U.S. Army Corps of Engineers'
Upper Mississippi River Restoration Program

Long Term Resource Monitoring Element

Technical Report

2015–T001

Accuracy Assessment/Validation Methodology and Results of 2010–11 Land-Cover/Land-Use Data for Pools 13, 26, La Grange, and Open River South, Upper Mississippi River System

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Preface

The U.S. Army Corps of Engineers' (USACE) Upper Mississippi River Restoration Program (UMRR), including its Long Term Resource Monitoring Program (LTRMP), was authorized under the Water Resources Development Act of 1986 (Public Law 99–662). The UMRR is a multi-federal and state agency partnership among the USACE, the U.S. Geological Survey's (USGS) Upper Midwest Environmental Sciences Center (UMESC), the U.S. Fish and Wildlife Service (USFWS), and the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The USACE provides guidance and has overall Program responsibility. UMESC provides science coordination and leadership for the LTRMP element.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP element is to support decision makers with the information and understanding needed to manage the UMRS as a sustainable, large river ecosystem, given its multiple use character. The long-term goals of the LTRMP are to better understand the UMRS ecosystem and its resource problems, monitor and determine resource status and trends, develop management alternatives, and proper management and delivery of information.

This report supports Goal 2: Advance knowledge for restoring and maintaining a healthier and more resilient Upper Mississippi River ecosystem in the Strategic Plan for the Upper Mississippi River Restoration Program 2015–2025 and fulfills milestone #2014V4 from the FY14 LTRM scope of work. This report was developed with funding provided by the USACE through the UMRR.

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By J.W. Jakusz,[1] J.J. Dieck,[1] H.A. Langrehr,[2] J.J. Ruhser,[1] and S.J. Lubinski[1]

Introduction/Background

The U.S. Geological Survey (USGS)-Upper Midwest Environmental Sciences Center (UMESC) was responsible for development of several land cover/land use (LCU) systemic datasets of the Upper Mississippi River System (UMRS). These efforts (1989 and 2000) were funded by the U.S. Army Corps of Engineer's Upper Mississippi River Restoration Program (UMRR) Long Term Resource Monitoring (LTRM) element. Development of systemic datasets includes the acquisition, processing, and serving of high-resolution aerial photography and land cover/land use spatial datasets (http://www.umesc.usgs.gov/data_library/land_cover_use/land_cover_use_data.html). In 2008, the UMRR reached a collaborative agreement with the U.S. Fish and Wildlife Service-Region 3 to collect high-resolution digital imagery of the entire UMRS floodplain during 2010–11 for LTRM. The UMESC helped acquire, process, and serve this imagery, as well as produce and serve the 2010–11 LCU systemic dataset of the UMRS floodplain. Digital imagery for Pools 13, 26, La Grange, and Open River South was collected using an Applanix DSS 439 digital sensor system with a 40 millimeter lens and Color Infrared (CIR) filter. The imagery was collected at a resolution of 20 centimeters/pixel (8 inches/pixel) for Pool 13 and 40 centimeters/pixel (16 inches/pixel) for Pools 26, Open River South, and La Grange. All imagery was projected to Universal Transverse Mercator (UTM) Zone 15, North American Datum of 1983 (NAD 83). The General Wetland Vegetation Classification (GWVC) system used for mapping is hierarchical, and its 31 classes can be collapsed into broader categories using either a 15- or 7-class level.

While the 1989 and 2000 LCU systemic datasets have not gone through a traditional thematic accuracy assessment (AA) in the past, nor have they undergone a validation analysis, the end products are of high quality. For each systemic dataset produced (1989, 2000, 2010–11), extensive field reconnaissance is performed before photointerpretation. The intent of this field reconnaissance is to learn, test, and verify image signatures as they relate to vegetation types. Questionable areas on the imagery are visited, and the plants or land features observed in the area are recorded for reference. This procedure verifies vegetation signatures on the imagery with those on the ground. In addition, once the photointerpretation is complete, the final LCU dataset undergoes extensive quality assurance/quality control to ensure the imagery is mapped correctly.

Since the 2000 LCU systemic dataset was developed, there has been a growing interest in completing thematic AAs for the LTRM LCU spatial datasets. The objective of an AA is to measure the probability that a particular location has been assigned its correct vegetation class. An AA estimates thematic (map class) errors in the data, giving users information needed to determine data suitability for a particular application. At the same time, data producers are able to learn more about the nature of errors in the data. Thus, the two attributes of an AA are "producers' accuracy," which is the probability that an AA point has been mapped correctly (also referred to as an error of omission); and "users' accuracy," which is the probability that the map actually represents what was found on the ground (also referred to as error of commission). Producers' and users' accuracies can be obtained from the same set of data by using different analyses.

Accuracy assessment is an extensive effort that requires seasonal field personnel and equipment, data entry, analyses, and post processing—tasks that are costly and time consuming. The geospatial team at the Upper Midwest Environmental Science Center (UMESC) has suggested a validation process for understanding the accuracy of the spatial datasets, which will be tested on at least some areas of the UMRS. Validation is not a true verification of map-class type in the field; however, it can provide the user of the map with useful information that is similar to a field AA.

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Similar to an AA, validation involves generating random points based on the total area for each map class. However, instead of collecting field data, two or three individuals not involved with the photo-interpretative mapping separately review each of the points onscreen and record a best-fit vegetation type(s) for each site. Once the individual analyses are complete, results are joined together and a comparative analysis is performed. The objective of this initial analysis is to identify areas where the validation results were in agreement (matches) and areas where validation results were in disagreement (mismatches). The two or three individuals then perform an analysis, looking at each mismatched site, and agree upon a final validation class. (If two vegetation types at a specific site appear to be equally prevalent, the validation team is permitted to assign the site two best-fit vegetation types.) Following the validation team's comparative analysis of vegetation assignments, the data are entered into a database and compared to the mappers' vegetation assignments. Agreements and disagreements between the map and validation classes are identified, and a contingency table is produced. This document presents the AA processes/results for Pools 13 and La Grange, as well as the validation process/results for Pools 13 and 26 and Open River South.

Accuracy Assessment

AA Point Selection

All 25 GWVC system map classes (Dieck and Robinson 2004) representing National Vegetation Classification Standard (NVCS) natural/semi-natural types (table 1) (Federal Geographic Data Committee, 2008) were assessed using the stratified random-sampling scheme described in the Thematic Accuracy Assessment Procedures: Version 2.0 (Lea and Curtis, 2010). UMESC staff used these guidelines to determine the appropriate buffer and the number of sites for each map class in Pool 13 and La Grange.

The number of samples needed for each map class (theme) takes into account both the statistical and operational aspects of sampling and were determined by the following scenarios (Lea and Curtis, 2010):

- Scenario A: The class is abundant. It covers more than 50 hectares (ha) in total area. The map class receives the maximum sample size of 30.
- Scenario B: The class is relatively abundant. It covers at least 8.33 ha, but no more than 50 ha in total area. The map class receives a sample size of 0.6 observations per hectare of the map class (= one observation for every 1.67 ha of map class area). (This ratio allocates observations at a density rate equal to 30 observations per 50 ha.)
- Scenario C: The class is relatively rare. It covers less than 8.33 ha in total area. The map class receives five observations (the recommended minimum sample size).

Table 1. The General Wetland Vegetation Classification system map classes with their respective map codes representing National Vegetation Classification Standard natural/semi-natural types.

Map class	Map code
Submersed Vegetation	SV
Rooted Floating Aquatics	RFA
Deep Marsh Annual	DMA
Deep Marsh Perennial	DMP
Shallow Marsh Annual	SMA
Shallow Marsh Perennial	SMP
Sedge Meadow	SM
Wet Meadow	WM
Deep Marsh Shrub	DMS
Shallow Marsh Shrub	SMS
Wet Meadow Shrub	WMS
Scrub-Shrub	SS
Wooded Swamp	WS
Floodplain Forest	FF
Populus Community	PC
Salix Community	SC
Lowland Forest	LF
Conifers	CN
Plantation	PN
Upland Forest	UF
Grassland	GR
Pasture	PS
Mudflat	MUD
Sand	SD
Sand Bar	SB

UMESC personnel buffered each sampling site from the polygon boundary to eliminate the possibility that the observed area (a circular area approximately the size of the minimum mapping unit) is of mixed map-class identity due to (1) confusion as to whether the observation area is wholly contained within the map class, (2) positional error due to global positioning system (GPS) error, and (3) allowable positional error in the map data. The United States National Map Accuracy Standards requirement for positional accuracy of 1:24,000 scale products is 12.2 meters (m) (Federal Geographic Data Committee, 1998).

To calculate the required buffer distance, the square root of the sum of squares of these error sources will be calculated with the following formula:

$$Buffer\ Distance = \sqrt{R^2+F^2+M^2}$$

where

R is the radius distance of the observation area,
F is the expected (e.g., 90th percentile) field positioning (GPS) error distance, and
M is the standard requirement (maximum positional error distance in the map) for positional accuracy.

The minimum mapping unit (MMU) for La Grange is 1 ha (2.5 acres). Given this MMU, the radius length of a circular 1-ha area is 56 (m), representing the value of R. The value of F is generalized to 15 m, and the value of M is generalized to 12 m. Therefore, a buffer distance of 59 m was applied to the interior polygon boundaries. The MMU for Pool 13 is 0.4 ha (1 acre). Given this MMU, the radius length of a circular 0.4-ha area is 36 m, representing the value of R. The value of F is generalized to 15 m, and the value of M is generalized to 12 m. Therefore, a buffer distance of 41 m was applied to the interior polygon boundaries. In instances where the point-selection process was not able to select points with an adequate distance from other vegetation polygons because the vegetation type was in a very small or linear polygon, a smaller buffer was used. For these small polygons, we provided the AA team with hard-copy maps showing the AA points and including lines that marked the interpreted boundaries between two map classes. Multiple observations in a polygon may occur, provided they did not overlap in area.

Once the number of sites was determined and the buffer applied, random AA points were generated for each map class using Geospatial Modeling Environment for ArcGIS (Beyer, 2004) (tables 2 and 3). Up to three points were allowed within any one polygon as long as the distance between the points was at least 1 MMU apart. These AA site coordinates (UTM projection, Zone 15 or 16, using NAD 83) were then provided to the AA team for uploading into their GPS unit.

Table 2. Number of points and buffers generated for accuracy assessment of the Pool 13 land cover/land use database.

Accuracy Assessment map code (see table 1)	Hectares	Buffer (meters)	Number of points needed	Number of points obtained
SV	3,551.93	41	30	30
RFA	1,464.55	41	30	30
DMP	713.57	41	30	30
SMA	6.81	5	5	5
SMP	939.45	41	30	30
WM	640.90	41	30	30
DMS	28.91	20.5	17	17
SMS	54.26	41	30	30
WMS	69.65	41	30	30
SS	172.67	41	30	30
FF	4,555.63	41	30	30
PC	143.97	41	30	30
SC	269.33	41	30	30
LF	804.95	41	30	30
CN	84.93	41	30	30
PN	101.21	41	30	30
UF	1,463.41	41	30	30
GR	2,323.11	41	30	30
PS	102.33	20.5	30	13
MUD	1.34	5	5	5
SB	3.81	5	5	5
TOTAL	**17,491.57**		**525**	**525**

Table 3. Number of points and buffers generated for accuracy assessment of the La Grange land cover/land use database.

Accuracy Assessment map code (see table 1)	Hectares	Buffer (meters)	Number of points needed	Number of points obtained
SV	301.30	41	30	30
RFA	289.63	59	30	30
DMP	246.79	59	30	30
SMA	2,505.96	59	30	30
SMP	709.64	59	30	30
WM	3,568.39	59	30	30
DMS	399.79	59	30	30
SMS	95.05	30	30	30
WMS	363.48	41	30	30
SS	4.13	0	5	5
FF	9,597.01	59	30	30
PC	436.75	59	30	30
SC	4,512.26	59	30	30
LF	1,927.74	59	30	30
CN	79.00	30	30	30
PN	739.78	59	30	30
UF	583.10	59	30	30
GR	31.19	15	18	18
PS	205.30	59	30	30
MUD	1,288.91	59	30	30
SD	23.58	15	14	14
SB	27.40	0	16	16
TOTAL	**27,936.18**		**593**	**593**

AA Field Data Collection

Field observation data were collected by La Grange field station staff (T. Cook, 2011–2012) and Pool 13 field station staff (J. Petersen and D. Bierman, assisted by T. Kueter, M. Bowler, and B. Reed, 2011) following the field manual procedures (appendix 1). The crews were trained in AA procedures by AA contractors for both projects. Field crews navigated to the pre-selected AA sites using GPS and hard-copy maps. Using a field key (appendix 2), the field crews selected the appropriate vegetation class within a circular area approximately the size of the MMU (36 or 56 m radius circle). In very narrow polygons (as indicated on the hard-copy maps by red boundary lines), the field crews considered the location of the point with regard to polygon boundaries when performing the assessment of the area.

Within the target assessment area, crews recorded GPS coordinate locations, dominant and indicator species, environmental data, and pertinent comments on the Accuracy Assessment Field Form (appendix 3). The field key directed the crews to the vegetation class that best fits the site. In unclear cases, such as instances where the key did not perform well enough to define a single vegetation class, the field crew still made a "best call," but also were directed to put a second call where needed. Extra notes on complicating factors also were documented. In addition, in areas where the polygon consisted of two or more communities, the crews were instructed to document the community type that contained the most acreage within the 36-m (Pool 13) or 56-m (La Grange) radius area.

AA Data Analysis–Pool 13/La Grange

Within Pool 13, field data for 523 AA sites were collected and entered into a Microsoft Access database specifically designed for the project. Thirty-three sites were dropped due to inaccessibility or unresolvable data issues (such as GPS error or incomplete field data sheets), leaving 490 sites that contributed to the final analysis. Field data for 457 AA sites, pertaining to the La Grange AA analysis, were collected and entered into a Microsoft Access database designed for the project. Fifty-eight sites were dropped from the La Grange analysis due to inaccessibility or unresolvable data issues, leaving 399 sites that contributed to the final analysis. Both databases were subsequently reviewed for data-entry errors. Analyses of map accuracy included the following steps:

- Initial comparative analysis of the field and map data,
- Review of all disagreements and correction of false errors as necessary,
- Final comparative analysis of the field and map data,
- Individual map-class analysis,
- Final output of results into a contingency matrix, and
- Final output of the analyses and results into a spatial database for use in a GIS.

Initial Comparative Analysis

The first step of the initial comparative analysis was the completion of a spatial join of the AA field-site data and the map-polygon data. This allowed the UMESC AA team to compare each AA field-site call (vegetation type) to the corresponding map-polygon call (map class representing vegetation type). The comparisons of primary and secondary field-site calls to the vegetative map-polygon call resulted in either agreement or disagreement.

Review of Disagreements

All mismatches (disagreements) were subsequently reviewed for false errors. A false error is defined as a mismatch between the AA field-site call and the map-polygon call if caused by an accuracy error in the GPS field-site coordinates, a missing or misapplied field-site call, or a field-site assessment of an area smaller than the MMU (an inclusion). This review process involved looking at the AA sites and their corresponding polygons by using ArcGIS (Environmental Systems Research Institute, Redlands, California) and a three-dimensional monitor to locate them. We also reviewed the field data sheet and field photos to gain fuller context of the ground data. From this process, we determined whether an initial disagreement was either a true error or indeed a match.

Spatial Error and GPS Errors

A spatial error might occur in one of two following ways: (1) the GPS device acquired inaccurate field coordinates due to lack of available satellites or as a result of the individual GPS unit accuracy or (2) a geospatial error existed within the vegetation map layer (called a "map-layer shift"). Either of these spatial errors could displace the newly acquired field coordinate inside an adjacent polygon on the map layer. By selecting sites, whenever possible, more than an MMU from polygon edges, we were able to minimize spatial errors in GPS coordinates, yet occasionally GPS accuracy could fall outside this parameter. GPS errors were created when field crews were unable to be physically present at a site but rather assessed the vegetation from a distance, recording coordinates outside the intended polygon.

Questionable Field Call

A field assessment call might be questioned during the analysis, especially when the perspective from the ground was limited by poor vantage points, such as heavy cover of vegetation or wet soils preventing the field worker from walking around the MMU, or when sites were assessed from some distance to avoid trespassing. If the MMU area was diverse, with more than one map class represented, it was possible to miss or fail to recognize other vegetation types present. We reviewed these situations by checking the aerial images for diversity at the site and by reviewing the field data sheets to check for possible problems.

Inclusion

The area assessed in the field during the AA might fall below the MMU for mapping (termed an inclusion). We discovered several instances wherein, after reviewing the aerial images, we could conclude that the site in question contained vegetation that was an inclusion to the surrounding map class. Certain vegetation features can be quite distinct from each other on aerial images (e.g., open woodland versus dense forest), allowing easy assessment of site inclusions in the lab. Another type of inclusion occurs when an area is a valid MMU, but the assessed area overlapped into an adjacent polygon. Particularly in the case of smaller polygons adjacent to those having similar vegetation types, it was sometimes difficult to determine if the assessed area actually fell within the intended polygon.

Time Change

Imagery was collected for Pool 13 during 2010 and for La Grange during 2011. Field data were collected during 2011 for Pool 13 and during 2011–12 for La Grange. In some instances, we could see changes between the field call and what was present on the imagery, primarily within the classes of submersed vegetation (SV) and Rooted Floating Aquatics (RFA), and occasionally in the emergent classes. For example, the 2010 imagery would show submersed aquatic vegetation, but the field crew would find none during the site visit in 2011. These changes are most likely attributed to flood waters in 2011 impacting the density of the vegetation. In these instances, where the change could be logically justified, the map call would then be accepted as correct. Additional instances were found where a time change was certainly possible at an AA site, however, could not be justified based on the comparison of numerous factors, including; CIR aerial imagery, field photos and the AA datasheet species list.

Final Output

The results of the final analyses for the map classes assessed in both Pool 13 (21 map classes assessed) and La Grange (22 map classes assessed) were transferred into their respective contingency tables (matrix). Within the matrix, percentages of users' and producers' accuracies were calculated for each map class. The matrix shows both the frequency of agreement and placement of disagreements. Also provided are two additional matrixes that assess the accuracy of the data at less detailed levels of the classification (15- and 7-class levels; in both cases, all classes may not be represented by AA due to lack of occurrence within a specific study area).

AA Spatial Database

For use in a GIS, we produced a feature-class layer of the AA site locations, along with supporting tables, and incorporated them into the geodatabase for the Pool 13 and La Grange vegetation-mapping projects. The field data for AA also are included in a Microsoft Access database for each pool.

AA Results–Pool 13

Of the 490 sites collected, the initial comparison revealed only 43 percent of the AA sites matched the corresponding polygons representing the classification. However, 41 percent of the mismatches were due to correctable issues or "false errors" such as GPS coordinates taken from outside the site due to inaccessibility (21 percent of the false errors), changes in the vegetation between the year of the imagery and the field sampling (22 percent of the false errors), borderline field calls where the percentage of vegetation on the data sheet was very close to similar types, or there were discernible classification errors on the data sheets (57 percent of the false errors). By correcting false errors, a true accuracy of 76.3 percent was obtained. A kappa adjustment for chance agreements resulted in a final overall accuracy of 75.0 percent. The 31-class contingency matrix for Pool 13 AA results is provided in appendix 4. The matrix shows the accuracy of each map class (along with 90-percent confidence intervals), with the users' accuracy reflecting errors of inclusion (commission errors) and producers' accuracy reflecting errors of exclusion (omission errors). The width of each confidence interval is affected by the sample size used to derive the point estimate.

Our overall AA fell short of the accuracy requirement of 80 percent for the 22 classes analyzed for this pool. Several classes contributed to the majority of issues. For users' accuracy, Shallow Marsh Annual (SMA), Wet Meadow (WM), Shallow Marsh Shrub (SMS), Wet Meadow Shrub (WMS), *Salix* Community (SC), and Lowland Forest (LF) had accuracies and confidence intervals that fell below 80 percent. The remaining classes had an average users' accuracy of 90 percent. The wet meadow and marsh classes overlap in signature appearances and are highly ecotonal, creating errors in closely related classes. The forest communities add further difficulty because the visual and classification differences between lowland and floodplain forest are subtle, and their relations to elevation and location within the floodplain are not clearly defined.

For producers' accuracy, Deep Marsh Perennial (DMP), Shallow Marsh Annual (SMA), Deep Marsh Shrub (DMS), and Floodplain Forest (FF) had accuracies and confidence intervals that fell below 80 percent. Also, Shallow Marsh Perennial (SMP), Wet Meadow (WM), Shallow Marsh Shrub (SMS), Wet Meadow Shrub (WMS), Lowland Forest (LF), and Upland Forest (UF) had accuracies below 80 percent but confidence intervals that included 80 percent. The remaining classes had an average producers' accuracy of 92 percent.

The following are map classes for which the mapping project did not meet the recommended rates of accuracy, in terms of either the actual percentage or within the confidence intervals.

Users' Comparison (Differences of Commission)

The users' accuracy for Shallow Marsh Annual (SMA) was 0 percent with a 90-percent confidence interval of −10 to 10 percent. Of the five AA sites mapped as SMA, five sites were found to contain different vegetation types, with errors attributed as follows:

- Two errors to Wet Meadow (WM) due to the AA crew finding species;
- One error to Open Water (OW) where no shallow marsh species were found;
- One error to Deep Marsh Perennial (DMP) due to the AA crew finding deep marsh species such as *Sagittaria*;
- One error to Shallow Marsh Perennial (SMP) due to the AA crew finding shallow marsh species such as *Scirpus, Sagittaria*, and *Polygonum*.

The users' accuracy for Wet Meadow (WM) was 35 percent with a 90-percent confidence interval of 17–52 percent. Of the 26 AA sites mapped as WM, 17 sites were found to contain different vegetation types, with errors attributed as follows:

- Nine errors to Deep Marsh Perennial (DMP) due to the AA crew finding deep marsh species such as *Sagittaria*;
- Five errors to Shallow Marsh Perennial (SMP) due to the AA crew finding shallow marsh species such as *Scirpus, Sagittaria*, and *Polygonum*;
- One error to Wet Meadow Shrub (WMS) due to the AA crew finding short *Amorpha* mixed in with *Phalaris*;
- One error to *Salix* Community (SC) due to the AA crew finding an MMU of *Salix* within the WM that had not been mapped;
- One error to Lowland Forest (LF) due to the AA crew finding an MMU of trees within the WM that had not been mapped.

The users' accuracy for Shallow Marsh Shrub (SMS) was 52 percent with a 90-percent confidence interval of 35–69 percent. Of the 29 AA sites mapped as SMS, 14 sites were found to contain Deep Marsh Shrub (DMS), due to high densities of buttonbush covering the water and deep marsh emergents on the imagery.

The users' accuracy for Wet Meadow Shrub (WMS) was 39 percent with a 90-percent confidence interval of 22–56 percent. Of the 28 AA sites mapped as WMS, 17 sites were found to contain different vegetation types, with errors attributed as follows:

- Six errors to Shallow Marsh Shrub (SMS) due to the AA crew finding shallow marsh species in water;
- Five errors to Deep Marsh Shrub (DMS) due to the AA crew finding buttonbush and emergents in deep water;
- Two errors to Shallow Marsh Perennial (SMP) due to the AA crew not finding a high enough density of shrubs;
- Two errors to *Salix* Community (SC) due to the AA crew finding willows;
- One error to Open Water (OW) due to the AA crew finding an MMU of a side channel with a small floating island around a log jam;
- One error to Lowland Forest (LF) due to the AA crew finding an MMU of trees.

The users' accuracy for Salix Community (SC) was 57 percent with a 90-percent confidence interval of 40–73 percent. Of the 30 AA sites mapped as SC, 13 sites were found to contain different vegetation types, with errors attributed as follows:

- Seven errors to Floodplain Forest (FF) due to the AA crew finding small silver maples rather than willow;
- Two errors to Wet Meadow Shrub (WMS) due to the AA crew finding a mix of shrubs instead of willow;
- Two errors to *Populus* Community (PC) due to the AA crew finding a mix of tree species including cottonwood but no willow;
- One error to Lowland Forest (LF) due to the AA crew finding a mix of trees covering an area of MMU size that had not been mapped by the photo interpreter;
- One error to Shallow Marsh Shrub (SMS) due to the AA crew finding a mix of shrubs instead of willow.

The users' accuracy for Lowland Forest (LF) was 36 percent with a 90-percent confidence interval of 17–56 percent. Of the 22 AA sites mapped as LF, 14 sites were found to contain different vegetation types, with errors attributed as follows:

- Six errors to Floodplain Forest (FF) due to the AA crew finding FF hydrology and dominance of silver maple;
- Four errors to Upland Forest (UF) due to the AA crew finding upland tree species;
- Four errors to Plantation (PN) due to the AA crew finding old pine plantations.

Producers' Comparison (Differences of Omission)

The producers' accuracy for the Deep Marsh Perennial (DMP) was 63 percent with a confidence interval of 49–77 percent. Of the 38 AA sites classified as DMP, 14 sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Nine sites mapped as Wet Meadow (WM) due to signatures not recognizable as deep marsh species;
- Four sites mapped as Shallow Marsh Perennial (SMP) due to vegetation having the dense cover of a shallow marsh on the imagery;
- One site mapped as Shallow Marsh Annual (SMA) due to misinterpreting the signature.

The producers' accuracy for the Deep Marsh Shrub (DMS) map class was 44 percent with a 90-percent confidence interval of 29–60 percent. Of the 34 AA sites classified as DMS, 19 sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Fourteen sites mapped as Shallow Marsh Shrub (SMS) due to vegetation obscuring the amount and depth of water present;
- Five sites mapped as Wet Meadow Shrub (WMS) due to misinterpreting the signatures.

The producers' accuracy for Floodplain Forest (FF) was 64 percent with a 90-percent confidence interval of 52–77 percent. Of the 45 AA sites classified as FF, 16 sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Seven sites mapped as *Salix* Community (SC) due to misinterpreting small silver maples (*Acer saccharinum*) for *Salix*;
- Six sites mapped as Lowland Forest (LF) due to difficulties interpreting the boundaries between the two types on the imagery;
- Three sites mapped as *Populus* Community (PC) due to overestimating the percentage of cottonwood present.

Fifteen- and Seven-Class Matrixes

The flexibility of the classification allows opportunities for users to use the classification in a variety of ways to suit their needs. Provided are two additional matrixes that assess the accuracy of the data at less detailed levels of the classification. It should be understood that in both the case of the 15-class (appendix 5) and 7-class (appendix 6) level matrixes, all classes may not be represented by accuracy AA due to lack of occurrence within a specific study area. This document thus presents the accuracies that result from 15 and 7 classes. When the 31 general classes are collapsed to the 15-class level, the accuracy improves to 88 percent with nearly all classes meeting or exceeding 80-percent accuracy. When the 31 general classes are collapsed to the 7-class level, the highest accuracy of 97 percent is realized. Individual classes in both users and producers' accuracy range from 89 to 100 percent.

Users' Comparison (15-Class Level)

Two classes still revealed low accuracy: Wet Meadow (WM) and Shallow Marsh (SM). Of the 26 AA sites mapped as WM, 17 sites were found to contain different vegetation types, with errors attributed as follows:

- Seven errors to Deep Marsh (DM);
- Seven errors to Shallow Marsh (SM);
- Two errors to Wet Forest (WtFo);
- One error to Wet Shrub (WtSh).

Of the 35 AA sites mapped as SM, 9 sites were found to contain different vegetation types, with errors attributed as follows:

- Five errors to Deep Marsh (DM);
- Two errors to Wet Meadow (WM);
- One error to Wet Shrub (WtSh);
- One error to OW (Open Water).

Producers' Comparison (15-Class Level)

One class still revealed low accuracy: Deep Marsh (DM). Of the 36 AA sites classified as DM, 12 sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Five errors to Shallow Marsh (SM);
- Seven errors to Wet Meadow (WM).

AA Results–La Grange

Of the 457 sites collected, the initial comparison revealed only 37 percent of the AA sites matched the corresponding polygons representing the classification. However, 63 percent of the mismatches were due to correctable issues or "false errors" such as GPS coordinates taken from outside the site due to inaccessibility (41 points, 23 percent of the false errors), changes in the vegetation between the year of the imagery and the field sampling, borderline field calls where the percentage of vegetation on the data sheet was very close to that of similar vegetation types, analysis of vegetation types excluded from the AA process, or discernible classification errors on the data sheets (139 points, 67 percent of the false errors).

After a review of the initial analysis, 44 of the 457 AA sites were dropped due to inaccessibility or incomplete/irreconcilable data. An additional 14 sites were left out due to unresolvable time-change issues (more specifically a change in land cover, to a cultural class or Open Water, between the date the imagery was taken and the date the AA analysis was performed). The exclusion of these 58 sites left 399 AA sites contributing to the final analysis. After correcting false errors, a true accuracy of 82.2 percent was obtained (328/399 classified as "Correct" or "Justified Correct"). A kappa adjustment for chance agreements resulted in a final overall accuracy of 81.1 percent. Overall, 272 AA sites were classified as "Correct," 56 sites were classified as "Justified Correct," and 71 fell within the category of "Incorrect." The contingency matrix for AA results is provided in appendix 7 (La Grange, 31-Class Level Accuracy Assessment Contingency Table). The matrix shows the accuracy of each map class (along with 90-percent confidence intervals), with the users' accuracy reflecting errors of inclusion (commission errors) and producers' accuracy reflecting errors of exclusion (omission errors). The width of each confidence interval is affected by the sample size used to derive the point estimate.

Our overall AA reached the 80-percent accuracy requirement for the 22 classes analyzed in this pool. Several classes, however, had accuracies below 80 percent. For users' accuracy, Shallow Marsh Perennial (SMP), Wet Meadow (WM), Shallow Marsh Shrub (SMS) and Plantation (PN) had accuracies and confidence intervals that fell below 80 percent. Also, Shallow Marsh Annual (SMA), Wet Meadow Shrub (WMS), Scrub-Shrub (SS), *Salix* Community (SC) and Lowland Forest (LF) had an accuracy below 80 percent but confidence intervals that included 80 percent. The remaining classes had an average users' accuracy of 94.7 percent. The wet meadow and marsh classes overlap in signature appearances and are highly ecotonal, creating errors to closely related classes. The forest and shrub communities add further difficulty because the visual and classification differences between Scrub-Shrub, *Salix* Community, and Lowland forest, along with their relations to elevation and location within the floodplain, are not easily defined.

For producers' accuracy, Scrub-Shrub (SS), Floodplain Forest (FF), and *Salix* Community (SC) had accuracies and confidence intervals that fell below 80 percent. Also, Deep Marsh Perennial (DMP), Shallow Marsh Perennial (SMP), Wet Meadow (WM), Shallow Marsh Shrub (SMS), Wet Meadow Shrub (WMS), Lowland Forest (LF), Plantation (PN), and Pasture (PS) had accuracies below 80 percent but confidence intervals that included 80 percent. The remaining classes had an average producers' accuracy of 93.4 percent.

The following are map classes did not meet the recommended rates of accuracy, in terms of either the actual percentage or within the confidence intervals.

Users' Comparison (Differences of Commission)

The users' accuracy for Shallow Marsh Perennial (SMP) was 50 percent with a 90-percent confidence interval of 28–72 percent. Of the 18 AA sites mapped as SMP, 9 sites were found to contain different vegetation types, with errors attributed as follows:

- Seven errors to Deep Marsh Perennial (DMP) due to the AA crew finding deep marsh species such as *Sagittaria*;
- Two errors to Wet Meadow (WM) due to the AA crew finding wet meadow species such as *Lythrum* sp.

The users' accuracy for Wet Meadow (WM) was 50 percent with a 90-percent confidence interval of 24–76 percent. Of the 14 AA sites mapped as WM, 7 sites were found to contain different vegetation types, with errors attributed as follows:

- Six errors to Grass (GR) due to the AA crew finding dry sites and upland grass species;
- One error to Pasture (PS) due to the AA crew finding the site being used as pasture.

The users' accuracy for Shallow Marsh Shrub (SMS) was 50 percent with a 90-percent confidence interval of 30–70 percent. Of the 22 AA sites mapped as SMS, 11 sites were found to contain different vegetation types, with errors attributed as follows:

- Five errors to *Salix* Community (SC) due to the AA crew finding abundance of *Salix* sp.;
- Three errors to Shallow Marsh Annual (SMA) due to the AA crew finding < 25 percent shrubs in the MMU;
- Two errors to Floodplain Forest (FF) due to the AA crew finding > 10 percent trees in the MMU;
- One error to Shallow Marsh Perennial (SMP) due to the AA crew finding shallow marsh perennial species such as *Lythrum* sp.

The users' accuracy for Plantation (PN) was 44 percent with a 90-percent confidence interval of 12–77 percent. Of the nine AA sites mapped as PN, five sites were found to contain different vegetation types, with errors attributed as follows:

- Two errors to Conifer (CN) due to the AA crew finding conifer species not planted or used as a plantation;
- One error to *Populus* Community (PC) due to the AA crew finding a stand of natural/successional *Populus* sp. instead of a plantation;
- One error to Scrub-Shrub (SS) due to the AA crew finding shrub species and a site not intended for use as a plantation;
- One error to Upland Forest (UF) due to the AA crew finding upland tree species lacking a plantation intent or environment.

Producers' Comparison (Differences of Omission)

The producers' accuracy for the Scrub-Shrub (SS) map class was 29 percent with a 90-percent confidence interval of −7 to 64 percent. Of the seven AA sites classified as SS, five sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Two sites mapped as Wet Meadow Shrub (WMS) due to misinterpreting the signatures;
- Two sites mapped as Grass (GR) due to underestimating the amount of shrubs;
- One site mapped as Plantation (PN) due to mistaking shrubs for planted trees.

The producers' accuracy for Floodplain Forest (FF) was 64 percent with a 90-percent confidence interval of 48–79 percent. Of the 33 AA sites classified as FF, 12 sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Four sites mapped as *Populus* Community (PC) due to overestimating the percentage of *Populus* on the imagery;
- Three sites mapped as Lowland Forest (LF) due to difficulties interpreting the boundaries between the two types on the imagery;
- Two sites mapped as Shallow Marsh Shrub (SMS) due to misinterpreting small *Acer saccharinum* for *Salix* sp.;
- Two sites mapped as *Salix* Community (SC) due to misinterpreting tall *Salix* species for floodplain forest;
- One site mapped as Wet Meadow Shrub (WMS) due to misinterpreting tall shrub species for floodplain forest.

The producers' accuracy for the Salix Community (SC) map class was 50 percent with a 90-percent confidence interval of 24–76 percent. Of the 14 AA sites classified as SC, 7 sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Five sites mapped as Shallow Marsh Shrub (SMS) due to *Salix* being mistaken for SMS species;
- One site mapped as Wet Meadow Shrub (WMS) due to misinterpreting the signatures;
- One site mapped as Deep Marsh Shrub (DMS) due to misinterpreting the signatures.

Fifteen- and Seven-Class Matrixes

When the 31 general classes are collapsed to the 15-class level (appendix 8), the accuracy improves to 87 percent with nearly all classes meeting or exceeding 80-percent accuracy. When the 31 general classes are collapsed to the 7-class level (appendix 9), the highest accuracy of 95 percent is realized. Individual classes in both users' and producers' accuracy range from 79 percent to 100 percent with no classes from either the users' or producers' accuracy falling below 80-percent accuracy.

Users' Comparison (15-Class Level)

Two classes still revealed low accuracy, Wet Meadow (WM) and Wet Shrub (WtSh). Of the 14 AA sites mapped as Wet Meadow (WM), 7 sites were found to contain different vegetation types, with errors attributed as follows:

- Seven errors to Grass/Forbs (GF).

Of the 50 AA sites mapped as Wet Shrub (WtSh), 17 sites were found to contain different vegetation types, with errors attributed as follows:

- Ten errors to Wet Forest (WF);
- Four errors to Wet Marsh;
- Two errors to Scrub-Shrub (SS);
- One error to Wet Meadow (WM).

Producers' Comparison (15-Class Level)

One class still revealed low accuracy: Scrub-Shrub (SS). Of the seven AA sites classified as SS, five sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Two errors to Wet Shrub (WtSh);
- Two errors to Grass/Forbs (GF);
- One error to Upland Forest (UF).

Validation

Validation-Point Selection

All 30 GWVC map classes (Dieck and Robinson, 2004) were assessed for mapping in Pools 13 and 26 and Open River South. However, three map classes (deep marsh annual, sedge meadow, and wooded swamp) were not mapped in Pool 13, five map classes (deep marsh annual, sedge meadow, wooded swamp, conifer, and sand) were not mapped in Pool 26, and four map classes (deep marsh annual, sedge meadow, conifer, and sand) were not mapped in Open River South. These map classes were subsequently eliminated from their respective analyses. Points for review were selected using the stratified random sampling scheme described in the Thematic Accuracy Assessment Procedures: Version 2.0 (Lea and Curtis, 2010). UMESC staff used these guidelines to determine the number of sites for each map class (refer to table 4). The GWVC map classes with their respective map codes representing National Vegetation Classification Standard types, for map classes analyzed during the validation process).

The number of samples needed for each map class (theme) takes into account both the statistical and operational aspects of sampling and was determined by the following scenarios (Lea and Curtis, 2010):

- Scenario A: The class is abundant. It covers more than 50 ha in total area. The map class receives the maximum sample size of 30.
- Scenario B: The class is abundant. It covers at least 8.33 ha, but no more than 50 ha in total area. The map class receives a sample size of 0.6 observations per hectare of the map class (= one observation for every 1.67 ha of map class area). (This ratio allocates observations at a density rate equal to 30 observations per 50 ha).
- Scenario C: The class is relatively rare. It covers less than 8.33 ha in total area. The map class receives five observations (the recommended minimum sample size).

UMESC staff within the Geospatial Sciences and Technologies Branch buffered each sampling site from the polygon boundary to eliminate the possibility that the observed area (a circular area approximately the size of the MMU) will overlap a neighboring vegetative type. Due to validation being an on-screen process, the buffer used for each sampling site was smaller than the buffer used for AA. A buffer of 14 m was used for Pools 13 and 26 and Open River South (tables 5, 6, and 7, respectively); however, this buffer was dropped to 4 m for three classes in Pool 13 in order to reach the sampling goal. Once the number of sites was determined and the buffer applied, random validation points were generated for each map class using Geospatial Modeling Environment for ArcGIS (Beyer, 2004). Up to three points were allowed within any one polygon as long as the distance between the points was at least one MMU apart. These validation site coordinates (UTM projection, Zone 15 using NAD 83) were then provided to the validation team as a shapefile to use in correlation with a spatial database for Pools 13 and 26 and Open River South. Tables 5, 6, and 7 present each class with the number of points needed based on the above formula and the buffer used.

Table 4. The General Wetland Vegetation Classification Map Classes with their respective map codes representing National Vegetation Classification Standard types.

Map class	Map code
Open Water	OW
Submersed Vegetation	SV
Rooted Floating Aquatics	RFA
Deep Marsh Annual	DMA
Deep Marsh Perennial	DMP
Shallow Marsh Annual	SMA
Shallow Marsh Perennial	SMP
Sedge Meadow	SM
Wet Meadow	WM
Deep Marsh Shrub	DMS
Shallow Marsh Shrub	SMS
Wet Meadow Shrub	WMS
Scrub-Shrub	SS
Wooded Swamp	WS
Floodplain Forest	FF
Populus Community	PC
Salix Community	SC
Lowland Forest	LF
Conifers	CN
Plantation	PN
Upland Forest	UF
Grassland	GR
Pasture	PS
Agriculture	AG
Levee	LV
Road	RD
Developed	DV
Mudflat	MUD
Sand	SD
Sand Bar	SB

In Pool 26, Scrub-Shrub (SS), designated as rare according to scenario C, had such low acreage the sampling goal could not be met, leaving the final number of points (667) short of the original target (671). Additionally, Pool 13 also saw low acreage within some classes; this lead to scenario C, again, not being met and the final number of points for Pool 13 falling 7 short (653) of the original target (660). Lastly, a number of classes within Open River South had low total acreage and few polygons; as a result, the number of points needed using scenario C could not be met, leaving the final number of points (689) short of the original target (697). There also were points within Open River South that had unresolvable spatial issues, leaving various classes with less than their originally targeted number of points (688 points were analyzed during the Open River South validation process). The results of each validation analysis are included in the final validation contingency tables for each pool (appendixes 10–18 [Pool 13, Pool 26, and Open River South Validation Contingency Tables]).

Table 5. Final number of points and buffers generated for validation of Pool 13.

Validation map code (see table 4)	Hectares	Buffer (meters)	Number of points desired	Number of points obtained
OW	7,175.02	14	30	30
SV	3,548.00	14	30	29
RFA	1,464.40	14	30	30
DMP	711.91	14	30	30
SMA	6.81	14	5	5
SMP	938.80	14	30	30
WM	633.65	14	30	30
DMS	28.90	14	17	17
SMS	54.26	14	30	30
WMS	69.65	14	30	30
SS	159.24	14	30	30
FF	4,549.72	14	30	30
PC	144.27	14	30	30
SC	268.68	14	30	30
LF	750.97	14	30	27
CN	73.46	14	30	30
PN	101.23	14	30	30
UF	723.68	14	30	29
GR	2,200.27	14	30	29
PS	21.20	14	11	11
AG	8,375.36	14	30	28
LV	221.51	14	30	22
RD	913.40	14	21	21
DV	1,501.53	14	28	30
MUD	1.34	4	5	5
SD	1.55	4	5	7
SB	3.81	4	5	3
TOTAL	**34,639.73**		**667**	**653**

Table 6. Final number of points and buffers generated for validation of Pool 26.

Validation map code (see table 4)	Hectares	Buffer (meters)	Number of points desired	Number of points obtained
OW	8,651.02	14	30	30
SV	11.04	14	7	7
RFA	42.13	14	25	25
DMP	97.17	14	30	30
SMA	223.21	14	30	30
SMP	551.31	14	30	30
WM	1,139.49	14	30	30
DMS	118.76	14	30	30
SMS	116.44	14	30	30
WMS	139.41	14	30	30
SS	1.97	14	5	1
FF	6,381.44	14	30	30
PC	27.78	14	17	17
SC	67.62	14	30	30
LF	1,707.87	14	30	30
PN	150.06	14	30	30
UF	56.61	14	30	30
GR	118.98	14	30	30
PS	27.99	14	17	17
AG	30,095.40	14	30	30
LV	857.30	14	30	30
RD	1,332.42	14	30	30
DV	3,576.65	14	30	30
MUD	73.72	14	30	30
SB	61.86	14	30	30
TOTAL	**55,627.66**		**671**	**667**

Table 7. Final number of points and buffers generated for validation of Open River South.

Validation map code (see table 4)	Hectares	Buffer (meters)	Number of points desired	Number of points obtained
OW	12,223.90	14	30	30
SV	47.32	14	28	31
RFA	234.81	14	30	30
SMA	1,866.43	14	30	30
SMP	277.97	14	30	30
WM	2,032.28	14	30	30
DM	719.03	14	30	30
SMS	153.31	14	30	30
WMS	825.82	14	30	30
WS	455.19	14	30	28
FF	8,259.33	14	30	30
PC	1,152.46	14	30	30
SC	1,640.32	14	30	30
LF	7,167.64	14	30	30
PN	884.63	14	30	30
UF	23.44	14	14	14
GR	37.57	14	23	18
PS	30.40	14	18	15
AG	60,763.08	14	30	30
LV	1,331.33	14	30	30
RD	1,696.99	14	30	30
DV	2,570.05	14	30	30
MUD	193.51	14	30	30
SB	185.90	14	30	29
TOTAL	**104,795.5**		**697**	**688**

Validation Process

A team of two or three individuals, having no prior involvement with the mapping process, viewed validation points (653 for Pool 13, 667 for Pool 26, and 688 for Open River South) using the *General Classification Handbook for Floodplain Vegetation in Large River Systems* (Dieck and Robinson, 2004) to determine the appropriate GWVC at each site. (It should be noted that two points were dropped from the Pool 26 analysis and final results due to unresolvable spatial errors.) As a first step, the two or three-person team individually assessed an MMU area around each validation site using ArcGIS (Environmental Systems Research Institute, Redlands, California) along with the Stereo Analyst Extension for ArcGIS (in conjunction with a three-dimensional monitor). The areas beyond each MMU also were observed to better understand patterns of hydrology in a broader context. The GWVCs that best fit each MMU were recorded in an attribute table. A second validation call was allowed at a site if the MMU being analyzed was equally representative of two vegetation classes. Following each of the individual analyses, attribute tables were combined in order to perform a comparative analysis of the validation vegetation-class assignments for each pool.

The combined table was reviewed for disagreements between the validators. In the instance of a disagreement between the validators, discussion ensued as to an appropriate map class for the site in question, as well as the possible reasons for the disagreement. A second best-fit vegetation call was included if the site was deemed too heterogeneous for a single vegetation call and differences in opinion could not be resolved. (Second best-fit validation calls also could be accepted as "matches" when in agreement with the map vegetation calls; in instances where the primary validation vegetation call was a mismatch.)

Lastly, final map call determinations of the validation team were compared to those of the mapper to define the percent agreement between the two datasets. During this process, the vegetation class designated by the mapper, at each validation point, was compared to the final validation map class call(s) for each individual pool (13, 26, and Open River South).

Instances where the validation team final vegetation assignment and the map class failed to agree were reviewed in further detail. The objective (or purpose) of this detailed review of mismatches was to evaluate site locations for errors. In this case, errors refer to areas of inclusion that were not recognized during the initial validation team analysis. Where these inclusionary errors were found, it was deemed the validation team analyzed an area within a polygon smaller than an MMU. In the aforementioned instances, mapper vegetation calls could be deemed "Justified Correct" if the validation team could reasonably conclude the map call was acceptable for the site in question.

Following the analysis of validation team and mapper vegetation calls, percent agreement was then calculated for each GWVC and for the study area as a whole. In many cases of disagreement, the validation team realized there was a high level of subjectivity in both the interpretation of signatures and the classification.

Validation Results–Pool 13

Comparison between the validators' calls and interpreted coverage was 73.0 percent. A kappa adjustment for chance agreements resulted in a final overall comparison of 71.8 percent with a 90percent confidence interval of 68.9–74.8 percent. The contingency matrix for validation results is provided in appendix 10 (Pool 13, 31-Class Level Validation Contingency

Table). The matrix shows the comparison of each map class (along with 90percent confidence intervals), with the users' comparison reflecting disagreements of inclusion (commission differences) and producers' comparison reflecting disagreements of exclusion (omission differences). The width of each confidence interval is affected by the sample size used to derive the point estimate. The contingency table also shows the frequency of agreement and placement of disagreements among map classes, as well as the overall comparison of the map with the validation.

The overall validation did not meet the requirement of 80 percent, which was established for the project. For users' comparison (or differences of commission), most of the disagreements fell within the following classes: Shallow Marsh Perennial (SMP), Shallow Marsh Annual (SMA), Shallow Marsh Shrub (SMS), Wet Meadow Shrub (WMS), *Salix* Community (SC), Conifer (CN), Sand (SD), Sand Bar (SB), and Mud (MD). For producers' comparison (or differences of omission) most of the disagreements fell within the following classes: Deep Marsh Perennial (DMP), Shallow Marsh Perennial (SMP), Shallow Marsh Annual (SMA), Grass (GR), Deep Marsh Shrub (DMS), Floodplain Forest (FF), and Upland Forest (UF).

The individual map classes that did not meet the 80-percent requirement (taking into account 90-percent confidence intervals) are listed in the next section. The disagreements were due to differences in interpretation of the signature, or a different application of the classification. In a few cases, an area of MMU size was missed during the delineations.

Users' Error (Error of Commission)

The users' comparison for the Shallow Marsh Perennial (SMP) was 53 percent with a 90-percent confidence interval of 37–70 percent. Of the 30 validation sites mapped as SMP, 14 validation sites were interpreted by the validators to be different vegetation types, with disagreements attributed as follows:

- Nine disagreements to Deep Marsh Perennial (DMP);
- Three disagreements to Wet Meadow (WM);
- One disagreement to Shallow Marsh Annual (SMA);
- One disagreement to Wet Meadow Shrub (WMS).

The users' comparison for the Shallow Marsh Annual (SMA) was 0 percent with a 90-percent confidence interval of −10 to 10 percent. Of the five validation sites mapped as SMA, five validation sites were found to be different vegetation types by the validators, with disagreements attributed as follows:

- Three disagreements to Deep Marsh Perennial (DMP);
- Two disagreements to Shallow Marsh Perennial (SMP).

The users' comparison for Shallow Marsh Shrub (SMS) was 57 percent with a 90-percent confidence interval of 40–73 percent. Of the 30 validation sites mapped as SMS, 13 validation sites were found to be different vegetation types by the validators, with disagreements attributed as follows:

- Eight disagreements to Deep Marsh Shrub (DMS);
- Four disagreements to Floodplain Forest (FF);
- One disagreement to Open Water (OW).

The users' comparison for Wet Meadow Shrub (WMS) was 40 percent with a 90-percent confidence interval of 24–56 percent. Of the 30 validation sites mapped as WMS, 18 validation sites were found to be different vegetation types by the validators, with disagreements attributed as follows:

- Eight disagreements to Shallow Marsh Shrub (SMS);
- Three disagreements to *Salix* Community (SC);
- Three disagreements to Floodplain Forest (FF);
- Three disagreements to Wet Meadow (WM);
- One disagreement to Deep Marsh Shrub (DMS).

The users' comparison for Salix Community (SC) was 53 percent with a 90-percent confidence interval of 37–70 percent. Of the 30 validation sites mapped as SC, 14 validation sites were found to be different vegetation types by the validators, with disagreements attributed as follows:

- Seven disagreements to Floodplain Forest (FF);
- Four disagreements to Wet Meadow Shrub (WMS);
- Two disagreements to Shallow Marsh Shrub (SMS);
- One disagreement to Deep Marsh Shrub (DMS).

The users' comparison for Conifer (CN) was 63 percent with a 90-percent confidence interval of 47–79 percent. Of the 30 validation sites mapped as CN, 11 validation sites were found to be different vegetation types by the validators, with disagreements attributed as follows:

- Five disagreements to Upland Forest (UF);
- Four disagreements to Plantation (PN);
- Two disagreements to Lowland Forest (LF).

The users' comparison for Mud (MUD) was 0 percent with a 90-percent confidence interval of −10 to 10 percent. Of the five validation sites mapped as MUD, zero of the validation sites within those polygons were recognized as MUD by the validators.

- Two disagreements to Open Water (OW);
- Two disagreements to Rooted Floating Aquatics (RFA);
- One disagreement to Deep Marsh Perennial (DMP).

The users' comparison for Sand Bar (SB) was 0 percent with a 90-percent confidence interval of −17 to 17 percent. Of the three validation sites mapped as SB, three validation sites were found to be Grass (GR).

- Three disagreements to Grass (GR).

The users' comparison for Sand (SD) was 29 percent with a 90-percent confidence interval of −7 to 64 percent. Of the seven validation sites mapped as SD, five validation sites were found to be Grass (GR).

- Five disagreements to Grass (GR).

Producers' Error (Error of Commission)

The producers' comparison for Deep Marsh Perennial (DMP) was 53 percent with a 90-percent confidence interval of 40–67 percent. Of the 43 validation sites classified by the validation team as DMP, 20 were mapped as other types:

- Nine sites mapped as Shallow Marsh Perennial (SMP);
- Five sites mapped as Rooted Floating Aquatics (RFA);
- Three sites mapped as Shallow Marsh Annual (SMA);
- One site mapped as Mud (MUD);
- One site mapped as Open Water (OW);
- One site mapped as Submersed Vegetation (SV).

The producers' comparison for Shallow Marsh Perennial (SMP) was 53 percent with a 90-percent confidence interval of 37–70 percent. Of the 30 validation sites classified by the validation team as SMP, 14 were mapped as other types:

- Six sites mapped as Wet Meadow (WM);
- Four sites mapped as Deep Marsh Perennial (DMP);
- Two sites mapped as Shallow Marsh Annual (SMA);
- One site mapped as Open Water (OW);
- One site mapped as Grass (GR).

The producers' comparison for Deep Marsh Shrub (DMS) was 60 percent with a 90-percent confidence interval of 42–78 percent. Of the 25 validation sites classified by the validation team as DMS, 10 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Eight sites mapped as Shallow Marsh Shrub (SMS);
- One site mapped as Wet Meadow Shrub (WMS);
- One site mapped as *Salix* Community (SC).

The producers' comparison for Grass (GR) was 64 percent with a 90percent confidence interval of 49–78 percent. Of the 36 validation points classified by the validation team as GR, 13 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Five sites mapped as Scrub-Shrub (SS);
- Five sites mapped as Sand (SD);
- Three sites mapped as Sand Bar (SB).

The producers' comparison for Floodplain Forest (FF) was 48 percent with a 90percent confidence interval of 36–60 percent. Of the 52 validation sites classified by the validation team as FF, 27 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Eight sites mapped as *Populus* Community (PC);
- Seven sites mapped as *Salix* Community (SC);
- Four sites mapped as Shallow Marsh Shrub (SMS);
- Four sites mapped as Lowland Forest (LF);
- Three sites mapped as Wet Meadow Shrub (WMS);
- One site mapped as Deep Marsh Shrub (DMS).

The producers' comparison for Upland Forest (UF) was 64 percent with a 90-percent confidence interval of 50–78 percent. Of the 39 validation sites classified by the validation team as UF, 14 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Five sites mapped as Lowland Forest (LF);
- Five sites mapped as Conifer (CN);
- Three sites mapped as Shrub-Scrub (SS);
- One site mapped as Plantation (PN).

The producers' comparison for Shallow Marsh Annual (SMA) was 0 percent with a 90-percent confidence interval of −50 to 50 percent. One validation site was classified by the validation team as SMA, which fell within a polygon mapped as another vegetation type:

- One site mapped as Shallow Marsh Perennial (SMP).

The producers' comparisons for Mud (MUD) and Sand Bar (SB) were 0 percent because the validators did not find either of these classes at the assigned validation points.

Fifteen- and Seven-Class Matrixes

The flexibility of the classification allows opportunities for users to use the classification in a variety of ways to suit their needs. Included within the LCU spatial datasets, the 31 classes are collapsed into 15 and 7 classes. This document thus presents the accuracies that result from 15 and 7 classes (the matrixes do not include all classes). When the 31 general classes are collapsed to the 15-class level (appendix 11), the accuracy improves to 82.5 percent with nearly all classes meeting or exceeding 80-percent accuracy. When the 31 general classes are collapsed to the 7-class level (appendix 12), the highest accuracy of 92.8 percent is achieved. Individual classes in both users' and producers' accuracy range from 81 to 100 percent with no classes from either the users' or producers' accuracy falling below 80-percent accuracy.

Users' Comparison (15-Class Level)

Two classes still revealed low accuracy, Shallow Marsh (SM) and Sand/Mud. Of the 35 validation sites mapped as SM, 16 sites were analyzed by the validation team as different vegetation types, with disagreements attributed as follows:

- Twelve disagreements to Deep Marsh (DM);
- Three disagreements to Wet Meadow (WM);
- One disagreement to Wet Shrub (WtSh).

Of the 16 validation sites mapped as Sand/Mud, 14 sites were analyzed by the validation team as different vegetation types, with disagreements attributed as follows:

- Eight disagreements to Grass/Forbs (GF);
- Two disagreements to Open Water (OW);
- Two disagreements to Rooted Floating Aquatics (RFA);
- Two disagreements to Deep Marsh (DM).

Producers' Comparison (15-Class Level)

Three classes still revealed low accuracy, Deep Marsh (DM), Shallow Marsh (SM), and Grass/Forbs (GF). Of the 44 validation sites interpreted as Deep Marsh (DM), 21 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Twelve disagreements to Shallow Marsh (SM);
- Five disagreements to Rooted Floating Aquatics (RFA);
- Two disagreements to Sand/Mud (SD/MUD);
- One disagreement to Submersed Aquatic Vegetation (SV);
- One disagreement to Open Water (OW).

Of the 31 validation sites interpreted as Shallow Marsh (SM), 12 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Six disagreements to Wet Meadow (WM);
- Four disagreements to Deep Marsh (DM);
- One disagreement to Grass/Forbs (GF);
- One disagreement to Open Water (OW).

Of the 52 validation sites interpreted as Grass/Forbs (GF), 17 sites fell within polygons that were mapped as other vegetation types, with errors attributed as follows:

- Eight disagreements to Sand/Mud (SD/MUD);
- Five disagreements to Shrub-Scrub (SS);
- Two disagreements to Agriculture (AG);
- One disagreement to Wet Meadow (WM);
- One disagreement to Developed (DV).

Validation Results–Pool 26

Overall agreement between the validators' vegetation assignments and interpreted coverage was 82.4 percent. A kappa adjustment for chance agreements resulted in a final overall comparison of 81.6 percent with a 90percent confidence interval of 79.1–84.1 percent. The contingency matrix for validation results is provided in appendix 13 (Pool 26, 31-Class Level Validation Contingency Table). The matrix shows the comparison of each map class (along with 90percent confidence intervals), with the users' comparison reflecting disagreements of inclusion (commission differences) and producers' comparison reflecting disagreements of exclusion (omission differences). The width of each confidence interval is affected by the sample size used to derive the point estimate. The contingency table also shows the frequency of agreement and placement of disagreements among map classes, as well as the overall comparison of the map with the validation.

The overall validation results reached the 80-percent accuracy requirement established for the project (82.4 percent). A small sample of map classes, however, failed to meet the 80-percent accuracy standard. Low accuracy, in regard to users' comparison (differences of commission), was found within the following classes: Shallow Marsh Perennial (SMP), *Salix* Community (SC), and Grassland (GR). Low accuracy, in regard to producers' comparison (differences of omission), was found within the following classes: Shallow Marsh Annual (SMA), Wet Meadow (WM), and Wet Meadow Shrub (WMS).

A closer look at individual map classes that failed to meet the 80-percent requirement (taking into account 90-percent confidence intervals) are listed in the next section. The disagreements were, in part, due to differences in signature interpretation or a difference in the application of the vegetation handbook, *General Wetland Vegetation Classification Systems* (Dieck and Robinson, 2004). Additionally, in some instances, delineation of an MMU size area was omitted during the photointerpretation process.

Users' Error (Error of Commission)

The users' comparison for Shallow Marsh Perennial (SMP) was 63 percent with a 90-percent confidence interval of 47–79 percent. Of the 30 validation sites mapped as SMP, 11 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Five disagreements to Shallow Marsh Annual (SMA);
- Four disagreements to Wet Meadow (WM);
- One disagreement to Deep Marsh Perennial (DMP);
- One disagreement to Deep Marsh Shrub (DMS).

The users' comparison for Salix Community (SC) was 50 percent with a 90-percent confidence interval of 33–67 percent. Of the 30 validation sites mapped as SC, 15 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Seven disagreements as Wet Meadow Shrub (WMS);
- Four disagreements as Floodplain Forest (FF);
- Three disagreements to Lowland Forest (LF);
- One disagreement as Shallow Marsh Shrub (SMS).

The users' comparison for Grassland (GR) was 53 percent with a 90-percent confidence interval of 37–70 percent. Of the 30 validation sites mapped as GR, 14 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Nine disagreements to Wet Meadow (WM);
- Two disagreements to Shallow Marsh Annual (SMA);
- One disagreement to Agriculture (AG);
- One disagreement to Pasture (PS);
- One disagreement to Sand Bar (SB).

Users' accuracy for Deep Marsh Annual (DMA), Sedge Meadow (SM), Wooded Swamp (WS), Conifer (CN), and Sand (SD) are recorded as 0 percent due to none of the aforementioned types being assigned by the mapper during photointerpretation.

Producers' Error (Error of Commission)

The producers' comparison for Shallow Marsh Annual (SMA) was 60 percent with a 90-percent confidence interval of 46–74 percent. Of the 40 validation sites classified by the validation team as SMA, 16 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Five sites were mapped as Shallow Marsh Perennial (SMP);
- Three sites were mapped as Submersed Vegetation (SV);
- Two sites were mapped as Wet Meadow (WM);
- Two sites were mapped as Grassland (GR);
- Two sites were mapped as Mud (MUD);
- One site was mapped as Deep Marsh Perennial (DMP);
- One site was mapped as Deep Marsh Shrub (DMS).

The producers' comparison for Wet Meadow (WM) was 49 percent with a 90-percent confidence interval of 36–62 percent. Of the 47 validation sites classified by the validation team as WM, 24 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Nine sites were mapped as Grassland (GR);
- Five sites were mapped as Shallow Marsh Annual (SMA);
- Four sites were mapped as Shallow Marsh Perennial (SMP);
- Two sites were mapped as Developed (DV);
- One site was mapped as Deep Marsh Perennial (DMP);
- One site was mapped as Wet Meadow Shrub (WMS);
- One site was mapped as Levee (LV);
- One site was mapped as Pasture (PS).

The producers' comparison for Wet Meadow Shrub (WMS) was 61 percent with a 90-percent confidence interval of 47–75 percent. Of the 41 validation sites classified by the validation team as WMS, 16 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Seven sites were mapped as *Salix* Community (SC);
- Four sites were mapped as Shallow Marsh Shrub (SMS);
- Two sites were mapped as Wet Meadow (WM);
- Two sites were mapped as Pasture (PS);
- One site was mapped as Deep Marsh Shrub (DMS).

Producers' accuracy for Deep Marsh Annual (DMA), Sedge Meadow (SM), Wooded Swamp (WS), Conifer (CN), and Sand (SD) are recorded as 0 percent due to the validation team not interpreting these classes at any of the assigned validation points.

Fifteen- and Seven-Class Matrixes

When the 31 general classes are collapsed to the 15-class level (appendix 14), the accuracy improves to 88.6 percent with nearly all classes meeting or exceeding 80-percent accuracy. When the 31 general classes are collapsed to the 7-class level (appendix 15), the highest accuracy of 93.3 percent is achieved. Individual classes in both users' and producers' accuracy range from 80 to 100 percent with no classes from either the users' or producers' accuracy falling below 80-percent accuracy.

Users' Comparison (15-Class Level)

One class still revealed low accuracy, Grass/Forbs (GF). Of the 47 validation sites mapped as GF, 16 sites were analyzed by the validation team as different vegetation types, with disagreements attributed as follows:

- Ten disagreements to Wet Meadow (WM);
- Two disagreements to Shallow Marsh (SM);
- Two disagreements to Wet Shrub (WtSh);
- One disagreement to Agriculture (AG);
- One disagreement to Sand/Mud.

Producers' Comparison (15-Class Level)

One class still revealed low accuracy, Wet Meadow (WM). Of the 47 validation sites interpreted as WM, 24 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Ten disagreements to Grass/Forbs (GF);
- Nine disagreements to Shallow Marsh (SM);
- Two disagreements to Developed (DV);
- One disagreement to Deep Marsh (DM);
- One disagreement to Wet Shrub (WtSh);
- One disagreement to Road/Levee.

Validation Results–Open River South

Overall agreement between the validators' vegetation assignments and interpreted coverage was 77.8 percent. A kappa adjustment for chance agreements resulted in a final overall comparison of 76.8 percent with a 90-percent confidence interval of 74.1–79.5 percent. The contingency matrix for validation results is provided in appendix 16 (Open River South, 31-Class Level Validation Contingency Table). The matrix shows the comparison of each map class (along with 90-percent confidence intervals), with the users' comparison reflecting disagreements of inclusion (commission differences) and producers' comparison reflecting disagreements of exclusion (omission differences). The width of each confidence interval is affected by the sample size used to derive the point estimate. The contingency table also shows the frequency of agreement and placement of disagreements among map classes, as well as the overall comparison of the map with the validation.

The overall validation results fell slightly short of the 80-percent accuracy requirement established for the project (77.8 percent). Several map classes, both from a users' and producers' accuracy standpoint, failed to meet the 80-percent accuracy standard for the project. Low accuracy, in regard to users' accuracy (differences of commission), was found within the following classes: Deep Marsh Perennial (DMP), Shallow Marsh Perennial (SMP), Shallow Marsh Shrub (SMS), Scrub-Shrub (SS), *Salix* Community (SC), Lowland Forest (LF), and Grassland (GR). Low accuracy, in regard to producers' comparison (differences of omission), was found within the following classes: Wet Meadow (WM), Deep Marsh Shrub (DMS), Shallow Marsh Shrub (SMS), and Floodplain Forest (FF).

A closer look at individual map classes that failed to meet the 80-percent requirement (taking into account 90-percent confidence intervals) are listed in the next section. The disagreements were, in part, due to differences in signature interpretation, or a difference in the application of the vegetation handbook, *General Wetland Vegetation Classification Systems* (Dieck and Robinson, 2004). Additionally, in some instances, delineation of an MMU size area was omitted during the photointerpretation process.

Users' Error (Error of Commission)

The users' comparison for Deep Marsh Perennial (DMP) was 38 percent with a 90-percent confidence interval of 3–72 percent. Of the eight validation sites mapped as DMP, five validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Five disagreements to Shallow Marsh Perennial (SMP).

The users' comparison for the Shallow Marsh Perennial (SMP) was 63 percent with a 90-percent confidence interval of 47–79 percent. Of the 30 validation sites mapped as SMP, 11 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Five disagreements to Wet Meadow (WM);
- Four disagreements to Shallow Marsh Annual (SMA);
- Two disagreements to Shallow Marsh Shrub (SMS).

The users' comparison for Shallow Marsh Shrub (SMS) was 43 percent with a 90-percent confidence interval of 27–60 percent. Of the 30 validation sites mapped as SMS, 17 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Eleven disagreements to Deep Marsh Shrub (DMS);
- Two disagreements to Floodplain Forest (FF);
- Two disagreements to *Salix* Community (SC);
- One disagreement to Wet Meadow Shrub (WMS);
- One disagreement to Open Water (OW).

The users' comparison for the Scrub-Shrub (SS) was 23 percent with a 90-percent confidence interval of 0–46 percent. Of the 13 validation sites mapped as SS, 10 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Six disagreements to Wet Meadow Shrub (WMS);
- Four disagreements to Upland Forest (UF).

The users' comparison for the Salix Community (SC) was 60 percent with a 90percent confidence interval of 44–76 percent. Of the 30 validation sites mapped as SC, 12 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Five disagreements to Floodplain Forest (FF);
- Four disagreements to *Populus* Community (PC);
- One disagreement to Deep Marsh Shrub (DMS);
- One disagreement to Shallow Marsh Shrub (SMS);
- One disagreement to Wet Meadow Shrub (WMS).

The users' comparison for the Lowland Forest (LF) was 60 percent with a 90-percent confidence interval of 44–76 percent. Of the 30 validation sites mapped as LF, 12 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Twelve disagreements to Floodplain Forest (FF).

The users' comparison for the Grassland (GR) was 39 percent with a 90-percent confidence interval of 17–61 percent. Of the 18 validation sites reviewed as GR, 11 validation sites were interpreted by the validators to be of different vegetative types, with disagreements attributed as follows:

- Seven disagreements to Wet Meadow (WM);
- Two disagreements to Shallow Marsh Annual (SMA);
- One disagreement to Wet Meadow Shrub (WMS);
- One disagreement to Developed (DV).

Users' accuracy for Deep Marsh Annual (DMA), Sedge Meadow (SM), Conifer (CN), and Sand (SD) are recorded as 0 percent due to none of the aforementioned types being assigned by the mapper during photointerpretation.

Producers' Error (Error of Commission)

The producers' comparison for Wet Meadow (WM) was 55 percent with a 90-percent confidence interval of 41–68 percent. Of the 44 validation sites classified by the validation team as WM, 20 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Seven sites were mapped as Grassland (GR);
- Six sites were mapped as Shallow Marsh Annual (SMA);
- Five sites were mapped as Shallow Marsh Perennial (SMP);
- Two sites were mapped as Pasture (PS).

The producers' comparison for Deep Marsh Shrub (DMS) was 58 percent with a 90-percent confidence interval of 42–74 percent. Of the 31 validation sites classified by the validation team as DMS, 13 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Eleven sites were mapped as Shallow Marsh Shrub (SMS);
- One site was mapped as *Salix* Community (SC);
- One site was mapped as Plantation (PN).

The producers' comparison for Shallow Marsh Shrub (SMS) was 59 percent with a 90-percent confidence interval of 40–79 percent. Of the 22 validation sites classified by the validation team as SMS, 9 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Three sites were mapped as Wet Meadow Shrub (WMS);
- Two sites were mapped as Shallow Marsh Perennial (SMP);
- Two sites were mapped as Deep Marsh Shrub (DMS);
- One site was mapped as Wet Meadow (WM);
- One site was mapped as *Salix* Community (SC).

The producers' comparison for Floodplain Forest (FF) was 47 percent with a 90-percent confidence interval of 35–59 percent. Of the 53 validation sites classified by the validation team as FF, 28 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Twelve sites were mapped as Lowland Forest (LF);
- Five sites were mapped as Wooded Swamp (WS);
- Five sites were mapped as *Salix* Community (SC);
- Two sites were mapped as Shallow Marsh Shrub (SMS);
- Two sites were mapped as Deep Marsh Shrub (DMS);
- One site was mapped as *Populus* Community (PC);
- One site was mapped as Plantation (PN).

Producers' accuracy for Deep Marsh Annual (DMA), Sedge Meadow (SM), Conifer (CN), and Sand (SD) are recorded as 0 percent due to the validation team not interpreting these classes at any of the assigned validation points.

Fifteen- and Seven-Class Matrixes

When the 31 general classes are collapsed to the 15-class level (appendix 17), the accuracy improves to 86.0 percent with nearly all classes meeting or exceeding 80-percent accuracy. When the 31 general classes are collapsed to the 7-class level (appendix 18), the highest accuracy of 93.9 percent is realized. Individual classes in both users' and producers' accuracy range from 78 to 100 percent with no classes from either the users' or producers' accuracy falling below 80-percent accuracy.

Users' Comparison (15-Class Level)

Three classes still revealed low accuracy: Deep Marsh (DM), Shrub-Scrub (SS), and Grass/Forbs (GF). Of the eight validation sites mapped as DM, five sites were analyzed by the validation team as different vegetation types, with disagreements attributed as follows:

- Five disagreements to Shallow Marsh (SM).

Of the 13 validation sites mapped as Shrub-Scrub (SS), 10 sites were analyzed by the validation team as different vegetation types, with disagreements attributed as follows:

- Six disagreements to Wet Shrub (WtSh);
- Four disagreements to Upland Forest (UF).

Of the 33 validation sites mapped as Grass/Forbs (GF), 16 sites were analyzed by the validation team as different vegetation types, with disagreements attributed as follows:

- Nine disagreements to Wet Meadow (WM);
- Three disagreements to Agriculture (AG);
- Two disagreements to Shallow Marsh (SM);
- One disagreement to Wet Shrub (WtSh);
- One disagreement to Developed (DV).

Producers' Comparison (15-Class Level)

One class still revealed low accuracy: Wet Meadow (WM). Of the 44 validation sites interpreted as WM, 20 sites fell within polygons that were mapped as other vegetation types, with disagreements attributed as follows:

- Eleven disagreements to Shallow Marsh (SM);
- Nine disagreements to Grass/Forbs (GF).

Discussion

The AA effort for the 2010–11 LCU for Pools 13 and La Grange, along with the validation effort for Pools 13, 26, and Open River South of the Upper Mississippi River System provided a greater understanding of the advantages and disadvantages of each method. Both processes can be used to obtain "producers' accuracy" and "users' accuracy" data, which can inform the map user on the level of confidence they can have in the overall accuracy of the map, as well as the accuracy of individual map classes. The overall accuracy percentage for Pool 13, which was assessed using both methods, was comparable at 75 percent as determined through AA and 73 percent as determined through validation. However, the two processes have significant differences.

An AA has the major advantage of comparing the map directly with vegetation data collected in the field for the same geographic point. These field data, collected by an independent field crew, are the key to a true understanding of how well the map represents the vegetation on the ground.

The process of the AA revealed some problems with the classification key used in the field (Appendix 2. Classification Key for the General Wetland Vegetation Classification System). Insufficient clarity in the key was cited as an inhibiting factor in the ability of the field crew to classify vegetation at specific sites. An example of this can be seen at couplet 20A/20B: landscape altered for human use versus landscape not altered for human use. The term "human use" is not described, and the field crew was unsure of the map-class assignment for a given area based on disturbance or lack thereof. A similar issue can be seen at couplet 24A/24B: wet versus dry soils. Another example of an issue with the vegetation key occurred when the field crew felt that they knew the vegetation type at a site but had trouble reaching it through the key. One example can be found at couplet 30A/30B: cultivated areas (i.e., orchards or pine plantation) versus non-cultivated areas. Field crews found areas of cultivated vegetation that were neither orchard nor pine plantation; for example, deciduous tree species planted in rows. Another example can be found at couplet 35A/35B: trees growing on wet soils versus trees growing on dry soil, where field crews recorded Lowland Forest or even Floodplain Forest species growing on upland sites. On occasion this was due to past disturbance; other instances were the result of a particular species tolerating dryer soil conditions. Greater depth and description in certain areas of the key would likely lead to higher confidence in vegetation-type assignment and determination in the field and also would help to increase the overall accuracy and confidence of the final AA results.

An AA has higher costs than validation and requires more time. The field crew must be properly trained, and the field data carefully collected at the sites, which can be challenging in difficult field conditions and impossible without access to private lands. In both Pool 13 and La Grange, many site locations fell on private lands and could not be evaluated. It also is desirable to perform the field work as closely as possible to the time the imagery was acquired, rather than later under what could be very different phenological phases given the wide fluctuations possible in the floodplain of a major river.

The validation process is simpler to conduct and takes less time, resulting in lower costs. However, it is limiting in that it compares the map to an assessment of the same imagery by other interpreters and not to field data. It is a measure of the reproducibility of the classification interpretation of the digital imagery and the variation arising from the same process being used by different reviewers. Commonly seen issues were that the classification is open to somewhat different interpretation, as are the spectral signatures of vegetation on the imagery, and the hydrological conditions of a particular area. Signature recognition was likely confounded by flooded conditions when the imagery was taken.

Validation proved to be useful primarily in that it can help refine a classification by pointing out the different ways both the classification and the imagery can be interpreted by different individuals. It may be possible to reduce some of the subjectivity by refining map-class descriptions and mapping methodologies, which in turn could improve overall accuracy. Experience gained from the validation process will aid in the understanding of spectral signatures of vegetation communities in future mapping efforts. Given the diverse habitats and transitioning mixes of species across changing hydrological conditions of the floodplain, it is not possible to remove all subjectivity from the interpretation of aerial imagery or even the evaluation of a plot in the field.

It is important that decisions to undertake AA or validation in the future are made with an understanding of how the advantages and limitations of each strategy align with the specific goals of the project. Validation departs from true AA in that there is not a comparison with vegetation data collected on the ground by an independent field crew. If future accuracy efforts on the UMRS LCU data are performed, traditional thematic AA would be recommended.

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Appendixes

Appendix 1. Upper Mississippi River Restoration Accuracy Assessment Field Manual, Upper Mississippi River System

Accuracy assessment (AA) for the 2010–11 General Land Cover/Land Use Mapping Project is designed to test how well photo interpreters were able to assign General Wetland Vegetation (GWV) classes to the landscape. The objective of an AA is to obtain a measure of the probability with which a particular location has been assigned its correct GWV map class. An AA estimates thematic errors in the data, providing users information needed to assess data suitability for a particular application. At the same time, data producers are able to learn more about the nature of errors in the data. Thus, there are actually two views to an AA: "producers' accuracy," which is the probability that an AA point has been mapped correctly (also referred to as an error of omission), and "users accuracy," which is the probability that the map actually represents what was found on the ground (also referred to as errors of commission). Both users' and producers' accuracy can be obtained from the same set of data using different analyses. Errors occur when GWV map classes are not the same as the GWV classes observed in the field. A major assumption of AA is that the process of mapping and the process of the assessment (i.e., the application of the classification system) are identical, so that a false error is not detected because of procedural differences.

GWV map classes are assigned to discreet polygons delineated on aerial photos based on visible vegetation signatures and hydrology. Accuracy assessment sites are then visited in the field to identify the most appropriate GWV class. These field data are then compared to the polygons to determine the accuracy of the map. The AA team will use the key provided in the handbook "General Classification Handbook for Floodplain Vegetation in Large River Systems" to assign the appropriate GWV class to each AA site visited.

AA sites for assessing the validity of the GWV map class polygons were randomly determined using a stratified random sampling approach. The area to be assessed is equal to the minimum map unit (MMU), which is the smallest area that can be reasonably defined by photo interpreters (La Grange, 1.0 hectare (ha); Pool 13, 0.4 ha). It is the task of the AA team to ensure that the area assessed is representative of the predominant GWV type in the MMU.

Methods

Select sample sites	Using maps created for the AA portion of the project, select a number of sites clustered in an area to be visited during the field day.
Navigate to the first point	Utilize the topographical maps and global positioning system (GPS) units. AA site coordinates have been loaded into GPS units.
Record Universal Transverse Mercator (UTM) coordinates	NOTE: Accuracy must be within **9 meters** (m) on the GPS unit in order to be considered a valid reading. Wait until the error is less than 9 m before recording the coordinates. The required datum is **North American Datum of 1983 (NAD 83)**.
Determine where to set up plot	This is of **crucial importance**, as the task of the AA team is to assess the most representative area of the MMU and to ensure that the area assessed is equivalent to the MMU (La Grange, 1.0 ha MMU; Pool 13, 0.4 ha MMU). Walk the area of the MMU to get an idea of what other GWV types may be present. Measure and mark the perimeter, if necessary. Take caution not to set up a plot in an ecotone or in a heterogeneous area, if possible. If the homogeneous area around the point can hold either a 56 m radius circle (La Grange) or a 36 m radius circle (Pool 13), then that is considered the MMU. Anything smaller than an MMU would have been mapped as an "inclusion," which is ignored during mapping and merged with the predominant type in the polygon. If a circle shape would fall into a different GWV class that is at one MMU, then the shape of the plot needs to be adjusted to fit within the GWV class you are observing and still be equivalent to one MMU. In most of these instances, the hard-copy maps will indicate 'lines' that mark the interpreted boundaries between the two GWV map classes.
Set up plot	After the placement of a plot has been determined, measure a circular plot equivalent to the corresponding MMU. Mark the plot edges with flagging, if necessary.
Collect data from the plot	From the plot center, take a photo of the data sheet with the AA plot number recorded; then take photos of the plot facing north, east, south, and west; and lastly take a photo that best represents the AA plot (a total of six pictures including the data sheet). Walk around the plot noting the dominant species and the hydrologic regime. Determine the GWV class (map code) using the vegetation key.
Percentages for determining map class type	Assessment area is a tree class if >10 percent trees Assessment area is a shrub class if <10 percent trees and >25 percent shrubs Assessment area is an herbaceous class if <10 percent trees and < 25 percent shrubs Assessment area is sand or mud if <10 percent plants
At the end of each week, copy the data sheets for your files and send the original data sheets and digital pictures to:	UMESC – USGS JC Nelson 2630 Fanta Reed Road

Filling out the Data Sheet

AA Site number	Site number of the AA plot
Date	Date of the AA plot assessment
Time	Time of day the AA plot assessment began
Primary observer	Name of field crew leader
Assisting observer	Name of second observer and any other personnel assisting with the AA assessment
GPS accuracy (meters)	
DOP	Record DOP (Dilution of Precision) reading from GPS unit.
EPE	Record EPE reading from GPS unit.
Picture numbers	File name of digital pictures of assessment site (data sheet, north, east, south, west, and best)
UTM Easting	Record the UTM Easting at the plot center.
UTM Northing	Record the UTM Northing at the plot center.
UTM zone	Record the UTM zone of the plot.
Datum	Record the datum of the GPS unit.
Proximity to actual point	Check the choice that includes the distance to the AA point coordinates. All efforts should be made to get to the actual point.
Explain if NOT "At point"	If check any box other than 'a. At point' above, then provide an explanation of why you could not reach the AA point (e.g., too heterogeneous to key because two or more types within plot, physical constraints).
Diagram of the area of assessment	Sketch the area of the assessment including the shape of the AA plot, hydrologic features within the plot (e.g., streams, ponds, wet areas), and where dominant species are located.
Choose one	Forest (>10 percent trees), Shrubs (<10 percent trees and >25 percent shrubs), Herbaceous (<10 percent trees and <25 percent shrubs) Circle which stratum describes the AA plot.
Map code	Using the vegetation key, record the GWV class that best fits the AA plot.
Second map code	Record a second GWV class if there is doubt about the first type; for example, could have gone either way in a choice in the vegetation key (the shrub community is right at 25 percent cover for determining if a plot is herbaceous or shrub).
Does plot key easily to map code?	Circle 'no' if uncertain about the map code or had difficulty applying the key; circle 'yes' if the plot keyed easily; circle H (high), M (medium), or L (low) for how confident you are in your map code determination.
If No to #18, explain	Provide an explanation of the problems in identifying or keying the vegetation within the AA plot.

Filling out the Data Sheet—Continued

Hydrologic regime	Check the appropriate hydrologic selection for the majority of the AA plot.
Dominant/characteristic species in tree layer	List one to five species of the dominant trees within the AA plot if there are trees present within the plot.
Dominant/characteristic species in shrub layer	List one to five species of the dominant shrubs within the AA plot if there are shrubs present within the plot.
Dominant/characteristic species in herbaceous layer	Dominant/characteristic species in herbaceous layer: List one to five species of the dominant grasses/forbs within the AA plot if there are herbaceous species present within the plot.
Other comments	Record anything that is noteworthy.
Equipment list	GPS unit Maps with accuracy assessments sites List of points with UTM coordinates Vegetation key Data sheets Pencils/pens Camera Clipboard Manual (General Classification Handbook for Floodplain Vegetation in Large River Systems)

Appendix 2. Classification Key for the General Wetland Vegetation Classification System

Below is a dichotomous key for the General Wetland Vegetation Classification System.	General Code
1a Vegetation<10% of the area	2
2a Aquatic—Open water, or Lemnaceae sparse enough to see <10% submerged vegetation present, or Lemnaceae too dense to see submerged vegetation	OW
2b Terrestrial	3
3a Residential homes, homesteads in rural settings, farmsteads, industrial complexes, parks, locks, dams, marinas, boat launches, riprap, or newly constructed artificial islands	DV
3b Exposed mud or sand	4
4a Mudflat	MUD
4b Sand	5
5a Sand bar	SB
5b Sand dunes, sand spoil banks, beaches, and other sandy areas that are upland	SD
1b Vegetation>10% of the area (not including Lemnaceae)	6
6a Includes residential homes, homesteads in rural settings, farmsteads, or parks	DV
6b Does not include residential homes, homesteads in rural settings, farmsteads, or parks	7
7a Shrub cover<25% and tree cover<10% of the area	8
8a Submerged vegetation>10% of the vegetation; all other life forms<10%	SV
8b At least one nonsubmerged species>10% of the vegetation, submerged vegetation may be present or absent	9
9a Rooted-floating aquatics (i.e. *Nelumbo*, *Nymphaea*, *Nuphar*) >50% of the vegetation	RFA
9b Annual or perennial emergents or perennial grasses/forbs >50% of the vegetation	10
10a Annual or perennial emergents >50% of the vegetation	11
11a Rooted floating aquatics>10%	DMP
11b Rooted floating aquatics<10%	12
12a Deep marsh species (e.g., *Pontederia*, *Sagittaria*, *Sparganium*, *Typha*, *Zizania*) >50% of the vegetation	13
13a Annuals (e.g., *Zizania*)	DMA
13b Perennials (e.g., *Pontederia*, *Sagittaria*, *Sparganium*, *Typha*)	14
14a One or two species; may include rooted-floating aquatics >10% of the vegetation	DMP
14b One species >50% of the vegetation and species other than rooted-floating or deep marsh >10% of the vegetation; or three or more deep marsh species	SMP
12b Carex or shallow marsh species (e.g., *Bidens*, *Cyperus*, *Echinochloa*, *Eleocharis*, *Lythrum*, *Phragmites*, *Scirpus*) >50% of the vegetation	15
15a *Carex* >50% of the vegetation	SM
15b Shallow marsh species >50% of the vegetation	16
16a Annuals (e.g., *Bidens*, *Cyperus*, *Echinochloa*, *Eleocharis*)	SMA
16b Perennials (e.g., *Lythrum*, *Phragmites*, *Scirpus*)	17
17a *Lythrum* >50% of the vegetation	18
18a Only *Lythrum* present	SMP
18b *Lythrum* >50% of the vegetation and one or more species >10% of the vegetation	WM
17b Shallow marsh species other than *Lythrum* >50% of the vegetation	19
19a One species or a combination of species >50% of the vegetation; except when *Phragmites* >50% of the vegetation and *Phalaris* >10% of the vegetation	SMP
19b *Phragmites* >50% of the vegetation and *Phalaris* >10% of the vegetation	WM

Below is a dichotomous key for the General Wetland Vegetation Classification System.—Continued	General Code
10b Perennial grasses or forbs >50% of the vegetation	20
20a Landscape altered for human use	21
21a Areas for agricultural or livestock use	22
22a Cultivated fields for crops	AG
22b Pastured area used for production of livestock	PS
21b Areas not for agricultural or livestock use	23
23a Roads or railroads including grasses, forbs, or shrubs in rights-of-way	RD
23b Levees (continuous dikes or embankments)	LV
20b Landscape not altered for human use	24
24a Wet soils (e.g., *Amaranthus*, *Leersia*, *Phalaris*, *Solidago*, *Spartina*)	WM
24b Dry soils	GR
7b Shrub cover >25% of the area or tree cover >10% of the area	25
25a Shrub cover >25% of the area and tree cover <10% of the area	26
26a *Salix* >50% of the vegetation	SC
26b Other shrubs >50% of the vegetation	27
27a Shrubs growing in standing water or with annual or perennial emergents	28
28a Shrubs (e.g., *Cephalanthus*, *Decodon*) growing in standing water or with deep marsh species (e.g., *Pontederia*, *Sagittaria*, *Sparganium*, *Typha*, *Zizania*)	DMS
28b Shrubs growing with shallow marsh species (e.g., *Bidens*, *Cyperus*, *Echinochloa*, *Eleocharis*, *Lythrum*, *Phragmites*, *Scirpus*)	SMS
27b Shrubs growing with perennial grasses or forbs	29
29a Wet soils (e.g., *Alnus*, *Cornus*, *Sambucus*)	WMS
29b Dry soils	SS
25b Tree cover >10% of the area	30
30a Cultivated areas (e.g., orchards or pine plantations)	PN
30b Noncultivated areas	31
31a *Populus* or *Salix* >50% of the vegetation	32
32a *Populus* >50% of the vegetation	PC
32b *Salix* >50% of the vegetation	SC
31b Other trees >50% of the vegetation	33
33a Coniferous trees >50% of the vegetation (e.g., *Pinus*, *Juniperus*)	CN
33b Deciduous trees >50% of the vegetation	34
34a Trees growing in standing water (e.g., *Taxodium*, *Nyssa*)	WS
34b Trees not growing in standing water	35
35a Trees growing on wet soils	36
36a Trees growing on alluvial soils; usually dominated by *Acer*	FF
36b Trees growing on moist, well-drained soils; usually dominated by *Quercus*	LF
35b Trees growing on dry soil	UF

Appendix 3. Accuracy Assessment Field Form

Accuracy Assessment Form
Upper Mississippi River Restoration

1. AA Site number: _____ 2. Date: _____ 3. Time: _____

4. Primary observer: _____

5. Assisting observer: _____

6. Global positioning system accuracy (meters [m]) DOP (Dilution of Precision): _____
EPE (Estimated Probable Error): _____

7. Picture numbers: _____

8. UTM Easting: _____

9. UTM Northing: _____

10. UTM Zone: _____ 11. Datum: _____

12. Proximity to actual point:

a. At point _____

b. Within 20 m _____

c. Within 50 m _____

d. Inaccessible _____

14. Diagram of area of assessment:

13. Explain if NOT 'At point': _____

15. Choose one:
☐ Forest (>10 percent trees)
☐ Shrubs (<10 percent trees and > 25percent shrubs)
☐ Herbaceous (<10 percent trees and < 25percent shrubs

16. Map code: _____
17. Second map code (if there is doubt about first map code call): _____

18. Does plot key easily to map code:
☐ Yes
☐ No

Your confidence in determination:
☐ H
☐ M
☐ L

19. If No to #18, explain: _____

20. Hydrologic regime:

☐ a. Permanently flooded (Water present all year round)

☐ b. Semipermanently flooded (Water present throughout the growing season except in periods of extreme drought)

☐ c. Seasonally flooded (Water present for most of the growing season)

☐ d. Temporarily flooded (Water only present early in the growing season)

☐ e. Saturated soil (Soils that are saturated with water during the growing season)

☐ f. Infrequently flooded (Water rarely present)

21. Dominant/characteristic species in tree layer (about one to five species, where layer is present:

_____

22. Dominant/characteristic species in shrub layer (about one to five species, where layer is present:

_____

23. Dominant/characteristic species in herbaceous layer (about one to five species, where layer is present):

_____

24. Other comments (if needed):

_____

Appendix 4. Pool 13, 31-Class Level Accuracy Assessment Contingency Table

		FIELD SAMPLES - REFERENCE DATA																					COMMISSION		
	MAP CODES	SV	RFA	DMP	SMP	SMA	WM	GR	DMS	SMS	WMS	SS	SC	PC	FF	LF	UF	CN	PN	MUD	SD	PS	TOTAL	USERS' ACCUR-ACY	90% Confidence Intervals
MAP DATA - PREDICTION DATA	SV*	27																					27	100%	98% 102%
	RFA*	3	25																				28	89%	78% 101%
	DMP	3	2	24	1																		30	80%	66% 94%
	SMP			4	25						1												30	83%	70% 96%
	SMA*			1	1	0	2																4	0%	-13% 13%
	WM			9	5		9				1		1				1						26	35%	17% 52%
	GR						1	23				3											27	85%	72% 98%
	DMS*								15								2						15	100%	97% 103%
	SMS								14	15													29	52%	35% 69%
	WMS*				2				5	6	11		2			1							27	41%	23% 58%
	SS							1				26					2						29	90%	79% 101%
	SC									1	2		17	2	7	1							30	57%	40% 73%
	PC													25	3	1							29	86%	74% 98%
	FF												1		29								30	97%	90% 104%
	LF														6	8	4		4				22	36%	17% 56%
	UF							1								2	26						29	90%	79% 101%
	CN																6	17					23	74%	57% 91%
	PN																1		28				29	97%	89% 104%
	MUD																			5			5	100%	90% 110%
	SD																				2		2	100%	75% 125%
	PS																					11	11	100%	95% 105%
	TOTAL	33	27	38	34	0	12	25	34	23	14	29	21	27	45	14	39	17	32	5	2	11	482		
OMISSION	PRODUCERS' ACCURACY	82%	93%	63%	74%	0%	75%	92%	44%	65%	79%	90%	81%	93%	64%	57%	67%	100%	88%	100%	100%	100%	Total Correct = 368		
	90% Confidence Interval -	69%	82%	49%	60%	0%	50%	81%	29%	47%	57%	79%	64%	82%	52%	32%	53%	97%	76%	90%	75%	95%			
	90% Confidence Interval +	94%	103%	77%	87%	0%	100%	103%	60%	84%	100%	101%	97%	103%	77%	82%	80%	103%	99%	110%	125%	105%			

OVERALL ACCURACY = 76.3% KAPPA INDEX = 75.0% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 71.6% KAPPA INDEX UPPER CONFIDENCE LEVEL = 78.3%

* Represents a map class with an error(s) to Open Water (OW); the overall accuracy is 75.1% when this data is included.

Appendix 5. Pool 13, 15-Class Level Accuracy Assessment Contingency Table

MAP DATA - PREDICTION DATA: MAP CODES	FIELD SAMPLES - REFERENCE DATA: Submersed Aquatic Vegetation (SV)*	Rooted Floating Aquatics (RFA)*	Deep Marsh (DMA/DMP)	Shallow Marsh (SMA/SMP)*	Wet Meadow (WM/SM)	Grass Forbs (GR/PS)	Wet Shrub (DMS/SMS/WMS)*	Shrub/Scrub (SS)	Wet Forest (FF/PC/SC/LF/WS)	Upland Forest (UF/CN/PN)	Sand/Mud (MUD/SB/SD)	TOTAL	COMISSION: USERS' ACCURACY	90% Confidence Intervals	
Submersed Aquatic Vegetation (SV)*	27											27	100%	98%	102%
Rooted Floating Aquatics (RFA)*	3	25										28	89%	78%	101%
Deep Marsh (DMA/DMP)	3	2	24	1								30	80%	66%	94%
Shallow Marsh (SMA/SMP)*			5	26	2		1					34	76%	63%	90%
Wet Meadow (WM/SM)			7	7	9		1		2			26	35%	17%	52%
Grass Forbs (GR/PS)					1	34		3				38	89%	80%	99%
Wet Shrub (DMS/SMS/WMS)*				2			66		3			71	93%	87%	99%
Shrub/Scrub (SS)						1		26		2		29	90%	79%	101%
Wet Forest (FF/PC/SC/LF/WS)							3		100	8		111	90%	85%	95%
Upland Forest (UF/CN/PN)						1			2	78		81	96%	92%	100%
Sand/Mud (MUD/SB/SD)											7	7	100%	93%	107%
TOTAL	33	27	36	36	12	36	71	29	107	88	7	482	Total Correct = 422		
OMISSION: PRODUCERS' ACCURACY	82%	93%	67%	72%	75%	94%	93%	90%	93%	89%	100%				
90% Confidence Interval -	69%	82%	52%	59%	50%	87%	87%	79%	89%	83%	93%				
90% Confidence Interval +	94%	103%	81%	86%	100%	102%	99%	101%	98%	95%	107%				

OVERALL ACCURACY = 87.6% KAPPA INDEX = 85.7% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 82.9% KAPPA INDEX UPPER CONFIDENCE LEVEL = 88.4%

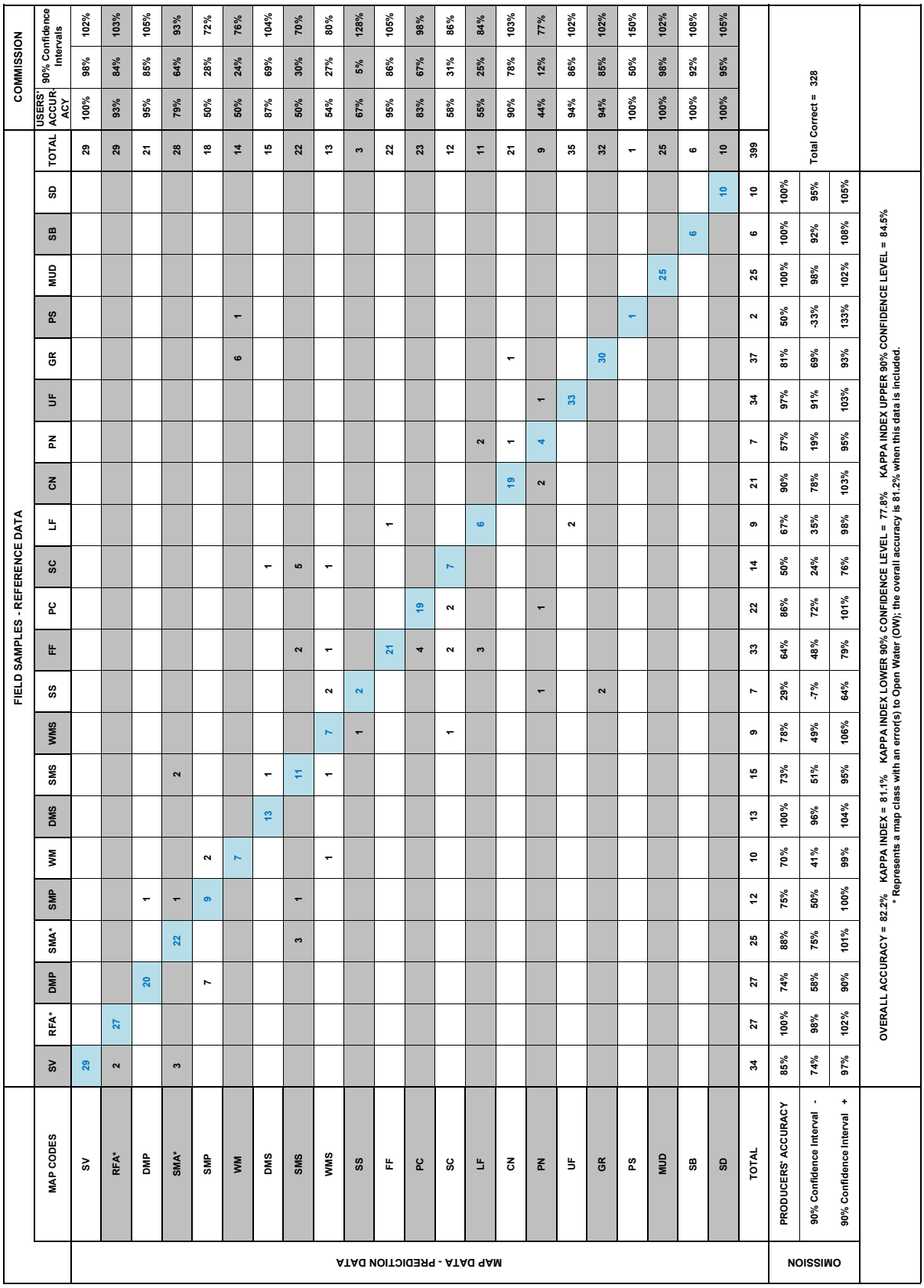
* Represents a map class with an error(s) to Open Water (OW); the overall accuracy is 86.1% when this data is included.

Appendix 6. Pool 13, 7-Class Level Accuracy Assessment Contingency Table

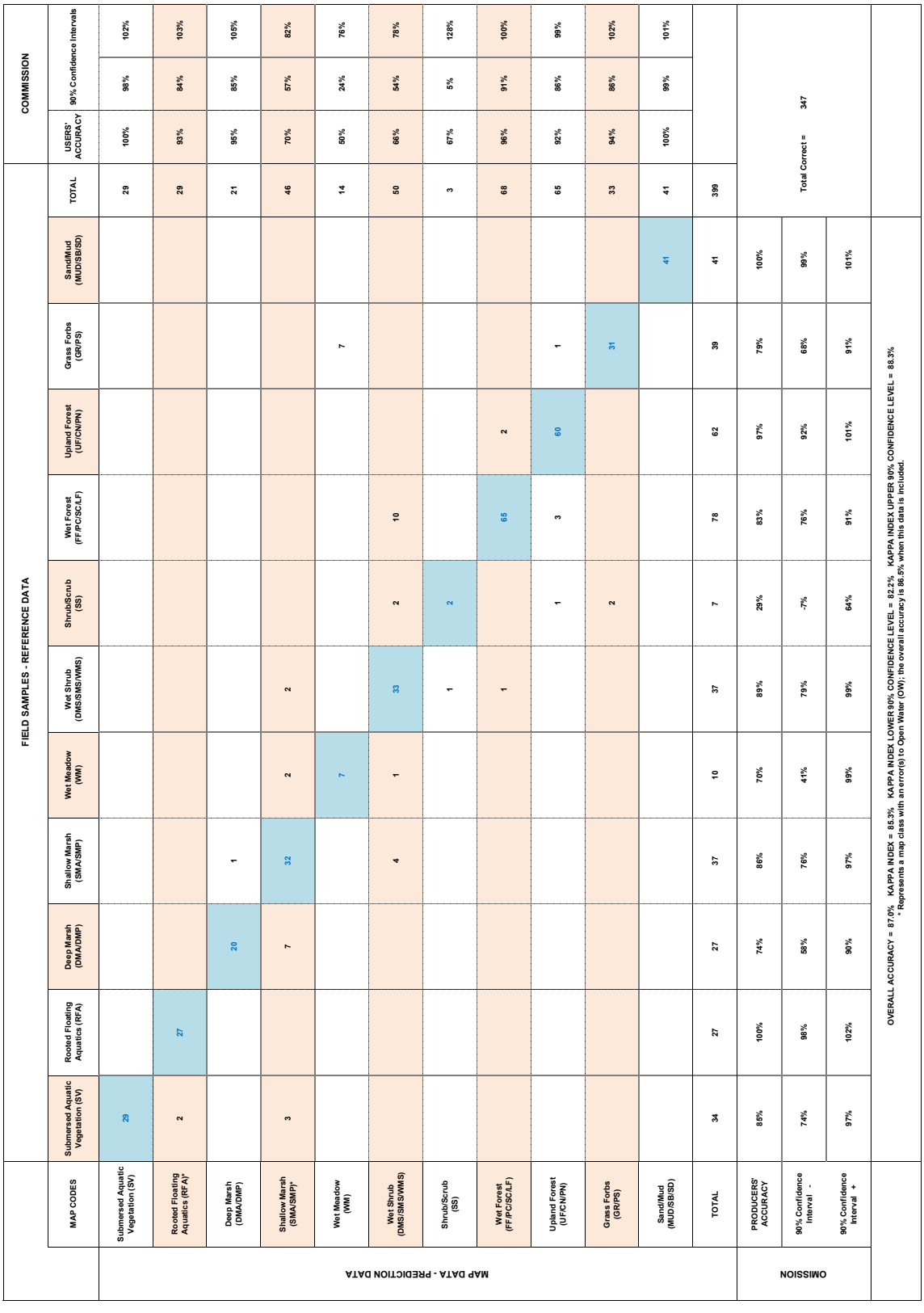
		FIELD SAMPLES - REFERENCE DATA							COMMISSION		
	MAP CODES	Open Water (SV/RFA)	Marsh (DMA/DMP/SMA/SMP/SM/WM)	Grass/Forbs (GR/PS/LV)	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SMS/WMS/WS)	Sand/Mud (MUD/SB/SD)	TOTAL	USERS' ACCURACY	90% Confidence Intervals	
MAP DATA - PREDICTION DATA	Open Water (SV/RFA)*	55					55	100%	99%	101%
	Marsh (DMA/DMP/SMA/SMP/SM/WM)*	5	81		4		90	90%	84%	96%
	Grass/Forbs (GR/PS/LV)		1	34	3		38	89%	80%	99%
	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SMS/WMS/WS)*		2	2	288		292	99%	97%	100%
	Sand/Mud (MUD/SB/SD)					7	7	100%	93%	107%
	TOTAL	60	84	36	295	7	482			
OMISSION	PRODUCERS' ACCURACY	92%	96%	94%	98%	100%	Total Correct = 465			
	90% Confidence Interval -	85%	93%	87%	96%	93%				
	90% Confidence Interval +	98%	100%	102%	99%	107%				

OVERALL ACCURACY = 96.5% KAPPA INDEX = 93.9% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 92.0% KAPPA INDEX UPPER CONFIDENCE LEVEL = 95.8% *
Represents a map class with an error(s) to Open Water (OW); the overall accuracy is 95.9% when this data is included.

Appendix 7. La Grange, 31-Class Level Accuracy Assessment Contingency Table



Appendix 8. La Grange, 15-Class Level Accuracy Assessment Contingency Table



Appendix 9. La Grange, 7-Class Level Accuracy Assessment Contingency Table

		FIELD SAMPLES - REFERENCE DATA							COMMISSION		
	MAP CODES	Open Water (SV/RFA)	Marsh (DMA/D/DMP/SMA/SMP/SM/WM)	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SM S/WMS/WS)	Grass/Forbs (GR/PS/LV)	Sand/Mud (MUD/SB/SD)	TOTAL	USERS' ACCUR-ACY	90% Confidence Intervals	
MAP DATA - PREDICTION DATA	Open Water (SV/RFA)*	58					58	100%	99%	101%
	Marsh (DMA/DMP/SMA/SMP/SM/WM)	3	69	2	7		81	85%	78%	92%
	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SM S/WMS/WS)		5	180	1		186	97%	94%	99%
	Grass/Forbs (GR/PS/LV)			2	31		33	94%	86%	102%
	Sand/Mud (MUD/SB/SD)					41	41	100%	99%	101%
	TOTAL	61	74	184	39	41	399			
OMISSION	PRODUCERS' ACCURACY	95%	93%	98%	79%	100%	Total Correct = 379			
	90% Confidence Interval -	90%	88%	96%	68%	99%				
	90% Confidence Interval +	100%	99%	100%	91%	101%				

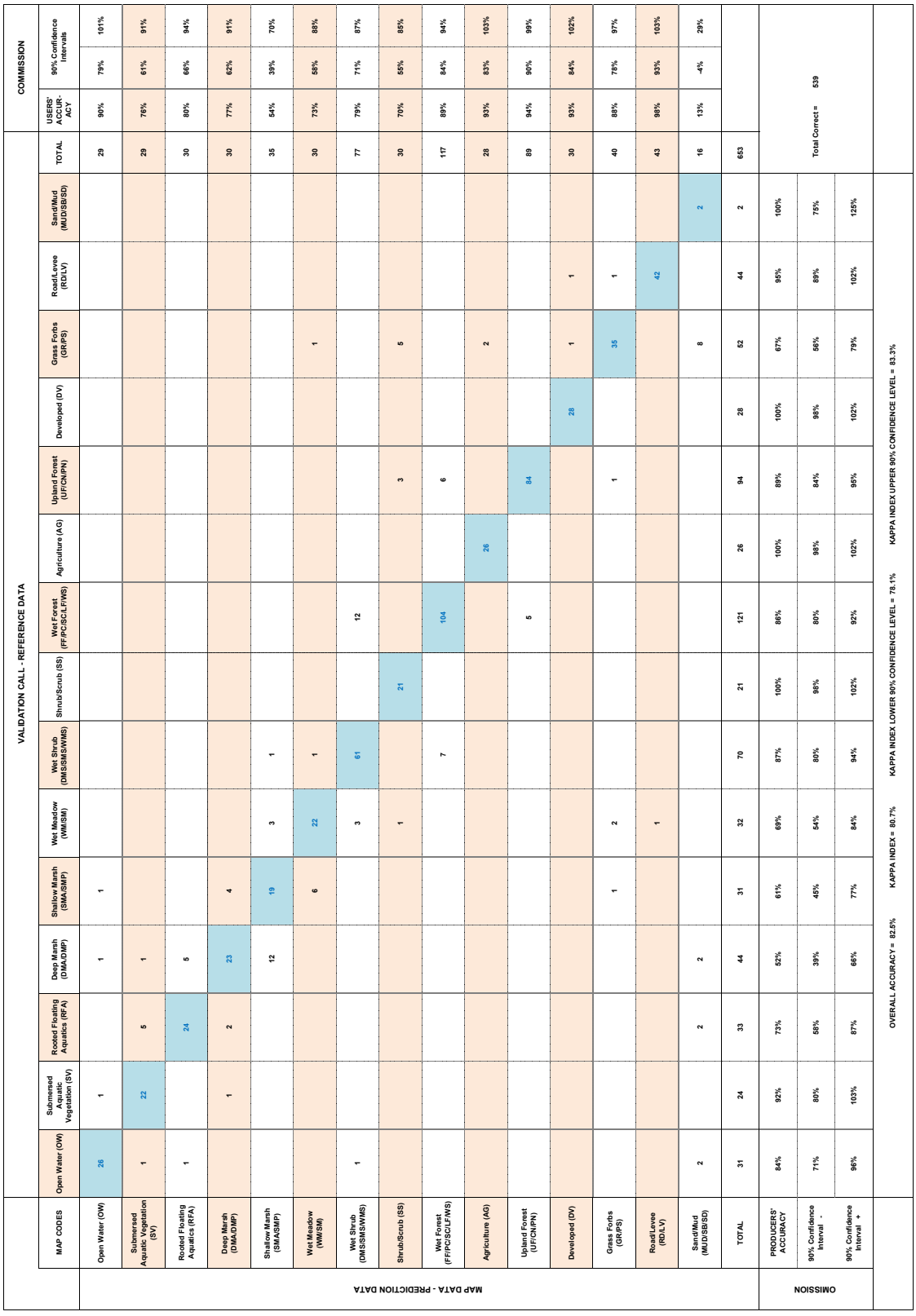
OVERALL ACCURACY = 95.0% KAPPA INDEX = 92.9% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 90.7% KAPPA INDEX UPPER 90% CONFIDENCE LEVEL = 95.1%
* Represents a map class with an error(s) to Open Water (OW); the overall accuracy is 94.7% when this data is included.

Appendix 10. Pool 13, 31-Class Level Validation Contingency Table

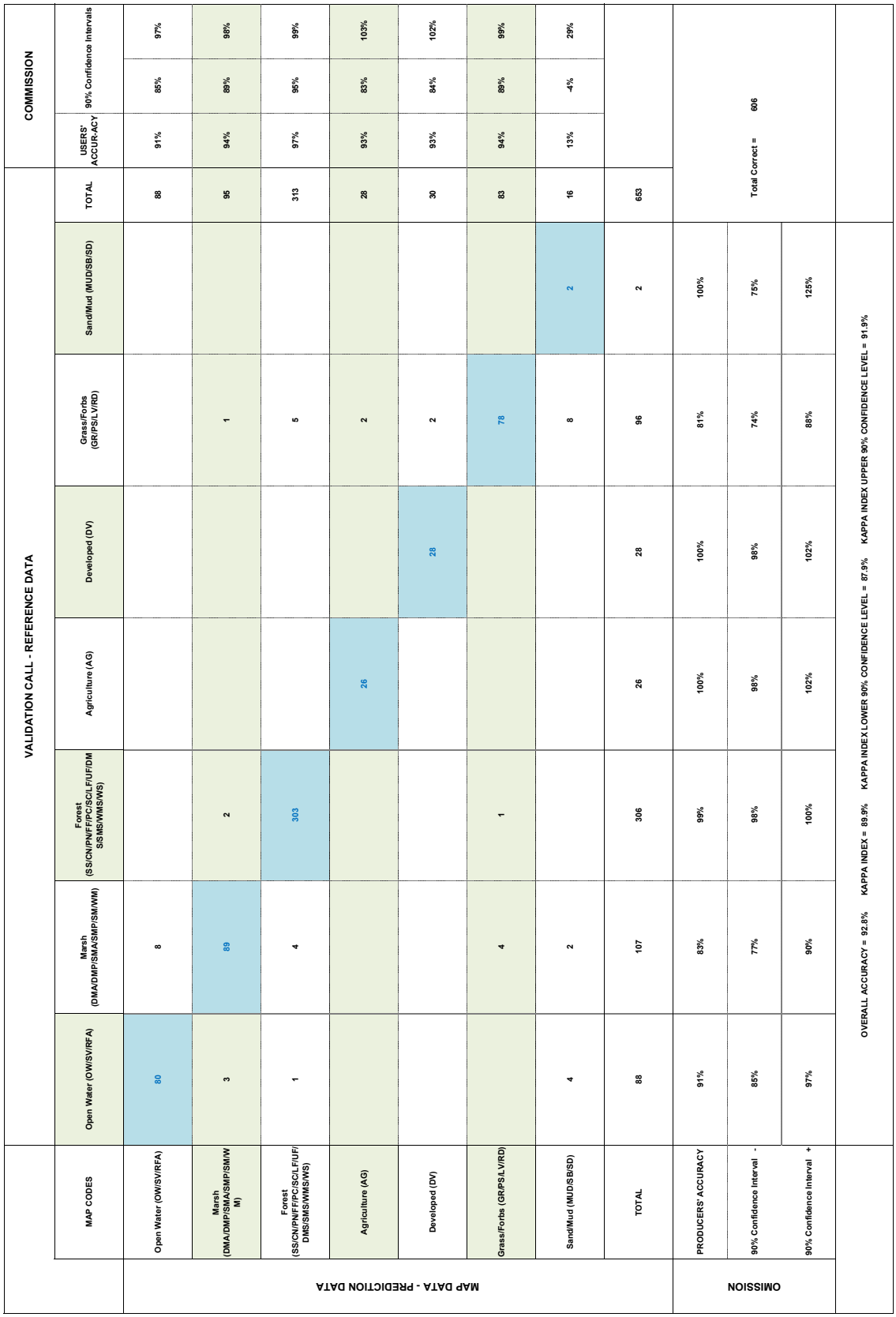
		VALIDATION CALL - REFERENCE DATA																											COMMISSION	
	MAP CODES	OW	SV	RFA	DMA	DMP	SMA	SMP	SM	WM	DMS	SMS	WMS	WS	SS	FF	PC	SC	LF	AG	CN	PN	UF	DV	GR	LV	PS	RD	MUD	SB	SD	TOTAL	USERS' ACCUR. ACY	90% Confidence Intervals	
MAP DATA - PREDICTION DATA	OW	26	1	1		1		1																							30	87%	75%	99%
	SV	1	22	5		1																									29	76%	61%	91%
	RFA	1		24		5																									30	80%	66%	94%
	DMA				0																										0	0%	0%	0%
	DMP		1	2		23		4																							30	77%	62%	91%
	SMA					3	0	2																							5	0%	-10%	10%
	SMP					9	1	16		3			1																		30	53%	37%	70%
	SM								0																						0	0%	0%	0%
	WM							6		22			1														1				30	73%	58%	88%
	DMS										15							1			1										17	88%	72%	104%
	SMS	1									8	17						4													30	57%	40%	73%
	WMS									3	1	8	12					3			3										30	40%	24%	56%
	WS													0																	0	0%	0%	0%
	SS									1					21								3								30	70%	55%	85%
	FF															25	1	2	2												30	83%	70%	96%
	PC															8	21	1													30	70%	55%	85%
	SC										1	2	4			7		16													30	53%	37%	70%
	LF															4			17			1	5								27	63%	46%	80%
	AG																			26							2				28	93%	83%	103%
	CN																		2		19	4	5								30	63%	47%	79%
	PN																				3	26	1								30	87%	75%	99%
	UF															3					1		25								29	86%	74%	98%
	DV																							28		1	1				30	93%	84%	102%
	GR							1		2								1			1				23		1				29	79%	65%	93%
	LV									1																21					22	95%	86%	105%
	PS																										11				11	100%	95%	105%
	RD																									2		19			21	90%	78%	103%
	MUD	2		2		1																							0		5	0%	-10%	10%
	SB																									3				0	3	0%	-17%	17%
	SD																									5				2	7	29%	-7%	64%
	TOTAL	31	24	34	0	43	1	30	0	32	25	27	18	0	21	52	22	23	24	26	24	31	39	28	36	25	16	19	0	0	653			
OMISSION	PRODUCERS' ACCURACY	84%	92%	71%	0%	53%	0%	53%	0%	69%	60%	63%	67%	0%	100%	48%	95%	70%	71%	100%	79%	84%	64%	100%	64%	84%	69%	100%	0%	0%	100%			
	90% Confidence Interval -	71%	80%	58%	0%	40%	-50%	37%	0%	54%	42%	46%	46%	0%	98%	36%	86%	52%	53%	98%	63%	71%	50%	98%	49%	70%	47%	97%	0%	0%	75%	Total Correct = 477		
	90% Confidence Interval +	96%	103%	85%	0%	67%	50%	70%	0%	84%	78%	80%	88%	0%	102%	60%	105%	88%	88%	102%	95%	96%	78%	102%	78%	98%	91%	103%	0%	0%	125%			

OVERALL ACCURACY = 73.0% KAPPA INDEX = 71.8% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 68.9% KAPPA INDEX UPPER 90% CONFIDENCE LEVEL = 74.8%

Appendix 11. Pool 13, 15-Class Level Validation Contingency Table



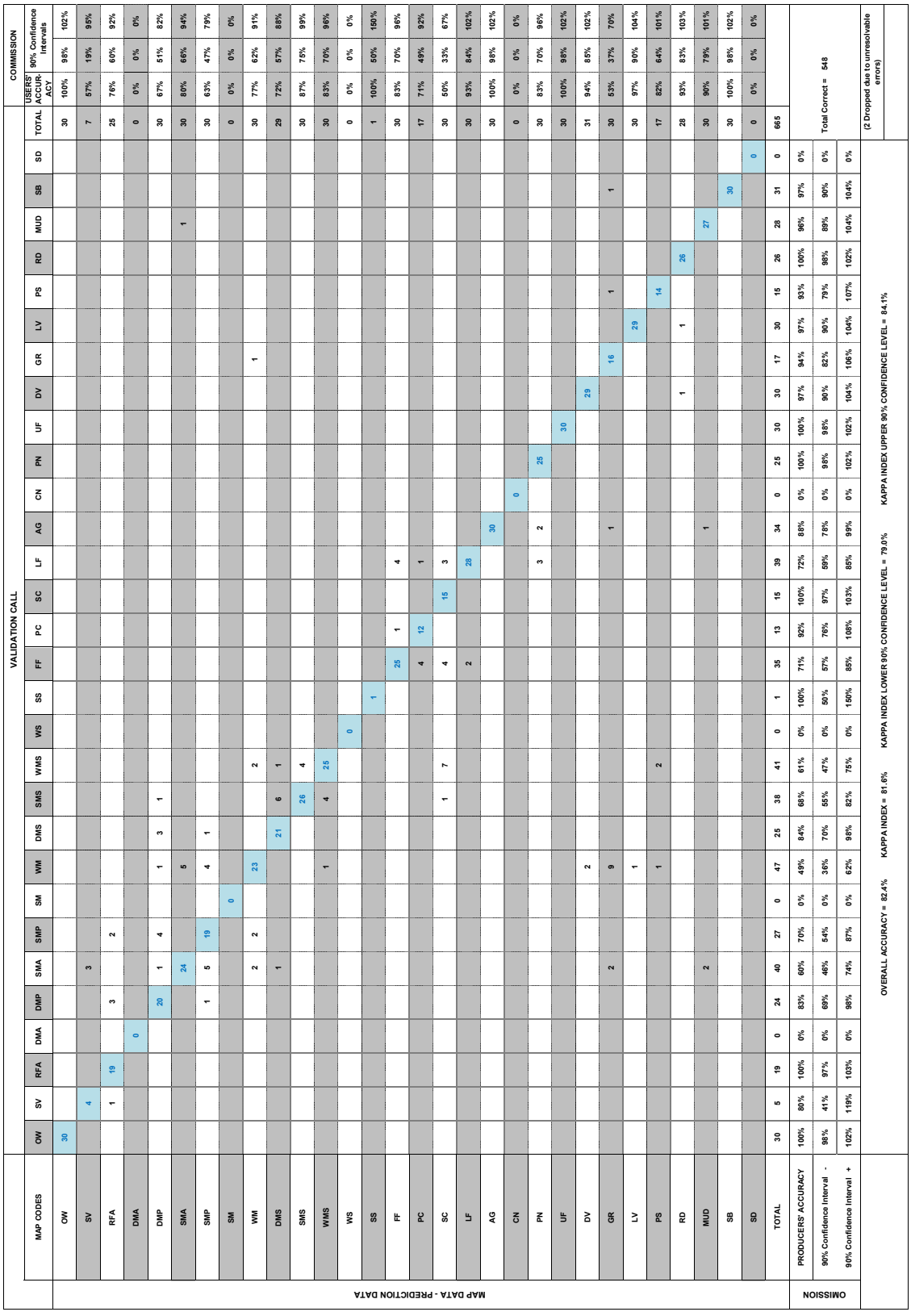
Appendix 12. Pool 13, 7-Class Level Validation Contingency Table



		VALIDATION CALL - REFERENCE DATA							COMMISSION		
	MAP CODES	Open Water (OW/SV/RFA)	Marsh (DMA/DMP/SMA/SMP/SM/WM)	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SS/MS/WMS/WS)	Agriculture (AG)	Developed (DV)	Grass/Forbs (GR/PS/LV/RD)	Sand/Mud (MUD/SB/SD)	TOTAL	USERS' ACCUR-ACY	90% Confidence Intervals
MAP DATA - PREDICTION DATA	Open Water (OW/SV/RFA)	80	8						88	91%	85% 97%
	Marsh (DMA/DMP/SMA/SMP/SM/WM)	3	89	2			1		95	94%	89% 98%
	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SMS/WMS/WS)	1	4	303			5		313	97%	95% 99%
	Agriculture (AG)				26		2		28	93%	83% 103%
	Developed (DV)					28	2		30	93%	84% 102%
	Grass/Forbs (GR/PS/LV/RD)		4	1			78		83	94%	89% 99%
	Sand/Mud (MUD/SB/SD)	4	2				8	2	16	13%	-4% 29%
	TOTAL	88	107	306	26	28	96	2	653		
OMISSION	PRODUCERS' ACCURACY	91%	83%	99%	100%	100%	81%	100%	Total Correct = 606		
	90% Confidence Interval -	85%	77%	98%	98%	98%	74%	75%			
	90% Confidence Interval +	97%	90%	100%	102%	102%	88%	125%			

OVERALL ACCURACY = 92.8% KAPPA INDEX = 89.9% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 87.9% KAPPA INDEX UPPER 90% CONFIDENCE LEVEL = 91.9%

Appendix 13. Pool 26, 31-Class Level Validation Contingency Table

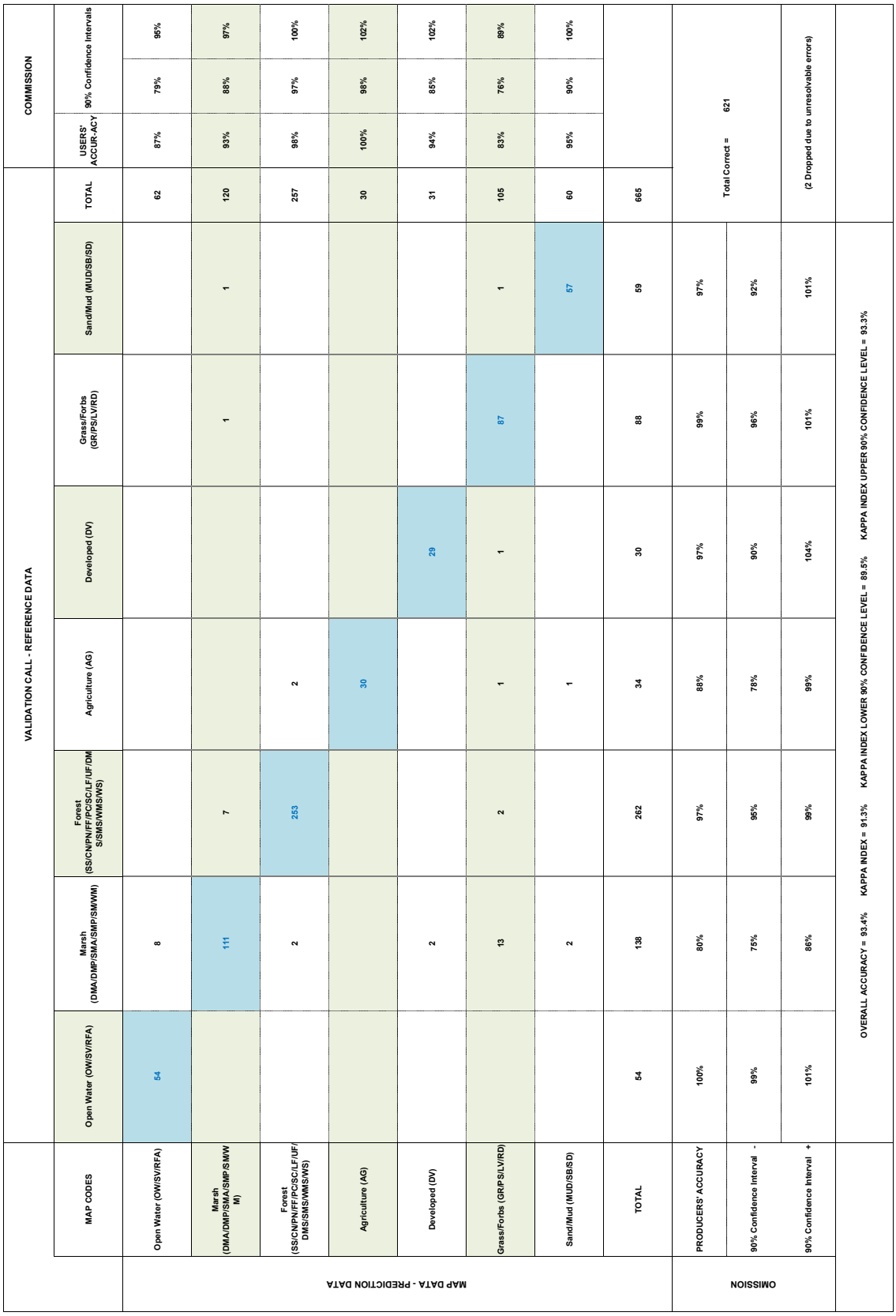


Appendix 14. Pool 26, 15-Class Level Validation Contingency Table

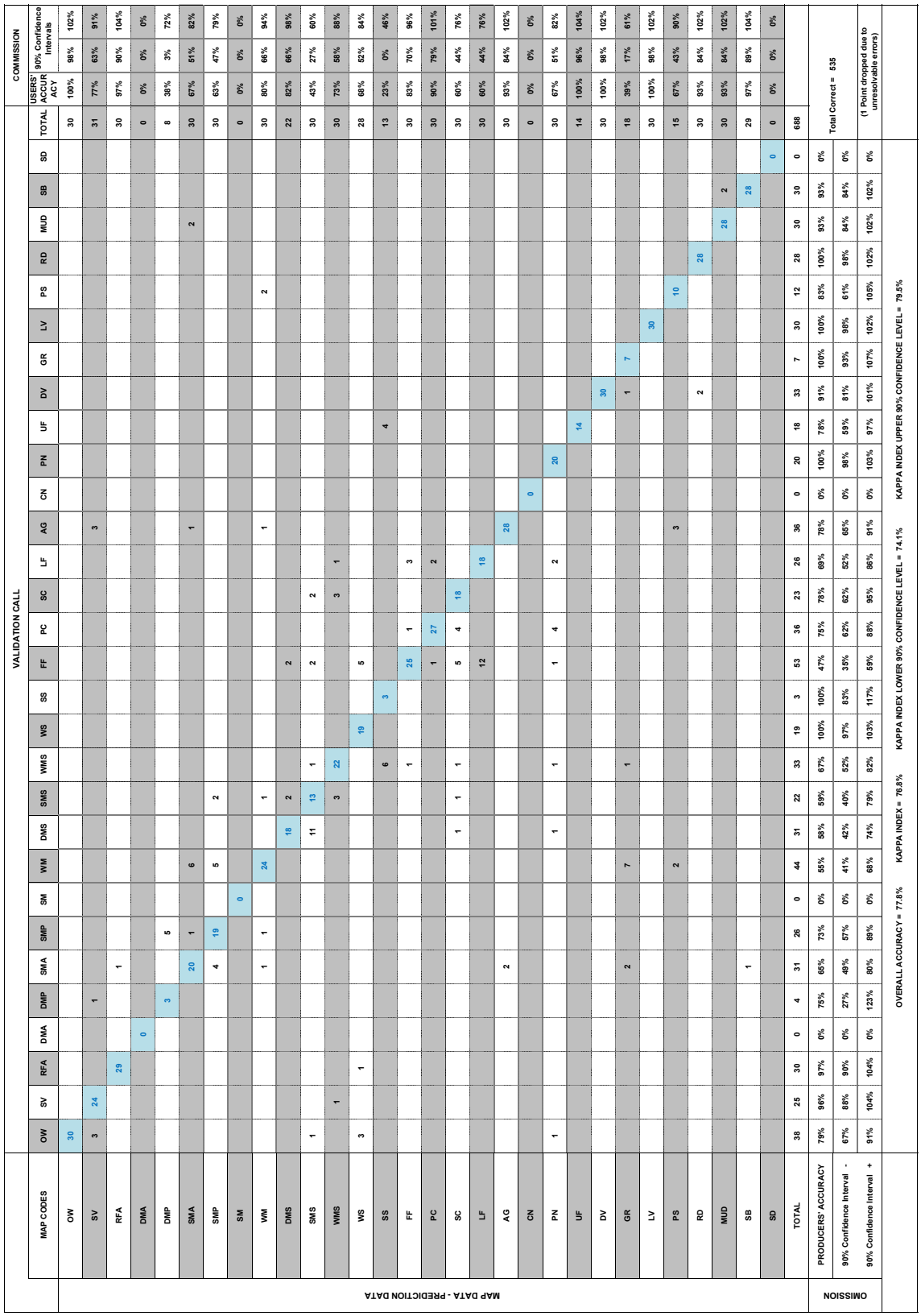
		VALIDATION CALL - REFERENCE DATA															COMMISSION		
	MAP CODES	Open Water (OW)	Submersed Aquatic Vegetation (SV)	Rooted Floating Aquatics (RFA)	Deep Marsh (DMA/DMP)	Shallow Marsh (SMA/SMP)	Wet Meadow (WM/SM)	Wet Shrub (DMS/SMS/WMS)	Shrub/Scrub (SS)	Wet Forest (FF/FPC/SC/LF/WS)	Agriculture (AG)	Upland Forest (UFC/NPN)	Developed (DV)	Grass Forbs (GR/PS)	Road/Levee (RD/LV)	Sand/Mud (MUD/SB/SD)	TOTAL	USERS' ACCURACY	90% Confidence Intervals
MAP DATA - PREDICTION DATA	Open Water (OW)	30															30	100%	102%
	Submersed Aquatic Vegetation (SV)		4			3											7	57%	95%
	Rooted Floating Aquatics (RFA)		1	19	3	2											25	76%	92%
	Deep Marsh (DMA/DMP)				20	5	1	4									30	67%	82%
	Shallow Marsh (SMA/SMP)				1	48	9	1								1	60	80%	89%
	Wet Meadow (WM/SM)					4	23	2						1			30	77%	91%
	Wet Shrub (DMS/SMS/WMS)					1	1	87									89	98%	101%
	Shrub/Scrub (SS)								1								1	100%	150%
	Wet Forest (FF/FPC/SC/LF/WS)							8		99							107	93%	97%
	Agriculture (AG)										30						30	100%	102%
	Upland Forest (UFC/NPN)									3	2	55					60	92%	98%
	Developed (DV)						2						29				31	94%	102%
	Grass Forbs (GR/PS)					2	10	2			1			31		1	47	66%	78%
	Road/Levee (RD/LV)						1						1		56		58	97%	101%
	Sand/Mud (MUD/SB/SD)					2					1					57	60	95%	100%
	TOTAL	30	5	19	24	67	47	104	1	102	34	55	30	32	56	89	665		
OMISSION	PRODUCERS' ACCURACY	100%	80%	100%	83%	72%	49%	84%	100%	97%	88%	100%	97%	97%	100%	97%	Total Correct = 589		90%
	90% Confidence Interval -	98%	41%	97%	69%	62%	36%	77%	50%	94%	78%	99%	90%	90%	99%	92%			
	90% Confidence Interval +	102%	119%	103%	98%	81%	62%	90%	150%	100%	99%	101%	104%	103%	101%	101%	(2 Dropped due to unresolvable errors)		

OVERALL ACCURACY = 88.6% KAPPA INDEX = 87.4% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 85.2% KAPPA INDEX UPPER 90% CONFIDENCE LEVEL = 89.6%

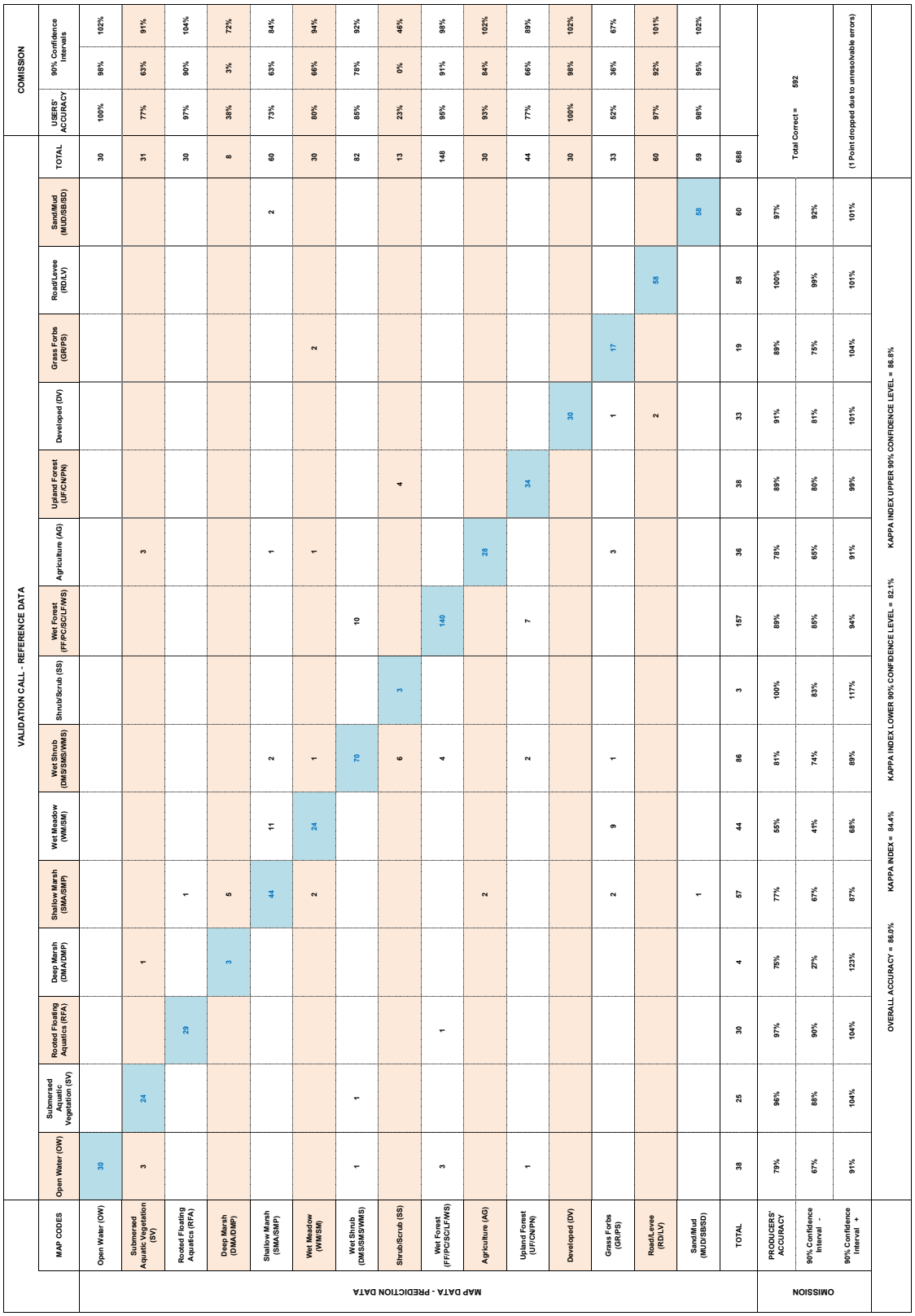
Appendix 15. Pool 26, 7-Class Level Validation Contingency Table



Appendix 16. Open River South, 31-Class Level Validation Contingency Table



Appendix 17. Open River South, 15-Class Level Validation Contingency Table



Appendix 18. Open River South, 7-Class Level Validation Contingency Table

		VALIDATION CALL - REFERENCE DATA								COMMISSION	
	MAP CODES	Open Water (OW/SV/RFA)	Marsh (DMA/DMP/SMA/SMP/SM/WM)	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SMS/WMS/WS)	Agriculture (AG)	Developed (DV)	Grass/Forbs (GR/PS/LV/RD)	Sand/Mud (MUD/SB/SD)	TOTAL	USERS' ACCUR-ACY	90% Confidence Intervals
MAP DATA - PREDICTION DATA	Open Water (OW/SV/RFA)	86	2		3				91	95%	90% 99%
	Marsh (DMA/DMP/SMA/SMP/SM/WM)		89	3	2		2	2	98	91%	86% 96%
	Forest (SS/CN/PN/FF/PC/SC/LF/UF/DMS/SMS/WMS/WS)	7		280					287	98%	96% 99%
	Agriculture (AG)		2		28				30	93%	84% 102%
	Developed (DV)					30			30	100%	98% 102%
	Grass/Forbs (GR/PS/LV/RD)		11	1	3	3	75		93	81%	73% 88%
	Sand/Mud (MUD/SB/SD)		1					58	59	98%	95% 102%
	TOTAL	93	105	284	36	33	77	60	688		
OMISSION	PRODUCERS' ACCURACY	92%	85%	99%	78%	91%	97%	97%	Total Correct = 646		
	90% Confidence Interval -	87%	79%	97%	65%	81%	94%	92%			
	90% Confidence Interval +	98%	91%	100%	91%	101%	101%	101%	(1 Point dropped due to unresolvable errors)		

OVERALL ACCURACY = 93.9% KAPPA INDEX = 92.0% KAPPA INDEX LOWER 90% CONFIDENCE LEVEL = 90.2% KAPPA INDEX UPPER 90% CONFIDENCE LEVEL = 93.8%

The Upper Mississippi River Restoration Program (UMRR), including its Long Term Resource Monitoring (LTRM) element, was authorized by the Water Resources Development Act (WRDA) of 1986. The mission of the LTRM element is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple use character. The LTRM element is implemented by the U.S. Geological Survey, Upper Midwest Environment Sciences Center, in cooperation with the five Upper Mississippi River System states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin; overall management responsibility of the UMRR is vested with the U.S. Army Corps of Engineers.

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