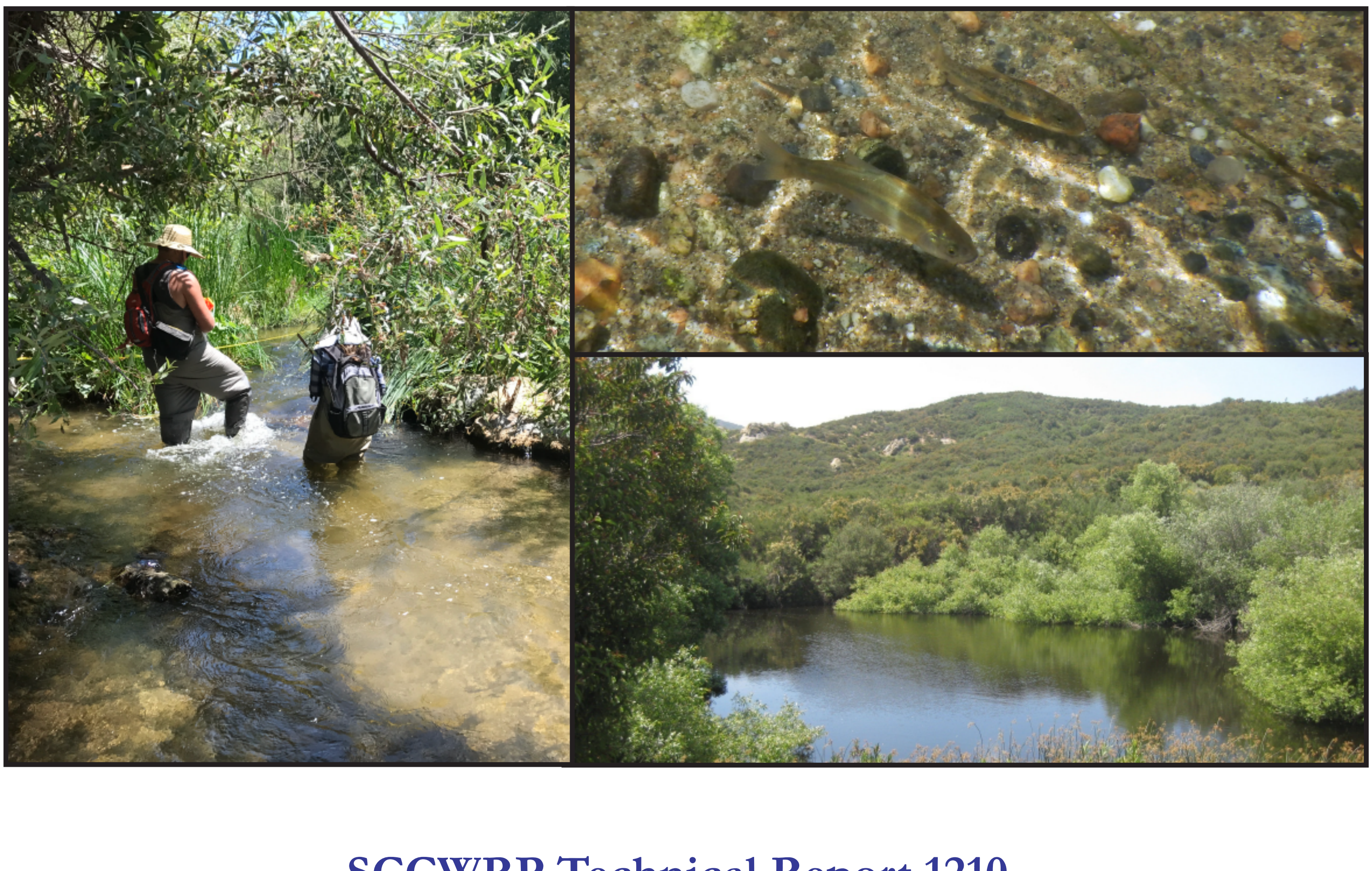
An Integrated Framework for Evaluating Wetland and Stream Compensatory Mitigation - Summary of Pilot Applications



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An Integrated Framework for Evaluating Wetland and Stream Compensatory Mitigation - Summary of Pilot Applications

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BACKGROUND AND OBJECTIVES

Compensatory mitigation is a commonly utilized strategy for offsetting unavoidable, adverse impacts to wetlands, streams and other aquatic resources as a result of permitted activities that affect aquatic resources. Program managers who are tasked with implementing and overseeing compensatory mitigation for wetlands, streams, and other aquatic resources often struggle to identify rigorous, standardized approaches for conducting monitoring and performance assessments, and to access and manage data relevant to their compensatory mitigation projects. To provide clearer recommendations and improve consistency of compensatory mitigation performance assessments across the country, the United States Environmental Protection Agency (USEPA) Office of Wetlands, Oceans, and Watersheds, in partnership with the Southern California Coastal Water Research Project (SCCWRP) and the Environmental Law Institute (ELI) developed a set of best practices for conducting compensatory mitigation assessments and produced *An Integrated Framework for Evaluating Wetland and Stream Compensatory Mitigation*[1].

The Framework includes a series of recommendations and best practices that states can use to augment their existing programs and ultimately improve their effectiveness. Also included in the proposed Framework are recommendations for data management that are aimed at helping to improve data accessibility across agency programs and to the public. The proposed Framework recommends that comprehensive compensatory mitigation evaluation include assessments of both project and program performance. To achieve this, the Framework recommends a flexible, modular approach that allows states to prioritize different modules depending on their needs and the status of their existing assessment programs. Where feasible, the Framework recommends implementation of all three modules to provide a comprehensive evaluation of program performance.

1. Compensatory mitigation site performance ("Performance"): This module evaluates the success of mitigation projects relative to defined ecological endpoints (e.g., morphology, habitats, species, communities), functional goals and permit requirements. This module can also help assess factors that influence mitigation success and the length of time necessary to achieve desired targets.

2. Program effectiveness ("Effectiveness"): This module evaluates the overall effectiveness of the regulatory program at achieving programmatic goals, such as no-net loss, specific area goals, and/or desired ecological targets at reach, watershed and regional scales.

3. Resiliency of compensatory mitigation practices ("Resiliency"): This module evaluates likely long-term trajectories of compensatory mitigation sites at achieving functional replacement of aquatic resource impacts. This includes the role of adaptive

[1] Stein et al. (2022) An Integrated Framework for Evaluating Wetland and Stream Compensatory Mitigation. EPA-840-S-22001.

management, ability to adapt for climate change effects, and vulnerability to future degradation due to changing land use, climate, and management practices.

To facilitate implementation of the Framework, USEPA funded two pilot projects in the states of Minnesota and Georgia aimed at demonstrating one or more modules of the framework and/or implementation of an open data system to produce data products based on monitoring data that can be used to inform decision making.

Both pilot projects focused on developing data management systems intended to improve access to information on compensatory mitigation projects, facilitate information sharing among agencies and programs and provide easier access of this information to stakeholders, and the public at large. Improved information access will allow agency staff to better address all three modules of the Framework.

This report provides a summary of the two pilot projects, lessons learned, and example products. Details of each pilot study are provided as appendices. These pilot studies are initial steps toward achieving the overall goals proposed in the Framework. Future efforts will be necessary to incrementally advance the ability of both programs to fully evaluate compensatory mitigation program effectiveness. The pilot projects provide examples of a state with a robust wetland regulatory, monitoring and assessment program (Minnesota) and a state that relies almost entirely on the Federal agencies for wetland protection and mitigation (Georgia). The results of these pilot studies, and the associated lessons learned and recommendations, can provide examples and ideas for other states as they contemplate implementation of the Framework and work to advance the capacity to address key management questions nationwide.

OVERVIEW OF PILOT PROJECTS

Minnesota and Georgia provide useful similarities and contrasts in their existing programmatic structure for regulation and implementation of compensatory mitigation and in their approaches to the pilot projects. Mitigation banking is the predominant strategy used in both states, with Minnesota having one of the most active and robust wetland banking markets in the country with an estimated 400 wetland banks approved since inception of the Minnesota State Wetland bank in the 1990s and Georgia having 190 banks listed in the Army Corps of Engineers (ACOE) Regulatory In lieu fee and Bank Information Tracking System (RIBITS). However, the regulatory structure differs between the two pilot projects. In Minnesota, the wetland banking program is administered by the Minnesota Board of Water and Soil Resources (BWSR, a state agency) through their Wetland Conservation Act (WCA) authorities, in coordination with the ACOE (although the scope and scale of the state program is much broader). In contrast, the role of the state is quite limited in Georgia, with the ACOE assuming the lead oversight role for compensatory mitigation. Reflecting this difference, Minnesota has a much more robust wetland mitigation monitoring and assessment program and consequently more state agency capacity for assessment and data management compared to Georgia. Despite these differences, both states need to improve their data management infrastructure to be able to answer key questions about compensatory mitigation performance, program effectiveness and resiliency, and chose this as the focus of their pilot studies. Minnesota hired a third-party contractor to develop the data management system, whereas the Georgia system was developed by faculty and staff from the University of Georgia. Figure 1 depicts the status of each state relative to the implementation process outlined in the Framework. The general implementation process was structured to provide the information necessary to efficiently address all three modules for a comprehensive evaluation of program performance. Individual programs may focus on different steps in the process depending on their needs and priorities.

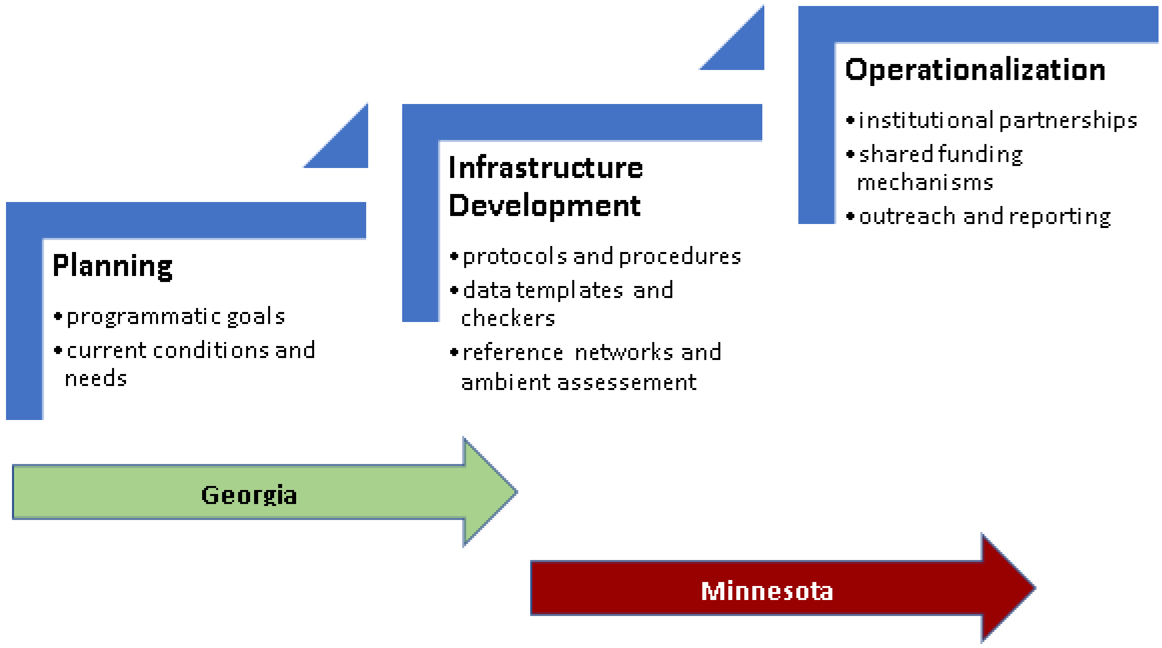

FIGURE 1: **Status of development of the two pilot project states relative to the implementation process outlined in the Framework (Stein et al. 2022).**

Minnesota

Minnesota state agencies and the ACOE have worked together for many years to increase consistency between state and federal policy regarding compensatory wetland mitigation programs and mitigation bank implementation. State agencies account for the majority of waters/wetlands permitting and compensatory mitigation requirements. For example, the Minnesota Board of Water and Soil Resources (BWSR) approved 175 wetland replacement plans in 2018 and has processed approximately 305 wetland banking transactions per year (withdrawals, deposits, and transfers) between 2015 and 2019. Responsibility for the monitoring of wetland replacement sites is divided based on the time that has elapsed since construction. The establishment period, roughly defined as the time from construction through the fifth full growing season, is conducted by the mitigation project sponsor and reviewed by the ACOE, BWSR, the Department of Natural Resources, and the local government unit with jurisdiction over the site under WCA. After the establishment period, BWSR takes over long-term monitoring with the focus primarily on compliance with the conservation easement recorded in favor of the State of Minnesota.

Once the establishment period has concluded, permittee responsible mitigation sites are only monitored if a regulatory agency randomly conducts an inspection or if a specific issue is identified that requires attention. Follow-up assessments to evaluate resiliency and overall functional condition for permittee responsible mitigation are infrequently performed by state and local agencies implementing WCA. Wetland bank sites in Minnesota are subjected to a more structured inspection approach because of a rule that requires BWSR to periodically inspect wetlands associated with the wetland banking program to ensure that easement conditions are being met. Data on all wetland banks is managed and organized by BWSR. Building on recent efforts funded by USEPA, BWSR is in the process of developing a more comprehensive long-term monitoring approach that will assess resiliency at mitigation sites at regular intervals using standardized methodologies. Additional details on the Minnesota program are available in Appendix A.

The Minnesota BWSR is developing a new Monitoring Data Management System (MDMS) to improve their ability to organize, track and report monitoring data from wetland mitigation sites. The current pilot study supports this larger effort through support of the following tasks: (1) developing the specifications and work flow processes for the monitoring module in the database; (2) developing standardized forms and processes for the collection of wetland mitigation monitoring data; (3) compiling wetland mitigation site metadata; (4) building the MDMS; and (5) testing the monitoring module and refining any data collection, submission, or standardization processes. The final version of the monitoring module will be driven by electronic data flow that is stored, presented, and accessed in a geospatial format. The stored data would be accessible via a web-based application operated and maintained by BWSR.

Georgia

Georgia's compensatory mitigation program is administered by the ACOE Savannah District under the auspices of the Clean Water Act Section 404 program. The mitigation banking program in the state is quite robust because the Savannah District was an early adopter of the banking concept and began permitting mitigation banks in the early 1990s. However, the State of Georgia has no written guidance, policy or regulatory program that regulates impacts to state waters[2]. Monitoring of mitigation banks occurs pursuant to the Savanah District's Standard Operating Procedure for Compensatory Mitigation, associated guidance, and individual banking instruments. There is currently no central database for cataloging monitoring data. Prior to 2018, compensatory mitigation in Georgia was governed by the Savannah District's 2004 Standard Operating Procedure for Compensatory Mitigation (2004 SOP). Under the 2004 SOP, each bank was responsible for its own data management (typically in Excel or ArcGIS) and there was no standard approach to organizing monitoring reports and data. Monitoring data was typically submitted as hard copy reports and had to be extracted and manually entered before it could be analyzed. In 2018, the Savannah District adopted a new SOP for Compensatory Mitigation (2018 SOP). The 2018 SOP is a major overhaul of compensatory mitigation in the state. It moves the District to a more function-based approach to mitigation, using the Hydrogeomorphic Approach for wetlands (HGM) and the Stream Quantification Tool for streams (SQT) as the frameworks for calculating credits for wetland and stream mitigation

[2] The State of GA has a Stream Buffer Variance program. The Georgia Erosion and Sedimentation Act (12-7-1) requires a 25-foot vegetated buffer along all state waters and a 50-foot vegetated buffer on state-designated trout streams. A variance may be obtained to allow impacts within these buffers under certain circumstances. Such a variance must be applied for and ultimately approved by the Georgia Environmental Protection Division. However, this program does not include a compensatory mitigation element.

projects in the state. The Savannah District also reworked its monitoring and performance requirements in 2018 with the 2018 Draft Monitoring Guidelines and Performance Standards for Freshwater Wetlands and Non-Tidal Streams (2018 Monitoring Guidelines). Under the 2018 Monitoring Guidelines, monitoring data must now be submitted electronically via Excel spreadsheet tools. Neither the 2004 SOP nor the 2018 SOP or associated guidance require long-term performance or resiliency monitoring beyond that required by permit conditions. Additional details on Georgia's program are available in Appendix B.

The goal of the pilot project was to build a prototype database and a web interface that supports existing compensatory mitigation data while also providing a template for desired new data collection. Specific tasks included: (1) bring together a working group of diverse stakeholders involved in compensatory mitigation programs in Georgia to address the diverse needs and common structures across stakeholders; (2) assess practices and standards for current mitigation data collection, reporting, and use and inventory available datasets; (3) construct a pilot geospatial database for mitigation monitoring and evaluation; and (4) generate a plan for scaling up based on stakeholder input and challenges confronted during pilot database construction. To accomplish these goals, 14 stakeholders involved in compensatory mitigation in Georgia were assembled for two workshops to provide insight into the state of current data collection and analysis, identify available datasets to populate the database, define database goals and priorities, and provide feedback on database elements during the development process. Due to the lack of consistency in historical data collection and reporting in Georgia prior to the implementation of the 2018 SOP, the team focused much of their database development efforts on creating data reporting standards for a range of metrics to facilitate future analysis. Therefore, the priority of this pilot project became developing tools and standards to facilitate future data analysis, rather than entering and analyzing trends in historic data to draw conclusions about the effectiveness of compensatory mitigation programs in Georgia.

MAJOR OUTCOMES

Minnesota

The MDMS functionality allows users to upload vegetation and hydrology data associated with long-term monitoring of wetland sites in Minnesota. For mitigation sites, long-term monitoring data is associated with other information about the site in the BWSR wetland banking application using a system derived site identification number as the primary key. The site identification number is assigned during the regulatory review process and is used to link all information in the BWSR wetland banking application collected during the mitigation site lifecycle. This includes tabular and geospatial information about the review process, monitoring, credits and transactions, and compliance inspections. Wetlands that are not mitigation sites (reference or conservation) can also be assigned a site identification number in the system to enable data uploads in the condition monitoring module. Using the site identification number users can access the condition monitoring features of the application and initiate the data upload process. The landing screen for uploading data, referred to as the Condition Monitoring Header, is shown in Figure 2.

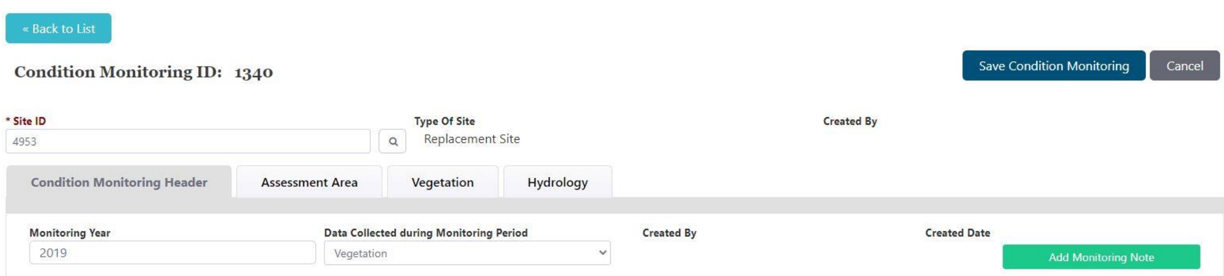

FIGURE 2: Minnesota Condition Monitoring Header landing page for uploading monitoring data.

Using the data entry fields on the Condition Monitoring Header the user provides the year monitoring data was collected and the type of data collected. Data uploads are then completed using the Assessment Area and Vegetation tabs for vegetation data and the Hydrology tab for water level measurements. Data upload is accomplished using standardized Microsoft Excel spreadsheet templates for both types of data. Currently BWSR has developed five vegetation upload templates (each recognizing different data collection methods) and two hydrology templates (one for time series data and one for manual readings). The user interfaces for each data type request additional information from the user to further define the data collection methods and areas of the site where the information is collected. For vegetation data, the Assessment Area tab is used to identify the boundaries of the area encompassed by the monitoring using a GIS mapping tool as well as the opportunity to upload maps (in pdf format) that show transect, meander, or plot locations within the assessment area. Specific information about the vegetative data collected within the assessment area is entered under the Vegetation tab. An example of the data capture screen for a circular plot with a 5-foot radius in a sedge meadow community is provided in Figure 3. After entering the descriptive information about the sample method, the user can upload data using the templates mentioned previously. All data submitted for upload are reviewed by an automatic data checker to ensure basic quality assurance requirements are satisfied before files are accepted into the MDMS. The MDMS provides specific information on fields that failed the data check to assist users with making corrections. Hydrology data entry is completed following a similar process under the Hydrology tab.

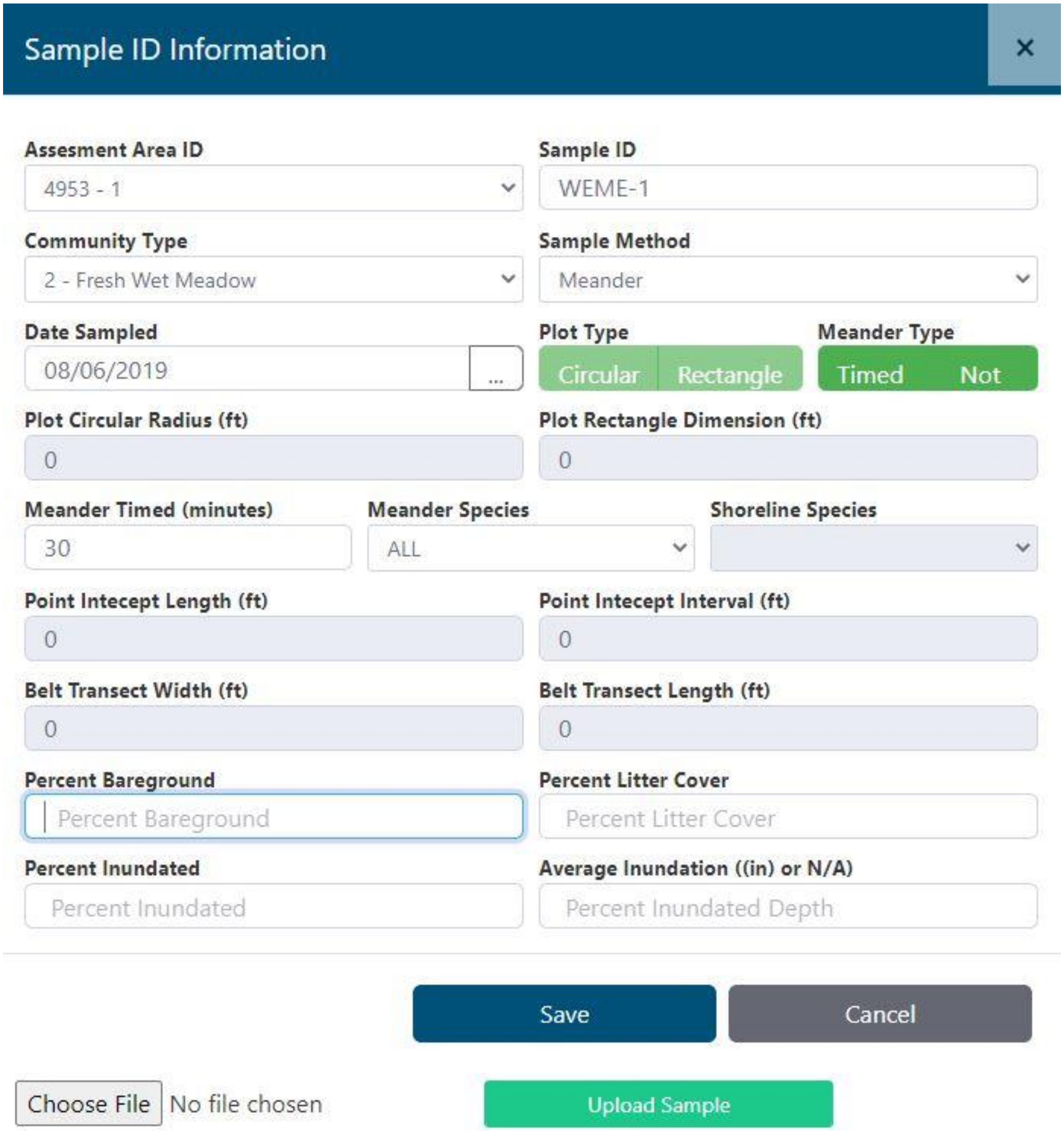

FIGURE 3: **Example MDMS data capture screen for vegetation data.**

An overview of the data compilation, upload, and checking process used in the MDMS is shown in Figure 4.

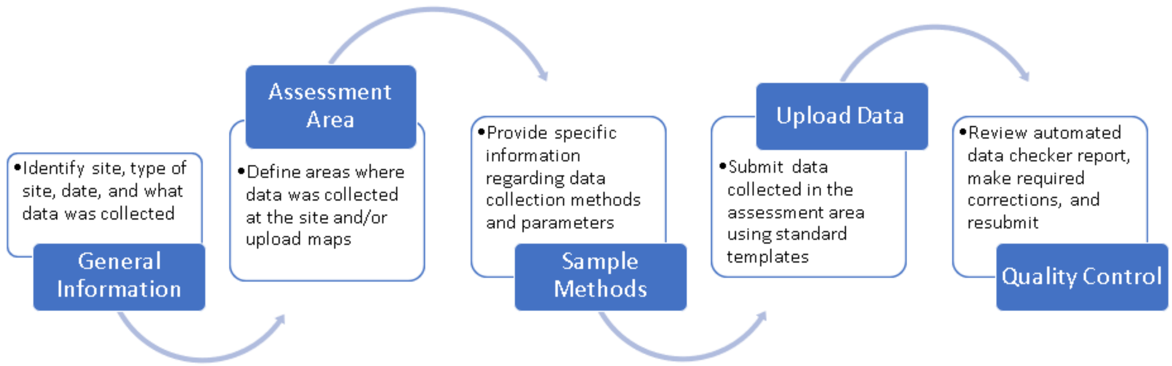

FIGURE 4: Overview of data submittal and automated checking process.

The MDMS will be linked with a relational database[3] maintained by the Minnesota Pollution Control Agency to share hydrology data for mitigation sites with other groundwater data collected and managed by the State of Minnesota. Ultimately, the monitoring data from the MDMS will be publicly available through the Minnesota Cooperative Groundwater Program managed by the Minnesota Department of Natural Resources. Through their web application the public can view the location and type of monitoring well data available across the state (Figure 5). Data can also be downloaded in several formats for further analysis.

[3] The Minnesota Pollution Control Agency uses WISKI, a data management platform developed by Kisters, to store and analyze water resources data.

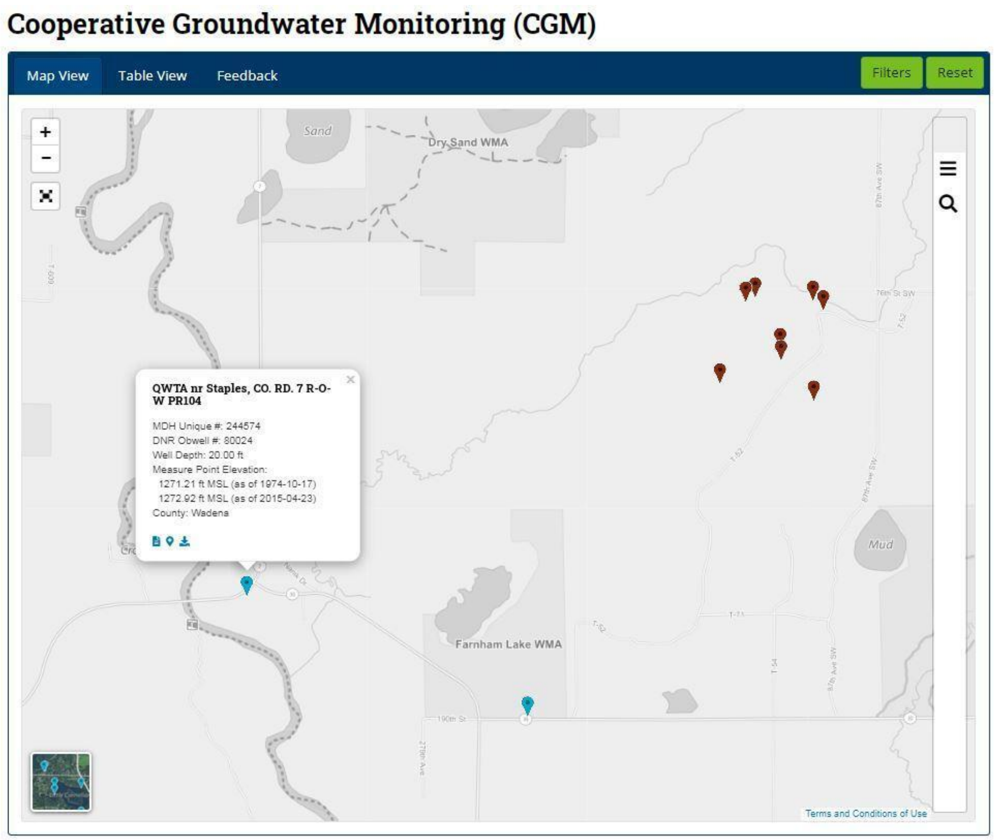

FIGURE 5: Minnesota web viewer for accessing groundwater monitoring data.

When completed, a public facing web interface will show the locations and types of condition monitoring data available across the State. Users will be able to identify sites of interest and download the selected hydrology and/or vegetation data (Figure 6). The interface also will include information on the location of approved wetland mitigation banks using geospatial data collected and maintained by BWSR as part of the agency's wetland banking review process and easement compliance activities.

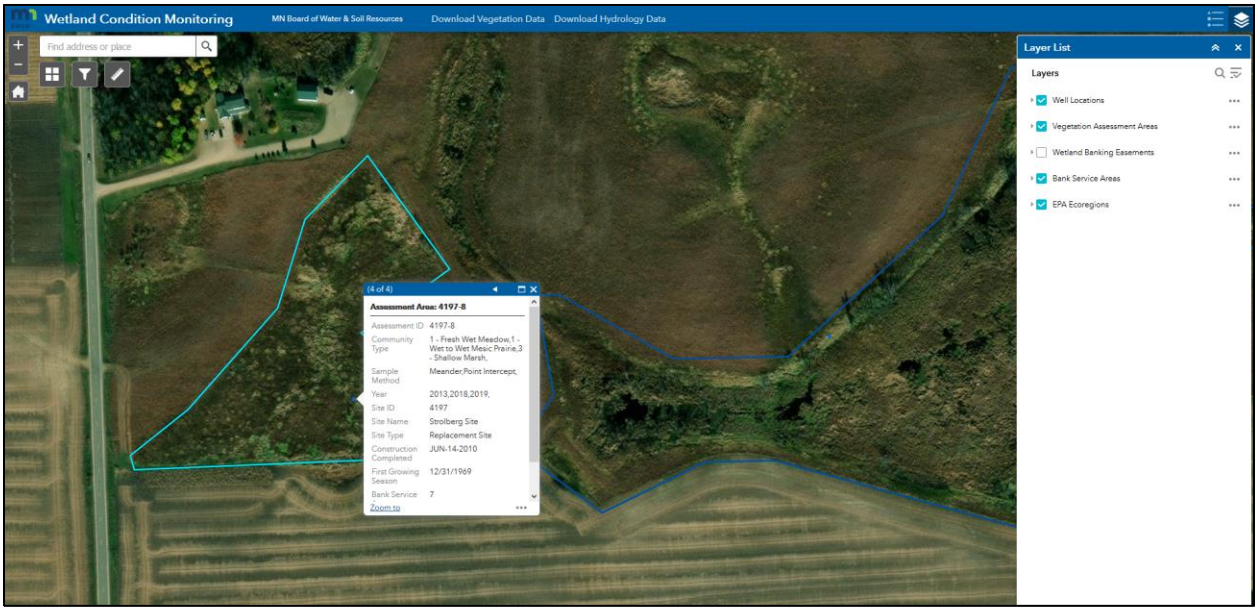

FIGURE 6: **Interactive public viewer map showing attribute information. The header in the map interface has links for downloading data.**

Georgia

The Georgia pilot project developed products under each of its objectives that will provide key benefits to compensatory mitigation evaluation both in Georgia and nationally. The Georgia team hosted two stakeholder workshops to bring together a working group of diverse stakeholders involved in compensatory mitigation programs to address needs and common structures across stakeholders (Objective 1). The workshops included members of 14 organizations involved with or interested in compensatory mitigation in Georgia. and provided a forum for participants to share insights into the state of current data collection and analysis, identify available datasets to populate the database, define database goals and priorities, and provide feedback on database elements during the development process (Objective 2). The team compiled a spreadsheet of available spatial data for each bank to highlight locations where spatial data is missing in current state databases to improve future data management (e.g., missing boundary polygon).

The main product developed through this project is a pilot interactive mitigation evaluation database for the state of Georgia (Objective 3). The database will be published online, allowing access to mitigation data upload, download, and visualization by all members of the Georgia mitigation community including bank providers and regulatory agencies. The construction of this database is a key step in the development of mitigation data entry standards for the state of

Georgia. The web database application was developed using the RSQLite[4] and R Shiny[5] packages in the open-source statistical program R[6].

The first tab of the online database (Figure 7) includes an interactive map depicting Georgia mitigation banks, which allows users to zoom into areas of interest within the state. The interactive map allows users to click on icons representing each bank to view site-level information (e.g., acres, date established) and turn on other key spatial layers (e.g., service areas) for the state of Georgia by checking boxes next to the name of each spatial layer in the panel to the left of the map. Menus on the side panel also allow users to zoom to specific service areas or banks of interest (Figure 8). Additionally, users can upload shapefiles containing the locations of individual sampling sites within banks using the “Browse” button at the bottom of the side panel on this tab. These shapefiles will ultimately be appended to a layer that will be displayed on the map in this tab in future iterations of the database.

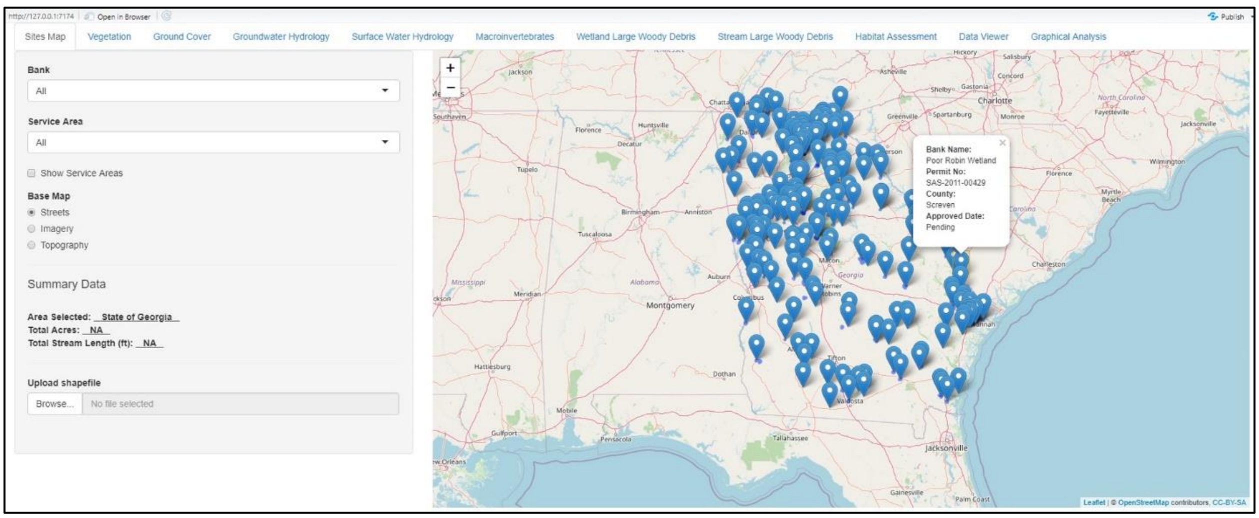

FIGURE 7: **Georgia bank sites viewer.**

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[4] Kirill Müller, Hadley Wickham, David A. James and Seth Falcon. 2020. RSQLite: 'SQLite' Interface for R. R package version 2.2.1. https://CRAN.R-project.org/package=RSQLite

[5] Winston Chang, Joe Cheng, JJ Allaire, Yihui Xie and Jonathan McPherson. 2020. Shiny: Web Application Framework for R. R package version 1.5.0. https://CRAN.R-project.org/package=shiny

[6] R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

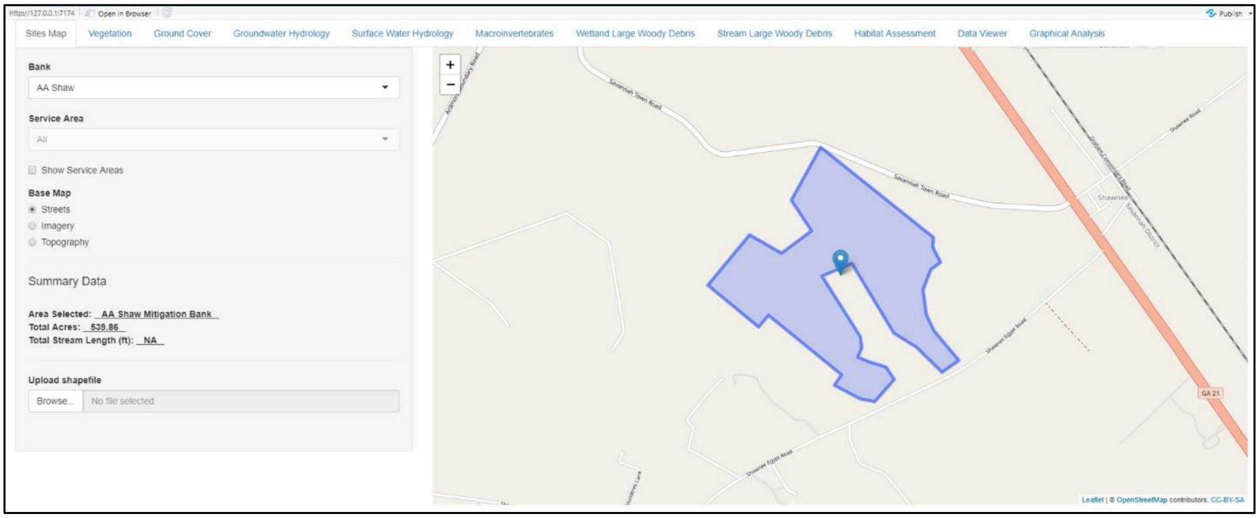


FIGURE 8: **Map zoomed into the AA Shaw mitigation bank.**

The database also includes eight data entry tabs that facilitate the upload of multiple types of data (e.g., vegetation, ground cover, groundwater hydrology, surface water hydrology, macroinvertebrates, wetland large woody debris, stream large woody debris, and habitat assessment characteristics) into the database in standardized formats. On each tab, data can be uploaded either as a batch by uploading a CSV file or entered manually as individual records in a standardized form (Figure 9). When the user browses and selects a CSV file for batch upload, the contents of the file will be previewed at the top of the screen (Figure 10). Data is appended to the database when the user clicks the “Upload” button in the batch entry box or the “Submit” button at the bottom of the form. While the batch upload tool is likely to be used for the vast majority of data uploads, the inclusion of the manual data entry form on each tab was deemed useful because it provides a helpful visualization to orient new users and facilitated discussion about field modification with stakeholders during database development.

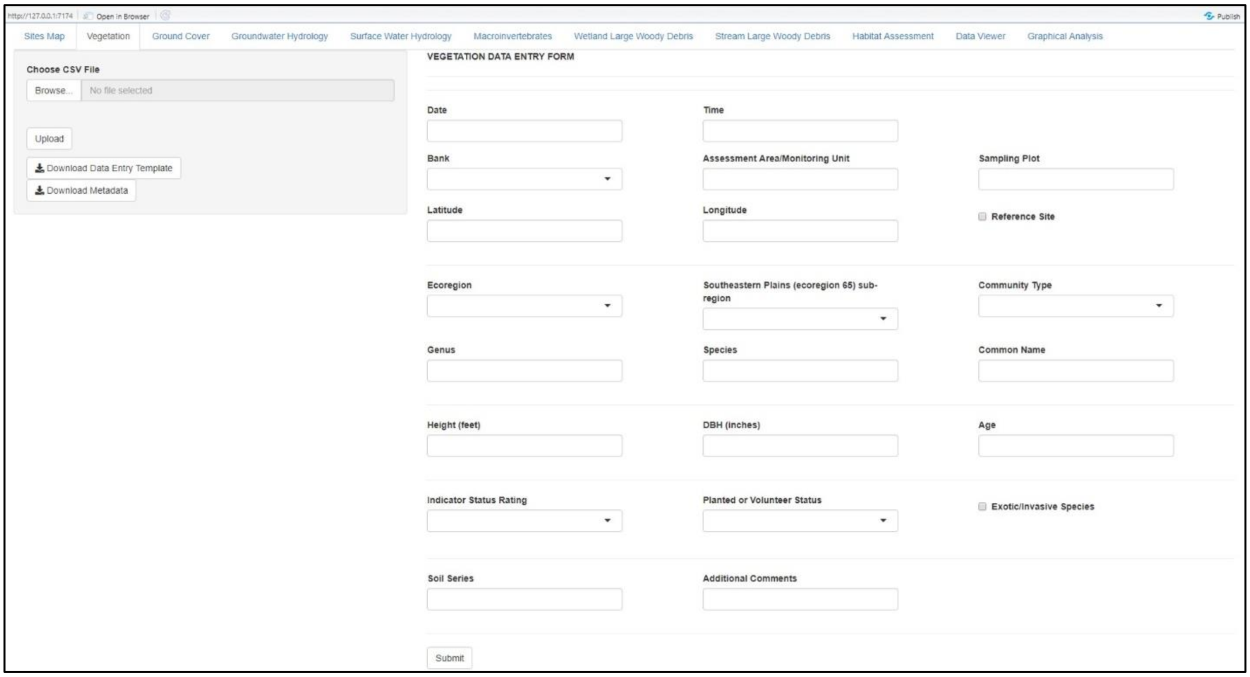


FIGURE 9: **Sample from vegetation data entry form.**

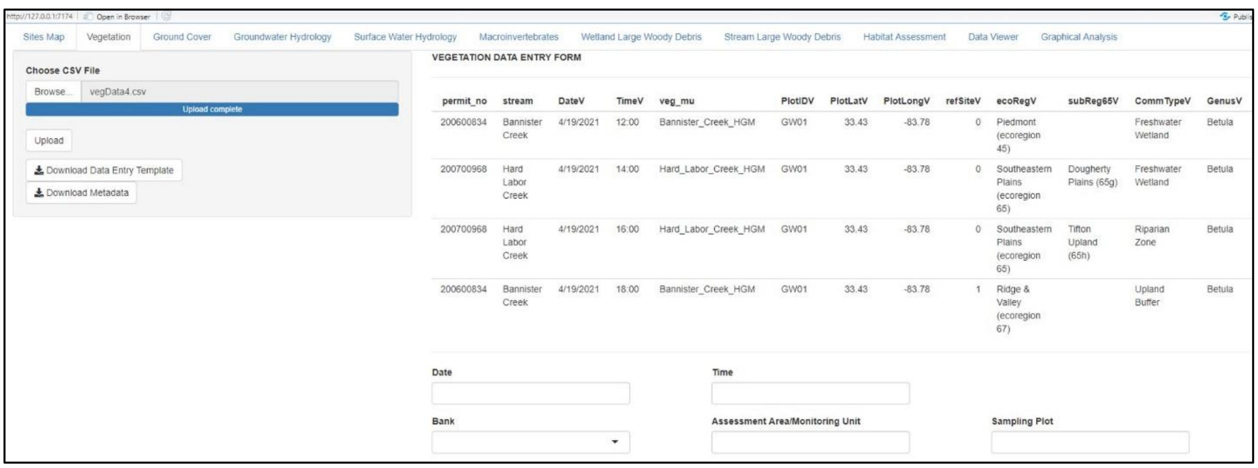


FIGURE 10: **Example batch data upload.**

QAQC protocols within the data entry forms were developed to flag potentially erroneous records before they are entered into the database. In the manual data entry forms, field text changes from black to red to alert the user that entered data is outside of the acceptable range (Figure 13). Additionally, if the user attempts to upload data with QAQC issues, an error message will be produced when the "Submit" button is pressed, alerting the user that the data failed a QAQC check and cannot be appended to the database. An additional message alerts the user to the specific field(s) that failed the QAQC check (Figure 14). The user must resolve these QAQC issues to successfully upload data to the database. The batch data upload tools require data to pass the same QAQC protocols and produce similar error messages highlighting cells that failed the protocols, forcing the user to correct the data to successfully upload it.

FIGURE 11: **Example of field highlighted to alert user to QAQC issue ("pH" text in red).**

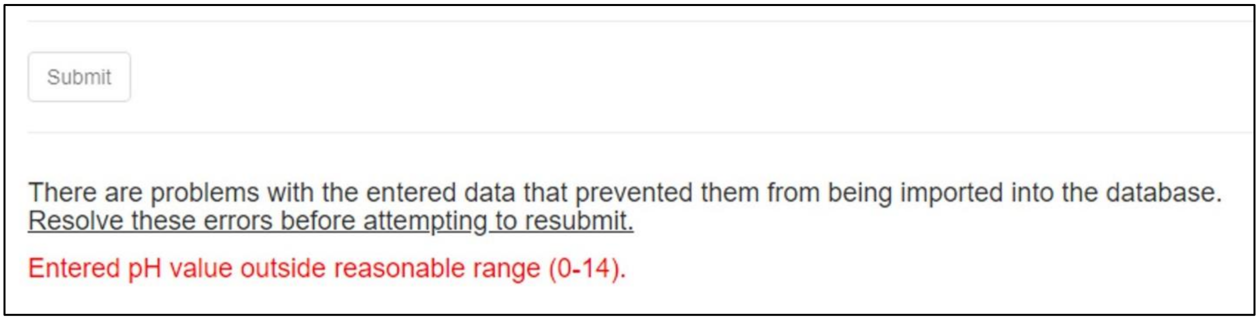


FIGURE 12: **Example of data submission error due to failing QAQC check.**

To supplement the database, metadata spreadsheets for each data entry type, which include QAQC protocols, units, and descriptions of all fields included in the database, are available for download in the side panel of each tab (Figure 13). Additionally, to facilitate batch uploads, CSV data templates can be downloaded from the side panel of each tab, allowing users to ensure that fields are formatted correctly prior to entering and attempting to upload data (Figure 14).

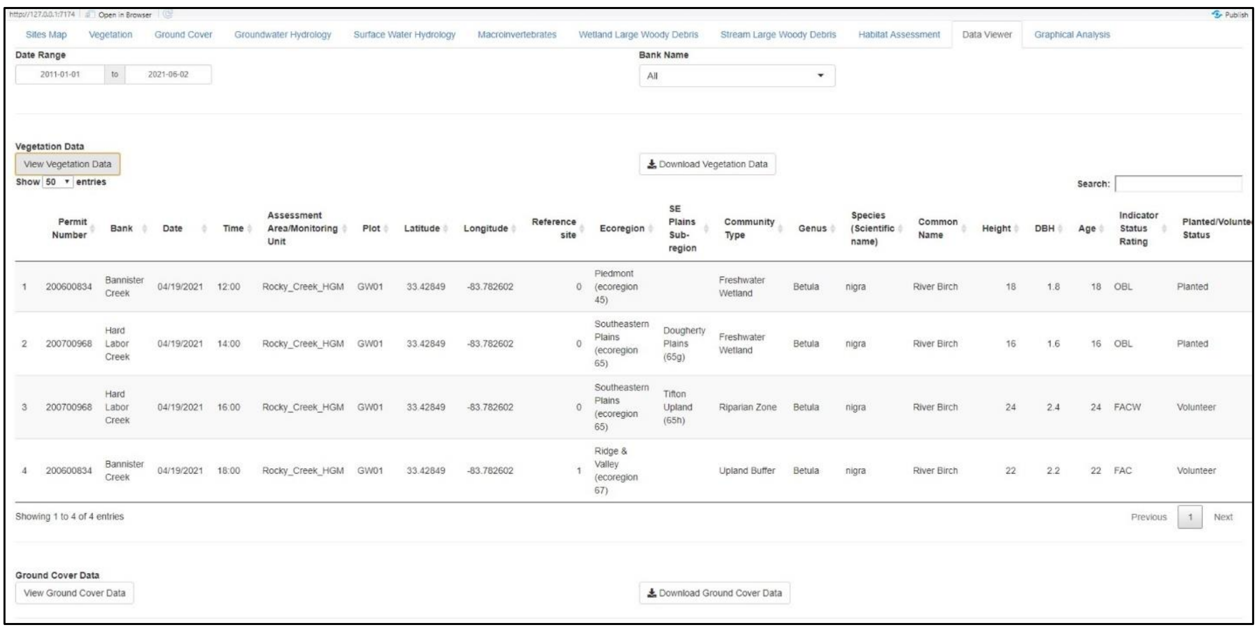
	A	B	C	D	E	F	G	H
1	**Variable**	**Code**	**Question Type**	**Data Type**	**Min**	**Max**	**Units**	**Options**
2	Date	DateV	Date	Date	1/1/1900	current date	N/A	N/A
3	Time	TimeV	Numeric	Numeric	0:00	24:00	24-hour format	N/A
4	Bank	BankID	Dropdown	Text	N/A	N/A	N/A	AA Shaw, Alaculsy, etc.
5	Assessment Area/Monitoring Unit	veg_mu	Text	Text	N/A	N/A	N/A	N/A
6	Plot	PlotIDV	Text	Text	N/A	N/A	N/A	N/A
7	Latitude	PlotLatV	Numeric	Numeric	30	35	Decimal Degrees	N/A
8	Longitude	PlotLongV	Numeric	Numeric	-86	-80	Decimal Degrees	N/A
9	Reference Site	refSiteV	Checkbox	Numeric	0	1	N/A	0 = FALSE, 1 = TRUE
10	Ecoregion	ecoRegV	Dropdown	Text	N/A	N/A	N/A	Piedmont (ecoregion 45), Southeastern Plains (ecoregion 65), Blue Ridge
11	Sub-region	subReg65V	Dropdown	Text	N/A	N/A	N/A	Dougherty Plains (65g), Tifton Upland (65h), Atlantic Southern Loam Plain
12	Community Type	CommTypeV	Dropdown	Text	N/A	N/A	N/A	Freshwater Wetland, Saltwater Wetland, Riparian Zone, Upland Buffer
13	Genus	GenusV	Dropdown	Text	N/A	N/A	N/A	All plant genera included in USACE-NWPL list for GA
14	Species Scientific Name	SpSciV	Dropdown	Text	N/A	N/A	N/A	All plant species included in USACE-NWPL list for GA
15	Common Name	SpCommV	Auto-fill	Text	N/A	N/A	N/A	N/A
16	Height	tHeight	Numeric	Numeric	0	200	Feet	N/A
17	DBH	DBH	Numeric	Numeric	0	100	Inches	N/A
18	Age	tAge	Numeric	Numeric	0	1000	Years	N/A
19	Indicator Status Rating	IndStatusV	Dropdown	Text	N/A	N/A	N/A	OBL, FACW, FAC, FACU, UPL
20	Planted or Volunteer Status	PlantVol	Dropdown	Text	N/A	N/A	N/A	Planted, Volunteer
21	Exotic/Invasive Species	ExInvV	Checkbox	Numeric	0	1	N/A	0 = FALSE, 1 = TRUE
22	Soil Series	soilSeriesV	Text	Text	N/A	N/A	N/A	N/A
23	Additional Comments	commentV	Text	Text	N/A	N/A	N/A	N/A

FIGURE 13: **Excerpt from the Georgia vegetation metadata spreadsheet.**

	A	B	C	D	E	F	G	H	I	J	K	L
1	permit_no	stream	DateV	TimeV	WAA	PlotID	PlotLat	PlotLong	refSiteV	CommTypeV	GenusV	SpSciV
2	{{character string}}	{{character string}}	{{mm-dd-yy}}	{{hh:mm}}	{{character string}}	{{character string}}	{{numeric}}	{{numeric}}	{{numeric}}	{{character string}}	{{character string}}	{{chracter string}}
3												
4												
5												

FIGURE 14: Excerpt from the Georgia vegetation data template.

The database also includes a tab allowing users to view, query, and download existing data stored within the database (Figure 15). On this tab, options are organized under headings for each data type (e.g., vegetation, ground cover, etc.) Under each heading, data can be viewed by clicking the "View Data" button, queried by field using dropdown menus (e.g., bank name), and downloaded by clicking on the "Download Data" button. The final database tab allows users to plot data stored in the database to facilitate visualization and analysis of data trends (Figure 16). This tool allows individual data fields to be selected for analysis and additional fields to be selected to group data. It also allows the user to specify the type of plot to use for data visualization.



	Permit Number	Bank	Date	Time	Assessment Area/Monitoring Unit	Plot	Latitude	Longitude	Reference site	Ecoregion	SE Plains Sub-region	Community Type	Genus	Species (Scientific name)	Common Name	Height	DBH	Age	Indicator Status Rating	Planted/Volunte Status
1	200600834	Bannister Creek	04/19/2021	12:00	Rocky_Creek_HGM	GW01	33.42849	-83.782602	0	Piedmont (ecoregion 45)		Freshwater Wetland	Betula	nigra	River Birch	18	1.8	18	OBL	Planted
2	200700968	Hard Labor Creek	04/19/2021	14:00	Rocky_Creek_HGM	GW01	33.42849	-83.782602	0	Southeastern Plains (ecoregion 65)	Dougherty Plains (65g)	Freshwater Wetland	Betula	nigra	River Birch	16	1.6	16	OBL	Planted
3	200700968	Hard Labor Creek	04/19/2021	16:00	Rocky_Creek_HGM	GW01	33.42849	-83.782602	0	Southeastern Plains (ecoregion 65)	Tifton Upland (65h)	Riparian Zone	Betula	nigra	River Birch	24	2.4	24	FACW	Volunteer
4	200600834	Bannister Creek	04/19/2021	18:00	Rocky_Creek_HGM	GW01	33.42849	-83.782602	1	Ridge & Valley (ecoregion 67)		Upland Buffer	Betula	nigra	River Birch	22	2.2	22	FAC	Volunteer

FIGURE 15: Data viewer tab, which allows data to be viewed, queried, and downloaded.

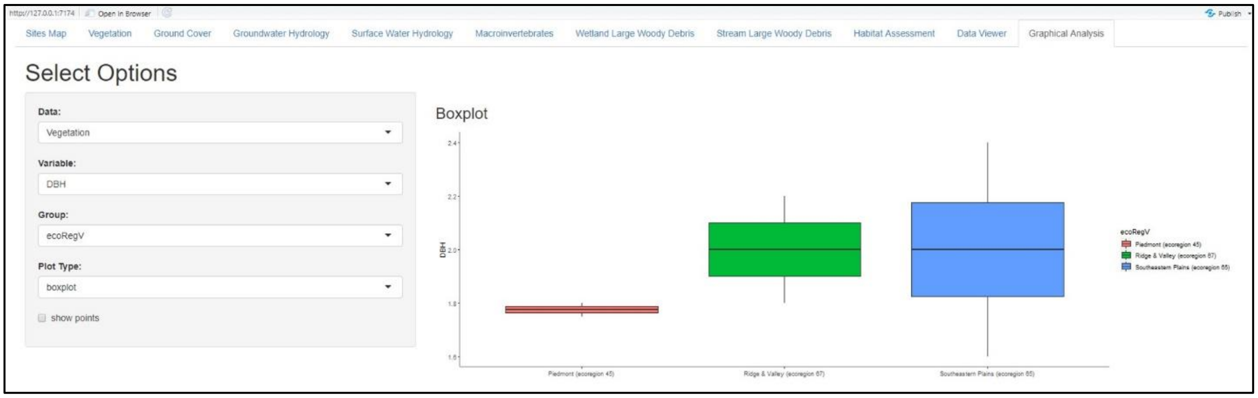


FIGURE 16: Graphical analysis tab, which allows data to be plotted for trend analysis.

Finally, the Georgia team produced a plan for scaling-up the database based on stakeholder input, lessons learned, and capacities developed through this pilot project (Objective 4). The plan for scaling-up the Georgia database was divided into three phases. Phase 1 encompasses pilot database development, which was accomplished under Objective 3 of the current project. Phase 2, which will last two years, will focus on implementing a soft launch of the database, beta testing, and iteratively building-out the database based on stakeholder feedback. During this phase, the team will work with USACE and other partners to lay the groundwork for requiring database use as part of the formal reporting process under mitigation evaluation guidelines, select a permanent host for the database, and design a funding model for long-term maintenance and hosting of the database. Phase 2 will conclude with the launch of the finalized database for use by all partners and the transition to the permanent hosting arrangement. Phase 3, which will begin at the conclusion of Phase 2, represents long-term hosting and maintenance of the database. This phase will require regular maintenance and user support, software/hosting updates, and adapting the database to meet evolving user needs. We estimate that these Phase 3 tasks will require about 20% of a data manager’s time. Specific details about the plans for scaling-up and implementing Georgia’s database can be found in Appendix B. The plans will also be circulated to all members of the Georgia mitigation community.

COMPATIBILITY OF DATA PRODUCTS

A long-term goal of the Framework is to develop capability to combine mitigation datasets from different state programs to be able to compare results among regions and assess overall condition on a regional or national level. To combine datasets from different agencies, the data needs to be in a similar format, or have data structures that can easily be matched or transformed (e.g., units) to correspond with variables across agencies. We used the preliminary results from the two pilot projects to evaluate the ability to combine data sets and to inform recommendations for future development of data tools.

In this section we evaluate the ability and effort required to combine completed vegetation data templates from mitigation projects in Georgia and Minnesota. This included one Excel file of database output from GA that had data for two example mitigation plots, and nine Excel files from MN, each with data for a separate plot.

Direct merging of all files as they currently exist is not possible, mostly due to differences in the assessment endpoints used. Some of the files expressed vegetation as a density (number of individual plant species per unit area), while other files used absolute cover (%) of each species, and one dataset used height and age (counts would be available by adding up the individuals of a species). These differences presumably reflect different mitigation performance objectives or data collection methods. Combining all datasets would be possible if a standard unit of measurement was used for each species, to derive either counts or percent cover for the data.

Other key differences among the files were the inclusion/omission of a sample date column and columns for site coordinates. Sample date is usually an important variable to include with all field data. It can be used to help combine additional indicators from a particular sampling period, or to help keep track of a mitigation project's age and succession. GIS data on the other hand may be included with the field data or maintained in a separate file that can be referenced by a plot (subplot) identification code.

The last difference to note among datasets is that some files had vegetation strata (e.g., tree, herbaceous, shrub-sapling) in separate sheets, while other files combined all strata measurements into a single sheet. While this would require additional effort to combine datasets, the type of data structure to use should be left to each agency to decide.

In conclusion, use of standard data templates and metadata forms made it easy to access and interpret the data from each state program. However, the ability to combine data sets to provide more integrative assessments would require states to adopt common data formats and assessment endpoints. Standard data formats developed through the National Wetlands Condition Assessment and National Rivers and Streams Assessment could form the basis of such standardization in the future.

HOW PILOT PROJECTS HAVE SUPPORTED APPLICATION OF THE FRAMEWORK

The intent of each pilot project was to demonstrate how investing in data management can help address the core questions of the Framework and establish a foundation for continued development of state capacity to evaluate mitigation program effectiveness.

1. How successful are mitigation sites/banks at achieving their ecological goals?
2. How effective has the overall program been at achieving its stated goals with respect to aquatic resource protection?
3. How resilient are compensatory mitigation sites/banks at replacing the intended functions over the long term?

Minnesota

With the enactment of WCA in 1991, the State of Minnesota expanded protection to wetlands not covered under a more limited permit program focused on lakes, streams, and large wetlands with persistent surface water. The new law established a goal of no net loss of the State's remaining wetlands. The comprehensive state approach to wetland protection combined with the requirements of the Clean Water Act Section 404 permitting program have created a regulatory framework where most wetland impacts require authorization as well as replacement of lost functions. With over 25 years of experience implementing these programs Minnesota has a wealth of information from which to evaluate the success in meeting protection goals such as no net loss. Since the inception of WCA data show that the State has met the goal of no net-loss of wetland area statewide, but it is unclear if wetland quality and function have been maintained. A review of wetlands between 2006-2014 observed no-net loss in area; however, concerns were raised regarding loss of wetland function due to conversions of wetland type[7]. A more recent study concluded that quality of depressional wetland mitigation sites 7-16 years after restoration was similar to quality observed in naturally occurring wetlands within the same region[8]. The evaluation of mitigation project success on a comprehensive, statewide basis has suffered from the same challenges seen in other states: disorganized data storage, varying report formats and mediums, and the absence of a structured approach and staff dedicated to a programmatic review of mitigation performance and assessment.

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[7] Kloiber, S.M. and D.J. Norris. 2017. Monitoring Changes in Minnesota Wetland Area and Type from 2006-2014. Wetland Science and Practice 34: 76-87.

[8] Strojny, C., J. Overland, and T. Smith. 2020. Assessing Wetland Quality of Depressional Wetlands to Refine Restoration Requirements and Strategies. Report for Grant No. CD-00E02072). Minnesota Board of Water and Soil Resources. https://bwsr.state.mn.us/sites/default/files/2020-11/CD%20-%2000E02072%20Final%20Project%20Report%2030Oct20.pdf

This pilot study has moved Minnesota forward in this context by supporting development of a data management system that, coupled with planned changes to the monitoring and reporting done during the mitigation site establishment period, will allow regular evaluations of program effectiveness and site resiliency. In addition, the structure of the MDMS allows for these evaluations to be conducted by agency staff directly involved in program implementation as well as individuals and organizations external to the regulatory programs. Although this pilot was specifically directed at building the infrastructure to collect and store mitigation site data and did not involve collection of field data to assess performance, BWSR is engaged in other efforts partially funded by the EPA to assess resiliency of mitigation sites. The data produced by these parallel efforts will be the first uploaded to the MDMS beginning in 2021. When the upload is completed, the MDMS will have vegetation community data for over 50 wetland bank sites across the state and hydrology data from 15 of these sites. Without development of the MDMS this information would be mostly unavailable outside of BWSR and would likely be lost for future assessments of resiliency because of the challenges associated with storage.

Georgia

Analysis of historical (pre-2018) mitigation data has been an immense challenge for agencies because the data were usually submitted in hard copy or PDF reports, meaning that data must be extracted and entered manually, which is a very inefficient process, and coupled with the volume of reports generated makes analysis very challenging. While the initial goal for the GA pilot database project was to begin addressing this issue by populating the database with historical data from a subset of sites to provide preliminary assessments of the ecological effects and resiliency of mitigation banks in Georgia, the project shifted focus away from this objective at the recommendation of several of key stakeholders, who believed that the lack of historical data standardization would make analysis of trends difficult or potentially misleading. Stakeholders noted that there historically was no standardized way to organize monitoring reports and collect and report many types of mitigation data in Georgia, and that the regulatory and scientific framework for data collection and reporting has evolved considerably over time, which would make comparisons between banks over time difficult to interpret. Thus, the pilot project focused largely on developing data compilation and entry standards to facilitate upload of current and future data into the electronic database, which will facilitate future mitigation evaluation in Georgia and permit the effectiveness of mitigation banks to meet ecological goals to be better assessed.

LESSONS LEARNED AND RECOMMENDATIONS

The two pilot projects were largely successful in that they (1) increased awareness and knowledge among agency staff and key partners on the needs and importance of managing compensatory mitigation data in a systematic way; (2) produced prototype systems that vastly improved data management capabilities; (3) provide a foundation for continued development and implementation of data management systems that will enhance the ability to answer the key management questions about compensatory mitigation program effectiveness; and (4) serve as examples for other states and programs that are considering developing their own wetland data management systems.

These projects generated important lessons that can inform continued pursuit of the goals of the Framework nationwide. The lessons learned, and associated recommendations have been grouped into three major categories of project management, technical approach, and stakeholder coordination (Table 1).

TABLE 1: Summary of key challenges and potential solutions identified during the case studies

	Issue	Potential Solution
Project Management and Scoping		
1	Desired objectives and product end points may not be clearly defined at the onset of the project from an IT/database architecture perspective	Clearly relate effort to programmatic goals. Consider utilizing user stories and clear descriptions when documenting specifications and work flows to provide as much detail as possible early in the process
2	Data access tools may be inconsistent with agency permissions and data policies	Scope development efforts to address access needs, such as server and firewall issues. Consult early to ensure appropriate data access specifications are included
3	Data products and formats may not directly address key questions	Include end users in development process
4	Third party IT contractors have limited familiarity with program scope and operations	Consider requiring vendors to have subject matter experts on team
5	Concern over the ability to manage and update the system over time as technology changes	Explore the use of standard formats or off-the-shelf applications with standard approaches vs. customized development
6	Costs and staff capacity for long term hosting and maintenance	Identify an agency hosted site or third party location (e.g., university) with dedicated funding or revenue source (e.g., fees)
Technical Approach		

Issue		Potential Solution
7	Difficulties in including legacy data due to changes in data collection metrics, standards, and quality	Identify and prioritize key legacy data sets and provide resources to digitize; focus database on present/future rather than trying to retrofit old data
8	Challenges with assessing long-term function/performance	Connect products with other available, current monitoring programs/data
9	Mechanism for data sharing/exchange with RIBITS or other data systems	Establish universal digital object identifier (DOI) or other unique identifiers and identify key data fields and coordinate via web services or application program interfaces (APIs)
10	Requirements for spatial and tabular data upload/storage are very different and could require different user interfaces	Identify data types and needs early and collaborate with IT staff to develop a workflow process and schematic that defines desired inputs and outputs and the relationships between spatial and tabular data.
11	Long-term monitoring data and mitigation site establishment data may have different objectives and/or varying collection methodologies	Identify core set of monitoring data for short- and long-term assessments and develop standardized methods
12	Need to make data collected at multiple sub-sites within each bank site (e.g., veg. plots) spatially explicit to facilitate post-hoc analysis, but these locations do not exist in single, standardized database	Create tool to allow banks to upload sub-site locations directly into the database as shapefiles or provide the ability to directly enter spatial information via points or polygons
14	Monitoring approaches are not standardized, and data collected for many metrics (e.g., vegetation) are not submitted in standardized formats across banks.	Create standardized data entry forms as part of the database using most up to date standards. Require data uploads to be standardized using either downloadable excel templates or a user interface within the application. Don’t focus on matching specifics from pre-existing data sheets
15	Need capability for “batch data upload tools” for many data entry types that require numerous inputs per site (e.g., macroinvertebrates, hydrology, vegetation) so that records don't need to be entered one at a time	Prioritize batch upload tool development and creation of downloadable excel templates to standardize formatting over development of single-entry forms in database app
Stakeholder Coordination and Outreach		

	Issue	Potential Solution
16	Coordination with other State agencies collecting and managing similar monitoring data	Identify POCs throughout state agencies with overlapping program areas early in process and involve IT staff in these discussions
17	Need to identify sentinel/reference sites with good long-term datasets to guide planning/assessment of other sites	Explore opportunities to partner/leverage other programs that may provide sentinel sites, e.g., ambient monitoring program, conservation programs. Consider development of regional reference site networks using a fee-based approach
18	Stakeholders' primary goal for the database is the ability to obtain/download raw data. Online analytical tools are a secondary priority.	Focus on aspects of the database that facilitate dataset querying and acquisition first, then create a few key example analytical tools, which can facilitate future discussion about developing an expanded suite of tools
19	Skepticism in user community about quality of older/existing data	Focus on future data collection and prioritize a selected set of past data to determine challenges and identify benefits of analyzing older data
20	Achieving consensus from stakeholder community on data input structure, priorities, and functionality of the database	Conduct outreach workshops to gain input and investment in products early in the process. Meet with key personnel to discuss examples and ideas for standardization and implementation protocols
21	Creating time-efficient opportunities for regular stakeholder engagement and feedback on database development.	Prioritize regular meetings with small groups of key stakeholders to share development progress and solicit feedback, which can allow more time for dialogue and reduce "information overload." Provide regular email updates to keep stakeholders engaged during periods when there is less tangible progress to showcase.

Scoping, Project Management and General Implementation

Agreeing on a clear set of goals and expectations and selecting (or building) the right project team are important early steps that influence progress and ultimate success of the project. Both teams emphasized the importance of early and frequent communication with their stakeholders to clearly define goals and establish a common vision for the desired outcomes and functionality. This vision is often refined over the course of a project, so ongoing communication is critical for ultimate success. The Georgia team invested time with stakeholders and end-users to build consensus around focused goals and well-defined end products. This not only built support for the project but established common expectations for the functionality of the products relative to the ability to address agreed upon questions/needs. However, they focused much of their effort on less frequent, larger stakeholder meetings and would have benefitted from increased communication with small groups of key stakeholders at more regular intervals between larger meetings to create more opportunities for iterative feedback on database development.

The Minnesota team outsourced the technical work to a third-party vendor. The Request for Proposal that was published for the wetland application did not require that the developer have individuals with wetland regulatory program familiarity or experience on their team nor did it require expertise working with GIS/Mapping programs. These were both identified as desired qualifications but were not required. The selected vendor did not have this expertise on their team which created significant communication issues associated with wetland mitigation terminology and familiarity with general program workflows. As a result, BWSR staff had to invest additional time to correct issues with functionality stemming from lack of subject matter expertise by the contractor.

Using off-the-shelf platforms for developing the data management system generally results in lower cost and greater longevity regardless of whether the work is done in house or outsourced. There are numerous data platforms that are commonly used and can be easily customized. These systems are typically more stable over time and can be more readily updated. Using such systems also reduces the likelihood of creating a system that is difficult to update or becomes obsolete due to its reliance on specific expertise or familiarity. However, the Minnesota case study lost some of the flexibility associated with developing a standalone version of their data system because vendors and state information technology staff gravitated towards consistency in approach for the entire application rather than making use of off-the shelf software that may have been more efficient or practicable for a single purpose application.

Finally, because all systems must be maintained and updated over time, it is critical to identify the intended long-term steward of the products and involve them in the scoping process. This will ensure that ease of maintenance is considered in the design and improve familiarity with the ultimate product by the entity ultimately charged with implementation. For states such as Minnesota that have an established program and internal state capacity, long-term stewardship can be incorporated into existing information technology programs and maintained using state resources or permit related fees. For states such as Georgia that lack an established program, a third party, such as university or local agency or conservancy may be able to serve as a long-term data steward. Reaching this stage in Georgia will require a two-year intermediate phase focused on a soft launch of the database, beta testing, database build out, and implementation. This phase will require a full-time database manager, along with additional staff support and web hosting service fees, which in total are estimated to cost approximately $120,000 annually. Long-term hosting and management of the database beyond the intermediate phase will require funding for a web hosting service and a significant portion of a database manager's time (estimated approximately 20%) to perform regular maintenance and user support, software and hosting updates, and adapt the database to evolving user needs, which is estimated to cost approximately $26,000 annually. For such a program to succeed permitting agencies (e.g., ACOE, State programs) should require mitigation monitoring data to be submitted to the designated database in specified formats (or using specified templates). In addition, the data stewardship entity will need a funding mechanism to maintain the data system (e.g., fees, grants, or dedicated internal funding).

Technical Approach

Creating standard data templates and mechanisms for data queries, access and linkages can address many of the technical challenges associated with developing data management systems. Both pilot projects identified a broad range of data types that can be produced in different formats (e.g., tabular, spatial, time series). Creating standard data templates in flat-file format was found to provide the maximum flexibility in accommodating a variety of data types. This approach can accommodate batch upload of data in addition to data entry via a user interface, which was a desire articulated by many stakeholders. Standard data templates also allow for the development of automated data checkers and automated data analysis, which can improve data quality and support timely and readily available data analysis.

Both pilot projects also identified a priority for providing linkages with other data systems through web services or application program interfaces (APIs). Such linkages can support connections with other data sets, such as hydrology data sets collected by the Department of Natural Resources in Minnesota. They can also make it easier to connect with existing wetland data sets, such as those maintained by US Fish and Wildlife Service and private bankers in Georgia.

How to accommodate legacy data was a challenge for both case studies. There is broad agreement of the important context provided by historic data sets, particularly for questions of resiliency and long-term success. However, integrating these data sets is challenged by lack of compatibility in data formats or unavailability of older data in digital form. One potential solution is to identify priority legacy data sets and use them to demonstrate the process, challenges, and benefit of incorporating them into contemporary data systems. These initial experiences can be used to determine which data sets provide sufficient benefit to warrant the investment necessary to integrate them into current data systems and to develop a strategy for accomplishing this integration. It has a secondary benefit of aiding in tool development by providing test data that can be used to refine data structures and analytical methods.

Stakeholder Coordination and Outreach

Conducting outreach workshops to gain input and investment in products early in the process is critical to eventual acceptance and use of any data management system. Both pilot study teams met with key personnel to discuss examples and ideas for standardization and implementation protocols early in the process. The Georgia team would recommend balancing larger workshops with more frequent, targeted meetings with key stakeholders to allow more opportunities for specific feedback on database development and modification and reduce “information overload.” In Minnesota, additional coordination would have been beneficial as well. Because of scheduling issues during development of the MDMS, BWSR staff was not able to include a stakeholder coordination task in the contractor’s scope of work and was forced to independently make decisions on data collection methods, standardization, and reporting that may have been better discussed in a broader interagency forum. In the future, they recommend a more coordinated up-front approach to identify stakeholder needs in advance of project scoping and establishment of a standing interagency workgroup to provide input when needed during the process. This would also be beneficial in adjusting agency policy to orient the state and federal wetland mitigation programs to direct monitoring data towards the local data management system and having it serve as a repository for all long-term monitoring data.

Sentinel sites provide important context for assessing resiliency of compensatory mitigation sites and long-term program success. These sites can often come from other programs such as ambient monitoring under water quality programs, status and trends sites, or conservation sites from wildlife or sensitive species protection programs. Considerable long-term benefit can be achieved by broadly surveying agency and community programs, watershed plans, and stakeholder groups to identify candidate sentinel sites with permanent protection or management. This allows targeted effort and resource allocation at sites with the greatest potential benefit for long-term monitoring. Early and ongoing communication helps identify these partnership opportunities, build collaborations, and account for data sharing between programs in design of the data management system from the onset of the program development process. For example, in Minnesota the Department of Natural Resources has assumed the lead role in establishing wetland hydrology reference sites across the state to gather data that can be used in permit decisions, mitigation site assessment, and long-term trend analysis. Other state and federal agencies have participated in the site selection process and the data will be available through the State’s Cooperative Groundwater Monitoring Program.

FUTURE EFFORTS

Conclusion of the pilot project does not constitute completion of the desired work for either state. Both states hope to build on the foundation of their initial efforts and continue to enhance their data management systems to support evaluation of compensatory mitigation. Future efforts will include:

- Expanding standard data templates and checkers to include additional data types
- Providing expanded functionality for batch uploads of data
- Improving capacity to accept and manage geospatial data
- Retrofitting historical data for inclusion in the data management system
- Expanding data query capabilities to better cross-link different data types and sources
- Developing tools to facilitate graphical analysis of data trends
- Automating routine data analyses to hasten output to end-users
- Securing commitments and funding for long term hosting and stewardship
- Enhancing dynamic data linkages with other data systems to better leverage data between programs

Robust data management is an important tool for full implementation of all three modules of the Framework, performance evaluation, program effectiveness assessment, and determination of long-term resiliency. A mature compensatory mitigation evaluation program will include infrastructure, staffing, funding, and partnerships necessary to support all three modules and to provide ready access to the data and information produced through these evaluations. This will in turn allow for ongoing program refinement and ongoing evaluation. As states work to improve their capacity for managing and analyzing data to assess compensatory mitigation effectiveness, USEPA will need to develop tools and approaches to synthesize state data into regional or national data sets. This will involve aligning and reconciling data fields, checking data accuracy and completeness, and compiling metadata (among other challenges). Only through development of these tools will larger/national evaluations of compensatory mitigation program effectiveness be possible.

Next Steps for Minnesota Program

<u>Technical</u>

- Link the newly developed database to a groundwater monitoring database managed by other state agencies such that hydrology data collected at wetland mitigation sites will be stored in a larger statewide database that can be accessed through a web-based application.

- Develop capacity for vegetation data to be accessible to external users (outside of BWSR) through a web-based interface. Although this data will not be integrated with wetland condition data collected by other agency staff in Minnesota it does provide a platform to build on and satisfies a short-term goal of organizing the data and making it available through a web-based interface.

- Upload data collected as part of recent long-term monitoring studies. Working with the other state and federal agencies in Minnesota establish a requirement for mitigation sites leaving the establishing monitoring period to provide standardized vegetation and hydrology data that will serve as a baseline for future monitoring as part of assessing site resiliency.

- Establish a process for determining historical wetland mitigation sites for which establishment data will be obtained from files and loaded into the MDMS.

- Develop automated quality control process to verify well identification number provided by the MDMS user is associated with the location information for the identification number in the state database.

Testing/Refinement

- Develop a protocol to integrate taxonomic changes into the MDMS data checker.

- Increase MDMS functionality by adding the ability to calculate standard metrics of interest, such as percent native cover, native species richness, and measures of floristic quality.

- Enhance user interface for accessing uploaded vegetation and hydrology data through improvements to BWSR website and GIS web maps.

Outreach

- Once long-term monitoring data processes have been established and successfully implemented, efforts will be directed toward integrating reporting and data collection from the establishment period into the MDMS so that all monitoring data for mitigation sites can be collected and stored in one location.

- Provide training to stakeholders on access to, and use of, the MDMS to increase awareness and familiarity.

Next Steps for Georgia Program

Technical

- Develop general user instructions document to serve as a database homepage to guide new users.

- Work with stakeholders to fine-tune QAQC protocols for specific data fields and locate missing spatial data (e.g., bank boundaries) for inclusion in the database.

- Expand QAQC protocols (e.g., coordinate system) for sampling site shapefile upload tool.

- Create additional query fields in data viewer tab to allow users to better filter data by fields of interest.

- Expand pilot graphical analysis tool to better allow users to explore trends in data.

- Decide on best way to link vegetation data with soil series (currently there is a placeholder text field).

Testing/Refinement

- Allow stakeholders to begin uploading sample datasets to beta test database and allow them to provide feedback on processes that were unclear or bugs that they encountered, which can then be iteratively addressed.

Outreach

- Circulate plan for beta testing, "going live," and scaling up the database within Georgia mitigation community.

- Once technical and testing objectives have been accomplished, share the link to the online database with all stakeholders in the GA mitigation community and encourage them to begin uploading recent datasets.

APPENDIX A: OVERVIEW OF MINNESOTA PILOT PROJECT

Section 1 Agency Overview

1.1 Key agencies and general structure

Alterations to lakes, rivers, streams and wetlands in Minnesota are regulated by a mix of programs administered by state and local governments. The main state water/wetland regulatory programs in

Minnesota is described briefly below.

- CWA Section 401 – authorizes state agencies to impose conditions or prevent issuance of Section 404 permits to ensure compliance with state water quality requirements; administered by the Minnesota Pollution Control Agency (MPCA).
- Public Waters Permit Program (PWPP) – regulates alterations to the course, current or cross section of public waters and public waters wetlands; administered by the Minnesota Department of Natural Resources (DNR). Public waters are a defined subset of all lakes, streams and wetlands meeting certain criteria.
- Water quality standards – regulates point source and non-point source discharges and physical alterations of wetlands. Generally applied through other regulatory programs, such as National Pollutant Discharge Elimination System (NPDES) permits or Section 404 permits. Administered by the MPCA.
- Wetland Conservation Act (WCA) – regulates draining, filling, and in some cases excavation in all wetlands exclusive of public waters wetlands; administered by local governments with oversight from the Minnesota Board of Water and Soil resources (BWSR). In state statute and rule, authorizations under WCA to impact wetlands are not referred to as "permits" – impacts are authorized under exemptions, no-loss determinations and wetland replacement plans.

Although the agencies administering each of these programs have the authority to require mitigation to offset approved impacts to waters/wetlands by far the most active program with respect to mitigation is WCA. Referred to as wetland replacement under this program, WCA requires that no person may impact a wetland, wholly or partially, without being eligible for an exemption, receiving a no-loss determination, or first having a wetland replacement plan approved by the local government unit. The requirement for replacement for most wetland impacts under WCA creates a significant demand for wetland replacement. In calendar year 2018, WCA local government units approved 175 replacement plans (i.e., permits) resulting in 84.23 acres of wetland impact. This does not include wetland impacts associated with local government road improvement projects which, based on historical wetland credit usage, would double this impact amount. Responsibility for the monitoring of wetland replacement sites (i.e., mitigation site) is divided based on the time that has elapsed since construction. The establishment period, roughly defined as the time from construction through the fifth full growing season, is done by the mitigation project sponsor with review and oversight provided by ACOE, BWSR, DNR, and the local government unit with jurisdiction over the site under WCA. After the establishment period, BWSR takes over long-term monitoring with the focus primarily on compliance with the conservation easement recorded in favor of the State of Minnesota.

1.2 Authorities

1.2.1 Minnesota Wetland Conservation Act

The Minnesota Wetland Conservation Act (WCA) was enacted in 1991 to protect wetlands not protected under DNR's public waters permit program and to provide no net loss of Minnesota's remaining wetlands. The basic requirement is that "[w]etlands must not be drained or filled, wholly or partially, unless replaced by restoring or creating wetland areas of at least equal public value under a[n approved] replacement plan." (Minn. Stat. § 103G.222, subd. 1(a)). As a result of legislation adopted in 2000, the WCA also applies to excavation in permanently and semi permanently flooded areas of types 3, 4, and 5 wetlands (See Minn. Stat. §103G.222, subd. 1).

1.2.2 Minnesota DNR Public Waters Permit Program (MnDNR PWPP)

Work in public waters has been regulated by the Minnesota Department of Natural Resources ("DNR"), or its predecessor the Department of Conservation, since 1937. The basic rule is that a public waters work permit must be obtained from the DNR for work affecting the course, current, or cross-section of public waters, including public waters wetlands (See Minn. Stat. § 103G.245, subd. 1(2)). This would include, for example, work involving draining, filling, excavating, and placing structures in public waters wetlands.

Public waters wetlands are a subset of the broader category of "public waters" regulated by the DNR, which includes most lakes and larger streams and rivers. Public waters and wetlands have been inventoried by the DNR and are shown on maps for each county. Public waters wetlands are defined in statute as follows:

> "Public waters wetlands" means all types 3, 4, and 5 wetlands, as defined in United States Fish and Wildlife Service Circular No. 39 (1971 edition), not included within the definition of public waters, that are ten or more acres in size in unincorporated areas or 2-1/2 or more acres in incorporated areas."

In general, PWPP rules stipulate that, "The commissioner may not issue a permit that causes pollution, impairment, or destruction of the air, water, land, or other natural resources so long as there is a feasible and prudent alternative consistent with the reasonable requirements of the public health, safety, and welfare."

1.3 General goals and mandates

The purpose of the WCA is to:

a. achieve no net loss in the quantity, quality, and biological diversity of Minnesota's existing wetlands;

b. increase the quantity, quality, and biological diversity of Minnesota's wetlands by restoring or enhancing diminished or drained wetlands;

c. avoid direct or indirect impacts from activities that destroy or diminish the quantity, quality, and biological diversity of wetlands; and

d. replace wetland values where avoidance of activity is not feasible and prudent.

Applicants seeking to impact a wetland where submission of a replacement is required must demonstrate that they have exhausted all possibilities to avoid and minimize wetland impacts according to the sequencing requirements codified in rule. In addition, the applicant must also provide information documenting that the replacement site meets the standards and guidelines in rule to ensure adequate replacement of wetland function and value.

Section 2 Overview of mitigation components of the state program

2.1 The Minnesota Wetland Bank

Under Section 404 of the Clean Water Act and Minnesota state regulatory programs, unavoidable wetland impacts are potentially subject to compensatory mitigation unless a specific exemption from this requirement exists. As the name implies, the goal of compensatory mitigation, or wetland replacement, is to compensate for or replace the functions and values that the impacted wetland provides. Minnesota state agencies and the ACOE have worked together for many years to achieve consistency between state and federal policy regarding compensatory wetland mitigation, and the ability of the COE to adapt their more flexible policy to changes in WCA rules has contributed to this consistency. In most instances, wetland mitigation projects that meet state requirements will also meet federal requirements and vice versa. Minor differences are generally the result of inconsistencies between COE, St. Paul District policy and WCA rules, rather than conflicts between state statutes and the Federal Mitigation Rule.

Both the state and federal regulatory programs in Minnesota have a stated preference in regulation/rule for mitigation that is completed in advance of the authorized impacts. Although some permittee responsible, or project-specific, mitigation is still used today the vast majority of the wetland mitigation in Minnesota is accomplished through wetland banking. Minnesota has one of the most active and robust wetland banking markets in the country with an estimated 400 wetland banks approved since inception of the Minnesota State Wetland bank in the 1990s. The strong demand for credits affects both the project development part of the program and the transaction side of the program. The state has documented a significant increase in the number of wetland bank documents submitted for review over the past three years with just over 80 different submittals in 2019. On the transaction side, staff at BWSR have processed approximately 305 wetland banking transactions per year (withdrawals, deposits, and transfers) between 2015 and 2019. Despite a strong wetland banking program and the high volume of wetland banking activity BWSR is pursuing an in-lieu fee (ILF) program. The ILF is specifically designed to service public transportation projects to assist local and state road authorities with obtaining mitigation credits for projects in a predictable and efficient manner.

2.2 Number of Mitigation Sites included

Once the MDMS is open for production in 2021, BWSR staff will begin entering data for sites that have been the focus of three recent USEPA grants focused on long-term condition monitoring of restored wetlands. Two of these grants are directed specifically at vegetative quality and the other is looking at hydrology. Results from the completed study can be found on BWSR's website. This BWSR led effort will result in long-term vegetative monitoring data (from 5 to 15 years post-construction) for approximately 50 wetland bank sites to be publicly available. In addition, hydrology data for 15 wetland bank sites in southern and southwestern Minnesota will also be uploaded and available. The MDMS also will be accessible for other agency staff and consultants to upload data on a voluntary basis. Additional coordination will be conducted in the near future to establish and implement procedures that will require wetland bank sponsors to collect and submit monitoring data into the MDMS for their projects as part of each site's monitoring requirement.

2.3 Timeframe covered by assessments

Post-construction monitoring of mitigation sites in Minnesota is the responsibility of multiple parties depending on the type of compensation site and the time that has elapsed since construction was completed. All mitigation sites in Minnesota are monitored from the time construction activities are completed (earthwork and initial vegetation establishment) until the site has met performance standards as determined by the federal, state, and local agencies with jurisdiction over the site. This is referred to as the establishment period. For wetland banks, both the federal and state programs require the site to be monitored for five years unless there is justification for a longer duration (e.g., wooded sites or bog restorations). Permittee responsible, or project specific, mitigation sites have less stringent monitoring requirements but still must demonstrate that the site has achieved the functional goals established in the approved mitigation plan. Establishment period monitoring is the responsibility of the wetland bank sponsor or the permittee in the case of project specific mitigation. Once the establishment monitoring period has ended the site enters what is referred to as the long-term monitoring phase. Long-term monitoring is handled differently for project specific and wetland banking sites.

Once the establishment period has concluded project specific mitigation sites are only monitored if a regulatory agency randomly conducts an inspection or if a specific issue is identified that requires attention. Follow-up assessments to evaluate resiliency and overall functional condition for permittee responsible mitigation are infrequently performed by state and local agencies implementing WCA. Specifics regarding follow-up assessments by federal agency staff are not available but is assumed they are equally as infrequent.

Wetland bank sites in Minnesota are subjected to a more structured inspection approach because of a rule that requires BWSR to periodically inspect wetlands associated with the wetland banking program to ensure that easement conditions are being met. The frequency is not specific in rule but BWSR has loosely adopted an approach that sets a goal of conducting at least a desktop review of each site every three to five years. Site visits are conducted where a desktop assessment identifies a potential issue at a site. The periodic inspections have not been focused on collecting site data to assess wetland condition in the context of resiliency. Instead, the inspections have focused on easement violations such as encroachment, vegetation alteration, signage requirements, trails, and structure maintenance and modification. BWSR's approach to long-term monitoring changed significantly in 2016 when the EPA awarded a Wetland Program Development Grant (WPDG) to assess the long-term condition of wetland mitigation sites, wetlands restored for other conservation programs, and unrestored reference wetlands. The study, which concluded in 2020, focused on the mixed woods plains and temperate prairies ecoregions of Minnesota and documented vegetative community condition at 32 wetland bank sites. Although resiliency is not mentioned specifically in the grant application, one of the primary objectives of the 2016 study is to assess this mitigation site attribute by focusing on sites that were 7-16 years post restoration. The study focused on depressional wetlands and found mitigation sites to have similar floristic quality as naturally occurring sites. In recognition of the value of the 2016 study, BWSR has received additional WPDGs from the EPA to study hydrology of restored sites in the same geographic area of the 2016 effort (focusing on many of the same sites) and to continue vegetative condition assessments throughout the rest of the State. Although these efforts are heavily subsidized through the award of EPA WPDGs, BWSR intends to use these initial studies as the baseline for a more comprehensive long-term monitoring approach that will assess resiliency at mitigation sites at regular intervals using standardized methodologies.

2.4 Resources (staff, budget, etc.)

BWSR is responsible for oversight of implementation of the WCA in Minnesota. This includes the day-to-day operations of a statewide regulatory program but also the responsibility for managing the State Wetland Bank and satisfying the requirements in statute and rule for the monitoring and enforcement of conservation easements. BWSR employs a Wetland Mitigation Monitoring Specialists who is the agency lead for planning, developing, and managing monitoring programs for wetland mitigation sites. These tasks are split between programs focused on long term monitoring of mitigation sites and those associated with establishment monitoring of BWSR sponsored wetland banks. Currently, this employee spends approximately 60% of their time annually on long term monitoring activities. The Wetland Mitigation Monitoring Coordinator position is supplemented by seasonal hires who are hired to conduct monitoring during the growing season in Minnesota (April through September). These seasonal staff typically add 0.5 to 1.0 full-time employees to BWSR each year. Additional staff assist with planning and implementing hydrology monitoring activities. Without this assistance it would be difficult to conduct site inspections at more than 10 to 15 sites annually.

Section 3 Objectives of the case study – what are you trying to accomplish

The study will enhance BWSR's ability to effectively manage monitoring data collected at wetland mitigation sites by developing a comprehensive data management system specifically for wetland mitigation sites. The ability to collect, organize, and make monitoring data available for analysis will help inform future program policies regarding compensatory mitigation. Minnesota has invested considerable resources in monitoring the status and trends of wetlands but lacks the ability to efficiently collect and integrate data from mitigation sites to evaluate overall program success and to integrate our mitigation programs with other status and trends data.

A new data management system, referred to as the Monitoring Data Management System (MDMS), will be integrated into the framework of a new wetland mitigation database currently being developed by BWSR. Funding for the study was used for five specific tasks. These include: (1) developing the business requirements of the monitoring module in the database; (2) developing standardized forms and processes for the collection of monitoring data; (3) compiling wetland mitigation site metadata; (4) building the MDMS; and (5) testing the monitoring module and refining any data collection, submission, or standardization processes. Consistent with the preliminary recommendations in the soon to be published technical report addressing the evaluation of stream and wetland compensatory mitigation, the final version of the monitoring module will be driven by electronic data flow that is stored, presented, and accessed in a geospatial format. The stored data would be accessible via a web-based application operated and maintained by BWSR. BWSR currently provides wetland bank credit availability and site location information in a similar manner using a web-based tool on our agency website. Providing access to monitoring data would benefit local, state and federal agencies involved in the regulatory programs in Minnesota as well as researchers, academics, and other individuals and/or organizations interested in assessing the success of mitigation activities.

Section 4 Main Challenges

The opportunity to develop the MDMS came at a time when BWSR was planning for replacement of its FoxPro based wetland banking database. Combining these two projects into one single project resulted in several significant challenges. Those associated with the MDMS are described below.

<u>Development Schedules and Prioritization of Functionality</u>: The more comprehensive database replacement project involved the development of an application with five functional areas, or modules, with the MDMS being housed within the monitoring module. The development schedule provided by the vendor had the modules built in series which resulted

in a silo approach and impacted the schedule when a module fell behind. Further, because other modules were determined to be higher priority for implementation of the State's wetland mitigation program the MDMS was pushed back in the schedule and was eventually released as part of the second version of the wetland application because of scheduling issues.

Qualifications of the Development Team: The Request for Proposal that was published for the wetland application did not require that the developer have individuals with wetland regulatory program familiarity or experience on their team nor did it require expertise working with GIS/Mapping programs. These were both identified as desired qualifications but were not required. The selected vendor did not have this expertise on their team which created significant communication issues associated with wetland mitigation terminology and familiarity with general program workflows.

Software Requirements/Options: As part of a larger database project, some of the flexibility associated with developing a standalone version of an MDMS like application was lost because vendors and state information technology staff gravitated towards consistency in approach for the entire application rather than making use of off-the shelf software that may have been more efficient or practicable for a single purpose application.

Other challenges not necessarily associated with the development approach are described below.

Agency Coordination and Consideration of Future Directions: Support for development of the MDMS was consistent throughout BWSR and other regulatory agencies in Minnesota. However, agreement on assessment methodologies and reporting protocols was not sought and obtained prior to initiation of the MDMS build. Instead, BWSR relied on its experience with conducting wetland condition assessments as the basis for setting the standards for the MDMS with respect to data upload especially data associated with vegetation. While this is not anticipated to be problematic from an agency coordination and concurrence standpoint there were situations where the MDMS build forced BWSR staff to make decisions on data collection methods, standardization, and reporting that may have been better discussed in a broader interagency forum. A more coordinated up-front approach to the MDMS and a standing agency workgroup to provide input when needed during the process would have been useful during the process. This would also be beneficial in adjusting agency policy to orient the state and federal wetland mitigation programs to direct monitoring data towards the MDMS and having it serve as a repository for all long-term monitoring data.

Section 5 Approach and Strategy Used

5.1 Staffing

Staffing support for the MDMS study was focused on the vendor development approach used for the larger BWSR database replacement project. Using a competitive request for proposal process, a third-party vendor was selected through a submission evaluation process that included members with expertise in information technology and wetland banking subject matter experts (preferred but not required). The contract, and communications with the vendor, was managed by Minnesota Information Technology Services (MNIT) who is the information technology agency for Minnesota's executive branch. MNIT provided a dedicated project manager and access to several staff who are assigned to a BWSR support team that aids with the development of new applications and the maintenance of existing ones. The Wetlands Section at BWSR provided a single point of contact that was familiar with the existing wetland banking application and the wetland banking program in general. This person provided direct input to the development process but also was responsible for obtaining input from other BWSR Wetlands Section staff when necessary. A summary of the MNIT/BWSR development team is provided in the table below.

TABLE A1: Summary of Minnesota Development Team.

Position	Agency	Roles/Responsibilities	Membership
Project Manager	MNIT	Manages contract, liaison between vendor and State agencies	Standing
Application Support Specialist	MNIT	Provides technical input regarding state data management requirements and standards.	Standing
GIS Specialist	MNIT	Provides technical support regarding geospatial data, data standards, and workflow processes	Standing
Wetland Mitigation Coordinator	BWSR	Wetland mitigation program subject matter expert	Standing
Various	BWSR	Wetland mitigation subject matter experts (monitoring, plant identification, hydrology, etc.)	As needed

5.2 Software Used

The MDMS is part of a larger effort by BWSR to replace an existing FoxPro application that was used to manage wetland banking activity in Minnesota regulated under WCA. The goal of the larger project was to replace the existing FoxPro application with an Oracle (or other) based solution that is able to meet all activities and specifications required by BWSR. The respondents to the State's RFP were given the flexibility to propose to develop/modify an existing application (if licensed to do so) or to build a new application as long as it could be demonstrated the solution would meet all business requirements and meet or exceed performance expectations.

The selected vendor chose to develop the wetland application on a Windows .Net platform as a web hosted service on the internal BWSR network with server-side session-based authentication. The web components will be Angular developed with a focus on security and accessibility so the application will meet current State of Minnesota standards. The application data will be hosted in an Oracle 12.x relational database.

Section 6 Outcomes

6.1 Products Produced

The MDMS consists of an Oracle based electronic data upload and retrieval system designed specifically for data associated with long-term monitoring of wetland mitigation sites. The application accepts vegetation and hydrology data for sites for multiple monitoring periods/events. General information regarding the mitigation site is in the application prior to monitoring or will be entered by BWSR to establish the site in the MDMS. Users have the opportunity to upload maps identifying the assessment area and sample locations for vegetation data. Hydrology data is associated with a well location and will be identified as time series data or manual readings. Data previously entered in the application will be displayed to users through a public GIS interface that shows the location of the mitigation sites in Minnesota and the types of data available at that location. For data retrieval, users will be directed to the Cooperative Groundwater Monitoring application for hydrology data, or an interactive site with filters for vegetation data downloads.

6.2 Capacities Developed

Development of the MDMS provides BWSR, and the State of Minnesota, the ability to compile, save, and make available long-term wetland mitigation site data. This is a significant improvement over the hard copy and/or disorganized electronic filing systems that exist currently. The MDMS allows monitoring data to be linked digitally with the wetland banking database where information on the site, conservation easement, and credit transactions are maintained. Further, the MDMS will be linked to spatial data for wetland mitigation site easements that is obtained during the establishment of the mitigation site as well as compliance data collected as part of BWSR's statutory responsibility to periodically inspect easements for these sites. The MDMS will bring these previously disconnected agency processes together thereby increasing BWSR's ability to assess the success of the wetland mitigation program.

6.3 Partnerships or Leverage Opportunities Enhanced

The State of Minnesota has three agencies participating in the regulation and assessment of wetlands. As expected, this has created silos between the programs with respect to the collection, storage, and availability of monitoring data. Efforts to address the barriers associated with wetland monitoring data began many years ago and progress has been made. However, many challenges remain and one of the most significant from a regulatory program perspective was the vast amount of data collected each year for the monitoring of wetland mitigation sites and the inability to access and make use of this information for purposes other than single site evaluations. This pilot study identified several opportunities to share this information outside of the regulatory arena. First, the MDMS will be linked to a groundwater monitoring database managed by other state agencies such that hydrology data collected at wetland mitigation sites will now be stored in a larger statewide database that can be accessed through a web-based application. Second, vegetation data will now be accessible to external users (outside of BWSR) through a web-based interface. Although this data will not be integrated with other wetland condition data collected by agency staff in Minnesota it does provide a platform to build on and satisfies a short-term goal of organizing the data and making it available through a web-based interface.

Section 7 Lessons Learned

The MDMS process was part of a larger database development project undertaken by BWSR to replace and upgrade an outdated application. In some ways, this combined approach was beneficial and in others it was a detriment to MDMS development. Combining the MDMS with a broader scale project was beneficial from a cost and staffing perspective because it took advantage of a dedicated team of IT program staff. It also allowed the architecture of the MDMS to be designed and integrated into the larger database as part of the build process as opposed to being done separately and facing limitations from existing applications. The downside of this approach were the competing priorities and schedules associated with other parts of the application. For example, the most important part of the application was the wetland bank accounting and transaction module. Because of its importance, this module was prioritized over other functional areas and had more of an influence on schedule and resource decisions. This ultimately led to work on the MDMS being deferred to make sure higher priority functionalities were completed and implemented on schedule.

The MDMS was completed using a third-party vendor selected using a competitive selection process. The request for proposal did not require respondents to have wetland banking expertise as part of their team (it was identified as a preferred quality). In hindsight, this stands out as our biggest mistake with the pilot. Bridging the knowledge gap between the world of wetland mitigation and information technology is a significant challenge and one that should not be overlooked. Requiring a third party vendor to have a member(s) of their team familiar with wetland mitigation or wetland regulatory program work flows would save staff time for the agencies involved in the project as well as reduce the number of iterations during review that result from basic misunderstandings. Other relevant lessons learned from this project are listed below.

- Invest ample time in defining business requirements and work flows before starting the project. Although there will always be items that require further definition during the process, spending time up front to establish a workflow and system components will reduce the time spent sorting out basic questions later.

- Utilize user stories (narrative case studies) from subject matter experts to illustrate processes for those unfamiliar with wetland mitigation.

- Utilize staff from other agencies who have worked through similar processes and can share their experiences. Minnesota is very active in developing applications to collect and store natural resource data. The MDMS process benefitted from work done by other agencies but many of these similar efforts were unknown at the beginning of the process.

Section 8 Conclusions and Roadmap for the Future

The MDMS is the first step in a comprehensive reevaluation of tracking mitigation site monitoring. The MDMS moves long-term monitoring of these sites in Minnesota from a disorganized multi-media approach to a centralized digital storage and access portal. Integrating vegetation and hydrology data with geospatial attributes from the mitigation sites will improve the quality and usability of the data while improving accessibility for users outside of BWSR. BWSR's near-term goal is to upload long-term monitoring data collected as part of recent studies and establish a requirement for mitigation sites leaving the establishing monitoring period to provide standardized vegetation and hydrology data that will serve as a baseline for future monitoring as part of assessing site resiliency. Once long-term monitoring data processes have been established and successfully implemented, efforts will be directed toward integrating establishment reporting and data collection into the MDMS so that all monitoring data for mitigation sites can be collected and stored in one location.

APPENDIX B: OVERVIEW OF GEORGIA PILOT PROJECT

Section 1 Summary of state program assessing mitigation performance

1.1. Key agencies and general structure

Georgia's compensatory mitigation program is administered by the U.S. Army Corps of Engineers (ACOE) Savannah District under the auspices of the Clean Water Act Section 404 program, with minimal involvement by state agencies. The mitigation banking program in the state is quite robust, since the Savannah District was an early adopter of the banking concept and began permitting mitigation banks in the early 1990s. Today, the vast majority of compensatory mitigation in Georgia occurs in mitigation banks. Monitoring of mitigation banks occurs pursuant to the District's 2018 Standard Operating Procedure for Compensatory Mitigation, associated guidance, and individual banking instruments. There is currently no central database for cataloging monitoring data, and no long-term performance or resiliency monitoring is required beyond that dictated by permit conditions.

1.2. Authorities

Compensatory mitigation in Georgia is almost entirely conducted pursuant to the Clean Water Act Section 404 program administered by the USACE Savannah District. State agencies have a very limited role – the Georgia Environmental Protection Division (EPD) of the state's Department of Natural Resources may impose conditions on or prevent issuance of 404 permits under Clean Water Act Section 401, require compensatory mitigation as a condition of stream buffer variances required under the state's Erosion and Sedimentation Act, or require compensatory mitigation as a component of consent orders. Compared to what is required under the 404 programs, however, the compensatory mitigation resulting from these authorities is quite small.

The USACE Savannah District began its wetland mitigation program in the early 1990s, and approved Georgia's first mitigation bank in 1992. In 2000, it became one of the first ACOE districts in the country to include streams in its program. Today, the Savannah District, which encompasses the entire state of Georgia, relies on mitigation banks for the vast majority of compensatory mitigation required for 404 permits. The Savannah District allows both public and private entities to own and operate 404 mitigation banks. Public entities owning banks include the Georgia Department of Transportation and some local and county governments. Private entities include mitigation banking firms, private landowners, timber companies, and Georgia Power. The Savannah District also oversees the state's In-Lieu Fee (ILF) program, which is sponsored by the Georgia-Alabama Land Trust (GALT). GALT collects fees from 404-permittees when there are no available mitigation credits in the permitted project's service area; when enough fees in that service area are collected, GALT requests proposals to develop a mitigation project there.

1.3. General goals and mandates

Mitigation bank development is currently guided by the USACE Savannah District's 2018 Standard Operating Procedure for Compensatory Mitigation (2018 SOP). Mitigation bank performance monitoring is guided by the Savannah District's 2018 Draft Monitoring Guidelines & Performance Standards for Freshwater Wetlands and Non-Tidal Streams (Monitoring Guidelines). These guidelines are designed to support the District's Freshwater Wetland HGM (Hydrogeomorphic) for Georgia and its Georgia Interim SQT (Stream Quantification Tool), which are used to calculate permitted projects' mitigation debits and compensatory mitigation project credits under the District's 2018 SOP, described below. The Monitoring Guidelines cover the following areas:

- General monitoring requirements
- Evaluation of normal precipitation and growing season
- Freshwater wetland monitoring
    - Vegetation monitoring
    - Prevalence index
    - Wetland hydrology monitoring
    - Large woody debris monitoring
- Non-tidal stream monitoring
    - Vegetation monitoring
    - Vegetation monitoring in streamside vegetation zones
    - Vegetation monitoring in riparian zones
    - Stream channel geomorphology and stream hydrology monitoring
    - Biological monitoring
    - Stream water quality monitoring
    - Large woody debris monitoring
- Freshwater wetland mitigation performance standards
- Non-tidal stream mitigation performance standards

Monitoring reports are submitted annually; parameters are assessed according to the following tables from the Monitoring Guidelines:

TABLE B1: Post-construction monitoring schedule for freshwater mitigation projects in Georgia.

Wetland Monitoring Parameter	Years preceding interim credit release			
	As-Built	Continuous	Annual	Bi-annual
Vegetation	X		X	
Hydrology		X		
Prevalence Index	X		X	
Wetland Monitoring Parameter	**Years following interim credit release**			
	As-Built	Continuous	Annual	Bi-annual
Vegetation				X
Hydrology		X		
Prevalence Index				X
Large Woody Debris				X

TABLE B2: Post-construction monitoring schedule for non-tidal stream mitigation projects in Georgia

Stream Monitoring Parameter	Years preceding interim credit release			
	As-Built	Continuous	Annual	Bi-annual
Hydrology		X		
Geomorphology				
Channel cross-sections	X		X	
Longitudinal profiles	X		X	
Vegetation	X		X	
Biology (macroinvertebrates)			X(1)	
Stream Monitoring Parameter	**Years following interim credit release**			
	As-Built	Continuous	Annual	Bi-annual
Hydrology	n/a	X		
Geomorphology	n/a			
Channel cross-sections	n/a			X
Longitudinal profiles	n/a			X
Large woody debris	n/a			X
Vegetation	n/a			X
Biology (macroinvertebrates)	n/a			X

(1) Sponsor may initiate biological monitoring at any time following construction, so long as s/he has at least two consecutive years of biological sampling that demonstrates attainment of interim success criteria prior to seeking the interim mitigation credit release.

The Monitoring Guidelines outline the following general requirements for annual monitoring reports:

- An executive summary that describes the overall monitoring results, including hydrologic monitoring, vegetation monitoring, large woody debris monitoring, geomorphological monitoring, water quality, and macroinvertebrate monitoring (as applicable), areas of concern (e.g., exotic/invasive vegetation, stream instability, nuisance herbivory, etc.) and any adaptive management activities undertaken during the previous year (e.g., supplemental planting, reconstruction or modification of structural habitat features, etc.).

- Results of any monitoring parameters required to demonstrate project specific performance standards.

- Performance standards, as provided in the Mitigation Work Plan or in the permit conditions, must be restated verbatim in each monitoring report.

- Each monitoring report should include a discussion/presentation of the current year's monitoring data in context with data collected during all previous years. Summary tables must include summary data from all previous years.

Section 2 Overview of mitigation components of the state program

Section 404 mitigation requirements in the Savannah District are guided by its SOP. In 2018, the District issued a new SOP to replace the previous version, which had been in place since 2004. The goals of the 2018 SOP are to "1) provide stakeholders with a consistent, repeatable, functionally-based mitigation credit assessment methodology for aquatic resources; and 2) establish a transition to functionally-based credit types to facilitate in-kind replacement of aquatic resources." It establishes what the District describes as a functional approach to mitigation, which was not utilized in the 2004 SOP and is identified as the preferred type of mitigation approach in the USACE and U.S. Environmental Protection Agency's 2008 Compensatory Mitigation Rule. The 2018 SOP uses Excel spreadsheet tools, the Hydrogeomorphic Approach (HGM) for wetlands, and the Stream Quantification Tool (SQT), to calculate credits awarded to wetland and stream mitigation projects in the state.

Section 3 Objectives of the case study – what are you trying to accomplish

The primary objectives of this project were to 1) bring together a working group of diverse stakeholders involved in compensatory mitigation programs in Georgia; 2) assess current practices and standards for mitigation data collection, reporting, and use; 3) construct a prototype database that includes basic data analytics and a web interface to support existing data in support of compensatory mitigation evaluation; and 4) provide a template for future needs and develop a plan for scaling up the database statewide and broadening the analytical and visualization tools based on shared objectives developed with stakeholders.

Partners:

1. Athens Land Trust
2. Georgia Department of Natural Resources - Coastal Resources Division
3. Georgia Department of Natural Resources - Wildlife Resources Division
4. Georgia Department of Natural Resources - Environmental Protection Division
5. U.S. Environmental Protection Agency
6. Georgia Department of Transportation
7. Georgia Environmental Restoration Association
8. Georgia/Alabama Land Trust
9. Georgia Power
10. Oconee River Land Trust
11. The Nature Conservancy
12. U.S. Army Corps of Engineers
13. U.S. Fish and Wildlife Service
14. University of Georgia

Section 4 Main challenges

This project encountered several key challenges. One key project objective was to upload historical (pre-2018) data into the database to assess the effectiveness of the Georgia mitigation program at achieving ecological goals and to identify trends over time. However, we decided not to pursue this objective during this pilot project due to challenges posed by working with historical mitigation data. In Georgia, data has primarily been submitted and archived in PDF format. Thus, entering data into the database from historical records must be done manually in a time-intensive process. We were further dissuaded from focusing on historical data due to concerns raised by key stakeholders about the lack of standardization and quality of historical data and changes in sampling protocols over time, which could limit analysis. These factors led us to decide to use this pilot project as an opportunity to promote data standardization moving forward, consistent with the USACE Savannah District's 2018 mitigation and monitoring guidance, rather than spending significant effort to enter and standardize historical data with little perceived benefit. Additionally, the relative lack of standardization of historical data reporting and recent implementation of new guidelines (2018 Monitoring Guidelines) required our team to work with partners to iteratively develop standard data reporting protocols and forms, rather than using pre-existing data forms for database development.

The development of the database also presented us with a series of challenges. We chose to develop the database in-house using a combination of the RSQLite[9] and R Shiny[10] packages in an effort to offer the greatest database flexibility, easy interfaces with multiple other platforms, and ultimately the best user experience. However, this undertaking required training and a period of working through a learning curve for project personnel to become proficient with database development using this software. Additionally, since locations of sampling sites within mitigation banks have historically been recorded in PDF reports, a high priority of stakeholders was to develop a database tool to upload spatial data. Uploading the data is not a significant issue by itself, but determining the ideal way to load and assure the quality of many types of spatial data (per mitigation project) posed some significant challenges. While we ultimately decided on a fairly straightforward approach for the pilot database, some additional complexity and utility could be added with the input of users as this pilot is scaled up.

Determining the best strategies and schedule for effective communication with stakeholders also proved to be a challenge, as meeting time had to be balanced with time spent on database development. This challenge was heightened by the need to adapt our plans to navigate the COVID-19 pandemic, which virtually eliminated our ability to conduct in-person meetings with stakeholders and required us to negotiate the challenge of hosting online meetings with an array of stakeholders, each with different agency mandates on permissible meeting platforms. We decided to hold two general stakeholder meetings, where we solicited feedback on database goals and progress, and conducted several follow-up meetings with key stakeholders. While the general stakeholder meetings provided our team with valuable information in a time-efficient format, it was a challenge to allow adequate time for discussion by a range of stakeholders with varying levels of specialization on a range of topics. In an effort to maximize efficiency, we also packed a substantial amount of information into each meeting, which may have resulted in "information overload" and some of the key takeaways were not as well communicated as desired. Additionally, the project would have benefitted from more frequent communication with key stakeholders to solicit input on database features. While this was our intent, early staffing challenges slowed initial progress on the database. Then, as database development accelerated, our desire for progress overshadowed reconnecting with key stakeholders, thus missing opportunities for iterative feedback. However, we ultimately were able to increase opportunities for feedback from stakeholders late in the project and respond with substantial changes and improvements. Moving forward, frequent feedback between the development team and key stakeholders will be prioritized.

[9] Kirill Müller, Hadley Wickham, David A. James and Seth Falcon. 2020. RSQLite: 'SQLite' Interface for R. R package version 2.2.1. https://CRAN.R-project.org/package=RSQLite
[10] Winston Chang, Joe Cheng, JJ Allaire, Yihui Xie and Jonathan McPherson. 2020. Shiny: Web Application Framework for R. R package version 1.5.0. https://CRAN.R-project.org/package=shiny

Section 5 Approach and strategy used

5.1. How was it staffed? (internal, contractors)

The Georgia mitigation evaluation database project was developed internally and staffed exclusively with University of Georgia personnel. Nathan Nibbelink, a professor in the Warnell School of Forestry and Natural Resources at UGA, served as the principal investigator on the project and was tasked with overseeing project administration and directly supervising and assisting in database development, facilitating stakeholder meetings, and generating reports. Katie Sheehan Hill, a research professional in the Odum School of Ecology's River Basin Center and Carl Vinson Institute of Government at UGA, served as the co-PI on the project and provided expertise on the mitigation banking system in Georgia and facilitated connections with key stakeholders. Maxwell Kleinhans, a research professional in the River Basin Center, provided expertise in developing the initial database framework. Cody Cox, a research professional in the Warnell School of Forestry and Natural Resources, managed day-to-day operations on the project, coordinated meetings with stakeholders, developed meeting agendas, and produced meeting summary reports. He also took over database development after the preliminary structure was created by Kleinhans and assisted in report writing.

5.2. Software used

The Georgia mitigation evaluation database was developed exclusively within the open source statistics software, R[11]. We used the RSQLite package[12] within R to construct a SQL database to store data on a range of metrics related to mitigation evaluation. The SQL database was then integrated into a user-friendly app developed using the R Shiny package[13] in program R, which permitted a visualization of bank sites within the state of Georgia, along with key bank data, data entry forms (individual records and batch upload) for multiple types of data (e.g., vegetation, hydrology, macroinvertebrates, large woody debris, and habitat assessment), a data query and download tool, and a tool that interfaces with the ggplot2[14] package to plot data for graphical analysis of data trends. This database app will be published online on a password-protected website after final approval of the partners. Initially the site will be hosted by Dr. Nibbelink's Spatial Analysis Lab at the University of Georgia until a permanent host is selected by the partners.

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[11] R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

[12] Kirill Müller, Hadley Wickham, David A. James and Seth Falcon. 2020. RSQLite: 'SQLite' Interface for R. R package version 2.2.1. https://CRAN.R-project.org/package=RSQLite

[13] Winston Chang, Joe Cheng, JJ Allaire, Yihui Xie and Jonathan McPherson. 2020. Shiny: Web Application Framework for R. R package version 1.5.0. https://CRAN.R-project.org/package=shiny

[14] H. Wickham. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2016. https://ggplot2.tidyverse.org

5.3. Process (e.g., stakeholder coordination, key agencies coordinated with, guidance docs used)

The Georgia mitigation evaluation database project began with a review of relevant literature to provide a foundational understanding of the current state of mitigation banking and evaluation in Georgia and identify goals for the future. The key piece of literature for understanding mitigation data collection standards in Georgia is a document produced by the Savannah District of the USACE in 2018 (Draft Monitoring Guidelines & Performance Standards for Freshwater Wetlands and Non-Tidal Streams, 2018), which provided new statewide requirements. The draft final version of the Integrated Framework for Evaluating Wetland and Stream Compensatory Mitigation (Stein et al. 2018), co-produced by members of the Southern California Coastal Water Research Project, Environmental Law Institute, and U.S. Environmental Protection Agency, supplied us with valuable examples of the range of mitigation evaluation practices occurring in various states and provided insights into goals for national-level synthesis.

Concurrent with our literature review, we researched platforms for developing and hosting our online database, and settled on using R Shiny for database development due to the flexibility that it offered as a free, open source program that would permit in-house database development and hosting. We then built a simple demonstration database as a vehicle for stakeholder feedback. For this initial version, we used template data sheets provided in the USACE 2018 guidance to guide construction of data input forms for both wetland and stream mitigation projects.

In May 2020, we held our first stakeholder meeting, which was attended by key personnel from 14 different organizations involved or interested in compensatory mitigation in Georgia. During this meeting, we acquired stakeholder feedback on the current state of mitigation evaluation in Georgia, including data collection and dataset availability, and discussed stakeholder database goals and priorities. At this meeting, we also provided a brief demonstration of an early version of our online database and solicited stakeholder feedback on its design. We subsequently conducted follow-up meetings with two key stakeholders (USFWS and Georgia Environmental Restoration Association) about data availability and potential sentinel sites to use in the database. We then synthesized all feedback and developed a brief summary report, which was sent out to all stakeholders.

Following these meetings, we entered a phase of intense database development in the fall of 2020. Based on our stakeholders' recommendations that historical data was not collected consistently and would not be useful for analysis, we focused our database efforts on developing standards for current and future data collection and entry and developing tools to facilitate analysis in the future. We then held a second stakeholder meeting in January 2021 in which we provided a more in-depth demonstration of our fleshed out database and solicited stakeholder feedback to better tailor the design to their needs and goals. Subsequently, we developed a meeting summary document, which we sent to all of our stakeholders. Following the stakeholder meeting, we conducted a follow-up meeting with key stakeholders (USACE, EPA) to discuss specific recommendations for adding additional data entry forms, fields, and tools to ensure that the database better aligned with their goals. We used the feedback provided by stakeholders in our meetings to guide our process of expanding and revising our pilot database during the winter/spring of 2021. We then held an additional meeting with key stakeholders (USACE, EPA) in April 2021 to highlight expansions and revisions made to the database during the previous months based on their feedback and solicit an additional round of feedback, which we incorporated into the final version of our pilot database. We intend to post the pilot database online to allow stakeholder beta testing during summer 2021.

Section 6 Outcomes

6.1. Products produced

Through this project, we developed a range of products that will benefit compensatory mitigation evaluation both in Georgia and nationally:

- The primary product developed from our efforts on this project is an interactive mitigation evaluation database for the state of Georgia. This interactive database will be published as an R Shiny app online to facilitate use by the mitigation community in the state. Key features of the database include:
    - An interactive map of mitigation banks and sampling sites within the state, which includes information (e.g., acres, date established) for each site and other key spatial layers (e.g., watersheds and ecoregions).
    - Data entry tools to facilitate the upload of multiple types of data (e.g., vegetation, hydrology, macroinvertebrates, large woody debris, and habitat assessment characteristics) into the database as either individual records or batch uploads.
    - A tool allowing shapefiles of sampling sites within banks to be uploaded into the database by users, since these have historically only been reported in PDF reports, which will facilitate future analysis.
    - A data viewer that permits data visualization, query by a range of fields, and download.
    - A pilot graphical analysis tool for data trend visualization.
- We also developed metadata spreadsheets for each data entry form, which can be downloaded from the corresponding database tab, and include information about each data entry field, such as data type, data range, and lists of options for categorical fields.
- We created downloadable Excel templates for each data entry form, which can be downloaded by users from the appropriate database tab, to standardize data entry for a range of mitigation evaluation criteria (e.g., vegetation, hydrology, macroinvertebrates,

large woody debris, habitat assessment characteristics), to facilitate data entry and future analysis.

- Additionally, we developed a spreadsheet listing the availability of spatial data for each bank site, which highlighted where spatial data is incomplete in current state databases, such as missing bank boundary shapefiles or banks not listed in RIBITS.

- Finally, we produced summary documents from the two stakeholder meetings that we conducted, which synthesized valuable insights from 14 organizations that comprise a large portion of the Georgia compensatory mitigation community on a range of topics, including current data collection and use, current dataset availability, database goals, and feedback on database progress.

6.2. Capacities developed

This project greatly enhanced the capacity to collect, share, and analyze mitigation data in Georgia through the development of standardized data entry forms, interactive maps, and data query and download tools, which will enhance access to data for all stakeholders in the Georgia mitigation community. Since we decided to develop the database in-house, this project provided the opportunity for project personnel at UGA to expand our capacity for database programming, management, and online application development using the R Shiny and RSQLite packages in the open source software program, R. This adds to our past experience with ArcGIS Online, VB for Applications, Python, and other tools to bring even more capacity to our ability to build and host geospatially-enabled database tools to enhance environmental management and decision-making.

6.3. Partnerships or leverage opportunities enhanced

This project helped UGA to develop important partnerships in the compensatory mitigation community within Georgia and to better connect mitigation evaluation efforts in Georgia to best practices being promoted or used in other states through review of the draft final version of Stein et al. (2022) document and meetings with teams from other states. This project allowed us to develop connections with a team undertaking a similar project in Minnesota and with national-level partners at the Southern California Coastal Water Research Project and EPA to better understand how Georgia fits in, and how we can contribute to (and learn from) national advances in mitigation evaluation. Our two stakeholder meetings and additional individual follow-up meetings helped us develop connections with 14 organizations involved with compensatory mitigation in Georgia, who provided us valuable insight and feedback during the course of our database development to allow our final product to best suit the needs of the Georgia mitigation community.

Section 7 Lessons learned

7.1. What worked well/keys to success

While our model for soliciting stakeholder feedback could have been improved (see 7.2, below), we believe that a key benefit of our in-house, user-driven approach avoids many of the pitfalls often associated with outsourcing database development. Based on our observation of other efforts, we were less prone to forcing elements into preconceived best practices from the computational world (often useful for “big data” with millions/billions of records), and more likely to make decisions that highlighted key needs of stream and wetland mitigation programs, for which databases are relatively modest in size, and thus optimal efficiency can be traded off for a better user experience. However, this decision required us to overcome a learning curve to gain experience using some newer (to us) packages for database programming. Our decision to use open-source software for database development will allow it to be more easily managed and expanded in the future. Another element that was key for project success was creating opportunities for stakeholder engagement and input during the database development process. While the project could have benefitted from more frequent engagement with key stakeholders, our meetings did provide us with a wealth of information and increased interactions late in the project resulted in a cycle of iterative feedback that increased the alignment between the database structure and stakeholder goals. Our two general stakeholder meetings also provided our team with valuable information about current data collection and analysis in Georgia, challenges in utilizing historical data for analysis, and preferences for database layout and development priorities. This input shaped our prioritization of project components, such as focusing more on setting standards for the present and future than loading historical data and helping to ensure that the pilot database will meet user needs to the greatest extent possible.

7.2. Challenges/things you would have done differently

While we made considerable progress during this pilot project, we experienced several notable challenges that can serve as valuable learning opportunities for other states undertaking similar database development, particularly where little historical regulation or oversight has occurred. The biggest challenge we faced early in the project was in working with historical data to meet broader project objectives of evaluating performance, effectiveness, and resiliency of compensatory mitigation in Georgia. Due to stakeholder concerns about data consistency and accuracy, we ultimately decided not to focus on including historical data to analyze trends in mitigation in our pilot database and instead used the development of the database as an opportunity to promote better standardization going forward. Including historical data in the database was further complicated by the fact that most historical mitigation data were submitted and archived in PDF format, which would require data to be manually entered into the database; a time-consuming process in which stakeholders saw little benefit relative to our other goals. The lingering lack of standardized data reporting in Georgia presented us with an additional challenge because we had to develop data entry standards for several metrics and new data entry forms as part of the database development, rather than using pre-existing forms as templates. Additionally, since most sampling sites within mitigation banks have historically only been identified in PDF reports and have not been compiled into existing geospatial databases, rather than creating a layer with locations of sampling sites in the database for user analysis, we were tasked with developing a tool to allow users to upload site locations of multiple feature classes (e.g., point, line, polygon) into the database, which required the development of additional QAQC procedures to ensure proper formatting of fields and coordinate systems. Our decision to develop the database in-house greatly increased our flexibility and ability to iteratively modify the database based on stakeholder feedback. However, these benefits did come with a learning curve, as previously mentioned. We do, however, think that the choice of platform was a good one in looking to the future, and served to add capacity for us to do more of this work.

We learned a few lessons that would lead us to make some different decisions in the database development process if we had it to do over again. These lessons primarily related to how we solicited stakeholder feedback in the database development process. We had anticipated that our first stakeholder meeting would provide important information about current data collection and analysis, available datasets for populating our database, and stakeholder visions for the database itself, which would guide our database development. Thus, we spent a relatively small portion of the meeting time actually performing a database demonstration and soliciting feedback on design elements, and only presented a relatively bare bones version of the database. While the meeting did provide valuable information on all topics presented, we likely would have benefitted from presenting a more fleshed out version of the database at this juncture and setting aside more time for direct feedback on its layout because most of the feedback that we received at the first meeting was more conceptual, and we found that a lot more ideas about the database structure and details emerged during our second meeting, held several months later, when we spent most of the meeting time soliciting direct feedback on design elements of a much more fleshed out version of the database. Had we presented some of these elements earlier, it might have provided us with more concrete database-specific feedback earlier in the process, which would have allowed more opportunities for iterative feedback during the development process and would have saved us from spending considerable time on elements deemed less important by the user community, such as matching the exact formatting details of existing data collection forms, since not all users use the exact same forms and would prefer to focus on batch upload of data. Additionally, “information overload” in large stakeholder meetings may have reduced the utility of these meetings. Originally, stakeholder meetings were designed as in-person, half-day workshops. Due to scheduling issues and “zoom fatigue” during the COVID-19 pandemic, the meetings were instead scheduled as shorter online sessions, which were not ideal.

Additionally, we would have benefitted from setting aside more time throughout the database development process to meet with key stakeholders to workshop elements of the database, including communicating more regularly about other project developments (e.g., key takeaways from meetings with national/MN teams) and more effectively sharing timelines and expectations. While more frequent meetings do require a diversion of time away from direct database development, they would have increased development efficiency in the long run by steering our efforts towards features of greater user priority, and thus avoiding sinking time into less important details. Due to early staffing challenges and learning curves, progress was initially slow. Nonetheless, more frequent communication during this period, followed by frequent opportunities for feedback as our progress accelerated would have been valuable. We ultimately achieved a higher level of feedback and iterative improvements late in the project, but would improve the model of engagement significantly if we could do it again.

7.3. Recommendations for others

Our primary recommendation is that communication with stakeholders is the biggest key to successfully and efficiently developing a database that meets the needs and goals of a diverse mitigation community. Creating opportunities to understand goals and priorities can inform database development and providing further opportunities for feedback throughout the development process can ensure that the database matches the needs of the community.

Section 8 Conclusions and roadmap for the future

Despite its robust number of mitigation banks, Georgia is still early in the process of improving the consistency and effectiveness of mitigation evaluation. Our approach to building a standardized, accessible database to better enable effective mitigation evaluation could be used as a roadmap for other states at a similar stage in the process. The development of standardized data entry forms and a queryable database through this effort will greatly improve the capacity for future evaluation of mitigation outcomes in the state. While significant progress was made on a functional database during the timeframe of this pilot project, additional work is needed to beta-test, publish, and scale-up the database to maximize its utility for mitigation evaluation in Georgia. We estimate that this process will take 2 years and require a full-time database manager/programmer. During this time period, the database manager would continue to build out and troubleshoot the database iteratively through user feedback, while developing additional query and analysis tools to facilitate future mitigation evaluation and assist with the upload of new (and high quality historical/sentinel site) mitigation data into the database. Having a full full-time database manager will enable a soft implementation phase that permits "on call" revisions and troubleshooting and culminates in dissemination to all partners with the expectation that they commit to using the new system. If the University of Georgia is selected to continue to develop the Georgia mitigation database, we could serve as the database host during that time period, which would allow time for the stakeholder group to determine (and secure funding) for a long-term host. Regardless of who is selected for the next phase of this work, UGA is committed to hosting the pilot database and logging feedback from partners for up to one year from project completion, and sharing all project components with anyone who would pick up the work moving forward.

8.1 Recommendations for next steps

Below we describe our recommendations for two additional phases of this work. We also propose a timeline and budget. However, budget projections are flexible, depending on the needs/desires of project partners, and the numbers reflect estimates based on salaries and time of personnel at the University of Georgia.

Phase 1: Pilot database development – complete

Phase 2: Soft launch, beta testing, build-out, and implementation (2 years)

Soft launch – Key partners would be selected to be beta testers of the database. We would propose a launch meeting with partners to highlight initial functionality and set goals for the build-out, including any initial modifications and additional functionality. After the launch meeting, partners would meet monthly to review progress and adjust goals as needed. In between meetings, the database manager would work on agreed-upon tasks and be on call for questions, edits, and suggestions as they arise. Phase 2 would also include working with USACE and other partners to lay the groundwork for requiring use of the database as a part of formal reporting under mitigation evaluation guidelines. Finally, during Phase 2, the database development team would work with partners to select a permanent host and design a funding model for long term maintenance and hosting of the database. By the end of Phase 2, the goal would be to fully launch the database tool for use by all partners and transition to the permanent hosting arrangement.

TABLE B3: Estimated Phase 2 budget for Georgia.

PERSONNEL	SALARY (monthly)	TIME (months)	SALARY	FRINGE RATE	**Year1**	**Year 2**	**Total**
Database manager	5,000	12	60,000	38.00%	82,800	84,870	167,670
Staff support (proj mngmt, communications)	3,400	2	6,800	46.00%	5,667	2,607	8,273
PERSONNEL SUBTOTALS					88,467	87,477	175,943
SUPPLIES							
R-Shiny Apps Hosting Service	99	12			1,188	1,188	2,376
Sub-TOTAL UGA Direct Costs					**89,655**	**88,665**	**178,319**
Indirect Costs (IDC) est @ 35%					31,379	31,033	62,412
TOTAL					**121,034**	**119,697**	**240,731**

Phase 3: Long term hosting and maintenance

Long term maintenance could take several forms, depending on the needs of the partners. We feel that this type of database will always require a minimum level of maintenance and user support, considering the variety of data types, necessary software/hosting updates, and evolving user needs. Based on communications with Eric

Stein's team, we are estimating high at about 20% of a data manager's time, plus some minor additional staff support and web app hosting services. These estimates could be revisited and revised as appropriate during Phase 2 as the project team considers funding models and needs for long term support.

TABLE B4: Estimated Phase 3 budget for Georgia

PERSONNEL	SALARY (monthly)	TIME (months)	SALARY	FRINGE RATE	Year1	Year 2	Total
Database manager	5,000	2.5	12,500	38.00%	17,250	17,681	34,931
Staff support (proj mngmt, communications)	3,400	0.5	1,700	46.00%	1,417	652	2,068
PERSONNEL SUBTOTALS					18,667	18,333	37,000
SUPPLIES							
R-Shiny Apps Hosting Service	99	12			1,188	1,188	2,376
Sub-TOTAL UGA Direct Costs					**19,855**	**19,521**	**39,376**
Indirect Costs (IDC) est @ 35%					6,949	6,832	13,781
TOTAL					**26,804**	**26,353**	**53,157**