I.   Project Title: Development of a Centralized PIT tag Database for the San Juan and Upper Basin Recovery Programs

II.   Bureau of Reclamation Agreement Number(s): R14AC00084

       Project/Grant Period: Start date (Mo/Day/Yr): 9/18/2014
                          End date: (Mo/Day/Yr): 12/312019
                          Reporting period end date: 09/30/2019
                          Is this the final report? Yes _____ No __X__

III.   Principal Investigator(s):

       Amy Greenwell
       GIS Program Manager
       Colorado Natural Heritage Program
       Colorado State University
       Phone: (970)491-2847
       Amy.Lavender@colostate.edu

IV.   Abstract: The Colorado Natural Heritage Program (CNHP) at Colorado State University has developed an online data system (the Species Tagging, Research and Monitoring System or STReaMS) for the Bureau of Reclamation and the Upper Colorado and San Juan River Endangered Fish Recovery Programs. The database is designed to track PIT tags and endangered fish activities in the Upper Colorado River Basin. CNHP is near completion of the fifth full year of the project. Throughout Year 5, new features and bug fixes were ongoing, remote antenna data were monitored and imported, and in-depth training for Database Managers was completed. While some features will continue to be refined in future years, the database has enhanced functionality and future years are focused on website and server maintenance. The data system can be accessed at streamsystem.org (registration is required). The current five year agreement ends on December 31, 2019.

V.   Study Schedule:
       FY14-FY19

VI.   Relationship to RIPRAP:
       General Recovery Program

       V.A.1. Conduct interagency data management program to compile, manage, and maintain all research and monitoring data collected by the Recovery Program.

VII.   Accomplishment of FY 2019 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

Deliverables thus far include the release of an enhanced version of the website at https://streamsystem.org/. The website is updated periodically, with release notes accessible on the website, https://streamsystem.org/webAdmin/webUpdateLog.php. Accomplishments in Year 5 include 1) Development of a non-tagged fish upload and data bin; 2) Development of quality control tools to identify potential data issues; 3) Establishing a data connection process for the new Biologic service and transition of PIAs to the new service; and 4) Performance optimization.

During Year 5, schedule adjustments were made due to funding delays. We received a no cost extension and will complete Year 5 activities by December 31, 2019.

See Appendices 1-5 for status of work accomplished compared to proposed tasks in the original 3 year proposal, and general task lists completed in Year 4 and Year 5.

A detailed list of completed tasks for FY19 is below.

October 2018
- Tested Biologic website. The website provided a sanitized version of the dat file which was not ideal for STReaMS
- Built FTPS secure site to receive PIA data directly from Biomark (for PIAs on the new Biologic service)
- PIA call with recovery program
- Identified steps to update bit fields in SQL server to remove null values and remove these entries from change tracking (since it would add millions of entries)
- Made a user to run scheduled tasks, tested and adjusted permissions

November 2018
- Worked with Biomark IT directly to get FTPS site working with Biologic, fixed port issues
- Coordinated with Peter MacKinnon to get PIA data for Hogback II (Intake), McElmo Creek Aneth Bridge, and Green River Tusher Diversion. Reviewed dat files and documented outages. Will follow up with Peter about outages on Hogback II.
- Inactivated Green River Canal "Below Siphon" and "Flume" arrays
- Back-up of MS SQL database file and website for recovery program
- Annual performance report
- Updated work plan with Julie Stahli

December 2018
- Year 5 SOW to CSU
- Investigated large number of encounters on Tusher Diversion

- Last upload for GRC flume and below siphon. Removed both PIAs from weekly batch uploads. Left in STReaMS and inactivated arrays.
- Fixed date sorting issue on stocking event lists and sample lists
- Hid documents page unless you are logged in; grayed out menu items that are off-limits when logged out
- Added 2018 patches to the website documentation
- Fixed bug from December patch where all menus were grayed out for registered users
- Fixed duplicate user issue

January 2019
- Purchased and replaced failed hard drive on STReaMS server
- Set up individual FTP folders on FTPS site for each PIA from the Biologic service
- Discussions with Peter and Biomark software engineers to connect FTPS folders to the correct Biologic units and get dat files in the correct format

February 2019
- Added PIA metadata to STReaMS with antenna configurations for new units
- Created a new download to export the complete encounter history for all tags in an encounter list
- Began new upload type for non-tagged fish
  - Added temporary upload tables to MS SQL
  - Added Bin table to store non-tagged fish data and adjusted template to match table
  - Reviewed contents of MS Access database with non-tagged fish data

March 2019
- Reordered filters on Browse Encounters so they line up correctly
- Continued to work on non-tagged fish upload
  - New domain table for fin clip values
  - Added rule to check for valid sample number. The upload compares sample numbers in non-tagged fish upload to sample numbers in corresponding site effort upload. If sample numbers do not exist in the study event (site effort) table, they are flagged as invalid in the non-tagged fish Bin.
  - Added rules for fish counts

April 2019
- Identified missing fish species codes for hybrids in non-tagged fish MS Access database

- Added new species codes and species attributes to STReaMS
- Quality controlled non-tagged fish data in the MS Access database, fixed errors and standardized attributes (e.g. people, orgs, etc.)
    - Added non-compliant information to comments field
    - Cross-checked site effort and rare fish upload IDs
    - Identified studies associated with non-tagged fish data
- Reformatted non-tagged fish data to match new template and burst into separate files based on Study in preparation for upload

May 2019
- Testing and revising code for new website release
- New release 5/8/2019 and release notes
- Imported non-tagged fish data to live website as multiple uploads split by study (> 600,000 records)
- Adjustments to registration page to prevent high level spammers from signing onto STReaMS
    - Banned specific emails and added other functionality to catch bots
- Created QC tools page
    - Developed query for orphaned individuals
    - Developed query for potential duplicate encounters

June 2019
- Reviewed and reformatted additional river miles and coordinates from Julie. Calculated latitude and longitude. Added to river mile table
    - Compared to Hydro Areas and Encounters in STReaMS to identify river miles in the database without lat/long coordinates available. Sent list to Julie.
- Upgraded test site to PHP 7 and fixed broken functionality
- Created draft version of the merge/split fish tool (to combine multiple fish into one or redistribute encounters between fish)
- Added Biologic PIA data into the weekly upload queue for new arrays (Canal Fish Screen, Price River Mounds, San Juan Shiprock, Price River Confluence (2018), Price River Woodside (2018))
    - Added new array dat files information to SQL tables
    - Wrote script to rename files and copy to network for weekly uploads
    - Tested uploads on test server
- Upgrades to PIA details pages to make managing PIA data easier for Peter
    - Reorganized the array table to include active status and upload dates.
    - Hyperlinked source files to array details
    - Added download button to PIA details
    - Added encounter section and download button to array details pages
    - Schematic changes

July 2019

- Fixed data schema issue where tag deploy attributes are not connected to deploy encounter attributes
  - QC tag deploy attributes.
    - Fixed deployed tags that do not have deploy encounter ID (as a result of manual data entry).
    - Fixed tags with the same deploy encounter.
  - Deleted extra deploy fields in tag table and pulled attributes from encounter table instead. Updated uploads, downloads, web pages, tag lists, rejected records (reconciliation for tags already deployed), undo uploads, and track changes accordingly.
  - Added new field to tag table for current tag. Updated code to reevaluate current tag during uploads, undo and when a record is deleted. Current tag is assigned based on deploy date or largest ID if deploy dates are unavailable. Updated individual and encounter lists to accommodate new way of reporting current tag.
- Added Biologic PIA data into the weekly upload queue for existing arrays which used to have Loggernet connections, but now have Biologic connections (McElmo Creek Aneth Bridge, Green River Tusher Diversion, Hogback Diversion Intake, PNM Weir)
  - Updated array dat files information in SQL tables
  - Reconciled new and old files (reset sequence IDS) and archived old files to maintain linkages between encounters and source files
  - Updated script to rename files and copy to network for weekly uploads
- Identified missing PNM Weir PIA data that was in master controller file but not in CR1000 file
  - Reformatted master controller file to work with STReaMS data file format
  - Compared to existing data and uploaded missing data to STReaMS
- Updated PIA Status spreadsheet for Julie and Peter
- Added download buttons to encounter tables on study details page and uploads page
- Hyperlinked associated individual and deploy encounter on tag details page.
  - Pulled deploy information displayed on page from deploy encounter so it is no longer editable from tag details.
- Set default values for bit fields to 0 (instead of null) during PIA uploads
- Removed "unknown" option from mortality and recapture filters on Browse Encounters and Browse Fish. Null is no longer an option for bit fields.
- Created script to run on live site in preparation for new release to change schema and triggers, reset change tracking, calculate new tag field, and replace null values with 0 in bit fields. Tested and reran script.
- Testing and revising code for new release
- Release notes for 8/5/2019 release

August 2019

- Tested and revised code for August release
- Pulled out transaction times in change tables so information is not lost when change tracking is turned on/off.
- New release 8/5/2019
    - Server downtime for new release to upgrade PHP. Ran scripts to upgrade database schema and populate data.
- Added Maybell Canal to river mile table
- Fixed bug in PIA upload where most recent tag was not getting set
- QC tools
    - Added to Fish – suspicious stocking date (stocking date is not the oldest encounter date), missing stocking encounters (has source hatchery data but no stocking encounter exists), mortality errors (dead individuals with new encounters, live individuals with encounters indicating mortality)
    - Added to tag – tag status errors (active tags with no fish, tags not deployed with fish), tags missing deploy encounters
    - Added Updated Calculated Fields to update Current Tag, Stock Encounter ID and Last Encounter ID
- Split / Merge tool
    - Created interface to swap encounters between fish so the same interface can be used for a merge or split
    - Adjusted individual IDs associated with encounters and tags based on user input
    - Calculated Revision Person ID on updated records, using ID of person logged in
    - Adjusted code to update calculated fields
- Added Upload IDs and Revision Upload IDs to Fish, Encounters, Tags and Tag Lots web pages. Hyperlinked them to Upload details.
- Cosmetic fixes to web pages – increase note fields for readability, standardize format of names in tag details on the fish page, add common name and nativity to fish page
- New filter for tag type on Browse Tags
- Added stocking encounter ID and last encounter ID to fish table for calculated fields.
    - Updated batch uploads and web page editing to populate these fields as data change
    - Updated queries on Browse Fish to use attributes of last encounter ID for Last Encounter Type, Last Encounter Date, and Last Encounter River.
    - Added "days in river" to Fish page and individual download. Set logic to calculate days using stock date and current date for live fish or stock date and last encounter date for dead fish. Update fish page to change logic used for days in river if mortality flag is checked/unchecked.

- Pulled river miles from river mile table to display on Encounter page and added to downloads
- Created script to populate calculated fields and update database schema for next release, allowing us to batch run data and schema changes that align with the new code changes once the new release is out.
- Troubleshoot issues with Biologic PIA dat files resetting themselves and erasing pre-existing data. Worked with Peter and Biomark engineers.
- Fixed bug where Data Administrators and Researchers get error message on Manage Uploads page (they have read only access to this page)
- Adjusted webpage on Rivers and Lakes to show start on parent river mile, river mile up, and river mile down. Change required fields. Populated min and max river mile using data from river mile table.
- Quality controlled and finalized river mile table
- Processed Dolores River Rio Mesa and San Juan waterfall PIA data
  - Reformatted San Juan waterfall dat files to be compatible with STReaMS upload process (no data logger on old files)

September 2019
- Developed descriptive content on QC tools page
- Rewrote web pages (encounters, arrays) and download files to pull latitude and longitude from the river mile table.
- Added "Days in river" to fish page and developed logic for calculating it on the fly. Added to Individuals download file.
- Set results of Merge / Split tool to dump results and user into log table.
- Removed MS Excel tabs named "Metadata" from the batch upload tool to reduce clutter
- Names displayed in Tag Details on the Fish page were reformatted to be Last Name, First Name which matches other columns
- Fixed issue on Hydro Areas page where DBA Flag was not included in Encounter list which offset the data by one column.
- Added additional fields to the hydro areas web page.
- Added source file hyperlinks to Samples and Stocking Events.
- Added a section on non-tagged fish uploads to the Database Manager User Guide
- Database Managers meeting to discuss non-tagged fish upload
- Look-up values cannot be deleted if they are used by records in the database. Look-up values in the non-tagged fish bin are now included in this check to prevent codes that aren't in STReaMS proper to be deleted if they are used in the non-tagged fish table. (Hydro Areas, Gear Types, Species, and Habitat Types)
- Extensive testing of QC Tools page and Split / Merge page

VIII.   Additional noteworthy observations:

As of November 13, 2019 the database has:
- 1,831,690 PIT Tags
- 1,280,480 Individual Fish
- 2,619,605 Encounters

Between September 2018 and September 2019, Google Analytics show:
- 36,517 page views
- 3,174 sessions
- Average session duration of 11:00 minutes
- Average of 11.51 pages per session
- Bounce Rate of 36.01%

IX.   Recommendations: Server maintenance will continue to be the responsibility of CNHP. Recommendations for Year 6 under a new agreement are listed below. CNHP will continue to work closely with Database Managers to adapt to emerging needs.

Server Maintenance
- Maintain the server, server security, and perform regular database backups
- Maintain the test server and development environment
- Perform necessary software upgrades including Windows updates, SQL Server updates, TFS updates, and PHP updates. Ensure all code performs as expected following updates.
- Assess overall performance and optimize resources
- Maintain Database Manager credentials to access SQL Server

Website Maintenance and New Features
- Enhancements to existing tools
    - Batch uploads
    - QC tools
    - Calculated fields
- Work with Peter Mackinnon and Julie Stahli to ensure complete PIA data in STReaMS
    - Shift units from Loggernet process to new upload process as they are upgraded
    - Needs assessment and training with Peter and Julie
- Work with Database Manager to develop any necessary custom queries, including non-tagged fish queries
- Bug fixes
- Internal testing and stress tests
- Update online help, data dictionary, user manuals, Data Managers user guide, and system documentation
- Train Recovery Program participants on new features and enhancements
- Discuss database connections with R and security
- Other priorities identified by Recovery Program Database Managers

Project Management

- Prepare annual reports
- Perform project management and CSU compliance
- Maintain regular communication with Database Managers

X.   Project Status:

Ongoing

XI.   FY 2019 Budget Status

    A.   Funds Provided: $54,132
    B.   Funds Expended: $43,306
    C.   Difference: $10,826 (will be spent and 100% work completed by project end date December 31, 2019)
    D.   Percent of the FY 2019 work completed, and projected costs to complete: 80%
    E.   Recovery Program funds spent for publication charges: $0

XII.   Status of Data Submission (Where applicable):

Not Applicable

XIII.   Signed: *Amy Greenwell* /s/   11/15/19
                  Principal Investigator   Date

Appendix 1. Proposed schedule for Year 1 and status of actual work accomplished. Shaded boxes indicate the proposed start of tasks in original proposal.

YEAR 1	Oct-14 - Dec-14	Jan-14 - Mar-15	Apr-15 - Jun15	Jul-15 - Sep-15
Work closely with investigators to assess database needs and design	Ongoing	Ongoing	Ongoing	Ongoing
Purchase and set up server to host database	Complete			
Server security, database backups and server maintenance		Ongoing	Ongoing	Ongoing
Prepare database mockups		Complete		
Develop SQL server database		In Progress	Complete	
QA/QC existing MS Excel and MS Access databases and reformat as needed				Complete
Import existing fishes data into MS SQL Server				Complete
Code web interface for entering and retrieving data				Complete
Code management system for managing users and permissions		In Progress	In Progress	Complete
Develop canned queries for basic downloads				Complete
Create online help, user manual and system documentation			In Progress	In Progress
Internal testing and stress tests		Ongoing	Ongoing	Ongoing
Post basic version of database online				Complete
Train USFWS and BOR personnel to use the database				Ongoing
Prepare quarterly, semi-annual and **annual** reports		Complete		
Project Management and CSU Compliance	Ongoing	Ongoing	Ongoing	Ongoing

Appendix 2. Proposed schedule for Year 2 and status of actual work accomplished through September 2016. Shaded boxes indicate the proposed start of tasks in original proposal.

YEAR 2	Oct-15 - Dec-15	Jan-15 - Mar-16	Apr-16 - Jun-16	Jul-16 - Sep-16
Work closely with investigators to assess database needs and design	Ongoing	Ongoing	Ongoing	Ongoing
Update online help, user manual and system documentation	In Progress	In Progress	In Progress	In Progress
Server security, database backups and server maintenance	Ongoing	Ongoing	Ongoing	Ongoing
Develop online Data Management System for quality control and database administration	Ongoing	Ongoing	Ongoing	Ongoing
Develop online Query Builder for customizing data downloads				
Develop upload capabilities for batch files and data recorded by PIAs			In Progress	In Progress
Develop revision tracking component				
~~Set up GitHub defect tracking~~	-	-	-	-
Set up tracking system using Google Analytics to track public use of the site	Complete			
Internal testing and stress tests	Ongoing	Ongoing	Ongoing	Ongoing
Post advanced version of the database online				Ongoing
Train USFWS and BOR personnel on using and managing the database	Ongoing	Ongoing	Ongoing	Ongoing
Prepare quarterly, semi-annual and annual reports	Complete			
Project Management and CSU Compliance	Ongoing	Ongoing	Ongoing	Ongoing

Appendix 3. Proposed schedule for Year 3 and status of actual work accomplished through November 3, 2017. Shaded boxes indicate the proposed start of tasks in original proposal.

YEAR 3	Oct-16 - Dec-16	Jan-16 - Mar-17	Apr-17 - Jun-17	Jul-17 - Nov-17
Work closely with investigators to assess database needs and design	Ongoing	Ongoing	Ongoing	Ongoing
Server security, database backups and server maintenance	Ongoing	Ongoing	Ongoing	Ongoing
Develop online Data Management System for quality control and database administration	In Progress	In Progress	In Progress	In Progress
Develop online Query Builder for customizing data downloads				Pushed back to Year 4
Develop upload capabilities for batch files and data recorded by PIAs	In Progress	Complete		
Finalize online help, user manual and system documentation	In Progress	In Progress	In Progress	Complete
Enhance features and functionality based on user feedback	In Progress	In Progress	In Progress	Ongoing
Internal testing and stress tests	Ongoing	Ongoing	Ongoing	Ongoing
Develop revision tracking component		In Progress	In Progress	Complete
~~Set up GitHub defect tracking~~	-	-	-	-
Post enhanced version of the database online				Complete
Train USFWS and BOR personnel on using and managing the database	Ongoing	Ongoing	Ongoing	Ongoing
Transfer server and database to BOR or setup maintenance agreement				Complete
Prepare quarterly, semi-annual and final reports	Complete			Complete
Project Management and CSU Compliance	Ongoing	Ongoing	Ongoing	Ongoing

Appendix 4. Task List for Year 4.

Server Maintenance
- Maintain the server, server security, and perform regular database backups
- Maintain the test server and development environment
- Perform necessary software upgrades including Windows Updates, SQL Server updates, and PHP Updates. Ensure all code performs as expected following updates.
- Assess overall performance and optimize resources as needed
- Maintain Database Manager credentials to access SQL Server

Website Maintenance and New Features
- Develop advanced SQL Query Builder and Query Builder User Guide*
- Create a collaborative resources page to share SQL queries and other helpful information*
- Develop QC Tools*
  - Change relationships (merge/split records)
  - QC Encounter attributes
  - Recalculate spatial attributes
- Create calculated fields*
  - Known distance travelled (based on Encounter history)
  - Days in river
- Uploads and monitoring of PIA data from various input source files
- Batch Upload enhancements
- Bug fixes
- Internal testing and stress tests
- Update online help, data dictionary, user manuals, and system documentation
- Train Recovery Program participants on new features and enhancements
- Other priorities identified by Recovery Program Database Managers

Project Management
- Prepare annual reports
- Perform project management and CSU compliance
- Maintain regular communication with Database Managers

*Pushed to Year 5

Appendix 5. Task List for Year 5.

Server Maintenance
- Maintain the server, server security, and perform regular database backups
- Maintain the test server and development environment
- Perform necessary software upgrades including Windows updates, SQL Server updates, TFS updates, and PHP updates. Ensure all code performs as expected following updates.
- Assess overall performance and optimize resources
- Maintain Database Manager credentials to access SQL Server

Website Maintenance and New Features
- Revise PIA import tools and tracking (Ongoing as Peter replaces units)
  - Automate connections and uploads to new Biologic service via FTPS
  - Develop import process for PIAs without data loggers
  - Reevaluate outage tracking
  - Streamline process to be more efficient and automated, adjust tables and import code accordingly
- Develop a movement tool to generate a list of Individuals that have moved upstream or downstream from a specific river mile. *
  - Adjust for transfers
- Develop QC Tools
  - Change relationships (merge/split records)
  - QC Encounter attributes (in progress, expect to be complete by December 2019)
  - Identify duplicate records
  - Identify orphaned Individuals
  - Recalculate spatial attributes
- Create calculated fields
  - Known distance travelled (based on Encounter history)
  - Days in river
  - Add calculated fields to Individual downloads and Individual details page
- Complete PIA location attributes and schematics
- Calculate XY coordinates for encounters from PIA coordinates and river mile coordinates
  - Update batch upload process accordingly
- Add an option to download the complete Encounter history for a list of Encounters
- Connect Tag deploy attributes to changes made to deploy Encounters and changes from "Undo" uploads
- Work with Database Manager to develop any necessary custom queries
- Batch Upload enhancements
- Bug fixes
- Internal testing and stress tests
- Update online help, data dictionary, user manuals, Data Managers user guide, and system documentation
- Train Recovery Program participants on new features and enhancements
- Other priorities identified by Recovery Program Database Managers

Project Management

- Prepare annual reports
- Perform project management and CSU compliance
- Maintain regular communication with Database Managers

*Pushed to Year 6 if resources are available