

Metadata Report

Project Name

Integrated UAS and Lidar Reveals the Importance of Land Cover and Flood Magnitude on the Formation of Incipient Chute Holes and Chute Cutoff Development

Summary

Meandering river sinuosity increases until the channel erodes into itself (neck cutoff) or forms a new channel over the floodplain (chute cutoff) and sinuosity is reduced. Unlike neck cutoff, which can be measured or modeled without considering overbank processes, chute cutoff must be at least partially controlled by channel-forming processes on the floodplain. Even though chute cutoff controls meandering river form, the processes that cause chute cutoff are not well understood. This study analyzes the morphology of two incipient chute cutoffs along the East Fork White River, Indiana, USA, using high temporal and spatial resolution UAS-based lidar and aerial photography. Lidar and aerial imagery obtained between 1998 and 2019 reveals that large scour holes formed in the center of both chutes sometime after chute channel initiation. A larger analysis within the study watershed reveals that scour holes within incipient chutes can be stable or unstable and tend to stabilize when the chute is colonized by native vegetation and forest. When the scour holes form in farmed floodplain, they enlarge rapidly after initial formation and contribute to complete chute cutoff. In addition, this study shows that the formation of scour holes can occur in response to common, relatively low-magnitude floods and that the amount of incipient chute erosion does not depend on peak flood magnitude. The role of scour holes in enlarging of chute channels could be an important mechanism for chute channel evolution in meandering rivers. This study also confirms that understanding the relationships among flow, land cover, and cutoff morphology is substantially improved with on-demand remote sensing techniques like integrated UAS and lidar.

Personnel

- Quinn W Lewis, Douglas A Edmonds, Brian J Yanites

Site Information – check the published paper (cited below) for more information

- Two incipient river cutoff sites on the East Fork White River in Indiana, USA. The upstream bend is called “Martin Bend” and the downstream bend is called “Bedwell Bend”
- Studying form and evolution of chute cutoffs
- 38°46'29.41"N; 86°12'51.60"W
- 4 different scans were undertaken at the sites – UAS1 = June 5, 2018, and June 7, 2018 for Bedwell and Martin chute, respectively: UAS2 = July 4, 2018: UAS 3 = July 19, 2018: UAS4 = April 10, 2019

Survey Results

- Reigl minivux-1UAV affixed to DJI M600 UAS.
- OPUS GPS solutions are attached below

Products

- UTM 16N
- 0.25 m DEM, ~50 pts per square m
- 2-3 cm
- 2-3 cm
- LAS, tiff
- Inertial Explorer to produce an SBET file → Phoenix Spatial Fuser to produce LAS, TerraSuite to produce TIFF

Lewis, Q.W., Edmonds, D.A., and Yanites, B.J. in press. Integrated UAS and Lidar Reveals the Importance of Land Cover and Flood Magnitude on the Formation of Incipient Chute Holes and Chute Cutoff Development. Earth Surface Processes and Landforms.



UAS1- Bedwell GPS solution:

FILE: 962582156A0.180 OP1532108912298

1008 NOTE: You provided a zero or negative antenna height.
1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
1008

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: qwlewis@iu.edu DATE: July 20, 2018
RINEX FILE: 9625156p.18o TIME: 17:49:53 UTC

SOFTWARE: page5 1603.24 master93.pl 160321 START: 2018/06/05 15:16:00
EPHEMERIS: igs20042.eph [precise] STOP: 2018/06/05 17:44:00
NAV FILE: brdc1560.18n OBS USED: 7013 / 7357 : 95%
ANT NAME: CHCX900R NONE # FIXED AMB: 52 / 52 : 100%
ARP HEIGHT: 0.000 OVERALL RMS: 0.012(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2018.4265)

X: 328514.076(m) 0.005(m) 328513.204(m) 0.005(m)
Y: -4968226.249(m) 0.002(m) -4968224.838(m) 0.002(m)
Z: 3972988.555(m) 0.003(m) 3972988.458(m) 0.003(m)

LAT: 38 46 31.51430 0.001(m) 38 46 31.54163 0.001(m)
E LON: 273 46 59.02442 0.004(m) 273 46 58.99224 0.004(m)
W LON: 86 13 0.97558 0.004(m) 86 13 1.00776 0.004(m)
EL HGT: 123.739(m) 0.004(m) 122.536(m) 0.004(m)
ORTHO HGT: 157.128(m) 0.023(m) [NAVD88 (Computed using GEOID12B)]

UTM COORDINATES STATE PLANE COORDINATES
UTM (Zone 16) SPC (1301 IN E)



Northing (Y) [meters] 4292146.365 391709.623
 Easting (X) [meters] 568021.030 52183.116
 Convergence [degrees] 0.49042778 -0.34462500
 Point Scale 0.99965697 0.99999481
 Combined Factor 0.99963756 0.99997540

US NATIONAL GRID DESIGNATOR: 16SEH6802192146(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM4654	INPA PAOLI CORS ARP	N383357.706	W0862930.634	33357.4
DM4656	INSG SCOTTSBURG CORS ARP	N384103.137	W0854743.301	38031.6
DM4658	INSY SEYMOUR CORS ARP	N385736.280	W0855142.432	37017.7

NEAREST NGS PUBLISHED CONTROL POINT

JA0021 P 69 TT 60 BRWE N384640.000 W0861340.000 977.7

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

UAS1 – Martin GPS:

FILE: 962582158A0.180 OP1532109865675

- 1008 NOTE: You provided a zero or negative antenna height.
- 1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
- 1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
- 1008

NGS OPUS SOLUTION REPORT

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All computed coordinate accuracies are listed as peak-to-peak values.
 For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: qwlewis@iu.edu DATE: July 20, 2018
 RINEX FILE: 9625158o.18o TIME: 18:05:37 UTC



SOFTWARE: page5 1603.24 master57.pl 160321 START: 2018/06/07 14:07:00
 EPHEMERIS: igs20044.eph [precise] STOP: 2018/06/07 16:38:00
 NAV FILE: brdc1580.18n OBS USED: 6367 / 7024 : 91%
 ANT NAME: CHCX900R NONE # FIXED AMB: 41 / 41 : 100%
 ARP HEIGHT: 0.000 OVERALL RMS: 0.011(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2018.4319)

X: 329090.447(m) 0.005(m) 329089.575(m) 0.005(m)
 Y: -4968181.272(m) 0.023(m) -4968179.861(m) 0.023(m)
 Z: 3972996.516(m) 0.014(m) 3972996.419(m) 0.014(m)

LAT: 38 46 31.85404 0.010(m) 38 46 31.88136 0.010(m)
 E LON: 273 47 22.97227 0.004(m) 273 47 22.94012 0.004(m)
 W LON: 86 12 37.02773 0.004(m) 86 12 37.05988 0.004(m)
 EL HGT: 123.410(m) 0.027(m) 122.207(m) 0.027(m)
 ORTHO HGT: 156.810(m) 0.035(m) [NAVD88 (Computed using GEOID12B)]

UTM COORDINATES STATE PLANE COORDINATES

UTM (Zone 16) SPC (1301 IN E)

Northing (Y) [meters] 4292161.804 391716.643
 Easting (X) [meters] 568598.792 52761.236
 Convergence [degrees] 0.49459444 -0.34045833
 Point Scale 0.99965795 0.99999413
 Combined Factor 0.99963859 0.99997477

US NATIONAL GRID DESIGNATOR: 16SEH6859892161(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
AI5432	IUCO INDIANA UNIVERSIT CORS ARP	N391026.605	W0863023.182	51149.9
DM4658	INSY SEYMOUR CORS ARP	N385736.280	W0855142.432	36532.5
DM4654	INPA PAOLI CORS ARP	N383357.706	W0862930.634	33782.2

NEAREST NGS PUBLISHED CONTROL POINT

JA0020 109/35 BORR N384707.000 W0861312.000 1373.7

This position and the above vector components were computed without any



knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

UAS2 Bedwell GPS:

FILE: 962582185A0.18O OP1532110584526

- 1008 NOTE: You provided a zero or negative antenna height.
- 1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
- 1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
- 1008

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: qwlewis@iu.edu DATE: July 20, 2018
RINEX FILE: 9625185m.18o TIME: 18:17:09 UTC

SOFTWARE: page5 1603.24 master71.pl 160321 START: 2018/07/04 12:40:00
EPHEMERIS: igr20083.eph [rapid] STOP: 2018/07/04 14:55:00
NAV FILE: brdc1850.18n OBS USED: 5805 / 6258 : 93%
ANT NAME: CHCX900R NONE # FIXED AMB: 36 / 40 : 90%
ARP HEIGHT: 0.000 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2018.5057)

X: 328514.062(m) 0.004(m) 328513.189(m) 0.004(m)
Y: -4968181.918(m) 0.006(m) -4968180.508(m) 0.006(m)
Z: 3973043.067(m) 0.009(m) 3973042.970(m) 0.009(m)

LAT: 38 46 33.79084 0.010(m) 38 46 33.81812 0.010(m)
E LON: 273 46 59.14502 0.004(m) 273 46 59.11277 0.004(m)
W LON: 86 13 0.85498 0.004(m) 86 13 0.88723 0.004(m)
EL HGT: 123.393(m) 0.005(m) 122.190(m) 0.005(m)
ORTHO HGT: 156.781(m) 0.023(m) [NAVD88 (Computed using GEOID12B)]



UTM COORDINATES STATE PLANE COORDINATES

UTM (Zone 16) SPC (1301 IN E)

Northing (Y) [meters]	4292216.563	391779.804
Easting (X) [meters]	568023.339	52186.449
Convergence [degrees]	0.49045556	-0.34460833
Point Scale	0.99965698	0.99999481
Combined Factor	0.99963763	0.99997545

US NATIONAL GRID DESIGNATOR: 16SEH6802392216(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM4654	INPA PAOLI CORS ARP	N383357.706	W0862930.634	33408.4
DM4638	INBD BEDFORD CORS ARP	N385147.104	W0863120.304	28228.5
DM4656	INSG SCOTTSBURG CORS ARP	N384103.137	W0854743.301	38047.4

NEAREST NGS PUBLISHED CONTROL POINT

JA0021	P 69 TT 60 BRWE	N384640.000	W0861340.000	964.1
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This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

UAS2 Martin GPS:

FILE: 962582185A1.18O OP1532110652083

- 1008 NOTE: You provided a zero or negative antenna height.
- 1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
- 1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
- 1008

NGS OPUS SOLUTION REPORT

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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: qwlewis@iu.edu	DATE: July 20, 2018
RINEX FILE: 9625185p.18o	TIME: 18:18:16 UTC



SOFTWARE: page5 1603.24 master71.pl 160321 START: 2018/07/04 15:54:00
 EPHEMERIS: igr20083.eph [rapid] STOP: 2018/07/04 18:18:00
 NAV FILE: brdc1850.18n OBS USED: 7339 / 7892 : 93%
 ANT NAME: CHCX900R NONE # FIXED AMB: 63 / 67 : 94%
 ARP HEIGHT: 0.000 OVERALL RMS: 0.020(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2018.5061)

X: 329101.459(m) 0.007(m) 329100.586(m) 0.007(m)
 Y: -4968216.997(m) 0.013(m) -4968215.586(m) 0.013(m)
 Z: 3972951.170(m) 0.010(m) 3972951.073(m) 0.010(m)

LAT: 38 46 29.96890 0.011(m) 38 46 29.99618 0.011(m)
 E LON: 273 47 23.32964 0.007(m) 273 47 23.29742 0.007(m)
 W LON: 86 12 36.67036 0.007(m) 86 12 36.70258 0.007(m)
 EL HGT: 123.370(m) 0.011(m) 122.166(m) 0.011(m)
 ORTHO HGT: 156.770(m) 0.025(m) [NAVD88 (Computed using GEOID12B)]

UTM COORDINATES STATE PLANE COORDINATES

UTM (Zone 16) SPC (1301 IN E)

Northing (Y) [meters] 4292103.770 391658.462
 Easting (X) [meters] 568607.917 52769.517
 Convergence [degrees] 0.49465000 -0.34039167
 Point Scale 0.99965796 0.99999413
 Combined Factor 0.99963861 0.99997477

US NATIONAL GRID DESIGNATOR: 16SEH6860792103(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
AI5432	IUCO INDIANA UNIVERSIT CORS ARP	N391026.605	W0863023.182	51204.6
DM4654	INPA PAOLI CORS ARP	N383357.706	W0862930.634	33748.6
DM4640	INCB INDOT COLUMBUS CORS ARP	N391150.495	W0855742.931	51588.7

NEAREST NGS PUBLISHED CONTROL POINT

JA0020 109/35 BORR N384707.000 W0861312.000 1425.2



This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

UAS3 Bedwell GPS:

FILE: 962582200A0.18O OP1532110889835

- 1008 NOTE: You provided a zero or negative antenna height.
- 1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
- 1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
- 1008

NGS OPUS SOLUTION REPORT

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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: qwlewis@iu.edu	DATE: July 20, 2018
RINEX FILE: 9625200o.18o	TIME: 18:22:44 UTC

SOFTWARE: page5 1603.24 master55.pl 160321	START: 2018/07/19 14:02:00
EPOCH: igr20104.eph [rapid]	STOP: 2018/07/19 16:40:00
NAV FILE: brdc2000.18n	OBS USED: 7037 / 7840 : 90%
ANT NAME: CHCX900R NONE	# FIXED AMB: 50 / 57 : 88%
ARP HEIGHT: 0.000	OVERALL RMS: 0.015(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2018.5470)

X: 328523.139(m) 0.003(m)	328522.265(m) 0.003(m)
Y: -4968181.108(m) 0.027(m)	-4968179.698(m) 0.027(m)
Z: 3973043.490(m) 0.025(m)	3973043.393(m) 0.025(m)

LAT: 38 46 33.80578 0.003(m)	38 46 33.83306 0.003(m)
E LON: 273 46 59.52245 0.003(m)	273 46 59.49016 0.003(m)
W LON: 86 13 0.47755 0.003(m)	86 13 0.50984 0.003(m)
EL HGT: 123.494(m) 0.036(m)	122.292(m) 0.036(m)



ORTHO HGT: 156.882(m) 0.042(m) [NAVD88 (Computed using GEOID12B)]

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 16)	SPC (1301 IN E)
Northing (Y) [meters]	4292217.102	391780.210
Easting (X) [meters]	568032.443	52195.562
Convergence [degrees]	0.49051944	-0.34454167
Point Scale	0.99965699	0.99999480
Combined Factor	0.99963762	0.99997542

US NATIONAL GRID DESIGNATOR: 16SEH6803292217(NAD 83)

BASE STATIONS USED				
PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM4638	INBD BEDFORD CORS ARP	N385147.104	W0863120.304	28236.9
DM4658	INSY SEYMOUR CORS ARP	N385736.280	W0855142.432	36968.5
DM4656	INSG SCOTTSBURG CORS ARP	N384103.137	W0854743.301	38038.7

NEAREST NGS PUBLISHED CONTROL POINT			
PID	DESIGNATION	LATITUDE	DISTANCE(m)
JA0021	P 69 TT 60 BRWE	N384640.000	W0861340.000 972.9

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

UAS4 bedwell GPS:

FILE: 962582100A1.190 OP1555359777646

- 1008 NOTE: You provided a zero or negative antenna height.
- 1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
- 1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
- 1008

NGS OPUS SOLUTION REPORT
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All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>



USER: qwlewis@iu.edu
RINEX FILE: 9625100r.19o

DATE: April 15, 2019
TIME: 20:56:16 UTC

SOFTWARE: page5 1603.24 master80.pl 160321 START: 2019/04/10 17:44:00
EPHEMERIS: igr20483.eph [rapid] STOP: 2019/04/10 20:09:00
NAV FILE: brdc1000.19n OBS USED: 6645 / 7037 : 94%
ANT NAME: CHCX91B NONE # FIXED AMB: 45 / 46 : 98%
ARP HEIGHT: 0.000 OVERALL RMS: 0.012(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2019.2734)

X: 328468.893(m) 0.007(m) 328468.009(m) 0.007(m)
Y: -4967988.077(m) 0.011(m) -4967986.667(m) 0.011(m)
Z: 3973287.232(m) 0.008(m) 3973287.136(m) 0.008(m)

LAT: 38 46 43.95234 0.009(m) 38 46 43.97970 0.009(m)
E LON: 273 46 57.80766 0.007(m) 273 46 57.77497 0.007(m)
W LON: 86 13 2.19234 0.007(m) 86 13 2.22503 0.007(m)
EL HGT: 123.203(m) 0.009(m) 122.001(m) 0.009(m)
ORTHO HGT: 156.589(m) 0.009(m) [H = h-N (N = GEOID12B HGT)]

UTM COORDINATES STATE PLANE COORDINATES
UTM (Zone 16) *** NOTE ***

Northing (Y) [meters] 4292529.513 Please manually select
Easting (X) [meters] 567988.390 SPC zone.
Convergence [degrees] 0.49025278
Point Scale 0.99965692
Combined Factor 0.99963760

US NATIONAL GRID DESIGNATOR: 16SEH6798892529(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
	IUCO		50524.1	
	INSG		38162.9	
	INSY		36830.6	



NEAREST NGS PUBLISHED CONTROL POINT

Information on nearest mark is not available due to database connectivity issues or has restrictions on when or how it can be published.

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

UAS4 Martin GPS:

FILE: 962582100A0.190 OP1555359816147

- 1008 NOTE: You provided a zero or negative antenna height.
- 1008 If ARP HGT = 0.0, OPUS solves for the position of your selected antenna's reference point (ARP).
- 1008 If ARP HGT < 0.0, OPUS solves for a location inside or above the antenna
- 1008

NGS OPUS SOLUTION REPORT
=====

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: qwlewis@iu.edu DATE: April 15, 2019
RINEX FILE: 9625100o.19o TIME: 20:56:46 UTC

SOFTWARE: page5 1603.24 master73.pl 160321 START: 2019/04/10 14:42:00
EPHEMERIS: igr20483.eph [rapid] STOP: 2019/04/10 16:57:00
NAV FILE: brdc1000.19n OBS USED: 5212 / 5937 : 88%
ANT NAME: CHCX91B NONE # FIXED AMB: 50 / 51 : 98%
ARP HEIGHT: 0.000 OVERALL RMS: 0.015(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2019.2730)

X:	329005.635(m)	0.005(m)	329004.751(m)	0.005(m)
Y:	-4968234.196(m)	0.011(m)	-4968232.786(m)	0.011(m)
Z:	3972937.037(m)	0.004(m)	3972936.941(m)	0.004(m)
LAT:	38 46 29.39167	0.004(m)	38 46 29.41900	0.004(m)



E LON: 273 47 19.32166 0.005(m) 273 47 19.28897 0.005(m)
W LON: 86 12 40.67834 0.005(m) 86 12 40.71103 0.005(m)
EL HGT: 122.961(m) 0.011(m) 121.758(m) 0.011(m)
ORTHO HGT: 156.359(m) 0.011(m) [H = h-N (N = GEOID12B HGT)]

UTM COORDINATES STATE PLANE COORDINATES

UTM (Zone 16) *** NOTE ***

Northing (Y) [meters] 4292085.143 Please manually select

Easting (X) [meters] 568511.359 SPC zone.

Convergence [degrees] 0.49395278

Point Scale 0.99965780

Combined Factor 0.99963851

US NATIONAL GRID DESIGNATOR: 16SEH6851192085(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
	INSY		36648.1	
	INSG		37541.8	
	INBD		28732.5	

NEAREST NGS PUBLISHED CONTROL POINT

Information on nearest mark is not available due to database connectivity issues or has restrictions on when or how it can be published.

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.