PNNL-11970

Pacific Northwest National Laboratory

Operated by Battelle for the U.S. Department of Energy

Monitoring Bank Erosion at the Locke Island Archaeological National Register District: Summary of 1996/1997 Field Activities

B. N. Bjornstad
P. R. Nickens
N. A. Cadoret
M. K. Wright

P. R. Nickens, Editor

August 1998

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest National Laboratory
Richland, Washington 99352

PNNL-11970

DISCLAIMER

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161

This document was printed on recycled paper.
(9/97)

PNNL-11970

Monitoring Bank Erosion at the Locke Island Archaeological National Register District: Summary of 1996/1997 Field Activities

P. R. Nickens, Editor
B. N. Bjornstad
N. A. Cadoret
P. R. Nickens
M. K. Wright

August 1998

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

Locke Island is located in the Columbia River in south-central Washington. The U.S. Department of Energy (DOE) owns Locke Island as part of its Hanford Site. Important archaeological components were first formally recorded and investigated on the island in the late 1960s. Included is a large area containing over 60 housepit depressions that was characterized at the time as "the best preserved and largest known remaining housepit site in the entire Columbia Basin" (Rice 1968a). Later archaeological testing of two of the Locke Island housepits confirmed the richness of the island's archaeological context.

Similarly, historic ethnographic use of the island and its environs is well documented. Early travelers on the river corridor often noted observations of Indians in the vicinity, particularly in the fall months. Historically, the Wanapum Indians annually camped and fished for fall chinook salmon in the river next to the island and reportedly used the island as a camping area and for grazing horses during the pre Hanford Site era. In recognition of Locke Island's archaeological significance, the island and surrounding area were placed in the National Register of Historic Places (National Register) in 1976 as the "Locke Island Archaeological District."

In the 1960s and 1970s, as a result of intensive irrigation developments on the inland shoreline to the east of the island, the White Bluffs, which form the eastern boundary of the Columbia River channel in this area, began to show geological failures as excess irrigation water seeped out along the bluffs. One of the largest such failures, known as the "Locke Island Landslide," is located just east of Locke Island. By the early 1980s, this landslide mass had moved westward into the river channel toward the island and was diverting the current at the island's eastern perimeter. Erosion of the bank in the center of the island accelerated, threatening the cultural resources. By the early 1990s, the erosion had exposed cultural features and artifacts along the bank, leading to the beginning of intermittent monitoring of the cutbank. In 1994, DOE initiated more scheduled, systematic monitoring of island erosion to better understand the physical processes involved as well as mitigate ongoing loss of the archaeological record.

The DOE asked Pacific Northwest National Laboratory (PNNL) to monitor erosion on Locke Island. The archaeological resource monitoring approach developed by PNNL's Hanford Cultural Resources Laboratory (HCRL) was designed not only to measure the rate of erosion on the island, but to 1) look at the physical dynamics involved in the erosion or landslide processes, and 2) identify, plot, and collect cultural data, as necessary, from already exposed cultural features, as well as others that might appear during monitoring.

The HCRL established 18 field erosion-measuring transects in November 1995; 14 monitoring trips were completed to Locke Island during 1996. The year was one of significantly increased river flow throughout the Columbia Basin, often reaching nearly 150% of average. The high flows were sustained for a longer period of time than normal, beginning in January and continuing well into the summer months. Although erosion to the east side of the island had occurred sporadically since the early 1980s, 1996 was undoubtedly the worst year overall for active bank recession. High runoff occurred again in late winter and spring 1997, which continued the very active erosion cycle begun the preceding year.

Based on the 2-year Locke Island monitoring effort, the following results can be summarized.

- Over half of the established transects experienced severe erosion and recession of the bankline; several of these measured up to 16 meters or more of horizontal loss just in 1996. About 6,900 square meters of surface land were lost along this bank, and approximately 41,000 cubic meters of sediment entered the river in 1996. Additionally, the length of the eroding bank was extended by more than 50 meters along the shoreline during the monitoring period.

- Additional erosion-measuring transects were placed to monitor the lengthened cutbank. Many cultural layers and features were periodically exposed along the cutbank, suggesting a much more extensive prehistoric occupational sequence than was previously known. Some archaeological materials are buried nearly 4 meters below the present surface of the island, and there are several stratigraphic levels containing artifacts, which clearly indicates separate periods of prehistoric occupation on the island.

- Based on the Locke Island experience with exacerbated erosion during 1996, additional monitoring was initiated at all exposed and actively eroding cutbanks along the Hanford Reach.

- Eighteen radiocarbon dates were processed from charcoal extracted from the eroding cutbank in 1996 and 1997. These dates indicate occupation of the island by aboriginal peoples from 200 years ago back to nearly 2,000 years before present. Archaeological data collected during monitoring have been used to gain a better understanding of the occupational sequence of the island and the association between it and the regional cultural history. Additional dates acquired in 1997 did not extend the period of occupation, but helped better define the cultural sequence for the island.

- Inspection of smaller eroding cutbanks around the island's edges revealed that buried cultural features and artifacts occur on both sides of the island and along its entire perimeter. Although the National Register evaluation of the island's archaeological resources was based solely on surface evidence, the buried archaeological layers at the island are equally as impressive, if not more so.

- Although historic Indian graves are known to exist on the island—given the extensive nature of the archaeological deposits and length of occupation on the island additional burials can be expected—none was noted in the eroding bank during the 1996-1997 monitoring period. Fragmentary human remains were observed at one point, however, on the southern end of the island eroding from an old looter's pit. Tribal representatives reburied these remains in place.

- In addition to the archaeological and erosion rate data, additional information was obtained on the geomorphologic and fluvial processes associated with the erosion, both on the island and at the landslide area. Of significance, the geomorphic sedimentary sequence exposed in the bank is geologically complex and is probably one of the best uninundated exposures of Holocene age sediments remaining along the Columbia. Preliminary evaluation of the Locke Island exposure has revealed a dozen or more distinct soil strata. By combining the radiocarbon dates and the stratigraphy, a sedimentation rate of ca. 1.1 meters per 1,000 years has been calculated. Assuming this rate of accumulation to be accurate, the island itself is probably about 6,000 years old.

- A significant finding was the realization that the landslide has continued its movement into the river channel during the past 10 years. Analysis in the early 1980s by the U.S. Geological Survey indicated that movement of the landslide had stabilized, as a result, in part, to intentional draining of nearby irrigation wastewater ponds. However, comparative analysis and careful measurement of aerial photographs from 1987 to 1996 shows that the lower part of the slide has actually moved another 150 meters into the channel toward Locke Island. This movement has reduced the width of the eastern river channel from 300 to 150 meters over the same period. Before the slide occurred, the channel on this side of the island was 450 meters wide.

- Before 1996, it was known that erosion was occurring along part of the east side of Locke Island, although the information was more anecdotal than precise, and the causal relationship between the landslide and erosion at the island was not fully established. Nothing was known about the actual rate of erosion, loss of important cultural information, or the physical dynamics involved in the erosion or landslide processes. The results of the HCRL 2-year monitoring project at Locke Island provide a clear example of the need to obtain systematic baseline measurements to define the problem and establish additional monitoring requirements. Project results also indicate the potential for efficiently collecting archaeological data during monitoring procedures that contribute to better understanding of natural and cultural settings.

- Although the monitoring effort has provided useful information concerning the erosion and the ongoing loss of significant cultural resources, it also has led to realization of the complexities involved in finding a cost-effective solution to resource management and protection issues. Several complicated factors are involved in addressing the problem and preserving the archaeological sites. These consist of: 1) multiple agency involvement and responsibilities, including many federal, state, county, and local agencies, along with regional tribes; 2) complex physical dynamics, including fluvial, erosional, and geological processes; and 3) difficult logistical and fiscal considerations in the design of engineering solutions to halt the slide activity and provide protection for the island's important cultural resources.

Contents

Figures

Tables

1.0 The Locke Island Erosion Project

Paul R. Nickens

1.1 Introduction

This section describes the physical and historical background of Locke Island and the need for and design of an erosion monitoring approach at the island. Locke Island, a large island in the Columbia River, south-central Washington (Figure 1.1), is located near the upper end of the prominent White Bluffs that border the river channel on the east side. In the regional Indian Sahaptin language, Locke Island is known as *K'watch* (Relander 1956). According to Wanapum elders interviewed in the early 1950s by newspaperman/author Click Relander, there is no modern translation in the native language for this term. The island is located in a stretch of the river referred to today as the "Hanford Reach" (Department of the Interior 1994). This segment of the Columbia is 51 miles long and is the last free-flowing non-tidal part of the river within U.S. borders. Although the Reach is considered undammed and free flowing, flows through the Reach are regulated because of operational considerations associated with several federal and county hydroelectric projects, located both above and below the island. Since 1943, the Hanford Reach has been located within the Hanford Site, a federally protected area encompassing 560 square miles managed by the U.S. Department of Energy (DOE).

1.2 Background

Locke Island is one of the largest mid-channel features in the Hanford Reach, measuring nearly 3 miles long and about one-half mile at its widest point. The height of the island extends up to 35 feet above the water level in some areas. The DOE administers the island's upland zone, located above the line of ordinary high water; the Washington Department of Natural Resources manages the shore below that line.

The island is prominently illustrated on early maps of the area, including the 1867 Government Land Office map, which notes that the island then comprised some 157.25 acres, and on an 1881 map produced by Col. T. W. Symons to accompany his report on the Columbia River and surrounding area (Symons 1882).

In historic times, before the federal government's Hanford Site was established, the island was owned by more than one early Euro-American settler families of the area. The island is variously referred to in the literature as Hay, Locke, or Borden Island. In the late 1800s, and into first few decades of this century, the island was used primarily for pasture. The Borden Family, who purchased the island in 1933 and eventually lost it to the government a decade later, ran both cattle and sheep on the island, using a barge to ferry animals back and forth (White Bluffs-Hanford Pioneer Association 1982). There is no record of the island having been inhabited or occupied for any length of time by white settlers.

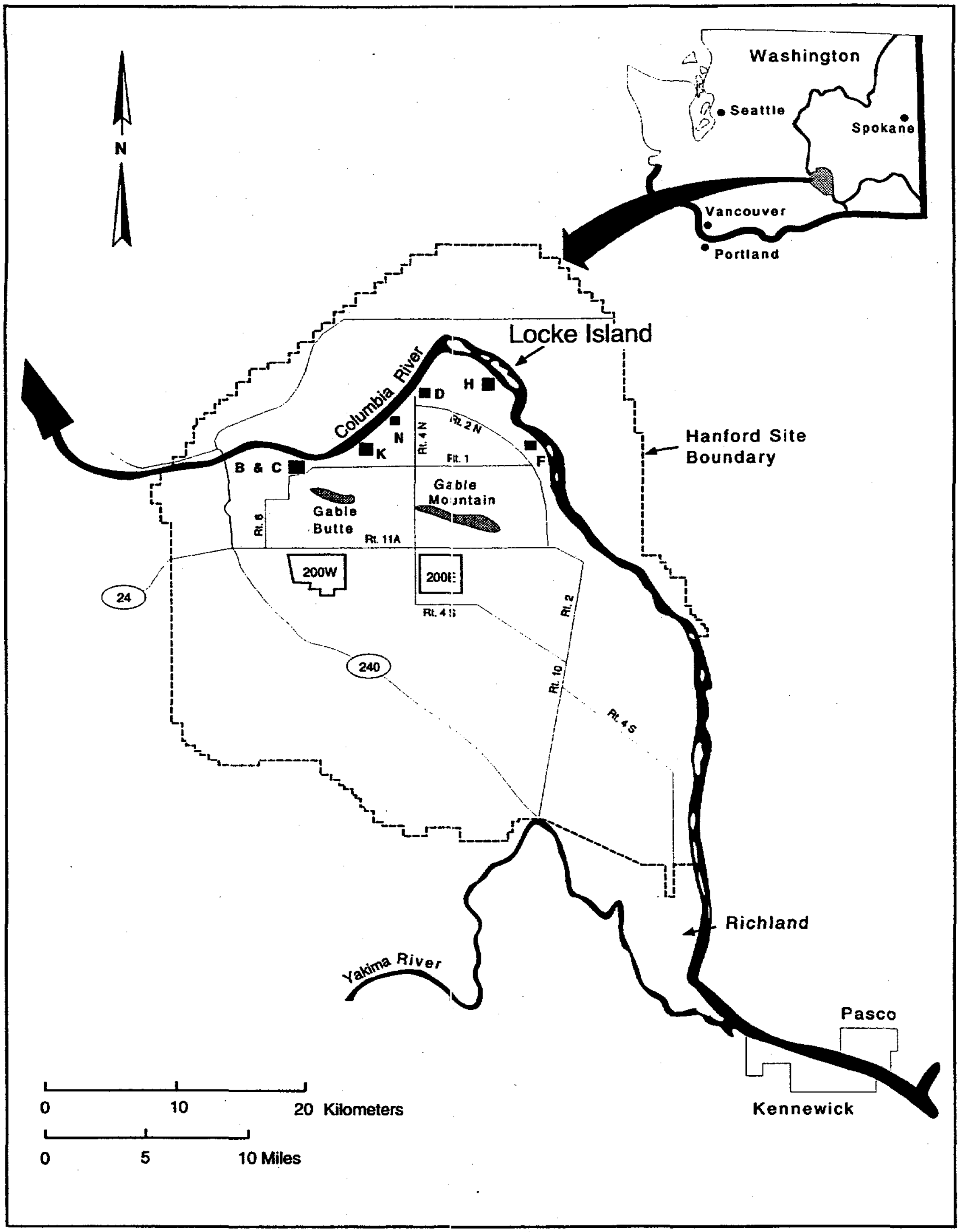

Figure 1.1. Location of Locke Island

Archaeologically, however, there is considerable surface and buried evidence to suggest that the island was used and occupied intensively, although probably intermittently, during the past few millennia. An archaeological survey of the island in the late 1960s recorded five distinct concentrations of prehistoric materials. Included is a large area containing over 60 housepit depressions at the southern end of the island that was characterized at the time as "the best preserved and largest known remaining housepit site in the entire Columbia Basin" (Rice 1968a). Later archaeological testing of two of the Locke Island housepits confirmed the richness of the island's archaeological context.

Similarly, historic ethnographic use of the island and its environs is well documented. Early travelers on the river corridor often noted observations of Indians in the vicinity, particularly in the fall months. Historically, the Wanapum Indians annually camped and fished for fall chinook salmon in the river next to the island, and reportedly used the island as a camping area and for grazing horses during the pre-Hanford Site era (Swindell 1942). Edward Swindell visited the fall 1941 Wanapum fishing camp, then located on the west bank of the river across from Locke Island, as part of his exhaustive study of fishing and other treaty rights throughout the Columbia Basin. Swindell's documentation of the fishing activity includes several photographs and written testimonies from two Wanapum elders, Johnny Buck and Cy Tamanawash, that provide critical detail about the historic use of this particular fishing location (Figure 1.2). A scaled map produced by Swindell of the 1941 camp and fishing area, along with the documented extent of the larger original camp grounds, show that part of the western bank of Locke Island had been also used for camping in previous decades (Figure 1.3).

According to Wanapum and other Yakama elders' depositions taken by Swindell, Wanapum fishing in the area had occurred as long as anyone could remember, and "they used to have some camps on the big island [Locke] in the river." Based on the respective ages of the elders interviewed in 1941, eye witness corroboration of fishing at this locale by the Wanapum can be extended back to at least the 1860s. That Wanapum fishing in this area was a principal activity right up to the federal government's taking of the land in 1943 is confirmed by numerous references to Indian fall fishing activities in the collected white settler family histories (White Bluffs-Hanford Pioneer Association 1982). Many of these recollections include references to Indian fishing at White Bluffs, including names of specific Indian people and Wanapum families. Today, the section of the Hanford Reach in the immediate vicinity of Locke Island is regarded as one of the principal fall chinook salmon spawning areas still extant on the Columbia River (Dauble and Watson 1990).

The island is also an identified historic Wanapum cemetery location, having been used for this purpose as recently as 1912 (Relander 1956). According to correspondence and other documentation in DOE files, Wanapum elders identified a locale near the center of Locke Island to Atomic Energy Commission personnel as one of the known historically used Indian cemeteries during a 1953 visit to the Hanford Site. Subsequently, five designated cemeteries on the western bank of the Columbia River were marked with concrete monuments; however, the one on Locke Island was neither visited nor marked, presumably because of logistics involved in reaching the island at the time and that its location on the island was not threatened by government construction activities of the time.

Use of the White Bluffs/Locke Island area for Wanapum autumn fishing and camping ended in 1943 when the U.S. Army Corps of Engineers, Manhattan District, took the land for defense purposes, evicting

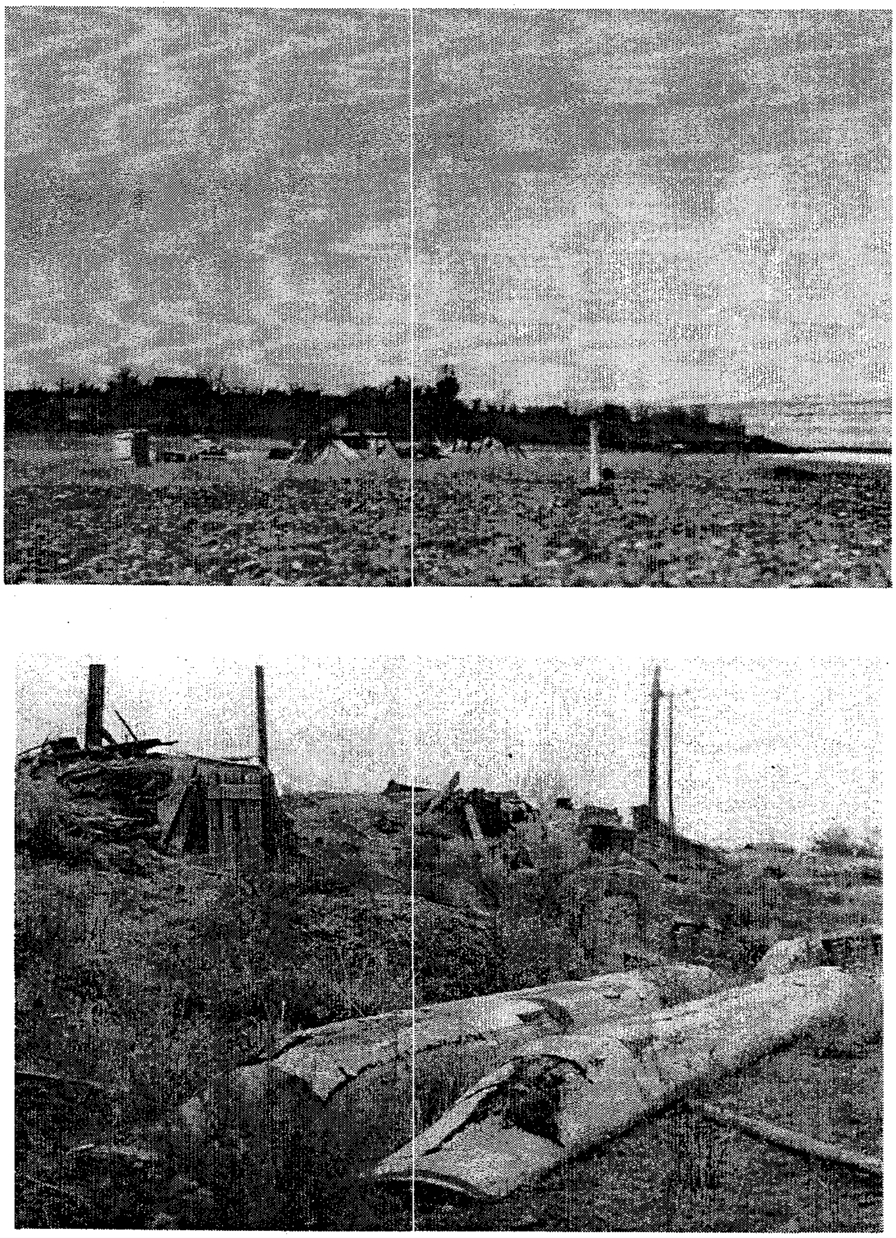

Figure 1.2. The 1941 Wanapum Indian Fishing Camp at White Bluffs, Located Immediately West of Locke Island. View of the camp on the cobble beach, looking northwest with the White Bluffs in the background (top). View of the storage structures in the edge of the terrace and wooden fishing canoes being stored (bottom). (Photographs were taken by Edward Swindell.)

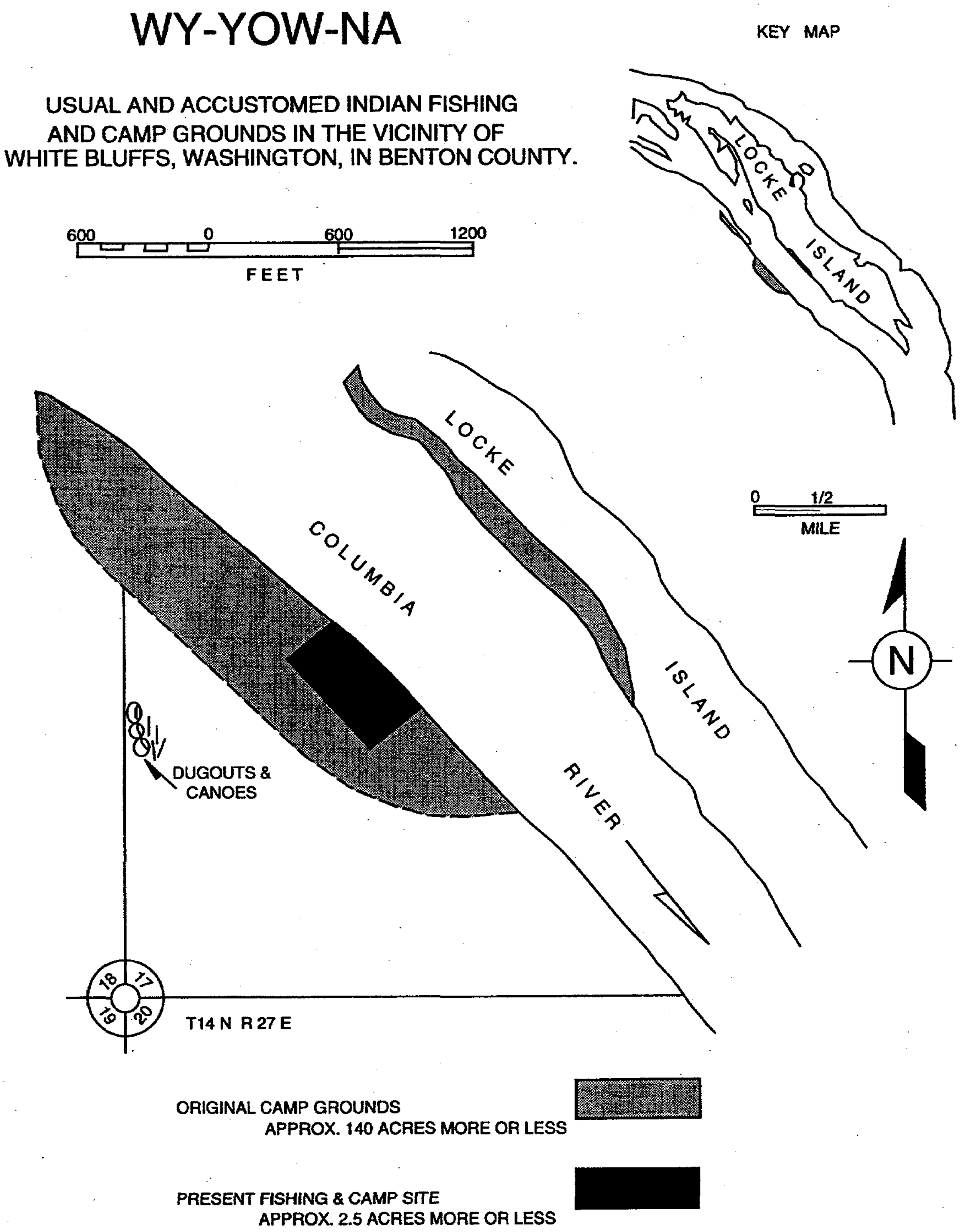

Figure 1.3. Redrawing of the Swindell Map of the 1941 Wanapum Fishing Camp Location, along with Defined Areas of Historical Use Areas including Locke Island

Indians, white homesteaders, and townspeople alike. The land remains today under governmental jurisdiction. In recognition of the scientific importance of the island's archaeological remains, and its importance to the Wanapum, Locke Island and the surrounding vicinity were nominated to and listed in the National Register of Historic Places (National Register) in 1976. Today, the district remains on the National Register as the "Locke Island Archaeological District."

1.3 Definition of the Problem

On the eastern shoreline of the Columbia River, across the channel from Locke Island, is the Locke Island Landslide (Figure 1.4), one of the largest such geological failures along this stretch of the river. These failures have causally been associated with the onset of nearby irrigation farming activities during the past few decades (Schuster, Chleborad, and Hays 1987; Marratt n.d). A particularly critical byproduct of irrigation farming and a primary contributor to the Locke Island slide are several wastewater ponds situated on high ground to the east of the bluffs, where water was channeled along a wasteway into and allowed to accumulate for enhanced wildlife management purposes. In time, stored water from these ponds appeared in seeps along the face of the White Bluffs. Seepage continues to contribute to bluff instability in this area even today (Figure 1.5).

Beginning in the mid-1970s, the Locke Island Landslide extended into the channel toward the island. By 1980-1982, it was nearly one-third (150 meters) of its original width (Hays and Schuster 1987). As mapped in the early 1980s, the still active Locke Island landslide area consisted of several earth slumps, avalanches, and flows in the Ringold Formation that covered an area about 1.5 miles (2.5 kilometers) long. The White Bluffs at this location reach a maximum height of about 330 feet (100 meters), creating significant potential for mass failures of this type.

One result of the Locke Island landslide and its associated movement into the river channel was to push the water current westward toward the eastern perimeter of Locke Island where, by 1995, an actively eroding cutbank had formed, measuring over 400 meters long and up to 7 meters high in places (Figure 1.6). Intermittent monitoring of this exposure since 1989 showed that buried prehistoric archaeological features and materials, such as hearths, roasting pits or ovens, and individual artifacts, were being exposed and subsequently lost to bank recession. However, little in the way of systematically collected data were available about the overall nature of the erosion or about the scientific or cultural importance of the cultural features and data that were being lost from this National Register property.

1.4 Monitoring Approach

The term "monitoring" means many things in different fields and contexts. As used in this report, monitoring refers to a methodology that consists of intermittent (regular or irregular) measurements or observations that, when analyzed and evaluated, offer a basis for making rational and sound management decisions for carrying out proper and effective long-term preservation of the cultural resource record. Such a methodology is critical for identifying and understanding baseline resource conditions and protective needs under either changing or unknown circumstances. Once the baseline conditions are established and the relationships between the rate and magnitude of the various impacts are understood, recommendations for mitigation of both natural and human-caused impacts can be formulated.

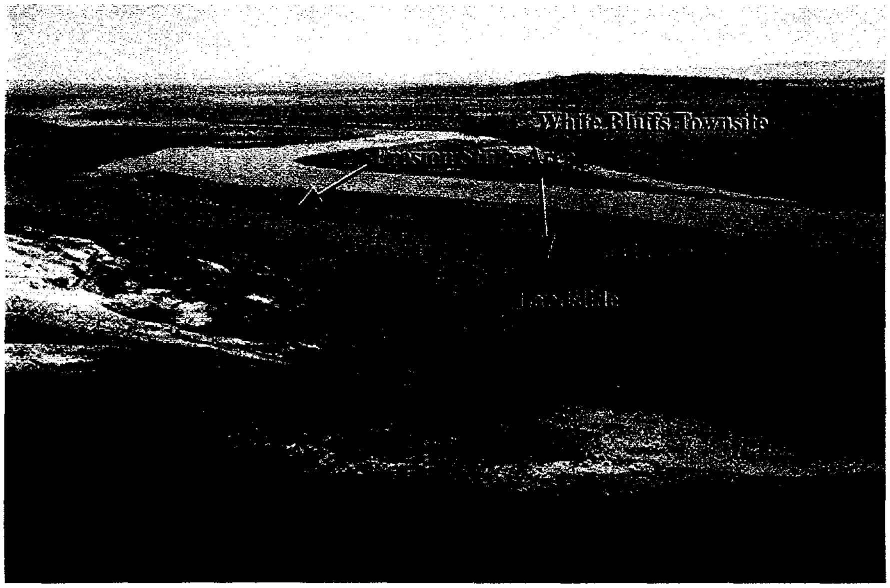

Figure 1.4. Oblique Aerial View to the Southwest From Above the Locke Island Landslide Across Locke Island

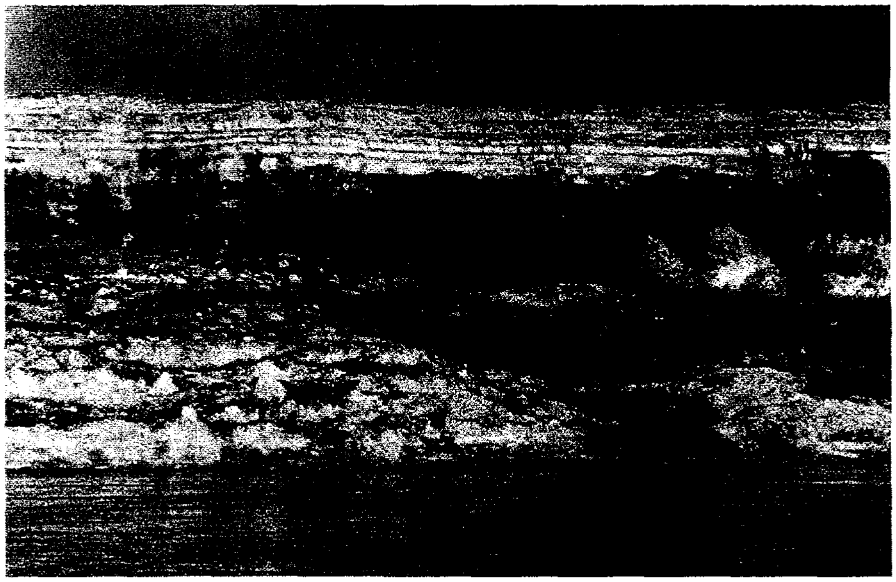

Figure 1.5. Photograph of the White Bluffs Above the Locke Island Landslide Showing Seepage From the Water Storage Ponds Above (February 1996)

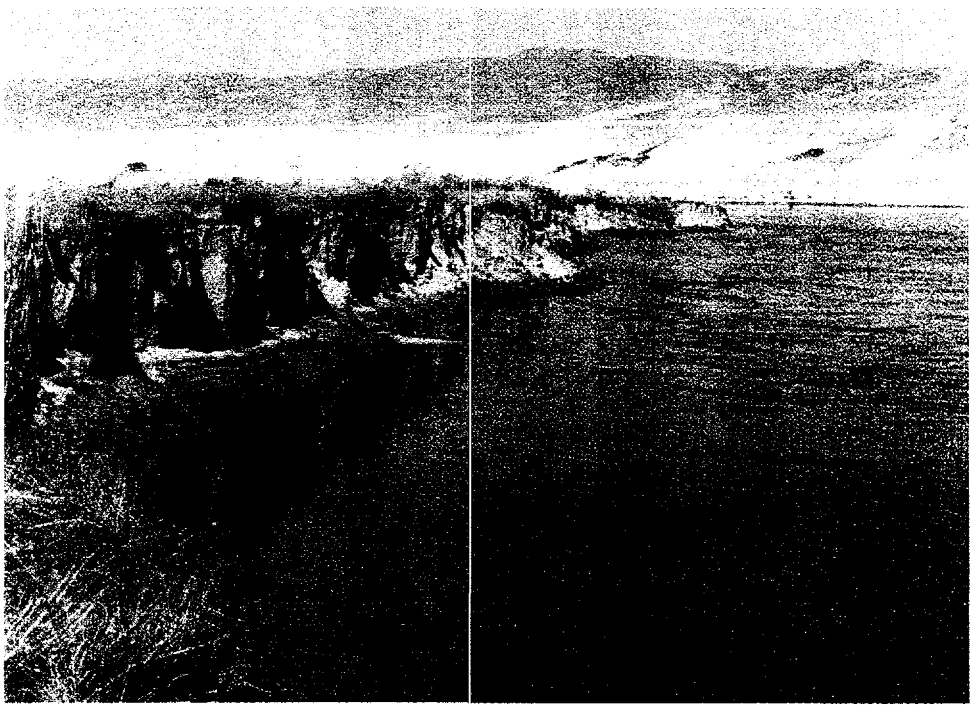

Figure 1.6. Overall View of the Eastern Shoreline of Locke Island Showing the Erosion Cutbank, Looking Northward Toward the White Bluffs (February 1996)

Cultural resource monitoring is most beneficial when it results in more effective management decisions—decisions that protect or preserve important archeological and historic resources. Other potential uses of monitoring in this context include:

- helping cultural resource managers meet compliance with historic preservation laws and implementing regulations and agency-specific requirements
- constructing, adjusting, and verifying quantitative predictive impact models to use in evaluating and selecting resource protection strategies
- providing early warning of future resource protection problems when they can be resolved more easily and at lower cost than if left unattended. Unfortunate inadvertent loss of significant cultural resources data also can be prevented through an effective monitoring program
- enhancing knowledge of past cultural events and patterns and their variability, based on monitoring results.

As a result of continued erosion on Locke Island, which exposed cultural features and artifacts along the bank in the center of the island, DOE initiated intermittent monitoring of the bank. In 1994, more scheduled, systematic monitoring was undertaken to better understand the physical processes involved in the erosion and to mitigate ongoing loss of the archaeological record. In 1995, DOE asked Pacific Northwest National Laboratory (PNNL) to monitor erosion on Locke Island. The 2-year cultural resource monitoring approach developed by PNNL's Hanford Cultural Resources Laboratory (HCRL) was designed not only to measure the rate of erosion on the island but also to 1) look at the physical dynamics involved in the erosion or landslide processes, and 2) identify, plot, and collect cultural data, as necessary, from already exposed cultural features, as well as others that might appear during monitoring.

To address these concerns, the HCRL placed 18 erosion-measuring transects perpendicular to and along the crest of the receding Locke Island bankline in November 1995 to begin documenting the process. The transects were placed at 50-meter intervals along the edge of the existing cutbank. HCRL staff conducted intermittent, but at least monthly, monitoring trips to measure the rate of sediment loss and record cultural features and items that might be exposed on the island. All location data were recorded with a global positioning system (GPS).

An important aspect of monitoring in 1996 and 1997 was participation of affected regional Indian tribes in field activities. Before each monitoring trip, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, the Yakama Indian Nation, and the Wanapum Tribe were contacted and nearly always sent representatives to accompany the HCRL monitoring crew. This participation allowed the tribes to observe field results in person and permitted in-field consultation on matters such as disposition of cultural features and objects, including, in one instance, human remains. In addition to American Indians, other participants were invited to accompany the field crew, including technical specialists such as geologists, and representatives of agencies with similar problems or whose management operations may affect this stretch of the Columbia River. According to field records, the total combined number of visits for all of the monitoring trips in 1996-1997 exceeded 250 person-trips.

1.5 Report Contents

The following sections summarize the 1996 and 1997 field monitoring activities and document both the erosion and cultural data exposed during the overall monitoring period. The findings of a geology/geomorphology analysis conducted to better understand the physical environment of the island are described in Section 2.0. Section 3.0 presents results of the monitoring and erosion measurements completed in 1996-1997. Section 4.0 discusses and evaluates the archaeological data acquired during the study period. Section 5.0 provides concluding remarks. Appendices A-C provide supporting information related to cumulative loss per monitoring trip, cultural materials and features observed, and archaeological deposits and river bank recession at each transect.

2.0 Geology and Geomorphology in the Vicinity of Locke Island

Bruce N. Bjornstad and Natalie A. Cadoret

2.1 Background

A 450-meter-long segment of the east bank of Locke Island is being severely eroded by channel diversion and restriction of the channel as a result of irrigation-induced landslides near the "horn" of the Columbia River on the Hanford Site. Geologic investigation has revealed the island is composed of three stratigraphic units: 1) Ringold Formation and/or reworked Ringold gravels, 2) cataclysmic flood deposits from Glacial Lake Missoula, and 3) Columbia River fine-grained alluvium, associated with late-Holocene lateral accretion and overbank deposits from the Columbia River, along with some eolian (windblown) deposits. Ringold gravels, of Miocene-Pliocene age and/or Ringold gravels reworked by cataclysmic floods are exposed along part of the cutbank exposure. Based on radiocarbon ages obtained from the overlying fine-grained alluvium, the average accumulation rate is about 1.1 meters/1,000 years. At least six major strata, ranging from 0.5 to 3 meters in thickness, can be correlated along the near-vertical walls of the cutbank. The upper and/or lower bounding surfaces of strata are defined based on differences in texture, color, and/or moisture. Numerous other substrata are present but are discontinuous and not laterally extensive. Buried soil horizons consist of weakly developed A (organic-rich) and C (calcic) horizons. The oldest exposed alluvial strata are less than 6,600 years; the youngest stratum was probably laid down during the last major pre-dam flood about 100 years ago.

The geomorphology of the island includes two sets of giant current ripples, formed during Pleistocene cataclysmic flooding, at the north end of the island. To the south are alluvial plains dissected by scour channels and depressions, all of which formed during periodic floods over the last few millennia and before 1930 (i.e., construction of upstream dams). Less scouring and more deposition occurred in the middle and southern portions of the island. Except for erosion of the eastern cutbank, Locke Island has not undergone any appreciable geologic change in the last 50-60 years.

2.2 Stratigraphy

2.2.1 Stratigraphic Units

Three principal stratigraphic units are represented at Locke Island. These are: 1) Ringold Formation gravels, 2) cataclysmic flood deposits from Glacial Lake Missoula, referred to as the Hanford formation within the Pasco Basin, and 3) recent Columbia River fine-grained alluvium. Figure 2.1 illustrates ages and stratigraphic relationships between these units. Outcroppings of the oldest unit, gravels of the Ringold Formation, are limited to a northwestern portion of the recent cutbank exposure at Locke Island (Figure 2.2). However, it is also possible these gravels represent Ringold sediments reworked by Pleistocene cataclysmic floods. Characteristics that indicate that these gravels belong to the Ringold Formation (Facies Association I of Lindsey 1995), and are in situ, include the quartzo-feldspathic composition and the degree of iron oxide staining displayed by the sand matrix. If these are Ringold-age

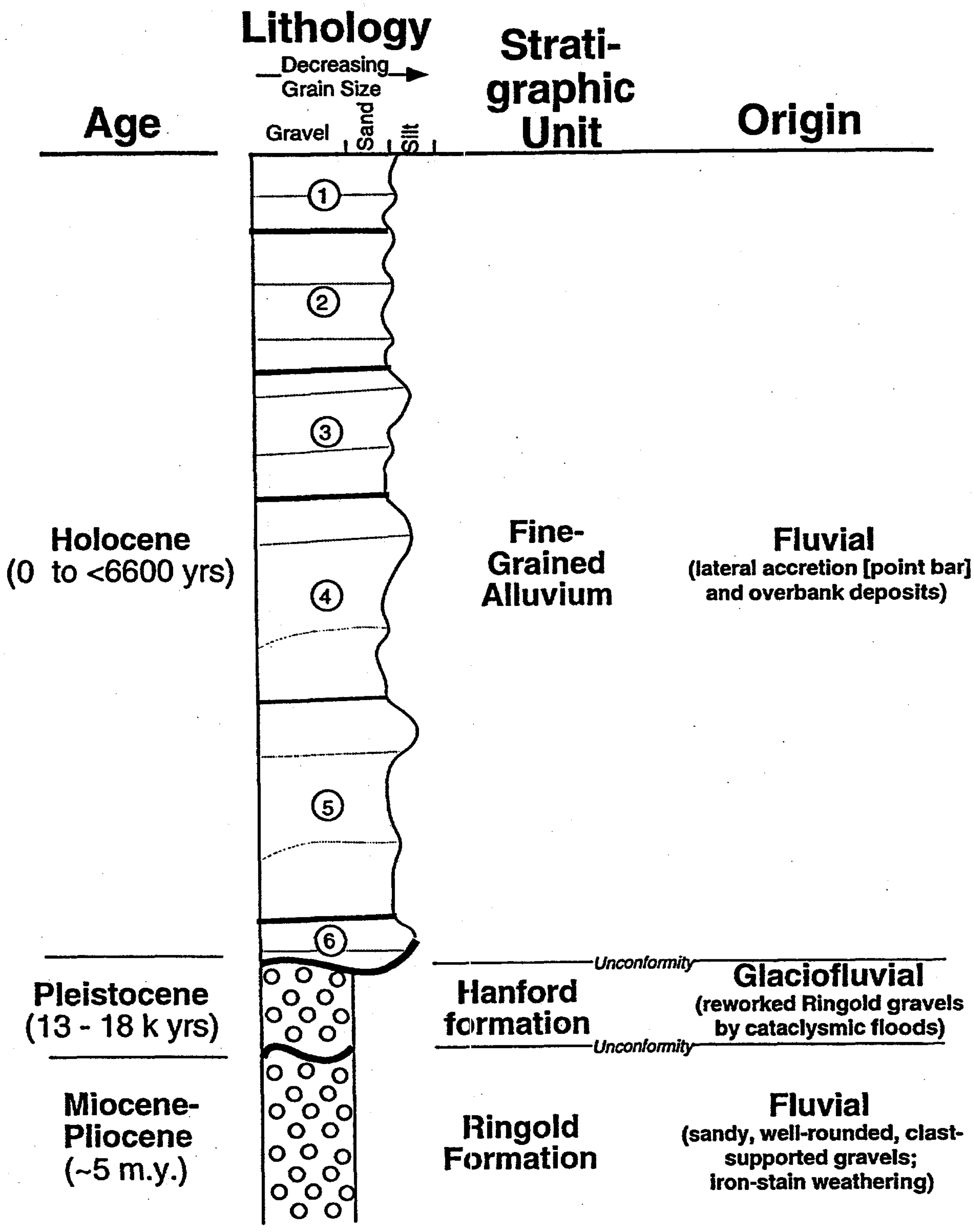

Figure 2.1. Locke Island Stratigraphy

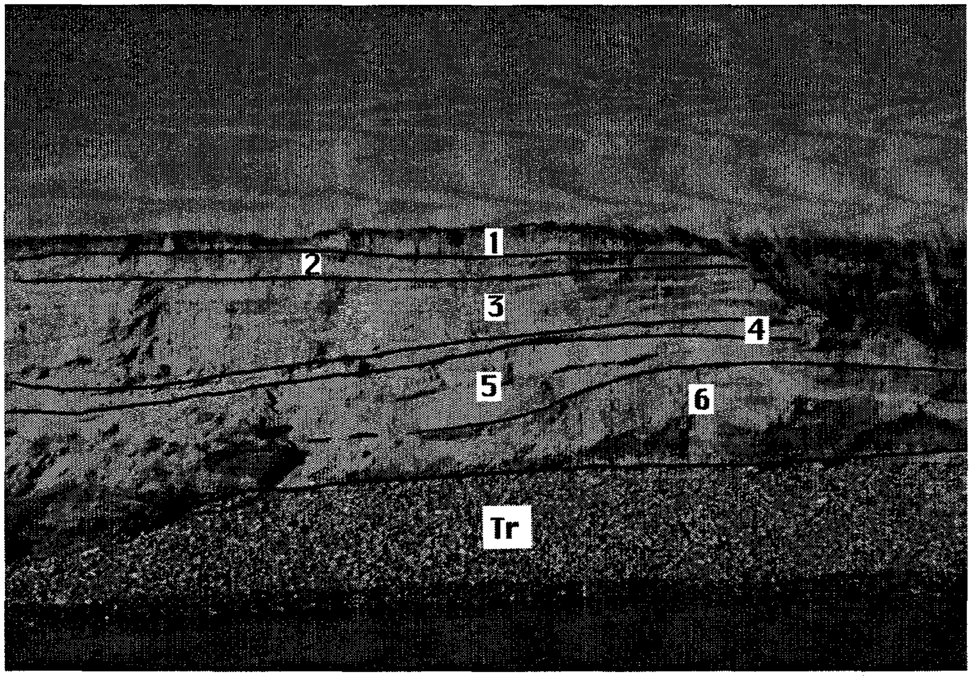

Figure 2.2. East Cutbank of Locke Island Near Transect 800. The bottom third of this exposure consists of well-rounded, clast-supported gravels with a matrix of iron-oxide-stained sand, characteristic of the Ringold Formation (Tr). Above the gravels is a fine-grained alluvial sequence. Six major strata in the fine-grained alluvium, which correlate with the vertical length of the cutbank exposure, are numbered on the photograph.

gravels they were exhumed after originally being deposited along an ancestral Columbia River channel about 5 million years ago. The contact between these gravels and overlying fine-grained strata dips to the south; the gravels disappear below river level along the southern half of the island.

Recent published reports of studies in the vicinity of Locke Island (Lindsey and Jaeger 1993; Peterson et al. 1996) have not recognized the presence of any intact gravel of the Ringold Formation near the surface. These previous reports assumed that coarse-grained sediments near the surface were all of cataclysmic flood origin or Ringold Formation gravels reworked by cataclysmic floods. Based on our findings, however, we believe some gravels previously interpreted to be Hanford formation actually are not cataclysmic flood deposits but belong to the Ringold Formation.

Pleistocene-age cataclysmic flood deposits are represented by giant current ripples preserved at the extreme north of the Locke Island, near river level. These dunes of coarse clastic material (mostly reworked Ringold gravels) have chord lengths similar to other giant current ripples left behind during Missoula flooding (Baker 1978). Two sets of giant current ripples have been delineated from aerial photographs. A younger set, with longer chord lengths and lighter color on aerial photos, overlies and is superimposed onto an older set of giant current ripples. The lighter color is due to differences in vegetation, moisture content, and/or sediment composition. These two sets of giant current ripples may represent separate cataclysmic flood events, which have been documented in the Pasco Basin (Baker et al. 1991). The older set of dunes, as they appear at ground surface, are shown in Figure 2.3.

Holocene-age fine-grained alluvium (mostly sand- and silt-sized particles) represents the most voluminous and widespread stratigraphic unit exposed at Locke Island. Radiocarbon dates range from 230 ± 40 years near the surface to 2130 ± 60 years at depth, suggesting that this stratigraphic unit probably aggraded throughout late Holocene time. The fine-grained alluvial unit mostly consists of lateral accretion and overbank deposits (Miall 1992), which were laid down over the last few millennia, during high flood stages of the Columbia River. Some of the fine-grained sediment may also be derived from eolian (windblown) deposition. Locke Island, located along the inside of the "horn" of the Columbia River, lies in a favorable location for the accumulation of lateral-accretion deposits. Lateral accretion surfaces exposed in the fine-grained alluvium of Locke Island dip moderately to the east-southeast, coincident with the direction of point-bar migration. The average sedimentation rate for the fine-grained alluvium is about 1.1 meters/1000 years (Figure 2.4), based on eight radiocarbon age dates collected within these strata.

In the northern portion of the island, the fine-grained alluvial unit is extensively eroded and, in places, completely stripped off by pre-dam (before 1933) floods of the Columbia River, so that only a few erosional remnants of fine-grained alluvial sediments remain in this area. To the south, the upper surface of

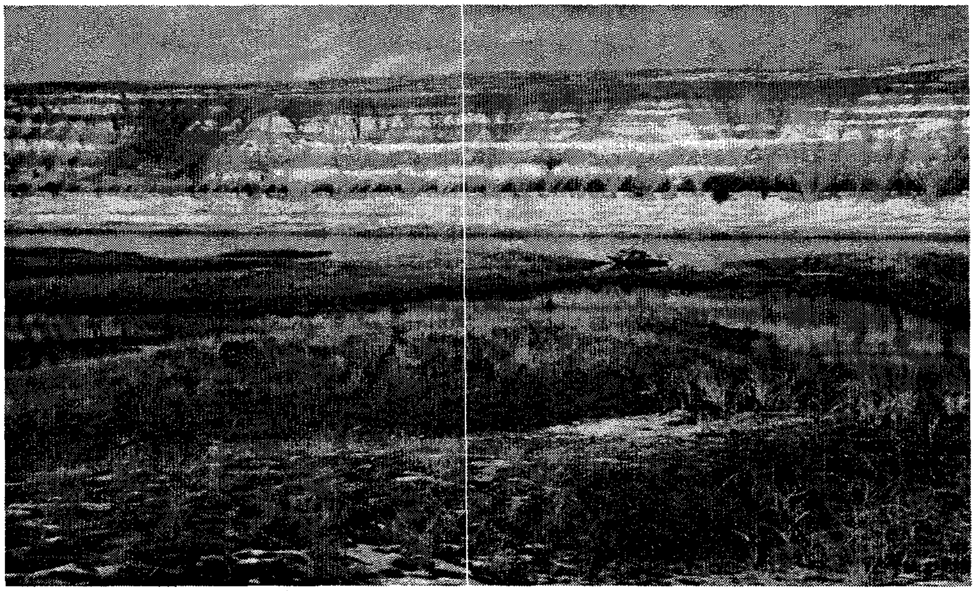

Figure 2.3. Giant Current Ripples. Ripples appear as partially submerged mounds near river level. Chord length is about 30 meters. Apparent ripple height is up to 3 meters. These giant ripples, formed during the Pleistocene cataclysmic flooding, have probably since been modified somewhat by "normal" Columbia River fluvial processes. (Boat for scale.)

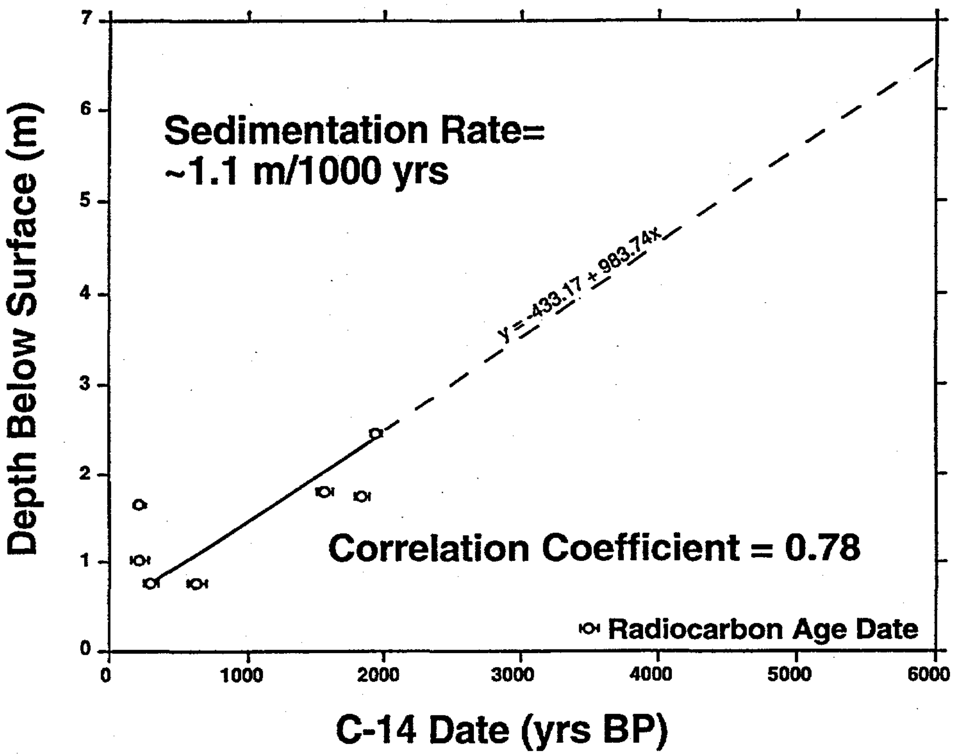

Figure 2.4. Sedimentation Rate of the Fine-Grained Alluvial Unit at Locke Island

the fine-grained alluvial unit becomes progressively less eroded and channeled; the extreme southern end of the island shows no surficial evidence for erosion and/or channeling (see Section 2.3).

2.2.2 Correlative Strata Within the Fine-Grained Alluvial Unit

A natural cross section of the fine-grained alluvial unit is well exposed where recent cutbank erosion has removed a portion of the island (see Figure 2.2). The strata exposed above river level were mapped and correlated from a continuous photomosaic that included most of the entire length of the 450-meter cutbank exposure. Based on this mapping, six major strata, represented in Figure 2.2, were identified within the fine-grained alluvial unit above river level. Table 2.1 summarizes these strata, including thickness, estimated age, and number of substrata. The upper and/or lower bounding surfaces of strata are defined based on differences in texture, color, and/or moisture. Substrata are present but are discontinuous and do not extend laterally. The lower strata (e.g., 4 and 5) often dip to the northeast, evidence for lateral accretion, whereas the upper strata are moderately undulating and more or less conform to the present surface of the island. Soil horizons (Figure 2.5) are present but are weakly developed, which corroborates the relatively young age and rapid sedimentation rate for the fine-grained alluvium. Identifiable soil horizons mostly consist of diffuse A horizons stained with dark organic matter (Figure 2.5); other distinguishable soil horizons include several light-colored C (i.e., calcic) horizons represented in strata 2 and 3, along the southern end of the cutbank. The base of the fine-grained alluvium is exposed

Table 2.1. Stratigraphic Properties of the Fine-Grained Alluvial Unit

Stratum	Thickness (m) [average/range]	Age (yrs. B.P.)[a]	Maximum Number of Substrata	Comments
1	0.5/0-1.0	100	3	Thickest @ south end of cutbank
2	1.0/0.5-3.0	200-300	5	Eolian(?) @ 802.5, thick channel fill @ 806.4
3	0.75/0.5-2.0	1500-1800	5	Thicker, more substrata to the north
4	1.0/0.5-1.5	2500-3500 (?)	4	Lateral accretion surfaces
5	1.25/1.0-2.0	3500-5000 (?)	6	Lateral accretion surfaces; saturated
6	? (base not exposed)	≤6600	?	Saturated

(a) Underlined ages based on radiocarbon dates.

only along the northern end of the cutbank (Figure 2.2). Here, a major unconformity (i.e., many millions of years) exists between the Neogene-age Ringold gravels and Holocene alluvium.

The fine-grained alluvial unit appears to be all late Holocene in age. Stratum 1 was most likely deposited during the last major pre-dam flood, which occurred in 1894, a little more than 100 years ago. Stratum 2 yields radiocarbon ages that range from about 200-300 years B.P. Elsewhere, near Transect 806, charcoal samples from strata 3-4 have been radiocarbon dated at 1500-1800 years B.P. Currently, there are no radiocarbon ages below this depth. However, there is reasonably good correlation ($r = 0.78$) between age and depth below the surface (Figure 2.4), so that depth may be used as an estimate for sediment age where no radiocarbon dates are available. A less than 6600 year age for the lower strata, which lie 6-8 meters below the top of the bluff face, is consistent with the projected average sedimentation rate of 1.1 meters/1000 years, calculated from radiocarbon dates of the younger strata (Figure 2.4). Also, volcanic tephra from Mount Mazama, dated at 6600 years B.P. is not present anywhere along the 450-meter cutbank exposure. Elsewhere in the Pasco Basin, the Mount Mazama tephra appears as an easily identifiable, light-colored ash layer up to several feet thick (Powers and Wilcox 1964). We believe the Mount Mazama tephra should be present somewhere along the 450-meter long cutbank exposure if these strata were older than 6600 years B.P., especially considering the types of depositional processes that have predominated throughout the formation of the fine-grained alluvial unit.

At least two buried, fluvial channels are present within the fine-grained alluvial unit, as indicated by channel cut and fill structures exposed in the cutbank. One of the buried channels occurs near Transect 801, the other near 806. Both channels exposed in the cutbank are also represented topographically at the surface of the island. The partially filled channel near Transect 801 lies along the extension of a northeasterly trending scour depression. The channel near Transect 806, on the other

Figure 2.5. Several Buried Soil Horizons (i.e., darker layers) Visible in Cutbank Exposure Near Transect 806

hand, is completely plugged with sediment, which was probably deposited over the last several hundred years. The southwestern end of this channel is still open, suggesting that this channel was scoured by a flood that occurred before a few hundred years ago and has since been filled by sediment associated with either alluvial and/or eolian processes.

2.3 Geomorphology

Based on an evaluation of historical aerial photographs, five geomorphic surfaces are identified on Locke Island (Figure 2.6). These surfaces are differentiated based on variations in sediment composition, elevation, and vegetation. The relative ages of the different surfaces are estimated based on the combination of radiocarbon dates reported in this study and crosscutting relationships between surfaces observed in aerial photographs.

2.3.1 Northern Portion of Locke Island

The northern end of the island is dominated by the three oldest surfaces, which are developed on coarse-grained, pebble-cobble gravels of the Ringold Formation (Figure 2.6). The oldest surface (1), an erosionally scoured surface, is composed of Ringold gravels originally deposited about 5 million years ago. Surface 2 consists of giant current ripples that developed during an older Missoula flood, locally

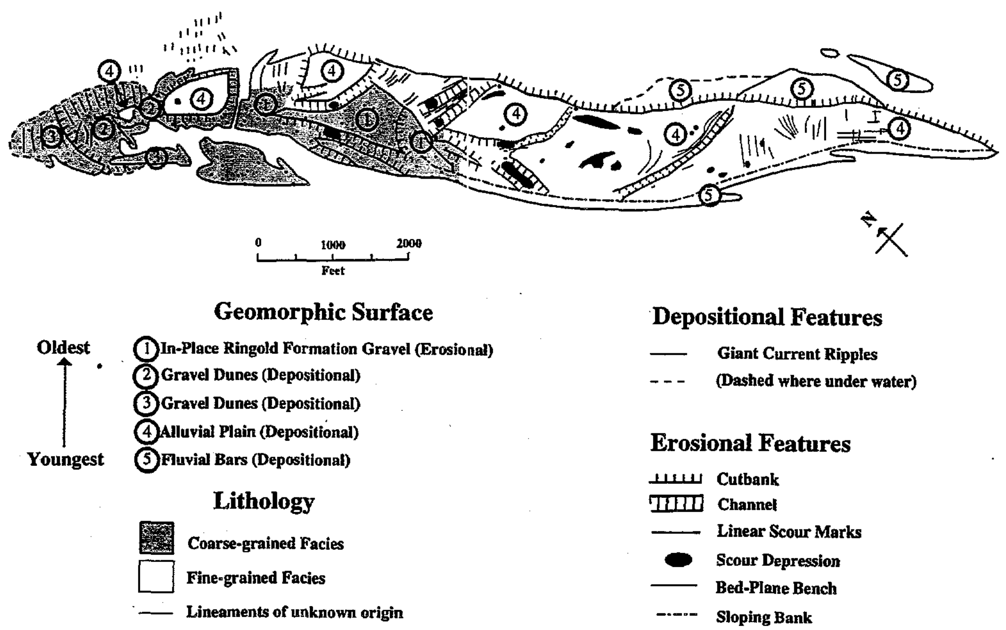

Figure 2.6. Geomorphic Map of Locke Island

covered with giant current ripples from a younger late-Pleistocene Missoula flood (surface 3). The chord length of the younger set of ripples is 1.5 to 2.0 times greater than the older set.

Although the chord lengths are similar to those reported for other giant current ripples from Missoula flooding, the ripples at the north end of Locke Island appear to have a greater relief than those reported in Baker (1978). The chord length on the older set of giant current ripples averages about 30 meters and heights are around 1.5-2.0 meters (Figure 2.3). Baker (1978, Figure 5.35), on the other hand, reported heights of about 1 meter for giant current ripples of comparable chord length. The increase in relief may be a product of modification of the giant current ripples by more recent erosion and scouring during "normal" Columbia River flood events since the Pleistocene.

Elsewhere within the northern portion of Locke Island there are few isolated areas with Holocene-age, fine-grained alluvium (surface 4). These represent erosional remnants of fine-textured lateral accretion and overbank deposits that were laid down by the Columbia River over the last few millennia.

2.3.2 Middle Portion of Locke Island

The middle portion of Locke Island is characterized by a combination of erosional and depositional features (Figure 2.6). The central portion of the island consists of a channeled complex (surface 1) eroded, in places, down to the Ringold gravels, which left behind a series of easterly trending channels, scour depressions, and linear scour marks. One of these east-trending channels is shown in Figure 2.7. This erosion is at least several hundred years old, since the eastern end of some of the channels are

Figure 2.7. Fluvial Channel. One of several that cut diagonally across the fine-grained alluvial unit and are scoured down to the Ringold Formation gravels, located just north of Transect 800.

partially filled by sediments dated at 200-300 years B.P. The next youngest surface is an alluvial plain formed by the Holocene-age fine-grained alluvial unit (surface 4, Figure 2.6). This is the highest-elevation surface on the island. In the middle portion (east side) of the island is where the maximum cutbank erosion is taking place. The rate of erosion is the greatest where the channel width substantially decreases (as a result of active landslides across the river). Erosion of this cutbank adds to the volume of sediment bars just downstream, where the river widens.

2.3.3 Southern Portion of Locke Island

The southern portion of Locke Island is dominated by the alluvial plain that makes up surface 4 (Figure 2.6). A single channel cuts diagonally across the island, although it appears to be filled along its east end, similar to the channel mentioned earlier, located about 550 meters to the northwest. Along this channel, incision into the fine-grained alluvium has exhumed some paleo-bedding surfaces, which have resulted in numerous bed-plane benches that in places parallel the channel. Numerous bars (surface 5, Figure 2.6), that lie near river level, flank Locke Island at its southern end. Some bars, similar to those that form surface 5, are present on aerial photographs taken in 1931, indicating they were present before damming of the Columbia River and movement of the Locke Island landslide.

2.4 Interpreted Geologic History of Locke Island

Locke Island has a complex history and has developed in several stages (Figure 2.8). The island originated during the Pleistocene, when cataclysmic floods that periodically moved through the Pasco Basin (Baker et al. 1991) deposited large giant current ripples. After the last cataclysmic flood (about

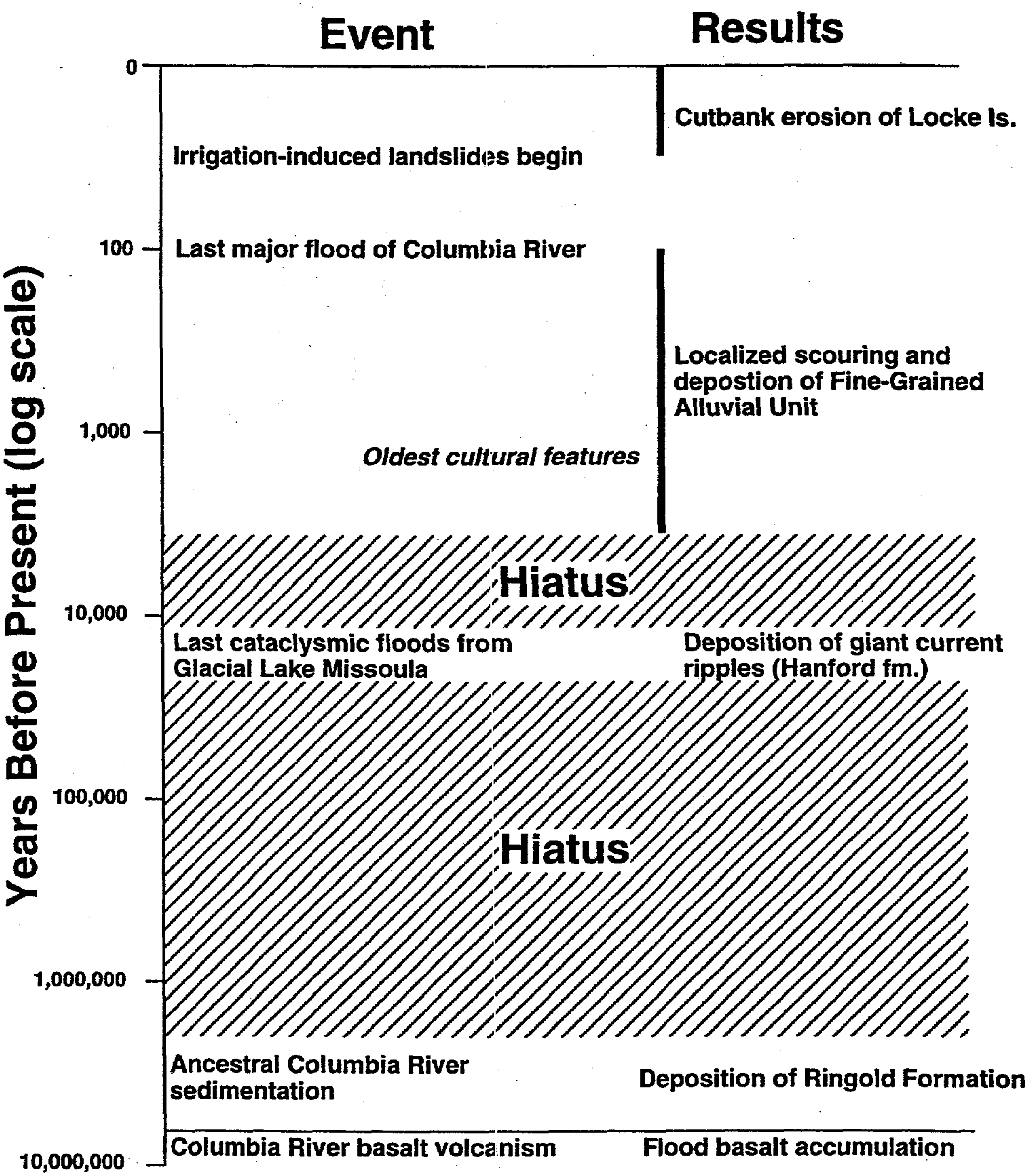

Figure 2.8. Summary of the Geologic History of Locke Island. (Note: time scale on vertical axis is logarithmic.)

12,000 to 13,000 years B.P.), the Columbia River reestablished itself along the thalweg of the lowermost flood channel, which is where it essentially has remained since that time. The geologically immature nature of the Columbia River is indicated by its confinement to a single, more-or-less straight channel without any significant development of river meanders or floodplain. The development of meanders and a floodplain are probably inhibited by the extremely course cataclysmic-flood sediments that flank the channel; as such, the Columbia River represents an underfit stream that lacks the power required to transport these deposits. Locke Island lies along a reach of the river that makes a wide bend and changes direction from northeast to southeast, referred to as the "horn" of the Columbia River. In general, river currents will be faster and more powerful on the outside of the bend (i.e., the White Bluffs side). The high steep walls of the White Bluffs, which consist of easily erodible, semiconsolidated fine-grained sediments of the upper Ringold Formation, attest to the more powerful river currents on the outside, which erode and undercut the bluffs. Because river currents move more slowly on the inside of the river bend, this is a site for sediment deposition. The "horn" of the Columbia River, then, is geologically similar to a huge point bar; some of the lower strata within the fine-grained alluvium preserved at Locke Island, in fact, reveal east dipping lateral accretion surfaces, which formed as a result of point-bar migration in this direction. Lateral accretion surfaces are not as common in the younger strata, suggesting that lateral accretion has since ceased.

Except for erosion of the eastern cut bank, associated with landsliding and channel diversion, Locke Island has probably not undergone any appreciable geologic changes in the last 50-60 years. This is probably due to the many hydroelectric dams built upstream that act to control flooding, which began in 1933 with the Rock Island Dam, followed in 1941 by the Grand Coulee Dam. Prior to 1933, when the Columbia was free flowing, large floods occurred periodically. The largest unregulated historical flood occurred in 1894 (750,000 cubic feet per second), which approached the 100-year flood level (Department of Energy 1988). During high flood stages, associated with this and previous large floods, the Columbia River probably flowed more east-west in the vicinity of Locke Island, rather than north-south as it does under normal-flow conditions. This is indicated by erosional channels that cut the island diagonally (see Figure 2.7). Since then, intermediate stage floods have eroded north-south trending channels in the middle portion of Locke Island, that parallel the trend of the island.

During large floods, Locke Island was probably completely submerged. Fine-grained alluvium was deposited by lateral accretion of bars and bedforms as well as overbank sedimentation over the southern part of the island, as floods waned. Erosion predominated over the northern portion of the island. Less scouring and more deposition of fine-grained alluvium occurred in the middle and southern portions of the island since these areas were further from the high-energy thalweg of the Columbia River. In these areas fine-grained alluvium accumulated as an aggrading alluvial plain (surface 4, Figure 2.6) developed.

Finally, cutbank erosion along the east side of Locke Island began only recently (i.e., last 50 years), when irrigation-induced landslides began to reduce the width of the channel and push the river channel against the island.

3.0 Erosion Monitoring on Locke Island Between November 21, 1995, and December 1997

N. A. Cadoret

3.1 Introduction

This chapter summarizes the Locke Island shoreline erosion monitoring results for 1996 and 1997. The field methodology also is discussed.

3.2 Methodology

In November 1995, the HCRL established 18 erosion transects (801-818) at Locke Island to collect quantitative measurements of ongoing bank recession. The transects were set perpendicular to the edge of the bank, approximately 50 meters apart, along the eastern edge near the middle of the island, where erosion is most critical (Figure 3.1). Three additional transects were established in March 1996. One (800) was placed 50 meters north of the previously established transects to record active slumping that was progressing northward. The other two (830 and 831) were located near the southern tip of the island along the southeastern bankline where erosion at a prominent cutbank threatens a large prehistoric housepit village site.

Each transect consisted of a series of wooden stakes, 1 foot long, placed vertically 1 meter apart extending 5 meters back from edge of the bankline, and a 2-foot section of rebar, tagged with the

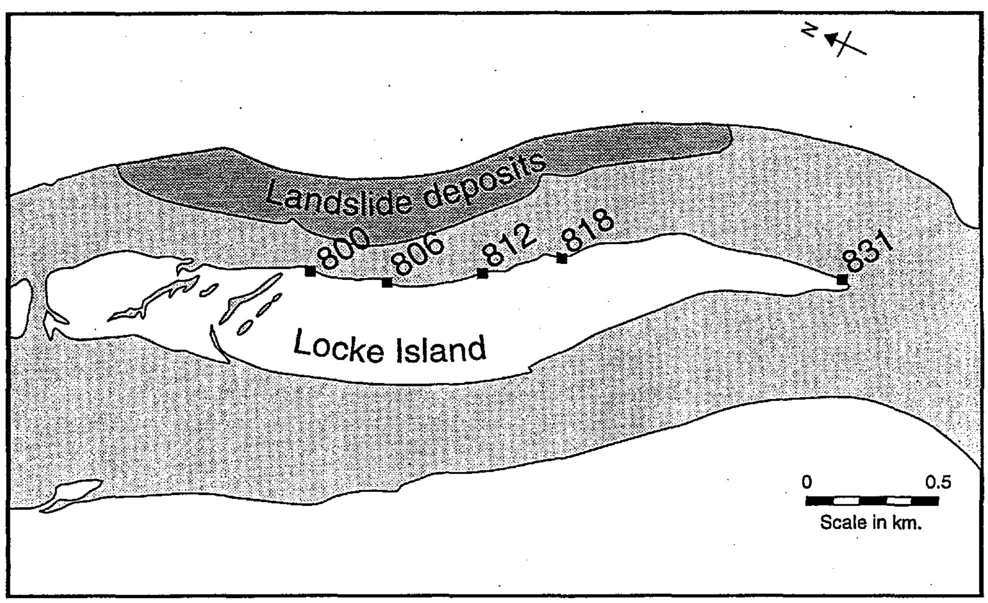

Figure 3.1. Location of Monitoring Transects Along the Eastern Shore of Locke Island

numerical transect designation, set 10 meters from edge of the bank to serve as a semi-permanent datum. As bank recession progressed inland during the study period, additional stakes and rebar were placed as necessary. In two instances, transects were reestablished after the rate of erosion was such that an entire 10-meter transect was lost before additional stakes had been set (designated #s 805a and 806a). In one instance, late February-early March 1996, one transect lost more than 10 meters in less than a 2-week period. The location of each transect was recorded both on aerial photos and maps and by using a Global Positioning System (GPS). GPS data were post-processed using the Hanford Base Station data, resulting in accuracy of these readings to within about 1 meter.

Fourteen monitoring trips were completed between January 22 and December 6, 1996, on an intermittent schedule, though generally at least once a month. Intervals between trips ranged from 6 to 62 days, depending on river flow and estimated potential for erosion. On each monitoring trip, loss at each transect was measured by using metric tape and recording the distance from the closest stake to the respective bank edge (Figure 3.2). When access was possible along the beach below the cutbank, the vertical face was visually inspected during field visits, and exposed cultural features, levels, or materials were similarly located with the GPS unit. Cultural resources were also recorded vertically within the bank. At times when the water level was too high to permit foot access below the cutbank, the face was visually inspected from the boat by eye or binocular view, depending on how close the boat pilot could access the bank. In some places, shallow gravel bars precluded close proximity.

3.3 Background

Although the Hanford Reach of the Columbia River is undammed, and therefore considered free flowing, the river flow is still very much regulated by upstream dams. The closest such dam is at Priest

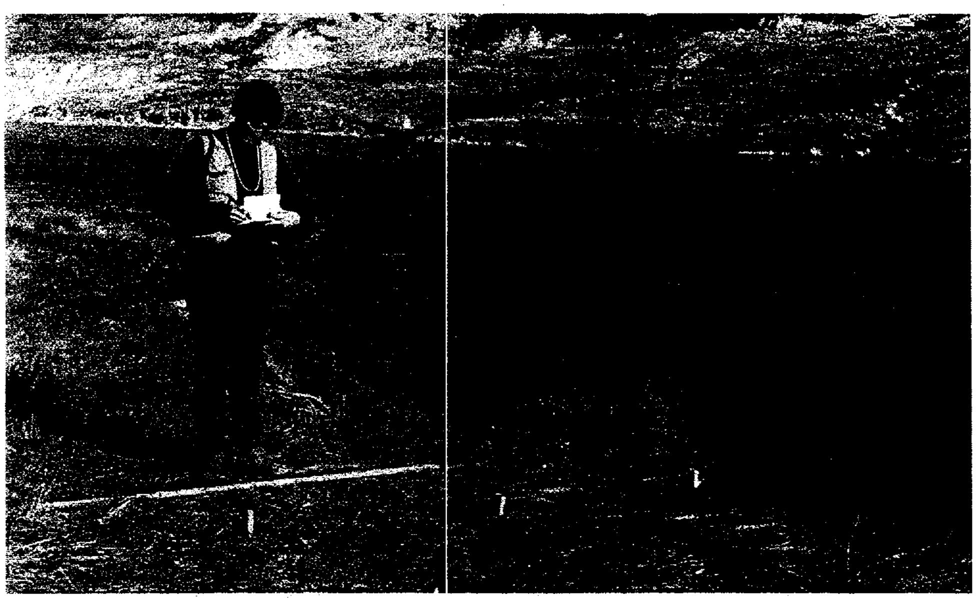

Figure 3.2. Field Crew Taking Measurements at One Erosion Monitoring Transect

Rapids, about 24 river miles above the study area, which is operated for hydroelectric power generation by the Grant County Public Utility District. The dam releases are generally maintained above 55,000 cubic feet per second for fisheries resources needs. The Reach experiences varying flow as a result of peaking operations at the upriver dams, and discharge may vary between about 36,000 and 200,000 cubic feet per second on any given day depending on power demand (Hall 1988). During the first year of the study period, daily fluctuation of the river height averaged a little less than 1 meter but was as great as 2.7 meters in early March 1996 during the flood period (Figure 3.3). Figure 3.4 illustrates the river fluctuation over a 3-day period.

The highest flows of the Columbia River typically take place during the spring freshet, starting in May and lasting into July, with peak flows generally occurring in mid- to late June. The year 1996 was no exception, with the highest average daily outflow occurring on June 13 at 282,000 cubic feet per second as measured at Priest Rapids Dam. Daily average outflow data were obtained from the Columbia River Data Access in Real Time (DART) database, available on the Internet from the University of Washington, School of Fisheries (www.cqs.washington.edu/dart/river.html), which receives data from the U.S. Army Corp of Engineers (USACE). However, an early season flood in late February of 1996 was almost as severe as the usual later spring flow, with the highest average daily outflow from Priest Rapids

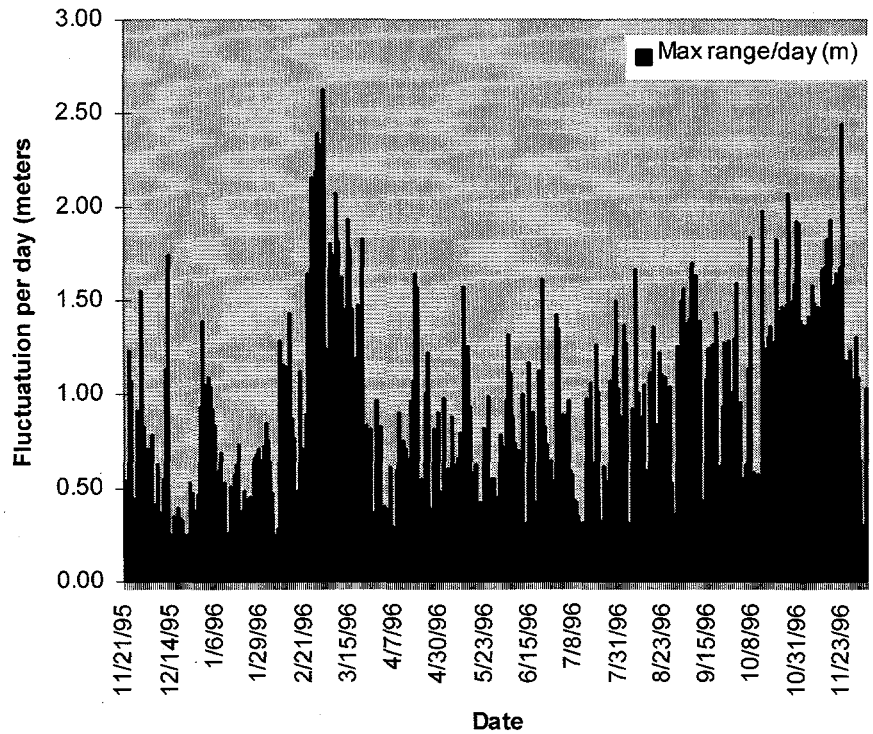

Figure 3.3. Fluctuation of the Columbia River Flow Throughout 1996

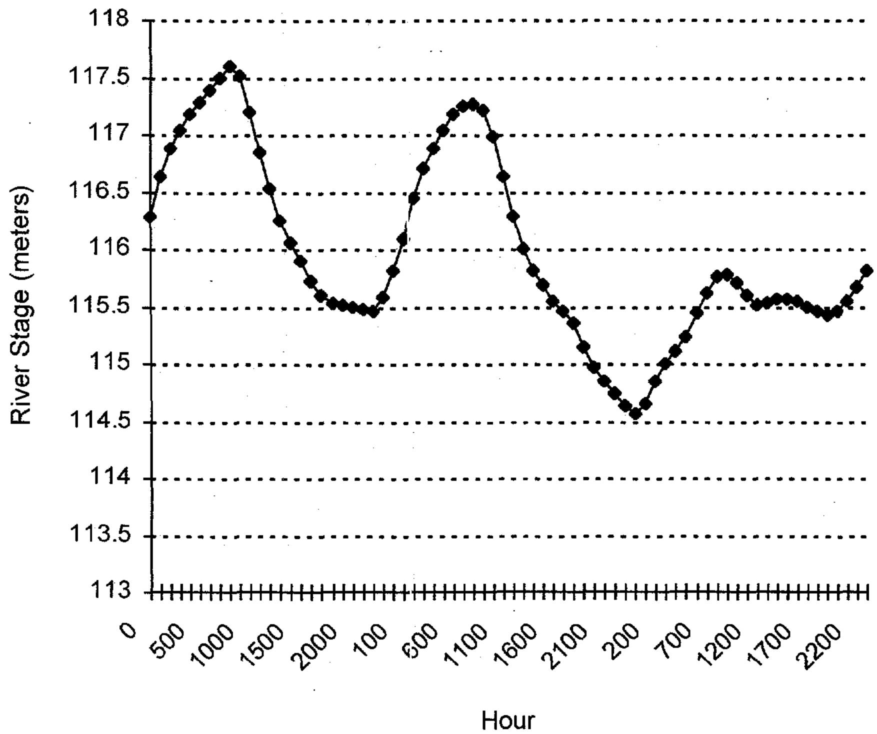

Figure 3.4. River Stage Fluctuation Over a 3-Day Period

Dam occurring on February 27 at 280,000 cubic feet per second. This particular early season flood is the most severe on record for this time of year along this stretch of the river since daily records have been kept at the dam starting in 1961.

3.3.1 Changes to the Bank During the 1996 Study Period

At the beginning of the study in November 1995, the severely eroding vertical bank measured about 450 meters in length. By December 6, 1996, the eroding cutbank exceeded 500 meters, having lengthened northward about 45 meters and to the south another 8 meters. Additionally, a section of the bank, which had been previously partially stabilized with vegetation, located near the center of the severely eroding face, was removed during the February flood period. This partially stabilized section of the bank had created a noticeable point along the bank about 70 meters long. A similar point of land along the same section of the bank in the vicinity of Transects 805 and 806 was reforming by the end of 1996, perhaps as a result of the island stratigraphy. At this location, a hard clay layer crops out near the water line. This clay layer is more resistant to erosion than the overlying friable sands and silts and may be protecting this lower part of the bank. Another point near Transect 800, which had been used as a boat landing area, was also eroded away during the study period, straightening this section of the bank. The bank where erosion is most active, between Transects 800 and 810, forms a concavity. Other changes to the adjacent river channel included new gravel bars, created as gravels eroded from the island shoreline in the vicinity of Transect 800 and were redeposited downstream.

3.3.2 Erosional Processes

Erosional features observed along the bank included undercutting by the river, failure of the bank in both slabs and high angle rotational slumps, and cutbank scalloping. The sizes of the blocks of sediment that fell were generally in the range between about 0.5 and 1 meter wide. Tension cracks within 0.5 meter of the upper bank edge were usually evident before bank slumpage in November 1995 and January 1996. Before the fall of a slump block the bank often appeared to "grow" by 10 to 20 centimeters; that is, the distance between the bank and transect stakes increased.

A number of factors affected bank erosion, including tensile strength and cohesiveness of the soil, stratigraphy of both the island and the landslide across the river channel, riparian vegetation, river stage, flow rate, and daily fluctuation of the river. Not surprisingly, the bank was most vulnerable to erosion when the water level was highest, especially if the high flow was sustained over a period of several days or longer. With saturation, the sediment lost its cohesive strength. The landslide materials opposite the east bank of Locke Island are composed primarily of the Ringold Formation sediments consisting of weakly indurated claystones, siltstones, and sandstones. These deposits are more resistant to erosion than the unconsolidated sands and silts that make up the upper strata of Locke Island and, thus, serve to direct the river current westward toward the eastern shoreline of the island. Not coincidentally, the area of the island displaying the most severe erosion is near the narrowest part of the channel between it and the Locke Island landslide area. As the landslide pushed into the river, water was diverted toward the island, and the channel narrowed resulting in deeper and faster flows.

3.3.3 Previous Flooding and Effects on Channel Morphology

The 1933 flood flow rate measured 401,000 cubic feet per second (Hall 1988). Comparison of aerial photographs from 1930 and 1943 suggest that this flood had little erosional effect on the bank in the study area. In contrast, flows of less than 280,000 cubic feet per second as occurred in February and June 1996 had a devastating effect on the bank, apparently a result of the narrowed channel. A study of the persistence of river bars along the Columbia River at the Hanford Site (Hall 1988) suggests that the river has exhibited a remarkable degree of channel stability over the past 90 years. According to that report, riverbed materials are sufficiently coarse along this stretch to resist movement by flows as high as the regulated 100-year frequency discharge. This stable channel bottom has resulted in very little pressure for the channel to migrate laterally.

3.4 1966 Erosion Monitoring Results

3.4.1 Erosion Monitoring

Over half the transects experienced severe erosion and recession of the bankline during the 1996 period of analysis. The greatest amount of loss occurred at Transect 806 where more than 16 horizontal meters were lost. Figure 3.5 graphically summarizes the field data by monitoring date, and Figure 3.6 summarizes cumulative loss at each transect by monitoring date. Appendix A itemizes the cumulative measured loss per monitoring trip. An additional 5 meters of loss is estimated to have occurred at Transect 800 since November 21, 1995, before that transect was established in March 1996.

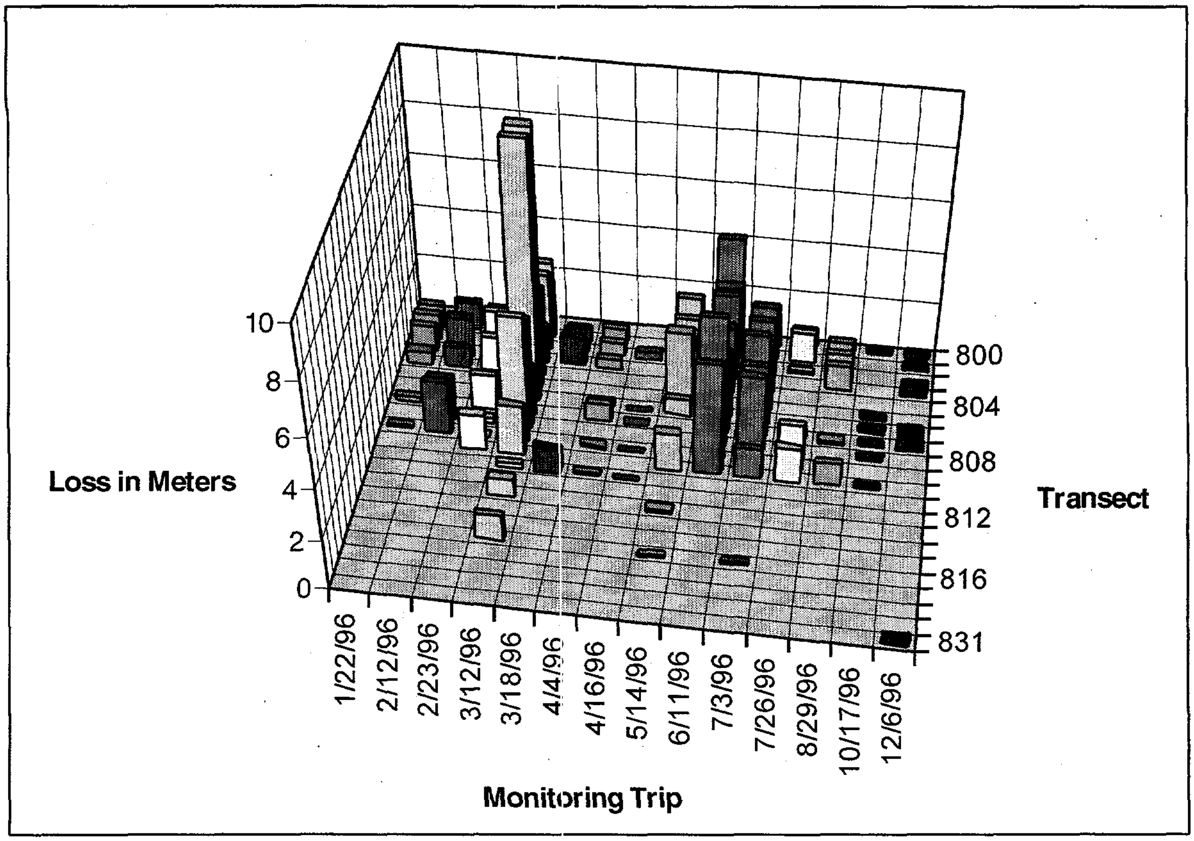

Figure 3.5. Bank Loss by Monitoring Trip for Selected Transects in 1996

A total loss of 1.7 acres of surface land was calculated along this section of the bank between November 1995 and December 1996. Using an average bank height of 6 meters along the crest of the bankline, this translates to some 41,000 cubic meters of sediment that entered the river during the monitoring period.

Not surprisingly, periods of significant erosion are correlated with periods of high water flow. River stage elevation data were obtained from the gagging station at 100-H reactor facility, opposite Locke Island on the west bank of the Columbia River. Lag time between the Priest Rapids Dam and Locke Island averages about 3 hours. About one-third of the total loss that occurred in 1996 happened during the February flood event (Table 3.1). Over 10 meters of loss occurred at Transects 805 and 806 during this time, between February 23 and March 12, 1996.

For the 18-day period between February 23 and March 12, 1996, the average area lost per day equaled 121 square meters. High erosion rates also occurred during the later spring freshet. Between May 14 and June 11, a total of 28 days, the average loss per day was 46 square meters. The slumping tended to follow a cyclical pattern with undercutting and bank failure followed by a period of relative stability as the bank was protected by the accumulated talus (Figure 3.7). Periods of high daily river fluctuation were also positively correlated with periods of high bank erosion (Figure 3.8).

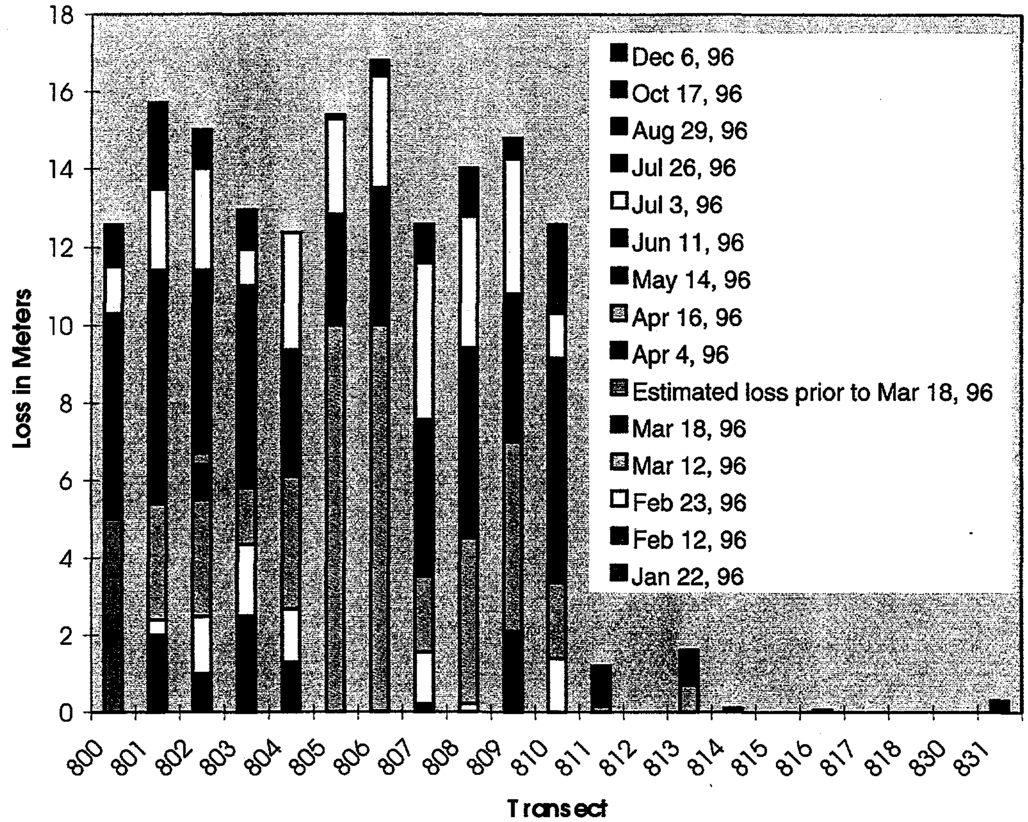

Figure 3.6. Cumulative Bank Loss for Each Transect in 1996 by Monitoring Trip

Relatively minor agents of erosion included bioturbation from nesting bank swallows and trenching by coyotes adjacent to the bank edge as they attempted to dig into swallow nests from above along the edge of the bank (Figure 3.9). Aside from the initial soil disturbance caused by these animals, the burrowing further added to bank instability during winter months, as surface water in the form of rain and snow is able to penetrate to greater depths, thereby further weakening the bank. Under current conditions, however, the accelerated bank recession easily mitigates the potential adverse effects that animals might have on bank stability during the summer months. In the case of nesting swallows, fairly rapid, incremental loss of the island sediments probably leads to far more detrimental consequences for the birds than the other way around.

In addition to the lengthy cutbank under study, there were several other smaller active bank exposures found around the perimeter of the island, including a critical erosional face along the southeast side that threatens a large prehistoric housepit village site. The sustained high water in 1996 increased erosion activity at each of these locations, although during times of more normal flow the lower banks and vegetation generally protect them. At the southern tip of the island, bank erosion is less catastrophic. The current is not as swift against the vertical portion of the bank, and the slumping that has occurred there seems to be more a result of winter precipitation.

Table 3.1. Estimated Bank Loss Between Monitoring Trips in 1996

Monitoring Date	Days Between Monitoring Trips	Total Loss m^2	Average Loss m^2/day	% of Total Loss
11/21/95	Transects established			
1/22/96	62	185	2.98	3
2/12/96	21	270	12.86	4
2/23/96	11	392	35.64	6
3/12/96	18	2178.5	121.03	34
3/18/96	6	147.5	24.58	2
4/4/96	17	150	8.82	2
4/16/96	12	25	2.08	<1
5/14/96	28	416.5	14.88	6
6/11/96	28	1300	46.43	20
7/3/96	22	938	42.64	14
8/29/96	57	409.5	7.18	6
10/17/96	49	22.5	0.46	<1
12/6/96	50	60	1.2	<1
	Total	6494.5		

A pedestrian survey was conducted of the island's perimeter in April 1996 to identify other areas of concern. Small cutbanks, no more than a few meters long, occur around much of the island in the fine-grained upper sediments; however, in general, established vegetation provides a stabilizing effect.

3.4.2 Continued Movement of the Locke Island Landslide

One of the most significant findings of 1996 was realized while examining sequential aerial photographs of the island and surrounding area, when it became apparent that the landslide deposits, assumed to be stable, were in fact still quite dynamic. A series of landslides along a 5-kilometer-long strip of the White Bluffs opposite Locke Island initiated in the early 1970s. The cause that appears to have led to the initiation of the failures is associated with surplus irrigation water that was channeled into ponds located east of the White Bluffs, about 2 miles from the river. In only a few years, subsurface water migrated from these ponds and began seeping out along the White Bluffs at the contact between the permeable Hanford formation, comprised of Pleistocene flood slackwater deposits, and the underlying, less permeable Ringold Formation. Examination of a 1976 aerial photograph shows several small landslides along this stretch of the bluff (Figure 3.10). The landslides were more extensive by 1983 as indicated by the 1986 USGS Locke Island 7.5' topographic map (mapped from 1983 photographs). The main mass of the cliff had given way by 1987. Aerial photographs taken in June 1996 show that the

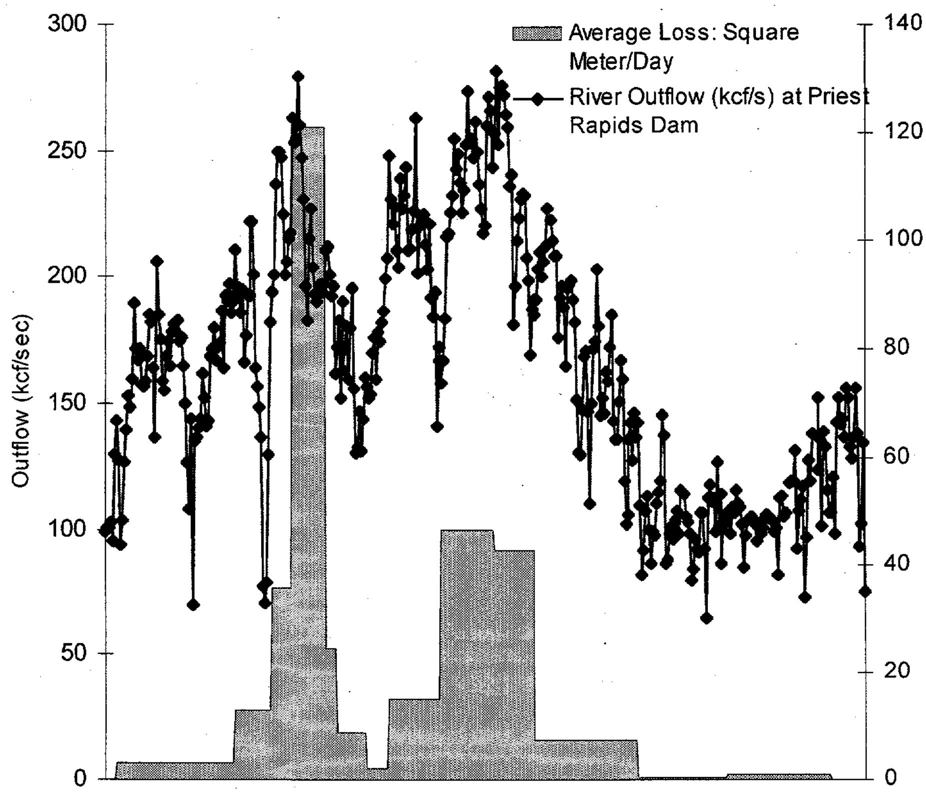

Figure 3.7. Comparison Between High Flow Regimes and Active Bank Erosion at Locke Island in 1996

channel continued to narrow and then was reduced to about one-third of its pre-slide width of about 450 meters. The lower edge of the slide appears to have moved an additional 150 meters during the last decade and is now only 150 meters from the edge of the island (Figure 3.10).

In an earlier analysis of this slide area in the early 1980s, Hays and Schuster (1987) noted that wastewater inflow into the ponds had almost been eliminated and that "within a few years, the seepage and resulting landsliding in this segment of the bluffs may cease." However, the aerial photographs taken in June 1996 conclusively indicate that water continues to seep out of the bank above the slide and within the lower part of the slide. A line of springs appears to be flowing from near a contact coincident with the original river shore, mobilizing and creating continued movement of the lower part of the slide. Most of the recent movement appears to be within the distal portions of the slides, above what used to be river channel. Water may be moving along contacts between rotational slump blocks; however, the exact mechanisms for the recent movements taking place within the slides are not presently understood.

Achieving a better understanding of the physical dynamics at work in the landslide zone opposite the island is critical to predicting erosion along the eastern perimeter of the island, and for identifying and designing possible protective strategies for the important cultural resources contained in the island's sediments. If engineered bank protection strategies are to be considered, it is imperative that the dynamics of

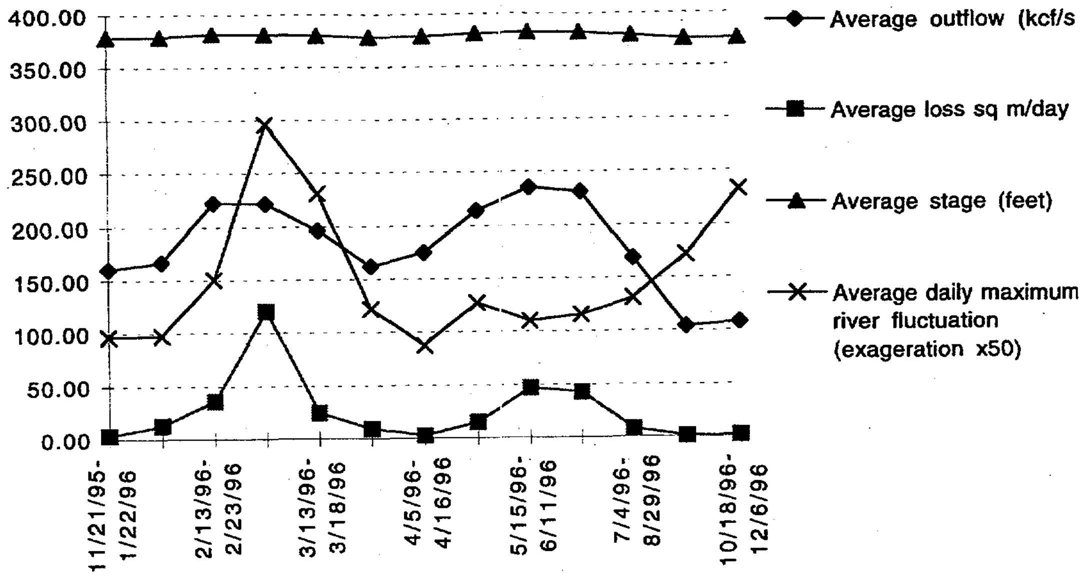

Figure 3.8. Comparison of Bank Loss at Locke Island in 1996 with River Stage and River Fluctuation

the landslide be understood. Although it is evident that the slide is still moving, no quantitative measurements on the rate of movement have been completed. A study of the mechanisms working within the slide area and a program to monitor the movement of the slide are strongly recommended.

Like all rivers, the Columbia River system in this area is dynamic. Not only is the eastern bank of Locke Island receding, but the toe of the landslide is also being eroded away by the current. Sediment from these sources is being redeposited below in the channel, affecting the flow of the river. As noted above, gravels are being eroded from the shoreline of the upper island and are changing the channel bottom east of Locke Island. Bank recession can be expected to continue along the eastern edge of Locke Island during periods of high flow as long as the river channel continues to be constricted by the major landslide on the opposite bank.

3.5 Locke Island Erosion Monitoring During 1997

3.5.1 Methodology

The monitoring program of natural erosion processes and exposure of cultural features along the east shore of Locke Island, established in fiscal year 1996, continued in fiscal years 1997 and 1998.

Between December 6, 1996, and December 12, 1997, a total of 18 additional monitoring trips were conducted. These occurred at least monthly with more frequent visits during periods of extremely high flow when erosion was most active. On each visit, erosion was measured at each transect, new transect

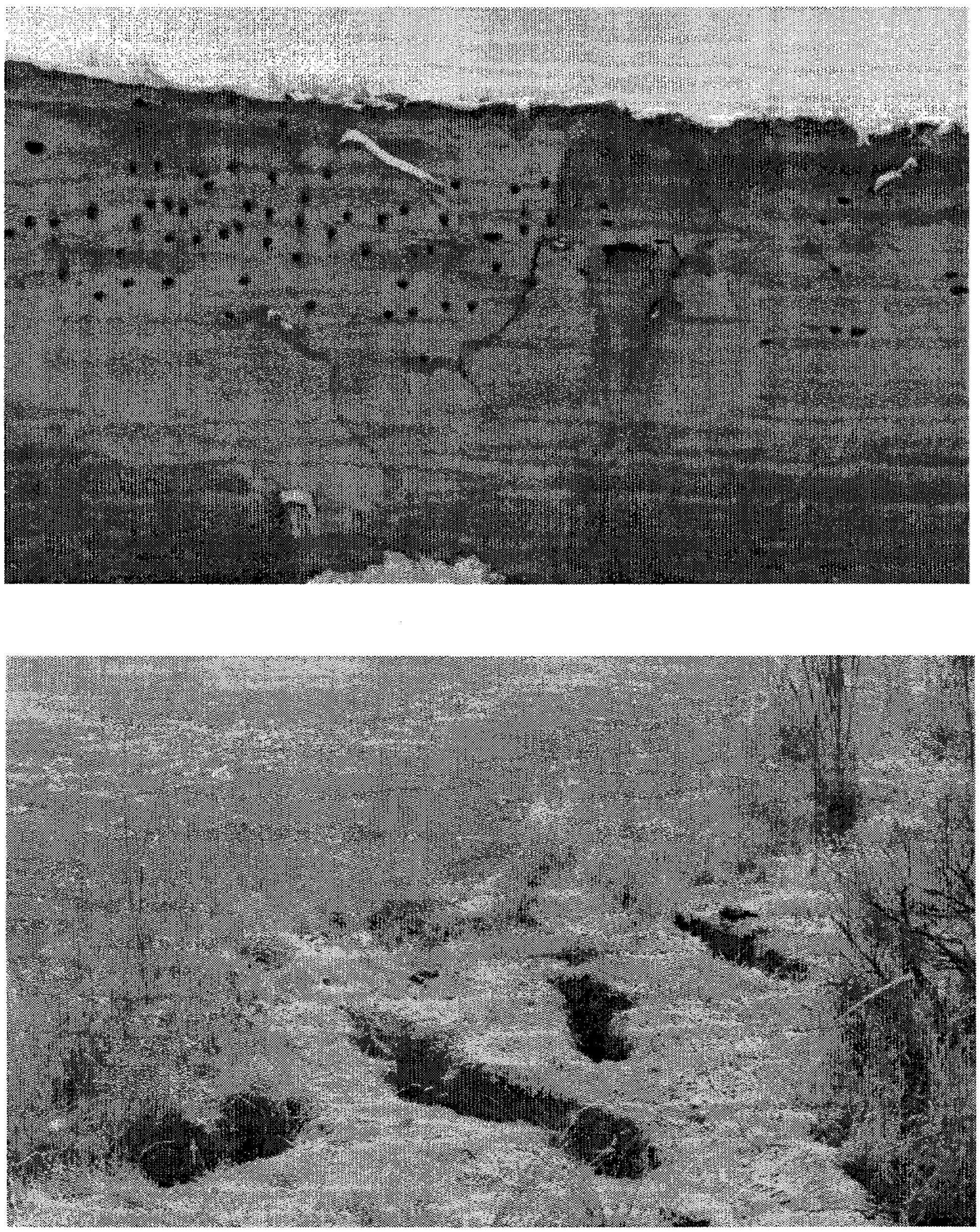

Figure 3.9. Photographic Documentation of Biological Intrusions Contributing to General Bank Instability. Bank swallow nests in the vertical face of the cutbank (top). Trenching by coyotes in an effort to reach the swallow nests (bottom).

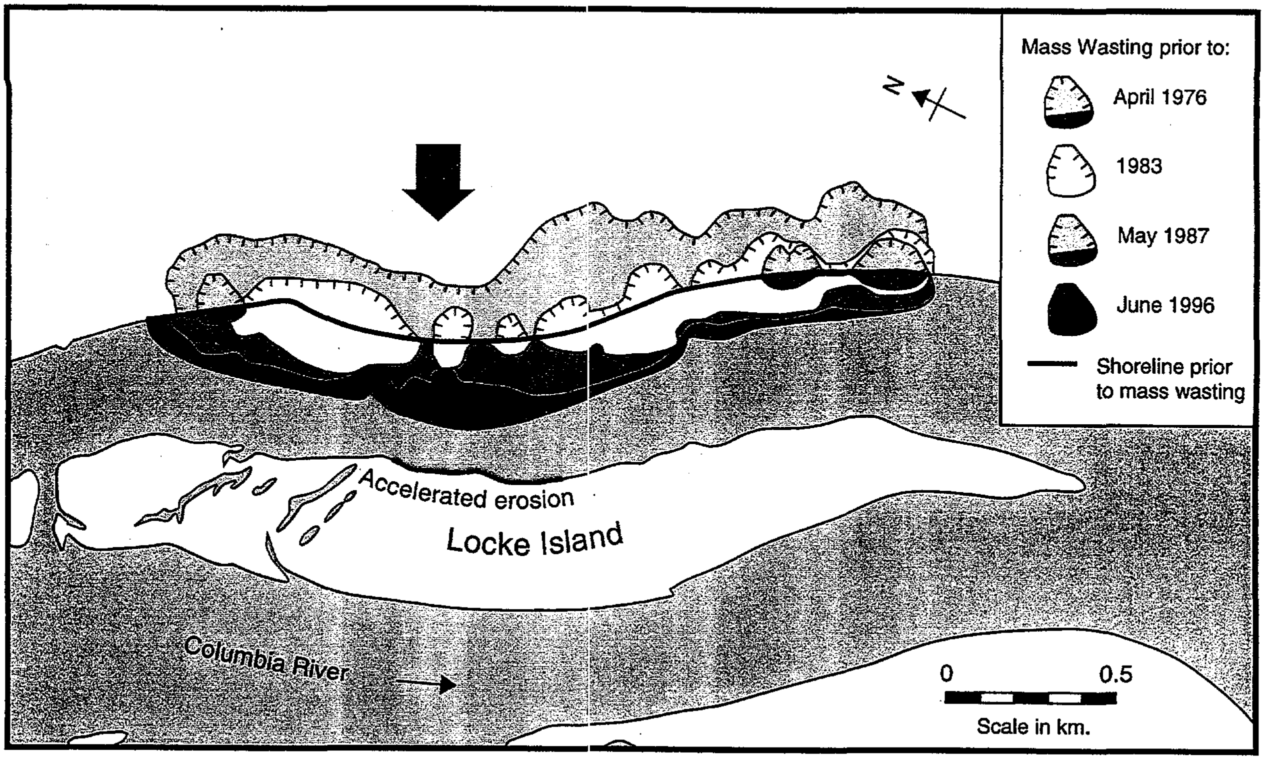

Figure 3.10. Schematic Representation of the Locke Island Landslide Movement at Distinct Points in Time, as Mapped From Aerial Photography

stakes set as needed, and the bank examined for cultural materials as river conditions allowed. Three new transects were also established (748, 750, and 799) (Figure 3.11). Transects 748 and 750 were set up opposite the north end of the landslide where the cutbank was near vertical, sediments fine-grained (sands and silts), and the bank over 5 meters high. These transects were established on May 16, 1997. Transect 799 was set up about 50 meters upstream of Transect 800 on a low gravel terrace that had begun to erode in 1996. Transect 799 was established on December 6, 1996.

3.5.2 Results

Erosion along the east shore of Locke Island and along the entire Hanford Reach was substantial as a result of sustained high waters during the spring flood of 1997. Approximately 2 acres of surface land was lost from the island during this reporting period. Assuming an average bank height of 6 meters, approximately 47,800 cubic meters of sediment entered the river during this time. Figure 3.12 summarizes the erosion that occurred at each transect. Transect 811 experienced the greatest loss (19.6 meters) during 1997 as a result of river current changes. Before the 1997 flood, the bank at Transect 811 had been relatively stable, well vegetated including a tree. Only 1 m was lost at this transect the previous year (Figure 3.13). The actively eroding cutbank expanded both to the north and south during the year. Indeed, much of the perimeter of the island suffered erosion as a result of the sustained high water. Figure 3.14 summarizes the total loss along the monitored bank since the project began in the fall of 1995.

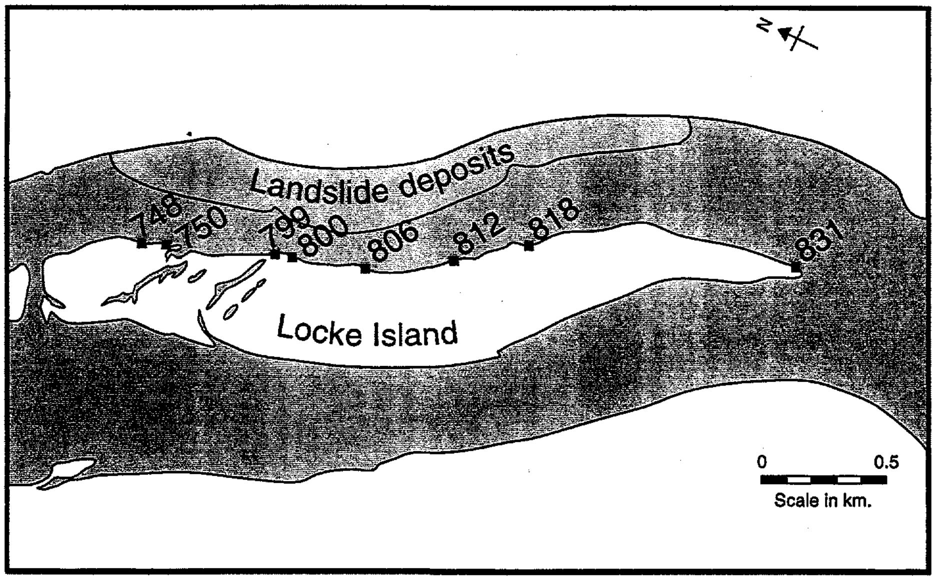

Figure 3.11. Locations of Additional Monitoring Transects Established in 1997

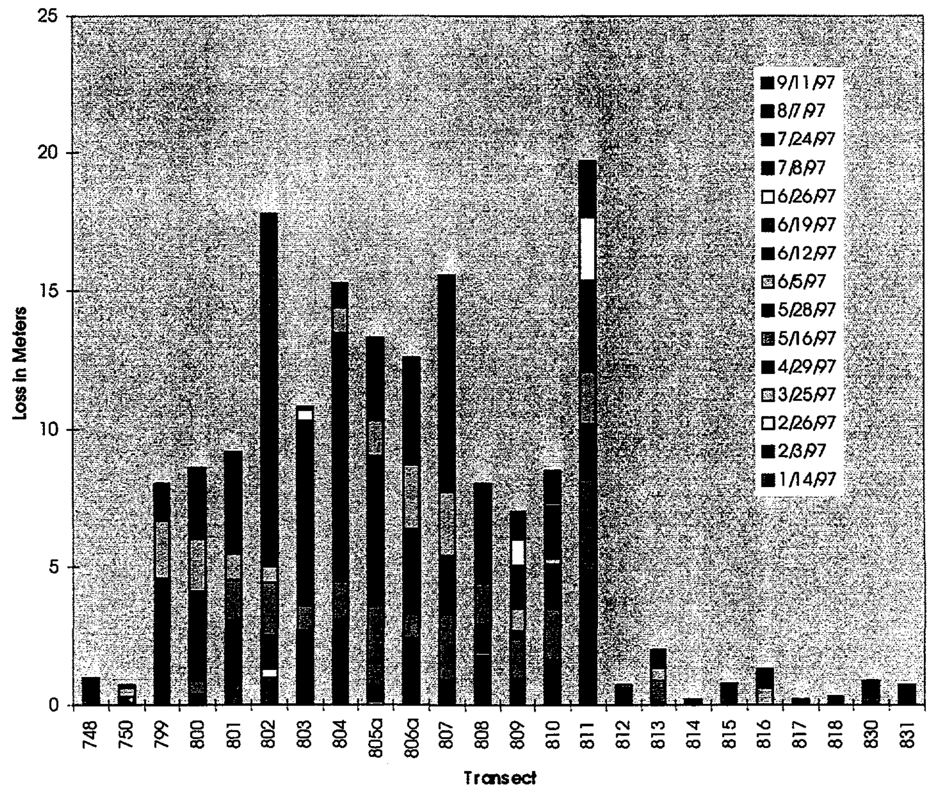

Figure 3.12. Erosion Along the Eastern Bank of Locke Island From December 6, 1996, Through December 11, 1997

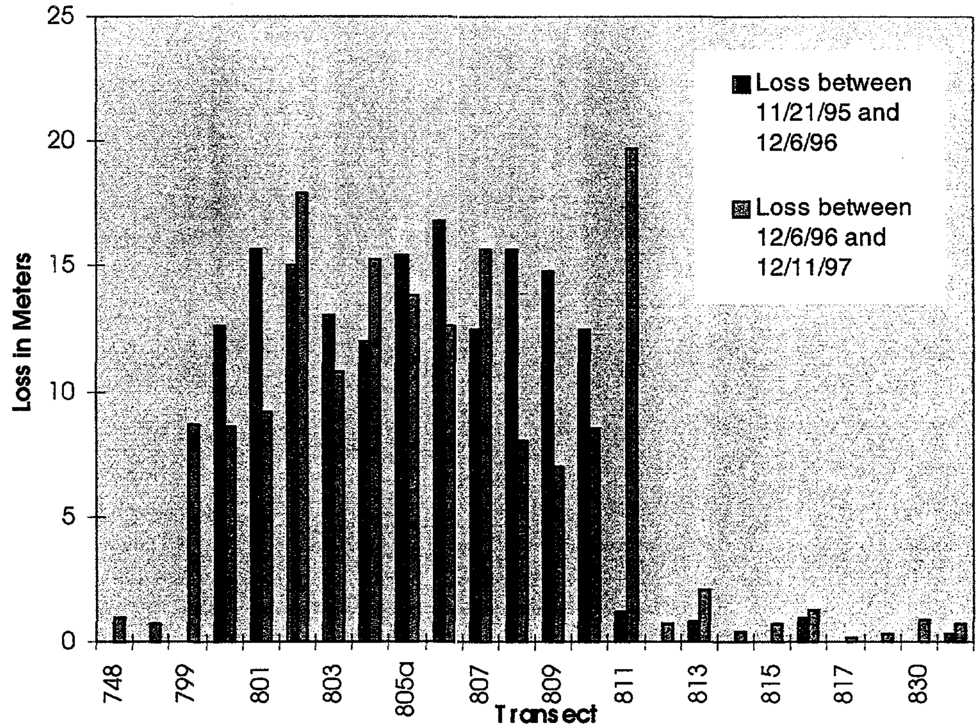

Figure 3.13. Comparison of Bank Erosion by Transect Along the Eastern Edge of Locke Island in 1996 and 1997

River flows were extremely high this year, surpassing the high flows of the spring of 1996 by almost 50%. The highest outflow recorded was 451, 000 cubic feet per second on June 12, 1997 (data from USACE Walla Walla District database available on the internet at www.npw.usace.army.mil/html/offices/pl/h/wm/ rreports.htm). Periods of rapid bank loss corresponded to periods of high flow, culminating in over 257 square meters a day lost in the week between June 5 and 12, 1997. Seventy five percent of the loss during 1997 occurred between mid-May and mid-June (Table 3.2), with close to a quarter of the loss in the week between June 5 and June 12. Figure 3.15 shows the average daily outflow from Priest Rapids Dam (data obtained from the DART database) and average area lost between Transects 799 and 818.

Figure 3.16 compares the loss and outflow between 1996 and 1997. The same pattern of high flow corresponding to periods of active erosion is evident, though with more dramatic results in 1997. River elevation at Locke Island in the study area can be closely estimated by using the river stage data from the gauging station at 100-H, located to the west of Locke Island across the western channel of the Columbia River. The highest elevation of 118.4 (388.4 feet) was recorded on June 12, 1997. This was less than one meter from overtopping the island. Figure 3.17 compares the river elevations during 1996 and 1997.

The daily river fluctuation was much less severe during 1997 during periods of high water compared to 1996. The maximum fluctuation was 1.14 meter during the period mid-May through June when flows

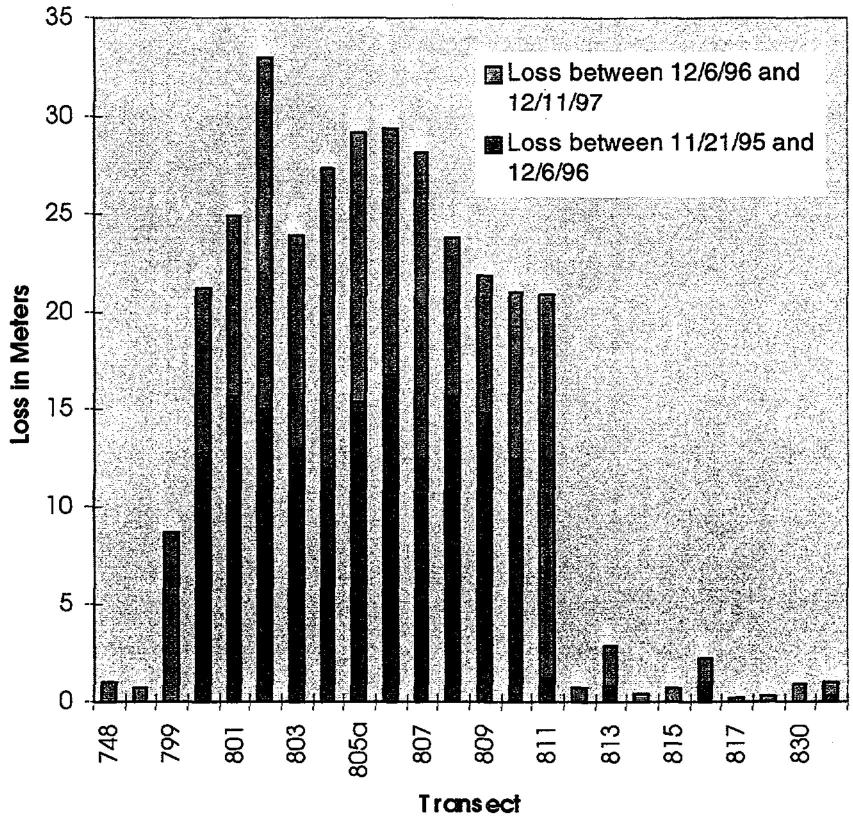

Figure 3.14. Cumulative Bank Erosion Along the Eastern Bank of Locke Island in 1996 and 1997

were the highest with the average of 0.41 meter during this time period (Figure 3.18) compared to 1996 fluctuations of up to 2.6 meters during high flows. Erosion rates may have been even higher had the river fluctuated as it did in 1996 during high water events. Figure 3.19 displays negative correlation between daily maximum fluctuation of the river with outflow and loss.

Based on aerial photo examination, between October 1995 and November 1997, the east channel in the study area widened approximately 40 meters a result of erosion along the east bank of the island and along the toe of the landslide (Figures 3.20 and 3.21). Most of the erosion of the landslide occurred in 1997. As a result of this wider channel, erosion of the island in subsequent years can be expected to be less severe than in the previous two years, especially if flows are closer to average and barring continued movement of the landslide.

Table 3.2. Bank Loss Between Monitoring Trips in 1997

Monitoring Date	Days Between Monitoring Trips	Total Loss m^2	Average Loss m^2/day	% of Total Loss
1/14/97	39	182.5	4.7	2
2/3/97	20	195.0	9.8	2
2/26/97	23	25.0	1.1	<1
3/25/97	27	2.5	0.1	<1
4/29/97	35	930.0	26.6	12
5/16/97	17	1052.5	61.9	13
5/28/97	12	1700.0	141.7	21
6/5/97	8	767.5	95.9	10
6/12/97	7	1802.5	257.5	23
6/19/97	7	627.5	89.6	8
6/26/97	7	187.5	26.8	2
7/8/97	12	115.0	9.6	1
7/24/97	16	210.0	13.1	3
8/7/97	14	76.3	5.4	1
9/11/97	35	2.5	0.1	<1
10/30/97	49	10.0	0.2	<1
11/13/97	14	41.3	2.9	1
12/11/97	28	40.0	1.4	1
	Total	7967.5		

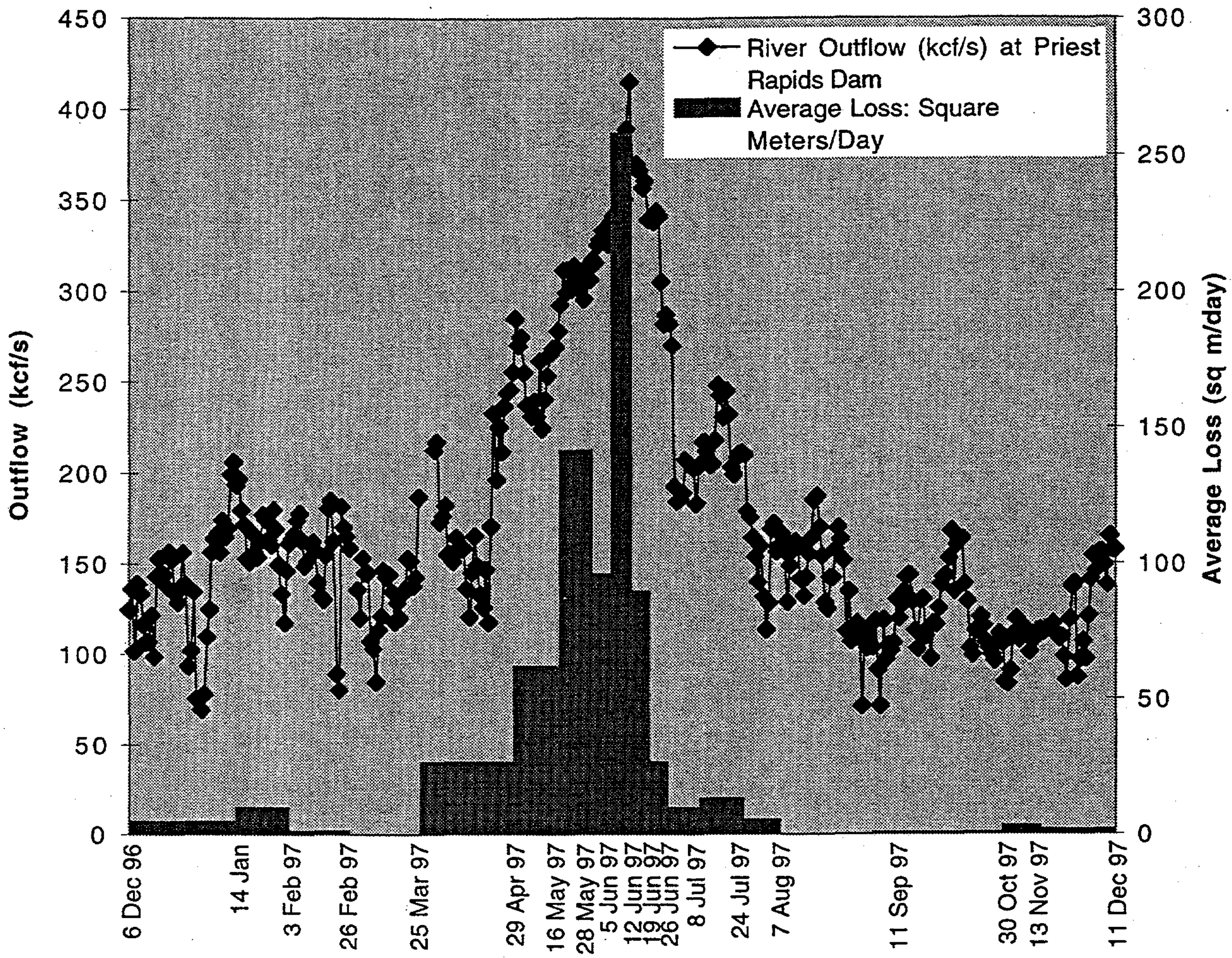

Figure 3.15. Comparison of High River Flow and Periods of Active Erosion in 1997

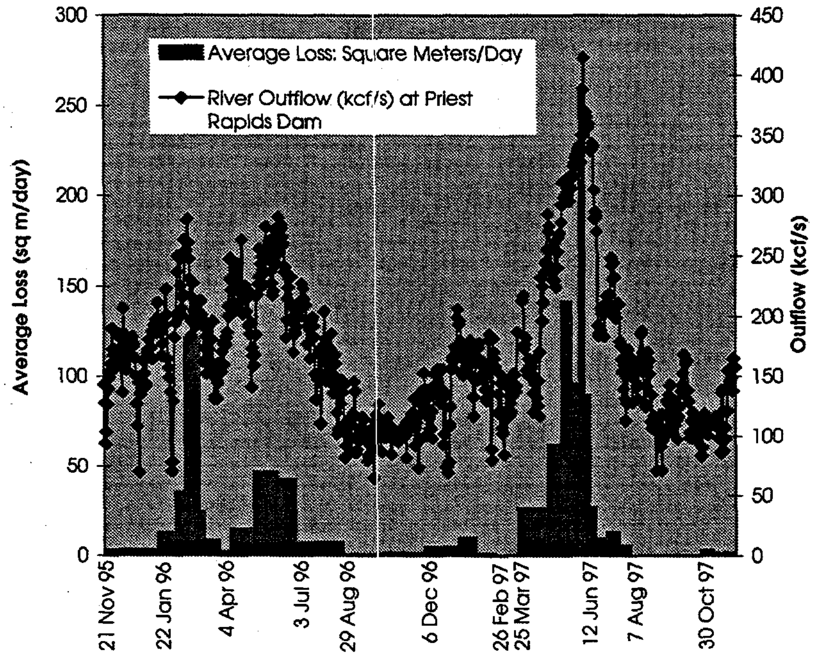

Figure 3.16. Comparison of High River Flow and Active Periods of Erosion in 1996 and 1997

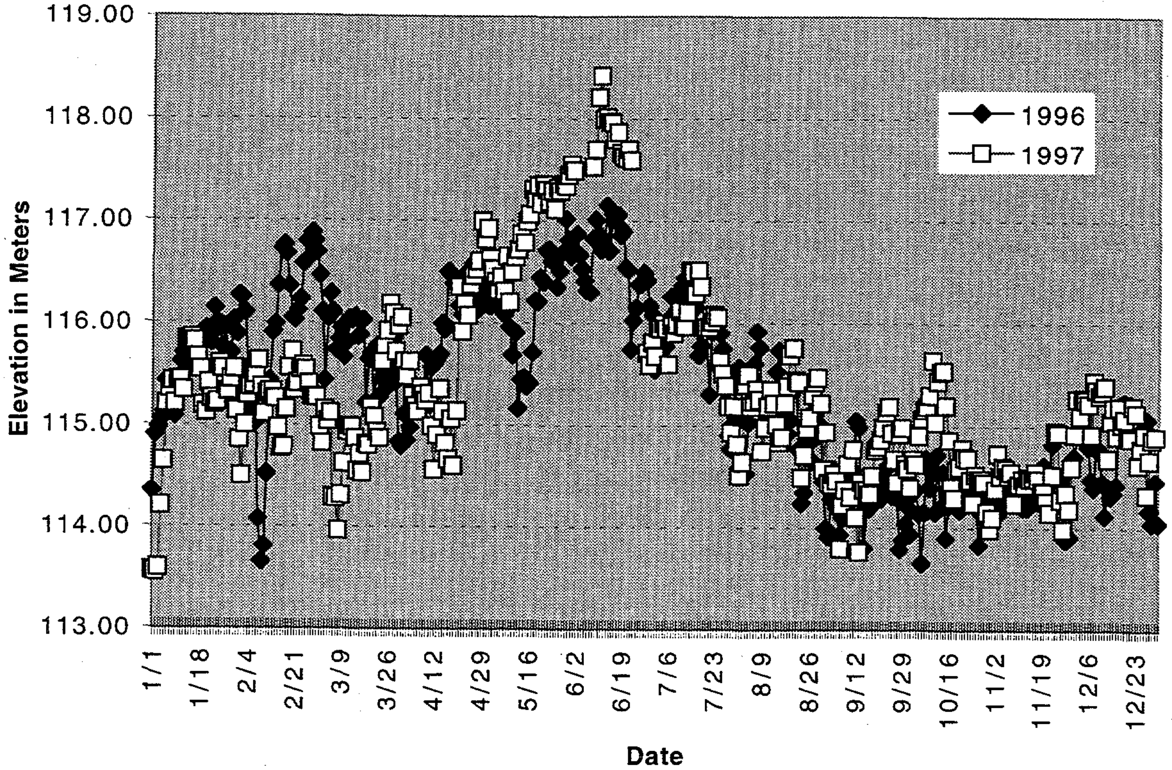

Figure 3.17. Elevation of the Columbia River at the 100-H Gauging Station in 1996 and 1997

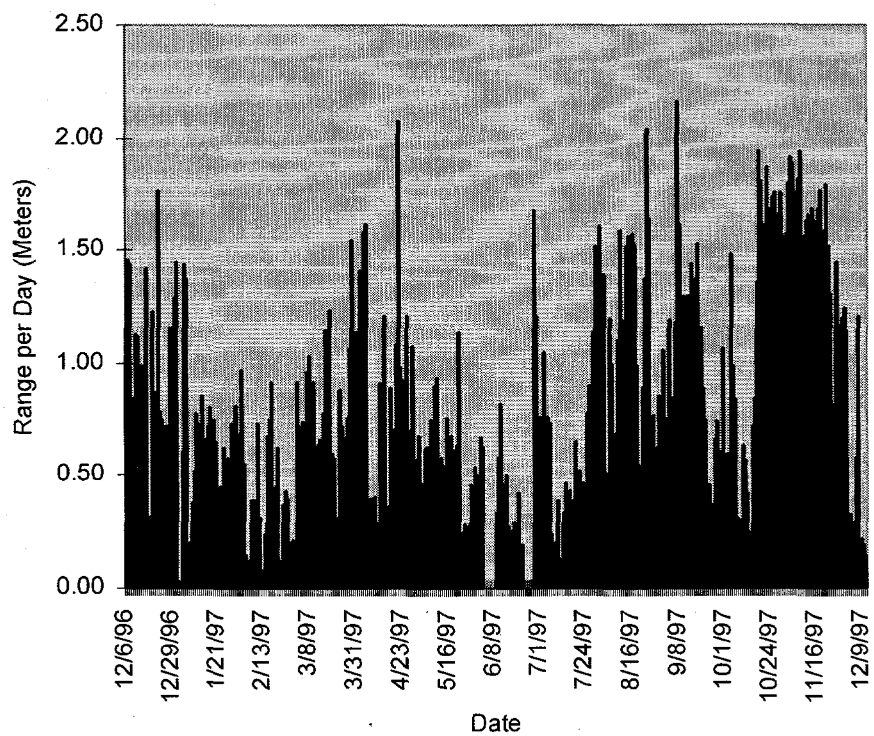

Figure 3.18. Fluctuation of the Columbia River in 1997

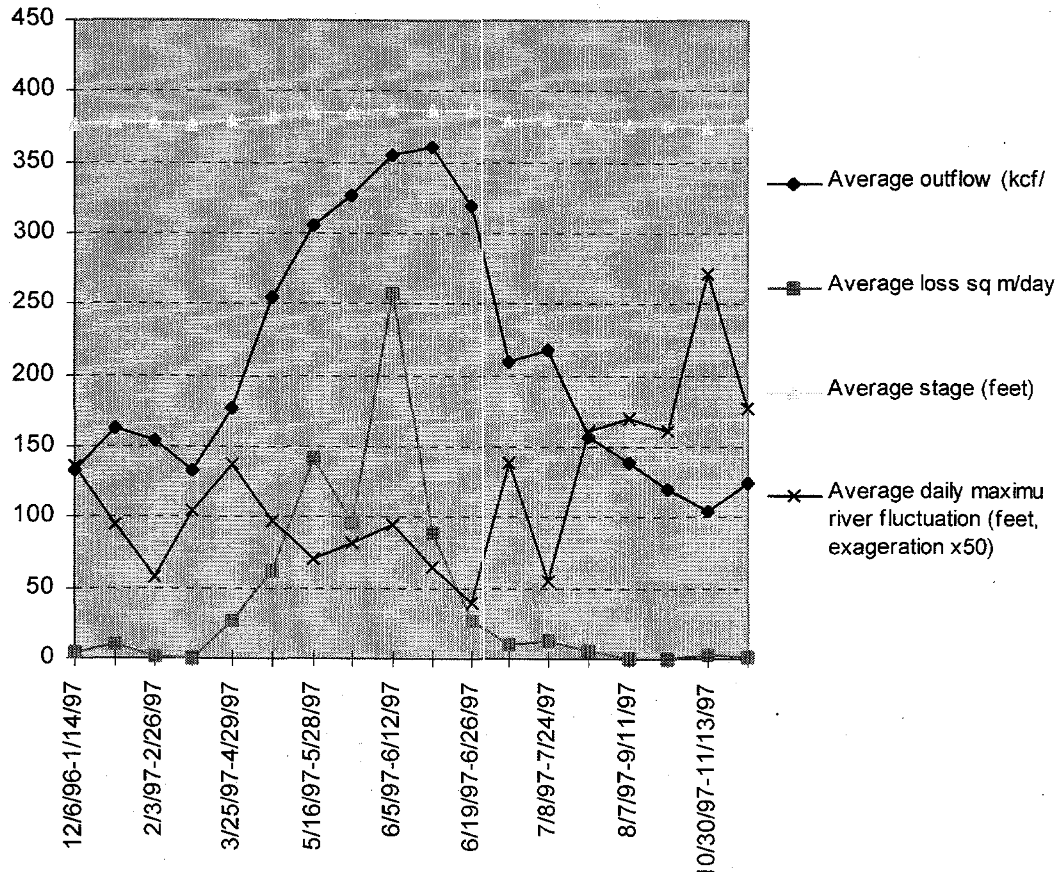

Figure 3.19. Comparison of Bank Loss at Locke Island, River Stage, and River Fluctuation

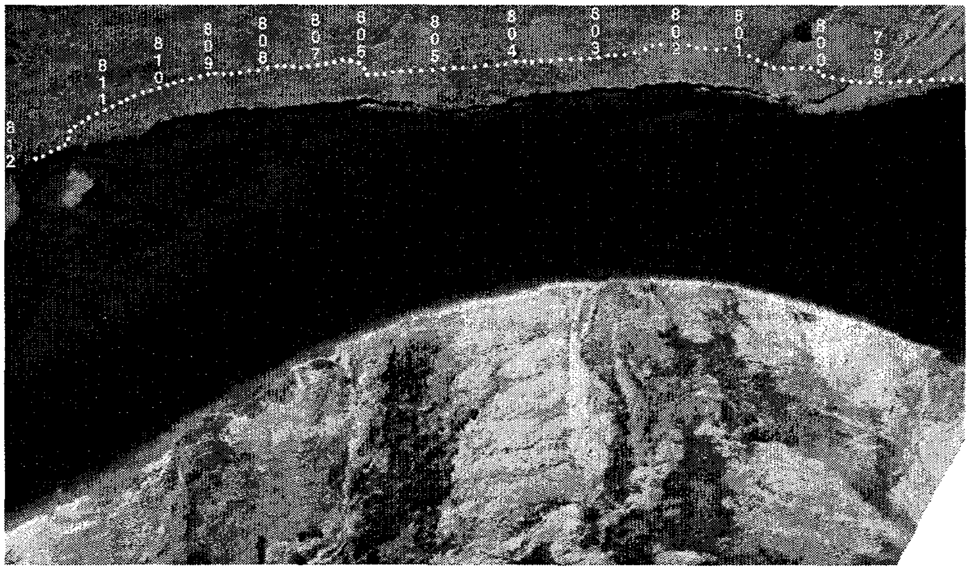

Figure 3.20 Aerial Photograph of the Locke Island Study Area and Landslide (October 5, 1995). Dotted line indicates bankline position on November 24, 1997, with transect locations indicated. (Photograph #W95-18-23).

Figure 3.21. Aerial Photograph of the Locke Island Study Area and Landslide (November 1997). Note newly formed gravel bars and truncated toe of the landslide. (Photograph #97120302-26CN).

4.0 A Preliminary Examination of Archaeological Deposits in Eroding Cutbanks at Locke Island

Mona K. Wright

4.1 Introduction

Monitoring activities associated with Locke Island represent the first study of its kind to be initiated on the Hanford Site although archaeological surveys, reconnaissance, and since 1927, test excavations have been intermittently conducted on lands the Hanford Site now comprise (Krieger 1928; Rice 1968a; Rice 1968b; Rice 1980; Chatters et al. 1990; Chatters et al. 1991; Chatters and Gard 1992; Chatters et al. 1993; Last et al. 1994; Nickens et al. 1995). The 1996 and 1997 monitoring efforts to define and quantify rates of erosion along the northeastern bank of Locke Island included investigation of numerous intermittently exposed cultural features and layers. Before 1996, approaches had not been developed to quantify and potentially predict impacts to cultural deposits as a result of erosion on the Hanford Site. Preliminary results of the current monitoring effort suggest that such a capability would be beneficial, particularly with regard to the management and preservation of archaeological sites listed in the National Register.

4.2 Methodology

The 1996 Locke Island monitoring effort focused on two separate but compatible activities. First, perpendicular transects were established to monitor rates of bank recession along approximately 1 kilometer of Locke Island's northeastern shoreline. Techniques and methodologies selected to document the anticipated exposures of archaeological deposits in the eroding cutbank included:

- use of a GPS to establish the location of cultural features
- documentation (measurement, description, and photographing, as applicable) of all exposed cultural features and materials
- documentation of contextual relationships such as below-surface measurements and distances to transect
- collection of charcoal samples and bulk soil samples from cultural features or layers exposed by cutbank recession.

Second, a survey of the island's perimeter was conducted to determine whether erosion was occurring at other locations along the shoreline and to note the presence or absence of archaeological deposits within any additional cutbank exposures.

Shortly after the monitoring process began, several adjustments in our methodology became necessary. Specifically, the entire length of cutbank exposures could not be consistently inspected because the toe of the cutbank was unpredictably submerged or exposed during each monitoring visit. The southern end of the monitored cutbank, although usually accessible, remained stable and vegetated during most of the monitoring cycle thereby reducing, but not eliminating, the need for in-depth investigations (Figure 4.1). And finally, an unexpectedly erratic, punctuated rate of erosion along the northernmost segment of the monitored cutbank meant that documentation of cultural features and any sample collection would have to be done at the time of discovery.

The process of monitoring cultural materials and features was consistent but intermittent. During the early portion of the monitoring effort, cutbank surfaces were not closely inspected because the toe of the vertical bank was consistently submerged, and active erosion was underway. When lower water levels coincided with transect monitoring visits, HCRL staff walked the base of the riverbank and documented exposed cultural features and materials, whether exposed in the vertical bank or the beach. When encountered, charcoal samples were recovered from the bank's vertical exposure; a high fraction of the samples recovered were found in hearth features.

When encountered, cultural materials and features were described and measured as appropriate. Descriptions of visible attributes were noted, and spatial relationships such as depth below surface, size,

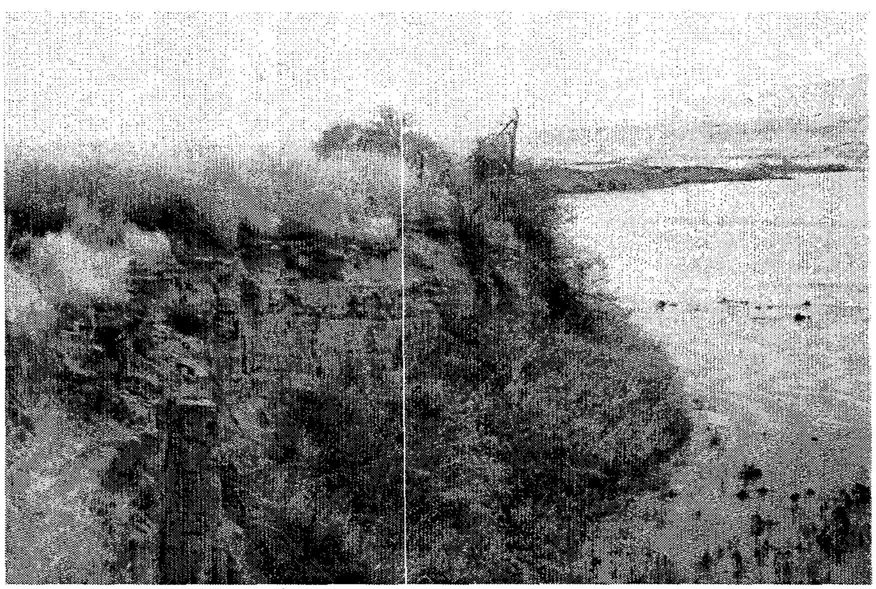

Figure 4.1. View of the Cutbank at Transect 816, Looking Northeast (November 21, 1995). The surface of the bank was weathered and the toe vegetated, suggesting relative stability of the cutbank at that point in time (PNNL 215/33).

and association(s) with cutbank transect were recorded. Location data were collected using a GPS to accurately define the position of discrete cultural features such as hearths or cultural layers retaining intact fire-cracked rock concentrations.

The 1997 Locke Island monitoring effort continued the methodological approaches pursued during 1996 with some refinement in technique and documentation. Given the erratic but predictable sediment loss ratio to high river levels experienced during the 1996 monitoring cycle, we increased our monitoring visits from a total of 14 in 1996 to 18 during the 1997 monitoring cycle, increasing our visit intervals during periods of high water. We continued to use procedures set in place in 1996: GPS systems to pinpoint cultural feature locations, documentation of contextual relationships between cultural materials and erosion monitoring transect locations, and opportunistic collection of charcoal samples from hearths and cultural layers exposed during cutbank recession. In addition to the basic procedures established in 1996, we conducted the following activities:

- established two new transects (748 and 750) at the northern end of Locke Island
- increased documentation of cultural materials encountered outside erosion transects perimeters, specifically along the eastern side of the island's southern tip—south of Transect 831—and at the informal boat launch used to access Transect 748 and Transect 750 at the northern end of Locke Island
- investigated cutbanks below Transect 812 through Transect 818 with the same consistency as we investigated cutbanks from Transect 748 through Transect 811 even though many of these cutbanks remained stable and vegetated during the 1997 monitoring cycle.
- recovered archaeological materials from a shoreline terrace that dated to approximately 700 years before present.

A survey of the island's perimeter conducted on April 16, 1996, suggested that impacts to the archaeological record were more common along the eastern shoreline as opposed to the western shoreline of the island. Although some eroding cutbanks were encountered along the western edge of Locke Island, much of the shoreline there was found to be fairly stable with heavy vegetation growth. However, cultural materials were present on beaches and in cutbank exposures along both sides of the island.

The archaeological information recovered in 1996 and 1997 at Locke Island is discussed in the following paragraphs. Data that support these discussions are summarized in Appendices B (cultural materials and features observed) and C (archaeological deposits and bank recession for each transect); field data are on file at the HCRL.

4.3 Archaeological Data Recovered

A wide range of archaeological items and contexts were encountered and recorded during 1996 at Locke Island, but they represent only a portion of the archaeological record now known to be incorporated within the island's sediments. At least 70 cultural features and individual items were observed and recorded in the Locke Island cutbank as it receded, including hearth features, shell, layers of fire-cracked rock, tools, concentrations of fire-cracked rock lying on the beach or talus, and faunal remains. Ten charcoal samples and two bulk soil flotation samples were recovered and processed in 1996 in an effort to date in situ cultural features and investigate potential avenues for recovery of information about plant usage and the history of plant community development on the island.

Substantial amounts of archaeological data were also gathered during 1997. It is currently not known what percentage of the cultural features recorded during the 1997 monitoring cycle were also documented in 1996. This understood, approximately 60 features were documented during 1997, although only 17 of the 60 were encountered in situ. The remaining 43 features can be classified as deflated scatters of fire-cracked rock or cobbles that were encountered at the base of cutbanks or on the beach. Seven additional charcoal samples and one organic sediment sample were recovered from cultural features and adjacent strata, then processed to expand our current knowledge about the temporal sequences of human activity on the island. One important aspect of the 1997 investigation was the recovery of a charred material sample from the deeply buried cultural layer first recorded during the 1996 monitoring cycle. Another important aspect of the 1997 effort was the fortuitous discovery of an archaeological surface below Transect 800.

4.4 Transect Monitoring Results

Cumulative results of cultural materials observed in all transects are decidedly preliminary. Twelve different types of cultural materials and features have been recognized in the eroding cutbank and on the shoreline. Several apparent clusters or groups seem to occur in the northernmost segment of the monitored cutbank. That is, cultural materials and features were frequently exposed at some transects and were minimally exposed or markedly absent in others (Figure 4.2). Clusters of cultural materials and features have been noted at Transect 800, between Transects 803 and 804, at Transect 806, and between Transects 807 and 808. Numerous features and a wide variety of cultural materials are also present at Transects 830 and 831 where impacts as a result of erosion are minimal. Transects 814 through 818 are staked above vegetated banks where neither erosion nor cultural materials were observed in 1996.

Associations between staked transects on the surface of the island and the cultural materials observed in the cutbank and on the talus below the transects are summarized below, beginning with the northernmost transect. Visual representations of the sequential erosion of each transect and the concomitant exposure of cultural materials are found in Appendix C.

Transect 748: Established May 16, 1997, this transect was placed to monitor rates of erosion at the northern end of Locke Island, along the northeastern cutbank where cutbank exposures were lengthening as a result of high water. Once established, the bank below the transect was inspected by boat throughout the monitoring cycle because of bank overhang. Several fire-cracked rock features were observed at this location on August 7, 1997; these were the only cultural materials observed at this location during the 1997 monitoring cycle.

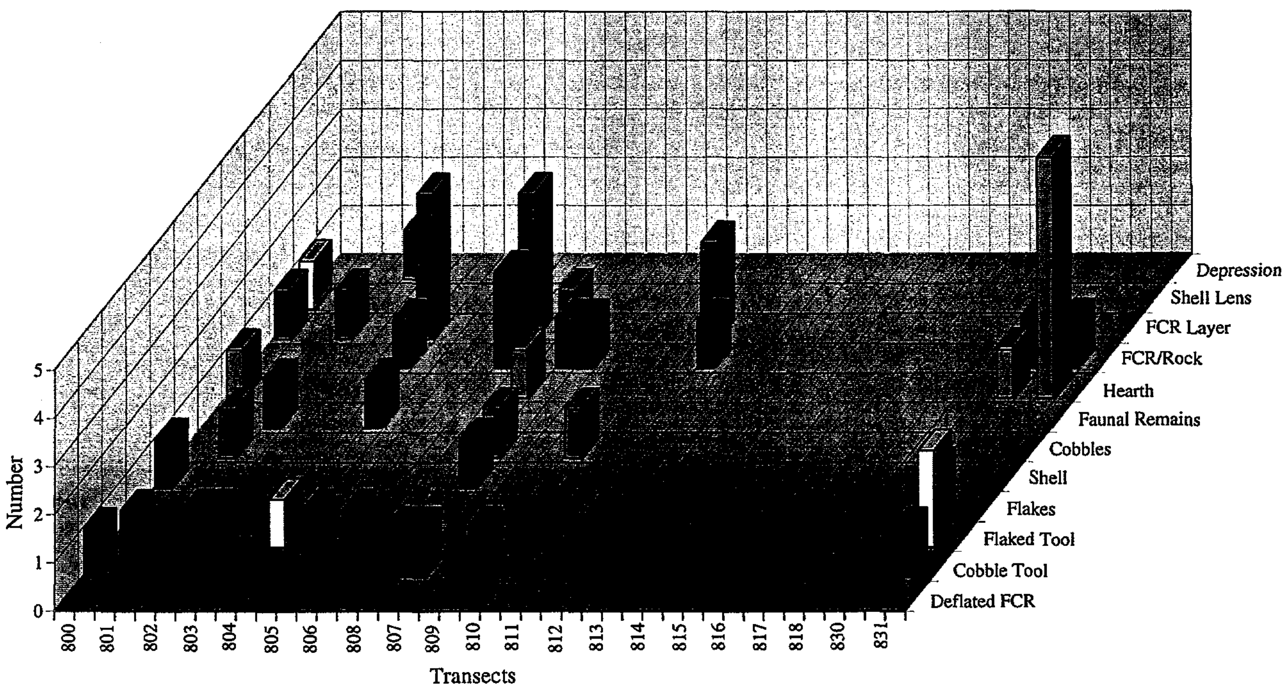

Figure 4.2. Twelve Different Types of Cultural Features and Materials Observed During the 1996 Monitoring Cycle (FCR = fire-cracked rock)

Transect 750: This transect was also established May 16, 1997. A cultural layer was observed approximately 40 meters north of this transect on June 26, and fire-cracked rock features were observed below the transect on August 7, 1997. As with Transect 748, all bank inspections were conducted by boat at this transect location.

Transect 799: This transect was set up December 6, 1996, during the last monitoring visit for the year. Erosional forces had begun impacting the gravel shoreline where an old stream channel bisected the upper stratigraphy of the island. Cultural materials were not present at this transect.

Although monitoring continued at this transect during 1997, no cultural materials were encountered here until two secondary, caramel-colored flakes were noted near the edge and surface of the cutbank on November 13, 1997. No other cultural materials were encountered at this location through the end of 1997.

Between Transect 799 and Transect 800: Approximately 10 widely scattered fire-cracked rocks were noted on slump material within a 30- to 40-meter stretch of shoreline during a monitoring visit conducted June 19, 1997.

Transect 800: Transect 800 was established March 18, 1996, 4 months after the establishment of Transects 801 through 818. Set at approximately 50 meters north of Transect 801, this transect encompassed a segment of the cutbank that was not only actively eroding but also contained a variety of exposed cultural materials and features. A fire-cracked rock feature (No. 800.1) was visible at 2.45 meters below surface. A charcoal sample taken from 0.8 meter above Feature No. 800.1 was later processed and provided a date of 230 ± 40 years B.P. (Beta-92477).

As the cutbank continued to erode during the next few months, this feature was lost, but new cultural materials were later exposed when many pieces of shell were encountered on the shore. Between July 3 and July 26, an additional 0.75 meter of the cutbank failed. The fresh exposure observed on this date contained a shell lens situated approximately 30 centimeters above basal gravel (No. 880.3) and a fire-cracked rock feature (No. 800.4) located approximately 10 meters north of the shell lens, also on the basal gravel layer. A dark-stained layer approximately 20 centimeters thick was above the feature and a reddish, sandy layer several centimeters thick below. A cobble tool with ground edges was found in slump material nearby. No cultural materials were observed at this transect after July through the end of 1996.

Early in the 1997 monitoring cycle, a cobble and fire-cracked rock layer became visible in the bank below Transect 800. A small net weight and fire-cracked rock scatter was also encountered here during the same time frame. By June 26, researchers encountered a small living floor resting on a stepped terrace below the transect. Several articulated fish bones, faunal remains, and a dense concentration of flaking debris were recorded then removed from the terrace surface. No additional cultural materials were noted at this location during the remainder of 1997.

Transect 801: Several fire-cracked cobbles were noted at the base of this transect on March 12, 1996, but no other cultural materials or features were recorded at Transect 801 through the remainder of the 1996 monitoring cycle. During a July 8, 1997, visit to the island, isolated, widely scattered fire-cracked rock was noted on the beach. In October 1997, a small cobble tool was encountered on the slump below the transect location. With the exception of these two events, no cultural materials were observed at this transect during 1997.

Between Transects 801 and 802: A variety of cultural materials were exposed here between May 14 and October 17, 1996; a large mammal bone and fire-cracked-rock were encountered on the beach in May, a concentration of fire-cracked rock that had probably come out low was recorded in July, and a rock layer with charcoal was visible at 1.5 meters below the surface in October. No additional cultural materials or features were observed through the end of December 1997.

Transect 802: Although cultural materials were not observed in the cutbank or on the beach below this transect throughout the 1996 monitoring cycle, a surface depression and three clumps of ryegrass were recorded here on the island's surface. During a July 1997 monitoring visit, widely scattered pieces of fire-cracked rock were noted on the beach at Transect 802. Except for the fire-cracked rock noted in 1997, no cultural materials were observed below this transect location.

Transect 803: Through the first half of the 1996 monitoring cycle (November 21 through June 12), 11.0 meters of the island collapsed and washed away at this transect. In spite of the multiple cutbank exposures observed during this erosion cycle, cultural materials at the transect location were minimal. Only one piece of fire-cracked rock was noted below this transect in 1996. On February 26, 1997, a scatter of fire-cracked rock and one cracked mammal bone were observed at this location and widely scattered fire-cracked rock pieces were noted resting on the beach during a July 8, 1997, monitoring visit.

Between Transect 803 and Transect 804: Cultural materials were consistently encountered on the beach and in the bank between Transects 803 and 804. This section of riverbank, although unmonitored to determine the rate of loss to erosion, slowly revealed a significant complex of archaeological deposits as each successive section of the bank fell, slumped, or dropped into the river.

On March 12, following a loss of approximately 6 meters at Transects 803 and 804, granitic fire-cracked rock and cobbles were observed in slump material midway between the two transects. On May 14, large pieces of fire-cracked rock were encountered 20 meters north of Transect 804, and a light scatter of fire-cracked rock was observed south of Transect 803. By July 3, a thick (8-15 centimeters), dark cultural layer and two associated cultural features were exposed. The rock concentrations and dark layer were present in the cutbank through July 26, 1996. Sometime within the 4-week period ending August 29th, sections of the cutbank collapsed at Transects 803 and 804. The rock concentrations and dark layer located in the bank between these transects were lost as well. Following this loss, no additional features or cultural materials were noted through the end of the 1996 monitoring cycle.

Cultural materials continued to be exposed at this location during 1997, although not at the same rate or density we observed in 1996. Pieces of fire-cracked rock, located at the water's edge and in the visible shallows of the river recorded by researchers during a February 3, 1997, visit may have been remnants of features lost during the August 1996 erosional event. High water levels precluded additional inspections at this transect location until September 11, 1997, when a mandible (faunal) was encountered on the beach.

Transect 804: Cultural materials were not observed on the beach or in the bank at this transect location before April 4, at which time 6.1 meters of the cutbank had fallen into the river. On April 4, the tip of a bifacially worked tool was noted on the beach, at water's edge, just south of Transect 804. Long mammal bones and a dark-stained stratum overlain by a prominent red-stained stratum were encountered in the same vicinity. In addition, scattered fire-cracked rock was encountered 15 meters south of Transect 804. No additional cultural materials were encountered at the transect after April 4, 1996, even though the cutbank continued to recede, reaching a combined loss of 12.0 meters by December 6, 1996.

Cultural materials continued to be observed at this transect early in the 1997 monitoring cycle when a cultural layer and hearth were encountered during a February 3, 1997 visit. Subsequent visits to the bank below the transect were relegated to inspections from a boat because of high water throughout much of the remaining 1997 monitoring cycle. Cultural materials were not observed during this period of high water. Once river levels fell, two features were observed on the beach: a deflated cobble feature containing flaked cobbles, cobble tools, and two pieces of shell recorded on September 11, 1997, and a grouping of sixteen red-colored cobbles with outlying fire-cracked rock pieces lying at the base of the bank in the sand documented on October 30, 1997. Water levels rose again after October, thereby eliminating opportunities to observe any additional cultural materials in this area.

Transect 805/805A: Following an initial pattern of stability, the entire 10-meter transect at Transect 805 was unexpectedly lost sometime between February 23 and March 12, 1996. The transect was reestablished and renamed as Transect 805A on March 18, 1996. On this same date, mammal bones were encountered on the shoreline in the vicinity of the transect, but no other cultural materials were recorded as the bank continued to recede, reaching a combined loss of 15.4 meters by December 6, 1996.

The river lapped against the base of this vertical cutbank for much of the first half of 1997 monitoring cycle. Following a drop in river levels, several features were recorded on the beach, including one basalt flake observed on a water-resistant shelf (July 24, 1997) and a deflated feature containing more than 18 cobbles, a large rock, and a bifacially flaked tool (documented September 11, 1997). Following this, water levels rose again—effectively precluding pedestrian inspections of the cutbank and beach at this location.

Transect 806/806A: The riverbank at Transect 806 appeared to be stable in November 1995 (Figure 4.3). However, the punctuated loss recorded at Transect 805 was mirrored at Transect 806 with a total of 10 meters dropping into the river sometime between February 23rd and March 12th. The transect

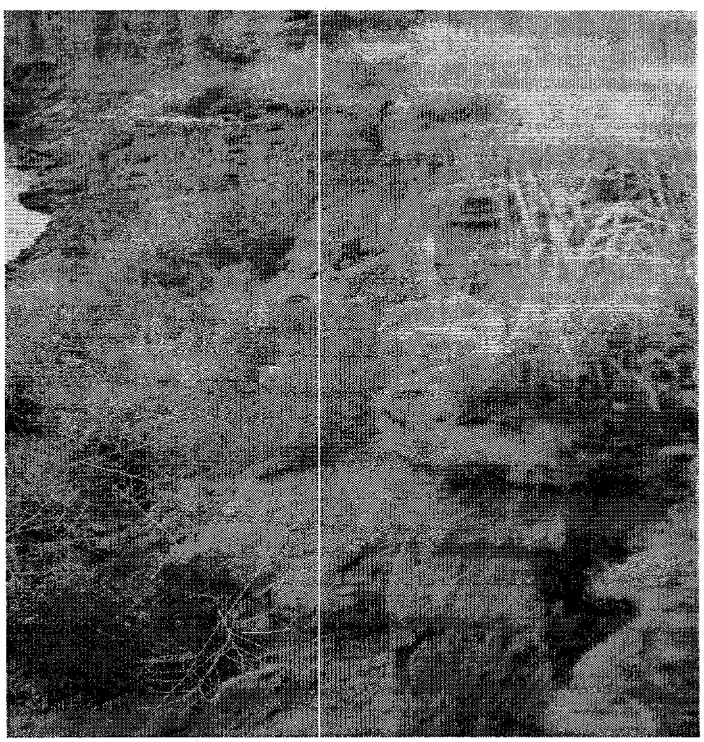

Figure 4.3. The Cutbank Below Transect 806 Appeared Eroded but Stable and Vegetated in 1995 (PNNL 215/08)

was reestablished as 806A on March 12th. The freshly exposed cutbank below Transect 806A contained a linear fire-cracked rock feature (No. 806.1) and cultural strata that could be traced for at least 12 meters. Trending at an approximate 10-degree slope from north to south, the layer represented the largest feature observed. Although 10 meters of the upper cutbank had collapsed into the river, remnants of the lowest underlying strata still remained exposed, just above the water level (Figure 4.4). Left behind was an extensive array of fire-cracked rock, cobbles, cobble tools, and a small scatter of bone fragments that stretched out into the river. A second concentration of fire-cracked rock, located immediately below the linear rock feature contained approximately 40 quartzite and basalt fire-cracked rocks.

A soil profile and description of the cutbank in the area of the linear rock feature was completed in 1996. The effort resulted in the documentation of one cultural layer and two dark-stained layers. Four charcoal samples, taken from cultural features and/or layers and other non-cultural charred wood fragments, provided a series of radiocarbon dates for the linear rock feature that ranged from 1570 ± 40 to 1940 ± 40 years B.P. (Beta-92473, Beta-92904, Beta-92474, and Beta-92476). In spite of continued bank recession, some portion of the fire-cracked rock layer continued to be visible throughout each of six consecutive monitoring trips taken to the island in March, April, May, and June (Figure 4.5). After June, three additional meters of the riverbank collapsed and washed away at the transect; the linear feature was presumably washed away as well.

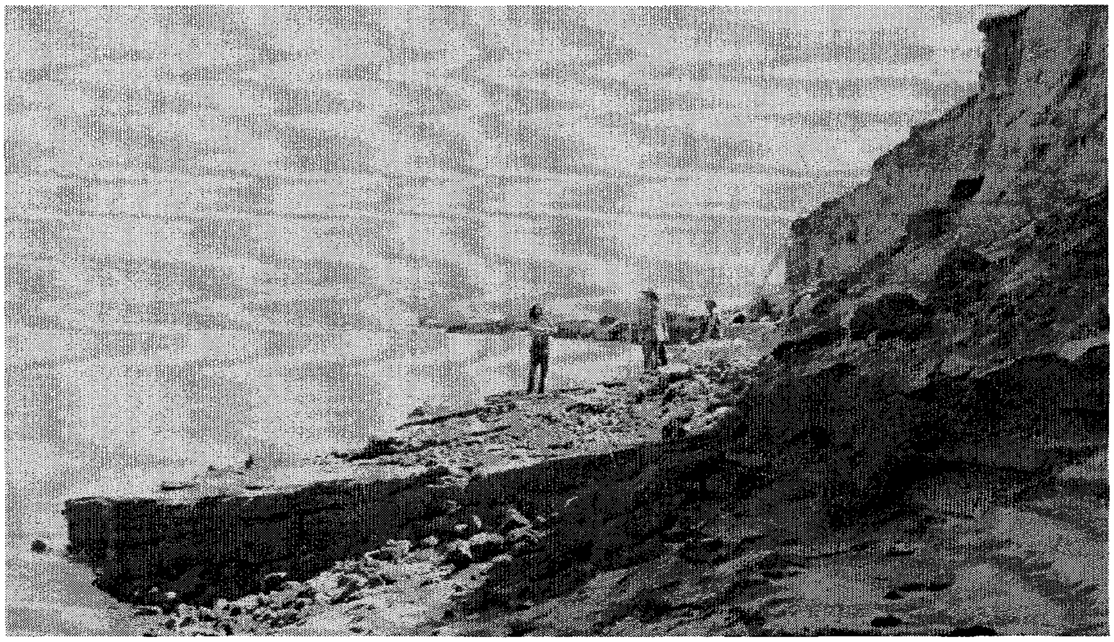

Figure 4.4. Southerly View of the Cutbank at Transect 806 Following the Loss of 10 Horizontal Meters. The individuals shown are standing on a remnant of the original cutbank; its face was to their immediate left of the photograph's lower center (PNNL 221/7).

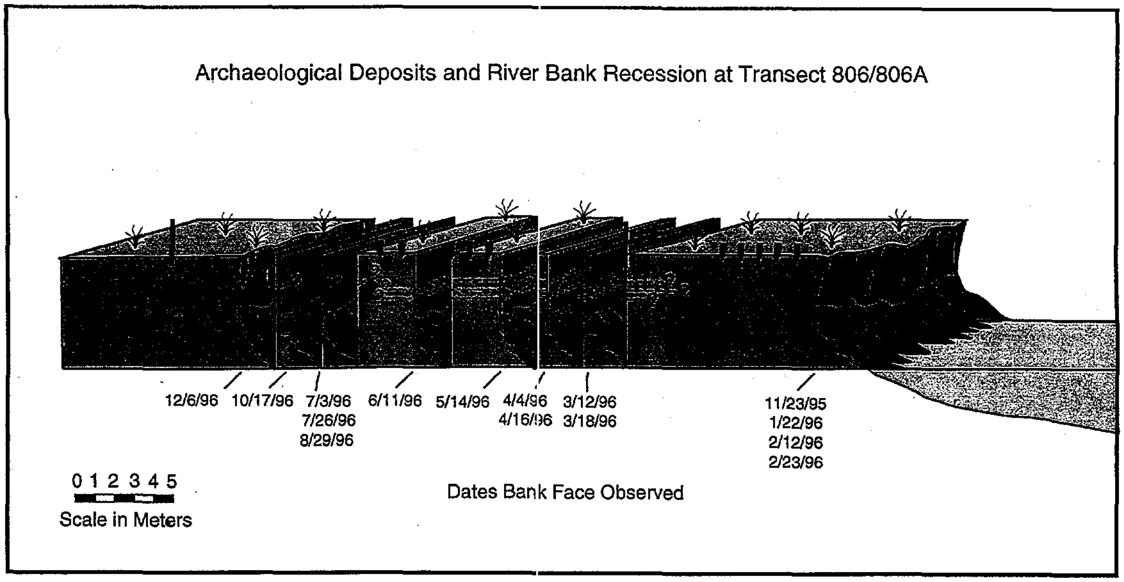

Figure 4.5. Large Cultural Layer Exposed at Transect 806 During the 1996 Monitoring Cycle

In spite of the severe erosional impacts, cultural features continued to be exposed at this transect location. On April 4, 1996, a circular/oval feature was encountered 3 meters north of Transect 806A. The feature was located approximately 95 centimeters below the linear fire-cracked rock feature profiled on March 18, 1996. On July 3, a small fire-cracked rock feature was recorded at 1.7 meters below surface, and on July 26 a small feature with over five fire-cracked rocks and an associated dark horizon 35 centimeters thick was documented at 1.6 meters below surface. At the end of the monitoring cycle, cumulative loss at this transect included all the cultural features just described and 16.8 meters of linear cutbank.

The consistent rate of exposure for cultural materials during the 1996 erosional cycle did not continue into 1997. Only a few artifacts were exposed during 1997 and all were encountered on the shoreline and in slump material; one cobble tool and a single round cobble were noted on the talus in June and July; 14 pieces of fire-cracked rock and cobbles were observed on the stepped shoreline in September, and approximately 10 pieces of fire-cracked rock were recorded at the water's edge in December 1997.

Between Transect 806 and Transect 807: No cultural materials were observed along this portion of the cutbank during 1996. In 1997, scatters of deflated fire-cracked rock features were recorded on July 24 and December 11, 1997.

Transect 807: The first cultural feature to be recorded was encountered at Transect 807 on November 21, 1995, the same day the transect was established. The feature was a well-preserved hearth with cobble, fire-cracked rock and charcoal staining located at 0.75 meter below surface. Samples of the charcoal and soil were recovered to gain information about the age and contents of the hearth. The hearth feature was severely undercut when a second monitoring visit was paid to the island on January 22, 1996. On February 12, a high concentration of fire-cracked rock was noted in the water on the talus below Transect 807 for a distance of 25 meters on either side of the transect. By February 23, 1996, the hearth feature was gone. The only other feature to become visible at this transect was fire-cracked rock. Recorded on July 26, 1996, the fire-cracked rock was located 7 meters south of Transect 807 and 0.5 meter below surface. No other features or cultural materials were recorded at this transect through December 1996.

Documentation of the hearth feature noted above included recovery of charcoal fragments and a bulk soil sample from the lower portions of the hearth. Two dates processed from the charcoal suggest that the hearth was used sometime between 310 and 640 years ago. Flotation analysis of a sample of the hearth fill yielded significant amounts of bitterbrush, sage, and generic hardwood bark charcoal fragments (Figure 4.6), as well as fire-modified basalt, a small basalt piece, a small amount of unburned bone, and some insect remains.

During 1997, pieces of widely scattered fire-cracked rock were observed on the beach below this transect during monitoring visits conducted on June 19, July 24, September 11, and December 11, 1997. These pieces of fire-cracked rock may well be remnants of the large concentration of fire-cracked rock observed at this location during the 1996 monitoring cycle.

Between Transect 807 and Transect 808: Several small features and cultural materials were observed in the bank between Transects 807 and 808. On February 12, 1996, a large cobble tool was

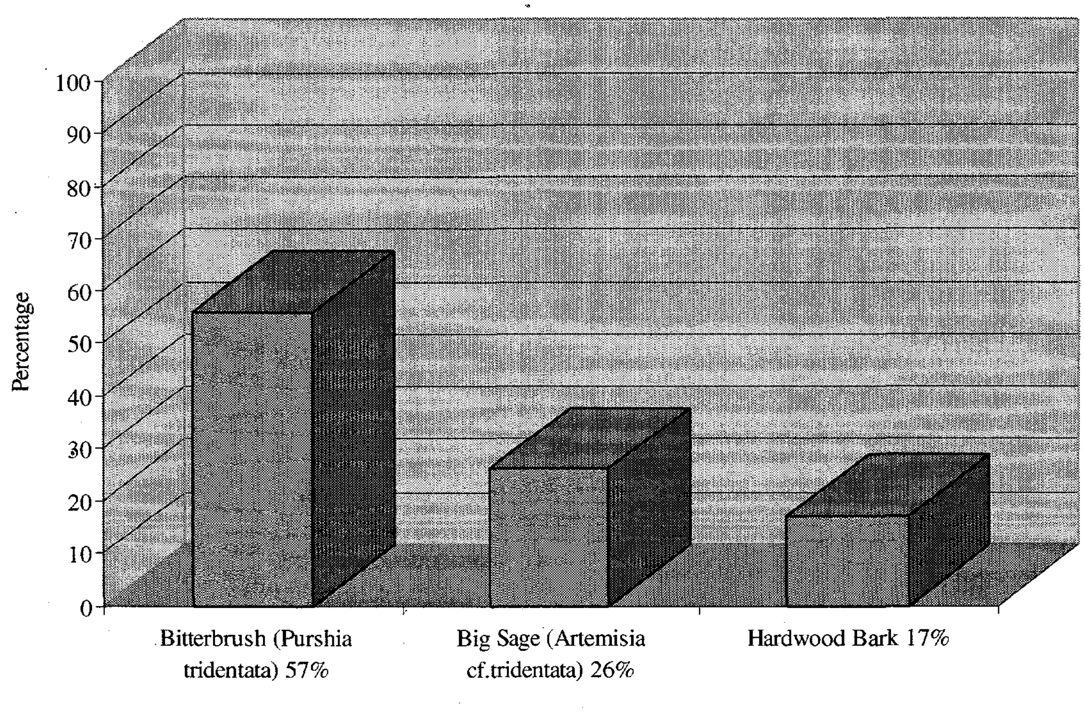

Figure 4.6. Plant Species in the Hearth at Transect 807. Small amounts of bone from fish or other small species, basalt, and insect remains were also found in the bulk soil sample.

collected from the beach following a net loss of more than a meter. On March 12, following a 2-meter loss, a large flat cobble and one piece of fire-cracked rock were encountered in slump material 20 meters down river from Transect 807. A shell (both halves present) was also found lying on a dark layer 2.4 meters below surface. Following an additional 4 meters of loss, a fire-cracked rock feature and dark paleosol was recorded at 1.87 meters below surface between Transects 807 and 808. No other cultural materials were encountered in this area through the end of the 1997 monitoring cycle.

Transect 808: One cobble tool was encountered in slump material at Transect 808 on March 18, 1996, but additional cultural features or materials were not encountered here until July 26, 1996, following a cumulative cutbank loss of 15.6 meters. On this date, a burnt earth feature (No. 808.1) with 11 visible, rounded cobbles and a smile-shaped cross-section was exposed at 2.22 meters below surface.

No in situ cultural features were encountered in the cutbank at this location during monitoring visits conducted during 1997. Instead, cultural materials were noted on the beach or talus slope. A small group of angular rocks was noted in this location on April 29, 1997, a few pieces of fire-cracked rock were observed at the base of the bank on September 11, 1997, and a cobble tool was recorded here October 30, 1997.

Transect 809: A cumulative loss of 14.8 meters was recorded at Transect 809 from November 21, 1995 through December 6, 1996. In spite of the many exposures that resulted as the cutbank eroded into the river, no cultural features were observed through the end of the 1997 monitoring cycle.

Between Transects 809 and 810: A small number of cultural materials were noted down river, between Transects 809 and 810. On March 12, 1996, several cobbles were encountered in slump material 18 meters down river (south) of Transect 809. Fire-cracked rock and a cobble tool were encountered between Transects 809 and 810 on May 14, 1996. Monitoring visits conducted at this location through December 11, 1997, did not result in documentation of any new cultural material.

Transect 810: No cultural features or materials were encountered at Transect 810 during 1996 in spite of a cumulative loss of 12.5 meters through August 29, 1996. On February 3, 1997, a large reddish-colored boulder was observed at the water's edge below this transect—a broken cobble was recorded just 10 meters north of the transect location.

Between Transects 810 and 811: On February 12, 1996, fire-cracked rock was noted in slump material approximately 12 meters down river from Transect 810. On May 14, 1996, at approximately 30 meters south of Transect 810, two layers of fire-cracked rock were recorded in the riverbank. The top layer of fire-cracked rock was buried 1.45-0.9 meters below surface; the dense lower layer (20-25 meters in length and up to 30 centimeters high) was overlain by 4.35 meters of sediment. The rocks visible in the lower layer were larger in size than other fire-cracked rock features previously recorded in the island riverbanks. The deeply buried cultural layer was submerged until December. At that time, the fire-cracked rock layer had collapsed; all supporting sediment had been washed away.

Portions of the collapsed, deeply buried layer was exposed again on September 11, 1997. This cultural layer was composed of several large concentrations of fire-cracked rock and cobbles lying on the shoreline and in shallow water. Situated above the collapsed fire-cracked rock layer was an in situ cultural layer in the cutbank. The in situ cultural layer was measured at 4.11 meters below the surface and contained fire-cracked rock fragments, stained sediments, and flakes. A sample of charred material was recovered from 4.35 meters below the surface, 25 cm below the in situ cultural layer and above the collapsed fire-cracked rock layer first observed in 1996. Following radiometric analysis, this sample yielded a date of 1950 ± 50 years B.P. (Beta-107585).

Transect 811: Following an initial period of relative stability (only 0.2 meter of the bank was lost before March 12, 1996) at this transect location, 1.1 meters of the bank failed sometime between March 12 to March 18, 1996. When the fresh cutbank exposure was inspected on March 18th, a fire-cracked rock feature was visible about 1.0 meter above the water level. This was the only cultural feature/item to be observed in this cutbank through the end of the 1996 monitoring cycle. This hearth feature was again observed on May 28, 1997. Other artifacts noted at this location include widely scattered cobbles and pieces of fire-cracked rock (June 19, 1997) and a large flat cobble tool found lying just under the water at the edge of the talus on July 24, 1997.

Between Transect 811 and Transect 812: Although there were no cultural materials observed along this stretch of the cutbank in 1996, several pieces of fire-cracked rock were encountered here on June 19, 1997. A cobble feature, lying just beneath the water in tree roots was encountered on February 26, 1997, and a large scatter of fire-cracked rock, containing over 100 fragments, was recorded on the beach September 11, 1997.

Transect 812: There was no recorded riverbank loss at this transect during the 1996 study period and no cultural materials or features were recorded in the bank at this transect during the 1996 study period. On February 26, 1997, several cobble tools and two mammal bones (one in situ at 70 centimeters below surface) were encountered below the transect. Pieces of widely scattered fire-cracked rock were found here on June 19 and again on September 11, 1997. Two pieces of in situ fire-cracked rock located at approximately 3.0 m below the surface were recorded at this transect on September 11 as well.

Between Transect 812 and Transect 813: Fire-cracked rock was observed on the talus along this section of cutbank on June 16 and October 30, 1997.

Transect 813: The riverbank remained stable at Transect 813 throughout the monitoring period following an initial loss of 0.7 meter measured on March 12, 1996. A small concentration of fire-cracked rock was noted in slump material on March 12 and again on April 4, 1996. No cultural materials or items were observed thereafter through the end of the monitoring cycle.

During the 1997 monitoring cycle, three cobble tools and one flaked cobble were observed on February 3, 1997, a single piece of fire-cracked rock was observed on September 11, 1997, and a cultural feature containing more than 25 fire-cracked rocks and cobble tools was recorded at approximately 4.5 meters below the surface of the island on October 30, 1997.

Transect 814: There was only recorded cutbank loss at this transect, and no cultural materials or features were recorded in the bank at this location during the 1996 study period. A child's blue plastic shovel stood upright in a small sandy beach below the transect. Cultural materials were not observed at this location until late in 1997. During October's monitoring visit, a cultural feature containing 12 pieces of fire-cracked rock was recorded at approximately 4.5 m below the island's surface. No other cultural materials were observed at this location through the end of the 1997 monitoring cycle.

Transect 815: There was no recorded riverbank loss at this transect, and no cultural materials or features were recorded in the bank at this location during the 1996 study period. During the 1997 monitoring cycle, hearth features were recorded and sampled on June 26 and July 24. No other cultural materials were encountered in the bank or on the shoreline beneath this transect through the end of 1997.

Transect 816: There was no recorded riverbank loss at this transect, and no cultural materials or features were recorded in the bank at this location during the 1996 study period. In 1997, however, a small cultural feature containing two pieces of fire-cracked rock was observed in a root cavity at approximately 4.0 meters below the surface. Other cultural features observed here included four fire-cracked rocks lying on the shore July 24 and a fire-cracked rock feature in the bank at approximately 4.0 meters below the surface. Two fire-cracked rocks were encountered on the beach below the transect October 30, 1997.

Between Transect 816 and Transect 817: No cultural features or tools were noted in this section of the monitored cutbank during the 1996 monitoring cycle. Late in 1997, two cobbles (September 11, 1997) and two fire-cracked rocks (October 30, 1997) were encountered on talus deposits.

Transect 817: There was no recorded riverbank loss at this transect, and no cultural materials or features were recorded in the bank at this location during the 1997 study period.

Transect 818: There was no recorded riverbank loss at this transect, and no cultural materials or features were observed in the bank at this location during the 1996 study period. A hearth feature was documented below this transect on July 24, 1997.

Transect 830: One fire-cracked hearth feature (No. 830.1) was visible at this transect on April 4, 1996. Centered under the transect, the feature was 3.70 meters long with a rock layer 10 centimeters wide. The entire layer was 1.1 meters below surface at the south end and 1.2 meters below surface at the north end. A discontinuous scatter of cultural materials, flakes and fire-cracked rock were noted between Transects 830 and 831.

Feature No. 830.1 was noted again on May 14, 1996, as were two fire-cracked rock concentrations that had just been exposed as water levels receded. The two concentrations lay approximately 20 meters north of Transect 830. Loss of the riverbank at this transect was minimal, 0.2 meters. Therefore, the cultural features first observed in May 1996 were still visible at the end of the 1997 monitoring cycle.

Transect 831: Four cultural features were visible in the riverbank at this transect; all were recorded on April 4, 1996. One layer of fire-cracked rocks (No. 831.1) at least 3 meters long is buried 1.6 meters below surface. A hearth feature (No. 831.2) with a rock and charcoal layer 1.47 meters long and 11 to 14 centimeters wide (from south to north) is located here 1.02 meters below surface. A third rock and charcoal feature measuring 1.15 meters long and 1.0 meters below surface (Figure 4.7). Several other cultural materials were also recorded at this location. One projectile point, modified into a drill, along with a unifacial scraper, and a small broken cobble net weight, were encountered on July 3, 1996 near, and south of Transect 831.

During the 1997 monitoring cycle, little new information was gathered near the transect location. HCRL researchers, however, continued to monitor and describe the extensive cultural deposits present at the southern tip of the island.

4.4.1 Transect 800 Living Floor

On June 26, 1997, a small archaeological surface or 'living floor' was recovered from a recently washed shoreline terrace (Figure 4.8). This archaeological surface was remarkable for several reasons.

- First, river currents had not washed the site away but appeared to have merely exposed them, probably within a few hours of the discovery.

- Second, the sediment upon/in which the cultural material was embedded appeared to contain a fairly high clay fraction that had been resistant to erosion by the river.

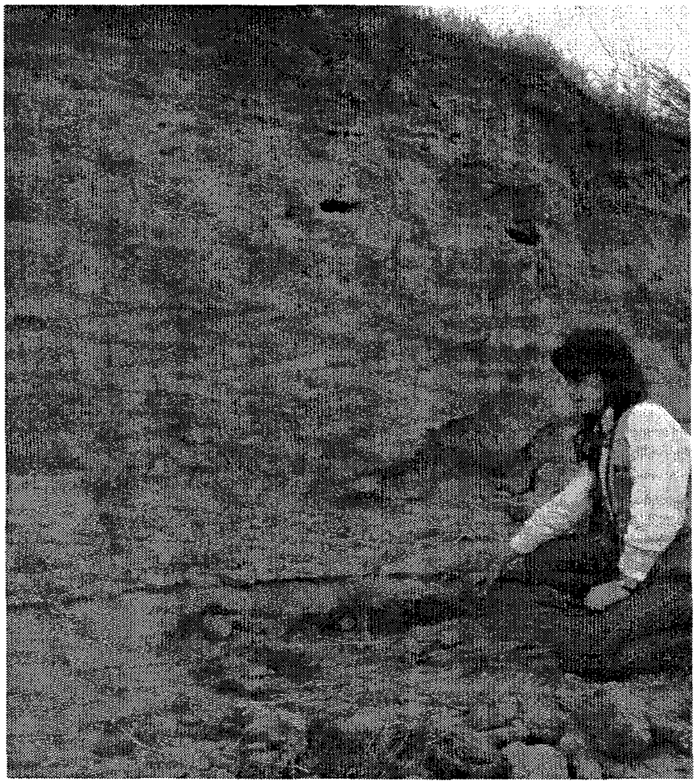

Figure 4.7. Buried Hearth Feature at Transect 831

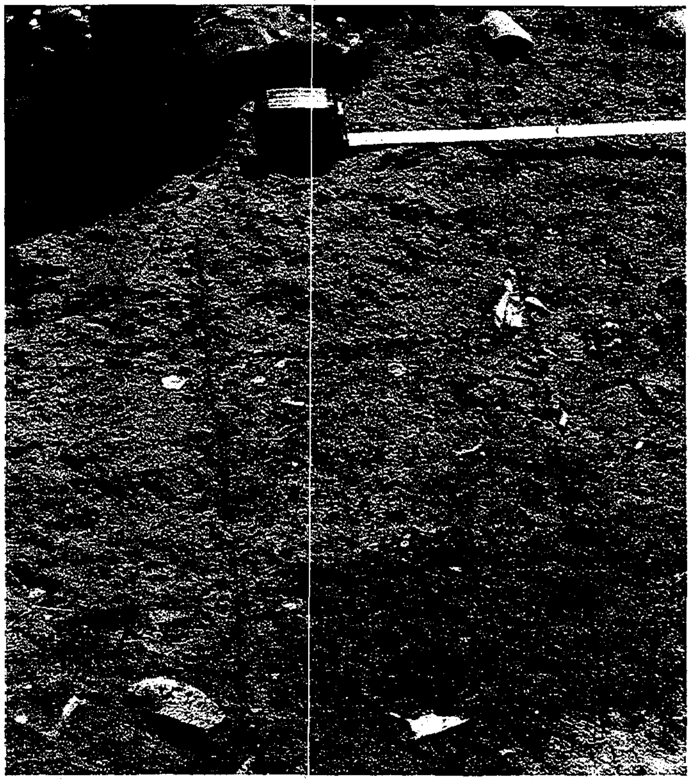

Figure 4.8. Archaeological Materials Recovered From the Columbia River Shoreline in 1997

- Third, the materials and sediment layer were still wet, suggesting that the river had only recently dropped in elevation (the footprints were in the talus above this sediment layer).

- Fourth, the presence of partial but articulated fish vertebrate sections underscored the integrity of this exposure.

- Fifth, fragments of charcoal were present providing the opportunity to date the cultural materials/ floor.

- Sixth, the configuration of artifacts and faunal remains suggested the presence of discrete activity areas; flakes were most dense in the northwestern portion of the mapped site, and fire-cracked rock/charcoal-covered cobbles were grouped in the southwestern portion of the site.

The materials were recovered from the shoreline using standard archaeological techniques. The surface was photographed and a datum and 20-centimeter grid were established—oriented to magnetic north. A scaled map (Figure 4.9) of the surface was drawn on graph paper to capture relationships between the artifacts. Once the map was complete, cultural materials from each square were removed with a trowel and placed in labeled plastic bags for transport. Cultural materials and associated sediments

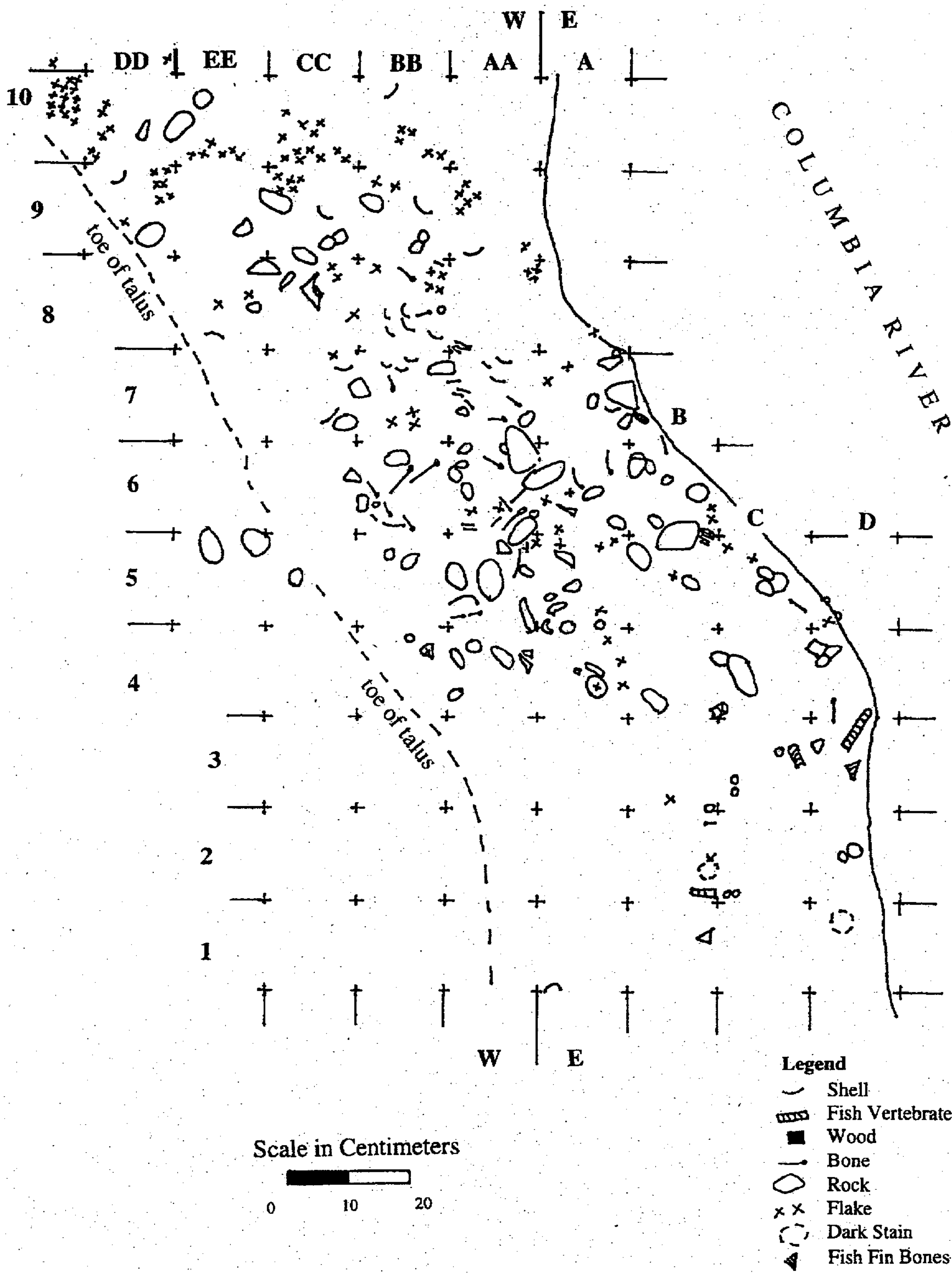

Figure 4.9. Mapped Relationships Between Archaeological Materials and the Grid System Established at Transect 800 Living Floor Before Removal

were collected from each square to an approximate depth of between 5 to 7 centimeters and/or to sterile sediments and bagged in labeled plastic bags. Talus covered the western extent of the archaeological surface; this portion of the surface was not removed. Given this, a portion of the surface remains within the cutbank located below Transect 800.

Before wet screening, two cups of unsorted sediment were removed from each bag and set aside for retention as bulk soil samples. The remaining sediment in each bag was water screened through a TylerStandard Screen Scale with mesh openings 0.589 millimeter (0.0232 inch) in size. Artifacts and faunal remains left in the screen were placed in labeled box-top drying trays to dry. Once dry, cultural remains were separated into seven categories: charcoal fragments, flakes, fish bone, faunal remains, shell, fire-cracked rock, and "undetermined." A charcoal sample from the surface was processed, providing a date of 720 ± 50 years B.P. Additional analysis of faunal and fish remains, lithics, and the bulk soil samples has not been conducted.

4.4.2 Radiocarbon Dating Results

The collection of charcoal samples for dating purposes was done opportunistically as charcoal fragments were encountered during cutbank inspections. Of the 18 dates processed during the 2-year monitoring cycle, six came from cultural features and strata ranging from 30-50 years B.P. to 1910 ± 50 years B.P. (Beta-107581) (Table 4.1). The sample yielding the oldest date processed from Locke Island, 2130 ± 60 years B.P. (Beta-107581) was not found in direct association with cultural materials but came from charcoal taken at the base of the riverbank near Transect 804. A deeply buried, cultural stratum overlain by 4.35 meters of bank sediment observed between Transects 810 and 811 dated to more than 1950 ± 50 years B.P. (Beta-10785) suggests that prehistoric use of Locke Island dates before 2000 years B.P. (Figure 4.10).

4.5 Discussion

An unexpected variety of archaeological information was generated as erosion transects were monitored during 1996 and 1997. The collection of charcoal samples for dating purposes was done opportunistically as samples were encountered during cutbank inspections throughout the monitoring cycle reported here. Samples were collected from non-cultural strata and cultural features in an effort to recover data pertinent to island formation processes and the timing of habitation and use by previous inhabitants. Twelve samples taken from cultural features suggest that previous inhabitants used the island from recent times to more than 1910 ± 50 years B.P. (Beta-107581). An apparent paucity of recovered dates in the sequence occurs between 640 ± 70 (Beta-92905) and 1550 ± 40 years B.P. (Beta-92473) (Figure 4.11).

The presence of a dated, deeply buried cultural stratum located between Transects 810 and 811 suggests that prehistoric use of Locke Island precedes the earliest documented cultural feature we have encountered to date (1910 ± 50 years B.P., Beta-107581). Although the cultural stratum has not been dated, it is beneath a recovered charcoal sample dated at 1950 ± 50 years B.P. (Beta-107585).

Table 4.1. Radiocarbon Dates Processed From Samples Recovered From Locke Island During the 1996 and 1997 Monitoring cycles

Measured ^{14}C Age in Yr B.P.	Convention[a] ^{14}C Age in Yr B.P.	Laboratory No.	Calibration to Calendar Years	Material	Stratigraphic Position	Site Number	Comments
50 ± 50	30 ± 50	Beta-107583	AD 1695 to 1725 and AD 1815 to 1920	Charred Material	1.5 m BS	Locke Island	10/17/96 Sample 801.1 taken (AMS Process)
110 + 50	110 + 50	Beta-107580	AD 1670 to 1950	Charred Material	0.4 m BS	Locke Island	2/26/97 (Radiometric-Standard process)
230 ± 40	230 ± 40	Beta-92477	AD 1640 to 1685 & AD 1740 to 1810 & AD 1930 to 1950	Charcoal	1.65 m BS	Locke Island	Sample 5-Boat Launch taken 0.8 m above cultural layer - did not come from a cultural feature.
230 ± 60	230 ± 60	Beta-92906	AD 1515 to 1585 & AD 1625 to 1825 & AD 1835 to 1880 & AD 1915 to 1950	Charred Material	1.02 m BS	Locke Island	Sample #831.2 from Locke Island. Small sample size given extended counting time. Taken from hearth feature.
340 ± 50	310 ± 50	Beta-92478	AD 1460 to 1670	Charred Material	.75 m BS	Locke Island	Sample #807 from hearth feature. Two samples taken from this feature, one from north end, one from south end.
350 ± 50	310 ± 50	Beta-107582	AD 1460 to 1670	Charred Material	1.45 m BS	Locke Island	6/26/97 F1 (AMS Process)
510 ± 50	470 ± 50	Beta-107590	AD 1405 to 1495	Organic Sediment	1.8 m BS	Locke Island	Sample F2 Hearth taken 6/19/97 (AMS Process)
640 ± 70	640 ± 70	Beta-92905	AD 1265 to 1425	Charred Material	.75 m BS	Locke Island	Sample #907 from Locke Island. Small sample given extended counting time. Sample taken from hearth feature. Two samples taken from this feature, one from north end, one from south end.
770 ± 50	720 ± 50	Beta-107591	AD 1235 to 1315 and AD 1345 to 1390	Charred Material	2.3 m BS	Locke Island	T800 Floor (AMS Process)
1070 ± 60	1070 ± 60	Beta-107584	AD 875 to 1040	Charred Material	2.6 m BS	Locke Island	804.3 (AMS Process)
1570 ± 40	1550 ± 40	Beta-92473	AD 425 to 615	Charcoal	~1.8 m BS	Locke Island	Sample 1-806-1 was a composite sample taken from cultural strata IX.

Table 4.1. (contd)

Measured ^{14}C Age in Yr B.P.	Convention[a] ^{114}C Age in Yr B.P.	Laboratory No.	Calibration to Calendar Years	Material	Stratigraphic Position	Site Number	Comments
1590 ± 50	1570 ± 50	Beta-92475	AD405 to 615	Charcoal	~1.6 m BS	Locke Island	Sample 3-806-1 was not taken from a cultural feature
1690 ± 60	1670 ± 60	Beta-92904	AD 245 to 5403	Charcoal	3 m north of 806A line. Located ~95 cm below feature 806.1	Locke Island	Sample 906A-1 taken from a 'feature' 23 cm wide [long] and 10 cm [in] height. (AMS Process)
1870 ± 50	1840 ± 50	Beta-92474	AD 75 to 330[3]	Charcoal	~1.8 m BS	Locke Island	Sample 2-806-1 taken from cultural strata IX
1900 ± 50	1910 ± 50	Beta-107581	AD 5 to 235	Charred Material	1.9 m BS	Locke Island	4/29/97 Feature-A (AMS Process)
1940 ± 40	1940 ± 40	Beta-92476	BC 5 to AD 145[3]	Charcoal	2.45 m BS	Locke Island	Sample 4-806-1. Sample not taken from a cultural feature.
1960 ± 50	1950 ± 50	Beta 107585	BC 40 to AD 160	Charred Material	4.35 m BS	Locke Island	8/29/97 Sample 810.1 (AMS Process)
2110 ± 60	2130 ± 60	Beta-92903	BC 365 to AD 5[3]	Charred Material	BS distance not recorded.	Locke Island	Sample 804.1. Sample not taken from cultural feature. (AMS Process)

Documentation of features and cultural materials in the eroding cutbanks along the monitored section of Locke Island's eastern shore was affected by several factors that defined the type and amount of information that could be retrieved:

- Inspection of the talus, toe, and shoreline of cutbanks was dependent on the water level of the Columbia River (during high water the toe of the bank was submerged).
- Bank failure as a result of erosional processes occurred at unpredictable rates.
- The volume of sediment slump and loss was variable with each new erosional event.
- Talus effectively covered the lower strata of cutbanks at various unpredictable intervals thereby precluding inspection of this portion of the cutbank.
- Distinctive features and materials such as fire cracked rock, shell, and hearths, were documented; small or indistinctively colored objects were not routinely noted or described.
- Tribal participants requested that cultural materials, faunal remains, and shell found during the monitoring process be left on Locke Island.

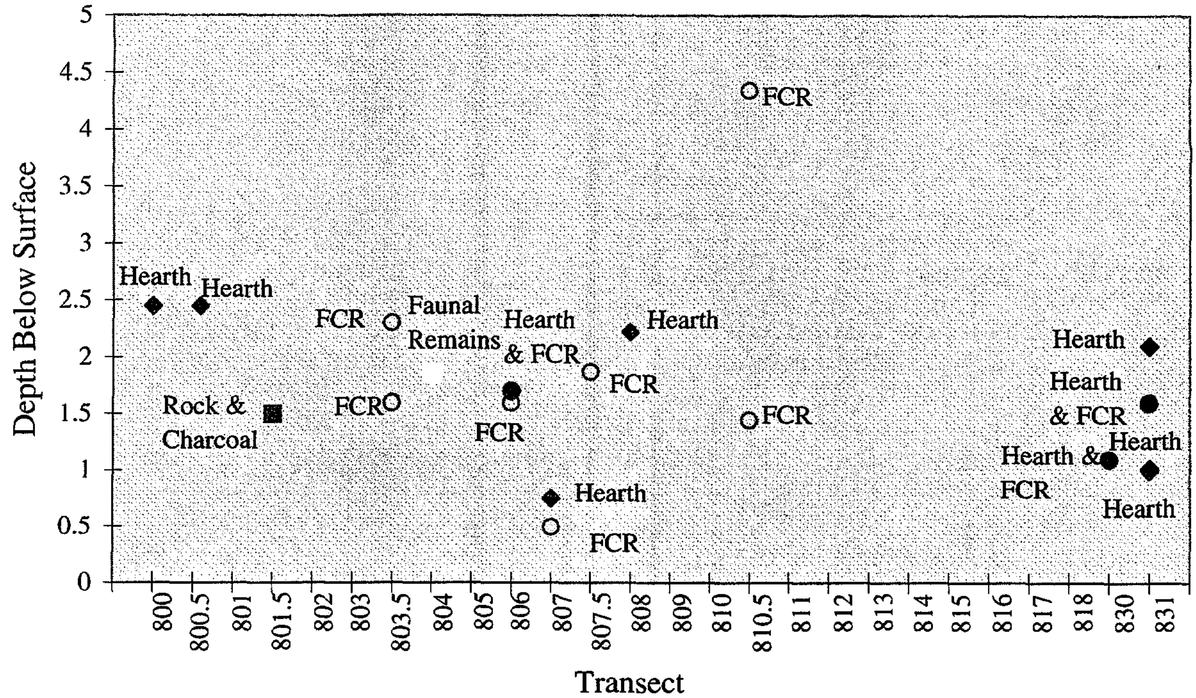

Figure 4.10. Associations of In Situ Cultural Materials and Features Documented During the 1996 Monitoring Cycle. *One deeply buried cultural layer suggests that people were on Locke Island approximately 1950 years ago.*

4.6 Implications of the Locke Island Data for Local and Regional Research

Of the 18 radiocarbon dates processed as part of this erosion monitoring project, only one date falls within an approximate 900-year period ranging from 640 ± 70 (Beta-92905) to 1550 ± 40 years B.P. (Beta-92473). Several reasons for this paucity are possible and may include, but not are limited to, sampling biases, destruction of the archaeological record, or the presence of an inhospitable island environment during the period in question. It is clear that the landscape surrounding Locke Island was inhabited during the period from 600 to 1500 years ago because dated cultural features have been documented for this time period at the nearby Wahluke Site, located just upriver from Locke Island (Table 4.2).

The paucity of radiocarbon dates associated with this time period at Locke Island has also been reported at Strawberry Island and to some extent at Ford Island (Cleveland et al. 1977; Cleveland 1978; Schalk 1983; Fryxell 1962) (Figure 4.12). A variety of factors may provide some insight into this anomaly. Several factors that may have some bearing on the issue have been alluded to by others with a variety of research interests:

1. Cochran (1978) noted in his study of late Quaternary stratigraphy and chronology at Johnson Canyon in central Washington that "the paucity of radiocarbon dates on alluvial deposits postdating 800 years

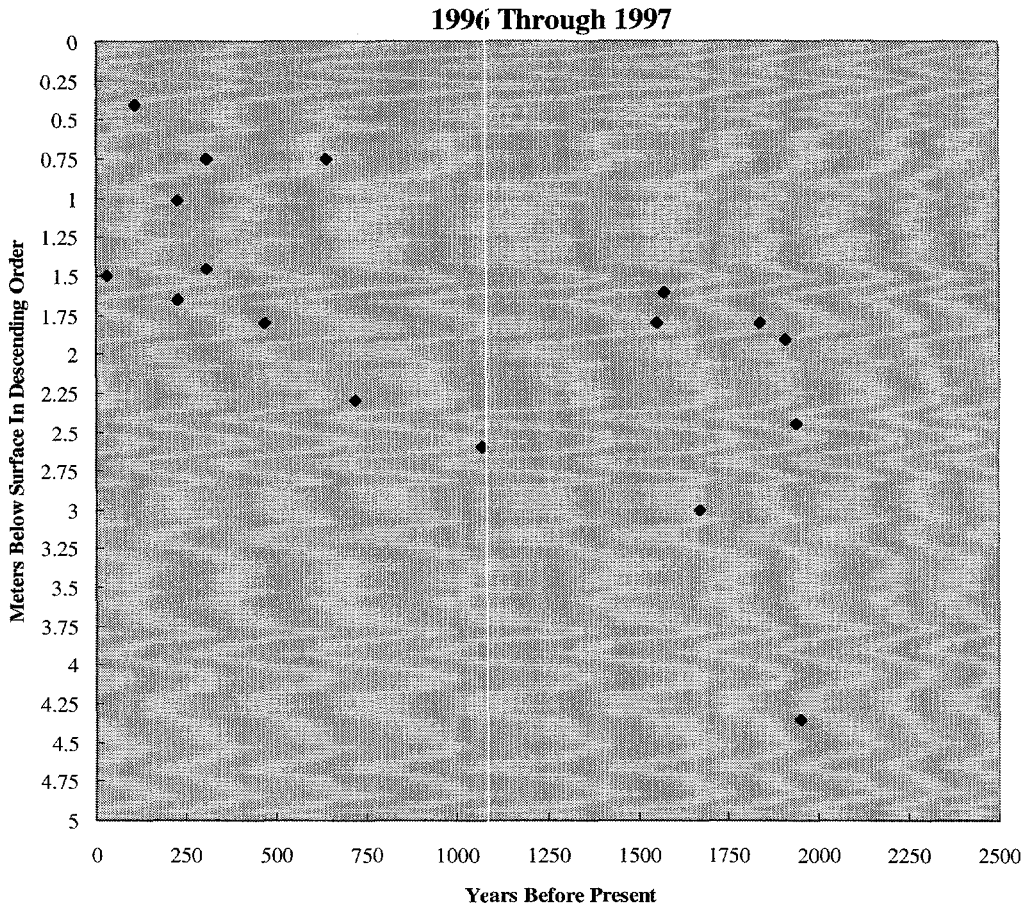

Figure 4.11. Relationships Between Radiocarbon Dates and Their Below-Surface Measurements. An eighteenth date, 2130 ± 60 years B.P. (Beta-92903) is not plotted because an exact below-surface measurement is not available. The sample was recovered from the base of the cutbank at more than three meters below the surface of the island.

ago may account for the incompatibility of the alluvial record when compared to glacial advances in the Cascades at this time. In other words, there may have been an erosional episode which dates to about 700 to 800 years before present that has not been recognized in central and eastern Washington" (1978:56).

2. Cleveland investigated the impacts of flooding on island topography at Strawberry Island. He found that "the inability to detect sequential deposits related to known historic floods on Strawberry Island suggest the possibility that infrequent floods of large magnitude are able to remove earlier deposits" (Cleveland et al. 1977).

3. At 45OK197, Chatters (1984) was able to investigate flood frequencies during the period in question (600 years B.O. to 1500 years B.P.). "Over 25 distinct flood events dating between 2000 and 0 years

Table 4.2. Radiocarbon Dates From the Wahluke Site (45G306B)

Measured ^{14}C Age in Yr. B.P.	Laboratory No.	Material	Stratigraphic Position	Site Number	Comments
990±90	Beta-33036	Charcoal	130-140 cm below unit datum or approximately 135-145 cm below surface; TU 4, Level 14	45GR306B	Charcoal sample twig/branch, hardwood
1150±110	Beta-33038	Charcoal	200-210 cm below unit datum or approximately 205-215 cm below surface; TU 4, Level 21	45GR306B	Charcoal sample, shrubwood, sagebrush (?*purshia*?)
1370±160	Beta-33035	Charcoal	110-120 cm below unit datum or approximately 115-125 cm below surface; TU 4, Level 12	45GRB3-6B	Charcoal sample conifer wood

before present were recorded at 45OK197 by the RM 590 project. A large number of radiocarbon dates tied to this sequence allowed analysis of variation in flood periodicity during this period.

Floods high enough to deposit on this surface [at 45OK197] occurred at a frequency of once per 83.65 years between 1870 years before present and 980 years before present Between 980 B.P. and 560 B.P., the flood frequency was once every 34 years, and since 560 B.P. they have been occurring only once every 137 years" (Campbell 1985:159).

4. Denton and Karlen (1973) note a period of glacial expansion from 1250-1050 years B.P. that is recorded only in western North America and a rise in the altitude of spruce tree lines from 1050-460 calendar years before present (1973:155).

5. Schroedl (1973) found no instances of archaeological bison remains associated with cultural components post-dating 1025 ± 200 B.P. (I-808) in his regional study of the prehistoric use of bison (*Bison bison*) on the Southern Plateau.

6. Also at Strawberry Island, Schalk suggested that changes in precipitation after 4,000 years B.P. meant "that much of the prehistoric human habitation at Strawberry Island and especially the later occupations (1,000-200 years before present), occurred during a dry interval" (1983:166).

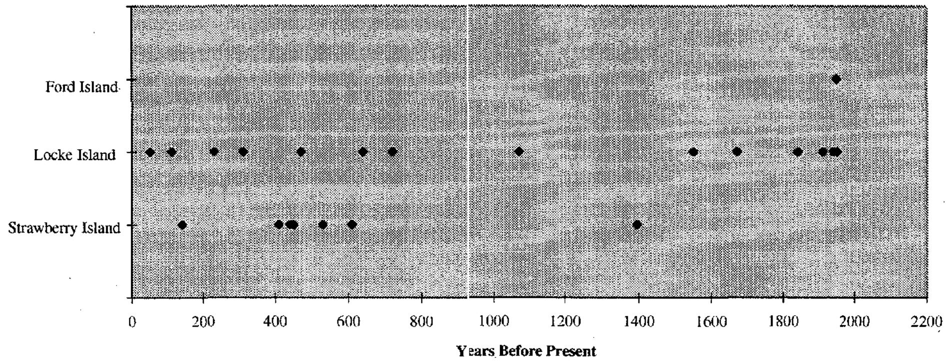

Figure 4.12. Radiocarbon Dates From Cultural Features on Ford, Locke, and Strawberry Islands

4.7 Conclusions

The Locke Island erosion monitoring project has provided important information with which to begin a process of assessing impacts to archaeological deposits resulting from natural and artificial erosion processes. The impacts resulting from these processes has long been acknowledged at the island, but the rate and extent of the impacts had not been measured. Cultural deposits have been encountered throughout the approximate 1 kilometer length of monitored riverbank, but only the northernmost half of the bank experienced severe erosion during the 1996 and 1997 monitoring cycles. The southernmost half of the monitored bank remained fairly stable.

Following initiation of the project in November 1995, 32 trips were taken to Locke Island to monitor the rate of erosion and impacts to archaeological deposits along Locke Island's northeastern shoreline. The results of these monitoring visits provide a startling record of rapid, punctuated loss of cultural deposits at the northernmost end of the monitored riverbank. With the exception of those cultural deposits remaining in the present cutbank, all the cultural features and materials noted since November 1995 are gone or have been modified by erosion processes. In spite of this important loss of cultural deposits, significant advances have been made in other areas. Samples taken from now lost hearths and cultural layers have provided dates for past use of Locke Island and have suggested differences in plant community composition during the recent past. Findings such as these, albeit preliminary, provide new information about recent prehistory in the central Pasco Basin. At a minimum, collection of charcoal samples from the eastern shoreline of Locke Island should continue throughout the life of the project to 1) ensure that the meager representation of dates between from 640 ± 70 (Beta-92905) to 1550 ± 40 years B.P. (Beta-92473) is "real" and not the product of sampling bias, and 2) ensure recovery of a charcoal sample to provide a date for the earliest use of the island currently suggested by the presence of a deeply buried cultural strata.

The shell lenses, shell fragments, and faunal remains encountered in the monitored cutbanks, in recovered materials from the archaeological floor at Transect 800, and along the shoreline represent a small but important portion of the various cultural materials documented along the northeastern shoreline of Locke Island. Analysis of these shell and faunal remains may provide information about previous subsistence patterns (e.g., seasonality) of early residents and potentially add new information to what is already known about local environments in the immediate vicinity of Locke Island.

5.0 Concluding Remarks

Paul R. Nickens

Earlier in this report, it was noted that effective and systematic field monitoring of ongoing impacts to cultural resource properties could assist those charged with managing and protecting significant resources in several ways. Among these are: 1) compliance with historic preservation laws and regulations; 2) providing quantitative data to use in identifying resource protection strategies; 3) identification of future resource protection needs; and 4) using monitoring results to expand knowledge of past cultural events and patterns. We believe the results of the 1996-1997 Locke Island monitoring effort achieve some success in contributing critical information to meet each of these needs.

Locke Island and the immediate area possess a high and unique level of past and present cultural importance in the region. The significance of the island's archaeological contexts was previously recognized by listing in the National Register in the 1970s. Today, we know that the archaeological picture at Locke Island is even more complicated and important and greatly exceeds the cultural resource qualities previously identified that led to its national recognition. Results from the monitoring program have shown that buried archaeological deposits exist throughout the island and include deeply buried levels. Each eroding cutbank examined around the island's perimeter revealed evidence of buried cultural features or artifacts. Surficial and limited archaeological testing information obtained in the 1960s led to the belief that there were only discrete archaeological areas located on the island.

The island and the surrounding area possess considerable traditional cultural significance for living Native American individuals and tribes. Historically, Native Americans used part(s) of the island as a cemetery location into the early twentieth century. Given the documented length and intensity of pre-historic occupation on the island, there are certain to be additional human interments in the island's sediments. There is at least one current Wanapum elder who was born on the banks of the Columbia River across from Locke Island before the Hanford Site was established. In the early 1950s, Wanapum elders noted names and associated significance for the island and several nearby places/resources. As stated, the area was used annually until 1943 as the primary fall fishing location by the Wanapum people and, because of the precluding presence of dams and reservoirs elsewhere along the Columbia River, could once again become a primary fishing locale with the relaxing or removal of access restrictions for Indian fishers.

It was fortuitous that initiating the systematic cultural resource monitoring effort coincided with 2 years of late winter and spring river flows that far exceeded average annual discharge, thereby allowing for collection of extensive archaeological data that would have been lost without any recording. Even so, the acquisition of archaeological data as an adjunct to the monitoring effort cannot be considered as a totally effective data recovery procedure. Despite acquisition of the data summarized in Section 4.0, an unquantifiable but overwhelming amount of important archaeological information was irretrievably lost from Locke Island in 1996 and 1997. And, while the Locke Island situation stands out and was selected at an opportunistic time for initiation of systematic monitoring, the higher than average flows in the river similarly impacted many additional but smaller eroding cutbanks along the Hanford Reach that contain buried archaeological deposits. As an example, a human burial was identified in an eroding bank on the east side of the river not far down river from Locke Island in the fall of 1996; by the spring of 1997 it had fallen into the high water lapping at the toe of the cutbank.

As an outgrowth of the Locke Island monitoring effort, DOE formed an interagency counsel in 1997 to address both the shoreline erosion at the island and landslide problems. This group includes federal, state and local agencies, along with representatives of the regional Indian tribes. Additional studies are currently underway to better understand the dynamics of the landslide itself, and to identify potential protective strategies for the important National Register-listed property. Ethnographic interviews have been conducted by agency and tribal cultural programs regarding the importance of the island and surrounding area. Finally, all eroding banks with archaeological remains have been identified on both shores of the Hanford Reach that flows through the Hanford Site, and two monitoring sessions have now been completed to establish baseline conditions from which future erosion can be measured. Consequently, beginning at Locke Island and now expanded to the entire Hanford Reach, the DOE has embarked on a field monitoring program that will provide a sound basis for addressing issues pertaining to providing effective management and protection of important cultural resources along this stretch of the Columbia River.

6.0 References

Baker, V. R. 1978. "Large-Scale Erosional and Depositional Features of the Channeled Scabland," In *The Channeled Scabland*, V. R. Baker and D. Nummedal (eds.), pp. 81-115. National Aeronautics and Space Administration, Washington, D.C.

Baker, V. R., B. N. Bjornstad, A. J. Busacca, K. R. Fecht, E. P. Kiver, U. L. Moody, J. G. Rigby, D. F. Stradling, and A. M. Tallman. 1991. "Quaternary Geology of the Columbia Plateau," In *Quaternary Nonglacial Geology; Conterminous U.S.*, R. B. Morrison (ed.) vol. K-2. Geological Society of America Boulder, Colorado.

Campbell, S. 1985. "Paleoenvironmental Reconstruction and the Sedimentary Sequence at Excavated Sites." In *Summary of Results, Chief Joseph Dam Cultural Resources Project, Washington*. University of Washington. Office of Public Archaeology. Seattle, Washington.

Chatters, J. C. 1984. "Flood Periodicity." In: *Human Adaptation Along the Columbia River, 4700-1600 B.P.*, by J. C. Chatters, Appendix J. Central Washington University, Graduate Studies and Research, Research Reports 84-1. Ellensburg, Washington.

Chatters, J. C., N. A. Cadoret, and P. E. Minthorn. 1990. *Hanford Cultural Resources Laboratory Annual Report for Fiscal Year 1989*. PNL-7362, Pacific Northwest Laboratory, Richland, Washington.

Chatters, J. C., H. A. Gard, and P. E. Minthorn. 1991. *Hanford Cultural Resources Laboratory Annual Report for Fiscal Year 1990*. PNL-7853, Pacific Northwest Laboratory, Richland, Washington.

Chatters, J. C., and H. A. Gard. 1992. *Hanford Cultural Resources Laboratory Annual Report for Fiscal Year 1991*. PNL-8101, Pacific Northwest Laboratory, Richland, Washington.

Chatters, J. C., et al. 1993. *Hanford Cultural Resources Laboratory Annual Report for Fiscal Year 1992*. PNL-8676, Pacific Northwest Laboratory, Richland, Washington.

Cleveland, G. C., J. J. Flenniken, D. R. Huelsbeck, R. Mierendorf, S. Samuels, and F. Hassan. 1977. *Preliminary Archaeological Investigations at the Miller Site, Strawberry Island, 1976: A Late Prehistoric Village near Burbank, Franklin County, Washington*. Project Report No. 46. Washington Archaeological Research Center, Washington State University. Pullman, Washington.

Cleveland, G. C. (ed.). 1978. *Second Interim Report on the Archaeological Investigations at the Miler Site (45FR5) on Strawberry Island (1977), a Late Prehistoric Village near Burbank, Washington*. Project Report No. 72. Washington Archaeological Research Center, Washington State University. Pullman, Washington.

Cochran, B. C. 1978. *Late Quaternary Stratigraphy and Chronology in Johnson Canyon, Central Washington*. Masters thesis, Department of Anthropology, Washington State University. Pullman, Washington.

Dauble, D. D., and D. G. Watson. 1990. *Spawning and Abundance of Fall Chinook Salmon (Oncorhynchus tshawyttcha) in the Hanford Reach of the Columbia River, 1948-88*. PNL-7289, Pacific Northwest Laboratory, Richland, Washington.

Denton, G. H., and W. Karlen. 1973. "Holocene Climatic Variations—Their Pattern and Possible Cause," *Quaternary Research* 3:155-205.

Department of Energy. 1988. *Consultation Draft: Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*. DOE/RW-0164, Volume 2, Chapter 3, U.S. Department of Energy, Washington, D.C.

Department of the Interior. 1994. *Hanford Reach of the Columbia River: Comprehensive River Conservation Study and Environmental Impact Study*. Two Vols. National Park Service, Pacific Northwest Regional Office, Seattle, Washington.

Fryxell, R. 1962. *The Archaeology of Ford Island: Section II Geologic Examination of the Ford Island Archaeological Site (45-FR-47), Washington*. Washington State University, Laboratory of Anthropology. Report of Investigations No. 18, Section II. Pullman, Washington.

Hall, B. 1988. *Persistence of River Bars, Columbia River at Hanford, Washington*. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington.

Hays, W. H., and R. L. Schuster. 1987. *Maps Showing Ground-Failure Hazards in the Columbia River Valley Between Richland and Priest Rapids Dam, South-Central Washington*. Miscellaneous Investigations Series, Map I-1699. U.S. Geological Survey, Washington, D.C.

Krieger, H. W. 1928. *A Prehistoric Pit House Village Site on the Columbia River at Wahluke, Grant County, Washington*. No. 2732 from Proceedings of the U.S. National Museum, Vol. 73, Article 11, pp. 1-29. U.S. Government Printing Office, Washington.

Last, G. V. et al. 1994. "Hanford Cultural Resources Laboratory Annual Report for Fiscal Year 1993." PNNL-10077, Pacific Northwest National Laboratory, Richland, Washington.

Lindsey, K. A. 1995. *Miocene to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*. BHI-00184, Bechtel Hanford Inc, Richland, Washington.

Lindsey, K. A., and G. K. Jaeger. 1993. *Geologic Setting of the 100-HR-3 Operable Unit, Hanford Site, South-Central Washington*. WHC-DD-EN-TI-132, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Marratt, W. J. n.d. *Study of Landslides Along the Columbia River in the Block 15 Area of Franklin County, Washington*. Franklin Conservation District, Pasco, Washington.

Miall, A. D. 1992. "Alluvial Deposits," In *Facies Models*, R. G. Walker and N. P. James (eds.), p. 119-142, Geological Association of Canada, St. Johns, Newfoundland.

Nickens, P. R. et al. 1995. *Hanford Cultural Resources Laboratory Annual Report for Fiscal Year 1994*. PNNL-11099, Pacific Northwest National Laboratory, Richland, Washington.

Peterson, R. E., R. F. Raidl, and C. W. Denslow. 1996. *Conceptual Site Models for Groundwater Contamination at 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units, BHI-00917, Rev. 0*. Bechtel Hanford, Inc., Richland, Washington.

Powers, H. A., and R. E. Wilcox. 1964. "Volcanic Ash From Mount Mazama (Crater Lake) and From Glacier Peak," *Science*, v. 144, p. 1334-1336.

Relander, C. 1956. "Drummers and Dreamers: The Story of Smowhala the Prophet and His Nephew Puck Hyah Toot, the Last Prophet of the Nearly Extinct River People, the Last Wanapums." *Northwest Interpretive Association* (Reprint edition, 1986), Seattle, Washington.

Rice, D. G. 1968a. *Archaeological Reconnaissance: Ben Franklin Reservoir Area, 1968*. Washington State University, Laboratory of Anthropology, Pullman, Washington.

Rice, D. G. 1968b. *Archaeological Reconnaissance: Hanford Atomic Works*. U.S. Atomic Commission, National Park Service and Washington State University, Pullman, Washington.

Rice, D. G. 1980. *Overview of Cultural Resources on the Hanford Reservation in South Central Washington State*. Report submitted to Richland Operations, U.S. Department of Energy. Troy, Idaho.

Schalk, R. F. (ed.). 1983. *The 1978 and 1979 Excavations at Strawberry Island in the McNary Reservoir. Project Report Number 19*. Laboratory of Archaeology and History. Washington State University, Pullman, Washington.

Schroedl, G. F. 1973. *The Archaeological Occurrence of Bison in the Southern Plateau*. Reports of Investigations, No. 51. Laboratory of Anthropology. Washington State University, Pullman, Washington.

Schuster, R. L., A. F. Chleborad, and W. H. Hays. 1987. *Irrigation-Induced Landslides in Fluvial-Lacustrine Sediments, South-Central Washington State*. In Conference Proceedings—Fifth International Conference and Field Workshop on Landslides, pp. 147-156. Christchurch, New Zealand.

Swindell, E. G., Jr. 1942. *Report on Source, Nature, and Extent of the Fishing, Hunting and Miscellaneous Related Rights of Certain Indian Tribes in Washington and Oregon, Together with Affidavits Showing Locations of a Number of Usual and Accustomed Fishing Grounds and Stations.* U.S. Department of the Interior, Office of Indian Affairs, Division of Forestry and Grazing, Los Angeles, California.

Symons, T. W. 1882. *Report of an Examination of the Upper Columbia River and the Territory in Its Vicinity in September and October, 1881, to Determine Its Navigability and Adaptability to Steamboat Transportation.* U.S. Army, Corps of Engineers, Washington, D.C. (Ye Galleon Press reprint edition, 1967).

White Bluffs-Hanford Pioneer Association. 1982. *Family Histories From Hanford and White Bluffs, Washington.* Hanford Science Center, Richland, Washington.

Appendix A

Cumulative Measured Loss Per Monitoring Trip to Locke Island

Table A.1. Measured Loss Along Transects During 1996 Reporting Period

	Total loss as of:													
Transect	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
800	na	na	na	na	na	0.5	0.5	1.2	5.3	6.5	7.3	7.3	7.4	7.6
801	0.9	2.0	2.4	5.4	5.9	6.5	6.5	8.7	11.4	13.5	14.6	?	15.5	15.7
802	1.0	1.0	2.5	5.5	5.9	6.4	6.7	8.5	11.4	14.0	14.1	15.0	15.0	15.0
803	1.0	2.5	4.4	5.8	6.9	7.3	7.3	9.0	11.0	12.0	12.0	13.0	12.0	13.0
804	0.5	1.3	2.7	6.1	6.1	6.1	5.8	6.4	9.0	12.0	12.0	12.0	12.0	12.0
805	0.0	0.0	0.0	10.0	>10	>10	>10	12.8	12.8	15.3	15.3	15.3	15.4	15.4
806	0.0	0.0	0.0	10.0	>10	>10.2	>10.2	10.8	13.5	16.4	16.4	16.4	16.5	16.8
807	0.2	0.2	1.6	3.5	3.5	4.2	4.2	4.2	7.5	11.5	11.8	11.9	12.0	12.5
808	-0.1	1.7	1.9	6.2	6.2	6.2	6.2	6.0	11.1	14.5	15.6	15.6	15.7	15.7
809	0.1	2.1	2.1	7.0	7.0	7.1	7.1	7.0	10.8	14.3	14.8	14.8	14.8	14.8
810	0.0	-0.1	1.4	3.4	3.4	3.4	3.4	4.9	9.2	10.4	11.7	12.6	12.5	12.5
811	0.0	0.0	0.0	0.2	1.1	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.2
812	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
813	0.0	0.0	0.0	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.8	0.0	0.8
814	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
815	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
816	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0	0.0	1.0
817	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
818	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
830	na	na	na	na	na	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
831	na	na	na	na	na	na	0.0	0.0	0.0	0.0	-0.3	-0.5	-0.5	0.3

Table A.2. Measured Loss Along Transects During 1997 Reporting Period

	Total loss as of:																	
Transect	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/27/97	7/8/97	7/24/97	8/7/97	9/11/97	10/30/97	11/13/97	12/11/97
748	na	na	na	na	na	na	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	no measurement	1.0	1.0
750	na	na	na	na	na	na	0.3	0.6	0.6	0.6	0.6	0.7	0.6	0.8	0.7	no measurement	0.7	0.7
799	0.0	-0.1	-0.1	0.0	0.0	0.0	4.6	6.7	?	8.0	8.0	7.8	7.4	8.1	7.5	7.5	8.1	8.1
800	7.7	7.9	7.8	7.8	7.9	8.4	11.6	13.5	15.8	15.9	15.9	16.1	16.1	16.0	16.0	16.0	15.8	16.1
801	16.7	17.0	17.0	16.9	18.7	20.2	20.2	21.1	24.1	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
802	15.5	16.0	16.3	16.3	17.5	19.4	19.4	20.0	24.8	30.7	30.7	32.0	32.0	32.8	32.6	32.7	32.7	32.9
803	13.0	14.3	14.3	14.3	15.7	16.6	21.0	21.0	23.0	23.3	23.7	23.8	23.8	23.8	23.8	23.8	23.8	23.8
804	12.0	12.0	12.0	12.0	15.1	16.5	25.5	26.4	27.3	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
805	15.4	15.2	15.3	15.3	15.9	18.8	24.2	25.5	28.2	28.4	28.4	28.3	28.4	28.5	28.4	28.4	29.0	29.0
806	16.8	17.2	17.2	17.2	19.2	20.1	23.2	25.5	29.4	29.4	29.4	29.4	29.3	29.4	29.3	29.3	29.3	29.3
807	12.5	12.5	12.5	12.5	13.5	15.8	17.9	20.2	27.9	28.0	27.8	27.8	27.9	28.0	27.8	27.9	27.9	27.9
808	17.5	17.4	17.5	17.4	18.5	19.9	19.9	19.9	22.2	23.1	23.1	23.1	23.4	23.5	23.5	23.5	23.5	23.5
809	14.8	14.8	14.8	14.8	15.8	17.2	17.5	18.3	19.9	19.9	20.8	20.8	21.1	21.0	21.0	21.0	21.1	21.0
810	12.5	12.5	12.5	12.6	14.2	16.0	17.6	17.8	18.5	19.7	19.8	19.8	21.0	21.0	21.0	21.0	21.0	21.1
811	1.1	2.3	2.3	2.3	6.0	9.3	11.3	13.2	15.0	16.5	18.8	19.3	20.8	20.8	20.8	20.8	20.8	20.8
812	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
813	0.8	0.8	0.8	0.7	0.8	1.6	1.5	2.0	2.1	2.7	2.6	2.6	2.6	2.6	2.6	2.7	2.6	2.6
814	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.2
815	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.7	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5
816	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.6	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2
817	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	-0.1	0.1	0.1	0.1
818	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
830	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
831	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Appendix B

Cultural Materials and Features Observed During the 1996/1997 Monitoring at Locke Island

Table B.1. Locke Island Cultural Features Exposed During Monitoring Cycle

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
799	12/6/96															Transect Set
800	3/12/96						Transect Set; Hearth Feature No. 800.1; 2.45 m BS	na	na	na	na	Many pieces of shell on shore below.	Shell lens Feature 800.3 ~30 cm above basal gravel layer. Cobble tool w/ground edges near TT800 in slump material.	na	na	na
800	3/12/96						na	na	na	na	na	na	FCR Feature 800.4 ~10 m N of 800.3 on gravel layer; 1.9 m long w/ ~11 FCR. Dark layer ~20 cm thick above 800.4; red-dish sandy layer several cm thick below 800.4.	na	na	na
801	11/21/95	na	na	na	na	Several cobbles in slump material.	na	na	na	na	na	na	na	na	na	na
Between 801-802	na	na	na	na	na	na	na	na	na	Between T801-T802 large mam-mal bone; FCR to S on beach.	na	Between T800-T801 5-7 pieces of FCR – prob-ably came out low.	na	na	Between T800 and T801 FCR in pile on beach. Rock layer w/charcoal @ 1.5 m BS	na
802	11/21/95	na	na	na	na	na	na	na	na	Surface depression at T802 w/3 rye grass clumps.	na	na	na	na	na	na

Table B.1. (contd)

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
803	11/21/95	na	na	na	na	na	na	na	na	Piece of FCR below T803 on the beach. Light FCR scatter S of T803; nothing in cutbank.	na	na	na	na	na	na
Between 803-804	na	na	na	na	na	Granitic FCR and cobble in slump material between T803 and T804.	na	na	na	Large pieces FCR 20 m N of T804.	na	3 Features; 1st 17 m N of T804, 2.3 m BS, 0.9 m x 30 cm high w/dark level ~15 cm thick, 2nd at 14 m N 1.6 m BS w/sm FCR pieces from 8-15 cm, dark layer ~15 cm thick—continues from 1st concentration.	Rock feature in thick dark layer between T803-T804.	na	na	na
804	11/21/95	na	na	na	na	na	na	Biface tip on shore. FCR at 15 m S of T804.	na	na	na	na	na	na	na	na
804	11/21/95	na	na	na	na	na	na	Feature 804.1.2.; 2 long bones 1.85 m BS near T804. The strata is dark-stained and underlain by a prominent red-stained strata. Stratigraphically appears to be below 806.1.	na	na	na	na	na	na	na	na

Table B.1. (contd)

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
805/805a	11/21/95	na	na	na	na	All transect stakes lost.	T805 re-set as T805A; Bones in vicinity of T805.	na	na	na	na	na	na	na	na	na
806/806a	11/21/95	na	na	na	na	Feature 18 m S of T806. ~16 white, angular FCR, 1 rock high. Feature base 1.77 m BS at the N end-1.90 m BS at the S end-3.1 m long. Largest rock is 10 x 11 x 8 cm. Dirt darker at rock level. Dark stains 17cm below & 55 cm (5-6 cm wide) above.	T806 reset as T806A. Feature 806.1, deeply buried cobble surface. [Same Feature described 3/12/96 at T806] (4 14C dates)	806.A.1. Circular/oval feature ~1.7 m BS (23 cm wide x 10 cm high 3.0 m N of T806A ~95 cm below 806.1.) 806.A.1 on dark 'A horizon' - silty.	na	Profile where FCR feature (806.1) documented still pretty much intact. FCR configuration may be different.	Rock layer still visible in cut bank. On beach ~20 FCR on resistant surface in group ~8 m long.	T806 FCR concentration 1.7 m BS (4 FCR and burned area)	806.A.2, 5+FCR on a dark horizon 35 cm thick. It is 1-6 m deep, 1 m wide and 1 rock thick.	na	na	na
806/806a	11/21/95	na	na	na	na	FCR concentration located below the Feature described above; rocks appear different-not white-washed off. Concentration composed of ~40 quartzite and basalt FCR.	na	na	na	na	na	na	na	na	na	na

Table B.1. (contd)

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
807	11/21/95	Hearth Feature w/ cobbles, FCR ~80 cm BS w/ charcoal staining ~1 m wide, 15 cm thick.	Hearth Feature severely undercut.	Hearth Feature eroded since 1/22/96. High concentration FCR in water at base of talus for 25 m centered at T807.	Hearth Feature gone.	na	na	na	na	na	na	na	FCR ~0.5 m below bank edge at 7 m S of T807.	na	na	na
Between 807-808	na	na	na	Large cobble tool collected from beach ~20 m downstream of T807 in talus.		Between T807-T808 shell on top of dark layer 2.4 m BS; both halves-thought to be natural occurrence.	na	na	na	FCR Feature 1.87 m BS is midway between T807 and T808. Dark paleosol on same level.	na	na	na	na	na	na
Between 807-808	na	na	na	na	na	Between T807-T808 a large flat cobble & 1 FCR in slump material	na	na	na	na	na	na	na	na	na	na
808	11/21/95	na	na	na	na	na	Cobble chopper or core at fenceline in slump material.	na	na	na	na	na	808.1-Burnt earth feature w/11 rounded rock. X-section is smile shaped; 90 cm long, center 22 cm thick; 10 cm from edge is ~11 cm thick/14 cm thick at rock, 2.2 2 m BS. Tapers to a point on each side. Soil orange in color.	na	na	na

Table B.1. (contd)

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
809	11/21/95	na	na	na	na	Several cobbles 18 m south of T809 in slump material.	na	na	na	na	na	na	na	na	na	na
Between 809-810	11/21/95	na	na	na	na	na	na	na	na	FCR and cobble tool between T809 and T810	na	na	na	na	na	na
810	11/21/95	na	na	FCR ~12 m downstream from T810 in talus.	na	na	na	na	na	na	na	na	na	na	na	na
Between 810-811	na	na	na	na	na	na	na	na	na	~30 m S of T810 2 layers FCR. Top layer 1.45 m to 0.9 m BS. Lr layer (dense) is overlain by ~4.35 m of sediment. Rocks in lr layer are larger in size than other FCR features. 20-25 m long/ ~30 cm & less.	na	na	na	na	na	na
811	11/21/95	na	na	na	na	na	FCR Feature exposed in cutbank about 1 m above the river level near T811.	na	na	na	na	na	na	na	na	na
812	11/21/95	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
813	11/21/95	na	na	na	na	One FCR in slump material 10 m N of T813.	na	FCR 8 m N of T813.	na	na	na	na	na	na	na	na
814	11/21/95	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Table B.1. (contd)

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
815	11/21/95	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
816	11/21/95	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
817	11/21/95	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
818	11/21/95	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
830	4/4/96	na	na	na	na	na	na	Transect Set. FCR Feature 830.1 centered at T830. 3.70 m long, rock layer 10 cm wide, 1.1 m BS at S end & 1.2 m BS at N end.	na	FCR layer at T830. 2 FCR features just exposed from water ~20 m N of T830.	na	na	na	na	na	na
830	4/6/96	na	na	na	na	na	na	Transect Set. Discontinuous cultural items – FCR-flakes for 65 cm to the S. [~T830 to ~T831].	na	na	na	na	na	na	na	na
831	4/4/96	na	na	na	na	na	na	831.1 – FCR Feature ~1.6 m below surface. Layer at least 3 m long contains FCR & flaked material.	na	na	na	na	na	Hearth Feature 831.2; 10cm x 1.45m, ~20 cm below Strat. 3. Dense charcoal at base of feature		
831	4/4/96	na	na	na	na	na	na	831.2-Hearth Feature. Rock and charcoal 1.47 m long, charcoal layer 7-10 cm wide S to N, rock and charcoal 11-14 cm wide S to N. 1.02 m BS	na	na	na	na	na	M47 Feature, 8 cm x 112 cm, 9 FMR w/silty sand gray-stained layer sediments massive above and below feature	na	na

Table B.1. (contd)

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
831	4/4/96	na	na	na	na	na	na	831.3 - Rock and charcoal feature 1.15 m long, 1.0 m BS	na	na	na	na	na	M48 Feature, 7 or 9? cm x 1.10 m reddish stain	na	na
831	4/4/96	na	na	na	na	na	na	831.4 – Hearth Feature is 2.1 m BS; 1.0 m long and 12 cm wide	na	na	na	Profile drawn from meter 17 - meter 48 includes 3 hearth features. On beach 1 projectile point modified into a drill, a unifacial scraper, and a small broken cobble net weight.	na	na	na	na
831	4/4/96	na	na	na	na	na	na	Cultural material exposed in slump material – cobbles/FCR.	na	na	na	na	na	na	na	na
831	4/4/96	na	na	na	na	na	na	36 m to the south is FCR/cobble concentration in slump - 50+ rocks.	na	na	na	na	na	na	na	na
SE Tip	No Transect	na	na	na	na	na	na	2 distinct layers are present, one 1.6 m BS w/FCR & small bone fragments, another at 1.2 m BS defined by FCR & lithics.	na	na	na	na	na	na	**Information Recorded 10/17/96**	**Information Recorded 12/6/96**

Table B.1. (contd)

Transect Number	Date Set	11/21/95	1/22/96	2/12/96	2/23/96	3/12/96	3/18/96	4/4/96	4/16/96	5/14/96	6/11/96	7/3/96	7/26/96	8/29/96	10/17/96	12/6/96
Lower SW Side	No Transect	na	na	na	na	na	na	Pestle	na	na	na	na	na	na	na	na
Lower SW Side	No Transect	na	na	na	na	na	na	3 grinding stones/anvil stones. 1 stone is 22 cm x 17 cm x 8 cm wide w/grinding area ~9 cm in diameter.	na	na	na	na	na	na	na	na
Lower SW Side	No Transect	na	na	na	na	na	na	Horse or cow bones.	na	na	na	na	na	na	na	na
Transect Number	**Date Transect Set**	**Informa-tion Recorded 11/21/95**	**Informa-tion Recorded 1/22/96**	**Informa-tion Recorded 2/12/96**	**Informa-tion Recorded 2/23/96**	**Informa-tion Recorded 3/12/96**	**Informa-tion Recorded 3/18/96**	**Informa-tion Recorded 4/4/96**	**Informa-tion Recorded 4/16/96**	**Informa-tion Recorded 5/14/96**	**Informa-tion Recorded 6/11/96**	**Informa-tion Recorded 7/3/96**	**Informa-tion Recorded 7/26/96**	**Informa-tion Recorded 8/29/96**	na	na
Lower SW Side	No Transect	None	None	na	na	na	na	FCR feature just under the water.	na	na	na	na	na	na	na	na
															na	na
															na	na
															Informa-tion Recorded 10/17/96	**Informa-tion Recorded 12/6/96**
															na	na

Table B.2. Information Recorded About Cultural Materials and/or Features Observed in Monitored Cutbank During FY98

Transect Number	Date Set	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/26/97	7/8/97	7/24/97	8/7/98	9/11/97	10/30/97	11/13/97	12/11/97
North of Transects	n/a	n/a	n/a	n/a	n/a	Hearth feature ~1.9 BS; Sample taken	n/a	n/a	n/a	n/a	n/a	Two features north of T748; one 30 cm BS with 4 FCR in bank. Broken cobble in float ~20 m south of T748.	Two features at boat landing	n/a	n/a	At upper island boat landing: Feature 6; hearth in rock layer ~4 m BS. Several cobble choppers along shoreline.	n/a	n/a	Boot prints and shovel cut in hearth feature.
748	5/16/97	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Several FCR features	n/a	n/a	n/a	n/a
750	5/17/97	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Rock in cutbank ~1.5 m BS to the north of T750	n/a	n/a	Several FCR features	n/a	n/a	n/a	n/a
751		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3 rocks about 1.4 m BS - 40 m north of T750	n/a	n/a	n/a	n/a	n/a	n/a	n/a
799	12/6/96	n/a	n/a	Dark stained layer ~1.2 - 1.6 m BS	n/a	Transect submerged	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 secondary, caramel-colored flakes	Flakes on shoreline
Between 799-800	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	10+ FCR and piece of shell in 30-40 m length on talus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table B.2. (contd)

Transect Number	Date Set	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/26/97	7/8/97	7/24/97	8/7/98	9/11/97	10/30/97	11/13/97	12/11/97
800	3/12/96	Cobble/FCR layer ~1.6 m BS	1 sm granitic net weight w/2 notches. 4 m S of T800, layer of rock/stain. Cobbles & FCR on beach at water's edge.	n/a	Dark layer 1.1 BS	n/a	n/a	n/a	n/a	n/a	10+ FCR in 30-40 m length on talus	Living floor w/ salmon bones and flakes. Floor extends under talus.	n/a	n/a	n/a	Small flat pebble tool near waters edge ~15 m south of T800	n/a	n/a	n/a
801	11/21/95	n/a	n/a	n/a	n/a	Hearth Feature w/FCR and char-coal ~0.5 m BS	Cobbles/ discontin-uous rock layer ~50 cm BS	n/a	n/a	n/a	n/a	n/a	n/a	1 unmodi-fied cobble on talus	n/a	1 piece of FCR	Small cob-ble tool on bank	n/a	n/a
802	11/21/95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Between 802-803	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1 small cobble	n/a	n/a	n/a	n/a	n/a
803	11/21/95	n/a	n/a	FCR scat-ter below water's surface; 1 cracked/ broken mammal bone.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1 flaked cobble at water's edge	n/a	n/a	2 pieces of shell on toe of bank	n/a	n/a	n/a
Between 803-804	n/a	n/a	FCR in and at waters edge and in shallow water.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1 mandible (faunal)	n/a	n/a	n/a

Table B.2. (contd)

Transect Number	Date Set	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/26/97	7/8/97	7/24/97	8/7/98	9/11/97	10/30/97	11/13/97	12/11/97
804	11/21/95	n/a	Feature 804.2: dense FCR layer 2.6 m BS. Feature 804.3: charcoal sample collected 40 cm away - same layer.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 pcs shell, 1 small FCR on talus	Group of cobbles showing just under water. Retrieved rebar stake from river shallows w/metal tag still on it.	n/a	2 pieces of shell, cobbles with flakes removed and cobble tools on beach.	Feature 4 - 16 red cobbles (~5 granitic) in sand at base of bank. Outliers are FCR pieces.	n/a	n/a
805	11/21/95	n/a	n/a	n/a	n/a	n/a	Stain w/ orange center ~2 n BS	n/a	n/a	n/a	n/a	n/a	n/a	1 basalt flake ~2.5 m BS on water resistant shelf.	n/a	F1 - More than 18 cobbles ~25 x 15 cm in size w/ large rock and a bifacially worked quartite tool.	n/a	n/a	n/a
806	11/21/95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Cobble tool on talus.	n/a	n/a	1 round cobble on talus toe	n/a	More than 14 pieces of FCR and cobbles on the stepped shoreline	n/a	n/a	~10 pieces of FCR at base of bank near water's edge
Between 806-807	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	7 FCR and 8 scattered FCR on toe of talus.	n/a	Sparsely scattered FCR from T806 to T807 (8 in one area).	n/a	n/a	Scattered FCR
807	11/21/95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	8-10 FCR widely scattered	3 FCR and broken cobbles on the beach	n/a	11 scattered FCR along toe of 8 - 10 m length of bank ~4 m BS	n/a	Sparsely scattered FCR from T806 to T807 (8 in one area).	Widely scattered FCR	n/a	Scattered FCR

Table B.2. (contd)

Transect Number	Date Set	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/26/97	7/8/97	7/24/97	8/7/98	9/11/97	10/30/97	11/13/97	12/11/97
808 (fence)	n/a	n/a	n/a	n/a	n/a	In area of T806 /T807/ T808 (viewed from boat mid-river) To north concentration of anugular rocks - no charcoal. To south - hearth feature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1 pc FCR ~10 m sout of fence; 2 pc of FCR 10 m north of T808; 3 pc FCR 20 m north of fence. Beach ~ 4 m BS here.	1 cobble tool on shore	n/a	n/a
809	11/21/95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Dark stain - no FCR or other cultural materials ~2.0 m BS	n/a	n/a	n/a
810	11/21/95	n/a	Viewed from top of bank: flat reddish boulder at water's edge - one broken cobble ~10 m north of transect.	n/a	n/a	2 red-stained crescents ~2 m BS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Sample taken 4.36 cm BS beneath cultural layer. Other features; cultural layer & pile of cobbles/ FCR; group of large cobbles, FCR, antler tip (pressure flaking tool?). Third feature in water - also has large FCR	Many flakes, FCR in the bank behind (west) the collapsed deeply buried layer first noted in 1995.	n/a	n/a

Table B.2. (contd)

Transect Number	Date Set	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/26/97	7/8/97	7/24/97	8/7/98	9/11/97	10/30/97	11/13/97	12/11/97
811	11/21/95	n/a	n/a	n/a	n/a	n/a	n/a	Hearth ~1 m BS noted from boat.	n/a	n/a	n/a	n/a	n/a	Large flat cobble tool just under water on talus edge	n/a	n/a	n/a	n/a	n/a
811.5	n/a	n/a	n/a	~30 m S of T811 large piece FCR on toe of talus ~0.5 m above water level. 7 rocks below water under tree root.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	FCR on the beach with over 100 pieces	n/a	n/a	n/a
812	11/21/95	n/a	n/a	Mammal bone 70 cm BS and 1.5 m south of T812. A second bone fallen to upper levels of talus.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Bank vegetated: 1 piece FCR on beach, 2 pieces FCR ~3 m BS, 1 piece FCR	n/a	n/a	n/a
Between 812-813	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	About 20 m north of T813 - 4 FCR and broken cobbles ~3 m BS. About 50 m north from T813 - 1 FCR on talus. About 50 m from T813.	n/a	n/a

Table B.2. (contd)

Transect Number	Date Set	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/26/97	7/8/97	7/24/97	8/7/98	9/11/97	10/30/97	11/13/97	12/11/97
813	11/21/95	n/a	3 cobble tools; one rock flake ~10 m south of T813.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Isolated FCR on beach.	n/a	n/a	1 piece of FCR	Feature 3 - more than 25 FCR and cobble tools ~4 m BS on the beach	n/a	n/a
814	11/21/95	n/a	Small blue shovel upright in beach	Toy shovel, blue plastic, upright in beach.	Toy shovel, blue plastic upright in beach	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 hearths previously recorded between T813 and T818 still in bank	n/a	n/a	n/a	Feature 2 - 12 pieces of FCR visible ~4.5 - 5.0 m BS	n/a	n/a
815	11/21/95	n/a	n/a	Stained soil layer present.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	10+ rounded, charcoal-stained cobbles beneath in-situ feature. C14 sample taken	Two hearths previously recorded between T813 and T818 still in bank	Hearth Feature 3 ~ 1.3 m BS; charcoal sample taken. 8-10 cobbles fallen onto bank.	n/a	Bank vegetated: Charcoal lens with charcoal already sampled	n/a	n/a	n/a
816	11/21/95	n/a	n/a	South of T816 ~10 m: 2 pieces FCR under root-supported cavity ~4 m BS.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 hearths previously recorded between T813 and T818 still in bank	Feature 4: 4 FCR on shoreline ~4 m BS	n/a	FCR feature in bank ~4.0 to 4.5 m BS. FCR is under 10 cm in size	2 pieces FCR on beach. Previously recorded feature ~4 m BS; 2 rocks in situ more than 60 FCR in 6 m area.	n/a	n/a
Between 816-817	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Two hearths previously recorded between T813 and T818 still in bank	n/a	n/a	Bank vegetated: 2 cobbles	2 pieces FCR	n/a	n/a

Table B.2. (contd)

Transect Number	Date Set	1/14/97	2/3/97	2/26/97	3/25/97	4/29/97	5/16/97	5/28/97	6/5/97	6/12/97	6/19/97	6/26/97	7/8/97	7/24/97	8/7/98	9/11/97	10/30/97	11/13/97	12/11/97
817	11/21/95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 hearths previously recorded between T813 and T818 still in bank	n/a	n/a	n/a	n/a	n/a	n/a
818	11/21/95	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Two hearths previously recorded between T813 and T818 still in bank	n/a	n/a	n/a	n/a	n/a	n/a
830	4/4/96	n/a	Lag deposits on beach	n/a	n/a	n/a	n/a	n/a	n/a	n/a	F3 1.9 m x 5 cm thick & 1.0 m BS	Features 2 through 4 in cutbank north of T830.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
831	4/5/96	n/a	Lag deposits on beach	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Southern Tip	n/a	Cobble tools, lag and flakes along w/ round cobbles on beach.	Long mammal bones on beach. Small bones under a near-surface plank	n/a	n/a	n/a	n/a	n/a	n/a	n/a	F1 ~40 FCR; F2 hearth 1.3 m x .1 m thick & 1.8 BS-2 samples taken; F4 87 cm BS to at least 1.7 m from bank edge-~30 FCR eroded out of bank; F5 dark stain w/charcoal chunks-sampled.	n/a	FCR lag and flaking debris	4 housepit? lenses - cross-bedded. Charcoal sample taken. Pronghorn tooth and biface tool on beach.	n/a	n/a	n/a	n/a	n/a

Appendix C

Archaeological Deposits and River Bank Recession at Each Transect

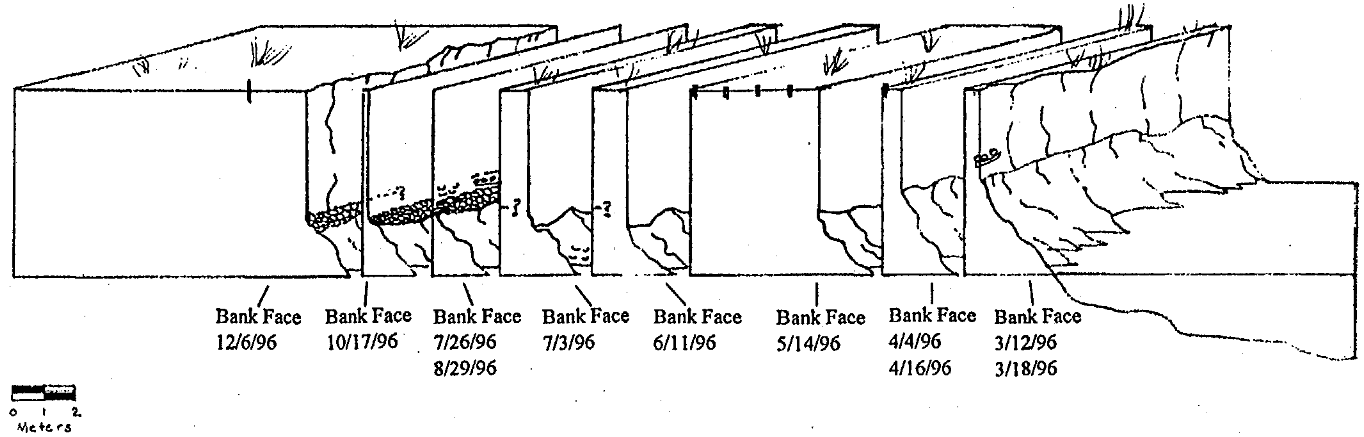

Figure C.1. Archaeological Deposits and River Bank Recession at Transect 800

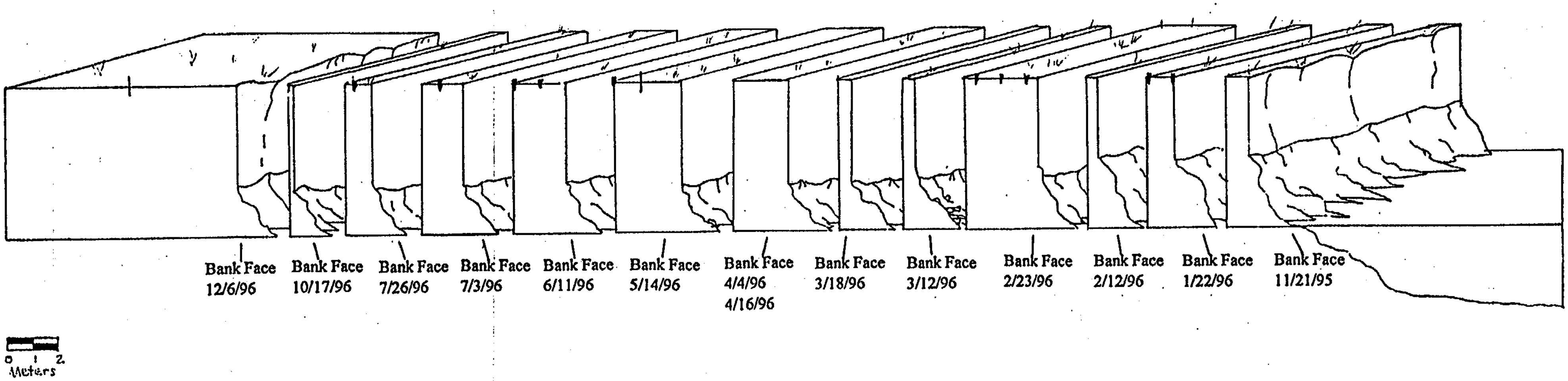

Figure C.2. Archaeological Deposits and River Bank Recession at Transect 801

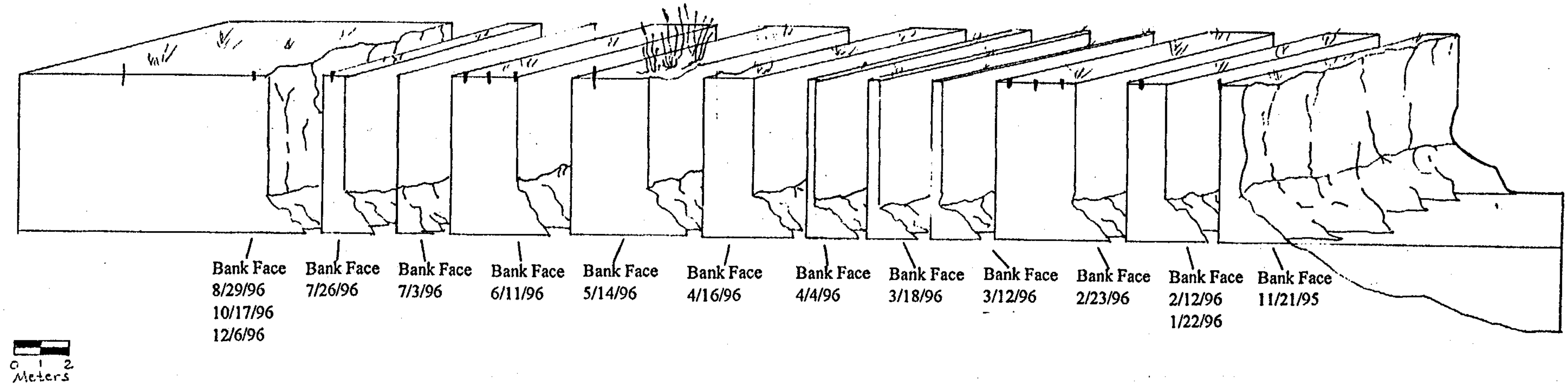

Figure C.3. Archaeological Deposits and River Bank Recession at Transect 802

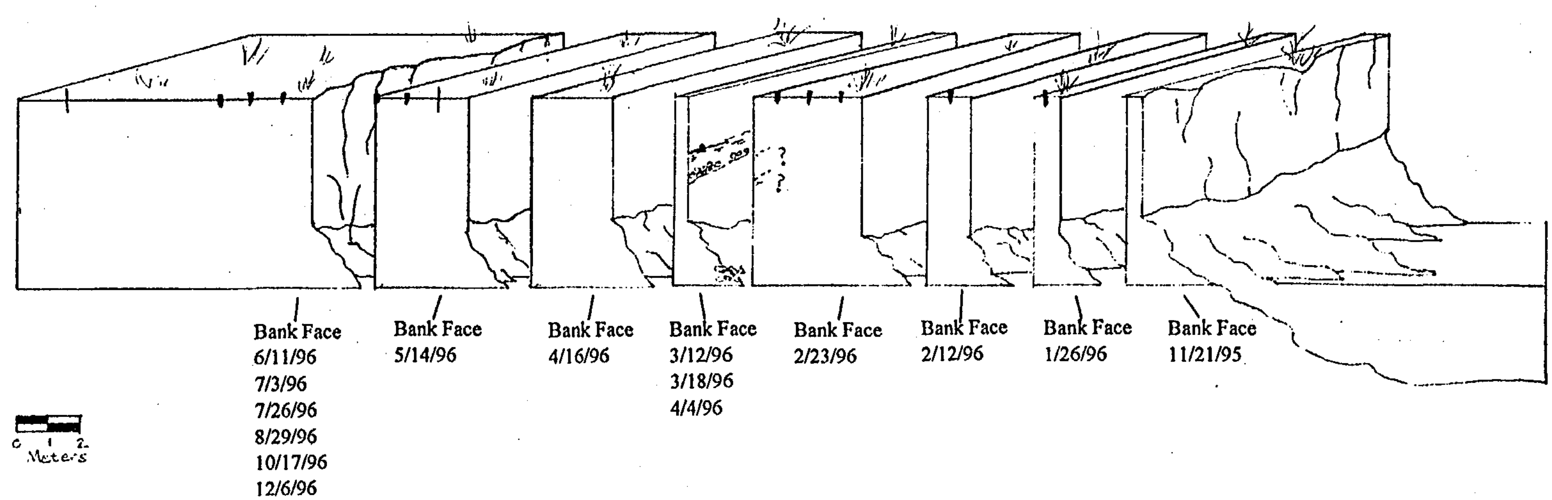

Figure C.4. Archaeological Deposits and River Bank Recession at Transect 804

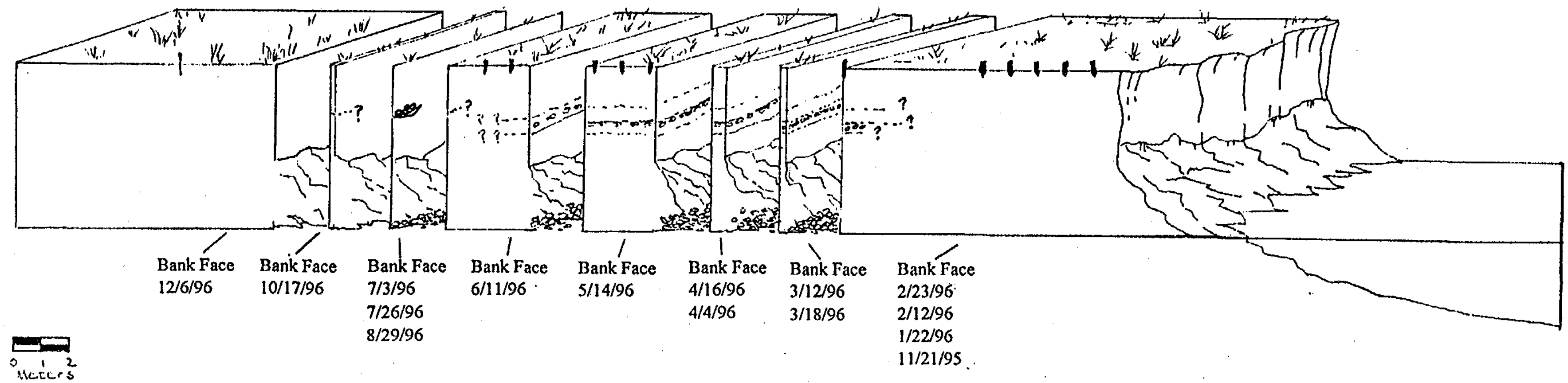

Figure C.5. Archaeological Deposits and River Bank Recession at Transect 806

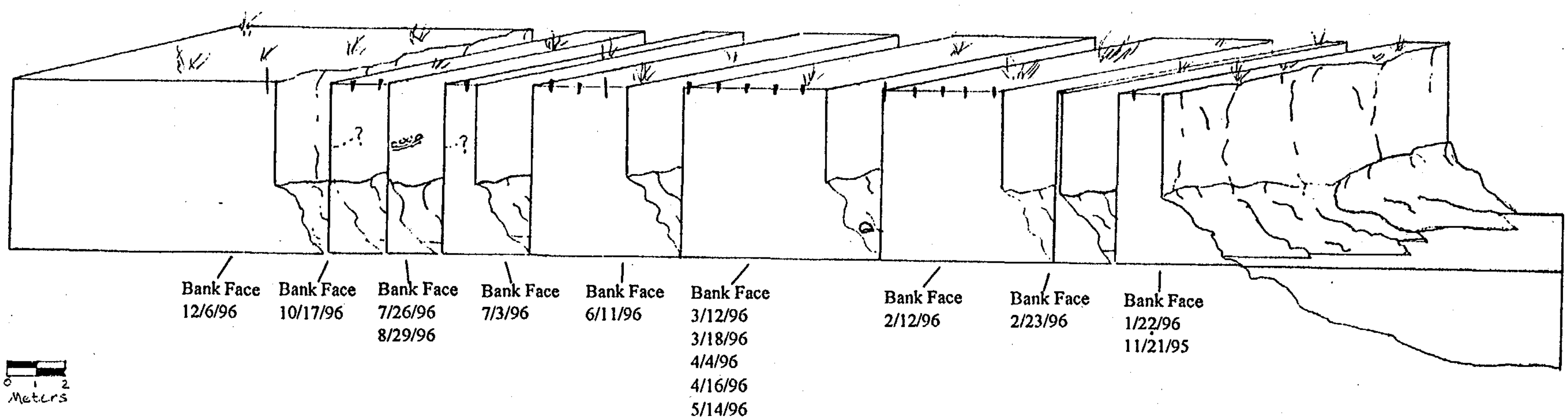

Figure C.6. Archaeological Deposits and River Bank Recession at Transect 808

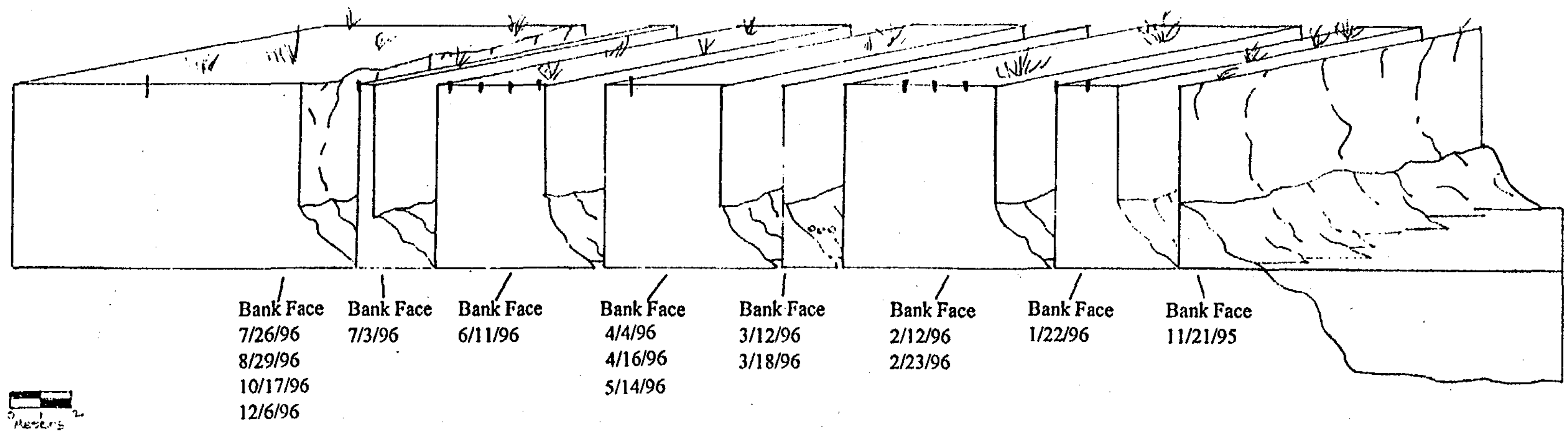

Figure C.7. Archaeological Deposits and River Bank Recession at Transect 809

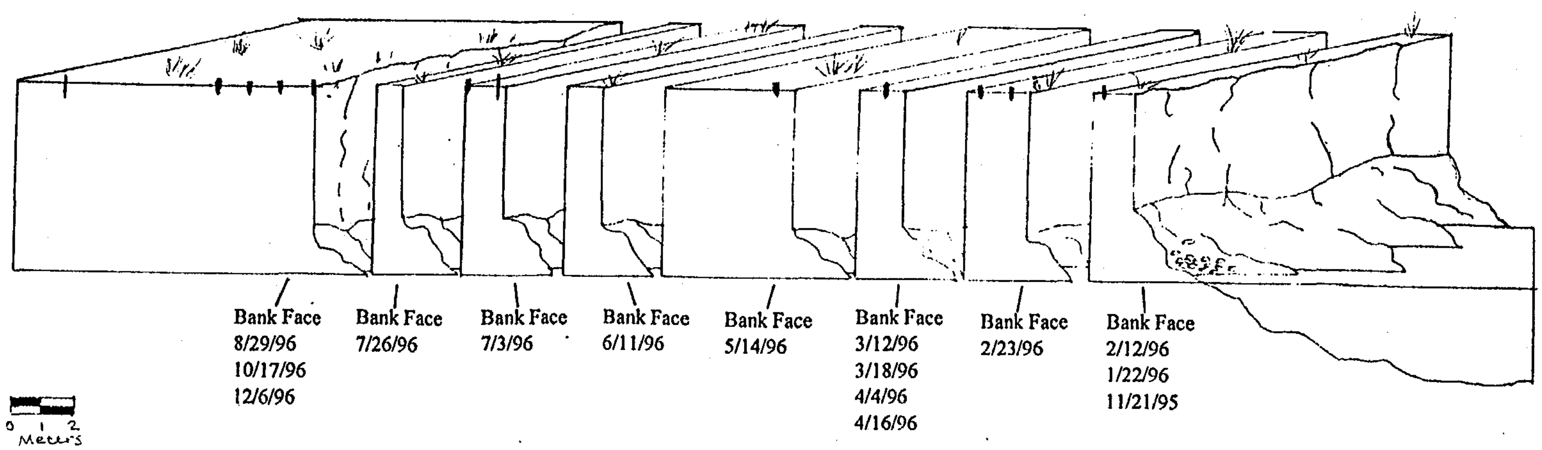

Figure C.8. Archaeological Deposits and River Bank Recession at Transect 810

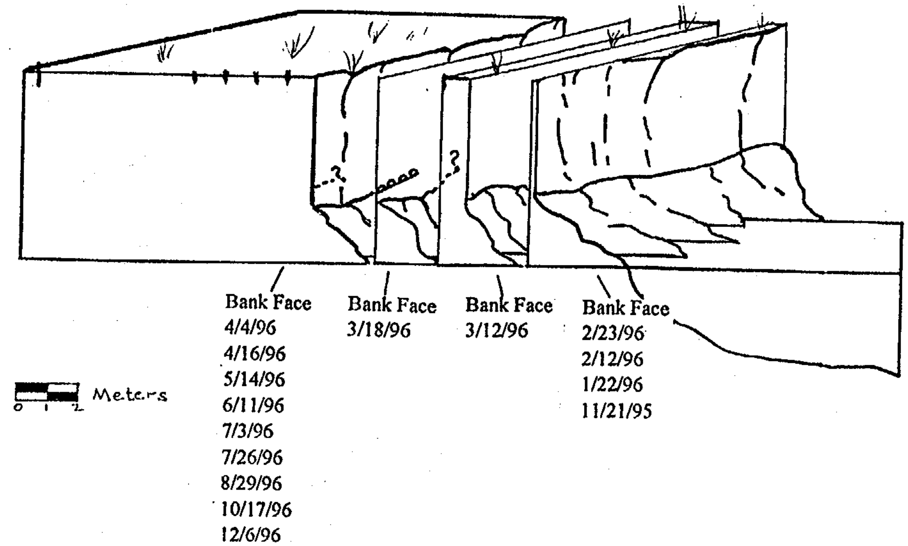

Figure C.9. Archaeological Deposits and River Bank Recession at Transect 811

Distribution

No. of Copies

OFFSITE

State Historic Preservation Officer
Office of Archaeology and Historic Preservation
P.O. Box 48343
Olympia, WA 98504-8343

The Confederated Tribes of the Umatilla Indian Reservation
J. Van Pelt
P.O. Box 638
Pendleton, OR 97810

The Wanapum Indian Tribe
L. Seelatsee
P.O. Box 878
Ephrata, WA 98823

The Yakama Indian Nation
Environmental Restoration and Waste Management
R. Jim
P.O. Box 151
Toppenish, WA 98948

Nez Perce Tribe Environmental Restoration and Waste Management
Attn: C. Lawyer
P.O. Box 365
Lapwai, ID 83540

ISNW
Margaret Saluskiu
230 N. Underwood Rd.
Wapato, WA 98951

No. of Copies

ONSITE

2 DOE/Office of Scientific and Technical Information

34 **DOE Richland Operations Office**

J. B. Hall	A5-55
D. W. Lloyd (30)	A5-15
D. C. Ward	A5-55
DOE Legal Library	A4-78
Public Reading Room	A1-65

2 **Bechtel Hanford, Inc.**

K. R. Fecht	HO-02
T. E. Marceau	H6-02

27 **Pacific Northwest National Laboratory**

B. N. Bjornstadt (2)	K6-81
R. W. Bryce	K6-75
N. A. Cadoret (2)	K6-75
D. D. Dauble	K6-85
P. R. Nickens (2)	K6-75
D. C. Stapp (10)	K6-75
M. K. Wright (2)	K6-75
Publishing Coordination (7)	