

DVRPC/LVPV/NJ/YCPC 2015 Orthoimagery Project Report



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1. Summary / Scope

1.1. Summary

This report contains a summary of the DVRPC/LVPV/NJ/YCPC 2015 Orthoimagery acquisition task order, issued by the USGS National Geospatial Technical Operations Center (NGTOC) under their Geospatial Products and Services Contract (GPSC) on March 30, 2015. The combined task orders yielded study areas covering the entire state of New Jersey as well as part of Pennsylvania. The intent of this document is to only provide specific validation information for the Ortho data acquisition/collection work completed for the project.

Please note that the acquisition information, processing, accuracies, etc. apply only to the data collected under Task Order G15PD00279. The information reported does not include imagery acquired and produced by the US Army Corps of Engineers (USACE) and AXIS Geospatial. However, tile counts and boundary coordinates include the USACE imagery.

1.2. Scope

High resolution digital aerial imagery was acquired in spring 2015. The total numbers of 16-bit, 4-band (R.G.B.NIR) orthophoto tiles produced are listed by area of interest below (all spatial references use the NAD83 (2011) datum):

- **DVRPC (NJ-PA):** The 6-county project area was covered by 1,342 tiles produced in UTM Zone 18; tile size is 2,100 m x 2,100 m and uses the DVRPC PA index.
- **DVRPC (NJ):** The 4-county project area was covered by 1,196 tiles produced in NJ State Plane South Zone; tile size is 8,745 ft x 5,022 ft and uses the DVRPC PA index.
- **DVRPC (PA):** The 2-county project area was covered by 1,540 tiles produced in PA State Plane South Zone; tile size is 8,745 ft x 5,022 ft and uses the DVRPC PA index.
- **LVPC:** The 1-county project area was covered by 472 tiles produced in PA State Plane South Zone; tile size is 5,000 ft x 5,000 ft and uses the LVPC index.
- **YCPC:** The 2-county project area was covered by 301 tiles produced in PA State Plane South Zone; tile size is 10,000 ft x 10,000 ft and uses the YCPC index.
- **NJ (UTM):** The 21-county project area was covered by 9,830 tiles produced in UTM Zone 18N; tile size is 1,500 m x 1,500 m and uses the US National Grid index.
- **NJ (State Plane):** The 21-county project area was covered by 9,201 tiles (12 pilot tiles) produced in NJ State Plane; tile size is 5,000 ft x 5,000 ft and uses the NJOIT index.
- **Mercer County:** The 1-county project area was covered by 1,280 tiles produced in NJ State Plane system; tile size is 2,500 ft x 2,500 ft and uses the Mercer County Index.

Project phases included aerial imagery acquisition with airborne GPS/IMU, ground control surveys, aerotriangulation, existing LiDAR DEM processing, and orthorectification. Ortho data collection was planned using the specifications listed below in Table 1.

Table 1. Originally Planned Ortho Specifications

| Raw GSD | Flight Altitude (AGL) | Min. Sun Angle | Side Overlap | Front Overlap |
|---------|-----------------------|----------------|--------------|---------------|
| 0.96 ft | 16,400 ft | 35° | 30% | 60% |
| 0.48 ft | 8,200 | 35° | 30% | 60% |

The delivered products conform to the specifications as stated in Task Order G15PD00279 and Quantum Spatial's Technical Proposal.

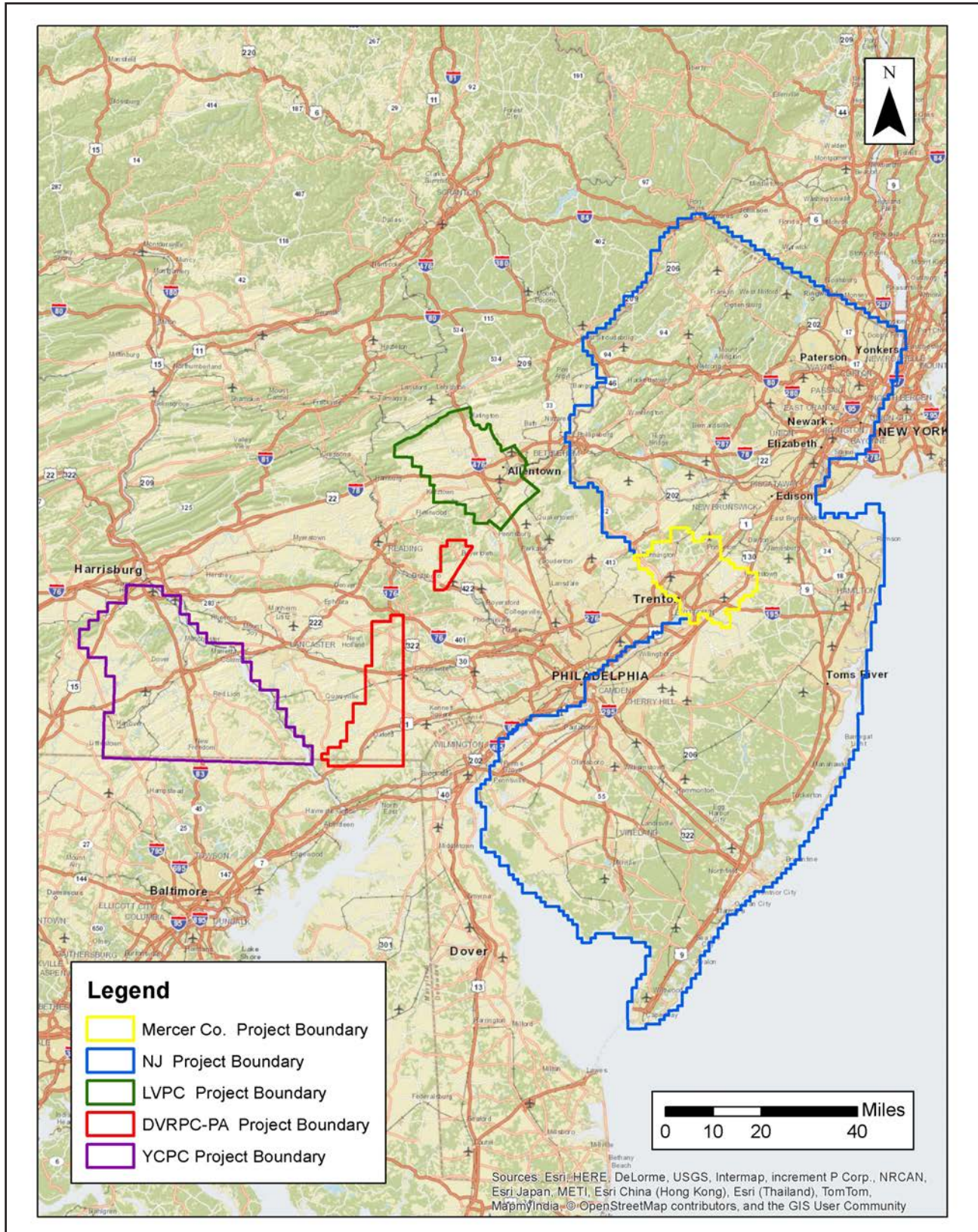
1.3. Location / Coverage

The Ortho project boundary includes all 21 counties of New Jersey and a total 6 counties in Pennsylvania, which totals approximately 10,532 square miles, as seen in Figure 1.

1.4. Duration

The imagery was acquired in a total of twenty lifts from March 29, 2015 through May 3, 2015. See "Section: 2.4. Time Period" for more details.

Figure 1. DVRPC/LVPC/NJ/YCPC Ortho Project Boundary



1.5. Issues

There were no issues reported with this project.

1.6. Deliverables

The following products were produced and delivered:

- Flight diagram (flight lines and exposures) in shapefile format
- Calibration report
- Camera station control report
- GPS/IMU data report
- Non-Orthorectified imagery ad uncompressed, 4-band, 16-bit GeoTiffs (with World file)
- Ground control
- Aerotriangulation report
- Digital orthorectified Imagery as uncompressed, untiled, full image 4-band, 16-bit GeoTiffs
- MrSID Images in MG4 format with a 10:1 compression ratio by tile (50:1 for county mosaics)
- Tile indices in shapefile format
- Seamlines in shapefile format
- Project Level metadata

2. Planning / Equipment

2.1. Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount / type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project name or area project using UltraNav planning software for imagery.

The entire target area was comprised of 113 planned flight lines and 7,128 planned exposures for orthoimagery acquisition (Figure 2 - Figure 3).

2.2. Orthoimagery Camera

Quantum Spatial also utilized a Microsoft UltraCam Falcon (serial number: 50811038) and UltraCam Eagle (serial numbers: 40312131, 817310, 50617043, and 50319383). These can be seen in Figure 4. The Microsoft UltraCam systems have 4 channel (RGB & NIR) multi-spectral capability. The combination of the camera's Forward Motion Compensation, along with the gyro stabilized mount, insures the best possible image collection. A single full resolution image is 20,010 by 13,080 pixels in size and utilizes a 100mm lens focal distance.

A brief summary of the aerial acquisition parameters for the project are shown in the Camera System Specifications in Table 2.

Figure 2. Planned Ortho Flight Lines

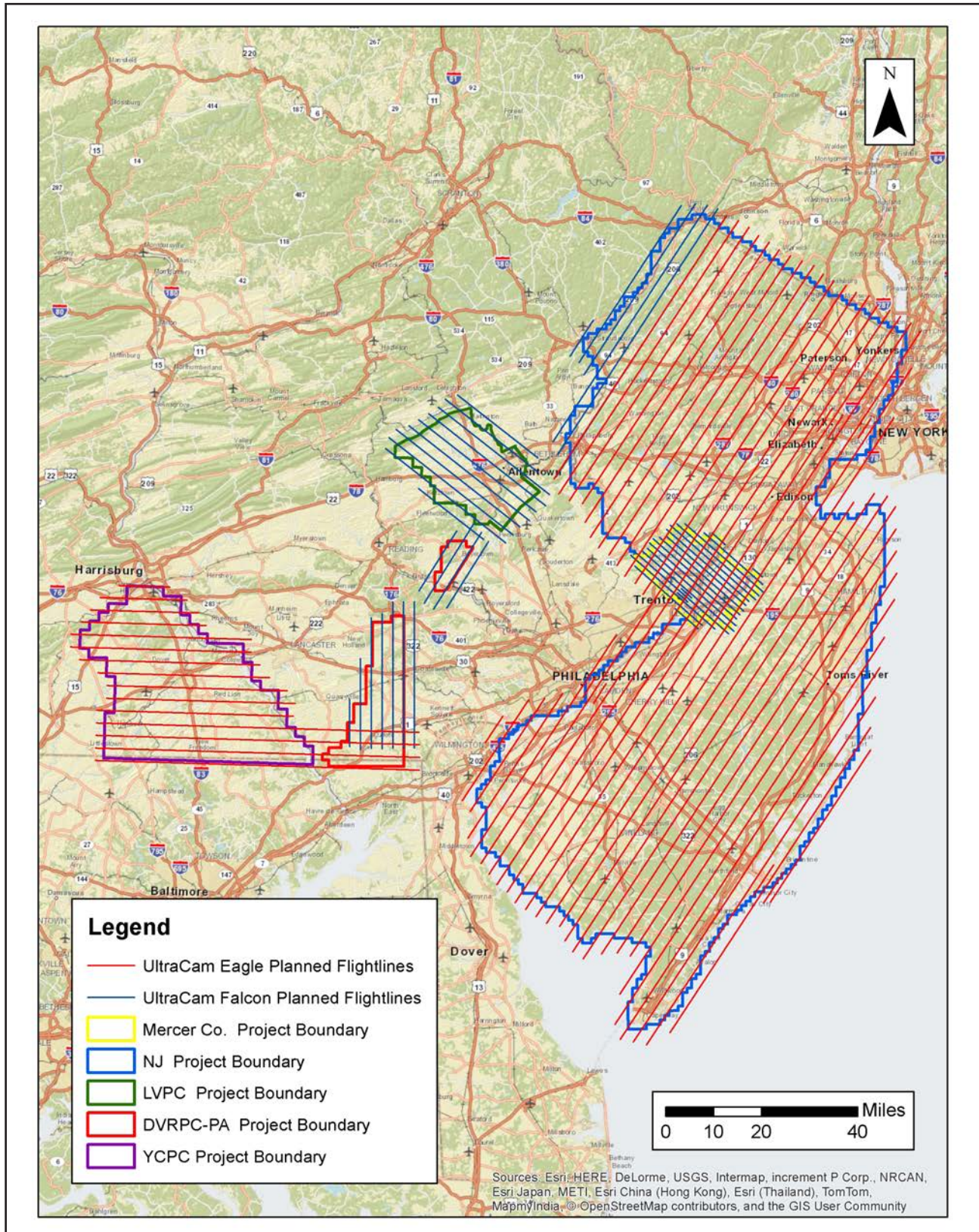


Figure 3. Planned Photo Centers

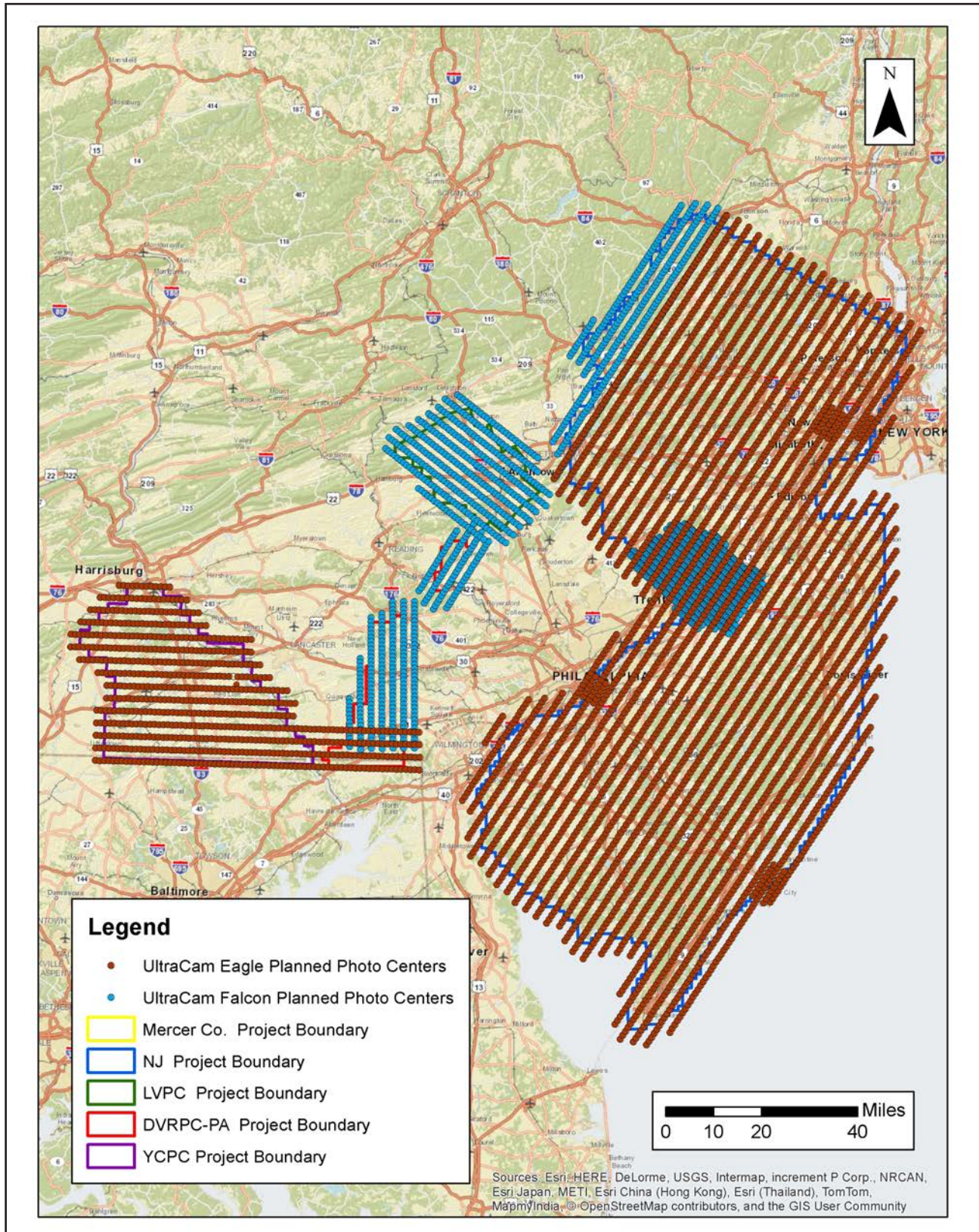


Table 2. Camera System Specifications

| | | 12" | 6" |
|----------------------|-------------------|-----------------------------------|----------|
| Terrain and Aircraft | Flying Height AGL | 16,400 ft | 8,200 ft |
| Overlap | Forward Overlap | 60% | 60% |
| | Side Overlap | 30% | 30% |
| Coverage | Strip Width | 7200 m (Falcon) 6170 m (Eagle) | 3730 m |
| Resolution | GSD | 1.0 ft | 0.5 ft |

Figure 4. Microsoft UltraCam Falcon (left) and Eagle (right) Cameras.



2.3. Aircraft

All flights for the DVRPC/LVPC/NJ/YCPC project were accomplished through the use of customized planes. Plane type and tail numbers are listed below.

- Cessna Executive Skynight (twin piston), Tail Number: N344Q
- Piper Aztec (piston-single), Tail Number: N170TA
- Cessna Conquest 2 (twin-turboprop), Tail Numbers: N441MD, N87WS
- Cessna Centurion (piston-single), Tail Number: N191TA
- Cessna Centurion (piston-single), Tail Number: N9WA

These aircraft provided an ideal, stable aerial base for orthoimagery acquisition. These aerial platforms has relatively fast cruise speeds which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which proved ideal for collection of high-density, consistent data posting using state-of-the-art Microsoft UltraCam Falcon and Eagle imagery systems.

2.4. Time Period

Project specific flights were conducted over several months. Twenty-one sorties, or aircraft lifts were completed. Accomplished ortho sorties are listed below.

DVRPC NJ-PA

- Apr 1, 2015-A
(N344Q; 40312131)
- Apr 2, 2015-A
(N170TA; 50811038)
- Apr 2, 2015-A
(N344Q; 40312131)
- Apr 6, 2015-A
(N441MD; 817310)
- Apr 16, 2015-A
(N87WS; 50617043)
- Apr 18, 2015-A
(N170TA; 50811038)
- Apr 18, 2015-A
(N441MD; 817310)
- Apr 19, 2015-A
(N170TA; 50811038)
- Apr 19, 2015-A
(N441MD; 817310)
- Apr 19, 2015-B
(N441MD; 818310)
- Apr 26, 2015-A
(N87WS; 60617043)
- Apr 29, 2015-A
(N191TA; 5039383)
- May 2, 2015-A
(N87WS; 50617043)

DVRPC NJ

- Apr 1, 2015-A
(N344Q; 40312131)
- Apr 2, 2015-A
(N344Q; 40312131)
- Apr 6, 2015-A
(N441MD; 817310)
- Apr 16, 2015-A
(N87WS; 50617043)
- Apr 19, 2015-A
(N170TA; 50811038)
- Apr 19, 2015-A
(N441MD; 817310)
- Apr 19, 2015-B
(N441MD; 818310)
- Apr 26, 2015-A
(N87WS; 60617043)
- Apr 29, 2015-A
(N191TA; 5039383)
- May 2, 2015-A
(N87WS; 50617043)

DVRPC PA

- Apr 2, 2015-A
(N170TA; 50811038)
- Apr 2, 2015-A
(N344Q; 40312131)
- Apr 18, 2015-A
(N170TA; 50811038)

New Jersey

- May 29, 2015-A
(N344Q; 40312131)
- May 29, 2015-B
(N344Q; 40312131)
- Apr 1, 2015-A
(N344Q; 40312131)
- Apr 2, 2015-A
(N344Q; 40312131)
- Apr 6, 2015-A
(N441MD; 817310)
- Apr 16, 2015-A
(N87WS; 50617043)
- Apr 18, 2015-A
(N441MD; 817310)
- Apr 19, 2015-A
(N170TA; 50811038)
- Apr 19, 2015-A
(N441MD; 817310)
- Apr 26, 2015-A
(N87WS; 60617043)
- Apr 29, 2015-A
(N191TA; 5039383)
- May 2, 2015-A
(N87WS; 50617043)
- May 3, 2015-A
(N87WS; 50617043)

Mercer County, NJ

- Apr 18, 2015-A
(N69WA; 50616147)
- Apr 19, 2015-A
(N69WA; 50616147)

LVPC-PA

- Apr 18, 2015-A
(N170TA; 50811038)
- Apr 19, 2015-A
(N170TA; 50811038)

YCPC-PA

- Apr 2, 2015-A
(N344Q; 40312131)
- Apr 6, 2015-A
(N441MD; 817310)
- Apr 5, 2015-A
(N344Q; 40312131)
- Apr 12, 2015-A
(N344Q; 40312131)

3. Processing Summary

3.1. Flight Logs

Flight logs were completed by ortho camera technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- System
- Flight Date / Lift Number
- Flight Line Number
- Flight Line Start Time
- Flight Line Stop Time
- Image Range
- F-Stop Setting
- Shutter Setting

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc). Project specific flight logs for each sortie are available in Appendix A.

3.2. Imagery Processing Summary

Within the UltraMap software suite, raw acquired images are radiometrically and geometrically corrected using the camera's calibration files and output as Level 2 images. The resulting radiometry is then manually edited to ensure each image has the appropriate tone, no pixels are clipped, and to blend each image with its neighbors. Once radiometry has been edited, separate RGBI and Panchromatic images are blended together to form single 4 band TIFF images.

Image radiometric values were calibrated to specific gain and exposure settings associated with each capture using Microsoft's UltraMap software suite. The calibrated images were saved in TIFF format for input to subsequent processes. Photo position and orientation were calculated by linking the time of image capture, the corresponding aircraft position and attitude, and the smoothed best estimate of trajectory (SBET) data in POSPAC. Adjusted images were then draped upon a ground model and orthorectified. Individual orthorectified tiffs were blended together to remove seams and corrected for any remaining radiometric differences between images using Inpho's OrthoVista.

3.3. Airborne GPS and IMU Post Processing

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Applanix POSPac processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: Max horizontal / vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory. All relevant processing results, plots and graphs produced in the POSPac processing environment

for each of the 21 sorties are provided in Appendix A.

3.4. Aerotriangulation

Using RAW images, Airborne ABGPS/IMU external orientation parameters and ground control data the imagery control solution was further extended and densified using analytical aerotriangulation adjustment techniques. This adjustment of the measurements was performed using a robust aerotriangulation software package, Image Station Aero Triangulation (ISAT) software, on softcopy photogrammetric workstations. A total of two aerotriangulation blocks were developed for the project, high and low. Each block was mathematically tied to its neighbor to ensure a uniform aerotriangulation solution for the entire area of interest. The final adjustment of these blocks was accomplished by using a rigorous simultaneous least squares bundle.

3.5. Orthophotography Creation

Digital orthophoto frames are created by using National Elevation Dataset (NED) Digital Elevation Models (DEM), which were in turn combined with processed RAW imagery and aerotriangulation data. Manual Seamlines were drawn in MicroStation on every frame. Then, using the grid created with in-house software a set of “base” mosaicked tiles were created in Intergraph OrthoPro using a bilinear interpolation method on the three data sources (processed RAW imagery, aerotriangulation data and surface data). At this stage a final color balancing is also done to ensure a superior balance across the entire dataset. The first step to the quality control process is to draw circles on areas of concern. Reviewers look for mismatches at seamlines, smears caused by elevation discrepancies (building lean, bridge warping) and radiometric distortions. Then, a different technician edits the circles. Thus, images were thoroughly reviewed by the technician who circled errors as well as the editor, so that each image has been seen by at least three sets of eyes before submitted. Please see the Aerotriangulation Reports in Appendix C for more information.

Tile layouts are shown in Figure 5 through Figure 12 on the following page.

Figure 5. DVRPC - NJ & PA - UTM 18 Tile Layout

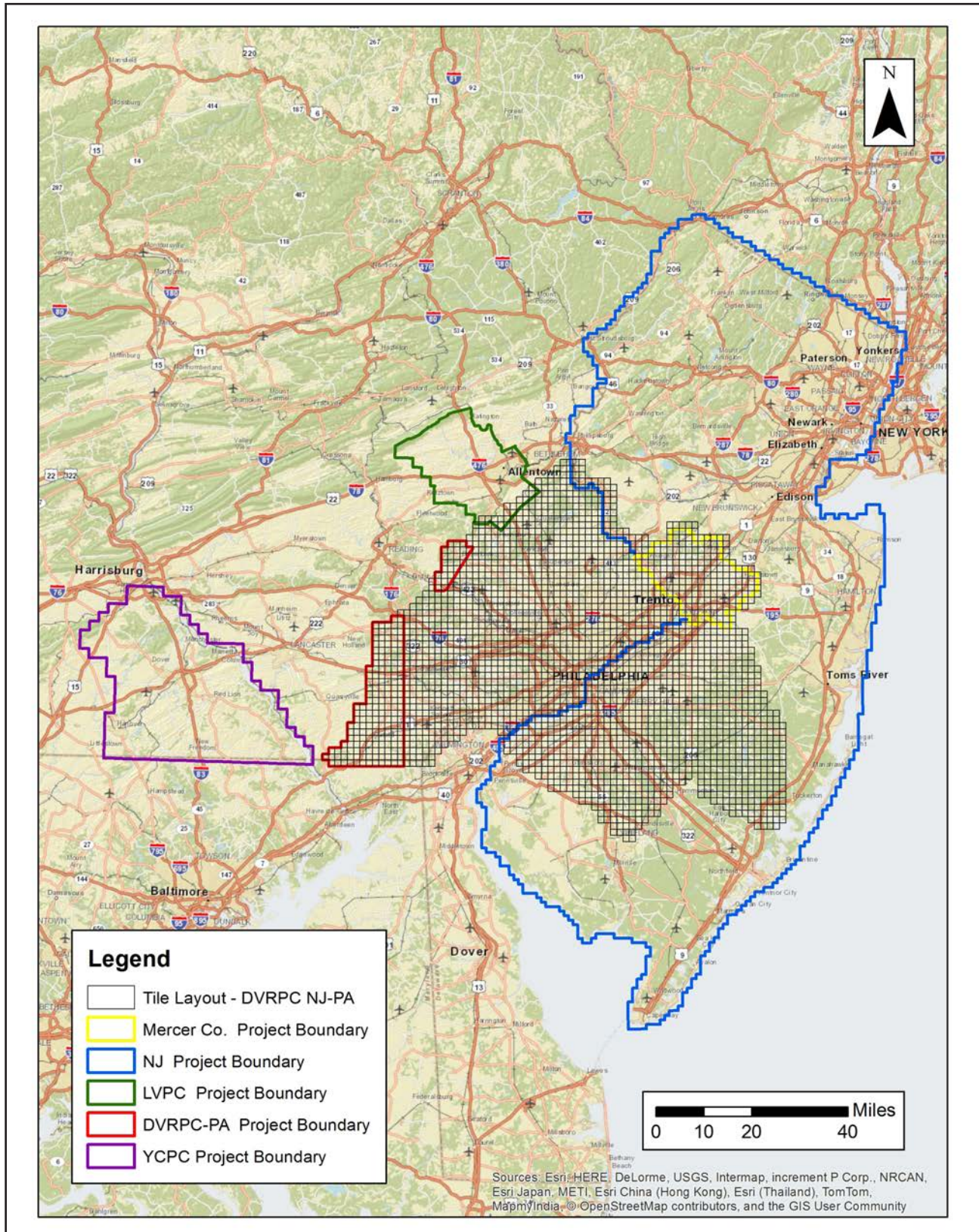


Figure 6. DVRPC - NJ - State Plane NJ Tile Layout

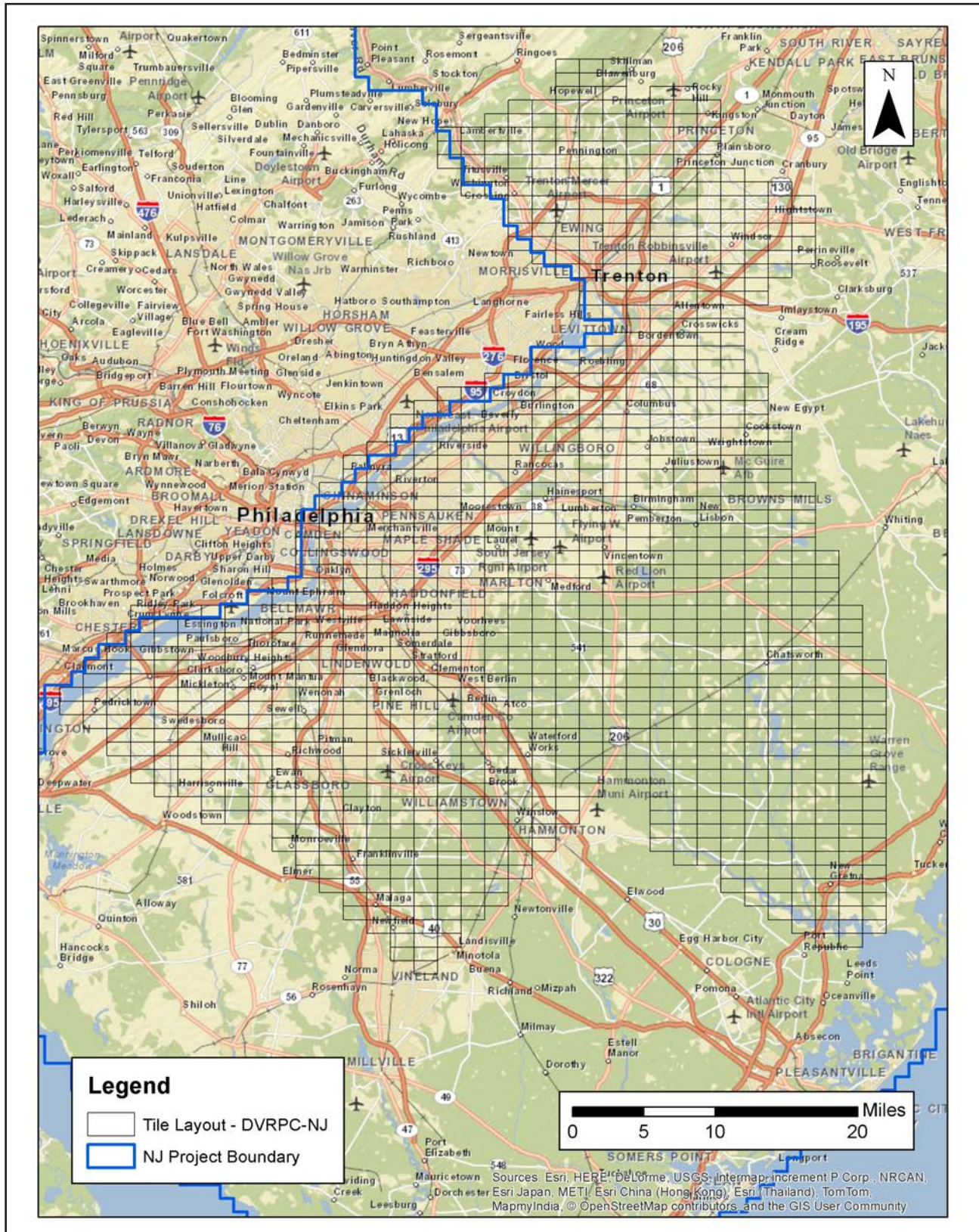


Figure 7. DVRPC - PA - State Plane PA South Tile Layout

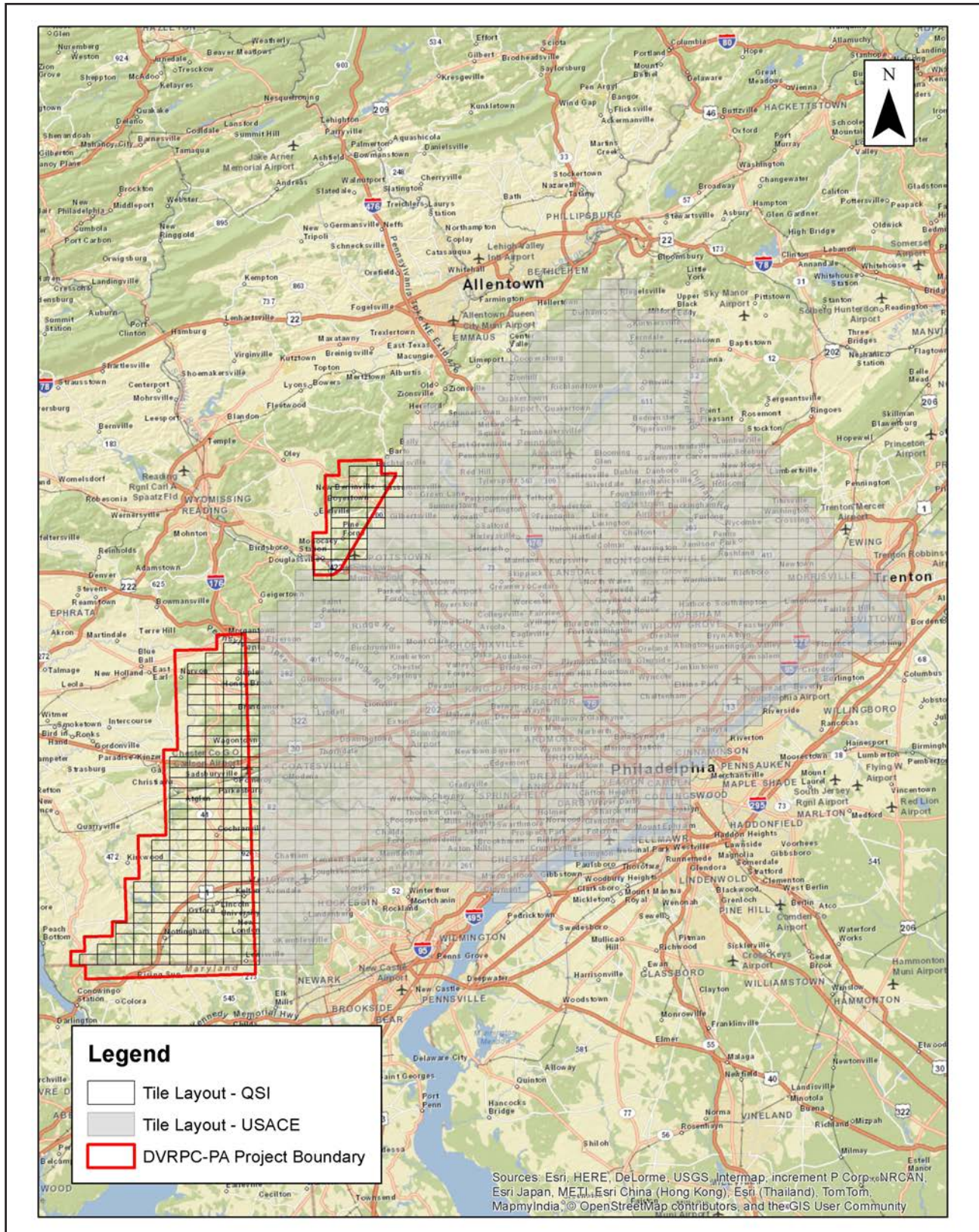


Figure 8. New Jersey NJOIT - UTM 18 Tile Layout

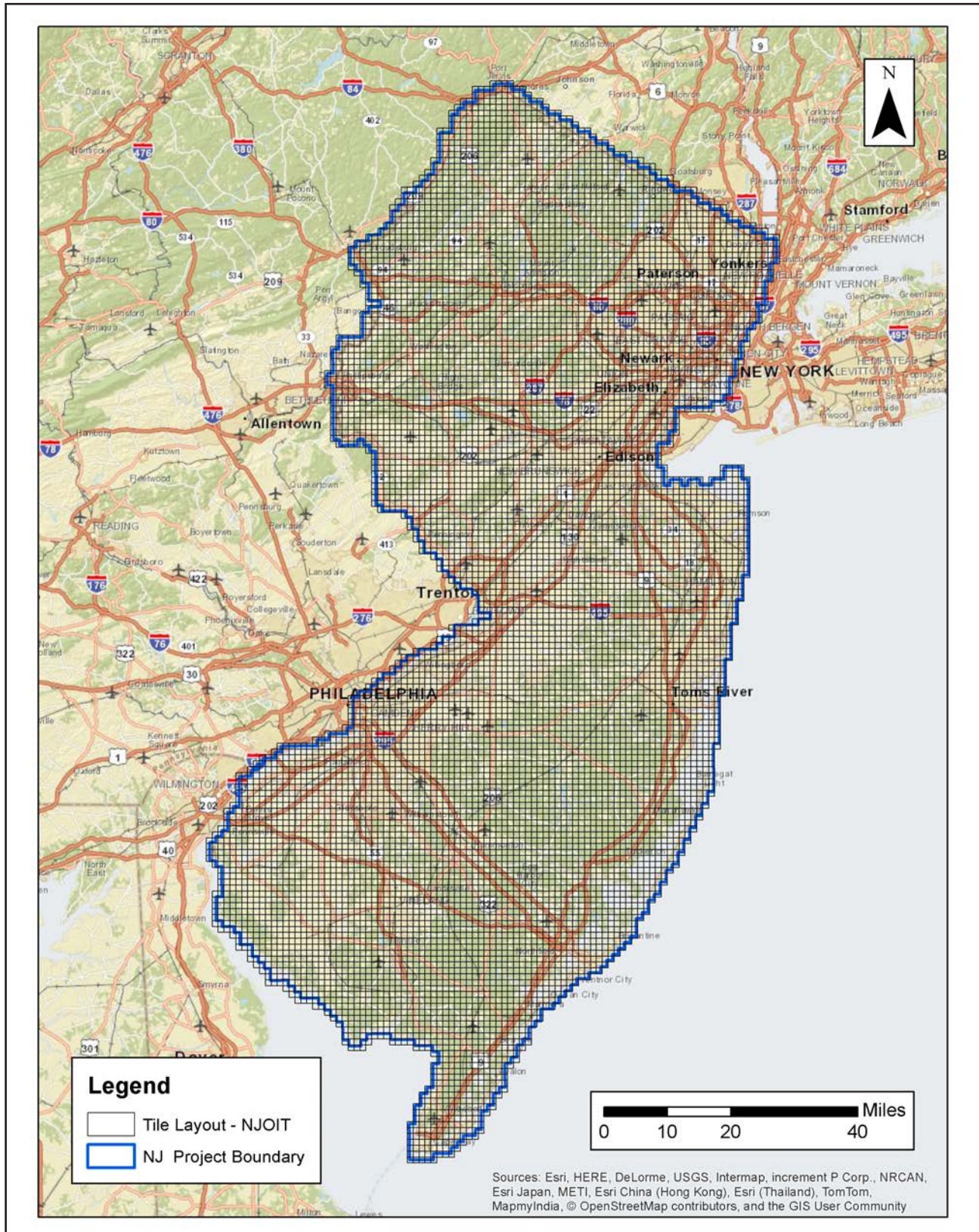


Figure 9. New Jersey NJOIT - State Plane NJ Tile Layout

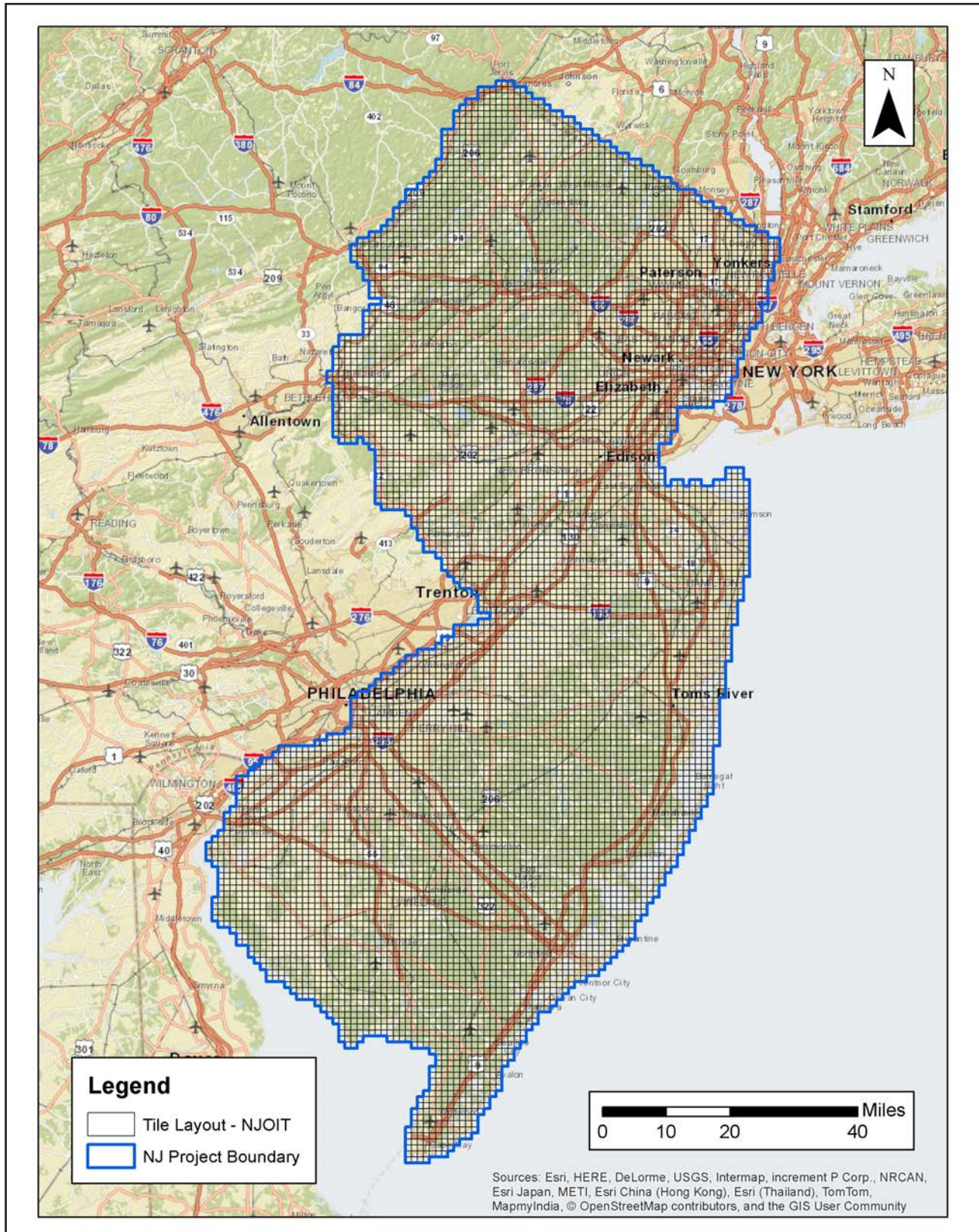


Figure 10. Mercer County, NJ - State Plane NJ

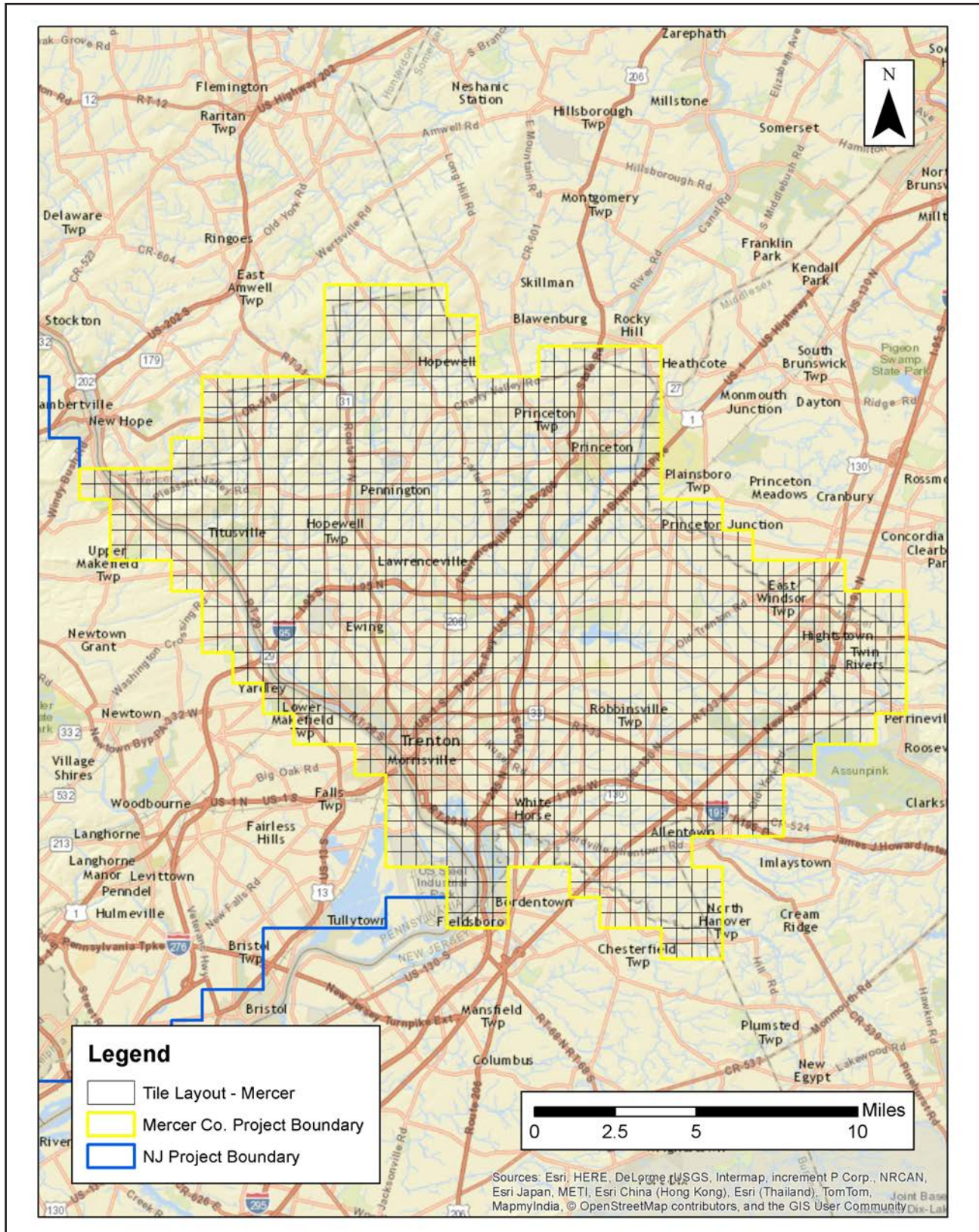


Figure 11. LVPC - State Plane PA South Tile Layout

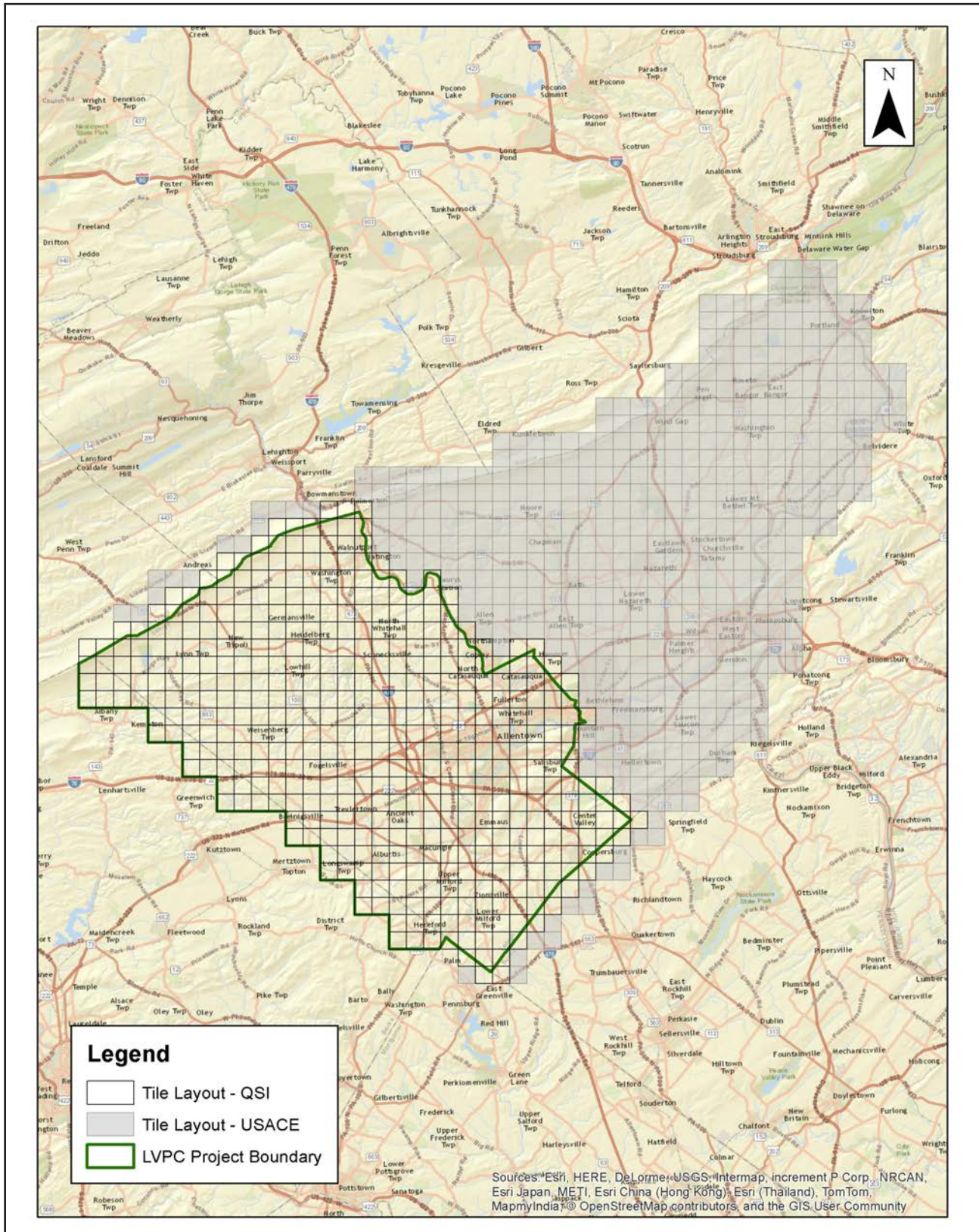
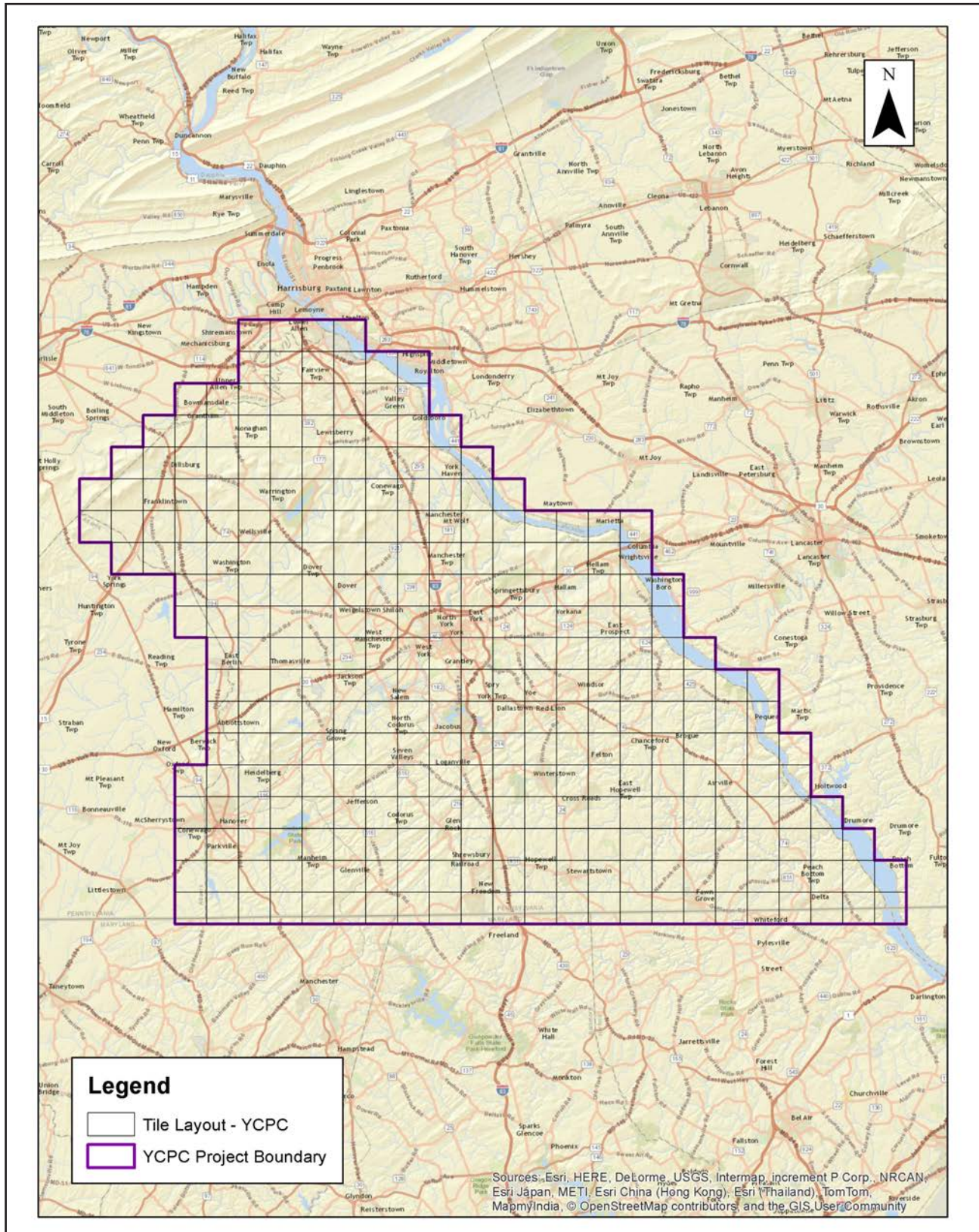


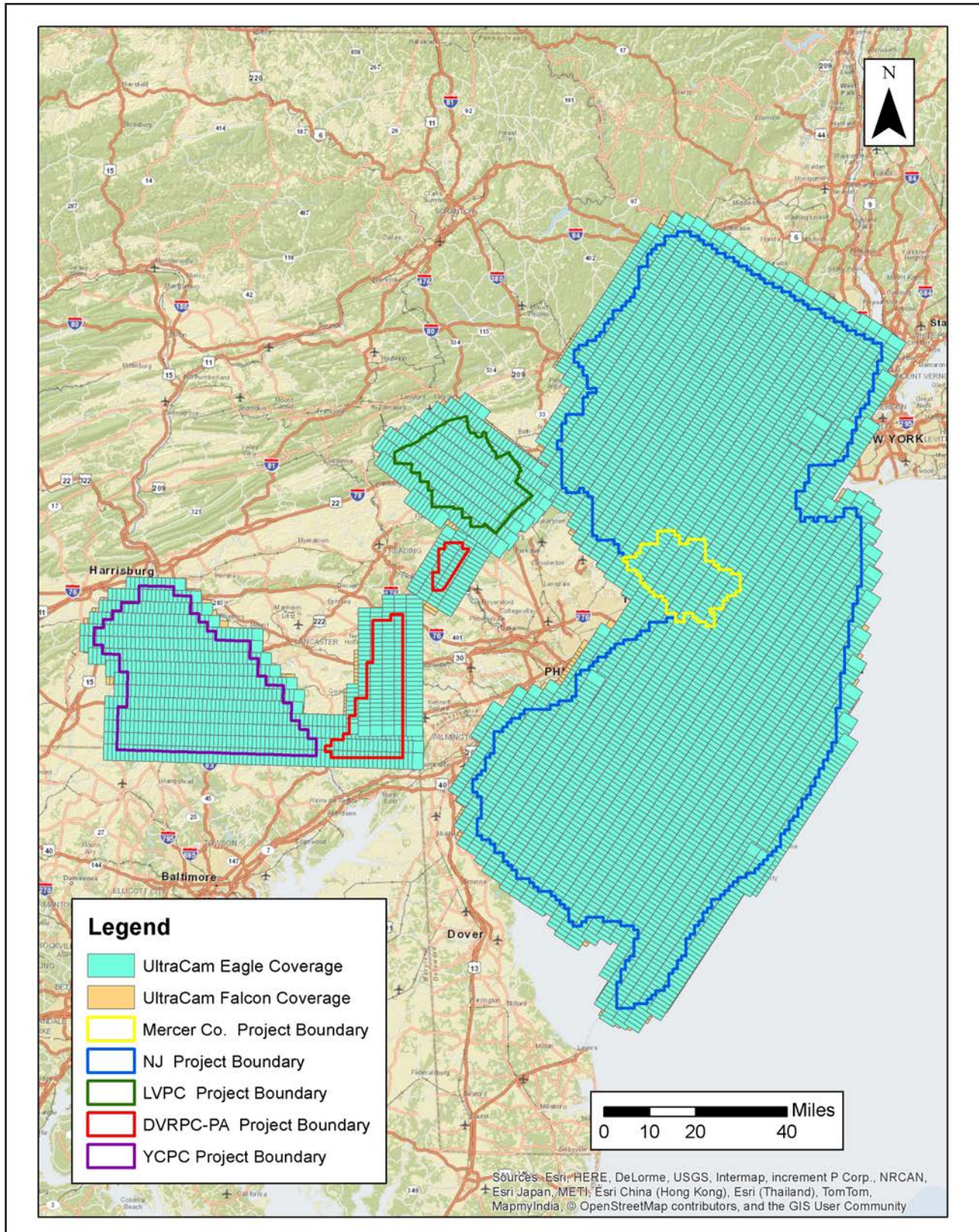
Figure 12. YCPC - State Plane PA South Tile Layout



4. Project Coverage Verification

The project area's imagery frame coverage (see Figure 13) and content verification was performed and validated by visual review. This action was performed in the field by flight crew during the acquisition phase as well as by imagery QA technicians at our processing center. The ABGPS/IMU and base station data was uploaded to the company FTP site after each flight for the INS processing team in Lexington, Kentucky to verify accuracy of data collected.

Figure 13. Project Area Coverage



5. Ground Control and Check Point Collection

5.1. Orthoimagery Testing

Upon completion of all production activities and prior to delivery of the final orthophoto dataset, Quantum Spatial used Accuracy Analyst QC software to compute the overall accuracy of the orthophoto data set using 57 of the 68 surveyed control points that were established for the project. Thirteen points were not visible on the final orthophotos due to ground obstructions. These points were not used in the production process. All point locations can be seen in Figure 14. Please see the Survey Report in Appendix C for more information.

Accuracies were computed for the entire 1-foot project area for the data in UTM Zone 18, meters. The overall RMSE_x was measured and computed to be 0.299 m. The overall RMSE_y was measured and computed to be 0.303 m. The horizontal accuracy at the 95% confidence level was computed to be 0.426 m. The NSSDA at the 95% confidence level was calculated to be 0.737 m, which meets the target value of 1.52 m. Please see the Ortho Accuracy Analyst report in Appendix D for more information.

Figure 14. QC Point locations

