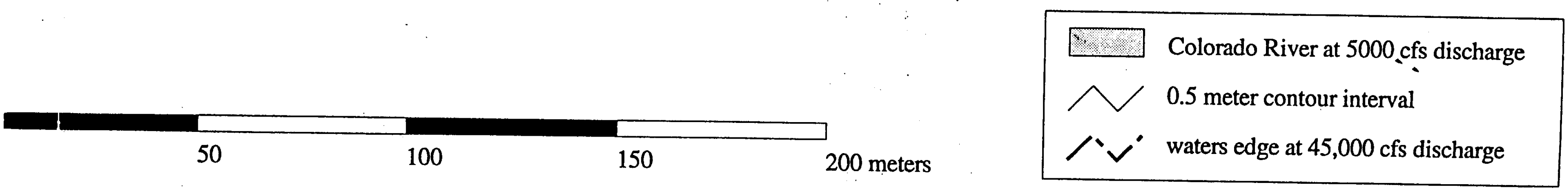
Maps of established campsites within GCES GIS reaches two weeks prior, two weeks after, and six months after the test flow. Dark gray polygons represent campable area at each site. The Colorado River at 5000 cfs delineation for all maps was determined from the 1990 aerial orthophotos so does not always correspond with the actual water's edge at 5,000 cfs during the time of the mapping. Water's edge at 45,000 cfs was determined on site two weeks after the test flood by observing cutbanks and driftlines.

Campable Area: 8.0R, Jackass

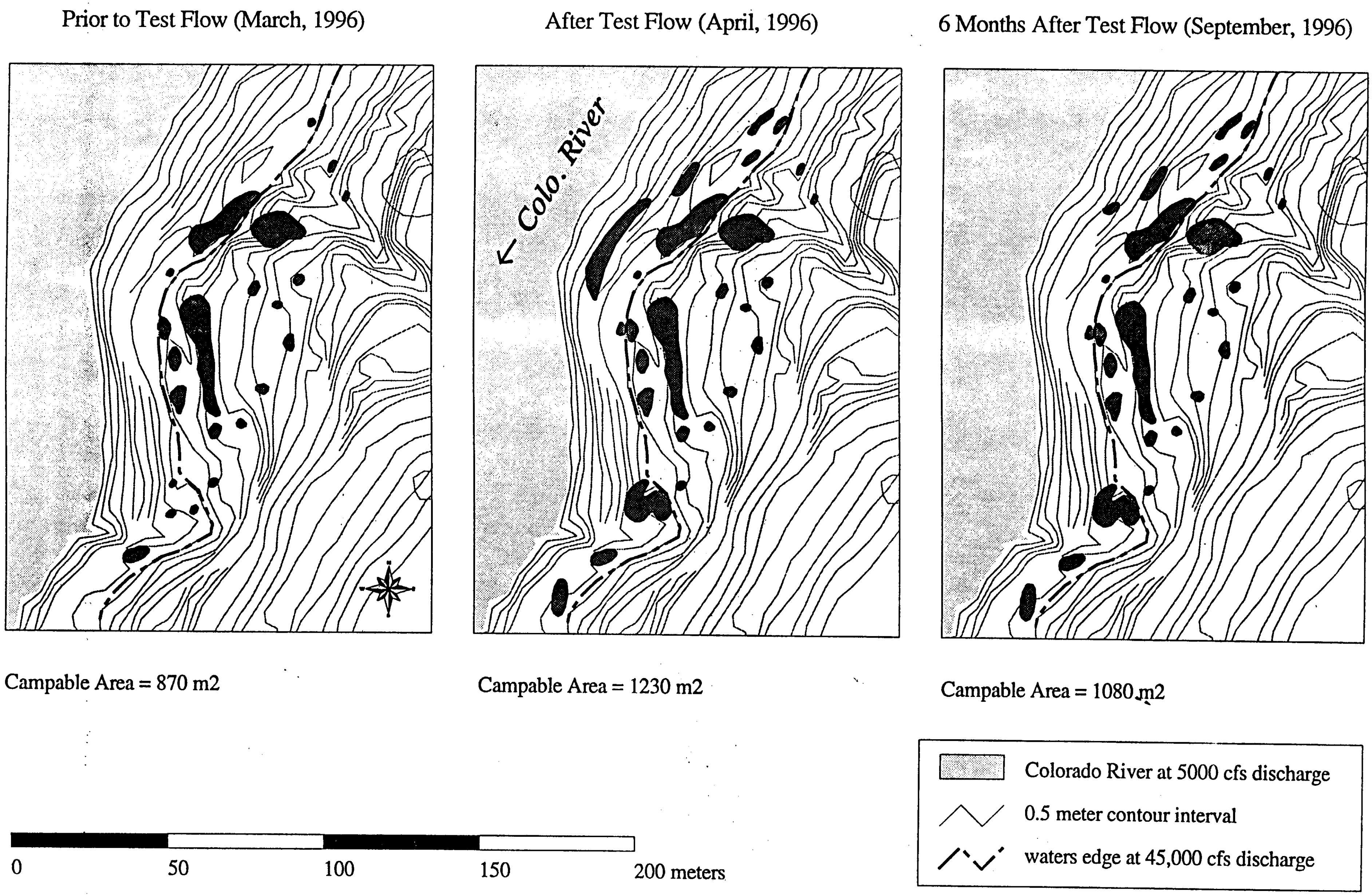
Prior to Test Flow (March, 1996) | After Test Flow (April, 1996) | 6 Months After Test Flow (September, 1996)



ımpable Area = 2380 m2 | Campable Area = 3370 m2 | Campable Area = 2850 m2



Campable Area: 44.2L, Eminence

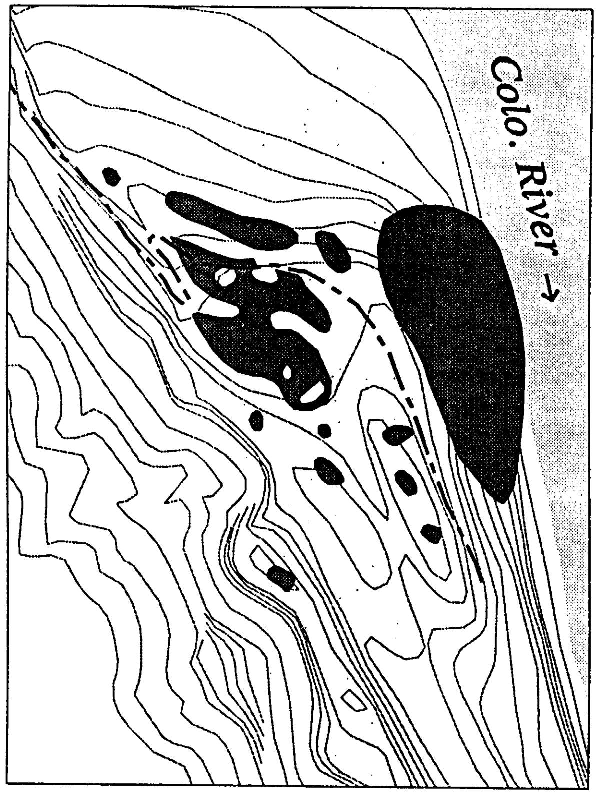


Campable Area: 47.2R, Lower Saddle

Prior to Test Flow (March, 1996)

Campable Area = 1570 m2

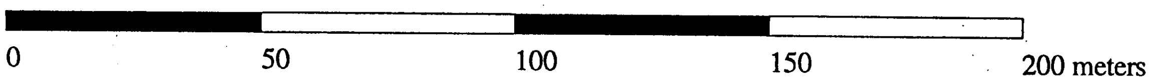
After Test Flow (April, 1996)

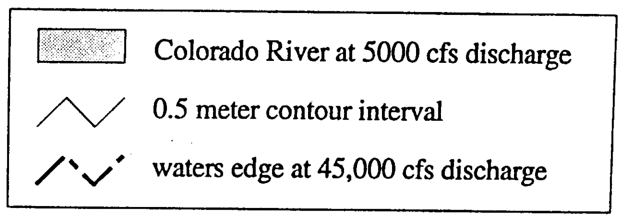


Campable Area = 1670 m2

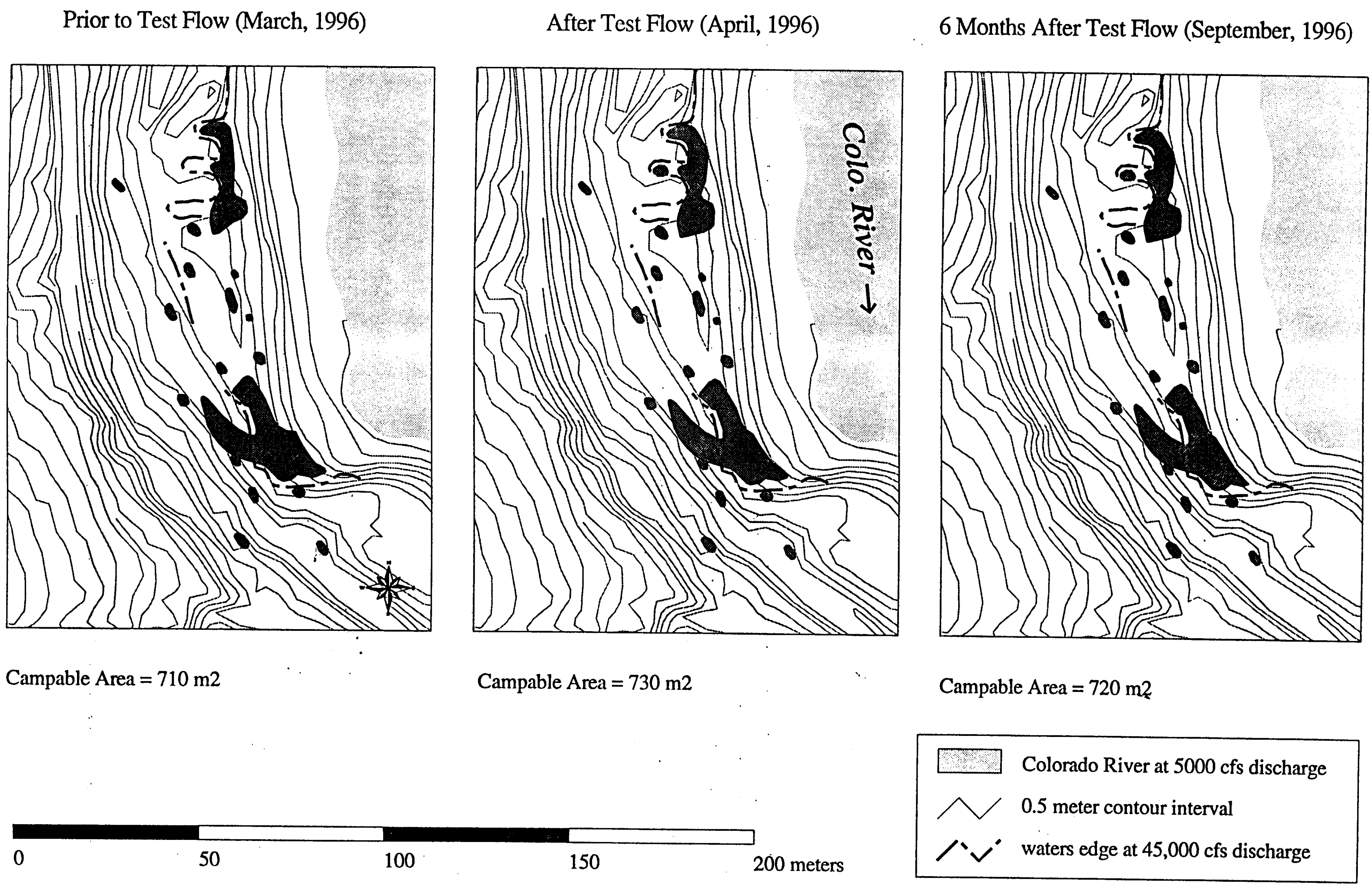
6 Months After Test Flow (September, 1996)

Campable Area = 920 m2

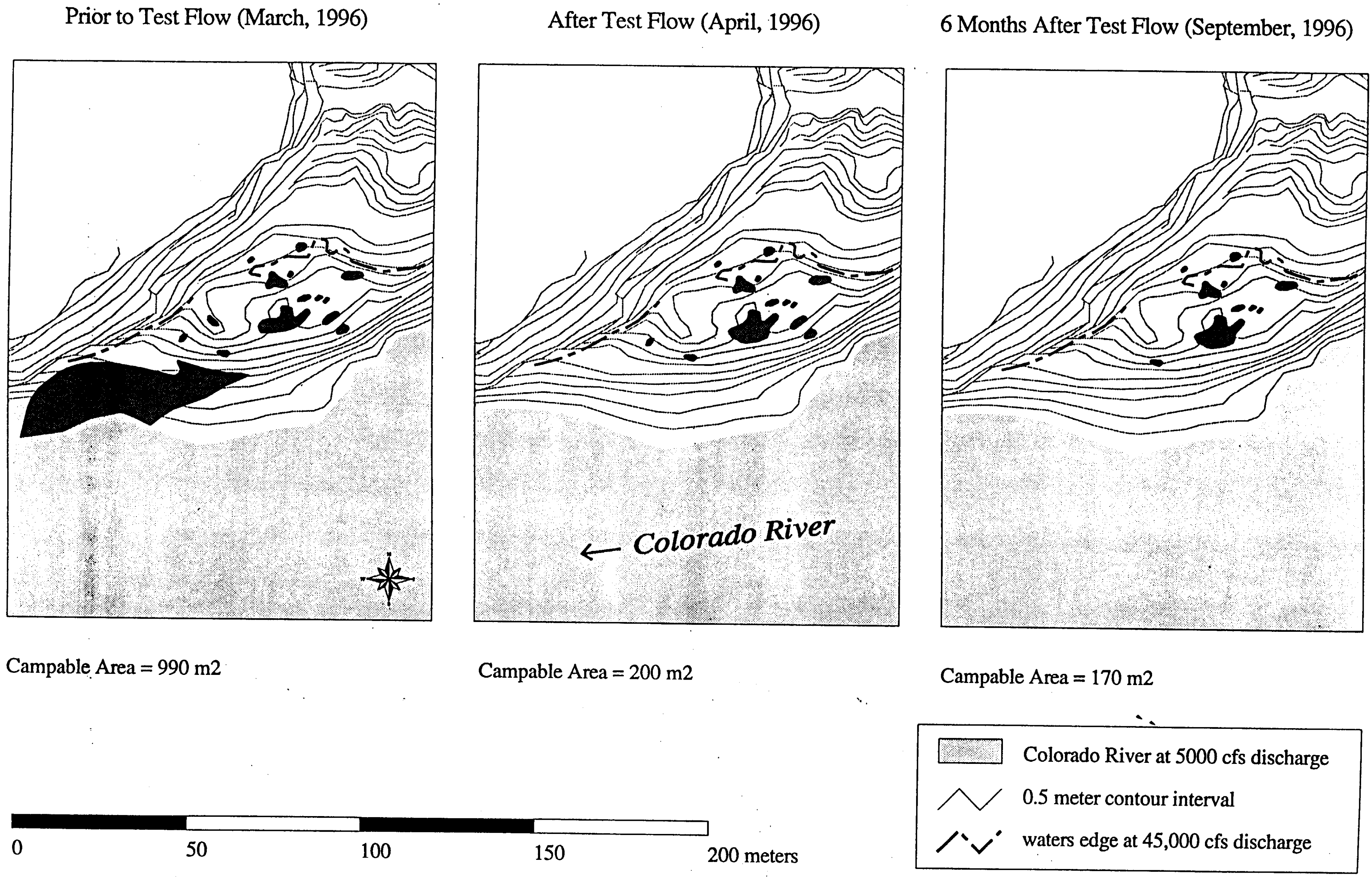




Campable Area: 53.0 Mile

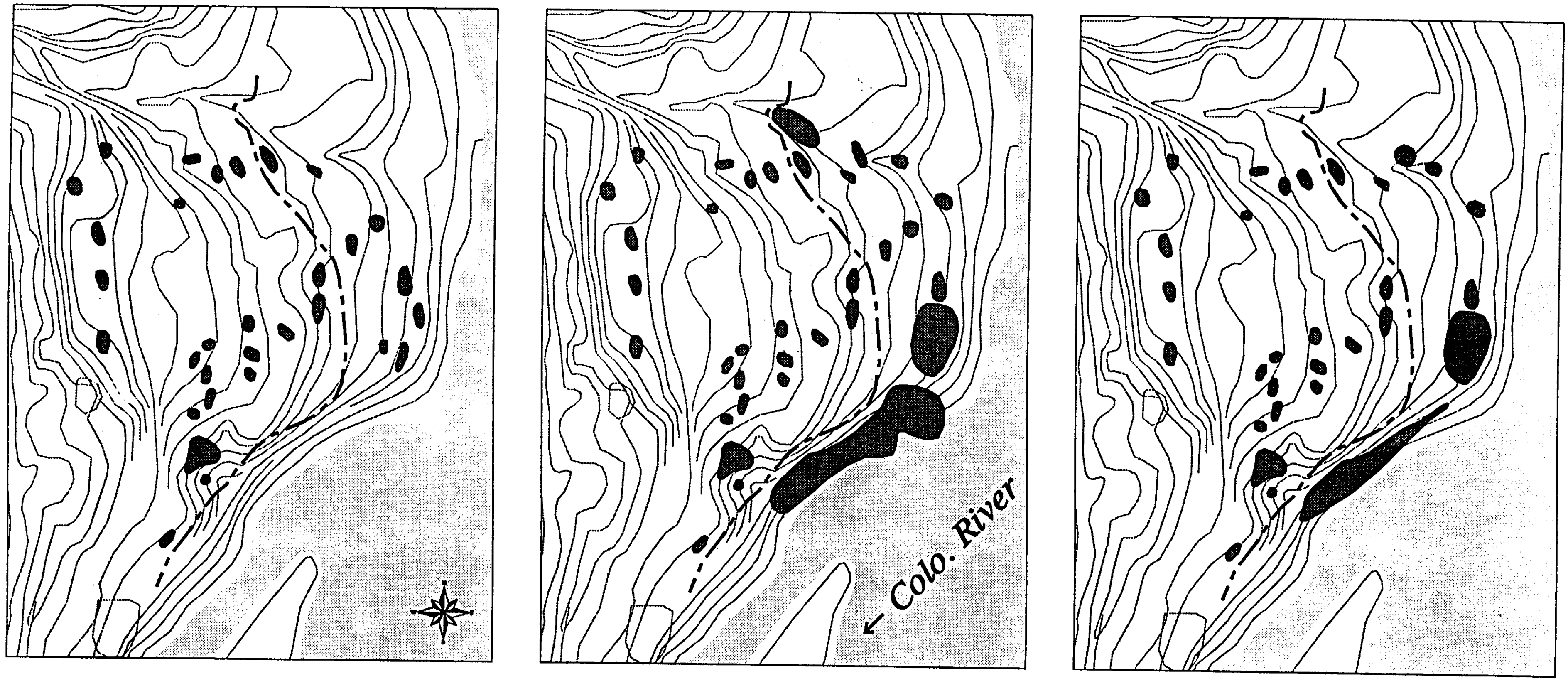


Campable Area: 61.7R, below LCR island

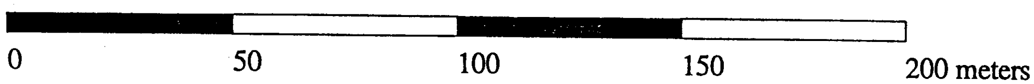


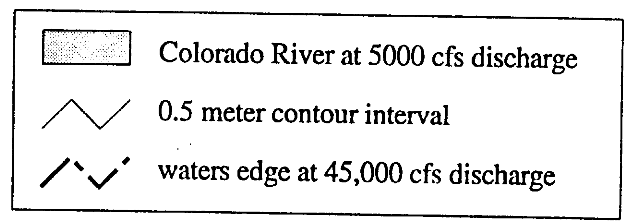
Campable Area: 64.7R, Carbon

Prior to Test Flow (March, 1996) | After Test Flow (April, 1996) | 6 Months After Test Flow (September, 1996)

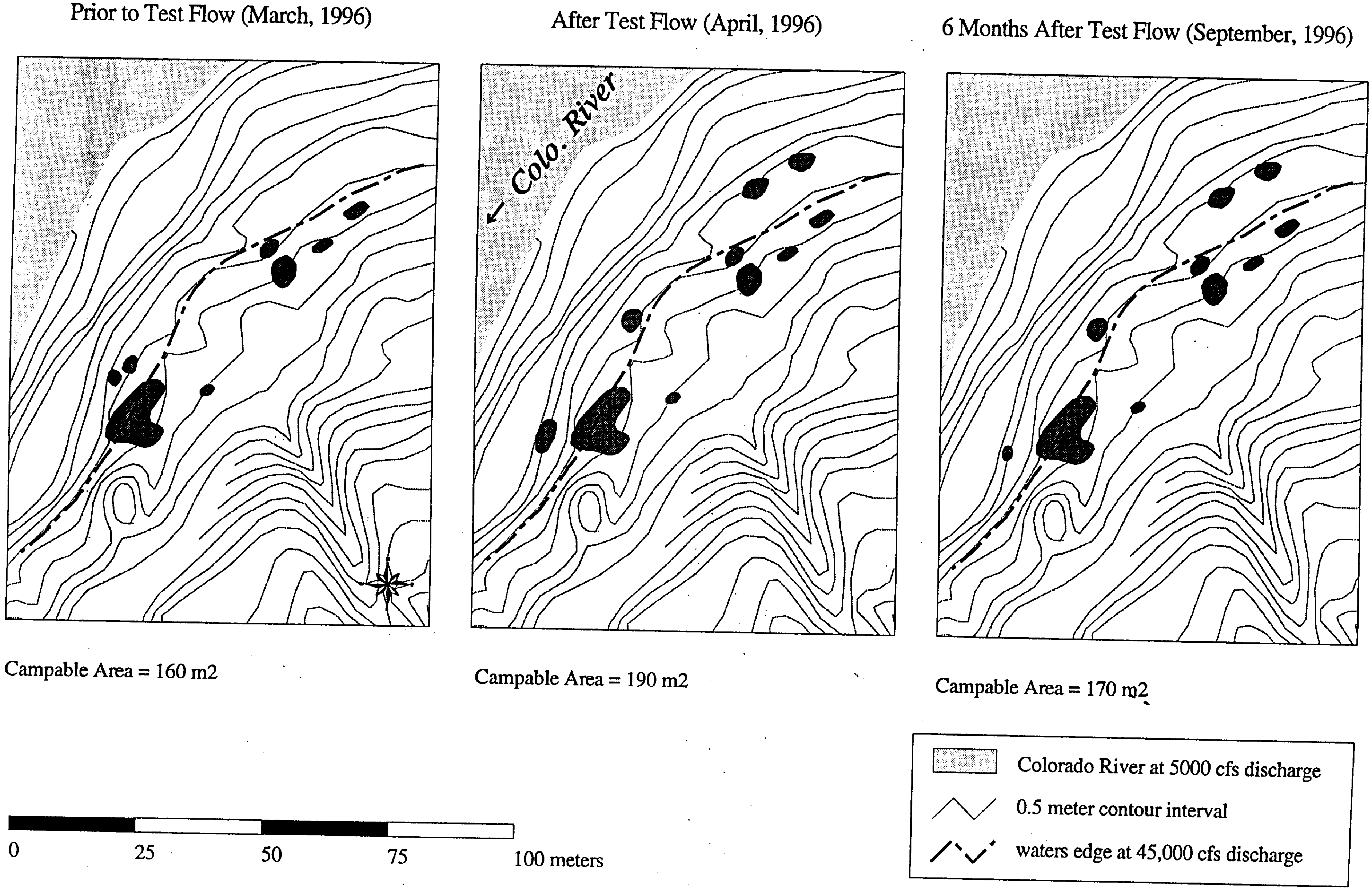


Campable Area = 300 m2 | Campable Area = 880 m2 | Campable Area = 500 m2

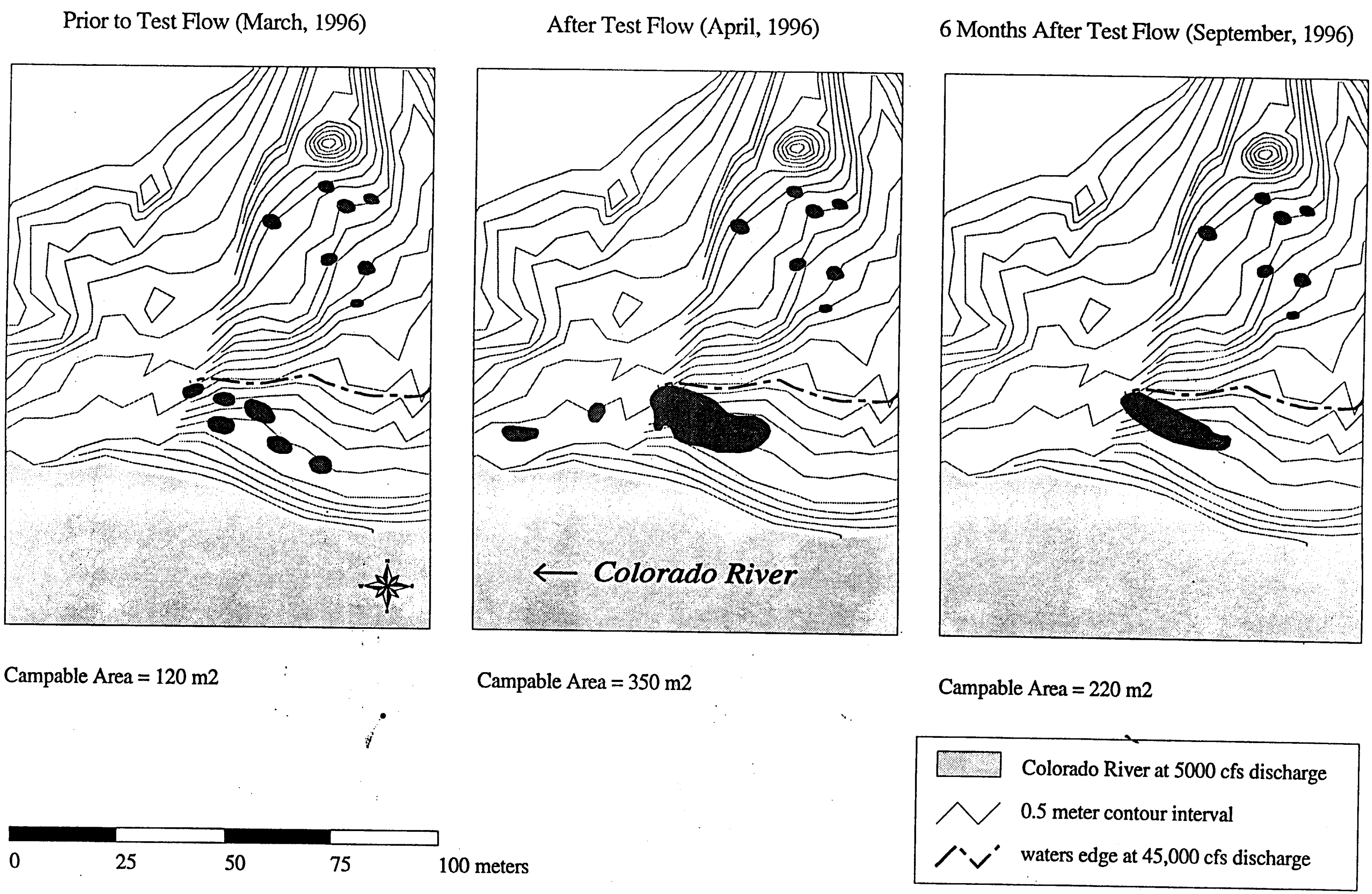




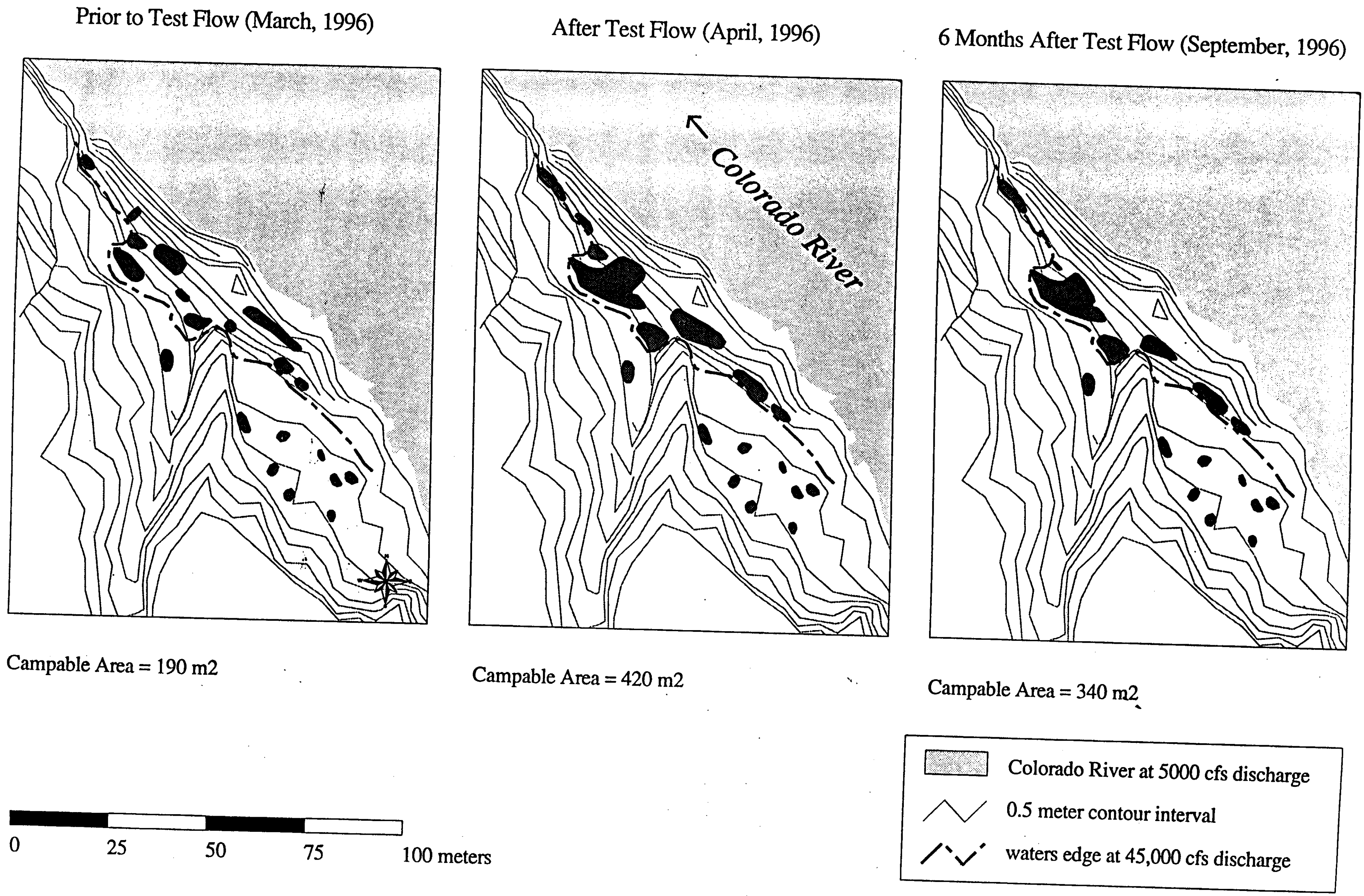
Campable Area: 66.8L, Espejo



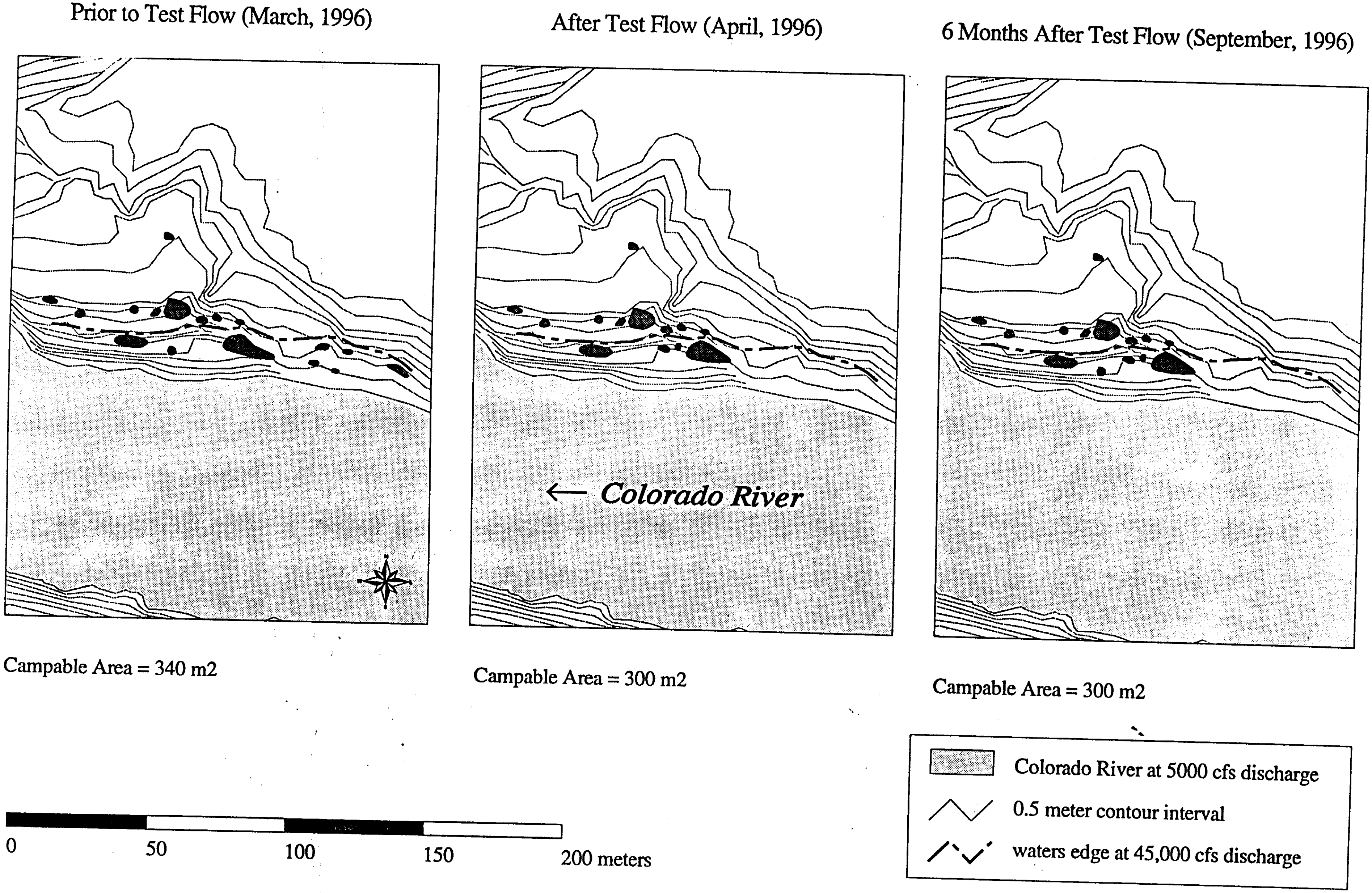
Campable Area: 94.3R, 94-mile



Campable Area: 96.1L, Schist

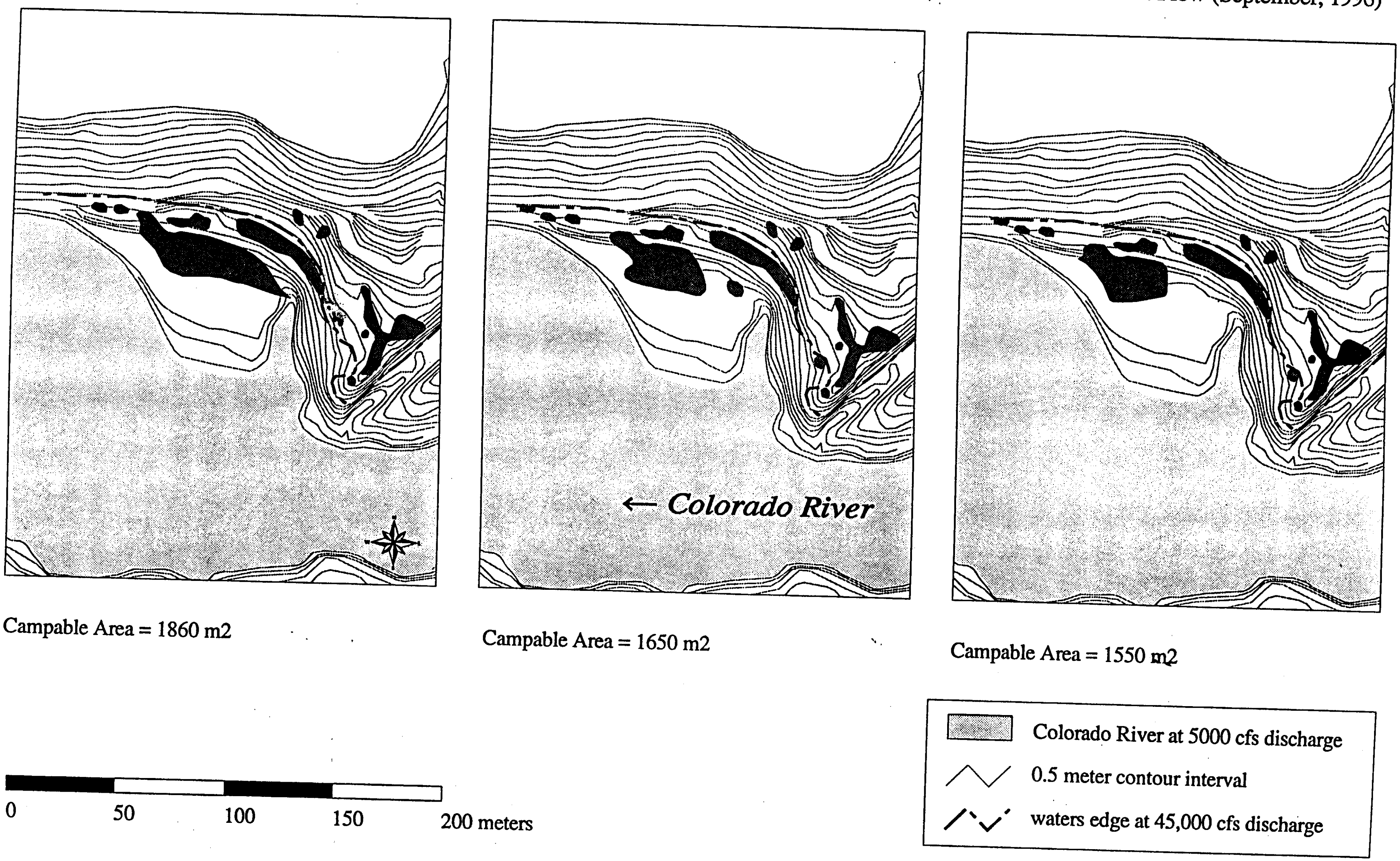


Campable Area: 98.0R, upper Crystal



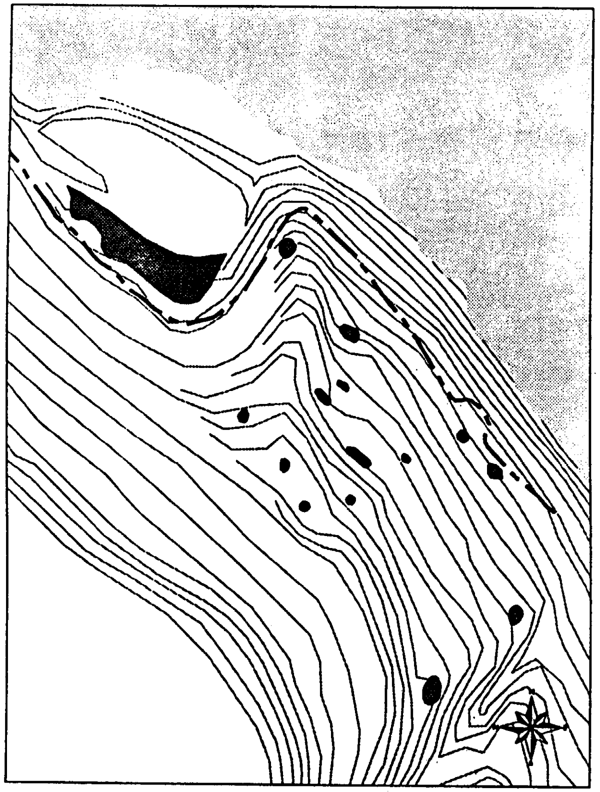
Campable Area: 122.2R, 122–mile

Prior to Test Flow (March, 1996) — After Test Flow (April, 1996) — 6 Months After Test Flow (September, 1996)



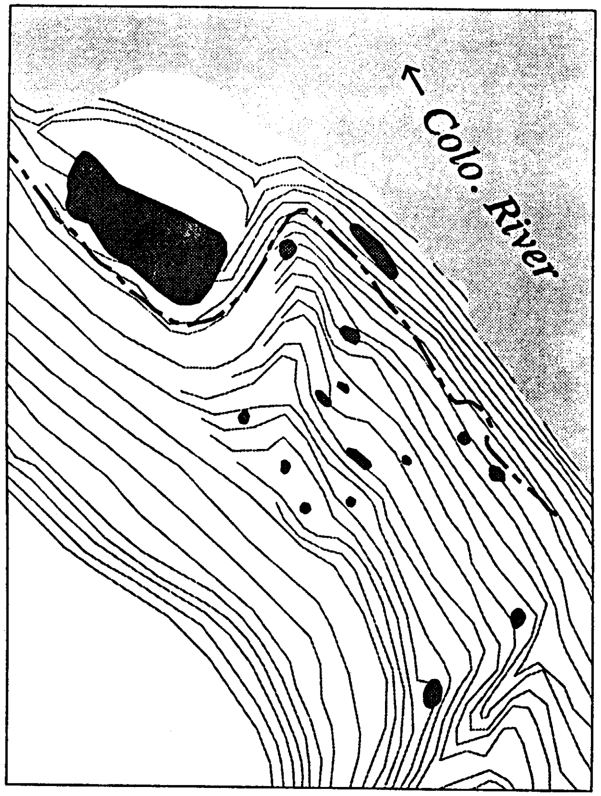
Campable Area: 133.0L, 133–mile

Prior to Test Flow (March, 1996)



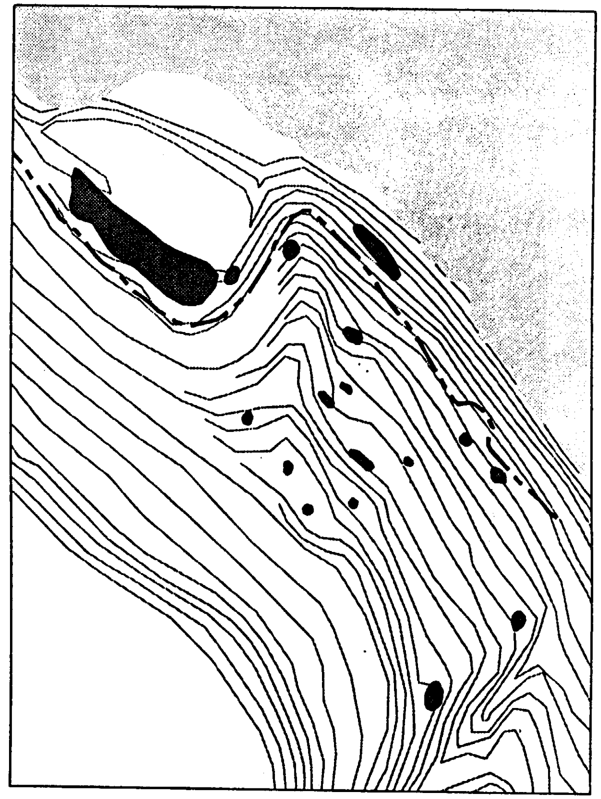
Campable Area = 240 m2

After Test Flow (April, 1996)

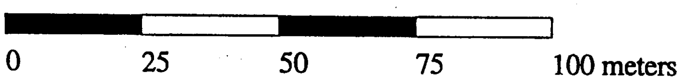


Campable Area = 470 m2

6 Months After Test Flow (September, 1996)



Campable Area = 310 m2



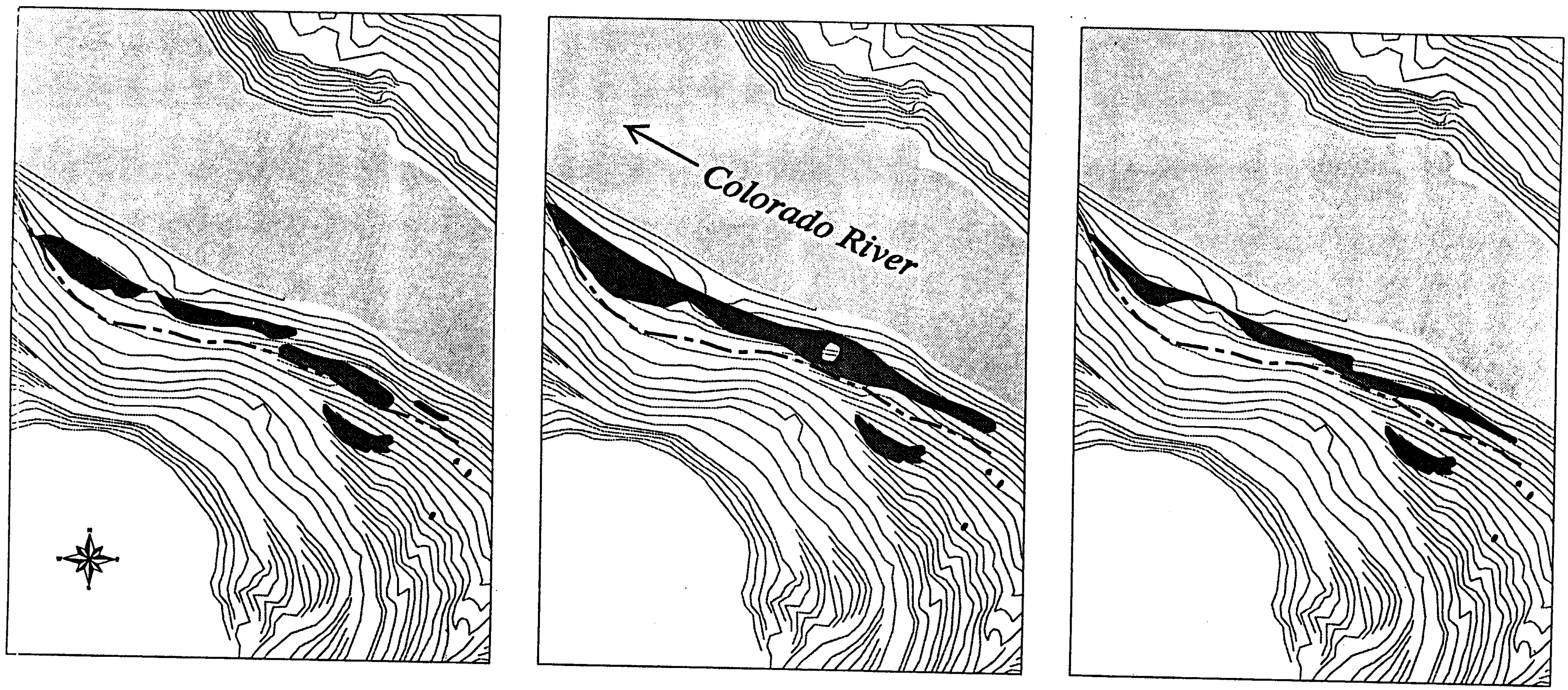
Colorado River at 5000 cfs discharge

0.5 meter contour interval

waters edge at 45,000 cfs discharge

Campable Area: 134.6L, Owl Eyes

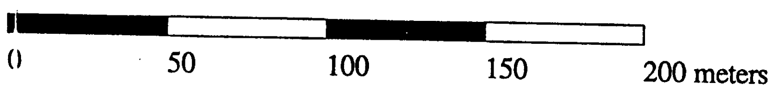
Prior to Test Flow (March, 1996) | After Test Flow (April, 1996) | 6 Months After Test Flow (September, 1996)

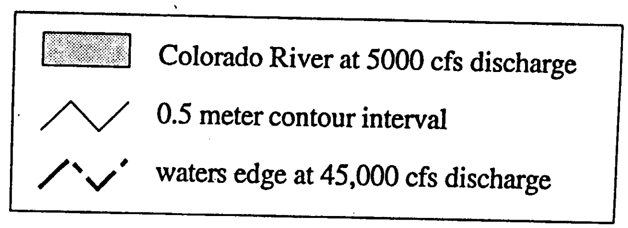


Campable Area = 1135 m2

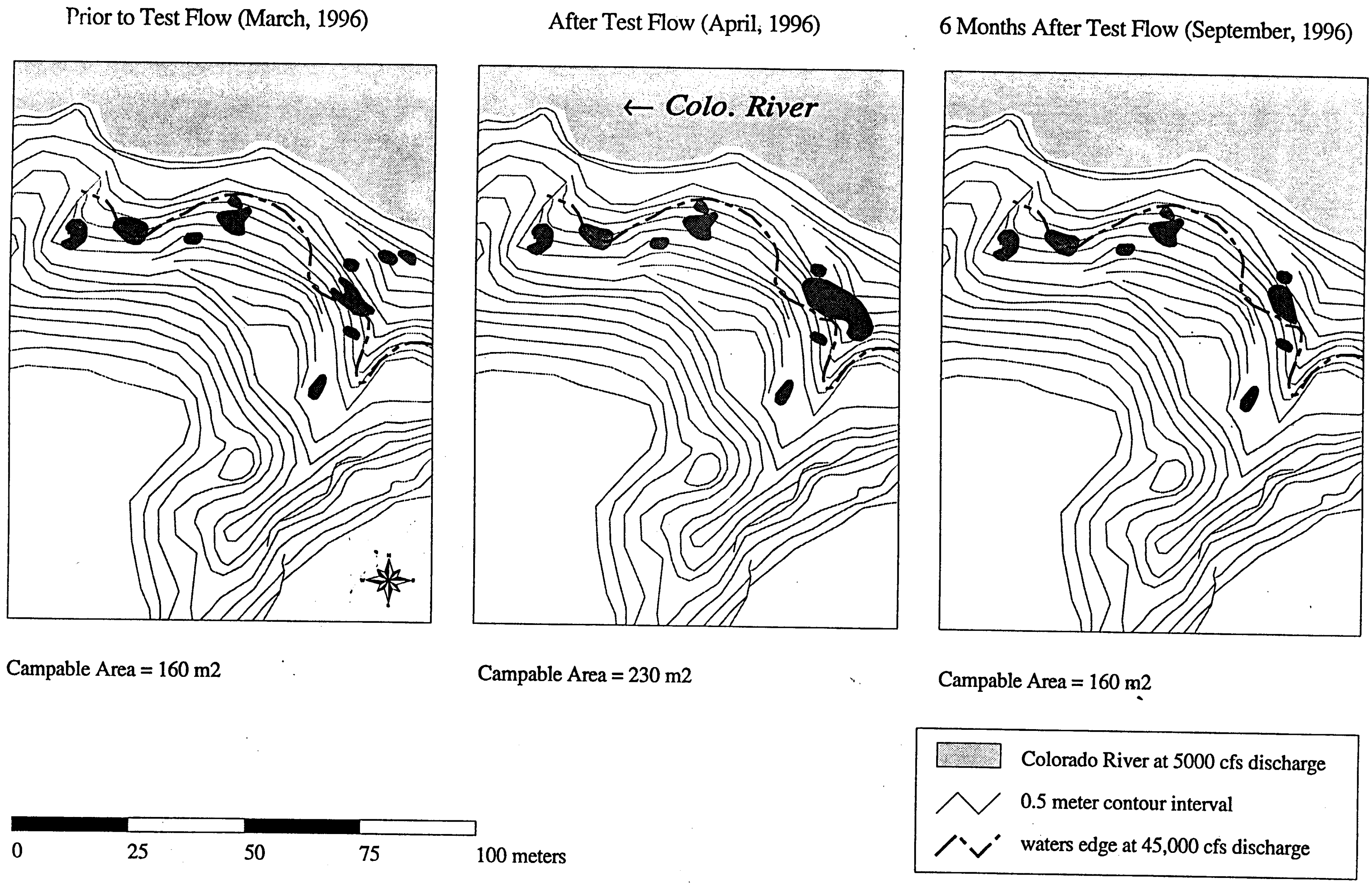
Campable Area = 1910 m2

Campable Area = 948 m2





Campable Area: 136.0L, Junebug



Campable Area: 137.0L, Backeddy