Integrated Regional Wetland Monitoring Pilot Project
California Bay-Delta Authority Science Program

Report of Collected Aerial Imagery

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1067

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Integrated Regional Wetland Monitoring Pilot Project

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1. Introduction

This report summarizes the activities performed by Wetlands and Water Resources (WWR) to 1) obtain high-resolution aerial imagery of the selected tidal marsh sites and 2) process this imagery for use by the different teams participating in the Integrated Regional Wetland Monitoring (IRWM) Pilot Project. This report is structured with the following sections:

- Section 1 provides the objectives for this scope of work, the photo scale and resolution targets, and a listing of the sites flown for aerial imagery acquisition and processing.
- Section 2 provides a detailed, step-by-step account of how the aerial imagery was acquired and processed, in order to obtain the final products necessary for the IRWM Pilot Project.
- Section 3 describes available imagery products and their intended uses and limitations.
- Four appendices (A through D) which provide the following information: A) flight line maps, B) metadata for the equipment used to collect the aerial imagery, C) a Readme text file presenting metadata for the aerial imagery, and D) a table listing the aerial imagery products. Two CDs with electronic copies of the product suite and the complete set of aerial imagery metadata is also included as part of this report.

1.1. Objectives

The objectives of the aerial imagery work are as follows:

- To obtain high-resolution aerial imagery of the selected sites;
- To process the imagery such that it can be used by the various teams involved in the IRWM Pilot Project; and
- To provide a detailed report documenting aerial imagery acquisition and processing activities.

1.2. Target Photo Scale and Pixel Resolution

The November 2002 "Scope of Work and Budgets for the IRWM Pilot Project" document submitted to the California Bay-Delta Authority Science Program identified WWR as being responsible for obtaining and processing high-resolution color infrared aerial imagery of the selected study sites. For this initial scope of work, we anticipated that our air photography vendor would fly 1:12,000 scale metric imagery, and that these images would be digitized at 1,500 dots per inch (dpi), leading to a pixel resolution of 0.67 ft and a file size that fits onto a single CD uncompressed. Both the Point Reyes Bird Observatory (PRBO) and WWR have used this pixel resolution successfully in recent wetland monitoring activities elsewhere in the San Francisco Estuary. At a scale of 1:12,000, it was anticipated that each image would cover about 1,800 acres on the ground, requiring 1 or 2 images per site. The overall goal was to achieve the same scale and pixel resolution for all sites, regardless of site size, in order to achieve uniform data for subsequent analyses.

Based upon our review of IRWM project needs with regard to scale and pixel resolution, site size, number of photos per site, and budget, once the project sites were chosen, the aerial photographs for all of the sites except one were flown at a scale of 1:9,600 and scanned at a resolution of 1,200 dpi, retaining the target 0.67 ft pixel resolution. The exceptions to this were the photo for Carl's Marsh, which was flown earlier in 2003 under a separate project, and consequently had a slightly different flight scale and pixel resolution, and the photos for Big Break.

1.3. Sites Flown

The IRWM Pilot Project principal investigators ulitmately chose the following six sites for the project:

- Brown's Island
- Bull Island
- Carl's Marsh (aka Petaluma River Marsh)
- Coon Island
- Pond 2A
- Sherman Lake (aka Lower Sherman Island)

The IRWM team also considered three other sites well into the site selection process, and therefore some of the aerial imagery acquisition and processing activities were also performed for these sites:

- Big Break
- San Souci
- Pond 3

Figure 1 shows the locations of all sites flown in 2003.

2. Aerial Imagery Acquisition and Processing

Each of the steps involved in the acquisition and processing of the aerial photographs is described below.

1. Identifying and establishing an appropriate projection for all site imagery (Section 2.1);
2. Place ground control at sites and obtain spatial coordinates with a Global Positioning System (GPS) unit (Section 2.2);
3. Collect aerial photographs of the sites (Section 2.3);
4. Image processing including rectification, mosaicing and compression (Section 2.4); and
5. Preparation of metadata (Section 2.5).

2.1. Projection

All of the imagery and map products, and the GPS data collected for this project conform to the following projection parameters:

- Projection: UTM
- Zone: 10N

- Datum: NAD 83
- Units: Meters

2.2. Ground Control

The purpose of ground control points is to provide locations across each site that can be identified in the aerial photographs, in order to facilitate rectification of the aerial photographs. At least four ground control points were selected for each photo. These points were generally spread out in different corners of each photo, in order to maximize the accuracy of the rectification process.

Ground control targets consisted of black and white crosses painted on 3 foot by 3 foot plywood platforms installed above tidal and vegetation obstructions. The targets were surveyed horizontally using a sub-meter-accuracy GPS unit (Trimble GeoXT). Sub-meter accuracy was verified during data post processing. The survey points were then converted to a Geographic Information System (GIS), and used as reference to match the crosses as seen on the photos to corresponding real-world coordinates of the survey/GIS points.

2.3. Aerial Photography

High-resoloution color infrared aerial photographs were collected for nine sites. Table 1 lists those sites, date, number of photos, rectification method, scale and pixel resolution. Appendix A presents the flight line maps for each of these sites.

Table 1
IRWM 2003 Aerial Imaging Summary Data

Site	Site Code	Date Flown	Number of Photos[1]	Rectification	Scale	Pixel Resolution[1]
Six Selected Sites						
Brown's Island	BrI	9/29/2003	2	Ortho	1:9,600	0.67 ft
Bull Island	BuI	10/24/2003	1	Ortho	1:9,600	0.67 ft
Carl's Marsh	CM	8/14/2003	1	Ortho	1:7,200	0.5 ft
Coon Island	CI	9/29/2003	2	Ortho	1:9,600	0.67 ft
Pond 2A	P2A	9/29/2003	2	Ortho	1:9,600	0.67 ft
Sherman Lake	SL	10/24/2003	5	Ortho	1:9,600	0.67 ft
Three Not-Selected Sites						
Big Break	BB	10/3/2003	2	Geo	1:6,000	0.41 ft
Pond 3	P3	9/29/2003	5	Geo	1:9,600	0.67 ft
San Souci	SS	9/29/2003	1	Geo	1:9,600	0.67 ft

Notes:

1. Flight lines shown in Appendix A.

2. At 1,200 dpi scan.

Aerial photographs were taken by Hammon, Jensen & Wallen Geospatial (HJW). Metadata for the plane and camera used for the aerial photography is provided in Appendix B.

Aerial photographs were flown at the lowest possible tide, at a scale of 1:9,600 (1" = 800' or 1 cm = 96 m). The photographs were then scanned at a resolution of 1,200 dpi providing 0.67 ft (20cm) pixel resolution. WWR received a DVD with an electronic file for each photograph (tiff format), and two diapositives from HJW.

The Carl's Marsh photograph was flown for a different project earlier in 2003. That project acquired imagery at 1:7,200, or 1" = 600'/ 1 cm = 72 m. The photograph was scanned at 1,200 dpi, providing a 0.5 ft (15 cm) pixel resolution.

The Big Break photographs were flown on a separate day, at a scale of 1:6,000, or 1" = 500'/ 1 cm = 60 m. The photograph was scanned at 1,200 dpi, providing a 0.41 ft (13 cm) pixel resolution.

2.4. Image Processing

Image processing includes rectification of individual photographs, clipping and mosaicing the individual photographs into one seamless image, and compressing the images into different file formats and resolutions. For this project, photographs from each of the six selected sites were ortho-rectified, while photographs from the remaining three non-selected sites were geo-rectified. A more complete description of each of these steps is provided below.

2.4.1. Ortho-rectification for Six Selected Sites

The scanned photo TIFFs were ortho-rectified to the aerial control points using ENVI photo processing software (version 3.6). Ortho-rectification accounts for camera tilt, topographic displacement and lens distortion, and warps the photo pixels (in addition to scaling and rotating) to fit the specified geographic model used in the control point surveys. To account for the local terrain's affect on image distortion, we employed digital elevation models (DEMs) in the rectification process. We used publicly available USGS DEMs, spaced at 10m spot elevations, because we did not have higher resolution DEMs available for the sites; however, because the terrain at all sites is relatively homogenous, these coarse DEMs were adequate for the ortho-rectification step.

The accuracy standards employed for ortho-rectification were such that approximately 90% of all control points on the photos are within two meters of their corresponding ground coordinate (which, as stated above, are of sub-meter accuracy—generally within 1-2.5ft of the nominal XY coordinate) determined using the GPS unit. Rectification accuracy information is available in .txt file format in the "Rectification Parameters" folder on DVD with the image files. The .txt files have the same name as their corresponding rectified photo image, with one exception - the Brown's Island rectification parameter files are in native Erdas Imagine file format (.gcc and .gms format) instead of the .txt file format.

2.4.2. Photo Clipping and Mosaicing

One trade off of producing such detailed, 1:9,600 scale photos, is that most of the sites are comprised of more than one photo. In order to view those sites in one seamless image, the individual photos must be combined, or mosaiced, into one image. This requires that each image be clipped to exclude the photo marginalia (date and time stamp, fiducial marks, etc.), because this information would otherwise obscure features on neighboring photos at the seams. Once clipped, we mosaiced photos into a seamless image using MrSID software.

2.4.3. Compression

Another trade off with using such high-resolution aerial photos, exacerbated by mosaicing several photos together, is the very large image file sizes. A typical single photo image in a TIFF format can be as large as 400 megabytes, which can significantly slow or even prevent the most basic digital processes.

The IRWM aerial photos have been converted to compressed MrSID and JPEG files to reduce file size. Each photo mosaic was compressed by a factor of 10, rendering file sizes of 30-50 megabytes per site. MrSID files retain pixel resolution (0.67ft /20cm for the IRWM series) and, for most purposes, are equivalent in quality to the original photo images. In addition, MrSID files are largely designed for use in GIS analysis, such that intensive processing can be performed on high quality images without being bogged down by very large file sizes.

Each site mosaic was converted to two different JPEG files, one at 600 and one at 300 dpi. JPEG compression does not maintain the quality that MrSID compression does, but the file sizes are smaller (on the order of 5-15 megabytes per photo) and many more software packages are able to read JPEG files, allowing for more general utility.

2.4.4. Geo-rectification for Three Not-Selected Sites

Geo-rectification is a process which scales and rotates imagery, essentially embedding the photo with real-world coordinates and scaling information. Unlike ortho-rectification, it does not correct for the effects of camera and topographic distortion on the image. While area information may be extracted from geo-rectified photos with reasonable accuracy, horizontal displacement is likely to be significantly greater than with ortho-rectification, especially toward the photo edges. Thus, temporal analysis comparing discrete locations from different photos of the same area over time would yield less accurate results (e.g., a channel that seems to have migrated from one year to the next is more likely to be a function of rectification error when using geo-rectification compared to ortho-rectification).

Imagery for the non-selected sites was geo-rectified using ArcView 3.2 Image Analysis software. As with the ortho-rectified photography, aerial control crosses were used as ground control. Rectification accuracy information is available in .dbf file format in the "Rectification Parameters" folder. The .dbf files have the same name as their corresponding rectified photo image.

2.5. Metadata

Metadata, or the documentation of technical specifications and background information pertaining to data, represents a very important component of any data set, and is particularly essential for complex geographic data. A thorough understanding of technical information such as ortho-rectification accuracy, coordinate system information, and specific spatial/temporal details about the images will greatly enhance the ability to extract meaningful information from them. More general metadata pertaining to "who," "how" and "why" is also useful for ensuring appropriate use of the data (including rights and limits of the user), as well as for providing proper credit to the data owners and producers, and for obtaining additional information if required.

WWR produced metadata for the IRWM aerial photos at two levels and in two file formats. Detailed technical information was recorded in separate files for each individual rectified image. These files include such information as the exact location of ground control points and the accuracy (e.g., RMS) of the photo's ties to those control points. Such statistics are used primarily for specific GIS analyses and high-level QA/QC. This rectification accuracy information is available in the "Rectification Parameters" folder, in .txt files for the ortho-rectified images, and in .dbf files for the geo-rectified images, one exception being the Brown's Island files, which are in native Erdas Imagine file format (.gcc and .gms). All of these files bear the same name as their corresponding rectified photo image.

More generic information relating to the photo mosaics for each site has been documented in .xml files, as well as .html files. These files include such all-purpose GIS documentation as generalized ortho-rectification accuracy and projection information, as well as data source and contact information. For most users, the majority of relevant information pertaining to each individual image is captured in the photo mosaic metadata, so these .xml and .html files were produced only for the latter. Two .html files—one in long form and one in FAQ form—are included with each photo mosaic.

In addition to these metadata, WWR produced a readme.txt file, which is a general and succint file, in order to provide quick access to metadata. This file contains information such as the WWR filenaming conventions used for the aerial imagery files, data projection information and contact information. This readme.txt file is included in Appendix C, and on both of the CDs containing the aerial imagery.

3. Imaging Products for Field and GIS Use

We have generated a number of photography and mapping products to fulfill anticipated IRWM Pilot Project needs. All these products are available as part of this report and at www.irwm.org. A table listing all of these products is provided in Appendix D

1) **Ortho-rectified, unclipped single image air photographs, multiple per site, six selected sites.** These images show the full photo prior to clipping and overlap in the mosaic and provide the data lost within the mosaic due to overlap. These products show 100% of the collected imagery data. These products are available in one resolution, with associated world files.

a) 0.67’ pixel resolution/1200dpi, JPEG

2) **Ortho-rectified, clipped, single image air photographs, multiple per site, six selected sites.** These images show the full photo minus the fiduciary data provided at the edge of the photo. These products can be easily imported into a GIS, for creation of customized mosaics. These products are available in one resolution with associated world files.

    a) 0.67’ pixel resolution/1200dpi, MrSID compressed-10x

3) **Ortho-rectified mosaic air photograph, one per site, six selected sites.** These images typically combine two or more individual photos into a single image and are the optimal GIS-ready products; they can also be viewed in imaging software such as PhotoShop. Two pieces of original data are lost in the mosaic: overlap between adjacent images and clipping areas external to the site. For the two sites (Carl’s Marsh and Bull Island) where only one aerial photograph was flown, the indvidual photograph and the mosaiced photograph are the same product. Mosaics are available in three resolutions and formats, all with associated world files. These photos are intended for quantitative analyses. Individuals using these products should select the appropriate pixel resolution for the intended application, and then use one consistent resolution across all sites.

    a) 0.67’ pixel resolution/1200dpi, MrSID compressed-10x
    b) 1.3’ pixel resolution/600dpi JPEG (same pixel resolution all sites)
    c) 2.7’ pixel resolution/300dpi JPEG (same pixel resolution all sites)

4) **Un-rectified, unclipped, single image air photographs, multiple per site, three not-selected sites (Big Break, Pond 3, San Souci).** These are the original aerial photographs, converted to JPEG format. These products show 100% of collected imagery data. Available in two resolutions.

    a) 1.34’ pixel resolution/600dpi, JPEG
    b) 2.68’ pixel resolution/300dpi, JPEG

5) **Geo-rectified mosaic air photograph, one per site, three not-selected sites.** Same product as ortho-rectified images but the simpler geo-rectification process yields somewhat lower spatial accuracy. Available in two resolutions, with associated world files.

    a) 1.3’ pixel resolution/600dpi JPEG (same pixel resolution all sites)
    b) 2.7’ pixel resolution/300dpi JPEG (same pixel resolution all sites)

6) **Map of each site mosaic, one per site, six selected and three not-selected sites.** These maps are 11x17 (tabloid) layouts showing the mosaic air photo for each site. These maps include scale bar and north arrow. To fit each site onto an 11x17 layout,

map scales (and therefore pixel dimensions) vary between sites. These products are ideal for printing as field maps or viewing in imaging software. However, because of the different pixel dimensions, these products are not suitable for quantitative analyses, and the rectified photo mosaic should be used instead. These products are available in two resolutions.

a) 550dpi/variable pixel resolution JPEG
b) 300dpi/variable pixel resolution JPEG

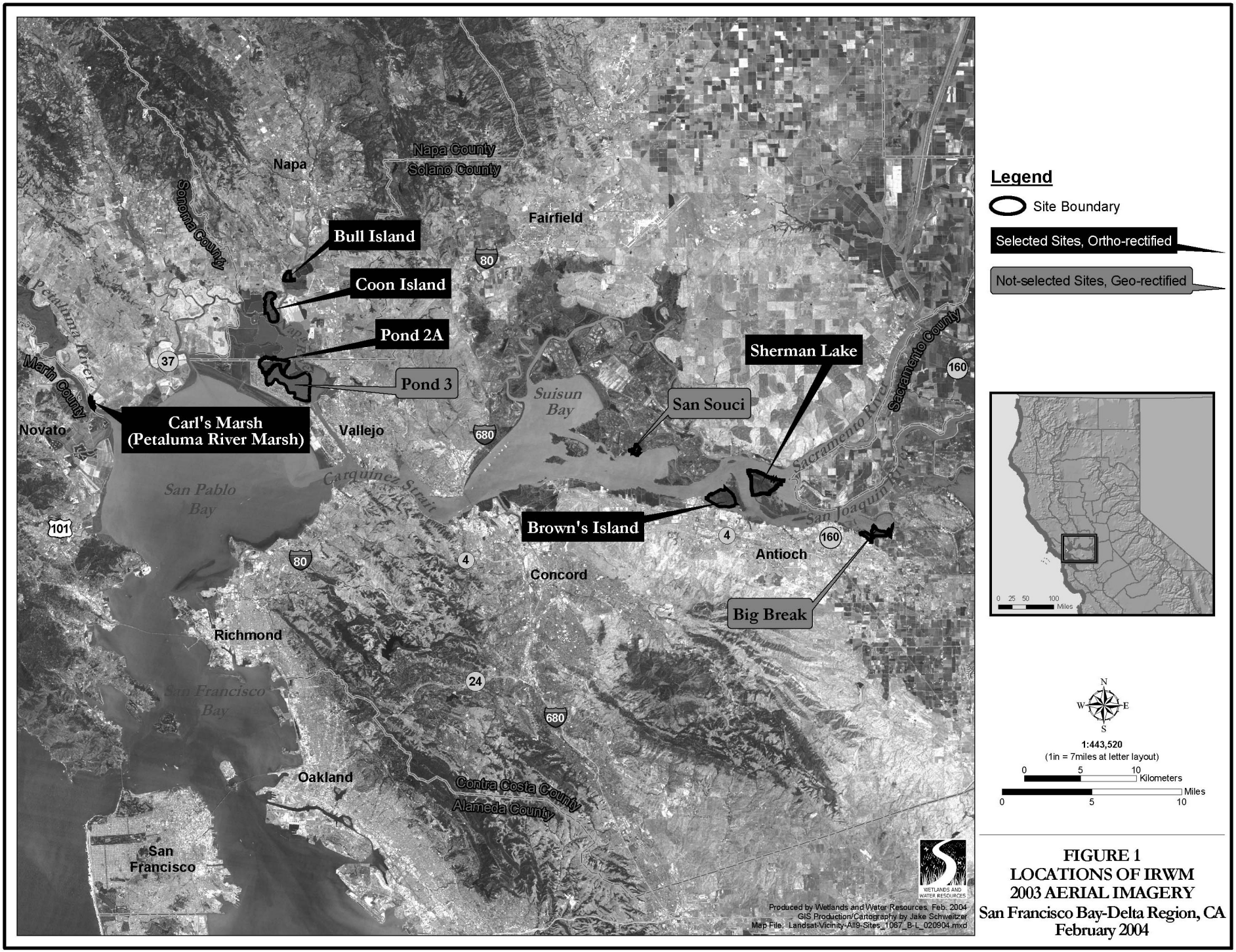


FIGURE 1
LOCATIONS OF IRWM
2003 AERIAL IMAGERY
San Francisco Bay-Delta Region, CA
February 2004

APPENDIX A

FLIGHT LINE MAPS

APPENDIX B

AIRPLANE AND CAMERA METADATA

USGS Report No. OSL/2835

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

April 5, 2002

Camera type: Zeiss RMK TOP 15*
Lens type: Zeiss Pleogon A3/4
Nominal focal length: 153 mm

Camera serial no.: 141291
Lens serial no.: 141314
Maximum aperture: f/4
Test aperture: f/4

Submitted by: Pacific Aerial Surveys
Oakland, California

Reference: HJW & Associates, Inc. purchase order No. 1535, dated April 4, 2002. Signed by Mr. Fred Benton.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: 154.061 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	-1	-2	-2	0	1	2
Decentering (um)	0	0	1	1	1	2

Symmetric radial distortion parameters

$K_0 = 0.6148 \times 10^{-4}$
$K_1 = -0.9639 \times 10^{-8}$
$K_2 = 0.3032 \times 10^{-12}$
$K_3 = 0.0000$
$K_4 = 0.0000$

Decentering distortion parameters

$P_1 = -0.1207 \times 10^{-6}$
$P_2 = -0.2045 \times 10^{-7}$
$P_3 = 0.0000$
$P_4 = 0.0000$

Calibrated principal point

$x_p = 0.006$ mm
$y_p = -0.005$ mm

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K_0, K_1, K_2, K_3, K_4), Decentering Distortion (P_1, P_2, P_3, P_4), and Calibrated Principal Point [point of symmetry] (x_p, y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ±3 microns.

* Equipped with Forward Motion Compensation

Lens Resolving Power in cycles/mm

Area-weighted average resolution: 96

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	113	113	113	113	95	95
Tangential lines	113	95	80	95	95	80	80

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

Filter Parallelism

The two surfaces of the Zeiss TOP 15 KL-F (36%) filter No. 141523, and USGS TOP 15 test filter KL-F (60%) No. 142399 are within 10 seconds of being parallel. The USGS test filter, in conjunction with the internal "B" filter, was used for the calibration.

V. Shutter Calibration

Indicated time (sec)	Rise time (μ sec)	Fall Time (μ sec)	½ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/100	3856	3980	11.14	1/120	79
1/200	1832	1859	5.23	1/250	79
1/300	1158	1096	3.60	1/350	79
1/400	887	900	2.60	1/490	79
1/500	708	704	2.11	1/600	79

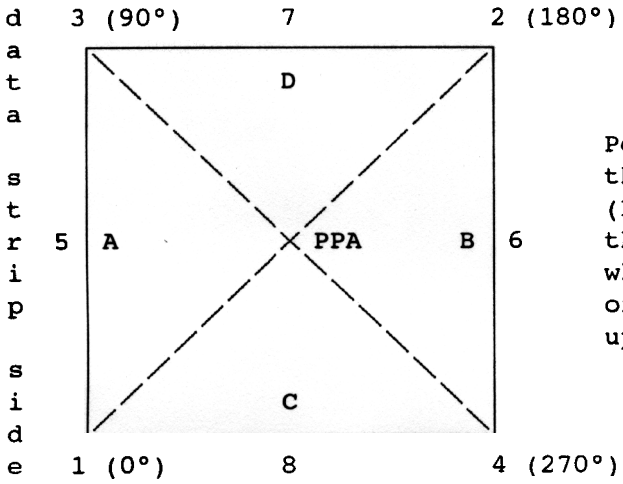
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platen mounted in T-MC film magazine No. 137711 does not depart from a true plane by more than 13 um (0.0005 in).

The platen for this film magazine is equipped with an identification marker that will register "141626" in the data strip area for each exposure.

Principal Points and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

	X coordinate	Y coordinate
Indicated principal point, corner fiducials	0.004 mm	-0.007 mm
Indicated principal point, midside fiducials	-0.002	-0.003
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.006	-0.005

Fiducial Marks

1	-112.986 mm	-113.012 mm
2	112.987	112.990
3	-113.012	113.002
4	113.016	-113.012
5	-113.000	-0.005
6	113.010	-0.001
7	-0.007	112.994
8	0.003	-112.995

Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 319.594 mm 3-4: 319.641 mm

Lines joining these markers intersect at an angle of 89° 59' 53"

Midside fiducials

5-6: 226.010 mm 7-8: 225.989 mm

Lines joining these markers intersect at an angle of 90° 00' 05"

Corner fiducials (perimeter)

1-3: 226.014 mm 2-3: 225.998 mm

1-4: 226.002 mm 2-4: 226.001 mm

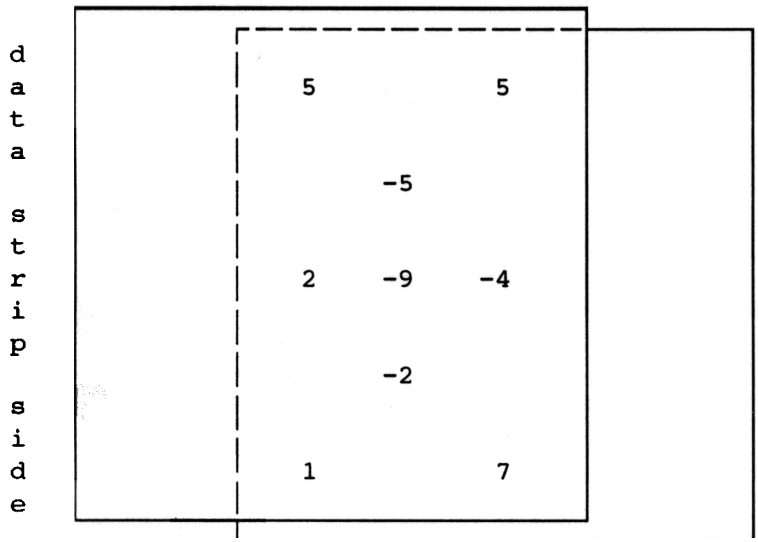
The method of measuring these distances is considered accurate within 0.003 mm

Note: For GPS applications, the nominal entrance pupil distance from the focal plane is 254 mm with a 10 mm filter thickness. Additional filter thickness will increase entrance pupil distance by 0.34 X added thickness.

IX. Stereomodel Flatness

FMC Magazine No.: 137711 Base/Height ratio: 0.6

Platen ID: 141626 Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereo models. The values are based on comparator measurements on Kodak 4425 copy film made from Kodak 2405 film exposures. These measurements can vary by as much as ± 5 μm from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 44 Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	48	48	48	48	48	48	40
Tangential lines	48	48	40	48	40	40	34

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2537, dated April 15, 1999.

John J. Lenart
Chief, Technology Operations Section
National Mapping Division

APPENDIX C

AERIAL IMAGERY METADATA README.TXT FILE

This file provides the most basic information pertaining to the images in this package.

The names of the photo files use the following convention:
Example using SL_Ortho-Mosaic_1067_102403_1200-10x.sid (MrSID format photo file):
SL-------Site name (see below)
Ortho----Rectification method (Photo was ortho-rectified, as opposed to Geo-rct, which means the photo was geo-rectified)
Mosaic---Consists of two or more individual photos, mosaiced together
1067-----WWR project number
102403---Date photo was taken (October 24, 2003)
1200-----Pixel resolution of photo image file
10x------Compression factor using MrSID software (compressed by a factor of 10)

The Site abbreviations are as follows:
SELECTED SITES
BrI - Brown's Island
BuI - Bull Island
CI - Coon Island
P2A - Pond 2A
CM - Carl's Marsh (Petaluma River Marsh)
SL - Sherman Lake
NOT-SELECTED SITES
BB - Big Break
P3 - Pond 3
SS - San Souci

Complete metadata is stored in each file's namesake HTML and XML files, but here are the basics:

--All of the selected site mosaics are in MrSID format (compressed from TIFF). MrSID files can be read in most GIS software, though an extension (included in all ESRI GIS products) may be required to view the photos.

--Clipped photos have been included to exclude non-data fiducial/flight information. Clippling occurred subsequent to ortho-rectification and prior to mosaicing.

--All aerial photos were taken between August and October, 2003.

--1:9,600 is the (geographic/fractional) scale for individual photos (and mosaics) for all sites except for Carl's Marsh, which is 1:7,200, and Big Break, which is 1:6,000. Pixel size for all ortho-rectified images is 0.2 meters (0.67ft).

--All image files conform to the following projection parameters:

  Projection: UTM
  Zone: 10N
  Datum: NAD83
  Units: Meters

Additional information regarding a photo's horizontal accuracy (rectification RMS)
can be found in the folder titled "Rectification Parameters"). For additional

information, contact Wetlands and Water Resources (WWR): (415) 457-0250 | www.swampthing.org

APPENDIX D

LIST OF AERIAL IMAGERY PRODUCTS

Table of Aerial Image Products					
IRWM Pilot Project					
Format	**Pixel Resolution**	**dpi**	**Site**	**Filename**	**Notes**
Product 1: Ortho-rectified, unclipped, single image photo (six selected sites)					Includes world files
JPEG	0.67	1200	Brown's Island	BrI-E_Unclipped-ortho_1067_092903_1200	
JPEG	0.67	1200	Brown's Island	BrI-W_Unclipped-ortho_1067_092903_1200	
JPEG	0.67	1200	Bull Island	BuI_Unclipped-ortho_1067_102403_1200	
JPEG	0.67	1200	Coon Island	CI-N_Unclipped-ortho_092903_1200	
JPEG	0.67	1200	Coon Island	CI-S_Unclipped-geo-rct_1067_092903_1200	Geo-rectified
JPEG	0.5	1200	Carl's Marsh	CM_Unclipped-ortho_081403_1200	
JPEG	0.67	1200	Sherman Lake	SL-NC_Unclipped-ortho_1067_102403_1200	
JPEG	0.67	1200	Sherman Lake	SL-NE_Unclipped-ortho_1067_102403_1200	
JPEG	0.67	1200	Sherman Lake	SL-NW_Unclipped-ortho_1067_102403_1200	
JPEG	0.67	1200	Sherman Lake	SL-SE_Unclipped-ortho_1067_102403_1200	
JPEG	0.67	1200	Sherman Lake	SL-SW_Unclipped-ortho_1067_102403_1200	
JPEG	0.67	1200	Pond 2A	P2A-E_unclipped-geo-rct_1067_092903_1200	Geo-rectified
JPEG	0.67	1200	Pond 2A	P2A-W_unclipped-geo-rct_1067_092903_1200	Geo-rectified
Product 2: Ortho-rectified, clipped, single image air photo (six selected sites)					Includes world files
MrSID	0.67	1200	Brown's Island	BrI-E_Ortho_1067_092903_1200-10x.sid	
MrSID	0.67	1200	Brown's Island	BrI-W_Ortho_1067_092903_1200-10x.sid	
MrSID	0.67	1200	Bull Island	BuI_Ortho_1067_102403_1200-10x.sid	
MrSID	0.67	1200	Carl's Marsh	CM_Ortho_1067_081403_1200-10x.sid	
MrSID	0.67	1200	Coon Island	CI-N_Ortho_1067_092903_1200-10x.sid	
MrSID	0.67	1200	Coon Island	CI-S_Ortho_1067_092903_1200-10x.sid	
MrSID	0.67	1200	Pond 2A	P2A-E_Ortho_1067_092903_1200-10x.sid	
MrSID	0.67	1200	Pond 2A	P2A-W_Ortho_1067_092903_1200-10x.sid	
MrSID	0.67	1200	Sherman Lake	SL-NC_Ortho_1067_102403_1200-10x.sid	
MrSID	0.67	1200	Sherman Lake	SL-NE_Ortho_1067_102403_1200-10x.sid	
MrSID	0.67	1200	Sherman Lake	SL-NW_Ortho_1067_102403_1200-10x.sid	
MrSID	0.67	1200	Sherman Lake	SL-SE_Ortho_1067_102403_1200-10x.sid	
MrSID	0.67	1200	Sherman Lake	SL-SW_Ortho_1067_102403_1200-10x.sid	

Table of Aerial Image Products					
IRWM Pilot Project					
Format	**Pixel Resolution**	**dpi**	**Site**	**Filename**	**Notes**
Product 3: Ortho-rectified, clipped, mosaiced photo (six selected sites)					Includes world files
MrSID	0.67	1200	Brown's Island	BrI_Ortho-Mosaic_1067_092903_1200-10x.sid	
MrSID	0.67	1200	Bull Island	BuI-Ortho_1067_102403_1200-10x.sid	
MrSID	0.67	1200	Carl's Marsh	CM_Ortho_1067_081903_1200-10x.sid	
MrSID	0.67	1200	Coon Island	CI_Ortho-Mosaic_1067_092903_1200_10x.sid	
MrSID	0.67	1200	Pond 2A	P2A_Ortho-Mosaic_1067_102403_1200-10x	
MrSID	0.67	1200	Sherman Lake	SL_Ortho-Mosaic_1067_102403_1200-10x.sid	
JPEG	1.3	600	Brown's Island	BrI_Ortho-Mosaic_1067_092903_600.jpg	
JPEG	1.3	600	Bull Island	BuI_Ortho_1067_102403_600.jpg	
JPEG	1.3	600	Carl's Marsh	CM_Ortho_1067_081403_600.jpg	
JPEG	1.3	600	Coon Island	CI_Ortho-Mosaic_1067_092903_600.jpg	
JPEG	1.3	600	Pond 2A	P2A_Ortho-Mosaic_1067_092903_600.jpg	
JPEG	1.3	600	Sherman Lake	SL_Ortho-Mosaic_1067_102403_600.jpg	
JPEG	2.7	300	Brown's Island	BrI_Ortho-Mosaic_1067_092903_300.jpg	
JPEG	2.7	300	Bull Island	BuI_Ortho_1067_102403_300.jpg	
JPEG	2.7	300	Carl's Marsh	CM_Ortho_1067_081403_300.jpg	
JPEG	2.7	300	Coon Island	CI_Ortho-Mosaic_1067_092903_300.jpg	
JPEG	2.7	300	Pond 2A	P2A_Ortho-Mosaic_1067_092903_300.jpg	
JPEG	2.7	300	Sherman Lake	SL_Ortho-Mosaic_1067_102403_300.jpg	
Product 4: Un-rectified, unclipped single image photo (3 non-selected sites)					Includes world files
JPEG	1.3	600	Big Break	BB-E_Unclipped-Photo_1067_100303_600	
JPEG	1.3	600	Pond 3	P3-E_Unclipped-Photo_1067_092903_600	
JPEG	1.3	600	Pond 3	P3-Mid-E_Unclipped-Photo_1067_092903_600	
JPEG	1.3	600	Pond 3	P3-Mid-W_Unclipped-Photo_1067_092903_600	
JPEG	1.3	600	Pond 3	P3-NE_Unclipped-Photo_1067_092903_600	
JPEG	1.3	600	Pond 3	P3-SE_Unclipped-Photo_1067_092903_600	
JPEG	1.3	600	San Souci	SS_Unclipped-Photo_1067_092903_600	
JPEG	2.7	300	Big Break	BB-E_Unclipped-Photo_1067_100303_300	
JPEG	2.7	300	Pond 3	P3-E_Unclipped-Photo_1067_092903_300	
JPEG	2.7	300	Pond 3	P3-Mid-E_Unclipped-Photo_1067_092903_300	
JPEG	2.7	300	Pond 3	P3-Mid-W_Unclipped-Photo_1067_092903_300	
JPEG	2.7	300	Pond 3	P3-NE_Unclipped-Photo_1067_092903_300	
JPEG	2.7	300	Pond 3	P3-SE_Unclipped-Photo_1067_092903_300	
JPEG	2.7	300	San Souci	SS_Unclipped-Photo_1067_092903_300	
Product 5: Geo-rectified, mosaiced photo, (3 non-selected sites)					Includes world files
JPEG	1.3	600	Big Break	BB_Geo-rct_1067_100304_600	
JPEG	1.3	600	Pond 3	P3_Geo-rct_Mosaic_092903_600	
JPEG	1.3	600	San Souci	SS_Geo-rct_1067_092903_600	
JPEG	2.7	300	Big Break	BB_Geo-rct_1067_100304_300	
JPEG	2.7	300	Pond 3	P3_Geo-rct_Mosaic_092903_300	
JPEG	2.7	300	San Souci	SS_Geo-rct_1067_092903_300	

Table of Aerial Image Products					
IRWM Pilot Project					
Format	**Pixel Resolution**	**dpi**	**Site**	**Filename**	**Notes**
Product 6: Tabloid Site Map (Rectified mosaic photo base layer)					Does not include world files
JPEG	1.09	550	Brown's Island	BrI_AP_1067-233_B-L_010804_550	Ortho-rectified
JPEG	0.64	550	Bull Island	BuI_AP_1067-233_B-L_010704_550	Ortho-rectified
JPEG	0.45	550	Carl's Marsh	CM_AP_1067-233_B-P_010704_550	Ortho-rectified
JPEG	1.21	550	Coon Island	CI_AP_1067-233_B-P_010704_550	Ortho-rectified
JPEG	1.21	550	Pond 2A	P2A_AP_1067-233_B-L_010704_550	Ortho-rectified
JPEG	1.52	550	Sherman Lake	SL_AP_1067-233_B-L_010704_550	Ortho-rectified
JPEG	1.09	550	Big Break	BB_AP_1067-233_B-L_010904_550.jpg	Geo-rectified
JPEG	0.83	550	San Souci	SS_AP_1067-233_B-P_010904_550.jpg	Geo-rectified
JPEG	2.12	550	Pond 3	P3_AP_1067-233_B-L_010904_550.jpg	Geo-rectified
JPEG	2	300	Brown's Island	BrI_AP_1067-233_B-L_010804_300	Ortho-rectified
JPEG	1.17	300	Bull Island	BuI_AP_1067-233_B-L_010704_300	Ortho-rectified
JPEG	0.83	300	Carl's Marsh	CM_AP_1067-233_B-P_010704_300	Ortho-rectified
JPEG	2.22	300	Coon Island	CI_AP_1067-233_B-P_010704_300	Ortho-rectified
JPEG	2.22	300	Pond 2A	P2A_AP_1067-233_B-L_010704_300	Ortho-rectified
JPEG	2.78	300	Sherman Lake	SL_AP_1067-233_B-L_010704_300	Ortho-rectified
JPEG	2	300	Big Break	BB_AP_1067-233_B-L_010904_300.jpg	Geo-rectified
JPEG	0.45	300	San Souci	SS_AP_1067-233_B-P_010904_300.jpg	Geo-rectified
JPEG	3.89	300	Pond 3	P3_AP_1067-233_B-L_010904_300.jpg	Geo-rectified