Appendix A. Baseline UAV survey report

Sears Point Pre-Construction Aerial Imagery and Photogrammetry Acquisition – June 2021

Technical Memorandum

To**:**   Julian Meisler, Sonoma Land Trust

From: Dan Gillenwater and Stuart Siegel

Date: September 22, 2021

The Sears Point Levee Adaptive Management Project (project) on the San Pablo Bay National Wildlife Refuge (Refuge) in Sonoma County, CA is undergoing construction in the fall of 2021. Prior to construction, aerial imagery and topography within the project area was required to document baseline conditions prior to project implementation. These baseline data are needed to confirm site conditions immediately prior to construction and to serve as the basis for comparison to as-built conditions and post-project conditions for assessing change over time and attainment of project goals and objectives. The pre-construction data collection consisted of two independent efforts: (1) a land-based topographic survey of the levee along pre-established transect alignments, and (2) an unmanned aerial vehicle (drone)-based imagery survey of the entire levee alignment. This memorandum describes the methods and results of drone survey effort. The purpose of the drone survey was to collect high-resolution, orthorectified aerial imagery and photogrammetry data along the north and west levees at the project site.

Methods

The drone survey extents along the north and west levees are displayed in Figure 1 and include the entire northern levee and approximately the northern half of the western levee. The survey extents include the levee crests, bayward levee side slopes, and a portion of the adjacent mudflats. The drone imagery was collected on June 16 and 30, 2021 by Dr. Bill Carmen of EnviroDrones using a Phantom 4 Pro drone equipped with an FC6310 18 mega-pixel camera. Flight planning was done in the DroneDeploy software suite. Flight lines were set to ensure minimum image overlap of 75% (frontlap) and 65% (sidelap) to optimize photogrammetry data quality. The imagery was collected in six discrete blocks for post-processing and data management purposes.

Ground control for image orthorectification and photogrammetry analysis was provided by a series of ground control points (GCPs) set along the levee crest and adjacent mudflat. The levee GCPs consisted of 2'x2' vinyl targets anchored to the ground with 5" (40d) common nails and washers. The mudflat GCPs consisted of crosses painted directly on the mudflat with yellow chalk marking paint. The center of each GCP was surveyed with an Emlid RS2 real-time kinematic (RTK) global positioning system (GPS) unit to provide position and elevation information. The Emlid RS2 was set up to receive real-time position corrections from the California Real Time Network (CRTN)[1] via a cellular link. The GCP surveys were held to NGS benchmark JT9545 located near the

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[1] http://sopac-csrc.ucsd.edu/index.php/crtn/

intersection of Hwy 37 and Hwy 121, approximately one mile from the project site (Figure 1). The ground control network for the June 16 drone flight was set and surveyed on June 15 and 16 by Dan Gillenwater of Gillenwater Consulting (GillenH$_2$O) with assistaince from Catherine Thow of San Francsico State University (June 15) and Amanda Dostie of the San Francisco Bay National Estuarine Research Reserve (June 16). The mudflat control points were re-set and surveyed by Amanda Dostie on June 30 to support the second drone flight. During the June 15 GCP survey, the surveyors also attempted to locate and survey the network of local elevation control benchmarks that were set by Ducks Unlimited in 2014 during construction of the Sears Point Restoration Project to determine their condition and suitability for use in construction of the adaptive management project in 2021 (Figure 1).

The drone imagery was post-processed by Bill Carmen in the DroneDepoly software suite to produce orthorectified imagery, photogrammetry point clouds, and resulting digital elevation models for each image acquisition block. The DEMs generated from the photogrammetry data were not corrected to remove vegetation or water interference. Any such corrections will be performed for specific analyses as necessary.

Results

The surveyed and established elevations at benchmark JT9545 for the June 15, 16, and 30 surveys are provided below in Table 1. The elevation data for each survey were adjusted by the difference values provided in Table 1 in order to hold the surveys to benchmark JT9545. Precision for the June 15 and 16 surveys was documented by surveying a local control point established on a bench along the north levee (CP1) at the beginning and end of the surveys. Precision for the June 30 survey was established by surveying benchmark JT9545 at the beginning and end of the survey. As shown in Table 2, all surveys had excellent precision. The established and surveyed (2021) elevations and status of the local Ducks Unlimited benchmarks are provided in Table 3. As indicated in the table, the only stable, recovered benchmark was BM-2 at the Refuge headquarters.

Table 1. Surveyed and Established Elevations for JT9545 and Elevation Adjustment Values

Date	JT9545 Elevation (ft ft NAVD88)		Difference (Elevation Adjustment Values) (ft)[1]
	Surveyed	Established	
June 15	13.57	13.98	0.41
June 16	13.46	13.98	0.52
June 30	13.52	13.98	0.46

1. *These differences between surveyed and established elevations of JT9545 were used to adjust all field survey elevations, in order to hold survey data to JT9545.*

Table 2. Survey Precision (Loop Cloure Error)

Date	Control Point	Elevation (ft NAVD88)		Difference (ft)
		Check-In	Check-Out	
June 15	CP1	16.14	16.13	0.01
June 16	CP1	16.17	16.12	-0.05
June 30	JT9545	13.50	13.54	-0.04

Table 3. 2021 Elevation and Status of Local Ducks Unlimited Benchmarks

Benchmark	Elevation (ft NAVD88)		Difference (ft)	2021 Status
	Surveyed (6/15/2021)	Established by Ducks Unlimited 2014		
1	--	14.26	--	Destroyed
2	21.65	21.69	-0.04	Stable
50	--	0.20	--	Unrecoverable
52	-0.59	-0.27	-0.32	Unstable
53	--	8.52	--	Unrecoverable
54	--	10.45	--	Not Investigated

The GCP networks for the June 16 and 30 drone flights are displayed on Figures 2 and 3 respectively. A total of 68 GCPs were set for the June 16 flight. Ten of these GPCs were set as quality control points (QCPs), which are not used for image recification or photogrammetry, but rather to evaluate the accuracy of the resulting image rectification and DEM. A total of 16 GPCs were utilized for the June 30 flight, with two of those GPCs being used as QCPs. The levee GCPs/QCPs were the same targets set for the June 16 flight, but the mudflat points had to be re-set and surveyed as the chalk markings set for the June 16 survey had since washed away.

The six orthomosaic images collected within the discrete acquisition blocks are shown on Figure 4. Image blocks 1-4 and 6 were collected on June 16, while image block 5 was collected on June 30. The DEMs generated for each imagery acquisition block are shown on Figure 5. The image processing and accuracy reports for each image/DEM are provided in Appendix A.
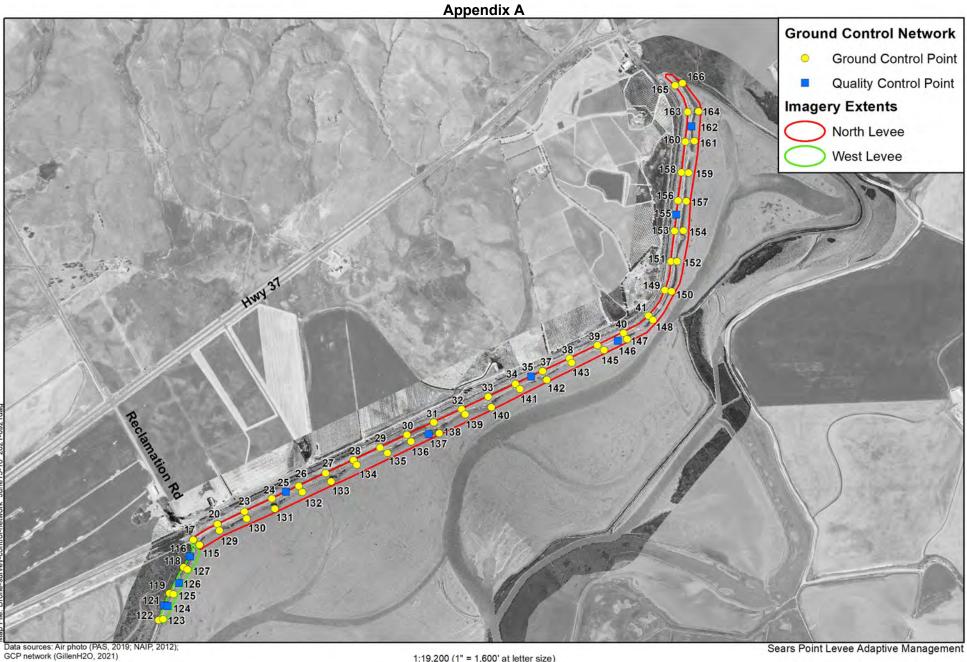
Hwy 121

Hwy 37

Access Rd

Benchmark is in a metal vault at the end of the fenceline along the north side of the access road, before the railroad crossing

See inset

BM 54

Benchmarks

● On-Site: Primary

● On-Site: Secondary

● NGS Benchmark JT9545

Drone operation location #2

BM 2

BM 1

North Levee
- 63 ac
- 12,750 LF
- 175 - 240 ft wide

Hwy 37

BM 53

Lakeville Hwy

BM 52

Reclamation Rd

Drone operation location #1

BM 50

West Levee
- 4.2 ac
- 1,400 LF
- 110 - 140 ft wide

Map File: drone-imagery-capture-areas_2021-0504dag

Data sources: Air photo (PAS, 2019; NAIP, 2012);
Location data (GillenH2O, 2020)

Benchmark Coordinates			
BM ID	Northing (ft)	Easting (ft)	Elevation (ft NAVD88)
1	1813251.37	6428487.45	14.26
2	1813355.38	6428340.69	21.69
50	1808564.20	6425499.16	0.20
52	1810620.00	6429166.49	-0.27
53	1811942.60	6432016.71	8.52
54	1816182.37	6433909.42	10.45
JT9545	1817256.38	6432961.46	13.98

Sears Point Levee Adaptive Management

1:19,200 (1" = 1,600' at letter size)

0   800   1,600
Ft

0   250   500
M

SIEGEL
ENVIRONMENTAL

Figure 1

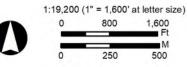**2021 Pre-Construction Drone Imagery Extent**

Sears Point Levee Adaptive Management
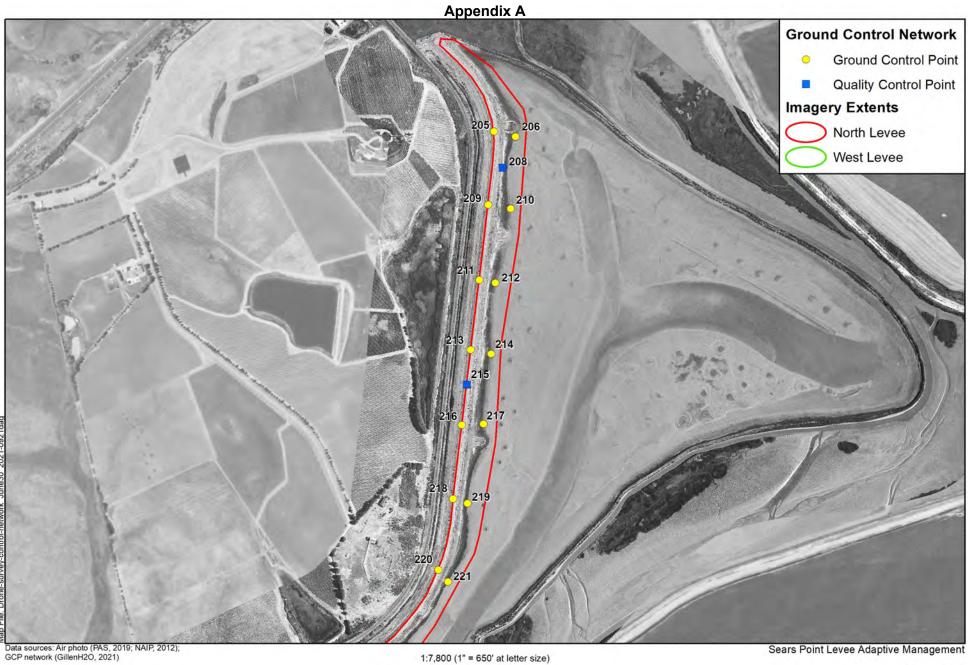
Figure 2

June 2021 Drone Survey Control Network

Ground Control Network

- ● Ground Control Point
- ■ Quality Control Point

Imagery Extents

- ⬭ North Levee
- ⬭ West Levee

205 206
208
209 210
211 212
213 214
215
216 217
218 219
220
221

Map File: Drone-survey-control-network June30 2021-0921dag

Data sources: Air photo (PAS, 2019; NAIP, 2012);
GCP network (GillenH2O, 2021)

Sears Point Levee Adaptive Management

1:7,800 (1" = 650' at letter size)

0   325   650
                Ft
0   100   200
                M

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Figure 3

June 30, 2021 Supplemental Drone Survey Control Network

Imagery Acquisition Blocks
1
2
3
4
5
6

Lakeville Hwy

Hwy 37

Reclamation Rd

Map File: drone-orthoimagery_SearsPt_June2021_2021-0921.aq

Data sources: Basemap photos (PAS, 2019; NAIP, 2012);
Orthomosaic imagery (EnviroDrones, 2021)

1:19,200 (1" = 1,600' at letter size)

0   800   1,600
                        Ft

0   250   500
                        M
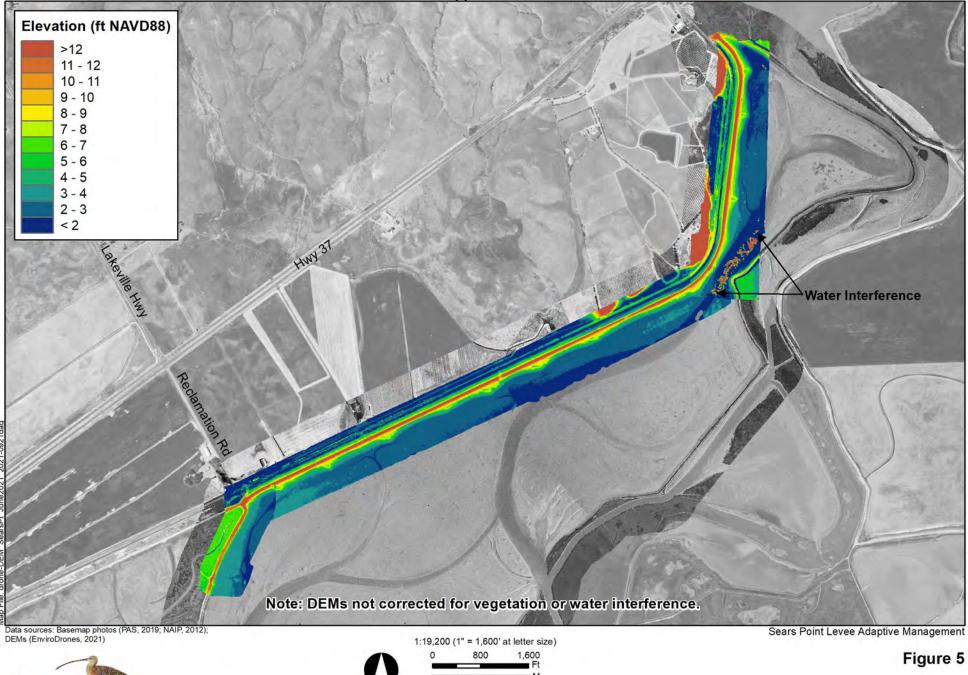
Sears Point Levee Adaptive Management

Figure 4

June 2021 Orthomosaic Image Blocks

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Elevation (ft NAVD88)

	>12
	11 - 12
	10 - 11
	9 - 10
	8 - 9
	7 - 8
	6 - 7
	5 - 6
	4 - 5
	3 - 4
	2 - 3
	< 2

Lakeville Hwy

Reclamation Rd

Hwy 37

Water Interference

Note: DEMs not corrected for vegetation or water interference.

Map File: drone-DEM_SearsPt_June2021_2021-0921dag

Data sources: Basemap photos (PAS, 2019; NAIP, 2012);
DEMs (EnviroDrones, 2021)

1:19,200 (1" = 1,600' at letter size)

0   800   1,600
                  Ft

0   250   500
                  M

Sears Point Levee Adaptive Management

Figure 5

June 2021 Photogrammetry DEMs

SIEGEL
ENVIRONMENTAL

Appendix A-1

Image Processing Accuracy Reports

DroneDeploy

Sears Point FAR WEST LEVEE

Accuracy Report

Report created on July 1, 2021

📄 Summary

Date Flown	06/16/2021
Drone Used	Phantom 4 Pro
Map Area	48.9006 Acres
Map Resolution	0.96 in/pixel

DroneDeploy

Processing Quality

The image density and stitching coverage indicate how likely an image set is to produce a high quality map. Lower numbers may indicate distortion or missing areas within the map.
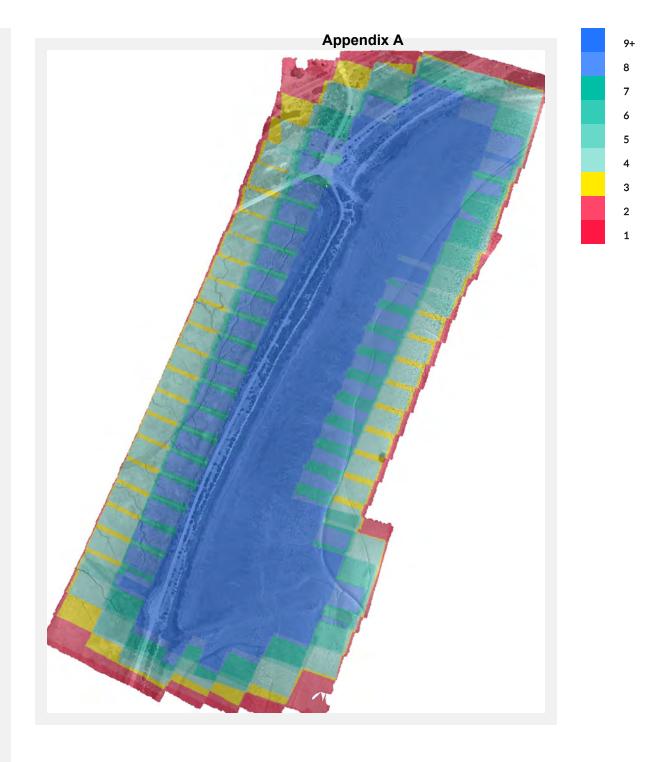
Image Stitching   100 % - Excellent   Avg. Images per Pixel   14.632 - Excellent

Number of Overlapping Images Per Pixel

Blue areas of the map with high numbers of overlapping images (8+ overlapping images per pixel) indicate high quality. Red and yellow areas with fewer overlapping images may appear distorted.

Appendix A

![color scale legend: 9+, 8, 7, 6, 5, 4, 3, 2, 1]

◉ Camera & Flight Info

Improving the quality of the data captured will improve the quality of the map generated.

Camera Model	FC6310	Image Resolution	18 MP
Avg. Flight Altitude	154.85 Feet	Number of Images	N/A
Frontlap Settings	75%	Sidelap Settings	65%

Appendix A

⊕ Accuracy

Relative Accuracy

Measurements of distance, area and volume within the map should be accurate to within 1-3 times the ground sampling distance. Map measurements are typically within 1-3% of ground-based measurements.

Ground Sampling Distance (GSD)	0.96 in/pixel
Approx Horizontal Relative Accuracy Range	0.89 in
Approx Vertical Relative Accuracy Range	0.99 in
Optimized Camera Location Error	**X** 0.59 in **Y** 0.67 in **Z** 0.99 in
Optimized Camera Location XYZ RMSE	1.33 cm/pixel

📍 Checkpoints

Checkpoint error is a measure of global accuracy determined by calculating the error between the locations of checkpoints on the map and the locations of these points measured with positioning equipment. Unlike ground control points (GCPs), checkpoint locations are not used in photogrammetric processing and are only used to measure map accuracy. ASPRS require use of checkpoints in order for a licensed surveyor to specify that a map is survey-grade.

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
checkpoint-3	0.0591	-0.0866	0.8032
checkpoint-6	0	0.0591	-1.6811
checkpoint-9	-0.8425	0.0984	-0.2598
checkpoint-11	-0.811	1.3268	0.5945
Total (RMSE)	0.5855	0.6673	0.9864

📍 Ground Control Points

Global accuracy, when using ground control points (GCPs), is directly correlated to the accuracy of the positioning equipment used. When processing a map without checkpoints, the accuracy is inferred from residual error in the GCPs after calibration, which is only an approximation of accuracy. To verify the accuracy of your map, use checkpoints. ASPRS guidelines require use of checkpoints in order for a licensed surveyor to specify that a map is survey-grade.

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
1	-0.6772	0.563	0.8425
2	0.8386	-0.9252	-0.9449
4	0.315	-0.3937	0.3189
5	0.0157	-0.2283	-1.4252
7	-0.2913	-0.3268	-0.4016
8	0.2795	0.1811	0.6693
10	0.1772	0.3858	0.9449
12	-0.6614	0.7402	0.0039
Total (RMSE)	0.4865	0.5264	0.8091

📍 Glossary

Camera Location XYZ RMSE

The camera location XYZ root mean squared error (RMSE) is the average image location error in the XYZ axis for all images in the map. The image location error is the difference between the image location that is recorded by your drone's GPS and the corrected image location that is calculated during map processing. Therefore, as an example, a 10ft Camera Location XYZ RMSE means that on average in the XYZ dimension image GPS locations were 10ft away from the corrected image locations.

*Please note that camera location error does not correspond to the true accuracy of a map. For example, poor GPS conditions can cause large camera location errors but if images are properly collected the processed map will still be highly accurate. To truly measure map accuracy you must include checkpoints or an object with known dimensions which can be measured in the processed map to check for differences.

Checkpoint XYZ RMSE

The checkpoint XYZ root mean squared error (RMSE) is the average checkpoint location error in the XYZ axis. The checkpoint location error is the difference between the checkpoint location as measured by your precision GPS device and the correction checkpoint location that is calculated during map processing.

*Please note that checkpoint location error is a measure of the absolute accuracy of your map. Systematic errors can cause a map to have large checkpoint location errors and a low absolute accuracy but the map may still have a high relative accuracy. For example, shifting all the points in a map by 1ft in the Z direction will create a 1ft checkpoint location error without effecting the relative map accuracy.

EPSG Code

An EPSG code is a registered shorthand for the full definition of a specific spatial reference system. This can include reference system parameters like the reference datum, refence ellipsoid, geoid, the map projection if used, and the units of measurement.

Ground Control Points

Ground control points (GCPs) are visual targets throught your mapping area. The geographic location of the center of each target is then measured with a precision GPS system. Then these known locations are used by the processing software to accurately position you map with respect to the real world.

Ground Sampling Distance (GSD)

The ground sampling distance is the distance between pixel centers as measured on the ground for nadir images. GSD can be decreased by flying lower or by using a camera with more megapixels. GSD will determine your maximum orthomosaic resolution.

GCP XYZ RMSE

The ground control point (GCP) XYZ root mean squared error (RMSE) is the average GCP location error in the XYZ axis across all the processed GCPs. The GCP location error is the difference between the GCP location as measured by your precision GPS device and the corrected GCP location that is calculated during map processing.

*Please note that GCP location error does not correspond to the true accuracy of a map. This is because the corrected GCP locations are calculated using a mathematical estimation which is weighted so corrected locations will be close to the measured location. To truly measure map accuracy you must include checkpoints or an object with known dimentions which can be measured in the processed map to check for differences.

DroneDeploy

Main Central Levee West

Accuracy Report

Report created on July 1, 2021

📄 Summary

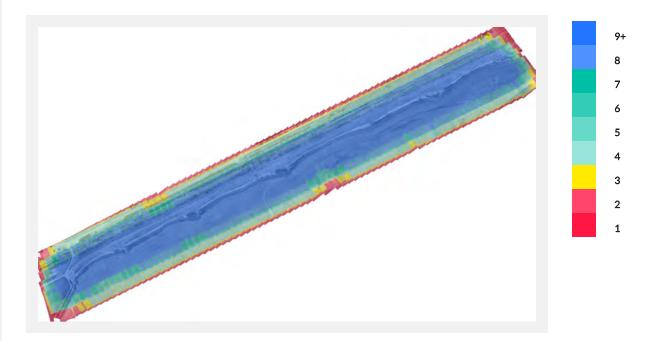|	
Date Flown	06/16/2021
Drone Used	Phantom 4 Pro
Map Area	432.4325 Acres
Map Resolution	0.96 in/pixel

DroneDeploy

⏱ Processing Quality

The image density and stitching coverage indicate how likely an image set is to produce a high quality map. Lower numbers may indicate distortion or missing areas within the map.

Image Stitching	100 % - Excellent	Avg. Images per Pixel	15.563046192259675 - Excellent

▦ Number of Overlapping Images Per Pixel

Blue areas of the map with high numbers of overlapping images (8+ overlapping images per pixel) indicate high quality. Red and yellow areas with fewer overlapping images may appear distorted.

Camera & Flight Info Appendix A

Improving the quality of the data captured will improve the quality of the map generated.

Camera Model	FC6310	Image Resolution	18 MP
Avg. Flight Altitude	167.14 Feet	Number of Images	N/A
Frontlap Settings	75%	Sidelap Settings	65%

◑ Accuracy

Relative Accuracy

Measurements of distance, area and volume within the map should be accurate to within 1-3 times the ground sampling distance. Map measurements are typically within 1-3% of ground-based measurements.

Ground Sampling Distance (GSD)	0.96 in/pixel
Approx Horizontal Relative Accuracy Range	0.76 in
Approx Vertical Relative Accuracy Range	4.23 in
Optimized Camera Location Error	**X** 0.41 in **Y** 0.64 in **Z** 4.23 in
Optimized Camera Location XYZ RMSE	4.3 cm/pixel

◉ Checkpoints

Checkpoint error is a measure of global accuracy determined by calculating the error between the locations of checkpoints on the map and the locations of these points measured with positioning equipment. Unlike ground control points (GCPs), checkpoint locations are not used in photogrammetric processing and are only used to measure map accuracy. ASPRS require use of checkpoints in order for a licensed surveyor to specify that a map is survey-grade.

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
checkpoint-9	-0.689	-0.2205	0.3661
checkpoint-18	-0.126	1.0709	7.3032
checkpoint-27	0.063	-0.1693	-0.5433
Total (RMSE)	0.406	0.6388	4.2334

📍 Ground Control Points

Global accuracy, when using ground control points (GCPs), is directly correlated to the accuracy of the positioning equipment used. When processing a map without checkpoints, the accuracy is inferred from residual error in the GCPs after calibration, which is only an approximation of accuracy. To verify the accuracy of your map, use checkpoints. ASPRS guidelines require use of checkpoints in order for a licensed surveyor to specify that a map is survey-grade.

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
3	-0.8268	0.9567	-1.0394
6	-0.6654	0.5157	-1.315
7	-0.3189	-0.1929	-0.8307
8	-0.0945	0.2205	-0.374
10	-0.2362	-0.1614	0.0512
11	-0.4173	-0.0433	-0.8307
12	-0.5827	-0.0276	-0.2717
13	-0.4606	-0.1496	0.248
14	-0.1142	-0.2638	0.9409
15	-0.2913	0.2717	1.5118
16	-0.752	0.0906	1.815
17	1.4685	-0.6575	1.9488
19	-0.1575	-0.3622	0.6457
20	0.3425	-0.6181	0.7402
21	0.1732	0.1457	0.0984
22	0.4843	0.5669	0.7717
23	0.2008	-0.5472	0.2402
24	0.4921	0.4528	0.1772
25	0.7165	0.0669	-1.1496
26	0.1339	0.0394	-0.6299
28	0.3543	0.0709	-1.3386
29	0.5551	-0.374	-1.4094
Total (RMSE)	0.5432	0.3939	0.9974

📍 Glossary

Camera Location XYZ RMSE

The camera location XYZ root mean squared error (RMSE) is the average image location error in the XYZ axis for all images in the map. The image location error is the difference between the image location that is recorded by your drone's GPS and the corrected image location that is calculated during map processing. Therefore, as an example, a 10ft Camera Location XYZ RMSE means that on average in the XYZ dimension image GPS locations were 10ft away from the corrected image locations.

*Please note that camera location error does not correspond to the true accuracy of a map. For example, poor GPS conditions can cause large camera location errors but if images are properly collected the processed map will still be highly accurate. To truly measure map accuracy you must include checkpoints or an object with known dimensions which can be measured in the processed map to check for differences.

Checkpoint XYZ RMSE

The checkpoint XYZ root mean squared error (RMSE) is the average checkpoint location error in the XYZ axis. The checkpoint location error is the difference between the checkpoint location as measured by your precision GPS device and the correction checkpoint location that is calculated during map processing.

*Please note that checkpoint location error is a measure of the absolute accuracy of your map. Systematic errors can cause a map to have large checkpoint location errors and a low absolute accuracy but the map may still have a high relative accuracy. For example, shifting all the points in a map by 1ft in the Z direction will create a 1ft checkpoint location error without effecting the relative map accuracy.

EPSG Code

An EPSG code is a registered shorthand for the full definition of a specific spatial reference system. This can include reference system parameters like the reference datum, refence ellipsoid, geoid, the map projection if used, and the units of measurement.

Ground Control Points

Ground control points (GCPs) are visual targets throught your mapping area. The geographic location of the center of each target is then measured with a precision GPS system. Then these known locations are used by the processing software to accurately position you map with respect to the real world.
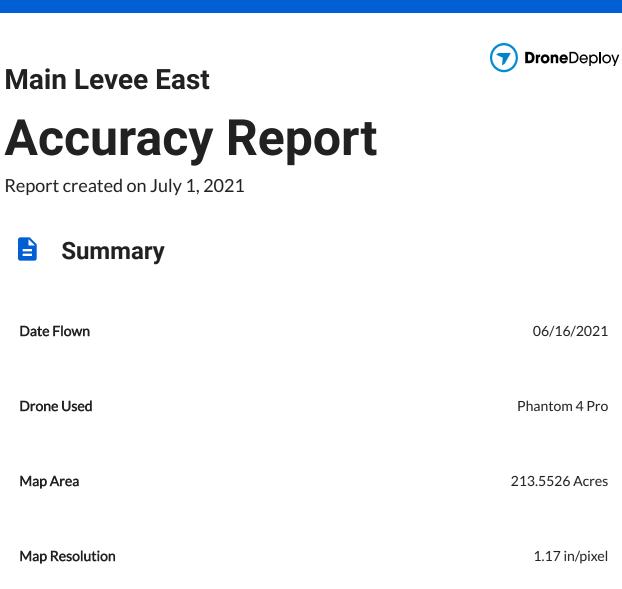
Ground Sampling Distance (GSD)

The ground sampling distance is the distance between pixel centers as measured on the ground for nadir images. GSD can be decreased by flying lower or by using a camera with more megapixels. GSD will determine your maximum orthomosaic resolution.

GCP XYZ RMSE

The ground control point (GCP) XYZ root mean squared error (RMSE) is the average GCP location error in the XYZ axis across all the processed GCPs. The GCP location error is the difference between the GCP location as measured by your precision GPS device and the corrected GCP location that is calculated during map processing.

*Please note that GCP location error does not correspond to the true accuracy of a map. This is because the corrected GCP locations are calculated using a mathematical estimation which is weighted so corrected locations will be close to the measured location. To truly measure map accuracy you must include checkpoints or an object with known dimentions which can be measured in the processed map to check for differences.

DroneDeploy

Main Levee East

Accuracy Report

Report created on July 1, 2021

📄 Summary

Date Flown	06/16/2021
Drone Used	Phantom 4 Pro
Map Area	213.5526 Acres
Map Resolution	1.17 in/pixel

DroneDeploy

⏱ Processing Quality

The image density and stitching coverage indicate how likely an image set is to produce a high quality map. Lower numbers may indicate distortion or missing areas within the map.
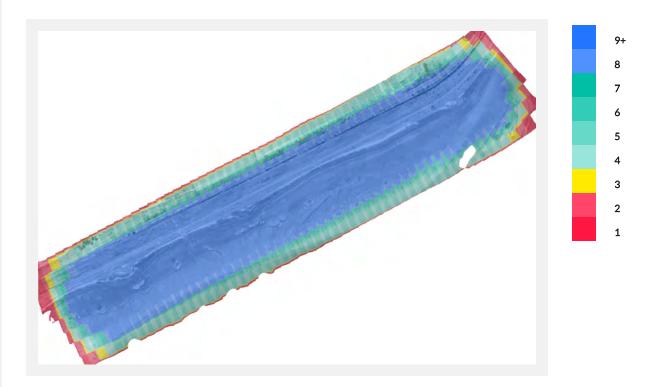
Image Stitching   100 % - Excellent   **Avg. Images per Pixel**   15.236 - Excellent

⬚ Number of Overlapping Images Per Pixel

Blue areas of the map with high numbers of overlapping images (8+ overlapping images per pixel) indicate high quality. Red and yellow areas with fewer overlapping images may appear distorted.

Camera & Flight Info Appendix A

Improving the quality of the data captured will improve the quality of the map generated.

Camera Model	FC6310	Image Resolution	18 MP
Avg. Flight Altitude	264.59 Feet	Number of Images	N/A
Frontlap Settings	75%	Sidelap Settings	65%

⊕ Accuracy

Relative Accuracy

Measurements of distance, area and volume within the map should be accurate to within 1-3 times the ground sampling distance. Map measurements are typically within 1-3% of ground-based measurements.

Ground Sampling Distance (GSD)	1.17 in/pixel
Approx Horizontal Relative Accuracy Range	2.42 in
Approx Vertical Relative Accuracy Range	0.57 in
Optimized Camera Location Error	X 2.37 in Y 0.5 in Z 0.57 in
Optimized Camera Location XYZ RMSE	2.49 cm/pixel

📍 Checkpoints

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Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
checkpoint-4	0.1732	0.4173	-0.0394
checkpoint-16	3.3504	-0.563	-0.7992
Total (RMSE)	2.3723	0.4955	0.5658

📍 Ground Control Points

Global accuracy, when using ground control points (GCPs), is directly correlated to the accuracy of the positioning equipment used. When processing a map without checkpoints, the accuracy is inferred from residual error in the GCPs after calibration, which is only an approximation of accuracy. To verify the accuracy of your map, use checkpoints. ASPRS guidelines require use of checkpoints in order for a licensed surveyor to specify that a map is survey-grade.

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
1	-0.2283	0.315	1.315
2	-0.122	0.1772	1.2362
3	0.4449	-0.4803	1.3898
5	-0.4252	0.4528	-0.185
6	-0.4803	0.0236	-0.4331
7	-0.311	0.0118	-1.4882
8	-0.0079	-0.5748	-0.4567
9	-0.5118	0.0827	-1.6575
10	0.5118	-0.2008	-1.4921
11	-0.2717	0.0945	-1.2441
12	-0.063	-0.063	-1.0945
13	0.0512	-0.3228	0.252
14	0.4843	-0.0748	0.3268
15	0.3386	-0.0315	1.2244
17	0.0197	0.7795	1.0866
18	0.5669	-0.189	1.2126
Total (RMSE)	0.3578	0.3271	1.1145

📍 Glossary

Camera Location XYZ RMSE

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EPSG Code

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Ground Control Points

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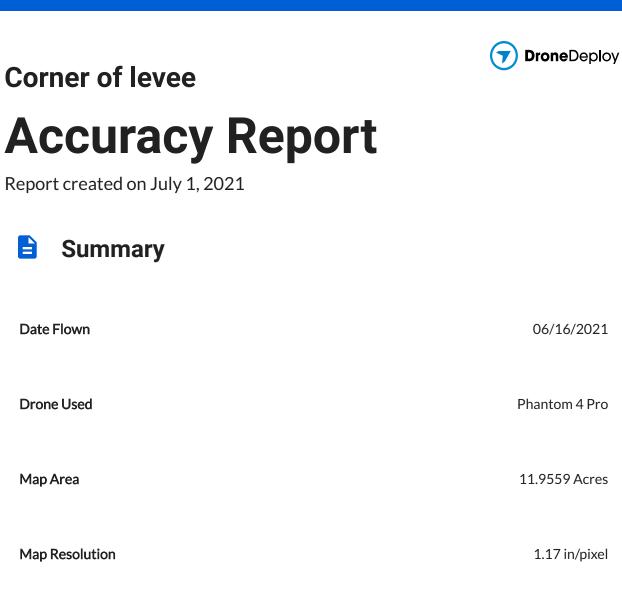
Ground Sampling Distance (GSD)

The ground sampling distance is the distance between pixel centers as measured on the ground for nadir images. GSD can be decreased by flying lower or by using a camera with more megapixels. GSD will determine your maximum orthomosaic resolution.

GCP XYZ RMSE

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Corner of levee

Accuracy Report

Report created on July 1, 2021

📄 Summary

Date Flown	06/16/2021
Drone Used	Phantom 4 Pro
Map Area	11.9559 Acres
Map Resolution	1.17 in/pixel

Processing Quality

The image density and stitching coverage indicate how likely an image set is to produce a high quality map. Lower numbers may indicate distortion or missing areas within the map.
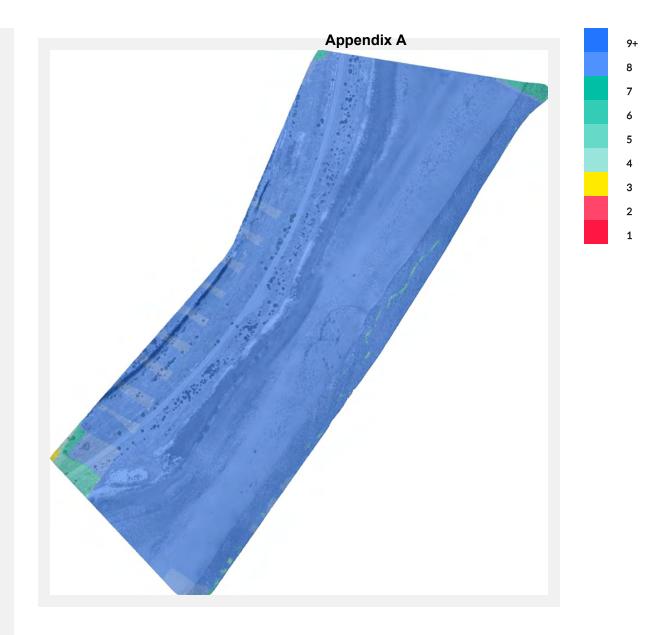
Image Stitching   100 % - Excellent   Avg. Images per Pixel   13.573 - Excellent

Number of Overlapping Images Per Pixel

Blue areas of the map with high numbers of overlapping images (8+ overlapping images per pixel) indicate high quality. Red and yellow areas with fewer overlapping images may appear distorted.

Appendix A

Camera & Flight Info

Improving the quality of the data captured will improve the quality of the map generated.

Camera Model	FC6310	Image Resolution	18 MP
Avg. Flight Altitude	266.48 Feet	Number of Images	N/A
Frontlap Settings	75%	Sidelap Settings	76%

⊕ Accuracy

Relative Accuracy

Measurements of distance, area and volume within the map should be accurate to within 1-3 times the ground sampling distance. Map measurements are typically within 1-3% of ground-based measurements.

Ground Sampling Distance (GSD)	1.17 in/pixel
Approx Horizontal Relative Accuracy Range	0.44 in
Approx Vertical Relative Accuracy Range	0.53 in
Optimized Camera Location Error	**X** 0.38 in **Y** 0.21 in **Z** 0.53 in
Optimized Camera Location XYZ RMSE	0.68 cm/pixel

📍 Ground Control Points

Global accuracy, when using ground control points (GCPs), is directly correlated to the accuracy of the positioning equipment used. When processing a map without checkpoints, the accuracy is inferred from residual error in the GCPs after calibration, which is only an approximation of accuracy. To verify the accuracy of your map, use checkpoints. ASPRS guidelines require use of checkpoints in order for a licensed surveyor to specify that a map is survey-grade.

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
1	-0.5827	-0.1772	0.5709
2	0.4882	0.2795	-0.5079
3	0.0787	-0.2165	-0.5433
4	0.0157	0.1102	0.4803
Total (RMSE)	0.3822	0.2053	0.5267

📍 Glossary

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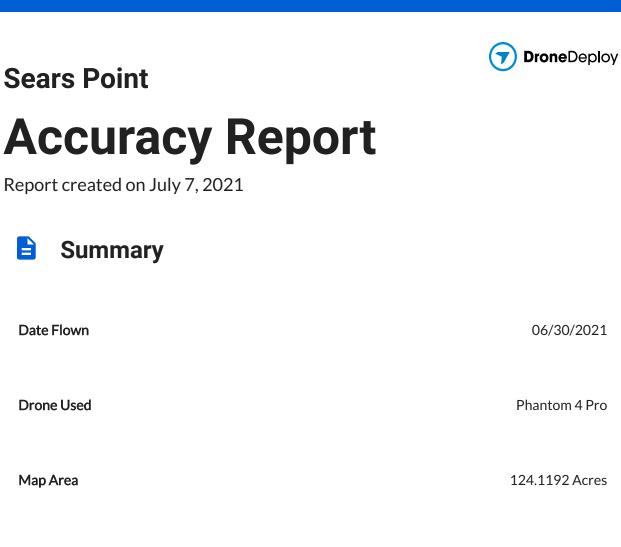
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DroneDeploy

Sears Point

Accuracy Report

Report created on July 7, 2021

📄 Summary

Date Flown	06/30/2021
Drone Used	Phantom 4 Pro
Map Area	124.1192 Acres
Map Resolution	1.15 in/pixel

DroneDeploy

Processing Quality

The image density and stitching coverage indicate how likely an image set is to produce a high quality map. Lower numbers may indicate distortion or missing areas within the map.
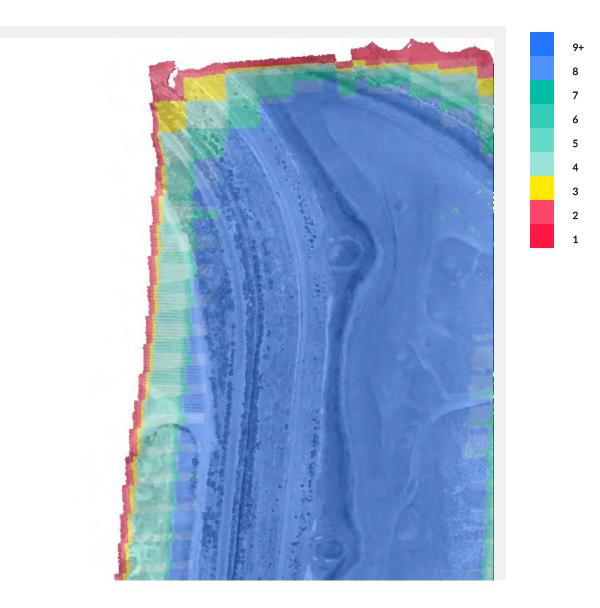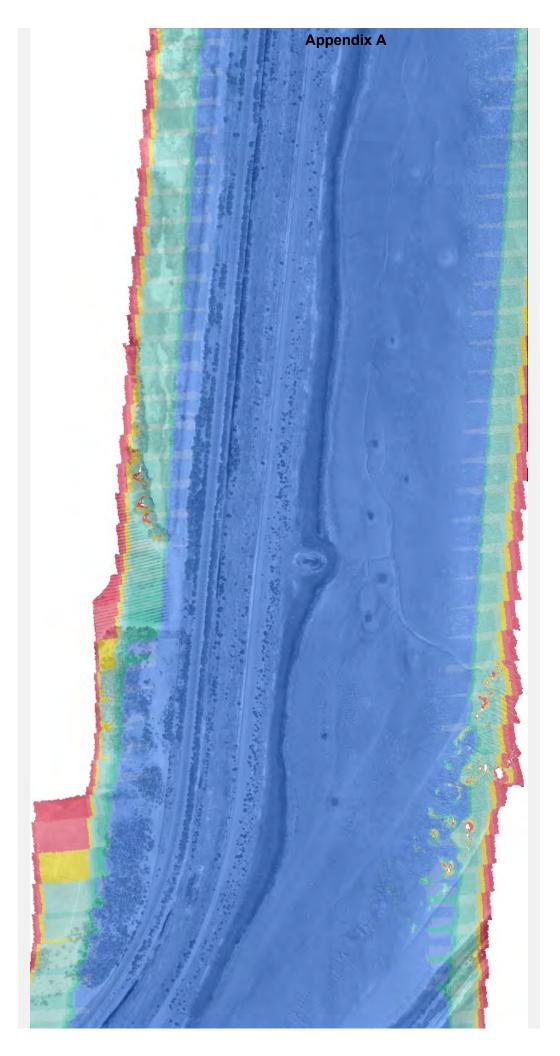
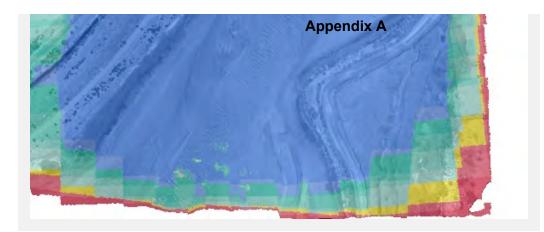Image Stitching   100 % - Excellent   Avg. Images per Pixel   17.316 - Excellent

Number of Overlapping Images Per Pixel

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🔵 Camera & Flight Info

Improving the quality of the data captured will improve the quality of the map generated.

Camera Model	FC6310	Image Resolution	18 MP
Avg. Flight Altitude	333.42 Feet	Number of Images	N/A
Frontlap Settings	75%	Sidelap Settings	65%

⊕ Accuracy

Relative Accuracy

Measurements of distance, area and volume within the map should be accurate to within 1-3 times the ground sampling distance. Map measurements are typically within 1-3% of ground-based measurements.

Ground Sampling Distance (GSD)	1.15 in/pixel
Approx Horizontal Relative Accuracy Range	0.6 in
Approx Vertical Relative Accuracy Range	0.57 in
Optimized Camera Location Error	**X** 0.16 in **Y** 0.58 in **Z** 0.57 in
Optimized Camera Location XYZ RMSE	0.83 cm/pixel

📍 Checkpoints

Checkpoint error is a measure of global accuracy determined by calculating the error between the locations of checkpoints on the map and the locations of these points measured with positioning equipment. Unlike ground control points (GCPs), checkpoint locations are not used in photogrammetric processing and are only used to measure map accuracy. ASPRS require use of checkpoints in order for a licensed surveyor to specify that a map is survey-grade.

Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
checkpoint-3	-0.2087	-0.1181	-0.7323
checkpoint-10	-0.0748	-0.811	0.3228
Total (RMSE)	0.1568	0.5795	0.5659

📍 Ground Control Points

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Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
1	-0.0157	0.2362	0.0039
2	-0.0079	-0.1457	-0.2677
4	0.1339	-0.0472	-0.4213
5	0.0197	0.1654	0.685
6	0.1299	-0.6654	-0.1693
7	-0.3661	0.4528	0.1575
8	0.0118	0.2598	0.0945
9	0.2559	-0.1457	0.378
11	-0.1102	0.1417	0.189
12	-0.3701	-0.5906	-0.374
13	0.4094	0.2402	-0.1929
14	0.0433	0.1339	-0.5787
15	-0.3701	0.0118	0.5709
16	0.2441	-0.0433	-0.0787
Total (RMSE)	0.2315	0.3035	0.3589

📍 Glossary

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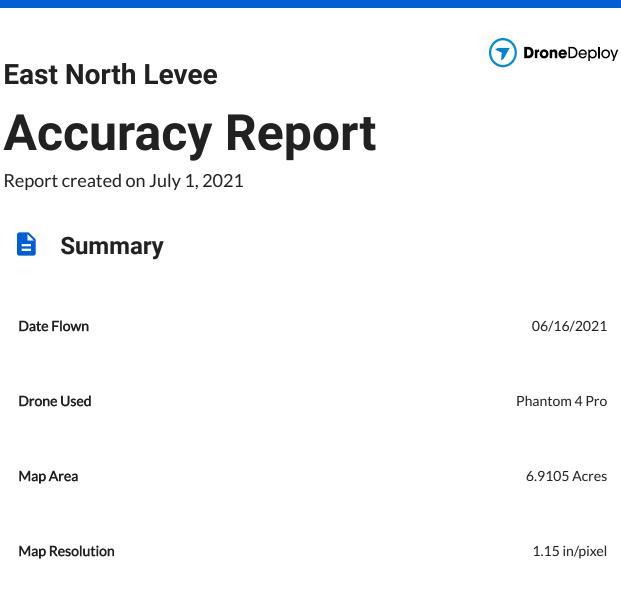
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GCP XYZ RMSE

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DroneDeploy

East North Levee

Accuracy Report

Report created on July 1, 2021

📄 Summary

Date Flown	06/16/2021
Drone Used	Phantom 4 Pro
Map Area	6.9105 Acres
Map Resolution	1.15 in/pixel

DroneDeploy

◑ Processing Quality

The image density and stitching coverage indicate how likely an image set is to produce a high quality map. Lower numbers may indicate distortion or missing areas within the map.
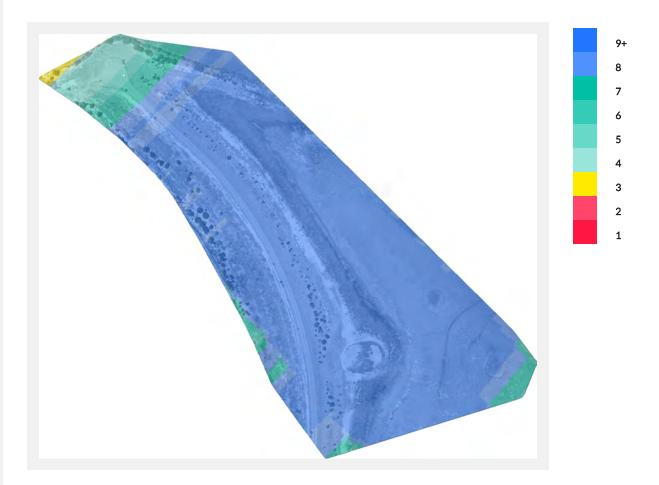
Image Stitching   100 % - Excellent   Avg. Images per Pixel   11.997 - Excellent

⬚ Number of Overlapping Images Per Pixel

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Camera & Flight Info Appendix A

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Camera Model	FC6310	Image Resolution	18 MP
Avg. Flight Altitude	271.54 Feet	Number of Images	N/A
Frontlap Settings	75%	Sidelap Settings	74%

◑ Accuracy

Relative Accuracy

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Ground Sampling Distance (GSD)	1.15 in/pixel
Approx Horizontal Relative Accuracy Range	0.23 in
Approx Vertical Relative Accuracy Range	0.1 in
Optimized Camera Location Error	**X** 0.17 in **Y** 0.16 in **Z** 0.1 in
Optimized Camera Location XYZ RMSE	0.25 cm/pixel

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Label	X Error (Inches)	Y Error (Inches)	Z Error (Inches)
1	0.2047	-0.2283	0.0866
2	-0.2559	0.1102	-0.0709
3	0.0866	-0.0709	-0.122
4	-0.0354	0.1929	0.1063
Total (RMSE)	0.1704	0.1632	0.0984

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