Appendix B

Habitat Evaluation and Quantification

Contents

1 INTRODUCTION

This appendix provides the documentation of the habitat evaluation and quantification process that was conducted to evaluate ecological benefits of alternative plans for emergent wetlands, floodplain forest, and floodplain woodland habitats within the study area of the Yorkinut Slough Habitat Rehabilitation and Enhancement Project (HREP). A multi-agency and interdisciplinary team from the U.S. Fish and Wildlife Service (USFWS) and the St. Louis District Corps of Engineers (USACE) conducted the habitat evaluation (Table 1).

Table 1. Participants in the Habitat Benefits Analysis for the Yorkinut Slough HREP

Team Member	Specialty	Affiliation
Matt Mangan	Fish and Wildlife Biologist	U.S. Fish and Wildlife Service
Charlie Deutsch	Wildlife Biologist	U.S. Fish and Wildlife Service
Brian Loges	Regional Zone Biologist	U.S. Fish and Wildlife Service
Kirsten Schmidt	Biologist	U.S. Fish and Wildlife Service
Ben McGuire	Wildlife Biologist	U.S. Army Corps of Engineers
Lane Richter	Wildlife Biologist	U.S. Army Corps of Engineers
Brandon Schneider	Project Manager	U.S. Army Corps of Engineers
Janet Buchanan	Plan Formulator	U.S. Army Corps of Engineers
Rob Cosgriff	Supervisory Wildlife Biologist	U.S. Army Corps of Engineers
Ryan Swearingin	Wildlife Biologist	U.S. Army Corps of Engineers
Kip Runyon	Fish Biologist	U.S. Army Corps of Engineers
Justin Garrett	Biologist	U.S. Army Corps of Engineers
Abby Hoyt	Project Manager	U.S. Army Corps of Engineers

The assessment includes a summary of the existing biological conditions used in the evaluation, as well as a forecast for future conditions under the No Action Alternative (Future Without Project; FWOP) and each considered action alternatives (Future With Project; FWP).

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

To begin the habitat evaluation process, participants reviewed the available USACE certified models and their associated habitat types. Two models were selected to evaluate the effects of Project measures on emergent wetland, floodplain forest, and floodplain woodland habitat in the study area. The Duck Use Days model was selected as a quantitative method to estimate emergent wetland habitat benefits and impacts (duck-use days based on daily energy requirements of Mallards) among restoration alternatives. This model was selected due to the importance of the region for migratory waterfowl and because management for waterfowl is a primary goal of the Two Rivers National Wildlife Refuge (Refuge). The floodplain forest community model was selected for already forested resources and for reforestation areas because the model evaluates well accepted structural variables found to be important to a wide diversity of wildlife resources as well as several variables specific to desired conditions on site. In addition, this model was recently developed by forestry experts along the Upper Mississippi

River System and was designed to have broad applicability to the full range of tree dominated plant communities (forest and woodland) found in the study area and regionally. The two models were selected because wetland, forest, and reforestation areas would be affected by some or all measures. The floodplain forest HSI and Duck Use Days models are both USACE-approved models selected to represent current and anticipated conditions at Yorkinut Slough HREP.

Table 2 summarizes what components of Project measures corresponded to what habitat model used in the evaluation. The floodplain forest HSI model was used to evaluate reforestation of former agricultural fields and timber stand improvement (TSI) within existing forest on Six Mile Island, and the Duck Use Days model was used to evaluated emergent wetlands.

Table 2. Project measures and components with corresponding habitat and HSI model

Measure/Component	Habitat Type	Model
Moist Soil Unit (MSU) construction	Emergent Wetlands	Duck Use Days
Modify berms (slope, elevation, location, configuration and seeping)	Emergent Wetlands	Duck Use Days
Modify drainage	Emergent Wetlands	Duck Use Days
Water Control Structure (WCS)	Emergent Wetlands	Duck Use Days
Pump station	Emergent Wetlands	Duck Use Days
Well pump	Emergent Wetlands	Duck Use Days
Timber Stand Improvement (TSI)	Forest	UMRS Floodplain Forest
Tree planting	Woodland/Forest	UMRS Floodplain Forest
Ridge construction	Woodland	UMRS Floodplain Forest

The Duck Use Days model is being used outside of its approved region but is applicable to the study area due to overlap in emergent plant community type, dominant food variables and waterfowl species inputs utilized in model calculations. The model author concurs with use of the Duck Use Days model for this study (Mickey Heitmeyer, Greenbriar Wetland Service, Advance, Missouri, personal communication) and the study team received approval from USACE Headquarters for one-time use. Reference values for the area of interest (e.g., Illinois River) were provided in model documentation and corroborate with known potential seed production ranges (e.g., Swan Lake, USFWS data) in managed wetlands for the region. The Duck Use Days model estimates potential food value of existing and predicted land cover changes and uses known caloric needs of waterfowl species to calculate the potential carrying capacity of a site. The Mallard (*Anas platyrhynchos*) is an abundant and widespread dabbling duck that commonly inhabits wetlands. Mallards occur year-round across much of the United States. Populations that breed across Canada and Alaska migrate to overwintering sites in the southern United States and northern Mexico. The study area, located off the Illinois River and near the Mississippi River, is situated along some of the primary migratory routes used by Mallards through the central United States. In addition, Mallards are the most abundant duck to migrate through the Refuge (INHS, 2019) and region so it was used as an indicator of habitat quality for dabbling ducks that use emergent wetlands. Existing and proposed emergent wetland habitat was assessed with this model using emergent vegetation seed production to estimate available food for migratory wildlife.

Floodplain forest communities are highly productive, provide valuable habitat for many species of wildlife (support plants and animals adapted to alternating wet and dry periods), improve water quality, control erosion (capture and disperse sedimentation), reduce flood damage by holding water, and contribute to local and regional commerce (Wiener et al., 1998; Johnson and Hagerty, 2008.) Although the system has undergone extensive changes in recent centuries, the remaining floodplain forests represent some of the largest contiguous tracts of forest on the landscape along the UMRS. The UMRS floodplain forest model is suitable for use in a wide variety of forest/woodland communities found in different growth stages and for evaluating various forest/woodland management activities along the UMRS. The model makes use of existing forestry data and management plans by incorporating information on percent canopy cover, percent desired forest type, percent invasive species, regeneration, and a structural diversity index to evaluate and compare changes in forest and reforestation area benefits among alternatives for this study.

Consistent with guidance from the USACE Ecosystem Restoration Planning Center of Expertise, the Agency Technical Review (ATR) Team for the Yorkinut Slough HREP will conduct an assessment of the models used for this study. The chosen models, all of which are USACE-approved (per Engineering Circular 1105-2-412) are the Duck Use Days model (Heitmeyer, 2010) and UMRS floodplain forest model (USACE, 2021). The Habitat Suitability Index (HSI) spreadsheet calculator for the UMRS floodplain forest model was reviewed by the Ecosystem Restoration Planning Center of Expertise and recommended for regional use (Memorandum for CECW-MVD; 08 September 2021; Enclosure 1) and the Duck Use Days quantitative model was recommended for regional use (Memorandum for CECW-MVD; 12 February 2020; Enclosure 1). No spreadsheet for the Duck Use Days model was available, so a project-specific spreadsheet was developed and reviewed 30 March 2022. The USACE Model Certification Panel concurred and the spreadsheet calculators were approved for UMRS Floodplain Forest Model (16 August 2021; Enclosure 3). This process evaluated the technical quality and appropriateness of the models utilized.

2 HABITAT EVALUATION METHODOLOGY

The purpose of the habitat benefit evaluation is to evaluate and quantify, to the extent possible, environmental benefits of Alternatives for aquatic and floodplain habitat improvements. Floodplain forest and woodland benefits were quantified through the use of the Habitat Evaluation Procedures (HEP; USFWS 1980). Emergent wetland benefits were calculated using a habitat-based waterfowl bioenergetics model (Heitmeyer 2010) which was converted to an index value to produce an HSI value of 0 to 1 for conditions between lowest and highest potential outputs.

Quantity Component

Traditionally, USACE has used the quantity and quality of habitat jointly, in the form of habitat units, to measure benefits provided by ecosystem restoration projects. The quantity portion is often measured as area, number of species, or length. The evaluation conducted for this study area uses acres, delineated by polygons, to represent the quantity. Polygons were created using ArcGIS 10.7 software. In all, 943 acres of forest were identified for TSI, 215 acres for woodland enhancement, and 532 acres of emergent wetland enhancement in the study area. Acreages across alternatives were similar for all except the minimum alternative which did not include TSI as a measure.

This resulted in different total acres for the Minimum and Intermediate Alternatives Future With Project (FWP) scenario. To ensure accuracy, the study team used that total acreage for a given FWP alternative to compare to the corresponding FWOP condition. In other words, the FWOP scenario acreage was not consistent to compare all alternatives, but each individual FWP scenario was compared to its own FWOP scenario (See Table 3 for all acreages used).

Table 3. Acres Used by Alternative (rounded to the nearest 10th acre)

Alternative Name	Scenario	Duck Use Days – Acreage Used	Floodplain Forest/Woodland – Acreage Used
Maximum	FWOP	531.7	901
Maximum	FWP	531.7	901
Intermediate B	FWOP	531.7	901
Intermediate B	FWP	531.7	901
Intermediate A	FWOP	531.7	269
Intermediate A	FWP	531.7	269
Minimum	FWOP	531.7	269
Minimum	FWP	531.7	269

FWOP – Future Without Project. FWP – Future With Project.

Quality Component

Habitat Suitability Index Models- Floodplain Forest

The qualitative component of the analysis is rated on a 0.0 to 1.0 scale, with higher values indicating better habitat for that species. The HSI per habitat type is determined by selecting values that reflect present and future conditions in the study area from a series of biotic metrics. Each value corresponds to a suitability index. 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 which varied depending on the footprint of measures used in each alternative. 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 FWOP and FWP 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:

$\int_0^T HU\ dt$	=	cumulative HU's
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 the beginning of time interval
3 and 6	=	constants derived from integration of HSI x 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 results in the Average Annual Habitat Units (AAHUs) (USFWS 1980). The calculation of the HUs and AAHUs were completed in a Microsoft Excel spreadsheet containing the formula above.

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

In preparation of using the HSI models, the study team conducted site visits and reviewed existing data. They also reviewed aerial photography, LiDAR data, 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.

Duck Use Days Model

Duck Use Days model outputs were converted to an index value between 0 and 1, and then followed the above procedure for calculating HUs and AAHUs to allow a clearer interpretation of habitat benefits in relation to different considered alternatives across habitat types. Outputs from the model calculations result in a raw number of Mallard-use-days. Model documentation identified 1454 kg/ha as an estimated average seed production rate in managed multi-species emergent wetlands for the Illinois River Valley. This value was confirmed to be accurate for high-quality managed emergent wetlands in the region by regional waterfowl management experts with USFWS. Conversion of the Duck Use Days model outputs into HSI values followed HEP procedures (USFWS 1980). Outputs from the Duck Use Days for each alternative were divided by the optimal output value to derive an index value between 0 and 1. An HSI value of 0 was the lowest potential output and represented units with loss of water management capabilities that convert to open water habitat, and an index value of 1 represents a unit that produces a maximum average output of 1454 kg/ha.

Period of Analysis

For the purpose of planning, design, and impact analysis, the 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 for the Duck Use Days Model and 0 (existing conditions), 5, 25, and 50 years for the UMRS Floodplain Forest HSI model. The interdisciplinary study team, which included regional foresters, recommended this change due to the lack of meaningful change in the considered forest structure variables over short intervals. Target years of 0 (existing condition), 1, 5, 25, and 50 (FWOP and FWP conditions) for the Duck Use Days model and 0 (existing condition), 5, 25, and 50 are used to analyze HUs and characterize habitat changes over the estimated period of analysis. Target years of 1 and 5 capture short-term changes following construction completion. While target years 25 and 50 capture ecological changes that would occur over a longer period of time. The period of analysis was determined to be 50 years based on the prediction that some Project measures (e.g., development of key ecological processes needed to restore ecosystem structure and function) would need a longer period of time to reach maximum benefits; and the accrual of benefits were predicted to level off after 50 years. HSIs and cumulative HUs for each evaluation model were calculated at each of these target years.

USACE guidance requires that the study team evaluate a suite of measures that can be combined in various ways, based on dependencies to form alternatives. The approach used to assess the benefits at Yorkinut Slough looked at benefits of individual measures for each alternative. The individual measures were combined for each alternative using formulation strategies. To determine the habitat units created by each measure, the habitat (wetland, reforestation, and floodplain forest) affected by the measure would be evaluated using the applicable HSI spreadsheets.

This appendix contains HSI summary tables and other data derived from the spreadsheet files not included in this appendix. These spreadsheets are available upon request. Please contact, Lane Richter, 314-925-5032, email Lane.A.Richter@usace.army.mil if you would like an electronic copy of these files.

3 ASSUMPTIONS

Habitat Cover Type Assumptions

The following assumptions were made when determining existing and FWOP conditions for the primary habitat cover types located within the study area:

Wetland. Existing wetland conditions were obtained from annual USFWS Integrated Waterbird Monitoring and Management survey data. Inherent in best professional judgment are the underlying assumptions, which are described in “General Assumptions”.

Floodplain Forest. USACE forest inventory data of the site from 2010 was used to determine Existing Conditions and used to determine Future Without Project (FWOP) conditions. This data was also used to predict Future With Project (FWP) conditions. Inherent in best professional judgment are the underlying assumptions, which are described in “General Assumptions and Habitat Characteristics.”

General Assumptions

1. It was assumed that target years of 0 (existing condition), 1, 5, 25, and 50 (FWOP and FWP conditions) for the Duck Use Days Model and 0 (existing condition), 5, 25, and 50 (FWOP and FWP conditions) are sufficient to analyze AAHUs and characterize habitat changes over the estimated period of analysis. The period of analysis was determined to be 50 years based on the prediction that some Project measures (e.g., tree planting leading to mature trees reproducing; development of key ecological processes needed to restore ecosystem structure and function) would need a longer period of time to reach maximum benefits; and the accrual of benefits were predicted to level off after 50 years.
2. Without the Project, the USFWS will continue to manage the study area. The USFWS will continue to maintain existing infrastructure such as access roads 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.
3. It was assumed that replacement of existing structures would not occur under the FWOP scenario.
4. We assumed that operation of Yorkinut Slough would continue under the current management plans and objectives for at least the life of the HREP.
5. Existing Yorkinut Slough habitat acreage analyzed is 1,432 acres, the acreage where the HREP measures would be constructed.
6. Current berms are approximately 20 feet wide on average throughout the study area.
7. Total, existing berm equals 42 acres based on an estimated 12 foot crown.
8. Existing berm acreages were subtracted from evaluation for existing conditions models and added for FWP models where berm degrades with emergent wetland enhancement in those locations occurred.
9. Where new water conveyance locations were added to FWP scenario, these areas were evaluated with the Duck Use Days model.
10. It was assumed that Mallard is representative of migratory waterfowl in the study area due to its nonbreeding season abundance in the region.
11. Model included only seed production in duck-use days calculation and was assumed to be representative of overall food resources available to migratory waterfowl, because

emergent vegetation is the monitoring target used by USFWS to guide management. Additionally, existing data was only available for seed product in units.

12. It was assumed that any of the Moist Soil Units (MSUs) can revert to open water or perennial vegetation with loss of management capabilities (aging infrastructure, sedimentation, and flooding). A 1-2 % loss in area per year was projected for the study area based on existing unit changes where management capabilities have been severly reduced as a result of structure failures. A 15% reduction in seed production from current conditions was also projected at years 25 and 50. This value was thought to be a conservative estimate based off of current unit conditions and production.
13. Seed production data was provided by USFWS for several units. It was assumed that these rates were representative of existing conditions during non-flood years. Units which lacked data were estimated based on expert opinion from USFWS.
14. Based on available data it was assumed that high-quality wetlands would average 1454 kg/ha in seed, 750-1000- kg/ha is representative of average wetland seed production, and <400 kg/ha was representative of low average wetland seed production when factoring in typical riverine and upland flood frequency in the study area.
15. USFWS gathered Integrated Waterbird Monitoring and Management data was used to estimate unit capacity for fall migration period. Accessible acreage was used to estimate food availability within unit for existing conditions and forecasted for both FWOP and FWP. Data was lacking at Duck Pond, MSU 8, and Yorkinut, and therefore capacity estimates were based off local knowledge from the Refuge.
16. Duck-use days were converted to an index (0 to 1) and AAHUs to allow a more straight forward comparison of habitat benefits across alternatives. Reference values to inform maximum average potential (index value of 1) was based on model documentation for the Illinois River Valley and agreed upon by regional waterfowl management experts with USFWS.
17. Berm degrade locations had a zero HSI for FWOP as they were not considered emergent wetland habitat. For FWP, expansion in wetland area was delineated to the 425' NGVD 88 contour and calculated in ArcGIS based on available LiDAR data.
18. TSI information was provided by the USACE Rivers Project Office for already developed prescriptions. These prescriptions contained a variety of TSI methods such as underplanting, invasive species control, vine control, midstory removal, crop tree release, area thinning, etc. For simplicity, a blanket assumption of some sort of TSI was to occur for those associated acreages, thereby improving overall regeneration for that area.
19. For the emergent wetland, it was assumed for FWOP conditions that the area would continue to lose water management capabilities with complete loss of infrastructure for Duck Pocket, MSU 8, and Yorkinut MSU. These three units would convert to open-water shrubland by year 25. The remaining units were expected to still support emergent vegetation of lower quality and extent according to assumption 12.
20. It was assumed that widespread mortality of Green Ash (Fraxinus pennsylvanica) would occur prior to year 25 as Emerald Ash Borer is present in the region, and patchy mortality of the species is already occurring in the study area stands on Six Mile Island related to borer activity.
21. Forecasted future conditions under FWOP and FWP scenarios factored in flood impacts from frequent low and moderate intensity events, but did not factor in impacts for potential major flood events.
22. Measures that improve drainage on Six Mile Island, including removal of sediment plugs and restoration of Six Mile Island side channel, were assumed to not be self-sustaining due to the frequency of flood events on the islands. As a result, forecasted benefits were minor over the long-term as drainage returns to pre-Project conditions before year 25.

23. For tree-plantings, we assumed that active maintenance of planting would occur for 5-7 years after planting and include mowing and herbicide application to reduce invasive species presence and competition.
24. Existing conditions for the floodplain forest evaluation model were populated with data from site visits, USACE forest inventory data, and stand prescriptions developed during the feasibility study. Forecasted values were based on expert forester's experience and knowledge of forest changes with and without management actions.
25. Widespread hard-mast and mature Cottonwood tree mortality was assumed to occur within the first 25 years due to age and hydrological factors.
26. Stand prescriptions were developed on a stand by stand basis by USACE River Project Office foresters. Desired forest conditions were based on the stand's ability to support a particular forest community as well as need for management of various species, size and age classes on the landscape. These guiding conditions were based on the UMRS Systemic Forest Stewardship Plan.
27. Tree growth and percent canopy cover for tree plantings were based on previous HREP projects in the Mississippi River floodplain as well as Refuge tree planting data in the study area. Both are expected to be representative of proposed tree plantings in the study area.

4 HABITAT BENEFIT EVALUATION

Chapter four of the main report, *Plan Formulation* describes each potential measure in detail. After a lengthy process involving preliminary analysis of function, identification of compatibility, and input from our resource agencies, the study team identified a list of measures to be formulated into alternatives before this habitat quantification exercise. Formulation strategies were used to combine measures into alternatives. For a detailed description of formulation strategies, see Chapter 4 of the Feasibility Report. Table 4 summarizes the measures by each considered alternative. Maps for the various alternatives are displayed at the end of this appendix.

Table 4. Alternatives and Measures

#	Measure (Retained measures)	Maximum	Intermediate B	Intermediate A	Minimum
1	Modify Moist Soil Units (MSUs)	**1a3** (Megaunit) **1b2** (2 new units) **1b3** New Upper HQ unit **1c1** (County Rd regrade)	**1a8** (unique configuration) **1b2** (2 new units) **1b3** New Upper HQ unit **1c1** (County Rd regrade)	**1a4** (Smaller units: Duck Club+Office; Calhouns; Pump Station+Schoolhouse) **1b2** (2 new units) **1b3** New Upper HQ unit **1c1** (County Rd regrade)	**1a1** (Duck Club+Office) **1a9** (new) - Fix Pump Station MSU seepage issues (no change to MSU boundaries) **1c1** (County Rd regrade)

3a	Enhance drainage to Illinois & Mississippi rivers through Calhoun Point	**3a**	**3a**	**3a**	
4a	Ridge and swale construction	**4a**	**4a**	**4a**	
5	Modify berms	**5a** (fix seepage issues) **5b** (shallower Yorkinut berm)	**5b** (shallower Yorkinut berm)	**5a** (fix seepage issues) **5b** (shallower Yorkinut berm)	
7	Tiered wetland units	**7a** ("Upper Schoolhouse") **7b** ("Brushpile")	**7c** (unique configuration)	**7a** ("Upper Schoolhouse") **7b** ("Brushpile")	
9	Wells & supporting pipe work for Ducks Unlimited wells	**9a** (New wells x2) **9b** (Pipework x4)	**9a** (New wells x2) **9b** (Pipework x4)	**9b** (Pipework x2)	**9b** (Pipework x2)
12	Raise Yorkinut Slough berm	**12**	**12**	**12**	**12**
16	Reroute upland flow	**16c** (straight berm)	**16c** (straight berm)	**16a** (long berm)	
19	Channel improvements on Six Mile Island	**19**			
20	Side channel on Six Mile Island	**20**			
21	Raise spillway on Six Mile Island/Illinois River berm	**21**	**21**	**21**	
24	Tree planting	**24a1** (Yorkinut maximum) **24b** (Six Mile Island)	**24a2** (Yorkinut medium) **24b** (Six Mile Island)	**24a3** (Yorkinut low)	**24a4** (Yorkinut minimum maintenance)
25	Timber Stand Improvement (TSI)	**25**	**25**		

4.1 Benefits

Table 5 & 6 provide the final suitability index from the Duck Use Days and floodplain forest models, acres for each alternative, habitat units, gross AAHUs and net AAHUs (ecological lift for each target year (1, 5, 25, and 50) under consideration.

Table 5: UMRS Floodplain Forest Habitat Suitability Benefit Evaluation Results by Alternative

Description	Year	Average HSI	Acres	HUs	Cumulative AAHUs	Net AAHUS
FWOP – Forest + Woodland*	0	0.30	901		n/a	n/a
FWOP – Forest + Woodland*	5	0.31	901	1262	n/a	n/a
FWOP – Forest + Woodland*	25	0.33	901	5333	n/a	n/a
FWOP – Forest + Woodland*	50	0.38	901	7487	303	n/a
FWP Max	0	0.29	901		n/a	n/a
FWP Max	5	0.56	901	1538	n/a	n/a
FWP Max	25	0.73	901	10762	n/a	n/a
FWP Max	50	0.73	901	16604	599	297
FWP Intermediate B	0	0.30	901		n/a	n/a
FWP Intermediate B	5	0.52	901	1868	n/a	n/a
FWP Intermediate B	25	0.69	901	10154	n/a	n/a
FWP Intermediate B	50	0.71	901	15888	571	269
FWOP – Woodland Only**	0	0.07	269		n/a	n/a
FWOP – Woodland Only**	5	0.08	269	100	n/a	n/a
FWOP – Woodland Only**	25	0.07	269	393	n/a	n/a
FWOP – Woodland Only**	50	0.10	269	551	21	n/a
FWP Intermediate A	0	0.07	269		n/a	n/a
FWP Intermediate A	5	0.32	269	261	n/a	n/a
FWP Intermediate A	25	0.64	269	2580	n/a	n/a
FWP Intermediate A	50	0.75	269	4693	172	151
FWP Minimum	0	0.07	269		n/a	n/a
FWP Minimum	5	0.17	269	161	n/a	n/a
FWP Minimum	25	0.19	269	952	n/a	n/a
FWP Minimum	50	0.26	269	1493	52	31

FWOP – Future Without Project condition. FWP – Future With Project condition. DUD – Duck Use Days. HSI – Habitat Suitability Index. HUs – Habitat units. AAHUs – Average Annual Habitat Units. *FWOP – Forest + Woodland – Larger FWOP acreage including Six Mile Island for comparison to Maximum and Intermediate B alternatives. **FWOP – Woodland Only – Smaller FWOP acreage not including Six Mile Island for comparison to Minimum and Intermediate A alternatives

Table 6: Duck Energy Days Habitat Benefit Evaluation Results by Alternative

Alternative	Year	DUD	HSI	Acres	HUs	Total Cumulative HUs	Net AAHUs
FWOP – No Action	0	348239	0.20	531.7	107	n/a	n/a
FWOP – No Action	1	348239	0.20	531.7	408	n/a	n/a
FWOP – No Action	5	314511	0.18	531.7	1485	n/a	n/a
FWOP – No Action	25	168378	0.10	531.7	982	n/a	n/a
FWOP – No Action	50	87178	0.05	531.7		60	n/a
Maximum	0	348239	0.20	531.7	215	n/a	n/a
Maximum	1	1048537	0.61	531.7	1627	n/a	n/a
Maximum	5	1595170	0.92	531.7	8614	n/a	n/a
Maximum	25	1212329	0.70	531.7	7577	n/a	n/a
Maximum	50	759301	0.44	531.7		361	301
Intermediate B	0	348239	0.20	531.7	213	n/a	n/a
Intermediate B	1	1036035	0.60	531.7	1595	n/a	n/a
Intermediate B	5	1561934	0.90	531.7	8454	n/a	n/a
Intermediate B	25	1187070	0.69	531.7	7444	n/a	n/a
Intermediate B	50	743480	0.43	531.7		354	294
Intermediate A	0	348239	0.20	531.7	194	n/a	n/a
Intermediate A	1	864485	0.50	531.7	1382	n/a	n/a
Intermediate A	5	1282269	0.74	531.7	7231	n/a	n/a
Intermediate A	25	974525	0.56	531.7	6380	n/a	n/a
Intermediate A	50	610360	0.35	531.7		303	243
Minimum	0	348239	0.20	531.7	130	n/a	n/a
Minimum	1	501558	0.29	531.7	744	n/a	n/a
Minimum	5	701570	0.41	531.7	3616	n/a	n/a
Minimum	25	469789	0.27	531.7	2858	n/a	n/a
Minimum	50	281829	0.16	531.7		146	87

FWOP – Future Without Project condition. FWP – Future With Project condition. DUD – Duck Use Days. HSI – Habitat Suitability Index. HUs – Habitat units. AAHUs – Average Annual Habitat Units

4.2 Total Habitat Benefits

The Cost Effective Incremental Cost Analysis (CE/ICA) was conducted to help inform in selecting a plan (See Chapter 5 in the main report). Table 7 provides a summary of the total net AAHUs for each alternative.

Table 7: Total Habitat Benefits (Net AAHUs) for each alternative

Alternative	**Forest Habitat Net AAHUs**	**Wetland Net AAHUs**	**Total Net AAHUs**
FWP Maximum	249	301	598
FWP Intermediate B	226	294.2	563
FWP Intermediate A	109	243.8	395
FWP Minimum	27	87	118

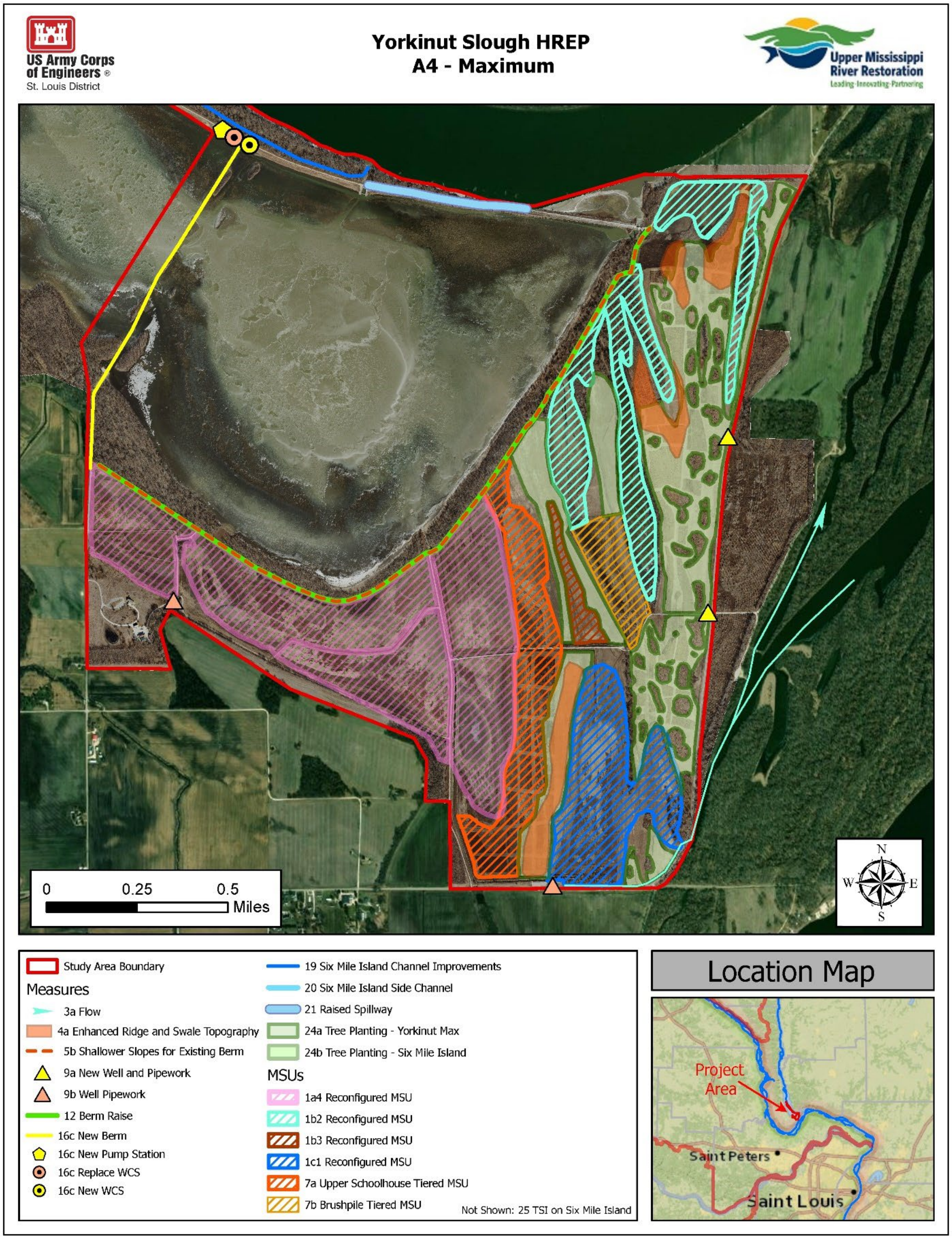

Figure 1 Maximum Alternative

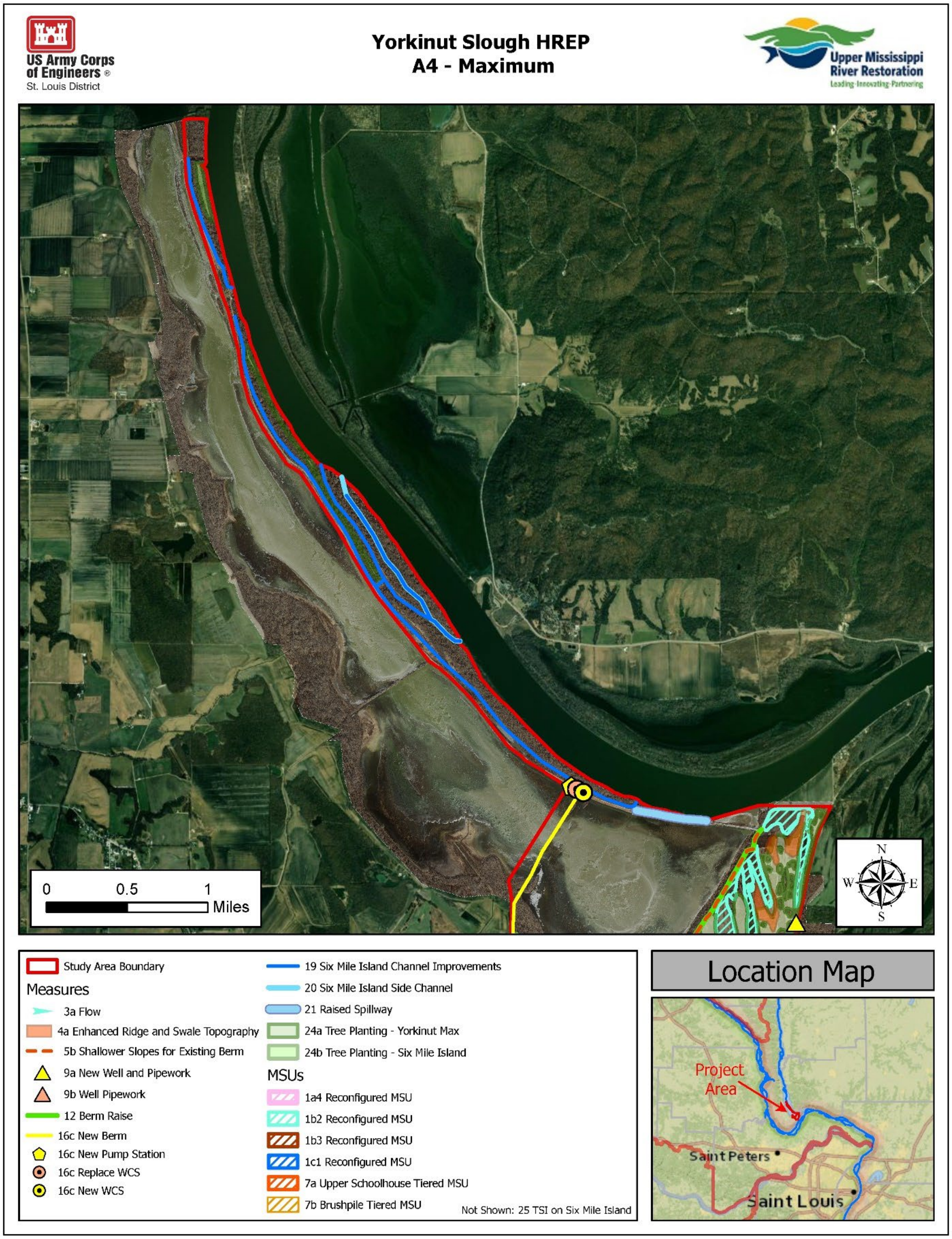

Figure 1 Maximum Alternative – Six Mile Island

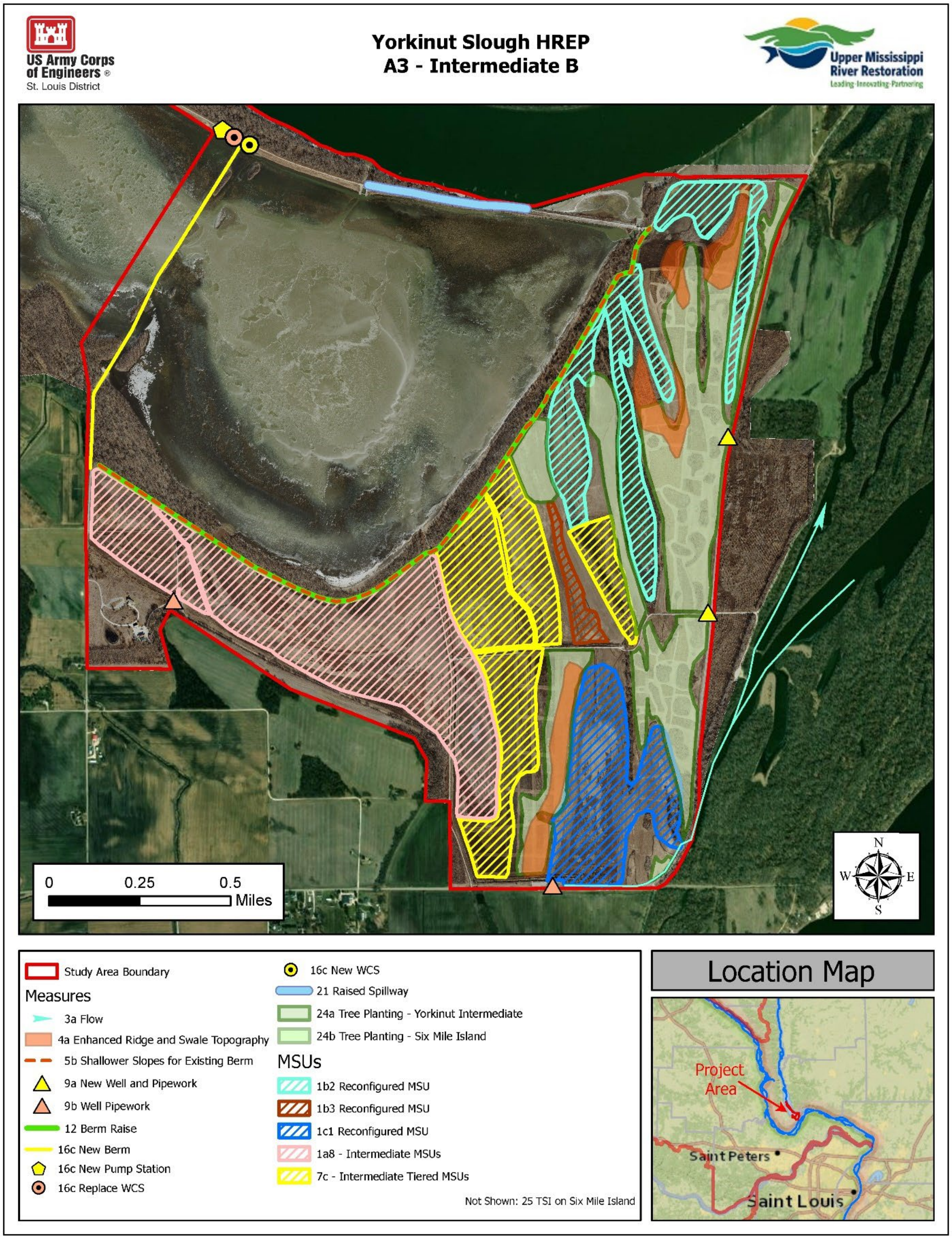

Figure 2 Intermediate B Alternative

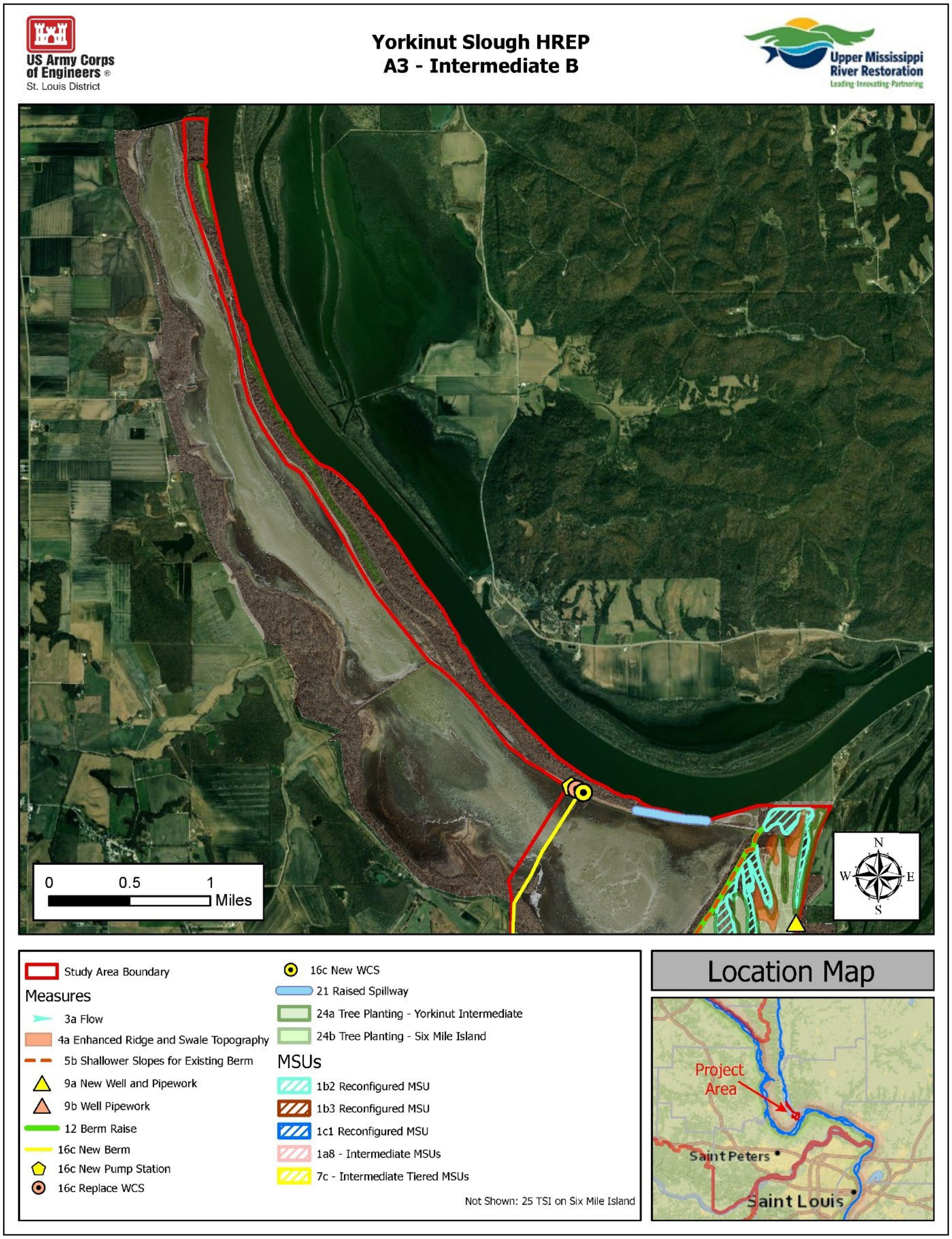

Figure 2 Intermediate B Alternative – Six Mile Island

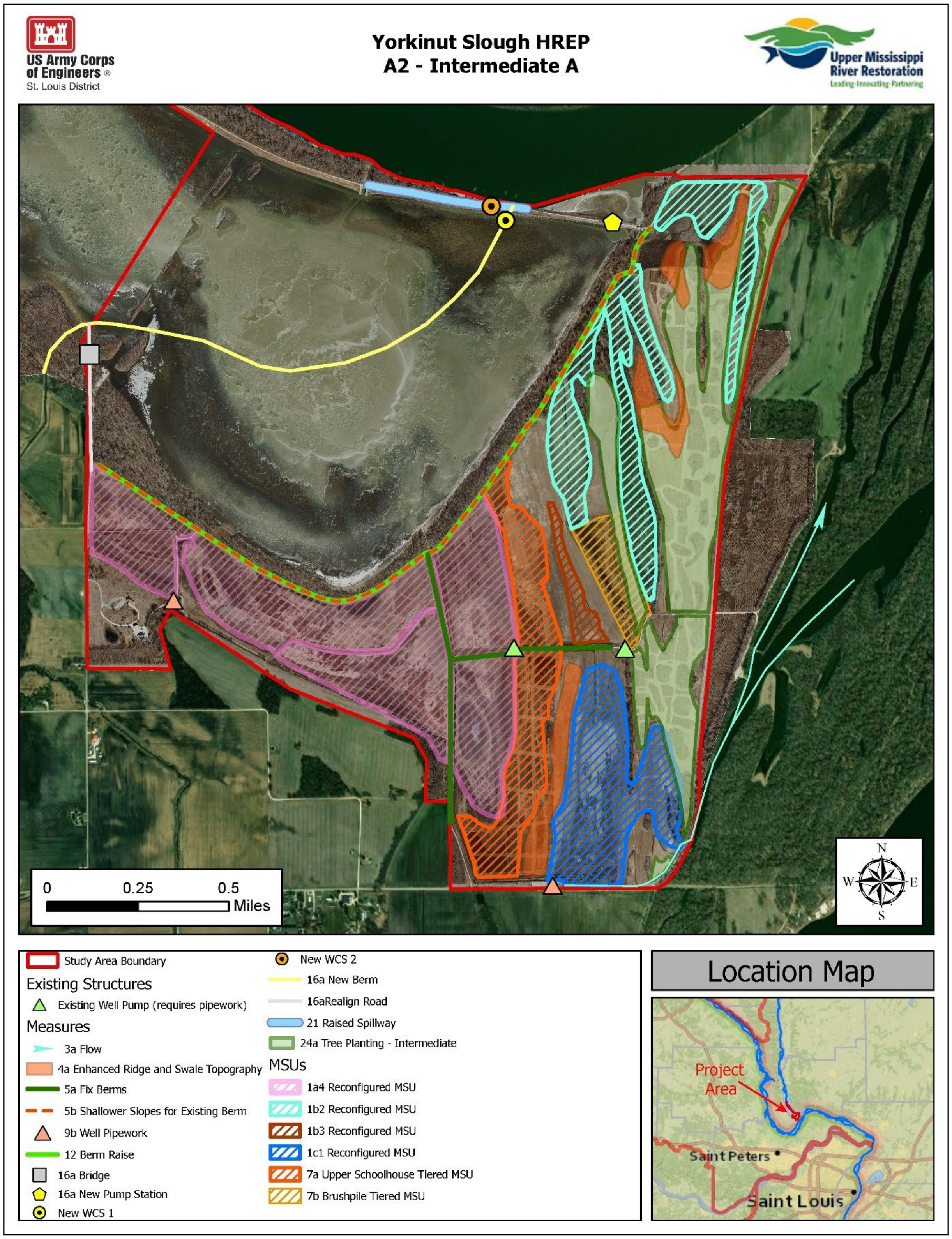

Figure 3 Intermediate A Alternative

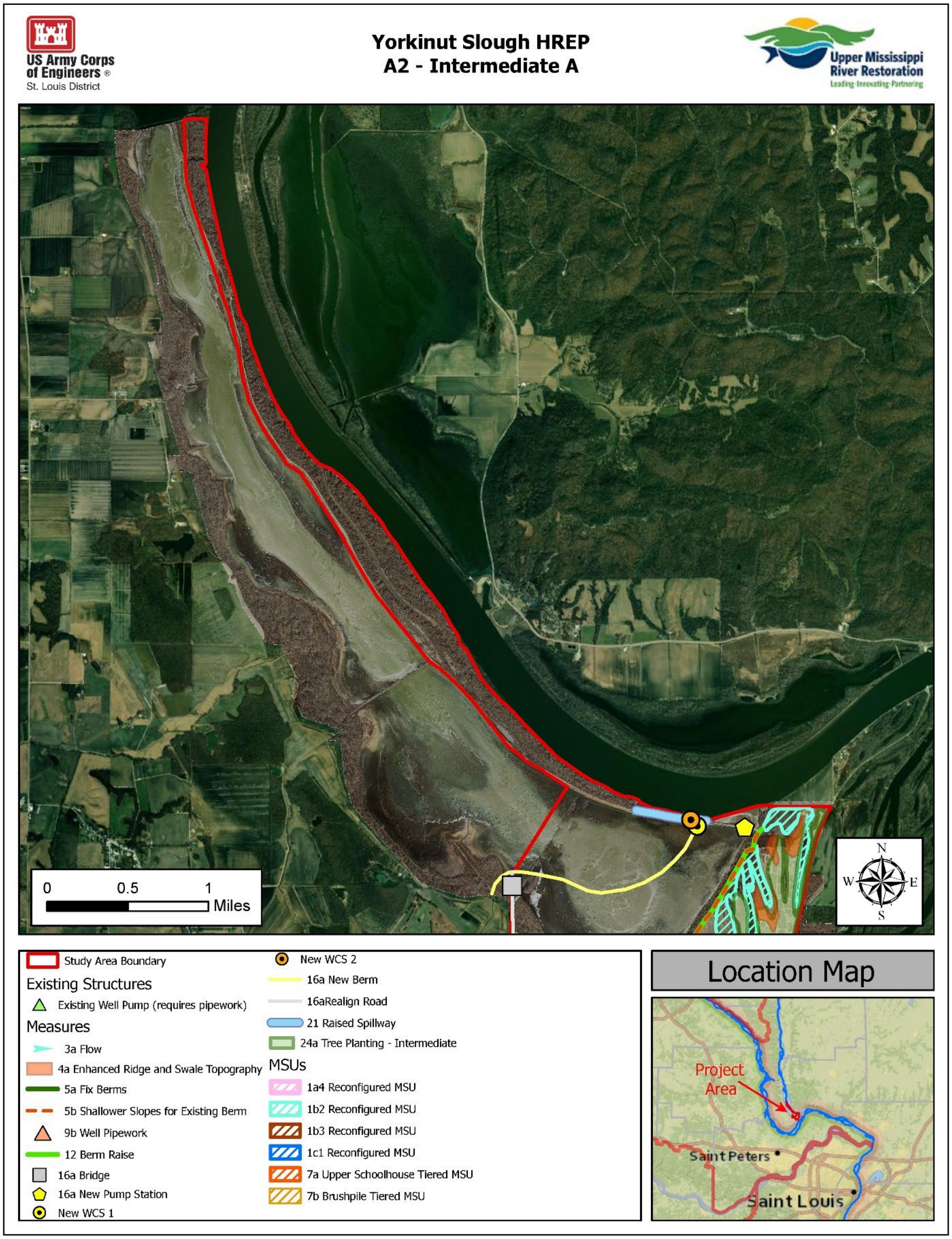

Figure 3 Intermediate A Alternative – Six Mile Island

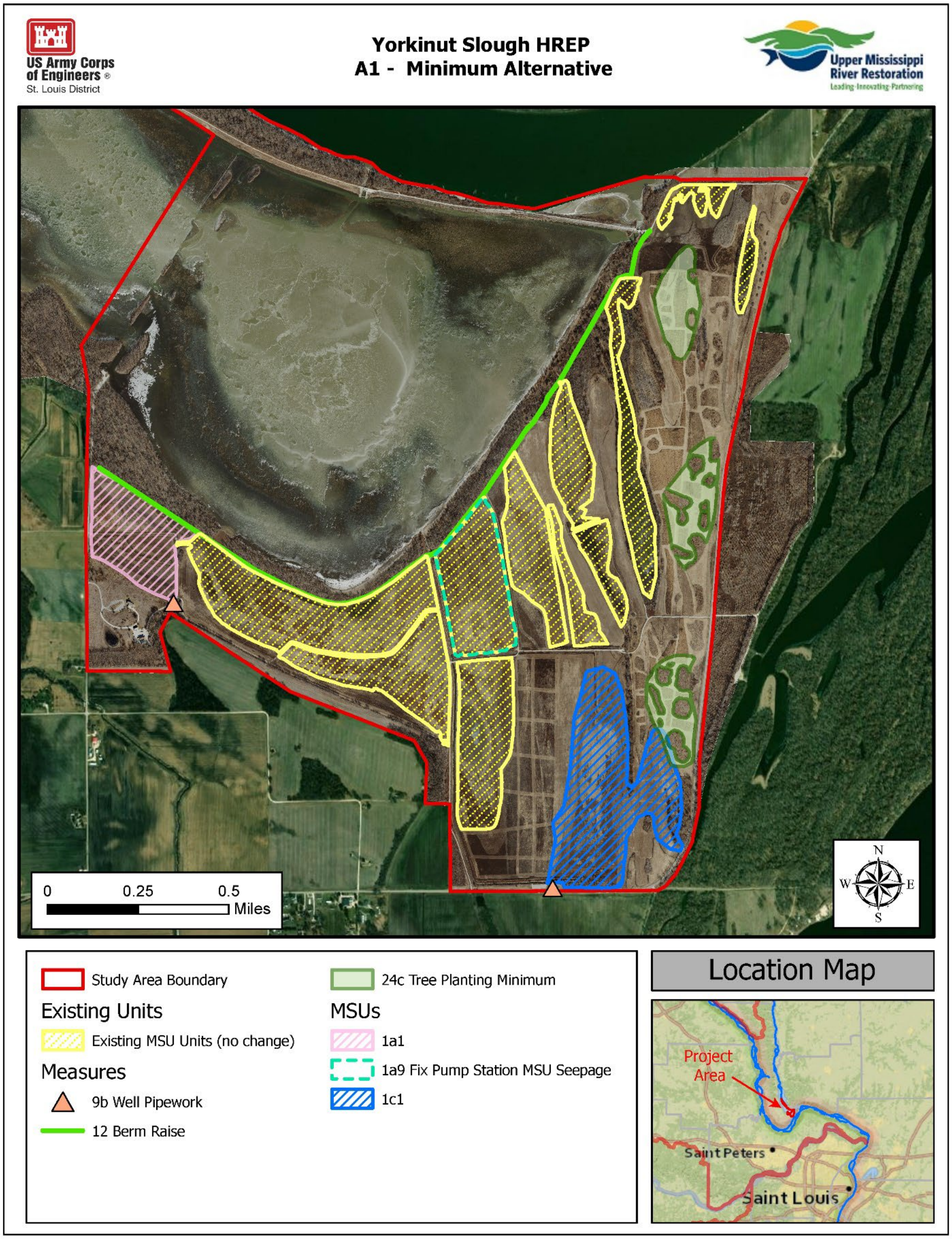

Figure 4 Minimum Alternative

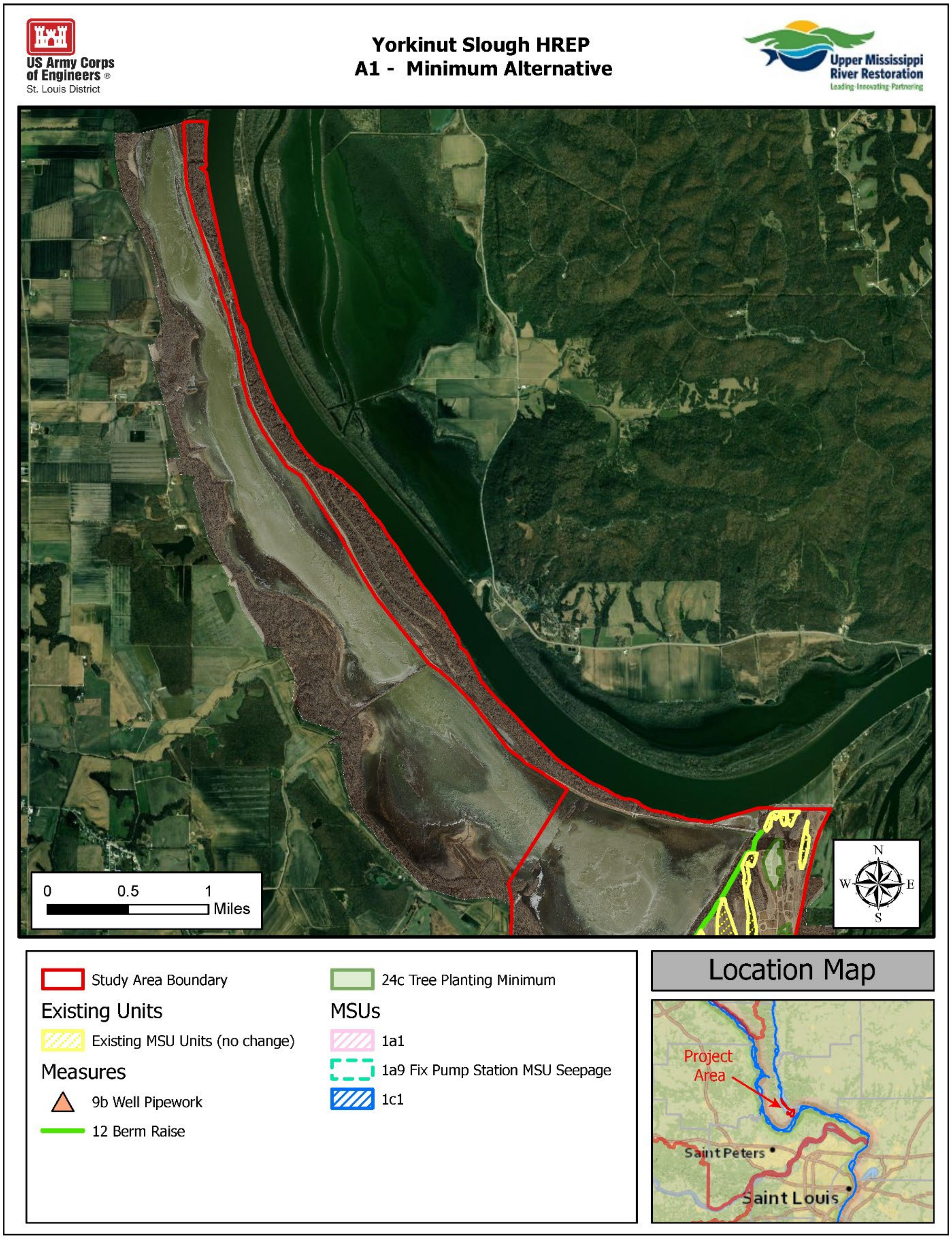

Figure 4 Minimum Alternative – Six Mile Island (no measures)

5 REFERENCES:

Heitmeyer, M.E. 2010. A Manual for Calculating Duck-Use-Days to Determine Habitat Resources Values and Waterfowl Population Energetic Requirements in the Mississippi Alluvial Valley. Prepared for U.S. Army Corps of Engineers, Memphis District by Greenbriar Wetland Services, Report 10-01. Greeenbrier Wetland Services, Advance, Missouri. 69 pp.

INHS (2019). Waterfowl unpublished aerial inventory data for Swan Lake. INHS Forbes Biological Station.

Johnson, B.L. and Hagerty, K.H. 2008. Status and Trends of Selected Resources of the Upper Mississippi River System. U.S. Geological Survey, La Crosse, WI. Technical Report LTRMP 2008-T002.

USACE. 2021. Upper Mississippi River System Floodplain Habitat Model. Prepared by USACE St. Paul, Rock Island, and St. Louis Districts. 78pp

U.S. Fish and Wildlife Service. 1980. Habitat Evaluation Procedures, Ecological Services Manual. Washington, D.C. 102 pp.

Wiener, J.G., Fremling, C.R., Korschgen, C.E., Kenow, K.P., Kirsch, E.M, Rogers, S.J., Sauer, J.S., 1998. Mississippi River in Status and Trends of Nations' Biologist Resources. (M.J. Mac, P.A. Opler, C.E.P Haecker, and P.D. Doran, Eds.). U.S. Geological Survey, Biological Resources Division, Reston, VA.

6 APPROVAL MEMO

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
MISSISSIPPI VALLEY DIVISION
1400 WALNUT STREET
VICKSBURG MS 39180-3262

CEMVD-PDP 01 March 2022

MEMORANDUM FOR Commander, St. Louis District, U.S. Army Corps of Engineers (Attn: Ms. Monique Savage, CEMVP-PDF)

SUBJECT: Single Use Approval of the Duck-Use-Days Model for the Upper Mississippi River Restoration Yorkinut Slough Habitat Rehabilitation and Enhancement Project

1. References:
   a. Engineer Circular 1105-2-412: Assuring Quality of Planning Models, 31 March 2011.

   b. US Army Corps of Engineers. Assuring Quality of Planning Models - Model Certification/Approval Process: Standard Operating Procedures. Feb 2012.

   c. Memorandum to Directors of National Planning Centers of Expertise – Subject: Modification of the Model Certification Process and Delegation of Model Approval for Use, 04 December 2017.

   d. Memorandum from the Director of Civil Works to MSC Commanders – Subject: Delegation of Model Certification, 11 May 2018.

   e. Memorandum to Director of the Ecosystem Restoration National Planning Center of Expertise - Subject: Recommend Single Use Approval of the Duck-Use-Days Model for the Upper Mississippi River Restoration Yorkinut Slough Habitat Rehabilitation and Enhancement Project, 28 February 2022.

2. The Ecosystem Restoration National Planning Center of Expertise evaluated the subject model for use on the Upper Mississippi River Restoration Yorkinut Slough Habitat Rehabilitation and Enhancement Project (Yorkinut Slough Project). The model was found to be appropriate for application on the project.

3. The Duck-Use-Days Model is approved for single use on the Yorkinut Slough Project. The model meets the criteria contained in References 1.a. and 1.b. There are no unresolved issues stemming from the review.

Jodi K. Creswell
Acting Chief, MVD Planning and Policy
and Acting Director, Ecosystem
Restoration National Planning Center of
Expertise

CEMVD-PDP
SUBJECT: Single Use Approval of the Duck-Use-Days Model for the Upper Mississippi River Restoration Yorkinut Slough Habitat Rehabilitation and Enhancement Project

CF
CEMVD-PDP (Lawton, Mallard, Mickal, Miller)
CEMVP-PDP (Richter, Runyon)
CEMVP-PDF (Savage)
CEMVS-PMF (Markert, Schneider, Brown)
CEMVR-PMS (Plumley)

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, MISSISSIPPI VALLEY DIVISION
P.O. BOX 80
VICKSBURG, MISSISSIPPI 39181-0080

CEMVD-PDP 16 August 2021

MEMORANDUM FOR CEMVD-PDP (Young)

SUBJECT: Recommend Certification for Regional Use of the Upper Mississippi River System Floodplain Forest Habitat Model

1. References:

    a. Engineer Circular 1105-2-412: Assuring Quality of Planning Models, 31 Mar 2011.

    b. US Army Corps of Engineers. Assuring Quality of Planning Models - Model Certification/Approval Process: Standard Operating Procedures. Feb 2012.

    c. Memorandum to Directors of National Planning Centers of Expertise – Subject: Modification of the Model Certification Process and Delegation of Model Approval for Use, 04 Dec 2017.

    d. Memorandum from the Director of Civil Works to MSC Commanders – Subject: Delegation of Model Certification, 11 May 2018.

    e. Model Review Plan, UMRS Floodplain Forest Habitat Model, February 2021 (Encl 1).

    f. Model Documentation, UMRS Floodplain Forest Habitat Model, June 2021 (Encl 2).

    g. Application Spreadsheet, UMRS Floodplain Forest Habitat Model, June 2021 (Encl 3).

    h. Model Review Comment Record, UMRS Floodplain Forest Habitat Model, June 2021 (Encl 4).

2. The Ecosystem Restoration National Planning Center of Expertise (ECO-PCX) evaluated the Upper Mississippi River System Floodplain Forest Habitat Model (Encl 2 and Encl 3) following references 1.a. and 1.b. Based on the results, the ECO-PCX evaluation team recommends certification of the model for regional use in the Upper Mississippi River System. In accordance with references 1.c. and 1.d., please review this recommendation and provide your concurrence, or, if appropriate, additional directions to the team.

CEMVD-PDP
SUBJECT: Recommend Certification for Regional Use of the Upper Mississippi River System Floodplain Forest Habitat Model

3. The model was developed by an interdisciplinary team from St. Paul, Rock Island, and St. Louis Districts. It provides an evaluation tool that can accurately capture the habitat changes associated with routine forestry techniques used in the region and thus provides a tool capable of quantifying benefits resulting from these techniques. The model consists of five variables representing the quality and health of floodplain forests: percent canopy cover, percent desired forest type, percent invasive species, regeneration, and structural diversity. The model was designed to be applicable across young, mature, and old forests found across the region, and can be used for all forest community types, including diverse forest communities and variable flooding regimes, found in the system. Model documentation consists of the User Manual and application spreadsheet.

4. The ECO-PCX conducted a review of the UMRS Floodplain Forest Habitat Model to assess the technical quality, system quality, usability, and conformance with USACE policy as required in EC 1105-2-412. The internal model reviewers (Mr. Kip Runyon, MVS and Mr. Ben McGuire, MVS) are well-versed in ecological model development, environmental planning methods, spreadsheet auditing, and UMRS floodplain forest ecology. The review also included external peer review by state and federal resource agency personnel familiar with UMRS floodplain forest ecology and restoration techniques (U.S. Fish and Wildlife Service and Wisconsin Department of Natural Resources). The User Manual and application spreadsheet were provided to the reviewers.

   The intermediate level of review resulted in 16 substantive comments (none of high significance). The following summarizes the overall review comments and modifications made to the model to improve system quality and usability.

   - Reviewers provided several comments requesting more detail be added to the model documentation to assist users in application of model variables. Model developers added clarifying language to the descriptions of all model variables accordingly to help users properly apply the variables.
   - Reviewers appreciated the numerous example photographs provided in the model documentation to assist users in scoring model variables. Reviewers suggested that adding even more photos would further add consistency to model application. Model developers committed to adding more examples in the future if warranted by user feedback from application of the model.
   - Reviewers requested adding flexibility to the recommended forest stand size appropriate for model application. Model developers adjusted the description of appropriate stand size in the model documentation accordingly.
   - Reviewers recommended adding more specificity to the documentation on the appropriate geographic range for model application. Model developers added language specifying that the model can be used across the UMRS but may be applicable in other areas as well.
   - Reviewers recommended adding more information on model assumptions and limitations and the developers added a section to the model documentation accordingly.

- Reviewers recommended changes to the model spreadsheet to limit user inputs to the allowable ranges, prevent inadvertent changes by users, and correct minor inconsistencies in variable equations. Model developers made the changes to the model spreadsheet accordingly.
- Reviewers provided numerous editorial comments to make the model documentation clearer for users and consistent with the terminology used in the model spreadsheet. Model developers updated the model documentation and spreadsheet accordingly.

The ECO-PCX reviewed the comments, evaluations, and revisions made to the model. All were made to the satisfaction of the ECO-PCX. The comments, evaluations, and revisions are in alignment with the requirements of assuring the quality of planning models. Overall, the model reviewers agreed that the model is well-suited for its intended purposes of evaluating relative changes in floodplain forest habitat in the UMRS.

5. The UMRS Floodplain Forest Habitat Model has sufficient technical quality. The model review team found that the model is based on sound ecological theory and agreed that the model is well-suited for its intended purposes of conducting a functional assessment needed to evaluate benefits or impacts to floodplain forests. The five variables analyzed by the model are reasonable because these factors are fundamental for measuring the quality of floodplain forest habitat. Key model assumptions are documented, and limitations are well-defined to indicate the objectives and intended use of the model.

6. The UMRS Floodplain Forest Habitat Model has sufficient system quality. Microsoft Excel is an appropriate format to perform model calculations and is readily available. The ECO-PCX tested the spreadsheet to ensure formulas and cell references were correct. Minor errors in the spreadsheet were identified and fixed and the spreadsheet was subsequently locked. The application calculator includes good spreadsheet practices such as data validation. Upon certification, the ECO-PCX will upload the model to the Ecosystem Restoration Model Library (https://ecolibrary.planusace.us/#/home).

7. The UMRS Floodplain Forest Habitat Model has sufficient usability. Input data requirements are clearly defined and are able to be collected. Outputs are consistent with USACE habitat evaluation procedures, understandable (i.e., 0-1.0 scale) and useful for planning purposes (i.e., Habitat Suitability Index scores). Users of the model should have considerable experience and understanding of floodplain forest assessment methodologies and local habitat conditions. Agency Technical Review teams should evaluate the quality of data and assumptions associated with model inputs and the application of model outputs to alternative evaluations.

8. The model and methodology are consistent with USACE policies and accepted procedures for conducting functional assessments. The model does not incorporate, facilitate, or encourage the use of non-ecosystem parameters or values. The model

CEMVD-PDP
SUBJECT: Recommend Certification for Regional Use of the Upper Mississippi River System Floodplain Forest Habitat Model

facilitates the use of established principles of alternative evaluation to produce outputs consistent with Civil Works required functional assessments.

9. The ECO-PCX team finds the Upper Mississippi River System Floodplain Forest Habitat Mode has sufficient technical and system quality and usability and is policy compliant. The ECO-PCX recommends certification for regional use of the model in the Upper Mississippi River System.

Gregory Miller

Encls (4)

Gregory Miller
Operating Director
Ecosystem Restoration National
Planning Center of Expertise

CF
CEMVD-PDP (Lawton, Mallard, Mickal)
CEMVP-PD-C (McGuire, Ray)
CEMVP-OP-RNR (Meier)
CEMVP-PD-F (Richards)
CEMVP-PD-P (McCain, Runyon)
CEMVR-OD-MN (Vandermyde)
CEMVR-PD-P (Michl)
CEMVR-PM-S (Plumley)
CEMVS-OD-NR (Cosgriff)