

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.

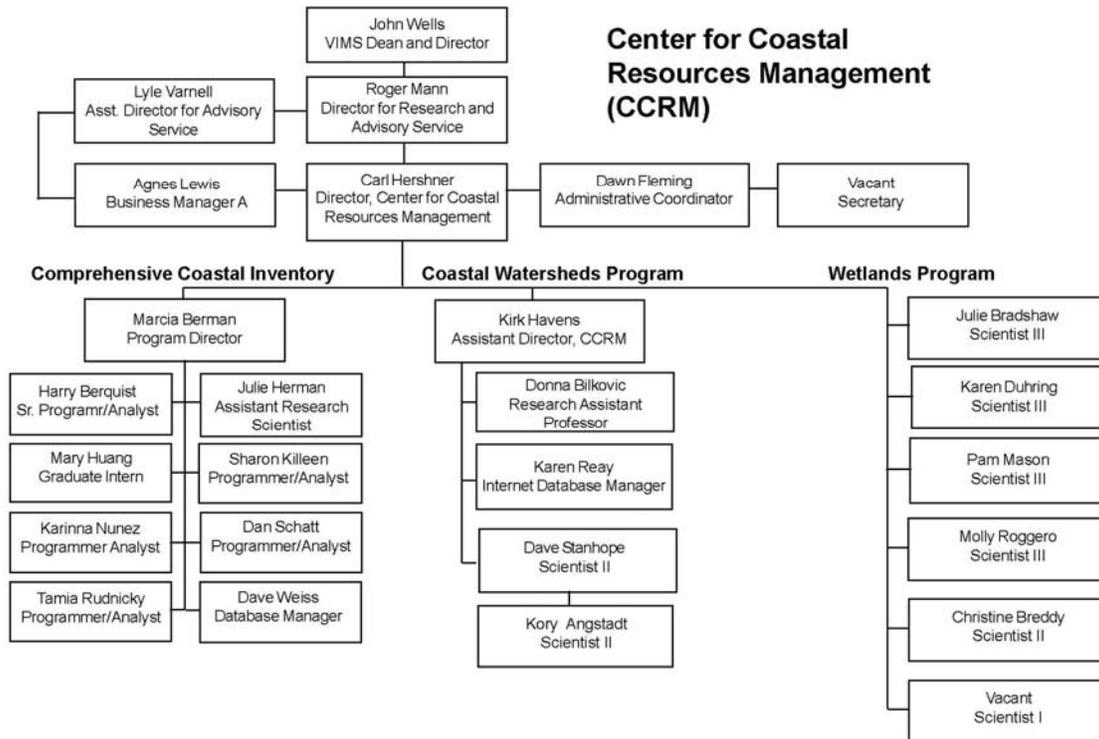
A myriad of activities occur within the Center, including direct support of laboratory and field investigations, support and training of graduate students and interns, training of resource agency personnel and the public, direct support of state agencies and local governments, and sponsorship of lectures, 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:

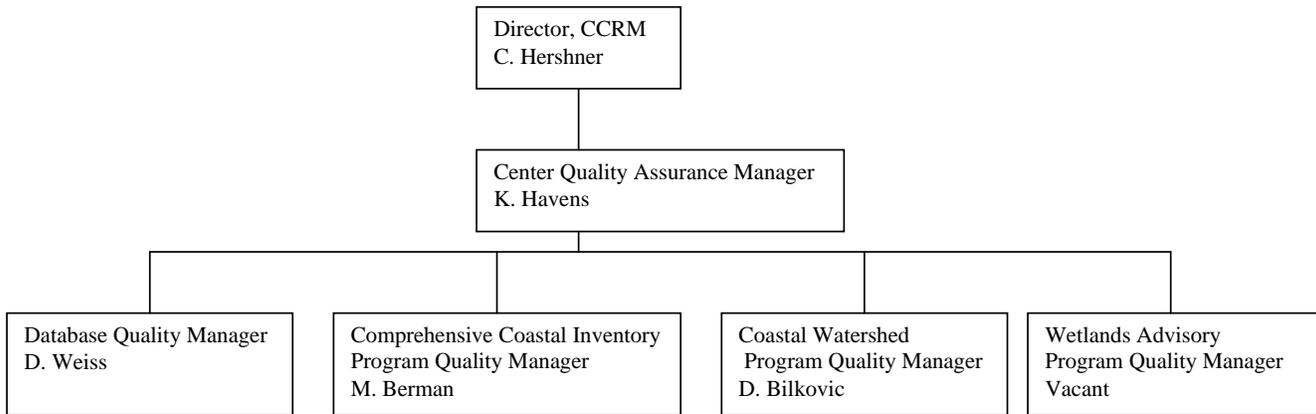
- The specific objectives of the project, including the hypothesis to be tested.
- The data quality objective for the variables to be measured.
- The specific sampling and analytical protocols required to meet the data quality objective.
- The individual responsible for quality assurance for the project.
- 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



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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), Tidal Wetlands Manual: Database and Arcview Reports (2000 CCRM/VIMS), and Tidal Wetlands Site Visit Checklist and Definitions (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 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.

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 stored in the Center computer files.

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 consists 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 semi-annual internal audits to verify that field and laboratory operations continue to comply with the requirements of the quality system.

The Center Quality Manager assigns each Program Quality Manager to assess the adequacy of the quality system in the other programs semi-annually. For example, the Coastal Watershed Program Quality Manager and the Wetland Advisory Program Quality Manager will assess the adequacy of the quality system of the Comprehensive Coastal Inventory Program. The Comprehensive Coastal Inventory Program Quality Manager and the Wetlands Advisory Program Quality Manager will assess the adequacy of the quality system of the Coastal Watershed Program. The Comprehensive Coastal Inventory Program Quality Manager and the Coastal Watershed Program Quality Manager will assess the adequacy of the Wetlands Advisory Program. The Program Quality Managers collectively assess the quality system of the database. The Program Quality Management Assessment Checklist is attached as Appendix D.

The Program Quality Managers and the Database Quality Manager meet with the Center Quality Manager to review the findings of the assessments and ensure corrective actions are made promptly.

Where audit findings cast doubt on the validity of the Center's results, an immediate action is initiated and the Program Director and Program 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 twice per year, generally coinciding with the semi-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 semi-annual reports and reviews. Review of these documents is performed by committee on a periodic basis.

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, NT, 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

[Link to CCRM computer equipment list](#)

Devices backed up

120 GB RAID 5 dsk array (attached to sweethall)
200 GB RAID 5 dsk array (attached to sweethall)
700 GB RAID 5 NAS storage device (stand alone)
8 GB hard drive on sweethall
10 GB hard drive on ccrm (the webservice)

20 GB hard drive on aristida
9 GB, 2 GB, and 17 GB hard drives on limonium
3.5 GB hard drive on nyssa
2 GB hard drive on acer

Backup hardware

Qualstar 4210 10 tape library with 2 AIT-2 tape drives.
Gateway E-5200 pc
22 AIT-2 tapes (approx. 80 GB capacity per tape)
30 AIT-1 tapes (approx 30 GB capacity per tape)
Quantum DX5000 virtual tape library with 3.5 TB of disk space

Backup software

Backup pc runs Red Hat Linux 2.4
Backup software is NetVault by Bakbone Inc Version 7.1

8.2 Network Security:

The primary means of protecting the CCRM computer network is through the UNIX and PC passwords. No files other than those made available on the web server can be accessed without user/password authentication. UNIX system logs are monitored for any indication of unauthorized use. 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 backup system includes a Pentium 350 MHz Gateway pc running linux and Netvault backup software from Bakbone (www.bakbone.com). There is a Qualstar 4200 robotic tape library with ten tape slots and 2 AIT-2 tape drives. Also, a Quantum DX5000 virtual tape library with 3.5 TB of disk space using hardware compression. The compression rate is currently obtaining 1.44 times capacity. The disk space is configured into 47 virtual tapes and there are 6 virtual tape drives.

Every Friday beginning at 6:00 PM the data from the Sun workstations is backed up to the DX5000 virtual tape library. All files, but not the operating system, from sweethall, limonium, acer, nyssa, aristida, ccrm and nas01 wetlan are copied. The following week these backup sets are copied from the virtual tape library to AIT-1 and AIT-2 tapes on the Qualstar 4200.

Monday through Friday mornings beginning at 2:00 AM incremental backups are done of all files created or modified since the last full backup. Incrementals are also done to the DX5000 virtual library.

This results in multiple copies of the files on the CCRM network. The original files on the various disk drives, the copies on the DX5000, and the offline copies on tapes.

Backup tapes are stored in the fireproof safes in the CCI trailer and Pollock House.

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 a web page on the main web site of the Virginia Institute of Marine Science, College of William and Mary. The web address is <http://ccrm.vims.edu/>.

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 file – 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

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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.

Deleted: This doesn't mean that the programmers shouldn't check that their code works before releasing it (which of course applies to any stage of testing.)

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- compatibility 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.

Deleted: exploratory testing - often taken to mean a creative, informal software test that is not based on formal test plans or test cases; testers may be learning the software as they test it.

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.

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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

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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. Templates of required 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 registered in the logbook. Bottles are stored on designated shelves for each project. Net 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.

1.2 Fish sampling protocols

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) Llanso (2002)
<http://www.baybenthos.versar.com/docs/ChesBayBIBI.PDF>; and
- 2) 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-VAzooplanktonOAPP2001.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). 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).

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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

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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. The project leader then signs each page of the log sheet. Samples are archived for future reference according to project specifications. All reference texts are maintained for review at the Coastal Watershed Program office.

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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-VAbenthicOAPP01-02.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_OA.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_OA.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 with glycerol. 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. Records of calibration, deployment and retrieval information, as well as conditions on site at the time of deployment are maintained. Data sheets are periodically checked to ensure that all data are up-to-date; a second party may check calibration values periodically to ensure proper probe maintenance and calibration.

3.0 Data Reduction, Review, Reporting and Records

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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. After the secondary review, the second researcher or supervisor signs each page of raw data. The principal investigator reviews all data, records and associated documents. All data entry, reduction and reviews are noted on the data log sheet, which is subsequently electronically archived as well.

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. YSI sondes—logbook in place
- c. YSI hand-held—logbook in place
- d. Analytical balance—logbook in place
- e. Drying Oven—logbook in place
- f. Fish board—logbook in place
- g. Fish nets—logbook in place
- h. Flow meters—logbook in place
- i. SET—logbook in place
- j. Light meter—logbook in place
- k. Refractometer

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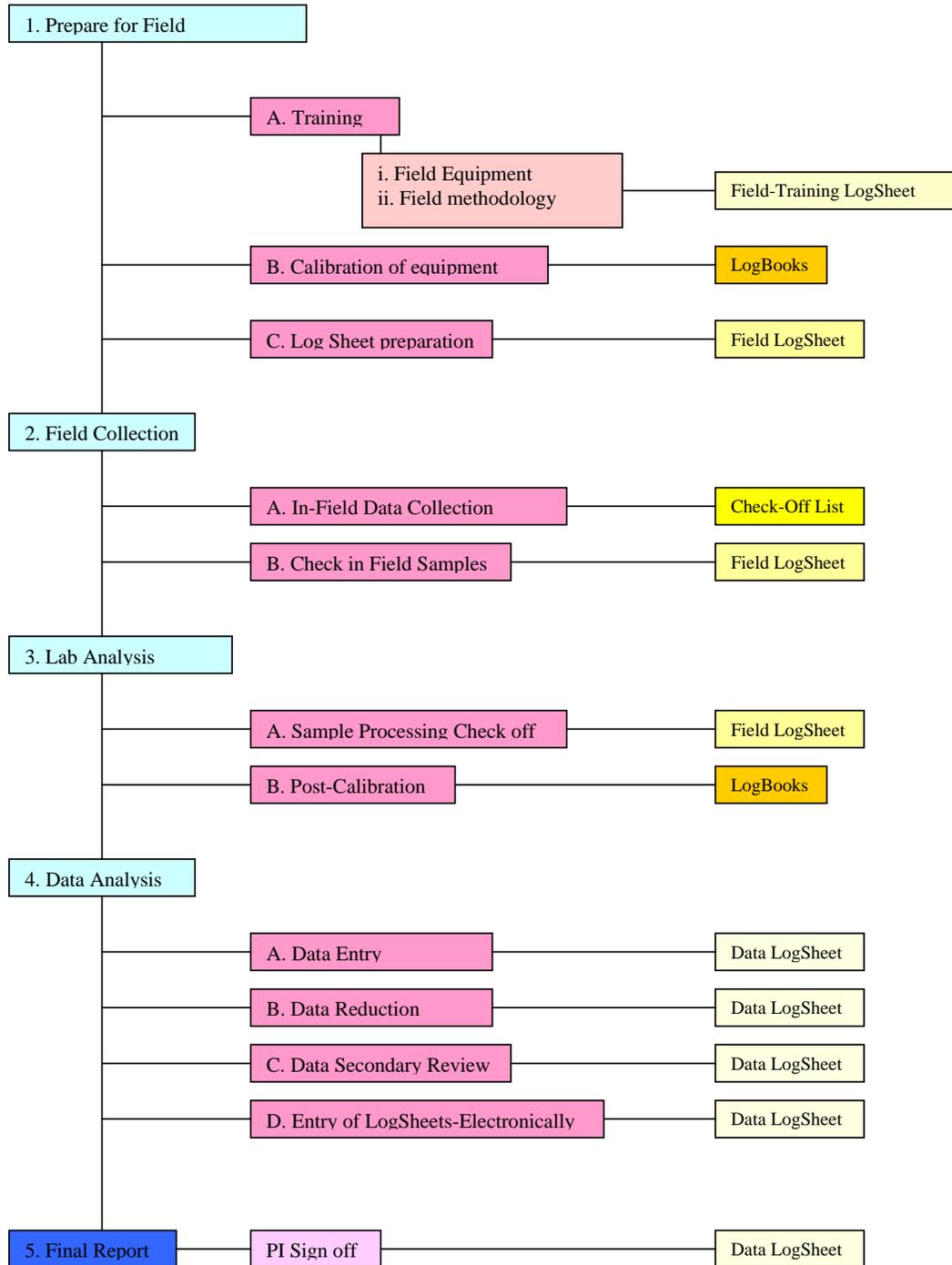
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6.0. Coastal Watershed Program QAQC Project Flow Chart



Appendix I. Continued. Link to Detailed CWP QAQC Flow Chart

[QAQC FlowChart.xls](#)

Appendix II. Summary of specific QAQC source and spot and semi-annual check information (Excel file link)

[QAQC Summary.xls](#)

Appendix III. Templates of Log Sheets utilized in the QAQC procedures for the Coastal Watershed Program (1. Field-Training Log Sheet, 2. Field Log Sheet, and 3. Data Log Sheet).

1. [Training Log Template.xls](#)
2. [FieldLog Template.xls](#)
3. [DataLog Template.xls](#)

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

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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.

2.0 SOP for Digital Map Production

This section covers the development of digital data from either existing hardcopy basemaps or from digital imagery. 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 coverages 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 Coverages Generated from Hardcopy Basemaps: There are several different levels and origins for QA/QC measures followed routinely in the development of GIS coverages from hardcopy basemaps. Some are inherent in the equipment and the software, and are therefore provided without option. Others are provided as options through the hardware and software. Still, other measures have been adopted by this Program voluntarily to minimize impacts from human error introduced by the operator. Many of these are in the form of programs written to automate routine procedures.

QA/QC measures built into the hardware and software are outlined below. Currently, this document treats only those standards exercised for all GIS coverages generated from hardcopy basemaps. To the extent possible, they will be discussed in procedural order relative to creation of the digital record. Full

documentation is available in Berman et. al., 1993. This document is on file in the GIS mapping laboratory as a reference.

2.1a. Numonics 2200 Digitizer - The Numonics 2200 Digitizer has a reported accuracy of 0.005 inches and precision of 0.001 inches. This is verified in the factory through a calibration procedure. Additional diagnostic tests can be performed routinely in the laboratory to verify the integrity of the original calibration over time. Documentation pertaining to this equipment is on file in the CCI laboratory (Numonics, 1988).

Positional data from a mapped medium is transferred to the host computer through an electromagnetic cursor moving over the internal sensing grid in the active digitizing area of the tablet. The coordinates are scaled and transformed through the host computer by the operator. The digitizer has the option of recording data in **stream** or **point** mode. In stream mode the digitizer continuously accepts coordinates when the cursor is in the digitizing area. To avoid undesirable input, digitizing is set to collect data in point mode. Point mode enables the user to control when coordinates are recorded through the cursor. Point mode gives the user more control, and therefore better accuracy and higher precision is achieved.

2.1b. Cursor - The cursor serves as the interface between the operator and the digitizing tablet. While there are no true QA/QC functions specifically built into the cursor, not all cursors are the same and their utility for digitizing different types of medium may vary. This program uses a 16 button cursor with a bull's-eye in the center of crosshairs for digitizing mapped products if the width of the plotted line approaches the diameter of the bull's-eye. For fine line basemaps, a fine line digitizing cursor is used.

2.1c. Base Map Selection - Whenever possible, only stable-based material is digitized. This includes single or double matte mylar material. Stable-based material is resistant to shrinking and stretching due to changes in temperature of the environment and normal handling of the material. The facility is temperature controlled to reduce humidity and minimize these problems

For products originally produced on paper, stable based double matte mylar material is used for reproductions when possible. New paper products are acquired for the reproduction. Contractors using flat bed copy machines only are utilized. These measures are all in place to reduce distortion in the final basemap to be digitized. The use of paper products as basemaps is avoided whenever possible. If necessary, new, clean paper copies are obtained for digitizing. They are generally used only once, since the handling causes the paper to be distorted easily.

2.1d. ArcInfo Procedures and Options - 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 a coverage. 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

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.

Weed Tolerance: CCI uses a weed tolerance or weed distance of 0.001 inches for all GIS coverages. 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.

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. Coverages Generated from Digital Products (pertains to shoreline):

Digital imagery is used to generate GIS coverages for certain Program elements. Currently, procedures are in place for developing digital shoreline coverages from color infra-red digital orthoquarter quadrangles. The procedure applies photo-interpretation techniques for recognizing the land-water interface. The shoreline coverage being generated is not corrected for tidal position.

2.2a. Automated Procedures: In house procedures developed require the ERDAS Imagine software module. Automated quality control measures include:

weed tolerance = .01 m
grain = .01 m (allows for short distances between vertices)
nodesnap closest = 2 m

2.2b. Photo-interpretation techniques: The user defined land-water 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 land water boundary under difficult conditions.

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.

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 side of the canopied reach.

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 are bulkheaded, additional vertices are added to insure straight, not jagged lines.

2.2c. Accuracy check: 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 ortho photography onscreen. Dangles are closed where appropriate for line continuity.

2.2d. 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.

2.2e. 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.

3.0 Data Processing for Shoreline Inventories

The development of Shoreline Inventories is a multi-step process. Each step 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 coverage is complete.

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.

3.1a. Field Data: 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.

3.1b. Differential Correction: Differential Correction is performed on each 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.

3.1c. Editing: 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.

3.1d. File Conversion: GPS files are converted to ESRI shape files for the next phase of data processing.

3.2 Shoreline Development: Digital shorelines provide the base map upon which all filed data are registered to. The digital shoreline is copied and coded to reflect conditions recorded on the digital GPS files collected in the field and logged on the handheld GPS units. Digital shorelines are developed in one of two ways.

3.2a. From Digital Imagery: Procedures described above for the development of shorelines from digital imagery is followed in the absence of some more recent shoreline products.

3.2b. Extracting Shoreline from Digital Terrain Model (.dgn) Files*: 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.

3.3 Processing Field Data: ArcMap 8.2 software is used to process the corrected GPS data. This multi-step process seeks to develop a final product, which can illustrate mapped features along the shoreline. The first challenge is to spatially transpose the field data that reflects boat position to a position that is geographically representative of the land water interface. The shoreline coverage developed above is used coincidentally with the field data and ancillary images with an accuracy of 1 meter or better to make this transformation.

The data transfer/spatial analyst tool in ArcMap is used to transfer the boat track data to the digitized shoreline. The imagery as a background reference aids in this

process. The shoreline coverage is split and recoded each time there is a change in linear features along the shore. Points are shifted from the boat track to the shoreline using a shore-normal transposition. Checklists mentioned above (Appendix 3) insure consistency and completeness in QA/QC measures.

3.4. Final Quality Control: Several steps are in place to insure quality in final products.

3.4a Digital File Check: 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.

3.4b. Hardcopy Check: Following the digital check a draft set of hardcopy maps illustrating data in final publication format is printed. Templates and AML's 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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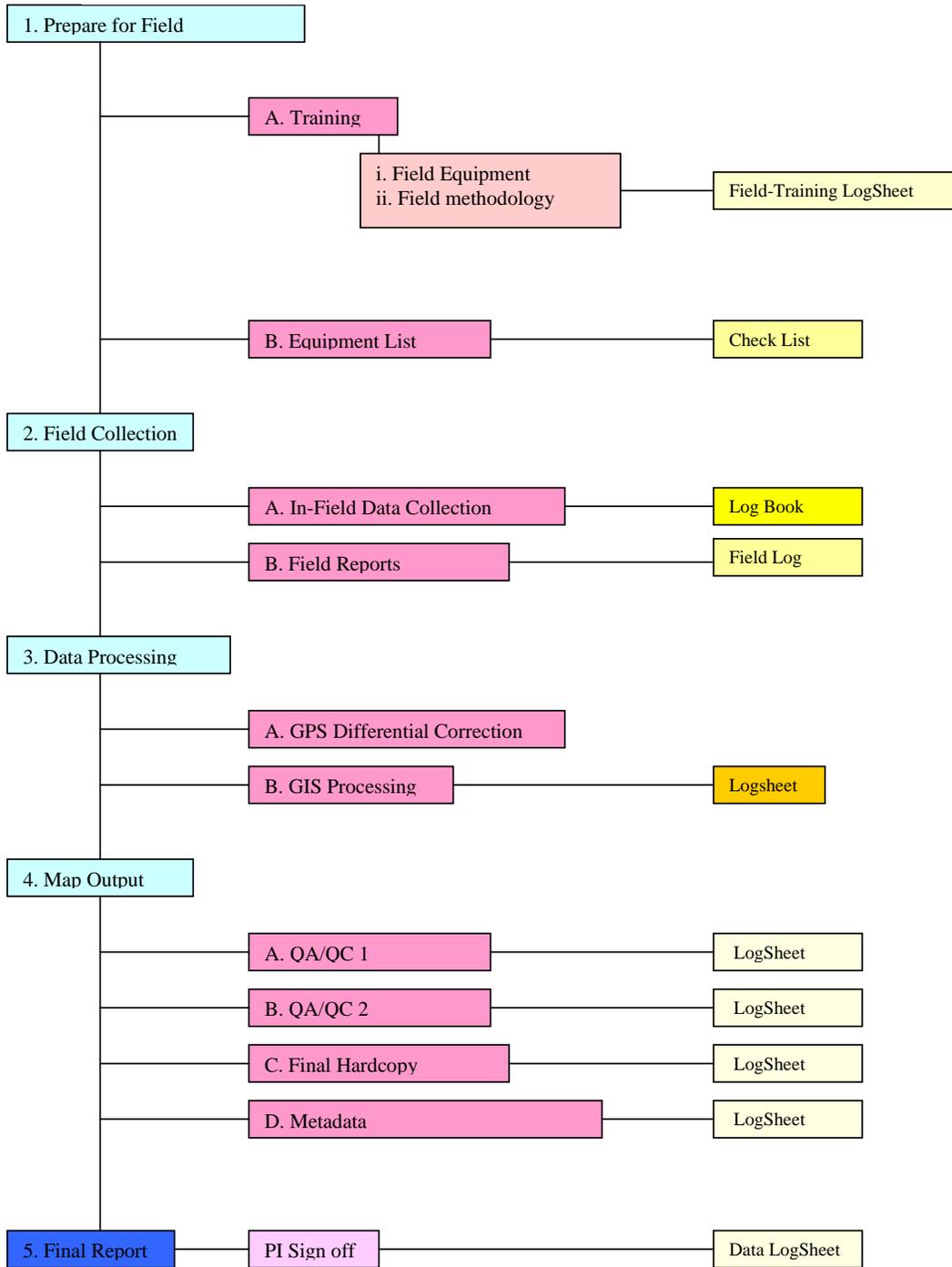
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Appendix I. Link to Coastal Inventory General SOP/QAQC Flow Chart

[SOPflowChart.doc](#)

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



Appendix III. Shoreline Inventory – Data Processing Log Sheet

<\\shsamba\public\cci\QAQC\ssr checksheet.xls>

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
Program for Joint Permit Application Review Process

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Wetlands Advisory Program - Standard Operating Procedures

Joint Permit Application Review Process

1.0 Purpose

The Wetlands Advisory Group is responsible for providing advisory service for projects in tidal waters that require authorization through the Joint Permit Application review process. The geographic area covered by this program includes 24 counties and 16 cities or towns in the Tidewater region of Virginia. This advisory service combines the influence of state law and promulgated guidelines with the best professional judgment of the program scientists.

This document outlines standard methodology employed by the Wetlands Advisory Group to minimize human error and ensure assessment accuracy among reviewing scientists. Verification checks to ensure this methodology is followed are also included.

- Administrative Review
- Field Review
- Review & Analysis of Supporting Information

Data Entry & Verification

- Advisory Comments
- Peer Review
- GIS-Based Advisory Report

2.0 Administrative Review

The Joint Permit Application (JPA) review process is initiated upon receipt of the application from VMRC, or other sources (such as local wetland boards, DEQ, USACOE, agents or applicants). Once in-house, the review process proceeds as follows:

2.1 Applications are reviewed by the Wetland Advisory Group (WAG) Program Director to determine if the criteria are met for a full review by Wetland Advisory Group staff. 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.

2.2 Joint permit applications to be reviewed are logged in by CCRM staff into a database, scanned to generate a digital copy and distributed to the appropriate reviewing scientist.

2.2 Each scientist reviews each application for:

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

2.3 Generally, all applications require a site visit. Each scientist coordinates with applicants, agents, and regulatory personnel, as necessary (See Field Review).

2.4 For applications that do not require a site visit, the project assessment skips the Field Review step in the process and continues with Review & Analysis of Supporting Information. A site visit is not always necessary for:

- Projects with impacts that do not require permits
- Offshore maintenance dredging projects
- Oyster and fish sanctuary reefs
- Projects for which previous knowledge of the site exist

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. Each marine scientist is responsible for scheduling and making arrangements for site visits based on assigned permit territories. Interagency coordination with local, state and federal agency reviewers is sometimes required for joint site visits. Each site visit includes an assessment of local ecological conditions plus estimates of proposed environmental impacts. A GPS point is collected and digital photographs are taken.

3.1 Take necessary equipment

1. Application
2. Dedicated Field Book
3. Handheld GPS unit
4. Digital camera
5. Extra batteries
6. Maps
7. Tape measure

3.2 Locate applicant's property, request permission for access if applicant is present. Walk and assess entire project impact area, preferably at shoreline level. Locate benchmarks, project flags or stakes, property line markers, other reference points.

3.3 Survey ecological and hydrogeomorphologic conditions

1. Look for erosion indicators - scarps, undercut banks, slip slopes, fallen trees, exposed banks, failing structures, exposed utilities
2. Observe 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

3.4 Conduct preliminary assessment of the need for and appropriateness of proposed activity, based on adopted guidelines and best available technical information (See State Law & Promulgated Guidelines and Other Standard References).

3.5 Review proposed activity

1. Note construction details
2. Measure or pace-off dimensions of activity (length, width, etc.) and verify benchmarks
3. Determine habitat type(s) to be impacted, as defined by Virginia
4. Wetlands Guidelines and Coastal Primary Sand Dunes/Beaches Guidelines
5. Estimate square footage of impact resulting from activity
6. Evaluate potential impacts of construction access
7. Note potential for adverse impacts to adjacent waterway, water quality and marine resources
8. Note potential for adverse impacts to adjacent properties
9. Consider avoidance and minimization measures
10. Evaluate proposed compensation measures

3.6 Record findings legibly in dedicated field book. This recorded information will be used for verification purposes. Each site visit entry should include:

1. Date and time of site visit
2. Locality
3. VMRC Permit Number
4. Applicant name
5. Immediate waterway
6. Activity type
7. Project dimensions
8. Estimated impacts & fill by habitat type
9. Additional notes of concern

3.7 Take high-resolution digital photo(s) of project area. Select angle that best represents the project or part of the project specifically mentioned in advisory comments.

3.8 Collect GPS position at center of project area or property, with a target accuracy of ± 5 meters (~ 16 ft.).

4.0 Review & Analysis of Supporting Information

The next step in the Joint Permit Application review process is the collection of information 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.

- Review Existing Information
- Maps & Photographs
- USGS topographic quadrangle
- Digital ortho quarter quadrangle (DOQQ)
- Nautical charts
- Project site photographs
- Aerial photographs
- Existing Resource Databases
- CCRM permit application & report archives
- CCRM GIS databases
- Tide charts (predicted & observed)
- VA Fish & Wildlife Information Service
- Existing Inventories
- Shoreline Situation Reports – current & historical
- Tidal Marsh Inventory
- National Wetlands Inventory
- Submerged Aquatic Vegetation (SAV)
- Locality Dune Inventory Reports
- Project Analysis
 - Perform calculations as necessary to estimate square footage of proposed impacts & fill
 - Review project proposal for consistency with guidelines
 - (See VA Law & Promulgated Guidelines)
- Perform qualitative reach assessment as needed
- Limits of the reach
- Historical patterns of erosion and accretion
- Source and volume of the sand supply
- Fetch & effective wave climate, direction of littoral drift
- Natural resources within reach, e.g. pocket marshes, sand spits, non-tidal wetlands, riparian buffer
- Validate potential impacts to marine resources & adjacent properties
- Evaluate avoidance & minimization measures
- Evaluate alternatives
- Evaluate cumulative & secondary impacts
- Evaluate proposed compensation measures

5.0 Data Entry & Verification

A Sybase database is maintained to track cumulative impacts to Virginia's marine resources authorized through the regulatory permit process. This database is password protected allowing access only by authorized reviewing scientists and system administrators. Each scientist is responsible for data entry using defined categories. Each scientist is also responsible for self-verification of data entry. For specific data entry procedures and activity definitions, see Shoreline Permit Application Reports Reference Manual.

- Project information entered by CCRM staff – applicant, locality, project purpose category, reported project cost, assigned reviewer, and cross-references to other projects by the same applicant
- Reviewing scientist verifies information entered by CCRM staff.
- Project information entered by reviewing scientist – site visit date, type of application (tidal wetlands, subaqueous and/or beach/dune), immediate & primary waterways, watershed, completion year, complete application, additional notes
- Select appropriate activity type(s) based on standard definitions. (See Shoreline Permit Application Reports Reference Manual-Data Entry)
- Enter impact and fill areas into data fields by activity, including both proposed and permitted data fields. The “proposed” impact and fill area is requested by the applicant, the “permitted” areas are approved through the regulatory process, as reported. Initial data entry assumes these values are equal. “Permitted” impact & fill areas are adjusted as needed based on information received from the regulatory agencies.
- Reviewing scientist self-verifies data entry for activity type(s), impact and fill areas using the Activity Summary form in the database.
- Reviewing scientist verifies that project data has been accurately transcribed and recorded in dedicated field book for future verification.

5.1 Digital photographs are downloaded by reviewing scientist and transferred to a designated CCRM network directory with file names that correspond to the JPA number. These photos are also posted on a CCRM web site with other permit records.

5.2 GPS points are downloaded by reviewing scientist and transferred to a designated CCRM network directory with file names that correspond to the JPA number. The GPS receiver settings must include NAD83 map datum and UTM coordinates for GIS processing.

- 5.3** Semi-annual data entry verification will be performed by generating a query of all cases in the database from the previous six-month period. A random sample across reviewers that represents 3-5% of the total number of cases will be selected. Each reviewing scientist will verify data entry by another scientist, who will sign and date the case list reviewed. The following data entry will be verified: project location (immediate & primary waterway, watershed), activity type(s) assignment, habitat type, linear extent and impact / fill areas.
- If corrections are discovered during the verification session, the original reviewing scientist will enter corrections needed to database. The case list will be initialed and dated by the reviewing scientist to document that the corrections were entered.
 - A form signed by the Program Director will summarize the findings of each verification session. The form will not be completed until all data entry corrections have been completed.
 - The summary form, master case lists, and copies of VIMS reports associated with the randomly selected sample of cases will be archived in the Wetlands Program library in a designated notebook.

6.0 Advisory Comments

The next step in the Joint Permit Application process is the review and interpretation of various guidance documents to provide project-specific findings and recommendations. This synthesis reflects the combined influence of the guidelines and the best professional judgment of the reviewing scientist. The program scientists strive for mutual understanding of current scientific knowledge for a uniform, regional approach to project reviews.

- A. Review appropriate guidelines for proposed project activity. (See VA Law & Promulgated Guidelines)
- B. Briefly describe existing shoreline conditions and project impacts.
- C. Express no concerns if project complies with guidelines, it is appropriate for site location and there are no other alternatives that would result in less impact.
- D. If these criteria are not met, summarize avoidance and minimization measures that may be available or suggest appropriate alternatives that would result in less environmental impact.
- E. Semi-annual verification of advisory findings and recommendations will be performed using the same list of random cases generated for data entry verification. At least 2 cases for each reviewing scientist will be discussed among all reviewers. The posted VIMS report will be reviewed for consistency with established guidelines and other pertinent observations. Other appropriate

comments not included in final report will be discussed. The purpose of this verification procedure is to improve shared understanding and awareness among reviewing scientists for future reference and case reviews. No corrections or changes to the original findings and recommendations will be made.

6.1 Peer Review

Internal peer review is sometimes performed among the reviewing scientist, other WAG scientists, the WAG Program Director, the Center Director, and/or other VIMS scientists. Peer review may occur at any time during the Joint Permit Application review process. The signature of the Program Director is sometimes included with the Advisory Comments depending on project circumstances.

6.2 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

6.3 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 water quality
2. Peer VIMS scientist has previous knowledge of shoreline processes

6.4 Possible triggers for peer review and signature by WAG Program Director

1. Project will require VMRC hearing
2. Project is likely to be controversial
3. Project is for commercial development, marina, etc.
4. Program Director has flagged the JPA for response to DEQ
5. Program Director has previously reviewed and provided comments through another process, such as Environmental Assessments, Environmental Impact Statement reviews, etc.
6. Reviewing scientist provides significant negative comments
7. Reviewing scientist recommends significant modifications to proposed project

6.5 Possible triggers for review by Center Director

1. Legislative involvement
2. Project is likely to be controversial
3. Project report incorporates comments from other VIMS scientists

7.0 Generating GIS-Based Advisory Reports

The final step in the Joint Permit Application Review Process is the generation of a GIS-based advisory report. This decision support tool incorporates project site and watershed information, digital photograph, proposed impact data, advisory comments with electronic signatures, project site and watershed scale maps. A standard form is also provided for the local government and others to report project modifications required through the permitting process. For a detailed description of the procedures required, see Shoreline Permit Application Reports Reference Manual – ArcView Reports.

- A. Open ArcView project file. Run and preview entire report. Each scientist is responsible for verifying the accuracy of project information as presented and for proofreading the advisory comments.
- B. Completed reports are posted automatically to a CCRM web site. Simultaneous, automatic e-mail notification is also sent to the locality, VMRC representative and reviewing scientist.
- C. After receipt of the e-mail notice, each reviewing scientist is responsible for checking the web site to verify that the entire report has been posted correctly.
- D. A hard copy of the final report is mailed to each applicant by CCRM staff.

8.0 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.

Beneficial Use of Dredge Material for Public Beach Nourishment

Other Standard References

Shoreline Permit Application Reports Reference Manual. Prepared by Wetlands Program, Virginia Institute of Marine Science. Revised 2004.

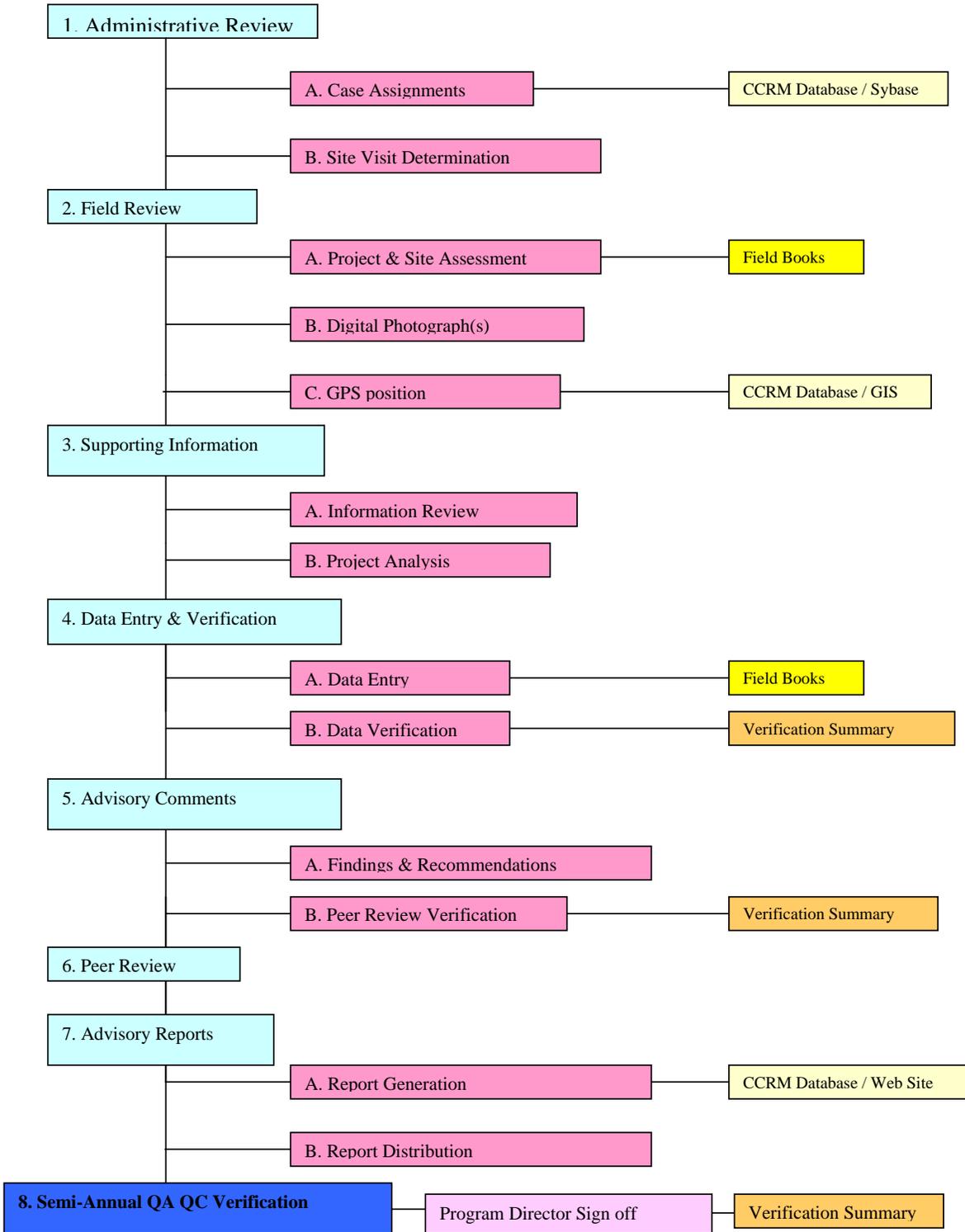
Virginia Wetlands Management Handbook, 2nd edition. Thomas A. Barnard, editor. Prepared by the Center for Coastal Resources Management at VIMS.

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

Appendix I. Wetland Advisory Group 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
- Dodge Dakota, crew cab, 4wd pickup
- Ford Explorer 4wd
- Chevrolet Silverado 2500 HD, Crew Cab, 4wd pickup
- Old Town canoe
- Laser level (2)
- Bushnell range finder
- Kestrel 3000 Handheld Weather Meter
- Fisher Scientific Isotemp Muffle Furnace 550 series
- digital 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

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)

Computing resources (fully networked system)

- 10 Unix workstation
- 28 NT pcs
- 2 100GB expandable RAID disk array
- AIT-1 tape back-up system with 10 tape changer
- 4 Numonics digitizing stations
- Canon 950 Color Copier
- Multi-user ArcInfo (University license)
- Multi-user ArcView (University license)
- ArcIMS
- 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