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DOE-0334
Revision 0

Basemap Generation from Imagery Acquired at the Hanford Reservation in June 1996

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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National Security Technologies LLC

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J. D. Aardal 11/01/2007
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10/16/2007

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DOE-RL	[x]	Security, G.I. Goldberg	(See e-mail pg. 2)	(Y) / N
Other OUO	[x]	N. A. Homan, DC	N.A. Homan	(Y) / N
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Date 11/01/2007

Simmons, Sally A

DOE-0334
Rev.0

From: Goldberg, Glenn I
Sent: Tuesday, October 16, 2007 9:07 AM
To: Leary, Kevin D; Simmons, Sally A
Subject: RE: RE: Security Clearance for OUO of the 1996 Aerial Radiological Survey of Hanford

Sally,

As long as the documents have been looked at by either RL (Kevin) or the Contractor (Aardal) I don't need to see them. The only reason I would need to see them is if the RL POC had some concerns or questions regarding OUO.

Since Kevin is OK with it, my approval is not necessary.

Thanks,

Glenn Goldberg
Security and Emergency Services
(509) 376-9552

From: Leary, Kevin D
Sent: Tuesday, October 16, 2007 8:59 AM
To: Simmons, Sally A
Cc: Goldberg, Glenn I
Subject: RE: Security Clearance for OUO of the 1996 Aerial Radiological Survey of Hanford

Sally--

I spoke with Glenn Goldberg this AM about doing a OUO review of the 1996 Aerial Radiological Survey of Hanford. Glenn stated since Nancy Hohman, Mark Williams, and Janice Aardall did a OUO review of the above-mentioned document, it is not necessary for him to review the document nor to sign-off on the clearance form. He said that he would send an e-mail to concur on this.

Thanks for your help.

Kevin D. Leary-*U-Plant Zone Closure/IS-1 Technical Lead*

U.S. Dept. of Energy-Richland

Certified Professional Soil Scientist/Hydrogeologist/Hydrologist

(509)-373-7285 (p) (509)-372-1926 (fax)

E-Mail: kevin_d_leary@rl.gov

"The only thing necessary for the triumph of evil is for good men to do nothing." --Sir Edmund Burke

"If you do the same thing over and over again, you cannot ever expect a different outcome." --Albert Einstein

National Security Technologies LLC
Vision • Service • Partnership

September 2007

Basemap Generation from Imagery Acquired at the Hanford Reservation in June 1996

Remote Sensing Laboratory
Las Vegas, Nevada

September 2007

Basemap Generation from Imagery Acquired at the Hanford Reservation in June 1996

Report By
Alan Klawitter

This document is UNCLASSIFIED

Reviewed by

David P. Colton, September 6, 2007
Derivative Classifier

Remote Sensing Laboratory
Las Vegas, Nevada

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INTRODUCTION

Aerial photography collected at the Department of Energy (DOE) Hanford Reservation Site by the Remote Sensing Laboratory (RSL) in 1996 was processed in March 2007 and used as an imagery basemap upon which radiation contours were overlaid to produce an aerial radiological survey report. This report details the production of the imagery basemap and geodetic accuracies of the rectified aerial photography for selected areas on the Hanford Reservation. Raw and processed digital imagery and ancillary digital data used to produce the imagery basemap with an index accompanies this report on an external hard drive.

DATA ACQUISITION

A total of 177 natural color aerial photographs of the Hanford Reservation were acquired with a calibrated RC-30 frame mapping camera on June 13 and 14, 1996, by the Imagery Science Department at RSL as part of a DOE proficiency exercise. The photographs were collected at 16,000 feet above ground level (AGL) resulting in a 9″ × 9″ contact print scale of 1:32,000. Flight lines were oriented north-south. Twenty frames were acquired on June 13 above the Umatilla bridge area during cloudy conditions. Most of the imagery of Hanford Reservation was acquired under clear sky conditions on June 14. Photo mission flight logs from this acquisition are appended to this report. This imagery collection proficiency exercise was coordinated with an RSL radiation survey that was also conducted at Hanford in 1996.

Nine regions of interest (ROI) were selected by officials at the DOE Richland Site Office for data processing. These areas are shown on Figure 1. The area designations listed on Figure 1 are for the purposes of this report only and do not refer to any official designations on the reservation. Aerial photographs encompassing the ROIs were identified and digitized from 9" × 9" contact prints using a 25 micron spot size. This spot size roughly corresponds to a ground sampling distance of one meter per pixel. Digitized aerial photographs were then grouped according to the area designations listed in Figure 1. Table 1 links the original photograph frame number designations to the area number spatially encompassed by the aerial photograph.

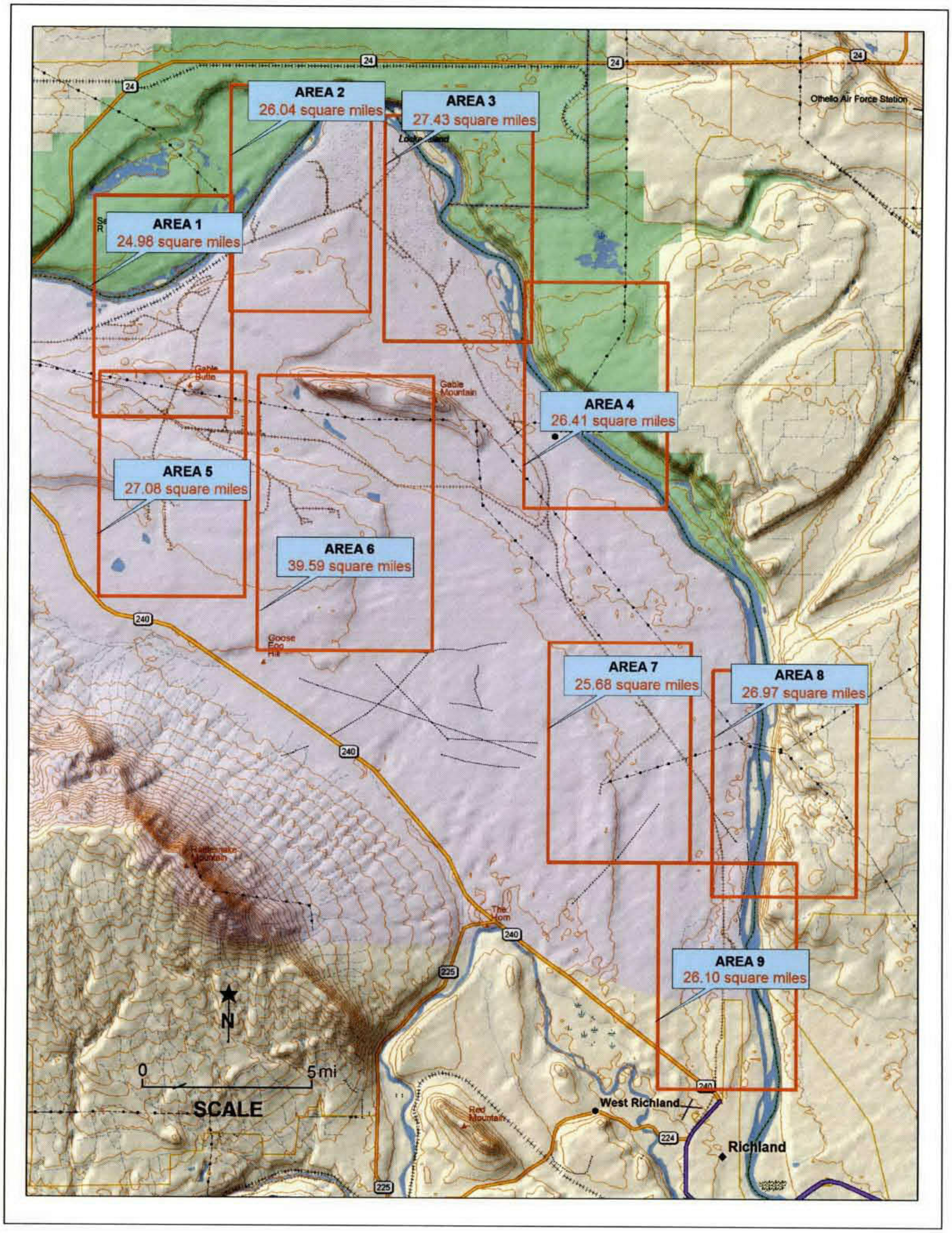

Figure 1. Location Map showing Regions of Interest

Table 1. Relationship Between Area Designations and Photo Frame Numbers

Regions of Interest	1996 Aerial Photograph Frame Number(s)
Area 1	47
Area2	110
Area 3	88, 89, 126, 127
Area 4	103
Area 5	48, 49
Area 6	112, 113, 114
Area 7	136, 137
Area 8	159
Area 9	160, 161

DATA PROCESSING

Digitized aerial photographs were individually orthorectified using ENvironment for Visualizing Images (ENVI) image processing software. To make effective use of aerial photography it is usually necessary to orient the image into its correct geographic space. Orthorectification minimizes the distortions caused by elevation and platform parameters which results in the creation of a geodetically correct image map. For single-image orthorectification, the technique involves two preprocessing steps to build the camera geometry: interior orientation, which transforms the pixel coordinate system to the camera coordinate system, and exterior orientation, which determines the position and angular orientation parameters associated with the image. The final processing step involves elevation corrections for the surface that was imaged.

Interior orientation parameters were determined by inputting the camera's calibration values and mapping the film fiducial mark locations to the appropriate locations in the camera's coordinate system. The exterior orientation parameters were determined by mapping image coordinates of points extracted from the digital aerial photograph to its corresponding ground control points (GCPs) located on a United States Geological Survey (USGS) Digital Orthophoto Quarter Quadrangle (DOQQ) map. In addition to tying the image control points to an x,y geodetic coordinate, in this case a UTM Zone 11 coordinate using a NAD83 datum, the surface elevation of that GCP was also determined from a USGS Digital Elevation Model (DEM), the z coordinate.

These DOQQ's have a ground spatial resolution of one meter and are rectified to a UTM Zone 11 projection using a NAD83 datum. USGS DOQQs must conform to National Map Accuracy Standards which state that the coordinates of 90 percent of well-identifiable points must be within 10.16 meters of their actual location. It has been our experience that the positional accuracies of USGS DOQQs have always exceeded the horizontal accuracy required by National Map Accuracy Standards.

A 10 meter USGS DEM was available for Hanford from the geology department of the University of Washington. National Map Accuracy Standards require that level 2 DEM products possess an average vertical error of less than one-half the contour interval of the map that they were produced from. The USGS DEM for Hanford has a ground spatial resolution of 10 meters and they were rectified to a UTM Zone 11 projection using a NAD27 datum. Vertical elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Between 11 and 19 GCPs were identified for each of the 17 aerial photographs that were orthorectified. GCPs were located as close as possible to each corner, each edge midpoint, and the centers of the digitized aerial photographs. Additional points were located throughout the image on easily identifiable, low-relief objects with high spectral contrast. The software estimated RMS positional errors for each point. GCPs with high positional errors were closely scrutinized. If the point was found to be errant, the point was eliminated. This was especially troublesome for GCPs located on the east side of the Columbia River north of Richland. It appears that the DEM may not accurately reflect the topography in those areas. Inclusion of GCPs from that side of the river doubled and tripled the estimated RMS positional errors; therefore, no GCPs were included from those areas on images 159, 160, and 161. ENVI estimated RMSxy errors of GCPs used to rectify the aerial photographs to the DOQQs was around 10 meters for each aerial photograph. After GCPs were collected and the interior and exterior orientation variables determined, aerial photographs were orthorectified using a USGS 10 meter DEM as the topographic model.

Orthorectified images were digitally mosaicked if necessary, to encompass the various regions of interest. All areas, once composited, were contrast stretched and spatially filtered with an omni-directional convolution filter to optimize the appearance of the images. After the images were enhanced, they were output from ENVI as digital GEOTIFF format files using a UTM Zone 11 projection and a WGS84 spheroid. Rectified images of each area were then transferred to the RSL Radiation department for use as basemaps.

After the aerial photographs were geodetically rectified, horizontal positional errors of the orthophotos were estimated using ground control data supplied by the DOE Management and Operations (M&O) contractor for DOE Richland, Fluor Daniel Hanford, Inc. (Fluor). Fluor's GIS Department provided RSL with data it had acquired on the Reservation. Ground control was in the form of CAD files for roads at Hanford. Vector data initially was in Washington State Plane South coordinates based on a NAD83 datum. The vector data was transformed into a UTM Zone 11 projection using a WGS84 spheroid so that they would have the same geometric properties as the orthophotos. Personnel within the Fluor GIS department estimated the horizontal positional error of the road vectors to be +/- 1 meter.

The purpose of determining the horizontal positional errors of the orthophotos was to qualitatively evaluate the goodness-of-fit of the imagery to independently derived ground control and was not a rigorous mathematical evaluation of all sources of positional error. To that end, horizontal positional error was calculated by comparing the UTM Zone 11 coordinate of an image control point on the orthorectified aerial photographs to the UTM Zone 11 coordinate of the corresponding point on the roads vector file.

Ground control points were extracted from the road vector data at road intersections. UTM Zone 11 coordinates of the intersections were recorded. Corresponding road intersections were located on the orthophotos, and their coordinates were recorded using an on-screen cursor. If any identification ambiguities existed, the intersection was not used. At least 10 road intersections were identified for each orthophoto. Sample results are illustrated in Tables 2 through 5.

Table 2. Horizontal Positional Error Calculation for Orthophoto Number 47

Orthophoto # 47	UTM Zone 11 x meters	UTM Zone 11 y meters	X Road – Image meters	Y Road – Image meters	RMSxy meters
road	299410.67	5170295.5	-1	-2	2.2
image	299409.67	5170293.5			
road	300871.67	5171197.5	10	3	10.4
image	300881.67	5171200.5			
road	296102.67	5167755.5	0	1	1.0
image	296102.67	5167756.5			
road	296620.67	5167737.5	-2	1	2.2
image	296618.67	5167738.5			
road	297046.67	5167125.5	-3	0	3.0
image	297043.67	5167125.5			
road	298156.67	5167672.5	-2	0	2.0
image	298154.67	5167672.5			
road	300919.67	5169324.5	-1	3	3.2
image	300918.67	5169327.5			
road	301435.67	5168595.5	3	-1	3.2
image	301438.67	5168594.5			
road	301920.67	5165184.5	0	2	2.0
image	301920.67	5165186.5			
road	302170.67	5170430.5	-1	0	1.0
image	302169.67	5170430.5		**Average RMSxy**	**3.0**

Table 3. Horizontal Positional Error Calculation for Orthophoto Number 48

Orthophoto # 48	UTM Zone 11 x meters	UTM Zone 11 y meters	X Road – Image meters	Y Road – Image meters	RMSxy meters
road	296092.4	5167201.31	-2	0	2.0
image	296090.4	5167201.31			
road	297334.4	5166717.31	1	4	4.1
image	297335.4	5166721.31			
road	298133.4	5167105.31	0	6	6.0
image	298133.4	5167111.31			
road	302504.4	5162795.31	1	2	2.2
image	302505.4	5162797.31			
road	302447.4	5161449.31	2	3	3.6
image	302449.4	5161452.31			
road	300067.4	5159470.31	2	7	7.3
image	300069.4	5159477.31			
road	299113.4	5159514.31	-3	0	3.0
image	299110.4	5159514.31			
road	297783.4	5159432.31	2	1	2.2
image	297785.4	5159433.31			
road	297775.4	5159229.31	2	2	2.8
image	297777.4	5159231.31			
road	295851.4	5160686.31	0	-1	1.0
image	295851.4	5160685.31		**Average RMSxy**	**3.4**

Table 4. Horizontal Positional Error Calculation for Orthophoto Number 161

Orthophoto # 161	UTM Zone 11 x meters	UTM Zone 11 y meters	X Road – Image meters	Y Road – Image meters	RMSxy meters
road	320972.5	5135849.45	-1	-5	5.1
image	320971.5	5135844.45			
road	321931.5	5135679.45	0	-1	1.0
image	321931.5	5135678.45			
road	324546.5	5137287.45	-2	-2	2.8
image	324544.5	5137285.45			
road	324813.5	5137005.45	-4	1	4.1
image	324809.5	5137006.45			
road	325158.5	5136851.45	-4	0	4.0
image	325154.5	5136851.45			
road	325422.5	5135591.45	2	0	2.0
image	325424.5	5135591.45			

Table 4. Horizontal Positional Error Calculation for Orthophoto Number 161 (continued)

Orthophoto # 161	UTM Zone 11 x meters	UTM Zone 11 y meters	X Road – Image meters	Y Road – Image meters	RMSxy meters
road	325103.5	5135568.45	-2	5	5.4
image	325101.5	5135573.45			
road	321666.5	5132849.45	-7	5	8.6
image	321659.5	5132854.45			
road	321195.5	5132987.45	0	5	5.0
image	321195.5	5132992.45			
road	320878.5	5132771.45	-2	5	5.4
image	320876.5	5132776.45		**Average RMSxy**	**4.3**

Table 5. Horizontal Positional Error Calculation for Orthophoto Number 103

Orthophoto # 103	UTM Zone 11 x meters	UTM Zone 11 y meters	X Road – Image meters	Y Road – Image meters	RMSxy meters
road	314690.17	5165098.6	0	0	0.0
image	314690.17	5165098.6			
road	316227.17	5163003.6	0	3	3.0
image	316227.17	5163006.6			
road	316204.17	5162188.6	0	2	2.0
image	316204.17	5162190.6			
road	316108.17	5160961.6	-3	0	3.0
image	316105.17	5160961.6			
road	318195.17	5161310.6	-1	-1	1.4
image	318194.17	5161309.6			
road	317960.17	5161039.6	-2	2	2.8
image	317958.17	5161041.6			
road	318771.17	5159844.6	2	1	2.2
image	318773.17	5159845.6			
road	319057.17	5159323.6	2	0	2.0
image	319059.17	5159323.6			
road	320189.17	5159673.6	1	2	2.2
image	320190.17	5159675.6			
road	318826.17	5160759.6	1	-1	1.4
image	318827.17	5160758.6		**Average RMSxy**	**2.0**

RSL scientists noted that when road vectors were digitally overlaid onto the orthophotos at full screen resolution, only minor positional errors between the data sets were apparent. However, spatial discrepancies between the data sets existed at some locations. For example, the vector traces of the curved road immediately northeast of complex

100-KE/KW on orthophoto number 47 do not correlate to the location of the road on the orthophoto. Positional errors of up to 32 meters were observed on this road. It is interesting to note that adjacent roads in this vicinity show very little spatial discordance between the data sets. Other examples of spatial disagreements between the vector and orthophoto infrastructure locations can be seen in other areas on the reservation. In areas that exhibit spatial divergence between these data sets, ground survey spot checks should be performed to determine the correct spatial locations of the infrastructure.

Tables 2 through 5 statistically verify the ocular comparison results between vector and orthophoto data. Average horizontal positional accuracy values for easily identifiable points on orthophotos 47, 48, 161, and 103 were 3.0, 3.4, 4.3, and 2.0 meters respectively. These images would exceed National Map Accuracy standards for map products produced at 1:3,500, 1:4,000, 1:5,080, and 1:2,360 scales respectively. This indicates that the horizontal positional accuracies of the USGS digital orthoimage quadrangles used for rectification of the aerial photographs were much more accurate than the National Map Accuracy standards required them to be.

SUMMARY

Seventeen natural color aerial photographs encompassing nine selected areas on the Hanford Reservation at 1:32,000 scale were digitized at a spatial resolution of approximately one meter. These aerial photographs were orthorectified using camera calibration parameters, USGS DOQQs, and USGS DEMs. Positional accuracies of the orthophotos were evaluated using ground control supplied by the M&O Hanford contractor, Fluor, for DOE Richland. All orthorectified aerial photographs exceed National Map Accuracy standards for maps at scales smaller than 1:5,080. The orthophotos were used as a basemap for radiation data collected by RSL in 1996.

APPENDIX

1996 Photographic Mission Flight Logs

EG&G ENERGY MEASUREMENTS
Las Vegas, Nevada

PHOTO MISSION FLIGHT LOG

Site/Location
1. Hanford Grid Map Sitewide 16,000 ft(agl) lines/
2. Richland, WA
3. Umatilla Bridge + Dam / Umatilla, Oregon
4.

Date Flown 13 - 14 - June 1996
Maps Used Hanford Site Grid Map

Coordinates N 46°32'30" Lat. W 119°34'30" Long.

Photographers 1. Marc Rivera 2.
Pilots John Brown Gary Butler
Aircraft Citation II N10EG Agency DOE
Job No. D71HAGM1
Nonphoto Sensors ASCOT

Site Elev. 1. 400 2. 2000 3. 4.
Solar Window 0815 to 10:45 and 15:15 to 17:45

	Roll 1	Roll 2
Film Type	Aerocolor	
Film Emulsion Number	2445-4171-004	
Dash Number	04 01/06	
Film Format	9" x 9"	
Camera Type	RC30	
Camera Serial Number	5219	
Lens Focal Length	153 mm	mm
Lens Serial Number	13233	
Lens Focus Setting	Fixed	
Filters λ50@	420nm AV 2x	
Lens Aperture	Varies	
Shutter Speed	Varies	
Film Magazine Numbers Supply	4176	
Film Magazine Numbers Take-Up	4175	
*Perf. Number	8678	

Processing Review By:	Roll 1	Roll 2
Date Processed:		
Processor Certification-Chart #/Plot #:	/	/
Overall Density-Normal/Over/Under:		
Sensi-Wedge on Head/Tail: Y or N	/	/
Batch & Mission Wedges Consistent?		

Comments/Anomalies:

Coverage Review Date/By:
The following comments comprise the post flight review of the frames listed on this log:

*To be filled in by Photo Lab at time of processing.
RSL-0132P (Feb 94)

FLIGHT PATH RECORD

Date(s) 6-13+14-1996

Magnetic Declination 18°E

Photo Conditions Cloudy - 13th / Clear - 14th

Site(s) Hanford 16 K (Agl) Gridlines
Umatilla bridge + dam

MSL Alt. (ft) 18,000
5,500
18,000

Site/ Flight Path	AGL (K)	Frame Counter Start	Frame Counter Stop	Overlap %	Ground Speed (knots)	Mag. Heading	Time of Day	6-13-96 Comments	Post Processing Comments	Center Site
Line 12	16	1	8	–	241	180	0845	Pts 9+10 not shot	32000	
12	16	9	11	–	250	0	0849	cloud shadows no good	Too cldy 32000 ,7 flt.	
Umatilla bridge	5	12	15	–	180	72	1547	OK (water reflections)	10,000	
Umatilla bridge + dam	5	16	20	–	179	272	1551	Good (water reflections)	10,000	
Hanford Grid Line 1	16	21	32	–	260	180	0838	6-14-96 Good ck first frames	32,000	redo Fr 1 N-end
Line 3	16	33	43	-	275	0	0849	Good		
Line 5	16	44	54	–	283	180	0859	Good		
Line 2	16	55	64	-	294	0	0910	Fr 55 no overlap Skiped Fr 10 TOO FAST		Acquire Fr. 10
" 4	16	65	74	–	283	180	0920	OK Missing 1st Fr HDG South		Acquire Fr 1
" 6	16	75	85	–	288	0	0930	Good		
" 8	16	86	96	–	275	180	0942	Good		
" 10	16	97	107	–	274	0	0951	Good end flt. 1.9 hrs.	3.4 used	✓
" 7	16	108	118	–	277	180	1657	Good		
" 9	16	119	129	–	271	0	1707	refly 1st fr. fr 119 off line or not level		
" 11	16	130	140	–	244	180	1719	Good		
" 13	16	141	151	–	270	360	1729			
" 12	16	152	164	–	250	180	1739	1st Fr Bad use fr. 1 above ck fr.	10? manual fire	
" 9	16	165	167	–	270	360	1744			

Film Type Aerocolor Perf. No. 8678 Focal Length 153mm Date Titled /By

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