U.S. Fish and Wildlife Service
Great Meadows National Wildlife Refuge
Concord Impoundments

Proposal to Maintain Ditches and Create Freshwater Refugia

Introduction:

Great Meadows National Wildlife Refuge (Refuge) is part of the National Wildlife Refuge System administered by the U.S. Fish and Wildlife Service. The Refuge was established in 1944, "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds", 16 U.S.C.§ 715d (Migratory Bird Conservation Act); and for purposes, "...suitable for (1) incidental fish and wildlife-oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species...",16 U.S.C. § 460k-1 (Refuge Recreation Act). The Concord Unit of Great Meadows Refuge includes two, 100-acre impoundments located adjacent to the Concord River off Monsen Road, referred to as the Concord Impoundments.

The primary objectives included in this project proposal are to: (1) perform maintenance cleaning of the drainage ditches in the two Concord Impoundments, (2) clean an existing refugia which will hold water during impoundment drawdowns and (3) create a total of four new (two within each impoundment) "refugia" to provide additional flooded habitat during drawdowns.

We are requesting a 5-year permit to successfully meet these objectives. The USFWS previously submitted a proposal for these objectives in July 2008 but the project proposal was withdrawn in early September 2008 following concerns expressed by the Massachusetts Natural Heritage and Endangered Species Program and the Concord Conservation Commission. Some concerns extend beyond the details of short-term work necessary to meet these objectives, to long-term management priorities and water level management. Therefore, we have included information in this proposal which addresses short- and long-term management concerns. Further, in response to inquiries, we've included (Appendix A) a summary of the process used by each national wildlife refuge when determining priority resources of concern.

Background of Management Capabilities:

Each of the two impoundments has one water control structure on the "back dike" that connects to the Concord River (Figure 1). There is also a water control structure on the cross dike that connects the two impoundments to each other. Each of the three water control structures consists of a cement culvert under the dike, with stop log structures located on either end of the culvert. There are two rows of stop logs on each side of the culvert. The stop logs may be removed to draw down water levels, and replaced to maintain or increase water levels.

The top of the cement headwall of the lower water control structure is set at 113.39 feet above see level (a reading of 5.68 on our water gauge). The bottom of the cement structure is at 107.71 feet. The top of the cement headwall for the upper water control structure is at 114.08 feet above

mean sea level (a reading of 5.63 on the water gauge). The bottom of the cement structure is at 108.45 feet.

The upper impoundment (upstream) is drained by removing stop logs from the water control structure connected to the Concord River and the water control structure at the cross dike between the two impoundments. The lower impoundment (downstream) is drained by removing the stop logs at the water control structure connected to the Concord River. At high water stages within the Concord River, water can be allowed to flow into each impoundment through its "back dike" water control structure. At extremely high river stages, water flows uncontrolled over the top of the back dike into the impoundments. This occurs almost every year in the spring.

Since acquiring this property in 1944, the impoundments were managed primarily as full level pools until the late 1990s. This management strategy dramatically minimized wetland dynamics, and subsequently reduced floral and faunal diversity to those species that are able to endure nearly constant water levels. Floral diversity in the impoundments was limited to cattail, water chestnut, arrow arum, purple loosestrife, American lotus, and other species that can tolerate standing water. Some sedges and rushes were present in the impoundments, but their density was quite low in most years.

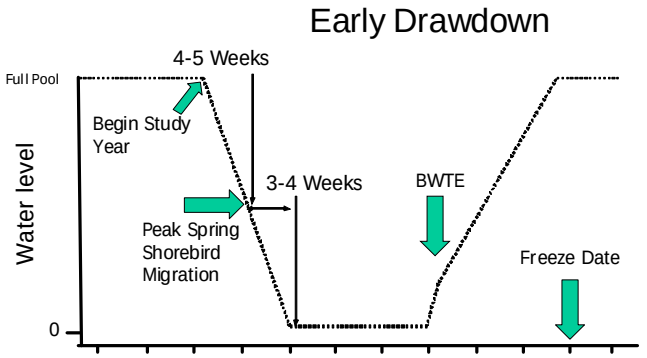
Description of Water Level Management Since 2000:

Since 2000, Refuge staff have been actively manipulating water levels in the two impoundments to provide habitat primarily for migratory birds. In most years, management has been conducted in conjunction with dozens of other Refuges located in the northeast (Maine to Virginia) and the midwest (Ohio to Minnesota) through the course of two different multi-year studies.

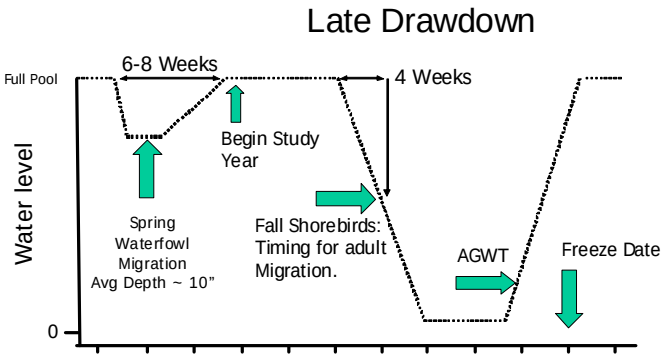
1. The first study was conducted from 2000-2002 and was designed to evaluate if water level management for spring migrating shorebirds (drawdowns to expose mudflats) could be conducted in concert with management for fall migrating waterfowl, or if management for one suite of species would preclude management for the other suite of species. During this study, two different methods of drawdowns were randomly assigned and used at the impoundments (when weather cooperated): a fast drawdown wherein many stop logs are removed at one time to rapidly drain large portions of an impoundment as quickly as possible; or, a slow drawdown wherein a fewer number of stop logs are removed. When this study ceased in 2002, Refuge staff continued water level management and annual drawdowns, but it was less structured than during the years of the study.

2. The second study was conducted from 2005-2008 and was designed to evaluate if impoundment management could provide habitat for spring and fall migrating shorebirds and waterfowl. Thus, it had a broader scope than the first study. During this study, two different methods of drawdowns were randomly assigned and used at the impoundments. Timing of drawdown, rather than speed, distinguished the two different management regimes. The targeted water level management schemes are shown in the diagrams

below, but the actual management capability (timing and quickness of drawdowns) was often hampered by spring and summer floods due to heavy rains.



Date	Description
Mid – Late Apr	Start gradual drawdown to continuously expose new mudflats for peak shorebird migration (May 15th)
Early – Mid Jun	Pool should be completely drawn down to promote veg growth
Mid - Late Aug	Start gradual fill of pool in time for waterfowl migration (BWTE start end of August)
Sept – Oct	Fill pool gradually before freeze
Dec	Freeze



Date	Description
Early – Mid Jul	Start gradual drawdown to continuously expose new mudflats for shorebird migration (Jul -Oct, peak early Aug)
Sept – Nov	Fill pool gradually (before freeze) for waterfowl migration
Dec	Freeze

Despite the variation in timing of drawdowns and reflooding, one impoundment typically has some water during most of the spring, summer, and fall (though which impoundment contains water varies within a season). Each year, both impoundments are flooded before winter freeze, and remain flooded until the following spring. Water level management has been carefully documented each year since 2000 through weekly water level measurements. Appendix B contains graphs of water levels for each impoundment from 2000-2008. While participating in the second study described above, we also created bathymetry maps for each impoundment that correspond with the water level gauges. Thus, for any water level gauge reading, we can estimate what percentage of the impoundment is providing varying depths of water for resources of concern. We can also estimate the total water being held in each impoundment at any given time. Bathymetry maps and related water depth figures are in Appendix C.

There has also been substantial data collection to document the response of vegetation and birds during different water level management schemes. Fluctuating water levels through the spring, summer and fall have impacted vegetation by promoting seed germination and growth of a diversity of plants. Beneficial wetland plants that have dominated both impoundments during the last five years include: beggars ticks (*Bidens spp.*), Walter's millet (*Echinochloa walteri*) and umbrella sedges (*Cyperus spp.*). These and other resulting vegetation provide high quality forage for migrating waterfowl. Other common vegetation include: broad-leaved cattail (*Typha latifolia*), spike rush (*Eleocharis* spp.), marsh purslane (*Ludwigia palustris*), duckweed (Lemnaceae), smartweed (*Polygonum* spp.), arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), false nettle (*Boehmeria cylindrical*), buttonbush (*Cephalanthus occidentalis*), arrowhead (*Sagittaria latifolia*), soft-stemmed bulrush (*Scirpus validus*), wild rice (*Zizania aquatica*), American lotus (*Nelumbo lutea*), rushes (*Juncus* spp.) and *Panicum* spp. Annual drawdowns have also likely benefitted rare plants such as Engelmann's umbrella-sedge (*Cyperus engelmannii*) and Long's Bulrush (*Scirpus longii*), both state listed Threatened.

In addition, lower water levels typically lead to warmer water temperatures which results in increased stimulation of invertebrate production which benefits waterfowl, shorebirds, and likely turtles and fish. Drawdowns which result in puddling in the impoundments also concentrate fish and therefore provide optimal foraging habitat for wading birds and marshbirds.

Impoundment Management and Rare Species

The Concord Impoundments fall within Estimated and Priority Habitats designated by the Massachusetts Natural Heritage and Endangered Species Program. There are also numerous rare species accounts within the project area including: marshbirds such as common moorhen (*Gallinula chloropus),* Pied-billed Grebe (*Podilymbus podiceps),* Least Bittern (*Ixobrychus exilis),* and American Bittern (*Botaurus lentiginosus)*; herptiles such as Blanding's turtle (*Emydoidea blandingii)* and blue-spotted salamander (*Ambystoma laterale)* and; plants such as river bulrush (*Scirpus fluviatilis*) (see enclosed NHESP map; Figure 2).

Nesting Marshbirds

Although nesting marshbirds were not systematically surveyed prior to 2000 when the impoundments were managed primarily as full pools year round, we believe there is currently more nesting habitat in the impoundments for marshbirds than existed 10 years ago. Quality of nesting marshbird habitat has likely increased as a result of periodic drawdowns allowing for plant germination and spread in subsequent years. During marshbird callback surveys conducted over the last five years, we have recorded primarily Virginia Rails (*Rallus limicola*) and Soras (*Porzana carolina*), but we've also documented one pair of Least Bittern in most years, and occasionally one pair of American Bittern, Common Moorhen and Pied-billed Grebe. The majority of marshbirds are detected in the upper impoundment, where more marshbird habitat is available.

Although it's likely there are more marshbirds calling at the Concord Impoundments now compared to 10 years ago, we have not made any attempt to determine which portion of these calling birds actually initiated nests. In addition, we have not monitored nest success and do not know the impacts of spring and summer drawdowns on nesting marshbirds.

Blanding's Turtles

Three concerns have been discussed relative to potential impacts of water level management to Blanding's turtles and these are summarized below.

1. Previously, there was concern that Blanding's turtles may leave the Concord Impoundments during times of drawdowns, and subsequently cross commuter roads in search of habitat. Research of radioed animals have since shown that Blanding's turtles stay in the impoundments during drawdowns and very few animals have crossed Route 62 during these times.
2. Concerns have also been raised regarding impoundment water levels at the start of the winter season. A die-off of head-started Blanding's turtles occurred in the winter of 2004/2005, and other turtles and fish were found dead during this time. The die-off was

likely a result of anoxic conditions in the impoundments and could have been caused by low water levels, severe winter temperatures and prolonged periods of ice, or both. USFWS can help prevent this occurrence in the future by ensuring that water levels in the impoundments are as full as possible prior to the start of winter. However, this alone may not prevent anoxic conditions and winter die-offs in winters with extreme cold temperatures and prolonged periods of ice. In addition, researchers no longer release head-started turtles in one spot but rather now release turtles at the original nesting site and let them disperse on their own (while being monitored) to the impoundments and other wetlands.

3. Lastly, there is still concern regarding the potential loss of feeding opportunities for Blanding's turtles during drawdowns. Since juveniles often occupy shallower water than adults, they are likely to become "stranded" in mud sooner than adults during a drawdown, and the net result may be more time lost feeding. Additionally, since it's likely more important for juveniles to be foraging and putting on weight during the summer and early fall, they may be more negatively impacted than adults by lost feeding opportunities. However, nesting females will also need consistent high quality foraging opportunities.

   In 2009, a Masters student from Ohio University will focus his research on this issue and hopefully help us gain a better understanding of Blanding's turtles' habitat selection and foraging behavior during drawdowns. This work has already begun and will continue through September. The Masters student will be working closely with Refuge staff and researchers. In addition to this research, we propose methods for minimizing impacts to Blanding's turtles in both the short- and long-term management strategies.

Rare Plants

Annual drawdowns have also likely benefitted rare plants such as Engelmann's umbrella-sedge and Long's Bulrush, both state listed Threatened and both generally documented in the lower impoundment. Englemann's umbrella-sedge was last seen in the lower impoundment in 2000 and was not found during a search in 2005. Long's bulrush was last seen in the mid 1900s and was not found during a search in 1999. We do not believe it has been looked for in almost 10 years. In addition, small patches of river bulrush (*Bolboschoenus fluviatilis*, Special Concern) have been documented by Refuge staff in the lower impoundment. It's likely that periodic drawdowns benefit all three of these species.

Impoundment Management and Non-native Plant Species

Invasive species have been noted in the impoundments since the 1960's. The two plants of main concern have been water chestnut (*Trapa natans*) and purple loosestrife (*Lythrum salicaria*). By the late 1970s and early 1980s, water chestnut had become a major nuisance within both impoundments. Hand pulling, chemical treatment and mechanical harvesting were all attempted, but these methods were unsuccessful in the long term. Water drawdowns were identified in the early 1980s as a possible way to eliminate water chestnut from the impoundments. Drawdowns were attempted but were not successful until 2000. At that time, a regular drawdown schedule

was implemented in conjunction with research studies, and water chestnut subsequently decreased within both impoundments. Today, there is little water chestnut within the impoundments, except in areas where shallow water remains during drawdowns. Over the past few years, as drawing down the upper impoundment has become more difficult, the area in which water chestnut survives has increased. This year we are going to hand pull water chestnut in the hopes of keeping these plants to a small area.

Purple loosestrife has also been a problem in and around the impoundments. As opposed to water chestnut, purple loosestrife thrives during drawdowns. In an effort to control this invasive plant, both biological and chemical controls have been used. Rodeo was first used in the impoundments in the 1980s. It was used for a few years, and then not again until 2001. Rodeo was then used most years, through 2007. Rodeo was very successful at controlling the loosestrife along the edges of the impoundments, but application was much more difficult and less successful within the impoundments. In 2007, *Gallerucella* beetles were noted on loosestrife within the impoundments and it was determined that a more intensive biological control program would be implemented in order to control loosestrife at the impoundments. The biological control program began there in 1997. Releases occurred along the edges of the impoundments were river bulrush prevented the application of herbicide. These releases were typically less than 5,000 beetles per year. Larger scale releases (> 10,000 beetles) first occurred in 2005, with beetles being released within the impoundments for the first time in 2008. Beetles will continue to be released over the next few years until the population has reached a sufficient level to negatively impact the loosestrife.

Existing Conditions:

During the last two years we have had an increasingly difficult time draining the impoundments during the desired times of year, largely due to our drainage ditch system.[1] Over time, the ditches have refilled with sediment which makes the drainage management schemes less efficient and less predictable. In addition, sediment-filled drainage ditches increase the chances of fish being stranded on the impoundment surface when water does finally drain out. This was the case in May 2008, when over 1000 dead carp were pulled from the lower impoundment, following our annual drainage activities.

While there will be short-term disruption to the habitat and possible disturbance to species, maintenance work will result in better habitat over the long-term, and creation of wetland refugia will provide more habitat for herptiles during times of impoundment drawdowns. Our proposed short-term work plan and strategies for minimizing impacts are detailed below. The water level drawdown schedule outlined for the short-term work is very similar to our current long-term plan. However, the long-term management plans may change depending on results of research in this and future years.

Project Plans – Objective 1 – Maintain Ditches

[1] Difficulty managing the impoundment water levels also results from weather (spring and summer floods), but our ability to drain pools following flooding events is especially hampered by the current degraded integrity of the ditches.

The main drainage ditch within the lower and upper impoundments will be cleaned as early as possible during the next 1-5 years and we anticipate this maintenance will need to be repeated every 5-10 years. We are proposing different strategies for each impoundment, but recognize final implementation will be largely dependent on weather and equipment availability.

Upper Impoundment:

Description of Work: Following discussions with the NHESP, we propose to maintain the ditches in the upper impoundment, without fully draining the impoundment. We will close the outlet structure to prevent any outflow from the impoundment to the river and therefore won't have any additional impacts to wetland habitats. We anticipate being able to operate equipment in approximately 1-2 feet of standing water. If this preferred strategy is not feasible due to habitat conditions or equipment availability, we will default to conducting this work in a dry impoundment (conducting a full drawdown first).

Following discussions with NHESP we also propose to deposit material from the drainage ditches in "piles", rather than sidecasting the material as thin as possible, to create more topography and vegetated areas for Blanding's turtles and nesting marshbirds. We will try to avoid placing sediment immediately adjacent to the ditch edge so as not to interfere with sheet action drainage at times when we do need to drain the impoundment. Locations of proposed sediment placement are in Figure 3, but will ultimately be determined in the field at the time of implementation.

Timing of Work: Timing of ditch maintenance in the upper impoundment will depend on equipment availability but the earliest we plan to conduct the ditch maintenance work is August 2009.

Proposed Equipment: If available, the equipment used to clean out the ditches in the upper impoundment will be that of an amphibious (floating) excavator with a bucket attachment. An amphibious excavator can easily operate in shallow water and the bucket will allow for more controlled handling of material. If this equipment is not available, we would likely need to drain the impoundment and use an "Ultra Low Ground Pressure Equipment", or postpone work until the following year. This would be our least preferred option however.

Photos of this equipment are included in Appendix D.

Equipment Ingress and Egress: All ingress and egress of equipment will be performed off of existing dikes, as close as possible to the existing ditches and water control structures or in locations where the soil is most stable to minimize impacts from equipment transport (Figure 3). No mats or corduroy roads will be required for the moving of equipment within the proposed work area.

Lower Impoundment:

Description of Work: In contrast to the upper impoundment, we propose to maintain the ditches in the lower impoundment after a complete drawdown. We also propose to deposit material from the drainage ditches in "piles", rather than sidecasting the material as thin as possible, as described for the upper impoundment.

Timing of Work: Timing of ditch maintenance in the lower impoundment will depend on equipment availability and how quickly the impoundment is drained and the substrate dries sufficiently. The earliest we plan to start the drawdown in the impoundment is late June and it's likely that the earliest we could conduct ditch maintenance work is August 2009.

Proposed Equipment: The main ditch in the lower impoundment will be cleaned of accumulated sediment using the same or similar amphibious excavator with a bucket attachment for strategic placement of the fill. In addition to or in place of the proposed amphibious equipment, we will utilize "Ultra Low Ground Pressure Equipment" from the Mosquito Control Commission to excavate material from the ditches and deposit it in the best locations for wildlife.

Photos of this equipment are included in Appendix D.

Equipment Ingress and Egress: All ingress and egress of equipment will be performed off of existing dikes, as close as possible to the existing ditches and water control structures or in locations where the soil is most stable to minimize impacts from equipment transport (Figure 3). No mats or corduroy roads will be required for the moving of equipment within the proposed work area.

Justification and Efforts to Minimize Impacts in Both Impoundments:

By not fully draining the upper impoundment, we will likely minimize impacts to Blanding's turtles by maintaining more consistent feeding opportunities. This will be especially important in July for female Blanding's turtles which are replenishing energy reserves at the end of the nesting season, and for juveniles which are presumably putting energy into growth. Although we don't know the impact of drawdowns in the summer to nesting marshbirds, it is very likely that maintaining some water in the impoundment will benefit marshbirds tending nests or young.

Additionally waiting until at least August to conduct maintenance in the upper impoundment will minimize disturbance impacts to Blanding's turtles and marshbirds, which will have largely finished nesting. Depending on the timing of the work, there may be short-term disturbance to migrating waterfowl. However, the long-term benefit of better management capabilities offsets this short-term impact.

By fully draining the lower impoundment prior to conducting work, we will likely have some impacts to Blanding's turtles and marshbirds because the drawdown will result in

major habitat changes. However, we will not start the drawdown until late June or early July. By this time, Blanding's turtles will have completed nesting attempts, and many marshbird species will also be finished nesting. Normally, we would start refilling the pool in late August or early September in time for waterfowl migration. However, since we are proposing to drawdown the pool at a later date than in past years, we will likely have delayed plant germination and growth, which will extend the optimal flooding time of this impoundment (based on plant maturation and waterfowl food production) until later in the season. If work is not completed until October or November, we will have short-term impacts due to reduced waterfowl habitat during migration, but we feel these short-term impacts are offset by the increased long-term management capability. And, since we'll be maintaining water in the upper impoundment, there will still be some habitat available for migrating waterfowl.

In general, Blanding's turtles are likely to be less active in August, minimizing chances of direct disturbance while operating equipment. However, we will have a portion of Blanding's turtles outfitted with radio transmitters in both impoundments and will be aware of their locations during ditch maintenance work. Biologists will be on site during the work, and although we won't know where every Blanding's turtle is, the known locations of the subsample will help us minimize the chances of direct take from equipment operations. Based on past studies, we don't expect Blanding's turtles to be using the ditches during drawdowns, so direct impacts during equipment operation are slim. However, other turtle species may be using the ditches, and operators will take care to prevent any take.

Currently, both impoundments have very little relief in topography and we would like to create areas of higher elevation in some portions to support plant growth and provide more diverse vegetated habitat for all species using the impoundments (turtles, marshbirds, and migrating waterfowl). Blanding's turtles do not like to use habitat that consists of open water with little vegetation. At full water levels, the lower impoundment has very little emergent vegetation, and although the upper impoundment has more vegetation, there are still large areas of open water. In particular, increased cattail edge or other thick emergent vegetation will benefit Blanding's turtles and nesting marshbirds.

Additionally, creating an increase in relief of elevation may allow us the option of partially draining the impoundments in the future to expose some mudflats, and stimulate emergent vegetation growth, while still maintaining some portions of the impoundment in standing water. Locations of proposed increased elevation are in Figure 3. These areas were chosen to maximize the chances of building elevation in areas with solid substrate and to also build on current patches of habitat that contain a mosaic of open water and emergent vegetation.

We will ensure that sediment is not placed on rare plants, but note that increased elevation could support more rare plants in the future. These elevated areas will also provide habitat for non-native plant species and we are currently investigating the potential of planting these areas with native vegetation from each impoundment (such as

cattail or wild rice). The final species chosen for planting will depend on the final elevation of these created areas.

Since this proposed work does not affect the total amount of sediment in each impoundment, and the total area being manipulated is relatively small, we do not expect that the flood storage capacity of the impoundments will be significantly altered. And, since we aren't proposing any changes to the dike system itself, river height and natural rainfall will continue to be the primary drivers of impoundment flooding.

If we are not able to create areas of higher elevation using sediment, we will use equipment with a rotary ditching head which casts the excavated material very thinly over a larger area. By utilizing this type of equipment we are virtually eliminating our equipment foot print as well as the impacts from depositing the excavated material. Because the rotary ditcher can cast material nearly 40 feet, the resulting deposition is usually only a few centimeters deep, having no significant impact on the bottom elevation or topography of the wetlands. The material removed from the ditches is comprised of suspended organic material (very wet muck). By casting the material thinly we are also able to retain and spread native seed of beneficial plants over a larger area. However, this will also increase the likelihood of spreading non-native plant seed as well.

Project Plans – Objectives 2 and 3 – Clean Existing and Create Additional Refugia

The current existing refugia in the upper pool will be cleaned as soon as possible during the next 1-5 years and we anticipate this maintenance will need to be repeated every 5-10 years. We are also proposing to create up to two additional refugia in each impoundment.

The existing refugia in the upper impoundment is a short, enlarged section of the ditch in the vicinity of the observation tower, which was constructed to serve as refugia for aquatic life during periods of drawdown or hot weather, as well as to provide an area in which young-of-the-year wading birds might find enhanced foraging opportunities (Figure 3). We propose to remove any built up sediment in this refugia using the same techniques described above for the ditch maintenance in the upper impoundment.

Creating additional refugia will benefit reptiles and amphibians during drawdown periods and create increased foraging opportunities for wading birds. We will target areas that don't have an abundance of wetland vegetation if possible, but locations will be largely dependent on sediment composition and firmness (feasibility of equipment access), and areas where priority species have been known to congregate. Potential locations are shown on Figure 3. We are proposing up to four refugia pools be created, but they may be created through the next five years, depending on staff time, funding, and equipment availability. We propose each refugia pool to be about 10,000 square feet in area, and about 24 inches deep (which allows a water level of 12-18 inches to be maintained during dry times. Although the material removed to create these pools will be more consolidated than that removed from the existing ditches, it is still comprised mainly of organic material, thus creating a good seed bed for plant germination. We propose to use this sediment to create diversity of elevation in other areas of the impoundments, as described above for the ditch maintenance work.

Affected Area:

The approximate dimensions of the ditches, with the calculated areas and/or volumes are displayed in Table 1 according to the pertinent Resource Areas described in the Massachusetts Wetland Protection Regulations, 310 CMR 10. The impoundments are physically within multiple Resource Areas; for example, the Land Under Water Bodies and Land Subject to Flooding Resource Areas found in the impoundments overlap each other in their entirety; and, the Riverfront Resource Area potentially affected also physically overlaps portions of the previously listed two Resource Areas in its entirety.

We plan to clean the ditches to their original width of 7 feet and depth of 4 feet; therefore, all calculations were based on these figures. The ditches are not completely filled with sediment and our calculations reflect and estimated depth of 2 feet of sediment.

Cleaning all of these ditches once will result in a total area affected equal to 39,634 square feet and a total of 2,936 cubic yards removed from this area. Most of this area is bordered by wetland vegetation (depending on the water levels) and this maximum is therefore included on the WPA Form, Section B2.

The existing refugia in the upper impoundment covers approximately 5,400 square feet. If it were completely refilled with sediment, it would contain approximately 800 cubic yards of organic material (wet muck). We estimate that it is currently filled 50% with sediment. We estimate each new refugia pool to be about 10,000 square feet in area, and about 24 inches deep (which allows a water level of 12-18 inches to be maintained during dry times. These four new pools would total about 40,000 square feet of area, and with a depth of 2 feet, would result in 2,963 cubic yards of excavated material.

Table 1. Calculations for Drainage Ditches

Drainage Ditch	Map Reference	Length (ft)	Width (ft)	Depth (ft) to Remove	Total Area Affected (sq ft)	Proposed Sediment Removed (cu yds)
Lower Pool	1	2,428	7	2	16,996	1259
Upper Pool	2	1,512	7	2	10,584	784
Upper Pool	3	1,722	7	2	12,054	893
TOTALS		**5,662**			**39,634**	**2,936**

Table 2. Calculations for Pool Refugia

Refugia Pool	Map Reference	Total Area Affected (sq ft)	Proposed Sediment Removed (cu yds)
Existing Pool	Yellow oval	5,400	400
Proposed Pools	Yellow circles	40,000 (4 pools)	2,963
TOTALS		**45,400**	**3,363**

Table 3. Impact Numbers for each Resource Area

Lower Impoundment

APPROXIMATE SIZE / QUANTITY	Total	Lands Subject to Flooding	Riverfront Area
Drainage Channel (s) Length (ft)	2428	2428	200
Drainage Channel (s) Width (ft)	7	7	7
Drainage Channel (s) Depth (ft)	2	2	2
Total Area of Impoundment / LSF / Riverfront	4356000	4356000	648000
Drainage Channel (s) Area (ft squared, LxW)	16996	16996	1400
Drainage Channel (s) Maximum Sediment Volume (ft cubed, LxWxD)	33992	33992	2800
Drainage Channel (s) Maximum Sediment Volume (yd cubed, LxWxD/27)	**1259**	**1259**	**104 total, about 52 of riverfront actually falls in ditch inside impoundment**

Upper Impoundment

APPROXIMATE SIZE / QUANTITY	Total	Lands Subject to Flooding	Riverfront Area
Drainage Channel (s) Length (ft)	3234	3234	200
Drainage Channel (s) Width (ft)	7	7	7
Drainage Channel (s) Depth (ft)	2	2	2
Total Area of Impoundment / LSF / Riverfront	4356000	4356000	378000
Drainage Channel (s) Area (ft squared, LxW)	22638	22638	1400
Drainage Channel (s) Maximum Sediment Volume (ft cubed, LxWxD)	45276	45276	2800
Drainage Channel (s) Maximum Sediment Volume (yd cubed, LxWxD/27)	**1677**	**1677**	**104 total, about 52 of riverfront actually falls in ditch inside impoundment**

Refugia

APPROXIMATE SIZE / QUANTITY	Total	Lands Subject to Flooding	Riverfront Area
New Refugia Area (ft squared, per Refugia	10,000	10,000	0
Total for 4 Refugias (ft squared)	40,000	40,000	0
Refugia (s) Depth (ft)	2	2	0
Existing Refugia Area (ft squared) Refugia	5,400	5,400	0
Refugia (s) Depth (ft)	2	2	0
Total Sediment to be Removed for all 5 Refugia (ft cubed)	90,800	90,800	0
Total Sediment to be Removed for all 5 Refugia (yd cubed)	**3363**	**3363**	**0**
Total Area of Sediment Placed (2 ft Avg Elevation, sq feet)	85034	45400	0
Total Area Impacted by Sediment Placement (acres)	**2**	**2**	**0**

Riverfront Area Alternatives Analysis:

Approximately 1026000 square feet (5130 ft x 200 ft; 23.5 acres) of Riverfront Area exists at the Concord Impoundments along the Concord River. However, a very small portion of the Riverfront Area will actually be impacted by this project - about 1400 square feet (200 ft x 7 ft ditch width), distributed between the two impoundments. We will not conduct ditch maintenance work on the outer edge of the impoundments and thus are reducing our overall impact to the Riverfront Area. Therefore, as much of the project as is feasible is already being sited outside of the Riverfront Area. However, siting the project entirely outside the Riverfront Area is not practicable. Conducting maintenance work along the entirety of the ditches inside the impoundments is critical to management capability. If we only maintain the portion of the ditches that is outside of the Riverfront Area (analogous to a No-Action Alternative), this will exclude the portion of the ditches closest to our water control structures where we often have large sediment build up. This will compromise the entire project and prevent us from effectively managing these impoundments for trust resources.

Long-term Management:

Depending on results of monitoring and research in 2009, we will likely continue managing the upper impoundment more for the benefit of Blanding's turtles and marshbirds. We would discontinue drawdowns in most years, but would still need to conduct occasional drawdowns to restimulate emergent vegetation growth. We will closely monitor the vegetative response in 2009 as well as the differential foraging opportunities for Blanding's turtles in the two impoundments with different management regimes. Since the overflow elevation of the upper impoundment to the lower impoundment will not change, we will still be able to occasionally drain some water from the upper impoundment to prevent flooding of adjacent properties as a result of maintaining a full impoundment. However, during times of heavy rains and river flooding we have no management capability to prevent flooding of the impoundments and adjacent wetlands. We will also likely continue managing the lower impoundment more for the benefit of migrating waterfowl and rare plants by continuing annual drawdowns. We will closely monitor the vegetative response in 2009 with our proposed later drawdown date to determine if a later drawdown impacts our ability to provide high quality food for migrating waterfowl. We expect that well-maintained ditches will increase our ability to quickly drain the impoundment, and the net result may be the same as in past years when we started the drawdown earlier in the season, but drained the impoundment much more slowly. Purple loosestrife and water chestnut will continue to be an issue at the impoundments. With less frequent drawdowns in the upper pool, water chestnut will have the ability to spread rapidly. Hand pulling will be attempted to keep this plant in control, but if this methods fails, then chemical control will be needed in years when drawdowns are not implemented. Loosestrife will continue to be a problem in both impoundments. Biological control will be our primary form of control. If biological control is not effective at this site, Rodeo will be used to control plants within the impoundments and along the edges.

List of Figures and Appendices:

Figure 1. Great Meadows National Wildlife Refuge
Location of Ditches and Water Control Structures at Concord Impoundments

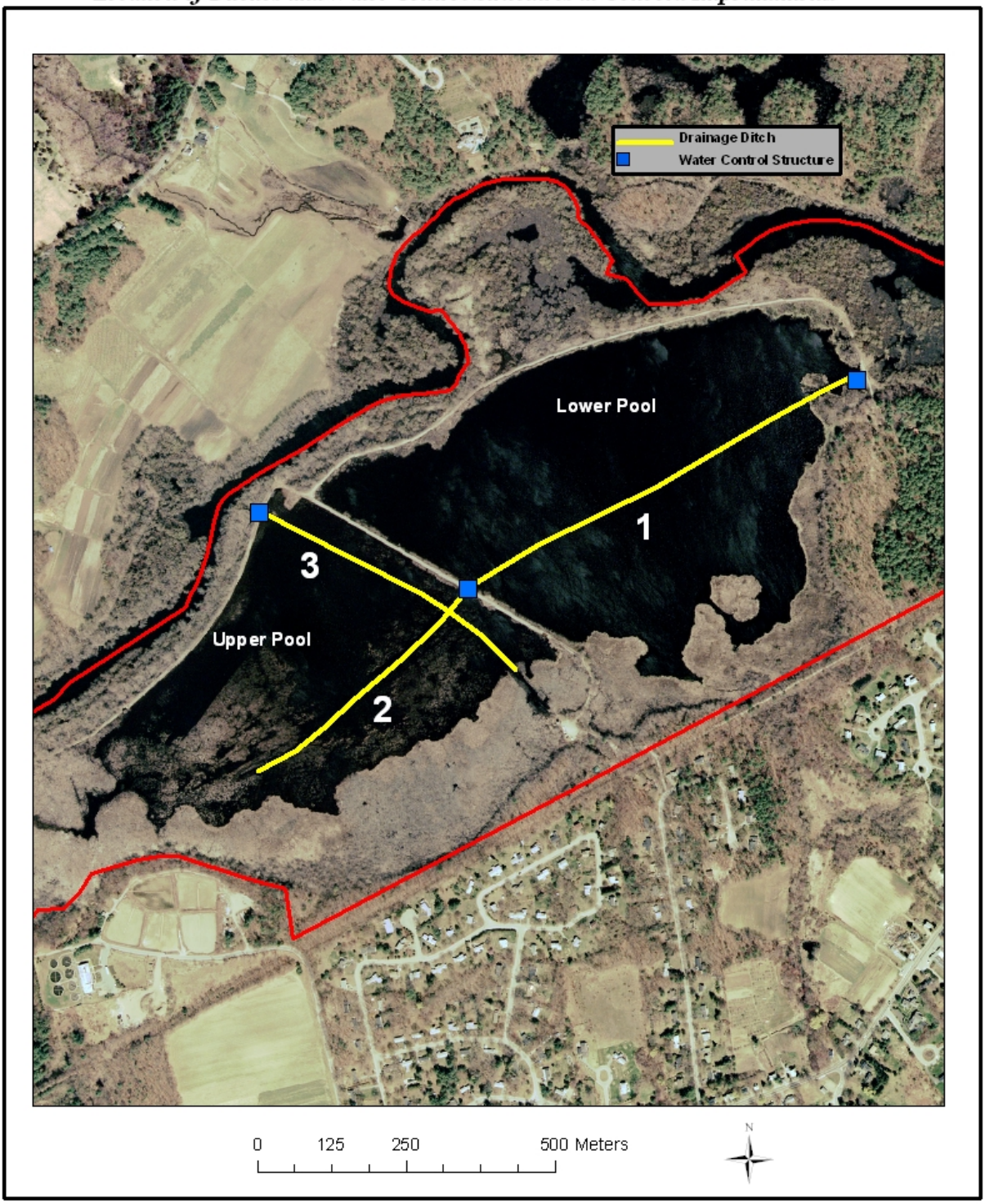


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Figure 2. Great Meadows National Wildlife Refuge
Estimated and Priority Habitat based on NHESP Data

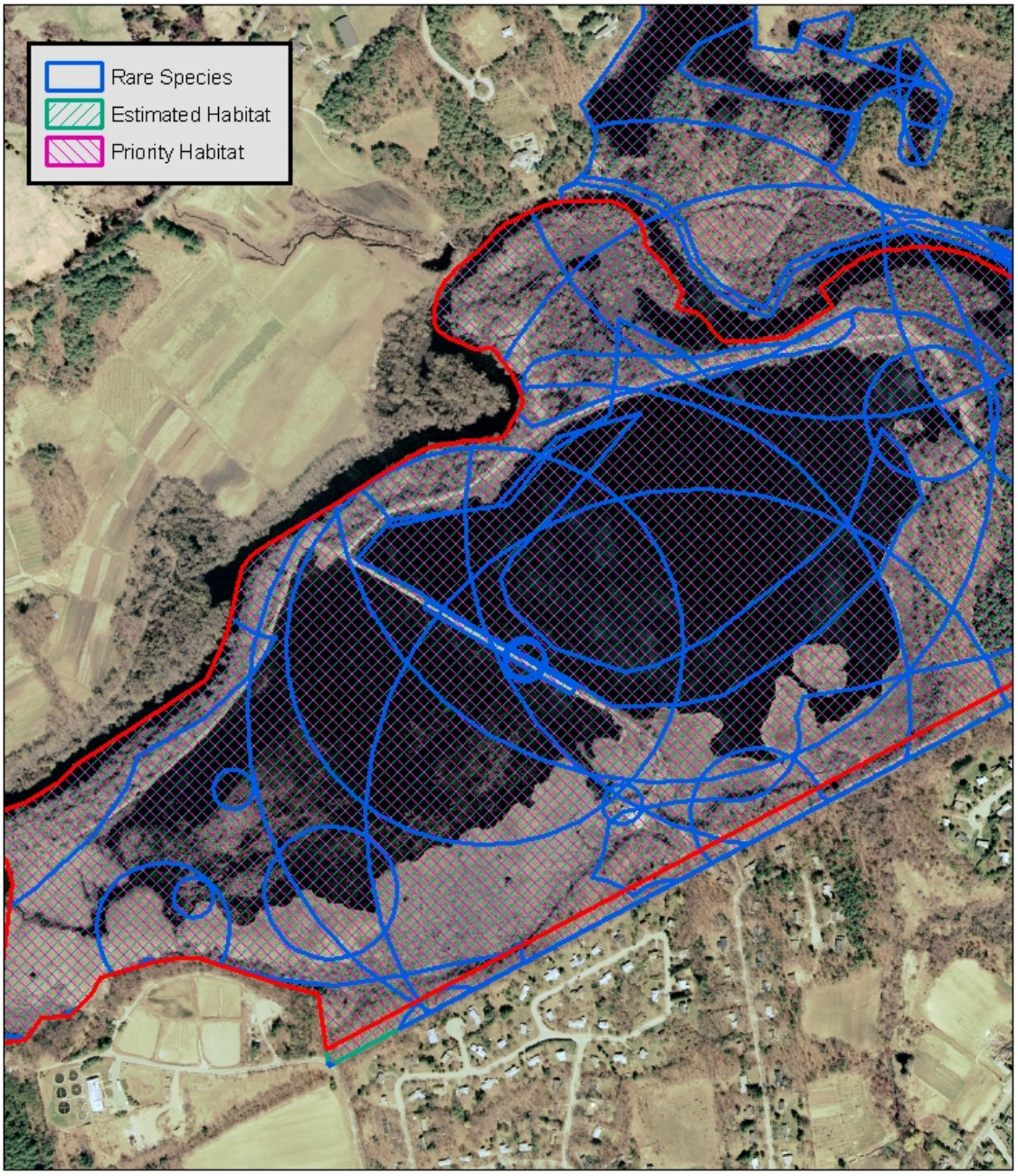

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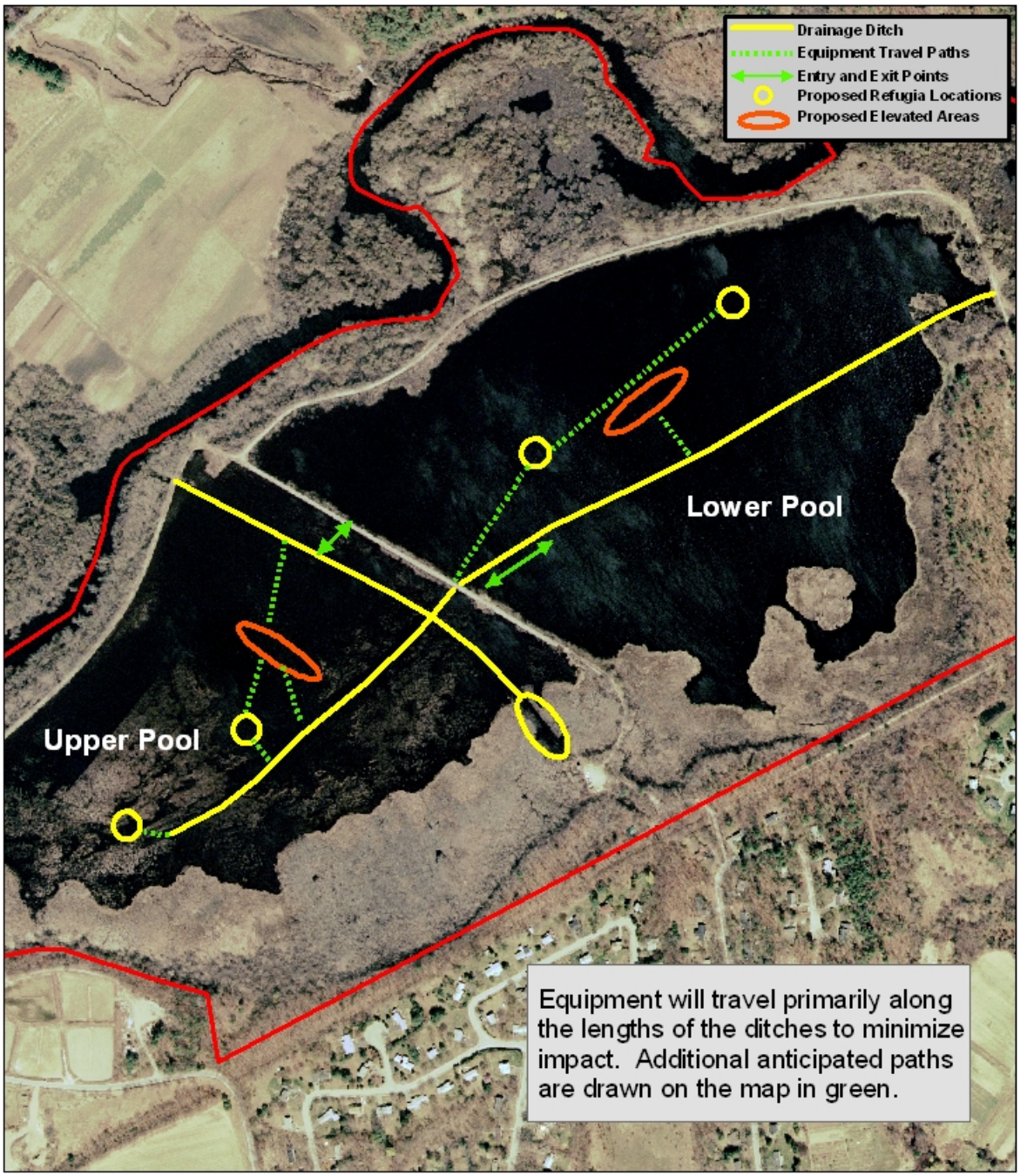
Figure 3. Great Meadows National Wildlife Refuge
Location of Existing and Potential Locations of Pool Refugia, Sediment Placement and Equipment Ingress and Egress at Concord Impoundments



Appendix A
Identifying Resources of Concern and Management Priorities for a Refuge[2]

Step 1: Identify Refuge Purposes

The Refuge System Improvement Act, and subsequent policy, requires that each refuge be managed to fulfill both its establishment purpose and the mission of the Refuge System. The Policy, *National Wildlife Refuge System Mission and Goals and Refuge Purposes* (601 FW 1), explains the relationship between these two. Where there is a conflict, individual refuge purposes have priority.

Step 2: Identify NWRS Resources of Concern

NWRS Resources of Concern are identified in the National Wildlife Refuge System Mission Goals and Refuge Purposes Policy (601 FW 1). Specifically, this policy states:

> "We will manage each refuge to fulfill the specific purpose(s) for which that refuge was established and the Refuge System mission. These goals will help guide development of specific management priorities during development of CCPs. Setting and implementing management priorities will help us achieve the purposes of the refuge, and, to the extent practicable, the Refuge System mission. The priorities for management activities and uses are: (1) conserving fish, wildlife, and plants and their habitats (Goals A, B, and C); (2) facilitating compatible wildlife-dependent recreational uses (Goals D and E); and (3) considering other appropriate and compatible uses. " (601 FW 1.10)
>
> "The goals in this policy provide guidance for accomplishing the Refuge System mission and directives on managing the Refuge System under the Administration Act, as amended. Collectively, these goals articulate the foundation for our stewardship of the Refuge System and define the unique and important niche it occupies among the various Federal land systems." (601 FW 1.11)
>
> "… Refuge System goals will help guide the development of comprehensive conservation plans (CCP) and the administration, management, and growth of the Refuge System…" (601 FW1.8)

The first 3 NWRS goals (601 FW 1.8) identify the natural resource conservation priorities for the System.

> **"A**. Conserve a diversity of fish, wildlife, and plants and their habitats, including species that are endangered or threatened with becoming endangered.
>
> **B.** Develop and maintain a network of habitats for migratory birds, anadromous and interjurisdictional fish, and marine mammal populations that is strategically distributed and carefully managed to meet important life history needs of these species across their ranges.
>
> **C.** Conserve those ecosystems, plant communities, wetlands of national or international significance, and landscapes and seascapes that are unique, rare, declining, or underrepresented in existing protection efforts."

Goals A and C address in part, the NWRS' legal mandate to maintain BIDEH. Together with the species identified in Goal A (threatened and endangered species) and Goal B (migratory birds, anadromous and interjurisdictional fish, and marine mammals) along with their supporting habitats are priorities for the NWRS and are considered NWRS Resources of Concern.

These species groups are also identified in numerous Federal statutes and international treaties (for example, see the Migratory Bird Treaty Act of 1918, as amended [16 U.S.C. 703-712] and the marine Mammal Protection Act of

[2] Taken from Draft Handbook, USFWS, August 2008.

1972, as amended [16 U.S.C. 1361-1471h]) as natural resource management priorities for the entire Fish and Wildlife Service and are often referred to as FWS "Trust Species". Consistent with the NWRS Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee), management to achieve its establishment and acquisition purpose(s) is the first and highest priority for each refuge. Secondarily, each refuge should be managed to achieve the NWRS mission. Consistent with these responsibilities, refuges should also be managed to support the species groups and their habitats listed above, and thereby comply with the associated Federal statutory mandates and help achieve the NWRS' goals.

Habitats or plant communities are also NWRS Resources of Concern when they are specifically identified in refuge purposes, when they support species or species groups identified in refuge purposes, and/or when they are important in the maintenance or restoration of BIDEH.

Each of these groups of NWRS Resources of Concern (FWS Trust Species) is further described below.

- Migratory Birds: A list of all species of migratory birds protected by the Migratory Bird Treaty Act (16 U.S.C. 703–711) and subject to the regulations on migratory birds is contained in subchapter B of title 50 CFR § 10.13. The Migratory Birds Program also maintains subsets of this list that provide priorities at the national, regional, and ecoregional (bird conservation regions) scales.

- Interjurisdictional Fish: Interjurisdictional fish are those "…populations that two or more States, nations, or Native American tribal governments manage because of their geographic distribution or migratory patterns (710 FW 1.5H)." Examples include anadromous species of salmon and free-roaming species endemic to large river systems, such as paddlefish and sturgeon (601 FW 1).

- Threatened and Endangered Species: The Endangered Species Act (16 U.S.C. §§ 1531-1544, December 28, 1973, as amended 1976-1982, 1984 and 1988) states in SEC. 8A.(a) that "The Secretary of the Interior… is designated as the Management Authority and the Scientific Authority for purposes of the Convention and the respective functions of each such Authority shall be carried out through the United States Fish and Wildlife Service." The Act also requires that "all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."

- Marine Mammals: The Marine Mammal Protection Act of 1972 (16 U.S.C. 13611407) prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S. The following is a list of marine mammals under the jurisdiction of the FWS:
    - West Indian Manatee (Antillean and Florida);
    - Polar Bear (AK Chukchi/Bering Seas and Beaufort Sea);
    - Pacific Walrus (AK); and
    - Sea Otter (South Central AK, Southeast AK, Southwest AK, CA, and WA).

Step 3: Address BIDEH

While achieving refuge purposes and the Refuge System mission, the Refuge Improvement Act, directs the NWRS to consider BIDEH

> "In administering the System, the Secretary shall…ensure that the biological integrity, diversity, and environmental health of the System are maintained for the benefit of present and future generations of Americans…" (Refuge Improvement Act, Section 4(a)(4)(B)).

This requires that we consider and protect the broad spectrum of native fish, wildlife, plants, and habitat resources found on a refuge. The *Policy on Biological Integrity, Diversity and Environmental Health* (601 FW 3.3) provides information and guidance to manage the refuge in such a way to maintain existing as well as restore lost or severely degraded components of BIDEH, where appropriate.

The policy explains the relationships among BIDEH, the NWRS mission, and refuge purposes as follows:

> "…each refuge will be managed to fulfill refuge purpose(s) as well as to help fulfill the System mission, and we will accomplish these purpose(s) and our mission by ensuring that the biological integrity, diversity, and environmental health of each refuge are maintained, and where appropriate, restored." (601 FW 3.7B).

In simplistic terms, elements of BIDEH are represented by native fish, wildlife, plants, and their habitats as well as those ecological processes that support them.

Most significant within the policy is the definition of BIDEH, which establishes historic conditions as a reference for implementation. Historic conditions are defined and qualified in the policy as follows:

> "Composition, structure, and functioning of ecosystems resulting from natural processes that we believe, based on sound professional judgment, were present prior to substantial human related changes to the landscape" (601 FW 3.6D.).

> "We consider the natural frequency and timing of processes such as flooding, fires, and grazing. Where it is not appropriate to restore ecosystem function, our refuge management will mimic these natural processes including natural frequencies and timing to the extent this can be accomplished [601 FW 3.10A.(4)]."

The policy on BIDEH requires careful examination of the refuge's historic conditions, the processes that maintained them, changes on the landscape that have altered those conditions or processes, and the remnant habitats or populations still present or that might be restored. Using the policy guidance, you must decide which of these you will manage for, and to what degree.

Remember historic conditions were dynamic, not static. Ecological communities (such as prairies, shrublands, and woodlands) moved back and forth via natural processes. As a result, it is not necessary to maintain refuge habitats at a specific point in historic time (e.g., early successional prairie), but may choose to manage within a natural range of variability. This strategy maintains processes that allow species, genetic strains, and natural communities to evolve with changing conditions.

The BIDEH also directs the NWRS to consider multiple landscape scales of BIDEH as follows:

> "Biological integrity, diversity, and environmental health can be described at various landscape scales from refuge to ecosystem, national, and international…Individual refuges contribute to biological integrity, diversity, and environmental health at larger landscape scales, especially when they support populations and habitats that have been lost at an ecosystem, national, or even international scale. In pursuit of refuge purposes, individual refuges may at times compromise elements of biological integrity, diversity, and environmental health at the refuge scale in support of those components at larger landscape scales. [601 FW 3.7C]"

Individual refuges contribute to BIDEH both locally and at larger landscape scales. The former occurs when you examine local or site-specific historic conditions and processes. Examples are protecting patches of unplowed prairie or fens, restoring agricultural fields to woodland, or removing a dam to establish historic stream flow. The latter occurs when you realize the refuge must support populations and habitats that have declined or been lost at an ecosystem, national, or even international scale (flyway). Examples are waterfowl refuges within California's Central Valley. Many of these refuges are islands of habitat surrounded by urban areas or intensive agriculture. They were established to provide nesting, migration, and wintering areas for migratory waterfowl and waterbirds in the face of such landscape-level changes. Such refuges must maintain wetland habitats and hydrologic regimes not historically present. Therefore, they forego some local elements of BIDEH in support of those components at larger landscape scales. Even these refuges, however, generally have local elements of BIDEH (such as vernal pools or unplowed grassland) that they can preserve or restore while meeting BIDEH at landscape-scales.

Maintaining or mimicking natural processes is another principle of BIDEH that assists with identification of priority resources for the maintenance and restoration of BIDEH on the refuge.

> "Management, ranging from preservation to active manipulation of habitats and populations, is necessary to maintain biological integrity, diversity, and environmental health. We favor management that restores or mimics natural ecosystem processes or functions to achieve refuge purpose(s). Some refuges may differ from the frequency and timing of natural processes in order to meet refuge purpose(s) or address biological integrity, diversity, and environmental health at larger landscape scales. [601 FW 3.7D]"

Ideally, to meet the letter and spirit of the policy, you would maintain or duplicate historic processes (such as floods or wildfire), mimicking as much as possible historic timing, frequency, and intensity. However, given changing conditions and landscape patterns (e.g., economic development) of the last century or more, it is often not feasible to rely on natural processes. Selection of resources required to maintain or restore BIDEH should consider if natural processes responsible for them are still intact. If not, are management strategies available that can be implemented to mimic natural processes so that elements of BIDEH can be maintained or restored on the refuge. The maintenance and, where appropriate, restoration of BIDEH provides tremendous flexibility in the selection of management priorities for a refuge. Although legislatively mandated requirements for management of NWR purposes will be the highest priority for management, most refuges have associated with them significant elements of BIDEH that must be maintained or potentially restored. The BIDEH policy provides the NWRS an opportunity to consider and protect a broad spectrum of fish, wildlife, plant, and habitat resources as well as the processes that support them found on refuges and associated ecosystems.

Step 4: Compile Comprehensive List of Refuge Resources of Concern

Using the information that describes refuge purposes, NWRS Resources of Concern (FWS Trust Species), and elements of BIDEH, compile a list of all species, species groups, and vegetation communities (habitats) that could be of management concern for the refuge. When identifying Refuge Resources of Concern, you must determine if *habitat/vegetation communities that meet the life history needs of these species are present or can be restored on the refuge*. Effectively, this list includes everything on and around the refuge addressed in the Refuge System's legal and policy mandates. In addition to these species and vegetation communities, include appropriate state-listed species and priority species identified in state wildlife action plans.

Various plans, reports, and datasets developed by the FWS or in cooperation with our conservation partners provide information to identify species and habitats that are, or could be, supported by the refuge. Here are some examples:

- Existing refuge species lists;
- Technical papers or reports identifying species or species groups, vegetation communities, habitat requirements, and life history needs for the ecoregion;
- Refuge inventory and monitoring data;
- Ecosystem assessment data from the Nature Conservancy;
- Trend and status maps for birds in BCR plans;
- Local university plant and animal collections;
- State wildlife action plans;
- Fisheries Management Plans;
- State Natural Heritage Program rankings for rare plants and natural communities;
- State priority habitat and species plans; and
- Federally listed species recovery plans.

Step 5: Identify Priority Refuge Resources of Concern

The Comprehensive Refuge Resources of Concern Table developed in Step 4 contains the full array of species and vegetation communities addressing a broad range of conservation needs. Now you must selectively reduce this table to those species and vegetation communities that will be managed to fulfill our obligations to refuge purposes, NWRS Resources of Concern, and BIDEH.

Selecting priority Refuge Resources of Concern from the comprehensive list uses the "focal species" concept. Focal species are highly associated with important habitat attributes or conditions that represent the needs of larger guilds of species that use habitats and respond to management similarly. By managing for focal species, important components of functional, healthy ecosystems will also be addressed. The use of focal species is particularly valuable when addressing FWS trust resources such as migratory birds. The process in this handbook is consistent with the Service's SHC framework. The SHC approach uses focal species to identify important habitats at the landscape or ecosystem scale that if protected, restored, or managed facilitate the Service's responsibility to conserve wildlife populations.

A filtering strategy can be used to help you select the appropriate focal species. We suggest a filtering strategy that uses site capabilities, predicted management response, and expert input. Together with these filters you should rely on your own professional judgment, as well as other resources professionals with state, federal, and private resource agencies as well as academia to assist with identification of focal species. Also seek advice from resource professionals engaged in the development of species habitat models for the SHC program.

The first filter to help you select focal species that will become your list of priority Refuge Resources of Concern is assessment of refuge "site capabilities". Often physical conditions and processes on or around the refuge may limit its ability to support certain Refuge Resources of Concern. Such conditions include patch size, connectivity of habitats, land cover, soil type, hydrology, topography, contaminants, urban/industrial encroachment, roads, climate change, invasive species, predation, and disease. Select a resource of concern as a *priority* only if the refuge has the capabilities (currently or through restoration) to provide the habitat components necessary for the specific life cycle needs of the species when it occupies the refuge.

The second filter is evaluation of how well a resource of concern will "respond to management or restoration" of habitat or habitats used by the species when it occupies the refuge. Select species and vegetation communities as priority Refuge Resources of Concern that respond to habitat management or restoration.

The third filter is adoption of "prioritization rankings" from Service programs, partner agencies and organizations, and other available experts. Many Regional FWS offices, state wildlife agencies, universities, and NGOs have special expertise on NWRS Resources of Concern, and they have prioritized them for conservation purposes. Examples of these rankings include NatureServe G and S ranks, PIF scores, and FWS prioritization scores for threatened and endangered species. While using the first two filters also consider rankings.

These filters should be considered equally when identifying priority refuge resources of concern.. When identifying Refuge Priority Resources of Concern, use these filters simultaneously. As noted previously, it is important to rely on your professional judgment and the opinions of trusted experts. In addition to the filters described above, consult handbooks and other literature developed for implementation of the SHC framework to facilitate the selection of focal species.

Step 6: Identify Priority Habitats

In Step 5, you identified priority Refuge Resources of Concern and the habitats on which those resources depend. You also identified the habitat characteristics or attributes required by each species (Table 5). Because the NWRS

primarily manages vegetation communities, or habitats, we linked priority refuge Resources of Concern to habitats that provide for their life cycle needs while they utilize the refuge. The specific *characteristics* or attributes of each habitat will be used to construct measurable objectives.

In this section we identify the highest priority habitats to manage on the refuge. These may be habitats that already exist, or ones that can be restored. Typically, high priority habitats will correspond to the highest priority Refuge Resources of Concern or will benefit the broadest number of Refuge Resources of Concern. High priority habitats are those which can be actively managed, maintained, or restored. Low priority habitats benefit fewer or less important Refuge Resources of Concern. Alternatively, these lower priority habitats may not require management, or they may be beyond our authority or ability to manage.

Simplistically, we define these two habitat categories as "Priority I" and "Priority II" habitats. By focusing on the former, refuge resources will be used to manage habitats for the highest priority Refuge Resources of Concern. Those in the latter category are still important, providing value to a range of species and contributing to the overall biodiversity of the refuge. They may also be important communities that do not require active management or that we lack authority to manage. These habitats will be managed, if necessary, when refuge, resources allow. For Step 6, you will use the factors identified below to rank habitats as priority I or II. Also in Table 6, explain why you ranked each habitat Priority I or II, and identify those factors which may constrain your management of each habitat.

The following factors to identify habitats as either Priority I or Priority II:

Priority I

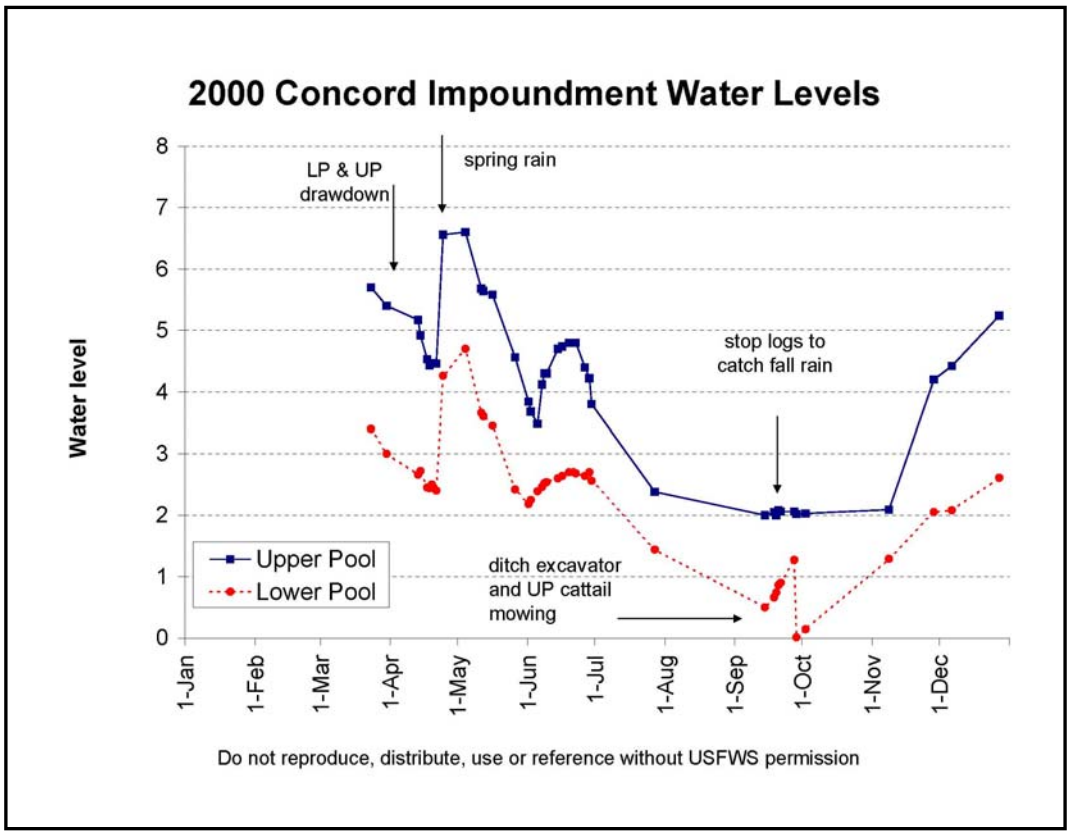
- Can be managed to provide the greatest conservation benefit to priority species, especially those specifically identified in the refuge purpose.
- Offer the greatest contribution to native habitats (BIDEH) not well represented within the landscape (including the broader ecoregion of which the refuge is a part) and address conservation needs of NWRS Resources of Concern.
- Habitat condition or other factors suggest an urgent need for active management.

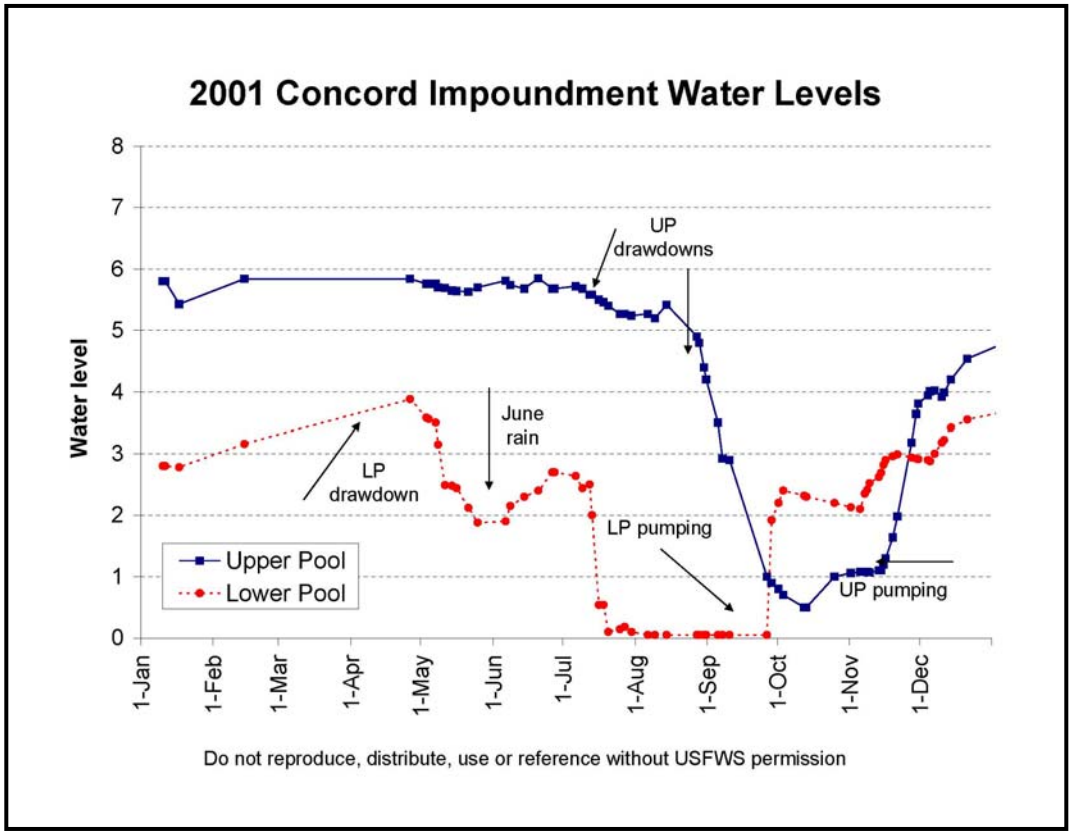
Priority II

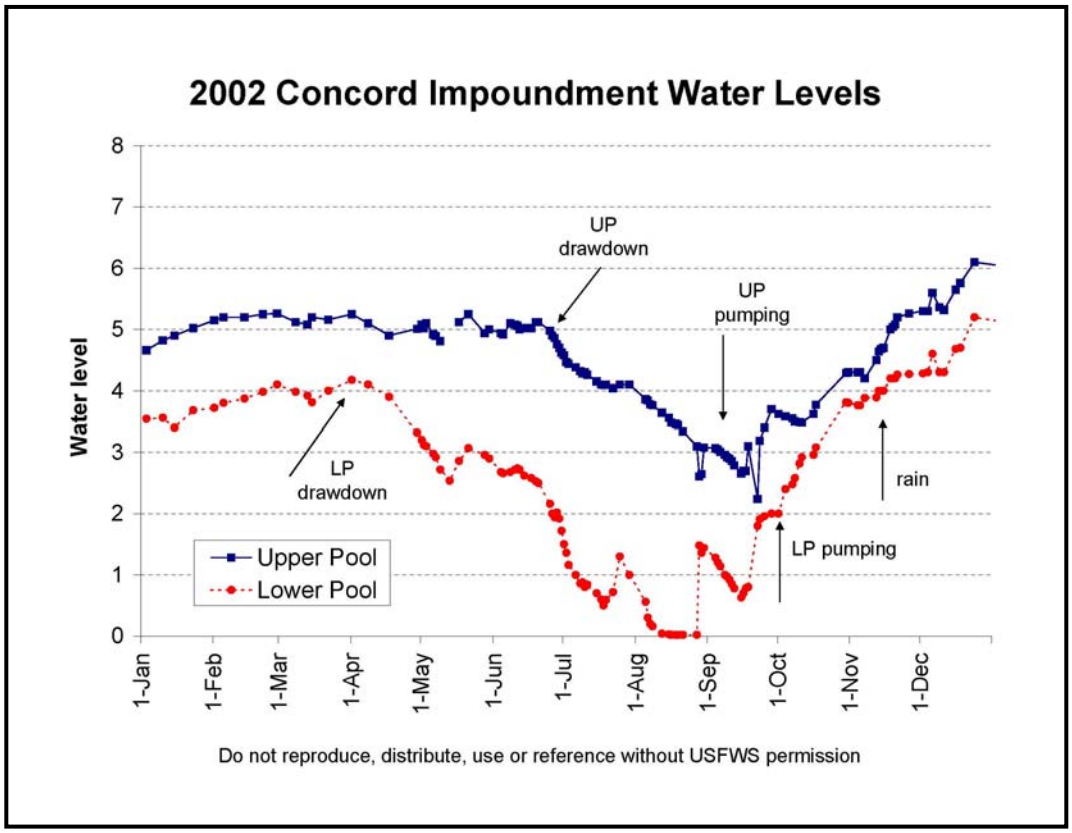
- To limited in extent to make a meaningful difference
- Outside the management authority or jurisdiction of the refuge

Priority I and II management categories are most useful for long-term planning. On a year-to-year basis, the actual habitats you choose to work on will vary, depending on resource conditions, needs, management cycles, and available staff and time. These are decisions you will make when preparing your annual habitat work plans. Also, changes on the landscape may push Priority II habitats into the higher category.

Appendix B
Water Levels at Concord Impoundments, 2000-2008






2002 Concord Impoundment Water Levels
Water level
8
7
6
5
4
3
2
1
0
UP drawdown
UP pumping
LP drawdown
rain
LP pumping
Upper Pool
Lower Pool
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
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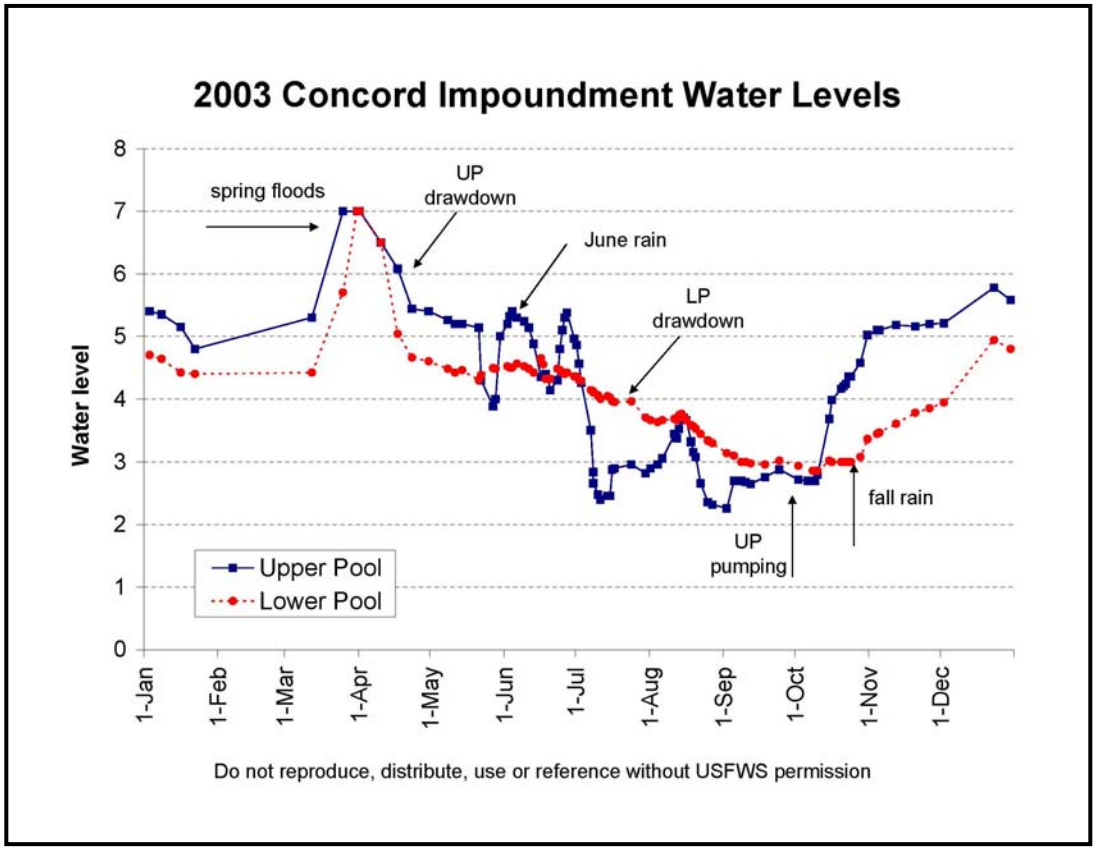
2003 Concord Impoundment Water Levels
Water level
8
7
6
5
4
3
2
1
0
spring floods
UP drawdown
June rain
LP drawdown
fall rain
UP pumping
Upper Pool
Lower Pool
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
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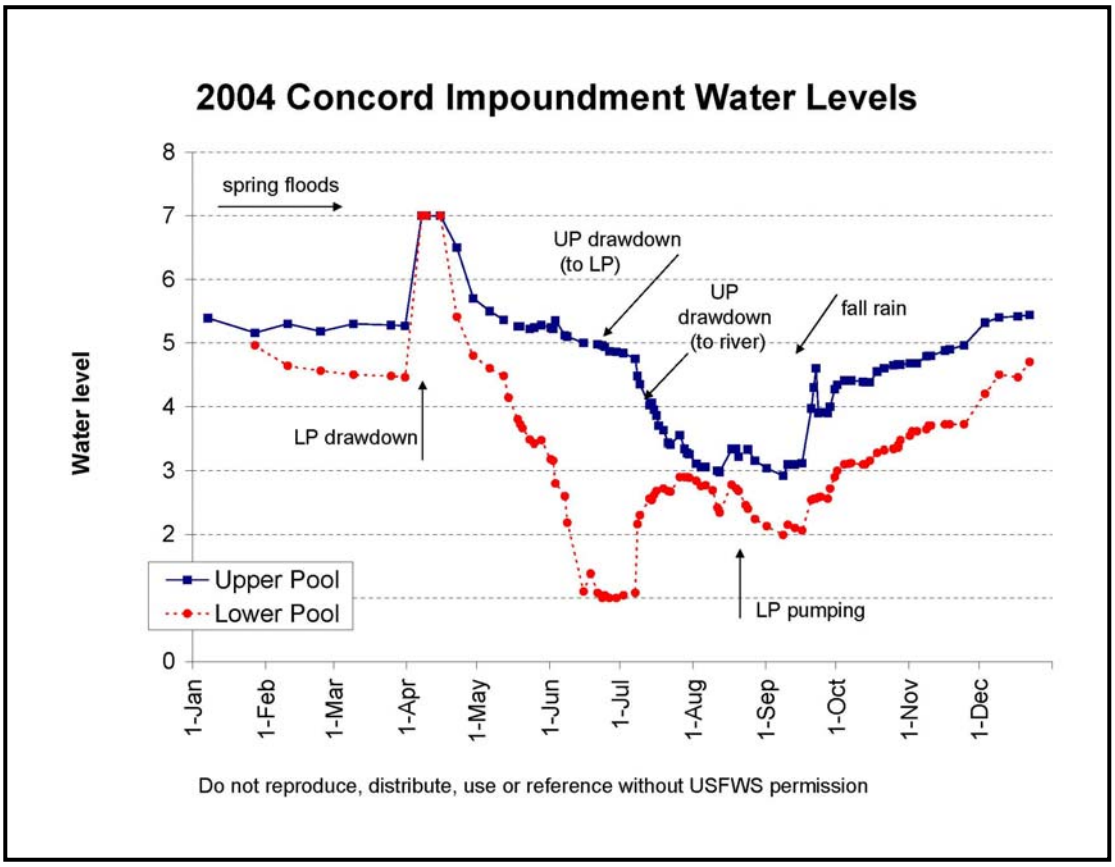
2004 Concord Impoundment Water Levels
Water level
spring floods
UP drawdown (to LP)
UP drawdown (to river)
fall rain
LP drawdown
LP pumping
Upper Pool
Lower Pool
0
1
2
3
4
5
6
7
8
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
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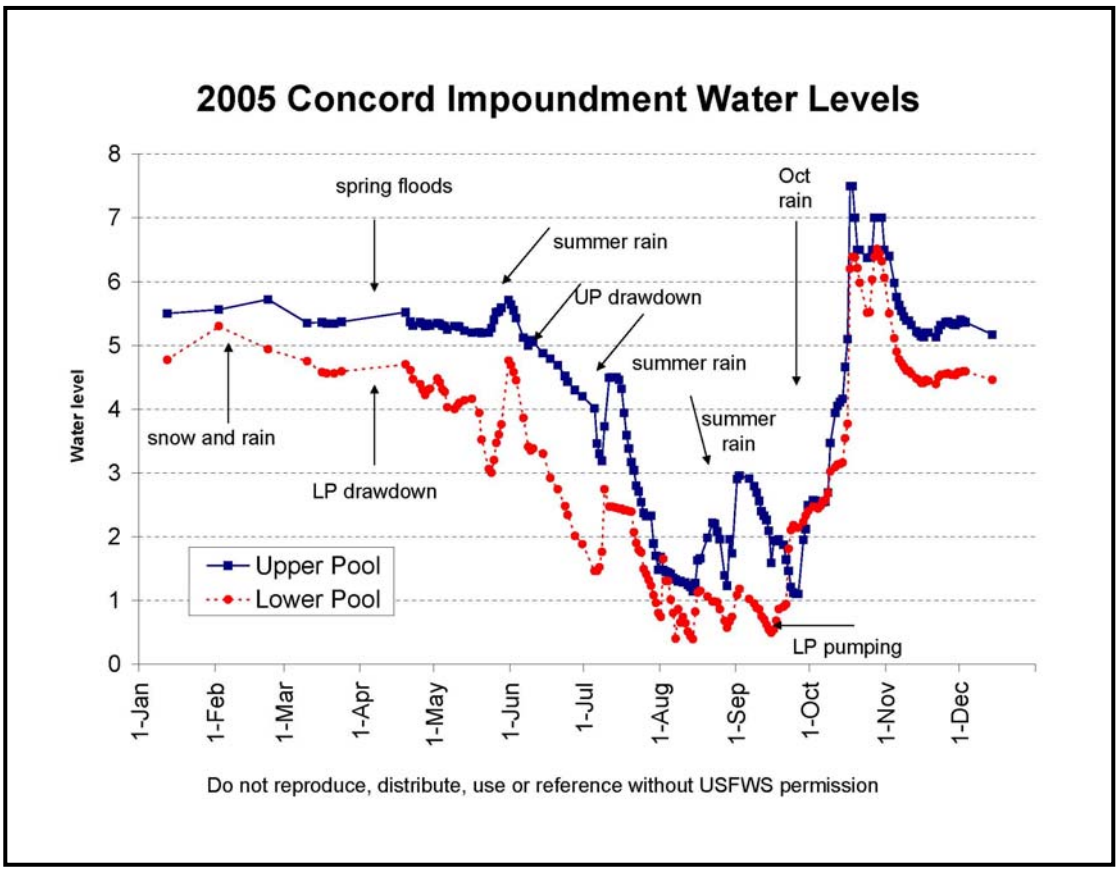
2005 Concord Impoundment Water Levels
Water level
spring floods
summer rain
Oct rain
UP drawdown
summer rain
summer rain
snow and rain
LP drawdown
LP pumping
Upper Pool
Lower Pool
0
1
2
3
4
5
6
7
8
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
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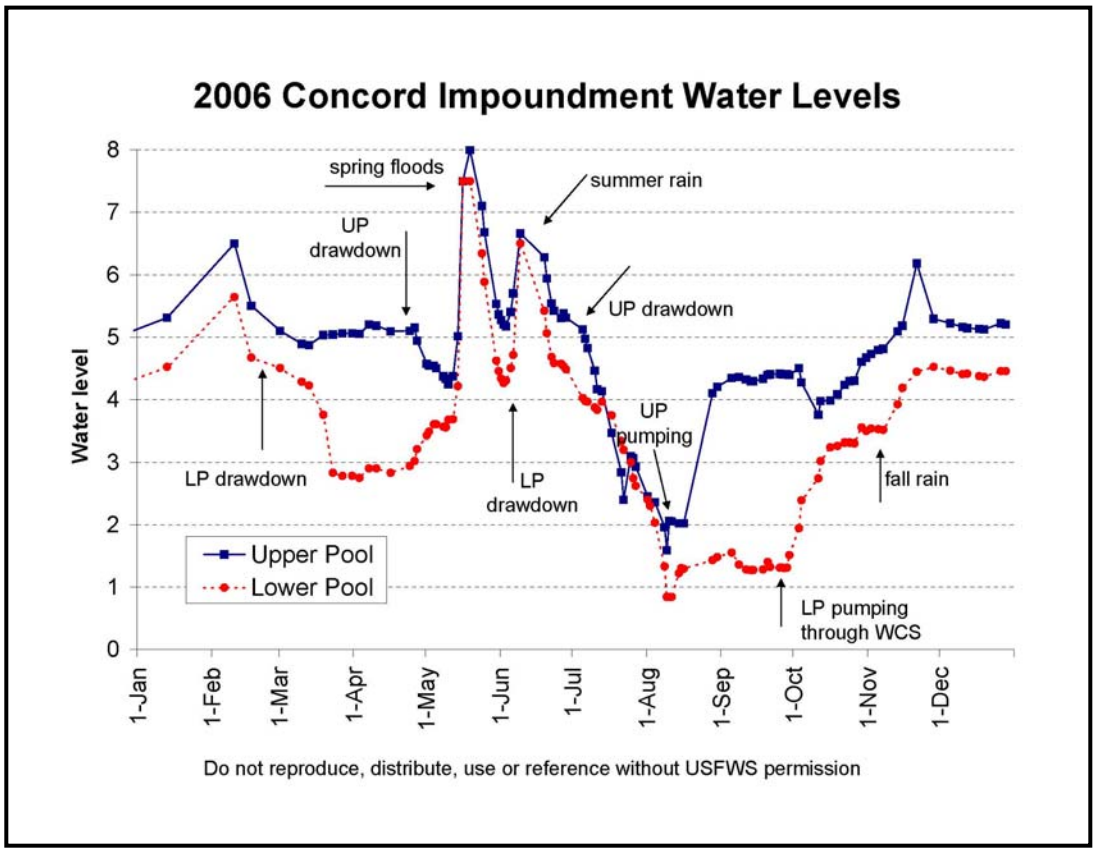
2006 Concord Impoundment Water Levels
Water level
spring floods
summer rain
UP drawdown
UP drawdown
UP pumping
LP drawdown
LP drawdown
fall rain
LP pumping through WCS
Upper Pool
Lower Pool
0
1
2
3
4
5
6
7
8
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
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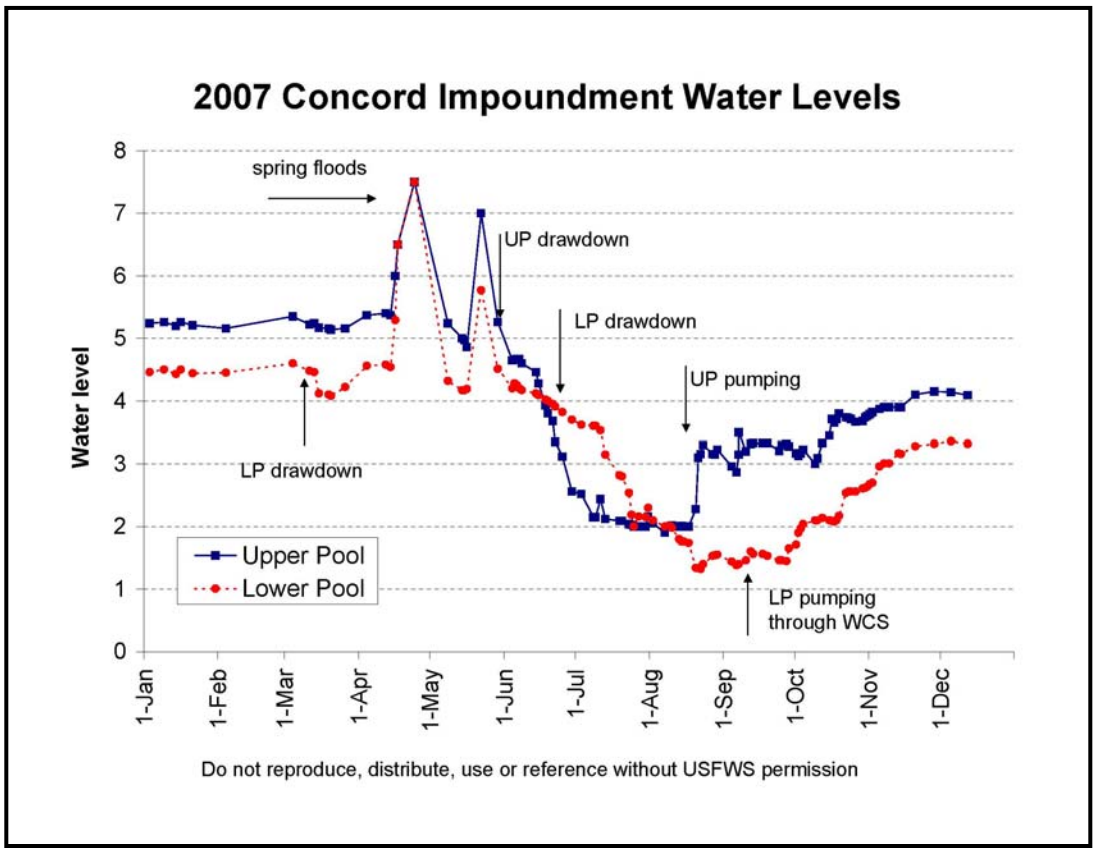
2007 Concord Impoundment Water Levels
Water level
spring floods
UP drawdown
LP drawdown
UP pumping
LP drawdown
LP pumping through WCS
Upper Pool
Lower Pool
0
1
2
3
4
5
6
7
8
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
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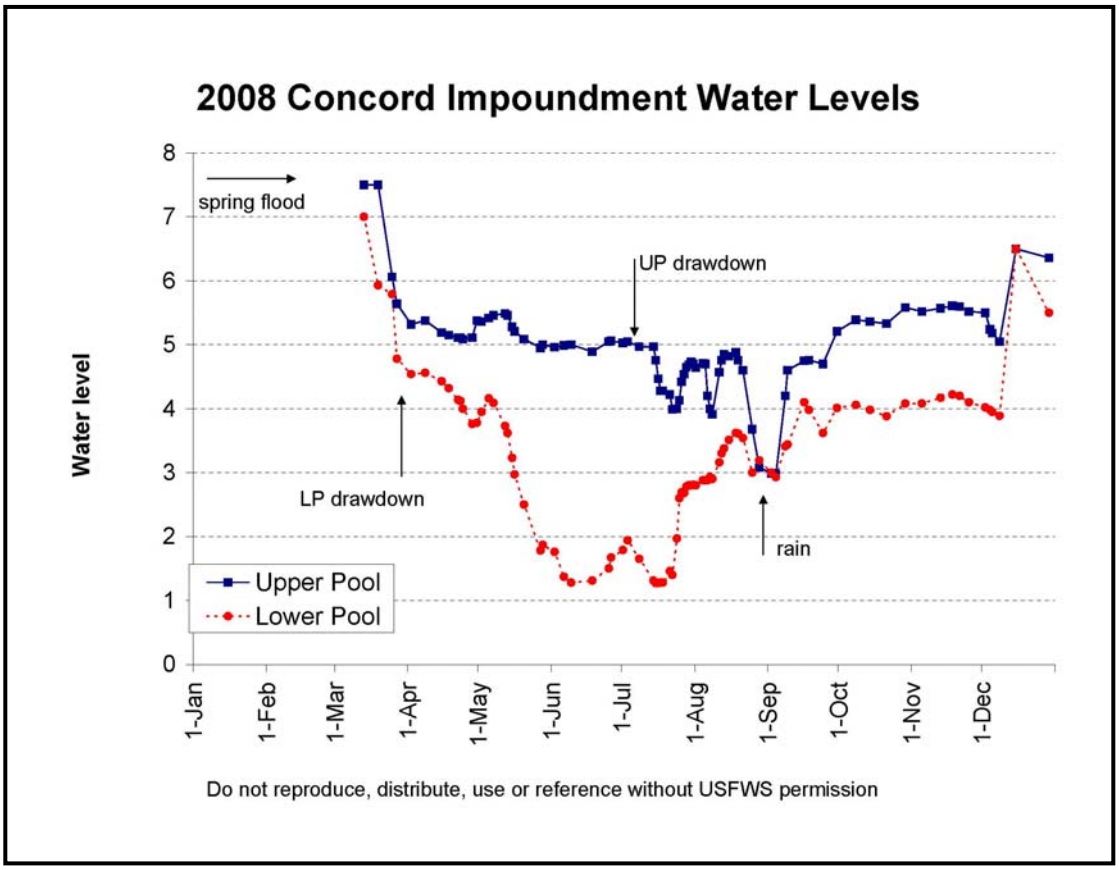
2008 Concord Impoundment Water Levels
Water level
8
7
6
5
4
3
2
1
0
spring flood
UP drawdown
LP drawdown
rain
Upper Pool
Lower Pool
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
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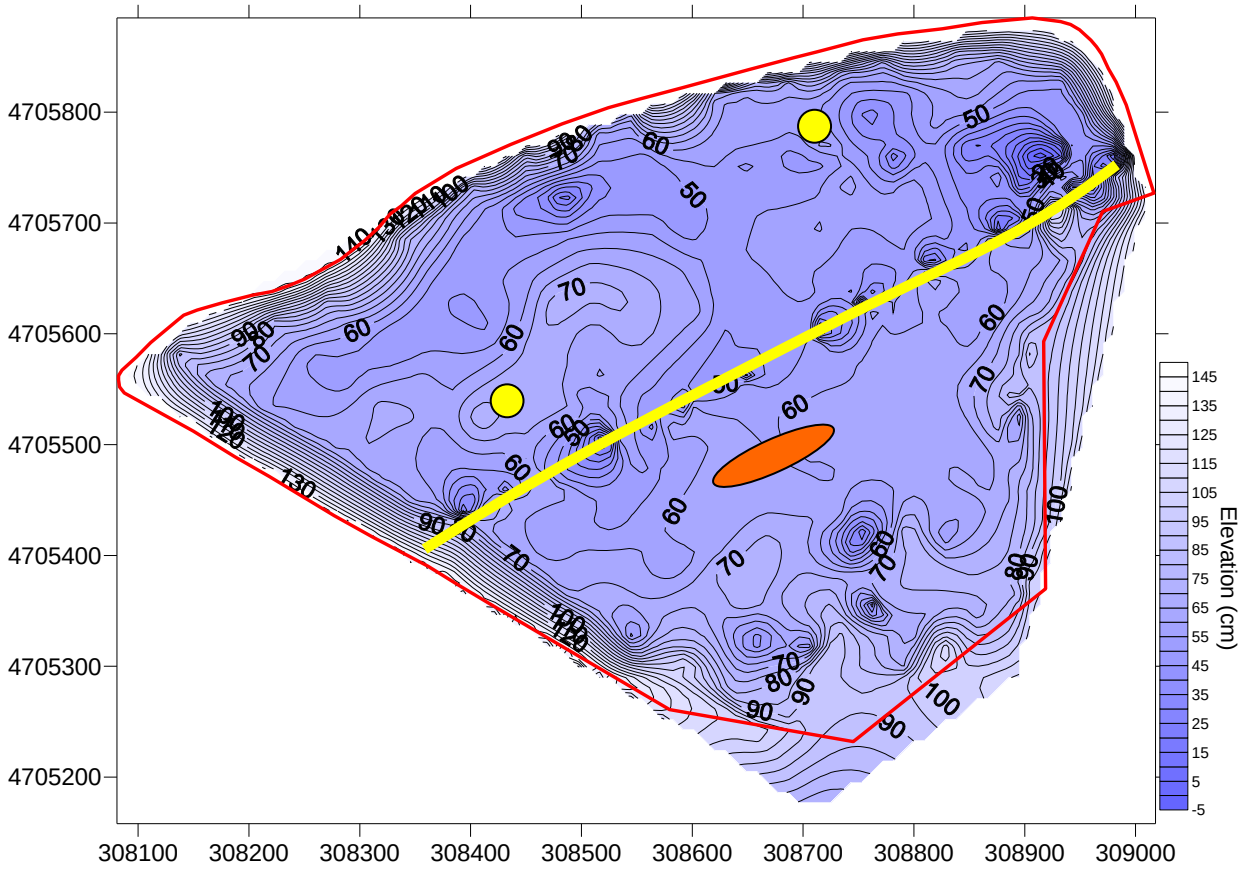
Appendix C
Bathymetry Maps and Estimated Water Levels of Concord Impoundments

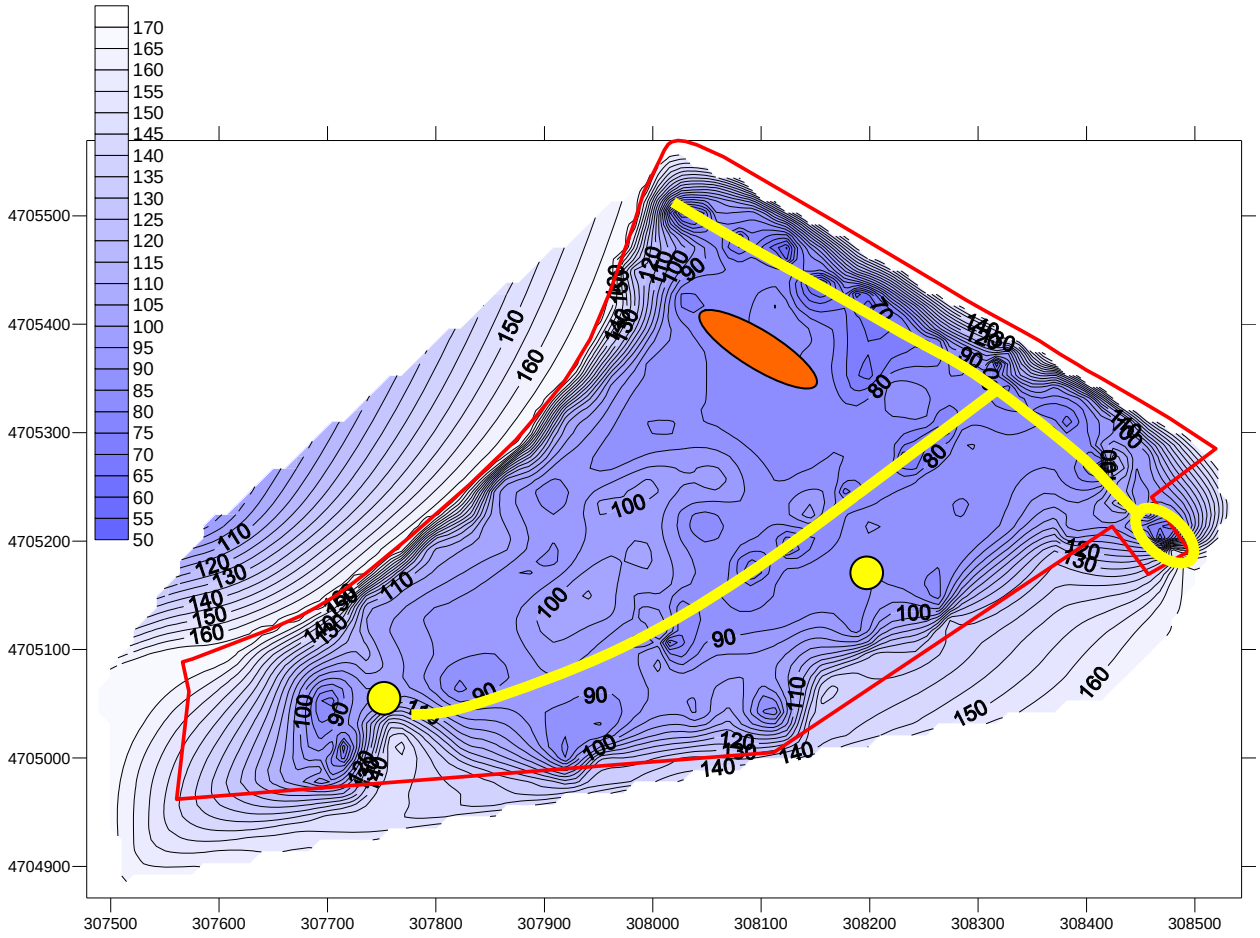
(x-axis represents easting and y-axis represents northing; yellow lines indicate approximate location of ditches; filled yellow circles indicate approximate locations of proposed refugia; hollow yellow circle indicates approximate location of current refugia; orange ovals indicate approximate location of proposed elevated areas)

Lower Pool

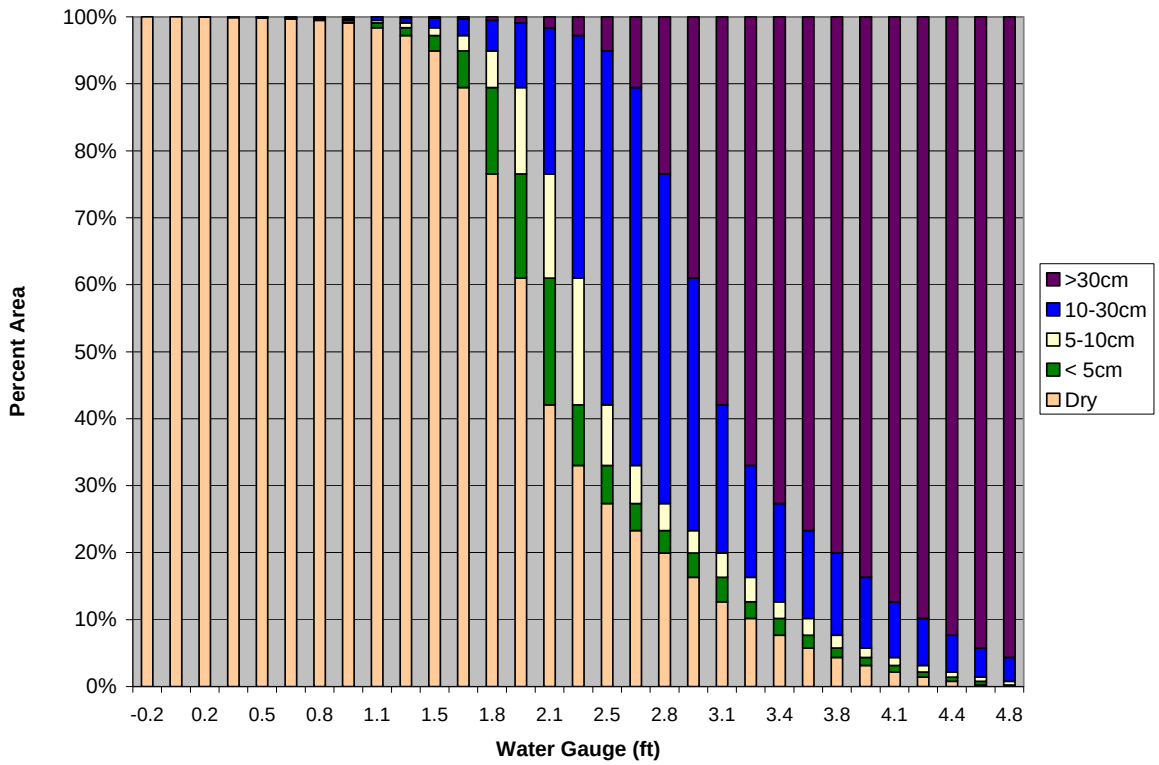


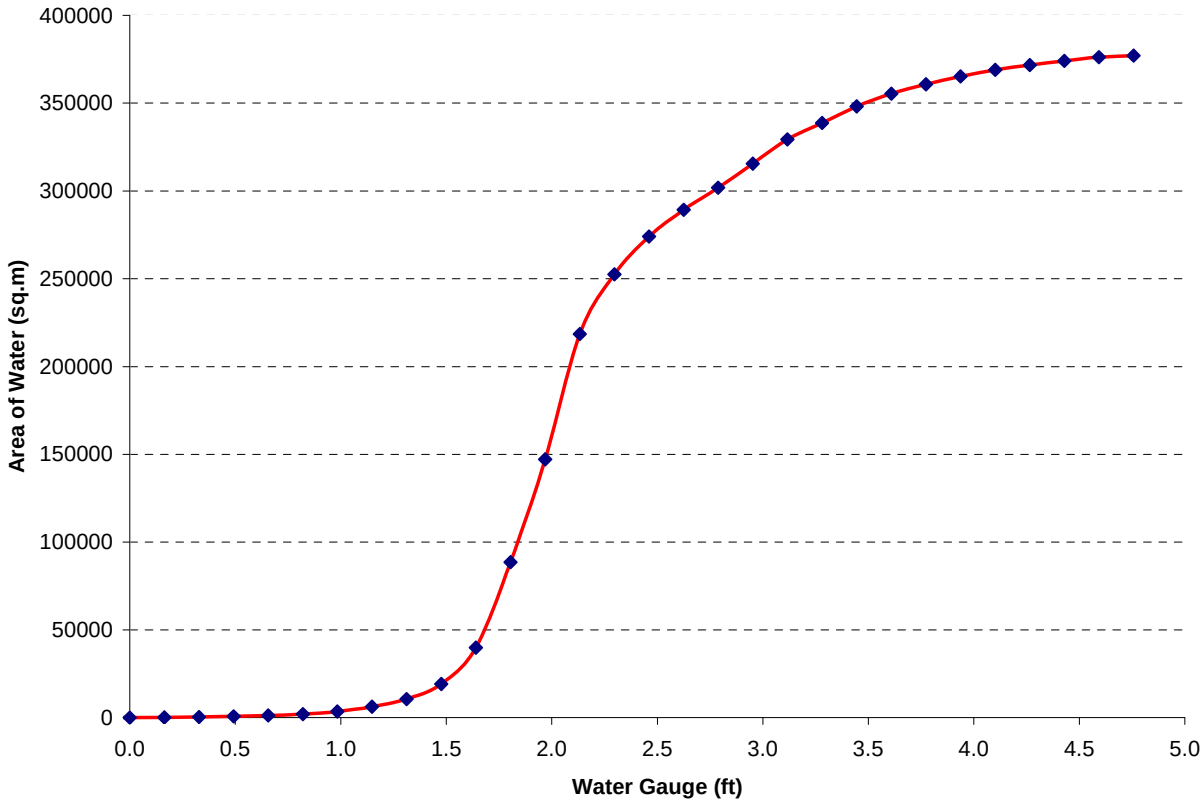
Appendix C continued
Bathymetry Maps and Estimated Water Levels of Concord Impoundments

Upper Pool

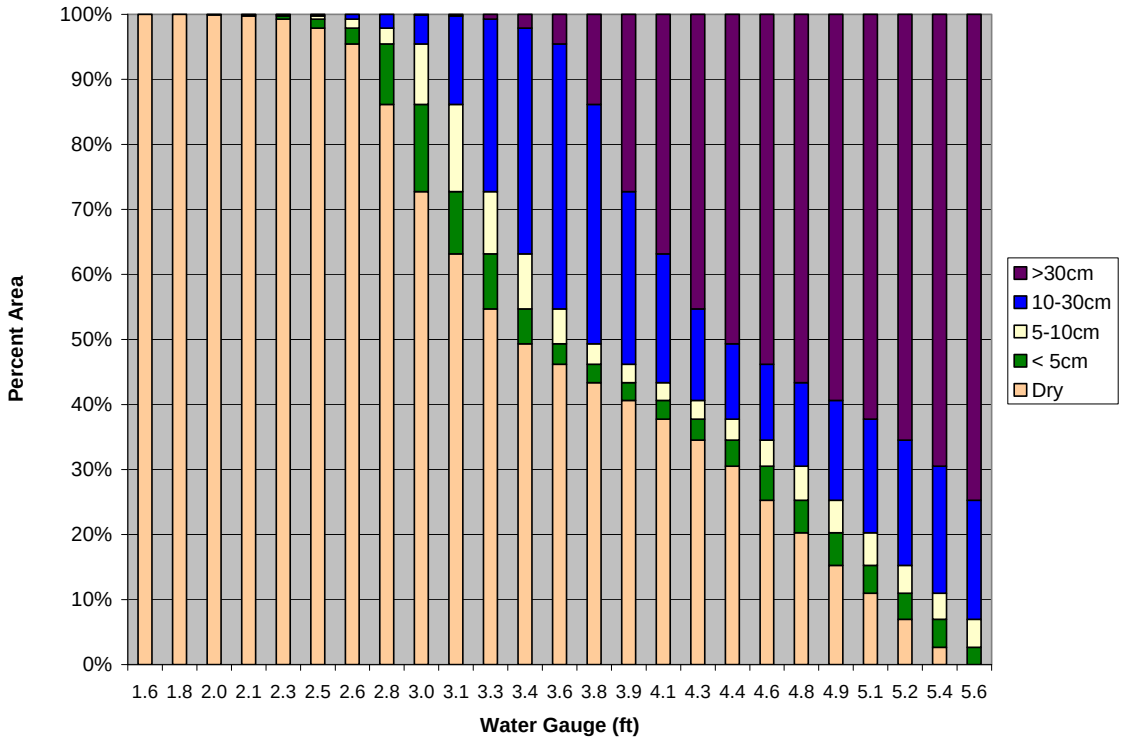


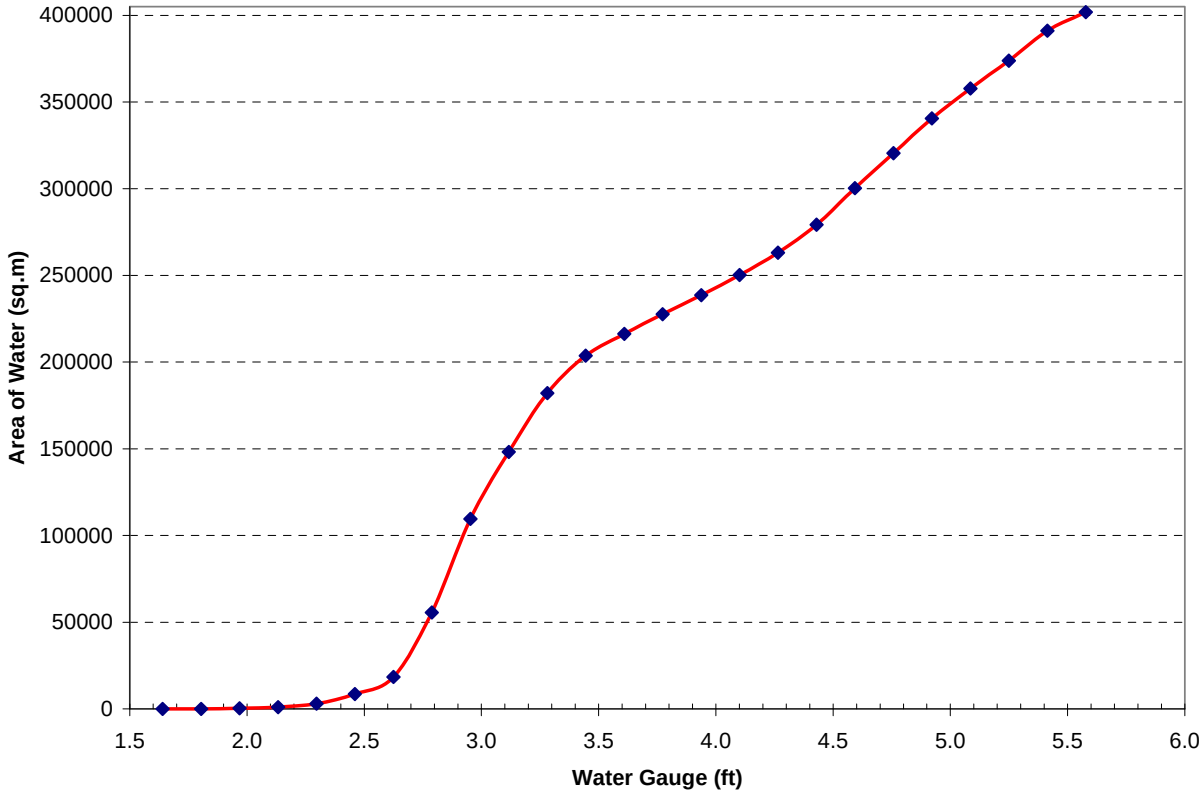
Lower Pool


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Area
-0.2
0.2
0.5
0.8
1.1
1.5
1.8
2.1
2.5
2.8
3.1
3.4
3.8
4.1
4.4
4.8
Water Gauge (ft)
>30cm
10-30cm
5-10cm
< 5cm
Dry


400000
350000
300000
250000
200000
150000
100000
50000
0
Area of Water (sq.m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Water Gauge (ft)

Upper Pool


Percent Area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1.6 1.8 2.0 2.1 2.3 2.5 2.6 2.8 3.0 3.1 3.3 3.4 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6
Water Gauge (ft)
>30cm
10-30cm
5-10cm
< 5cm
Dry


Area of Water (sq.m)
400000
350000
300000
250000
200000
150000
100000
50000
0
1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Water Gauge (ft)

Appendix D
Equipment Proposed for Ditch Maintenance and Refugia Creation

Amphibious Excavator

Ultra-low Ground Pressure Equipment

Bucket Attachment

Rotary Ditching Attachment

Appendix E
USGS Topo Map of Concord Impoundments

U.S. FISH & WILDLIFE SERVICE

Great Meadows National Wildlife Refuge, USGS Topo Map