Appendix E

Habitat Evaluation & Quantification

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Habitat Evaluation & Quantification Appendix E

1. Introduction

This appendix provides the documentation of the habitat evaluation and quantification process that was conducted to evaluate the benefits of various habitat features for the Clarence Cannon National Wildlife Refuge Habitat Rehabilitation and Enhancement Project (CCNWR HREP). Active participants included biologists from the St. Louis District Corps of Engineers, the U.S. Fish and Wildlife Service (CCNWR, Two Rivers, and Southern Illinois Ecological Services Office), and the Missouri Department of Conservation (Table 1).

Table 1. The team that participated in the Habitat Benefits Analysis for the Clarence Cannon National Wildlife Refuge Habitat Rehabilitation and Enhancement Project.

Team Member	Specialty	Affiliation
Candy Chambers	Wildlife Refuge Specialist	USFWS
Ken Dalrymple	Wildlife Biologist	USFWS
Mike Flaspohler	Wildlife Biologist	MDC
Mick Hanan	Wildlife Biologist	USFWS
Donovan Henry	Fisheries Biologist	USACE
Matt Mangan	Fish and Wildlife Biologist	USFWS
Kat McCain	Ecologist	USACE
Jason Wilson	Refuge Manager	USFWS

Quantification is needed in the project planning process to evaluate benefits of project features because traditional benefit/cost evaluation is not applicable. To determine environmental restoration project benefits, models have been developed to quantify habitat benefits of project features for selected species.

We used both wildlife and fisheries based models to evaluate the effects of project features on species at CCNWR. This was done because wildlife and aquatic habitats would be affected by some or all of the proposed features. For wildlife, we used the Wildlife Habitat Appraisal Guide (WHAG), developed by the Missouri Department of Conservation and the U.S. Department of Agriculture, Soil Conservation Service (now Natural Resources Conservation Service) (MDC & NRCS 1991). The WHAG was adapted from the U.S. Fish and Wildlife Services' Habitat Evaluation Procedures (USFWS 1976). WHAG is widely accepted by local agencies, and it has become the primary wetland habitat evaluation method used in the St. Louis District Army Corps of Engineers.

The aquatic model that has gained the most acceptance within the St. Louis District and along the Upper Mississippi River is the Aquatic Habitat Appraisal Guide (AHAG) (Kilgore & Hardy 1992; Mathias et al. 1996). It was developed by the Corps of Engineers Waterways Experiment Station (WES) and the Rock Island District Corps of Engineers. The AHAG methodology follows that of the Wildlife Habitat Appraisal Guide (WHAG; MDC & NRCS 1991).

Under the UMRR-EMP, the model certification process per EC 1105-2-407 for both of these models has begun. Consistent with guidance from the USACE Ecosystem Planning Center of Expertise, the Agency Technical Review (ATR) Team for the CCNWR HREP conducted an assessment of the models used for this project. This process evaluated the technical quality and appropriateness of the models utilized. A member of the ATR team evaluated the models during the 2013 ATR. The models were found to be correctly applied and appropriately used for this study.

2. Habitat Evaluation Methodology

The WHAG and AHAG are numerical models that evaluate the quality and quantity of particular habitat for species selected by team members (Table 1). The qualitative component of the analysis is known as the habitat suitability index (HSI) and is rated on a 0.0 to 1.0 scale, with higher values indicating better habitat for that species. The HSI for a particular habitat type is determined by selecting values that reflect present and future project area conditions from a series of abiotic and biotic metrics. Each value corresponds to a suitability index for each species. Future values are determined using management plans, historical conditions, and best professional judgment. The quantitative component is the number of acres of the habitat being evaluated. From the calculated qualitative and quantitative values, the standard unit of measure, the habitat unit (HU) is calculated using the formula (HSI × Acres = HUs). Habitat units are calculated for specific target years to forecast changes in habitat values over the life of the project with- and without-project conditions. When HSI scores are not available for each year of analysis, a formula that requires only target year HSI and area estimates is used (USFWS 1980). This formula is:

$$\int_0^T HU\ dt \equiv (T_2 - T_1)\left[\left(\frac{A_1H_1 + A_2H_2}{3}\right) + \left(\frac{A_2H_1 + A_1H_2}{6}\right)\right]$$

Where:

$$\int_0^T HU\ dt = CumulativeHUs$$

T_1= first target year of time interval

T_2 = last target year of time interval

A_1 = area of available habitat at beginning of time interval

A_2 = area of available habitat at end of time interval

H_1 = habitat suitability index at the beginning of time interval

H_2 = habitat suitability index at end of the time interval

3 and 6 = constants derived from integration of HSI × Area for the interval between any two target years

This formula was developed to precisely calculate cumulative HUs when either HSI or area or both change over a time interval, which is common when dealing with the unevenness found in nature. Habitat Unit gains or losses are annualized by summing the cumulative HUs calculated using the above equation across all target years in the period of analysis and dividing the total (cumulative HU) by the number of years in the life of the project (i.e., 50 years). This calculation results in the Average Annual Habitat Units (AAHUs) (USFWS 1980).

The benefits of each proposed project feature (net AAHUs) are then determined by subtracting with-project benefits from without-project benefits. The effects of various habitat improvement feature combinations (alternatives) can then be evaluated by comparing the net AAHUs and costs for each alternative considered.

In preparation of using the WHAG and AHAG models, the evaluation team conducted a site visit and took part in a Value Engineering Study. They also reviewed aerial photography, topographic maps, and preliminary hydrological modeling. During the field evaluation, assumptions were developed regarding existing conditions and projected with-project conditions relative to habitat changes over time and management practices.

For the purpose of planning, design, and impact analysis, period of analysis was established as 50 years. To facilitate comparison, target years were established at 0 (existing conditions), 1, 5, 25, and 50 years. HSIs and cumulative HUs for each evaluation species were calculated at each of these target years.

Corps guidance requires that the team evaluate a suite of features that can be combined in various ways to form project alternatives. The approach used to assess the benefits at CCNWR looked at benefits of project features and their combinations independently. This process is called the iterations process. To determine the habitat units created by each feature, the habitat (bottomland, cropland, non-forested wetland, and aquatic) affected by the feature would be evaluated using the applicable WHAG or AHAG spreadsheet.

This appendix contains WHAG and AHAG summary tables and other data derived from the 11 spreadsheet files not included in this appendix. These spreadsheets are available upon request. Please contact, Dr. Kat McCain, 314-331-8047, email Kathryn.mccain@usace.army.mil if you would like an electronic copy of these files.

3. Habitat Evaluation Species Selection

To begin the habitat evaluation process, the team reviewed the species in each model. They selected four fish species and 7 wildlife species (Table 2). Species were selected because they utilize the current or are anticipated to use the future habitat at CCNWR, and they represented different guilds from different taxonomic families.

Table 2. Aquatic and wildlife evaluation species selected for analysis.

Species	Scientific Name	Family	Habitat Type
AQUATIC (AHAG)			
Flathead catfish	*Pylodictis olivaris*	Ictaluridae	Lentic
Smallmouth Buffalo	*Ictiobus bubalus*	Catostomidae	Lentic
Largemouth Bass	*Micropterus salmoides*	Centrarchidae	Lentic
Bluegill	*Lepomis macrochirus*	Centrarchidae	Lentic
WETLAND (WHAG)			
Mallard	*Anas platyrhyncos*	Anatidae	Non-forested wetland, Bottomland forest, Cropland
Wood Duck	*Aixs sponsa*	Anatidae	Bottomland forest
Least Bittern	*Ixobrychus exilis*	Ardeidae	Non-forested wetland
Prothonotary Warbler	*Protonotaria citrea*	Parulidae	Bottomland forest
Lesser Yellowlegs	*Tringa flavipes*	Scolopacidae	Non-forested wetland
King Rail	*Rallus elegans*	Rallidae	Non-forested wetland
Canada Goose	*Branta Canadensis*	Anatidae	Cropland

AHAG species included flathead catfish, smallmouth buffalo, largemouth bass, and bluegill for the area of the proposed setback and the areas of the proposed excavating.

Flathead catfish, in the family Ictaluridae, are carnivorous fish that dwell in slack water areas along the bottom of perennial large streams, rivers, and lakes (Pflieger 1997).

The smallmouth buffalo, in the family Catostomidae, is an important commercial fish in the Mississippi River drainage basin. This species occurs in deep, flowing water, as well as sloughs, oxbow lakes and other backwaters for resting, spawning, and rearing. They feed on organisms in the substrate of large rivers and backwater lakes.

Largemouth bass are in the family Centrarchidae. They are a predatory warm water sport fish that inhabit side channels and backwaters and utilize submerged structures for cover.

Bluegill are in the family Centrarchidae and are abundant in the Mississippi River drainage basin. They are popular panfish and prefer backwaters of rivers where they feed on zooplankton, aquatic and wetland insects, and some plant materials.

WHAG species included mallard, wood duck, least bittern, prothonotary warbler, lesser yellowlegs, king rail, and Canada goose. The mallard is a migratory waterfowl species that utilize early successional non-forested wetland habitat and forage in bottomland forest and cropland. The wood duck is another migratory waterfowl species whose primary habitat is forested wetlands. Unlike mallards, wood ducks utilize mature forest snags and cavity trees for nesting. The least bittern uses permanent wetlands as well as mid-successional non-forested wetland habitats. It is listed by MDC as a species of concern (MNHP 2012). The prothonotary warbler is a neotropical migratory songbird that uses bottomland forest habitats closely associated with water for feeding, nesting, and shelter. Lesser yellowlegs is a migratory shorebird that feeds in shallow water non-forested wetlands. King rail is critically imperiled species in Missouri known to occur at CCNWR (Darrah and Krementz 2009). This species prefers expansive stands of permanent freshwater herbaceous wetlands. Canada goose is common and live in a variety of habitats near water and grain fields.

4. Site Specific Methodology and Assumptions

During the second step of the evaluation process, the team determined what habitats would be affected by the project features and locations in the project area to evaluate these changes. The following WHAG spreadsheets were used: non-forest, cropland, and bottomland hardwood wetlands. There were a total of 10 evaluation locations; one in the center of each of the proposed subunits (8 total) as well as the existing water bodies and historic meander restoration. The subunits were combined into functional management units: South, North, and Riverside (Table 3).

The 1996 AHAG was used to evaluate the four aquatic areas proposed for excavation and the area of the setback. This AHAG version was selected because it was thought to provide a better analysis of the aquatic habitats in the project area, all of which are proposed to become reconnected to the Mississippi River.

Table 3. Habitat benefit analyses worksheets used for each evaluation location

Habitat	Existing Water Bodies	Historic Meanders	South Unit	North Unit	Riverside Unit
Non-forested Wetland WHAG			X	X	X
Cropland WHAG		X			X
Bottomland Hardwood WHAG					X
Aquatic AHAG	X	X			X

Final calculations included determining the acreage of non-forested, cropland, bottomland hardwood, and aquatic habitats using topographical data, management plans, land coverage data files, and aerial photography. Habitat suitability index scores (HSIs) were calculated for each species used in the WHAG and AHAG models. In evaluations that included multiple species, the HSIs were averaged then multiplied by the appropriate acreage to generate HUs and cumulative HUs (see above equation). The

cumulative HUs were then annualized to yield AAHUs for with and without project. WHAG and AHAG AAHUs were summed when a particular feature was affected by both.

General Assumptions and Habitat Characteristics

1. It was assumed that target years of 0 (existing condition), 1, 5, 25, and 50 (future without and future with project conditions) are sufficient to analyze HUs and characterize habitat changes over the estimated period of analysis.
2. For planning purposes we used existing spillway elevation to determine overtopping flood events for the period of record 1941 to 2011. This was done to ease the hydrologic modeling calculations since the exterior berm and spillway elevations have changed four times. With this assumption, 19 of the 71 years of record (27%) the spillway would have been overtopped. It was assumed that the same percentage of overtopping events would occur over the period of analysis (13 of the next 50 years).
3. For future with project conditions, the exterior berm degrade elevation was set at 441.0 NGVD. This elevation was used in calculating flood frequency, number of days connected, and other hydrological parameters.
4. The duration and severity of Mississippi River floods have increased with changes to floodplain management. Current Environmental Pool Management of the Mississippi River which has led to an elevated water table at the site is assumed to be sustained during the 50-year period of analysis.
5. The water control structures throughout the site are undersized causing flood waters to remain on the site longer increasing the severity of flood impacts. During future flood events, the project would allow for faster removal of flood waters reducing impacts from inundation and sedimentation.
6. After the flood of 1993, tree mortality was severe in forested areas. Most of the oaks and some pecans have died in the period after the flood, likely due to stress from the flood height and duration. There is little natural regeneration of oaks and pecans in these areas. It is assumed that without the project these bottomland hardwood communities would convert to more river front forest dominated by silver maples and cottonwoods.
7. Without the project, USFWS will continue to manage the project area. USFWS will continue to maintain existing infrastructure (including water control structures, pump station, ditches, and spillway) and habitats dependent on funding, staffing, and natural disasters. However, it is assumed no substantial increases to current operation and maintenance budget for the site would occur while efforts to maintain aging infrastructure would increase along with increases in projected prices of consumables (*i.e.,* diesel fuel) which will take away from habitat management.
8. Without the project, it is assumed that the existing exterior berm will not be removed.
9. Under the with-project conditions, water control and movement would be enhanced and operated at a higher level of effectiveness throughout the 50-year planning period.
10. We assumed that operation of Clarence Cannon National Wildlife Refuge would continue under the current management plans and objectives for at least the life of the HREP.
11. Without the project, fish use of the existing water bodies will continue to be restricted in many years by the lack of connectivity with the main channel. Additionally, it was assumed that without the project, the acreage of existing water bodies would be reduced 10% every 10 years. With the project it was assumed that acreage of the existing water bodies would remain constant through the period of analysis.

12. We assumed that all existing water bodies on site (Rabourn Slough, Crane Pond, Buttonbush Pond, Heron Pond) have similar conditions, and that field data collection during May 2011 accurately represents the conditions of these water bodies.

Feature Specific Assumptions

1. *Pump Station.* It was assumed the diesel versus electric pump station would generate the same HSI scores.

   WHAG Evaluation – We chose to evaluate this feature using the non-forested wetland spreadsheet. It was assumed this feature would directly impact habitat conditions within the managed wetland units on the site by improving water delivery and drainage.

   AHAG Evaluation – No fisheries benefits are expected to be generated from this feature, consequently no AHAG evaluation was conducted.
2. *New Subunits.* It was assumed that each of the newly proposed management subunits created by berm removals and new water control structures would generate the same HSI scores. The difference in HUs between the subunits is tied to the acres. We assumed that material from the berm modification would be used to fill in any adjacent borrow areas. We assumed existing berms provide no habitat benefits. The subunits were grouped into 3 functional management units based on location: South Unit, North Unit, and Riverside Unit.

   WHAG Evaluation – We chose to evaluate this feature using the non-forested wetland spreadsheet. It was assumed that restoring larger management areas would increase habitat benefits as it has been observed on site in MSU7.

   AHAG Evaluation - No fisheries benefits are expected to be generated from this feature, consequently no AHAG evaluation was conducted.

3. *Setback.* It was assumed that if the setback with water control structure was chosen, connectivity would be managed to mimic the prevailing environmental conditions. With this assumption, it was assumed that both options (water control structure or exterior berm degrade) would generate the same HSI score.

   WHAG Evaluation – We chose to evaluate this feature using the bottomland hardwood, and non-forested wetland spreadsheets. We used the bottomland hardwood spreadsheet for the existing forest and the cropland proposed for conversion to bottomland forest. We used the non-forested wetland spreadsheet to evaluate the non-forested areas impacted by this feature.

   AHAG Evaluation – The setback would increase the area available to spring and fall flooding. Stage data and topographic surveys indicate that overbank flooding would occur on land outside of the new berm 85% of the time. Thus, this area would provide habitat for spawning and rearing during these times. The acreage of land that would be placed outside the setback was used in the calculation of AAHUs. Calculated AAHUs were reduced by 15% because overbank flooding does not occur every year.

4. *Excavating.* It was assumed that excavating of the existing water bodies and historic meanders cannot occur without the setback option due to the high risk and uncertainty of crossing a sand lens ultimately increasing seepage at the site. We assumed excavated material would be used in the construction of proposed setback.

   WHAG Evaluation – No wetland benefits are expected to be generated from this feature, consequently no WHAG evaluation was conducted.

   AHAG Evaluation – According to USFWS, the conditions of the existing water bodies are shallow and lack connectivity to the main channel. It is assumed that the long-term impacts of the disconnection from the river would lead to continued shallow water and eventual loss of the

sloughs, backwaters, and old meander scars along with continued degradation of aquatic ecosystem resources. If no action is taken to restore these water bodies and improve connectivity, it is assumed that approximately 70-acres of seasonal fisheries habitat would be reduced by 10% every 10 years. For with-project conditions, it is assumed that the 71 acres would be maintained during the period of analysis. For the historic meanders, it was assumed that these historic meanders would be excavated to approximately 95 feet wide at surface, with 6:1 side slopes, 5 feet deep, and with 35 feet wide at bottom; resulting in 21 surface area acres of aquatic habitat.

5. *Reforestation.* It was assumed that reforestation using tree planting would not occur without the setback because risk of tree mortality without improving water drainage first is too great. It is assumed that the proposed area for tree plantings would remain in rotational agricultural without the proposed setback project feature. With project alternatives that do not include tree plantings, it is assumed that the 350 acre agricultural field would no longer be cropped and by year 25 trees would naturally regenerate. With project alternatives that did include 300 acres of tree plantings, it is assumed that the remaining 50 acres (less any acres for historic meander restoration) would naturally regenerate by year 25.

   WHAG Evaluation - We chose to evaluate this feature using the bottomland forest and cropland spreadsheets. Conversion of the cropland to bottomland forest generated sufficient habitat units over the period of analysis to make it a viable project feature. The cropland acres would be reforested with a variety of bottomland species, utilizing containerized or bare root stock. The forest canopy in the proposed reforested area will ultimately close over the life of the project making this area nearly a solid block of bottomland forest.

   AHAG Evaluation - No fisheries benefits are expected to be generated from this feature, consequently no AHAG evaluation was conducted.

Acreage Determination

The aquatic acreages used in the AHAG evaluation were determined using National Agriculture Imagery Program (NAIP) imagery from 2009 in ArcGIS 10. The aquatic evaluation locations included existing water bodies (Buttonbush Pond, Heron Pond, Rabourn Slough, and Crane Pond), two different setback options, and the historic meanders. The future without project acreages of the existing water bodies was calculated by the evaluation team as a 10% reduction every 10 years, while the setback and historic meander restorations would have no acreage because under existing conditions these areas do not support fish. Table 4 lists the acreage of each of the AHAG evaluation locations.

Table 4. Acreage of each the AHAG evaluation locations with and without project acres

AHAG Evaluation Location	Existing	Future Without Project				Future With Project
	Acres Yr 0	Acres Yr 1	Acres Yr 5	Acres Yr 25	Acres Yr 50	Acres Yrs 1 - 50
Existing Water Bodies	71	71	71	55	42	71
Setback	0	0	0	0	0	818*
Historic Meanders	0	0	0	0	0	21

*only when flooded

The wetland acreages used in the WHAG evaluation were determined using NAIP 2009 imagery in ArcGIS 10. Land cover types were digitized and areas of each were calculated using ArcGIS. For future management units, the difference between existing and future acres is due to the additional acreage of

the ditches and or berms which were removed. Additionally, the evaluation team decided that the acreages of non-forested wetlands would remain the same between existing and future without project conditions, and the future with project acres would be the same from year 1 through year 50 (Table 5).

Table 5. Evaluation location acreages used for the Non-Forested WHAG evaluation

WHAG Non-Forested Evaluation Location Existing Management Unit Name	Existing & FWOP Acres	Future Management Unit Name	New Subunits	Future With Project Non-forested Acres
Supply Pond	40	**South**	Supply Pond	40
MSU5	128		Southwest	368
MSU 3E	92			
MSU3W-WM1	84			
MSU9	58			
MSU1	52		Central	329
MSU2	156			
MSU4	77			
MSU6	39			
MSU11	118		Eastern	164
MSU12	43			
Big Pond	148		Big Pond	174
Non-forested Acres	**1035**	**South Subtotal**		**1075**
Proposed Berm Removal Acres	**40**			
SUBTOTAL	**1075**			
MSU 7	720	North	MSU 7	720
Goose Pasture & 6A	177		Northern	504
MSU8	168			
MSU10	139			
Non-forested Acres	**1204**	**North Subtotal**		**1224**
Proposed Berm Removal Acres	**20**			
SUBTOTAL	**1224**			
MSU10N	33	**Riverside**	Riverside	143
Rabbit Ears	85			
Little Rabbit Ears	7			
Non-forested Acres	**125**	**Riverside Subtotal**		**143**
Proposed Berm Removal Acres	**18**			
SUBTOTAL	**143**			

The forested area evaluated on site only included the forest areas within the proposed setback location including the area proposed for conversion from cropland to forest with the reforestation feature (300 acres of planting). The evaluation team determined that the acreages of forest would remain the same between existing and future without project (343 acres); however the community composition would shift from bottomland hardwoods to more riverfront forest community. Additionally, of the 350 acre field, 50 acres are set aside for borrow sites needed for setback construction. Alternatives with meanders will have 21 acres of the 50 acres of borrow site converted to aquatic habitat and these 21 acres are evaluated using AHAG. Otherwise, the borrow site acres are assumed to provide no habitat benefits and therefore not evaluated. Additionally, the evaluation team determined that by year 25 the former agricultural field would be converted to forest (300 acres) in the alternatives without plantings due to regeneration. Table 6 lists the acreages used in the Bottomland Forest WHAG as well as the Cropland WHAG evaluations by target year.

Table 6. Forested and cropland acres by target year (TY) used by alternative for forested area within proposed setback

Alternative	TY	Forested Acres	Cropland Acres	Acres Converted to Borrow[1]
Existing Conditions	0	343	350	0
Future Without Project	1-50	343	350	0
Setback Only	1-5	343	300	50
	25-50	643	0	50
Setback + Meanders[2]	1-5	343	300	50
	25-50	643	0	50
Setback + Plantings	1-5	643	0	50
	25-50	643	0	50
Setback + Meanders[2] + Plantings	1-5	643	0	50
	25-50	643	0	50

[1]Fifity acres are set aside for borrow sites needed for setback construction. Assumed these acres would not provide any habitat benefits.
[2]meanders require approximately 21 acres of the 50 acres of borrow would be converted to aquatic habitat and evaluated using AHAG

5. Results

WHAG Evaluation

Individual species HSI scores were averaged prior to calculating cumulative HUs. To see individual species HSI please refer to excel spreadsheets available upon request. With, without, and net average annualized habitat units were calculated using this averaged HSI score for each of the non-forested WHAG evaluation locations (Table 7). Each of the future management units has a different acreage but the same HSI. Furthermore, cumulative HUs were generated for all feasible feature combinations (i.e., berm removal, pump station, and setback) to assess any synergistic effects the feature combinations may have on the habitat rather than simply adding the “only” options together. The evaluation team also assumed that either pump station type (diesel vs. electric) would provide the same benefits to the habitat. They also assumed that the either setback option (water control structure or exterior berm degrade) would also provide the same habitat benefits.

For forest areas and proposed tree plantings areas, the evaluation team used the Bottomland Forest WHAG and the Cropland WHAG to evaluate the project area that would be on the riverside of the proposed setback (Table 8). This area contains the majority of the forested habitat in the project area. The AAHUs calculated using both evaluations were summed together for each feature and alternative (different combinations of setback with plantings).

Table 7. With, without and net average annualized habitat units determined using the non-forested WHAG evaluation for the future management unit evaluation locations.

ROW	FEATURE COMBINATION		SOUTH UNIT						NORTH UNIT			RIVERSIDE UNIT
			Supply Pond	Southwest	Central	Eastern	Big Pond	TOTAL AAHUs	MSU 7	Northern	TOTAL AAHUs	TOTAL AAHUs
1	Future Without Project		**14.13**	**133.34**	**119.34**	**59.3**	**56.76**	**382.87**	**281.91**	**185.62**	**467.53**	**44.15**
2	New Management Units Only[1]	With	24.11	241.29	215.72	105.41	111.75	698.28	472.39	330.87	803.26	91.81
		Net	**9.98**	**107.95**	**96.38**	**46.11**	**54.99**	**315.41**	**190.48**	**145.25**	**335.73**	**47.66**
3	Pump Station Only	With	21.80	204.60	183.12	91.00	86.63	587.15	430.84	283.32	714.16	68.13
		Net	**7.67**	**71.26**	**63.78**	**31.70**	**29.87**	**204.28**	**148.93**	**97.70**	**246.63**	**23.98**
4	Setback Only	With	21.63	203.02	181.71	90.29	85.99	582.64	427.70	281.2	708.90	67.58
		Net	**7.50**	**69.68**	**62.37**	**30.99**	**29.23**	**199.77**	**145.79**	**95.58**	**241.37**	**23.43**
5	New Units[1] + Pump Station	With	25.42	253.38	226.53	110.80	117.47	733.60	496.06	347.06	843.12	96.51
		Net	**11.29**	**120.04**	**107.19**	**51.50**	**60.71**	**350.73**	**214.15**	**161.44**	**375.59**	**52.36**
6	New Units[1] + Setback	With	25.16	250.97	224.38	111.85	116.33	728.69	491.34	343.76	835.10	95.57
		Net	**11.03**	**117.63**	**105.04**	**52.55**	**59.57**	**345.82**	**209.43**	**158.14**	**367.57**	**51.42**
7	Setback + Pump Station	With	24.38	227.90	203.98	101.36	96.16	653.78	477.19	314.47	791.66	76.18
		Net	**10.25**	**94.56**	**84.64**	**42.06**	**39.40**	**270.91**	**195.28**	**128.85**	**324.13**	**32.03**
8	New Units[1] + Pump Station + Setback	With	29.71	292.84	261.81	128.39	136.11	848.86	573.25	401.09	974.34	111.83
		Net	**15.58**	**159.50**	**142.47**	**69.09**	**79.35**	**465.99**	**291.34**	**215.47**	**506.81**	**67.68**

[1] = New subunits consist of berm removals and new water control structure for each subunit

Table 8. With, without, and net average annualized habitat units determined using the Bottomland Hardwood WHAG and Cropland WHAG for the forest and proposed forest habitat.

Alternative		BLH WHAG	Cropland WHAG	Summed AAHUs
Future Without Project		**163.66**	**84.67**	**248.33**
Setback Only	With	432.82	38.36	471.18
	Net	**269.16**	**-46.31**	**222.85**
Setback + Historic Meanders	With	432.82	38.36	471.18
	Net	**269.16**	**-46.31**	**222.85**
Setback + Plantings	With	514.70	1.28	515.98
	Net	**351.04**	**-83.39**	**267.65**
Setback +Historic Meanders + Plantings	With	514.70	1.28	515.98
	Net	**351.04**	**-83.39**	**267.65**

AHAG Evaluation

Individual species HSI scores were averaged prior to calculating cumulative HUs. To see individual species HSI please refer to excel spreadsheets available upon request. AHAG cumulative habitat units were calculated for the existing water bodies (Heron Pond, Buttonbush Pond, Rabourn Slough, and Crane Pond), the proposed historic meanders, and for the area that will be on the riverside of proposed setback. AAHUs were calculated for each project feature as well as for all feasible project feature combinations that affect aquatic habitat (setback, excavating of existing water bodies, and excavating of historic meanders) (Table 9).

Table 9. With, without, and net average annualized habitat units determined using the AHAG evaluation for the aquatic evaluation locations. Note no AHAG AAHUs are derived from the pump station; the differences are result of acreage

Alternative		AHAG AAHUs
Future Without Project		**8.97***
Setback Only	With	378.15
	Net	**378.15**
Setback + Excavating	With	437.41
	Net	**428.43**
Setback + Historic Meanders	With	395.26
	Net	**395.26**
Setback + Historic meanders + Excavating	With	454.52
	Net	**445.55**

*Only for existing water bodies. FWOP AAHUs equals 0.00 for project features of setback and historic meanders, since there are no benefits to aquatic habitat without them.

There are no benefits for spawning and rearing without the project features of the setback or historic meander restoration. Without the project the area is surrounded by an exterior berm and fish do not have access. Thus net AAHUs equals total AAHUs for alternatives containing these features. For the excavating of existing water bodies feature, net AAHUs = alternative AAHU – FWOP AAHU since this feature does restore depth to these areas improving aquatic habitat.

Additionally, the calculated AAHUs for the setback have been adjusted to reflect the fact this area would only receive aquatic habitat benefits when flooded (85% of the time and 25% of each year flooded during the spring season).

Incremental Cost Analysis

For ICA, alternatives can consist of all possible combinations of project features contingent on dependency and combinability relationships. For this project, some features cannot be combined (e.g. exterior berm degrade and fish friendly river water control structure) while some features depend on other features (e.g., excavating depends on setback). Additionally, some features when combined generated habitat units that do not equal the sum of their individual habitat units. For example in the South Unit, creating new management subunits only generates a total of 315.41 AAHUs and the Pump Station only generates 204.28 AAHUs. However, based on the habitat evaluation team WHAG analysis, for the South Unit new subunits+ pump station combination generates 350.73 (not the sum of 315.41 + 204.28 = 519.69). Based on combinability and dependency between features, the ICA code and generated total AAHUs are depicted in Table 10, and were then incorporated with costs into the ICA (Incremental Cost Analysis, Appendix F).

6. References

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Table 10. The project feature code used for the incremental cost analysis, the project feature description, and the total net average annualized habitat units (AAHUs) summed across all AHAG and WHAG analyses.

ICA Code	Feature	Total Net AAHUs	Source of AAHUs
NEW SUBUNITS ONLY (cannot be combined with anything else)			
A1	South Unit (SU)	315.41	NF WHAG; in Table 7 row 2
A2	North Unit (NU)	335.73	
A3	Riverside Unit (RU)	47.66	
A4	SU+NU	651.14	
A5	SU+RU	363.07	
A6	NU+RU	383.39	
A7	SU+NU+RU	698.80	
DIESEL PUMP STATION OPTIONS (cannot be combined with A or C-H)			
B1	Diesel Pump Station Only	474.89	NF WHAG; in Table 7 row 3 South + North + Riverside Unit
B2	Diesel Pump Station + SU	621.34	NF WHAG; B1 above + in Table 7, the difference between row 5 & row 3
B3	Diesel Pump Station + NU	603.85	
B4	Diesel Pump Station + RU	503.27	
B5	Diesel Pump Station + SU+NU	750.30	
B6	Diesel Pump Station + SU+RU	649.72	
B7	Diesel Pump Station + NU+RU	632.23	
B8	Diesel Pump Station + SU+NU+RU	778.68	
ELECTRIC PUMP STATION OPTIONS (cannot be combined with A-B, or D-H)			
C1	Electric Pump Station Only	474.89	NF WHAG; in Table7 Row 3 South+ North + Riverside
C2	Electric Pump Station + SU	621.34	NF WHAG; B1 above + in Table 7 the difference between row 5 and row 3
C3	Electric Pump Station + NU	603.85	
C4	Electric Pump Station + RU	503.27	
C5	Electric Pump Station + SU+NU	750.30	
C6	Electric Pump Station + SU+RU	649.72	
C7	Electric Pump Station + NU+RU	632.23	
C8	Electric Pump Station + SU+NU+RU	778.68	
SETBACK WITH WATER CONTROL STRUCTURE OPTIONS (cannot be combined with A-C; E)			
D1	Setback with WCS only	1065.57	NF, BLH, Crop WHAGs, and AHAG summed
D2	Setback + plantings	1110.37	
D3	Setback + excavating	1115.85	
D4	Setback + meanders	1082.68	
D5	Setback + plantings + excavating	1160.65	
D6	Setback + plantings + meanders	1127.48	
D7	Setback + excavating + meanders	1132.97	
D8	Setback + plantings + excavating + meanders	1177.77	
SETBACK WITH EXTERIOR BERM DEGRADE OPTIONS (cannot be combined with A-D)			
E1	Setback with EBD only	1065.57	NF, BLH, Crop WHAGs, and AHAG summed
E2	Setback + plantings	1110.37	
E3	Setback + excavating	1115.85	
E4	Setback + meanders	1082.68	
E5	Setback + plantings + excavating	1160.65	
E6	Setback + plantings + meanders	1127.48	
E7	Setback + excavating + meanders	1132.97	
E8	Setback + plantings + excavating + meanders	1177.77	
SETBACK + NEW SUBUNITS (Depends on D or E; cannot be combined with A-C; G-H)			
F1	+SU	146.05	NF WHAG; in Table 7, the difference between row 6 & row 4
F2	+NU	126.20	
F3	+RU	27.99	
F4	+SU+NU	272.25	
F5	+SU+RU	174.04	
F6	+NU+RU	154.19	
F7	+SU+NU+RU	300.24	
SETBACK + DIESEL PUMP STATION and/or NEW SUBUNIT OPTIONS NET BENEFIT (Depends on D or E; cannot be combined with A-C; F; H)			
G1	+ Diesel Pump Station	162.50	NF WHAG; in Table 7, the difference between row 7 and row 4
G2	+Diesel Pump Station + SU	357.58	NF WHAG; G1 above + the difference between row 8 and row 7 for designated unit in Table 7
G3	+Diesel Pump Station + NU	345.18	
G4	+Diesel Pump Station + RU	198.15	
G5	+Diesel Pump Station + SU+NU	540.26	
G6	+Diesel Pump Station + SU+RU	393.23	
G7	+Diesel Pump Station + NU+RU	380.83	
G8	+Diesel Pump Station + SU+NU+RU	575.91	
SETBACK + ELECTRIC PUMP STATION and/or NEW SUBUNIT OPTIONS NET BENEFIT(Depends on D or E; cannot be combined A-C, F-G)			
H1	+ Electric Pump Station	162.50	NF WHAG; in Table 7, the difference between row 7 and row 4
H2	+Electric Pump Station + SU	357.58	NF WHAG; H1 above + the difference between row 8 and row 7 for designated unit in Table 7
H3	+Electric Pump Station + NU	345.18	
H4	+Electric Pump Station + RU	198.15	
H5	+Electric Pump Station + SU+NU	540.26	
H6	+Electric Pump Station + SU+RU	393.23	
H7	+Electric Pump Station + NU+RU	380.83	
H8	+Electric Pump Station + SU+NU+RU	575.91	