Center for Coastal Resources Management

Field and Laboratory Quality Assurance Plan

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1.0 Quality Assurance Policy

1.1 Quality Assurance Policy Statement

The Center for Coastal Resources Management conducts applied research and serves as a scientific advisor to federal, state and local agencies, and the general public. The Center recognizes the importance of how work processes are implemented to ensure that data collected are of the needed and expected quality for their desired use. In order to provide accurate information to user groups, the CCRM is dedicated to an aggressive, proactive Quality Assurance and Quality Control program.

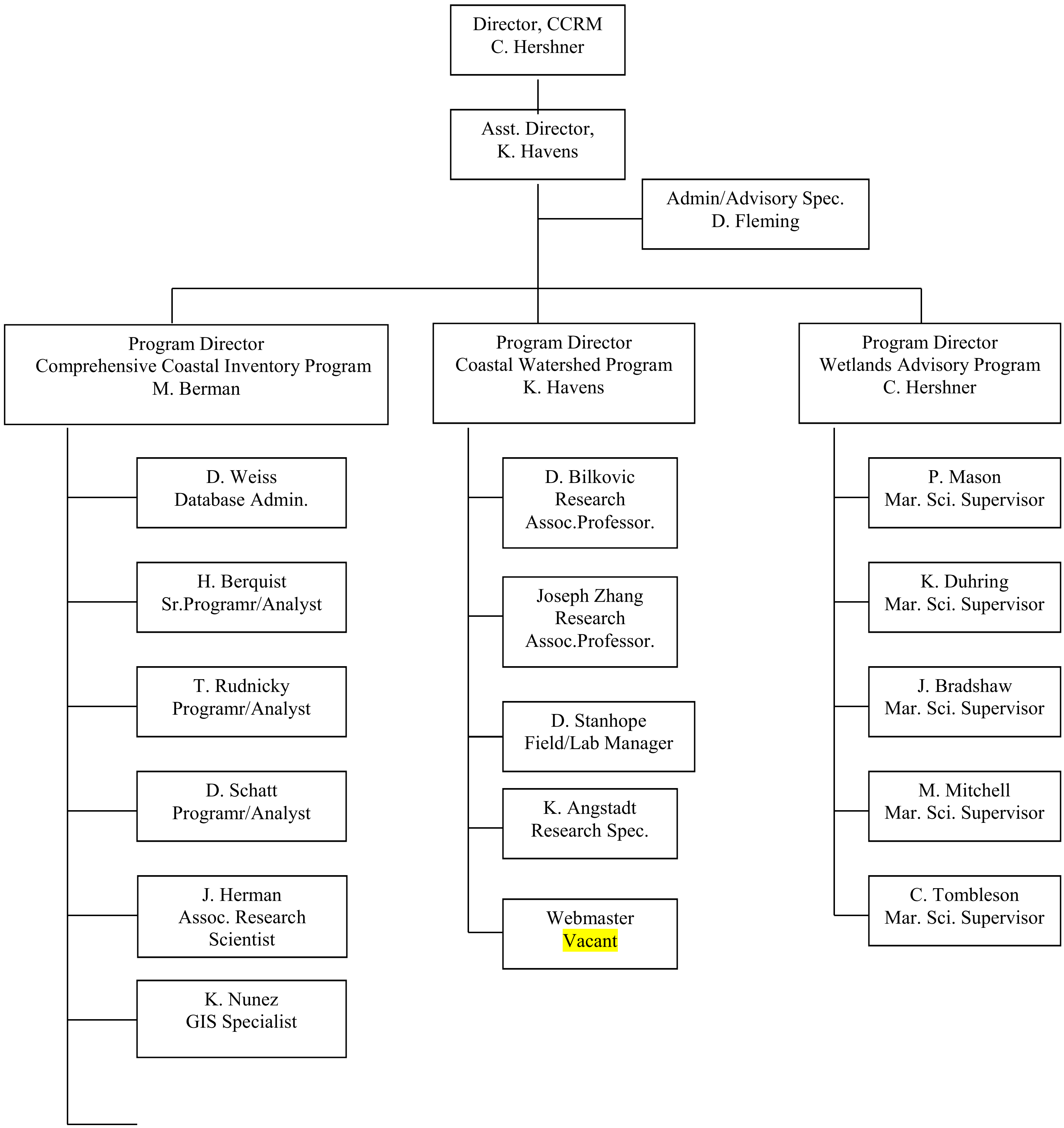
A myriad of activities occur within the Center, including direct support of laboratory and field investigations, support and training of graduate students and interns, training of resource agency personnel and the public, direct support of state agencies and local governments, and sponsorship of lectures, seminars, conferences and visiting scientists. Research activities include both field and laboratory measurements and the development and validation of ecological models. The general goal of the CCRM Quality System is to ensure accurate, reproducible, and unbiased data.

1.2 Operational Procedures

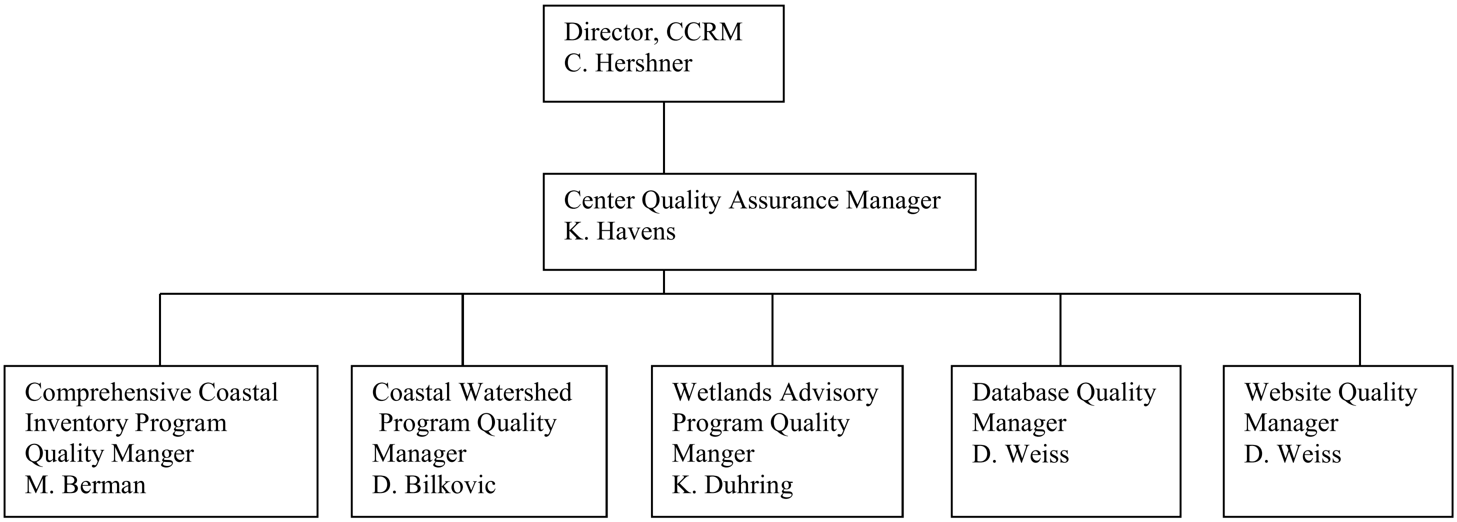
The Center recognizes the need for specific plans for individual data collection operations to ensure that data or information collected are of the needed and expected quality for their desired use. As a Center, the quality assurance operation procedures differ from that of an individual research contract. Each principal investigator is responsible for submitting a project-specific quality assurance plan to the relevant Program Quality Assurance Manager and the Center Quality Assurance Manager. The principal investigators will use the underlying principles described in this document as a framework for the specific quality assurance and quality control plans for each project. These plans should detail:

- The specific objectives of the project, including the hypothesis to be tested.
- The data quality objective for the variables to be measured.
- The specific sampling and analytical protocols required to meet the data quality objective.
- The individual responsible for quality assurance for the project.
- All noncompliance or deviation from the approved quality assurance plan will be reported to the Program Quality Assurance Manager and the Center Quality Assurance Manager.

1.3 Organizational Chart



1.4 Center Quality Assurance Management



1.5 Training

The Center is committed to providing quality training to ensure that all staff have the necessary skills to effectively accomplish their work. This may include training with specific instruments and equipment, software, sampling protocols, or continuing education. The Program Director in consultation with the Center Quality Manager ensures that all personnel within the respective programs have the appropriate knowledge, skill, and statutory, regulatory, professional or other certifications, accreditations, licenses, or other formal qualifications necessary for the performance of their tasks. Program Quality Managers are responsible for identifying retraining needs. The Center encourages continuing undergraduate and graduate level courses at the Virginia Institute of Marine Science, the College of William & Mary, and other accredited Universities for staff to increase their knowledge and skills.

2.0 Quality Assurance Objectives

2.1 Data Quality Objectives

The overall quality assurance objective for the Center for Coastal Resources Management is to develop and implement procedures for field and laboratory analysis, chain-of-custody, and reporting that will provide results that are of documented quality. Data Quality Objectives (DQOs) are used as qualitative and quantitative descriptors in interpreting the degree of acceptability of data. This section summarizes how specific QA objectives are achieved. The specific applications of these various activities are contained in the applicable Standard Operating Procedure (SOP) method. Terms used to express data quality standards are given below (Sherman et al. 1991):

1) *Precision* - is a measure of mutual agreement among individual measurements of the same variable, usually under prescribed similar conditions. Data precision of field sampling and laboratory samples can be checked through the use of replicate field measurements and standard procedures.
2) *Accuracy* - is the degree to which a measurement reflects the true or accepted value of the measured parameter. It is a measure of the bias in a system. Accuracy depends on the technique used to measure a parameter and the care with which it is executed. Standard operating procedures and QA audits are used to maintain data accuracy.
3) *Completeness* - is a measure of the amount of valid data actually obtained compared with the expected amount under normal conditions. Ideally, 100% of the data should be collected. Data may be incomplete due to incomplete data collection, lost or damaged data forms, or errors in data transcription. The acceptable level for completeness is 95% usable data.
4) *Representativeness* - expresses the degree to which data accurately and precisely represent a characteristic of the parameter measured. Representativeness is established by proper site selection and arrangement of sampling areas.

5) *Comparability* - expresses the confidence with which one data set can be compared to another. Collection of data by different investigators is one of the primary causes of variability in the data. Standardized operating procedures, internal QA audits, and training minimize variability in the data.

3.0 Field and Laboratory Data

3.1 Standard Operating Procedures

CCRM maintains Standard Operating Procedures (SOPs) that accurately reflect all laboratory and field activities. These SOPs provide detailed information to personnel on the performance of their work. Copies of all SOPs are accessible to personnel and are located within each Program and on the Center website.

SOPs are used to ensure consistency and efficiency. Field sampling and laboratory analytical methodologies employed in each Center project will be internally consistent and compatible with previous projects. Any deviation from an established procedure is documented.

The Program Quality Manager is responsible for ensuring that work is performed according to the approved Program SOPs as well as identification of operations needing procedures, preparation, review, approval, revision, and withdrawal of these procedures and policy for use. The Program Quality Manager is responsible for controlling and documenting the release, change, and use of planned procedures, including any necessary approvals, specific times and points for implementing changes, removal of obsolete documentation from work areas, and verification that changes are made as prescribed.

A. Coastal Watershed Program

Standard operational procedures for the Coastal Watershed Program field and laboratory data collection and analysis follow generally accepted methods such as those described in Mueller-Dombois and Ellenberg (1974), Avery and Burkhardt (1983), Murphy and Willis (1996). Identification of flora and fauna generally follows accepted references such as Gleason and Cronquist (1963) and Jenkins and Burkhead (1993), Pollock (1998), and Murdy et al. (1997), respectively. Collection and preservation of voucher specimens generally follows Hellquist (1993). All reference texts are maintained for review at the Coastal Watershed Program office. Specific Program SOPs have been developed and are attached as Appendix A.

B. Comprehensive Coastal Inventory Program

Standard operational procedures for the Comprehensive Coastal Inventory Program field and laboratory data collection and analysis follow the

Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998, Federal Geographic Data Committee http://www.fgdc.gov/metadata) and the Spatial Data Transfer Standard (SDTS). Specific Program SOPs have been developed and are attached as Appendix B.

C. Wetlands Advisory Program

Standard operational procedures for the Wetlands Advisory Program follow the Wetland Guidelines (Virginia Marine Resources Commission), the Subaqueous Guidelines (Virginia Marine Resources Commission), the Coastal Primary Sand Dunes and Beaches Guidelines (Virginia Marine Resources Commission), and Project Review Guidance (2012 CCRM/VIMS). Specific Program SOPs have been developed and are attached as Appendix C.

All SOPs are reviewed yearly by the Center Quality Manager and the Program Quality Managers and are developed according to the following documents:

- American National Standard. 1995. Specifications and guidelines for quality systems for environmental data collection and environmental technology programs. American Society for Quality Control, Energy and Environmental Quality Division, Environmental Issues Group, Milwaukee, Wisconsin.

- EPA QA/G-6. 1995. Guidance for the Preparation of Standard Operating Procedures (SOPs) for Quality Related Documents.

- Taylor, J.K. 1985. The quest for quality assurance. American Laboratory 17:67-75.

4.0 Data Reduction, Review, Reporting, and Records

4.1 Data Reduction and Initial Review

Data are reviewed and validated to ensure that the data are properly reduced and properly transcribed to the correct reporting format. Raw data from field and laboratory samples are reduced according to Program SOPs. Computer programs used for data reduction are validated before use and verified by manual calculations on a regular basis. All information used in sample preparation, field data collection, and calculations is recorded and maintained in order to enable reconstruction of the final result at a later date. Staff reports any noncompliance to the supervisor and initiate corrective action. The principal investigator reviews all data, records, and associated documents.

4.2 Secondary Data Review

All data are reviewed by a second researcher or supervisor according to field and laboratory procedures to ensure that calculations are correct and to detect transcription errors. Spot checks are performed on computer calculations to verify program validity. Errors detected in the review process are referred to the principal investigator for corrective action. After the secondary review, the second researcher or supervisor signs each page of raw data.

4.3 Metadata

Metadata is "data about data" and describes the content, quality, condition and other characteristics of data. The three main functions of metadata are to:

- Preserve the meaning and value of a data set.
- Contribute to a catalog or clearinghouse.
- Aid in data transfer.

Metadata is provided for all Center datasets.

4.4 Records

The Center recognizes the need to maintain quality-related documents and records. Records provide the direct evidence and support for the necessary technical interpretations, judgments, and discussions concerning Center results. These records provide the historical evidence needed for later reviews and analyses. All records are retained for a minimum of 5 years.

The Principal Investigator, Program Director, Database Quality Manager and Program Quality Manager identify quality-related documents and ensure that the records and documents accurately reflect completed work and are responsible for maintaining documents and records including transmittal, distribution, retention, access, preservation, traceability, retrieval, removal of obsolete documentation, and disposition.

Field and laboratory records generally consist of electronic tablets, notebooks, equipment maintenance and calibration forms, chain-of-custody forms, and personnel qualification and training forms. All records are recorded with permanent markers and retained for 5 years. Records that are stored or generated by computers have hard copies or write-protected backup copies.

Long Term Data Storage
The long-term data storage plan includes the deposition and preservation of all data and metadata on the CCRM/VIMS server and in the institutional digital archive (*W&M Digital Archive; https://digitalarchive.wm.edu/*) with the goal of archiving the data in perpetuity. The *W&M Digital Archive* is the College of William & Mary and Virginia Institute of Marine Science's online repository of research. The *W&M Digital Archive* is a university-wide effort to collect, preserve, and distribute digital material related to and produced by the university and its students, faculty, and staff and is accessible to the public.

Center records include the following:

Standard Operating Procedures.
Any revisions to field and laboratory procedures are written, dated, and distributed to all affected individuals to ensure implementation of changes.

Equipment Maintenance Documentation.
A history of the maintenance record of each system serves as an indication of the adequacy of maintenance schedules and parts inventory. As appropriate, the maintenance guidelines of the equipment manufacturer are followed. When maintenance is necessary, it is documented in logbooks.

Calibration Records.
The frequency, conditions, standards, and records reflecting the calibration history of a measurement system are recorded.

Original Data.
Field and laboratory raw data and calculated results are maintained in notebooks, logs, files, or other tracking or data entry forms.

Metadata.
Explanatory information about all created databases is stored on the Center computer files.

Correspondence.
Correspondence pertinent to a project is scanned and stored in the Center computer files.

Deviations.
All deviations from SOPs are reviewed and approved by the Program Quality Manager.

Final Reports.
A copy of any report issued is sent to the VIMS librarian Coughlin@vims.edu and stored in the College of William & Mary, Virginia Institute of Marine Science Digital Archive as a permanent URL https://digitalarchive.wm.edu/handle/10288/21771

Administrative Records.
Personnel qualifications, experience and training records are stored in the Center computer files.

5.0 Calibration Procedures and Frequency

5.1 Traceability of Calibration

All calibrations and working standards are documented in laboratory field logbooks and traceable to certified standards. Analytical support equipment is maintained in proper working order and records of all activities including service calls are kept. Analytical support equipment is calibrated or verified prior to use or at least annually.

Each calibration is dated and sufficient information is recorded to permit reconstruction of the calibration. Acceptance criteria for calibration comply with method requirements or are established and documented.

5.2 Instrument Calibration

Calibration procedures for a specific instrument consist of an initial calibration or initial calibration verification when the initial instrument calibration is not performed on the day of use. The SOP describes the calibration procedures, frequency, acceptance criteria, and conditions that will require recalibration.

6.0 Performance, Audit, and Frequency

6.1 Internal Audits

The Center for Coastal Resources Management is committed to ensuring an effective and a high level of performance in its quality system.

The Program Quality Managers are responsible for identifying, planning, implementing, and evaluating the effectiveness of quality improvement activities within their respective programs. The Center Quality Manager is responsible in ensuring that conditions adverse to quality are prevented, identified promptly, corrected as soon as practical, documenting all corrective actions, and tracking such actions to closure.

The Center Quality Manager oversees the assessment process to ensure that the personnel conducting assessments have sufficient authority, access to programs, managers, documents, and records, and the organizational freedom to identify both quality problems and noteworthy practices, propose recommendations for resolving quality problems, and independently confirm implementation and effectiveness of solutions.

The Center conducts annual internal audits to verify that field and laboratory operations continue to comply with the requirements of the quality system. The Center Quality Manager and each Program Quality Manager, the Database Quality Manager, and the Website Quality Manager collectively assess the quality system of each program element, review the findings of the assessments and ensure corrective actions are made promptly. The Quality Management Assessment Checklist is attached as Appendix D.

Where audit findings cast doubt on the validity of the Center's results, an immediate action is initiated and the Program Director and the appropriate Quality Assurance Manager, working closely with senior staff, have three weeks to provide a written response to the Center Quality Manager detailing corrective actions and implementation dates.

6.2 Managerial Review

At least once per year, generally coinciding with the annual internal audit, the Center Management conducts a review of the quality system to ensure its continuing suitability and effectiveness and to introduce any necessary changes or improvements. The review takes account of reports from managerial and supervisory personnel, the outcome of recent internal audits, any assessments by external bodies, the results of proficiency tests, any changes in workload, feedback from user groups, corrective actions and other relevant factors.

6.3 External Audits

The Center Director, in consultation with the Center Quality Assurance Manager, periodically conducts external audits. The Center Quality Assurance Manager maintains records of each audit and associated findings.

6.4 Documentation

Documentation of these actions is in the form of stored annual reports and reviews. Review of these documents is performed by committee on a periodic basis.

A quality assurance report is prepared as part of project final reports. The focus of the report is to highlight any factors that contribute to the uncertainty or reliability of the research conclusions. The report details the nature and frequency of problems that were (1) prevented, (2) discovered, and (3) corrected.

7.0 Facilities, Equipment, and Preventative Maintenance

7.1 Facilities and Equipment

The Center recognizes that quality control extends to items and services purchased for environmental data collection.

The Center is dedicated to providing quality products to its various user groups. CCRM has an extensive GIS network, wetlands application database, laboratory, and field research stations. The Principal Investigator, Program Director, and Program Quality Manager review and approve procurement items purchased for environmental data collection. This includes the associated technical and quality requirements and the supplier's responsibility. The Principal Investigator, in consultation with the Program Quality Manager, ensures that the documents satisfy all technical and quality requirements and are of acceptable quality.

The entire CCRM complex is secured by dedicated key access and is patrolled by security guards. All major equipment is listed in Appendix E. Records are maintained for all major equipment and include documentation on all routine and non-routine maintenance activities and reference material verifications. These records include:

- The name of equipment.
- The manufacturer's name, type identification, serial number or other unique identification.
- Date received.
- Current location (where appropriate).
- Copy of manufacturer's instructions.
- Dates and results of calibrations.
- Details of maintenance.
- History of any damage, malfunction, modification or repair.

7.2 Preventative Maintenance

Preventative maintenance is performed according to the procedures delineated in the manufacturer's instrument manual, including the frequency of such maintenance. Precision and accuracy data are examined for trends and excursions beyond control limits to determine evidence of instrument malfunction.

Instrument maintenance logbooks are maintained in the laboratory at all times. The logbook contains a complete history of past maintenance, both routine and non-routine. The nature of work performed, the date, and the signature of the person who performed the work are recorded in the logbook. Preventative maintenance is scheduled according to each manufacturer's recommendation.

8.0 Computers, Network Administration and Electronic Data Security Requirements

The Center recognizes the importance of computer hardware and software QA/QC protocols to record and maintain data. The Database Quality Manager in consultation with the Center Quality Manager, the Program Director, the Program Quality Manager, and the Principal Investigator (when appropriate) is responsible for developing, installing, testing, maintaining, controlling, and documenting computer hardware and software used in data collection and storage. The Database Quality Manager is responsible for assessing and documenting the impact of changes to user requirements and/or the hardware and software on performance. The Database Quality Manager, in consultation with the Principal Investigator, is responsible for evaluating purchased hardware and software to ensure it meets project requirements and complies with applicable contractual requirements and standards. The Principal Investigator, in consultation with the Database Quality Manager is responsible for ensuring that the data and information produced from, or collected by, computers meet applicable information source management requirements and standards.

8.1 Network Administration

The Center for Coastal Resources Management including the three internal programs constitutes a moderate size network of hardware and software running in Unix and Windows based operating systems. Table 1 lists computer equipment catalogued in the current computer inventory at press time. The various programs are noted for generating large datasets and require high storage capacity and archival devices. Two principal administrative activities relate to quality control. The first insures security of the system from external intrusion. The second insures security and safety of the data stored on the network.

Table 1. CCRM Backup Technology and Network

Devices backed up

13 TB Equalogic storage
12 TB RAID 1 disk space on ccrm (the webserver)

Backup hardware

4 RAID 5 Snapservers
EqalLogic Storage unit share with ITNS 7.2 TB of space for disaster recovery

Backup software

Cobian backup
Windows and unix scripts

8.2 Network Security:

The primary means of protecting the CCRM computer network is through the VIMS domain and PC passwords. No files other than those made available on the web server can be accessed without user/password authentication. Access from outside of VIMS for logging into the CCRM subnet or downloading files is restricted, and in most cases blocked by firewalls maintained by the VIMS' Information Technology and Networking Services (ITNS) center. No subnet firewalls are in place.

8.3 System Back-ups:

The CCRM online files and web server area is backed up weekly to the Snapservers and disaster recovery Equalogic storage. A combination of Windows and UNIX scripts duplicate the data.

This results in multiple copies of the files on the CCRM network. The original files on the disk drives, the copies on the Snapservers, and the offline copies on the disaster recovery unit.

There is no industry standard for frequency of full and incremental backups and no standard retention time for backup copies. These issues are determined by an organization's needs, resources and data volatility. CCRM procedures are consistent within the guidelines outlined in Little and Chapa, Implementing Backup and Recovery: The Readiness Guide for the Enterprise by David B. Little and David A Chapa.

8.4 Web Page Design and Administration

The Center maintains several web sites at the main Virginia Institute of Marine Science, College of William and Mary. The web addresses are http://ccrm.vims.edu/
http://vacoastadapt.org
http://schism.wiki
http://sagecoast.org

8.4a Web Design Quality Assurance

Quality assurance involves the entire development process. CCRM web administrator monitors the process, making sure that standards and procedures are followed, and ensuring that problems are corrected.

8.4b Testing

Testing involves operation of a system or application under controlled conditions and evaluating the results. Items within each site are evaluated and procedures to test each page include:

- Target browser check on Windows and MacIntosh for differences in layout, color, font sizes and default browser window size
- Check for internal broken links
- Check that external links work since other sites undergo redesign and reorganization
- Orphaned files (unreferenced filed – file exists in the site but there are no other files linking to it)
- Check for spelling errors
- Evaluate file size of each page and the time they take to download
- Insert appropriate bread crumb trail links
- Check main VIMS header links
- Include all text as Arial or Verdana sans serif font
- Run Site Reports program in Dreamweaver to test and troubleshoot the entire site
- Validate code to locate tag and syntax error

8.4c Verification and Validation

Verification typically involves reviews and meetings to evaluate documents, plans, code, requirements, and specifications. This can be done with checklists, issues lists, walkthroughs, and inspection meetings. Validation typically involves actual testing and takes place after verifications are completed.

8.4d Walkthrough and Inspection

A 'walkthrough' is an informal meeting for evaluation or informational purposes. The purpose is to assess potential problems or missing elements. Items to be inspected include:

- functional testing - black-box type testing geared to functional requirements of an application; this type of testing should be done by testers.
- acceptance testing - final testing based on specifications of the end-user or customer, or based on use by end-users/customers over some limited period of time.
- usability testing - testing for 'user-friendliness'. Clearly this is subjective, and will depend on the targeted end-user or customer. Programmers and testers are usually not appropriate as usability testers.
- security testing - testing how well the system protects against unauthorized internal or external access, willful damage, etc.
- compatability testing - testing how well software performs in a particular hardware/software/operating system/network/etc. environment.
- user acceptance testing - determining if software is satisfactory to an end-user or customer.
- alpha testing - testing of an application when development is nearing completion; minor design changes may still be made as a result of such testing. Typically done by end-users or others, not by programmers or testers.
- beta testing – secondary testing when development and primary testing are essentially completed and final bugs and problems need to be found before final release. Typically done by end-users or others, not by programmers or testers.

8.4e Development requirements and Maintenance

A web site life cycle begins when an application is first conceived and ends when it is no longer useful. It includes aspects such as initial concept, requirements analysis, functional design, internal design, coding, testing, maintenance, updates, retesting, phase-out, and other aspects. Materials on the web site that are no longer useful will be removed by the webmaster. Once a site has been developed and the bulk of the material has been published, it is important to continue to update and maintain the site.

8.5f References

Guidelines for CCRM web site QA/QC were developed with the following references:

- Dreamweaver MX 2004 User's Manual, Macromedia, Inc., 600 Townsend St., San Francisco, CA 94103

- Hover, Rick. *Software QA and Testing Frequently-Asked-Questions (Parts 1 and 2)* Available http://www.softwareqatest.com/about.html.

- http://www.rapidstability.com/qa.php

- "Software *Testing White Papers, An Introduction to Software Testing"* Quality Checked Software, IPL Information Processing Ltd., http://www.aqtlab.com/Quality Assurance Reasons and Basics.pdf

- Wilson, Nancy. June 2004. Personal communication with VIMS webmaster regarding web development QA/QC guidelines.

Program Standard Operating Procedures

A. Coastal Watershed Program
B. Comprehensive Coastal Inventory Program
C. Wetlands Advisory Program

Appendix A
Standard Operating Procedures for the Coastal Watershed Program

SOP-CWP Table of Contents

1.0 Standard operating procedures (SOPs)

Standard operating procedures (SOPs) for research projects conducted at the Coastal Watershed Program, a subgroup of the Center for Coastal Resources Management (CCRM), are broadly grouped in four sections: 1) Field Procedures; 2) Laboratory Procedures; 3) Data Reduction, Review, Reporting and Records and 4) Equipment Maintenance and Calibration. Example templates of Log sheets are archived electronically within the Coastal Watershed Program (Data Log Sheet, Field Log Sheet and Field-Training Log Sheet). QAQC Procedures for each project are outlined in Appendix A (Coastal Watershed Program QAQC Project Flow Chart).

1.1 Field Procedures

Field methodologies are based on generally accepted sampling protocols. Crews are trained prior to sampling and each crewmember is designated with specific tasks to maintain consistency. Project leaders sign off after the field crew is adequately trained and knowledgeable in methodologies. Log sheets are created prior to biotic sampling with sample identification numbers and location information depicted. The project leader then supervises the checking in of any samples collected in the field with information previously listed in the logsheetNet meshes, flow meters, sondes and other field equipment is inspected and repaired, when necessary, prior to use in the field. Field equipment lists are created and rechecked prior to fieldwork to account for equipment distribution for each project. To identify the most effective and efficient field sampling methods, literature reviews are regularly conducted on methods of sampling (database search of Aquatic Sciences and Fisheries Abstracts; example keywords "tidal marsh, sampling, fish survey").

1.2 Fish sampling protocols

Fish sampling protocols abides by IACUC guidelines. In the rare instance that an animal must be euthanized in the field for further identification in the laboratory, prior to fixing a specimen with formalin the animal is euthanized by immersion in an ice-water (4 °C or less) bath (see Wilson et al. 2009, J Am Assoc Lab Anim Sci. 48(6): 785–789). Capture of fish is based on generally accepted protocols for the given habitat type following

1) Durell and Weedon (2002) *http://www.dnr.state.md.us/fisheries/juvindex/index.html*;
2) Virginia Institute of Marine Science, Juvenile Striped Bass Beach Seine Survey *http://www.fisheries.vims.edu/trawlseine/sbmain.htm*;
3) Rozas and Minello (1997);
4) Havens et al. (1995); and
5) Murphy and Willis (1996).

1.3 Macroinvertebrate sampling protocols

Benthic macroinvertebrate sampling is based on generally accepted protocols for the given habitat type following

1) Identification of macroinvertebrates will follow CCRM/ Quality Management Plan standard operating procedures including the EPA Chesapeake Bay Program's online reference http://www.baybenthos.versar.com/docs/LTB_QAPP15.pdf
2) Llanso (2002) *http://www.baybenthos.versar.com/docs/ChesBayBIBI.PDF*; and
3) Chesapeake Bay Program Benthic Monitoring Project: *ftp://ftp.chesapeakebay.net/Pub/Living_Resources/benth/vabedoc.pdf*, *ftp://ftp.chesapeakebay.net/Pub/Living_Resources/benth/mdbedoc.pdf*.

1.4 Zooplankton sampling protocols

Zooplankton sampling is based on generally accepted protocols for the given habitat type following

1) Versar (2001) *http://www.chesapeakebay.net/Pubs/subcommittee/amqawg/doc-MDmesozooQA01.pdf*;
2) Carpenter (2001) *http://www.chesapeakebay.net/Pubs/subcommittee/amqawg/doc-VAzooplanktonQAPP2001.PDF*;
3) UNESCO (1968);
4) Jarvis (2003) http://www.tobyjarvis.com/pdf/phd3.pdf; and
5) Chesapeake Bay Program Zooplankton Monitoring Project *ftp://ftp.chesapeakebay.net/Pub/Living_Resources/plank/meso/vamzdoc.pdf* *ftp://ftp.chesapeakebay.net/Pub/Living_Resources/plank/meso/mdmzdoc.pdf*

1.5 Wetland sampling protocols

Protocol follows generally accepted methods such as those described in Mueller-Dombois and Ellenberg (1974), Avery and Burkhardt (1983), and Clairain et al. (1997) and the EPA National Wetland Condition Assessment Field Operations Manual (*latest edition*). Identification of flora follows accepted references such as Gleason and Cronquist (1963), Radford et al. (1968) and Gray's Manual of Botany (1987). Preservation of voucher specimens follows Hellquist (1993). Soil organic matter sampling follows Nelson and Sommers (1996) and ASTM (2000).

1.6 Water quality sampling protocols

Protocol follows generally accepted methods following YSI manuals; additional calibrations and data reduction/validation follow documentation by the Chesapeake Bay National Estuarine Research Reserve (CBNERR) program (NERR_YSI_macro.xls).

2.0 Laboratory Procedures

2.1 Biota Sorting Protocols

Sorting, enumeration, identification and weighing protocols correspond to generally accepted methods and references and are detailed by biotic type below. Information is recorded on laboratory data sheets and all data is filled in completely. After samples are sorted, they are checked off for verification on the original log sheets, which list sample identification numbers. Samples are archived for future reference according to project specifications. All reference texts are maintained for review at the Coastal Watershed Program office.

2.2 Macroinvertebrates

The sorting, enumeration and biomass estimation protocols for macroinvertebrates is based on generally accepted methodology following

1) Dauer (2002) http://www.chesapeakebay.net/pubs/subcommittee/amqawg/doc-VAbenthicQAPP01-02.PDF;
2) Versar (2001) http://www.chesapeakebay.net/pubs/subcommittee/amqawg/doc-MDbenthicQAPP01.PDF; and
3) Russell (2001) http://www.epa.gov/bioindicators/pdf/marine_benthos_sorting_QA.pdf;

Identification of macroinvertebrates follows references such as Gosner (1971); Pollock (1998); and Russell (2001) available online at http://www.epa.gov/bioindicators/pdf/marine_benthos_QA.pdf. A reference collection of macrobenthic species will be established. Up to 10 representative specimens of a taxon will be placed in labeled vials and archived in 70% ethyl alcohol. When specimens are removed from replicate samples for the reference collection, it will be noted on the appropriate Lab Data Sheet. Attempts will be made to include a variety of size classes for each species. For problematic and/or poorly known taxa, the appropriate taxonomic experts will verify reference specimens.

2.3 Zooplankton

The sorting, enumeration and biomass estimation protocols for zooplankton are based on generally accepted methodology following

1) Chesapeake Bay Program Zooplankton monitoring:

ftp://ftp.chesapeakebay.net/Pub/Living_Resources/plank/meso/mdmzdoc.pdf
ftp://ftp.chesapeakebay.net/Pub/Living_Resources/plank/meso/vamzdoc.pdf

Identification of zooplankton follows references such as Gerber (2000) and Pollock (1998). If zooplankton identification is unknown, then voucher specimens are sent to a second party.

2.4 Fish

Species identification follows accepted references such as Lippson and Moran (1974); Hardy (1978); Jenkins and Burkhead (1994); and Murdy et al. (1997). Voucher specimens are brought to the lab for identification based on accepted references and keys. If species identification is still unknown, then voucher specimens are sent to a second party.

2.5 Water quality assessment

The maintenance, preparation, deployment and retrieval of YSI sonde units follow procedures outlined in the YSI manual retained at the Coastal Watershed Program office. Data extraction procedures developed for the Coastal Watershed Program are accessible on the public server.

3.0 Data Reduction, Review, Reporting and Records

Procedures follow general QAQC operating protocols (Section 4.0 Data Reduction, Review, Reporting and Records). Data are reviewed and validated to ensure that the data are properly reduced and transcribed to the correct reporting format. Computer Programs used for data reduction are validated before use and verified by manual calculation on a regular basis. All information used in calculations is recorded in order to enable reconstruction of the final result at a later date. Information on sample preparation and field data collection is maintained in order to enable reconstruction of the final result at a later date. Staff reports any noncompliance to the supervisor and initiates corrective action.

In addition, a second party routinely checks progress on data entry to ensure the timely transcription of data. To ensure that calculations are correct and to detect transcription errors, a second researcher or supervisor according to field and laboratory procedures reviews all data. Spot checks are performed on computer calculations to verify program validity. Errors detected in the review process are referred to the principal investigator for corrective action. The principal investigator reviews all data, records and associated documents. All data entry, reduction and reviews are noted within a metadata file maintained with the database and electronically archived.

4.0 Equipment maintenance and calibration

Logbooks are maintained for laboratory equipment to record information on use, calibration and maintenance. Logbooks are periodically examined and initialed by project leaders to ensure entries are up-to-date.

a. Muffle furnace—logbook in place
b. Analytical balance—logbook in place
c. Drying Oven—logbook in place
d. Fish board—logbook in place
e. Flow meters—logbook in place
f. SET—logbook in place
g. Light meter—logbook in place
h. Humminbird Side Scan Units

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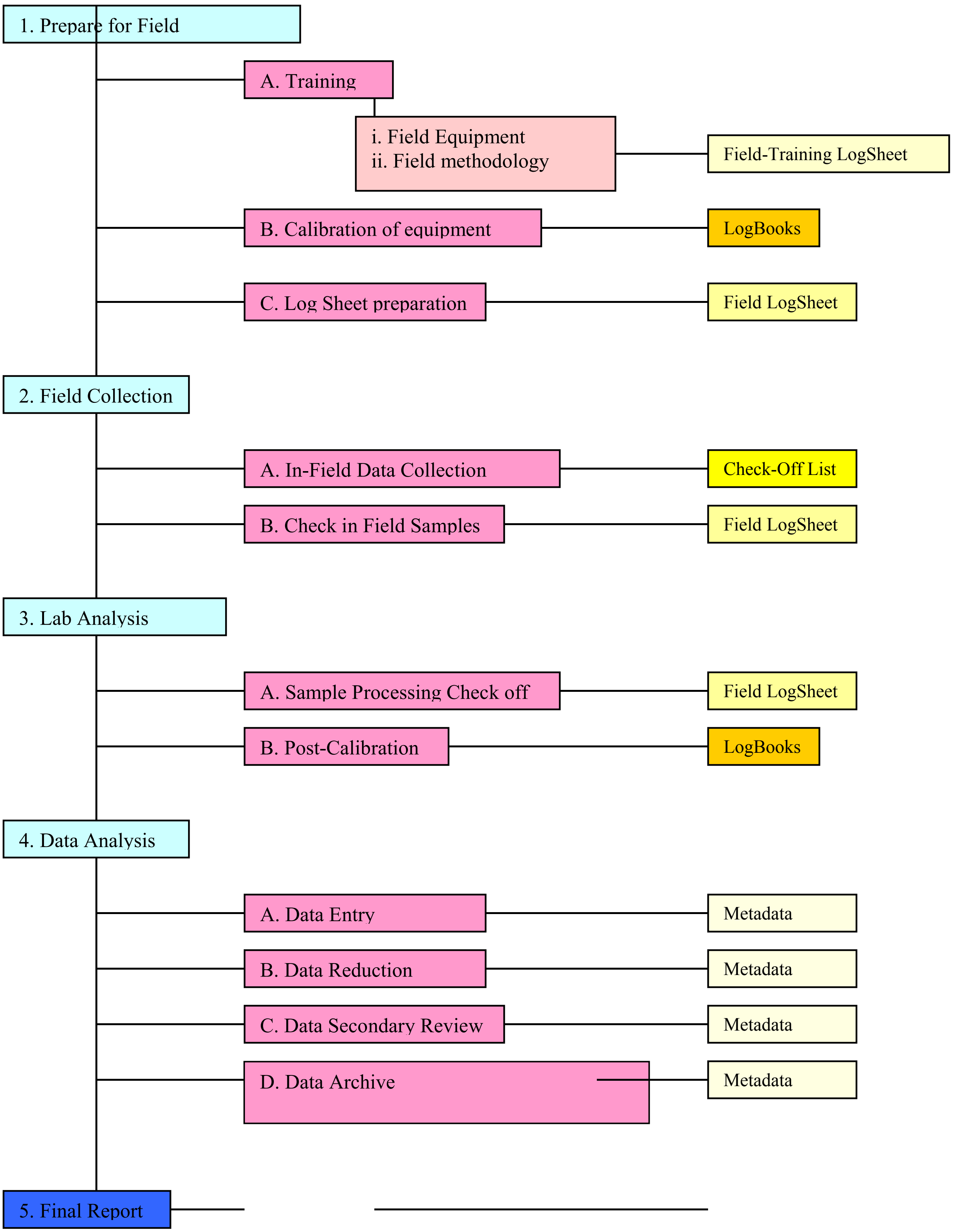
6.0. Coastal Watershed Program QAQC Project Flow Chart



Appendix B
Standard Operating Procedures for the Comprehensive Coastal Inventory Program for the Development of General Digital Data, GPS, and Shoreline Inventories

SOP-CCI Table of Contents

Introduction

Standard operating procedures (SOPs) for research projects conducted within the Comprehensive Coastal Inventory Program (CCI), a subgroup of the Center for Coastal Resources Management (CCRM), are broadly grouped in four sections: 1) Field Procedures; 2) Digital Data Development; 3) Project Development; and 4) Network Administration. Since CCI generates large spatial data sets, the program has instrumented a large data handling, storage, and back-up system that also serves the larger CCRM users and programs.

The link to the flow chart in Appendix I provides an outline of overall Quality Assurance steps.

1.0 Standard Operating Procedures (SOP) for Field Work
Field work can encompass a broad range of activities to satisfy enumerable research activities within the Comprehensive Coastal Inventory Program and its partner programs. Sections below include both generic and specific procedures in place for several of the program's core field operations. This includes the development of Shoreline Inventories. This section will evolve as specific projects require specialized protocols for data collection in the field. Field methodologies are based on generally accepted sampling protocols. Crews are trained prior to data collection. Tasks to be accomplished under the assigned project are communicated in advance of all work.

1.1 Training: It is the responsibility of the Project Manager or Field Manager (if assigned) to insure all crew is properly trained prior to field work. During the training process, trainees may be supervised by one or more trained crew member. Sign off sheets, requiring signatures from the trainer and Project Manager must be on file before an individual can perform field tasks independently. A standard Field-Training Log Sheet (Appendix 2) is available. The Field-Training Log Sheets are reviewed and modified for each new project by the project manager to reflect all equipment or procedural training necessary for specific projects. Project leaders sign off after the field crew is adequately trained and knowledgeable in methodologies.

1.2 Field Logs: A *Field Log Book* contains a continuous record of shoreline surveys throughout the sampling season. The log book is used to transcribe daily surveys, describe start and end points, describe digital photos captured, survey times, and launch locations. *Field Log Sheets* are submitted following each field trip (Appendix 2). These sheets identify crew members, vessel name, locations surveyed during the trip, general climatological conditions at the site, location of public or private access points utilized, time on the water, survey times, nautical charts required, cell phone number, directories for data download on field computer, and directory for data download on the network. Following each field trip, colored highlighter markers are used to delineate areas covered each day on nautical charts. The project manager reviews and signs off on all field log sheets to insure completion and proper archive of the field data collected.

1.3 Field Check List (pertains to Shoreline Inventory): A checklist is used prior to departure for each field trip to insure all required gear is accounted for (Appendix II).

1.4. GPS Data Collection (pertains to Shoreline Inventory): Following protocols published in Berman and Hershner, 1999, data are logged on Trimbles' GeoExplorer 3 and GeoXT handheld GPS units. These systems have accuracies of 5 meters or better in real-time and sub-meter with postprocessing. Both units have preprogrammed data dictionaries that insure continuity in attribute collection. Attributes are collected as either static points or continuous line features. For linear features GPS positions are collected at the rate of 1 position every 3 seconds while the boat is moving. Point features are collected while the boat is stopped directly off the feature with a minimum of 5 positions collected at 1 point per second. Manuals for the operation and accuracy of the Trimble units are available in the laboratory or online. Product specifications are reported in company materials and are in-house for review. Accuracy pertaining to GPS surveys is a function of many parameters. A review of conditions and procedures that can influence GPS accuracy and data collection are reported and noted in (Trimble, 2002) which is available in the CCI facility as a reference.

1.5. Geo-Referenced Video Capture (pertains to Shoreline Inventory): Shoreline conditions are captured using a Red Hen® video system which is a manufactured video camera interfaced with a GPS system. This system interfaces a standard video camera (e.g. Sony ACC-HDV7) with an external GPS and uses specialized hardware (VMS300) to convert the GPS data into an audio signal which is transmitted to the video through the microphone input connector on the camera. As the video is recorded, GPS data are transmitted once per second to the video camera. Each GPS location is linked with a time code on the video. Therefore, the survey is a set of geographically referenced videos of the shoreline referenced to the position of the boat as it moves alongshore. The advantage of this system is that it allows for permanent visual archive of shoreline conditions at the time of data collection. Videography is collected from a moving vessel using a stabilizing tri-pod to minimize movement in the film capture. The system is not operated under abnormal or turbulent sea conditions. If such conditions exist, the field crew defers to collection techniques described in 1.4. Vendor developed software allows the video to be viewed geo-spatially in the ArcGIS platform. The video is collected continuously and viewed in the laboratory using proprietary software. Manuals for the operation and accuracy of the equipment, as well as product specifications are stored in the laboratory.

2.0 SOP for Digital Map Production

This section covers the development of digital map data from some other source other than GPS. In prior years, much of digital map production was conducted from hardcopy map bases and used digitizing tablets and user operated cursors to delineate base map features. While these data may still be in use today, the development of new digital data has shifted from tablet digitizing to onscreen, also known as, heads up digitizing. This constitutes the majority of baseline data development. Coverages generated under these guidelines frequently describe "raw" constituents of the landscape. These data do not pertain to shape files that are generated as a result of model output (see below). They do, however, include the majority of digital data that will be utilized within GIS models for synthesized output.

2.1. Basic Settings and Parameters in ArcInfo - There are programmable options or settings within the ArcInfo product that enhance quality and accuracy in digital data. Many of these arguments have built in default values that can be reassigned by the user. Others must be assigned initially by the user prior to digitizing. These functions are briefly described below.

Dangle Tolerance: CCI uses a dangle tolerance of 0.1 inches (1.0 m in UTM). The dangle tolerance is the minimum length allowed for dangling arcs during the CLEAN operation. Dangling arcs shorter than the dangle length will be removed.

Fuzzy Tolerance: CCI uses a fuzzy tolerance of 0.001 inches (1.0 m in UTM). The fuzzy tolerance is the smallest distance between all arc coordinates. It defines the coordinate resolution of all arcs in the coverage. The fuzzy tolerance is a very small value (in inches or meters) that is used to resolve inexact intersection locations due to limited arithmetic precision of computers. It is set during the CLEAN operation

TRANSFORM: Transform converts coordinates from digitizing units into a selected "real world" coordinate system through translation, rotation, and scaling. A root mean square (RMS) error is calculated for every transformation. The RMS value represents the amount of error between the original and the new coordinate locations. The lower the RMS value, the more accurate the digitizing will be. Arc/Info specifies that RMS values should be kept under 0.004 for highly accurate geographic data. CCI maintains an acceptable RMS value of 0.002 (inches). Corner registration tics are re-entered and TRANSFORM repeated until this value is achieved. Poor transformation can be attributed to low quality hard copy base maps. Another base map product will be sought if low RMS values persist.

BUILD: The BUILD command constructs topology and creates feature attribute tables for point, line, polygon, node, or annotation coverages. BUILD recognizes existing arc intersections and checks node intersections for overlap. If overlap is detected CLEAN is performed. An operator may choose to clean the coverage manually rather than run CLEAN; which is a slower operation. If a coverage is manually cleaned, BUILD will be run again to check for correctness in the topology.

CLEAN: The CLEAN command constructs topology and creates feature attribute tables for polygon and line coverages only. Unlike BUILD, CLEAN performs coordinate editing and creates intersections where arcs cross, adds nodes at arc intersections, and clips dangle nodes. Prior to CLEAN the fuzzy tolerance and the dangle tolerance are set.

LABELERRORS: LABELERRORS checks for and identifies potential errors in polygon labels.

2.2. Generating Shoreline from Digital Imagery: Digital imagery is used to generate shapefiles representing baseline shoreline used for many Program applications. Currently, procedures are in place for developing digital shoreline from color infra-red or natural color high resolution digital ortho rectified imagery. This represents a significant increase in resolution from earlier efforts which used digital ortho-quarter quadrangles. The procedure applies photo-interpretation techniques for recognizing the land-water interface. The shoreline data being generated is not corrected for tidal position.

Digital shorelines provide the base map upon which all field data are registered to. The base shoreline is generated by using on-screen, digitizing techniques in ArcMap® v10.0 - ArcGIS v 10.2.2, using the latest imagery from the Virginia Base Mapping Program (VBMP). Online Bing Imagery may also be used, when available, to assist in areas where the land-water interface is obscured. The defined baseline represents the land-water interface and is not a tidally referenced or surveyed demarcation.

The user defined interface is subject to enormous interpretive error. To minimize errors and insure consistency in definition, a series of protocols combined with checks are in place. Below is a list of rules applied in photo interpretation to assist in delineating the boundaries.

For beach environments, the land water interface is delineated between the dry beach and wet beach (if present) or the dry beach and the shallow water (if wet beach is not present). These parameters are defined by their signature color explicit in the imagery where:

Dry beach: spectral signature in color infra-red is generally "stark white"
Wet beach: spectral signature in color infra-red is generally " gray white" Shallow water: spectral signature in color infra-red is generally "bluish white"

For intertidal marsh environments, the shoreline is drawn at the seaward edge of the marsh. Indeed, this potentially extends to the shoreline seaward of the boundary defined for beach environments, but here the intertidal zone can be extensive and the true limit of the tidal inundation across the marsh surface cannot be estimated. An inland demarcation is also delineated for studies that are interested in observing change in marsh geography over time.

For mud flat environments, the shoreline is defined along the upland edge of the flat.

For tree canopy environments, the shoreline is extended through the canopy to join the lines delineated on either size of the canopied reach.

Along bank dominated shorelines, the land-water interface visible in the image could represent the base of the bank, but might also represent high tide water levels.

When shadows fall landward due to sun angle, the shoreline is digitized on the seaward side of the shadow.

When shadows fall seaward due to sun angle, the shoreline is estimated and digitized through the center of the shadow.

When shorelines have bulkheads, additional vertices are added to insure straight, not jagged lines.

2.3. Extracting Shoreline from Digital Terrain Model (.dgn) Files : In 2002 and again in 2007 the Virginia Base Mapping Program has released a digital product in Virginia that contains a digital coverage of streams, rivers, tributaries, and creeks. Each must be extracted from the larger dataset. A procedure has been developed to facilitate this extraction. Appendix 4 provides details. This shoreline is rarely used as a basemap since the positional data is out-dated. However the shoreline may be extracted as a reference for historic comparison or if a specific project milestones requires rapid acquisition of a baseline shoreline covering a large geographic area in a short time frame. In the later case, QA/QC includes a visual review of the shoreline for gross error and change as well as QA/QC steps used for the development of the digital shoreline from digital imagery.

2.4. Automated Procedures: Automated quality control measures set by the operator and within the GIS software include:

Weed Tolerance: CCI uses a weed tolerance or weed distance of 0.01m for all GIS shape files. The weed distance equals the minimum allowable distance between any two vertices along an arc. The weed tolerance is a parameter set before digitizing begins. If two consecutive vertices are within the set weed tolerance, the second vertex is disregarded. A weed tolerance = .01 m and grain = .01 m (allows for short distances between vertices) is used.

Node Snap Tolerance: CCI generally sets a node snap tolerance less than 0.05 inches (<10.0 m in UTM). The node snap distance is the minimum distance within which two nodes will be joined (snapped) to form one node. The node snap provides an automated mechanism for eliminating small gaps in arcs where dangles would normally be created. The nodesnap closest is set to = .02 m.

3.0 Shoreline Inventories - Data Development and Processing

The development of Shoreline Inventories is a multi-step process which can include different collection techniques depending upon the attribute being mapped. Each step in the development of a compiled Shoreline Inventory has its unique quality control and assurance measures. Some are software defined, while others are user initiated. A log sheet tracks personnel signatures at various steps to insure all procedures are followed (Appendix 3). The program manager signs off when a shape file is complete.

For all inventories the first step is the baseline shoreline development which serves as a record of the shoreline position fixed in time. It also serves as the basemap for the mapping of shoreline conditions. Baseline shoreline can be developed from digital imagery or extracted from digital terrain models. This process has been described above in section 2.0.

The inventory is a collection of shoreline conditions recorded and stored as digital attributes in GIS. They attributes characterize the condition of the shoreline at any given location along the estuary shoreline. Collection techniques can include the use of GPS in the field, GPS referenced videography from the field, or the extraction of data using high resolution imagery and heads up digitizing techniques.

For all operations, the digital shoreline is copied and then recoded to reflect conditions that are either recorded on the digital GPS files collected in the field or attributes which are digitized using heads-up digitizing techniques on the desktop,

3.1. GPS Processing: GPS data are processed using the Trimble Pathfinder Office software. GPS data includes a log of all features recorded in the field. Geographically the data represents the position of the boat track. This is corrected to reflect the land-water interface in later steps.

Field data are downloaded following each field day from the GPS units and reviewed for completion and continuity in collection. Upon return to the laboratory, field data are downloaded to the program's network computer and processed there.

Differential Correction is performed on each GPS file using time-synchronized data collected at various CORS (continuously operating reference stations). These stations are installed and maintained by the National Geodetic Survey and data are available online. This phase of post-processing uses Trimble's Pathfinder Office software. After correction, Pathfinder Office will report the 68% precision for each feature.

The editing function is used to clean the GPS data. This corrects breaks in data that occur when satellite lock is lost and when the unit is not set to pause when the boat makes unnecessary movements. Several features out of each day's survey are randomly checked to assure acceptable quality.

GPS files are converted to ESRI shape files for the next phase of data processing.

3.2 Shoreline Inventory Data Processing from Videography

Two different software packages from Red Hen Systems are used to process the field data collected with the Red Hen Video package: PixPoint and GeoVideo for GIS. The PixPoint software package is used to generate a point shapefile containing points representing locations of geo-referenced still photos taken during the survey. GeoVideo software package is an ArcGIS extension. It is a desktop mapping application that brings geo-referenced video directly into the ArcGIS environment. This software enables users to digitally map videos using GPS coordinates. After the videos are downloaded into the computer, the GeoVideo software is used to generate a point shapefile which is geotagged to the video survey. This shapefile references the boat track of the survey and the video linked to it.

3.3 Shoreline Inventory Processing - General

Whether data are generated from GPS files, videography files, or from photo interpretation of high resolution VBMP imagery, GIS personnel use the shoreline developed from the VBMP imagery as the baseline for the Inventory. This shoreline is code for the attributes observed in either the video survey, imagery (VBMP, Google Earth, Bing) or from processed GPS data. Recent VBMP imagery is used in the background for reference during the data processing. All ancillary data resources are utilized for accuracy purposes including additional imagery from different year classes.

Each section of the digital shoreline is coded using ArcGIS 10.2.2. The total length of the shoreline is inspected by a second GIS analyst using different imagery sources (VBMP, Google Earth, Bing Maps). The final stage in the QA/QC process involves additional inspection by a third professional. This person particularly inspects the coding for shoreline structures, shoreline access features, as well as presence of beaches for the entire locality. Based on onsite experience, as well as using background imagery for certain landscape features not easily identified in the video, corrections are made as necessary

4.0. Quality Assurance/ Quality Control (QA/QC): CCI follows a series of checks, reviews, and correction procedures prior to publishing and releasing any new dataset. Procedures may vary depending on the data being developed. For all GIS datasets developed:

Metadata: This program uses FGDC compliant metadata. Documentation pertaining to the development of accepted metadata practices is on file in the CCI laboratory. Metadata is generated upon completion of all new digital coverages. Metadata records are distributed with all digital products and are archived with the original product.

Digital Coverage Checklist: A checklist logs the progression of the coverage development from start to finish. The program manager reviews and signs off when all elements have been met.

4.1 QA/QC for Digital Shoreline: All mapping is accomplished at a scale of 1:1,000. The QA/QC process for the shoreline involves running topology rules to ensure that the arc has no overlapping segments or dangles. With this step, we define and enforce data integrity rules.

When the digital delineation of the shoreline is completed, the coverage is checked for errors. A senior programmer analyst performs this step. Specifically, the coverage is reviewed for accuracy in the delineation and then checked to insure there are no incomplete arcs (dangles). The accuracy check is performed with the digital imagery onscreen. Dangles are closed where appropriate for line continuity.

During the development of the Shoreline Inventory data, multiple reviews of the baseline shoreline shapefile also occur at specific points. As each attribute file is generated, the shoreline file is revisited by GIS personnel and corrections are made where necessary.

4.2 QA/QC for Shoreline Inventory Data: Several steps are in place to insure quality in final products. When coverages are complete, a second GIS Programmer reviews the files for correctness and completeness. This review focuses on coding, arc and point development, and correctness in data transfer from the original shape files. Background imagery provides additional quality control for certain landscape features not easily identified in the field. Corrections are made as necessary.

4.3. Hardcopy Check: Following the digital check a draft set of hardcopy maps illustrating data in final publication format is printed. Templates have been prepared to minimize errors in formatting output products (Appendix 4). These templates insure consistency in color, design, and placement, as well as content. Hardcopy maps endure separate reviews by two additional staff to insure consistency and quality in the deliverable.

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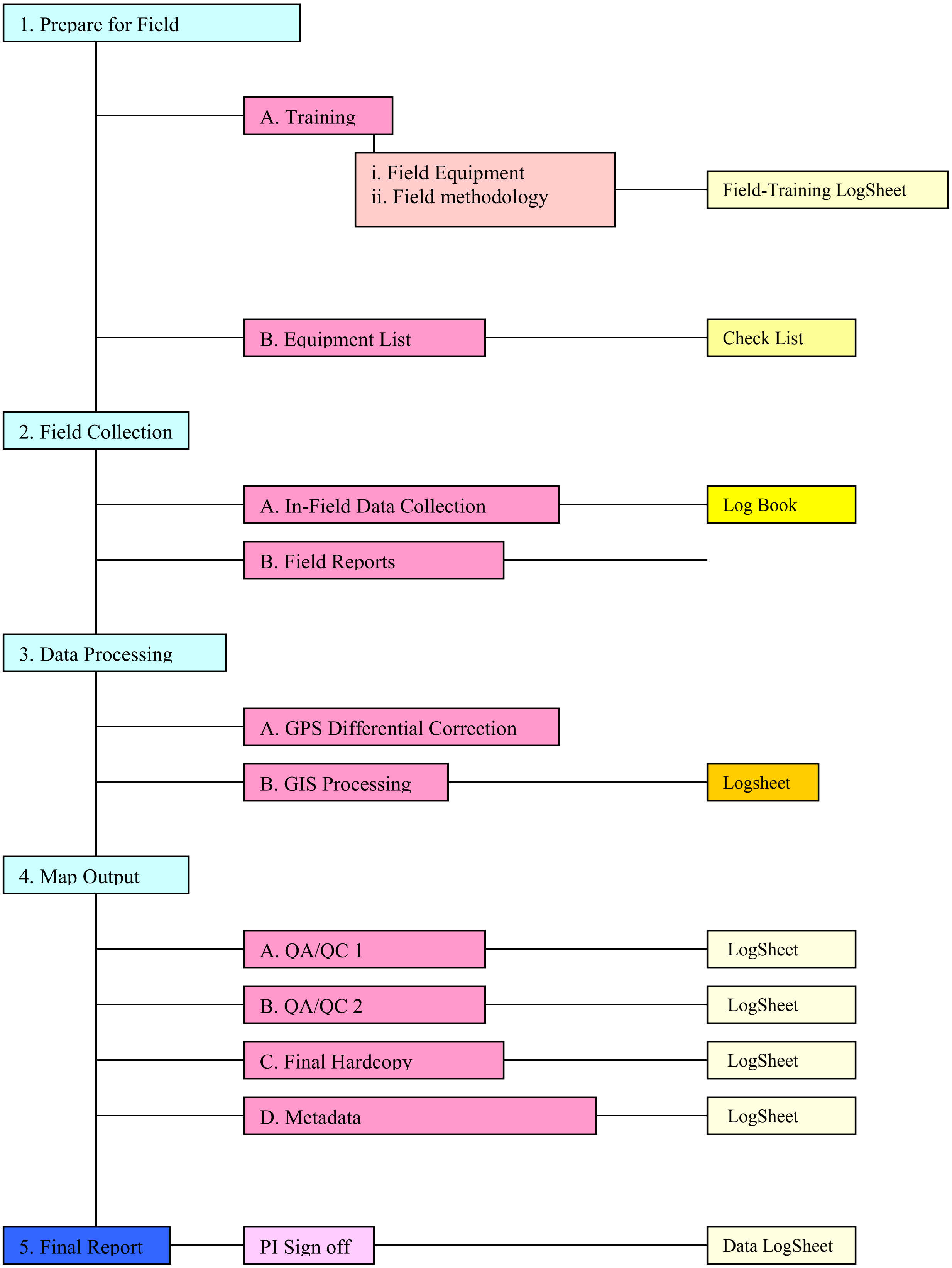
Appendix I. Link to Coastal Inventory General SOP/QAQC Flow Chart

SOPflowChart.doc

Appendix II. Comprehensive Coastal Inventory QAQC Flow Chart – Shoreline Inventory



Appendix III. Shoreline Inventory – Data Processing Log Sheet

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Appendix IV. Procedures for Extracting Shoreline from Digital Terrain Model (.dgn) Files*

1. All files containing the desired shoreline are loaded as layers in ArcMap.
2. All annotation, point and polyline layers are removed, leaving only the polyline layers.
3. The polyline layers are merged to a shape file using the GeoProcessing Wizard.
4. The resulting shape file attribute table is edited to remove all polylines that do not have level codes 41 (Visible shoreline of the Atlantic Ocean and Chesapeake Bay), 42 (Lakes and ponds with visible water), and 44 (Rivers and streams with visible water).
5. The projection associated with the DTM files is either VA North or VA South State Plane Coordinates NAD 1983 (HARN), using U.S. Survey Feet. This information is attached to the shape file using the Define Projection Wizard in the Arc Toolbox.
6. For our use the file is projected to UTM NAD 1983 (Meters) using the Project Wizard in Arc Toolbox.
7. For shoreline inventory use a copy of the file is interactively edited on screen to remove all polylines not directly connected to tidal water.

* Virginia Base Mapping Project digital terrain models in micro station .dgn format, derived from high-resolution, vertical aerial photography collected in Spring 2002. These files are presently available on a DVD in CCI Room #106 and will soon be put on the CCRM network. For more information see the VBMP Project Manual also in CCI Room #106 or on-line at http://www.vgin.virginia.gov/VBMP/VBMP.html

Appendix C
Standard Operating Procedures for the Wetlands Advisory Program

SOP-Wetlands Table of Contents

Wetlands Advisory Program - Standard Operating Procedures
Updated January 2014

1.0 Purpose

The Wetlands Advisory Group (WAG) provides advisory service for a regulatory program in the tidal waters of coastal Virginia known as the Joint Permit Application or JPA process. The geographic area covered by this regulatory program includes 24 counties and 16 cities or towns in coastal Virginia. These WAG public interest reviews are provided mostly to local and state regulatory agencies, which includes government staff and appointed Board members, as well as the general public. This advisory service combines the influence of state law and promulgated guidelines with the best professional judgment of the Wetlands Advisory scientists at the Center based on the current scientific understanding of tidal shoreline conditions and management programs.

The Wetlands Advisory Group is also responsible for conducting Tidal Marsh Inventories (TMI) collaboratively with the Comprehensive Coastal Inventory program (CCI) at the Center. The geographic area covered by each Tidal Marsh Inventory is typically within the boundaries of a specific local government area or targeted watershed. This research is intended to document general tidal marsh community types and geographic extent. The collected information supports wetland trend analysis and shoreline resource management guidance.

This quality assurance plan outlines standard methodology employed by the Wetlands Advisory Group to minimize human error and ensure assessment accuracy among multiple scientists for these two programs. These Standard Operating Procedures provide consistency among various scientists performing similar tasks and accountability for professional assessments and advisory service.

2.0 Joint Permit Application Administrative Review

The Joint Permit Application (JPA) review process is initiated upon receipt of a special request from third parties such as local government staff, Local Wetlands Boards, and state or federal regulatory agencies (e.g. MRC, DEQ, USACOE). Once in-house, the review process proceeds as follows:

2.1 JPA Review Qualifications

Applications are reviewed by a designated WAG JPA review coordinator to determine if the criteria for a full review are met. The application must involve tidal waters, beaches, dunes or subaqueous lands as regulated by state law and involve activities other than private, residential piers, moorings and/or osprey nest platforms. Virginia law requires comments by the Virginia Institute of Marine Science for all erosion control structures that encroach into designated Baylor survey grounds, which are public oyster beds, rocks, and shoals (Section 28.2-556, Code of Virginia).

Joint Permit Applications to be reviewed are logged into a Microsoft Access advisory tracking database and assigned to the appropriate reviewing scientist. Case assignment is based on who received the initial request, prior experience or familiarity with the project and/or location, level of expertise required, and/or extent of internal peer review by other VIMS scientists that is required.

Each incoming application is reviewed to ensure there is sufficient information to perform an environmental assessment, including but not limited to:

- Locality
- Type of project
- Agent/contractor/adjacent property owners
- Completeness of information in both text and drawings
- Location map and driving directions

Each assigned reviewer is responsible for requesting any missing information necessary for environmental and public interest review from regulatory agencies, agents, and/or applicants.

2.2 Site Visit Determination

The need for a site visit is determined by the reviewing scientist based on the project type, potential amount of controversy or public protest, and/or other unique factors. If a site visit is determined to be necessary, then each reviewer coordinates with applicants, agents, and/or regulatory personnel, as necessary. Data collection and handling for site visits are described in 3.0 Field Review.

For JPA cases that do not require a site visit, the project assessment continues with 4.0 Desktop Review & Analysis of Supporting Information. Examples of projects where a site visit is usually not necessary include:

- Projects with impacts that do not require permits
- Projects with sufficient environmental assessment information available through a desktop review
- Offshore maintenance dredging projects
- Oyster and fish sanctuary reefs
- Projects for which previous knowledge of the site exists

3.0 Field Review

The JPA includes a form signed by applicants that allows duly authorized representatives to enter upon the premises of the project site at reasonable times to inspect and photograph site conditions. This grants permission to conduct a site visit with or without the property owner present and to collect information about the property that will become public record. Each JPA site visit includes an assessment of local ecological conditions plus estimates of proposed environmental impacts that require permit approval.

Digital photographs may be taken by WAG scientists or provided by third parties. Site visit information and photographs are entered into the advisory database by the reviewing scientist. See also 8.0 Posting Public Records.

For JPA Review site visits, the survey of ecological and hydrogeomorphologic conditions may include one or more of the following:

1. For erosion stabilization projects, look for erosion indicators - scarps, undercut banks, slip slopes, fallen trees, exposed banks, failing structures, exposed utilities
2. Observe physical and biological indicators of mean high water (MHW), mean low water (MLW), upper limit of wetlands (ULW) and/or landward limit of primary dune (slope break)
3. Observe site topography
4. Observe indicators of littoral drift direction and sand availability
5. Observe fetch, exposure to storm tides
6. Observe land use/land cover of subtidal, intertidal, and upland habitats, including submerged aquatic vegetation (SAV), oyster reefs, marshes, beaches and forests
7. Observe adjacent properties for habitat type, similar erosion characteristics, structures
8. Observe indications of anthropogenic disturbance
9. Estimate area of each habitat type(s) to be impacted, as defined by Virginia Wetlands Guidelines and Coastal Primary Sand Dunes/Beaches Guidelines

4.0 Desktop Review & Analysis of Supporting Information

The next step in the Joint Permit Application review process is the collection and analysis of information available at the desktop. This process may be used solely or to augment observations made during the Field Review. A Reach Assessment may be performed through the review of existing database resources, inventories and aerial photography.

4.1 Existing Information

Each JPA review may include one or more of the following information sources:

- CCRM scanned permit records
- CCRM GIS databases, including but not limited to:
    - Shoreline Assessment Mapper (SAM)
    - Shoreline Inventories – current & historical

- Tidal Marsh Inventories – current & historical

- Project site photographs
- Google Earth, Bing Maps, Pictometry, and other aerial photographs
- Tide charts (predicted & observed)
- VA Fish & Wildlife Information Service
- National Wetlands Inventory
- VIMS Submerged Aquatic Vegetation (SAV) inventory
- VIMS Dune Inventory Reports
- VIMS Shoreline Evolution Reports

4.2 Project Impact Analysis

Each JPA review may include one or more of the following project analysis steps:

- Review project proposal for consistency with guidelines (See Section 10.0 VA Law & Promulgated Guidelines)
- Perform qualitative reach assessment as needed
- Evaluate historical patterns of erosion and accretion, source and volume of local sand supply
- Fetch & effective wave climate, direction of littoral drift
- Natural resources within reach, e.g. pocket marshes, sand spits, non-tidal wetlands, beaches and sand dunes, riparian buffers
- Perform calculations as necessary to estimate square footage of proposed impacts & fill
- Validate potential impacts to marine resources & adjacent properties
- Evaluate avoidance & minimization measures
- Evaluate alternatives with potentially less adverse environmental impact
- Evaluate potential cumulative & secondary impacts
- Evaluate proposed compensation measures or potential need for compensation if not proposed (as needed)

5.0 Peer & Expert Review

Internal peer review is sometimes performed among WAG scientists, with the Center Director, and/or other VIMS expert scientists. Peer and expert review may occur at any time during the Joint Permit Application review process. The intent of the peer & expert review is to ensure that the WAG advisory recommendations are interdisciplinary and objectively based on the current state of the science.

5.1 Other WAG Scientists

Possible triggers for peer review with other WAG scientists:

1. Peer scientist has previously conducted site visit/written report
2. Peer scientist has knowledge or experience in particular area or waterway
3. Validation of comments and concurrence of conclusions
4. Proofreading & editing

5.2 Other VIMS Scientists

Possible triggers for peer review by other VIMS scientists:

1. Project activities will impact specific marine resources, such as blue crabs, SAV, sea turtles, anadromous fish, and/or water quality
2. Peer VIMS scientist has previous knowledge of shoreline processes in project vicinity

5.3 CCRM Center Director

Possible triggers for peer review by Center Director:

1. Project will require VMRC public hearing
2. Project is likely to be controversial
3. Project report incorporates comments from other VIMS scientists
4. Reviewing scientist intends to provide significant negative comments in report
5. Reviewing scientist intends to provide significant modifications to proposed project
6. Legislative involvement

5.4 VIMS Associate Dean of Research & Advisory Services

Possible triggers for review by Associate Dean of Research and Advisory Services:

1. Project is likely to be controversial
2. Other VIMS scientists may be contacted independently by outside interests
3. Project report incorporates comments from other VIMS scientists
4. Legislative involvement

6.0 Advisory Comments

Project-specific findings and recommendations are generated by each reviewing scientist. The final format of the advisory comments may be verbal with a written summary in the advisory database, e-mails, e-letters, or formal letters. Regardless of format, the content of the final advisory comments are captured and stored in the advisory database.

7.0 JPA Review Data Entry

The Center has an advisory database using Microsoft Access (2010) to track external requests for JPA reviews and how the Wetlands Advisory Group (WAG) responds to each request. Each WAG scientist is responsible for data entry into the advisory database for their assigned JPA review cases. Each scientist is also responsible for self-verification of data entry.

All correspondence, supporting references, site photographs, impact assessments, and advisory reports with recommendations are stored in the advisory database for each JPA review. Database access is restricted to authorized staff. The database is backed up through the Center's network security system.

The WAG JPA review coordinator periodically checks the status of assigned cases. Assigned reviews still open or in progress for prolonged periods are brought to the attention of reviewing scientists. Any discovered inconsistencies or missing information is discussed between original reviewing scientist and JPA review coordinator. Corrections are made to the database accordingly (e.g. closed cases that appear to be still in progress).

8.0 Posting Public Records

The Center maintains a searchable, public access web site for electronic permit records related to the Joint Permit Application regulatory program in tidal waters. These JPA public permit records may include the Original Applications, Additional Information, digital photographs, VIMS advisory reports, Public Hearing Information, and Wetlands Board Minutes as this information is made available. WAG scientists are responsible for exporting all relevant public records from the advisory database to designated CCRM network folders for automatic posting to the permit records web site.

Photographs provided by third parties should not be posted as public records or used by CCRM for any purpose without the express consent of the photographers. Other electronic permit records received from third parties are processed and posted to the web site by the Center's administrative staff using standard file formats for on-line documents and viewing.

9.0 Semi-Annual Verification

The WAG JPA review coordinator is responsible for semi-annual summaries of advisory service activity for grant reporting, including JPA reviews. This summary includes a count of how many JPA reviews were requested and a general assessment how these JPA reviews were handled. This is an opportunity to verify that all cases are assigned, in progress, or closed and also that all relevant public records have been exported to the CCRM permit records web site.

10.0 Virginia Law & Promulgated Guidelines

Laws of Virginia Relating to Submerged Lands, Wetlands and Coastal Primary Sand Dunes and Beaches. Title 28.2 Fisheries and Habitat of the Tidal Waters. Code of Virginia.

Wetlands Guidelines. Developed Pursuant to Chapter 13 of Title 28.2, Code of Virginia. Prepared by the Virginia Institute of Marine Science and the Virginia Marine Resources Commission. Reprinted 1993.

Coastal Primary Sand Dunes/Beaches Guidelines. Guidelines for the Permitting of Activities Which Encroach into Coastal Primary Sand Dunes/Beaches. Developed Pursuant to Chapter 14 of Title 28.2, Code of Virginia, effective September 26, 1980. Issued by the Virginia Marine Resources Commission. Reprinted September 1993.

Subaqueous Guidelines. Developed pursuant to Chapter 12 of Title 28.2, Code of Virginia. Issued by the Virginia Marine Resources Commission. Reprinted September 1993.

Wetlands Mitigation-Compensation Policy. VR 450-01-0051. Developed Pursuant to Chapter 13 of Title 28.2, Code of Virginia. Prepared by the Virginia Marine Resources Commission.

Guidelines for the Establishment, Use and Operation of Tidal Wetland Mitigation Banks in Virginia. Developed pursuant to Chapter 13 of Title 28.2 of the Code of Virginia, effective January 1, 1998. Prepared by the Virginia Institute of Marine Science and the Virginia Marine Resources Commission.

Guide to Virginia's Laws, Regulation and Requirements for Marine Shellfish Aquaculture Activities. Prepared by the Virginia Marine Resources Commission. October 1998.

Other Standard References

Comprehensive Coastal Resource Management Guidance: Planning Information and Guidance for the Living Shoreline Preference. Prepared by Center for Coastal Resources Management, Virginia Institute of Marine Science. January 2013.

JPA Project Review Guidance. Prepared by Wetlands Advisory Group, Virginia Institute of Marine Science. Revised January 2012.

Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments. C. Scott Hardaway, Jr., Donna A. Milligan, and Karen Duhring. Virginia Institute of Marine Science, Special Report in Applied Marine Science and Ocean Engineering No. 421. September 2010.

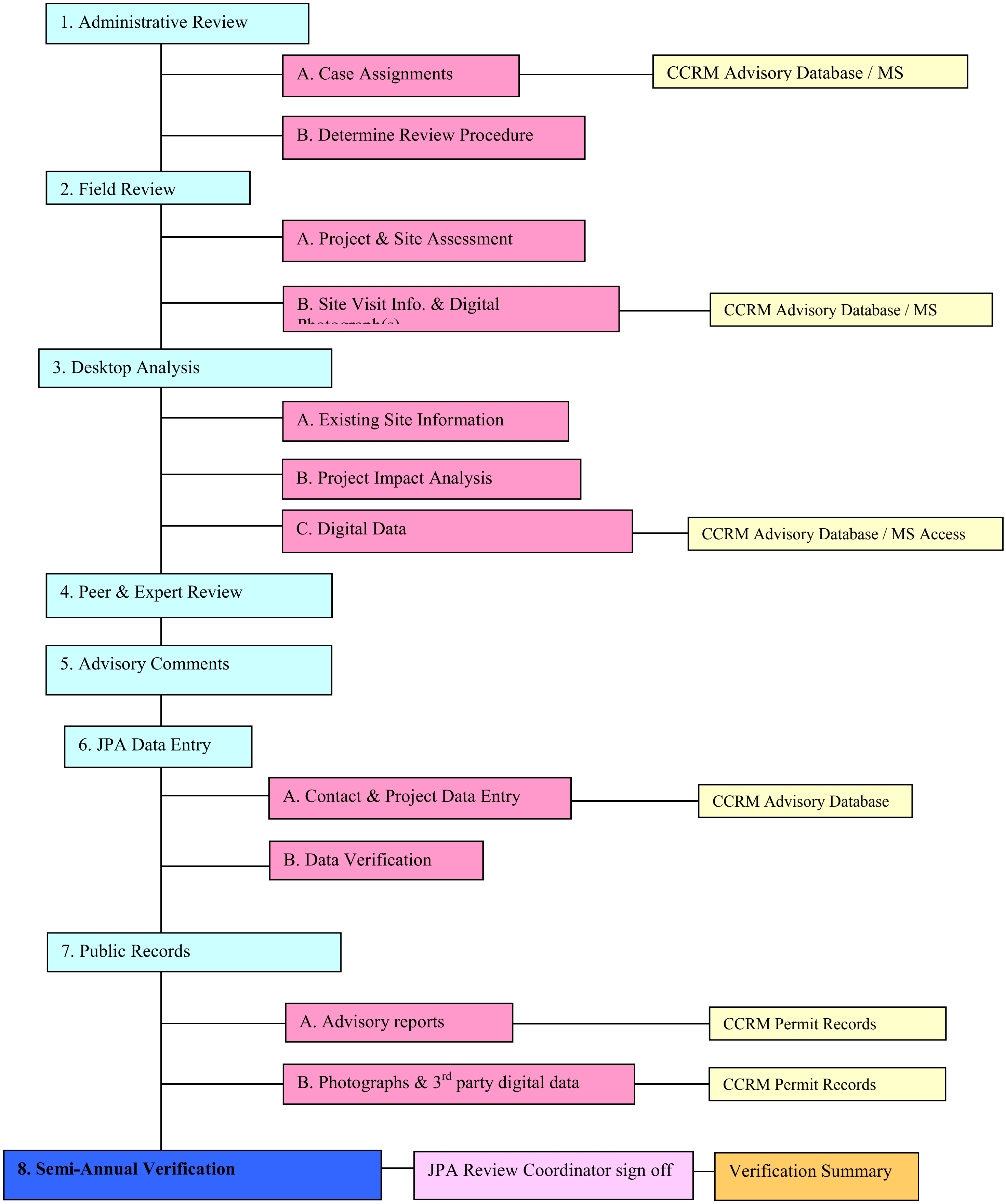
Shoreline Management in Chesapeake Bay. C. Scott Hardaway, Jr. and Robert J. Byrne. Virginia Institute of Marine Science, Special Report in Applied Marine Science and Ocean Engineering No. 356, 1999. Virginia Sea Grant Publication VSG-99-11.

Shoreline Development BMP's. Best Management Practices for Shoreline Development Activities Which Encroach In, On, or Over Virginia's Tidal Wetlands, Coastal Primary Sand Dunes and Beaches, and Submerged Lands. Produced by the Virginia Marine Resources Commission. Reprinted August 1999.

The Virginia Clean Marina Guidebook. VIMS Educational Series No. 49. Virginia Sea Grant Publication VSG-01-03

Best Management Practices for the Virginia Shellfish Culture Industry. Michael Oesterling and Mark Luckenbach. VIMS Marine Resource Report Number 2008-10, Virginia Institute of Marine Science, September 2008.

Appendix I. Wetland Advisory Group – Joint Permit Applications QAQC Project Flow Chart



11.0 Tidal Marsh Inventories (TMI)

The Wetlands Advisory Group (WAG) collaborates with the Comprehensive Coastal Inventory (CCI) program at the Center to conduct Tidal Marsh Inventories for designated localities or waterways. These tidal marsh inventories are a combination of remote sensing and field surveys. Project-specific data collection and processing protocols may also be developed based on the specific project requirements.

11.1 Pre-Field Digitizing Tidal Marsh Boundaries

Before field data collection begins, base maps are generated with recent aerial photography and uniquely numbered tidal marsh polygons. The pre-field digitizing uses standard remote sensing photo interpretation (see Appendix B, 2.2 Coverages generated from digital products).

Using the high resolution (0.5 foot) color infra-red digital imagery from the Virginia Base Mapping Program, standard on-screen digitizing techniques are applied to delineate tidal wetlands boundaries. Ancillary or supporting data to assist with the delineation include digital data from the National Wetlands Inventory, the Virginia Shoreline Inventory, the 1970s baseline Tidal Marsh Inventory, and other aerial imagery from sources such as bing.com, Google Earth, and Pictometry, as available. These sources help resolve issues associated with time of year differences in imagery, presence of tree canopy, and tide levels. When using high resolution imagery as the base map product, digitizing scale is set at 1:1,000 to maximize the benefit of the high resolution source data for most products.

Heads up or on-screen digitizing is known to have a higher accuracy than traditional tablet digitizing since the operator can use zoom functions for closer inspection of the base raster or vector data. Some operator error will always exist but this can be computed using laboratory error tests. Standard tests of error have been conducted to compute acceptable error in the onscreen digitizing techniques.

Consistency in identifying and digitizing marsh boundaries were tested using repetitive sampling techniques. Six marshes of varying size and complexity were selected and each digitized three times. Each digitized area was compared to the mean. The average difference in calculation of area for each sample was +/- 0.0003 acres. It is impossible to resolve or explain these small differences with any certainty. They are largely operator error and must be accepted as inherent in any data product.

For archival and analytical purposes, all pre-field digitized tidal marsh polygons are attributed with a marsh number and morphologic type (embayed, extensive, fringe or island). All GIS work includes a metadata file. The pre-field digitizing is double-checked by WAG or CCI staff and corrections made before base maps are printed for field surveys.

11.2 TMI Field Observations & Data Collection

At this time, the Tidal Marsh Inventories are intended to be a general examination of tidal marshes in each project area. Both remotely sensed and field-checked tidal marshes are included in the inventory. TMI field observations are qualitative, not quantitative, with best professional judgment used to identify unique plant species, estimate percent cover, and assign dominant community types. TMI field surveys are limited by shallow water navigation, tide cycles, waterways blocked by low roads and bridges, property ownership, and other impediments to field access.

Multiple WAG scientists with experience identifying tidal wetland plant species and communities are responsible for field data collection following a standard protocol. Field data is collected primarily from boat surveys. During boat surveys, observations of tidal marshes visible along the shoreline are made with the aid of binoculars when necessary. Where marshes are inaccessible by boat, ground surveys may be conducted, as time and resources permit.

During TMI field surveys, WAG scientists compare observed tidal marshes with the pre-field digitized polygons on the base maps. Not all digitized polygons are field checked. For those that are field checked, the presence or absence of tidal marsh in the same general proximity is noted. Polygon boundaries are corrected as needed. Digitized polygons that do not correlate with an observed marsh are recorded as "Not Marsh".

It is not possible to accurately capture all tidal marshes with digitizing alone, particularly narrow fringing marshes under tree canopy. New Marshes that are observed but not delineated as numbered polygons are drawn onto the base maps using legible ink for future map corrections. Each New Marsh is assigned a unique New Marsh number.

All observed and recognizable tidal wetland plant species within each marsh polygon are recorded with either dominance (>50%) or trace (<1%) cover indicated where appropriate. Tidal wetland field guides are used to assist with plant identification when needed. The community type is determined based on species occurrence and an established tidal marsh community classification (e.g. saltmarsh cordgrass community, brackish mixed community with no dominant species). Unknown plant species may be collected, labeled and returned to the lab for identification using standard wetland plant identification keys. A portion of the marsh polygons for each survey area are then visited and assessed by a second observer for quality assurance.

11.3 TMI Map Production

WAG scientists work collaboratively with CCI staff to process TMI field data into geospatial maps and end user products. Several quality assurance measures help confirm that wetland field observations are correctly transferred to final geo-spatial databases and maps.

Field data is entered into a project-specific spreadsheet in a standard format that allows for assimilation into a geo-referenced database that coincides with the CCI Shoreline

Inventory. The base maps and data entry forms used for recording field observations are cataloged by project area and archived.

Map corrections are made to the pre-field digitized shape file based on field survey illustrations on the base maps. New Marsh polygons are delineated and coded. The plant species and community types are then merged with the marsh polygons.

Pre-field polygons determined through observation to be "Not Marsh" are deleted from the geo-spatial database. The Not Marsh polygons are reviewed to determine what actual ground conditions were misidentified as tidal marsh. Relevant corrections to the protocol for pre-field digitizing are made to avoid similar future errors.

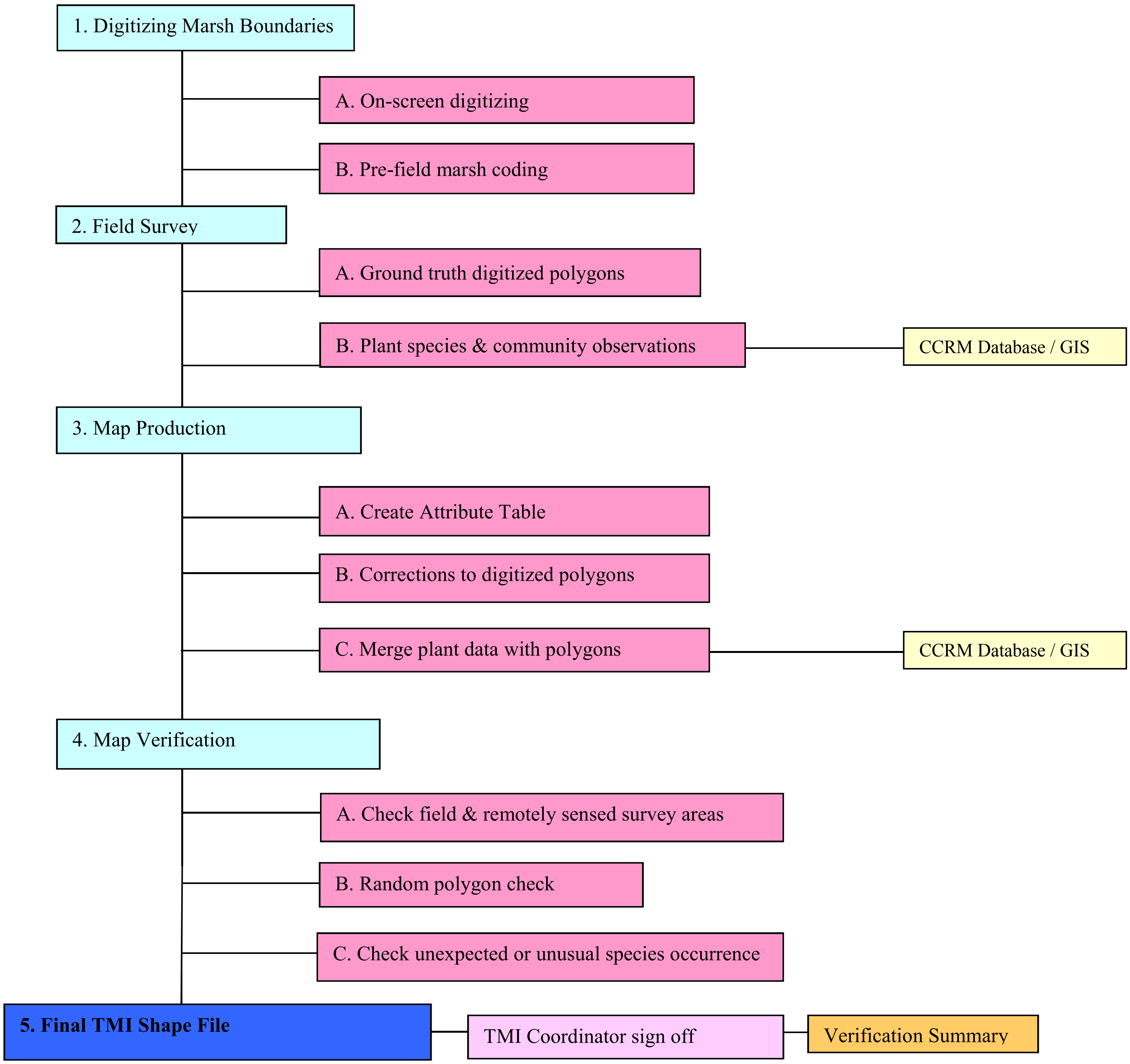
11.4 TMI Map Verification

The final TMI shape files are checked to ensure all field-checked tidal marshes are correctly depicted. Randomly selected polygons are checked for consistency with plant species and community observations contained in the field data. After the final TMI shape file is generated by CCI staff, the WAG TMI coordinator will produce a verification summary that the designated final shape file does in fact accurately represent the TMI digitizing and field data.

The final TMI shape files are stored within CCI's established network for the Shoreline Inventory program. See Appendix B for how the CCI program provides quality assurance that the final, corrected TMI shape files are served on the CCRM web site for public access downloading and incorporated into final CCRM end user products.

A pre-determined list of likely species for the sampled areas (developed from previous TMI's) will be compared to the collected data. Data from sites with unexpected species or unusual abundance of typically trace species will be re-examined to ensure accurate data entry.

Appendix I. Wetland Advisory Group – Tidal Marsh Inventory QAQC Project Flow Chart



Appendix D. Program Quality Management Assessment Checklist

- ❑ Program Quality Management Assessment Checklist

Program under review ____________________________________

Quality Assessment Team _________________________________

Date of Assessment ______________________________________

Acceptable	Unacceptable	
☐	☐	Standard Operating Procedures adequate for Program operations. **Comments**:
☐	☐	Standard Operating Procedures easily accessible to personnel. **Comments:**
☐	☐	Instrument calibration logbooks up-to-date and maintained. **Comments:**
☐	☐	Spot check on raw data transcription. **Comments:**
☐	☐	Spot check on Standard Operating Procedure use and consistency among personnel. **Comments:**

Appendix E. Center Equipment Inventory

Laboratory/Field Equipment:

- YSI 6600 Sonde units with probes for depth, temperature, dissolved oxygen, pH, conductivity/salinity and turbidity (6)
- YSI 650 Multiparameter Display System connected to a YSI 6820 handheld probe for depth, temperature, dissolved oxygen, pH, conductivity/salinity and turbidity (2 each)
- remote solar powered acoustic tide gauge with cell phone data transmission system
- videomicroscopy system
  - trinocular stereomaster zoom microscope with an 88 mm working distance (small objects)
  - trinocular stereomaster zoom microscope with an 56 cm working distance (large objects)
  - high resolution digital camera
- fiberoptic light sources
- drying oven
- analytical balance
- Spectronic 20 spectrophotometer
- Limnoterra Electronic Fishboard
- malaise tent insect traps (4)
- blacklight insect traps (12)
- Eckman Grabs (2)
- fyke nets (4)
- beach seine net
- otter trawl
- plankton net
- mesocosm nets (36)
- plankton pump
- Flowtracker Current Meter
- 100’ unguyed, self-erecting tower for weather instrumentation
- RDS water level wells, programmable, recording (30)
- trash pump
- soil compaction meter
- SET table
- Ford Explorer 4wd
- Ford Escape
- Toyota Camry
- Old Town canoe
- Laser level (2)
- Bushnell range finder
- Kestrel 3000 Handheld Weather Meter
- Fisher Scientific Isotemp Muffle Furnace 550 series
- digitial cameras

- Cruz All Angles (11)
- Palm Pilot Vx (4)
- Palm Pilot m515 (3)
- Palm Pilot Tungsten E (3)
- Smith Root LR-24 electrofisher
- RDS Rain gauges, programmable, recording
- General Oceanics mechanical flowmeter (3)
- Teaching Marsh Remote Camera
- DJI Quadcopter Drone

Survey Equipment

- Trimble 4000ST survey grade, single frequency GPS units (3)
- Trimble Geo-Explorers, mapping grade handheld GPS units (7)
- Trimble 4700 geodetic grade, dual frequency GPS unit
- Trimble GPS base station
- Garmin GPS12 (15)
- Garmin GPS72 (3)
- TopCon Total Station survey system
- Marine Sonics side scan sonar (600 kHz)
- Marine Sonics Side Scan Sonar (900 kHz)
- Humminbird Side Scan Imaging Units

Computing resources (fully networked system)

- 30 Windows PCs
- Linux web server
- 2 Windows servers for GIS applications
- Multi-user ArcInfo (University license)
- Multi-user ArcView (University license)
- ArcGIS Server
- ESRI 3D Spatial Analyst
- ESRI Spatial Analyst
- ESRI ArcPad
- Multi-user Erdas Imagine (Higher education lease agreement/University license)
- Multi-user Erdas Modules (Vector, Virtual GIS, Orthomax, Sub-pixel classifier)
- Visual Learning Systems= Feature Analyst software
- Mr. Sid