Statement of Opinions
Wayne M. Grip
President
Aero-Data Corporation

Illinois River Watershed

Case No.: 4:05-cv-00329-GKF-SAJ
United States District Court
Northern District of Oklahoma

In the Matter of

State of Oklahoma, ex rel. W.A. Drew Edmondson, in his capacity as Attorney General of the State of Oklahoma and Oklahoma Secretary of the Environment C. Miles Tolbert, in his capacity as the Trustee for Natural Resources for the State of Oklahoma

v.

Tyson Foods, Inc., Tyson Poultry, Inc., Tyson Chicken, Inc. Cobb-Vantress, Inc., Aviagen, Inc., Cal-Maine Foods Inc., Cal-Maine Farms Inc., Cargill Inc., Cargill Turkey Production, LLC, George's Inc., George's Farms, Inc., Peterson Farms Inc., Simmons Foods, Inc., and Willow Brook Foods, Inc.

January 2009

Wayne M. Grip

Assignment

Since the submission of my October 2008 report on the Illinois River Basin, I have been asked to quantify the volume of sediments eroded from the river banks from the 1970's to the present. In my 2008 report, I used historical maps and aerial photography to map the channel of the Illinois River over time so as to identify those areas where the position of the channel had shifted (meandered). The 2008 report contained exhibits of the aerial photography, maps I obtained and channel locations I mapped.

Methods

In order to accomplish this additional task, I have used the channel mapping from my previous report to identify the stream reaches where active meanders were present at some time during the period of the study. A photomission of those reaches was then flown in December 12, 2008 from an elevation of 3,000 feet above terrain using my company airplane, 9" aerial mapping film camera and flight crew. Multiple east/west flight lines were flown with three or more overlapping exposures per flight line. I chose not to fly the eastern half of the river, because I had found little evidence of active meanders and channel movement in my 2008 study.

The exposed film was then processed, scanned and the resulting digital images were georegistered in the same coordinate system as the historical aerial photography and maps in my previous study. The current position of the river channel was then mapped in those reaches which had just been photographed.

The current mapped position of the river channel merged with the post 1972 mapped channel locations was then compared to the 1972 river channel using a Geographic Information System (GIS). The surface area of channels falling outside the 1972 channel locations was determined. This surface area represents all the areas cut by channel movement since 1972.

In many cases within active meander areas, there were slight gaps between successive mapped historical channel locations indicating that the channel had probably moved smoothly through that area, but the multiple dates of historical photography obtained for the study did not happen to fall within the period of time when the river channel was in that position. In this case, the entire area was assumed to have been part of the river channel at one time from 1972 forward.

In other cases, the gaps between historical channel locations were larger and located in reaches of the river where avulsions (jumps in the channel) were more likely. An example of this is the recent avulsion in the Echota Bend area. This cut was first visible forming in recent floodplain deposits in the photography of 2003 and by 2008 was carrying the main flow of the river. By 2008, the new channel formed by the avulsion had already meandered on its outside bend approximately 150 feet to the north of the original channel cut. In dealing with avulsions in this study, only the mapped surface areas of the historical channel locations were used in my area calculations. Gaps between the historical channels were not included in my surface measurements.

The surface area of changed channel was measured only on the western half of the Illinois River starting just above Lake Tenkiller and extending to the location of the Lake Frances dam that failed. The changed western channel area based on measurements using the GIS is 886 acres.

The channel upstream and east of the Lake Frances dam was much more stable and narrower than the western half of the river. In some reaches because of overhanging vegetation cover, the banks were difficult to map in the aerial photography. As a result, channel movement was difficult to measure accurately. However, the large area of post dam closure muds that formed behind the failed dam which are now visible on dry land provide evidence that significant volumes of sediments were being transported even within a relatively stable portion of the river.

The second step in computing sediment volume was to determine the average thickness of sediments cut in various reaches by the movement of the channel across the recent floodplain and often into older stream terrace deposits. Using a digital stereoplotter, multiple elevation measurements were made of the river bed, river surface, recent floodplain above the river surface and stream terraces tangent to meanders with active cut banks. Based on the other dates of photography obtained in this study, the river at the time of the recent photomission in December 2008 appeared to be at a lower than normal stage.

The elevation measurements were accomplished with a digital stereoplotter by running multiple transects spaced approximately 250 meters apart across the stream channel. A total of 165 transects were utilized. Each elevation transect contained an average of 30 spot elevations. In most areas, the river water was so clear that it was possible to map the surface elevations of the river bed. I had not expected to be able to do this when I planned the photomission, because my experience had been that river water is usually too turbid. The locations of the elevation transects are depicted in Attachment B on Figures 1 through 7.

The surface elevations obtained fall into four categories: river bed, river surface, recent floodplain and older stream terraces. The recent floodplain deposits had been reworked and relocated by the river much more recently than the terrace deposits whose sediments have probably been in place for hundreds or more years. In addition, the thalweg, active cut banks and terrace slopes were also mapped.

In a later step in the study, I again used the digital stereoplotter to view the photography and spot elevations simultaneously so as to deselect the spot elevations in locations which were not representative (too high in elevation) of the terrain through which the river channel had moved.

For the purpose of this study on any given stereoplotter transect, it is my opinion that the average elevation of the land surface outside the river channel minus the elevation of the deepest point of the river bed provides the best approximation of the thickness of the sediments cut by the river as it meandered through the area.

The average thickness of the channel cut was determined for each of eight individual channel reaches. Each reach contained from three to twenty five elevation transects. The December 12, 2008 photomission did not contain continuous photography of all of the reaches as some of the reaches contained stable areas of the river as well as active meander areas. Thus not all portions of the reach may have been photographed. The average thickness of channel cut on the reaches varied from a low of 8.94 feet to a high of 12.48. The average thickness of all channel cuts is 10.8 feet.

The elevation measurements attached in table 1 show that at the time of the Aero-Data photomission, the recent floodplain deposits and terrace deposits averaged 8.3 feet higher in elevation than the river water as measured at the land/water contact. Terrace deposits were higher than the recent floodplain and much more variable in elevation. The deepest point of the river bed was typically 2.5 feet below the land/water contact. The thickness of sediments cut and moved within the recent floodplain by a typical shift of the river bed is approximately 10.8 feet. The average thickness of channel cuts is listed individually by reach in table 2.

This cut thickness,10.8 feet, times the surface area of new channel (river channel outside the 1972 channel position), 38,594,160 square feet (or 886 acres), equals 416,816,928 cubic feet (or approximately 15,500,000 cubic yards) which is the volume of sediments moved. This assumes that the floodplain and river bed have maintained the same basic profile over the past thirty five years. I used the deepest point of the river bed, because it is my understanding that during high flow events (floods) the channel is scoured out and thus temporarily deepened by the rapidly moving water. As the rate of flow decreases, the elevation of the river bed likely increases back to pre-flood levels.

The movement of the river channel was normally confined within the extents of the recent floodplain. However, there were many areas where, during the period of the study, the river was cutting into much older, elevated terrace deposits such as in the Echota Bend area. At Echota Bend at the time of the recent photomission, the water depth was approximately 3 feet and the terrace surface was 15 feet higher than the water surface. The thickness of the cut caused by the meander was thus 18 feet. In this area, between 1958 and 1997 the channel shifted up to 460 feet to the west and eroded away 202,000 square feet (4.6 acres) of farm land.

Assuming a cut thickness of 18 feet at the Echota Bend area, the volume of terrace deposits eroded by the river in that area from 1958 to 1995 is 3,636,000 cubic feet (approximately 135,000 cubic yards). After 1997, a bank stabilization project was completed which halted (for the time being) further movement of the channel to the west.

From 1972 to 1995 (within the time frame of this study), a surface area of 108,000 square feet totaling 1,944,000 cubic feet (approximately 72,000 cubic yards) of older sediments from former (hay and/or pasture land) were eroded in that area and moved down stream by the river after which the stabilization project halted further migration (Attachment B Figure 8). The channel also gradually shifted 200 feet to the west by 1995. By 2005, as a result of an avulsion of the main channel which developed approximately 1,000 feet to the southeast of the stabilization project structures, the entire portion of the bend has been virtually cut off and no longer carries the main flow of the river. The avulsion shortened the channel by approximately 2,000 feet. The 72,000 cubic yards cut by the river after 1972 in the Echota Bend area are included in the 15,500,000 cubic yards cut in the western half of the river.

In other areas elevated, eroding banks generally on the outside bends of meanders were visible where the river was butting up against and cutting into older terrace deposits rather than lower elevation recent floodplain deposits. Often, the steep banks were un-vegetated and on occasion evidence of clumps of recently caved bank sediments were visible in the waters of the channel. These clumps were visible because the water in the river was unusually clear. The total length of these unstable banks mapped by me from the current high resolution aerial photography is 36,715 feet or 6.95 miles.

The section of the river upon which I have measured channel erosion is approximately 59 miles long and extends from above the Lacustrine and transition zones of Lake Tenkiller upstream to the failed Lake Frances dam. My mapping shows that since 1972, 15,500,000 cubic yards of sediment have been relocated within this section of the river. This is equivalent to approximately 263,000 cubic yards of sediment per river mile. I would expect that only a fraction of this sediment has reached Lake Tenkiller at this time as most of it is deposited down stream a short distance from its previous position within the floodplain. The sediments eroded from the river banks would have a negative impact on water clarity.

The erosion I have detected through aerial mapping of the main channel does not include the sediments resulting from soil erosion of agricultural lands and commercial/ residential development transported by river tributaries into the main channel. It also does not include the sediments eroded from the banks of the tributaries.

Dr. Fisher in his report of May 15, 2008 provided information on the thickness as well as chemical analyses of sediments deposited in Lake Tenkiller following construction of the dam. He indicated that that the "post dam sediments tend to be thickest within the lacustrine and transition zones of the lake where the sediments are typically approximately 1.6 feet thick." His report had little to say about the impacts of river channel erosion on water quality or its contribution to the accumulation of post dam sediments in Lake Tenkiller. I found nothing in Dr. Fisher's report that conflicted with my findings.

I have also reviewed the reports written by Russell Dutnell concerning streambank erosion in northeast Oklahoma and in the Illinois River. I have also reviewed Mr. Dutnell's deposition transcript. I found nothing in these materials that conflicted with my findings.

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Attachment A
Information Relied Upon

DOCUMENT/ PHOTO DATE	DOCUMENT/ PHOTO SOURCE	PHOTO RATIO	FILM TYPE	ROLL NUMBER	FRAMES FOR PROJECT	DESCRIPTION	RESEARCH STATUS
6/27/1958	USDA	20000	BW	7V	49-50	Stereo Aerial Photography	2
11/12/1964	USDA	20000	BW	2FF	212-213	Stereo Aerial Photography	2
1/1/1970	MAPEXPRESS	24000	MAP			7.5 Minute Quad Map DRG Gallatin, Robinson, Wheeler, Prairie Grove, Strickler	2
1/1/1972	MAPEXPRESS	24000	MAP			7.5 Minute Quad Map DRG Moodys, Talequah, Proctor, Kansas, Siloam Springs NW, Siloam Springs, Watts, Cheney	2
4/4/1972	USDA	40000	BW	272	124-125	Stereo Aerial Photography	2
1/1/1973	MAPEXPRESS	24000	MAP			7.5 Minute Quad Map DRG Park Hill	2
11/28/1979	USDA	40000	BW	179	101-102	Stereo Aerial Photography	2
7/22/1984	USDA	58000	CIR	3084	88-89	Stereo Aerial Photography	2
4/24/1991	USDA	40000	BW	5190	18-19	Stereo Aerial Photography	2
3/3/1994	USGS	40000	BW		used in study	DOQQS: Watts; Gallatin; Prairie Grove; Robinson; Siloam Springs; Strickler; Wheeler;	2
3/15/1994	USGS	40000	BW		used in study	DOQQS: Fayetteville (NE, SE); Bentonville South (NE, SE); Springdale (NE, SE)	2
2/18/1995	USGS	40000	BW		used in study	DOQQS: Fayetteville (NW, SW); Springdale (NW, SW)	2
2/25/1995	USGS	40000	BW		used in study	DOQQS: Moodys; Proctor (NE, SE); Kansas (NW, SW); Chewey	2
3/21/1995	USGS	40,000	BWN	8436	48-49	Stereo Aerial Photography	2
3/21/1995	USGS	40000	BW		used	DOQQS: Park Hill (NE, SE); Tahlequah (NE, SE);	2
3/23/1995	USGS	40000	BW		used	DOQQS: Park Hill NW, SW; Proctor NW, SW; Siloam Springs NW; Tahlequah (NW, SW); Kansas (NE, SE);	2
3/26/1996	USGS	40000	BW		used	DOQQS: Bentonville South (NW, SW)	2
9/19/1997	Report					Dutnell, Russell C. P.E., "Echota Bend Bank Stabilization Project : Implementation Report"	2
1/1/1999	Paper					Harmel, R, Haan, C.T., and Dutnell, R., "Bank Erosion and Riparian Vegetation Influences: Upper Illinois River, Oklahoma" <u>Transactions of the ASAE.</u> Vol42(5): 1321-1329	2
2/1/1999	Paper					Harmel, R, Haan, C.T., and Dutnell, R., "Evaluation of Rosgen's Streambank Erosion Potential Assessment in Northeast Oklahoma" <u>Journal of the American Water Resources Association</u>, Vol 35, No. 1, 2/99.	2
2/5/2001	USGS	40000	CIR		used	DOQQS: Rogers (NE, SE)	2
2/19/2001	USGS	40000	CIR		used	DOQQS: Bentonville South (NE, NW, SE, SW); Fayetteville (NE, NW, SE, SW); Springdale (NE, NW, SE, SW); Rogers (NW, SW)	2
1/1/2003	USDANAIP	40000	COL		.sid	NAIP Ortho Imagery	2
1/1/2004	USDANAIP	40000	COL		.sid	NAIP Ortho Imagery	2
1/1/2005	USDANAIP	40000	COL		.sid	NAIP Ortho Imagery	2
1/1/2006	USDANAIP	40000	COL		.sid	NAIP Ortho Imagery	2

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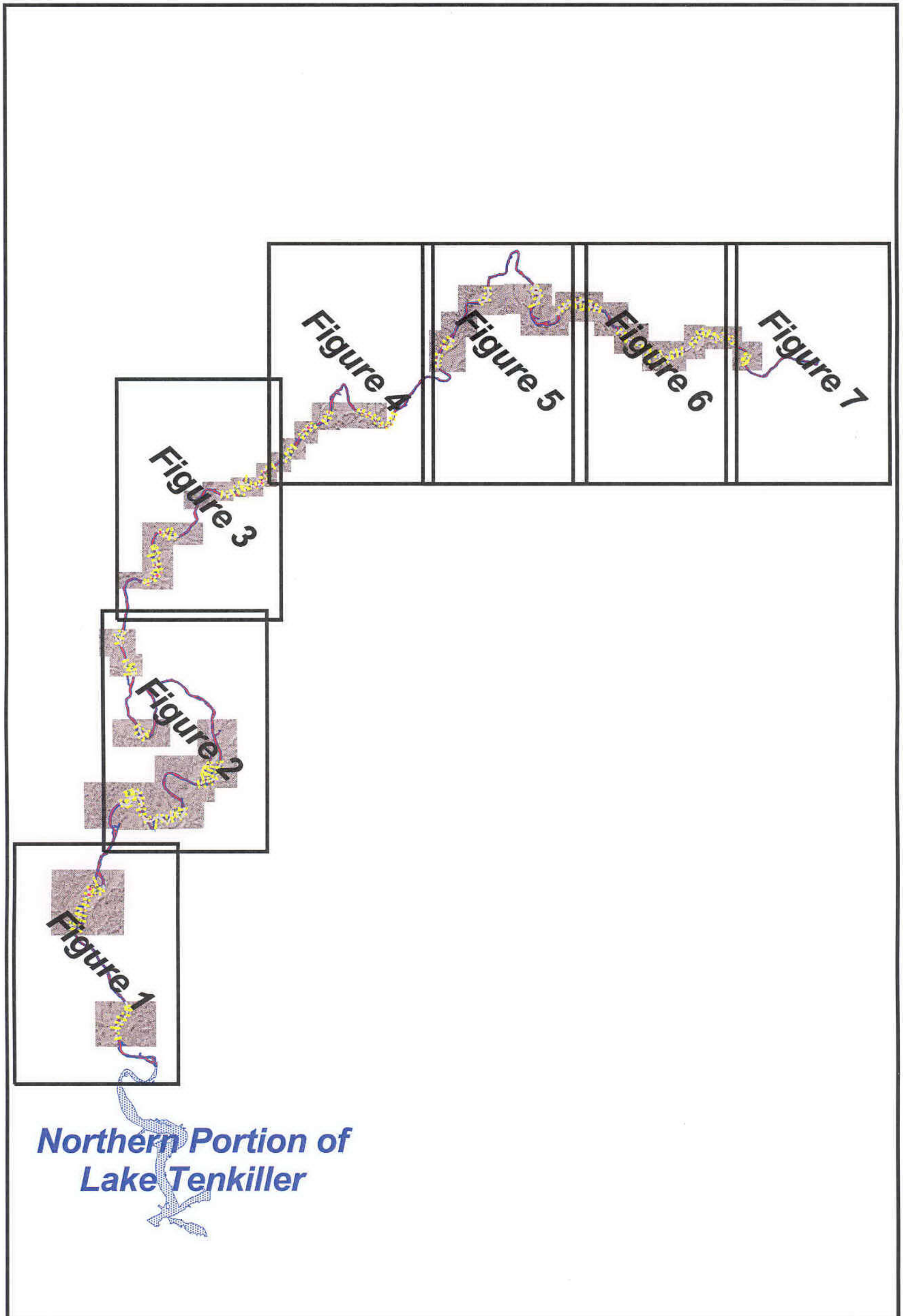
Attachment A
Information Relied Upon

DOCUMENT/ PHOTO DATE	DOCUMENT/ PHOTO SOURCE	PHOTO RATIO	FILM TYPE	ROLL NUMBER	FRAMES FOR PROJECT	DESCRIPTION	RESEARCH STATUS
11/15/2007	Deposition					Deposition of Russell Dutnell on behalf of the Defendants 11/15/2007	2
1/1/2008	USDANAIP	40000	COL		.sid	NAIP Ortho Imagery	2
5/15/2008	Report					Fisher, J. Berton, Expert Report in the matter of State of Oklahoma et al. v. Tyson Foods et al. 5/15/2008	2
12/12/2008	Aero-Data	6000	BW			Stereo Aerial Photography	2

Attachment B



Illinois River Meander Study Figure Index

0 — 4 Miles

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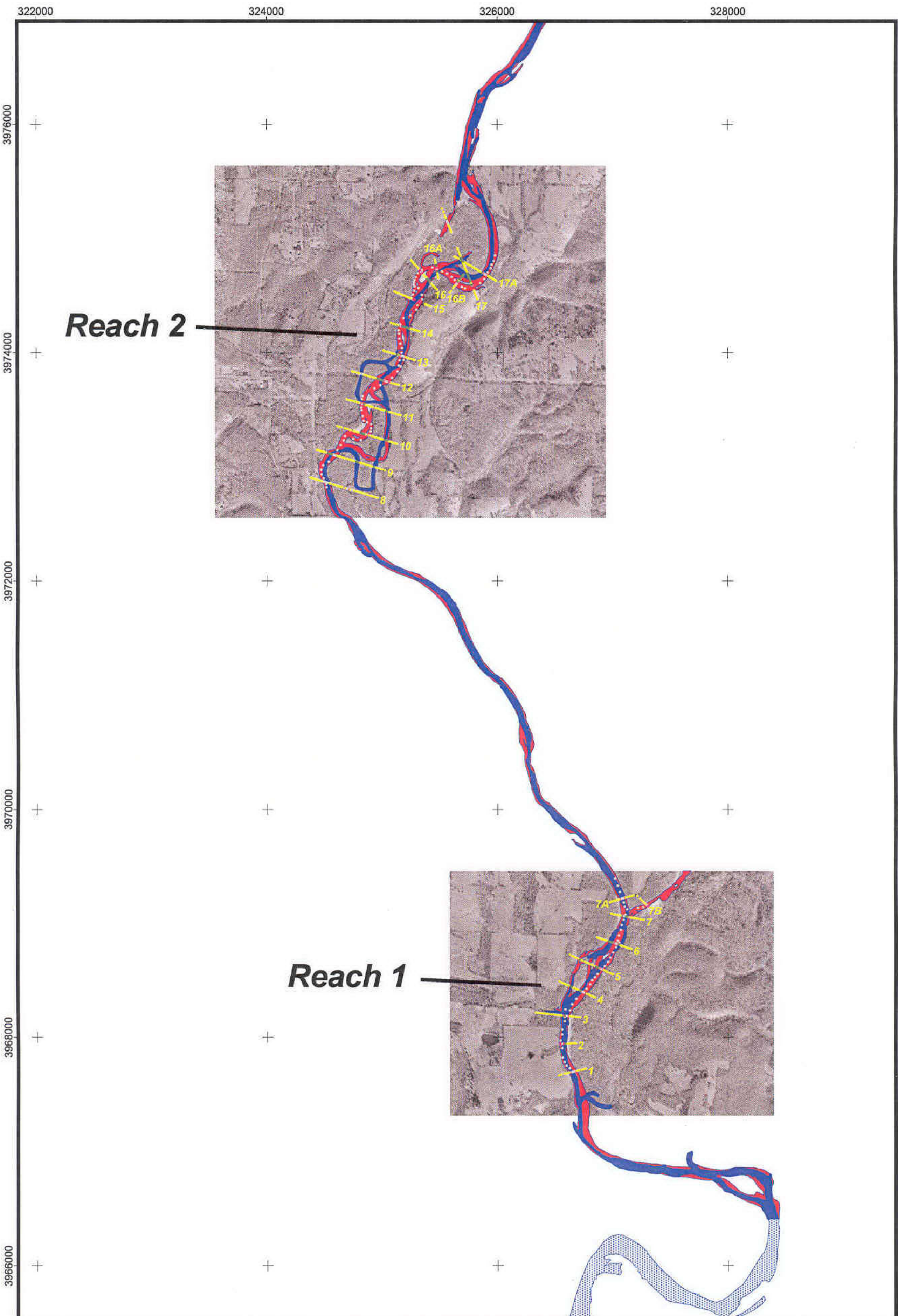
Film Source : 12/12/2008 Aero-Data Corporation



Illinois River Meander Study Figure 1

0 — 0.5 Miles

Film Source : 12/12/2008 Aero-Data Corporation

- Flood Plain Elevations
- Historic River Corridor Elevations
- Shoreline
- Channel Bottom Elevations
- River Channel Located Outside of 1972
- 1972 River Channel

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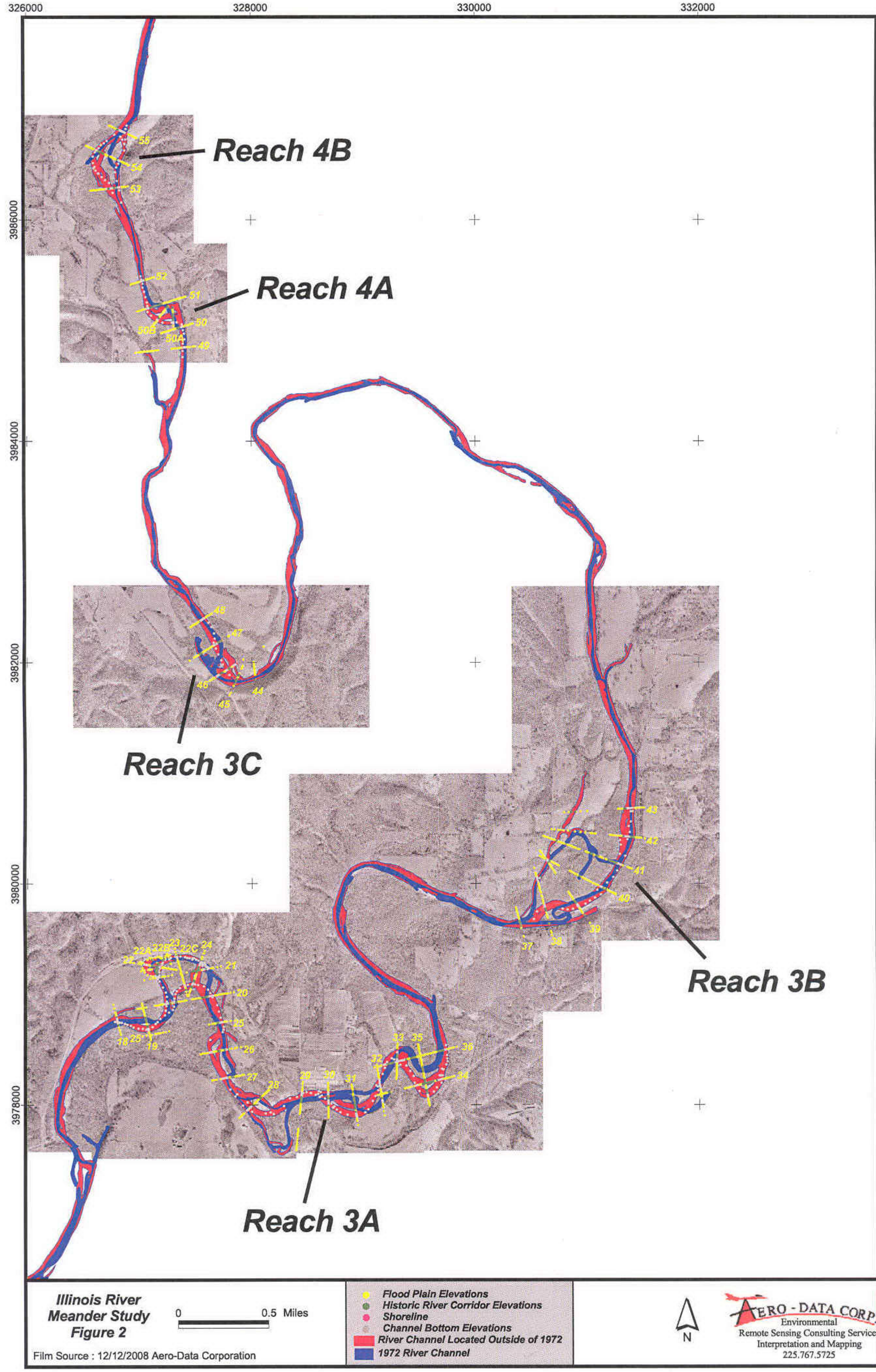
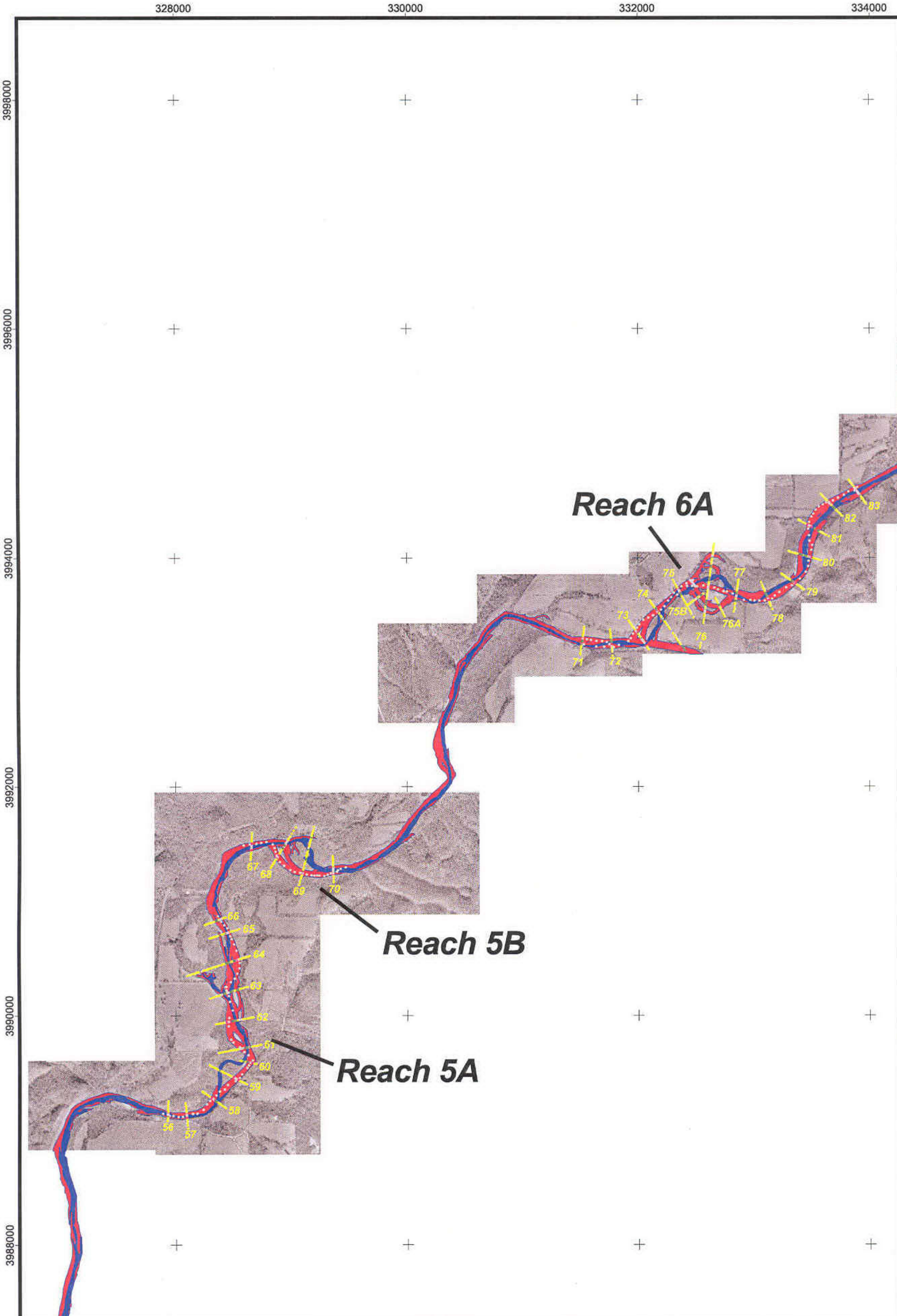


Illinois River Meander Study Figure 2

Film Source : 12/12/2008 Aero-Data Corporation



Illinois River Meander Study Figure 3

0 — 0.5 Miles

Film Source : 12/12/2008 Aero-Data Corporation

- Flood Plain Elevations
- Historic River Corridor Elevations
- Shoreline
- Channel Bottom Elevations
- River Channel Located Outside of 1972
- 1972 River Channel

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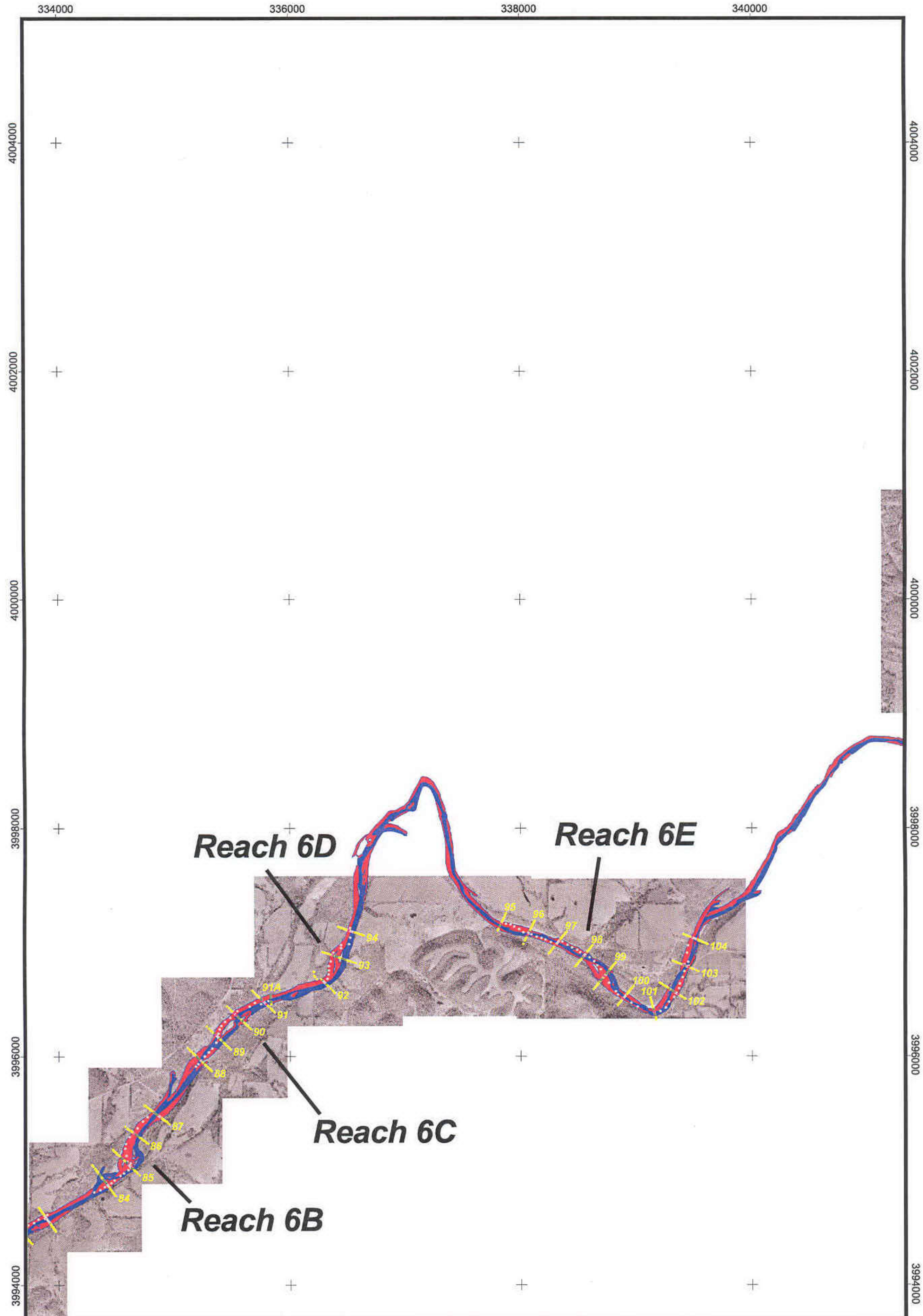

Illinois River Meander Study Figure 4

0 0.5 Miles

- Flood Plain Elevations
- Historic River Corridor Elevations
- Shoreline
- Channel Bottom Elevations
- River Channel Located Outside of 1972
- 1972 River Channel

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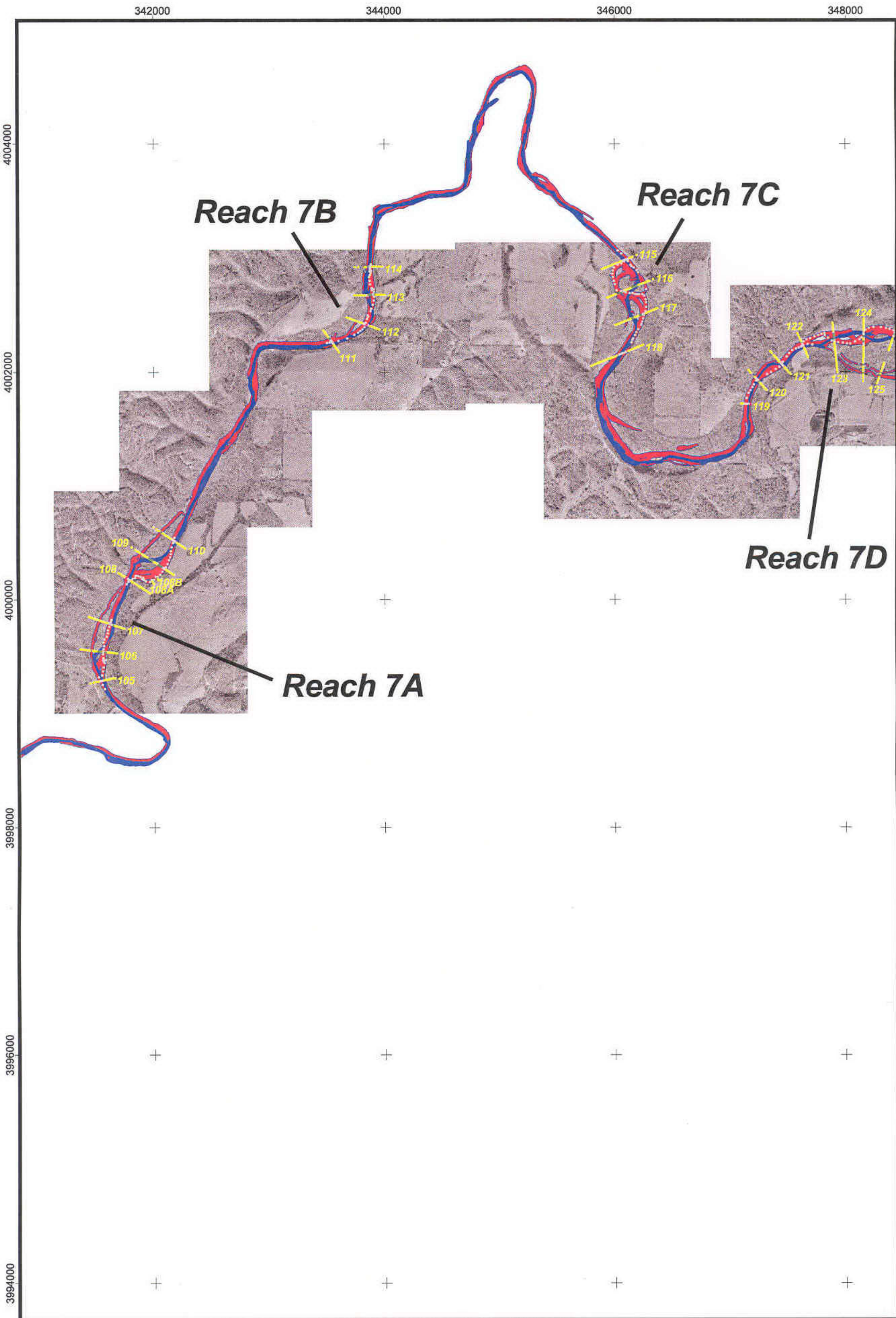
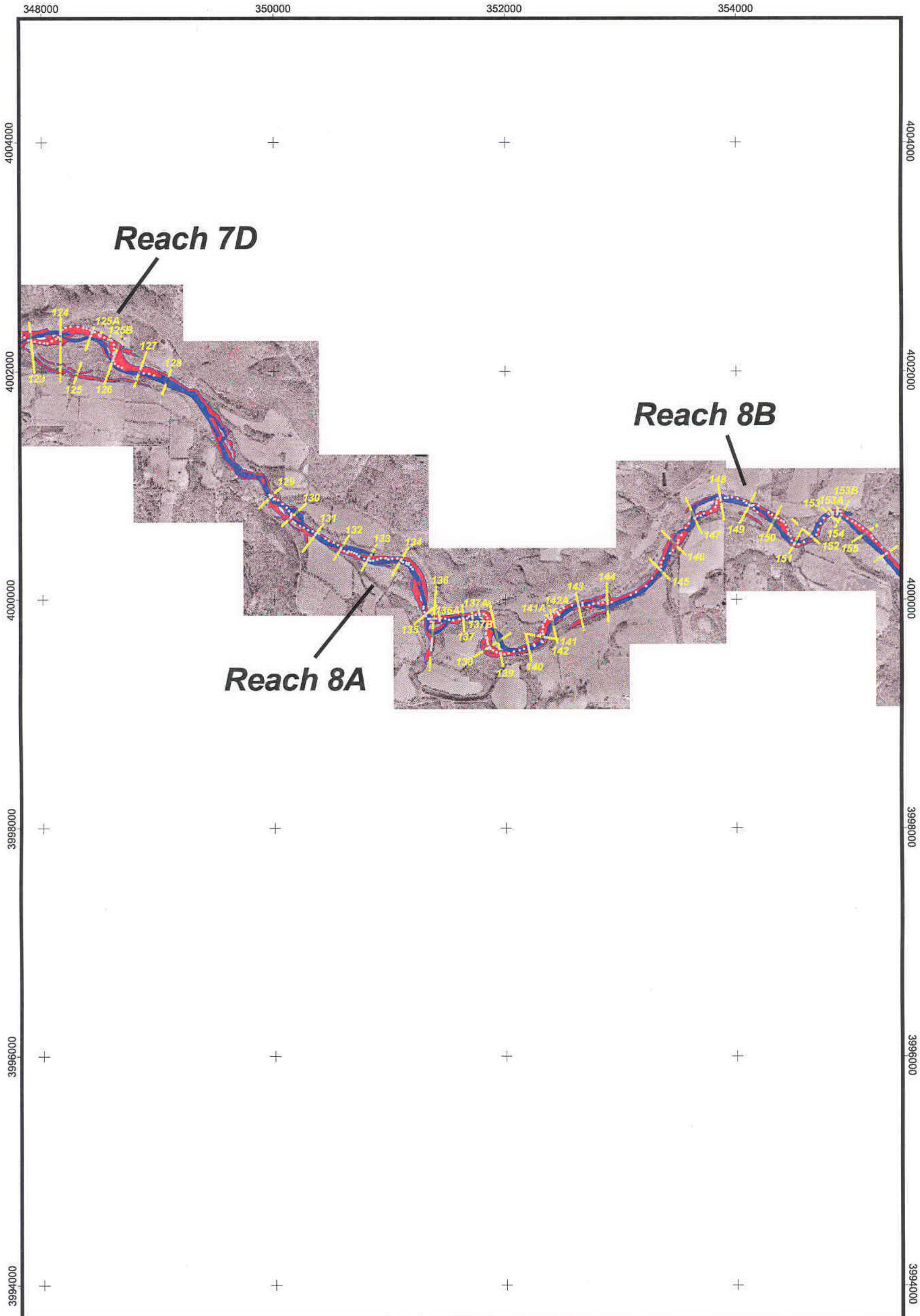
Film Source : 12/12/2008 Aero-Data Corporation



Illinois River Meander Study Figure 5

Film Source : 12/12/2008 Aero-Data Corporation



Illinois River Meander Study Figure 6

0 0.5 Miles

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- Flood Plain Elevations
- Historic River Corridor Elevations
- Shoreline
- Channel Bottom Elevations
- River Channel Located Outside of 1972
- 1972 River Channel

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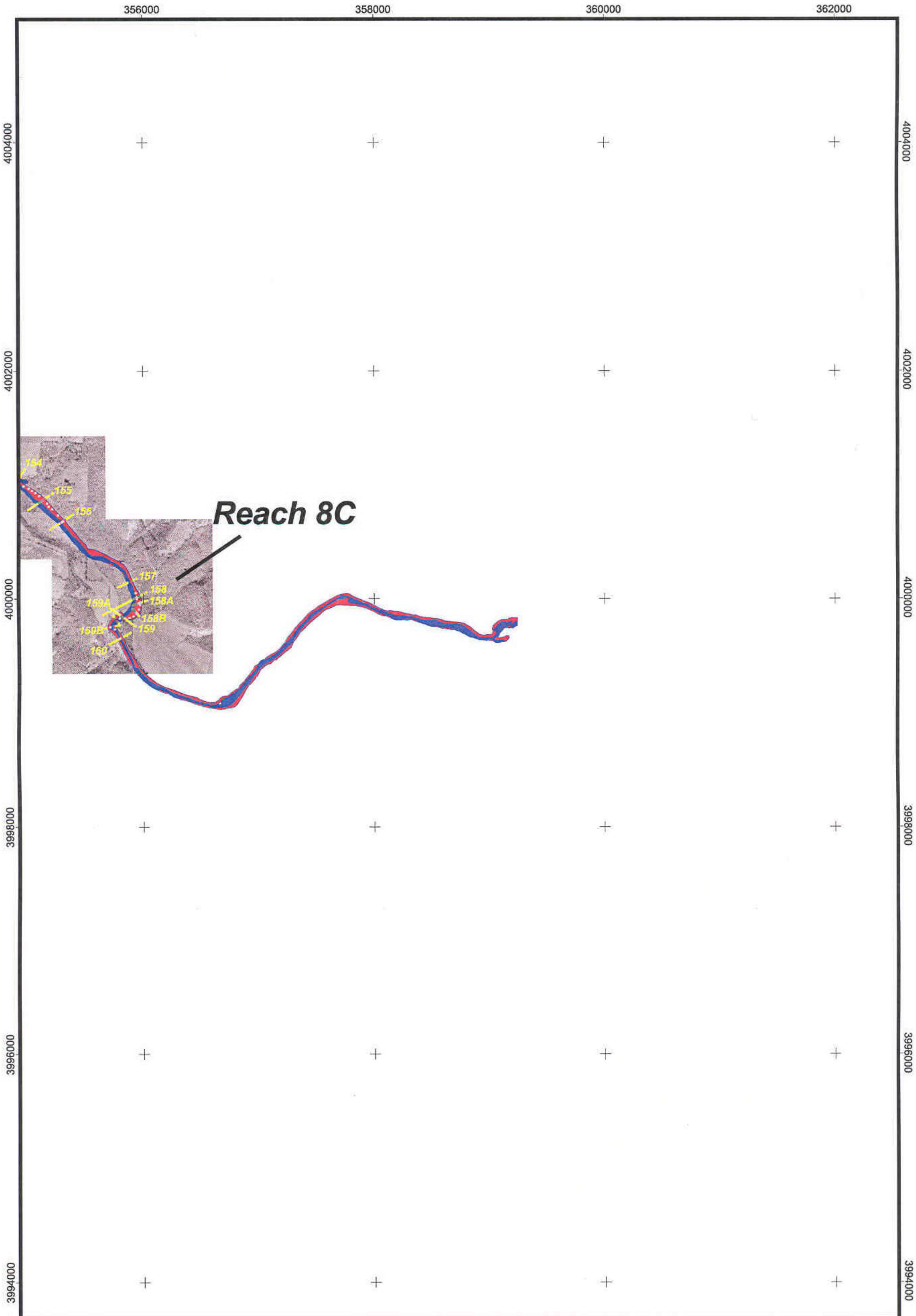
Film Source : 12/12/2008 Aero-Data Corporation



Illinois River Meander Study Figure 7

0 0.5 Miles

Film Source : 12/12/2008 Aero-Data Corporation

- Flood Plain Elevations
- Historic River Corridor Elevations
- Shoreline
- Channel Bottom Elevations
- River Channel Located Outside of 1972
- 1972 River Channel

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