

# **NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT**

## ***PROJECT WA0401D***

### ***Willapa Bay, Washington***

#### **Introduction**

Coastal Mapping Program (CMP) Project WA0401D provides a highly accurate database of new digital shoreline data for Willapa Bay and the outer coast of the state of Washington, including all shoreline and offshore islands from Cape Shoalwater southward to Cape Disappointment. WA0401D is a subproject of a larger project WA0401, which includes detailed digital mapping of the Mean High Water Line (MHW), Mean Lower Low Water Line (MLLW), and other coastal features from Cape Flattery to Cape Disappointment and includes Grays Harbor and Willapa Bay, in addition to other offshore islands in the vicinity.

Successful completion of the project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric-quality aerial photographs, and a Geographic Cell (GC) of the coastal zone which complements the Nautical Charting Program (NCP) as well as geographic information systems (GIS) for a variety of coastal zone management applications.

The project database consists of information measured and extracted from aerial photography and metadata related to photogrammetric compilation. Base mapping was conducted in a digital environment using stereo softcopy photogrammetry and associated cartographic practices.

#### **Project Design**

The design of project WA0401 was based on a comparison of image analysis to cartographic detail depicted on the pertinent NOAA nautical charts of the project site. The Remote Sensing Division (RSD) of the National Geodetic Survey, NOAA, formulated the WA0401 Project instructions (November 7, 2006) which contains the specific field and photo mission operational guidelines. The instructions, as provided to Science Applications International Corp (SAIC), discussed the project's purpose, geographic area of coverage, scope and priority, compilation, feature attribution, final product preparation, and preparing reports. For Phase II of this project SAIC is acting as a subcontractor to the prime contractor, Tuck Mapping Solutions Inc. (TMSI). The first phase (Phase I), which included planning, tide prediction, aerial photography, ground control surveys, airborne GPS surveys, data reduction, and preparing reports, was previously completed.

Nautical charts provided by RSD showed the limits of the compilation. Photo scales for the color and B&W IR photography were determined by RSD staff to attain the required mapping accuracies on Phase I of the project under a prior contract. The technical proposal for WA0401 Phase II included a Quality Control plan which described the procedures and requirements that were followed by SAIC and TMSI throughout the project.

## **Field Operations**

SAIC photographic mission operations were conducted between May 24, 2005 and October 9, 2006. Aerial photographic coverage of the project site consisted of natural color photographs and black & white infrared (B&W IR) photographs, collected at nominal scales of 1:30,000 for the bays, and at 1:40,000 for the outer coast. The B&W IR photographs were captured in coordination with both the mean high water (MHW) and mean lower low water (MLLW) tide levels. The color photographs were acquired at no particular tide levels.

Control for this project was based on three CORS and two standard control stations contained in the National Spatial Reference System (NSRS). HTDP was used to adjust the NAD83 [98] positions of the two standard control stations to NAD83 [CORS96 – Epoch 2002]. In addition to these five stations, NAD83 [CORS96 – Epoch 2002] positions were established on two UNAVCO Plate Boundary Observatory (PBO) CORS by running 10 consecutive days of data through the NGS Online Processing User Service (OPUS) to calculate the average of the results.

Control on the new stations was established by means of fast-static GPS. Each of the stations was tied directly to at least two of the seven above mentioned control stations. Each station was occupied at least twice for one hour with a constellation time shift of at least two hours between occupations. Observations were made between August 17<sup>th</sup> and September 15<sup>th</sup>, 2005. No unusual circumstances or equipment malfunctions occurred during observations or processing.

The airborne GPS data was collected utilizing a combination of Trimble geodetic receivers and CORS sites. All data was planned to be collected at a 2Hz rate with a 10° horizon mask. The ground monitoring stations were situated approximately every 75 km to ensure that each photo center would be within 100 km of two stations. Ground monitoring stations were a combination of six permanent CORS, two NSRS stations and one temporary control point. CORS ‘NEAH’ (AF9672), ‘PABH’ (AF9558) and ‘P415’ (DH093) are in the national CORS network. CORS ‘P401’, ‘P403’ and ‘P408’ are operated by the PBO. Data was collected only during times with a minimum satellite count of 5 and a maximum PDOP of 5.0. Session initialization required 6 satellites for a minimum of 10 minutes prior to photo collection.

See the Photographic Flight Reports and Ground Control Reports for additional information.

## **GPS Data Reduction**

The ground control survey data was processed and adjusted in Trimble Geomatics Office version 1.63. The 137 non-trivial base lines resulted in accuracies of 0.020 meters in all three dimensions at 95% confidence, exceeding the 0.1 meter horizontal and 0.2 meter vertical ground control accuracy requirements for the project.

NAD83 [CORS 96 – Epoch 2002] coordinates for the PBO CORS were established by running a minimum of ten 24 hour observations through OPUS and averaging the results. NAD83 [98] values for ‘AST A’, and ‘HQM ARP 2’ were shifted to NAD83 [CORS96 – Epoch 2002] with the use of HTDP. The coordinates for temporary point ‘QUEETS’ were established by submitting 27 hours of data, spread over four days, to OPUS.

The airborne kinematic GPS data was processed to provide the precise positions of the camera centers for photogrammetric control in the aerotriangulation. The kinematic data was processed at 2 Hz utilizing a precise ephemeris in GrafNav Version 7.60.2425. Data not collected at a 2 Hz rate was resampled to 2 Hz using GrafNav's routine. Preliminary processing was completed after each mission to check for data integrity. Upon final processing, the data was reviewed for quality and then directly extracted in a format suitable for use in the aerial triangulation process. The median 3D standard deviation of the processing results for all 11 aerial photo missions varied between 0.049 and 0.086 meters.

See the Ground Control Report and Airborne GPS Control Report for additional information.

## **Aerotriangulation**

Routine softcopy aerotriangulation methods were applied to extend the network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. The aerotriangulation (AT) work was performed by [j][f][k] Inc. under sub-contract to SAIC. AT was initiated in October 2007, utilizing Z/I Imaging's ISDM (Image Station Digital Mensuration) version 054.03.00.08 and ISAT (Image Station Automatic Triangulation) software products. Once the AT data were measured and verified, the data was then processed using [j][f][k]'s PC-RABATS/BRATS software package. The softcopy aerotriangulation work was completed in December 2007.

The natural color photographs, B&W IR MLLW photographs, and B&W IR MHW photographs were processed as individual blocks for each emulsion. Upon successful completion of each block adjustment, the ISAT software provided the RMS of the standard deviations for all aerotriangulated ground points, which were used to compute predicted horizontal circular error at the 95% confidence level of 0.6 meters for all adjusted photographs. A separate Aerotriangulation Report was written for each emulsion, and all three are on file with other project data within the RSD AB Project Archive.

The project database consists of camera calibration data, interior orientation parameters for each frame, airborne GPS antenna position and offset data, adjusted exterior orientation parameters for each frame, positional listing of all measured points, the control file, and refined image coordinates as listed in the Project Database section of each Aerotriangulation Report.

Positional data is based on NAD83, and is referenced to UTM Zone 10.

## **Compilation**

The data compilation phase of the project was initiated by SAIC in February 2008. Digital mapping was performed using Digital Photogrammetric Workstations (DPWs) in conjunction with BAE SOCET SET ver. 5.3.1. Feature identification and the assignment of cartographic codes were based on image analysis of natural color and B&W IR photography and information extracted from appropriate NOAA Nautical Charts and the US Coast Guard Light List. Cartographic feature attribution was assigned in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST) as required.

Cartographic features were compiled to meet a horizontal accuracy of 1.2 meters at the 95%

confidence level. This predicted accuracy of compiled, well-defined points is derived by doubling the circular error derived from aerotriangulation statistics.

See the table below for information on aerial photographs used for project WA0401D.

<b>Date</b>	<b>Time (UTC)</b>	<b>Roll Number</b>	<b>Frames</b>	<b>Scale (nominal)</b>	<b>Tide Level*</b>
05/24/2005	21:42 – 21:45	0505CN01	002 – 007	1:30,000	1.9 – 2.1
05/24/2005	21:52 – 22:01	0505CN01	008 – 023	1:30,000	2.0 – 2.1
05/24/2005	22:06 – 22:13	0505CN01	025 – 040	1:30,000	2.2 – 2.1
05/24/2005	22:18 – 22:28	0505CN01	041 – 056	1:30,000	1.9 – 2.2
05/24/2005	23:27 – 23:29	0505CN01	097 – 102	1:30,000	1.8 – 1.6
05/24/2005	23:39 – 23:42	0505CN01	103 – 108	1:30,000	1.6 – 1.8
05/25/2005	00:11 – 00:14	0505CN01	118 – 124	1:30,000	1.4 – 1.7
05/25/2005	17:49 – 17:56	0505CN01	126 – 136	1:40,000	(-0.1) – (-0.2)
05/25/2005	18:05 – 18:11	0505CN01	137 – 146	1:40,000	(-0.1) – (+0.1)
04/22/2006	22:22 – 22:29	0605R02	019 – 034	1:30,000	0.0 – (-0.1)
04/22/2006	22:32 – 22:41	0605R02	035 – 050	1:30,000	0.0 – 0.1
04/22/2006	22:45 – 22:52	0605R02	051 – 066	1:30,000	(-0.1) – (+0.1)
04/22/2006	23:13 – 23:16	0605R02	076 – 081	1:30,000	0.0 – 0.2
04/22/2006	23:23 – 23:26	0605R02	082 – 088	1:30,000	0.24 – 0.26
04/23/2006	17:00 – 17:08	0605R02	118 – 133	1:30,000	2.1 – 2.0
04/23/2006	17:13 – 17:21	0605R02	134 – 149	1:30,000	2.0 – 2.1
04/23/2006	17:26 – 17:29	0605R02	150 – 156	1:30,000	1.8 – 2.0
04/23/2006	17:35 – 17:42	0605R02	157 – 172	1:30,000	2.0 – 1.8
04/23/2006	17:49 – 17:52	0605R02	173 – 178	1:30,000	1.7 – 1.8
05/04/2006	18:07 – 18:12	0605R03	023 – 030	1:40,000	0.15 – 0.16
05/04/2006	20:21 – 20:28	0605R03	111 – 120	1:40,000	0.1
05/04/2006	20:36 – 20:38	0605R03	121 – 124	1:40,000	0.2 – 0.1
10/09/2006	19:40 – 19:43	0605R10	001 – 006	1:40,000	2.3 – 2.4
10/09/2006	19:55 – 20:03	0605R10	008 – 018	1:40,000	2.4 – 2.5
10/09/2006	20:22 – 20:23	0605R10	019 – 021	1:40,000	2.6 – 2.7

\*Tide levels are given in meters above MLLW, and are based on verified observations from the Toke Point tide station, adjusted for CO-OPS Tidal Zoning. The elevation of the MHW datum varies between 2.2 – 2.5 meters above MLLW throughout the project area.

## Final Review

An SAIC team and a TMSI team completed the final review in November 2008. The GC was evaluated for completeness and accuracy. The review process included analysis of aerotriangulation results and assessment of the identification and attribution of cartographic features within the GC according to image analysis and criteria defined in C-COAST. The quality control process concluded with an inspection of topological connectivity within the GC using GIS software. All project data was evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with natural color photographs and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following nautical charts were used in the comparison process:

18500, Columbia River to Destruction Island, WA, Scale 1:180,789, 30<sup>th</sup> Ed., May /08  
18504 Willapa Bay, WA, Scale 1:40,000, 66<sup>th</sup> Ed., Jul. /06  
    Inset 18504, Toke Point, Scale 1:10,000  
    Inset 18504, Continuation of Willapa River, Scale 1:40,000  
18521 Columbia R., Pacific Ocean to Harrington Pt., Scale 1:40,000, 73<sup>rd</sup> Ed., Apr. /08

## **End Products and Deliverables**

The following specifies the location and identification of the products generated during the completion of this project:

### **RSD Applications Branch Project Archive:**

- Hard copy of Airborne Positioning and Orientation Report (APOR)
- Hard copy of Aerotriangulation Report
- Hard copy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10747 file contents

### **RSD Electronic Data Library:**

- Project Database
- GC10747 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

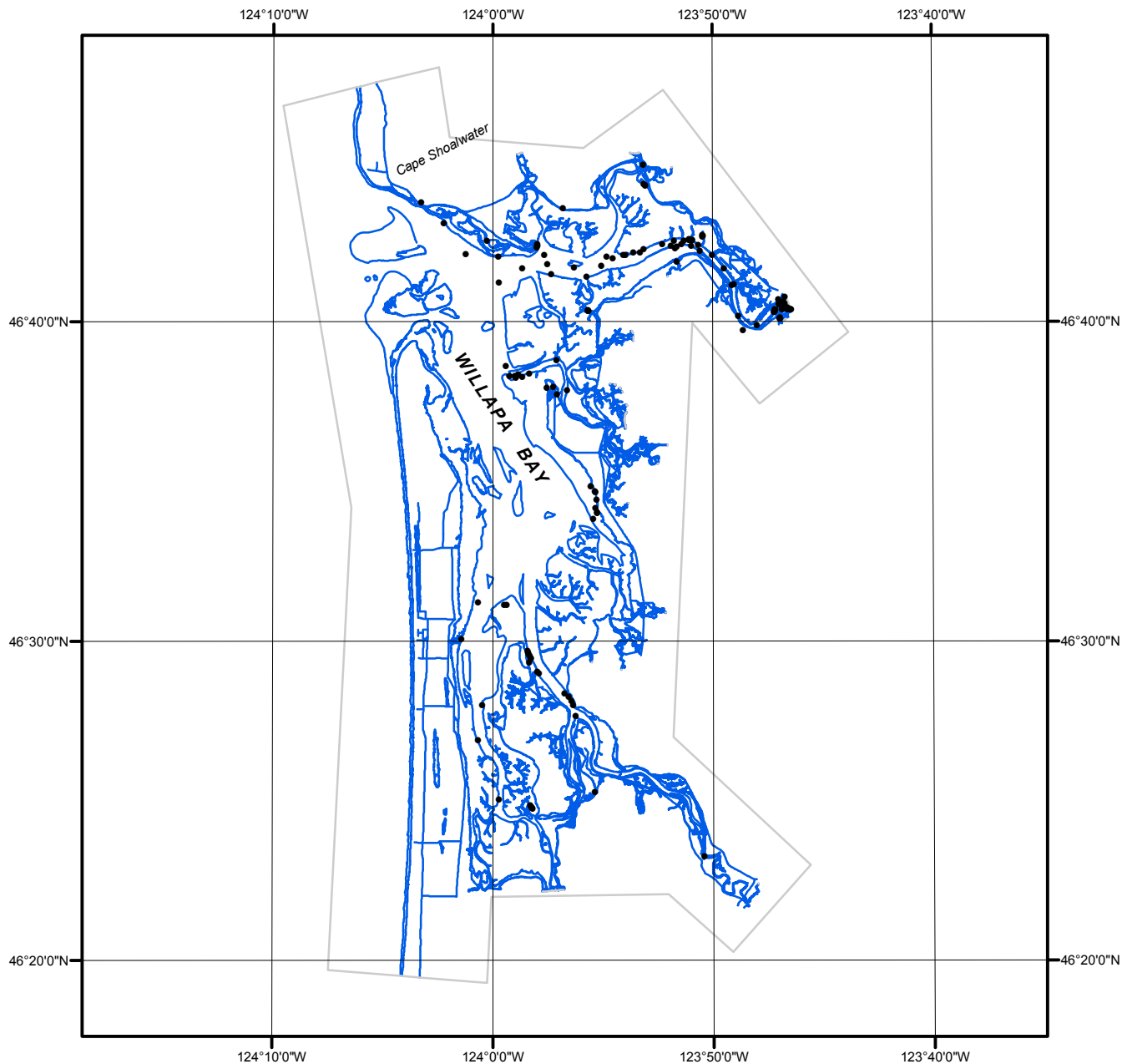
### **NOAA Shoreline Data Explorer:**

- GC10747 in shapefile format
- Metadata file for GC10747
- Digital Copy of the PCR in Adobe PDF format

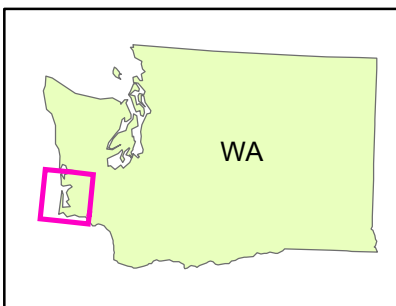
## **End of Report**

# WILLAPA BAY

## WASHINGTON



Overview



WA0401D

GC10747