Final Report
McClellan - Kerr Arkansas River Navigation Study: Freshwater Mussel (Unionid) Survey

Prepared for:

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Prepared by:

Ecological Specialists, Inc.
O'Fallon, Missouri

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Table of Contents

List of Figures

List of Tables

1.0 Introduction

The Arkansas and Tulsa districts of the U.S. Army Corps of Engineers (USACE) are preparing an Environmental Impact Statement (EIS) on the improvement of the efficiency of the McClellan-Kerr Arkansas River Navigation System (MKARNS). The EIS evaluates the modification of flows to reduce the number of days that exceed 100,000 cubic feet per second (cfs) and deepening the channel from 9-feet (ft) to 11ft or 12ft to accommodate larger vessels. The EIS is part of the MKARNS study that was initiated in a FY99 Congressional Add to study MKARNS operational issues in the Fort Smith, Arkansas area.

Since unionids could potentially be affected by dredging and dredge disposal in conjunction with channel deepening activities, part of the EIS will address impacts to freshwater unionid mussels (unionids) in the MKARNS, particularly federal and state threatened and endangered species (T&E species). The study area for the EIS geographically encompasses the entire MKARNS from the Port of Catoosa near Tulsa, OK downstream to its confluence with the Mississippi River in southeastern Arkansas, as well as 11 reservoirs in Oklahoma that influence river flow within the MKARNS. This unionid study was limited to the commercial navigation channel, Navigation Mile (NM) 8.5 to NM 450.0 (Figure 1-1), since this area would be affected by dredge and disposal activities. Approximately 51.4 and 60.6 river miles, respectively, would need to be dredged in Arkansas' portion of the MKARNS, and 62.4 river miles would need to be dredged in Oklahoma to achieve an 11ft and 12ft channel (Table 1-1). The material dredged from the Arkansas portion of the river will be placed in 105 permitted and six proposed disposal sites (Table 1-2). Material from the Oklahoma portion of the river will primarily be placed on land, but 15 permitted and 13 proposed open water disposal will also be used for dredged material disposal (Table 1-2).

North America's unionid fauna is the most diverse in the world, and consists of nearly 300 nominal species (Turgeon *et al*., 1998; Williams *et al*., 1993). This diverse group of sedentary filter feeding animals is an important ecological component of benthic communities in many riverine systems. However, pollution and modification of riverine systems has resulted in the decline of many unionid species. Over 10% of North American unionid species are already presumed to be extinct (McMahon and Bogan, 2001), and approximately one-third of the species in North America are listed or are proposed for listing on the Federal List of Endangered and Threatened Wildlife and Plants (USFWS, 2004a and 2004b). Factors that appear to be contributing to the decline of unionids include damming, dredging, siltation of backwater areas, navigation, floodplain development, commercial harvest, and zebra mussel infestation.

Dredging will displace unionids within dredge areas and disposal will bury unionids within disposal

sites. In addition, increased turbulence and resuspended silt, which could occur during dredging and disposal, has been shown to reduce unionid growth (Yokley, 1976), feeding rates (Miller *et al*., 1984; Aldridge *et al*., 1987), oxygen consumption, and nitrogen excretion (Aldridge *et al*., 1987). Sedimentation is detrimental to unionids and is implicated in the decline and extinction of numerous species (Stansbery, 1971). Silt can clog unionid gills and filtration systems, preventing respiration and causing nutritive stress. Ellis (1936) demonstrated that most unionids died when covered by as little as 1.3 to 5.1cm of silt for 14 months.

Little is known about unionid species composition and distribution in the MKARNS system. A few of the Arkansas River tributaries (White River, Verdigris, Poteau, Grand Rivers) are known to harbor unionids, but previous unionid studies in the main stem are limited to Isely's (1925) study of eastern Oklahoma (Verdigris River), Davidson's (1997) work in the Dardanelle and Ozark pools, and Harris' (1992) study in Lake Dardanelle. Based on Isley (1925), Shepard and Covich (1982), Gordon (1982, 1984), Branson (1982, 1983, 1984), Harris and Gordon (1986), Harris (1992), Davidson (1997), and Vaughn and Spooner (2004), 54 unionid species have been reported from the Arkansas River system (Table 1-2). Of these, 37 were found in Arkansas and 48 in Oklahoma. Federal and state threatened & endangered (T&E) species records from the system include *Cyprogenia aberti* (Verdigris River; Isley, 1925) and *Quadrula cylindrica* (Neosho and Verdigris rivers; Branson, 1982), which are Oklahoma category II species (ODWC, 2005), *Lampsilis abrupta* (White River; Gordon, 1982) and *Potamilus capax* (White River; J.L. Harris, AHTD, personal comm., 2004), which are federally endangered species, and *Lampsilis rafinesqueana* (Neosho and Illinois rivers, Branson, 1984), which is a candidate for federally endangered status. Branson (1963) reported *P. capax* (federally endangered) from the Verdigris River, but the record was questioned by USFWS (1989).

Recent studies in the main stem of the MKARNS are limited to those of Davidson (1997) and Harris (1992). Davidson (1997) found 14 live species in the Dardanelle Pool and 10 species in the Ozark Pool (Table 1-3). Both authors found unionids primarily on mud flats near the banks, with *Plectomerus dombeyanus* and *Quadrula quadrula* being the dominant species. No federal or state listed species were found.

Since information on unionid species composition and distribution for MKARNS is limited, this study was conducted to 1) determine unionid distribution and species composition in the MKARNS, focusing on proposed dredge and dredge disposal areas, 2) estimate how construction, operation, and maintenance of a deeper channel would affect unionid communities, and 3) assist in determining if any animals should be relocated.

2.0 Methods

The study area included the MKARNS from NM 8.5, downstream of the confluence with the White River, to NM 445.2 at the head of navigation (see Figure 1-1). Preliminary sample points were selected during a meeting in June 2004 with USACE (Little Rock and Tulsa Districts), USFWS (Oklahoma and Arkansas field offices), and Arkansas Game and Fish Commission (AGFC). Sites were selected and prioritized based on dredge and dredge disposal locations, likelihood of harboring unionids- particularly T&E species, and personal knowledge of the study area provided by Bill Posey (AGFC), John Harris (AHTD), Dave Martinez (OK, USFWS) and Chris Davidson (AR, USFWS). Additionally, points were added to coincide with fish and habitat sites (ERDC, 2004). Preliminary sample points were grouped into 51 sites (Table 2-1). Forty-three (43) of these sites encompassing 82 proposed dredge areas, 13 proposed disposal areas, 17 maintenance dredge areas, 46 permitted disposal areas, and six areas reported to harbor mussel beds were sampled during three field trips: September 20 to 26, October 3 to 9, and December 7 to 14, 2004. Sites were distributed throughout the river and represented a variety of riverine habitats (Table 2-2). Dredge and disposal areas were numbered downstream to upstream for purposes of discussion (see Tables 1-1 and 1-2).

Each site was divided into subsites based on habitat (*i.e.*, channel, cove, inside bend, island, outside bend, oxbow, peninsula, straight reach, tailwater, tributary mouth) and proposed or existing channel activity (maintenance or proposed dredging-DR; permitted or proposal dredge disposal-DI). Sample points within subsites were selected in the field based on likelihood of harboring unionids or to represent DR or DI areas. At each point, a diver visually and tactually searched the river bottom for 5-min and collected any unionids or unionid shells (spot dives). Depth, substrate type, presence of zebra mussels (*Dreissena polymorpha*), and a visual estimate of unionid density were recorded for most points. If unionids were encountered, additional 5-min dives were conducted to determine species composition and the areal extent of the unionid concentration. The position of each sample point was recorded in the field with a Trimble Pathfinder Pro or Humminbird Matrix 67 GPS system.

Collected unionids were categorized as live, freshly dead (FD-nacre lustrous, tissue present or absent; probably died within the past year), weathered shell (WD-nacre chalky, no tissue present, most of the periostracum intact; probably died more than a few months year ago), and subfossil (SF-no periostracum, entire shell extremely chalky, valves detached; probably died over 10 years and maybe centuries ago). Live and freshly dead unionids were further classified as juveniles (≤3 years old for Anodontinae and Lampsilinae; ≤5 years old for Ambleminae) or adults, identified, and counted. Weathered and subfossil shells were noted as present. Unionids were returned to the river within their collection area. Representative freshly dead, weathered dead, or subfossil shells were

retained.

Unionid abundance at each sample point was entered into ArcGIS along with coordinates of dredge and disposal sites to estimate unionid distribution with respect to proposed dredging or disposal areas. Points that yielded more than a few unionids were grouped and defined as patches (small areas containing unionids) or beds (long linear areas with unionids) primarily based on area. Bed area was typically more than 50,000m^2 (average 192,843m^2) and Patches were typically less than 35,000m^2 (average 8407m^2; Table 2-3). Beds that were less than 50,000m^2 were those that we suspect may extend beyond the sampled area. Patches with larger area consisted of a series of smaller patches that were grouped together. Beds had a significantly higher number of samples, catch per 5min sample (CPUE), number of species, species represented by juveniles, area, and depth ($p<0.05$; see Table 2-3). Beds and Patches were labeled by site and numbered within the site (*e.g.*, B1-1= the first bed found within Site 1). For purposes of discussion, sites were grouped by navigation pool and by river reach. Reaches are defined as: Reach 1-NM 0 to 75.2 (mouth to Pine Bluff), Reach 2-NM 75.2 to 119.5 (Pine Bluff to Little Rock), Reach 3-NM 119.5 to 220.3 (Little Rock to Dardanelle), Reach 4-NM 220.3 to 308.7 (Dardanelle to Fort Smith), Reach 5-NM 308.7 to 394.0 (Fort Smith to Muskogee), and Reach 6-NM 394.0 to 445.2 (Muskogee to Catoosa).

Species-area curves was calculated for all beds downstream of Lock and Dam 3, to estimate whether additional species (primarily *Potamilus capax*) were likely to occur within these beds. The log (cumulative number of individuals) vs. cumulative number of species was regressed to estimate the number of individuals needed to find additional species.

3.0 Results

In general, MKARNS consists of a navigation channel with loose sand substrate, and channel borders that range from steep rip rapped banks to extensive shallow mud flats. Unionids beds or patches were primarily found in substrate consisting of a sand, silt, and clay mixture. This substrate mixture typically occurred as a transition zone between the clay, silt, or rip rapped banks, islands, or dikes and the sand channel. This habitat was most frequently associated with a gently sloping shelf between two steeper slopes at depths of >10m (most of the beds) or gently sloping banks near islands, dikes, and riverbanks <1m deep (most of the patches). Only a few small zebra mussels were attached to unionids and other hard substrate in 2004, but shells in the substrate and byssal threads on unionids indicate infestation may have been greater in the recent past. A total of 5,467 live unionids representing 27 species were collected, and two species were found only as weathered shells. *Quadrula quadrula* (27.6%), *Plectomerus dombeyanus* (23.4%), *Obliquaria reflexa* (15.5%), and *Amblema plicata* (10.5%) were the most abundant species (Table 3-1).

3.1 Reach 1 (NM 0-75.2)

Reach 1 extends from the confluence with the Mississippi River (NM 0) to Bunge Corporation dock near Pine Bluff, AR (NM 75.2) (see Figure 1-1a), and it includes the first 10 miles of the White River, the Arkansas Post Canal (Pool 1 and part of Pool 2), and Pools 2, 3, and 4 of the Arkansas River. The river downstream of Lock and Dam 3, which includes Sites 1, 2, 3, 4, 5, 6, and 7, has the highest potential of harboring *P. capax*, as this species was recently (2003) found in the lower 10mi of the White River (J.L. Harris, AHTD; W. Posey, AGFC, personal communication, 2004). Fourteen dredge areas (DR-1 to DR-14), approximately 22.9 miles, will be needed for the 11ft and 12ft channel alternatives (see Table 1-1), and 32 permitted and one proposed disposal area (DI-1 to DI-33) occur within this reach (see Table 1-2). Ten of the 14 proposed dredge areas and 19 of the 33 disposal areas fell within Sites 1-7 (see Table 2-1). Habitats sampled included inside and outside bends, channel and straight reaches, islands, tributaries, and tailwaters (see Table 2-2). Most of the proposed dredge areas are in the channel (mid-river), but one is along outside bend and two are in straight reaches nearer the bank, and two were in the tailwaters of locks. Substrate was primarily unconsolidated sand and depth was greater than 3m. Most of the permitted disposal sites are within dike fields along the channel borders (inside and outside bends, straight reaches), and a few were near islands, or within a tributary (see Table 2-2). Substrate in sampled areas varied from 100% sand, to mixtures of sand, silt, and clay, and depth ranged from <1m to >12m (Table 3-2).

A total of 3,053 live unionids representing 25 species were collected from Reach 1 (see Table 3-1). *Plectomerus dombeyanus* (29.8%) was the dominant species, and *Q. quadrula* (20.8%) and *A. plicata* (17.7%) was also abundant. No other species comprised more than 10% of the total. Species only

found alive in Reach 1 included *Lampsilis cardium*, *Lampsilis siliquoidea*, *Lasmigona c. complanata*, and *Obovaria olivaria*, which were all collected within Sites 1 and 2.

Most of the unionids (98.6%) and all of the species from Reach 1 were collected from either beds or patches (Table 3-3). The highest catch per unit effort (CPUE) was observed in straight reaches, particularly those leading into bends (Table 3-4). Unionid beds were found downstream of Lock and Dam 1 (B1-1; Figure 3-1), in the Arkansas Post Canal (B2-1, B2-2, B2-3; Figure 3-1), along the channel borders in straight reaches (B4-1, B6-1; Figures 3-1 and 3-2), and in tributary mouths (B5-1, B7-1; see Table 3-4; Figure 3-2). Substrate in these areas consisted of mixtures of gravel/sand, sand/silt/clay, boulder/sand/clay, and silt/clay. Smaller patches of unionids were also found along channel borders, near islands, and in tributary mouths; also in sand/silt/clay substrate (see Table 3-4). Dominant species in both beds and patches were *P. dombeyanus*, *Q. quadrula*, and *A. plicata* (see Table 3-3). However, 24 species were found in beds and only 13 species were found in patches.

Many of the beds and patches within Reach 1 sites are within the 100m lateral and downstream distance or 300m upstream distance limits established for unionid protection by USFWS and AGFC (USFWS, 2005). B2-1, B2-2, and B2-3 occur within proposed dredge areas. B4-1, P4-1, P4-2, P5-1, B6-1, P6-3, B7-1, P7-1, and P7-2 occur within or adjacent to permitted disposal areas (see Table 3-2; Figures 3-1 and 3-2).

Site 1 is the only site sampled in the lower White River (NM 0.0 – 10.4). Site 1 (NM 8.0 – 10.0) will be unaffected by all channel modification activities (see Figure 3-1). No future dredging or disposal will be needed within Site 1 due to the increased depth provided by the new Lock and Dam near the confluence with the Mississipppi River. Sample points were limited to near bank areas, as substrate immediately riverward consisted of unconsolidated sand. A total of 416 live unionids representing 17 species were found within Site 1 (Table 3-5). A few unionids (nine) were found scattered along both the left descending and the right descending banks, but the majority were confined to two concentrations: B1-1 and P1-1 (see Table 3-5 and Figure 3-1). Neither B1-1 nor P1-1 will be affected by the proposed 11ft or 12ft channel.

B1-1 is located on the right descending bank of the straight reach leading into a bend just downstream of the confluence with the Arkansas Post Canal (see Figure 3-1). The sampled area was limited to 60m. Only a few unionids were found downstream of the sampled area, however the upstream extent of the bed was not determined. The bed is located in a thin strip (<20m wide) of primarily sand substrate, mixed with gravel and silt that occurs between the steep rip rapped bank and the deeper sand channel. The channel riverward of this bed was a maintenance dredge area, but

is now impounded by the Montgomery Point Lock and Dam near the mouth of the Mississippi River. At the time of the survey, depths in the bed exceeded 11m and the substrate consisted of a sand/gravel mixture. A total of 390 unionids representing 14 species were collected from B1-1 (see Table 3-3). Regression analysis indicated that most of the species within the bed were recovered, however 17 species could be collected within 1000 individuals, and (R^2=0.98, p<0.01; slope (b)=5.80 ±0.27; Figure 3-3). Sites 1 and 2 combined yielded 23 species, and 25 species were found within Reach 1 without finding *P. capax*. The presence of *P. capax* cannot be ruled out, but the lower frequency species within Site 2 are probably more likely to be found in this bed than *P. capax*. *Quadrula quadrula* and *Quadrula aspera* were the dominant species. Density was estimated as 1 to 5 unionid/m^2 (see Table 3-5), and CPUE averaged 35.5 unionids/5 min (see Table 3-3). Only minimal recruitment appears to be occurring in this bed with only 2.5% of individuals collected as juveniles. However, at least one young individual was collected for 43% of the species in the bed. Only one zebra per 10 unionids was collected.

P1-1 is located in the White River on the left descending bank of a straight reach immediately upstream of the confluence of the canal (see Figure 3-1). Unionids were concentrated in a narrow seam at the base of a clay bank, approximately 7.6m deep. Substrate consisted of a sand/silt/clay mixture. Both CPUE (5.7 vs. 35.5 unios/5min) and species richness (5 vs. 14) were much lower than in B1-1 (see Table 3-3). The dominant species were *Lampsilis teres* and *O. reflexa*. Recruitment in P1-1 was higher (11.8%) than in B1-1, and juveniles were collected for two of the five species (see Table 3-3).

Site 2A extended from Lock and Dam 1 to Lock and Dam 2 (NM 10.3 - 13.3), and Site 2B extended from Lock and Dam 2 to the upstream end of the Arkansas Post Canal (see Figure 3-1). All of the points surveyed within this site will be affected by dredging for both the 11ft and 12ft channel alternatives (see Table 2-1). Unionids within Site 2A were concentrated into two distinct areas; from the right bank to midchannel (B2-1), and in a thin strip at the bottom of the rip rap along the left bank (B2-2). While these beds are most likely not ecologically separated due to their close proximity, unionids were lacking from the primarily 100% clay that occurred between the beds. Within Site 2B unionids were found throughout the canal. A total of 1,111 unionids representing 19 species were found within Site 2. *Plectomerus dombeyanus* (41%) and *A. plicata* (26%) were the dominant species (Table 3-6). Regression of Site 2 cumulative individuals vs. cumulative species was significant (R2=0.97, p<0.01). The slope of the regression (5.75±0.15) was very similar to B1-1 (5.80±0.27). A total of 19 species were collected within Site 2, and 25 species were collected within Reach 1. Approximately 3000 individuals would need to be collected to find 20 species, and over 30,000 unionids would be needed to find 26 species (Figure 3-4). As with Bed 1-1, *P. capax* cannot be ruled

out, but the low frequency species collected within Bed 1 are more likely to be collected than *P. capax*.

No zebra mussels were found on unionids within Site 2.

B2-1 was defined as the area from midchannel to the right descending bank between Lock and Dams 1 and 2. Depth ranged from 2.4 to 4.9m and substrate was a mixture of sand, silt, and clay (see Table 3-4). Unionid densities ranged from approximately 1 to 5/m^2 (see Table 3-6). CPUE averaged 38 unionids/5min, and 16 species were collected. Dominant species included *A. plicata*, *P. dombeyanus*, and *O. reflexa*. Juveniles were abundant, with 22% of the individuals being ≤5 years old, and 63% of the species represented by at least one juvenile (see Table 3-3). The distance between locks is approximately 4000m, the channel is approximately 200m wide, and B2-1 extends over approximately half of the channel (100m wide). If unionid density averaged 2.5 unionids/m^2 in B2-1 (400,000m^2), approximately 1,000,000 unionids could occur within this bed.

A narrow strip of unionids, approximately 10m wide, was found to the left of midchannel at the base of the left descending bank (B2-2). Depth was 2.4m to 4.9m, and substrate along the left bank was primarily silt/clay. Unionids in B2-2 were less dense (≤1/m^2), and CPUE averaged 14.8 unionids/5min). Although only eight species were collected in B2-2, all of the species in B2-1 are likely to occur in B2-2 as well. Similar to B2-1, *P. dombeyanus* and *A. plicata* were the dominant species, and juveniles again made up a relatively large percentage (25.8%) of the total (see Table 3-3). B2-2 is approximately 4000m long and 10m wide, with an average density of 1.0 unionid/m^2, approximately 40,000 unionids could occur in this bed.

Site 2B (NM 13.3 – 19) will be affected by dredging and contains B2-3 (see Figure 3-1). This bed is separated from B2-1 and B2-2 by Lock and Dam 2. Unionids at this location were evenly distributed throughout the canal, as opposed to the two seams displayed in the lower portion of the canal (B2-1 and B2-2). Substrate consisted primarily of clay with some silt. Depths ranged from 0.9m near the bank to 4.6m in the midchannel (see Table 3-4). Average unionid density ranged from 1 to 5 unionids/m^2, and CPUE averaged 16.4 unionids/5min (see Tables 3-3 and 3-6). Thirteen species were found and *P. dombeyanus*, *A. plicata* and *L. teres* were the dominant species. Fewer juveniles representing fewer species were collected in B2-3 (4.3%) than in B2-1 and B2-2 (see Table 3-5). This portion of the canal is approximately 9000m long; if a 100m wide area is dredged and density is approximately 1/m^2, 900,000 unionids could be affected by dredging activities.

A total of approximately 1,940,000 individuals of at least 19 species will be affected by dredging in

the Arkansas Post Canal.

Site 3 (NM 19) is in the Arkansas River, immediately downstream of the head of the canal (see Figure 3-1). The right side of the channel is a shallow sand flat, and the left side is 3 - 13m deep and rip rapped on the outside bend. This area is a permitted disposal site (see Figure 3-1 and Table 3-2). Three areas were sampled in this site and no unionids were collected. The sample immediately downstream of the canal was 12.6m deep with a clay and boulder substrate. At the mouth of the oxbow substrate was 100% boulder. Depth was 13m and decreased to approximately 1m as the diver approached the oxbow. Three freshly dead shells of *Leptodea fragilis* were found in the shallow area. Immediately downstream of the oxbow, depth increased to 13m and substrate was 100% sand. Since no unionids were found within Site 3, none are likely to be affected by future dredge disposal.

The remainder of Pool 2 (NM 13.3 - 50.2) is fairly narrow and meandering (see Figure 3-1 and Figure 3-2). The channel is homogeneous unconsolidated sand beginning within 20m of the riverbanks. The highest concentrations of unionids were again found in straight reaches leading into bends, but unionids were also found along an inside and outside bends as well as near tributary mouths and around islands. Unionids were limited to within 20m of a bank, dike, or island where substrate consisted primarily of a mix of sand, silt, and clay (see Table 3-4).

Site 4 (NM 23 - 24) is along a sharp bend, and contains three permitted disposal sites, one maintenance dredge area, and one proposed dredge area (see Table 2-1 and Figure 3-1). No unionids were found beyond 20m off the bank in the channel, and thus are not likely to be affected by proposed dredging (Table 3-7). However, B4-1, P4-1, and P4-2 are within or near permitted disposal sites (see Table 3-2), and could be affected by future disposal activities.

Site 4 yielded 864 unionids representing 13 different species concentrated in three aggregations: B4-1, P4-1 and P4-2 (see Table 3-7). Bed B4-1 occurs within 20m of the left descending bank, along a shelf that is 3-4m deep at the upstream end and 5-8m near the middle of the bed. Unionids were found in shallow pockets (<2m deep) along the shelf in the downstream end of the bed (see Figure 3-1 and Table 3-7). Substrate was primarily sand, silt and clay with silt and clay between boulders in the middle portion. Density ranged from 1-10 unionids/m^2 (see Table 3-7), and CPUE averaged 36.7unionids/5 min (see Table 3-5). Recruitment was apparent with 9% of the unionids being juveniles, and 69% of the species were represented by at least one juvenile. Dominant species included *P. dombeyanus*, *Q. quadrula*, and *Potamilus purpuratus*. The regression slope for B4-1 was lower (4.69 ±0.11, R^2=0.95, $p<0.01$) than for B1-1 and Site 2 beds. Approximately 1000 unionids would need to be collected to recover one additional species (14) and almost 350,000 unionids would

need to be collected to retrieve 26 species (one more than collected in Reach 1; Figure 3-5). It is unlikely that *P. capax* occurs within B4-1.

Bed B4-1 is approximately 600m shoreward of the proposed dredge area and will not be affected by any dredge activity. However, part of B4-1 is within DI-2, and part is shoreward of DI-3. B4-1 should be considered in future disposal of dredge material.

P4-1 and P4-2 are located along the right descending bank, adjacent to a permitted land disposal area (DI-4) in what is known as the Pendleton Revetment. Substrate varied from clay with a thin layer of silt along the bank to primarily sand at inlets throughout the revetment (see Table 3-7). Six species were collected in P4-1 including *P. purpuratus*, *L. teres*, and *A. plicata* (see Table 3-3). Juveniles accounted for 15% of all individuals collected, and 33.3% of the species were represented by juveniles. P4-2 was located in an inlet of Pendleton Revetment just downstream of P4-1. Only three species were found in P4-2: *A. plicata*, *L. teres*, and *P. dombeyanus*. All individuals collected were ≥ 5 yrs old.

These patches are approximately 100m from the proposed dredge area and should not be affected by dredge activity. Disposal of dredge material could affect P4-1 and P4-2, as they are only 80 and 30m away from the DI-4, respectively.

One proposed dredge area (DR-4) and three existing disposal areas (DI-5, DI-6, and DI-7) occur between Sites 4 and 5 (NM 25 to 30; see Figure 3-2). No sampling was conducted in these areas, and habitat appeared similar to Site 4. Unionids are not expected to occur in the channel and should not be affected by dredge activity. However, unionids may occur along the banks and near the inlets of side channels near the permitted disposal areas. Banks may need to be investigated to identify areas that should be avoided during future dredge disposal.

Site 5 (NM 30.0 – 32.5) includes a dredge area (DR-5) and two permitted disposal areas (DI-9 and DI-10; see Figure 3-2). DI-9 did not appear conducive for unionid colonization and was not sampled. A total of 180 live unionids representing nine species were collected within Site 5, and *A. plicata*, *Q. quadrula*, *P. dombeyanus*, and *P. purpuratus* were the dominant species (Table 3-8). One mussel bed (B5-1) was found in the mouth of Big Bayou Meto, one mussel patch (P5-1) was found within DI-10, and one patch (P5-2) was found in a side channel along the right bank near NM 30.5 (see Figure 3-2 and Table 3-8). No unionids should be affected by dredge activity at this site, as unionids were greater than 100m upstream and shoreward, and 400m downstream of the DR-5 (see Table 3-2). Additionally, the disposal of material along the right bank DI-9) should not affect any unionids, and

disposal on the left bank (DI-10) should only affect a small patch of unionids P5-1).

B5-1 is limited to a 3m strip along the right descending bank just inside the mouth of Big Bayou Meto (see Figure 3-2). The substrate consisted primarily of sand, silt, and clay, and depth was approximately 7.6m (see Table 3-4). Unionid density was low and CPUE averaged 12.8unionids/5 min. Nine species were collected and *Q. quadrula*, *P. dombeyanus*, *A. plicata*, and *Megalonaias nervosa* were the dominant species. Recruitment was evident with 16% of all individuals collected being juveniles and 44% of the species being represented by juveniles (see Table 3-3). B5-1 will not be affected by either proposed dredging or placement of dredge material.

P5-1 is located among a series of islands and dikes in the disposal area along the outside bend (DI-10). This was the only patch of unionids found within these islands. Substrate was clay and silt over sand, and depth ranged from 0.6 to 1.1m (see Table 3-8). Density was low, and CPUE averaged only 7.7unionids/5 min (see Table 3-3). Unionids representing four species were collected, and nearly 75% were *A. plicata*. No juveniles were collected.

At P5-2, unionids were confined to small area within a side channel along the inside bend between an island and the right descending bank. Depths ranged from 1.5 to 2.7m and the substrate consisted of a mix of sand and clay with a thin layer of silt (see Table 3-8). Density was low, and CPUE averaged 8.9unionids/5min. Unionids representing eight species were collected, and 5% were juveniles. Similar to P5-1, most of the unionids in this bed were *A. plicata* (see Table 3-5). This area should not be affected by dredging or dredge disposal.

One proposed dredge area (DR-6) occurs between Sites 5 and 6, NM 32.5 – 35.0 (see Figure 3-2). The channel area of both Site 5 and 6 was unconsolidated sand with no unionids, and no unionids are expected to occur in DR-6. No additional dredge material disposal areas are planned in this area, therefore unionids that may occur along the riverbanks will not be affected.

Site 6 (RM 35-40) consists of a series of bends with disposal areas scattered along both banks and two dredge areas in the channel (see Figure 3-2). Substrate composition ranges from mixtures of sand, silt, and clay near the banks to 100% sand in the channel. Samples were collected in dredge areas DR-7 and DR-8, within permitted disposal sites DI-11, DI-12, DI-13, DI-14, and DI-15, and between disposal areas (see Figure 3-2). DI-16 was not sampled due to lack of habitat. A total of 244 unionids representing 11 species were collected within Site 6, and 95% of the unionids and all 11 species were found in the bed and patches. *O. reflexa* (29.5%), *A. plicata* (23.0%), *Q. quadrula* (22.5%) were the dominant species (Table 3-9). Unionids were scattered along both banks

throughout the site, and four concentrations were found: B6-1 at the downstream end of DI-12, P6-1 on the outside bend between DI-13 and DI-14, P6-2 along the outside bend downstream of DI-13, and P6-3 at the upstream end of DI-11 (see Table 3-9 and Figure 3-2). No unionids were found in the 100% sand substrate within the proposed dredge areas, and dredging will not affect any unionids at this site. B6-1 and P6-3 could be affected by future disposal in DI-12 and DI-11, respectively (see Table 3-2).

B6-1 is along the right descending bank at the downstream end of DI-12 and shoreward of DR-7 (see Figure 3-2). The bed begins in shallow water (≤1m) near the edge of the rip-rapped bank. Density estimates averaged ≤1unionids/m^2 within the disposal area. Downstream of the disposal area along a natural bank, unionids were fairly dense (1 to 7/m^2) where the river bottom had a slight slope (see Table 3-9). The bed ends as the slope and the amount of silt in the substrate increased toward the outside bend. Substrate was primarily clay, and depth ranged from 0.6 to 3.1m (see Table 3-4). Recruitment appears to be relatively low, with only 4% of individuals being juveniles (see Table 3-3). An average of 17 unionids/5 min. and 10 species were collected within B6-1 (see Table 3-3). *Amblema plicata*, *O. reflexa*, *Q. quadrula*, and *P. dombeyanus* were the dominant species. The slope of the species area curve for B6-1 (4.84 ±0.26; R^2=0.83, $p<0.01$) was similar to B4-1 (4.69 ±0.11) and B5-1 (5.05 ±0.30). More than the 10 species collected are likely to occur in B6-1, as the inflection point of the species area curve was not reached within the 119 unionids collected (Figure 3-7). Approximately 290 unionids and over 230,000 would need to be collected for 11 (one more than collected) and 26 (one more than found in Reach 1) species, respectively.

B6-1 would not be affected by future dredge activity, but could be affected by future dredge disposal activity.

P6-1 is located along the outside bend near the left descending bank between DI-13 and DI-14. Unionids were found in an area 0.9m deep where substrate was primarily sand with a small amount of silt and clay (see Table 3-4). CPUE averaged 16.3unionids/5 min. and <2% of the animals collected were juveniles (see Table 3-3). Seven species were collected and *O. reflexa*, *Q. quadrula*, *A. plicata*, and *P. purpuratus* were the dominant species. P6-1 should not be affected by dredge material disposal as long as it is contained within the permitted sites (see Table 3-2).

P6-2 is approximately 200m downstream of DI-13 and 110m shoreward of DR-7. Unionids were found in 1.8 to 3.7m depth, and clay, sand and silt substrate (see Table 3-4). CPUE averaged 8.3 unionids/5 min. and 4% of the animals were juveniles (see Table 3-3). Seven species were collected, and *A. plicata*, *Q. quadrula*, and *O. reflexa* were the dominant species. P6-2 should not be affected

by dredging or dredge material disposal (see Table 3-2).

P6-3 is at the upstream end of the inside bend containing DI-11 and could be affected by future disposal. Unionids were in shallow water (0.6 to 1.2m deep) and clay, sand, and silt substrate (see Table 3-4). CPUE averaged only 5.5 unionids/5 min., and only three species were found.

Only two disposal areas occur between Site 6 and Site 7; DI-17 (left bank) and DI-18 (right bank).

Site 7 extends from Lock and Dam 3 tailwaters (NM 50.0) around two bends to approximately NM 44.0 (see Figure 3-2). Four proposed dredge areas (DR-9, DR-10, DR-11, DR-12) that each contain a maintenance dredge area, and seven permitted disposal areas (DI-19 through DI-25) occur within the site. Substrate was a mixture of boulder, cobble, gravel, and sand in the tailwaters downstream of the lock, and nearly 100% sand in the channel and along most of the channel borders (Table 3-10). No unionids were collected in these substrate types, and the proposed dredge activity should not affect unionids (see Table 3-2). Two small patches of unionids (P7-1 and P7-2) and one bed (B7-1) were found in substrate containing a mix of sand, silt, and clay. P7-1 is at the downstream end of DI-25, P7-2 is along the inside bend at the edge of the DI-24. Both patches could be affected during future dredge disposal. B7-1 is within the mouth of Mud Lake-Little Bayou Meto and will not be affected by dredging. Sampling yielded 238 unionids representing nine species, and *Q. quadrula* (39.5%), *A. plicata* (19.7%), and *O. reflexa* (19.3%) were the dominant species. No unionids were found at any of the other points sampled within Site 7 (see Table 3-10).

B7-1 is within Mud Lake/Little Bayou Meto near the confluence with the Arkansas River. Depths ranged from 0.8m to 3.4m and substrate was composed primarily of clay and sand with some silt and gravel (see Table 3-4). Recruitment was low with only 8.8% of the unionids collected as juveniles, however at least one juvenile collected for three of the five species. CPUE averaged 19.0unionids/5min, but only five species were collected, including *Q. quadrula*, *O. reflexa*, *A. plicata*, *Pyganodon grandis*, and *P. dombeyanus* (see Table 3-3). B7-1 was the least species rich bed in Reach 1. Only five species were found in 114 unionids, and the slope of the species area curve was only 2.42 ±0.23 (R^2=0.79, P<0.01). Over 300 unionids would need to be collected before finding the sixth species, and the collection of 1,500,000 unionids would be required to find 25 species (Figure 3-9). *Potamilus capax* is not likely to occur within P7-1.

P7-1 is in the shallow slope at the downstream end of DI-25 on the right descending bank (see Figure 3-2). Depth ranged from 0.6 to 1.2m, and substrate was a clay, silt and sand mix (see Table 3-4). CPUE averaged 5.5unionids/5min and eight species were collected in this patch. *Quadrula*

quadrula, *A. plicata*, and *P. dombeyanus* were the dominant species (see Table 3-3). Only a few juvenile unionids (3% of total) were collected. Patch P7-1 could be affected by future dredge material disposal. Additionally, P7-1 is 65m shoreward of DR-11. However, DR-11 has been dredged in the past; 2003 was the most recent dredge activity (see Table 1-1).

P7-2 is along an inside bend, and within and near the middle of DI-24 (see Figure 3-2). This patch was in deeper water 3.1 to 5.0m, and substrate was primarily clay mixed with sand (see Table 3-4). Although CPUE was fairly high (16unionids/5min.), only six species were collected (see Table 3-3). Recruitment was low, as only 3% of the unionids collected were juveniles. This patch is within DI-24 and could be affected by future disposal. P7-1 is also within 50m of DR-11.

No sites were sampled in Pool 3 due to a perceived lack of available habitat (J.L. Harris, AHTD, and B. Posey, AGFC, pers. comm., 2004). Banks between Lock and Dam 3 (NM 50.2) and NM 75.2 are either rip rapped (outside bends) or contain dike fields (inside bends). Proposed dredge sites within Pool 3 include DR-13 and DR-14; DR-14 is also a maintenance dredge site that is frequently dredged (see Table 1-1). Permitted disposal sites within Pool 3 include DR-26 to DR-31 (see Table 1-2). Two permitted disposal sites (DI-32 and DI-33) are located in Pool 4 (see Table 1-2). Based on the location of unionids in the sampled sites within this reach, unionids are unlikely to occur in the dredge areas. However, small patches of unionids may occur within or near permitted disposal areas.

3.2 Reach 2

Reach 2 extends from the Bunge Corporation Dock in Pine Bluff, AR (NM 75.2) to the Union Pacific Railroad (119.5) crossing in Little Rock, AR (see Figure 1-1b). This reach includes portions of Pools 4, 5, and 6. The Arkansas River in this reach is similar to the upstream portions of Reach 1. The channel is approximately 500m wide with a substrate of primarily sand. Most of the riverbank is either rip rapped or within a dike field. Six dredge areas (DR-15 to DR-20) and two proposed (DI-34, DI-37) and five existing disposal areas (DI-35, DI-36,DI-38, DI-39, and DI-40) within Reach 2 will need for the 11ft and 12ft channel (see Tables 2-1 and 2-2). Dredge areas are within the channel and Tailwaters, while disposal sites are along inside bends, outside bends, and in tailwaters (Table 3-11).

Only two sites (Sites 8 and 9) were sampled in this reach due to an apparent lack of suitable habitat and influence by factors such as urbanization and commercial dredging. Sites 8 and 9 each contained one proposed dredge and one permitted disposal area (Figures 3-9). Riverbanks were steep within these sites and substrate was a mix of unconsolidated sand and gravel in the channel (Tables 3-12 and 3-13). The narrow seam of sand, silt, and clay found between the channel and

banks within Reach 1 was lacking in Reach 2, and very few unionids were found. Only 20 unionids representing four species, 70% of which were *Q. quadrula*, were found throughout the entire reach (see Table 3-1). Most samples yielded no unionids; however, P8-1 was found between the islands at Warnings Bend Cutoff (RM 102.4) and the left descending bank (see Figure 3-4).

Site 8 (NM 100.8 to 104.0) encompasses one channel dredge area (DR-19) and a permitted disposal area (DI-39) within a dike field along the outside bend (see Figure 3-4). Substrate throughout the site is primarily unconsolidated sand and gravel from bank to bank (see Table 3-12). Some silt has accumulated within the dike field, but the only patch of suitable unionid substrate (sand, silt, clay mix) within Site 8 was in a side channel near the downstream end of the site (see Figure 3-4). Eighteen (18) of the 20 unionids found in Reach 2 were collected at Site 8. *Quadrula quadrula* (72.2%), *O. reflexa* (22.2%), and *P. grandis* (5.6%) were the only species collected alive. Fresh shells of *Leptodea fragilis* and a weathered shell of *P. ohiensis* were also recovered.

Most samples in Site 8 did not yield any unionids; unionids were limited to a very small point in the DI-39 and P8-1 between the islands at Warnings Bend Cutoff (RM 102.4) and the left descending bank (see Table 3-12). P8-1 may not merit the status of a concentration of unionids, as CPUE (3.3unionids/5min) and species richness (N=2) were low compared to patches in the other reaches (Table 3-13). Unionids in P8-1 were found between 1.5 and 3.7m deep in substrates comprised primarily of sand with clay and some silt and detritus (Table 3-14). P8-1 is 325m downstream of the existing disposal site DI-39 and should not be affected by future disposal activity.

Since no unionids occur within the channel area, proposed dredging should not affect any unionids within Site 8. Although a few unionids were found within the permitted disposal area, they are likely transient individuals as substrate is likely scoured and deposited during high water. Thus, disposal in DI-39 may affect a few individuals but not a stable community. P8-1 is behind an island and therefore protected from any dredge or disposal activity.

Site 9 (NM 107 – 107.6) contains one proposed dredge area (DR-20), most of which is a maintenance dredge area that was last dredged in 2003 (see Table 1-1). One permitted disposal area (DI-40) also occurs within this site along the left descending bank in a dike field downstream of Lock and Dam 6. Substrate ranged from 100% sand in the navigation channel to a mix of cobble, gravel, and sand near the banks. No suitable unionid substrate was found. Only two unionids, *Q. quadrula* and *L. fragilis*, were collected in Site 9, and they were found adjacent to a dike along the right descending bank (Table 3-15 and Figure 3-4). Since no unionid habitat occurs within Site 9 ,few unionids will be affected by future dredging or disposal.

The four dredge areas that were not sampled within Reach 2 are unlikely to harbor unionids, based on the results of the two sampled dredge areas (DR-19 and DR-20). Likewise, DI-39 and DI-40 did not contain suitable habitat for unionids, and the unsampled disposal areas DI-34, DI-35, DI-36, and DI-37 are equally unlikely to contain suitable unionid habitat. DI-38 is around an island at the downstream end of an oxbow, and a few small pockets within this area could harbor a few unionids. Unionid habitat may occur within or near this disposal area and it should be surveyed before any further disposal activity occurs.

3.3 Reach 3

Reach 3 extends from the Union Pacific Railroad crossing in Little Rock, AR (NM 199.5) to NM 220.3 near the Shoal Creek Light. This includes Pools 6 through 9 and a portion of Lake Dardanelle. The Arkansas River in this Reach is similar to Reach 2. Pools 6 through 9 are generally 500 to 700m wide, but slightly wider in some parts (>1000m wide near Site 11). Channel substrate is unconsolidated sand and gravel. Most of the riverbank is either rip rapped or within a dike field, and scattered unionids and low density patches of unionids were found where silt and clay have accumulated between the banks and the channel (Figures 3-10, 3-11, and 3-12). The upper portion of Pool 6 and downstream portion of Pool 7 are affected by the city of Little Rock. Other urban areas include Conway and Morrilton, Arkansas in Pool 8. The Lake Dardanelle portion of this reach is much wider and shallower, with extensive coves, islands, and tributaries (Figure 3-13). Russelville and Dardanelle, Arkansas occur within the upper end of Pool 9 and the lower end of Lake Dardanelle. Twenty-nine (29) areas totaling 12.7 miles of river will need to be dredged to achieve an 11ft channel and 46 areas totaling 16.1 miles of river will need to be dredged to achieve a 12ft channel (see Table 1-1). Additionally, 38 permitted and two proposed disposal sites occur within this reach (see Table 1-2).

Ten sites within Reach 3, all in Lake Dardanelle, have previously been sampled for unionids (Table 3-16). Fourteen species were collected, and *P. dombeyanus* and *Q. quadrula* were the dominant species. Davidson (1997) indicated that scattered unionids occur throughout Lake Dardanelle in mud flat areas, but he found only two areas with more than a few unionids: NM 206.8 - 207.4, just upstream of Dardanelle Dam (our Site 22); and NM 209, at the mouth of Illinois River.

Eight unionid sites were sampled in Reach 3: four in Pool 7, two in Pool 8, one in Pool 9, and one in Lake Dardanelle (see Table 2-1). These eight sites contain 24 of the 46 proposed dredge areas, 14 of the 38 permitted disposal areas, one of the two proposed disposal area, and one area that was previously sampled by Davidson (1997) (see Table 2-1). Sixteen (16) proposed dredge sites and 11

permitted disposal sites were sampled (Table 3-17). A total of 927 unionids representing 17 species were collected in Reach 3 (see Table 3-1). *Quadrula quadrula* (26.8%) was the dominant species collected followed by *P. dombeyanus* (25.7%) and *O. reflexa* (22.3%). Unionids were most commonly associated with substrates comprised of a mixture of sand, silt, and clay; however, percentages of each varied with location. Only three unionid beds were found in Reach 3, and all were within mud flats (see Tables 3-13 and 3-14): B11-1 in the pooled area upstream of Lock and Dam 6 (Site 11; see Figure 3-10), and B22-1 and B22-2 along the mud flats of the channel leading into Dardanelle Dam (Site 22; see Figure 3-13). Patches of unionids were found around an island (Site 12, P12-1 to P12-6), along an outside bend (Site 13, P13-1), and in a tributary mouth (Site 13, P13-2; see Table 3-14).

No sampling was conducted in the upper portion of Pool 6 (NM 119.5 - 125.3), which contains three permitted disposal areas and one dredge area (see Table 3-17). The dredge area will be needed for both the 11 and 12ft channels. This dredge site is immediately downstream of Lock and Dam 7, and within the Little Rock city limits. Part of this dredge area is a maintenance dredge area, last dredged in 2003 (see Table 1-1). Neither of the unionid samples collected downstream of Lock and Dam 3 or Lock and Dam 6 yielded any unionids. This dredge site is unlikely to affect any unionid communities due to the effects of urbanization and previous dredging, and considering samples in similar habitat did not yield unionids.

Pool 7 (NM 125.3 to 155.9), however, included Sites 11 to 14 with B11-1, P12-1 to P12-6, and P13-1 and P13-2 (see Table 3-14). These sites, which included 16 dredge and 11 permitted disposal sites, yielded 537 unionids representing 16 species (see Figures 3-10 and 3-11; Table 3-18). *Obliquaria reflexa* and *Q. quadrula* were the most common species collected. Substrate composition varied with location of bed or patch; however, most areas are comprised of a mixture of sand, silt and clay (see Table 3-14).

Site 11 (NM 126.5 - 127.0) included two permitted disposal areas and one proposed dredge site (see Figure 3-10). A total of 145 unionids representing 9 species were collected (Tables 3-18 and 3-19). The most common species collected were *Q. quadrula* (29.7%), *P. ohiensis* (18.6%), *P. purpuratus* (15.2%), and *L. fragilis* (13.1%). A few scattered unionids were found in both disposal areas, however a low-density community (B11-1; 9.1unionids/5min) was found along the left descending bank (see Table 3-19). This area also supported an established community of aquatic macrophytes. A few small zebra mussels occurred in the substrate at the upstream end of the bed, but none were found attached to unionids. Unionids were found in areas where depths were ≤3.7m and the substrate was composed of a mixture of gravel/sand/silt, silt/clay/zebra mussel shells, silt/clay/detritus, sand/silt/clay, and sand/clay (see Table 3-19). Nine unionid species were collected in B11-1, and the

dominant species were *Q. quadrula*, *P. ohiensis*, *P. purpuratus*, and *L. fragilis*. This is the downstream most bed where the thinner-shelled species were abundant. Recruitment also appeared to be high, as this area had the highest percentage of juveniles (54%) of any bed in this study. Part of B11-1 is within DI-44, and seems to have been avoided by previous disposal activity. This bed should be avoided during future disposal activity. B11-1 is also approximately 450m shoreward of DR-22 and should not be affected by dredge activity. A few samples were collected within DI-45, however CPUE was only 2 unionids/5min and only 4 species were found (see Table 3-17).

Five permitted disposal areas occur between Sites 11 and 12. These sites are along riverbanks and near islands; habitats that have yielded unionids at other sites (see Figure 3-10). These disposal areas should be surveyed for unionids prior to future disposal activity.

Site 12 (NM 134 - 135) is an unaffected area located around an island just downstream of a peninsula along the right descending bank. A total of 124 unionids representing 12 species were found in six patches. These patches occurred in shallow water (<2m depth, except one point at 3.5m) on a gently sloping shelf just riverward of *Justicia sp*. beds. *Quadrula quadrula* (46.8%) and *O. reflexa* (16.9%) were the dominant species (Table 3-20).

P12-1, P12-2, and P12-3 were all located along the riverward side of the islands in depths of 0.8m to 3.5m and a substrate of sand and clay or silt. Although habitat characteristics were similar among all patches community characteristics varied somewhat. Average CPUE ranged from 4.0 to 6.8unionids/5min, species richness ranged from 3 - 9, and percent juveniles ranged from 0 to 42% (see Table 3-13). In P12-1 and P12-3, *Q. quadrula*, *O. reflexa*, and *P. grandis* were the most common species. *Megalonaias nervosa*, *Q. quadrula*, and *Utterbackia imbecillis* were the dominant species in P12-2.

P12-4, P12-5, and P12-6 were found between the island and the right descending bank. Community characteristics also varied among these patches. Average CPUE was higher than in P12-1, P12-2, and P12-3, at (11 to 15unionids/5min). The relative abundance of juveniles varied from 20% to 36% in P12-4, P12-5, and P12-6 (see Table 3-13). In P12-4, only three species were collected and *Q. quadrula* was the dominant species. Unionids representing four species, *Q. quadrula*, *O. reflexa*, *L. teres*, and *U. imbecillis*, were collected from P12-5. *Anodonta suborbiculata*, *M. nervosa*, O. *reflexa*, and *Q. quadrula* were the most common of the seven species collected in P12-6.

Two dredge areas and two permitted disposal areas occur between Sites 12 and 13. Both dredge areas will only need to be dredged for the 12ft channel and should not affect unionids, as they occur

midchannel. The permitted disposal area along the right descending bank covers a side channel and some islands, and habitat appears similar to Site 12. Depending on the extent of previous disposal activity, this disposal area may contain patches of unionids. The disposal area on the left descending bank occurs along a straight reach downstream of an outside bend; habitat that has yielded unionids at other sites. This area could also potentially harbor patches of unionids. Both areas should be investigated before future disposal activity.

Site 13 (NM 140 - 148) includes 13 dredge and five permitted disposal sites (see Figure 3-11). Samples within and between dredge and disposal sites yielded 265 live unionids representing 13 species (Table 3-21). Dominant species were *O. reflexa* (61.5%) and *Q. quadrula* (22.3%). Unionids were scattered along the right descending bank along a straight reach between an inside and outside bend (see Figure 3-11). Most of Site 13 had homogeneous sand or sand/gravel substrate. A few unionids were found within proposed dredge and permitted disposal sites where substrate contained more silt and clay (see Table 3-21). Two concentrations of unionids, P13-1 and P13-2, were found along the right descending bank, shoreward of a dredge area, and within a permitted disposal area near the confluence of the Fourche la Fave River. P13-1 is just downstream of the confluence with the Fourche la Fave River, in depths ranging from 0.5 to 2.1m, and in substrate of sand, silt, clay, and detritus (see Table 3-14). CPUE averaged 7.6unionids/5 min, but only yielded individuals of four species. Over 90% of the unionids in this bed were *O. reflexa* and *Q. quadrula*. This patch could be affected by future disposal activity.

P13-2 is on a shelf that ranges from 0.9m to 2.4m deep, along the left descending bank of the Fourche la Fave River just upstream of the confluence with the Arkansas River. Although this patch is small, CPUE averaged 31.0unionids/5min., including individuals of eight different species were collected (see Table 3-13). *Obliquaria reflexa* and *Q. quadrula* were the most common species, and the only individual of *Quadrula p. pustulosa* in Reach 3 was collected within this patch. Unionids in P13-2 were most commonly collected in substrate comprised of a mixture of sand, clay, gravel, and silt (see Table 3-18). P13-2 is within the mouth of the river, but the peninsula between the Fourche la Fave and Arkansas Rivers is a permitted disposal site. This patch had the highest CPUE in Reach 3 and needs to be protected from future disposal activity.

Four dredge areas and three permitted disposal areas occur between Sites 13 and 14. Three and four dredge areas will be required for the 11ft and 12ft channel alternatives, respectively (Table 3-17). All of the dredge areas are midchannel and should not affect any unionid communities. Two permitted disposal areas are along the inside bend on the left descending bank, and the third is within an island complex on the right descending bank. Depending on the extent of previous

disposal activity, these disposal areas may contain patches of unionids. All three areas should be investigated before future disposal activity.

Site 14 (NM 153.0 to Lock and Dam 8) includes two proposed dredge areas that will be needed for both the 11ft and 12ft alternatives, and one permitted disposal area. Substrate composition throughout the site was loose sand and gravel (Table 3-22). Only three *O. reflexa* were found in this site. All were collected from a point on the riverward edge of the inside bend permitted disposal (DI-61) area, at approximately NM 153.8 in a sand, gravel, and cobble substrate (see Figure 3-11). Neither dredging nor disposal will affect unionids in this area.

Three dredge areas occur between Sites 14 and 15 (see Table 3-15). These areas will only be needed for the 12ft channel alternative. All are midchannel, and substrate is most likely loose sand and gravel as are other midchannel sites in the Arkansas River. No impacts to unionids are expected in these areas. However, an island complex occurs on the inside bend between NM 158.0 and 160.0 that could be investigated for the presence of unionids.

Sites 15 and 16 are within Pool 8 (see Figure 1-1b). Site 15 (NM 164 to 165.3) is near mid-pool, and contains two proposed dredge areas. Only one is needed for the 11ft channel alternative (DR-47). Site 15 also contains one permitted disposal area (DI-63, right descending bank; see Figure 3-12). A few tiny zebra mussels (most likely 2004 year class) were found in the substrate and on a few of the unionids. Substrate composition was >95% sand in nine of the 13 points sampled (Table 3-23). No unionids were found within sandy areas. A few unionids were found where substrate consisted of ≥10% silt or silt and clay on both the right and left banks near the downstream end of permitted disposal and at the edge of the proposed dredge area. This substrate occurred on a narrow shelf between the steeply sloping bank and the steep drop off into the navigation channel. Only nine unionids representing three species, *O. reflexa*, *P. purpuratus*, and *Q. quadrula*, were collected. No unionid patches or beds were found within Site 15, and only a few unionids may be affected by dredge or disposal activity.

Three and one dredge areas needed for the 12ft and 11ft alternative, respectively, and five permitted disposal sites occur between Sites 15 and 16 (see Table 3-17 and Figure 3-12). Unionids are unlikely to occur within the dredge areas, as the dredge areas are located midchannel and along a sharp outside bend. Permitted disposal areas are within dike fields or island complexes, where patches of suitable habitat might occur. These areas should be surveyed for unionids before future disposal activity.

Site 16 (NM 174 - 176) is near the tailwaters of Lock and Dam 9 (see Figure 1-1b). The site includes two proposed and one maintenance dredge area, and one permitted disposal area (see Table 3-17 and Figure 3-12). Only 14 unionids representing five species were found within this site (Table 3-24). Channel depth ranged from 0.9 to 4.6m, inside bend depth ranged from 2.1 to 5.8m, and outside bend depth ranged from 0.8 to 6.1m (see Table 3-24). Zebra mussels covered ≤1% of the substrate within a few of the points sampled midchannel. Substrate in these habitats was primarily sand and gravel. Two unionids were found in the channel, but these are likely transient individuals. Most of the unionids at Site 16 (nine of four species) were found in the mouth of Point Remove Creek (NM 174.9). Tributary mouth depth was 1.5m, and substrate consisted of mostly clay, mixed with cobble, sand, silt, and zebra mussel shells (see Table 3-24). The remaining three unionids were found within and just upstream of the dike field on the outside bend where substrate was a mix of boulder, cobble, and silt or gravel, silt and clay. Even though this bank is not affected by disposal and has similar substrate to other areas in this reach where patches of unionids were found (sand, silt, clay mixture), the areas did not contain stable patches of unionids. Neither dredging nor disposal will affect unionids at this site.

One proposed dredge area for the 12ft channel alternative occurs in the Lock and Dam 9 tailwater (see Table 3-17). Dredging in this area is unlikely to affect any unionids. Three proposed dredge areas (11ft and 12ft alternatives) and one permitted disposal area occur between Lock and Dam 9 and Site 18 (see Figure 3-12). Since few unionids were found and substrate is primarily sand both upstream (Site 18) and downstream (Site 16), dredge and disposal activity in this reach (NM 176.0 – 182.0) is unlikely to affect unionids. The outside bend near NM 179.0 may contain a mud flat with some unionids, however this area will not be affected by dredge or disposal activity.

Pool 9 (NM 176.9 to 205.4) included only one site, Site 18 (NM 181.7 to 185.5). This site is located within a sharp river bend, and included one permitted disposal area along the inside bend, and three proposed dredge areas (two in the upstream approach to the outside bend and one downstream of the outside bend (see Figure 3-12). No samples were collected in the permitted disposal area, as no unionid habitat seemed likely based on bank characteristics. The left descending bank suggested unionid habitat, with a slight slope and *Justicia sp*. beds from the upstream to downstream end of the site. However, immediately riverward of the bank depth increased to 3.4 to 6.7m, and substrate was a mixture of boulder, cobble, gravel, and sand (Table 3-25). Only one *A. suborbiculata* was found (see Table 3-25). The channel was shallower than the outside bend, at 1.8 to 3.4m, but substrate was 100% sand. Only one *O. reflexa* was recovered. Neither dredging nor disposal activity will affect unionids at this site.

The remaining portion of Pool 9 contains four proposed dredge areas (only two for the 11ft alternative), one maintenance dredge area, and six permitted disposal areas. Unionids are unlikely to occur in either the proposed dredge areas or maintenance area, based on results from other sites within Pool 9. Unionids are also unlikely to occur in the permitted disposal areas, as both ortho-quadrangles and the navigation maps indicate that these areas are sanded in, and similar disposal areas in Pools 8 and 9 did not contain unionid habitat.

The lower portion of Lake Dardanelle (NM 205.4 - 220.3) is also part of this reach. One proposed dredge area DR-66 and disposal area DI-80 occur in the straight reach upstream of Lock and Dam 10 (Figure 3-13). Site 22 (NM 206.5 - 207.7) was the only site that fell within this section of the lake. Site 22 was located in a straight stretch just upstream of Lock and Dam 10, along the channel borders adjacent to the proposed dredge site at NM 207.0 - 207.6 (see Figure 3-13). The channel was very deep, 11.6m at the bankward edges, substrate was primarily sand, and no unionids were collected within DR-66 (Table 3-26). DI-80 occurs at the downstream end of B22-1. Zebra mussel shells were abundant and in places covered the entire substrate; however, very few live zebra mussels were observed and none were attached to unionids. Unionids were found from the edge of the proposed dredge area to both riverbanks (see Figure 3-13), in depths from 1.5m to 10.5m on the right descending bank (B22-1) and 3.1 to 9.3m on the left descending bank (B22-2). Substrate within B22-1 was sand, silt, clay and zebra mussel shells, and substrate within B22-2 was gravel, sand, clay, and zebra mussel shells (see Tables 3-14 and 3-26). Unionid densities decreased sharply near the edges of the dredge area, as depth increased and substrate changed to sand.

The right descending bank between NM 206.8 and 207.4 (part of B22-1) was previously surveyed by Davidson (1997), who sampled seven points that yielded 45 unionids of six species (see Table 3-16 and Figure 3-8). *Plectomerus dombeyanus* and *Q. quadrula* were the dominant species. Species collected by Davidson (1997) that were not found in this study included *Arcidens confragosus* and *P. ohiensis* (see Table 3-16).

In this study, two unionid concentrations were found within the site, one on each side of the dredge area. A total of 365 unionids representing eight species were collected from these beds (see Table 3-26). As in Davidson's (1997) study, *P. dombeyanus* (63.3%) and *Q. quadrula* (21.4%) were the dominant species collected. Species found in this study, but absent from Davidson's (1997) study included *A. suborbiculata*, *M. nervosa*, *P. grandis*, and *Q. aspera*. *Potamilus ohiensis*, collected by Davidson (1997), was only found as a weathered shell in 2004. The same eight species were found in both beds; however, B22-1 CPUE was higher than that of B22-2, averaging 12.0unionids/5min and 8.1unionids/5min, respectively (see Table 3-13). Juvenile unionids comprised at least 23% of the

unionids collected in B22-1 (juveniles and adults were not differentiated in B22-2).

CPUE and species richness in B22-1 and B22-2 were comparable to beds found in Pools 2, 5, and 7 (see Tables 3-5 and 3-13). Recruitment (% juveniles) was >20% only in B2-1 and B2-2 (Pool 1 canal), B11-1 (Pool 7), B22-1 (Site 22), and Bed 33-1 in Reach 5; thus, these beds are worth protecting. Dredging near these beds probably will not be needed, as depths were >10m at the edges of the channel. However, the downstream end of B22-1 may be necessary before this proposed disposal site is used.

Upstream of the canal leading to Lock and Dam 22, the Arkansas River widens to form a shallow, wide lake, and inundates the mouths of Bay Ridge Creek, Illinois Bayou, and Delaware Creek (see Figure 3-13). All three of these coves were sampled by Davidson (1997). Only a few scattered unionids were found within Bay Ridge Cover (LD-4M) and along the peninsula upstream of Illinois Bayou (see Table 3-16). However, unionids were numerous within the Illinois Bayou Cove (see Table 3-16). A total of 536 unionids representing 12 species were found at three points within the cove (D97a; see Figure 3-13). Dominant species were *P. dombeyanus* and *Q. quadrula*, similar to the beds within Site 22. A small patch of unionids was found in the mouth of Delaware Creek (M5), but only 24 unionids were found, 23 of which were *Q. quadrula*.

The lake narrows between NM 214.0 and 221.0 (see Figure 3-13). Within this narrower reach Davidson (1997) sampled along the left descending bank near NM 215.8, along the inside bed near NM 218.2 (6M), and along the outside bend near the mouth of Shoal Creek (NM 220.0). Only a few unionids were found at 6M and near Shoal Creek. Three species and 17 unionids were found at two points near NM 215.8. However, Harris (1992) recovered 142 unionids representing seven species (mostly *P. dombeyanus* and *Q. quadrula*) along the inside bend near NM 216.8, and 72 unionids representing nine species (mostly *Q. quadrula*) on the opposite bank near the channel and within a cove between NM 217.8 to 218.6 (see Figure 3-8 and Table 3-14).

3.4 Reach 4 (NM 220.3 – 308.7)

Reach 4 extends from NM 220.3, near the Shoal Creek Light, to NM 308.7, near the mouth of the Poteau River, and includes portions of Lake Dardanelle, Ozark Lake, and Pool 13. Seven maintenance dredge areas occur in Reach 4, and 18 (12.4 miles) and 29 (15.5 miles) dredge sites will be needed for the 11ft and 12ft channel alternatives, respectively (see Table 1-1). Dredge material will be placed in 29 permitted disposal sites (see Table 2-2). Two maintenance dredge areas, nine proposed dredge areas, and four permitted disposal sites were sampled within Reach 4 in 2004 (see Table 2-1).

The downstream portion of Lake Dardanelle (NM 221 to 237) is very wide (almost 3000m within Site 23), with numerous islands and mud flats. Davidson (1997) found unionids at seven locations within this site (Table 3-27). Site 23 occurs within this wide lake area (see Figure 1-1c). Eight proposed dredge sites, one maintenance dredge site, and two permitted disposal sites are within this wider portion of Lake Dardanelle (Table 3-28).

From NM 237.0 to approximately NM 249.9, the lake narrows to <1000m wide. In this stretch, the river is a series of slight bends, with islands (typically sanded in dike fields) on the inside bends and rip rapped banks along the outside bends. Davidson (1997) found only two unionids within this area (see Table 3-27). Five proposed dredge areas, two maintenance dredge areas, and seven permitted disposal areas occur in this narrower meandering section of Lake Dardanelle (see Table 3-28).

From approximately NM 250.0 to Ozark Dam the river is <500m wide and primarily consists of the navigation channel, with dike fields lining the inside bends. Two proposed dredge areas and two permitted disposal area occur in the narrower section leading up to the dam (see Table 3-28). Davidson (1997) sampled one site in the section (see Table 3-27).

Ozark Lake (NM 257.0 - 292.5) is narrower (<750m in the widest areas) and meandering (see Figure 1-1c and 1-1d). Dike fields with island complexes occur in the widest sections. Lake Ozark contains 14 proposed dredge areas, three maintenance dredge areas, and 12 permitted disposal areas. Three sites within Ozark Lake were sampled in 2004 (Sites 26, 27, and 28), and Davidson (1997) found unionids at seven sites, two of which fall within Site 26 (Table 3-29).

The four sites sampled in 2004 contained nine proposed dredge areas, two maintenance dredge area, four permitted disposal areas, and three patches previously found by Davidson (1997) (see Table 2-1). Samples were from channel, straight reach, and tailwater dredge areas, as well as inside and outside bend disposal areas (see Table 2-2). Unaffected habitats sampled included channels, inside and outside bends, straight reaches, islands, and tributaries (see Table 2-2). A total of 388 unionids representing 14 species were collected in the four sites sampled in Reach 4 (see Table 3-1). *Plectomerus dombeyanus* (34.0%), *Q. quadrula* (30.2%), and *O. reflexa* (21.7%) were the most common species. Most of the unionids found within sampled sites were collected from B23-1 and B23-2 (Site 23) and P26-1 and P26-2 (Site 26; Table 3-30). Davidson (1997) found 166 unionids representing eight species at 10 sites in Lake Dardanelle, and 134 unionids representing 10 species at seven sites in Lake Ozark (see Tables 3-27 and 3-29). *Quadrula quadrula* (42.7%), *P. dombeyanus* (19.3%), *P. grandis* (14.7%), and *O. reflexa* (14.3%) were the most commonly collected species (see

Table 3-29). Between this study and Davidson (1997), 15 species have been found in Reach 4. Species found in this study but not by Davidson (1997) included *M. nervosa*, *Quadrula aspera*, *Truncilla donaciformis*, *Truncilla truncata*, and *U. imbecillis* (see Table 3-1). *Lasmigona complanata* was found by Davidson (1997), but not in this study (see Table 3-27 and 29).

Lake Dardanelle (NM 220.3 – 256.7)

One proposed dredge site (needed for both alternatives) and one maintenance dredge site (last dredged in 2002) occur between NM 220.3 and Site 23 (NM 225.5) (see Table 1-1 and Table 3-30). Davidson (1997) sampled several points within this section, and found unionids scattered along the outside bend, inside bend, and a few islands (see Figure 3-13). Catch per sample point ranged from 1.0 to 11.0, and six species were found (see Table 3-27). Both the dredge and maintenance dredge areas are within the main channel, and occur over 1km from points where unionids were found. Therefore, dredging in this area will not affect unionids. However, the nearest permitted disposal area is at NM 233, over 10 miles from the proposed dredge site. If a disposal area is needed in this area, proposed sites will need to be surveyed to avoid unionids.

Site 23, (NM 225.5 - 231.0) includes four dredge areas, two of which are not needed for the 11ft channel alternative (see Figure 3-8). A total of 311 unionids representing 13 species were found within Site 23, with *P. dombeyanus*. (42.1%), *Q. quadrula* (26.7%), and *O. reflexa* (18.0%) being the dominant species (Table 3-32). This area is a sharp bend in the river with numerous islands on the inside portion of the bend. Unionids were scattered throughout the site, with a few collected in most places where silt or clay were constituents of the substrate. The channel area was primarily sand, and only four unionids were found in the seven points sampled. Unionids were also scattered along the outside bend near NM 228.0, along the right bank straight reach shoreward of the proposed dredge site between NM 229.5 and 230.0 (primarily sand substrate), near many of the islands (substrate mostly sand), and along the right bank inside bend shoreward of the islands (substrate mostly clay with silt) (see Table 3-31). Davidson (1997) also found scattered unionids along the right descending bank shoreward of the islands: seven unionids representing four species within six sample points (see Table 3-27). Two areas were found where unionids were consistently collected: B23-1 and B23-2, both on the left descending bank leading into and out of the outside bend (see Figure 3-13).

B23-1 was located along the upstream side of the outside bend, approximately 140m shoreward of DR-70. Unionids were concentrated on a 10m wide shelf between 2.0 and 7.3m deep, approximately 15 to 20m riverward of the bank. This shelf was 2.0 to 4.2m deep at the upstream end, and 4.6 to 7.3m deep near the downstream end. Substrate was mostly clay mixed with sand, covered with a

thin layer of silt (Table 3-31). CPUE averaged 14.5unionids/5min. Eleven (11) species were found, and *P. dombeyanus* and *O. reflexa* were the most abundant species (see Table 3-30). Some recruitment was apparent, as over 50% of the species were represented by young animals. However, only 12% of the unionids collected were juveniles; similar to beds in Reaches 1 and 2 (2 to 26%, see Table 3-5), but less than the 23 to 54% juveniles in Reach 3 beds (see Table 3-13). The upstream portion of B23-1 was located behind a series of islands. This bed should not be affected by proposed dredging, as the upstream portion of the bed is over 500m from DR-71, and the downstream portion is over 100m shoreward of DR-70 (see Table 3-28).

B23-2 was located along the downstream side of the outside bend, just downstream of B23-1. These beds may not be ecologically separate, as fish are likely to travel between beds. However, depth between the beds ranged from 7.0 to 10.7m, and substrate contained less clay and more cobble, sand, and silt than within the beds. Only three unionids were found between beds (see Table 3-32). Within B23-2, unionids were found along a clay and silt shelf. Depth ranged from 1.5 to 10m deep, but was <2m at all points except two at the upstream end of the bed (see Table 3-31). Community characteristics in B23-2 were similar to B23-1. CPUE averaged 10.0unionids/5min, eight species were found, 11% of the unionids collected were juveniles, and *P. dombeyanus* and *Q. quadrula* were the dominant species (see Table 3-30). The upstream portion of B23-2 is approximately 235m shoreward of DR-69, and islands separate the downstream portion from the channel (see Figure 3-13). Dredging should not affect unionids in B23-2. However, the nearest disposal site is approximately three miles upstream. If additional disposal areas are needed within Site 23, the islands and riverbanks on the left descending side of the channel should be avoided.

Ten dredge sites (five for the 11ft alternative), and ten permitted disposal sites occur in the remainder of Lake Dardanelle. Proposed dredged sites occur in a variety of habitat types including midchannels, straight reaches, outside bends, and in the tailwaters of Lock and Dam 12 (see Table 3-30). Davidson (1997) sampled four locations in the upper part of Lake Dardanelle. Unionid densities appeared low in these sites with the densest areas yielding only three species and an average catch of 3.0unionds/sample point (see Table 3-28). None of Davidson's (1997) points were near proposed dredge or permitted disposal sites. Based on the location of B23-1 and B23-2, the right descending bank between NM 233.0 and 231.0 (particularly near the coves), and along the left descending bank downstream of Horsehead Creek (NM 235.5 – 234.0) have potential to harbor unionids. One proposed dredge area occurs within this section. At least the left descending bank and perhaps all of the moderate outside bends, particularly those near creek mouths and near dredge or disposal areas, should be surveyed before future dredge and disposal activity.

Sites 26, 27, and 28 in this study, and seven of Davidson's (1997) sites occur in Ozark Pool (NM 256.7 - 292.8; see Figure 1-1d). Fourteen (14) proposed dredge sites (10 for the 11ft channel alternative; see Table 3-30) and 12 permitted disposal sites occur within Lake Ozark. Dredging is not needed and no permitted disposal areas occur between Lock and Dam 12 (NM 257.0) and NM 271.0, thus no samples were collected in this study (see Figure 1-1d). Davidson (1997) found unionids at three sites within this section: the outside bend above the Lock and Dam (NM 257.4 - NM 258.0), the channel near NM 266.5, and the islands near NM 267.2 (see Table 3-28). A total of 44 unionids representing six species were recovered, 27 and 10 of which were *Q. quadrula* and *O. reflexa*, respectively (see Table 3-29). Davidson (1997) found the most unionids and species between NM 257.4 and NM 258. This is an outside bend near a creek mouth, similar to the habitat where beds were found in Lake Dardanelle. Since no dredge or disposal sites occur within the lower portion of Lake Ozark, unionids will not be affected by dredge or disposal activity. However, searching additional moderate outside bends could reveal additional unionid beds.

Two proposed dredge sites (both needed for 11ft and 12ft alternatives) occur within Site 26 (NM 269.5 - 273.0). A total of 51 unionids of seven species were found in this study, and *Q. quadrula* (49.0%) and *O. reflexa* (37.3%) were the dominant species (Table 3-33). Davidson (1997) sampled in the mouth of the Mulberry River, NM 272.0 and 273.0 (Figure 3-14), and found 16 unionids representing four species, *A. suborbiculata*, *P. ohiensis*, *P. grandis*, and *Q. quadrula* (see Table 3-29).

The proposed dredge areas were 3.1 to 4.6m deep, and substrate varied from clay and cobble to a mixture of gravel, sand, silt and clay. No unionids were found in the proposed dredge areas (see Table 3-28). Only three unionids were found on the right descending bank, shoreward of the proposed dredge areas. Depth ranged from 3.7 to 6.1m, and substrate was a mixture of gravel, sand, silt, and clay (see Table 3-33). Since no unionid concentrations occur near the proposed dredge sites, only a few scattered unionids could be affected by the proposed dredging.

The remainder of Site 26 will not be disturbed by dredging or disposal activities. The islands between NM 273.0 and 271.0 were in depths from 0.9 to 5.1m, and substrate comprised primarily of sand. The six unionids found in this area were in at depths of 1.5 and 5.1m, in clay and silt substrate (see Table 3-33). A patch of unionids was found at the mouth of the Mulberry River (see Figure 3-14). Unionids in P26-1 were located in depths ranging from 1.8 to 3.1m, in substrate of clay covered with silt (see Table 3-31). CPUE averaged 5.7unionids/5min, five species were found, and 12% of the unionids collected were juveniles (see Table 3-30). *Quadrula quadrula*, *O. reflexa*, and *P. grandis* were the dominant species. Species found in this tributary by Davidson (1997) that were not found in this study included *P. ohiensis* and *A. suborbiculata* (see Table 3-29). Species found in this

study and not by Davidson (1997) included *A. confragosus*, *L. fragilis*, and *O. reflexa* (see Table 3-29).

No unionids were found in the channel downstream of the proposed dredge area (100% sand; see Table 3-33). Only a few scattered unionids were found along the islands downstream of the dredge areas along the left descending bank. Substrate was primarily clay, with some silt, but two sampled points had substrate of >90% sand. The three unionids recovered were riverward of patches of *Justicia sp.*, in shallow water (≤1.5m) and where substrate was a clay and silt mix (see Table 3-33).

A second patch of unionids (P26-2) was found in 6.1m of water, in clay with silt substrate, along the right descending bank at the downstream end of Site 26 (see Figure 3-14). Only three species were collected (*Q. quadrula*, *O. reflexa*, and *P. dombeyanus*); CPUE averaged 7.3unionids/5min, and 5% of the unionids were juveniles (see Table 3-30). Neither of the unionid patches in this site will be affected by dredging or disposal activity.

Seven proposed dredge areas (four for the 11ft channel alternative), and six permitted disposal areas occur between Sites 26 and 27 (see Table 3-28 and Figure 3-14). No samples were collected within the channel or channel borders, but Davidson (1997) found a unionid bed in a cove along the left descending bank between NM 277.0 and 278.9 (see Table 3-29). He found six species and 73 unionids in nine sample points (average 8.1unionds/ point). Dominant species were *P. grandis*, *Q. quadrula*, and *O. reflexa* (see Table 3-29). This unionid bed is protected within the cove from any dredge or disposal activity. Dredging will occur midchannel and should not affect any unionids. Permitted disposal areas, particularly those along outside bends, could harbor patches of unionids and should be surveyed before future disposal activity.

Site 27 occurs along a sharp bend between NM 281.0 and NM 284.2 (see Figure 3-14). Two proposed dredge areas (both needed for 11ft and 12ft channel alternatives) are in the channel, and two permitted disposal areas are along the inside and outside bends (see Figure 3-14). The proposed dredge areas are 3.4 to 4.9m deep, and have primarily sand or gravel substrate (Table 3-34). Only 22 unionids representing five species were found within Site 27. The dominant species were *Q. quadrula* (31.8%), *O. reflexa* (31.8%), and *P. grandis* (22.7%). One *O. reflexa* was found in the channel. This was most likely a transient individual, as unionids cannot maintain position within a loose sand and gravel substrate. Unionids were also absent from the channel samples outside of the proposed dredge areas. The channel border along the right descending bank adjacent to the upstream dredge area did harbor a few scattered unionids. Scattered unionids were also found within the disposal areas near dikes. Unionids were found in depths of 0.9 to 1.8m, in substrate consisting of clay and silt mixture, with some sand within the outside bend disposal areas, and in

primarily sand with some silt and clay within the inside bend disposal area (see Table 3-34). No unionids were found within the tributary mouth or outside bend area downstream of the proposed dredge area. No concentrations of unionids were found within Site 27. Dredging and disposal of material may affect a few scattered unionids, but will not affect any significant unionid resources.

Two proposed dredge sites (one for the 11ft alternative) and three permitted disposal sites occur between Sites 27 and 28 (see Figure 3-9). The proposed dredge areas are midchannel and unlikely to affect unionids. Davidson (1997) collected one sample midchannel near NM 289.7, and found one *L. fragilis* (see Table 3-28), which was likely a transient individual. Permitted disposal areas may contain a few patches of unionids if a silt and clay substrate is available. However, these areas are within a narrow channel, and no more than a few scattered unionids have been found in channel borders within Lake Ozark. Only a few unionids are likely to be affected by disposal activity in this area.

Site 28 (NM 288.8 - 292.0) is within the tailwaters of Lock and Dam 13 (see Figure 3-14). One proposed dredge area, and two permitted disposal areas occur within the site. The dredge area is along the outside bend in depths ranging from 3.1 to 4.6m. Substrate at the upstream end of the dredge area was cobble, gravel, and sand, and no unionids were found (Table 3-35). At the downstream end of the dredge area substrate was partly bedrock, with gravel and silt near the bank, and one *O. reflexa* was recovered. This again is likely a transient individual. Dredging with Site 28 should not affect any unionid communities. The disposal area along the left descending bank is within a dike field. Only one point was sampled near the end of a dike, as no areas appeared suitable for unionids. Depth at the sampled point was 1.8m, substrate was loose cobble, gravel, and sand, and no unionids were collected. The second disposal area is behind rip rap along the outside bend (see Figure 3-14). Depth was 4m, and substrate was bedrock, boulder, cobble, and gravel. Substrate was unsuitable for unionids, and no unionids were found. Since no unionid habitat occurs within these disposal areas, future disposal activity will not affect unionids.

Even the areas along the bank that were not near disposal areas had poor unionid habitat. The dike field along the right descending bank at the downstream end of the site was primarily boulder, cobble and sand (see Table 3-35). A small patch with some silt was found behind a dike, and one *Q. quadrula* was found. Along the inside bend, depth was <2m and substrate was primarily sand and silt. Two unionids were found on the downstream side of the bend in <1m of water. Both unionids had four tiny zebra mussels attached (see Table 3-35). The downstream most outside bend along the left descending bank was also rip rapped. Depth ranged from 1.5 to 6.4m, and substrate contained mostly boulder, cobble, and sand with some silt. One sample was primarily clay with silt, however

no unionids were found.

The Arkansas portion of Pool 13 (NM 293.0 – 308.0) is also within Reach 4 (see Figure 3-14). Van Buren and Fort Smith, AR occur on the banks of the Arkansas River, which may affect water quality. No dredge areas are proposed, but four permitted disposal areas in this portion of Pool 13. No sampling was conducted in this part of Reach 4, due to the urban character of the area.

3.5 Reach 5

Reach 5 extends from NM 308.7, near the Oklahoma border, to NM 394.0, where MKARNS diverts from the Arkansas River to the Verdigris River (see Figure 1-1d and 1-1e). Four maintenance dredge sites (0.8 miles of river) occur within this reach. For the 11 and 12ft alternatives, 28 sites will need to be dredged, 40.1 river miles (see Table 1-1). Additionally, 15 aquatic disposal sites will be needed for placement of dredge material (Table 3-36). Two maintenance dredge areas, 21 proposed dredge areas, and 15 new disposal areas fell within the 15 sites sampled in this reach (see Table 2-1). A total of 407 samples were collected within the 37.9 river miles (45% of the reach). Twelve of the 15 sites were in the Arkansas River, one was in an oxbow, and two were within tributaries (Poteau River and San Bois Creek).

Arkansas River habitat varied within this reach. Most of the proposed dredge areas were within the channel, but dredging will also occur in a cove, outside bend, tailwater, and tributary habitats (see Table 2-2). Most proposed disposal areas are near or over islands, but cove, inside bend, and peninsula habitats will also be affected. Many of the points sampled in this reach were outside the proposed dredge or disposal areas. At least one of each habitat type, in unaffected areas, was sampled (see Table 2-2).

Pools 13 and 14 consisted of a narrow meandering channel <300m wide. Five proposed dredge areas, two maintenance dredge areas, and two proposed disposal areas occur within these pools. Both disposal areas were sampled, and four of the five dredge areas were sampled. Poteau River occurs within Pool 13 (see Figure 1-1d). The Poteau River within the study areas is primarily a navigation channel. Both of the dredge areas in the Poteau were sampled.

The lower portion of Pool 15 is a wide lake (Lake Kerr), with several coves around the perimeter (see Figure 1-1d). Sallisaw and San Bois Creek feed into the lake. Upstream of Lake Kerr the river narrows to a meandering channel, with the exception of a wide shallow outside bend at NM 355. San Bois Creek within the study area consists of a channel, surrounded on both sides by wide

shallow mud flats. Numerous islands and coves occur in the mud flats. Eleven of the 13 proposed dredge sites and 11 proposed disposal sites were sampled in Pool 15 (see Table 3-36).

Pool 16 from the dam to the confluence with the Verdigris River is primarily a narrow meandering channel, with a wide outside bend near NM 374, and a large oxbow near NM 380 (see Figure 1-1e). Four of the eight proposed dredge sites, and two proposed disposal sites were sampled in Pool 16 (see Table 3-36).

A total of 902 unionids of 21 species were collected in the 417 samples within this reach (see Table 3-1). Although the number of species in Reach 5 was high, two species, *Q. quadrula* (53%) and *O. reflexa* (24%), accounted for over 75% of all unionids collected. Only a few individuals (≤25) of other species were found. Most of these unionids (65%) and species (86%) were concentrated in small patches within Sites 30, 31, 32, 33, 35, 36, 39, and 39 (Table 3-37, Figures 3-15, 3-16, 3-17, 3-18).

In general, unionids were found near the bank, in areas with a gentle slope, and a substrate mixture of clay, sand, and silt (Table 38). These conditions occurred within most habitats, except the main channel and long outside bends. Catch per unit effort in proposed dredge areas was generally ≤3 unionids/5min (see Table 3-36). Only one patch (P35-2) was found within a proposed dredge area. CPUE in proposed disposal areas was slightly higher, as disposal areas are primarily in shallow water in coves, on islands, or along peninsulas. Two patches (P35-1) and one bed (P33-1) were found in disposal areas (see Table 3-38).

In the Poteau River (Site 30; Table 3-39), a few unionds were found along the slopes at the edges of the channel in the downstream dredge area (DR-96). Some unionids will be affected by dredging in this area.

One patch of unionids (P31-1) was found along the inside bend within Site 31 (Table 3-40; see Figure 3-15). However, P31-1 is approximately 100m shoreward of DR-100 and should not be affected by dredging. Impacts within Site 31 will be limited to a few scattered unionids.

The dredge area in Site 32 contains a considerable amount (50 to 100%) of bedrock and boulder (Table 3-41). A few unionids would be affected by dredging at Site 32, as P32-1 was within a small shallow cove, and <100m downstream of DR-102.

Site 33 consists of two proposed disposal areas, both behind the dikes separating the lock approach from the channel borders; one on the right side and one on the left side (see Figure 3-16). A unionid

patch occurs in DR-116 on the right side of the channel (P33-1; Table 3-42). This bed would be affected by disposal of dredge material and should be avoided if possible.

A few unionids were found at five of the six points sampled within the two proposed dredge areas in Site 34 (Table 3-43). Substrate within the dredge areas consisted of a mixture of sand, clay, and silt, which is the substrate preferred by unionids in the Arkansas River. A few unionids could be affected by dredging at this site; however, no concentrations of unionids were found, and unionids are likely scattered throughout this lake area. Thus, dredging is likely to affect only a small percentage of the unionids within this site.

Unionids were found throughout Site 35 (Table 3-44). The sampled area contained 271 of the 902 unionids collected in Reach 5 (30%), and 17 of the 19 species found in Reach 5 (Table 3-44). Patches of unionids were found in gently sloping shallow areas with primarily clay and silt substrate. Water willow was common along the bank, shoreward of the patches. Seven patches were found. P35-4 was in a cove near the upstream end of the site, and within 100m of DR-108 (see Figure 3-16 and Table 3-36). P35-2 and P35-7were along the edge of DR-108, primarily along the riverward edge of an island, but extended into the channel and could be affected by dredging activity. P35-1 was the largest patch, and much of this patch would be buried by proposed disposal activity at DI-119. This disposal site should be avoided if possible. P35-3 was in a cove, well away from proposed dredging and disposal activity. P35-5 and P35-6 were small patches associated with islands near DR-108. These dredge and disposal sites should be more thoroughly investigated before channel maintenance activity.

Unionids were also found scattered throughout Site 36 (Table 3-45). However, only one patch of unionids was found (P36-1). Although this patch was small, unionids within P36-1 were fairly dense (13.3/5minutes). However, only four species and no juvenile unionids were found within the patch. P36-1 is approximately 715m shoreward of the main channel dredge area (DR-109) and should not be affected by dredge activity. However, substrate within DR-109 is clay and silt, and unionids were found in 50% of the samples (see Table 3-45). Ten unionids were collected from the point near NM 343.8. Similarly, unionids were found at over 50% of the points sampled within DR-110 (Sallisaw Creek dredge area), with up to nine unionids at a few points. Both of these dredge areas should be investigated further before dredge activity. Unionids were also scattered throughout the proposed disposal area in the Sallisaw Creek cove (see Figure 3-16). Unionids were found in a strip of silt and clay substrate, approximately 20m from the bank. If disposal could be contained on land, it should not affect these unionids.

Most of Site 37 was too shallow for access. Since this sampling trip occurred under high to moderate flow conditions, much of this area is probably dry during low flow. No concentrations of unionids were found (Table 3-46). A few scattered animals may be affected by proposed disposal activity. However, if disposal is limited to shallow areas few unionids should be affected. Site 38 was also a complex of islands in very shallow water (Figure 3-17). Most of Site 38 was sand, and only four unionids of three species were found in 17 samples (Table 3-47). Dredge and disposal activity at Site 38 should not affect unionids.

Six patches of unionids were found in Site 39, primarily along the right descending bank (Figure 3-18). As at other sites, unionid patches were found either in small shallow areas with a gently sloping bank, or in deeper water at the interface of the riverbank and the channel in clay, silt, and sand substrate (Table 3-48). A few tiny zebra mussels were found on many of the unionids collected at this site. None of the unionid patches are within the dredge areas; however, P39-3 and P39-4 are within 100m of the dredge area, as the channel hugs the right descending bank. As long as dredging does not disturb the area within 20m of the riverbanks, unionids should not be affected by dredge activity within Site 39.

No patches of unionids were found within Sites 40 through 44. Several species of weathered shells were found at Site 40, suggesting the area supported unionids at one time. Additionally, substrate was a mixture of sand, silt, and clay and much of the area seemed conducive to unionids. A few unionids were found in both the dredge and disposal areas (Table 3-49). This area may require further investigation before dredge or disposal activity. Similarly, unionids and shells of six species were scattered throughout Site 41 (Table 3-50). Unionids may have previously occupied this area; however, most of the area near the islands was very shallow. Disposal within these islands should only affect a few unionids.

One unionid was found at the mouth of the oxbow at Site 42, and no unionids were found at Sites 43 or 44 (Tables 3-52, 3-53).

3.6 Reach 6

Reach 6 extends from NM 394, at the junction of the Grand River and the Arkansas River, and extends to the head of navigation on the Verdigris River (NM 445; see Figure 1-1e). Site 51 extended approximately 1 mile upstream of navigation. The Verdigris River has been extensively channelized. The channel is fairly straight and less than 100m wide (Figures 3-19, 3-20, and 3-21). The river is generally <3m deep along the banks, but depth increases rapidly to over 4m in most of the dredge areas (Tables 3-54 to 3-60). Approximately 22.3 river miles and 18 locations will need to be dredged

for the 11 and 12ft channel alternatives (Table 3-61). No aquatic disposal areas are planned in Reach 6.

A total of 27.5 river miles and 227 points were sampled in Reach 6 (see Table 2-1). However, only 177 unionids of 10 species were collected (see Table 3-1). *Obliquaria reflexa* comprised 50% of the unionids collected. Species that were more common in Reach 6 than in other reaches included *Q. nodulata* (only collected in Reaches 1 and 6), *Q. p. pustulosa*, and *T. verrucosa* (see Table 3-1). In the early 1900's, this section of the Verdigris River harbored 19 unionid species, (see Table 1-2). Species that previously occurred in this reach that no longer seem to be present include *Cyprogenia aberti*, *Ellipsaria lineolata*, *Fusconaia flava*, *Lampsilis cardium*, *Pleurobema rubrum*, *Pleurobema sintoxia*, *Ptychobranchus occidentalis*, *Q. aspera*, *Quadrula metanevra*, *T. donaciformis* and *T. truncata* (see Table 1-2). Most of these species were not collected in this study (see Table 3-1). Additionally, *A. plicata* was the most abundant species collected by Isley (1925), and only a few individuals were found in Reach 6 in this study.

Fifteen of the 18 proposed dredge sites in Reach 6 were sampled. Habitats that will be affected include the main channel, inside bend, outside bend, straight reaches, and tailwaters (see Table 2-2). Samples were also collected from unaffected channel, inside bend, outside bend, oxbow (old channel), straight reach, tailwater, and tributary habitats. Only a few scattered unionids were found in most dredge areas, (see Table 3-61), primarily along the clay banks at the edge of the channel. However, one patch of unionids (P50-1) was found within the dredge area that extends from NM 441.6 to 443.3 (see Table 3-61). P50-1 is along a straight reach leading into an inside bend. The channel area is bedrock, and this patch occurs in the clay and silt substrate on the left side of the channel. Zebra mussels were found on several unionids within Site 50, and 50 tiny zebra mussels were found on each of two unionids (see Table 3-59). Only two other patches of unionids were found in Reach 6, P49-1 and 49-2. P49-1 was found near the bank, leading into an outside bend, and P49-2 was found near the bank leading into an inside bend (see Figure 3-21).

Few unionids will be affected by dredging in Reach 6. If possible, P50-1 should be avoided.

Site 51 was above navigation. Approximately 1 mile of river was searched, including straight reaches, inside bends, outside bends, and the channel. Substrate seemed suitable throughout the site; however, only one live *P. purpuratus* was found.

4.0 Summary and Conclusions

The MKARNS study area extends from the mouth of the Mississippi River (NM 0) to the head of navigation at NM 445 (see Figure 1-1). To achieve an 11ft channel, 113 locations (117.0 river miles) will need dredging, and to achieve the 12ft channel alternative 141 locations (124.0 river miles) will need dredging (see Table 1-1). In Reaches 1 through 4, permitted disposal areas will meet the needs of dredge material disposal. In Reaches 5 and 6, additional aquatic disposal sites will be needed.

Unionid samples were collected from 42 sites, which covered 129.9 river miles. A total of 1,202 samples were collected, which included 80 of the 141 dredge locations, 15 proposed disposal areas, and 40 permitted disposal areas. Points were also sampled in habitats that would not be affected by dredging or disposal of dredge material.

In general, unionid beds consisted of a thin strip of unionids (typically <25m wide) at the interface of the silt or riprap that occurs along the bank and the nearly 100% sand channel. Substrate in these areas was an equal mix of clay, sand, and silt. Patches of unionids were found along the banks and in coves, with gently sloping banks. Many of the patches of unionids were found riverward of water willow beds. Unionids were absent from homogeneous substrate, such as the 100% sand in the channel and areas near the bank that contained a high percentage of silt.

Very few unionid beds or patches were found within the MKARNS. These scattered patches and beds although a major unionid resource, are the only unionids within the MKARNS, and should be avoided whenever possible. Unionids were most abundant in Reach 1, Reach 3, and Reach 5. Eight beds and 10 patches were found in Reach 1 (Table 4-1). B1-1 was downstream of Lock and Dam 1 along the edge of a maintenance dredge area, B2-1, B2-2, and B2-3 were found in the Arkansas Post Canal (dredge areas), B4-1 and B6-1 were within permitted disposal areas, and B5-1 and B7-1 were in the mouths of tributaries. Four of the 10 patches in Reach 1 also fall within permitted disposal areas (see Table 4-1). Dredging will have a major impact on the unionids in the Arkansas Post Canal, and dredge disposal will affect unionids in B4-1, P5-1, B6-1, P6-1, P7-1, and P7-2. Disposal will not affect as many unionids as dredging in the Post Canal, but very few patches and beds of unionids were found throughout the river due to the lack of habitat.

Only one patch of unionids (P8-1) was found in Reach 2, and CPUE in Patch 8-1 averaged only 3.3 unionids/5min sample. This patch will not be affected by dredge or disposal. The disposal area at NM 95.0 was not sampled in this study, but habitat looks similar to habitat where unionids patches were found. This area should be investigated before disposal activity.

Three unionid beds and eight patches were identified in Reach 3 (see Table 4-1). Two of the three beds were in dredge areas, and the third bed is within a permitted disposal site. Beds 22-1 and 22-2 were the most significant beds in this reach. These beds were on the edges of the channel in the approach to Dardanelle Lock and Dam, and would be impacted if dredging widens the channel. Beds and patches within disposal areas should be delineated and avoided during future disposal activity.

Dardanelle and Ozark Lake were studied by Davidson (1997). His study and this study found unionids in most areas sampled; however, few large beds or dense patches were found. Two unionid beds and two patches were found in Reach 4 in this study. Davidson (1997) found unionid beds in coves and backwater areas that were not sampled in this study. Neither the patches nor beds found in Reach 4 were in dredge or disposal areas.

Much of Reach 5 outside of the main channel is very shallow and probably dries out during low water. Unionids are limited to areas that are inundated most of the time. They can move to deeper water or tightly close their valves to avoid dessication; however, repeated exposure often leads to high mortality. Deeper areas had either very loose sand and gravel substrate or very hard bedrock and boulder substrate. Since few areas with suitable depth and substrate occur in this reach, unionids were primarily limited to small patches. The only bed found, was within a proposed disposal site just upstream of Lock and Dam 15. Substrate was sand, clay and silt, and depth ranged from 1.5 to 3.4m. Four small unionid patches were found in San Bois Creek. P35-1 falls within a proposed disposal area and P35-2 falls within a dredge area. However, unionids were scattered along the edges of the channel, within coves, and around most of the islands and peninsulas that were sampled in San Bois Creek. Unionids will be moderately affected by dredging and disposal within the Creek.

Six patches of unionids were found along the edges of the channel downstream of Lock and Dam 15. Most areas with gentle slope to the bank, water willows on the bank, and clay, sand, silt substrate contained unionids. However, no unionids were found within proposed dredge areas. If areas within 20m of the bank are avoided, unionids should be protected.

Most of Reach 6 was devoid of unionids. The channel stretched from bank to bank, with <10m between the channel and the bank. Most of the bank areas were too shallow for unionids. Three patches were found within the nearly 15 miles that were sampled. Only one of the patches P50-1 was near a dredge area. Although only a few unionids would be affected by dredging in this area, only a few occur within the reach. Any unionids found within Reach 6 should be protected.

The MKARNS does not provide an abundance of habitat for unionids. All of the species in the river are common, and the river does not support a signifcant unionid community. However, since unionids were only found in a few areas, any disturbance to unionid beds and patches would affect a large portion of the unionid community in that area. Therefore, the 11ft and 12ft channel alternatives will have a moderate impact to the MKARNS unionid community. Areas known to harbor unionids should be avoided where possible, and areas that may harbor unionid beds or patches between the sampled sites should be investigated for unionids before dredge or disposal activity. The only area that cannot be avoided is the Arkansas Post Canal. The canal provides some of the best unionid habitat in the navigation system.

5.0 Mitigation Recommendations

The largest impact the 11ft or 12ft channel alternatives will have to unionids will be to the beds in the Arkansas Post Canal. As many as 2 x 10^6 unionids could occur in the canal; however, all of the species in the canal are common and no federal or state T&E species were found. To mitigate the impact to these unionids, some could be moved upstream into the Verdigris River within Site 51, where habitat seems suitable but no unionids were found. These animals would need to be checked annually for a few years to determine survival, growth, and reproduction. Unionids could also be moved to and stored at Mammoth Spring National Fish Hatchery, then seeded back into the canal after dredging. The fish hatchery can hold up to 10,000 unionids. Unionids from the canal could also be used to enhance unionid communities in other Arkansas Rivers.

Beds 22-1 and 22-2 should be protected from dredge activity. To protect these beds, they should be delineated before dredging activity occurs. Dredging should not occur within >150m from the beds. If dredging is to occur within 150m of the beds, unionids should either be relocated or surveyed for impacts for a few years following dredge activity.

In general, beds and patches found within permitted and proposed disposal sites should be avoided. Relocation of the unionids from these beds/patches would not be prudent. Since so little unionid habitat occurs in the river, preservation of unionid habitat should be a higher priority than preserving individual animals. Additionally, areas between sites that appear to have unionid habitat should be investigated before dredging or disposal activity.

Since dredging and disposal activity within the MKARNS system that is associated with the 11ft and 12ft channel alternatives will moderately affect the systems unionid community, a river wide management plan should be developed to protect unionids. Unionid beds and patches should be selected at intervals throughout the study area. These beds should be quantitatively sampled to establish current density, recruitment, mortality, and species richness. Unionid community trends should be assessed annually for at least five years, then a subset of sites assessed each year for five additional years.

A summary of planned mitigation is provided in Tables 5-1 and 5-2.

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Figure 1-1. Overview of 2004 sample sites and locations of historical sample areas on the Arkansas and Verdigris Rivers.

Figure 1-1b

Figure 1-1c

Figure 1-1d

Figure 1-1e

Figure 3-1. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 1, Sites 1 to 4.

Figure 3-2. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 1, Sites 5 to 7.

Figure 3-3. Species-Area curve based on samples collected from B1-1, 2004.

Figure 3-4. Species-Area curve based on samples collected from Site 2 (B2-1, B2-2, B2-3 combined), 2004.

Figure 3-5. Species-Area curve based on samples collected from B4-1, 2004.

Figure 3-6. Species-Area curve based on samples collected from B5-1, 2004.

Figure 3-7. Species-Area curve based on samples collected from B6-1, 2004.

Figure 3-8. Species-Area curve based on samples collected from B7-1, 2004.

Figure 3-9. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 2, Sites 8 to 9.

Figure 3-10. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 3, Sites 11 to 12.

Figure 3-11. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 3, Sites 13 to 14.

Figure 3-12. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 3, Sites 15 to 18.

Figure 3-13. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 3 and 4, Sites 22 to 23.

Figure 3-14. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 4, Sites 26 to 28.

Figure 3-15. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 5, Sites 30 to 31.

Figure 3-16. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 5, Sites 32 to 36.

Figure 3-17. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 5, Sites 37 to 38.

Figure 3-18. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 5, Sites 39 to 43.

Figure 3-19. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reaches 5 and 6, Sites 44 to 46.

Figure 3-20. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 6, Site 47.

Figure 3-21. Proposed 12ft channel maintenance activity with respect to unionid beds and patches, Reach 6, Sites 48 to 51.

Table 1-1. MKARNS dredging areas by reach, pool, and navigation mile.

Table 1-2. Disposal sites in the MKARNS by reach, pool, and navigation mile.

Table 1-3. Species historically recorded from the Arkansas River drainage.

Table 2-1. Unionid sample sites in the MKARNS, 2004.

Table 2-2. Habitats of channel modification and unaffected areas within and between sites, MKARNS, 2004.

Table 2-3. Characteristics used in defining unionid beds and patches in the MKARNS, 2004.

Table 3-1. Number of unionids and species collected within each MKARNS reach, 2004.

Table 3-2. MKARNS proposed dredge and permitted disposal areas with respect to unionid sample sites in Reach 1, 2004.

Table 3-3. Species composition and CPUE within unionid beds and patches, Reach 1.

Table 3-4. Location, habitat characteristics, and CPUE of unionid beds (B) and patches (P), MKARNS Reach 1, 2004.

Table 3-5. Site 1 unionid species and habitat characteristics.

Table 3-6. Site 2 unionid species and habitat characteristics.

Table 3-7. Site 4 unionid species and habitat characteristics.

Table 3-8. Site 5 unionid species and habitat characteristics.

Table 3-9. Site 6 unionid species and habitat characteristics.

Table 3-10. Site 7 unionid species and habitat characteristics.

Table 3-11. MKARNS proposed dredge and permitted disposal areas with respect to unionid sample sites in Reach 2, 2004.

Table 3-12. Site 8 unionid species and habitat characteristics.

Table 3-13. Species composition and CPUE[1] within unionid beds and patches, Reaches 2 and 3, MKARNS, 2004.

Table 3-14. Location, habitat characteristics, and CPUE[1] of unionid beds (B) and patches (P), Reaches 2 and 3, MKARNS, 2004.

Table 3-15. Site 9 unionid species and habitat characteristics.

Table 3-16. Unionid species previously collected within Reach 3[1].

Table 3-17. MKARNS proposed dredge and proposed/permitted disposal areas with respect to unionid sample sites in Reach 3, 2004.

Page 3

Table 3-18. Unionid species collected in Reach 3, MKARNS, 2004.

Table 3-19. Site 11 unionid species and habitat characteristics.

Page 2

Table 3-20. Site 12 unionid species and habitat characteristics.

Table 3-21. Site 13 unionid species and habitat characteristics.

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Table 3-22. Site 14 unionid species and habitat characteristics.

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Table 3-23. Site 15 unionid species and habitat characteristics.

Table 3-24. Site 16 unionid species and habitat characteristics.

2

Table 3-25. Site 18 unionid species and habitat characteristics.

2

Table 3-26. Site 22 unionid species and habitat characteristics.

2

3

Table 3-27. Unionid species previously collected within Reach 4, Lake Dardanelle.

Table 3-28. MKARNS proposed dredge areas with respect to unionid sample sites in Reach 4, 2004.

Table 3-29. Unionid species previously collected within Reach 4, Ozark Lake.

Table 3-30. Species composition and CPUE within unionid beds and patches, Reaches 4 and 6.

Table 3-31. Species composition and CPUE within unionid beds and patches, Reaches 4 and 6.

Table 3-32. Site 23 unionid species and habitat characteristics.

Table 3-33. Site 26 unionid species and habitat characteristics.

Table 3-34. Site 27 unionid species and habitat characteristics.

Table 3-35. Site 28 unionid species and habitat characteristics.

Table 3-36. MKARNS proposed dredge areas with respect to unionid sample sites in Reach 5, 2004.

Table 3-37. Species composition and CPUE within unionid beds and patches, Reach 5.

Table 3-38. Location, habitat characteristics, and CPUE of unionid beds (B) and patches (P), Reach 5, MKARNS, 2004.

Table 3-39. Site 30 unionid species and habitat characteristics.

Table 3-40. Site 31 unionid species and habitat characteristics.

Table 3-41. Site 32 unionid species and habitat characteristics.

2

Table 3-42. Site 33 unionid species and habitat characteristics.

Table 3-43. Site 34 unionid species and habitat characteristics.

Table 3-44. Site 35 unionid species and habitat characteristics.

Table 3-45. Site 36 unionid species and habitat characteristics.

Table 3-46. Site 37 unionid species and habitat characteristics.

Table 3-47. Site 38 unionid species and habitat characteristics.

Table 3-48. Site 39 unionid species and habitat characteristics.

Table 3-49. Site 40 unionid species and habitat characteristics.

Table 3-50. Site 41 unionid species and habitat characteristics.

Table 3-51. Site 42 unionid species and habitat characteristics.

Table 3-52. Site 43 unionid species and habitat characteristics.

Table 3-53. Site 44 unionid species and habitat characteristics.

Table 3-54. Site 45 unionid species and habitat characteristics.

Table 3-55. Site 46 unionid species and habitat characteristics.

PAGE 2

Table 3-56. Site 47 unionid species and habitat characteristics.

PAGE 3

PAGE 5

Table 3-57. Site 48 unionid species and habitat characteristics.

Table 3-58. Site 49 unionid species and habitat characteristics.

PAGE 2

PAGE 3

PAGE 4

Table 3-59. Site 50 unionid species and habitat characteristics.

PAGE 2

PAGE 3

Table 3-60. Site 51 unionid species and habitat characteristics.

PAGE 2

Table 4-1. Number of unionid beds and patches, their occurrence in dredge and disposal areas.

Table 4-2. Summary of impacts to unionids and mitigation suggestions.

Table 5-1. Arkansas Mussel Mitigation

Table 5-2. Oklahoma Mussel Mitigation