

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

## ***PROJECT WA1406D-CM-N***

### ***Southern Puget Sound, Olympia to Oakland Bay, Washington***

#### **Introduction**

NOAA Coastal Mapping Program (CMP) Project WA1406D-CM-N provides a highly accurate database of new digital shoreline for Southern Puget Sound, from Olympia to Oakland Bay, in Washington. This is a subproject of a larger imagery acquisition project, WA1406-CM-N, which provides coverage of Southern Puget Sound from Vashon Island to Oakland Bay, Washington. The Geographic Cell (GC) may be used in support of the NOAA Nautical Charting Program (NCP) as well as geographic information systems (GIS) for a variety of coastal zone management applications.

#### **Project Design**

Photographic mission instructions for WA1406-CM-N were formulated by the Requirements Branch (RB) of the Remote Sensing Division (RSD) following the guidelines of the Photo Mission Standard Operating Procedures. The instructions discussed the project's purpose, geographic area of coverage, scope and priority, image requirements, Global Positioning System (GPS) data collection procedures and guidelines, instructions for data recording and handling, and mission communication protocols. RB created a Project Layout Diagram, flight maps and input files for the aircraft flight management system.

#### **Field Operations**

The field operations for Project WA1406-CM-N consisted of the collection of static and kinematic GPS data and Inertial Measurement Unit (IMU) data, and the acquisition of digital aerial imagery. Aerial survey operations were conducted from August 2014 through June 2016, and included 49 flight lines of natural color (RGB) and near-infrared (NIR) imagery acquired concurrently with Applanix DSS 439 (2014 imagery) and DSS 580/560 (2016 imagery) dual cameras on the NOAA King Air aircraft (N68RF) in coordination with both the Mean High Water (MHW) and Mean Lower Low Water (MLLW) tide stages. For subproject WA1406D-CM-N, a subset of sixteen flight lines were used. All imagery was acquired at a nominal altitude of 10,500 feet resulting in an approximate Ground Sample Distance (GSD) that varies between 0.33 – 0.37 meters depending on the camera used and imagery type acquired.

#### **Direct Georeferencing Data Processing**

The GPS/IMU data were processed by RSD personnel to yield precise camera positions and orientations for direct georeferencing (DG) of the imagery. A local GPS base station was established for use as a reference station for kinematic GPS processing operations. The position of the base station was determined using the NGS Online Processing User Service (OPUS), which computed fixed baseline solutions from nearby CORS stations. The Airborne kinematic data for project WA1406-CM-N was processed using Applanix POSPac MMS (ver. 6.2 and 7.1)

software from September 2014 to September 2016. For further information refer to the Airborne Positioning and Orientation Reports (APORs) on file with other project data within the RSD Electronic Data Library.

The processed GPS/IMU data were used to derive precise exterior orientation (EO) values of the camera centers required for digital feature extraction. The predicted horizontal accuracy of the imagery was calculated using the Exterior Orientation Total Propagated Uncertainty (EO-TPU ver. 2.1) tool developed by NGS. Using this tool, the predicted horizontal uncertainty at the 95% confidence level for imagery used in subproject WA1406D-CM-N was calculated to be 0.9 meters. All positional data is referenced to the North American Datum of 1983 (NAD83).

NGS third order control was used to verify the horizontal integrity of the DG data. Stereo models were examined and found to have acceptable levels of parallax for mapping purposes.

## **Aerotriangulation**

Aerotriangulation (AT) was performed in March 2021 in order to further refine the positioning of a subset of the project imagery, specifically those images covering the Port of Olympia. Routine softcopy AT methods were applied to establish a network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. Images were measured and adjusted as a single block using the Multi-Sensor Triangulation module of BAE Systems' SOCET SET (ver. 5.6) photogrammetric software suite. Upon successful completion of this process, the triangulation software provided the standard deviations for each aerotriangulated ground point, which were used to compute a predicted horizontal circular error of 0.40 meters based on a 95% confidence level. An AT Report was written and is on file with other project data within the RSD Electronic Data Library.

## **Compilation**

The data compilation phase of this project was completed by RSD Applications Branch (AB) personnel in May 2021. Digital mapping was performed using the Feature Extraction software module within SOCET SET (ver. 5.6). Feature identification and attribution within the GC were based on image analysis of the aerial imagery and information extracted from the largest scale NOAA nautical charts and other ancillary sources. Feature attribution was assigned in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST), which provides the definition and attribution scheme for the full range of cartographic features pertinent to the CMP. Selected features were further modified with additional descriptive information to refine general classification.

Spatial data accuracies for project WA1406D-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features compiled from images utilizing DG were compiled to meet a horizontal accuracy of 1.8 meters at the 95% confidence level, derived by doubling the accuracy computed from the EO-TPU tool. Features compiled from aerotriangulated images were compiled to meet a horizontal accuracy of 0.8 meters at the 95% confidence level, derived by doubling the circular error calculated from AT statistics. All computed accuracies apply specifically to compiled well-defined points.

The following table provides further information on the imagery used to complete this project:

Date	Time (UTC)	Color Imagery		Infrared Imagery		Tide Level*
		Roll	Strip / Images	Roll	Strip / Images	
8/25/2014	19:59	14NC74	53-008 / 17564 – 17566	14NR65	53-008 / 14312 – 14312	0.3 m
8/25/2014	20:13 – 20:14	14NC74	53-010 / 17601 – 17607	14NR65	53-010 / 14349 – 14355	0.4 m
5/7/2016	00:28	16VC50	53-008 / 12602 – 12604	16VR50	53-008 / 12606 – 12608	4.0 m
5/7/2016	18:16	16VC51	53-011 / 12747 – 12749	16VR51	53-011 / 12751 – 12753	0.1 – 0.2 m
5/7/2016	20:47 – 20:50	16VC52	53-001 / 12860 – 12876	16VR52	53-001 / 12864 – 12880	-0.4 m
5/7/2016	20:55 – 20:56	16VC52	53-003 / 12877 – 12886	16VR52	53-003 / 12881 – 12890	-0.3 m
5/7/2016	21:04 – 21:05	16VC52	53-004 / 12887 – 12897	16VR52	53-004 / 12891 – 12901	-0.2 m
5/7/2016	21:06 – 21:07	16VC52	53-005 / 12898 – 12902	16VR52	53-005 / 12902 – 12906	-0.2 m
5/7/2016	21:12 – 21:13	16VC52	53-009 / 12911 – 12923	16VR52	53-009 / 12915 – 12927	-0.1 m
5/7/2016	21:15 – 21:17	16VC52	53-006 / 12924 – 12937	16VR52	53-006 / 12928 – 12941	-0.1 m
5/7/2016	21:22 – 21:25	16VC52	53-013 / 12938 – 12959	16VR52	53-013 / 12942 – 12963	0.0 – 0.1 m
5/7/2016	21:29 – 21:32	16VC52	53-018 / 12960 – 12978	16VR52	53-018 / 12964 – 12982	0.1 m
5/7/2016	21:37 – 21:38	16VC52	53-002 / 12979 – 12988	16VR52	53-002 / 12983 – 12992	0.2 – 0.3 m
5/7/2016	21:42 – 21:44	16VC52	53-021 / 12989 – 13004	16VR52	53-021 / 12993 – 13008	0.3 – 0.4 m
5/8/2016	00:47 – 00:48	16VC53	53-011 / 13074 – 13076	16VR53	53-011 / 13078 – 13080	3.8 – 3.9 m
5/8/2016	00:52 – 00:53	16VC53	53-010 / 13077 – 13083	16VR53	53-010 / 13081 – 13087	3.9 m
5/10/2016	15:39 – 15:40	16VC55	53-005 / 13237 – 13241	16VR55	53-005 / 13241 – 13245	4.1 m
5/10/2016	16:02 – 16:04	16VC55	53-009 / 13286 – 13298	16VR55	53-009 / 13290 – 13302	4.0 m
5/10/2016	16:05 – 16:07	16VC55	53-006 / 13299 – 13312	16VR55	53-006 / 13303 – 13316	4.0 – 4.1 m
5/10/2016	16:13 – 16:16	16VC55	53-013 / 13313 – 13334	16VR55	53-013 / 13317 – 13338	3.9 – 4.0 m
5/10/2016	16:20 – 16:21	16VC55	53-004 / 13335 – 13345	16VR55	53-004 / 13339 – 13349	3.9 m
5/10/2016	16:26 – 16:28	16VC55	53-001 / 13346 – 13362	16VR55	53-001 / 13350 – 13366	3.8 m
5/10/2016	16:33 – 16:35	16VC55	53-003 / 13363 – 13372	16VR55	53-003 / 13367 – 13376	3.8 m
5/10/2016	16:39 – 16:43	16VC55	53-012 / 13373 – 13398	16VR55	53-012 / 13377 – 13402	3.7 m
5/10/2016	20:33 – 20:37	16VC56	53-012 / 13500 – 13525	16VR56	53-012 / 13504 – 13529	0.1 – 0.2 m
5/10/2016	20:41 – 20:45	16VC56	53-020 / 13526 – 13553	16VR56	53-020 / 13530 – 13557	0.0 m
5/10/2016	20:50 – 20:55	16VC56	53-015 / 13554 – 13581	16VR56	53-015 / 13558 – 13585	-0.1 m
6/04/2016	23:39 – 23:43	16VC67	53-015 / 15659 – 15686	16VR67	53-015 / 15663 – 15690	3.6 – 3.7 m**
6/04/2016	23:47 – 23:51	16VC67	53-020 / 15687 – 15714	16VR67	53-020 / 15691 – 15718	3.8 m
6/04/2016	23:54 – 23:57	16VC67	53-021 / 15715 – 15730	16VR67	53-021 / 15719 – 15734	3.8 – 3.9 m
6/05/2016	00:02 – 00:05	16VC67	53-018 / 15731 – 15749	16VR67	53-018 / 15735 – 15753	3.9 – 4.0 m
6/05/2016	00:11 – 00:13	16VC67	53-002 / 15750 – 15759	16VR67	53-002 / 15754 – 15763	4.0 m

- \* Tide levels are given in meters above MLLW and were calculated using the Pydro software tool with a TCARI grid referenced to verified water level observations at NOS gauges. The height of the MHW tidal datum in the project area varies between 3.96 – 4.13 meters above MLLW.
- \*\* Out of standard tolerance for tide coordination.

## **Quality Control / Final Review**

Quality control tasks were conducted during all phases of project completion by a senior member of the CMP. The final QC review was completed in June 2021. The review process included analysis of the DG and AT results and assessment of the identification and attribution of digital feature data 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 ArcGIS (ver. 10.8.1) desktop GIS software. All project data was evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA chart products with source imagery and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following Electronic Navigational Charts (ENCs) were used in the comparison process:

- US4WA10M, 38<sup>th</sup> Ed., Jan. 2020
- US5WA23M, 14<sup>th</sup> Ed., Dec. 2018
- US5WA24M, 11<sup>th</sup> Ed., Aug. 2017

## **End Products and Deliverables**

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

### **Remote Sensing Division Electronic Data Library**

- Project database
- Airborne Positioning and Orientation Reports
- Aerotriangulation Report
- GC11685 in shapefile format
- Project Completion Report (PCR)
- CEF in shapefile format

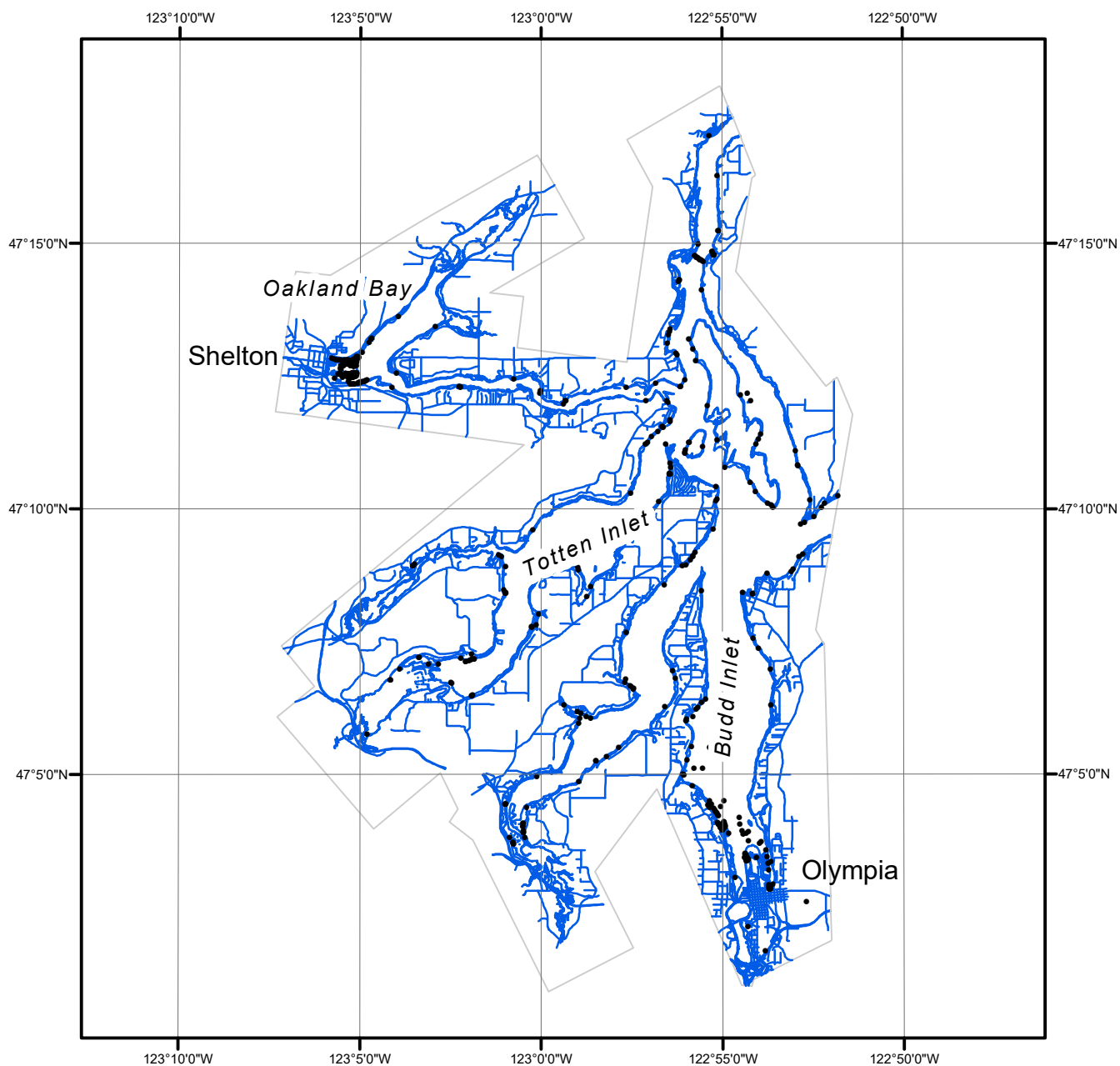
### **NOAA Shoreline Data Explorer**

- GC11685 in shapefile format
- Metadata file for GC11685
- PCR in Adobe PDF format

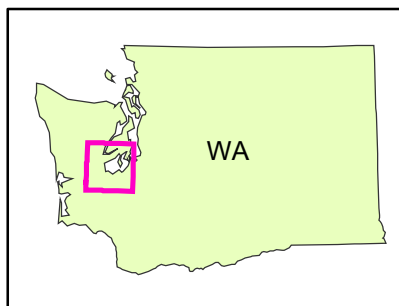
## **End of Report**

# SOUTHERN PUGET SOUND, OLYMPIA TO OAKLAND BAY

## WASHINGTON



Overview



WA1406D-CM-N

GC11685