ensure genetic and demographic viability, and subadult numbers show that reproduction and recruitment provide self-sustainability (see Appendix A). Maintenance of the Green River subbasin population is vital for the upper basin metapopulation that includes the upper Colorado River subbasin and potentially the San Juan River subbasin.

4.0 THREATS TO COLORADO PIKEMINNOW BY LISTING FACTOR

The Colorado pikeminnow was designated as an endangered species prior to enactment of the ESA, and a formal listing package identifying threats was not assembled. Construction and operation of mainstem dams, nonnative fish species, and local eradication of native minnows and suckers in advance of new human-made reservoirs in the early 1960's were recognized as early threats (Miller 1961; Holden 1991), and the species was included in the United States List of Endangered Native Fish and Wildlife on June 4, 1973 (38 FR No. 106). A description of Threatened Wildlife of the United States compiled by the Office of Endangered Species and International Activities (U.S. Bureau of Sports Fisheries and Wildlife 1973) identified the reasons for decline of the Colorado pikeminnow as:

> *"Modification of habitat by man through construction of large reservoirs. The species will not reproduce in cold tailwaters below high dams nor in reservoirs behind these dams. The species is adapted to life in turbid, swift, warm rivers. Introduced fishes may have a decimating effect in waters not affected by dams."*

Although habitat losses were documented, the threats were poorly understood and distribution and abundance of the species were not well known. Threats were further identified in the Recovery Plan (U.S. Fish and Wildlife Service 1991):

> *"In summary, the absolute cause for the decline of Colorado squawfish is not fully understood but is probably related to a combination of factors, including direct loss of habitat, changes in flow and temperature, blockage of migration routes, and interaction with introduced fish species."*

Hence, the primary threats to Colorado pikeminnow populations are streamflow regulation and habitat modification (including cold-water dam releases, habitat loss, and blockage of migration corridors); competition with and predation by nonnative fish species; and pesticides and pollutants (Box 5). These threats are associated with the five listing factors (see section 2.1), and a summary of each is presented in the following sections. Site-specific management actions and objective, measurable criteria associated with five recovery factors to minimize or remove threats are provided in section 5.0.

Box 5. Primary Threats To Colorado Pikeminnow

- Streamflow regulation.
- Habitat modification.
- Competition with and predation by nonnative fish species.
- Pesticides and pollutants.

4.1 Listing Factor (A): The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Streamflow regulation and associated habitat modification are identified as primary threats to Colorado pikeminnow populations. Regulation of streamflows in the Colorado River Basin is manifested as reservoir inundation of riverine habitats and changes in flow patterns, sediment loads, and water temperatures. For example, streamflow regulation has generally reduced the magnitude of spring peak flows and increased the magnitude of summer–winter base flows. Since 1950, annual peak flows of the Colorado River in occupied Colorado pikeminnow habitat upstream of Westwater Canyon have decreased by 29–38% (Van Steeter and Pitlick 1998). Flows of the Green River at Jensen, Utah, upstream of principal Colorado pikeminnow nursery habitat, have decreased by 13–35% during spring and increased by 10–140% during summer through winter due to regulation by Flaming Gorge Dam (Muth et al. 2000). Peak discharge of the San Juan River during the post-dam period (1962–1991) averaged 54% of the spring peak during the pre-dam period (1929–1961), and median monthly flow for the base-flow months of August through February averaged 168% of the pre-dam period (Holden 1999). The effect of flow modifications on Colorado pikeminnow includes reduction in high-velocity flows that flush sediments from spawning cobbles (Van Steeter and Pitlick 1998), reduced channel and habitat complexity and concomitant losses in food production (Osmundson 1999), reduced availability and quality of backwater nursery habitats (Tyus and Karp 1989), and loss of flooded bottomlands during spring runoff as feeding areas and as thermal refugia for maturation of gonads (Tyus 1990).

The Colorado pikeminnow was first listed as endangered following a period of dam construction throughout the Colorado River Basin. Starting with Hoover Dam in 1935, numerous dams were constructed that fragmented and inundated riverine habitat; released cold, clear waters; altered ecological processes; affected seasonal availability of habitat; and blocked fish passage. Reservoirs formed by these dams were stocked with a variety of nonnative fishes for recreational fisheries, and these fishes preyed upon and competed with the native fishes. In the 1960's, major dams were also constructed in the upper basin, primarily through the Colorado River Storage Project (CRSP) Act, including Flaming Gorge Dam (1962) on the Green River, Navajo Dam (1962) on the San Juan River, the Aspinall Units (1963) on the Gunnison River, and Glen Canyon Dam (1963) on the Colorado River. These dams had similar effects as seen in the lower basin, but there remained large undammed reaches in which the Colorado pikeminnow could complete its life cycle. The decline of the species throughout the basin and its extirpation from the lower basin is attributed largely to extensive habitat loss, modification, and fragmentation and blocked fish passage associated with dam construction and operations. Following the dams of the CRSP, fewer and smaller dams were constructed on tributaries, including McPhee Dam (1985) on the Dolores River and Taylor Draw Dam (1987) on the White River. Dams have not been constructed within occupied habitat of Colorado pikeminnow since 1987, and the threat of dam construction has been minimized considerably.

Total Colorado pikeminnow habitat lost to reservoir inundation in the upper basin is about 700 km, including Flaming Gorge Reservoir on the Green River (160 km), Lake Powell (320 km

on the Colorado River and 120 km on the San Juan River), and Navajo Reservoir on the San Juan River (100 km). Much of the habitat lost to reservoir inundation cannot be reasonably regained in the near future. Inundated habitat still occupied by Colorado pikeminnow includes the Colorado River and San Juan River inflows to Lake Powell. Large numbers of age-0 and juvenile Colorado pikeminnow are found seasonally in the Colorado River inflow and fewer numbers are reported in the San Juan River inflow, but adults are rarely caught in the reservoir; Colorado pikeminnow do not survive well in reservoirs and are not known to reproduce in lentic habitats.

Cold-water releases have eliminated most native fishes from river reaches immediately downstream of dams, except for small numbers of flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker *(C. discobolus*), and speckled dace (*Rhinichthys osculus*) that remain in some tailwaters. River temperatures have been modified from seasonal lows of near freezing and highs of nearly 30°C to relatively constant dam releases of about 4–13°C. Depending on dam elevation, time of year, and river volume, river temperatures may not equilibrate with atmospheric temperatures for nearly 400 km downstream (as in the Colorado River below Glen Canyon Dam). These cold releases have caused reproductive failure and slowed growth of the warm-water native fishes. Colorado pikeminnow were last reported in Grand Canyon below Glen Canyon Dam in the early 1970's, as dam release temperatures became constant; a proposed temperature modification on Glen Canyon Dam (U.S. Bureau of Reclamation 1998) is not expected to restore Colorado pikeminnow in the region because of the lack of a full complement of habitats. The species was last reported in the San Juan River below Navajo Dam shortly after dam construction, but is currently found only in the reach starting 105 km downstream of the dam. Penstock modifications on Flaming Gorge Dam in 1976 (Holden and Selby 1979; Holden and Crist 1981) allowed for warmed releases down the Green River beginning in 1978, and Colorado pikeminnow have reinvaded Lodore Canyon, upstream of the Yampa River confluence (Bestgen and Crist 2000). In the Gunnison River, warming releases from Aspinall Unit dams could provide suitable temperatures for Colorado pikeminnow to expand their present range upstream of Delta, Colorado.

Adult Colorado pikeminnow are long distance migrators to and from spawning sites (Tyus 1990). Historically, the only physical barriers to movement were natural rapids and swift turbulent flows, which were probably only seasonal impediments to fish movement. Since 1905, numerous human-made dams have been constructed throughout the Colorado River Basin, fragmenting Colorado pikeminnow habitat and blocking migration corridors. These dams have also reduced river flow, altered water-temperature and flow regimes, trapped sediments and nutrients, changed water quality, and created reservoirs as a source of nonnative fishes (Maddux et al. 1993). In the lower basin, 14 major dams have restricted fish movement through the Colorado, Gila, Salt, and Verde rivers since completion of Hoover Dam in 1935; other dams on the Colorado River include Davis, Parker, Palo Verde Diversion, Imperial, and Laguna. Glen Canyon Dam approximately divides the lower from the upper basin and also is a barrier to fish movement.

Ten barriers are identified in the upper basin upstream of Glen Canyon Dam within occupied habitat of Colorado pikeminnow (Burdick and Kaeding 1990; Holden 1999; Table 3). Five of

Table 3. Existing dams and diversion structures within occupied Colorado pikeminnow habitat.

River	Structure	Current Status	Access to Suitable Habitat
Upper Colorado River	Grand Valley Diversion	Year-around passage completed in 1998	Passage adds 5 km additional habitat up to Price-Stubb Diversion
Upper Colorado River	Price-Stubb Diversion	Environmental Assessment to remove or modify in progress	Passage would add about 9 km additional habitat up to Government Highline Diversion
Upper Colorado River	Government Highline Diversion	No formal passage proposal	Passage would add 8 km additional habitat based on existing temperature units[a]
Gunnison River	Redlands Diversion	Fishway installed in 1996; successfully passing fish	Passage adds 50 km additional habitat based on existing temperature units[a]
Green River	Tusher Wash Diversion	Passage may be difficult at very low flows	Occupied habitat both up and downstream
Yampa River	Craig Diversion	Structure modified in 1992; successfully passing fish	Occupied habitat downstream
White River	Taylor Draw Dam	Dam completed in 1983, no current fish passage	Fish have been found downstream of dam in apparent attempt to migrate to habitat upstream of dam
San Juan River	PNM Weir	Diversion being modified to allow passage	Fish found below.
San Juan River	Cudei Diversion	Diversion has been modified to allow passage	Fish found above and below.
San Juan River	Hogback Diversion	Diversion has been modified to allow passage	Fish found below

[a]Osmundson (1999).

these barriers are classified as medium or high-head structures that are partial or seasonal barriers to fish movement or that have been modified to allow passage. The Price-Stubb Diversion presently defines the upper-most distribution of the Colorado pikeminnow in the upper Colorado River; a second structure, the Government Highline Diversion, is immediately upstream. Passage by these diversions could allow the species to expand its range by about 22 km (Osmundson 1999). The Redlands Fishway on the lower Gunnison River has allowed Colorado pikeminnow and other native fishes to move past the Redland Diversion and regain access to about 50 km of the Gunnison River. A diversion structure on the Yampa River near Craig, Colorado, was recently replaced, in part, to allow unassisted fish passage (Masslich 1993). On the San Juan River, several diversion structures are in historic habitat and act as fish barriers to limit the range of Colorado pikeminnow (Masslich and Holden 1996). The Cudei and Hogback diversions have been modified to allow fish passage and work is being done on the PNM Weir; other diversions are being evaluated. Modification of these dams and diversions could allow for considerable range expansion and increases in populations. Furthermore, water withdrawn at diversion structures can entrain Colorado pikeminnow and isolate them in canal systems where their survival is potentially low. Diversion structures should be screened (as needed) to minimize or prevent entrainment of at least subadult and adult Colorado pikeminnow.

Maintenance of streamflow is important to the ecological integrity of large western rivers (Tyus 1992; Collier et al. 1996; Poff et al. 1997; Schmidt et al. 1998). Life histories of many aquatic species, especially fish, are often specifically tied to flow magnitude, frequency, and timing, such that disruption of historic flows can jeopardize native species. The importance of flow management to the endangered fishes of the Colorado River is recognized (Tyus 1992; Stanford 1994). Enhancing natural temporal and spatial habitat complexity through flow and temperature management is the basis for benefitting the endangered fishes (Osmundson et al. 2000b).

Flow recommendations have been developed for some river systems in the Upper Colorado River Basin that identify and describe flows with the necessary magnitude, frequency, duration, and timing to benefit the endangered fish species (e.g., Modde and Smith 1995; Osmundson et al. 1995; U.S. Department of the Interior 1995b; Holden 1999; Modde et al. 1999; McAda 2000 [under revision]; Muth et al. 2000). These flows were designed to enhance habitat complexity (e.g., suitable spawning areas, inundation of floodplain areas) and to restore and maintain ecological processes (e.g., sediment transport, food production) that are believed to be important to the life history of these endangered fishes. Spring peak flows are important to the dynamic sediment processes that maintain in-channel habitat complexity, and prevent vegetation encroachment and channel narrowing. For example, cobble and gravel deposits used for spawning are relatively permanent features formed at high flows. Lower peak flows in subsequent years result in deposition of fine sediments over cobble and gravel deposits. Peak flows, whose timing coincides with the natural runoff cycle, are needed to ensure that suitable sites, cleansed of fine sediments, are available during the spawning period. Conversely, low and relatively stable base flows in summer, fall, and winter provide stable, warm, and productive nursery habitats for young fish.

Flows necessary to restore and maintain required habitats of Colorado pikeminnow mimic the natural hydrograph and include spring peak flows and summer–winter base flows. Adults utilize pools, deep runs, and eddy habitats maintained by high spring flows (see Appendix A for details on habitat requirements). These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats (McAda 2000; Muth et al. 2000). Spawning activity begins after spring runoff at water temperatures typically between 18 and 23°C . Increased production and recruitment have been correlated with moderate-to-high water years (Converse et al. 1999; McAda and Ryel 1999; Valdez et al. 1999). Larvae typically drift downstream from spawning areas to broad alluvial reaches where they occupy sheltered nursery backwaters, restructured by high spring flows and maintained by relatively stable base flows. High spring flows also disadvantage nonnative fishes (McAda and Kaeding 1989; Valdez 1990; Hoffnagle et al. 1999), reducing predation and competition. Low base flows also increase shoreline food production.

Flow recommendations have been developed that specifically consider flow-habitat relationships within occupied habitat of Colorado pikeminnow (see section 3.1.2; Table 1) in the upper Colorado River (Osmundson et al. 1995; McAda 2000), Gunnison River (McAda 2000), Yampa River (Modde and Smith 1995; Modde et al. 1999), Green River (Muth et al. 2000), and San Juan River (Holden 1999). These flow recommendations will be evaluated and revised (as

necessary) as part of an adaptive-management process, and flow regimes to benefit the endangered fishes will be implemented through multi-party agreements or by other means (see section 4.4).

4.2 Listing Factor (B): Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization of Colorado pikeminnow for commercial, recreational, scientific, or educational purposes is not currently considered a threat to the species. This factor will be reevaluated and, if necessary, actions to ensure adequate protection will be identified before downlisting and attained before delisting.

Historically, Colorado pikeminnow were opportunistically used as food by American Indians and early explorers to the region, and were commercially harvested as "white salmon" in the early 1900's (see section A.2). Colorado pikeminnow will strike at lures and flies, and some fish are incidentally caught by recreational anglers, but the number harmed or killed is believed to be insignificant based on creel census (personal communication, T. Nesler, Colorado Division of Wildlife). All angler access points near occupied habitat are posted with signs advising anglers to release any endangered fish unharmed.

Collection of Colorado pikeminnow for scientific or educational purposes is regulated by the Service under Section 10(a) of the ESA. Scientific collecting permits are issued to investigators conducting legitimate scientific research, and "take" permits are issued where a reasonable loss of fish is expected. Permits to collect Colorado pikeminnow for educational purposes are normally not requested but are regulated by the same provisions of the ESA.

4.3 Listing Factor (C): Disease or Predation

4.3.1 Diseases and parasites

Diseases and parasites currently are not considered singly significant in the decline of the Colorado pikeminnow (see section A.11 for expanded discussion of parasites), but these factors will be reevaluated and, if necessary, actions will be identified to minimize adverse effects before downlisting. Adequate protection from deleterious diseases and parasites will be attained before delisting.

4.3.2 Nonnative fishes

Colorado pikeminnow populations in the upper basin live sympatrically with about 20 species of warm-water, nonnative fishes (Tyus et al. 1982; Lentsch et al. 1996) that are potential predators, competitors, and vectors for parasites and diseases. Backwaters and other low-velocity shoreline habitats in alluvial reaches of the upper Colorado, Green, and San Juan rivers are important nursery areas for larval and juvenile Colorado pikeminnow (Tyus 1991; Holden 1999; McAda 2000; Muth et al. 2000; see Appendix A), and researchers believe that nonnative fish species in

those habitats limit the success of Colorado pikeminnow recruitment (e.g., Muth and Nesler 1993; Bestgen 1997; Bestgen et al. 1997; McAda and Ryel 1999; Valdez et al. 1999). Osmundson (1987) confirmed predation by black bullhead (*Ameiurus melas*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*) as a significant mortality factor of young-of-year and yearling Colorado pikeminnow stocked in riverside ponds along the upper Colorado River. Adult red shiner (*Cyprinella lutrensis*) are known predators of larval native fish in backwaters of the upper basin (Ruppert et al. 1993), and predation by nonnative fishes such as red shiner may influence within-year-class recruitment of Colorado pikeminnow (Bestgen et al. 1997). In laboratory experiments on behavioral interactions, Karp and Tyus (1990) observed that red shiner, fathead minnow (*Pimephales promelas*), and green sunfish shared activity schedules and space with young Colorado pikeminnow and exhibited antagonistic behaviors toward smaller Colorado pikeminnow. They hypothesized that Colorado pikeminnow may be at a competitive disadvantage in an environment which is resource limited and concluded that nonnative fishes could have a negative impact on growth and survival of young Colorado pikeminnow. High spatial overlap in habitat use has been documented among young Colorado pikeminnow, red shiner, sand shiner (*Notropis stramineus*), and fathead minnow (McAda and Tyus 1984; McAda and Kaeding 1989). Muth and Snyder (1995) compared the diet of young-of-year Colorado pikeminnow with the diets of other small fishes collected from backwaters of the Green River. They concluded that the potential for competition for food between Colorado pikeminnow and other fishes in backwaters appeared greatest with red shiner, which are often the most abundant fish in backwaters.

Channel catfish (*Ictalurus punctatus*) and northern pike (*Esox lucius*) have been identified as the principal nonnative threats to subadult and adult Colorado pikeminnow in the upper basin. Adult Colorado pikeminnow apparently use the same habitats as adult channel catfish and northern pike suggesting the potential for negative interactions, especially during periods of limited resource availability (Wick et al. 1985; Tyus and Karp 1989; Tyus and Beard 1990; Nesler 1995). Channel catfish were first introduced into the Upper Colorado River Basin in 1892 (Tyus and Nikirk 1990) and are now considered common to abundant throughout much of the upper basin (Tyus et al. 1982; Nelson et al. 1995). The species is one of the most prolific predators in the upper basin and, among the nonnative fishes, is thought to have the greatest adverse effect on the endangered fishes (Hawkins and Nesler 1991; Lentsch et al. 1996; Tyus and Saunders 1996), largely due to predation on juveniles and resource overlap with subadults and adults. Additionally, mortality of adult Colorado pikeminnow that prey on channel catfish has occurred due to choking on pectoral spines (McAda 1980; Pimental et al. 1985). Northern pike accidentally became established in the Yampa River in the early 1980's when individuals escaped from Elkhead Reservoir (Tyus and Beard 1990). Since then, northern pike have established a reproducing population in the Yampa River and have expanded their numbers and range in both the Yampa and middle Green rivers (Tyus and Beard 1990; Hawkins and Nesler 1991; Nesler 1995) where they pose a competitive and predatory threat to endangered and other native fishes (Wick et al. 1985; Tyus and Karp 1989; Tyus and Beard 1990; Martinez 1995; Nesler 1995).

A Strategic Plan for Nonnative Fish Control was developed for the Upper Colorado River Basin (Tyus and Saunders 1996) and implemented by the UCRRP in 1997. Some activities include

mechanical removal of nonnative fishes through intensive sampling, and modification of habitats used as residential or nursery areas by nonnative fishes. Preliminary results of the control program are inconclusive as to the beneficial effects for Colorado pikeminnow. However, increases in abundances of Colorado pikeminnow during the 1980's and 1990's in both the Green and upper Colorado rivers (see section 3.2) suggest that other factors, such as restoration of naturalized river flows, may allow the species to proliferate even in the presence of nonnative species. Colorado pikeminnow are predators during their first year of life and as major predators, may have an advantage over other sympatric native species. Data from a 7-year research period on the San Juan River suggest that efforts to date were effective in reducing density of large channel catfish, but efforts were not effective in reducing overall abundance of channel catfish in the river (Holden 1999). A positive population response by native fishes to this channel catfish reduction has not been reported (personal communication, San Juan River Basin Recovery Implementation Program, Biology Committee). A strategic control program has also been recommended for Grand Canyon (Valdez et al. 1999), and a Science Plan is being developed for implementation of nonnative fish removal starting in 2003 (GCMRC 2002).

Control of the release and escapement of nonnative fishes into the main river, floodplain, and tributaries is also a necessary management action to stop the introduction of new fish species into occupied habitats and to thwart periodic escapement of highly predaceous nonnatives from riverside features. Agreements have been signed among the Service and the States of Colorado, Utah, and Wyoming to review and regulate all stockings within the Upper Colorado River Basin (U.S. Fish and Wildlife Service 1996) in order to reduce the introduction and expansion of nonnative fishes. A Memorandum of Agreement implementing these procedures was signed on September 5, 1996, by the Service and the States and remains in effect through the life of the UCRRP. This agreement regulates releases of nonnative fishes within the 50-year floodplain of the river, and provides security against State or Federal endorsed programs introducing new species into the system or increasing the numbers or distribution of existing species. The agreement also allows the States to regulate and restrict stocking of privately owned ponds. These procedures will also reduce the likelihood of new parasites and diseases being introduced through nonnative fish stockings. Similar procedures need to be developed and implemented in the San Juan River subbasin.

Annual flooding of the river can inundate riverside ponds potentially containing large numbers of green sunfish, black bullhead, largemouth bass, and other nonnative fishes that may escape to the river during high flows (Valdez and Wick 1983). Riverside features determined to be problematic must be either isolated from high river floods, designed to drain annually with the rise and fall of the river, or treated with piscicidal compounds to eradicate nonnative fishes. The Colorado Division of Wildlife is to prepare a Colorado River Fisheries Management Plan (Plan) that will implement a more detailed nonnative fish control effort. The Plan is to be reviewed and approved by the Colorado Wildlife Commission and UCRRP. The Plan will be finalized and implemented by the dates specified in the Recovery Implementation Program Recovery Action Plan (RIPRAP) of the UCRRP. One aspect of the Plan will be pond reclamation, which can include complete removal of nonnative fish, screening ponds to prevent escapement to the river, and/or reshaping ponds so that they no longer support year-round habitation by nonnative fish.

Another aspect of nonnative fish control in the upper basin is removal of bag and possession limits on nonnative fishes in designated critical habitat of Colorado pikeminnow. For example, the State of Colorado has removed bag and possession limits on all nonnative, warm-water sport fishes within critical-habitat reaches of the Colorado and Yampa rivers. Colorado also has agreed to close river reaches to angling where and when angling mortality is determined to be significant to native fishes.

Three management actions are identified to reduce the threat of nonnative fishes: high spring flows, nonnative fish control strategies, and stocking agreements. There is documented evidence that high flows temporarily disadvantage nonnative fishes in several ways, including displacement from sheltered habitats, disruption of spawning activities, increased mortality in high mainstem currents, and physical downstream transport of individuals. Studies from the Upper Colorado River (McAda and Kaeding 1989), Green River (Valdez 1990), Yampa River (Muth and Nesler 1993), and Lower Colorado River through Grand Canyon (Hoffnagle et al. 1999; Valdez et al. 2001) showed reductions in densities of small-bodied species of fish (e.g., fathead minnow, red shiner, sand shiner, plains killifish [*Fundulus zebrinus*]) following high flows. On the San Juan River, no evidence exists to support the hypothesis that high flows even temporarily disadvantage nonnatives and promote endangered fish reproduction and recruitment (Holden 1999). Strong year classes of Colorado pikeminnow have consistently occurred in 1–3 years following high runoff years, and have been attributed to cleansing of spawning gravels and short-term reduction in nonnative fishes (McAda and Ryel 1999). Hence, even a short-term reduction in nonnative fishes could allow increased survival and recruitment of native forms (Tyus and Saunders 1996). Flow recommendations include the provision of high flows, which provide these unsuitable conditions for nonnative fishes and may at least temporarily reduce numbers of these predators and competitors.

Active control programs should be implemented or continued (as needed) for problematic nonnative fishes in Colorado pikeminnow nursery habitats, northern pike in the Yampa and middle Green rivers, and channel catfish in river reaches occupied by Colorado pikeminnow. Guidance is not provided in this document with regard to target reduction levels because such criteria may be premature and unreasonable to achieve, or may be easily achieved and exceeded. Little is known with respect to responses by nonnative fish populations to overt control measures, and these must be evaluated as part of nonnative fish control programs. Another unknown aspect of nonnative fish control is the need to maintain control measures indefinitely or periodically over time. These decisions will have to be made from information gained through these control programs during the downlist monitoring period.

4.4 Listing Factor (D): The Inadequacy of Existing Regulatory Mechanisms

Implementation of regulatory mechanisms are necessary for recovery of the Colorado pikeminnow and to ensure long-term conservation of the species. Regulatory mechanisms affect many aspects of legal protection, such as habitat and flow protection, regulation and/or control of nonnative fishes, regulation of hazardous-materials spills, and angling regulations. Flow regimes to benefit Colorado pikeminnow populations must be identified, implemented, evaluated, and

revised (as necessary) before downlisting can occur (existing flow recommendations are described in section 4.1). By the time of delisting, legal protection of habitat (including flows) necessary to provide adequate habitat and sufficient range for all life stages of Colorado pikeminnow to support recovered populations must be accomplished through various means, including instream-flow appropriations, legal agreements, contracts, operating criteria, and/or other means. Additionally, certain States may issue policies that also afford flow protection. As examples, the State of Utah has instituted a policy that subordinates all future water-rights appropriations for the Green River from Flaming Gorge Dam to the Duchesne River confluence for the summer and autumn periods to provide flows to benefit the endangered fish; actions proposed under this policy would not affect pre-existing water rights (Utah Division of Water Rights 1994). Also, the State of Colorado has established two instream-flow rights on the Colorado River under its state instream-flow law.

Before delisting, the primary regulatory mechanism for protection of Colorado pikeminnow is through Section 7(a)(2) of the ESA, as administered by the Service. *"Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency... is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with affected States, to be critical..."* In the Upper Colorado River Basin, the UCRRP provides a mechanism for dealing with Section 7 consultations in a unified manner. The SJRRIP provides a similar consolidated effort for addressing Biological Opinions in the San Juan River, including Navajo Dam. Neither of these two programs are regulatory mechanisms that provide permanent, long-term protection for the species after delisting.

In addition to Federal protection under the ESA, Colorado pikeminnow are protected by all basin States under categories such as "endangered", "threatened", or "sensitive". This protection prohibits intentional take and keeping or harming in any way any fish captured incidentally, and may need to remain in place after the species is Federally delisted. However, the States do not address the major problem of habitat destruction, and especially streamflow modification. Most States have instream-flow laws that allow "beneficial use" of water left in streams for wildlife, but these laws typically only provide for flow that is the minimum amount necessary to maintain the fishery. With some States, there is also an inherent conflict between management of nonnative sport fish and recovery of endangered fishes. Where valued sport fisheries occur, there is an ongoing dilemma between public demands for maintenance and expansion of fisheries and management actions to conserve and recover endangered fish. There is no immediate solution to the dilemma, but predation by nonnative fishes is clearly identified as a cause for the decline of many of the native Colorado River fishes, and long-term agreements between States and the Service are essential.

After removal from the list of species protected by the ESA, the Colorado pikeminnow and its habitat will continue to receive consideration and some protection through the following Federal laws and related State statutes, and will need the provisions to protect habitat previously discussed. The National Environmental Policy Act (NEPA; 42 U.S.C. 4321–4370d) requires Federal agencies to evaluate the potential effects of their proposed actions on the quality of the

human environment and requires the preparation of an environmental impact statement whenever projects may result in significant impacts. Federal agencies must identify adverse environmental impacts of their proposed actions and develop alternatives that undergo the scrutiny of other public and private organizations as a part of their decision-making process. Recovery actions identified for Colorado pikeminnow are linked to federal actions, which must undergo review under NEPA.

Section 101(a) of the Federal Water Pollution Control Act (i.e., Clean Water Act; 33 U.S.C. 1251–13287) states that the objective of this law is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters and provide the means to assure that *"...protection and propagation of fish, shellfish, and wildlife..."*. This statute contributes in a significant way to the protection of the Colorado pikeminnow and its food supply through provisions for water quality standards, protection from the discharge of harmful pollutants, contaminants [Section 303(c), Section 304(a), and Section 402] and discharge of dredge or fill material into all waters, including certain wetlands (Section 404).

The Organic Act (16 USC 1, as amended) provides for management of National Park Service areas in such a manner *"...to promote and regulate the use of the...national parks...which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."* The National Park Service is the largest single jurisdictional land owner in reaches with critical and other occupied habitats for the four Colorado River endangered fishes (Maddux et al. 1993).

The Fish and Wildlife Coordination Act (16 U.S.C. 661–666c) requires that Federal agencies sponsoring, funding, or permitting activities related to water resource development projects request review of these actions by the Service and the State natural resource management agency. These comments must be given equal consideration with other project purposes. Also, the Federal Land Policy and Management Act (43 U.S.C. 1701–1784) requires that public lands be managed to protect the quality of scientific, ecological, and environmental qualities and preserve and protect certain lands in their natural conditions to provide food and habitat for fish and wildlife.

Hazardous-materials spills are identified as a threat to Colorado pikeminnow. Although the States of Colorado, Utah, and New Mexico, where the species occurs, have state-wide hazardous-materials plans, these may not be adequate to provide protection against spills into the river. Research into the adequacy of these plans is identified as a recovery element. Hazardous-materials spills are regulated by the Hazardous Materials and Waste Management Division of the Colorado Department of Public Health and Environment; the Hazardous Waste Branch of the Utah Department of Environmental Quality; and the New Mexico Department of Environment.

The need for conservation plans and agreements was identified to provide reasonable assurances that recovered Colorado pikeminnow populations will be maintained. These plans are to be implemented after delisting and are intended to assure that relisting does not become necessary. They would be developed to ensure long-term management and protection of the species, and

should include (but not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.

4.5 Listing Factor (E): Other Natural or Manmade Factors Affecting Its Continued Existence

4.5.1 Pesticides and pollutants

The potential role of pesticides and pollutants in suppressing populations of Colorado pikeminnow is not well understood. Pesticides find their way to the Colorado River from agricultural runoff, and other pollutants in the system include petroleum products, heavy metals (e.g., mercury, lead, zine, copper), nonmetals (i.e., selenium), and radionucleides.

Potential spills of petroleum products threaten wild populations of Colorado pikeminnow. For example, numerous petroleum-product pipelines cross or parallel the Yampa River upstream of Yampa Canyon, most of which lack emergency shut-off valves. One pipe ruptured in the late 1980's releasing refined oil into the Yampa River during the spawning period for Colorado pikeminnow.

All States have hazardous-materials spills emergency-response plans that provide a quick cleanup response to accidental spills (see section 4.4). These responses may not be sufficiently rapid to minimize deleterious effects to fishes, especially a species like the Colorado pikeminnow with site-specific spawning areas. Quick response may, therefore, be inadequate to protect the species and preventive measures must be incorporated into these plans. These preventive measures may include safety shut-off valves on petroleum-products lines in or near the floodplain and filtration systems in case of accidental spills of hazardous materials at bridge crossings above occupied habitats. Identifying and implementing the most reasonable and prudent preventive measures will require a comprehensive review of existing State and Federal hazardous-materials spills emergency-response plans. These preventive measures must be implemented before delisting.

Another cause of degraded water quality is the Atlas Mills tailings pile located on the north bank of the Colorado River near Moab, Utah. In 1998, the Service determined in a final biological opinion that this pile *"...is likely to jeopardize the continued existence of..."* the Colorado pikeminnow and razorback sucker. This biological opinion was withdrawn on February 8, 2001, because of refusal by the Nuclear Regulatory Commission to reinitiate consultation. Section 3405 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (P.L. 106-398) requires that the Atlas Mills tailings site be transferred to the Department of Energy for remediation. Congress authorized $300 million for clean-up of the Atlas Mills tailings pile. Remediation is outside of the purview of the UCRRP.

There are two significant threats to endangered fish posed by the Atlas Mills tailings pile. The first is from toxic discharges of pollutants, particularly ammonia, through groundwater to the Colorado River. The second is the risk of catastrophic pile failure, that could bury important nursery areas and destroy other fish habitat. To address the threats posed by the discharge of toxic pollution, whether tailings are reclaimed on site or removed to another location, the groundwater must be cleaned up to the extent necessary to prevent the discharge of ammonia, uranium, and other toxic pollutants into the Colorado River and meet the State of Utah surface-water and groundwater quality standards for fish and wildlife. To assess whether such clean-up has occurred, groundwater-system compliance and measuring points must be established.

Selenium is hypothesized as contributing to the decline of the endangered fishes of the Colorado River Basin (U.S. Fish and Wildlife memorandum, December 22, 1998). It is a water-quality factor that may inhibit recovery by adversely affecting reproduction and recruitment (Hamilton and Wiedmeyer 1990; Stephens et al. 1992; Hamilton and Waddell 1994; Hamilton et al. 1996; Stephens and Waddell 1998; Osmundson et al. 2000a). Selenium concentrations in certain areas of the basin (e.g., Green River near Jensen, Utah; Gunnison River downstream from the Uncompahgre River confluence; and upper Colorado River downstream from Palisade, Colorado) exceed those shown to impact fish and wildlife elsewhere, and, although results are inconclusive as to exposure thresholds that cause specific effects, some studies suggest deleterious effects on Colorado pikeminnow and razorback sucker. The National Irrigation Water Quality Program is addressing selenium issues in the upper basin by implementing remediation projects to reduce selenium levels in areas of critical habitat. The adverse effects of selenium contamination on Colorado pikeminnow reproduction and survival of young will be reevaluated before downlisting and necessary protection will be implemented before delisting.

5.0 RECOVERY GOALS

The following are site-specific management actions and objective, measurable recovery criteria for the Colorado pikeminnow presented for the Upper Colorado River Basin (including the Green River, upper Colorado River, and San Juan River subbasins). The need for self-sustaining populations in the lower basin and associated site-specific management actions/tasks necessary to minimize or remove threats will be reevaluated at the status review of the species. The Colorado pikeminnow was listed prior to the 1996 DPS policy, and the Service may conduct an evaluation to designate DPSs in a future rule-making process if, in the future, lower basin populations are determined necessary for recovery. Provisional site-specific management actions/tasks and objective, measurable recovery criteria for the lower basin are presented in Appendix B as guidelines for conservation efforts (e.g., nonessential, experimental populations; see section 3.1.2).

Steps for downlisting and delisting presented in this section are consistent with provisions specified under Section 4(a)(1), Section 4(b), Section 4(c)(2)(B), and Section 4(f)(1) of the ESA (see section 2.0 of this document). The five recovery factors (i.e., Factor A, Factor B, etc.) were derived from the five listing factors (see section 2.1) and state the conditions under which threats are minimized or removed. For each recovery factor, management actions and tasks are

identified that minimize or remove threats to the Colorado pikeminnow. Under objective, measurable recovery criteria, demographic criteria and recovery factor criteria are presented for downlisting and delisting. Generally, for each downlisting criterion there is a corresponding delisting criterion. Reclassification can be considered when appropriate recovery criteria are met.

5.1 Requirements and Uncertainties Associated with Recovery Goals

5.1.1 Demographic criteria and monitoring

Demographic criteria that describe numbers of subbasin populations and individuals (adults and juveniles) for downlisting and delisting are presented for the Upper Colorado River Basin. These criteria specify maintenance of a metapopulation, based on requirements of no significant decline in numbers of adults for each population and recruitment equal to or exceeding adult mortality. To maintain the metapopulation, these criteria require a genetically and demographically viable, self-sustaining population in the Green River subbasin; and self-sustaining populations that meet or exceed estimated carrying capacity either in only the upper Colorado River subbasin, or in both the upper Colorado River subbasin and San Juan River subbasin.

Wild populations of Colorado pikeminnow have been studied since the 1960's, and population dynamics and responses to management actions have been evaluated since the early 1980's. A 5-year monitoring period is required for downlisting, and a 7-year monitoring period beyond downlisting is required for delisting. The downlist monitoring period begins with the first reliable estimates for all populations acceptable to the Service. The downlist and delist monitoring periods are expected to be continuous, and reclassification cannot be considered until each population has been monitored for the required period of time. The total 12-year monitoring period is equivalent to approximately one generation time for Colorado pikeminnow, and is considered sufficient to determine if populations are stable, increasing, or decreasing. Generation time is equal to the mean adult age and is computed as the average age of attaining sexual maturity; i.e., $age_{sex\ maturity}$ plus (1/d), where d is equal to death rate (Seber 1982; Gilpin 1993). For Colorado pikeminnow, the age of attaining sexual maturity is 5 years and the adult survival rate is 0.85 (d=1-0.85); hence, generation time is 5 + [1/(1-0.85)] = 5 + 7 = 12. It is important to note that under Section 4(g)(1) of the ESA, *"The Secretary shall implement a system in cooperation with the States to monitor effectively for not less than five years the status of all species which have recovered to the point at which the measures provided pursuant to this Act are no longer necessary..."*. Hence, populations would be monitored for at least 5 additional years after delisting.

The Service considers a reliable estimate as one that is based on a multiple mark-recapture model. Direct enumeration of fish populations is not feasible in turbid rivers, and removal estimates are unreliable because of the difficulty of blocking reaches of large rivers to meet the model assumption of no migration. Instead, closed-population, multiple mark-recapture estimators (Otis et al. 1978; Burnham et al. 1987; Chao 1989; Osmundson and Burnham 1998) are recommended for deriving population point estimates and to guide development of sampling

designs that conform to these models. The accuracy and precision of each point estimate will be assessed by the Service in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting the point estimates and with qualified statisticians and population ecologists. If, for example, an estimate is made that is considered unreliable (i.e., lacks precision and accuracy) because of poor sampling conditions or other causes, a determination will be made if an additional estimate is needed in the following year in order to accurately assess if downlisting or delisting criteria are met. Field sampling methodologies should be developed and refined to attain a balance between the need for accurate and precise population estimates while minimizing stress to fish from excessive handling.

Monitoring must be designed to determine if the demographic criteria are being met. At least three point estimates are needed for each of the Colorado pikeminnow populations to downlist, and at least five more estimates are needed to delist. Point estimates should be made in each of 3 consecutive years with 1–2 years between blocks of estimates. In order to ensure no net loss in each population, the trend in adult (age 7+; ≥450 mm TL; see section A.8) point estimates cannot decline significantly; i.e., slope is not significantly less than zero over the trend period ($p \leq 0.05$), requiring that the population is either stable or increasing during the monitoring period. Also, mean estimated recruitment of age-6 (400–449 mm TL; see section A.8) naturally produced fish in each population must equal or exceed mean annual adult mortality (i.e., ≥15%). This criterion requires that each population is reproducing, recruiting, and self-sustaining. To meet the requirement of a genetically and demographically viable, self-sustaining population in the Green River subbasin, each population point estimate must exceed 2,600 adults (MVP; see section 3.3.2). In addition to the demographic criteria, adequate habitat and sufficient range are required to support recovered populations. Recovery goals require maintenance of populations within areas of designated critical habitat (59 FR 13374).

5.1.2 Recovery factor criteria

The recovery factor criteria are directly linked to management actions/tasks. Recovery factor criteria for downlisting generally call for identification, implementation, evaluation, and revision of management tasks. Corresponding criteria for delisting call for attainment of necessary and feasible levels of protection that minimize or remove threats.

Each of the four threats identified in section 4.0 (i.e., streamflow regulation, habitat modification, competition with and predation by nonnative fishes, and pesticides and pollutants) is addressed in this section with appropriate management actions/tasks. Details of these and other management actions/tasks that contribute to recovery are or will be identified in the RIPRAP of the UCRRP and Annual Work Plan of the SJRRIP. These programs function under the general principles of adaptive management, and the plans are periodically revised. In the context of these programs, adaptive management is the process by which management actions are identified, implemented, evaluated, and revised based on results of research and monitoring.

Providing and legally protecting habitat are necessary elements in recovery of the Colorado pikeminnow. Habitat as used in these recovery goals is defined as the physical and biological components of the environment required for recovery of the species, including flow regimes

necessary to restore and maintain those environmental conditions. Hence, identification, implementation, evaluation, and revision of adequate flow regimes through adaptive management are identified as criteria necessary for downlisting. By the time of delisting, flows (as well other habitat components) identified as necessary to the life history of the species must be provided and legally protected through various means, including instream-flow appropriations, legal agreements, contracts, operating criteria, and/or other means. As stated in the governing documents of the UCRRP and the SJRRIP, under these programs legal protection of flows referenced in these recovery goals for upper basin rivers and the San Juan River will be consistent with State and Federal laws related to the Colorado River system (sometimes referred to as "Law of the River"), including State water law, interstate compacts, and Federal trust responsibilities to American Indian tribes. It is recognized that flow management alone is not sufficient to ensure self-sustaining populations of the endangered fishes, and that a combination of flow and non-flow management actions will be necessary for recovery. It is anticipated that flow management actions identified in these recovery goals can be achieved in balance with non-flow management actions to improve ecosystem conditions and enhance recovery and sustainability of the endangered fish populations. Population and demographic data collected through monitoring will be used to track progress toward meeting the habitat needs of the species.

Implementation of conservation plans is required in order to provide for the long-term management and protection of Colorado pikeminnow populations after delisting. These conservation plans will be developed and implemented through agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties, and may include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats.

Use of hatchery fish (progeny of cultured broodstock) may be necessary to expand or augment existing populations of Colorado pikeminnow. Provisions and recommendations of the UCRRP Genetics Management Plan (Czapla 1999) and the Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act (65 FR 56916) should be used as guidelines for use of hatchery fish in recovery. The UCRRP is revising a facilities-needs plan based on revised State stocking plans.

5.1.3 Uncertainties

These recovery goals are based on the best available scientific information, and are structured to attain a balance between reasonably achievable criteria (which include an acceptable level of uncertainty) and ensuring the viability of the species beyond delisting. It is expected that research, management, and monitoring activities directed by the UCRRP and SJRRIP will fill information gaps and considerably narrow, if not eliminate, many of the uncertainties that affect recovery criteria. Additional data and improved understanding of Colorado pikeminnow biology may prompt future revision of these recovery goals. The Service intends to review, and revise as needed, these recovery goals at least once every 5 years from the date of their publication in the *Federal Register*, or as necessary when sufficient new information warrants a change in the

recovery criteria. Review of these recovery goals will be part of the review of listed species as required by Section 4(c)(2)(A) of the ESA, *"The Secretary shall ... conduct, at least once every five years, a review of all species..."*. Uncertainties associated with these recovery goals include:

- Demographic Viability. The level of exchange of individuals between the San Juan River and populations in the Green River and upper Colorado River subbasins is unknown.
- Carrying Capacity. Inferences about carrying capacity for some Colorado pikeminnow populations have been largely drawn from recent population estimates, information on condition factor and forage base, and analyses of thermal regimes. However, the information is preliminary and hypotheses associated with carrying capacity have yet to be fully tested.
- Genetic Viability. Although determination of genetic effective population size (N_e) was based on principles in conservation genetics (i.e., "50/500 rule"), genetic information on Colorado pikeminnow was insufficient to derive a species-specific value of N_e and a ratio of N_e/N_g.
- Flow and Temperature Recommendations. Flow and temperature recommendations have been developed that specifically consider flow-habitat relationships in habitats occupied by Colorado pikeminnow. However, it is uncertain to what extent these recommendations can be met and what flow regimes will be necessary to meet the life history needs of the Colorado pikeminnow. Streamflow reduction and modification from dams and water withdrawal systems have reduced spatial and temporal variability in flow regimes, reduced available habitat, and changed ecosystem function and structure. A paradigm in river management suggests that the ecological integrity of river ecosystems is linked to their natural dynamic character (Stanford et al. 1996; Poff et al. 1997), and restoring a more natural flow regime is the cornerstone of river restoration. This paradigm and the response by endangered fishes of the Colorado River Basin is largely untested, and as these flow regimes to benefit the endangered fishes are implemented, it is important to be aware of associated uncertainties and plan for management of unanticipated results. Response of Colorado pikeminnow to flows will need to be monitored in order to identify and provide flow regimes that are necessary to restore and maintain adequate habitat and sufficient range for all life stages.
- Nonnative Fish Response. Uncertainty exists regarding the responses of nonnative fishes to active control measures and to flow regimes to benefit the endangered fishes. Many of these nonnative fishes, both warm-water and cold-water, prey on and compete with native fishes. There are indications that high spring flows have a negative effect on nonnative fishes, but the overall response of nonnative fish populations to flow recommendations is uncertain. Long-term response by nonnative fishes to mechanical removal is also an uncertainty. It is unknown if reduction in numbers of nonnatives will result in lower population numbers, altered age structure, or opening of niches for new or existing nonnative fishes. It is also unknown if reduction in nonnative fishes will result in increased numbers of native fishes.

- Efficacy of Monitoring Programs. The precision and reliability of long-term monitoring programs to accurately measure the response of Colorado pikeminnow populations to management actions is an uncertainty. Mark-recapture population estimates may reflect high variability because of population variability and/or sampling variability. This variability in estimates may exceed the level of population response to a management action, masking measurement of short-term responses and cause-effect relationships. Demographic criteria proposed in this document attempt to account for this variability and set numbers that are measurable under current conditions.
- Establishing Self-Sustaining Populations. Hatchery fish may be used to expand or augment existing populations. The survival, recruitment, and reproductive success of these fish in the wild is uncertain. This uncertainty is greater in rivers or river reaches that have been extensively modified.
- Response to Management Actions. Management actions, such as regulation of escapement of nonnative fishes, control of nonnative fishes, and minimization of the risk of hazardous-materials spills, may vary in their effectiveness to benefit Colorado pikeminnow. Tasks and recovery criteria associated with each of these management actions are intended to provide some measure of success before reclassification can occur.

5.2 Site-Specific Management Actions and Tasks by Recovery Factor

5.2.1 Factor A.—Adequate habitat and range for recovered populations provided

Management Action A-1.—Provide flows necessary for all life stages of Colorado pikeminnow to support recovered populations, based on demographic criteria.

Task A-1.1.—Identify, implement, evaluate, and revise (as necessary through adaptive management) flow regimes to benefit Colorado pikeminnow populations in the Green River, upper Colorado River, and San Juan River subbasins (see section 4.1 for discussion of existing flow recommendations to benefit the endangered fishes and for discussion of Colorado pikeminnow flow-habitat requirements; see Appendix A for a synopsis of Colorado pikeminnow life history).

Task A-1.2.—Provide flow regimes (as determined under Task A-1.1) that are necessary for all life stages of Colorado pikeminnow to support recovered populations in the Green River, upper Colorado River, and San Juan River subbasins.

Management Action A-2.—Provide passage for Colorado pikeminnow within occupied habitat to allow adequate movement and, potentially, range expansion.

Task A-2.1.—Continue to provide fish passage over Redlands Diversion and Grand Valley Diversion to allow adequate movement of Colorado pikeminnow in the upper Colorado River and Gunnison River (see section 4.1 for a discussion on barriers to fish passage).

Task A-2.2.—Modify Price-Stubb Dam and Government Highline Dam to allow adequate movement of Colorado pikeminnow in the upper Colorado River.

Task A-2.3.—Identify, evaluate, and modify (as necessary) barriers on the San Juan River (e.g., Cudei Diversion and Hogback Diversion) to allow adequate movement of Colorado pikeminnow.

Management Action A-3.—Investigate options for providing appropriate water temperatures in the Gunnison River that would allow for range expansion of Colorado pikeminnow.

Task A-3.1.—Investigate the feasibility of modifying releases from Aspinall Unit dams to increase water temperatures in the Gunnison River that would allow for upstream range expansion of Colorado pikeminnow in the Gunnison River (see section 4.1 for discussion on warm-water releases).

Task A-3.2.—Modify releases from Aspinall Unit dams to increase water temperatures in the Gunnison River, if determined feasible and necessary to achieve demographic criteria for the upper Colorado River subbasin (see section 5.3.2.1.2).

Management Action A-4.—Minimize entrainment of subadult and adult Colorado pikeminnow in diversion canals.

Task A-4.1.—Identify measures (e.g., screens, baffles) to minimize entrainment of subadult and adult Colorado pikeminnow at problematic diversion structures, such as the Green River Canal, Grand Valley Irrigation Canal, Government Highline Diversion Project, and the Redlands Canal Company Diversion (see section 4.1 for discussion on entrainment).

Task A-4.2.—Install devices and/or implement other measures (as determined under Task A-4.1) to minimize entrainment.

5.2.2 Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes

Management Action B-1.—Protect Colorado pikeminnow populations from overutilization for commercial, recreational, scientific, or educational purposes.

Task B-1.1.—Reevaluate and, if necessary, identify actions to ensure adequate protection from overutilization of Colorado pikeminnow for commercial, recreational, scientific, or educational purposes; not currently identified as an existing threat (see section 4.2).

Task B-1.2.—Implement identified actions (as determined under Task B-1.1) to ensure adequate protection of Colorado pikeminnow populations from overutilization for commercial, recreational, scientific, or educational purposes.

5.2.3 Factor C.—Adequate protection from diseases and predation

Management Action C-1.—Minimize adverse effects of diseases and parasites on Colorado pikeminnow populations.

Task C-1.1.—Reevaluate and, if necessary, identify actions to minimize adverse effects of diseases and parasites on Colorado pikeminnow populations; not currently identified as an existing threat (see sections 4.3.1 and A.11 for discussion of diseases and parasites).

Task C-1.2.—Implement identified actions (as determined under Task C-1.1) to ensure adequate protection of Colorado pikeminnow populations from deleterious diseases and parasites.

Management Action C-2.—Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.

Task C-2.1.—Develop, implement, evaluate, and revise (as necessary through adaptive management) procedures for stocking nonnative fish species in the Upper Colorado River Basin (including the San Juan River subbasin) to minimize negative interactions between nonnative fishes and Colorado pikeminnow (see sections 4.3.2 and A.7 for discussion of effects of nonnative fishes).

Task C-2.2.—Finalize and implement procedures (as determined under Task C-2.1) for stocking nonnative fish species in the Upper Colorado River Basin to minimize negative interactions between nonnative fishes and Colorado pikeminnow.

Management Action C-3.—Control problematic nonnative fishes as needed.

Task C-3.1.—Develop control programs for small-bodied nonnative fishes (e.g., cyprinids and centrarchids) in backwater nursery habitats in river reaches occupied by young Colorado pikeminnow to identify levels of control that will minimize negative interactions (e.g., competition and predation; see sections 4.3.2 and A.7 discussion of effects of nonnative fishes).

Task C-3.2.—Implement identified levels (as determined under Task C-3.1) of nonnative fish control in backwater nursery habitats in river reaches occupied by young Colorado pikeminnow.

Task C-3.3.—Develop channel catfish control programs in river reaches occupied by Colorado pikeminnow to identify levels of control that will minimize negative interactions.

Task C-3.4.—Implement identified levels (as determined under Task C-3.3) of channel catfish control in river reaches occupied by Colorado pikeminnow.

Task C-3.5.—Develop northern pike control programs in reaches of the Yampa and middle Green rivers occupied by Colorado pikeminnow to identify levels of control that will minimize negative interactions.

Task C-3.6.—Implement identified levels (as determined under Task C-3.5) of northern pike control in reaches of the Yampa and middle Green rivers occupied by Colorado pikeminnow.

5.2.4 Factor D.—Adequate existing regulatory mechanisms

Management Action D-1.—Legally protect habitat (see definition of habitat in section 5.1.2) necessary to provide adequate habitat and sufficient range for all life stages of Colorado pikeminnow to support recovered populations, based on demographic criteria.

Task D-1.1.—Determine mechanisms for legal protection of adequate habitat through instream-flow rights, contracts, agreements, or other means (see section 4.4 for discussion of regulatory mechanisms).

Task D-1.2.—Implement mechanisms for legal protection of habitat (as determined under Task D-1.1) that are necessary to provide adequate habitat and sufficient range for all life stages of Colorado pikeminnow to support recovered populations.

Management Action D-2.—Provide for the long-term management and protection of Colorado pikeminnow populations and their habitats.

Task D-2.1.—Identify elements needed for the development of conservation plans that are necessary to provide for the long-term management and protection of Colorado pikeminnow populations; elements of these plans may include (but are not limited to) provision of flows for maintenance of adequate habitat conditions for all life stages of Colorado pikeminnow, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats (see section 4.4 for discussion of need for conservation plans).

Task D-2.2.—Develop and implement conservation plans and execute agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties to provide reasonable assurances that conditions needed for recovered Colorado pikeminnow populations will be maintained.

5.2.5 Factor E.—Other natural or manmade factors for which protection has been provided

Management Action E-1.—Minimize the risk of hazardous-materials spills in critical habitat.

Task E-1.1.—Review and recommend modifications to State and Federal hazardous-materials spills emergency-response plans to ensure adequate protection for Colorado pikeminnow populations from hazardous-materials spills, including prevention and quick response to hazardous-materials spills (see section 4.5.1 for discussion of hazardous-materials spills).

Task E-1.2.—Implement State and Federal emergency-response plans that contain the necessary preventive measures (as determined under Task E-1.1) for hazardous-materials spills.

Task E-1.3.—Identify locations of all petroleum-product pipelines within the 100-year floodplain of critical habitat and assess the need for emergency shut-off valves to minimize the potential for spills.

Task E-1.4.—Install emergency shut-off valves (as determined under Task E-1.3) on problematic petroleum-product pipelines within the 100-year floodplain of critical habitat.

Management Action E-2.—Minimize threats from degraded water quality on Colorado pikeminnow.

Task E-2.1.—Identify actions to remediate groundwater contamination from the Atlas Mills tailings pile located near Moab, Utah, in order to restore water quality of the Colorado River in the vicinity of the pile in accordance with the State of Utah and Environmental Protection Agency (EPA) water-quality standards for fish and wildlife (see section 4.5.1 for discussion of groundwater contamination).

Task E-2.2.—Implement actions (as determined under Task E-2.1) to remediate groundwater contamination from the Atlas Mills tailings pile.

Management Action E-3.—Minimize adverse effects of selenium contamination on Colorado pikeminnow reproductive success and survival of young and reduce deleterious levels of selenium contamination, if necessary.

Task E-3.1.—Reevaluate the effects of selenium contamination on Colorado pikeminnow reproductive success and survival of young, and, if necessary, identify actions to reduce deleterious levels of selenium contamination (see section 4.5.1 for discussion of selenium effects).

Task E-3.2.—Implement identified actions (as determined under Task E-3.1) to reduce deleterious levels of selenium contamination.

5.3 Objective, Measurable Recovery Criteria

5.3.1 Downlist criteria

5.3.1.1 Demographic criteria for downlisting (population demographics in all subbasins must be met in order to achieve downlisting)

5.3.1.1.1 Green River Subbasin

1. A self-sustaining population is maintained over a 5-year period, starting with the first point estimates acceptable to the Service, such that:

    a. the trends in separate adult (age 7+; ≥450 mm TL) point estimates for the middle Green River and the lower Green River do not decline significantly, and

    b. mean estimated recruitment of age-6 (400–449 mm TL) naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and

c. each population point estimate for the Green River subbasin exceeds 2,600 adults (Note: 2,600 adults is the estimated MVP number; see section 3.3.2).

5.3.1.1.2 Upper Colorado River Subbasin

1. A self-sustaining population of at least 700 adults (number based on inferences about carrying capacity) is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that:

    a. the trend in adult (age 7+; ≥450 mm TL) point estimates does not decline significantly, and

    b. mean estimated recruitment of age-6 (400–449 mm TL) naturally produced fish equals or exceeds mean annual adult mortality.

5.3.1.1.3 San Juan River Subbasin

1. A target of 1,000 age-5+ fish (≥300 mm TL; number based on estimated survival of stocked fish and inferences about carrying capacity) is established through augmentation and/or natural reproduction.

5.3.1.2 Recovery factor criteria for downlisting

Factor A.—Adequate habitat and range for recovered populations provided.

1. Flow regimes to benefit Colorado pikeminnow populations in the Green River, upper Colorado River, and San Juan River subbasins identified, implemented, evaluated, and revised (Task A-1.1), such that:

    a. Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.

    b. Adequate nursery habitat is available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.

    c. Adequate juvenile and adult habitat (e.g., cover, resting, and feeding areas) is available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.

2. Passage over Redlands Diversion and Grand Valley Diversion continued to allow adequate movement of Colorado pikeminnow in the upper Colorado River and Gunnison River (Task A-2.1).

3. Modification of Price-Stubb Dam and Government Highline Dam initiated to allow adequate movement of Colorado pikeminnow in the upper Colorado River (Task A-2.2).

4. Barriers on the San Juan River identified and evaluated, and modifications initiated to allow adequate movement of Colorado pikeminnow (Task A-2.3).

5. Investigations initiated on the feasibility of modifying releases from Aspinall Unit dams to increase water temperatures in the Gunnison River that would allow for upstream range expansion of Colorado pikeminnow (Task A-3.1).

6. Measures identified to minimize entrainment of subadult and adult Colorado pikeminnow at problematic diversion structures (Task A-4.1).

Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes.

7. Overutilization of Colorado pikeminnow for commercial, recreational, scientific, or educational purposes reevaluated and, if necessary, actions identified to ensure adequate protection (Task B-1.1).

Factor C.—Adequate protection from diseases and predation.

8. Effects of diseases and parasites on Colorado pikeminnow populations reevaluated and, if necessary, actions identified to ensure adequate protection (Task C-1.1).

9. Procedures developed, implemented, evaluated, and revised for stocking nonnative fish species in the Upper Colorado River Basin (including the San Juan River subbasin) to minimize negative interactions between nonnative fishes and Colorado pikeminnow (Task C-2.1).

10. Control programs for small-bodied nonnative fishes in backwater nursery habitats in river reaches occupied by young Colorado pikeminnow developed and implemented to identify levels of control that will minimize negative interactions (Task C-3.1).

11. Channel catfish control programs in river reaches occupied by Colorado pikeminnow developed and implemented to identify levels of control that will minimize negative interactions (Task C-3.3).

12. Northern pike control programs in reaches of the Yampa and middle Green rivers occupied by Colorado pikeminnow developed and implemented to identify levels of control that will minimize negative interactions (Task C-3.5).

Factor D.—Adequate existing regulatory mechanisms.

13. Mechanisms determined for legal protection of adequate habitat (Task D-1.1).

14. Elements of conservation plans identified that are necessary to provide for the long-term management and protection of Colorado pikeminnow populations (Task D-2.1).

Factor E.—Other natural or manmade factors for which protection has been provided.

15. State and Federal hazardous-materials spills emergency-response plans reviewed and modified to ensure adequate protection for Colorado pikeminnow populations from hazardous-materials spills (Task E-1.1).

16. Locations of all petroleum-product pipelines within the 100-year floodplain of critical habitat identified and the need for emergency shut-off valves assessed (Task E-1.3).

17. Actions identified for remediation of groundwater contamination at the Atlas Mills tailings pile located near Moab, Utah (Task E-2.1).

18. Effects of selenium contamination on Colorado pikeminnow reproductive success and survival of young reevaluated and, if necessary, actions identified to reduce deleterious levels of selenium contamination (Task E-3.1).

5.3.2 Delist criteria

5.3.2.1 Demographic criteria for delisting (population demographics in all subbasins must be met in order to achieve delisting)

5.3.2.1.1 Green River Subbasin

1. A self-sustaining population is maintained over a 7-year period beyond downlisting, starting with the first point estimates acceptable to the Service, such that:

    a. the trends in separate adult (age 7+; ≥450 mm TL) point estimates for the middle Green River and the lower Green River do not decline significantly, and

    b. mean estimated recruitment of age-6 (400–449 mm TL) naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and

    c. each population point estimate for the Green River subbasin exceeds 2,600 adults (MVP).

5.3.2.1.2 Upper Colorado River and San Juan River Subbasins

1. One of the following must be met over a 7-year period beyond downlisting, starting with the first point estimate acceptable to the Service:

    A self-sustaining population that exceeds 1,000 adults (age 7+; ≥450 mm TL) is maintained in the upper Colorado River subbasin **OR** a self-sustaining population that exceeds 700 adults is maintained in the upper Colorado River subbasin and a self-sustaining population that exceeds 800 adults is maintained in the San Juan River subbasin, such that for each population (numbers of adults based on inferences about carrying capacity):

    a. the trend in adult point estimates does not decline significantly, and

    b. mean estimated recruitment of age-6 (400–449 mm TL) naturally produced fish equals or exceeds mean annual adult mortality.

5.3.2.2 Recovery factor criteria for delisting

Factor A.—Adequate habitat and range for recovered populations provided.

1. Flow regimes provided that are necessary for all life stages of Colorado pikeminnow to support recovered populations in the upper Colorado River, Green River, and San Juan River subbasins (Task A-1.2), such that:

    a. Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.

    b. Adequate nursery habitat is available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.

    c. Adequate juvenile and adult habitat (e.g., cover, resting, and feeding areas) is available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.

2. Passage over Redlands Diversion and Grand Valley Diversion continued to allow adequate movement of Colorado pikeminnow in the upper Colorado River and Gunnison River (Task A-2.1).

3. Modification of Price-Stubb Dam and Government Highline Dam completed to allow adequate movement of Colorado pikeminnow in the upper Colorado River (Task A-2.2).

4. Barriers on the San Juan River modified to allow adequate movement of Colorado pikeminnow (Task A-2.3).

5. Releases from Aspinall Unit dams to increase water temperatures in the Gunnison River are modified, if determined feasible and necessary to achieve demographic criteria for the upper Colorado River subbasin (see section 5.3.2.1.2) to allow for upstream range expansion of Colorado pikeminnow (Task A-3.2).

6. Devices installed and/or measures implemented at problematic diversion structures to minimize entrainment of subadult and adult Colorado pikeminnow (Task A-4.2).

Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes.

7. Adequate protection of Colorado pikeminnow populations from overutilization for commercial, recreational, scientific, or educational purposes attained (Task B-1.2).

Factor C.—Adequate protection from diseases and predation.

8. Adequate protection of Colorado pikeminnow populations from deleterious diseases and parasites attained (Task C-1.2).

9. Procedures finalized and implemented for stocking nonnative fish species in the Upper Colorado River Basin to minimize negative interactions between nonnative fishes and Colorado pikeminnow (Task C-2.2).

10. Identified levels of nonnative fish control to minimize negative interactions attained in backwater nursery habitats in river reaches occupied by young Colorado pikeminnow (Task C-3.2).

11. Identified levels of channel catfish control to minimize negative interactions attained in river reaches occupied by Colorado pikeminnow (Task C-3.4).

12. Identified levels of northern pike control to minimize negative interactions attained in reaches of the Yampa and middle Green rivers occupied by Colorado pikeminnow (Task C-3.6).

Factor D.—Adequate existing regulatory mechanisms.

13. Habitat necessary to provide adequate habitat and sufficient range for all life stages of Colorado pikeminnow to support recovered populations in the Green River, upper Colorado River, and San Juan River subbasins is legally protected in perpetuity (Task D-1.2).

14. Conservation plans developed and implemented, and agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties executed to provide reasonable assurances that conditions needed for recovered Colorado pikeminnow populations will be maintained (Task D-2.2).

Factor E.—Other natural or manmade factors for which protection has been provided.

15. State and Federal emergency-response plans implemented that contain the necessary preventive measures for hazardous-materials spills (Task E-1.2).

16. Emergency shut-off valves installed on all problematic petroleum-product pipelines within the 100-year floodplain of critical habitat (Task E-1.4).

17. Groundwater contamination remediated at the Atlas Mills tailings pile located near Moab, Utah, and water quality of the Colorado River in the vicinity of the pile restored in compliance with the State of Utah and EPA water-quality standards for fish and wildlife (Task E-2.2).

18. Deleterious levels of selenium contamination reduced to minimize adverse effects on Colorado pikeminnow reproductive success and survival of young (Task E-3.2).

5.4 Estimated Time to Achieve Recovery of the Colorado Pikeminnow

Estimated time to achieve recovery of the Colorado pikeminnow is 5 years for downlisting and an additional 7 years for delisting. First point estimates were completed for all populations in 2001. The Service is reviewing those estimates for reliability, and, if they are accepted by the Service and all recovery criteria are met, downlisting could be proposed in 2006 and delisting could be proposed in 2013 (Figure 4). This estimated time frame is based on current understanding of the status and trends of populations and on the monitoring time required to meet the downlisting and delisting criteria.

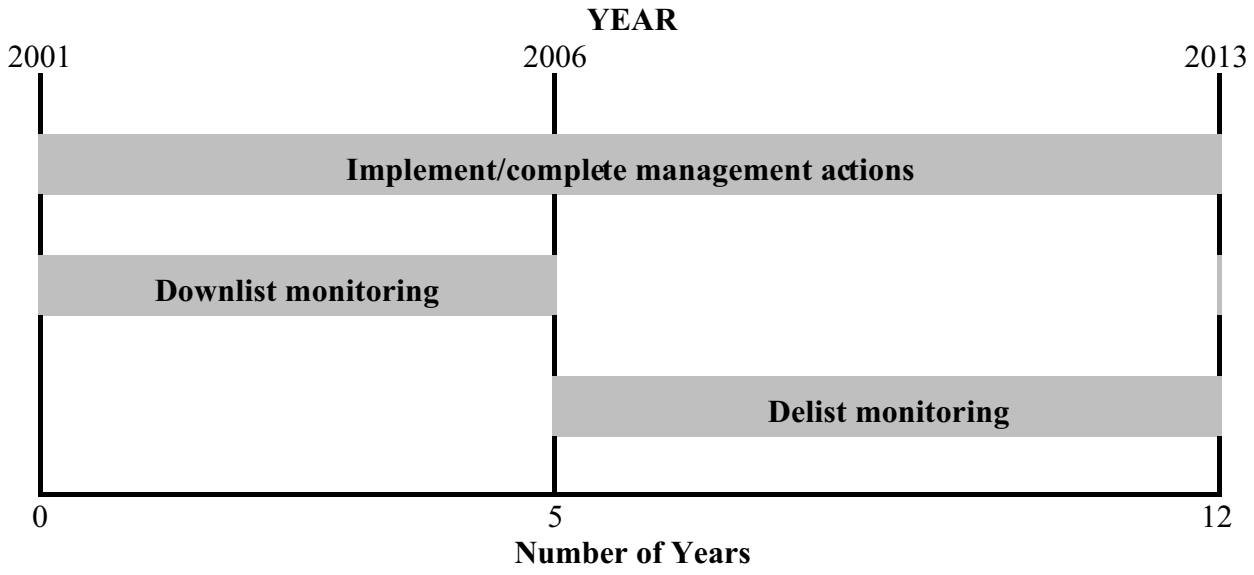

Figure 4. Estimated time to achieve recovery of the Colorado pikeminnow.

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