Sustainable Rivers Program

Kaskaskia River
Environmental Pool Management
Implementation 2021

Prepared by: U.S. Army Corps of Engineers, St. Louis District
1222 Spruce Street
St. Louis, Missouri 63103

August 2023

Above: View of cove exposed by drawdown at Carlyle Lake (USACE photo).

Contents

1 Introduction

The Kaskaskia River Basin encompasses parts or all of 22 counties in Illinois, with 30 main tributaries and 5,840 mi^2 of drainage (Figure 1). It is a major tributary of the Mississippi River, with headwaters just west of Champaign, Illinois and flows southwesterly across the state for approximately 325 miles to its confluence with the Mississippi River about eight miles north of Chester, Illinois at river mile (RM) 117. Two reservoirs, Lake Shelbyville and Carlyle Lake, and one lock and dam, the Jerry F. Costello Lock and Dam (Jerry Costello L&D) were constructed and are operated by the Corps. As identified in the 2019 Midwest Regional Operations and Water Management Meeting (USACE 2020), opportunity exists at Carlyle Lake, Lake Shelbyville, and Jerry Costello L&D for the implementation of water level management.

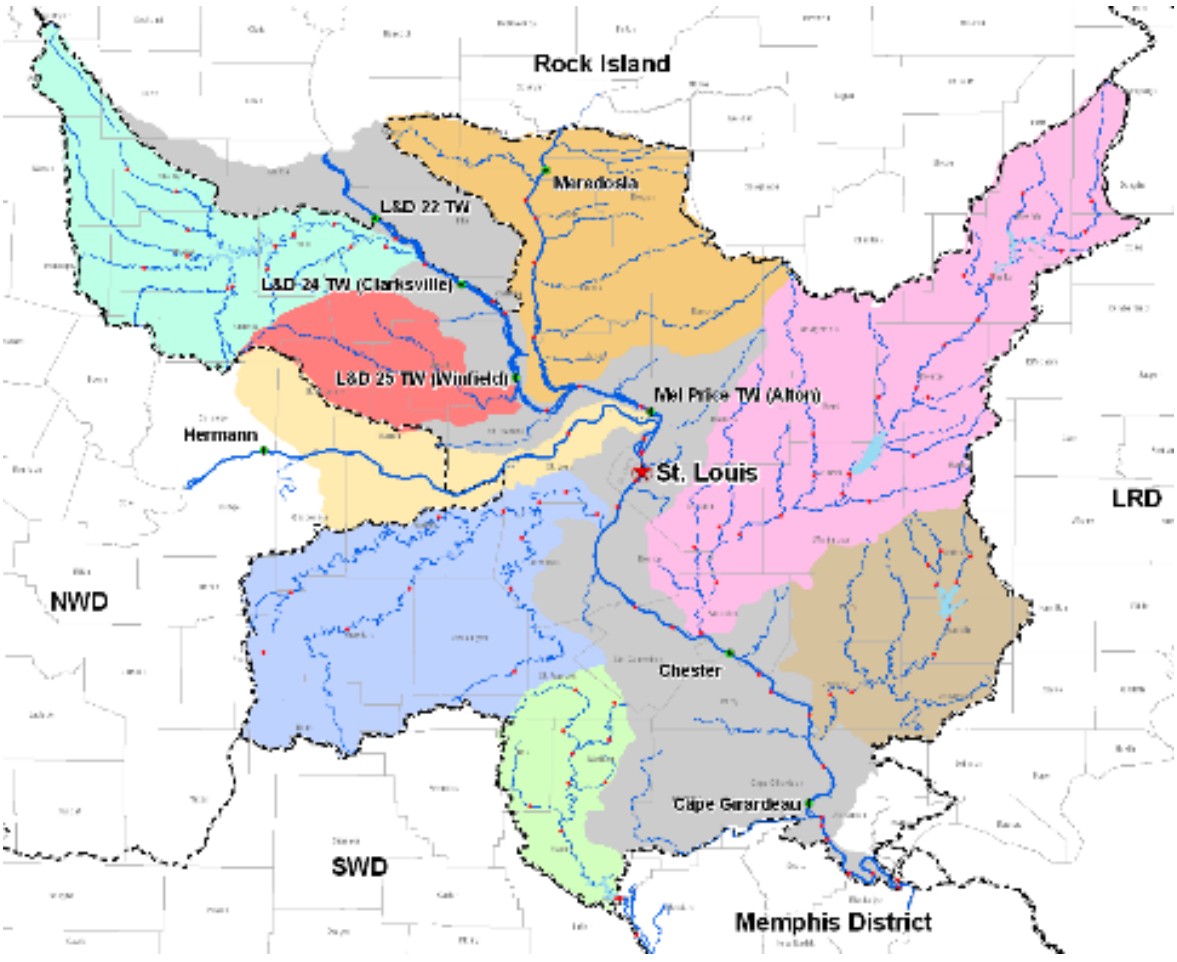

Figure 1. Watershed map of St. Louis District. The Kaskaskia River Basin falls with the pink area.

Lake Shelbyville was completed in 1970 and is approximately 11,100 water surface acres in size. Normal lake levels during the summer are held at a stage of 599.7 feet above mean sea level. The upstream portions, where the Kaskaskia River and West Okaw River flow into the lake, contain areas that would be most likely to benefit from a drawdown during the growing season. Carlyle Lake was completed in 1967

and is approximately 62,420 water surface acres in size. Normal lake levels during the summer are held at a stage of 445.0 feet above mean sea level. The upstream portions, where the Kaskaskia River flow into the lake, contain areas most likely to be exposed by and benefit from a drawdown during the growing season.

Downstream of Carlyle Lake, Jerry Costello L&D provides a nine-foot navigation channel for approximately 36 miles from the Mississippi River to Fayetteville, IL. Within this stretch the navigation channel was straightened during construction, resulting in the creation of a large number of remnant oxbows and additional shoreline that could be exposed with water level management to grow vegetation. Normal pool above the Kaskaskia River Lock and Dam is at a stage of 368.8 feet above mean sea level.

This effort would be similar in nature to Environmental Pool Management on the Mississippi River, which has been successful nearly every year since 1994. The intent for the Kaskaskia reservoirs was to implement a seasonal 0.5 ft drawdown to evaluate the environmental benefits that could be achieved. This drawdown would be within the operation elevations described in the approved water control plans for all 3 locations. A summary of EPM operations, including target management elevations for the 2021 growing season is provided in Section 1.1 EPM Operations.

Lake Shelbyville and Carlyle Lake are authorized and operate for flood risk management, recreation, navigation, water quality, fish and wildlife conservation and water supply. Jerry Costello L&D is authorized and operates for navigation, recreation, and fish and wildlife conservation.

1.1 EPM Operations

The goal for Lake Shelbyville, Carlyle Lake, and Jerry Costello L&D was to draw pool elevations down approximately half a foot during the growing season (May through September). While the goal was the same at each project, the hydrologic and hydraulic constraints vary for each project, which affected the ability to accomplish the desired drawdown at the different pools, especially in 2021. The following sections highlight the constraints and what drawdowns, if any, were accomplished at the projects.

1.1.1 Lake Shelbyville

Lake Shelbyville is a headwater flood risk management reservoir with 1,054 mi^2 of unregulated drainage upstream. Lake Shelbyville primary purpose is to reduce flooding downstream with control points at Cowden, Ramsey, and Vandalia. The drainage area between Lake Shelbyville and Vandalia is unregulated and covers 886 mi^2. The constraints of inflow coming into the lake from upstream and regulating for downstream local flows coming into the Kaskaskia River between Lake Shelbyville and Vandalia, drive reservoir pool stages. To accomplish a half foot drawdown during the growing season, relatively low inflows and low local flows downstream are needed for the months of April through September so that reservoir pool stages can be maintained at or near seasonal guide curve and accomplish the desired drawdown. Drier than normal to drought like conditions are the ideal conditions to accomplish the desired drawdown regulation during the growing season.

The 2021 season started with ideal conditions to accomplish multiple environmental pool management objectives, initially inflows were manageable to meet fish spawn regulations. However, while slowly evacuating water to reach seasonal guide curve an untimely inflow event in late June caused pool stages

to rise to levels that made attaining a half foot drawdown unfeasible. Figure 2 shows the 2021 pool stage hydrograph and the zone rules and targets required of the water control plan.

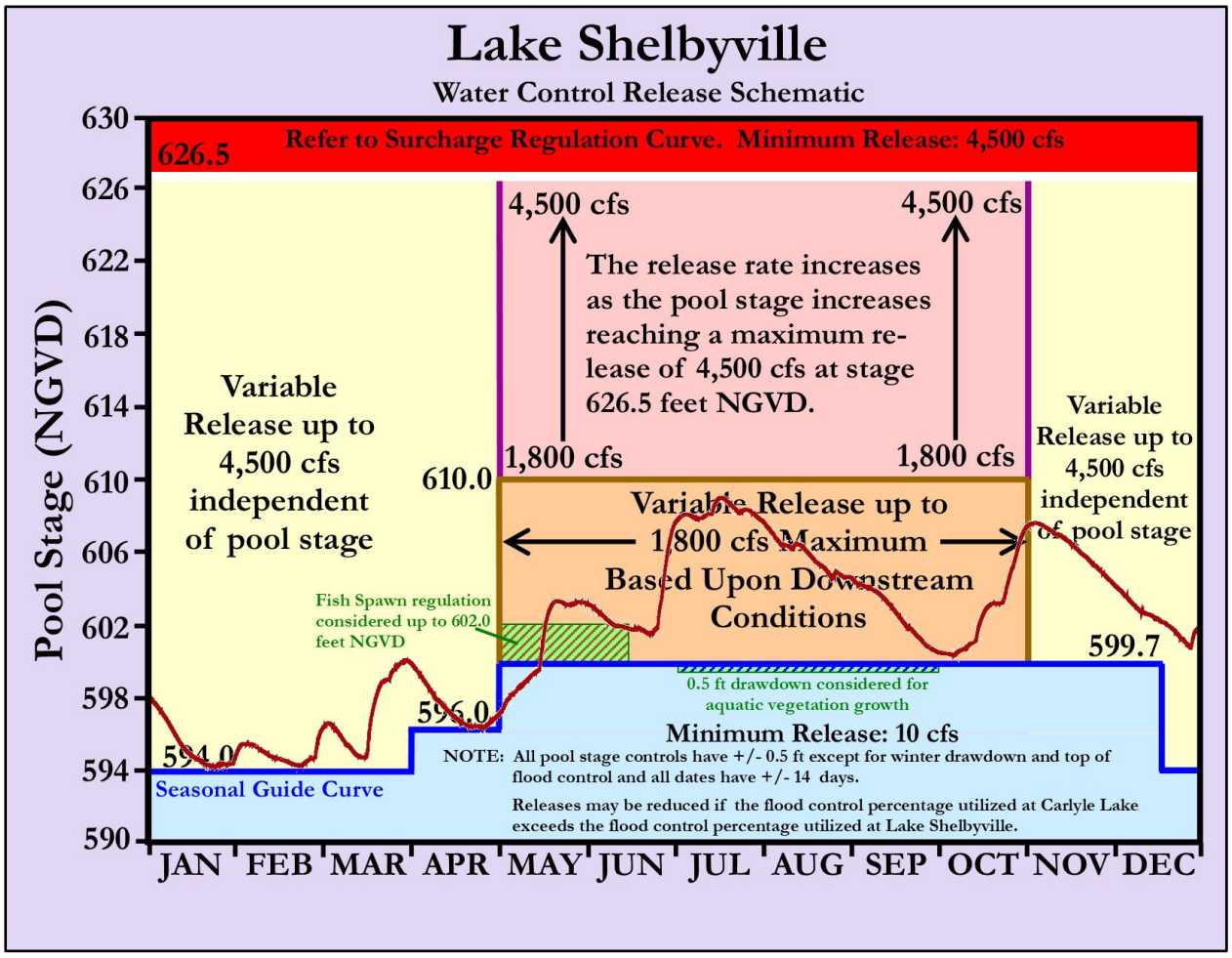

Figure 2. Lake Shelbyville water control plan release schematic and 2021 pool stage hydrograph.

1.1.2 Carlyle Lake

Carlyle Lake is a flood risk management reservoir located approximately in the center of the Kaskaskia River watershed with a total drainage area of 2,717 mi^2, 1,054 mi^2 upstream of Lake Shelbyville and 1,663 mi^2 between Lake Shelbyville and Carlyle Lake. In addition to the upstream drainage area, Carlyle regulates for downstream local flows to Venedy Station, which has a local drainage area of 1,676 mi^2 below Carlyle Dam. Though the Upper Kaskaskia River watershed is regulated by Lake Shelbyville, any volume of water that enters Lake Shelbyville must be released over time. As a result, large events that result in sustained releases from Lake Shelbyville and also result in sustained elevated inflows to Carlyle Lake, thereby increasing the chances that local rainfall events between Lake Shelbyville and Carlyle Lake will further elevate inflows resulting in increased Carlyle Lake pool stages. In addition to the upstream constraints driving inflows influencing lake stages, release constraints in regulating to reduce flooding downstream also influence lake stages.

As at Shelbyville Lake, the 2021 season began with ideal conditions to accomplish multiple environmental pool management objectives. Initially inflows were manageable to meet fish spawn regulations and lake stages were near guide curve at the beginning of growing season (May). However, untimely late June and July inflow events resulted in elevated lake stages and a drawdown was not accomplished until late growing season (end of August and September). Figure 3 shows the 2021 pool stage hydrograph and the zone rules and targets required of the water control plan.

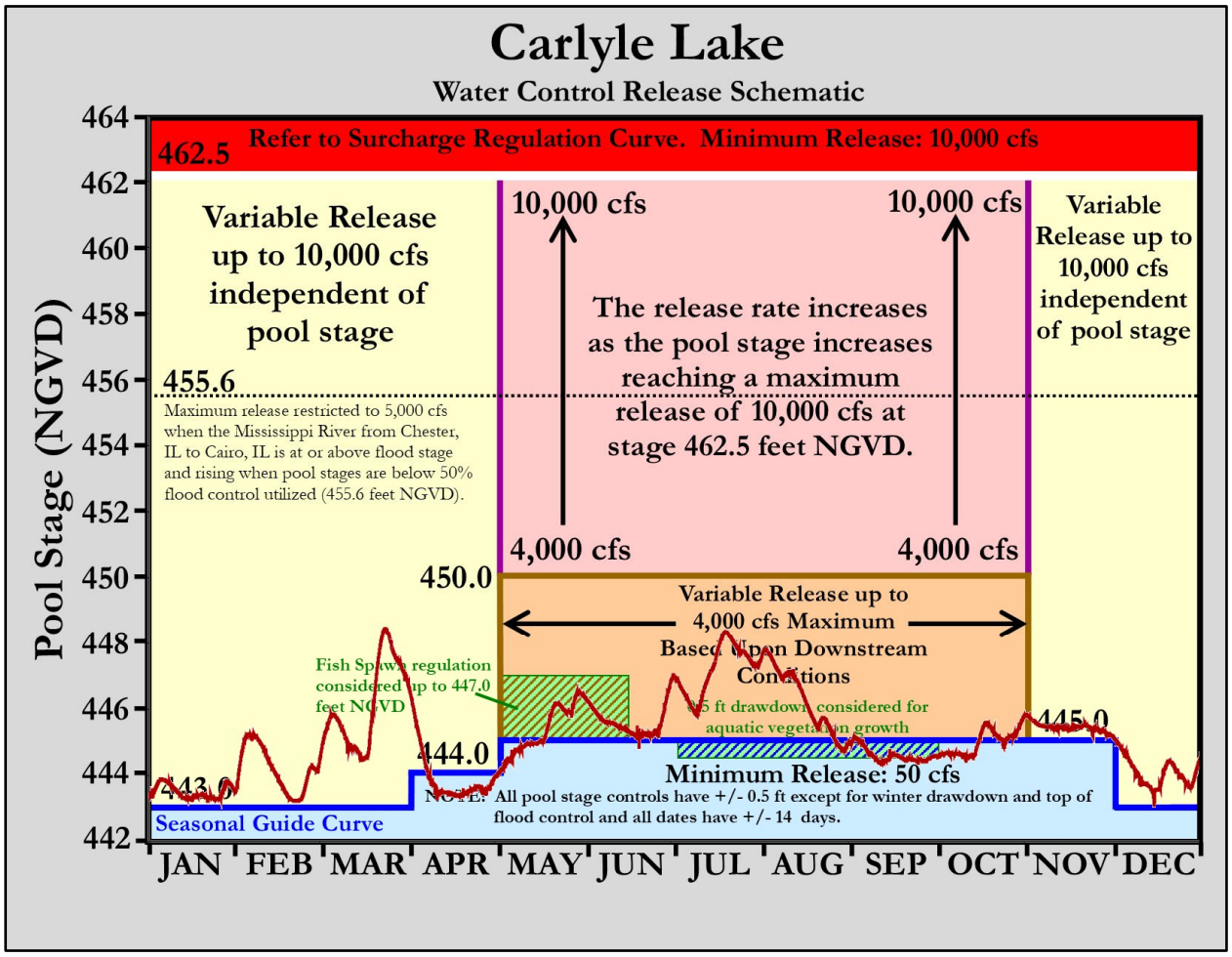

Figure 3. Carlyle Lake water control plan release schematic and 2021 pool stage hydrograph.

1.1.3 Jerry F. Costello Lock and Dam

Jerry Costello L&D is a navigation lock and dam located 0.7 mi upstream of the outlet of the Kaskaskia River basin. There is a total of 5,840 mi^2 of drainage area. 2,717 mi^2 are upstream of Carlyle Dam and 3,123 mi^2 of largely unregulated drainage area are located downstream of Carlyle Lake. Jerry Costello L&D is a hinge point operated run of the river lock and dam project and pool stages are driven by inflow to meet hinge point operating limits and influenced by backwater from the Mississippi River during high flow events. Figure 4 illustrates how Jerry Costello L&D is operated with varying river conditions.

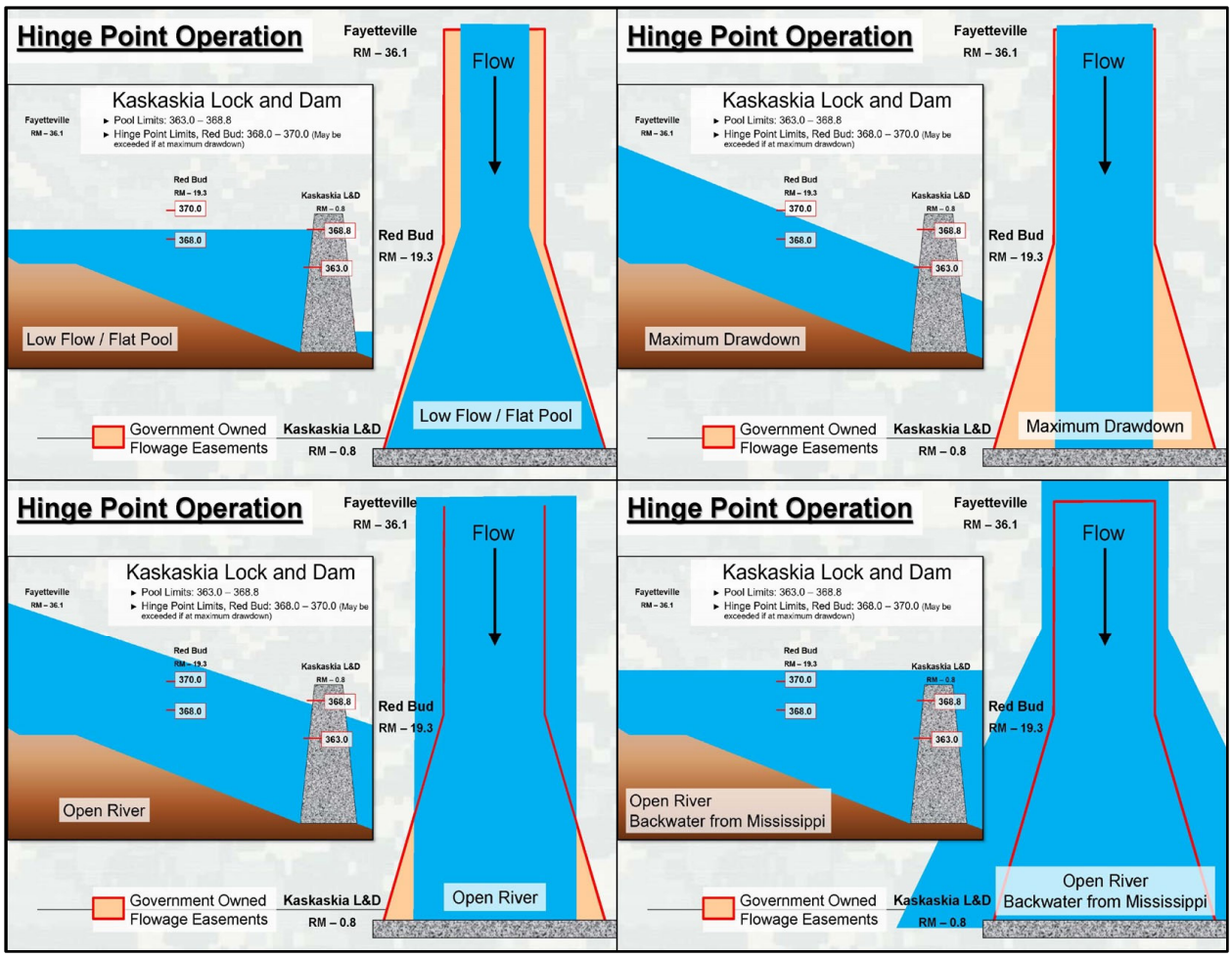

Figure 4. Jerry F. Costello Lock and Dam illustrative operating limits.

Accomplishing environmental pool management (EPM) at Jerry Costello L&D requires high enough inflows (>1,500 cfs) to sustain sufficient navigation depths while accomplishing a half foot drawdown and inflows cannot be too high (<10,000 cfs) to maintain hinge point stage low enough to attain the desired drawdown benefits. Additionally, the Mississippi River must remain low enough not to cause open river conditions due to backwater. Ideal conditions for regulating Jerry Costello L&D for EPM involves relatively low Mississippi River stages/flows and sustained inflows above 1,500 cfs either from timely events downstream of Carlyle Lake or events that cause sustained elevated outflows from Lake Shelbyville and/or Carlyle Lake.

Conditions leading into the 2021 growing season were favorable until an event on the Mississippi River occurred in late June and mid-July that resulted in open river conditions due to backwater from the Mississippi River. Flows on the Mississippi receded in time to conduct late season environmental pool management, which resulted in a successful nearly 60 day half foot drawdown. Figure 5 shows the 2021 pool stage hydrograph and operating constraints throughout the year.

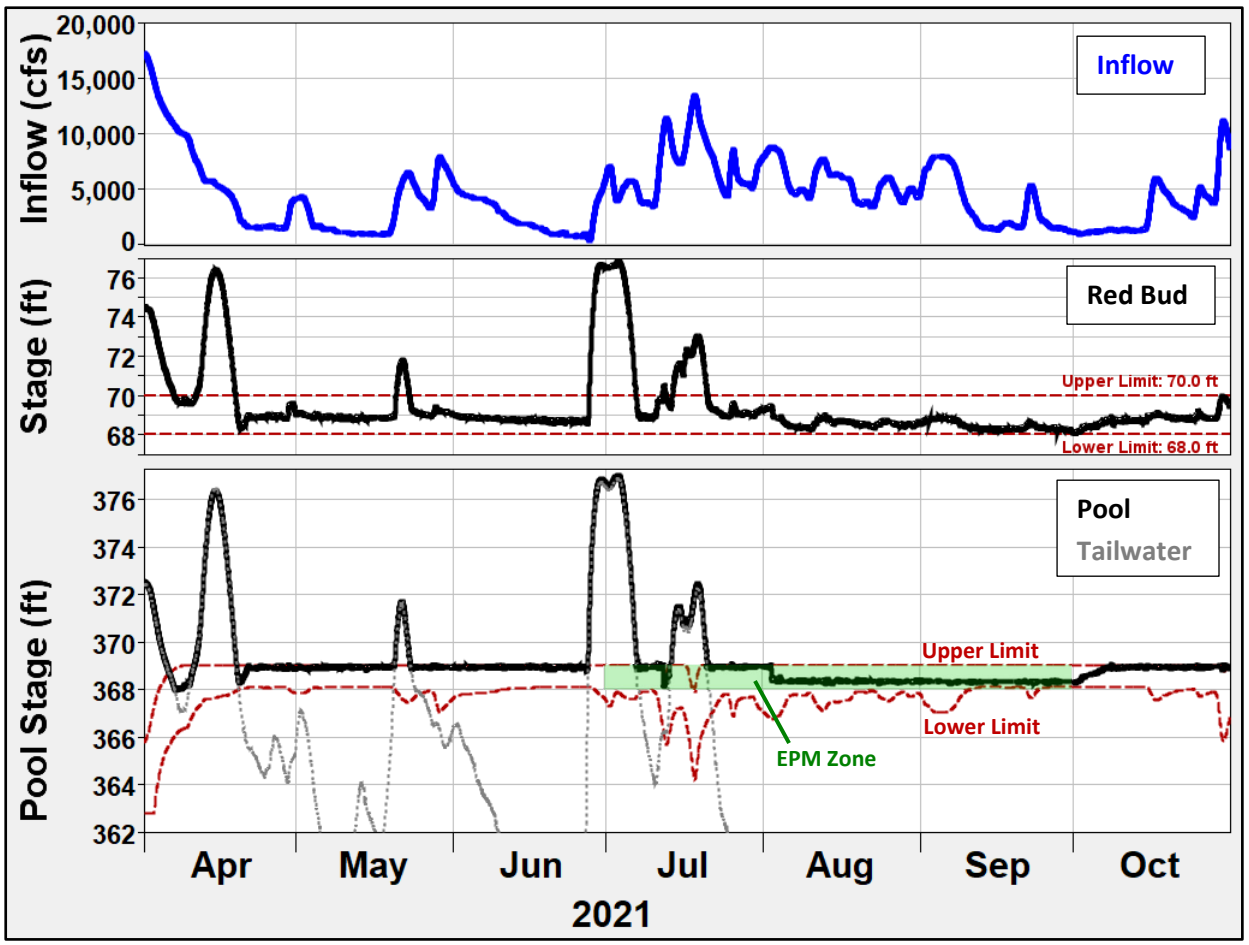

Figure 5. Jerry F. Costello Lock and Dam 2021 pool stage hydrograph and operating constraints.

2 Vegetation

2.1 Site Selection

An aerial imagery assessment was conducted to locate areas with exposed mudflat during previous years when water surface elevations were below normal pool conditions. Aerial imagery was accessed through Digital Globe and Google Earth. Sites disconnected from the river or lake that contained a water control structure of some sort were not included due to a difference in hydrology compared to the river or lake levels, respectively. The preliminary sites were then screened for accessibility. Six sites from the Lower Kaskaskia River (RM 7.5-18; Figure 6) were visited and five were sampled to assess vegetative response. Observations at the RM 18 site on the Kaskaskia River were limited to a visual assessment from distance. Water was too shallow to access RM 18 vegetated areas by boat and flooded areas with adequate depth for the boat were too unconsolidated to access vegetation on foot. At Carlyle Lake, six sites were visited twice in the fall (Figure 7). As at the RM 18 site, site 7 at Carlyle Lake could not be accessed by boat or foot and was visually assessed from a roadway. Samples at Tamalco Access at Carlyle Lake were split into North and South locations due to obvious visual differences in

substrate and disturbance frequency. Therefore, six sites were visited and 6 samples (no sample at site 7 and two samples at Tamalco) were collected to evaluate vegetative response to the late-season drawdown at Carlyle. Imagery at Shelbyville was not evaluated due to high surface water elevations throughout the growing season which prevented vegetation establishment below normal pool in 2021 (Figure 2).

Table 3. Sampling sites visited fall 2021 at Carlyle Lake and lower Kaskaskia River. Site codes in the table below correspond with site labels in Figures 6 and 7.

Location	Site Code	Site Name	Size (ac)*	Date of 1st visit (# days since onset of drawdown)	Date of 2nd visit (# days since onset drawdown)
Kaskaskia River	1	RM 18	121	Sept 17 (46+)	Nov 4 (N/A)
	2	RM 17	21		
	3	RM 14	155		
	4	RM 13.5	98		
	5	RM 7.5	64		
	6	RM 8	37		
Carlyle Lake	7	Dam West Area	27	Sep 20 (14++)	Oct 9 (33)
	8	Hazlet State Park	135		
	9	Allen Branch Access	31		
	10	Muskrat Flats Access	153		
	11	Horseshoe Island Access	12		
	12	Tamalco Access (North and South)	75		

*Acreage includes entire oxbows (Kaskaskia River) or coves (Lake Carlyle) and thus includes open water as well as shoreline area. + Drawdown for the lower Kaskaskia River began on August 2 and ended on October 6, 2021 (65 days). ++Drawdown for Carlyle Lake began on September 6 and ended on October 15 (39 days).

Figure 6. 2021 sample sites along the lower Kaskaskia River with exposed sediment supporting emergent vegetation.

Figure 7. 2021 sample sites visited at Carlyle Lake with exposed sediment supporting emergent vegetation.

2.2 **Integrated Waterbird Management and Monitoring Vegetation Surveys**

2.2.1 Methods

A total of 12 samples as described in Section 2.1 were collected to assess individual emergent plant species cover at the Kaskaskia River and Carlyle Lake sites. The Kaskaskia River was visited during near optimal conditions on September 17 as much of the vegetation had produced seed and reached peak coverage. A second visit occurred on November 4 focused on documenting waterfowl use of oxbows. Unfortunately, timing did not align with peak migration prior to opening of waterfowl season so reporting is limited to vegetation response. Carlyle Lake vegetation was sampled twice due to the relatively immature stage of growth present during the September 20 sampling date (i.e., 14 days of drawdown). The second sampling date occurred on October 9 as surface water elevations began returning to normal pool (Figure 3). Some additional species were recorded on the second date, but the lower band of vegetation was overtopped at several sites. As a result, data from the first date is provided as it was able to capture a larger number of sites with emergent plant growth and is more representative of the plant community response to the drawdown. The Integrated Waterbird Management and Monitoring protocol was utilized to assess species abundance and percent cover (USFWS 2021). Only emergent vegetation from the current growing season was assessed. To complete the vegetation surveys while adhering to the protocol, two assessments were completed: 1) percent cover of emergent vegetation within the survey unit and 2) species inventory and species-specific percent cover within areas of emergent vegetation (Figures 8 to 11).

To complete the first assessment, locations of all emergent vegetation areas within each survey unit were determined. This was done by a visual assessment throughout each survey unit. Once areas of emergent vegetation were identified, an estimate of the percent cover of the survey unit by emergent vegetation was completed. Percent cover is defined as the percentage of the survey unit covered by vertical projections from the outermost perimeter of the plants' foliage (Anderson 1986).

To complete the second assessment, a list of all common emergent vegetation species was compiled, and an estimate of each species' percent cover was completed. For this estimate, percent cover is defined as above except that it is estimated as a percentage of emergent vegetation area, not as a percentage of the total survey unit area. For example, a survey unit might contain a single emergent vegetation species that covers 50% of the total survey unit area and 100% of the emergent vegetation area within the survey unit. Therefore, 100% would be recorded for this assessment. Total cover across species can exceed 100% due to stratification of plant species with varying heights and growth habits.

In addition to the two above measurements taken at each site, qualitative estimates of seed head size and density were completed for each common emergent plant species at Kaskaskia River sites. Seed head sizes were assigned a size of average, smaller, or larger than the average size for each species as compared to diagrams provided in the IWMM protocol. For seed head densities, the density of stems for a species and proportion of as species' stems with seed heads were assessed. Densities were assigned as low, moderate, or high. Low densities were characterized by large areas of bare ground and low proportion of seed heads to plant stems. High seed head densities were characterized by areas with

little bare ground and a high proportion of seed heads to stems. Moderate seed head densities fall between the two aforementioned categories.

Seed head size and density estimates were also performed at Carlyle Lake but for descriptive purposes only. Due to the later start date for the drawdown at Carlyle Lake, seed head production was limited to just a few species that could reach maturity in under 35 days of soil exposure.

Several diversity metrics were utilized to assess plant community composition at surveyed sites. Hill Numbers are calculated from other diversity indices such as Shannon's Entropy or Simpson's Index and describe the equivalent number of equally common species needed to give the same value of a diversity measure. When these values are plotted (Figures 12 and 13), a comparison of diversity and evenness can be made. When q = 0 the value equals overall species richness. When q increases to 1 the effective number equals the inverse of Shannon Entropy and is a balance between richness and species evenness. The value at q = 1 gives the approximate number of 'typical' species in the plant community for a given site. When q increases to 2 the effective number equals the inverse of Simpson diversity), and there is greater weight given to more abundant species in the plant community. A value at q = 2 gives the approximate number of 'very abundant' species in a community (Hill 1973). A value at q = ∞ is equal to the reciprocal of the Berger-Parker Dominance value, which is a measure of the numerical importance of the most abundant species. As the reciprocal of the Berger-Parker Dominance Value (proportional abundance of the commonest species) increases there is an increase in diversity and a reduction in dominance within the community. Taken together, Hill Numbers can be used to evaluate species richness and evenness. Units with a shallower slope as q increases from 0 to ∞ reflect greater community evenness and larger values mean greater overall diversity within the community.

2.3 Results

Table 4. Species encountered at Kaskaskia River sampling sites on September 17 2021.

Kaskaskia River		
Species Code	**Scientific Name**	**Common Name**
AMETUB	*Ameranthus tuberculatus*	water hemp
AMMCOC	*Ammania coccinea*	scarlet toothcup
BACROT	*Bacopa rotundifolia*	round-leaf water hyssop
BIDARI	*Bidens aristosa*	bearded beggarticks
BIDCER	*Bidens cernua*	nodding marigold
CYPESC	*Cyperus esculentus*	yellow nutsedge
CYPERY	*Cyperus erythrorhizos*	redroot flatsedge
ECHCRU	*Echinochloa crus-galli*	wild millet
ECLPRO	*Eclipta prostrata*	yerba de tajo
ELEOCHARIS	*Elocharis sp.*	spikerush sp.
ERAHYP	*Eragrostis hypnoides*	teal lovegrass
HELIND	*Heliotropium indicum*	Indian heliotrope

HIBLAE	*Hibiscus laevis*	halbard-leaved rose mallow
LEPPAN	*Leptachloa panicoides*	Amazon sprangletop
LINDUB	*Lindernia dubia*	false pimpernel
POLLAP	*Polygonum lapathifolium*	nodding smartweed
POLPEN	*Polygonum pensylvanicum*	Pennsylvania smartweed
RORSES	*Rorippa sessiflora*	sessile-flowered yellow cress
SAGLAT	*Sagittaria latifolia*	arrowhead
XANSTR	*Xanthium strumarium*	cocklebur

Table 5. Species encountered at Carlyle Lake sampling sites on September 20 2021 sampling date

Carlyle Lake		
Species Code	**Species Name**	**Common Name**
ACAPHYLA	*Acalphya sp.*	mercury species
AGATEN	*Agalinis tenuifolia*	slender false foxglove
AMBART	*Ambrosia artemisifolia*	common ragweed
AMETUB	*Ameranthus tuberculatus*	water hemp
AMMCOC	*Ammania coccinea*	scarlet toothcup
BACROT	*Bacopa rotundifolia*	round-leaf water hyssop
BIDARI	*Bidens aristosa*	bearded beggarticks
BIDCER	*Bidens cernua*	nodding marigold
BOLAST	*Boltonia asteroides*	false aster
CAREX	*Carex sp.*	*Carex* species
CARHYA	*Carex hyalinolepis*	shoreline sedge
CARMUS	*Carex muskingumensis*	palm sedge
CEPOCC	*Cephalanthus occidentalis*	buttonbush
CHAFAS	*Chamaecrista fasciculata*	partridge pea
COMDIFF	*Commelina diffusa*	climbing dayflower
CYPERUS	*Cyperus sp.*	flatsedge species
CYPESC	*Cyperus esculentus*	yellow nutsedge
ECHCRU	*Echinochloa crus-galli*	wild millet
ELEOCHARIS	*Eleocharis sp.*	spikerush species
ERAHYP	*Eragrostis hypnoides*	teal lovegrass
EUPMAC	*Euphorbia maculata*	spotted spurge
HIBLAE	*Hibiscus laevis*	rose mallow
IVAANN	*Iva annua*	marsh elder
LEPPAN	*Leptachloa panicoides*	Amazon sprangletop
LINDUB	*Lindernia dubia*	false pimpernel
PANICUM	*Panicum sp.*	*Panicum* species
PENSED	*Penthorum sedoides*	ditch stonecrop
PHYLAN	*Phyla lanceolata*	frog fruit

POLHYD	*Polygonum hydropiper*	marshpepper
POLLAP	*Polygonum lapathifolium*	nodding smartweed
POLPEN	*Polygonum pennsylvanicum*	Pennsylvania smartweed
RORSES	*Rorippa sessiflora*	sessile-flowered yellow cress
RUMCRI	*Rumex cripus*	curly dock
SAGLAT	*Sagattaria latifolia*	arrowhead
SALIX	*Salix sp.*	willow species
SIUSUA	*Sium suave*	water parsnip
SYMERI	*Symphyotrichum ericoides*	heath aster
SYMLAN	*Symphyotrichum lanceolatum*	panicled aster
XANSTR	*Xanthium strumarium*	cocklebur

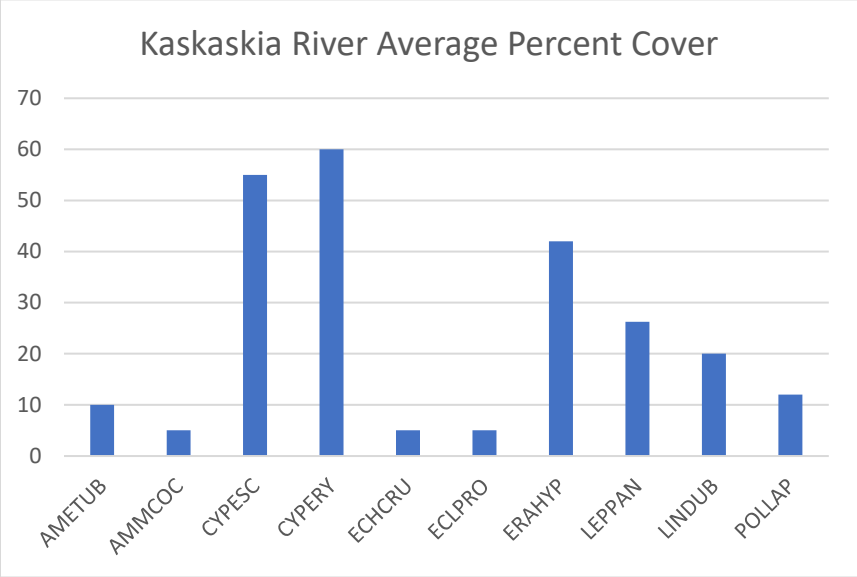

Figure 8. Average percent plant cover by species (≥ 5%), per five samples, Kaskaskia River sites (IWMM).

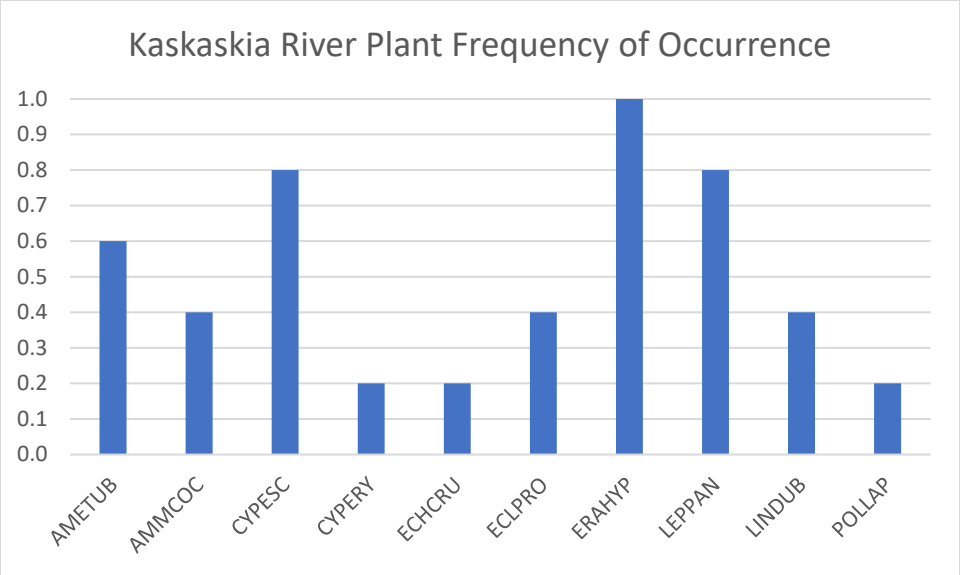

Figure 9. Frequency of occurrence by species, per five samples, Kaskaskia River sites (IWMM).

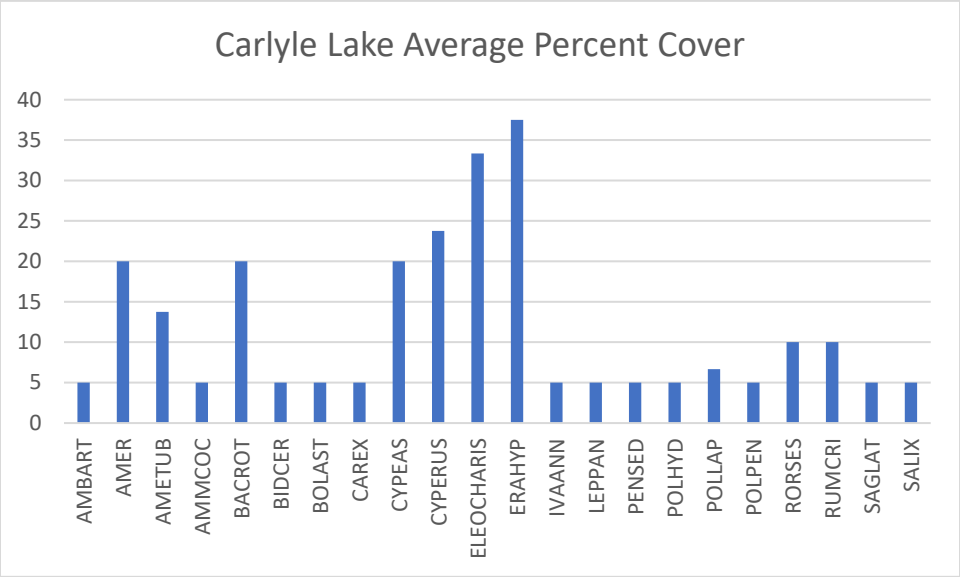

Figure 10. Average percent plant cover by species (>5%), per six samples, Carlyle Lake sites (IWMM) on September 20 2021 sampling date.

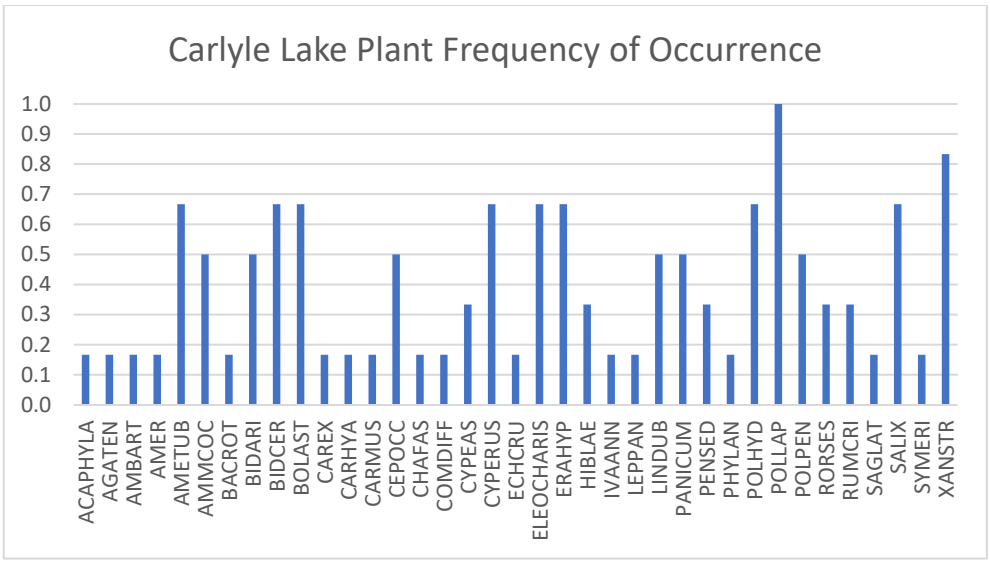

Figure 11. Frequency of occurrence by species, per six samples, Carlyle Lake sites (IWMM) on September 20 2021 sampling date.

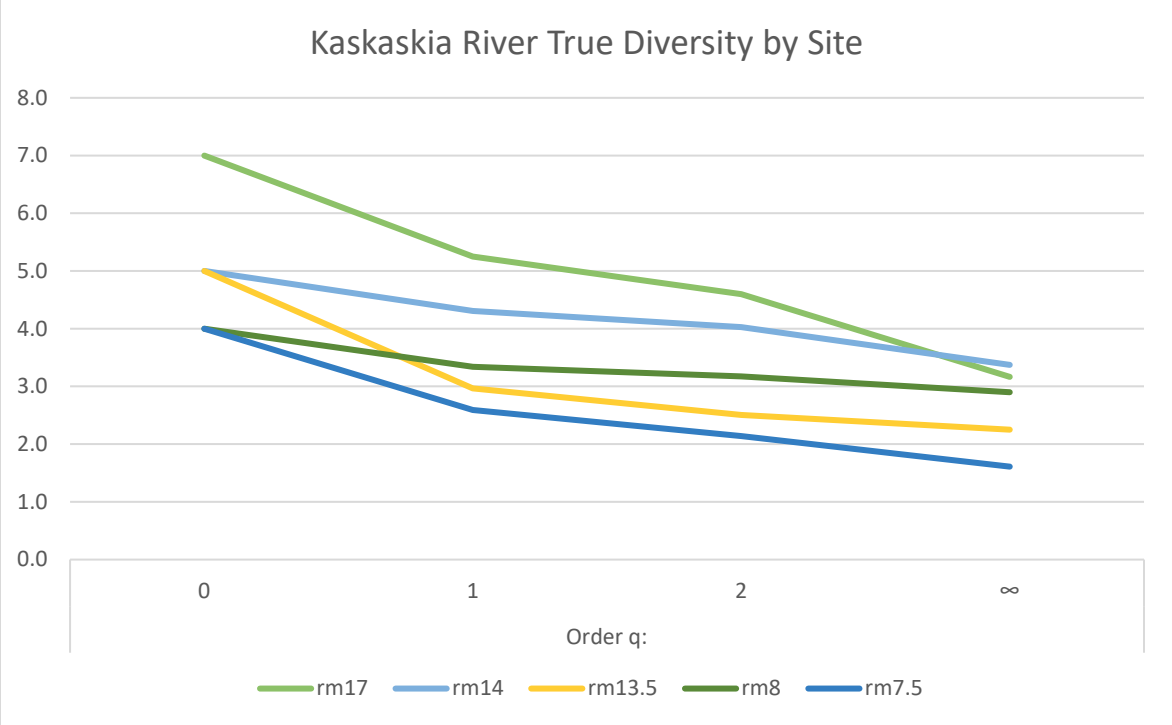

Figure 12. Kaskaskia River true diversity by site. q=0 (richness), q=1 (inverse of Shannon's Index) approximates the number of typical species, q=2 (inverse of Simpson's Index) approximates the number of very abundant species, and q=∞ is a measure of dominance (lower value representing a community with high dominance and lower overall diversity).

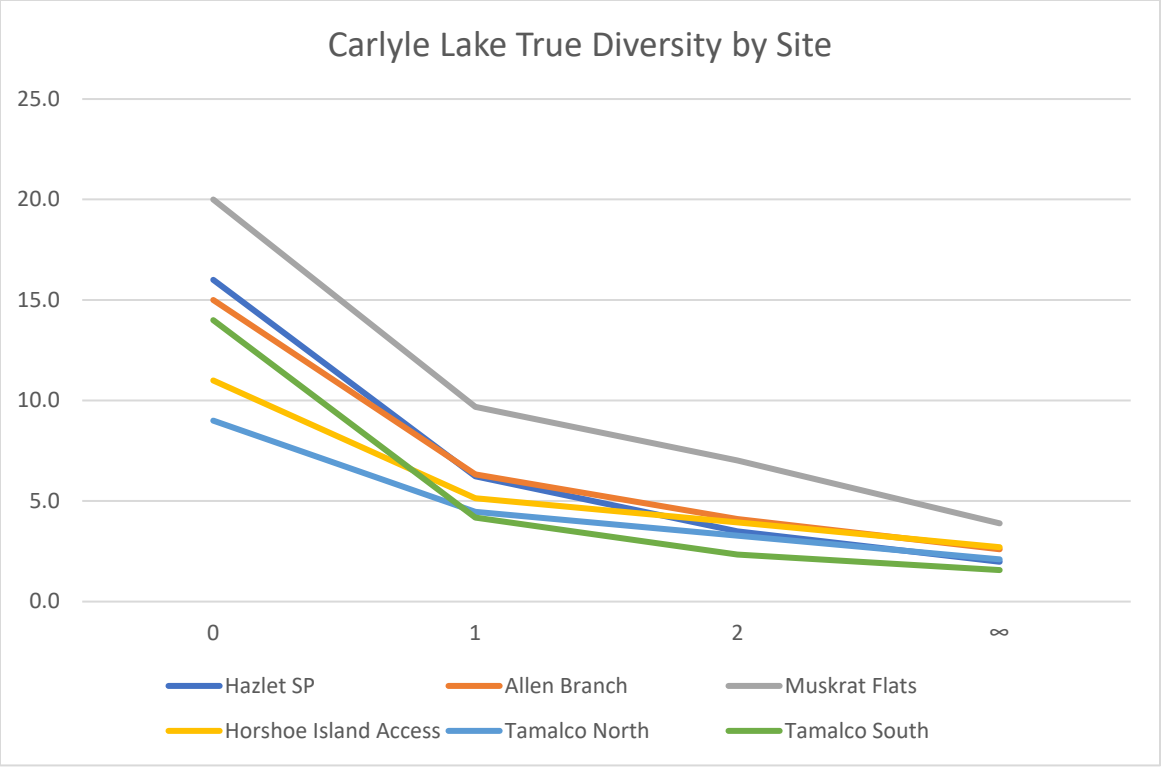

Figure 13. Carlyle Lake true diversity by site. q=0 (richness), q=1 (inverse of Shannon's Index) approximates the number of typical species, q=2 (inverse of Simpson's Index) approximates the number of very abundant species, and q=∞ is a measure of dominance (lower value representing a community with high dominance and lower overall diversity).

Table 6. Average seedhead size and density at Kaskaskia River sites (IWMM). Seedhead sizes include: 1) small, 2) average, and 3) large. Seedhead densities include 1) low, 2) average, and 3) high.

Species Code	Average Seedhead Size	Average Seedhead Density
CYPESC	3	3
CYPERY	3	3
ECHCRU	1	1
ERAHYP	3	3
LEPPAN	2.5	2.5

2.4 Discussion

Overall, twenty species were recorded at sampling sites along the lower Kaskaskia River and thirty-eight species were recorded at Carlyle Lake sites. Differences in species richness were likely influenced by greater topographic diversity that created a wider range of moisture and exposure conditions along the Carlyle Lake shoreline compared to the oxbows visited on the Kaskaskia River. Additionally, timing could have impacted species germination at the two locations. The slightly later drawdown at Carlyle resulted in germination that was delayed until there was a mixture of warm, summer-like conditions as well as cooler, fall-like conditions that may trigger germination in different plant species.

2.4.1 Kaskaskia River - Plant cover and frequency of occurrence

Species percent cover varied by site, but all sites along the Kaskaskia River were dominated by emergent plant species that germinate during the mid- to late-growing season. The species with the greatest average percent cover when present included two flat sedge species, *Cyperus esculentus* and *Cyperus erythrorhizos* (55-60%), teal lovegrass (*Eragrostis hypnoides*; 42%), Amazon sprangletop (*Leptochloa panicoides*; 26.3%), and false pimpernel *(Lindernia dubia*; 20%). Cumulatively, percent cover of these species at each sampling site exceeded 100% cover due to foliage layering and staggered plant development. For example, teal lovegrass and false pimpernel germinated and reached maturity first. Both species are low in stature (< 10 inches tall) at maturity so there is sufficient light and space for the slightly taller flatsedges and sprangletop (< 24 inches tall) to dominate the upper canopy.

Frequency of occurrence was calculated as the proportion of sampling sites occupied by a species. Along the Kaskaskia River, species with the highest frequency of occurrence included yellow nutsedge, teal lovegrass, Amazon sprangletop, and water hemp (*Ameranthus tuberculatus*). All but water hemp were species with high average percent cover along the Kaskaskia River. Water hemp percent cover was relatively low (i.e., < 10%) due primarily to its growth habit. The species was frequently encountered even within a sampling site, but the more vertical structure and narrow leaves occupy less horizontal space. In addition, water hemp was one of the first species to produce seed and its foliage was starting to senesce as it reached the end of its annual growth cycle.

Overall, the Kaskaskia River sites had high coverage and vegetation layering at elevations exposed by the drawdown. The dominant species at the sites were comprised of mostly desirable species for migratory waterfowl. The biomass produced by all emergent species should provide variety of suitable sites for foraging and developing macroinvertebrates which are eaten by a wide assortment of wildlife species, including fish, amphibians, reptiles, and waterfowl.

2.4.2 Carlyle Lake - Plant cover and frequency of occurrence

Species percent cover varied by sampling site at Carlyle Lake and the diversity of conditions resulted in suitable exposure time, substrate, and moisture conditions for 37 species by the September 20 sampling date. Many of the sampling sites were adjacent to higher elevation terrestrial areas and the transition between normal lake levels and more upland areas supported species not encountered at Kaskaskia River sites in 2021. The species with the greatest average percent cover included teal lovegrass (37.5%), a spikerush species (*Eleocharis* sp.; 33%), flatsedge species (*Cyperus* spp.; 20-24%), round-leaf water hyssop (*Bacopa rotundifolia*; 20%), and water hemp (*A. tuberculatus*; 20%). Hazlet Park, Allen Branch Access, Muskrat Flats Access, and the Tamalco Access Sites were revisited on October 9 to attempt to document any additional growth that might have occurred since the September 20 sampling date. Slight changes occurred but not enough to warrant repeat vegetative sampling as ratios had not changed. However, species lists were generated for each site visited on October 9 and compared to the September 20 species lists. Overall, 10 additional species were added to the cumulative list to bring total species observed at Carlyle Lake sites to 47 (Table 7). These additional species each occupied $\leq$1% cover at a site. Some of the species added to individual sites were present during the first site visit, but not observed during that trip. Others likely germinated later at these sites as conditions became more suitable for growth as sediment drying continued. For example, arrowhead was only recorded at

Tamalco Access - North during the September site visit. Young arrowhead was observed at Hazlet State Park, Allen Branch, and Tamalco Access - South during the October site visit. In several locations, arrowhead germination was quite extensive. This demonstrates that there is potential in the lake shoreline seedbank and that a wide diversity of emergent species could be supported and reach maturity under more optimal conditions (e.g., a 0.5 ft drawdown occurring in July).

Table 7. Additional species recorded at Carlyle Lake during October 9 site visit.

Scientific name	**Common Name**
Bidens tripartita	strawstem beggarticks
Eupatorium serotinum	late-flowering thoroughwort
Ipomoea lacunosa	small white morning glory
Lemna minor	duckweed
Leucospora multifida	Obi-Wan-Conobea
Ludwigia peploides	water primrose
Lycopus sp.	water horehound species
Ranunculus sp.	buttercup species
Scirpus sp.	bulrush species
Spermacoce glabra	smooth false buttonweed

Fifteen species had a frequency of occurrence $\geq$ 0.42 and nine of those species had a $\geq$ 0.50 frequency of occurrence on the September 20 sampling date. Species that occurred at four or more of the six sampled locations included: water hemp, nodding marigold (*Bidens cernua*), false aster (*Boltonia asteroides*), *Cyperus* spp., *Eleocharis* sp., teal lovegrass, waterpepper (*Polygonum hydropiper*), nodding smartweed (*Polygonum lapathifolium*), willow (*Salix* sp.), and cocklebur (*Xanthium strumarium*) (Figure 11). Teal lovegrass, *Cyperus* spp., *Eleocharis* spp., and water hemp had both a relatively high frequency of occurrence and average percent cover. Although nodding smartweed and cocklebur were present at most sites, 1.0 and 0.83 respectively, they contributed minimally to percent plant cover. Cocklebur never exceeded 1% plant cover and nodding smartweed was $\leq$ 5% cover for all but one site at Carlyle Lake. Cocklebur is an undesirable species in emergent wetlands due its low value for wildlife and ability to dominate sites under certain conditions. An abundance of cocklebur (high frequency and high cover) is typically indicative of sediments that dry rapidly under high temperatures. The low coverage shows that there was a more gradual drying of sediments late in the season that allowed desirable species to germinate and establish. Nodding smartweed is a desirable species for waterfowl seed production but is generally more abundant and prolific during earlier season drawdowns. A gradual drawdown earlier in the season would support a diversity of desirable emergent plant species, help maximize plant coverage, and continue to minimize cover of undesirable species like cocklebur.

2.4.3 Kaskaskia River - Seedhead Size and Density

Seedhead size and density is often used as an indicator of food production for waterfowl. When both metrics are high environmental conditions were near optimal for an extended duration and allowed plants to devote resources toward reproduction. Higher seed production not only helps to enhance

resources for wildlife but also builds up a seedbank which helps to increase the resilience of the wetland during less optimal environmental conditions. Under less optimal conditions a plant may devote more resources to plant height to keep up with rising water surface elevations for example. Emergent plants may grow slowly and only produce sparse, small seedheads when soils are too dry to minimize water loss.

Seedhead size and density estimates were limited to species included within the IWMM manual. Optimal conditions were provided for teal lovegrass and the two flatsedge species (redroot and nutsedge). Each of the three species had high seedhead densities and high seedhead size values. Millet was the only species recorded with both low seedhead size and density. Seedheads for most millets encountered had already shattered prior to our vegetation sampling date. However, based on the leftover stems from the millet and the few intact seedheads encountered we believe the values in the table are representative of conditions prior to seed shatter. Sprangletop was the last species that we were able to estimate seedhead size and density for. Seed head size and density for all sites and species on the Kaskaskia River averaged values of 2.5, meaning that values observed were between average and high levels for both size and density. When factoring in species dominance, Kaskaskia River sites had high seed production values for size and density. The high seed production will add to the seedbank which may help to enhance the plant response during future drawdown attempts as well as increase the available food resources for migratory waterfowl in the region.

2.4.4 Carlyle Lake - Seedhead Size and Density

All species had a slightly later growth period at Carlyle Lake and as a result most did not reach maturity prior to the end of the growing season. The one exception was teal lovegrass which was present at all vegetated sites and achieved high seedhead size and high density. Due to the low number of other species with seedheads, a formal seedhead survey was not conducted at Carlyle Lake. Other species that had some individuals reach maturity to produce seedheads of low size and density included: redroot flatsedge, yellow nutsedge, and sprangletop. Although seed production was low at Carlyle Lake, plant biomass should provide additional resources for macroinvertebrate growth and diversity. Macroinvertebrates provide important protein-rich resources to waterfowl in the spring and also provide important food resources for a variety of fish species.

2.4.5 Diversity Measures

Overall, sites on the lower Kaskaskia River had lower diversity but consisted of many species of importance for waterfowl seed production. The site at RM 17 on the Kaskaskia River had higher overall richness but was comprised of a few dominant species and a few species with low abundance (Figure 12). By comparison the site at RM 14 (Figure 14) had lower richness but the shallow slope of the Hill's numbers illustrated that the plant community was comprised of species of more equal abundance than the RM 17 site (∞ greater for RM 14 and slope flatter than RM 17 site). RM 8 also shows a shallow slope and was comprised of species with more equal abundance than RM 13.5 and RM 7.5 (Figure 12). A plant community that has relatively high richness and evenness is most desirable as that helps to diversify seed availability and nutritional resources for wildlife.

Figure 14. Area of the Kaskaskia River, RM 14, on September 17, 2021, forty-six days of drawdown. The most dominant species at the site consisted of sprangletop and nutsedge, both of which are important forage for migrating waterfowl (photo by Lane Richter, USACE).

At Carlyle Lake, the Muskrat Flats Access area had higher overall richness than the remaining surveyed sites at Carlyle Lake on September 20 (Figure 13). The Horseshoe Island Access area had the second lowest richness value, but the second highest $q = \infty$. Therefore, the plant community at Horseshoe Island was comprised of fewer but more evenly abundant species (less dominance by the most abundant species) than the other sites. The higher richness at Muskrat Flats was likely due to the broad range of germination conditions and staggered exposure times provided by the broad, shallowly sloped shoreline. The site (Figure 15) was also protected from wind generated wave action to a greater degree than sites located on the main bank of lake. Several sites that were more exposed to wave action, such as Tamalco Access area (Figure 16), likely required several germination events for individuals to grow to sufficient size to withstand wave action. Substrate composition may also be a factor at some locations like portions of the Tamalco area shown in Figure 16 due to higher sand content. Tamalco area visits demonstrated that plant establishment can occur with sufficient time. It appeared that these vegetated areas have been able to begin trapping fine sediments and organic material which should increase suitability for plant establishment in the future. Over time we would expect that larger areas would become vegetated with emergent vegetation as fine sediments accumulate around existing vegetation.

Figure 15. Area of Carlyle Lake, Muskrat Flats Access, on September 20, 2021, fourteen days of drawdown. This location was the most diverse site visited with teal lovegrass, spikerush, round-leaf water hyssop, and sessile-flowered spring cress being the most abundant species, and numerous other species filling in gaps between low-profile plants. The site also had shallow slope and exposed mudflats in several areas that attracted foraging shorebirds during this site visit (photo by Lane Richter, USACE).

Carlyle had greater overall richness per site, but sites had greater topographic, sediment, and exposure diversity than Kaskaskia sites. Development of the Carlyle Lake plant community was shaped by several flushes of germination that occurred over about four weeks with germination still occurring on October 9 for some species. This later season drawdown occurred during a period of variable temperatures and moisture conditions that promoted different species to establish. Whereas the Lower Kaskaskia River plant community appeared to largely germinate at the same time fairly uniformly. This was likely due to timing of the drawdown, moisture availability, and sediment slope and composition. The Kaskaskia River oxbows tended to have relatively flat bottoms which were exposed at roughly the same time triggering germination over a relatively short period of time.

Figure 16. Area of Carlyle Lake, Tamalco Access, on October 9, 2021, thirty-three days of drawdown. This area was more exposed to wind and wave fetch effects and had coarser substrates which resulted in more uneven plant establishment than observed in protected coves (photo by Lane Richter, USACE).

2.5 Conclusion

The Kaskaskia River and Carlyle Lake showed positive responses to the relatively brief late-season drawdowns. The 0.5 ft drawdown elevation was initiated at the Kaskaskia River earlier than at Carlyle Lake due to suitable flows and this resulted in extensive stands of productive flatsedges, sprangletop, and teal lovegrass (drawdown for the lower Kaskaskia River began on August 2 and ended on October 6 (65 days); drawdown for Carlyle Lake began on September 6 and ended on October 15 (39 days). Although the drawdown occurred later at Carlyle Lake, widespread germination occurred on most exposed sediments. The exception being areas that were impacted regularly by wave action or were comprised of largely unsuitable substrates such as loose, shifting sand. Carlyle Lake plant growth was also reduced due to the later start which resulted in shorter day length and lower average temperatures as fall approached. However, germination was still actively occurring on October 9 when several sites were revisited. The response from the seedbank at both locations show that a wide diversity of species can be supported through implementation of environmental flow methods.

3 Other Notable Observations from Carlyle Lake Site Visits

3.1 Waterbird Use

Extensive waterbird use was observed during the September 20 visit. Several of the sites, including Tamalco Access, Horseshoe Island Access, Muskrat Flat Access, Hazlet State Park, and Lakeside Access areas were being utilized by shorebirds for foraging (Figure 17 for example). Each site had a shallow bank slope that provided a range of sediment saturation levels and depths to support different shorebird taxa. Most shorebirds observed during the September 20 visit consisted of Killdeer, other plovers, and several *Calidris* species pecking at and probing sediments near the shoreline/water interface. Lesser Yellowlegs and a small number of other larger-bodied sandpipers were observed at further distances and not identified to species for that reason. Cumulatively, there were over 200 shorebirds observed on this single site visit which occurred in the latter half of the fall shorebird migration period. Additionally, herons and egrets were observed actively utilizing both the coves and shallow water sites for hunting and foraging. Numerous small-bodied fishes were observed swimming through the relatively clear waters in coves and other areas protected from main lake waves. Finally, large flocks of pelicans were observed utilizing sandbars near Horseshoe Island Access, Muskrat Flats Access, Tamalco Access, and the Dam West Access Area. American White Pelicans are cooperative surface feeders (i.e., utilize upper couple feet of the water column) that benefit from shallow water areas which help increase foraging success by restricting fish movement away from the group. The drawdown created numerous protected sandbar areas for loafing and resting, but also suitable shallower foraging areas near resting sites.

While not a direct focus of the 2021 monitoring efforts, the level of waterbird use seen at the Carlyle Lake is a good indication that these areas, and the drawdown, are providing critically important seasonal habitat for migrating shorebirds and other important waterbirds.

3.2 Shoreline

Vegetation was most abundant and continuous in coves that consisted of calmer waters (i.e., less wave action) and sediments with higher proportions of fine sediments. The clear waters in these protected coves were utilized by small-bodied fishes and were allowing establishment of some emergent plants within the shallow aquatic edges (Figure 18). The duration and timing of the drawdown was the factor that limited plant establishment and growth the most.

Germination was still frequently occurring in areas more impacted by wave action and significant differences were visible between September 20 and October 9 visits (Figures 16 and 17). Moreover, the exposed shoreline provided protection to higher elevation areas and likely benefited emergent vegetation as well as adjacent forest resources in these areas by providing an additional low water growing season period. This is a process that naturally occurs in regional wetlands, and which is partially mimicked with the 0.5 ft drawdown.

Plant establishment in areas like Tamalco Access, with higher sand content and more exposure to wave action, still occurred but to a lesser degree. Seedling germination was more sporadic and appeared to be associated with fine sediment accumulation near the seedlings (Figure 19). Species composition was

more limited to species that either thrive in sandier soils or can grow in more mesic areas in general such as slender false foxglove, water hemp, nodding marigold, bearded beggarticks, nutsedge, and *Panicum* sp. An earlier drawdown which would help produce more herbaceous plant biomass in these areas would likely help to slowly build more fine sediments and make areas more suitable for additional species over time. Additionally, emergent vegetation would help reduce wave action at the shoreline, likely increasing the overall nearshore plant response, and improving overall water clarity, if a drawdown occurred early enough in the season to allow more plants to reach maturity.

Figure 17. Area of Carlyle Lake, Tamalco Access, on September 20, 2021, fourteen days of drawdown. Shallowly flooded shoreline with exposed mudflats were actively being utilized by egrets and shorebirds (photo by Lane Richter, USACE).

The difference in plant response to drawdown between Carlyle Lake and the lower Kaskaskia River sites illustrates what is possible with just a few additional mid- to late-summer weeks of growth for flatsedges, sprangletop, and teal lovegrass (Figure 20). In future years, it would be ideal to begin the drawdown earlier in the growing season at Carlyle Lake to help promote more complete plant coverage at sites and allow more plants to reach maturity. This year drawdown timing was limited by

management of stormwater runoff moving through the system, which led to a later than planned drawdown.

Figure 18. Area of Carlyle Lake, cove at Allen Branch Access, on October 9, 2021, 33 days of drawdown. Previously germinated plants are shown growing through clear water amid rising lake elevations (photo by Lane Richter, USACE).

3.3 Pollinator Resources

During two site visits, a variety of native bees, honeybees, wasp species, flower flies, and tachinid flies were observed visiting flowers in the drawdown zone. Emergent flowers, including those from arrowhead, *Bidens* species, false pimpernel, false aster, horehound species, scarlet toothcup, water parsnip, smartweeds, *Symphyotrichum* species, and others were noted. These species provided nectar and/or pollen for pollinators as many were preparing for winter phases of their lifecycle (Figure 21). These floral resources complemented adjacent areas that were in natural landcover types. These conditions likely would be even more enhanced in years when a drawdown could be initiated earlier than the drawdown in 2021.

Figure 19. Area of Carlyle Lake, Allen Branch Access, on October 9, 2021, 33 days of drawdown (photo by Lane Richter, USACE).

Figure 20. Area of the Kaskaskia River, RM 7.5, on September 17, 2021, 46 days of drawdown. The relatively flat slope of the areas exposed by the drawdown in this oxbow resulted in a mostly uniform plant response due to the similar germination timing, duration of drawdown, and moisture levels that were created (photo by Lane Richter, USACE).

Figure 21. Vegetation flowering in the drawdown zone at Carlyle Lake provided additional late-season nectar sources for pollinators (photos by Lane Richter, USACE).

4 Imagery Analysis

Understanding the true area and extent of the impact of a drawdown is one of the key requirements for both operationalizing water level management and conducting effective public outreach with the diverse stakeholder groups at all 3 reservoir locations. The team began work to quantify acreages of exposed bank at Carlyle Lake, Shelbyville Lake, and Kaskaskia River (RM 0 to 36) utilizing an imagery analysis. Imagery was acquired for Carlyle Lake and Lake Shelbyville at drawdown. The water line was then digitized at each location from acquired imagery into separate polygon files. Imagery was acquired for the Kaskaskia at drawdown near the end of September 2021 and at normal pool for Kaskaskia and Lake Carlyle in November 2021. Shelbyville Lake is in the queue for imagery acquisition at normal pool in 2022. Acreage exposed will be calculated for each of the three reservoirs once the water line is digitized at both water levels by subtracting the drawdown polygon from the normal water level polygon (Figures 22 to 24).

Digitizing the waterline for the remaining imagery to calculate acreages is a needed activity for the upcoming year (2022). Resulting acreages will be a critical component of outreach efforts and general information about the project. Acreages can be paired with vegetation data to calculate potential habitat benefits for migratory waterfowl which is a direct and readily visible ecological benefit provided by drawdowns.

Drone imagery was gathered by the MVS survey team during the last week of September at several Kaskaskia River sites exposed by the drawdown. A combination of video and still images were taken to better capture the extent of plant coverage compared to normal pool conditions. An example area is provided in Figure 25 of a site adjacent to the river that was positively impacted by the 0.5 ft drawdown.

We intend to use the images and video for outreach to help communicate and illustrate the positive environmental impacts of the drawdowns and as part of a video that is being worked on currently for the Kaskaskia River project.

Figure 22. Aerial image of Carlyle Lake shoreline with the drawdown water level delineated in red.

Figure 23. Aerial image of Carlyle Lake shoreline with normal water level delineated in yellow (same area as shown in Figure 22).

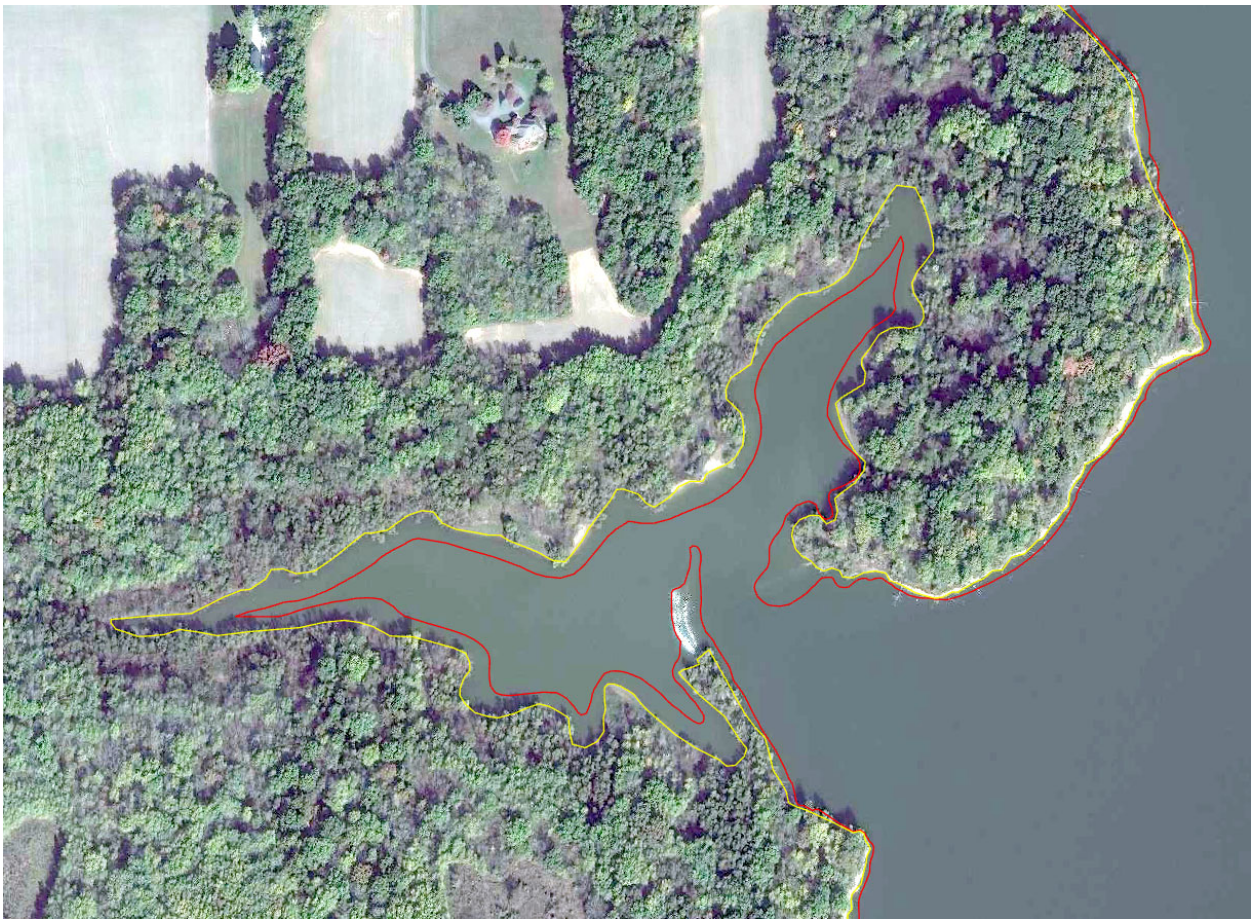

Figure 24. Aerial image of Carlyle Lake shoreline with drawdown and normal water levels shown in red and yellow, respectively. Area between the red and yellow lines is exposed by a 0.5 ft drawdown (same area as shown in Figures 22 and 23).

Figure 25. Example drone imagery gathered at a backwater area of the Kaskaskia River.

5 Public Meetings and Outreach

Two public meetings were held in 2021 for the Kaskaskia project. The first occurred in New Athens, IL on May 27 and consisted of approximately 30 individuals interested in learning more about the potential of the project for the lower 36 miles of the Kaskaskia River. The second occurred in Carlyle, IL on November 5 to discuss the drawdown at Carlyle Lake as well as a dam safety summary and other mission updates for USACE authorizations at the reservoir. The second meeting consisted of approximately 15 individuals representing businesses as well as user groups at Carlyle Lake.

At the New Athens meeting, most attendees were members of a local waterfowl group and had a strong interest in improving moist-soil plant diversity and productions in oxbows of the Kaskaskia River. The meeting began with a presentation from St. Louis District Water Control staff to describe what management for environmental flows with a 0.5 ft drawdown is and when it can be achieved above the

Jerry Costello L&D located near the confluence of the Mississippi and Kaskaskia Rivers. This was followed with a presentation by Environmental Planning illustrating the results that have been achieved by drawdowns on the Mississippi River and what can be expected with similar management on the lower Kaskaskia River. Overall, the presentation was well received. The team fielded an assortment of questions related to the Kaskaskia River and its current state. Several questions were related to other authorities and general information was provided for those and appropriate contacts were given. Questions related to the drawdown centered around duration of drawdown possible, timing, and production expected. Information was provided on the anticipated conditions for summer 2021 and timeframe that a drawdown was planned if upstream flow conditions and downstream conditions supported a drawdown. In the end, the group was very supportive of the plan to implement a 0.5 ft drawdown.

Coordination with local groups and the Illinois Department of Natural Resources (IDNR) occurred during the drawdown period to ensure water level management was achieving desired results. A couple site visits with the local waterfowl group were coordinated in the fall of 2021 to document plant production resulting from the drawdown. In addition, interviews were conducted with the IDNR site manager for the Lower Kaskaskia River management areas and a representative from the waterfowl group to discuss their perspectives on the results and potential habitat benefits created through the first drawdown attempt. IDNR voiced a desire to implement drawdowns in future years to aid and complement their management priorities in the region.

At the Carlyle meeting, Water Control provided an update on lake management during the previous year as well as anticipated management during the winter. This was followed with a summary of benefits provided by the trial late-season drawdown and images of vegetation production. Questions raised in regard to the drawdown occurred primarily after all presentations were finished and on a one-to-one basis. One business owner voiced concerns on impacts to his marina during certain periods of time. This was followed by a discussion to better understand the conditions that occurred at these times. In the end, the business owner shared that the drawdown was fine but there is little room for fluctuation around this level before he notices launching impacts at the marina. Another marina owner asked several questions related to understanding when the lake will be at certain water surface elevations and relayed general support for the effort. Finally, several representatives from a local waterfowl group enthusiastically supported continued drawdowns and agreed with the benefits provided by the drawdown this year. The waterfowl group asked if drawdown duration could be extended to earlier in the growing season. The marina owners noted that boat use declines after the fourth of July so waiting until mid- to late- summer results in fewer impacts at marinas during higher-use periods.

Additional coordination will be needed at Carlyle Lake due to the more diverse interest groups and their respective desires for how the lake is managed for multiple uses. At the conclusion of the meeting, all attendees were open to future drawdowns although further discussion on timing and duration would be beneficial.

6 2022 Efforts

In 2022, we plan to develop products to support outreach and education and highlight some significant benefits that can be provided by drawdowns at Shelbyville Lake, Carlyle Lake, and on the Kaskaskia River. A summary of proposed work at each location is provided below.

Shelbyville Lake. Public meetings were not held at Shelbyville Lake in 2021 due to lake levels that were unfavorable for drawdowns. In 2022, in person outreach will be conducted to share information about environmental flows and the potential benefits provided by a 0.5 ft drawdown. Initial meetings can also highlight some of the successes from the 2021 drawdown at Carlyle Lake and Jerry Costello L&D. Quantifying acreage exposed by a drawdown is a critical communication piece for the public. To achieve this, satellite imagery will be acquired from Digital Globe at normal pool conditions and the water line delineated. The drawdown boundary was delineated in 2021 and can be used to identify the net area exposed. The acreage calculation will be tied into a series of quantitative and qualitative vegetation monitoring methods that will be used to evaluate species diversity, richness, frequency of occurrence, plant coverage, and seed production of emergent wetland at Shelbyville Lake. Lastly, drone imagery collection is proposed to gather additional visual resources that can be used to capture plant growth and potentially bird usage of areas impacted by the drawdown.

Carlyle Lake. We plan to build on public outreach from 2021 to help build support and address concerns from some stakeholders. Carlyle Lake has a substantial birding community that visit the lake during certain periods of the year and outreach with them could provide an opportunity to better capture drawdown benefits and responses from non-game waterbird species (e.g., wading birds, shorebirds, pelicans, etc.). To help build a strong case for benefits provided, we will focus on completion of the drawdown acreage delineation that was started in summer of 2021. Resulting acreage will be combined with seed production estimates to produce a duck-use days estimate (number of waterfowl that can be supported by food for one day during the non-breeding season). Additionally, quantitative and qualitative methods will be used to evaluate and document emergent plant growth and produce the visuals needed to relay the results of a drawdown. Drone imagery is also proposed for Carlyle Lake to help provide additional visual resources for capturing some of the most significant visual environmental benefits which will be incorporated into our public outreach strategies.

Kaskaskia River. We received very positive feedback from state agencies and public-use groups on the successful drawdown in 2021. In 2022, we plan to continue our previous outreach and enhance information shared through delineation of acres exposed, quantitative plant monitoring, sampling to calculate seed production estimates (and associated duck-use days), and finishing development of an outreach video that focuses on the 2021 drawdown. Drone imagery gathered at Kaskaskia River sites in 2021 will be incorporated into public outreach information as a communications resource.

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