

APPENDIX G:

Noise Analysis Methodology and Noise Figures

Noise Analysis Methodology

The sound propagation modeling occurred in Cadna-A, a 3-dimensional acoustical analysis software package designed for evaluating environmental noise from stationary and mobile sources. Cadna-A uses as the basis for its models the International Organization for Standardization (ISO) standard 9613-2, "*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*," adopted by the ISO in 1996 (ISO 1996). This standard provides a widely accepted engineering method for the calculation of outdoor environmental noise levels.

FTA's *Transit Noise and Vibration Assessment* (FTA 2006) provides a method for computing sound levels from fixed-guideway (train) sources. These calculation methods were mathematically manipulated to derive input data which is compatible with the Cadna-A software package. These manipulations yielded a Sound Power Level (symbol: L_W ; abbreviation: SWL) and some adjustment factors, depending upon the type of noise source.

Table G-1 shows the parameters derived for use in train-noise-source modeling. OEA validated these parameters in abstract model scenarios and compared them with hand calculations using the FTA propagation equations. The Cadna-A results were found to under-predict levels by 0.1 to 1.0 dBA. Therefore, a conservative 2 dBA is added to compensate.

Table G-1. Train Noise Source Modeling Parameters				
Train Noise Source	Point-source Modeling Parameter			
	Type	Quantity ^a	SWL ^b (dBA)	Adjustment ^c (dBA)
Diesel-electric locomotives	Moving	$Q = V \times N_{\text{loco}}$	$120 + 2 = 122$	$+ C_{\text{throttle}}$
Railcars	Moving	$Q = V \times N_{\text{cars}}$	$97 + 2 = 99$	$+ 30 \log(S/S_{\text{ref}}) + C_{\text{track}}$
Locomotive warning horns	Moving	$Q = V$	$142 + 2 = 144$	$+ 0$
Idling locomotive on siding	Stationary	$T = \{\text{special}^d\}$	104.6	$+ 0$

Where:

- Q = Number of noise events for moving point sources.
- T = Duration of noise events for stationary point sources.
- V = Train traffic volume (number of trains).
- N_{loco} = Number of locomotives per train.
- N_{cars} = Number of railcars per train.
- S = Average speed of train.
- S_{ref} = Reference speed of 50 mph [80.5 km/h].
- C_{throttle} = Adjustment for throttle setting: 0 to 5 = 0 dBA; 6 = 2 dBA; 7 = 4 dBA; 8 = 6 dBA.
- C_{track} = Adjustment for track conditions: CWR = 0 dBA; jointed track = 5 dBA.

Source: FTA 2006, *Transit Noise and Vibration Impact Assessment*, FTA-VA-90-1003-03,
http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf.

Notes:

- ^a Quantities are distributed among daytime (07:00 AM to 10:00 PM) and nighttime (10:00 PM to 07:00 AM) proportionately such that an average daytime hour and an average nighttime hour will have equal quantities.
- ^b Sound Power Level (SWL) derived from values in FTA (FTA 2006, *Transit Noise and Vibration Impact Assessment*, FTA-VA-90-1003-03, http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf). The moving point-source adjustment +2 for is to compensate for under-predicting levels by 0.1 to 1.0 dBA when computer model is validated against hand-calculations.
- ^c Adjustment formulas derived from detailed noise assessment formulas in FTA (2006). These are the remaining terms after balancing the FTA equation against the computer-modeling equation for each type of noise source.
- ^d Assumptions for duration of stationary noise events are discussed below.

The input data for the model were drawn from the operational characteristics of the Line. Table G-2 and Table G-3 present, respectively, the existing and proposed Line operational characteristics which affect noise levels. There are 2 types of train consists identified to run on the rail line segments under the Proposed Transaction. To facilitate this analysis, OEA aggregated the characteristics of the 2 types of train consists to an “average” train consist.¹ OEA divided track segments into sub-segments where speed changes would occur.

Table G-2. Existing Rail Line Operational Characteristics									
Segment No.	Sub-segment No.	Milepost		Total TPD^a	Average Loco^b	Average Cars^c	Speed (mph)	Throttle Setting^d	Track Condition
		Begin	End						
LIRC-01	01.A	4.0	20.0	2.0	2.0	43.1	25.0	8	Jointed ^e
	01.B	20.0	20.7	2.0	2.0	43.1	25.0	8	Jointed
	01.C	20.7	37.0	2.0	2.0	43.1	25.0	8	Jointed
	01.D	37.0	42.0	2.0	2.0	43.1	20.0	8	Jointed
	01.E	42.0	58.9	2.0	2.0	43.1	25.0	8	Jointed
	01.G	58.9	59.3	2.0	2.0	43.1	25.0	8	Jointed
LIRC-02	02.A	59.3	104.5	4.0	2.0	57.0	25.0	8	Jointed
LIRC-03	03.A	104.5	106.0	7.0	2.0	51.1	20.0	8	Jointed
	03.B	106.0	108.3	7.0	2.0	51.1	10.0	8	Jointed
	03.C	108.3	108.9	7.0	2.0	51.1	20.0	8	Jointed
	03.D	108.9	109.0	7.0	2.0	51.1	6.0	8	Jointed
	03.E	109.0	110.5	7.0	2.0	51.1	10.0	8	Jointed

Source: CSXT 2011, LIRC Easement Information Request, June 1, 2011.

Notes:

^a Total trains per day is sum of LIRC trains per day (TPD) and CSXT TPD.

^b Average number of locomotives per train is TPD-weighted average of LIRC and CSXT train consists.

^c Average number of railcars per train is TPD-weighted average length of LIRC and CSXT train consists, where each car is assumed to be 70 feet.

^d A throttle is a device controlling the flow of power sent to the drive wheels. There are 8 settings; the higher the setting, the faster the locomotive moves and the louder it is.

^e A jointed track is made of rail segments bolted together using joint bars.

¹ A train consist is a sequence of railroad cars and locomotives that make up a train.

Table G-3. Proposed Rail Line Operational Characteristics									
Segment No.	ID	Milepost		Total TPD^a	Average Loco^b	Average Cars^c	Speed (mph)	Throttle Setting	Track Condition
		Begin	End						
LIRC-01	01.A	4.0	20.0	17.0	2.0	97.8	49.0	8	CWR ^d
	01.B	20.0	20.7	17.0	2.0	97.8	40.0	8	CWR
	01.C	20.7	37.0	17.0	2.0	97.8	49.0	8	CWR
	01.D	37.0	42.0	17.0	2.0	97.8	20.0	8	CWR
	01.E	42.0	58.9	17.0	2.0	97.8	49.0	8	CWR
	01.G	58.9	59.3	17.0	2.0	97.8	35.0	8	CWR
LIRC-02	02.A	59.3	104.5	17.0	2.0	97.8	49.0	8	CWR
LIRC-03	03.A	104.5	106.0	20.0	2.0	89.6	20.0	8	CWR
	03.B	106.0	108.3	20.0	2.0	89.6	20.0	8	CWR
	03.C	108.3	108.9	20.0	2.0	89.6	20.0	8	CWR
	03.D	108.9	109.0	20.0	2.0	89.6	20.0	8	CWR
	03.E	109.0	110.5	20.0	2.0	89.6	20.0	8	CWR

Source: CSXT 2011, LIRC Easement Information Request, June 1, 2011.

Notes:

^a Total TPD is sum of LIRC TPD and CSXT TPD.

^b Average number of locomotives per train is TPD-weighted average of LIRC and CSXT train consists.

^c Average number of railcars per train is TPD-weighted average length of LIRC and CSXT train consists, where each car is assumed to be 70 feet.

^d Continuously welded rail track is made of rails welded together to form a continuous rail as opposed to a jointed rail track.

In addition to modeling trains in motion, OEA also modeled idling trains on sidings in the study area. The following assumptions are the basis for the duration of idling locomotives on a siding:

- All of the existing train traffic, for practical purposes, does not use any of the existing sidings.
- Of the proposed train traffic, 25 percent would need to idle on any one siding, and would be equally distributed among the 4 proposed sidings (2 new and 2 expanded).
- Each train would have 2 locomotives on one end and would have equal probability that it would face one way or another on a siding.
- Each train that idles on a siding would do so for 15 minutes at a time.

Given that sidings are on segments LIRC-01 and LIRC-02 only, there would be 17 trains per day (TPD) proposed on the rail line alongside each of the 4 proposed sidings. Each train would have 2 locomotives; therefore, each siding would have 4 potential locomotive positions – 2 locomotives at each end. Based on these assumptions, each of the 4 positions would have a daily average of 0.53 locomotives idling for 15 minutes. Therefore, the duration of the 4 locomotive noise point-sources would be 8 minutes per day, each (using the symbol “T” for the duration in Table G-1).

With the input data identified in the tables above, the locomotives and railcars were entered as moving point-sources in the sound propagation model, divided into rail-line segments and subsegments. OEA modeled horn noise at all public at-grade crossings (no QZs were identified in the rail lines) as moving point-sources. Stationary sources such as idling locomotives were entered as individual point-sources in the sound propagation model.

As part of the data entry, the sound propagation model calculated the sound power levels per unit-length of rail line. OEA used these values to find the increase in noise emission levels that would result from the proposed project, as compared to existing train traffic.

After completing calculations for both existing and proposed train operations, the output of the sound propagation model (noise contours) was imported into the GIS database. Obstructions which interrupt the line-of-sight to train sound sources provide a measure of shielding and correspondingly reduce sound levels. Therefore, the shielding effects due to intervening buildings were applied within the GIS database (noise contours were adjusted).

This analysis incorporated the shielding elements of the *FRA Horn Noise Model*. Aerial photographs dated 2011 were used to identify built-up areas where buildings are likely to provide shielding. In locations with a contiguous built-up area adjacent to the Line, for example, where the Line passes through cities and towns, assumptions associated with the FRA's "rural" shielding condition described below were used to apply shielding values to the sound propagation model results and adjust the noise contours.

The *FRA Horn Noise Model* uses generalized shielding conditions, rather than calculating the shielding due to particular obstructions (FRA 2011b). FRA identifies the following shielding conditions:

- Dense Urban
- Light Urban
- Dense Suburban
- Light Suburban
- Rural
- No Shielding

Table G-4 shows the assumptions associated with the above shielding conditions.

Table G-4. Shielding Condition^a Parameters				
Building Density		Building Environment		
Dense	Light	Urban	Suburban	Rural^b
Shielding Value (dBA)		Shielding Distance (ft)		
None	None	< 100	< 200	< 300
5.0	3.0	100 to 300	200 to 400	300 to 500
6.5	4.5	300 to 500	400 to 600	500 to 700
8.0	6.0	500 to 700	600 to 800	700 to 900
9.5	7.5	700 to 900	800 to 1,000	900 to 1,100
11.0	9.0	> 900	> 1,000	> 1,100

Notes:

^a Shielding condition is a combination of building density and building environment, for example the shielding condition “Dense Suburban.”

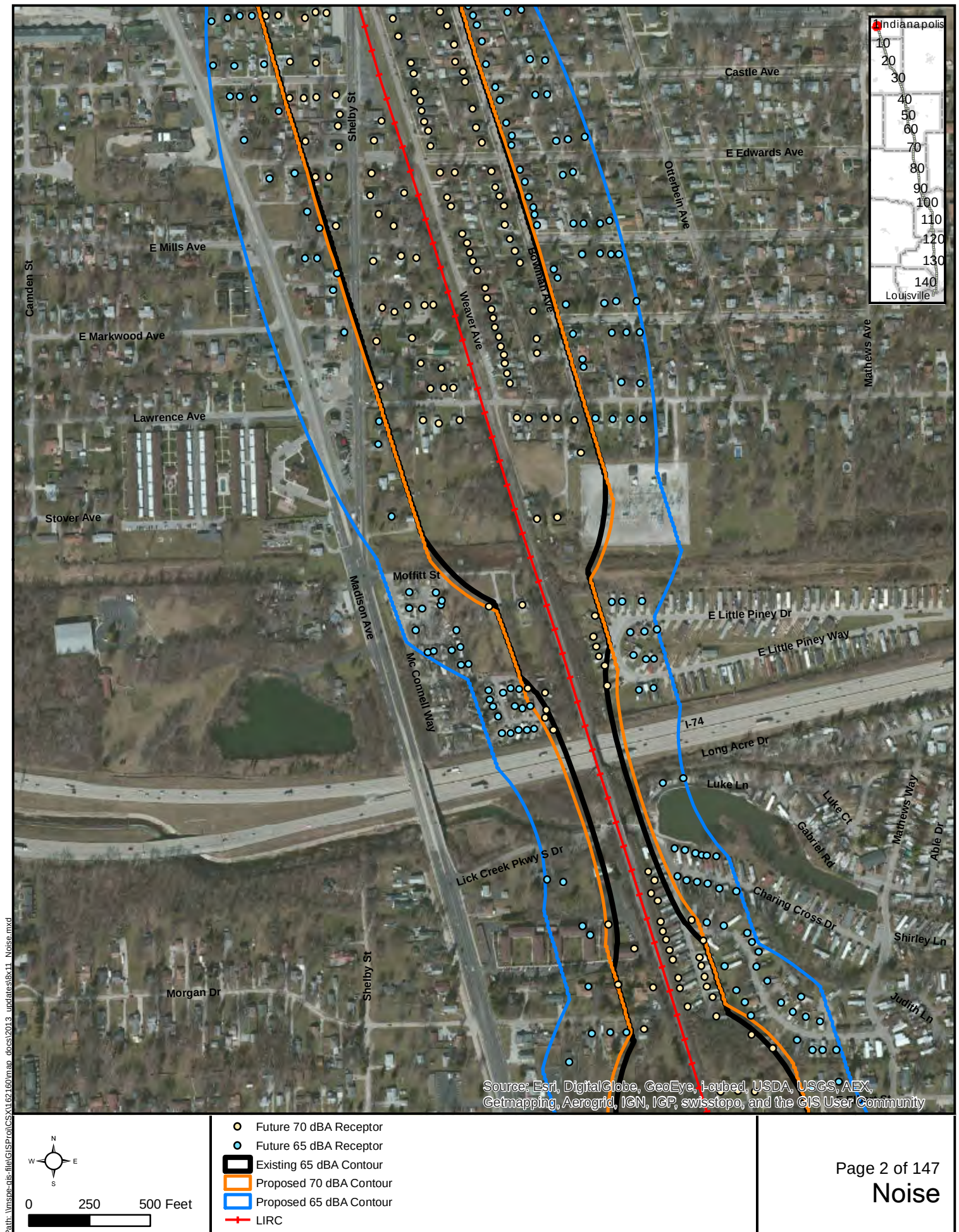
^b Rural shielding conditions only use “Light” building density – there is no “Dense Rural” shielding condition.

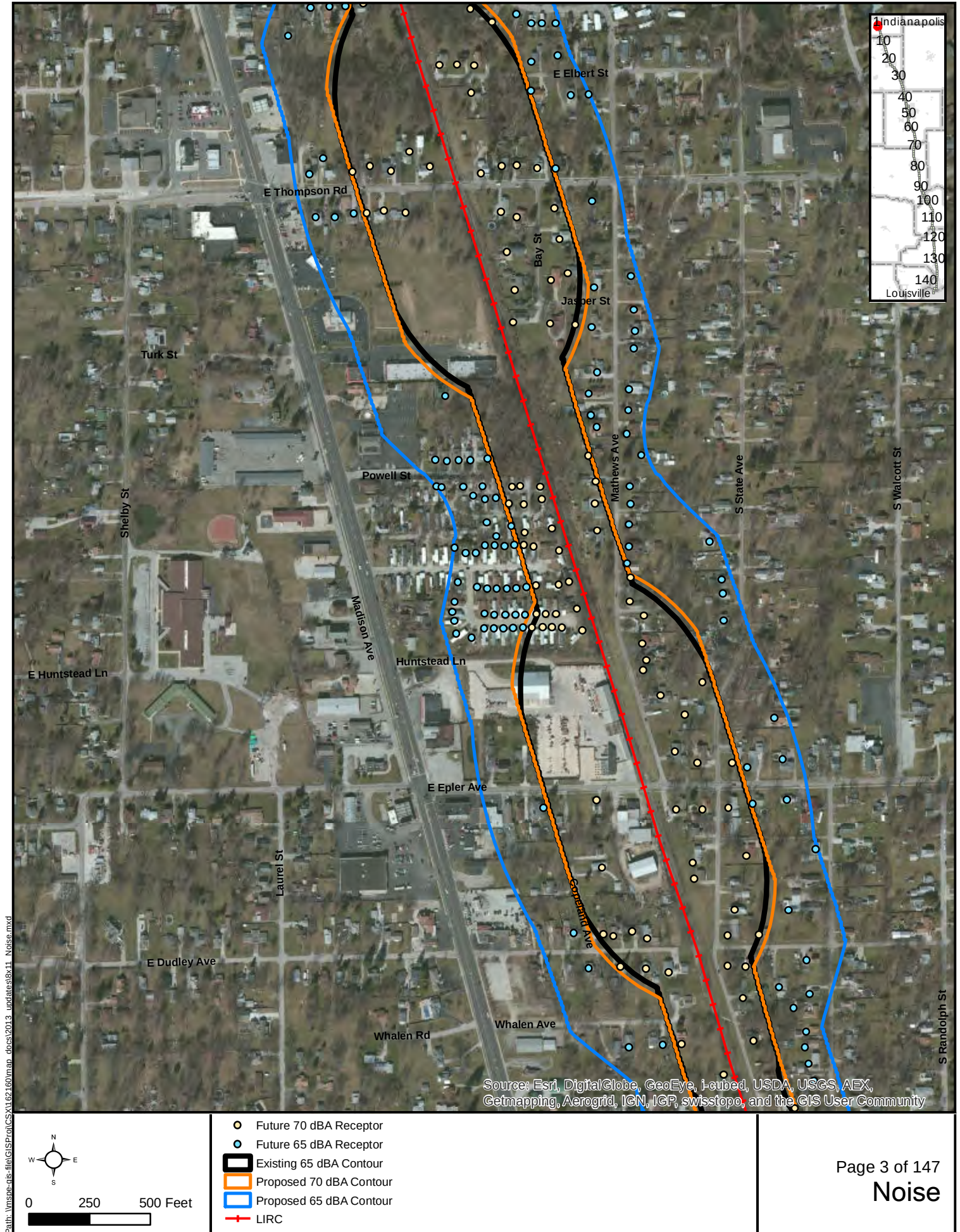
Finally, the analysis identified where the L_{dn} due to the proposed trains is predicted to be 65 dBA or greater. The 65-dBA L_{dn} contour was plotted in GIS, based on the calculated project-related noise levels. In addition, noise-sensitive receptors (as defined by the Board) within the contour were identified through a visual inspection of 2011 publicly available digital aerial photography.

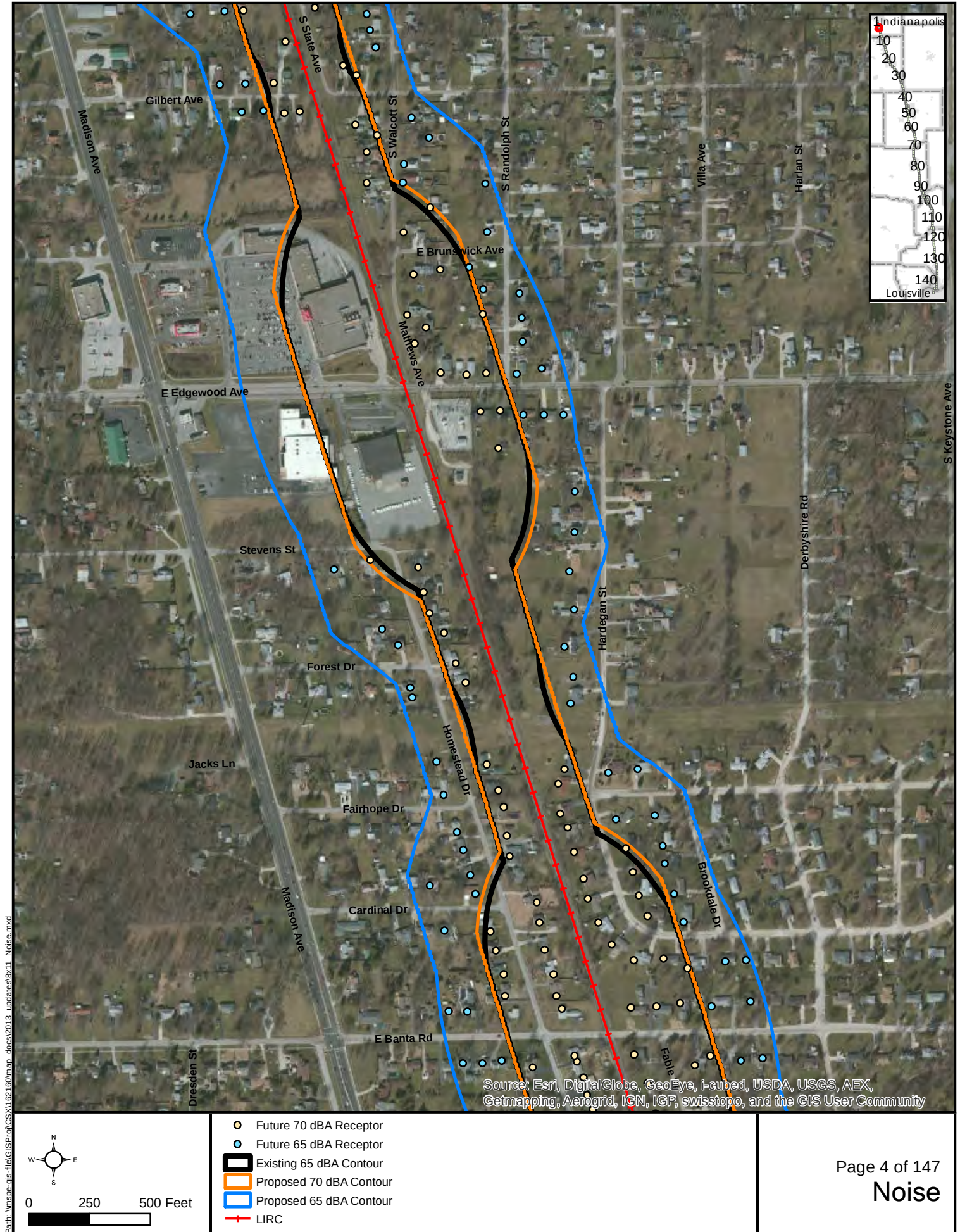
Other noise modeling parameters can be summarized as:

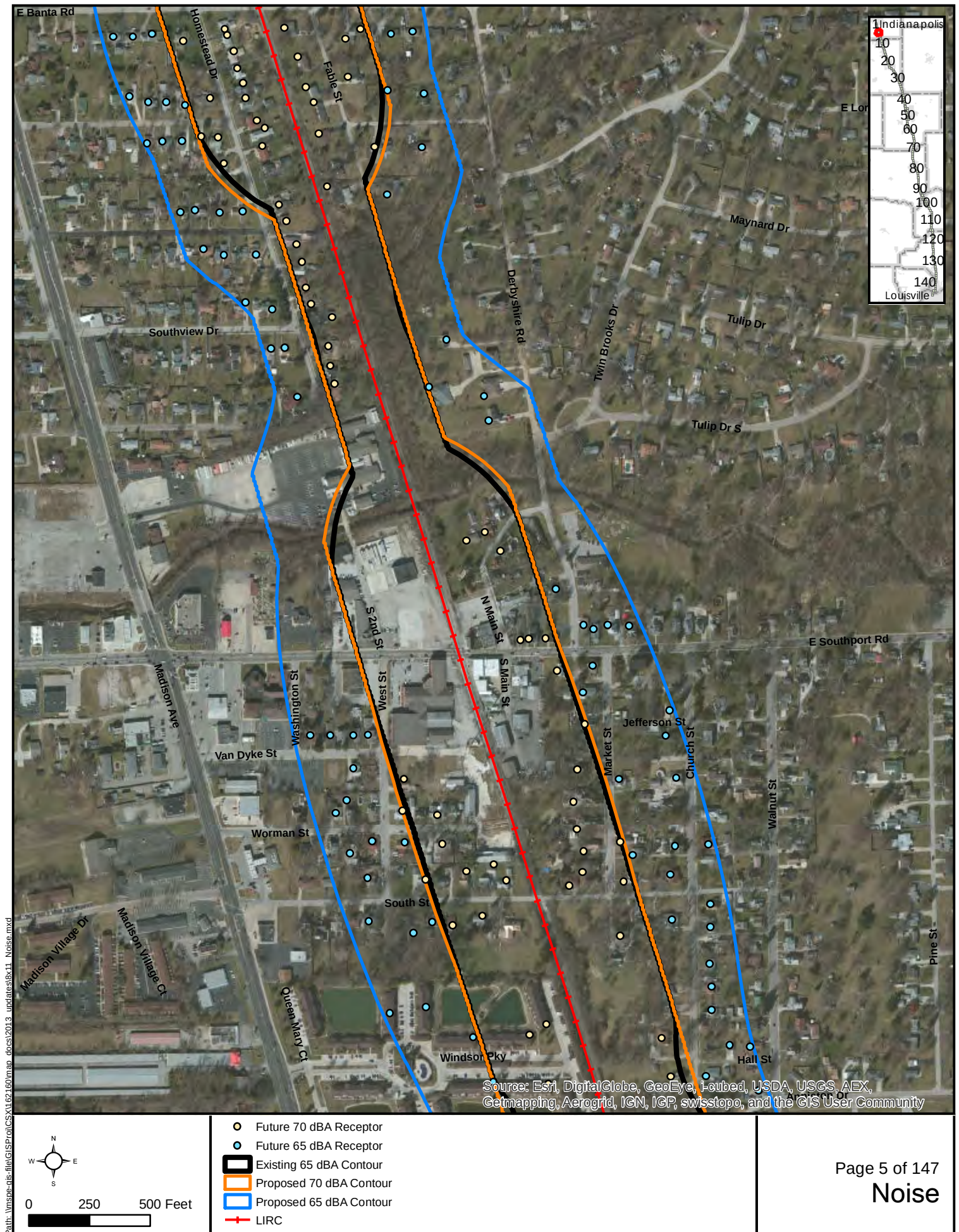
- The track conditions would change to continuously welded rail from the existing jointed rail.
- The proposed number of trains per day and the train speeds would increase from the existing number.
- The proposed number of locomotives in an average train would not change from the existing number, but the proposed number of railcars in an average train would increase.
- The locations and number of at-grade crossings would not change.
- The proposed number and duration of idling locomotives would increase over the existing number and duration of zero idling locomotives.
- The shielding conditions would not change.

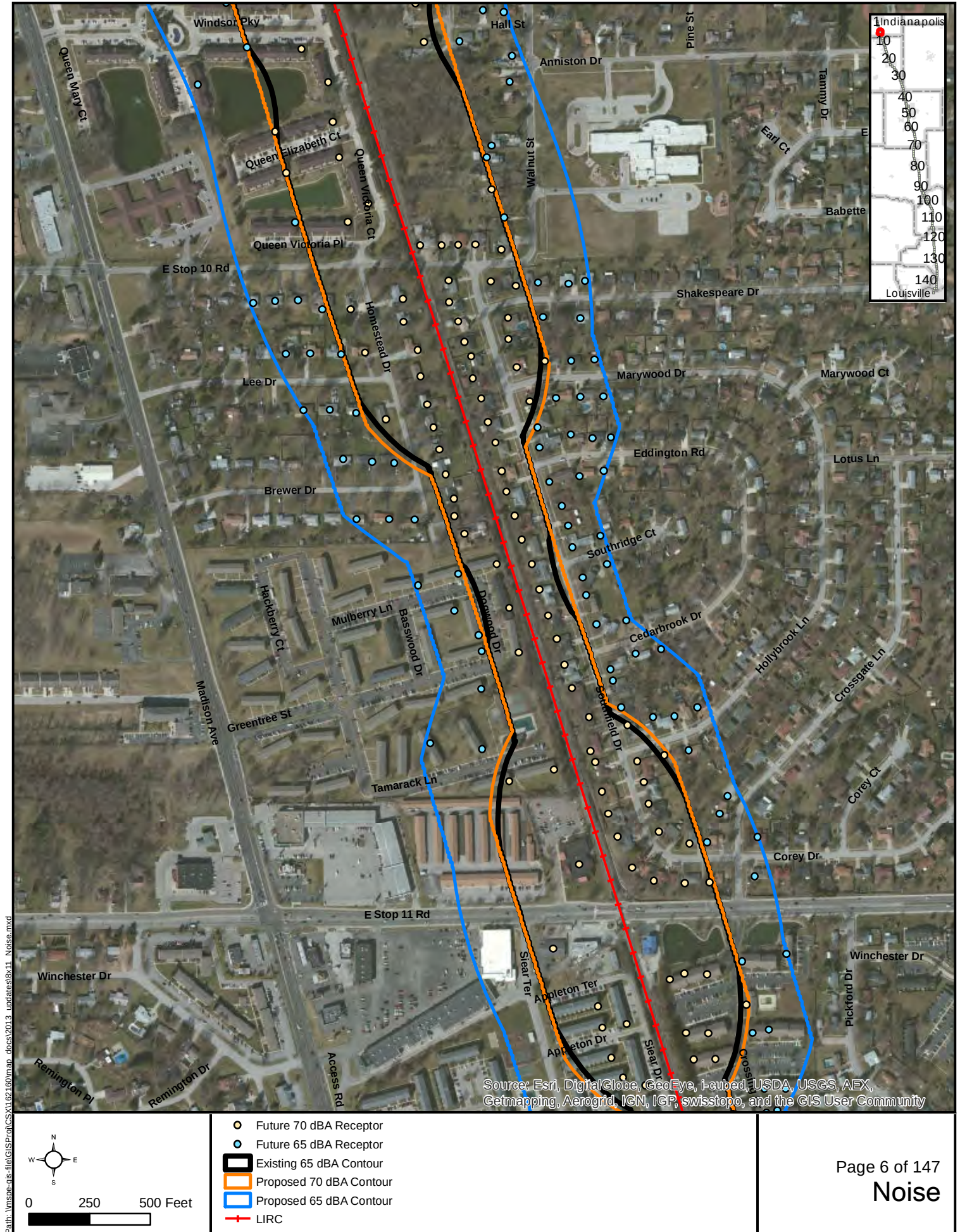


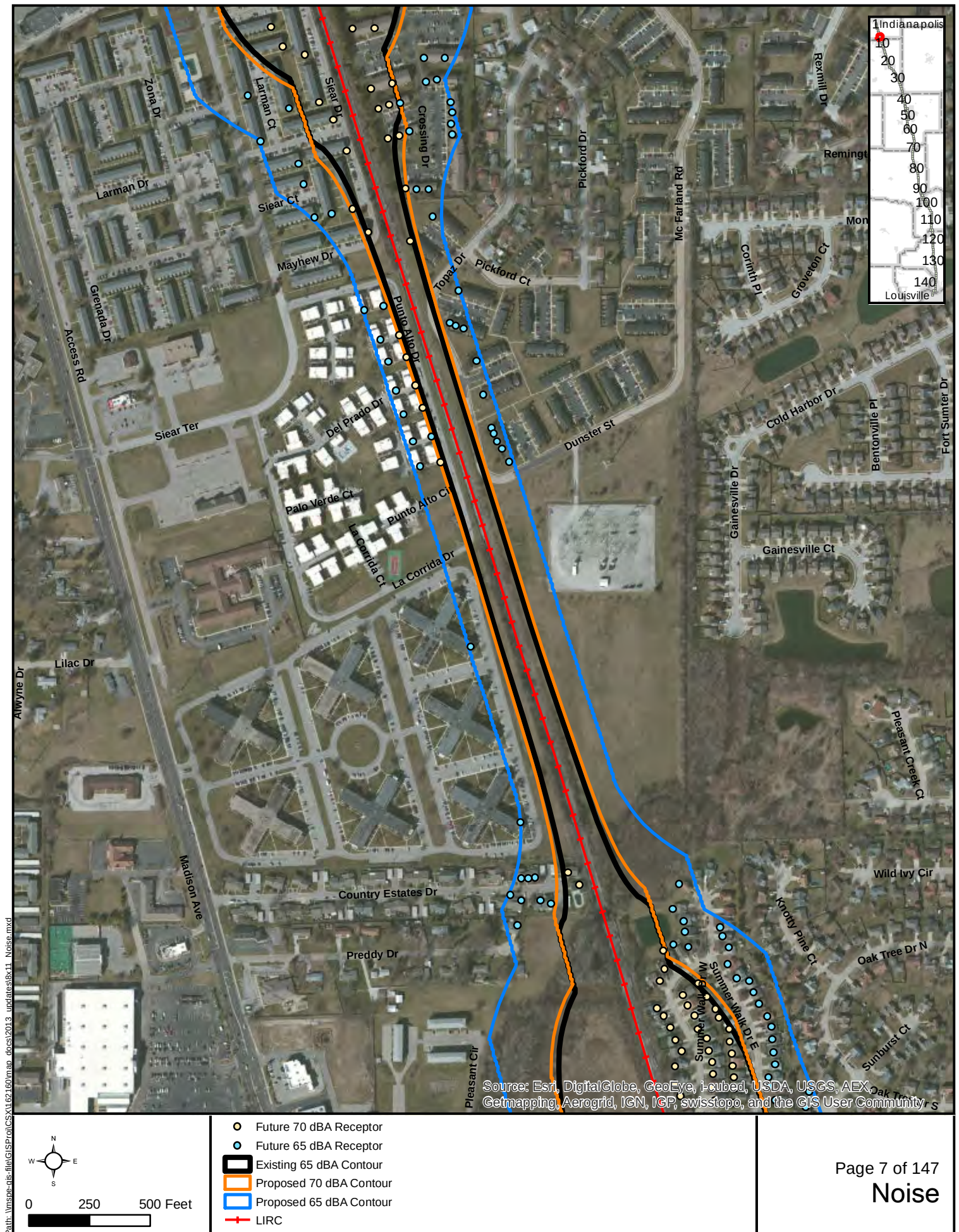


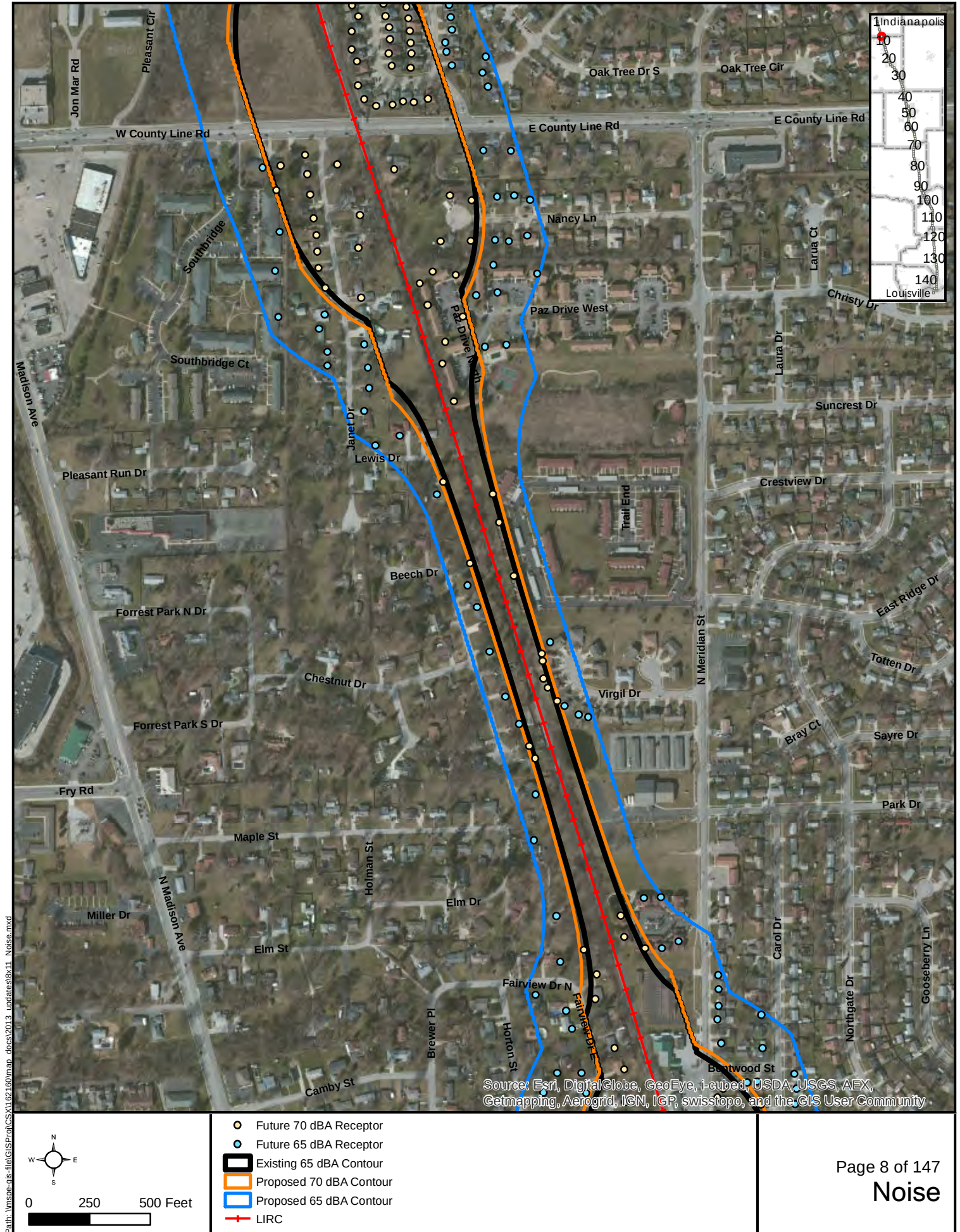




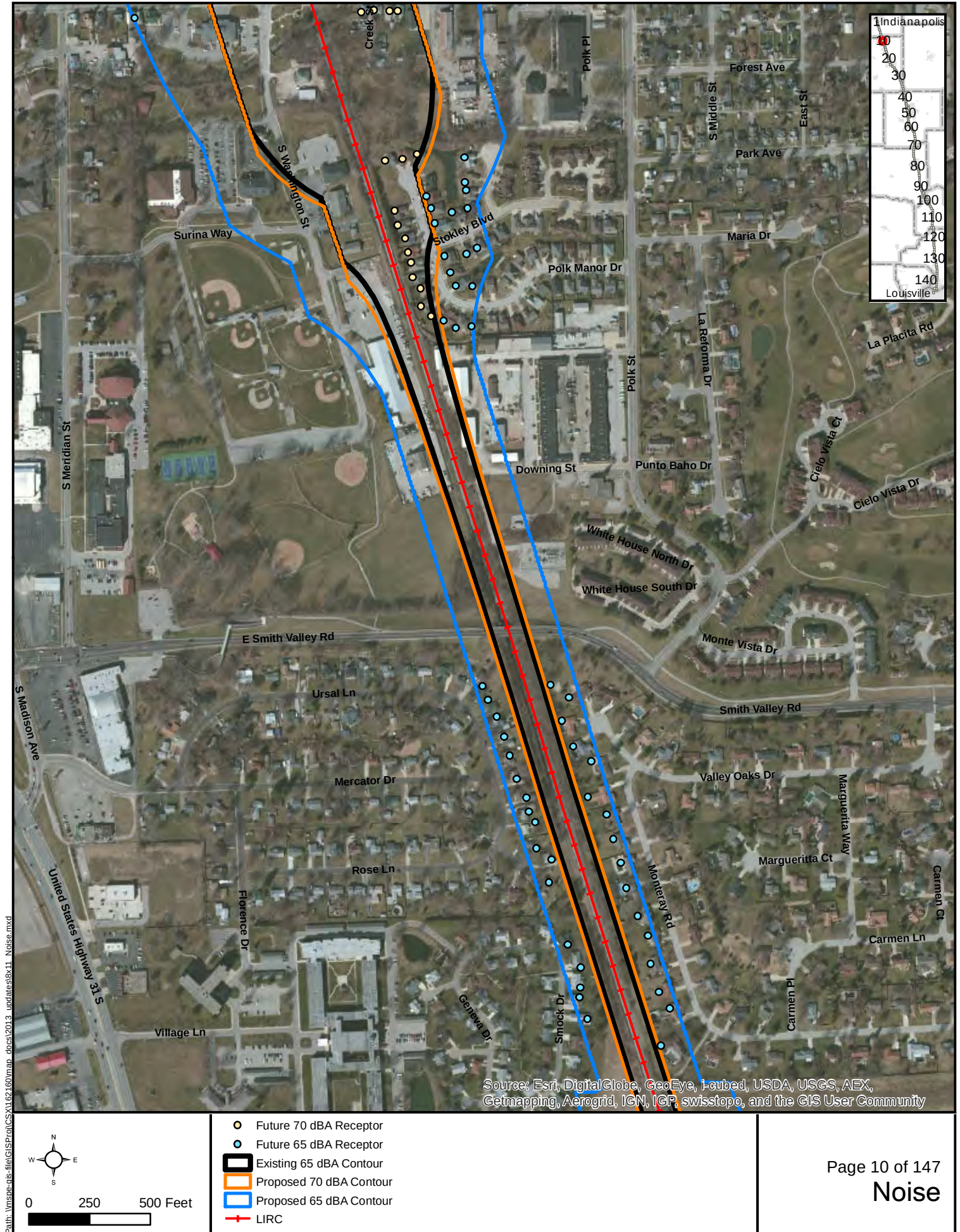


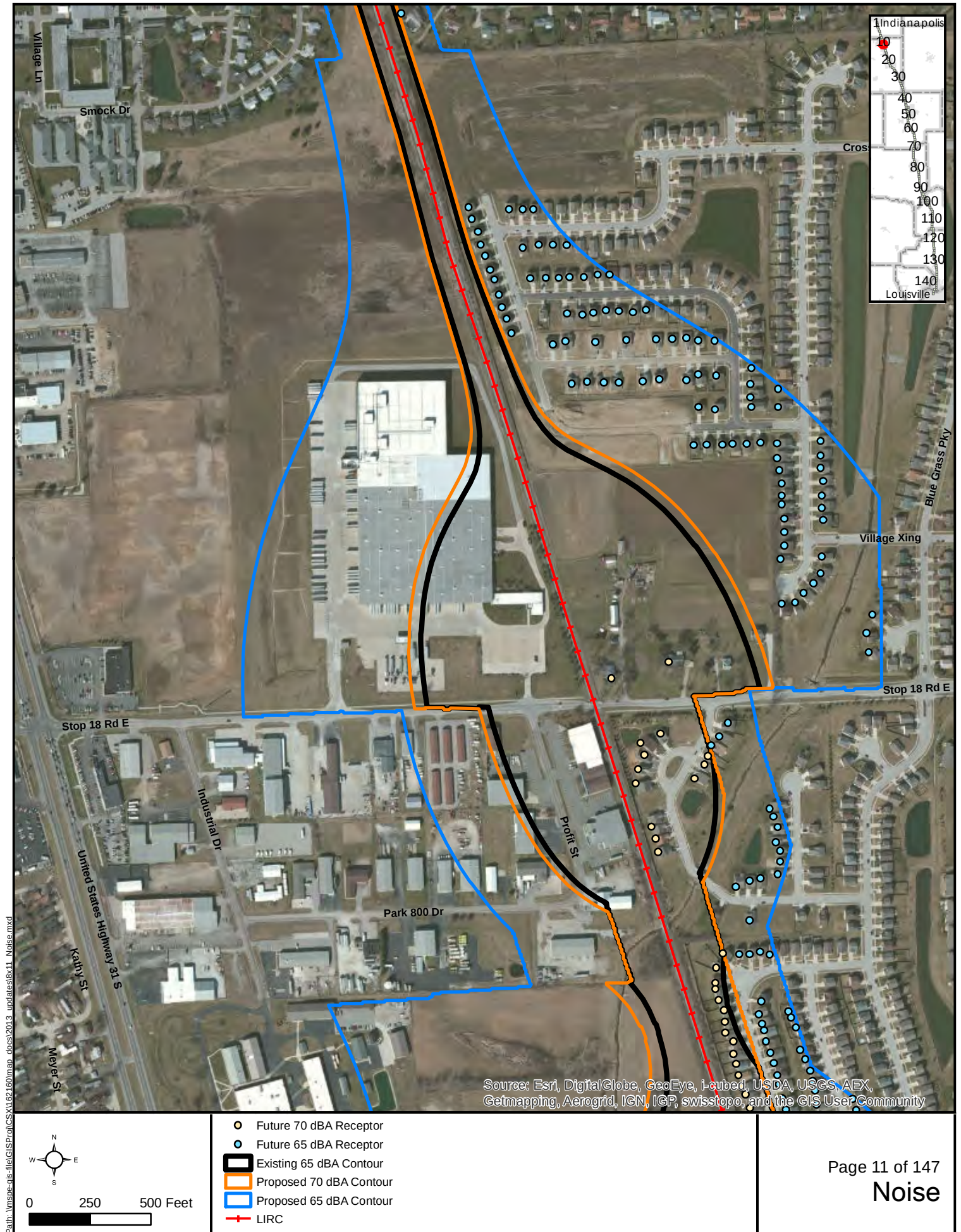


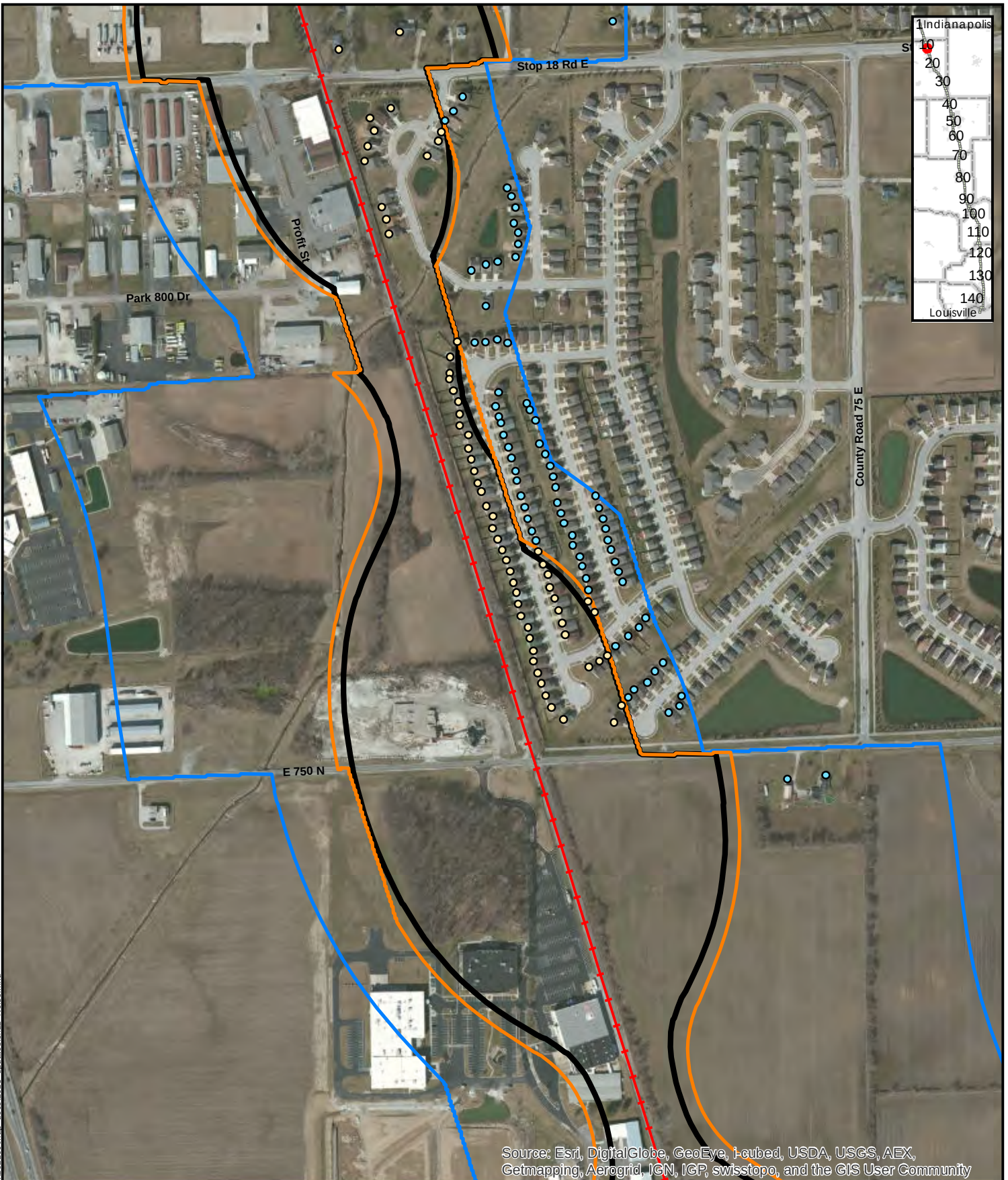












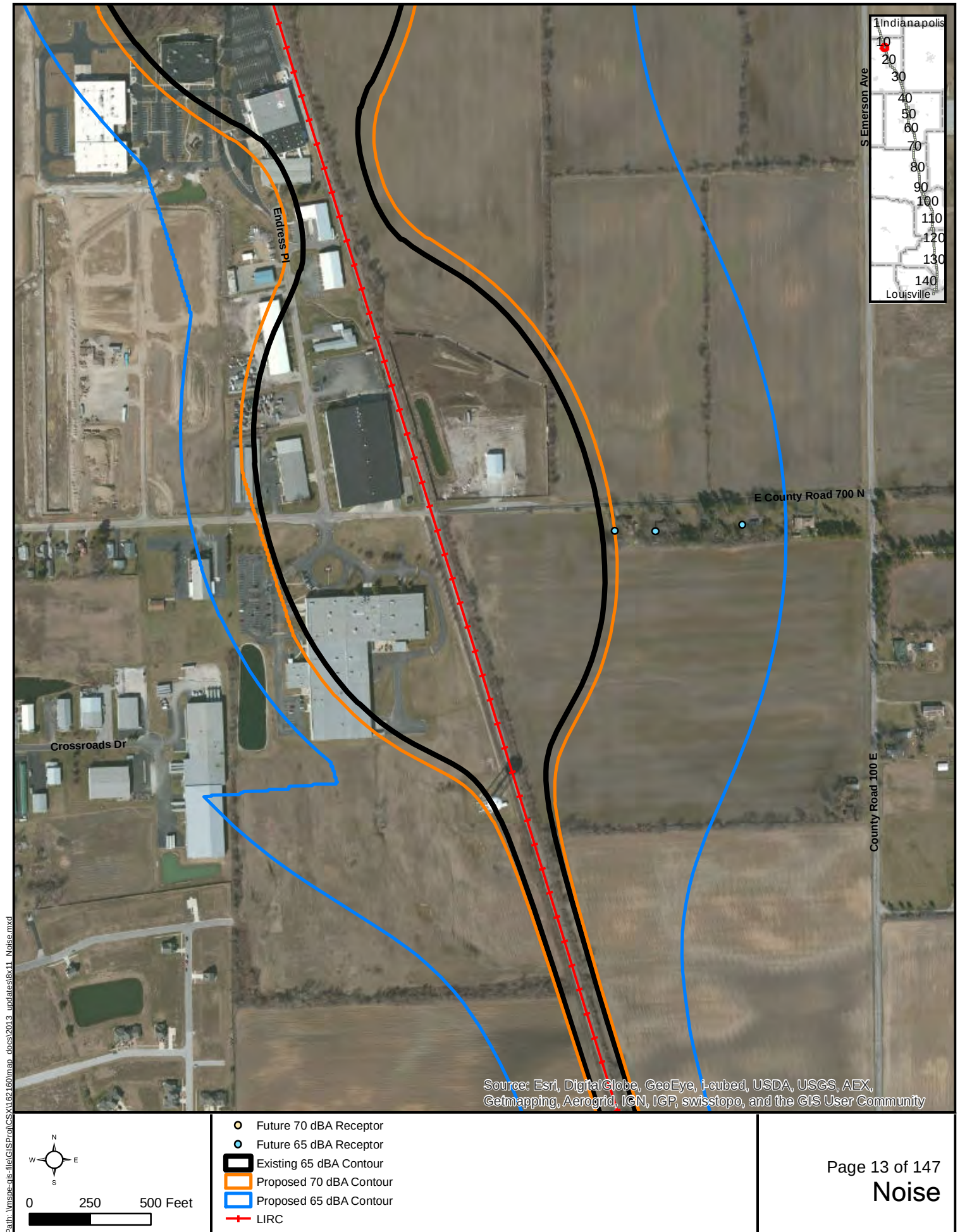
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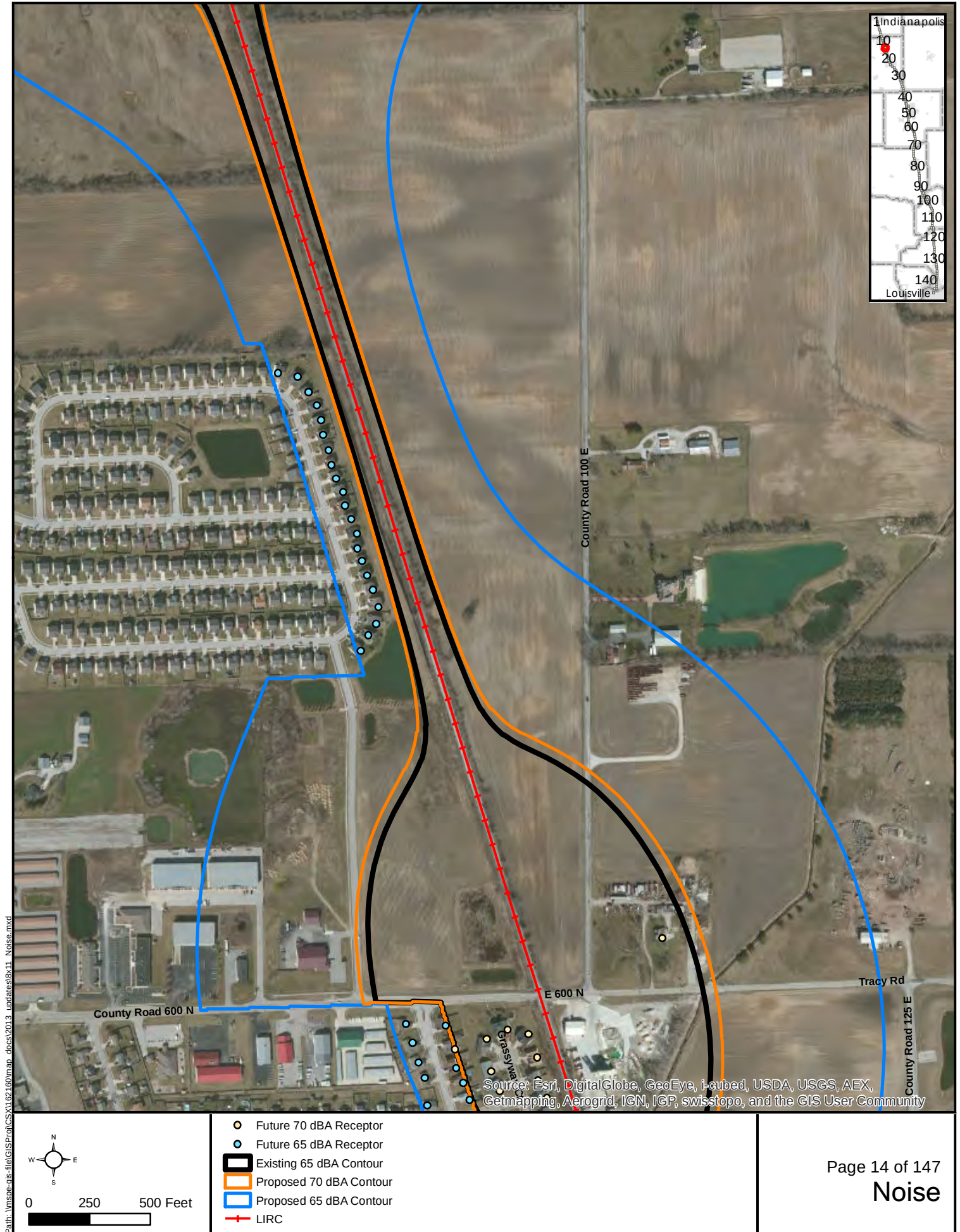


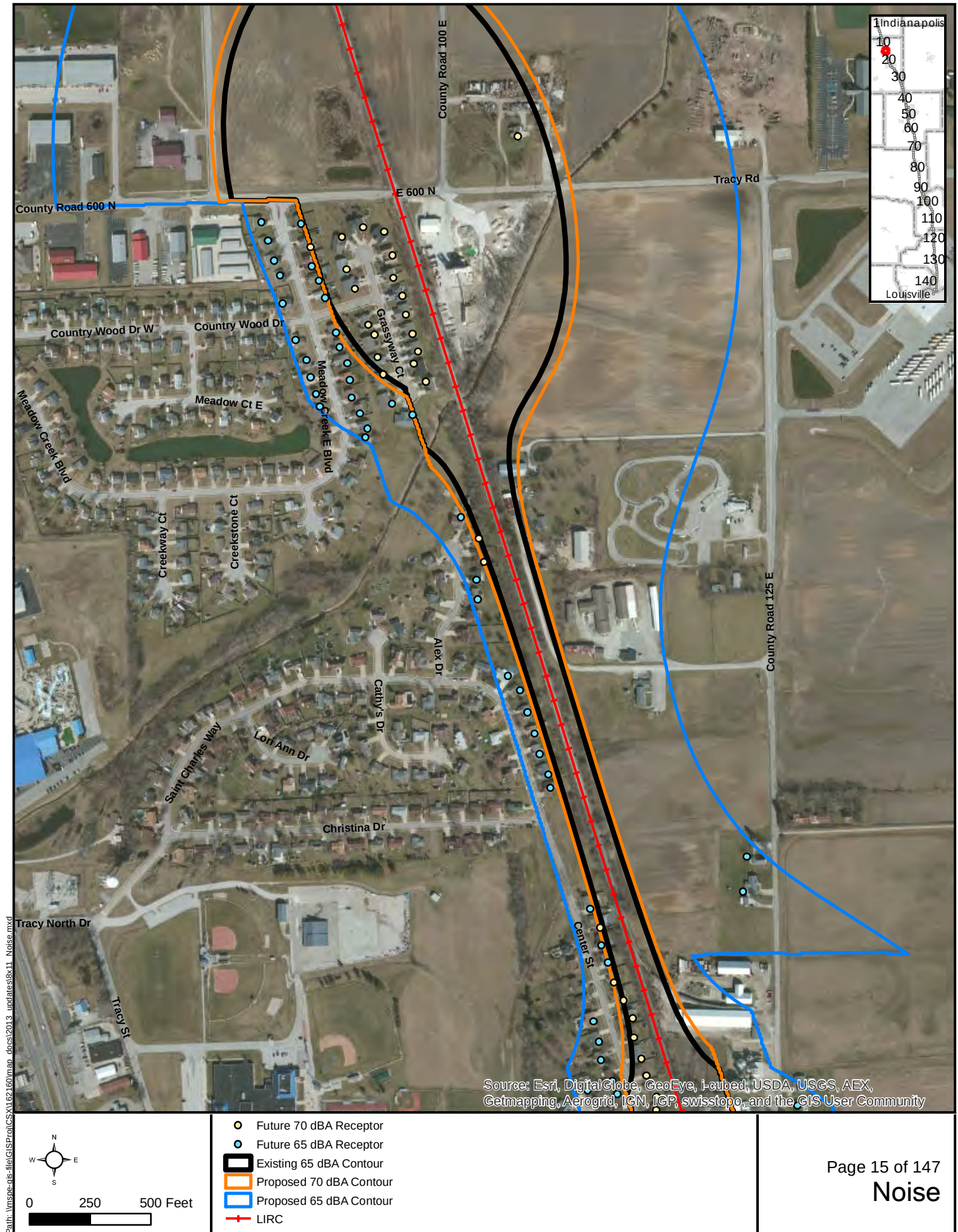
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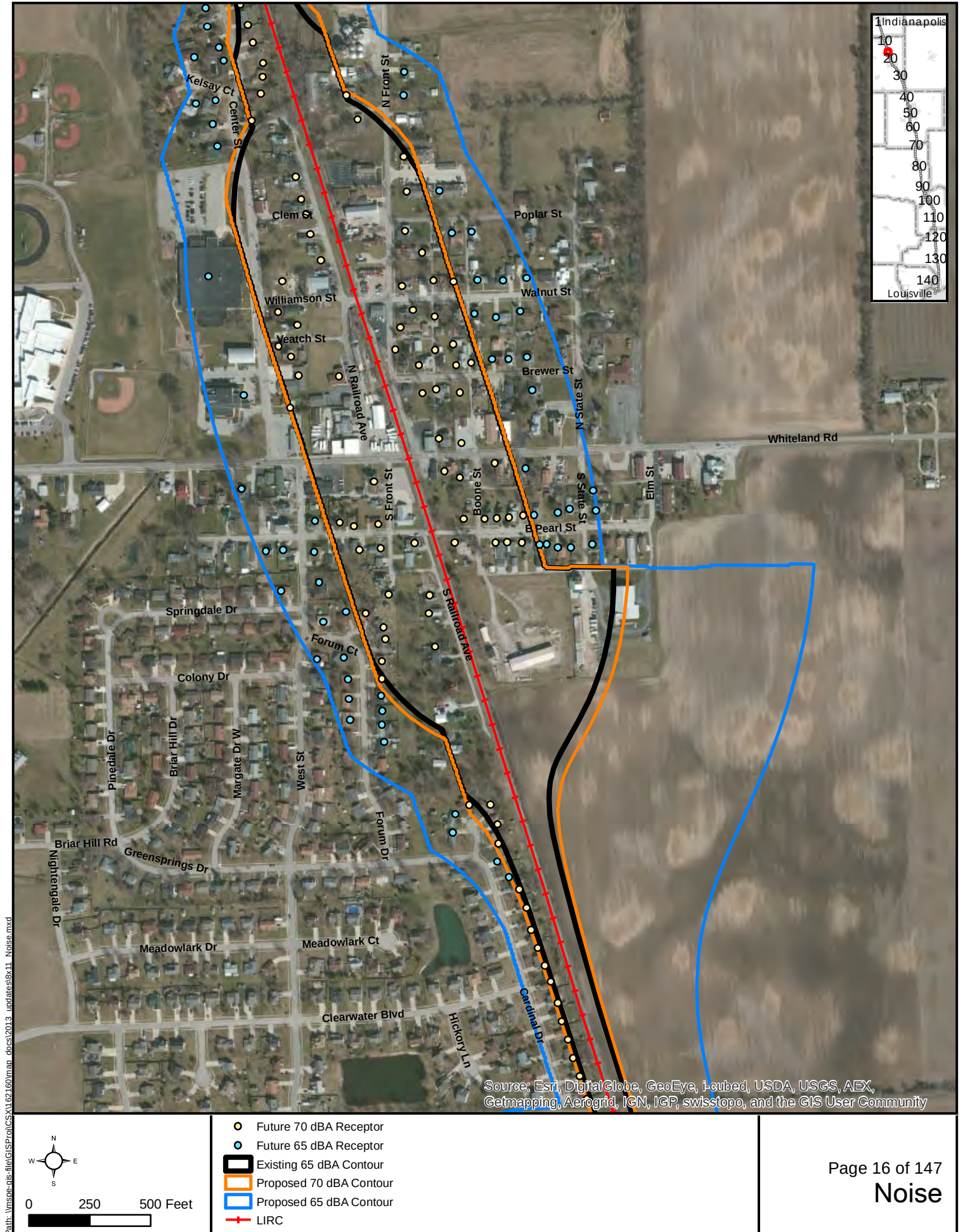


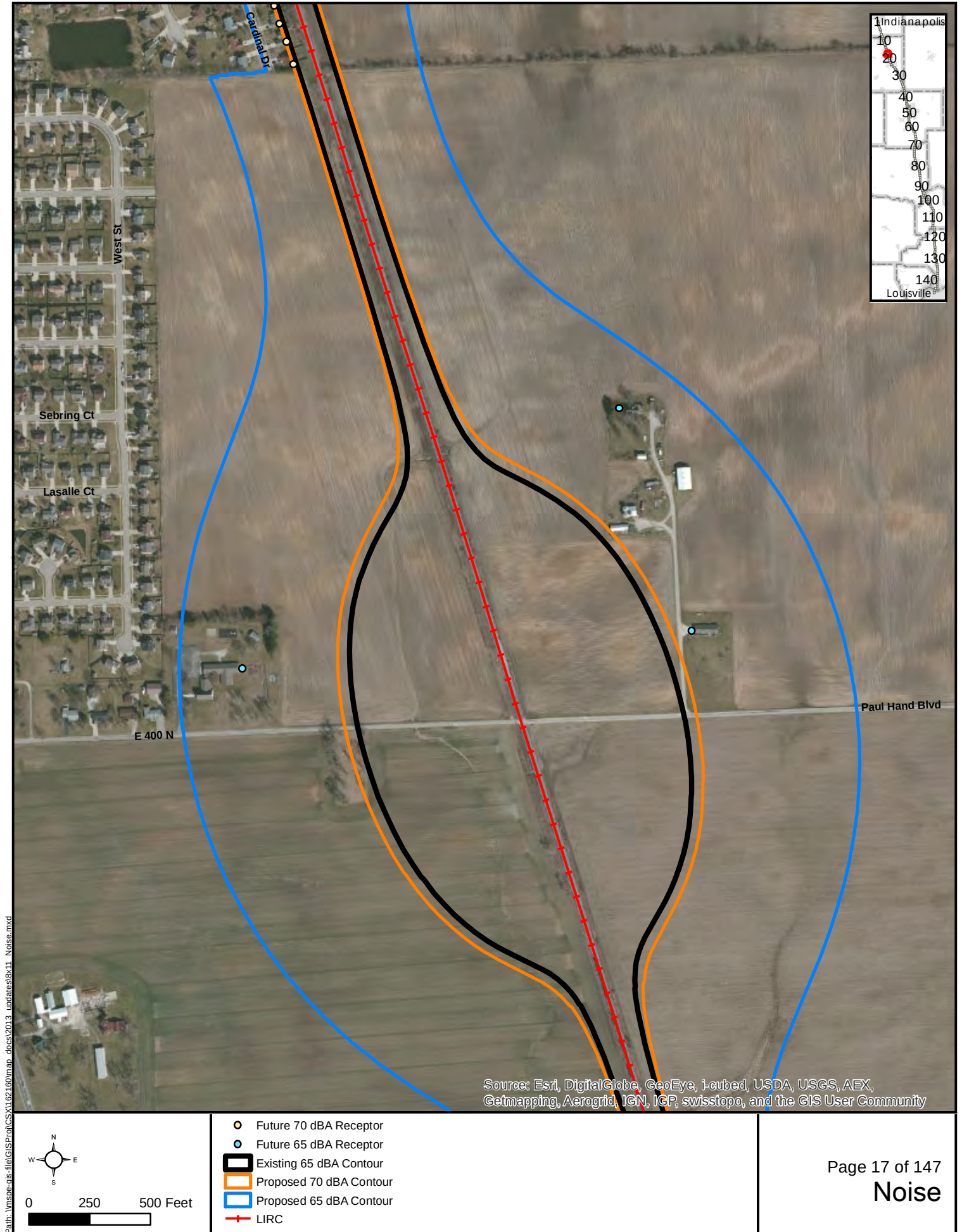
- Future 70 dBA Receptor
- Future 65 dBA Receptor
- ▬ Existing 65 dBA Contour
- ▬ Proposed 70 dBA Contour
- ▬ Proposed 65 dBA Contour
- + LIRC

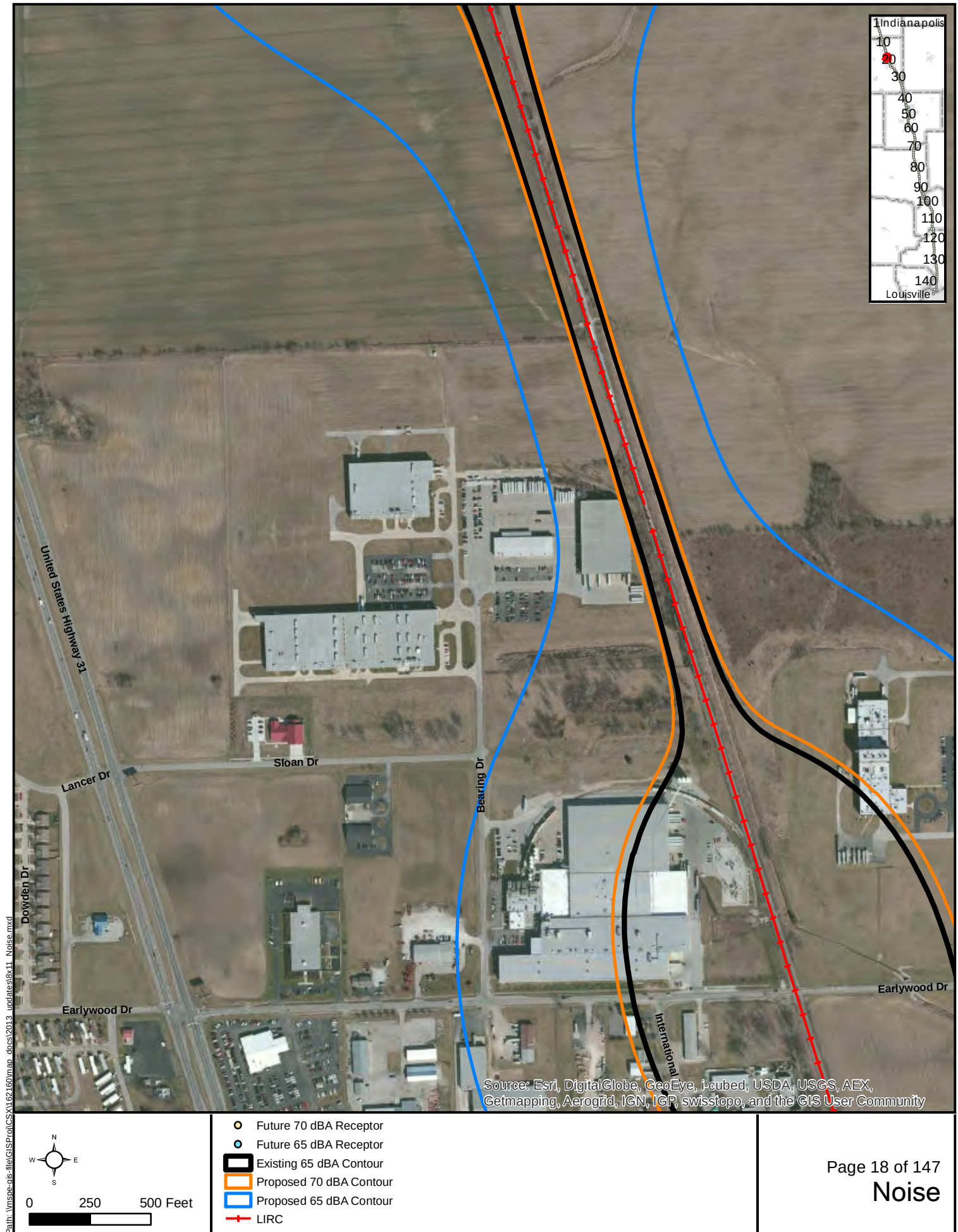


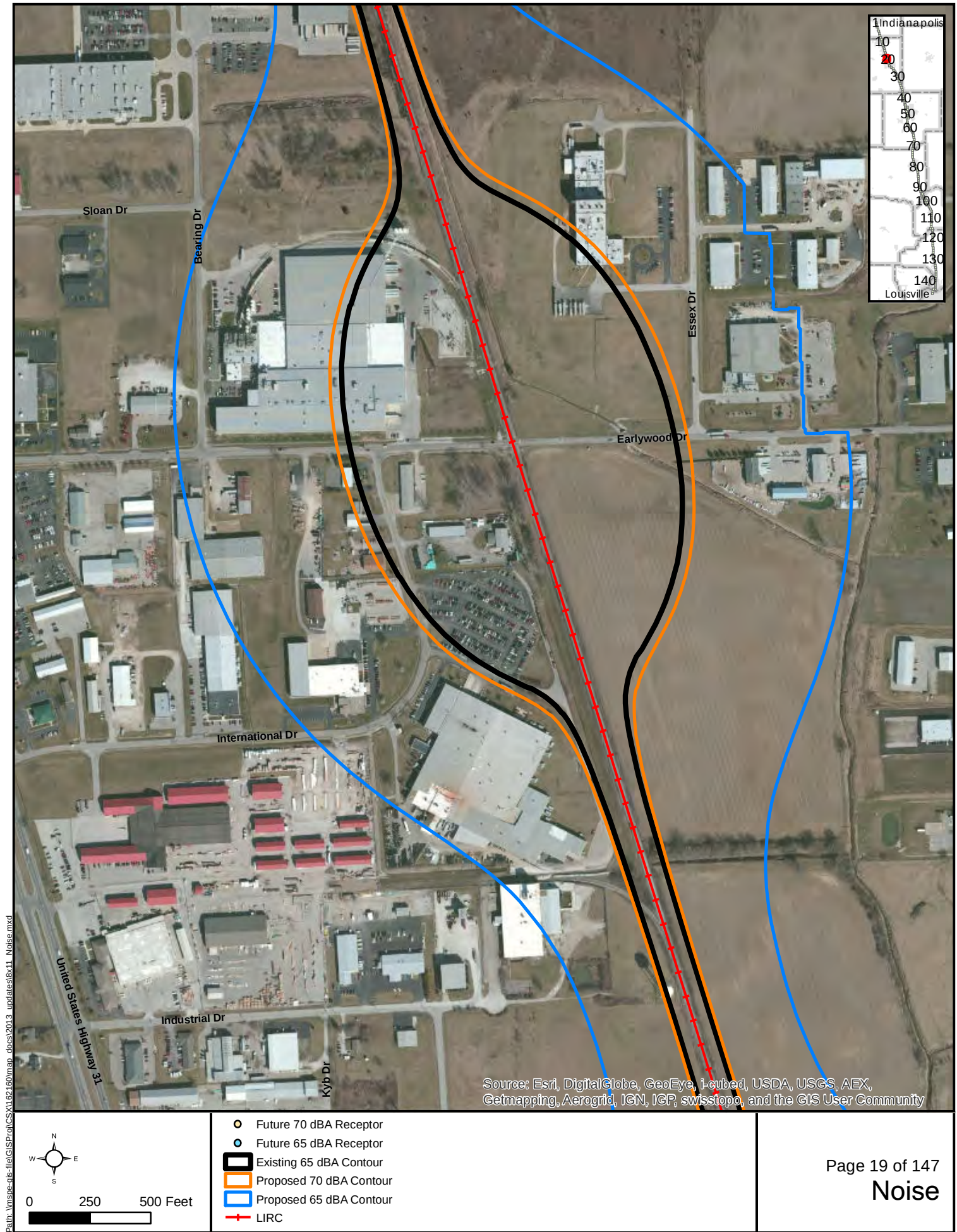


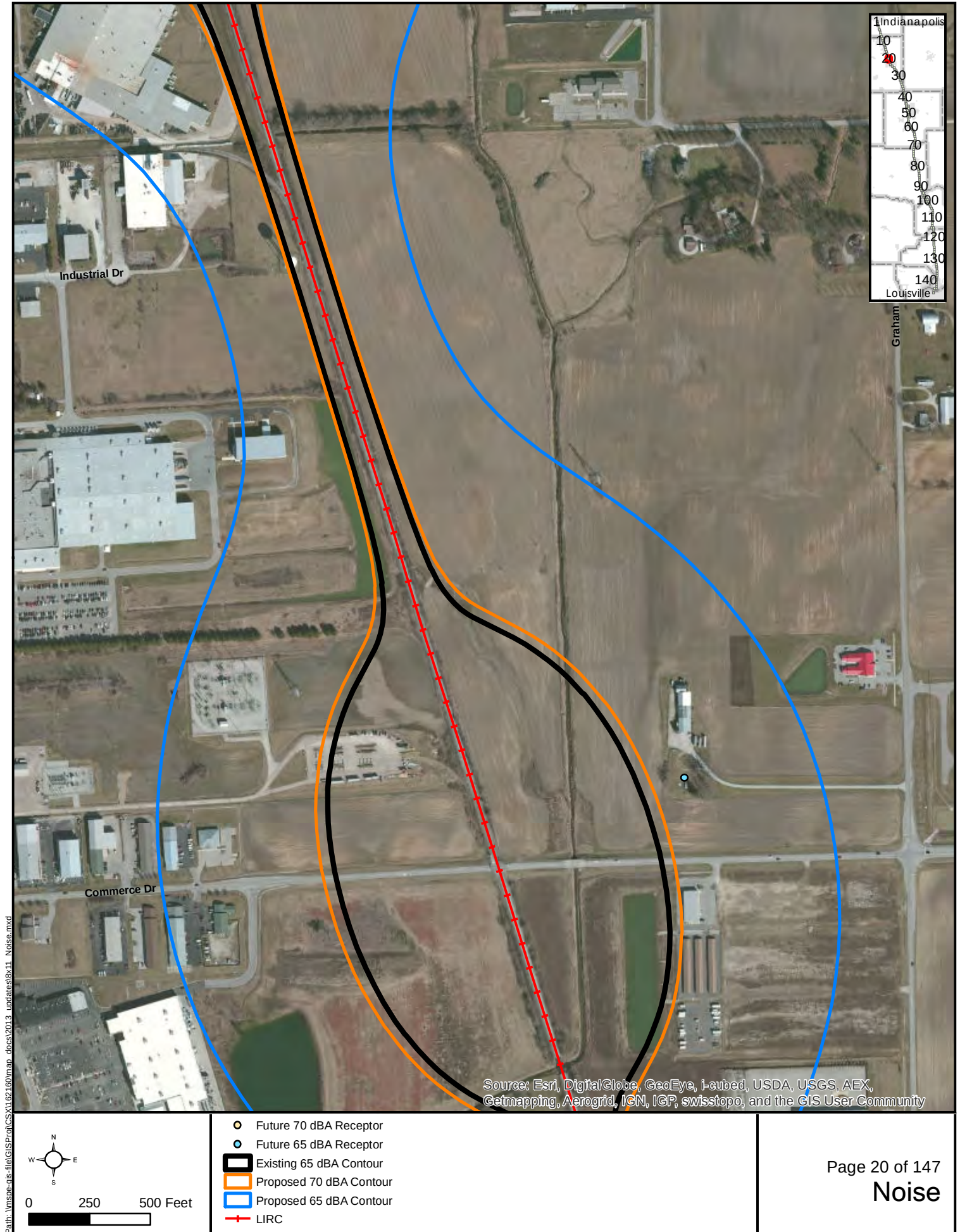


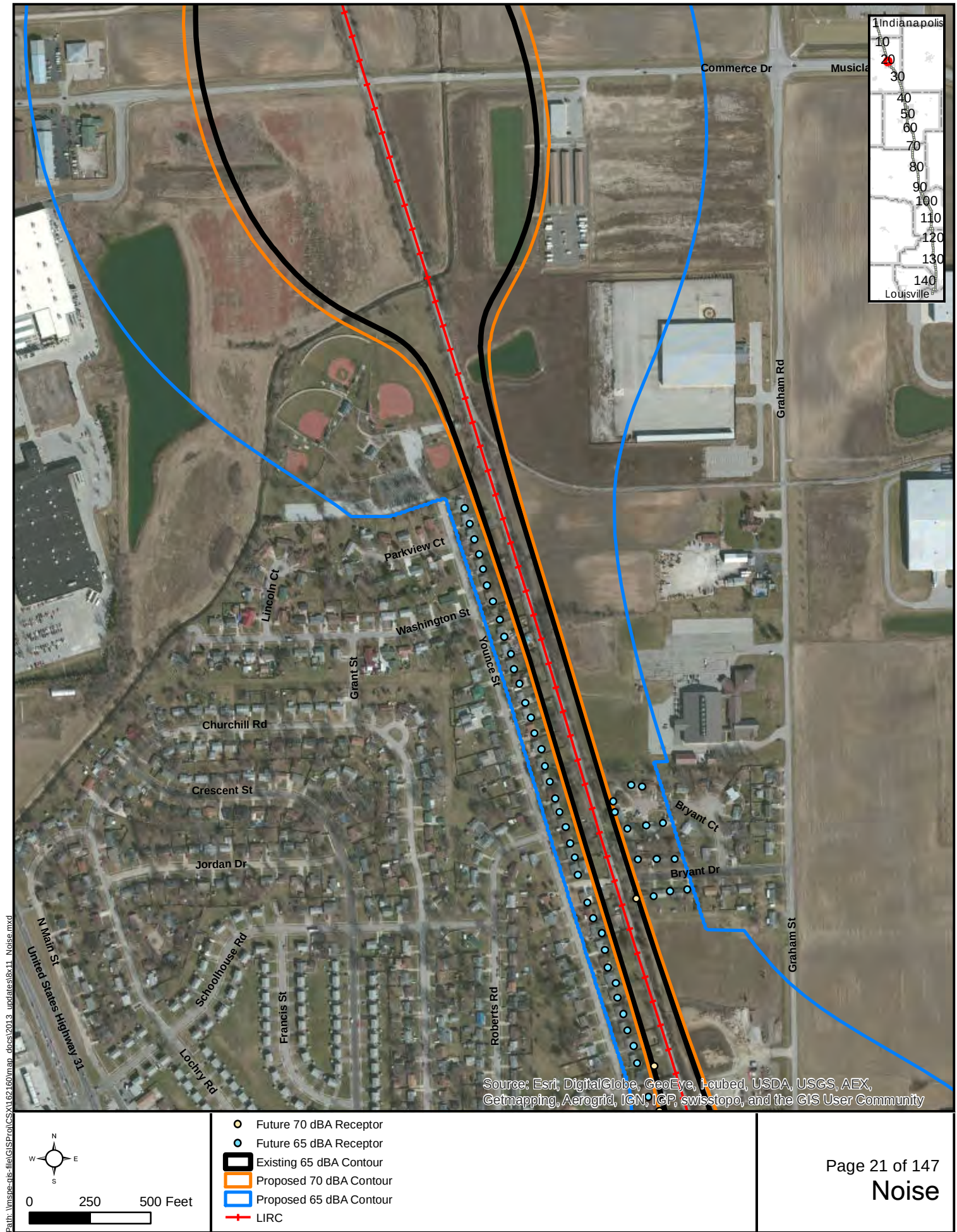


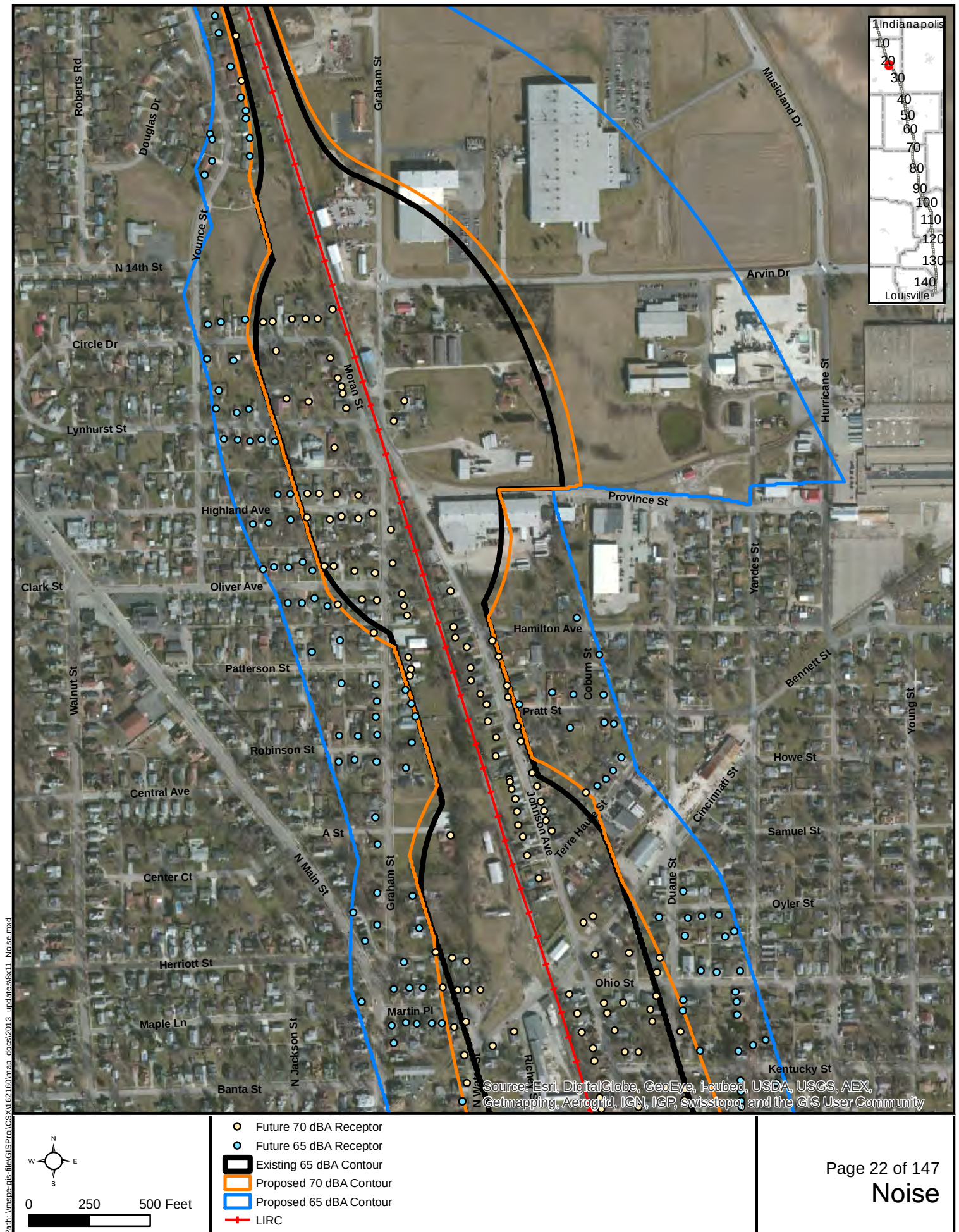


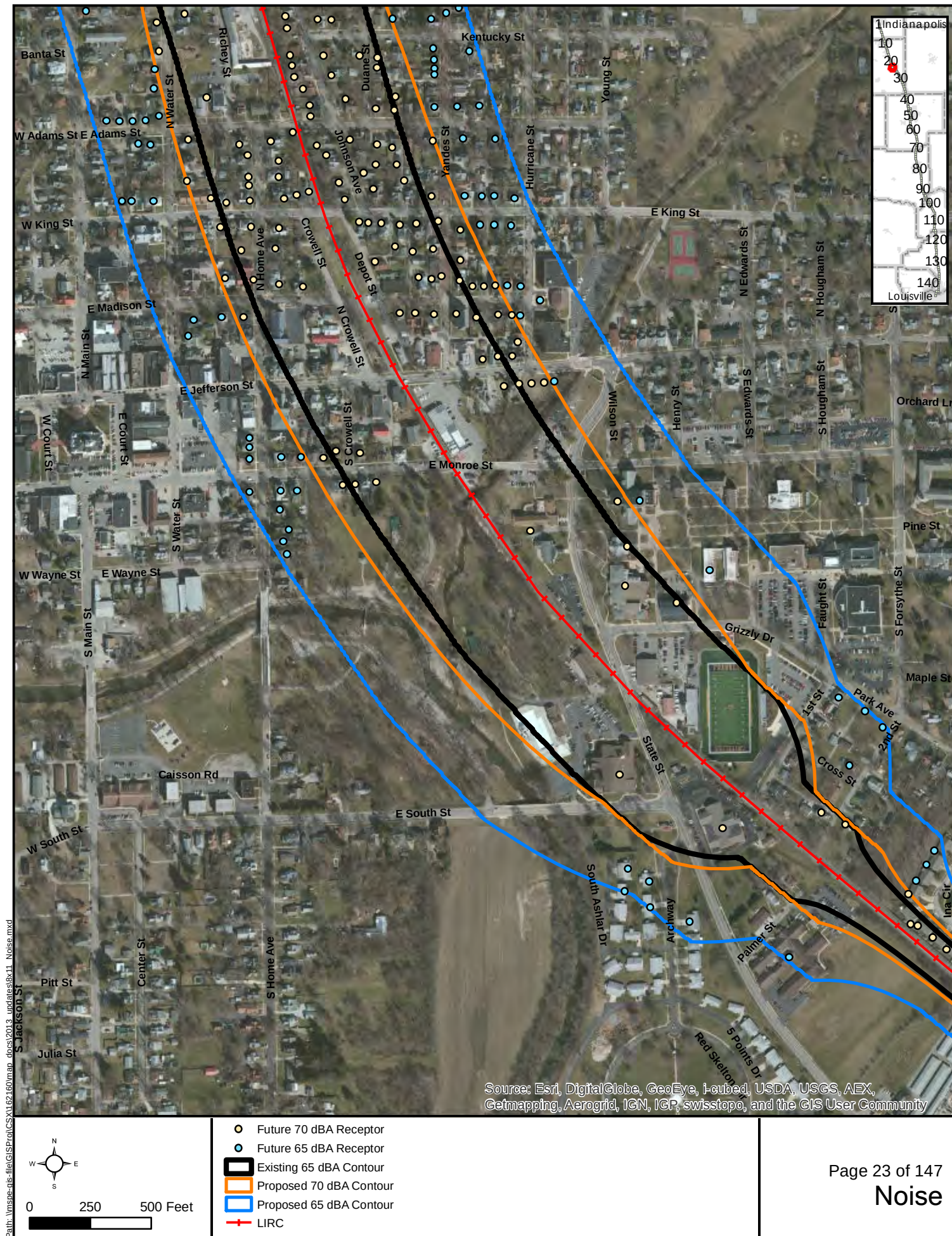




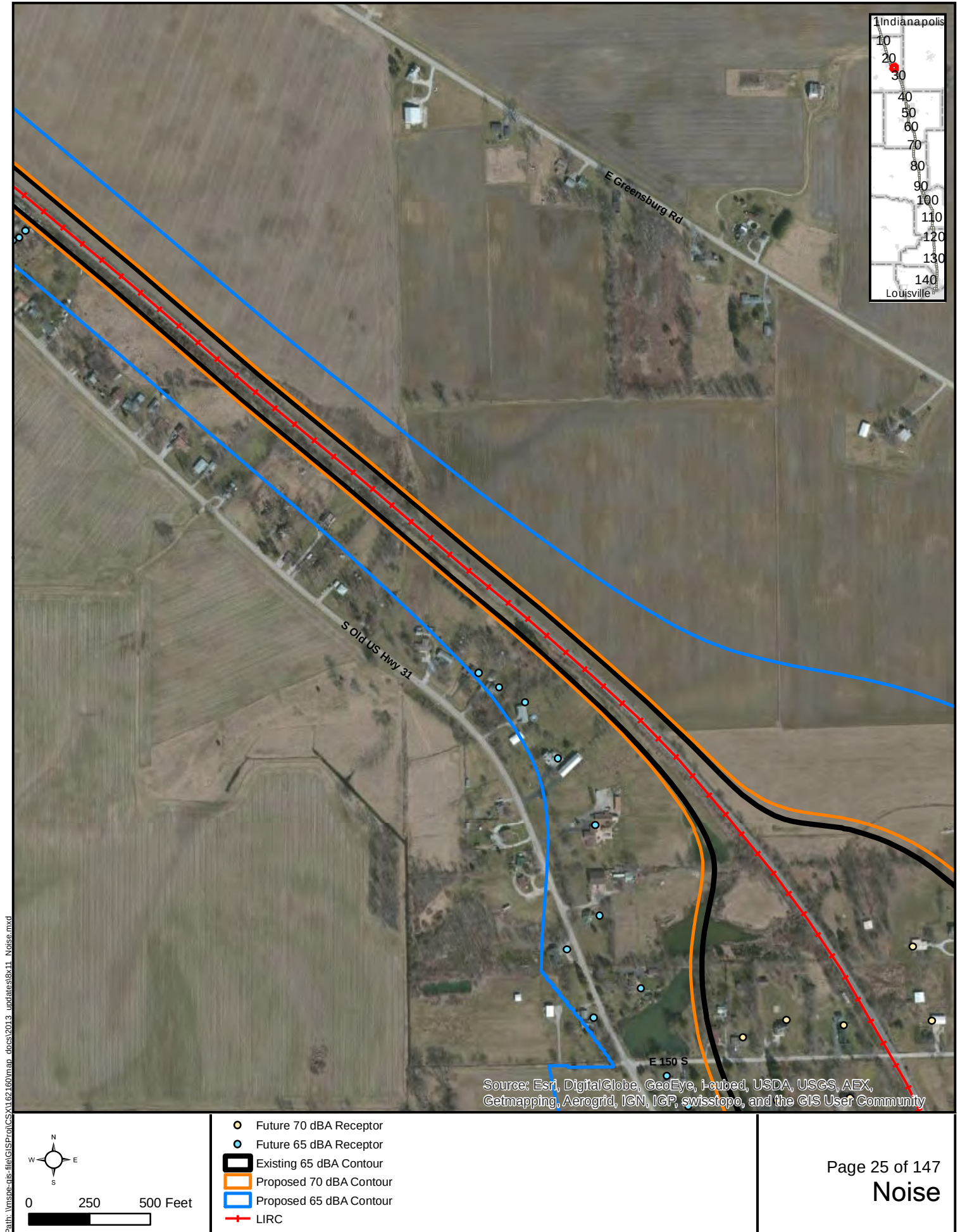


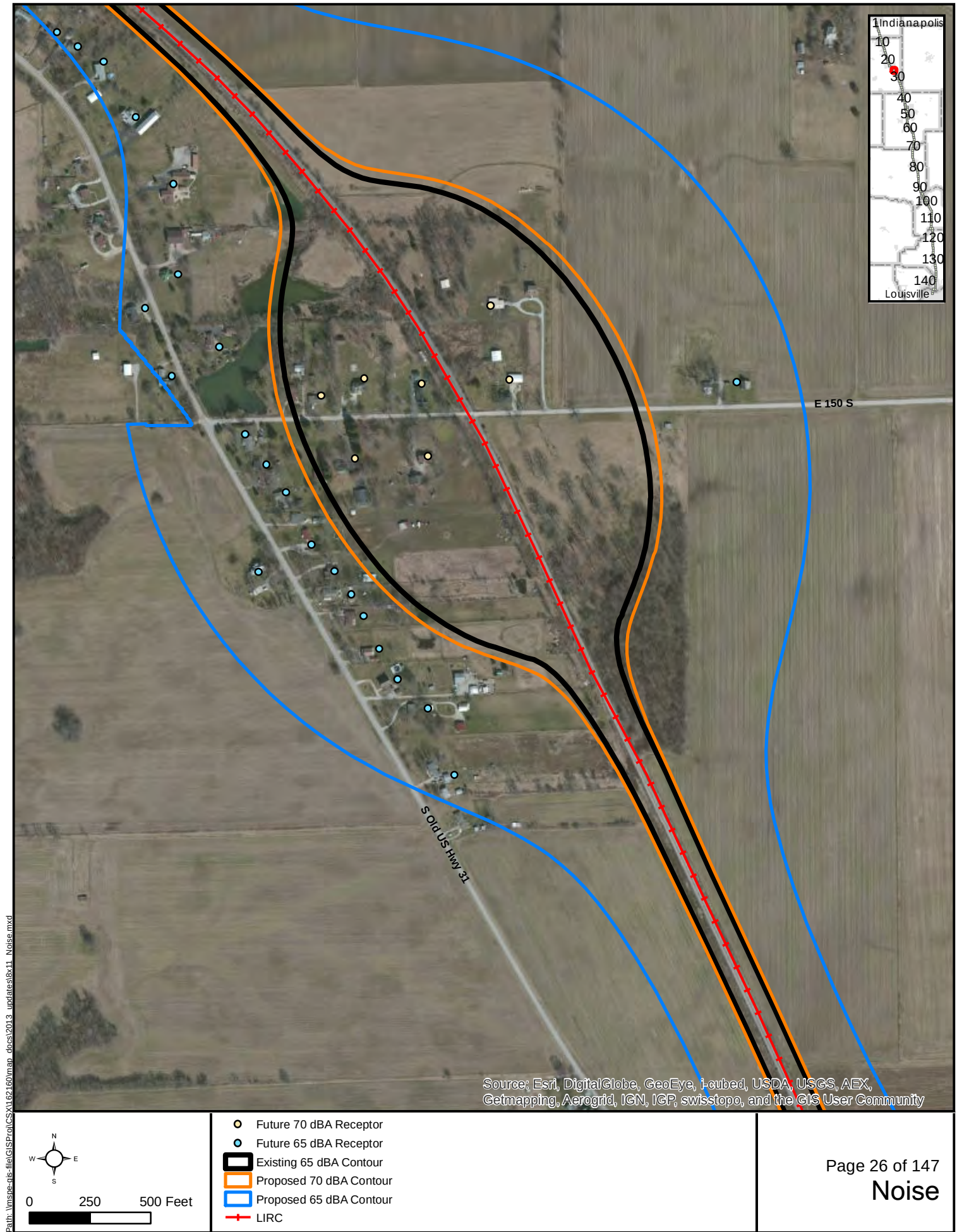


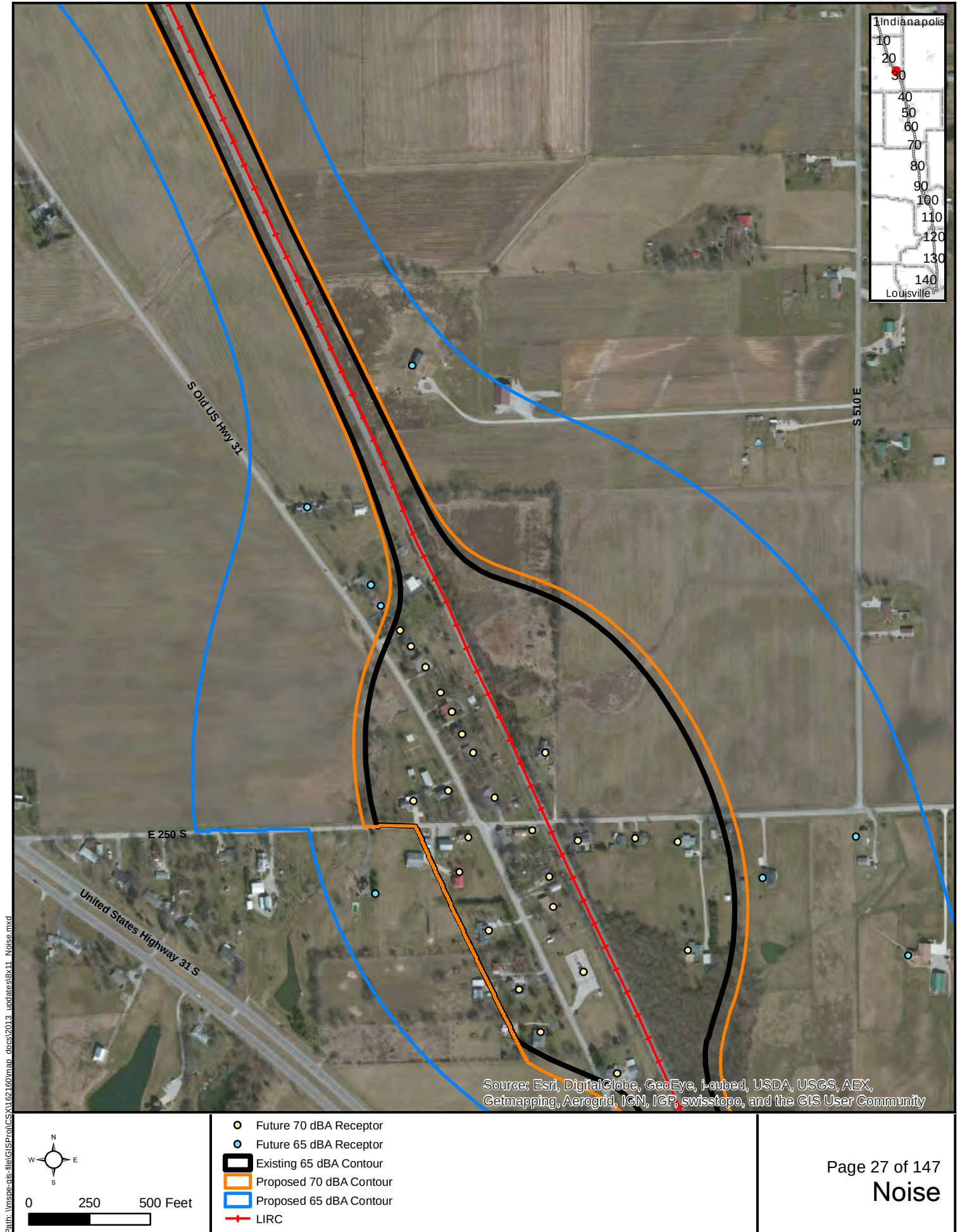


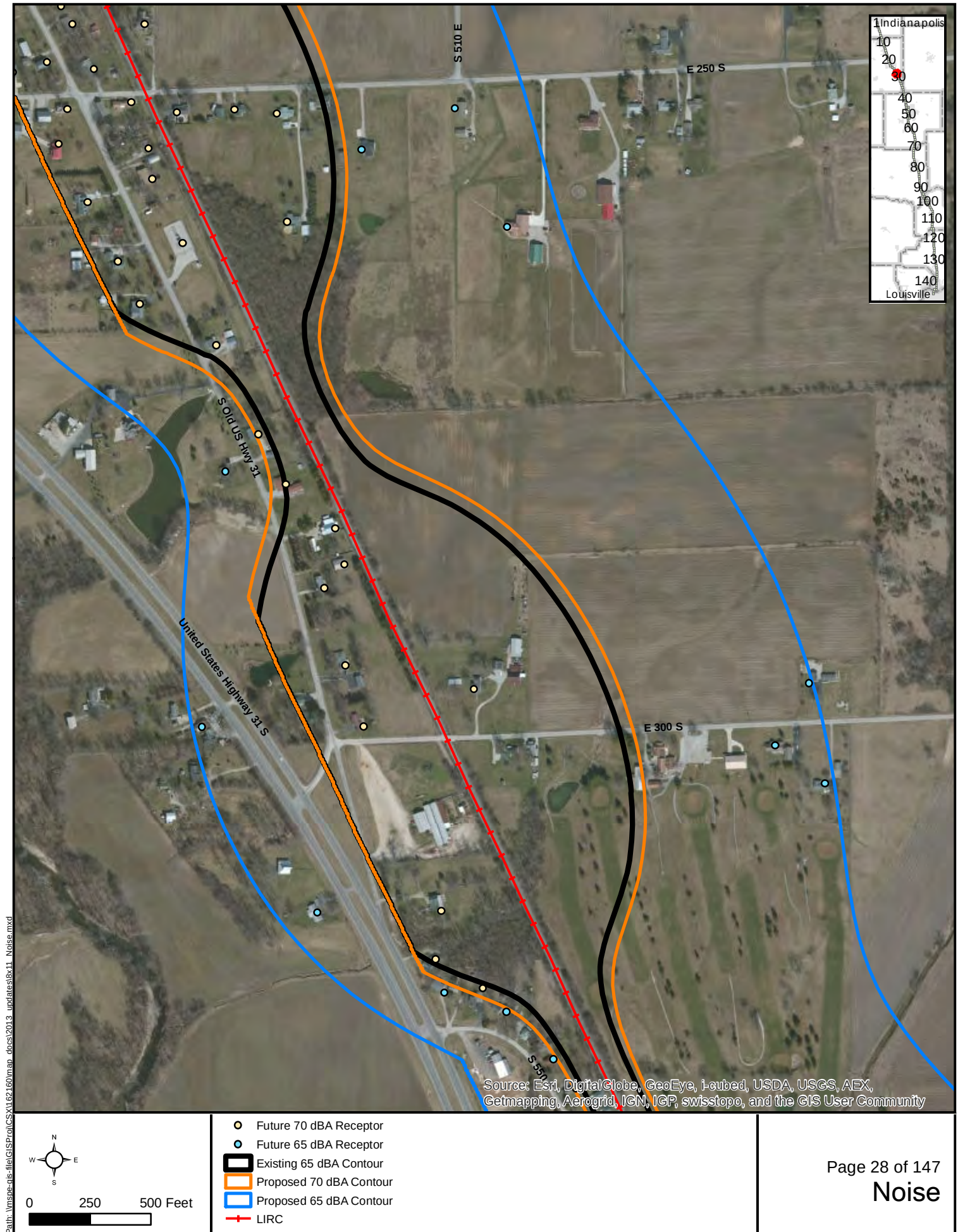


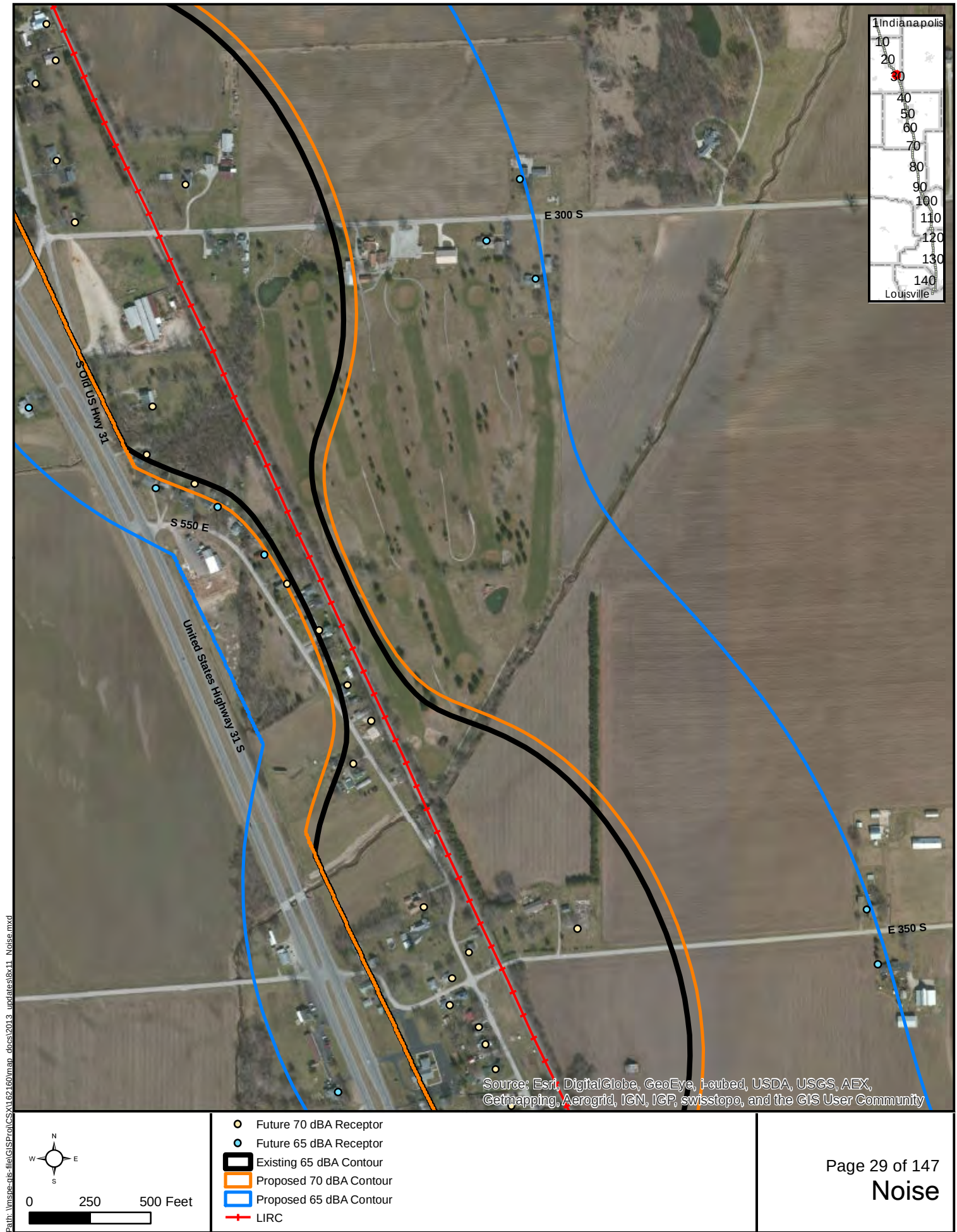


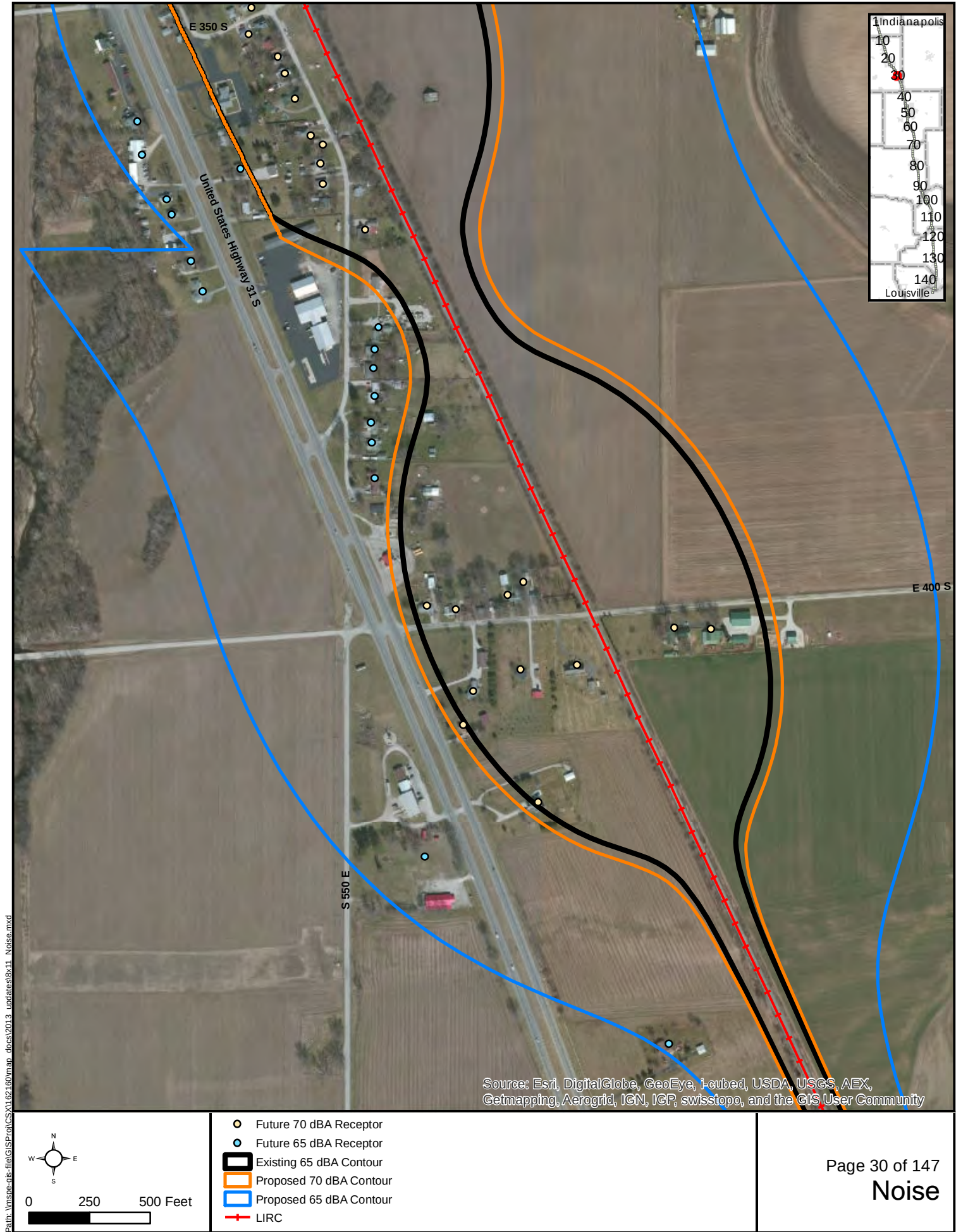


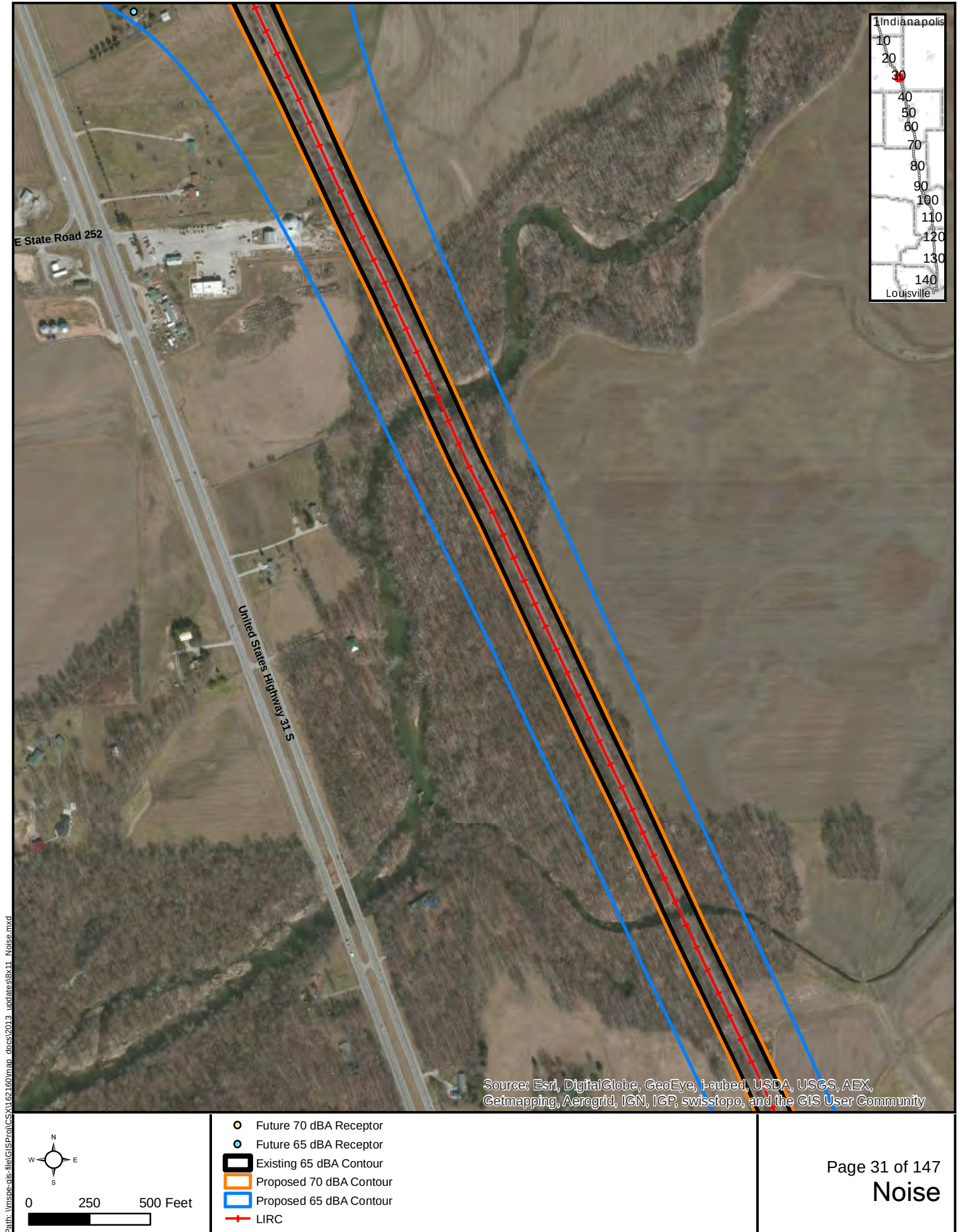


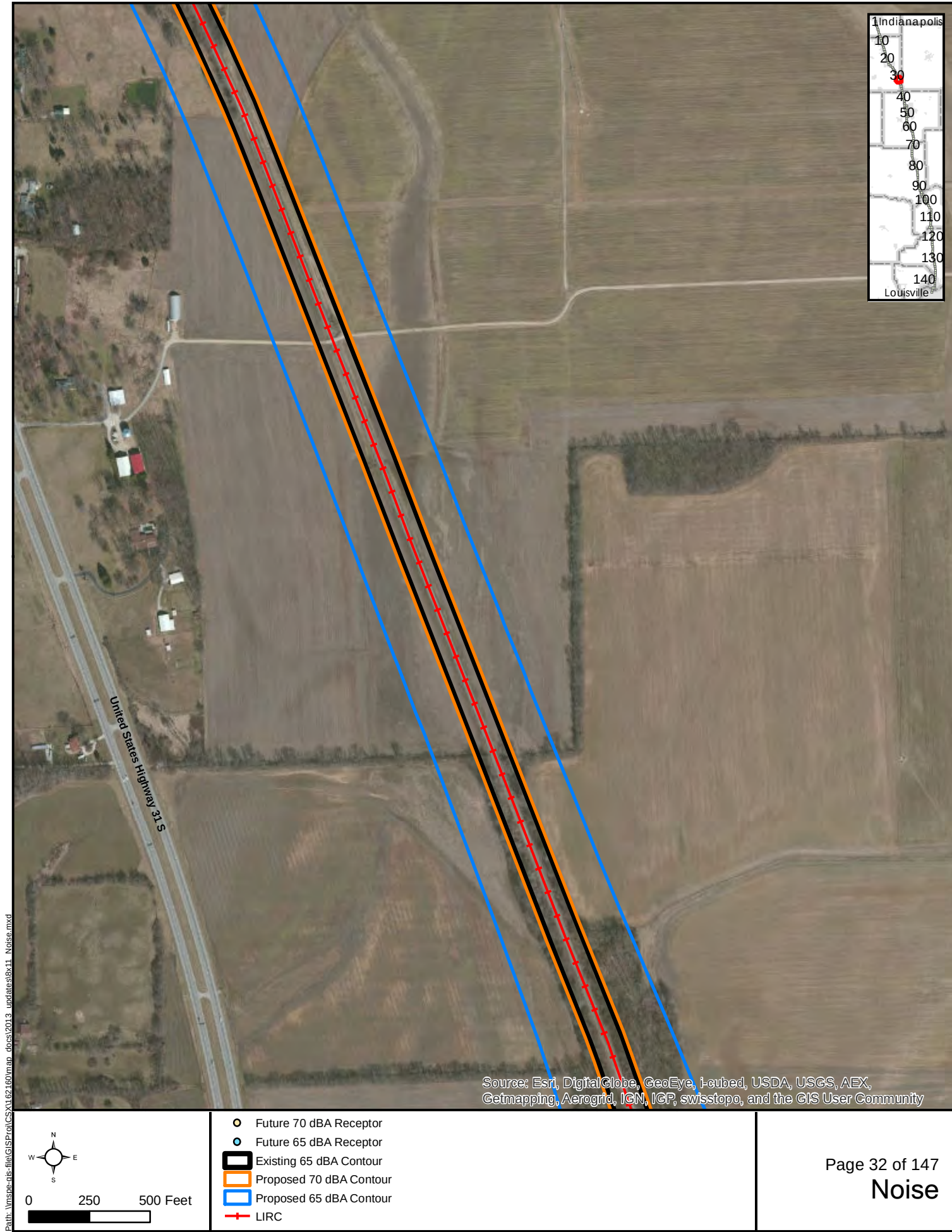


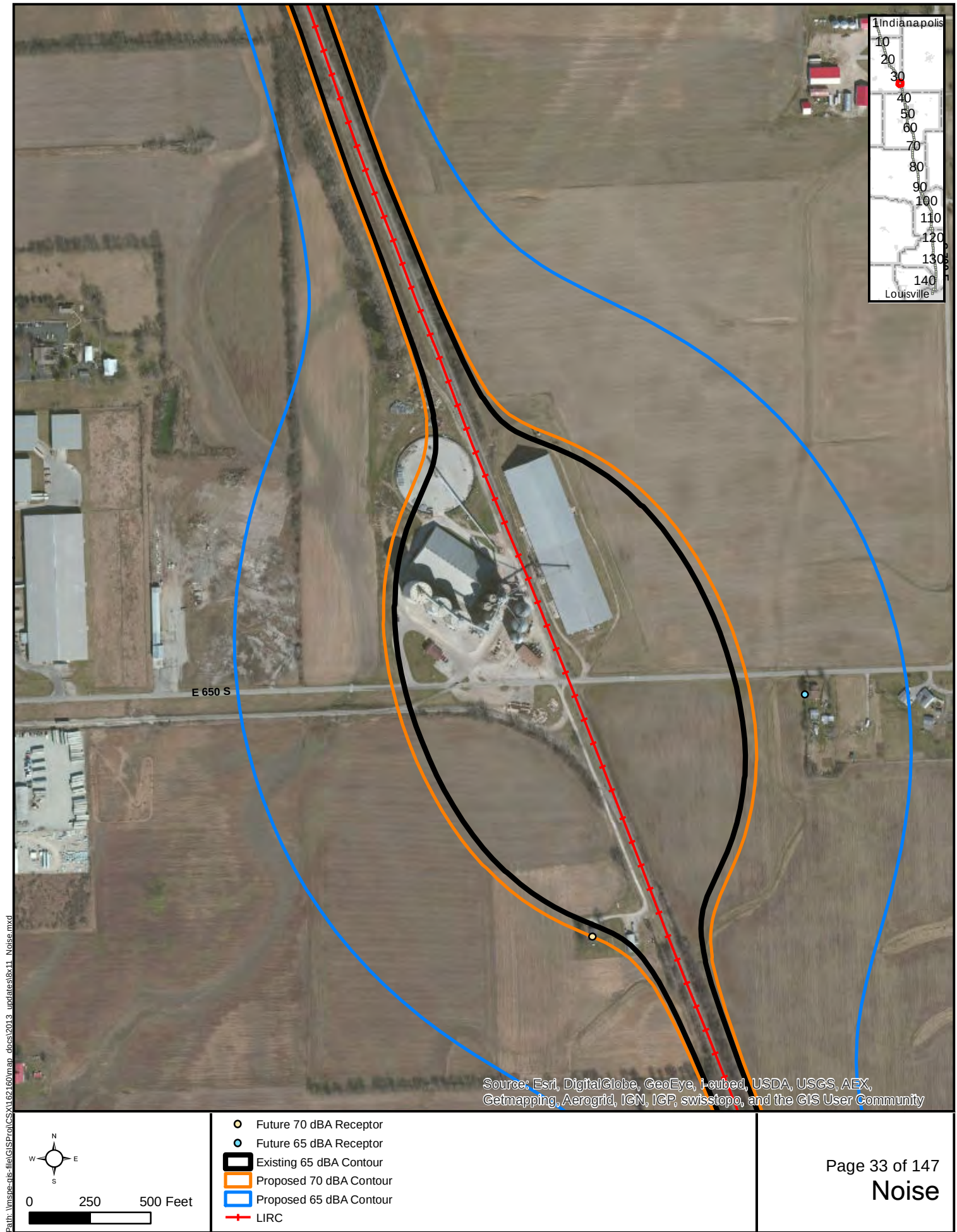


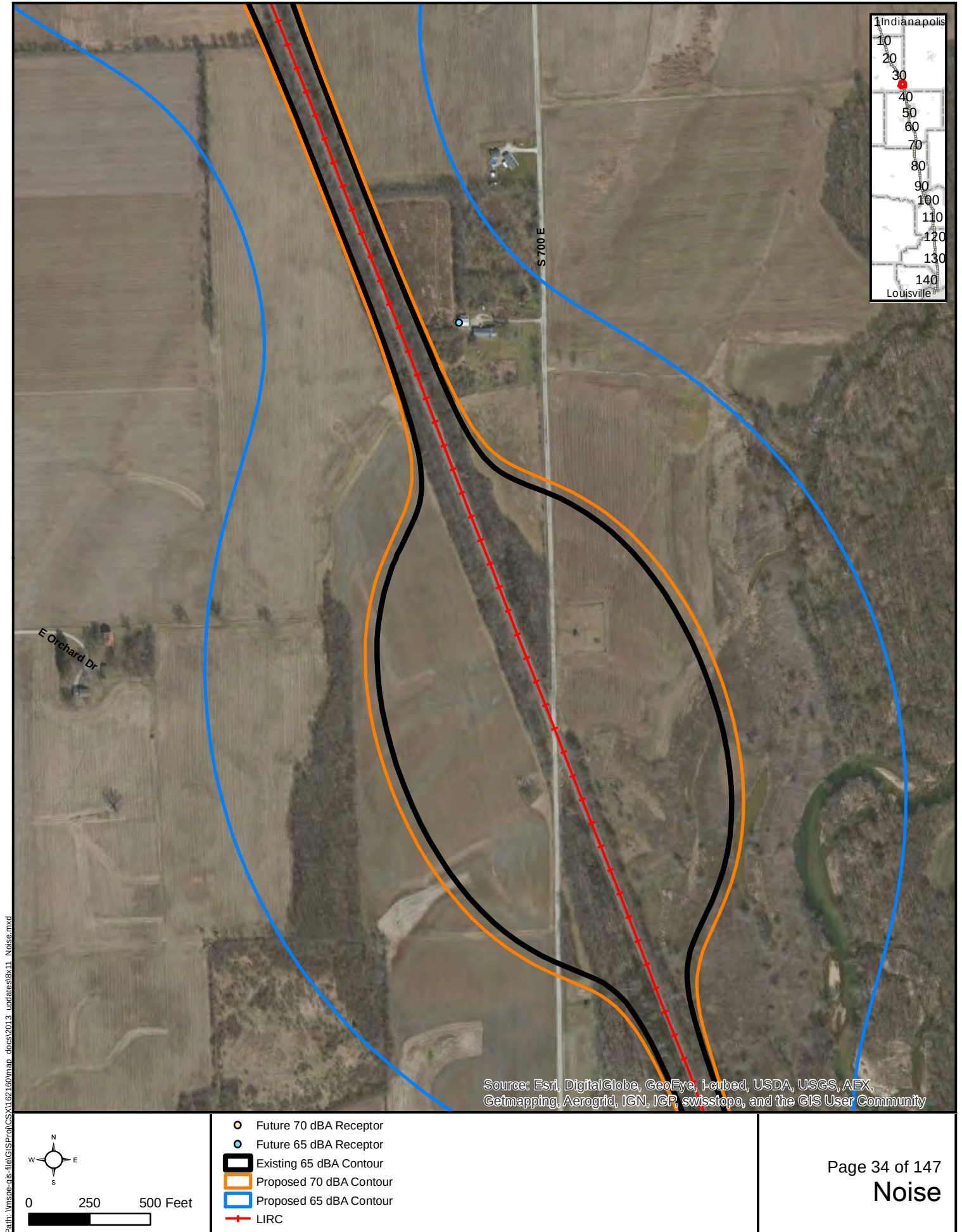


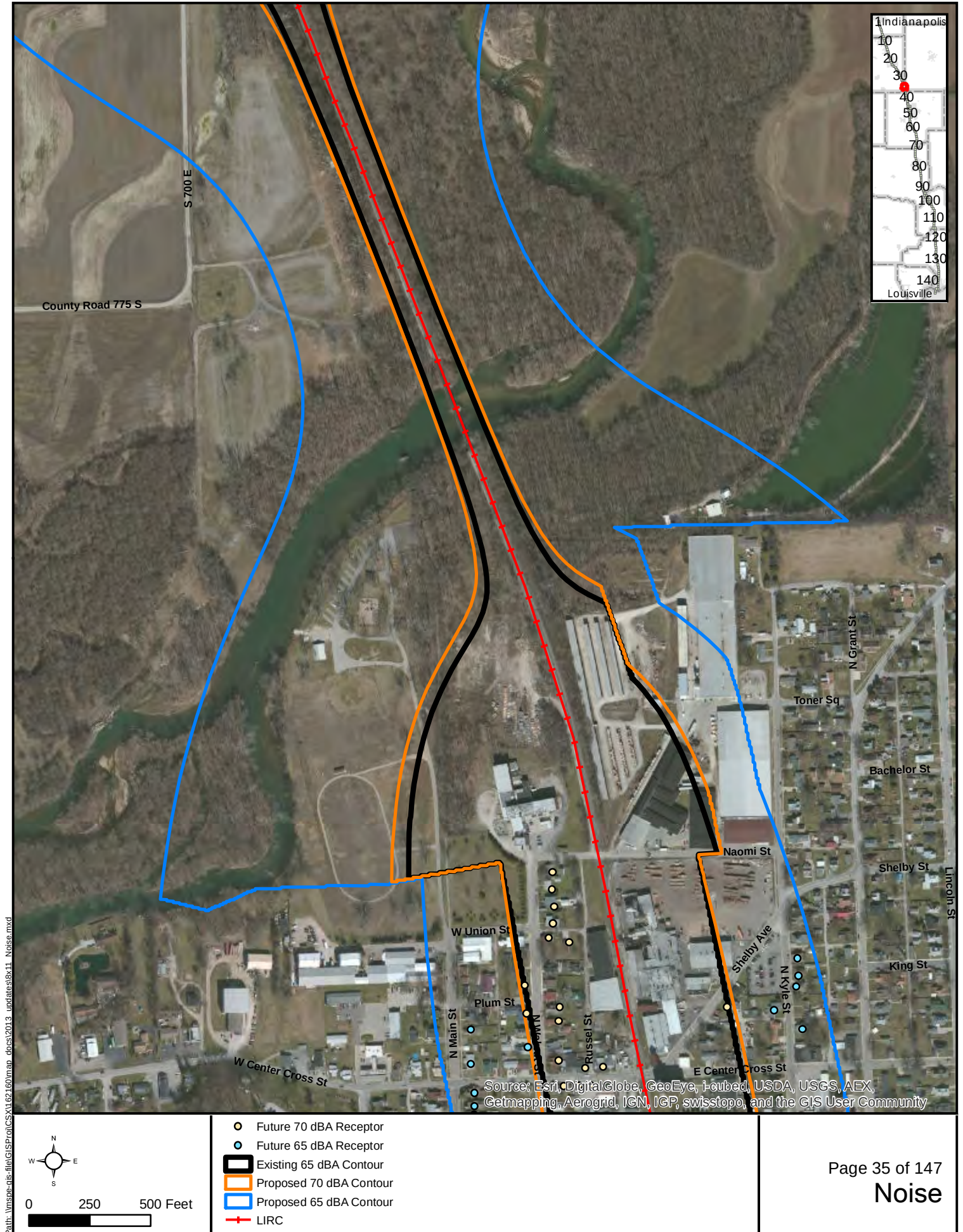


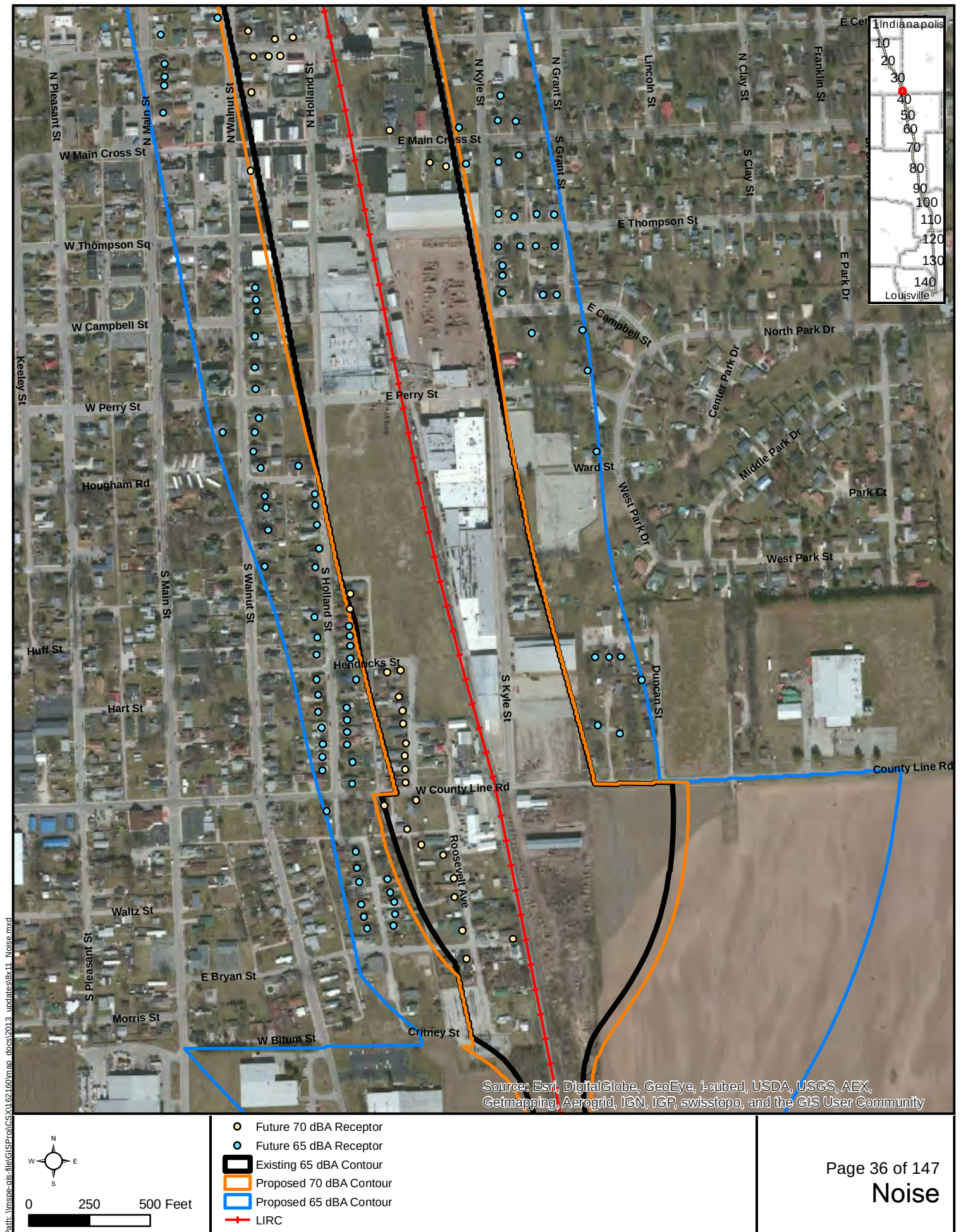


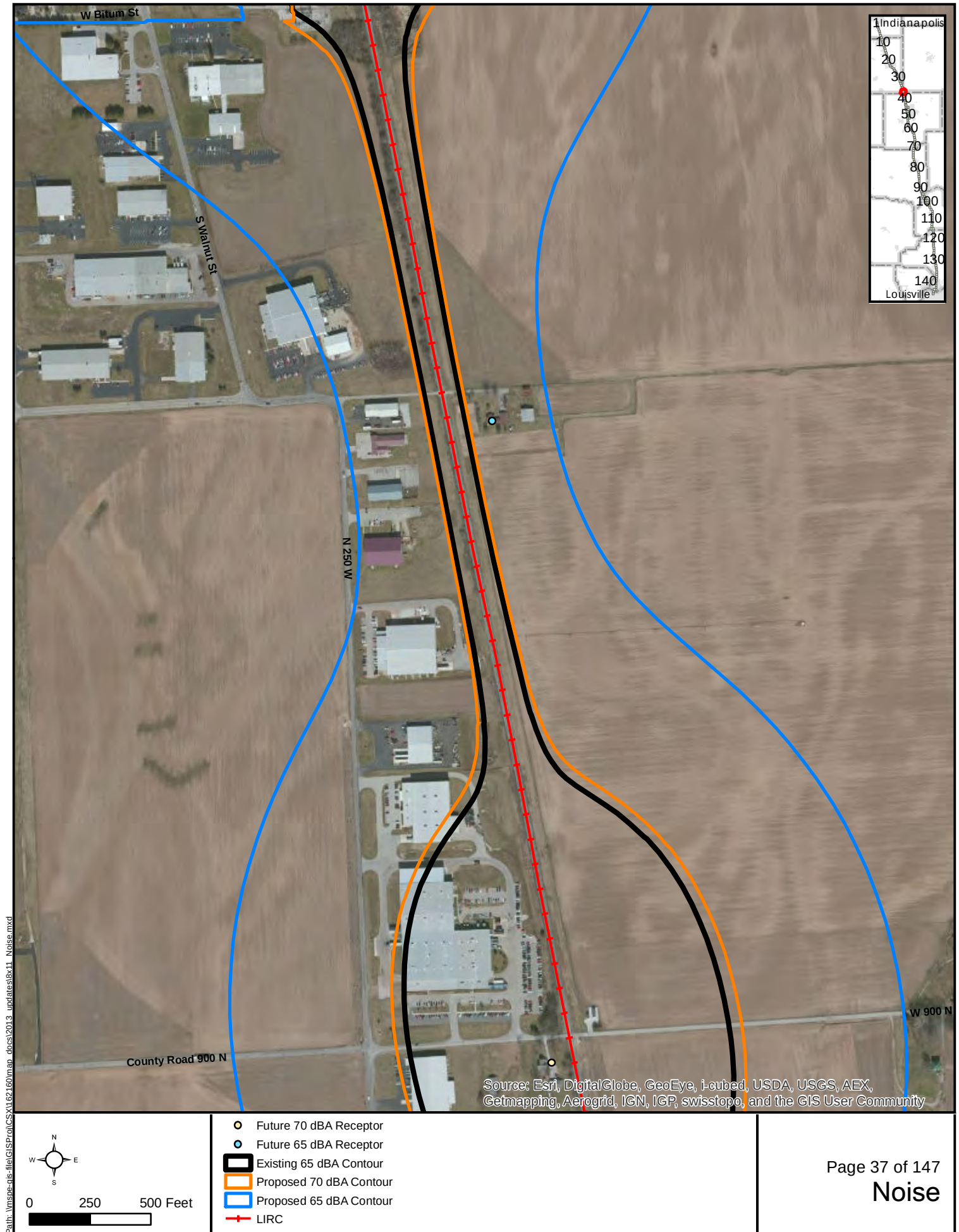


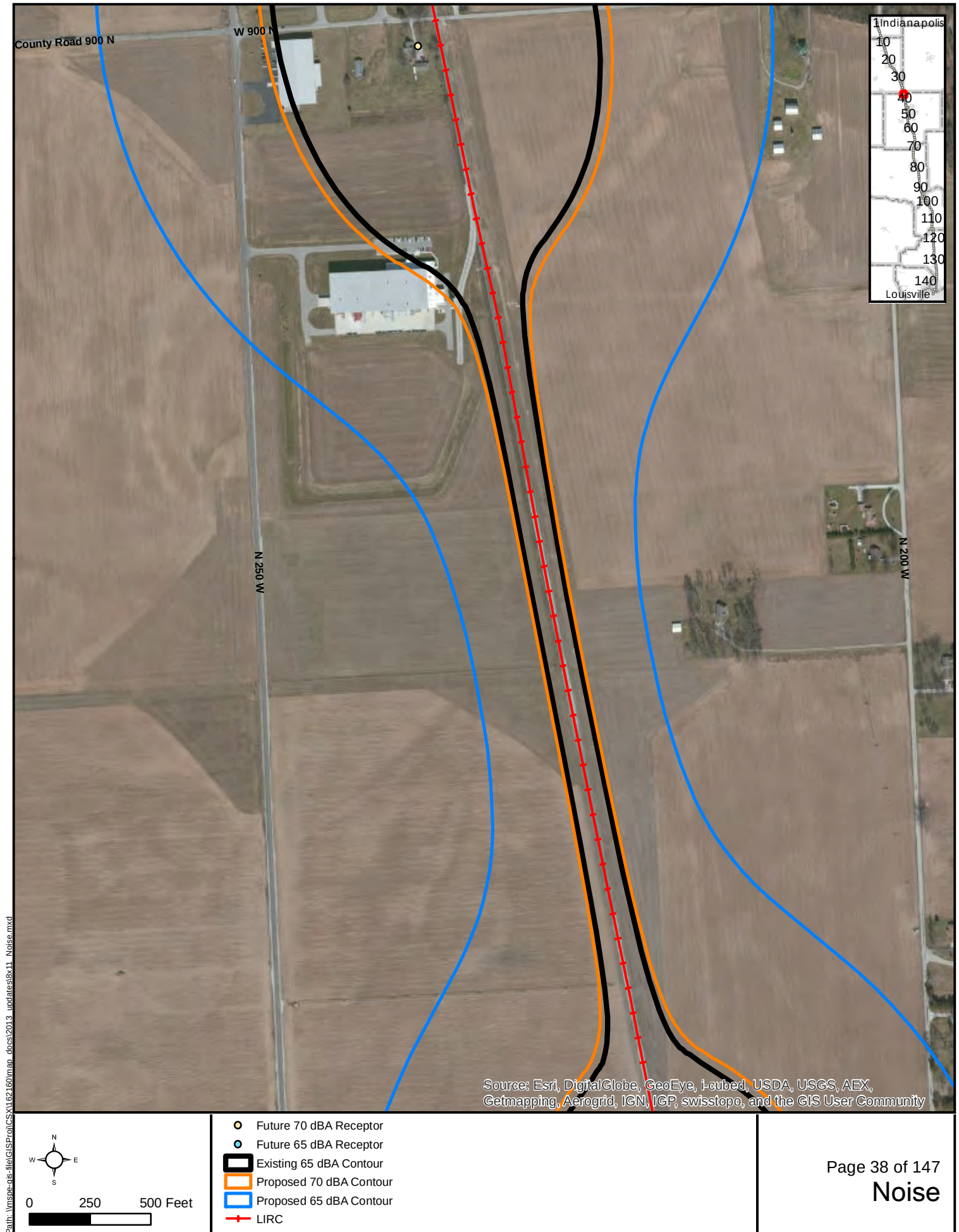


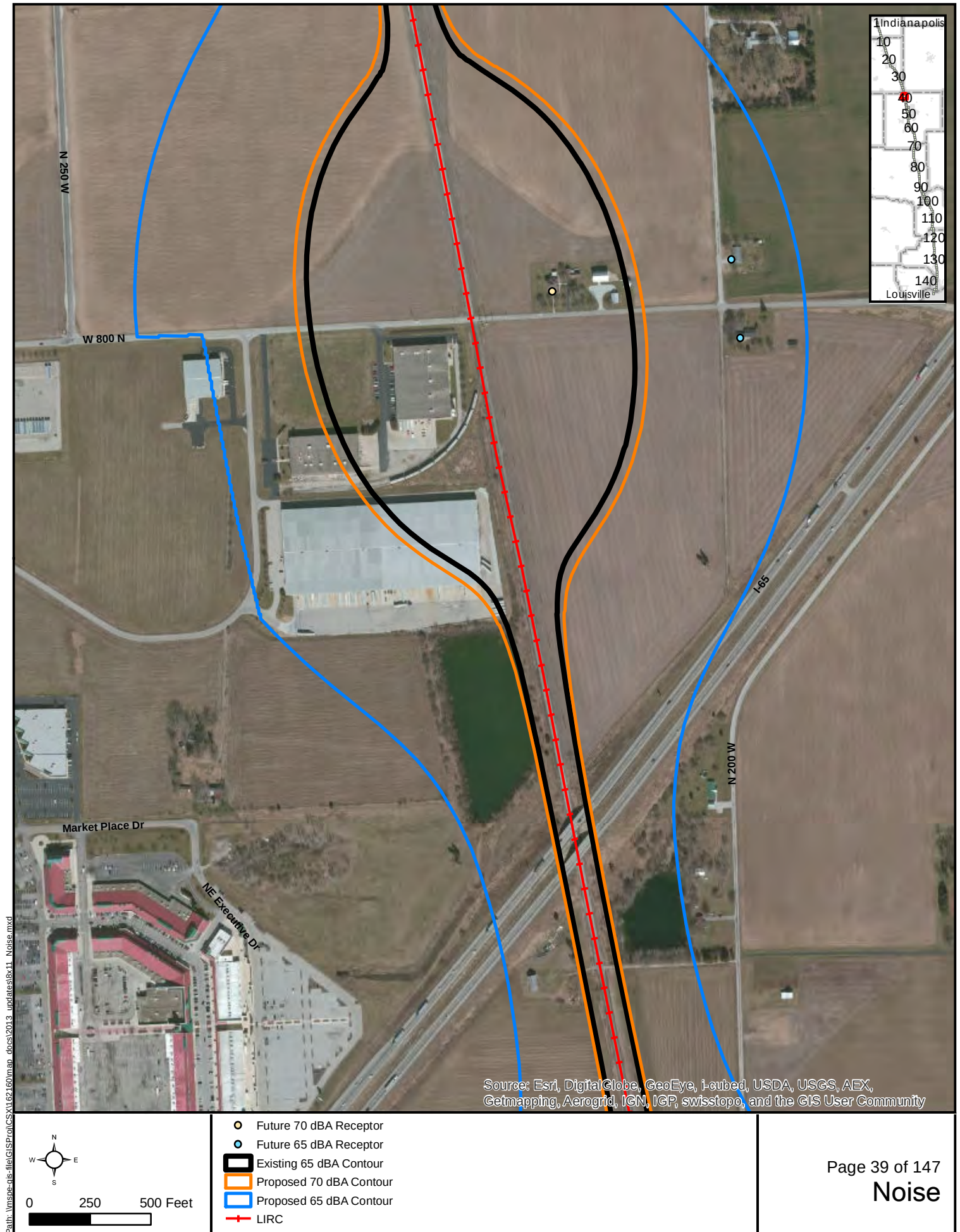


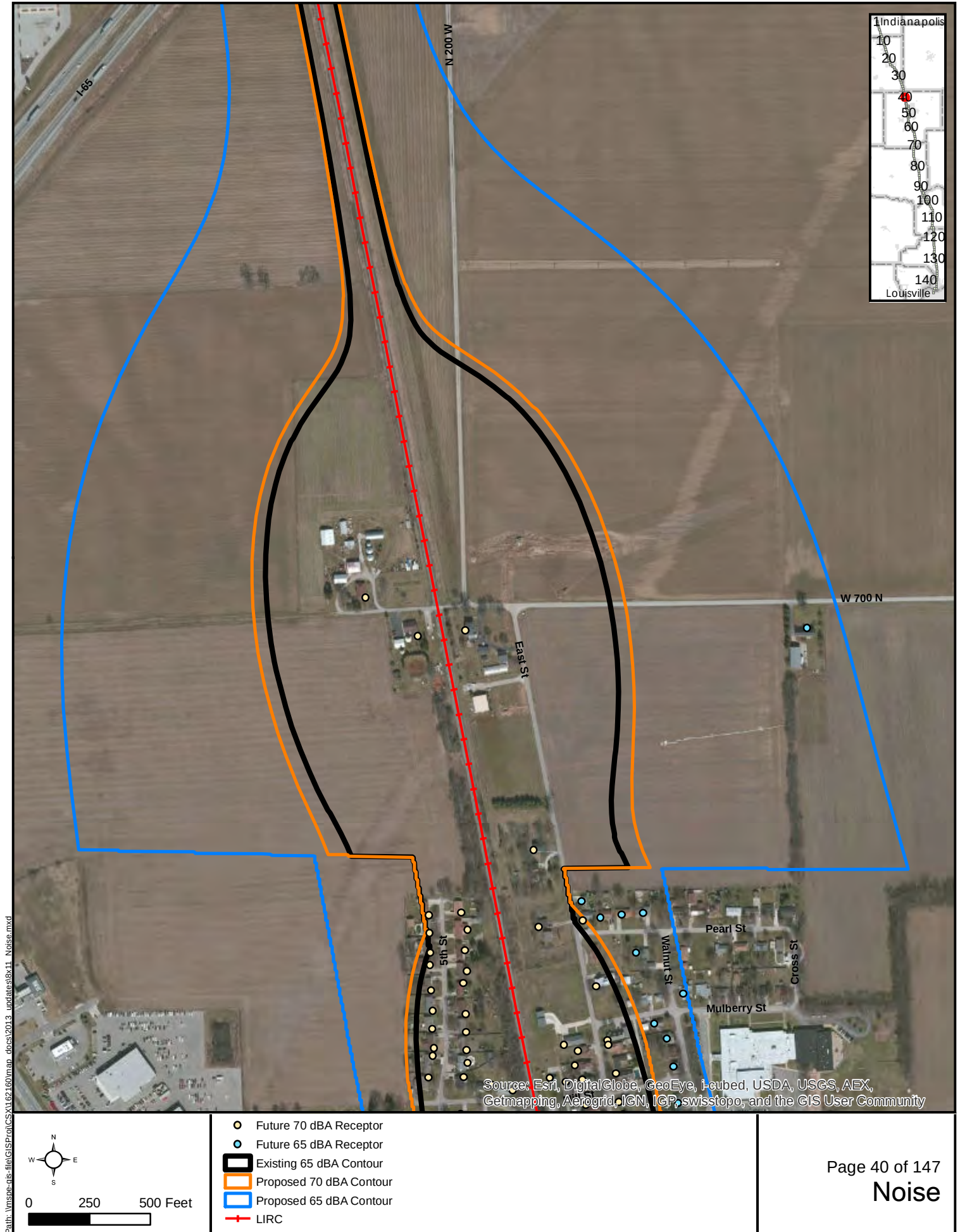


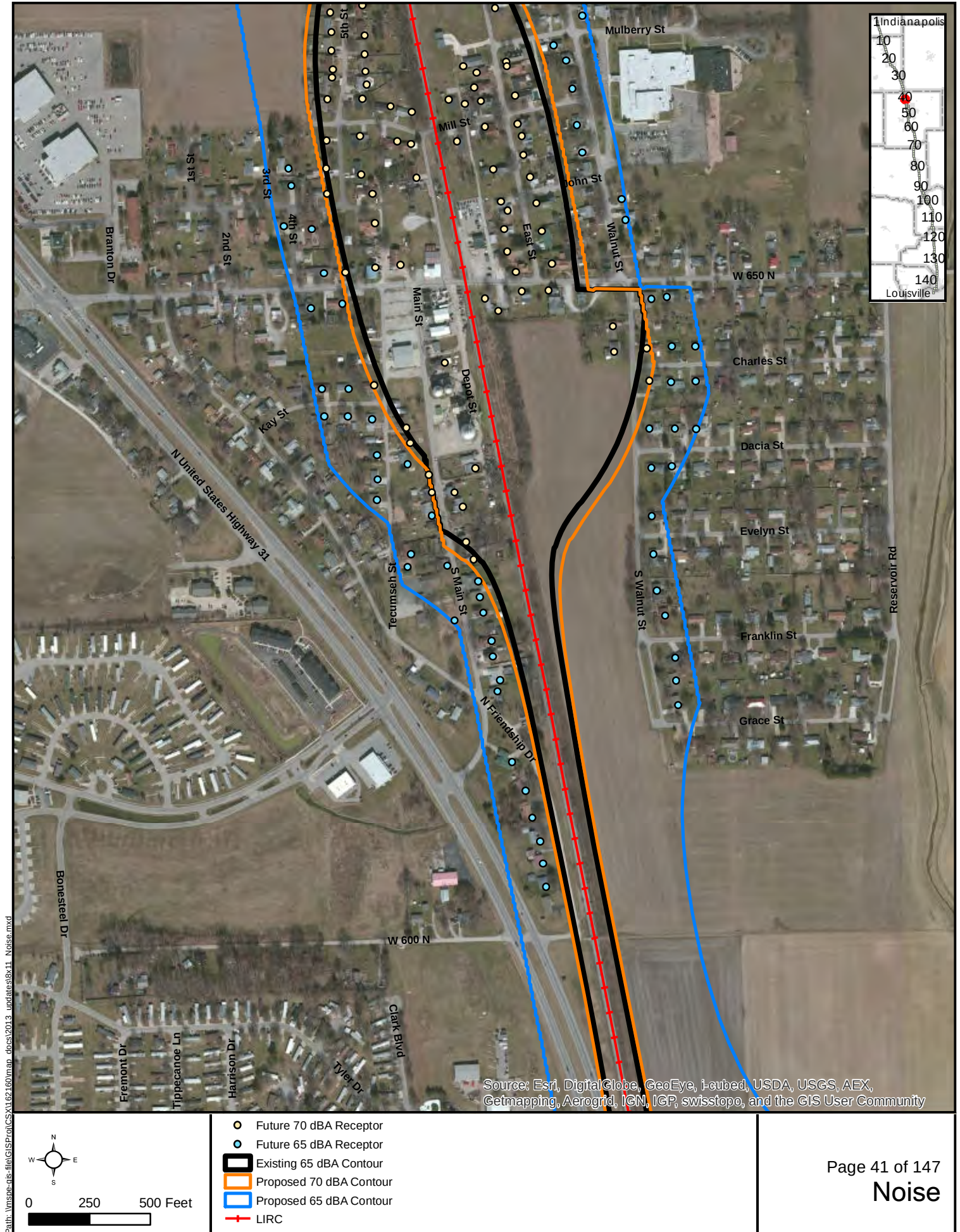


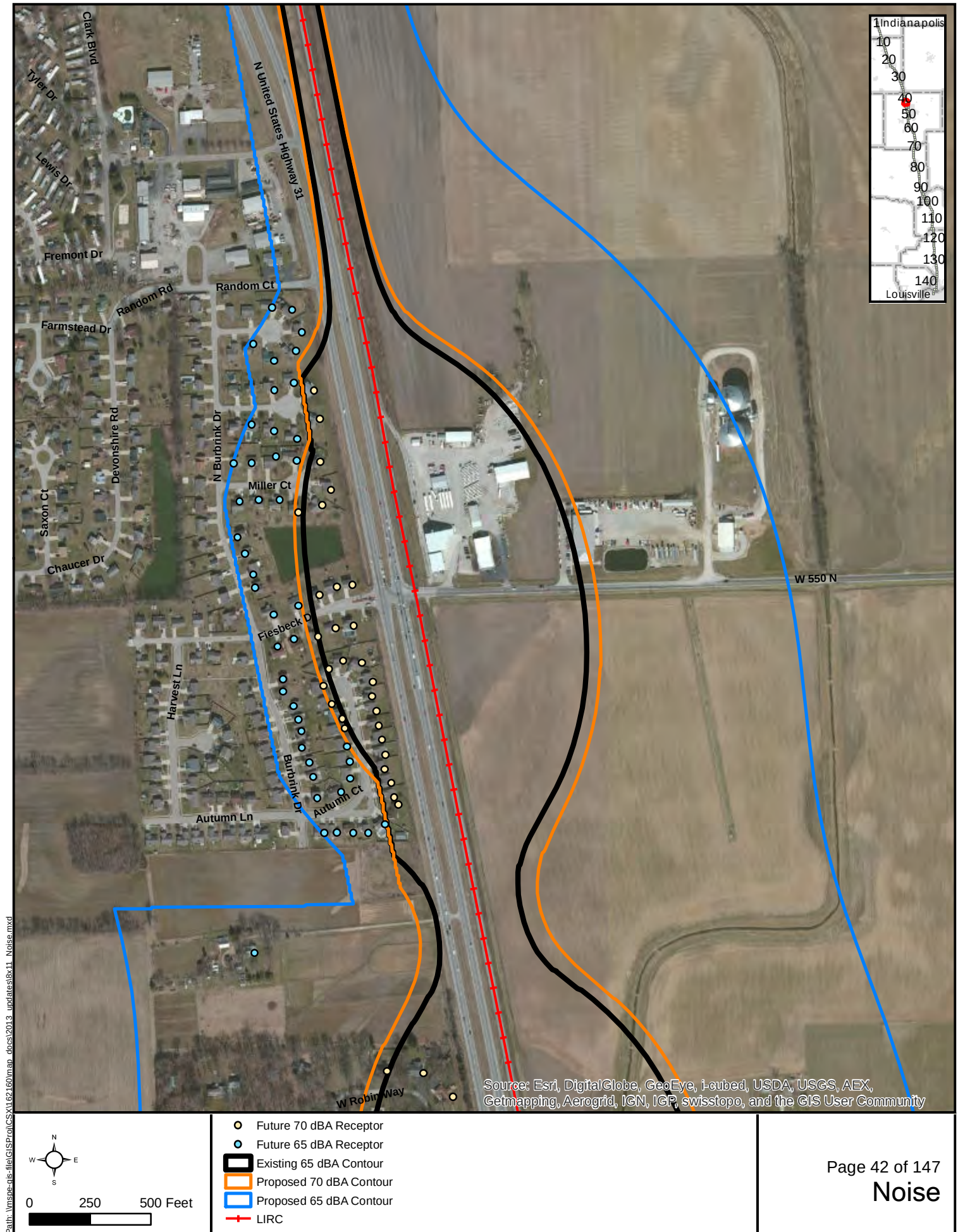


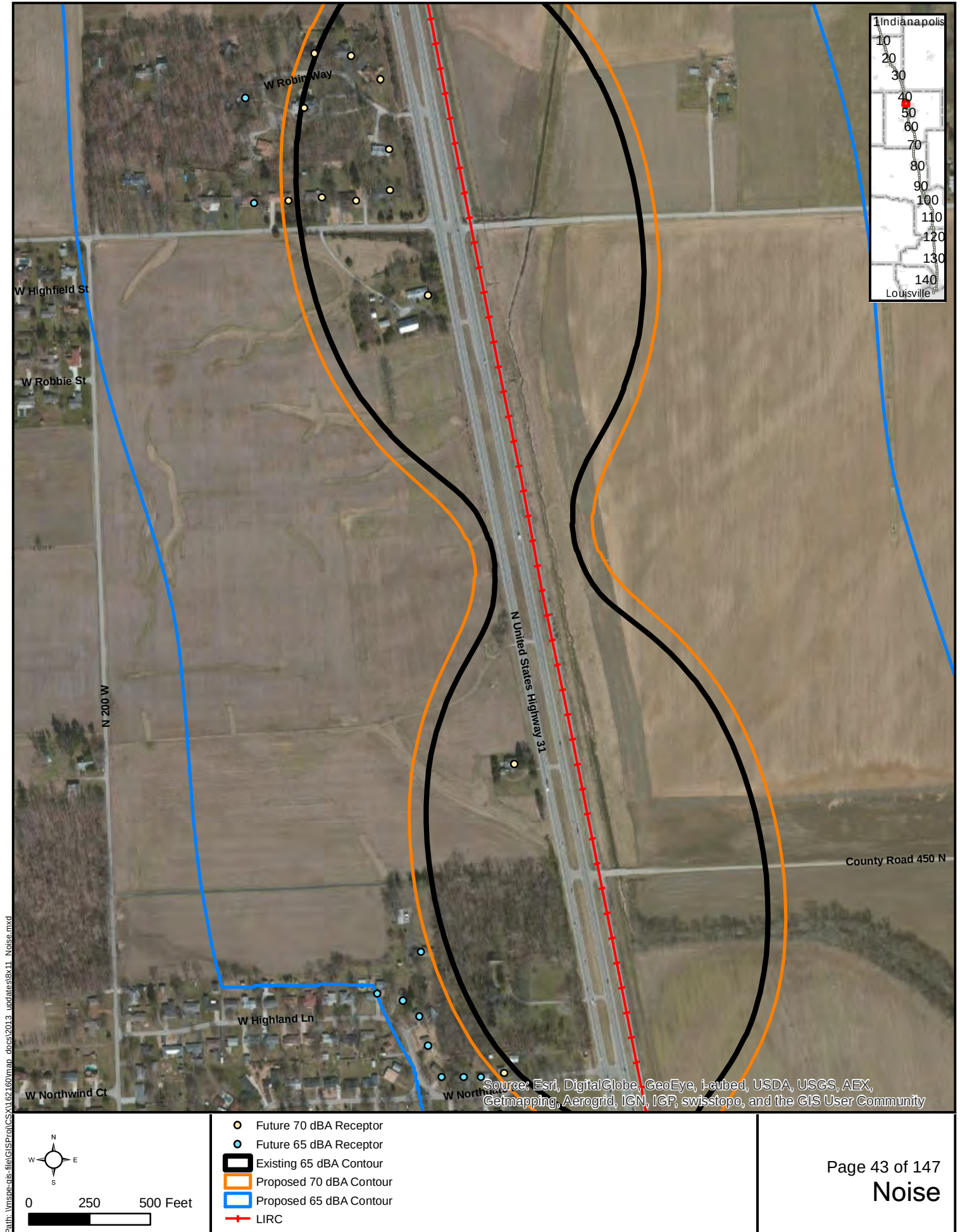


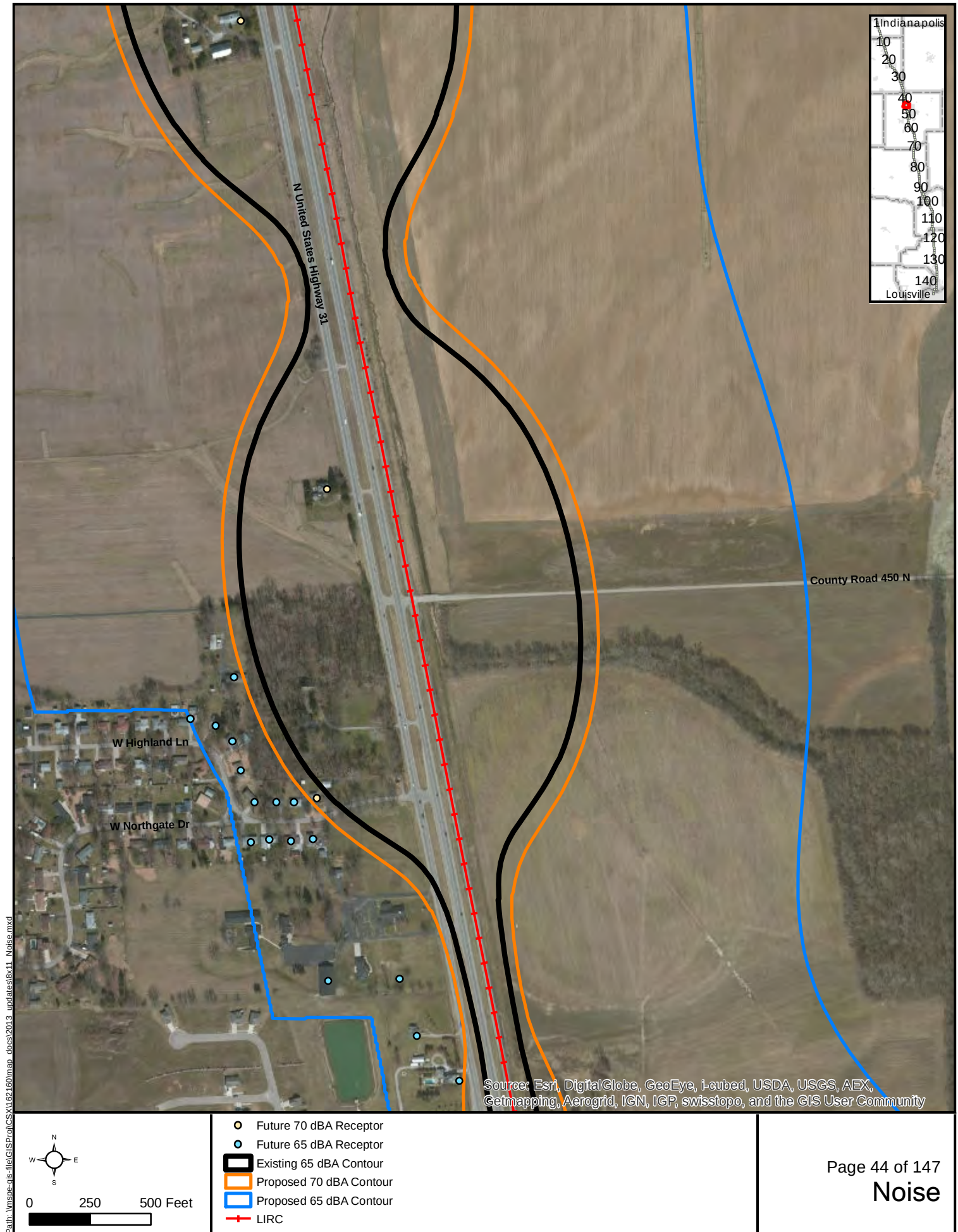


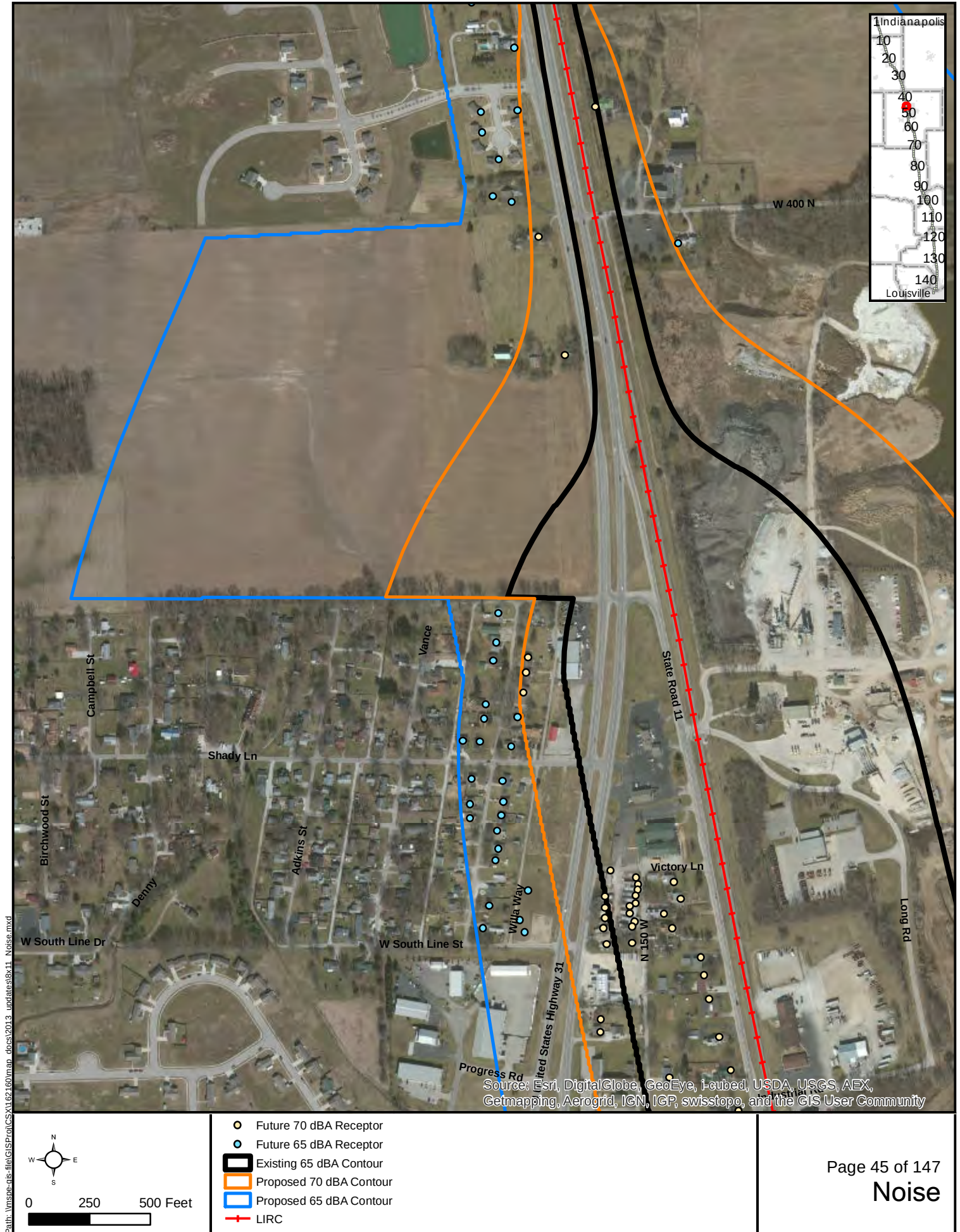






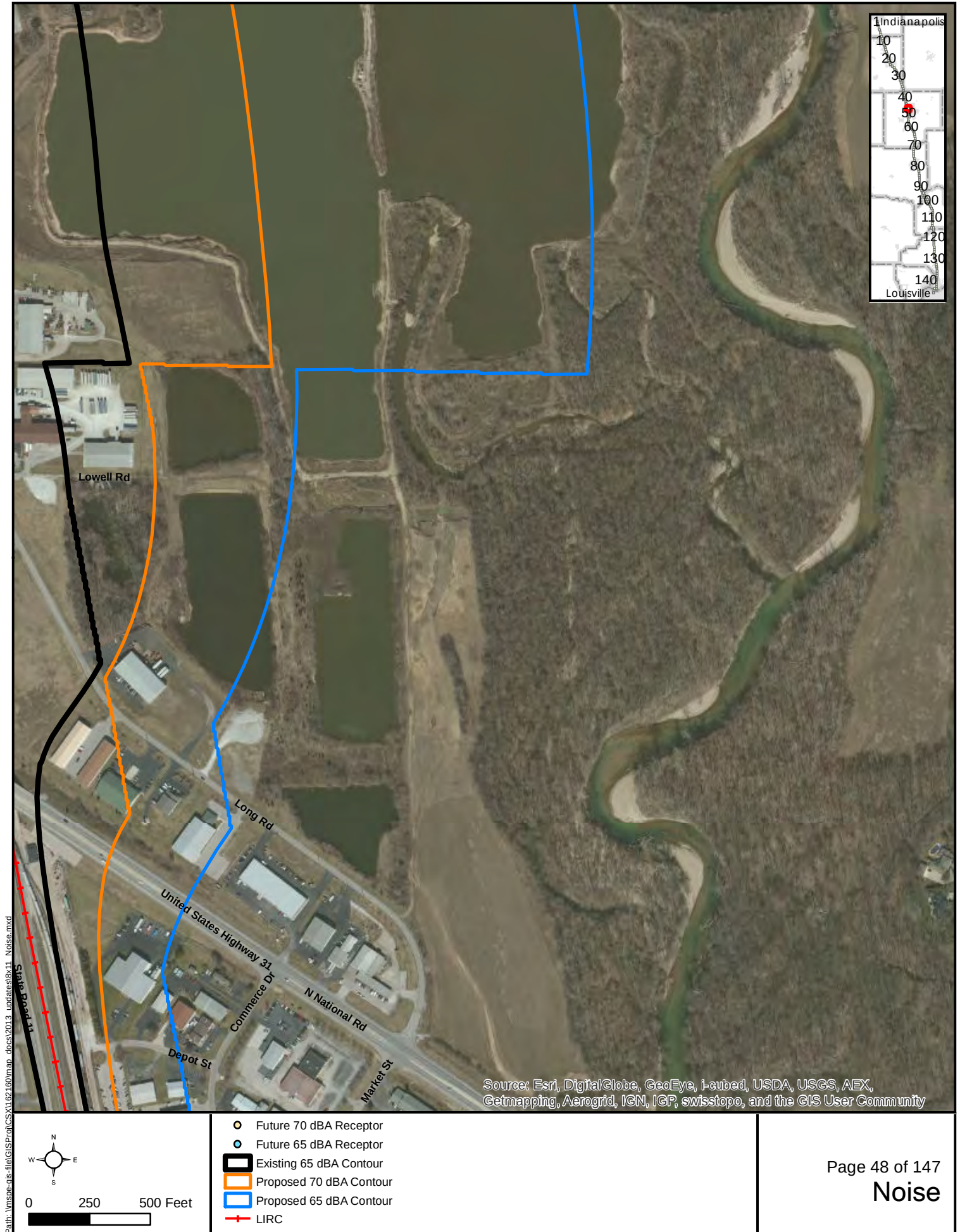


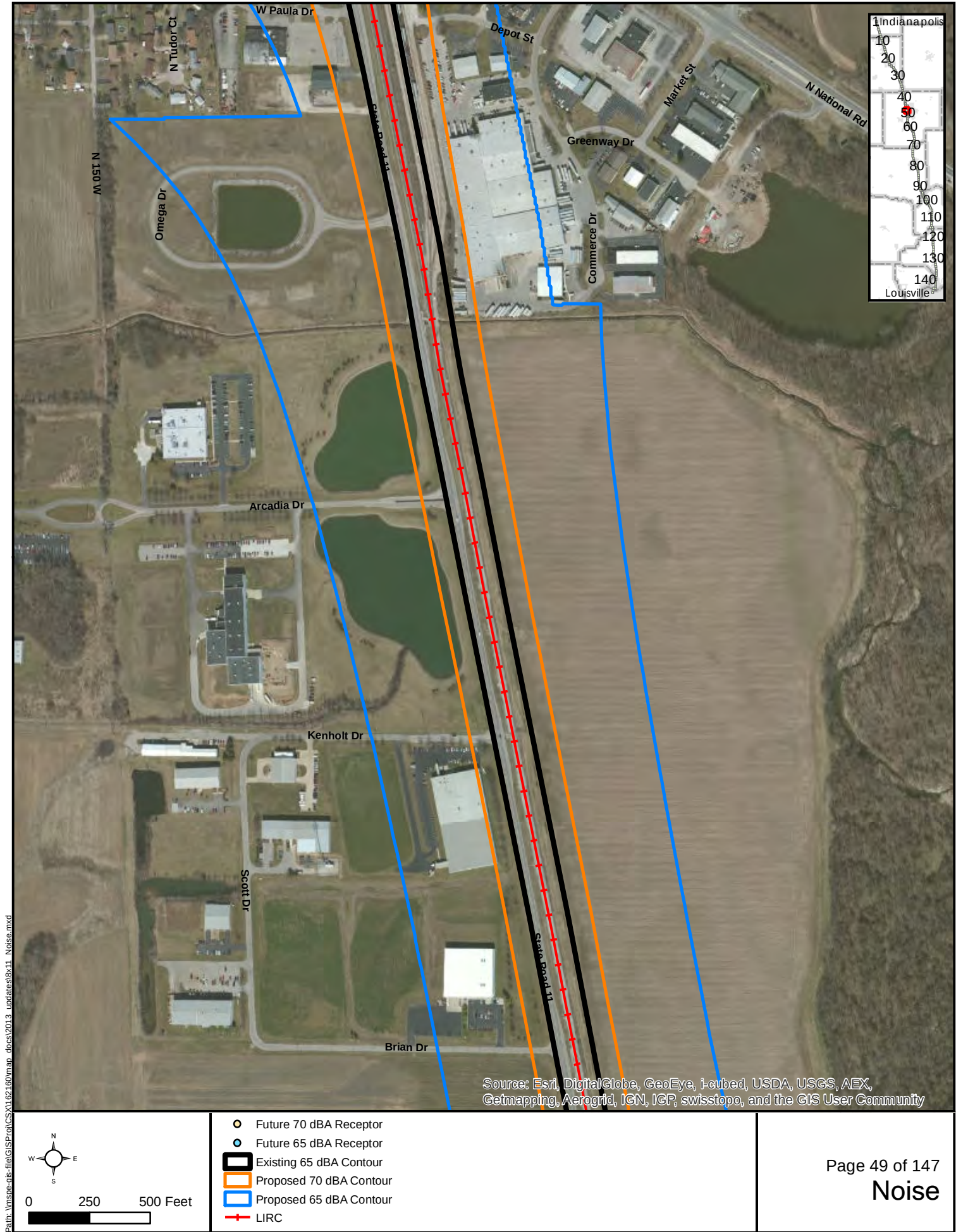


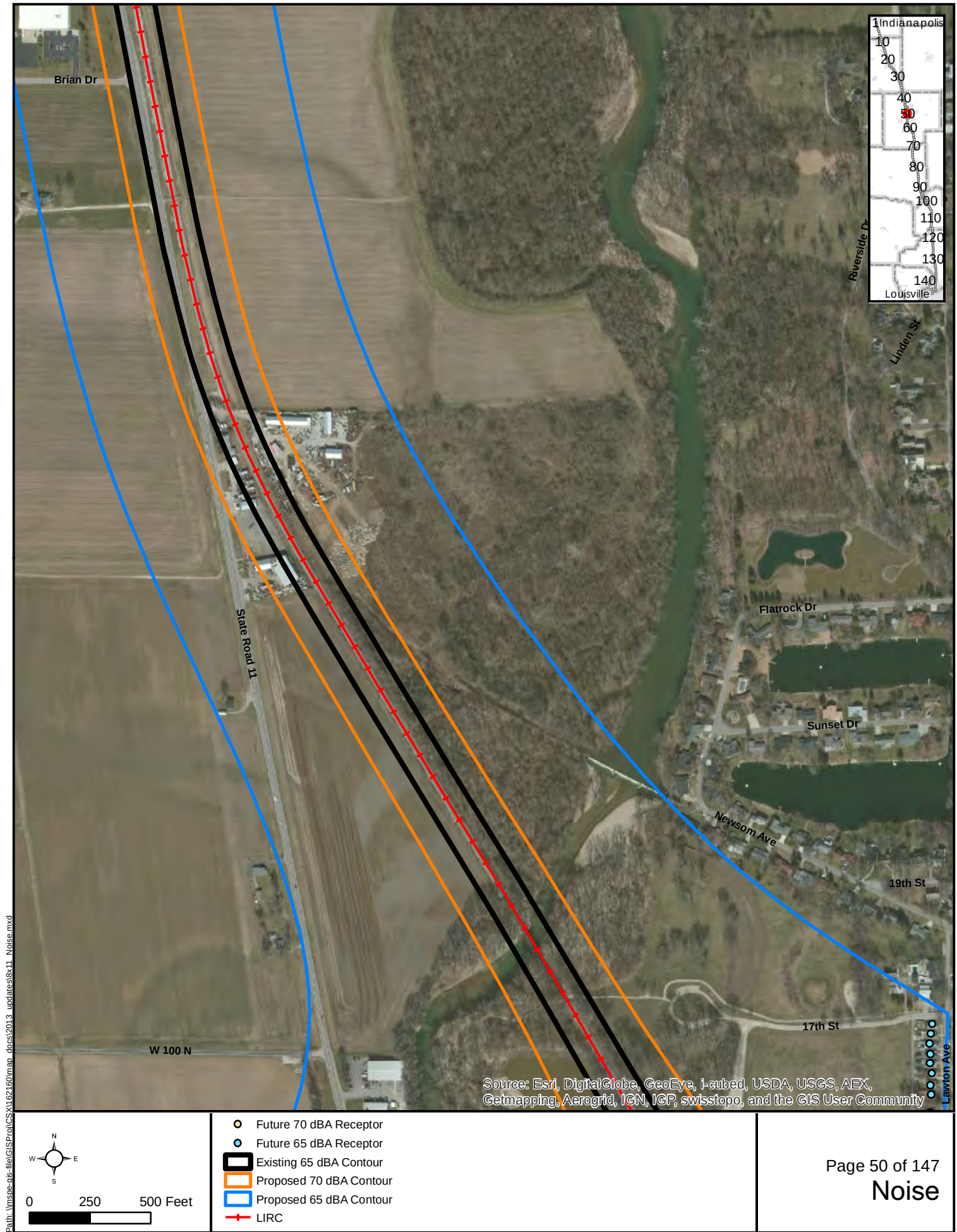


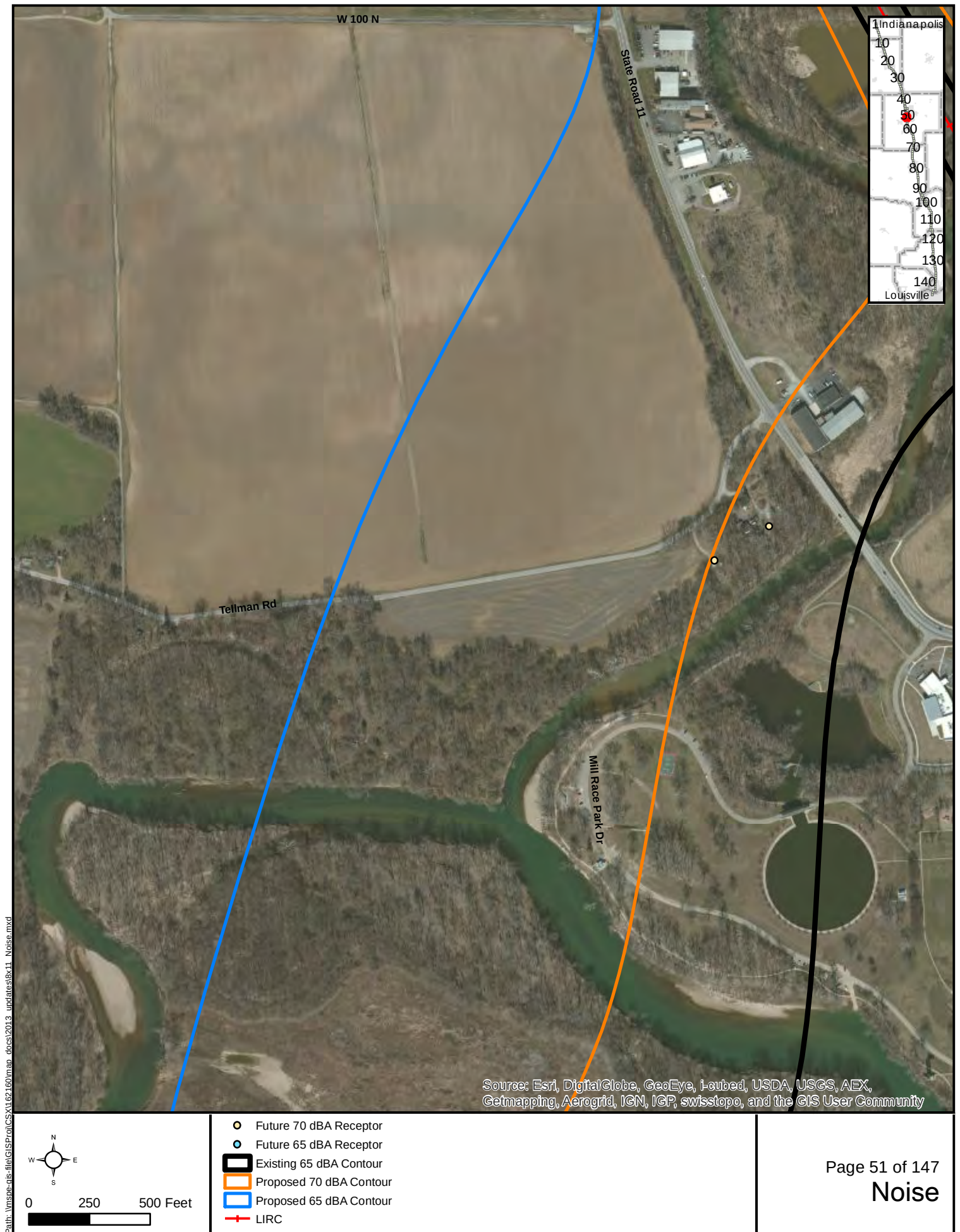










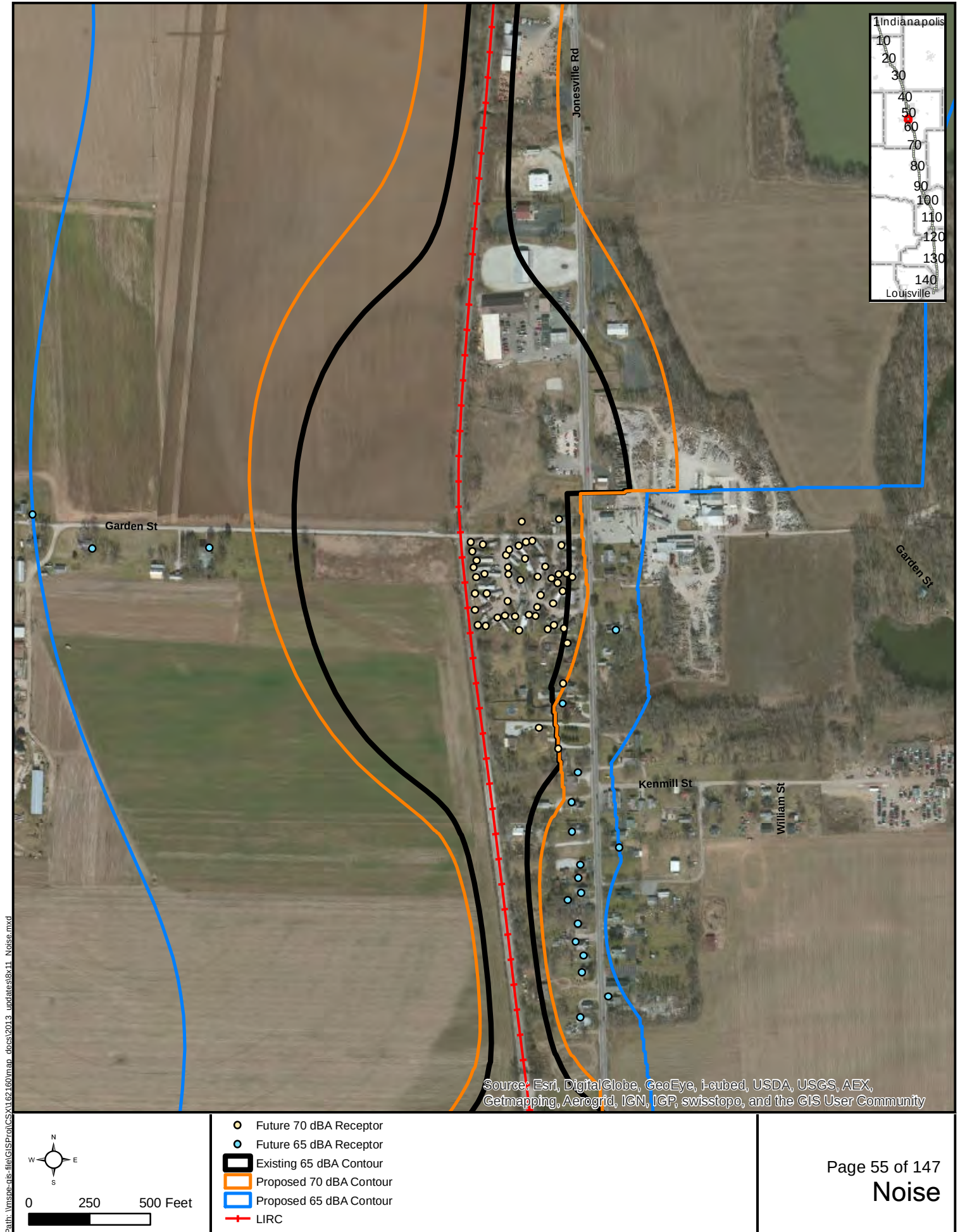


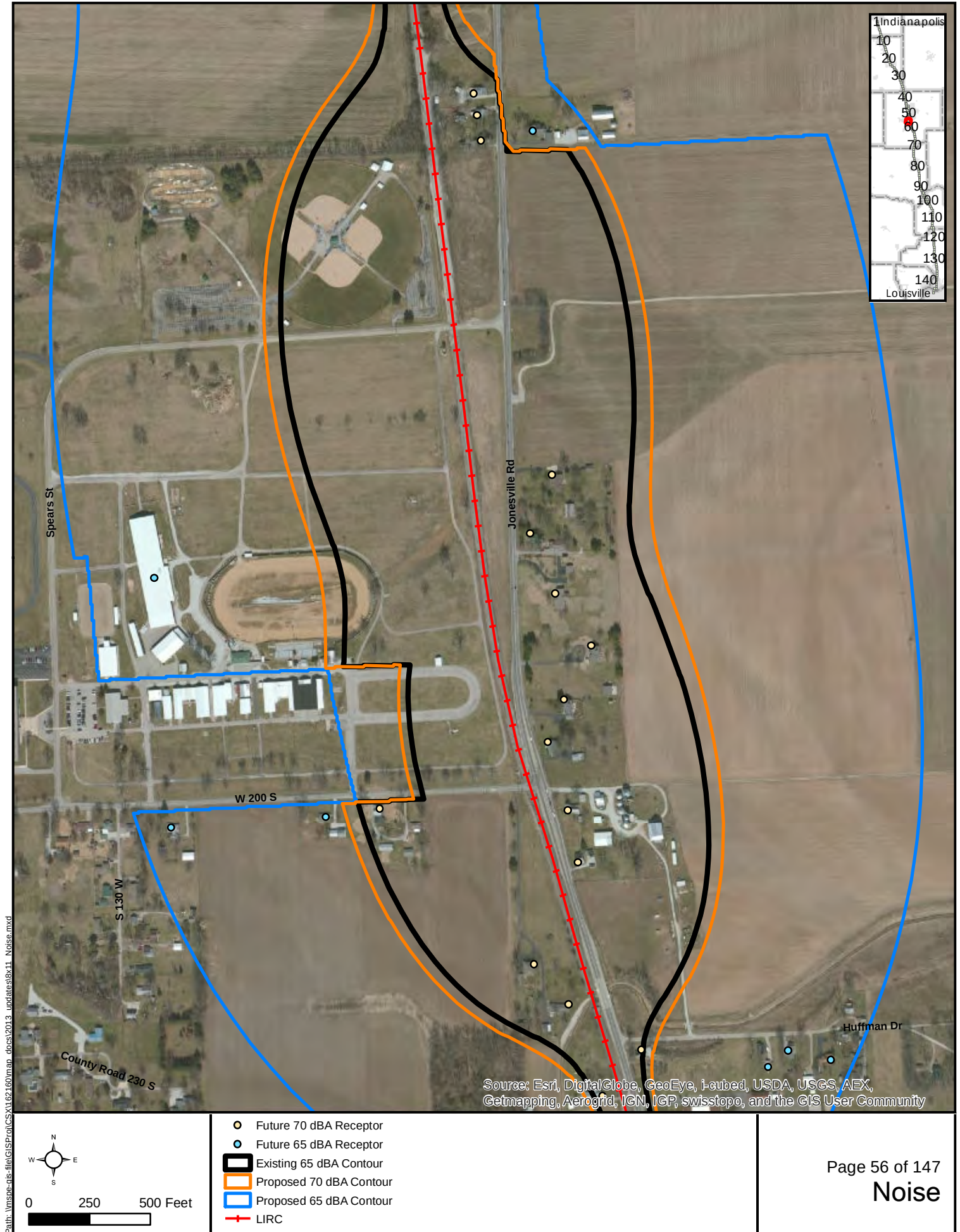


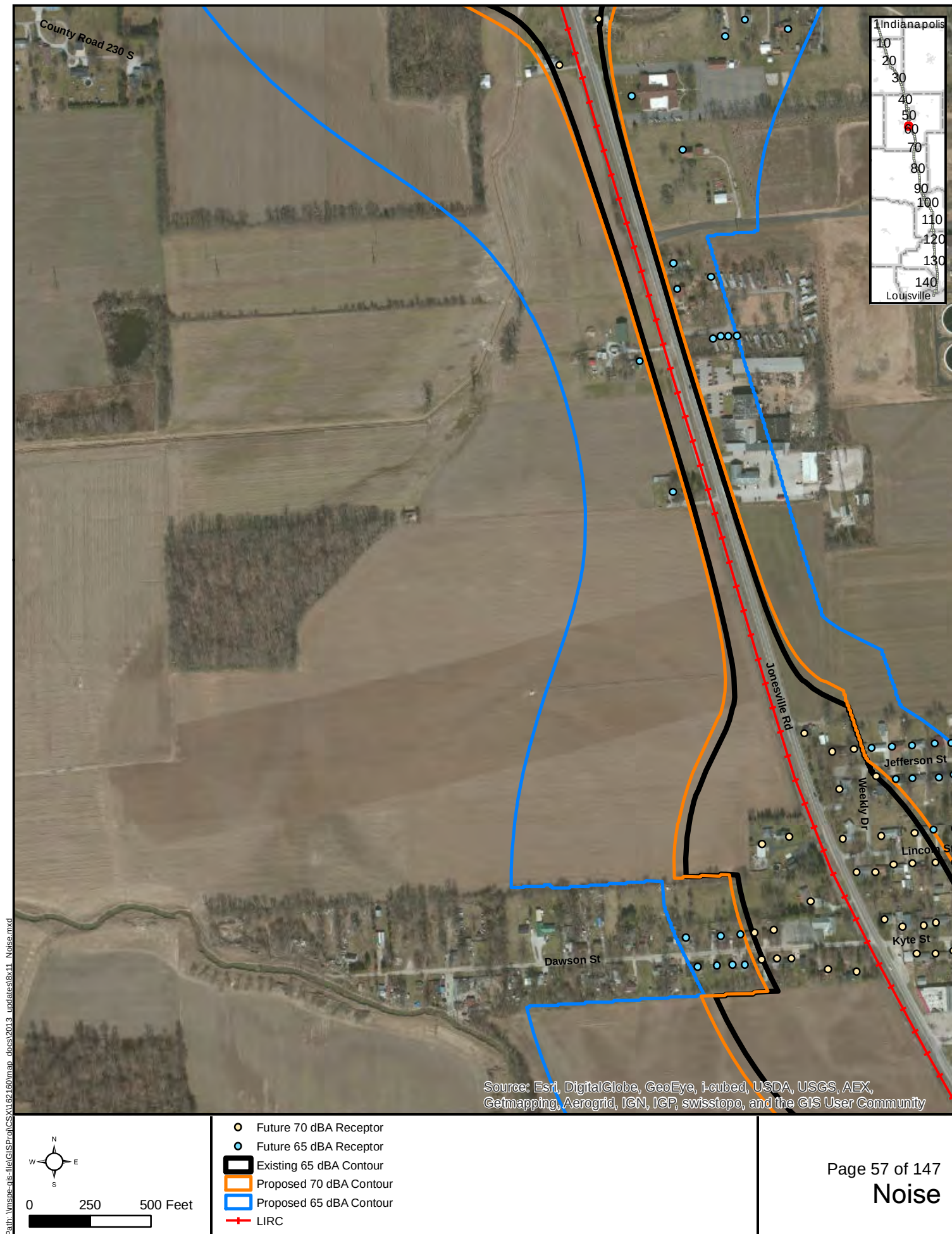


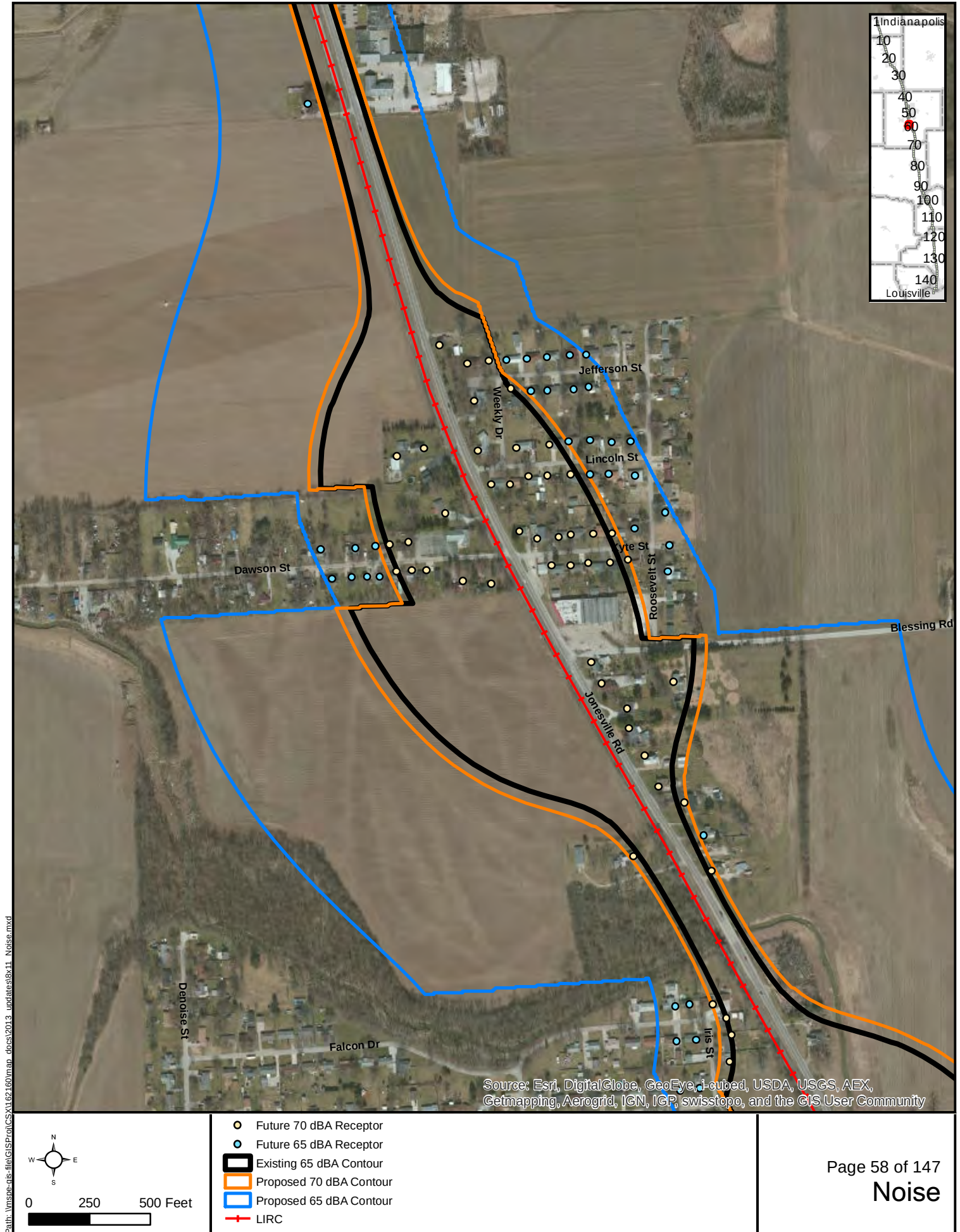


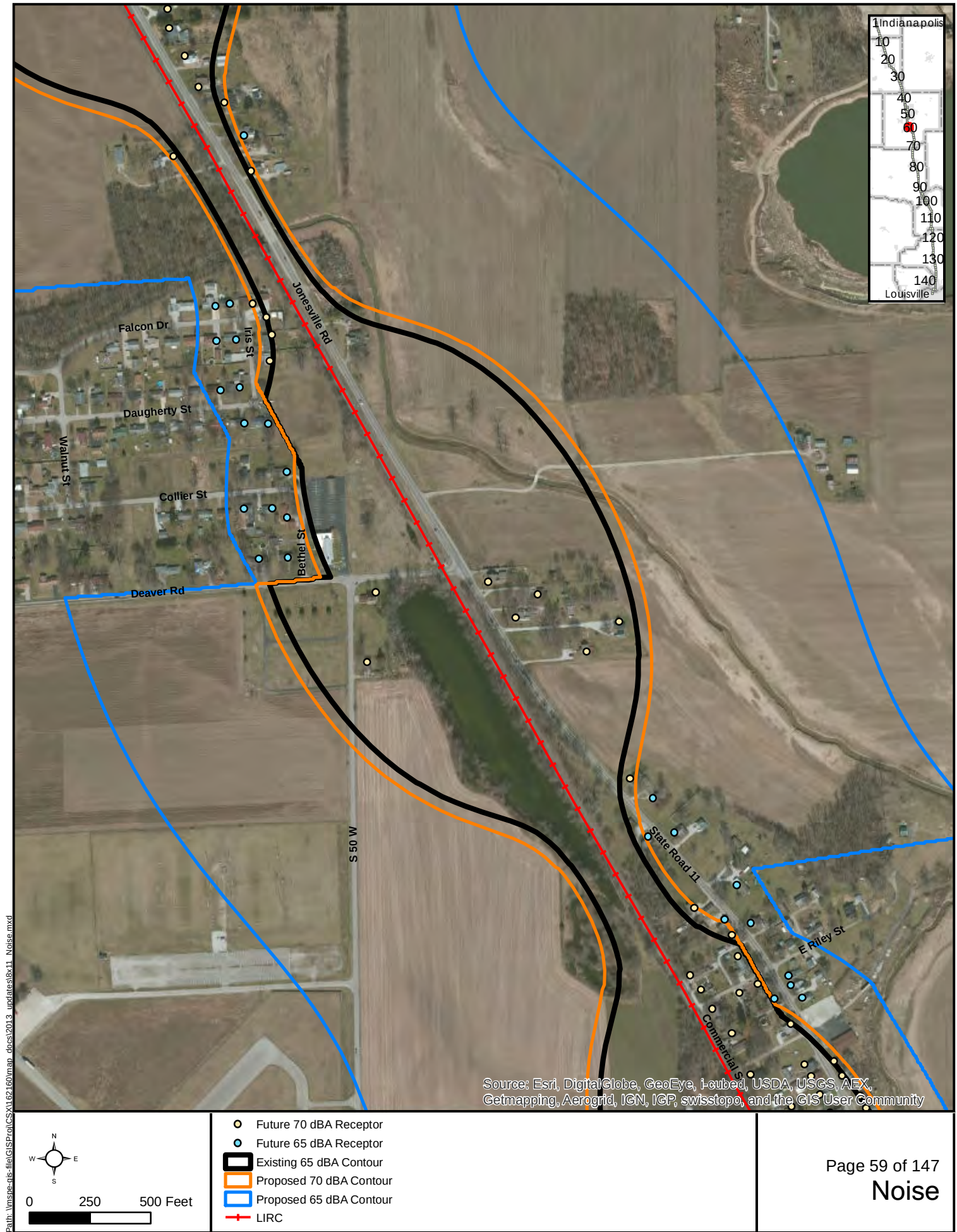
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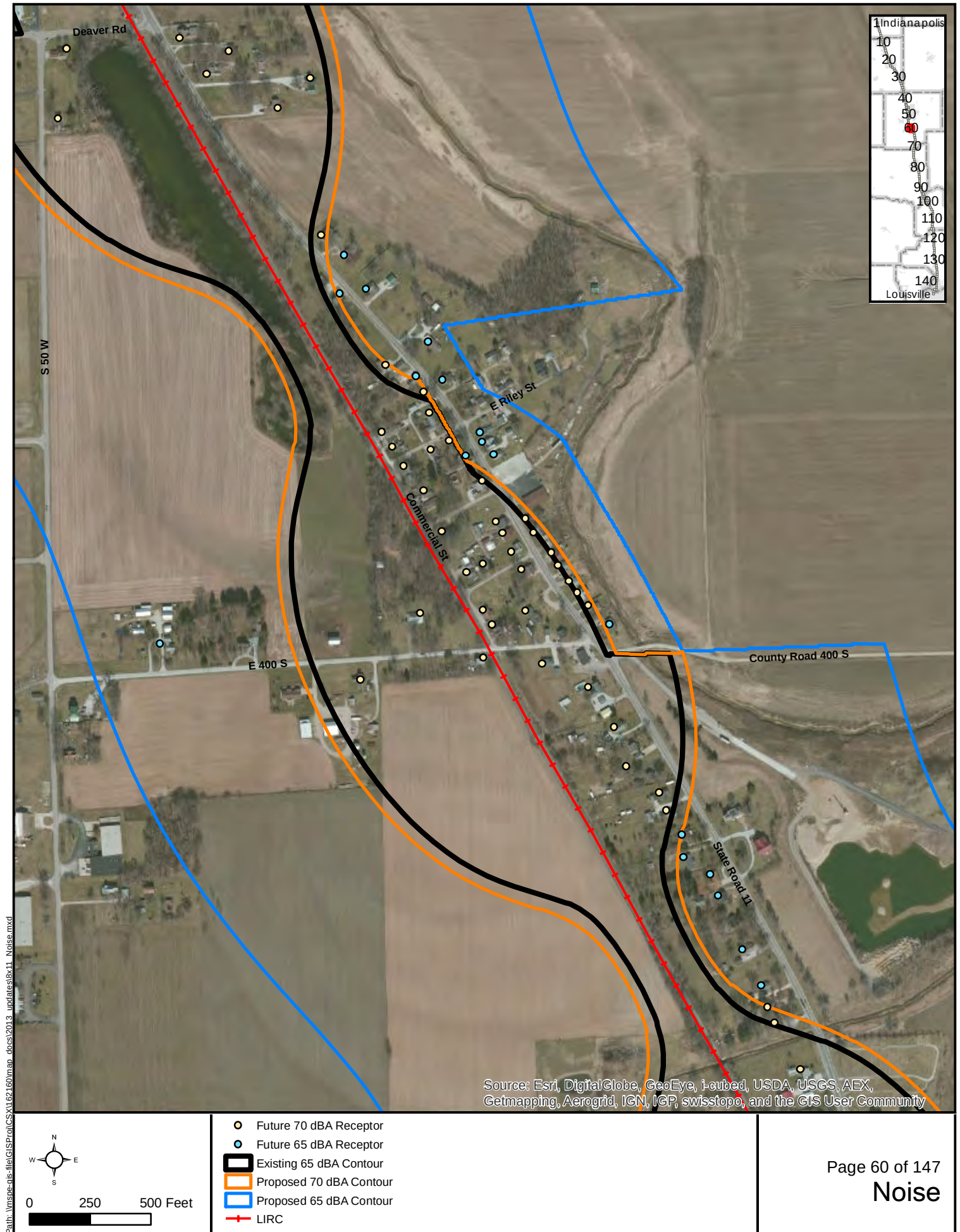


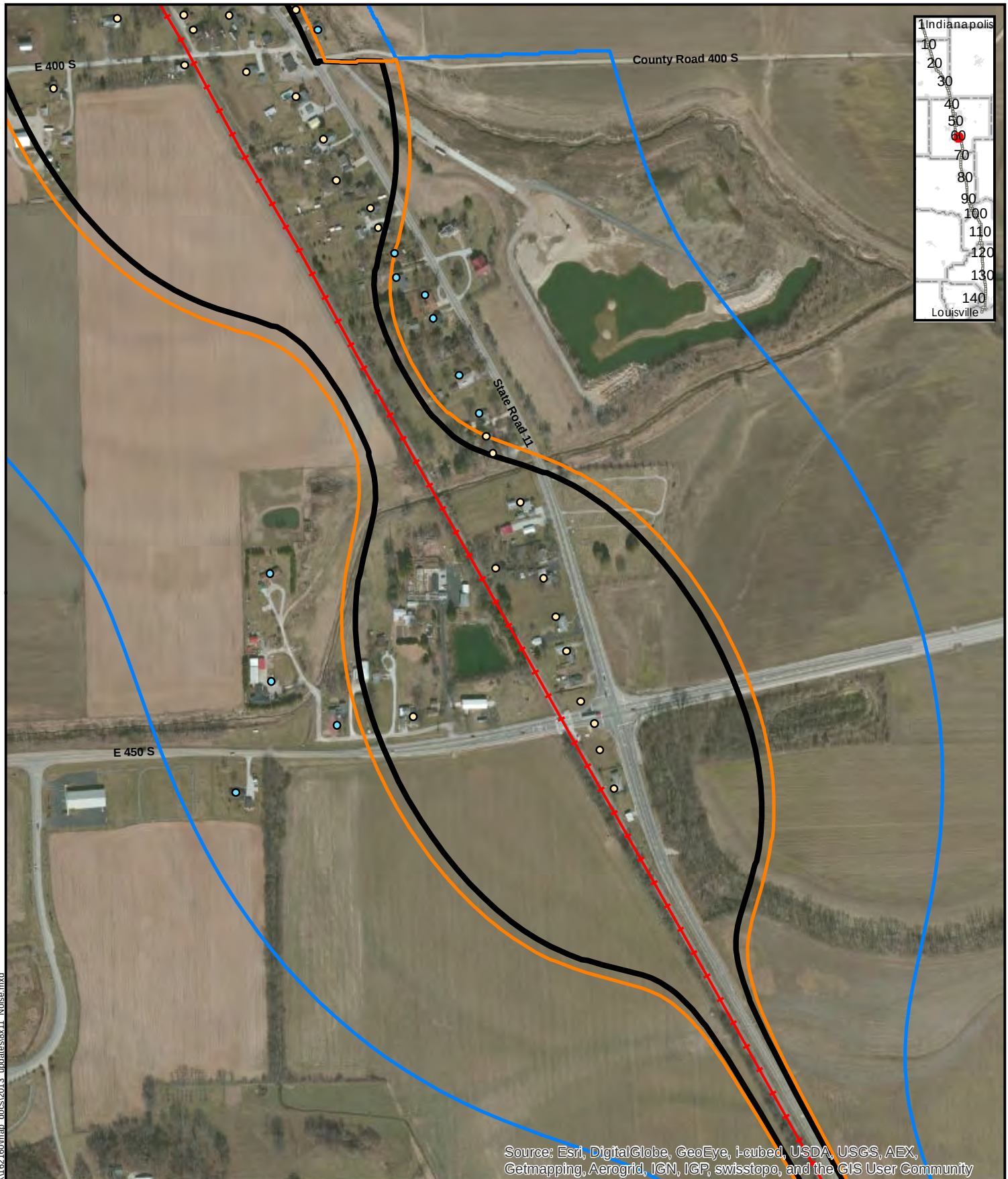










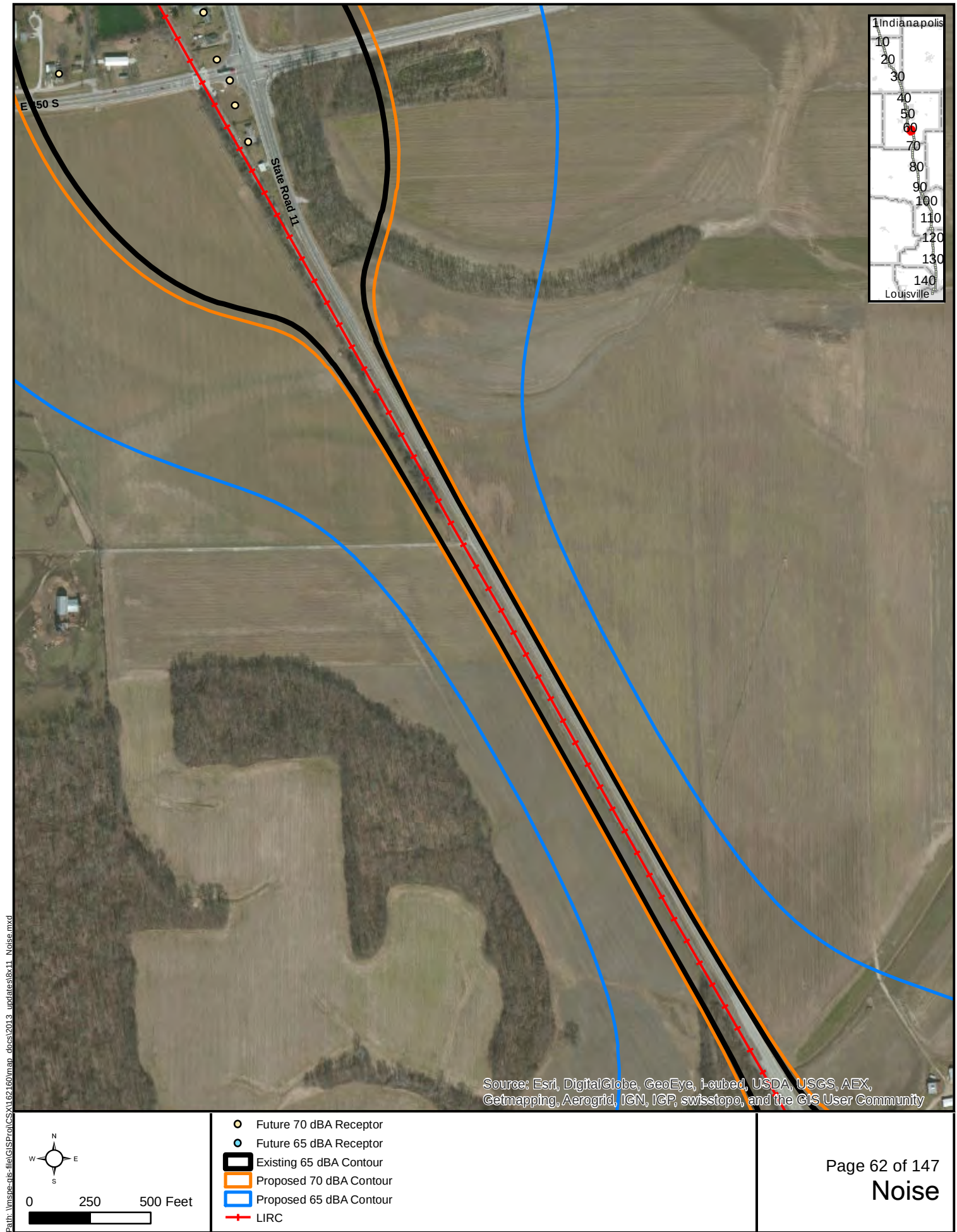


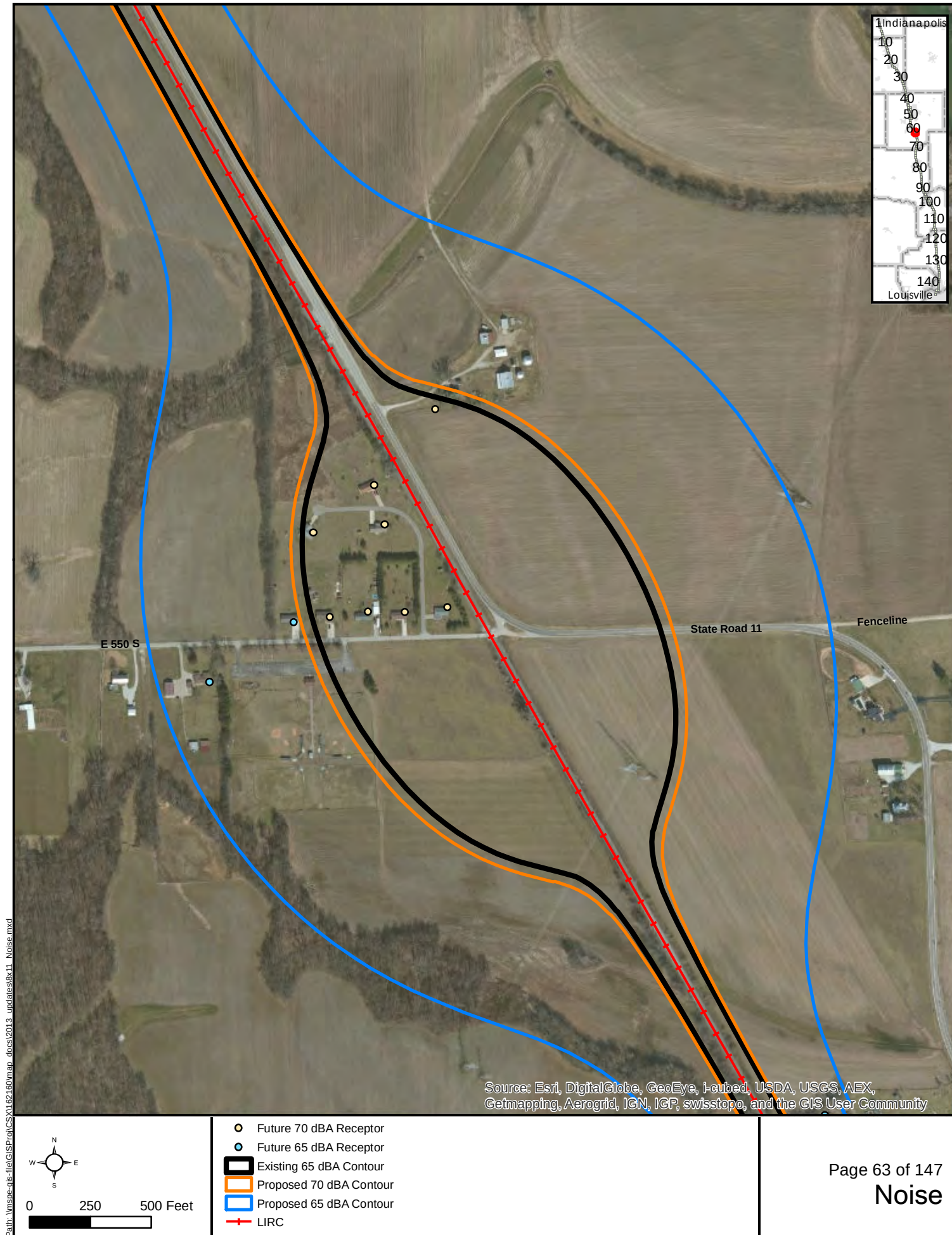
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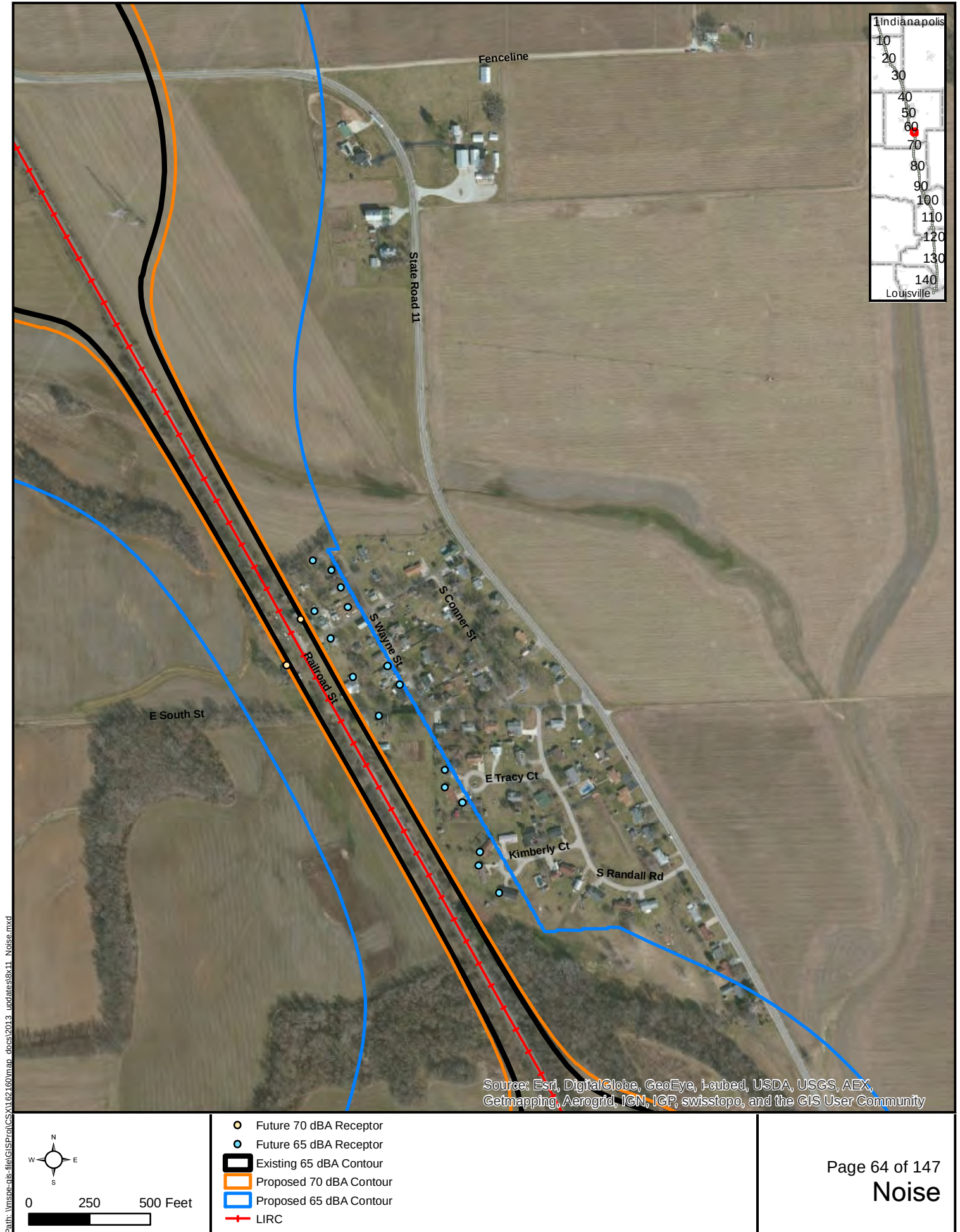


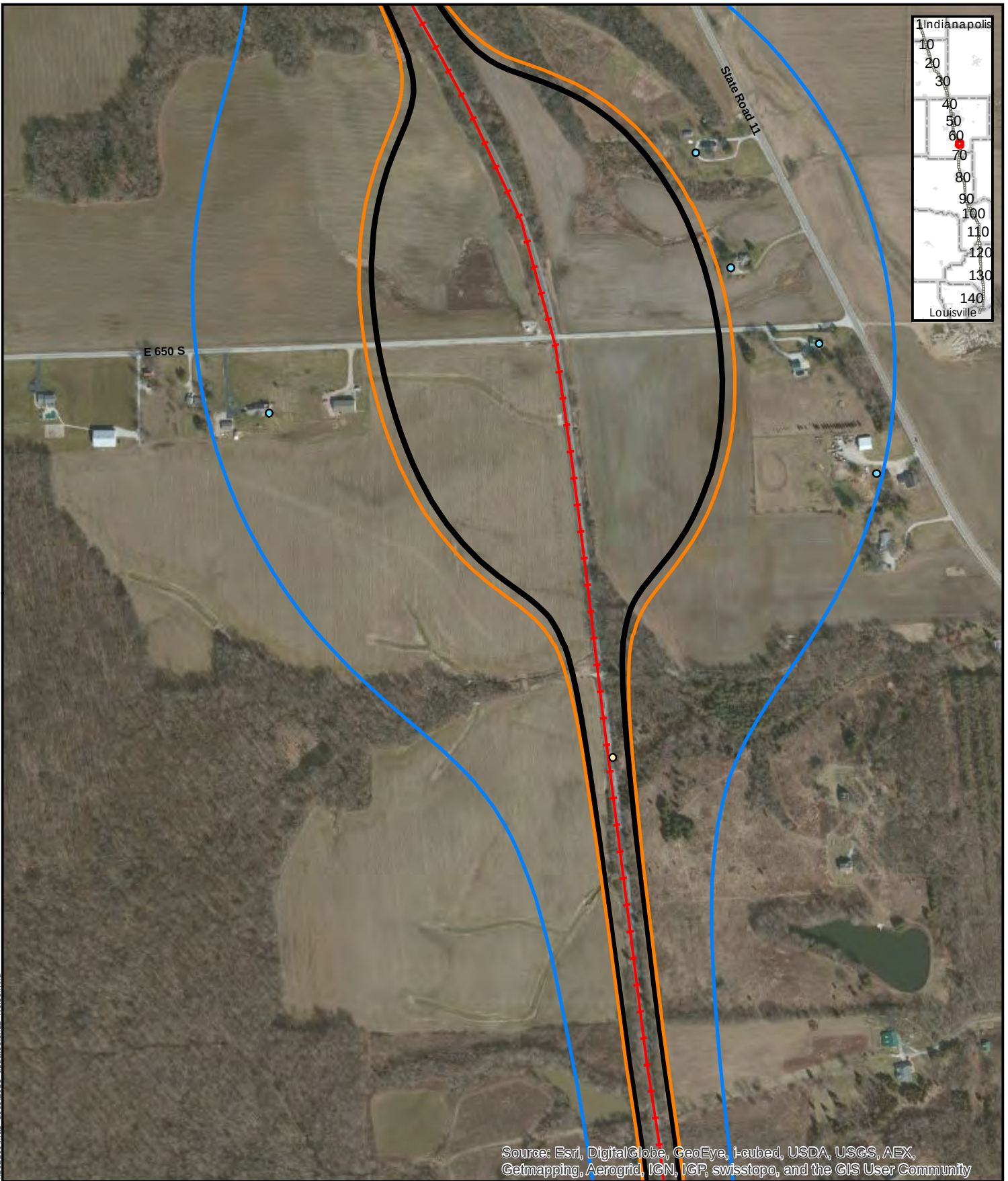
0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- +— LIRC







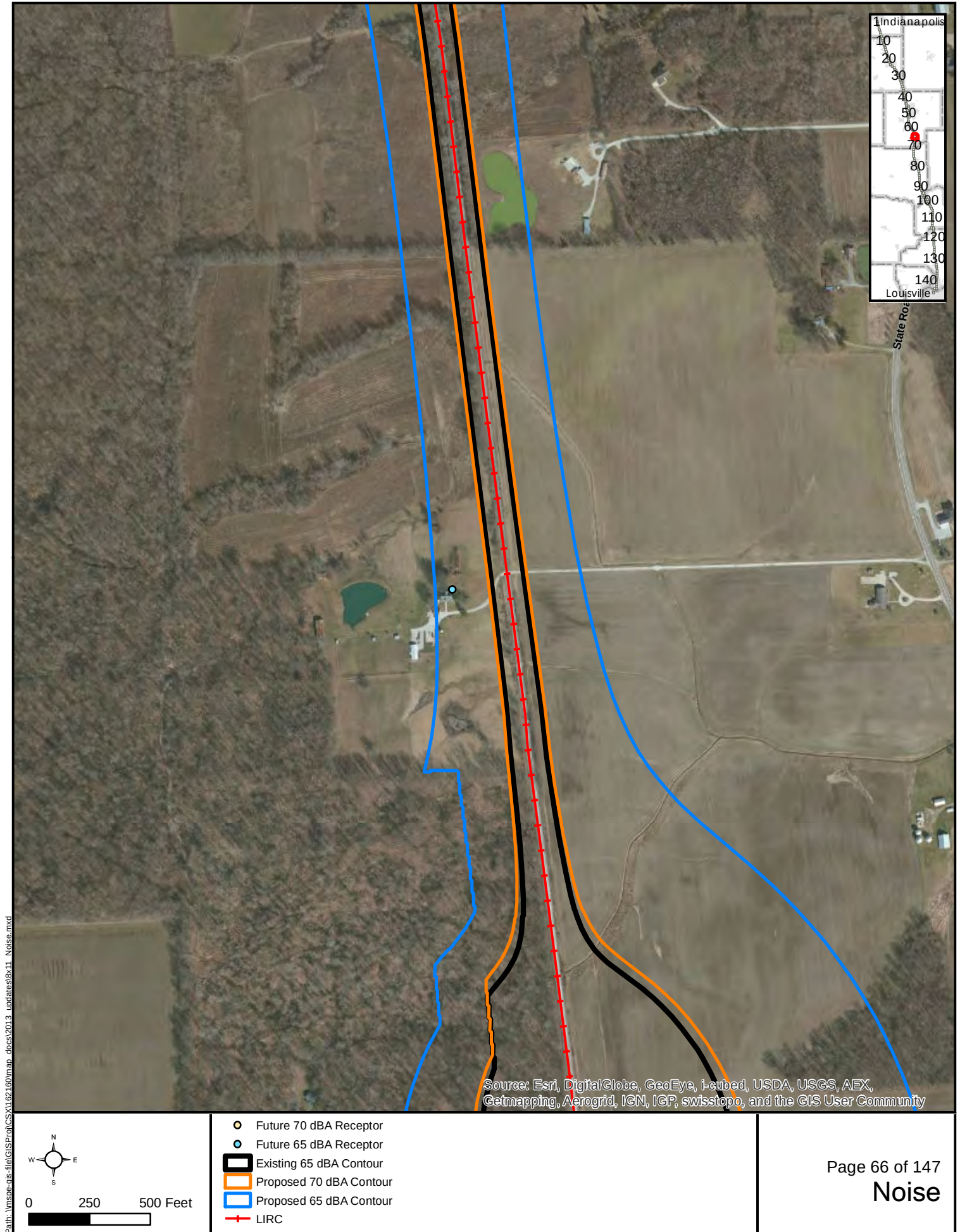


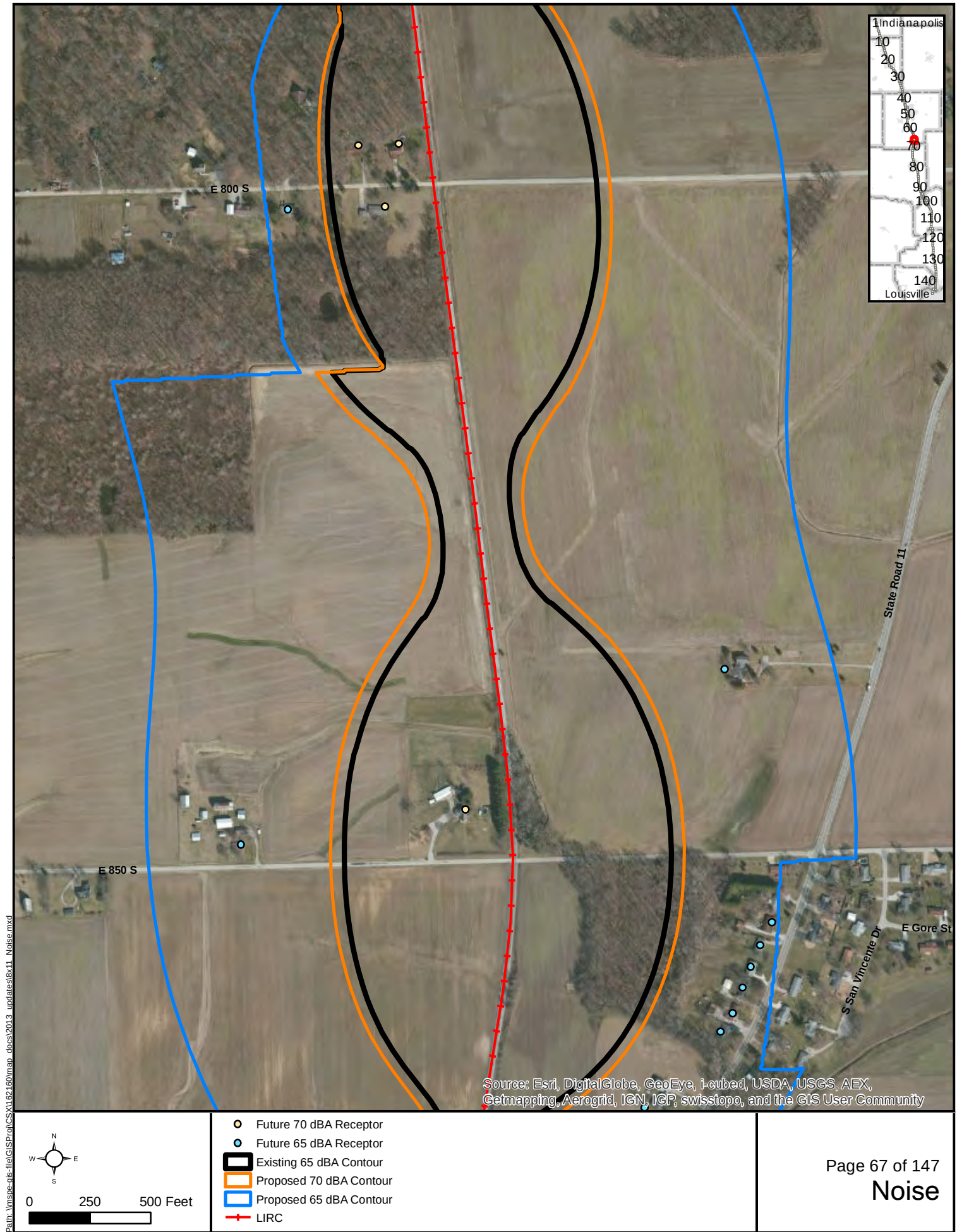
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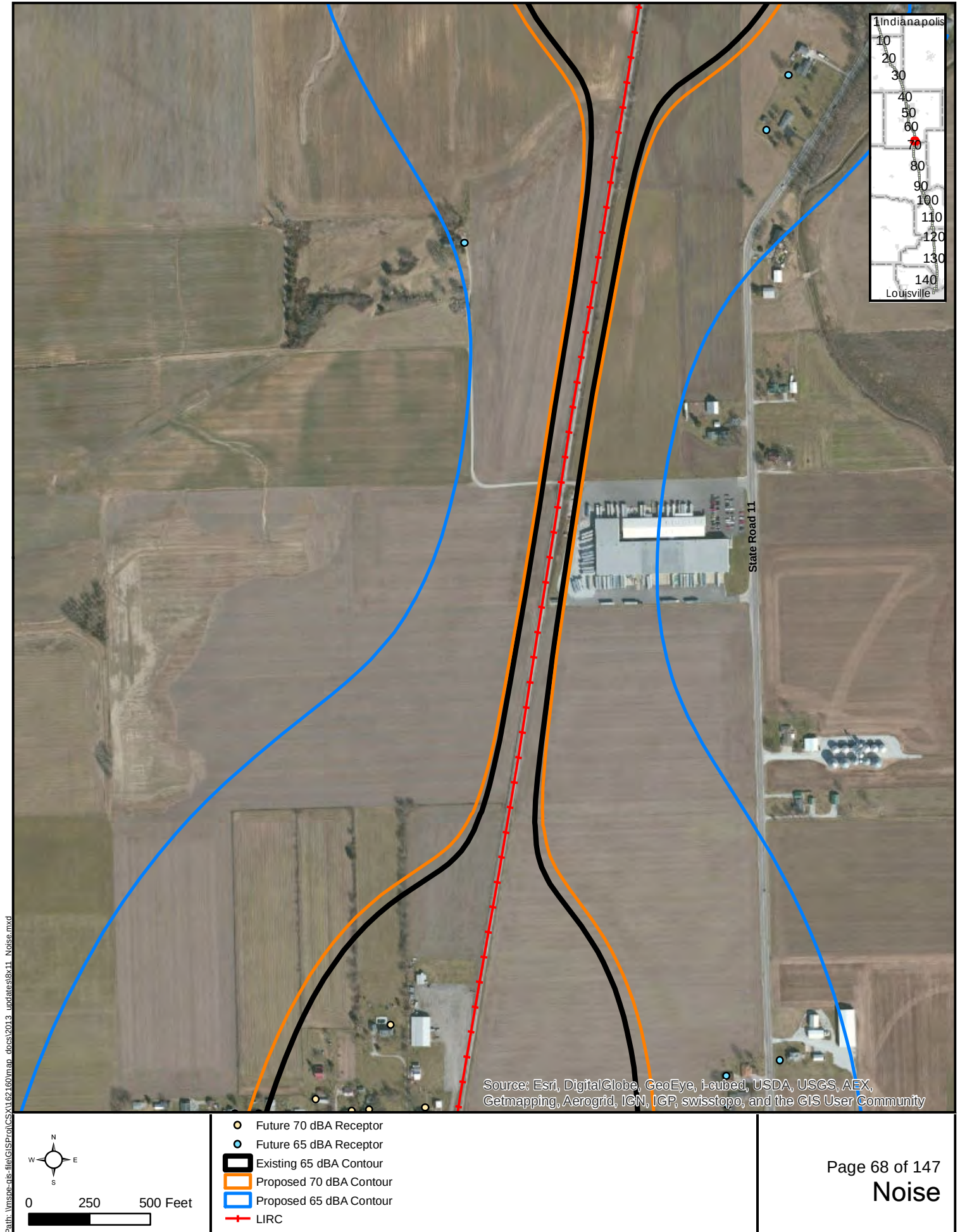


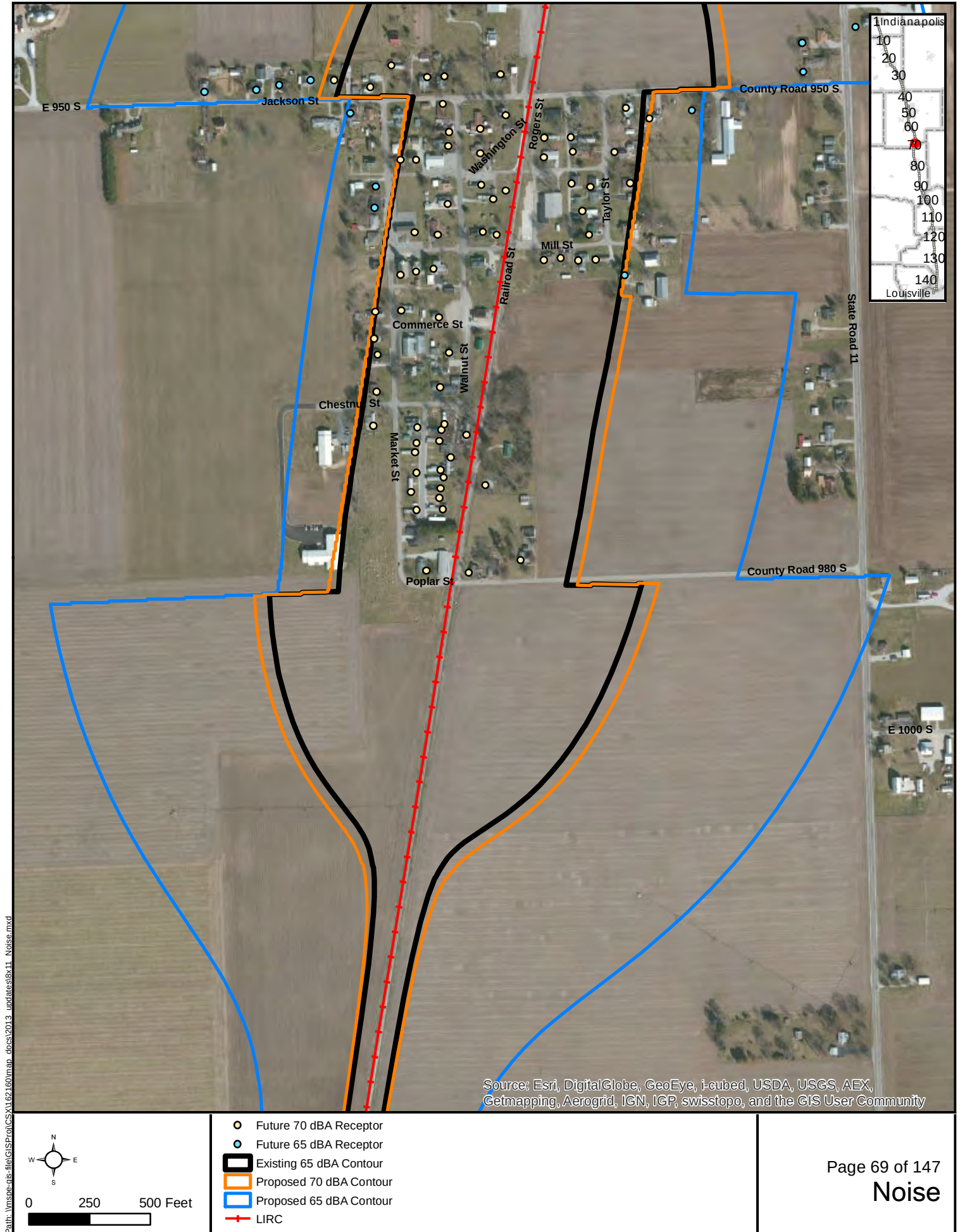
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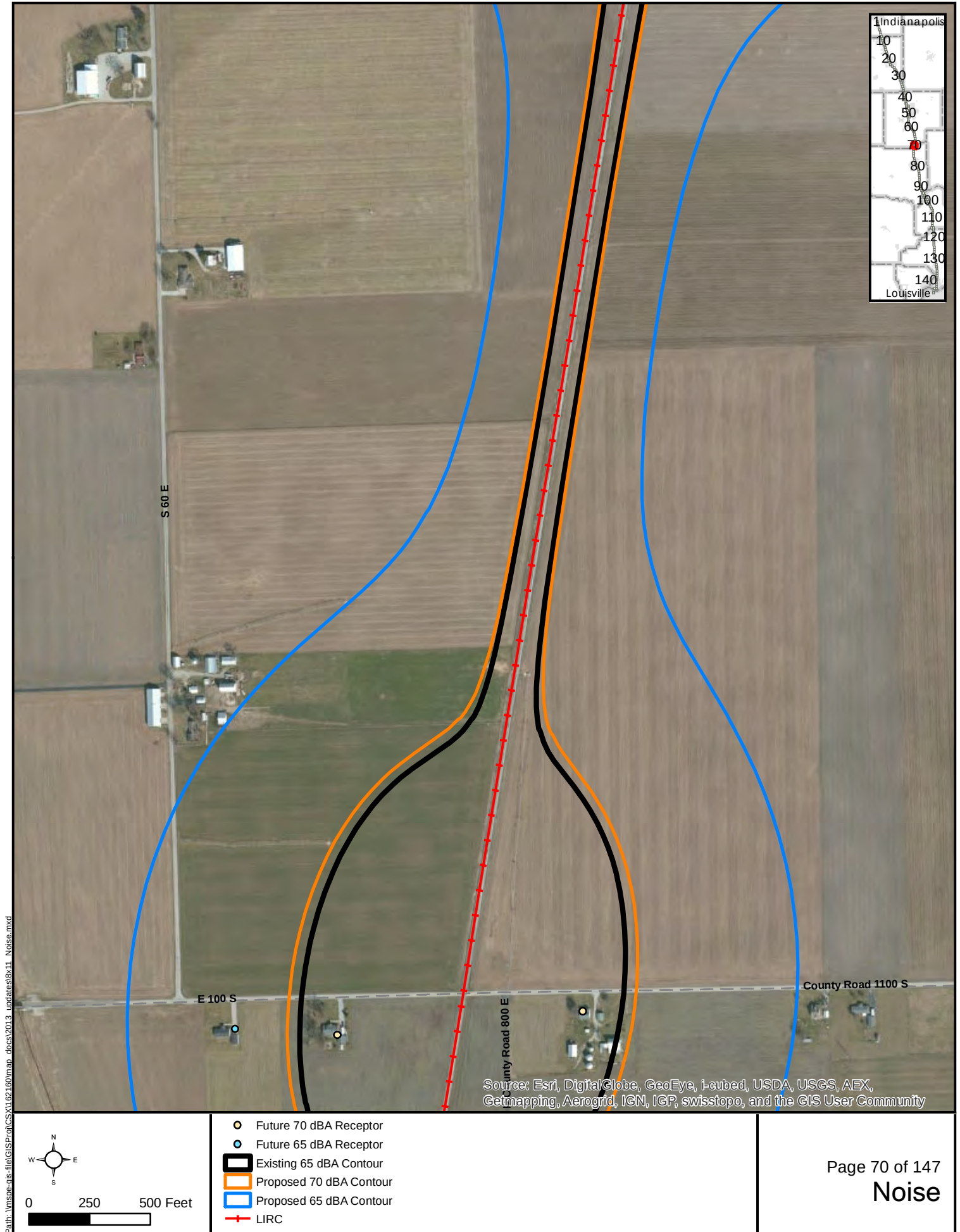
- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- +— LIRC

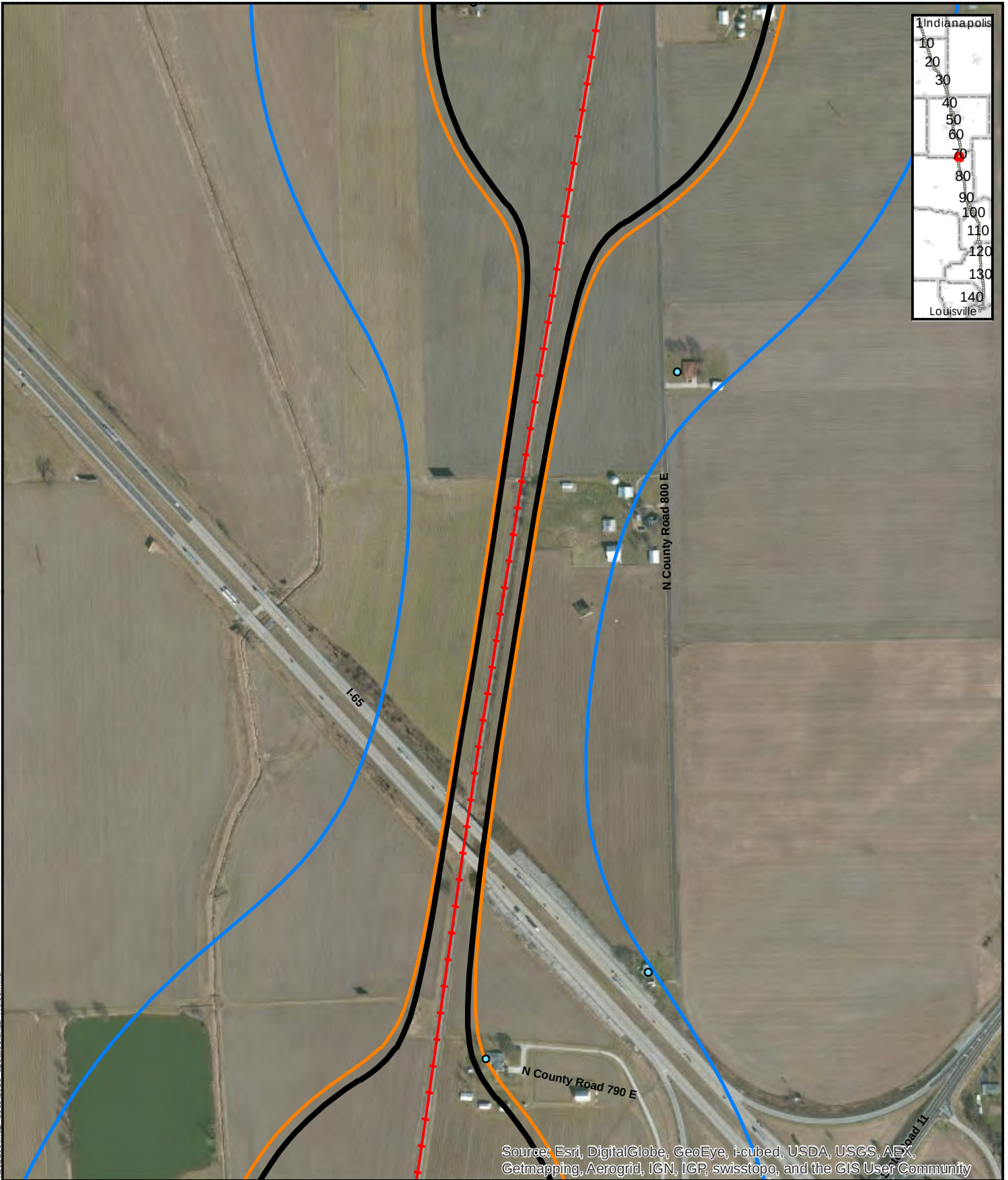










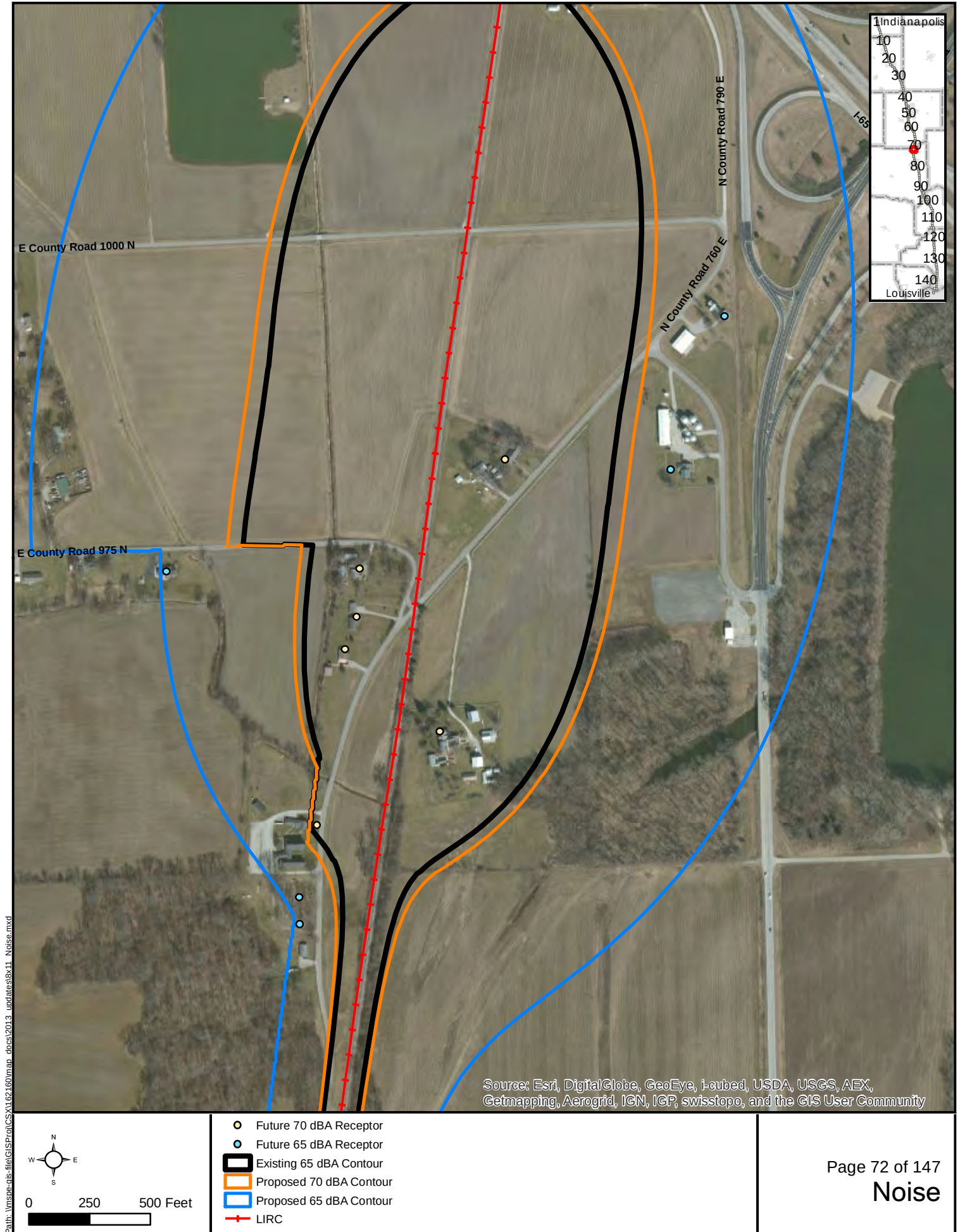


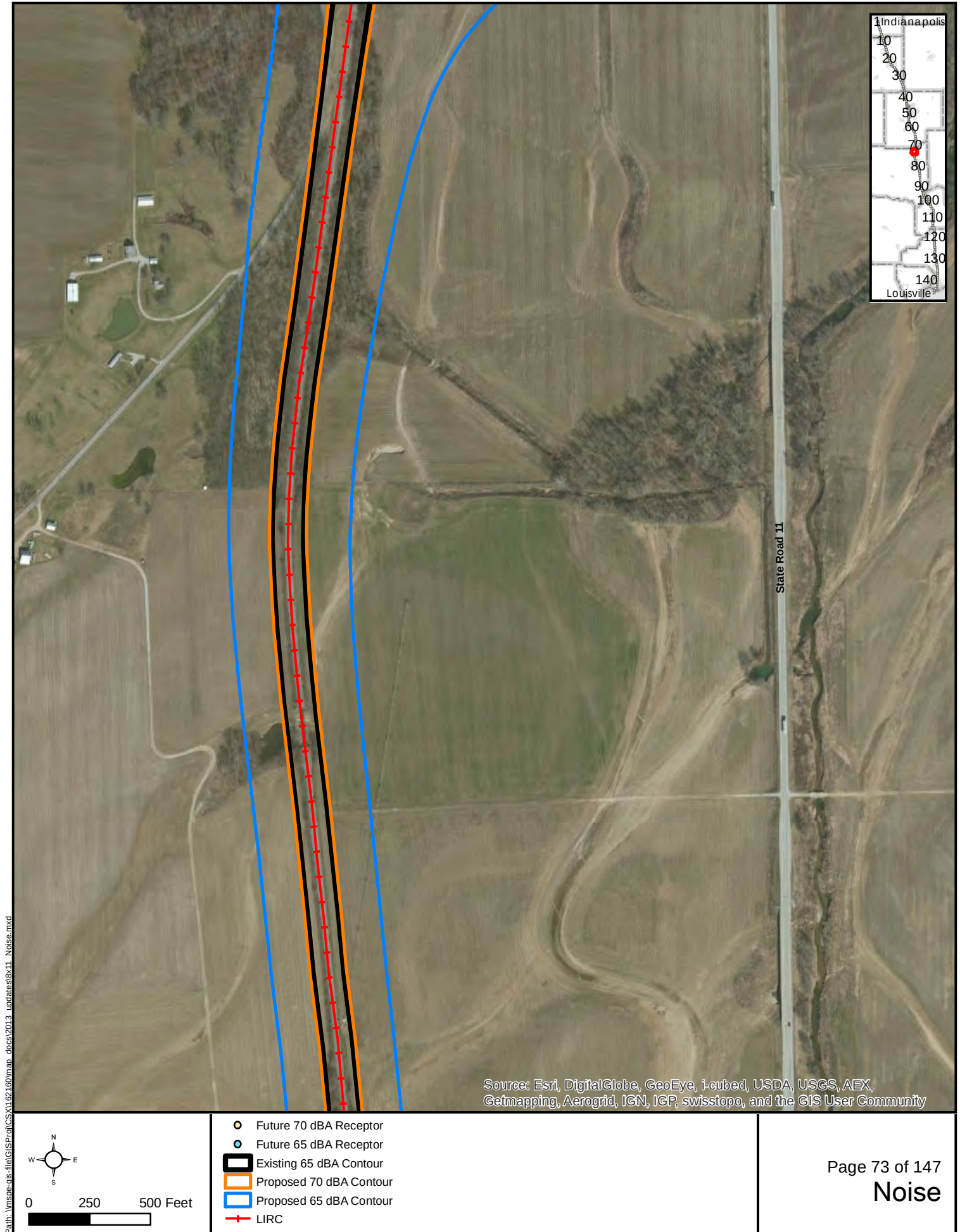
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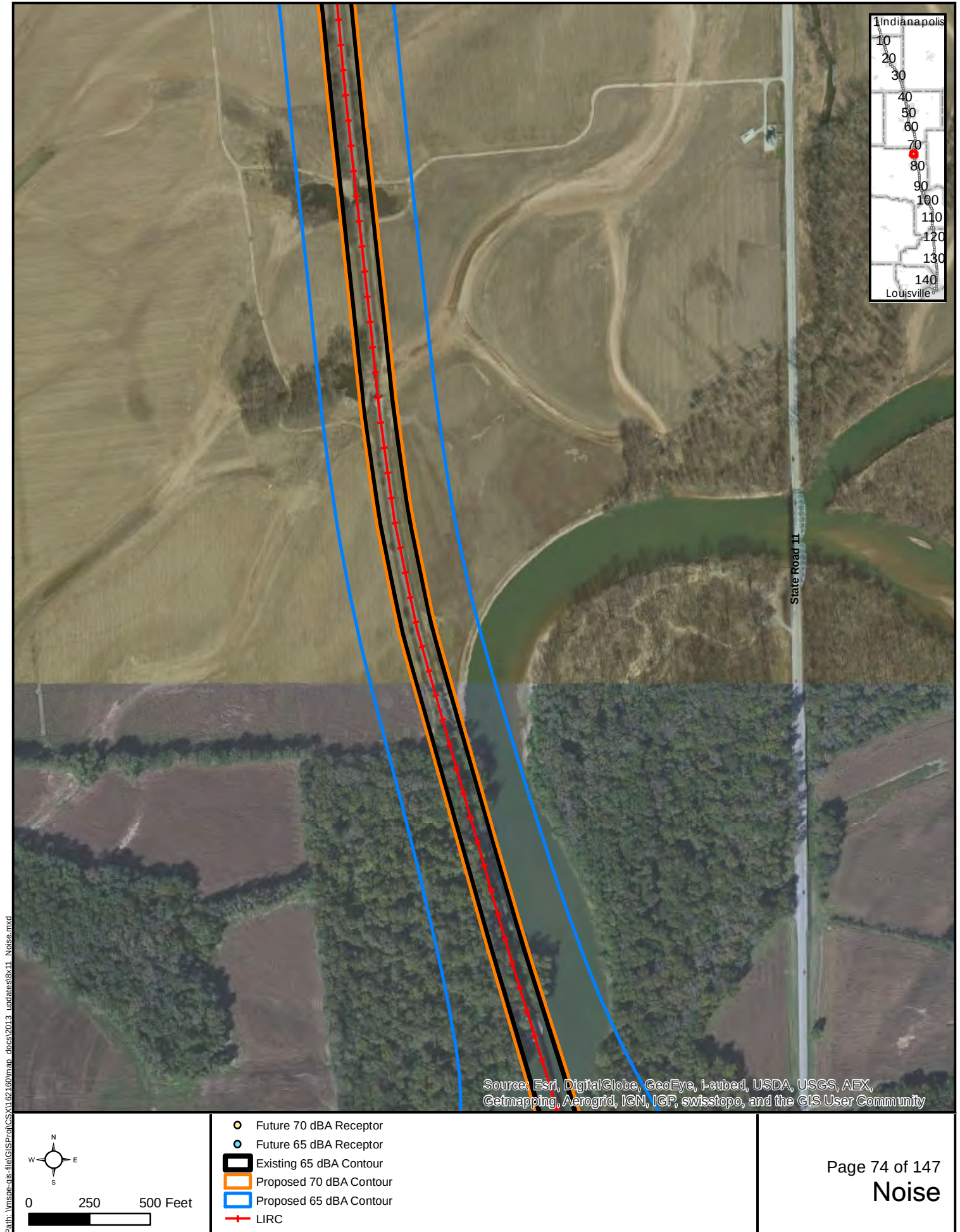


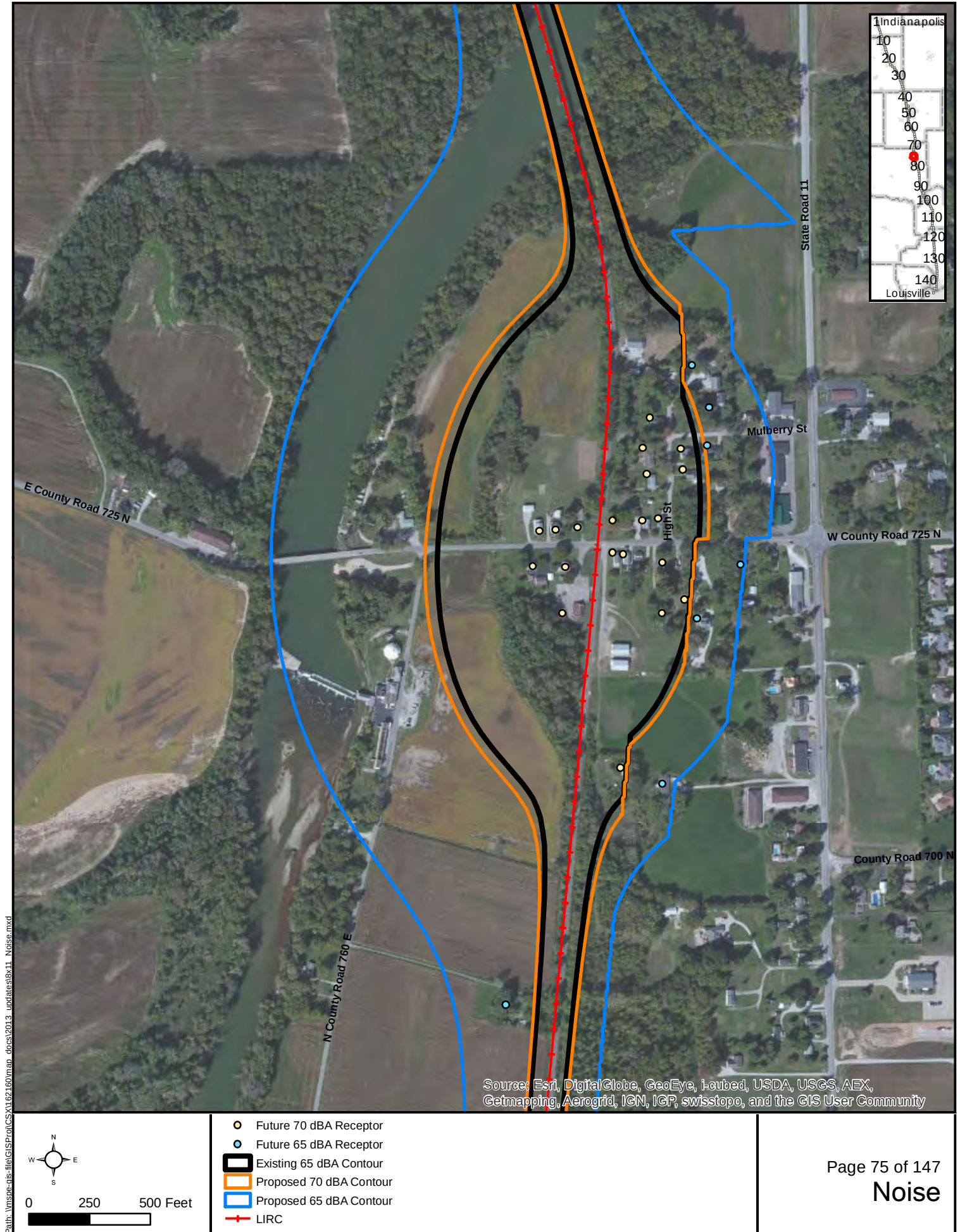
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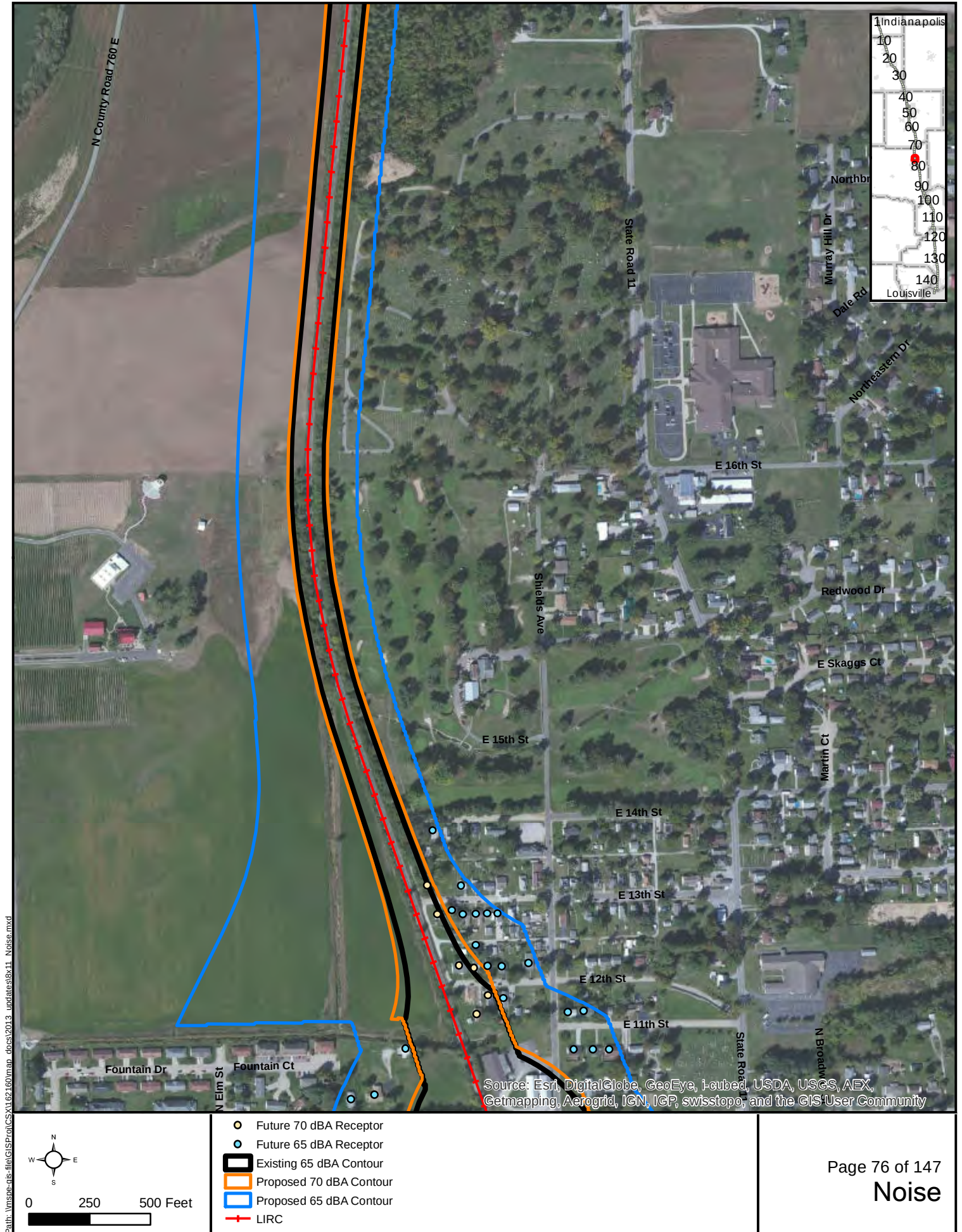
- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- ++ LIRC

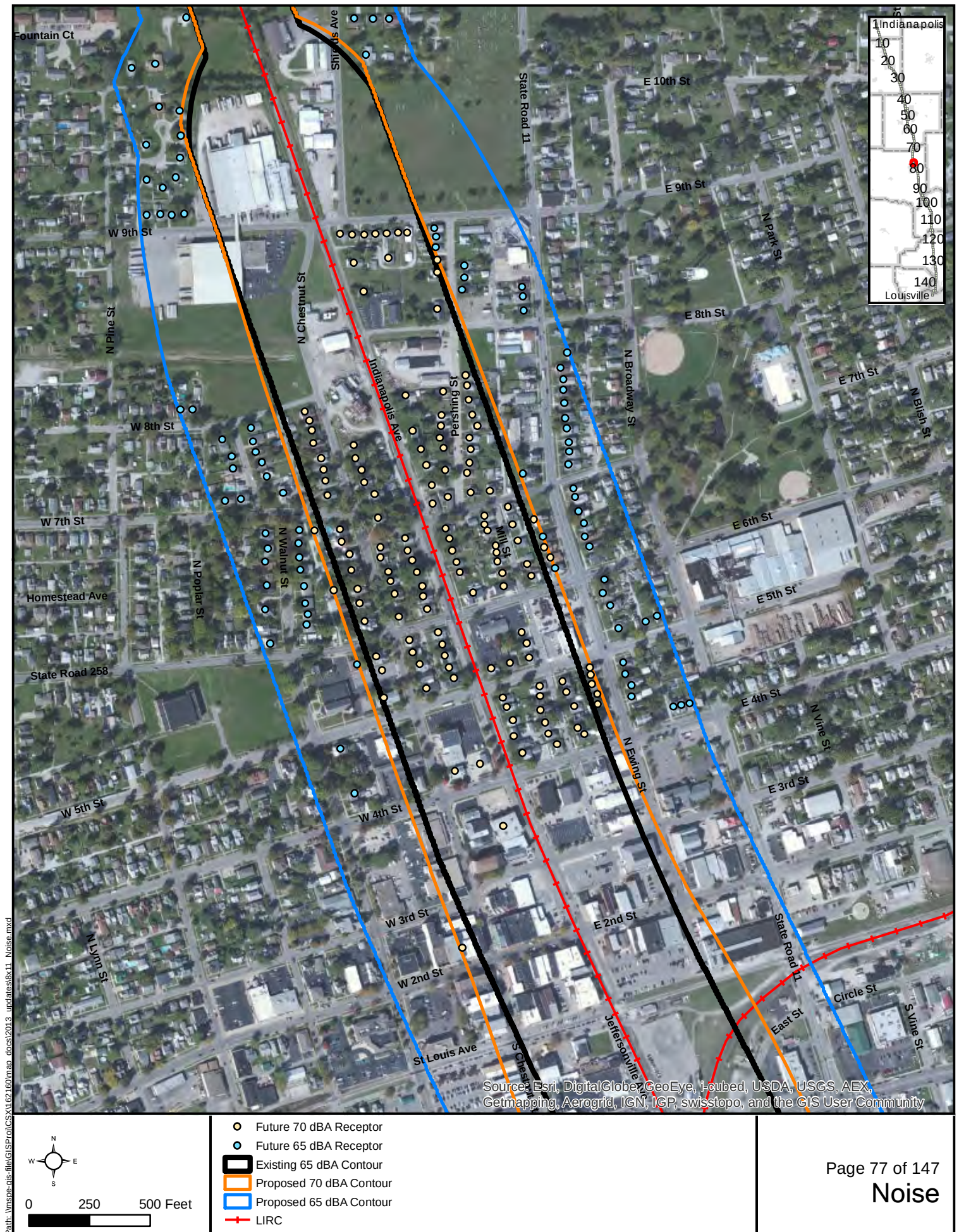


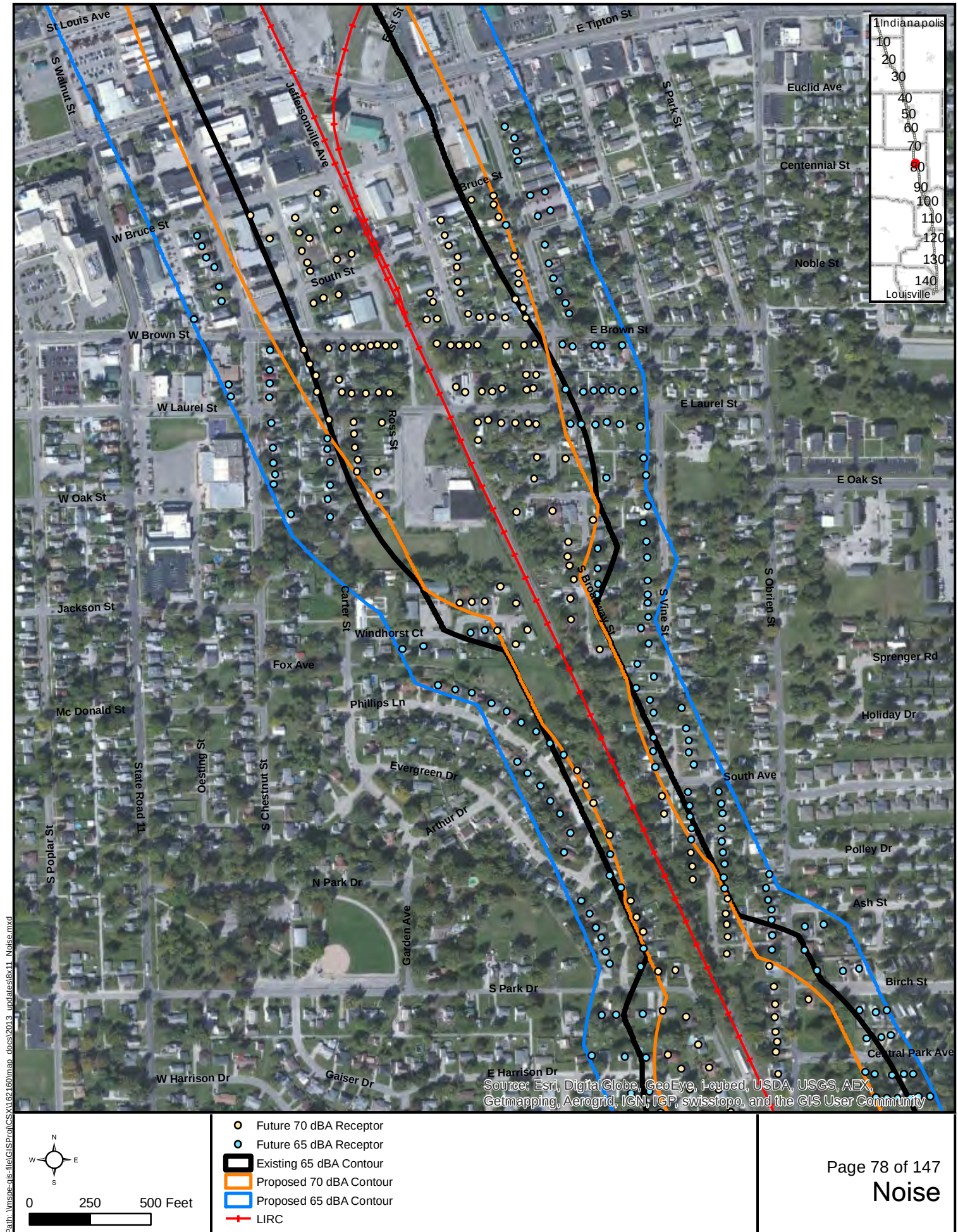


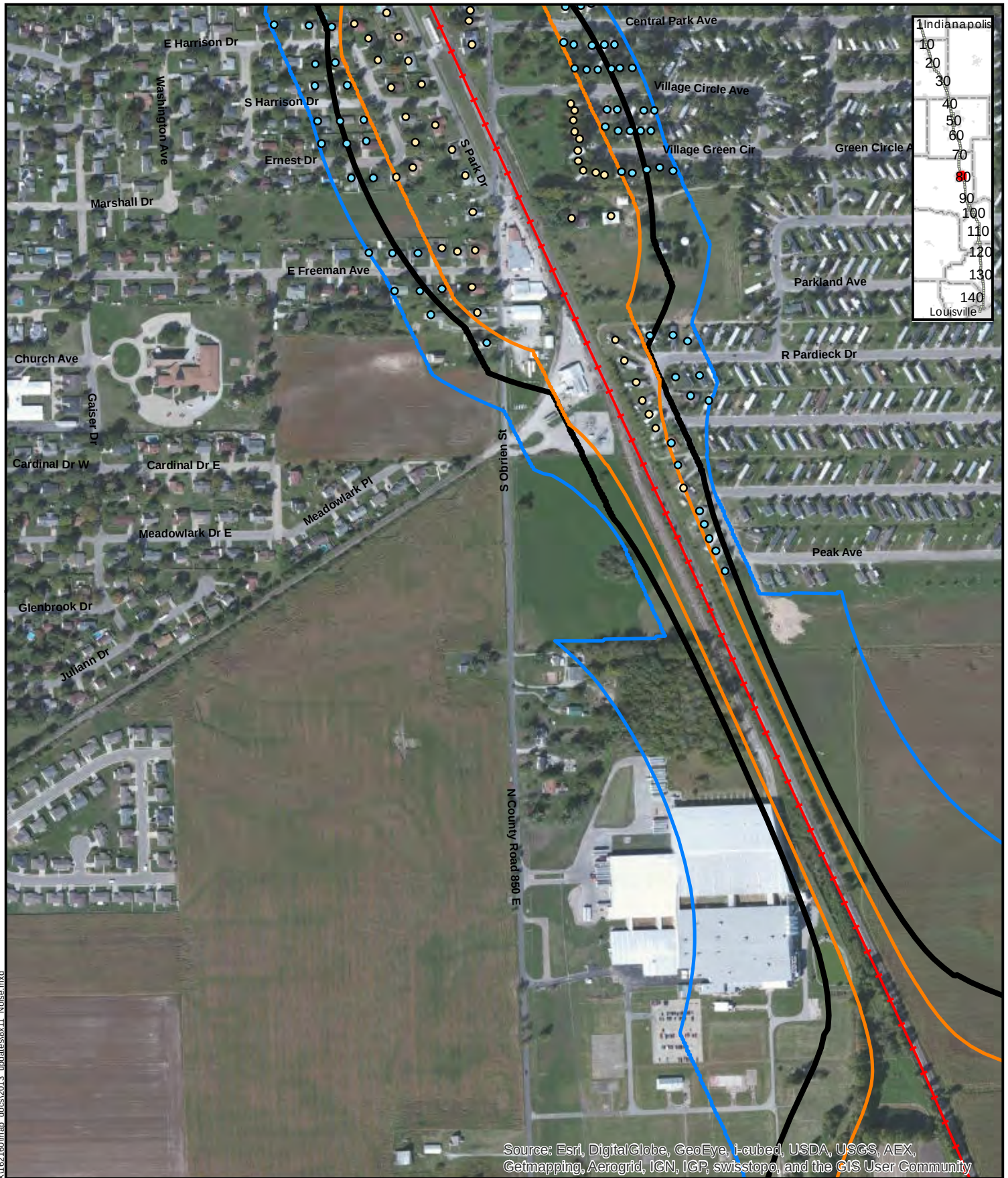






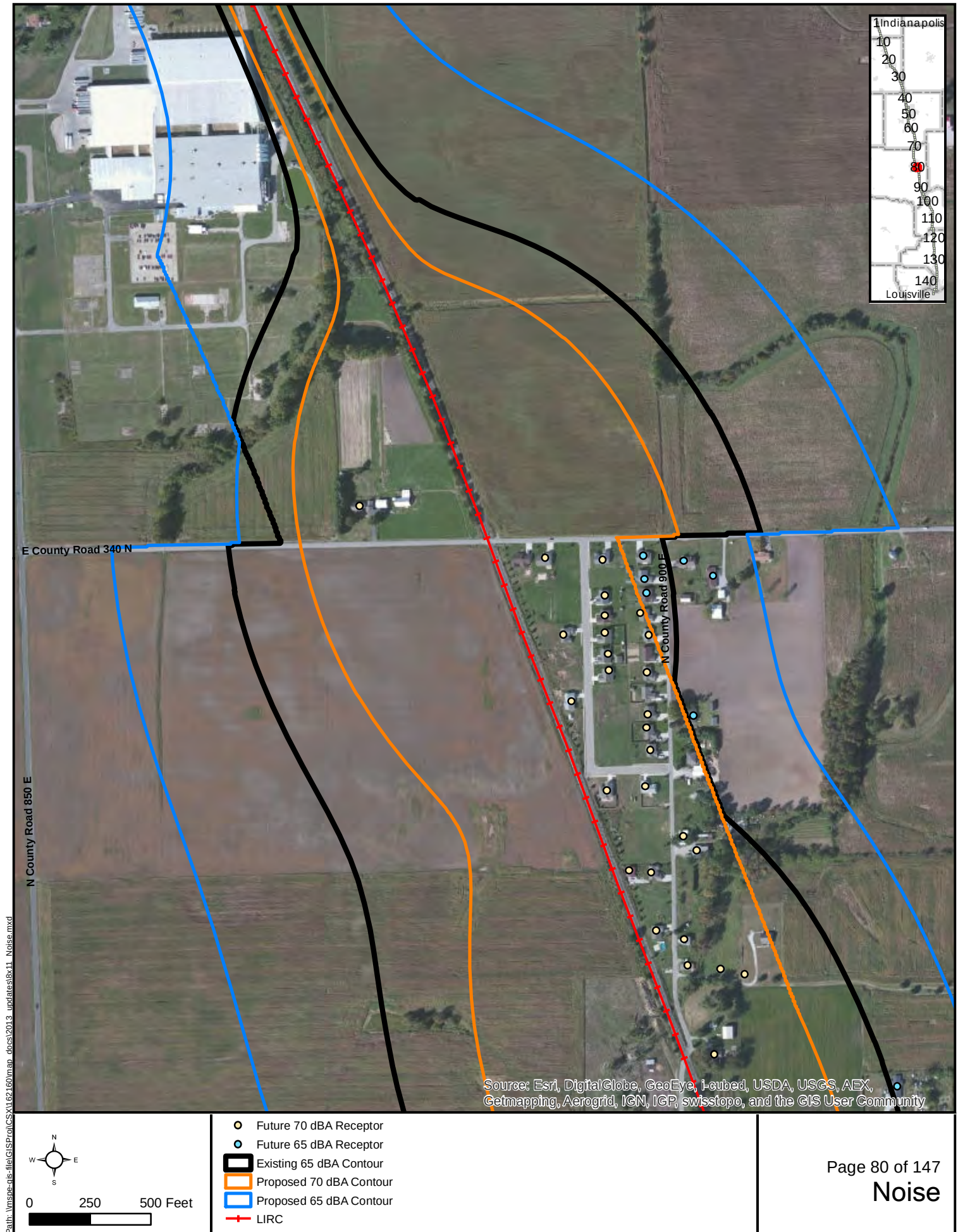


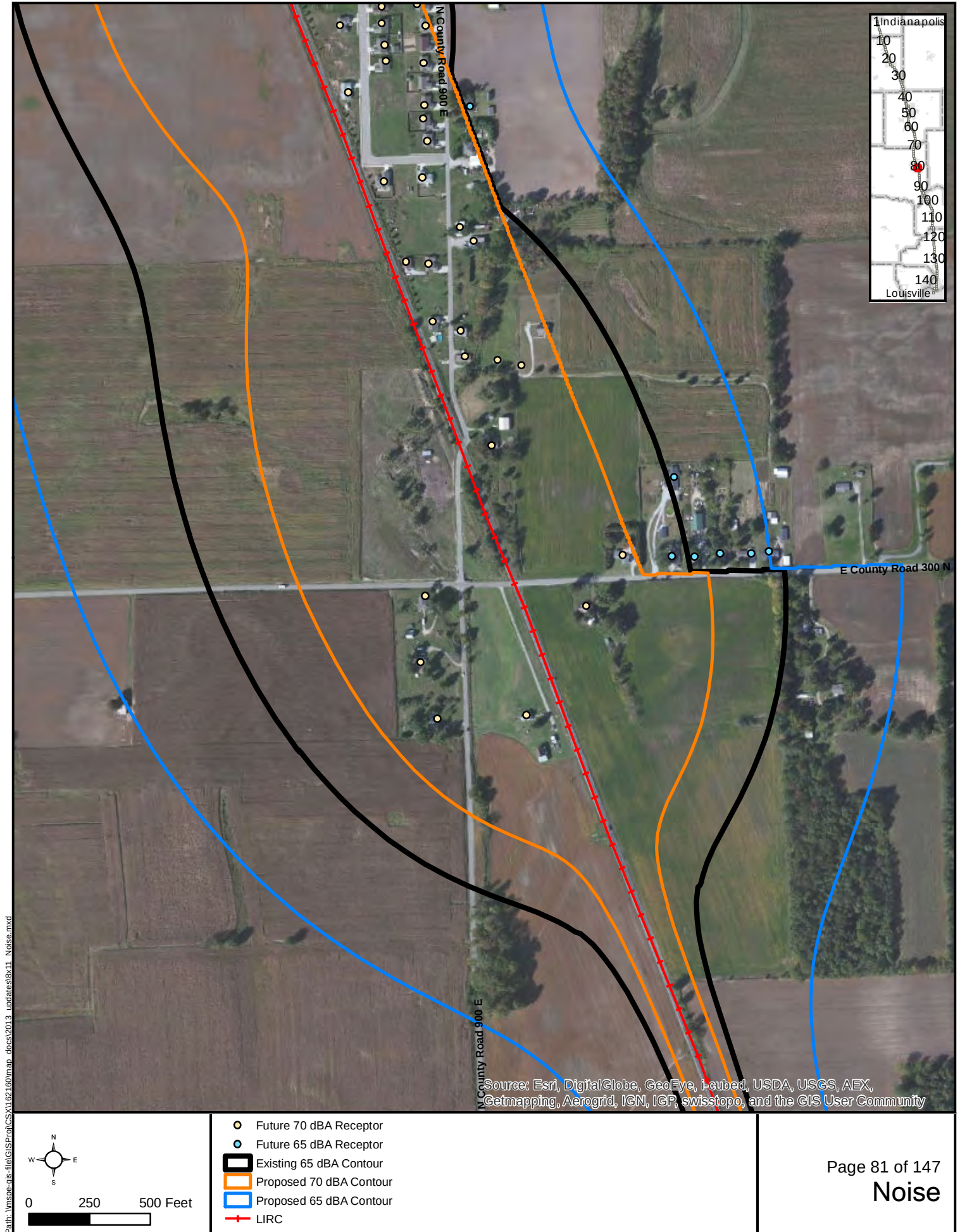


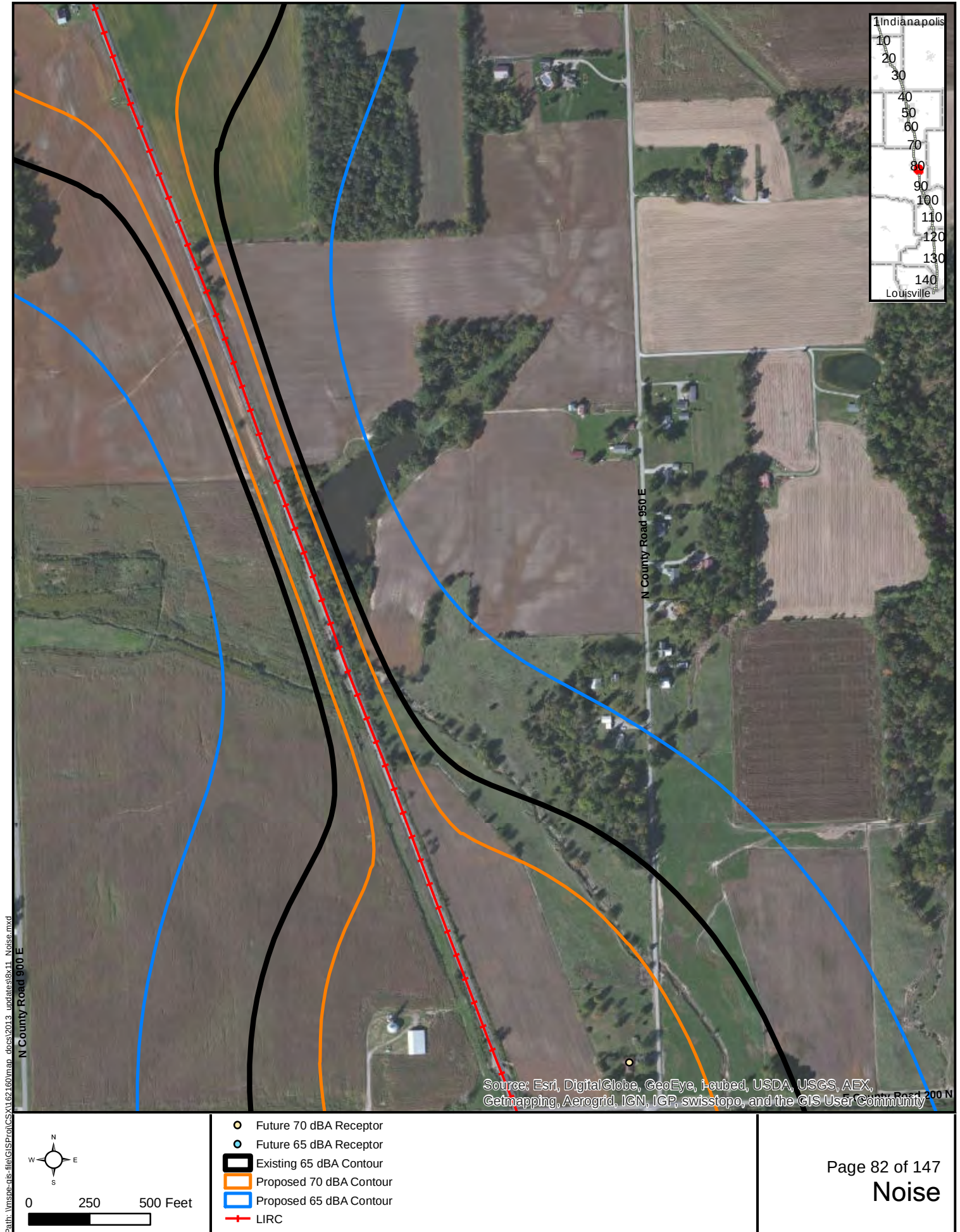


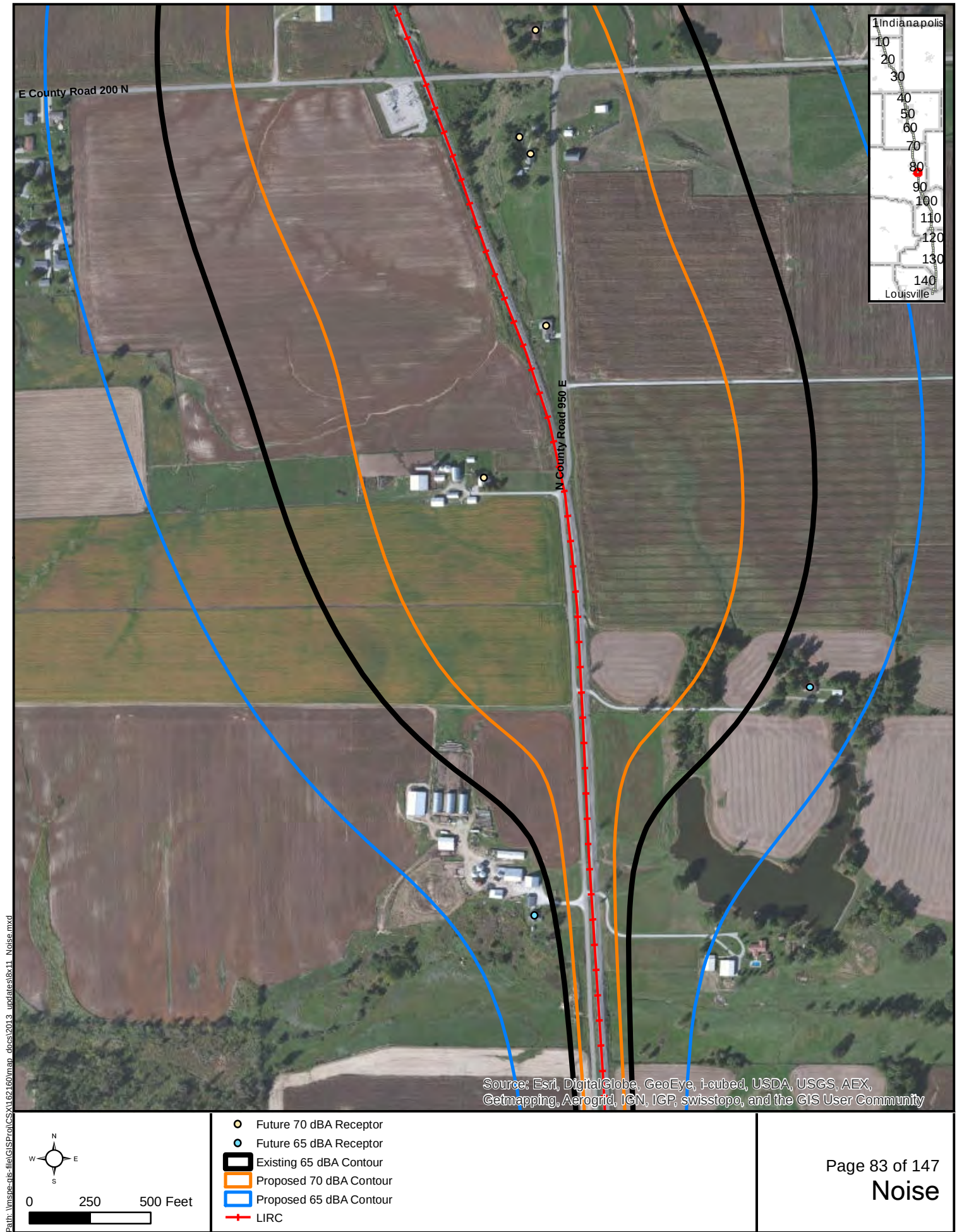
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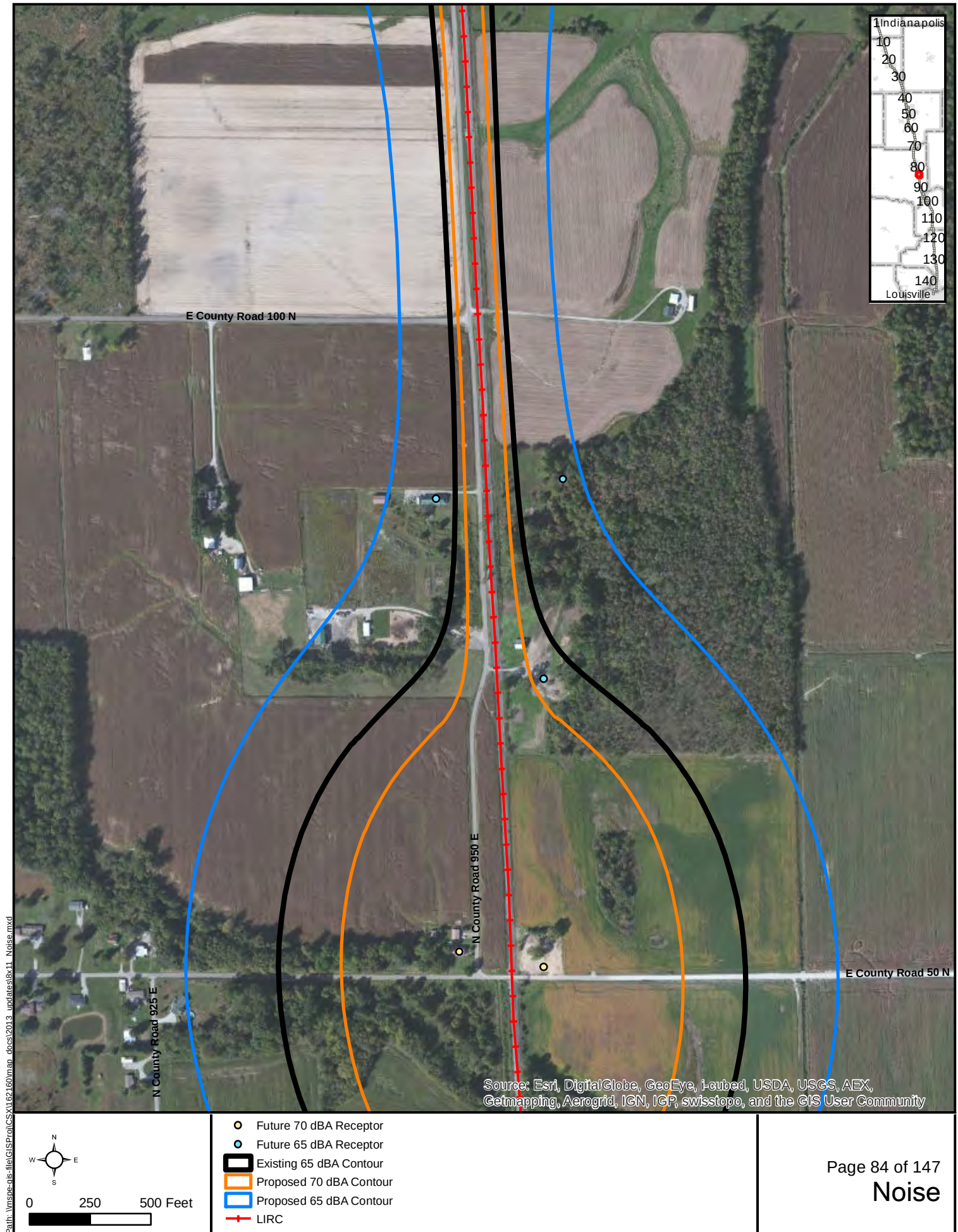
	 Future 70 dBA Receptor Future 65 dBA Receptor Existing 65 dBA Contour Proposed 70 dBA Contour Proposed 65 dBA Contour LIRC	Page 79 of 147 Noise
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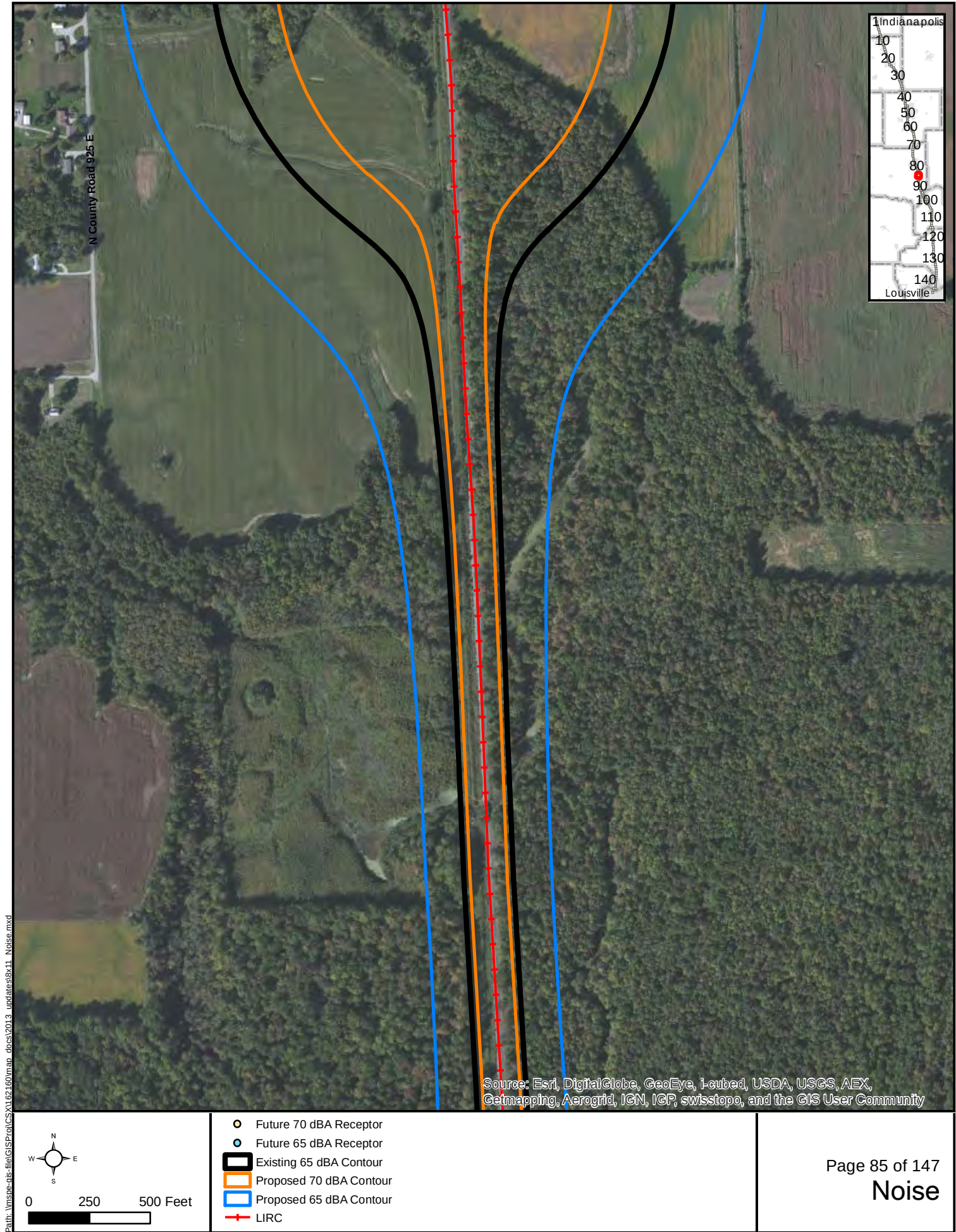


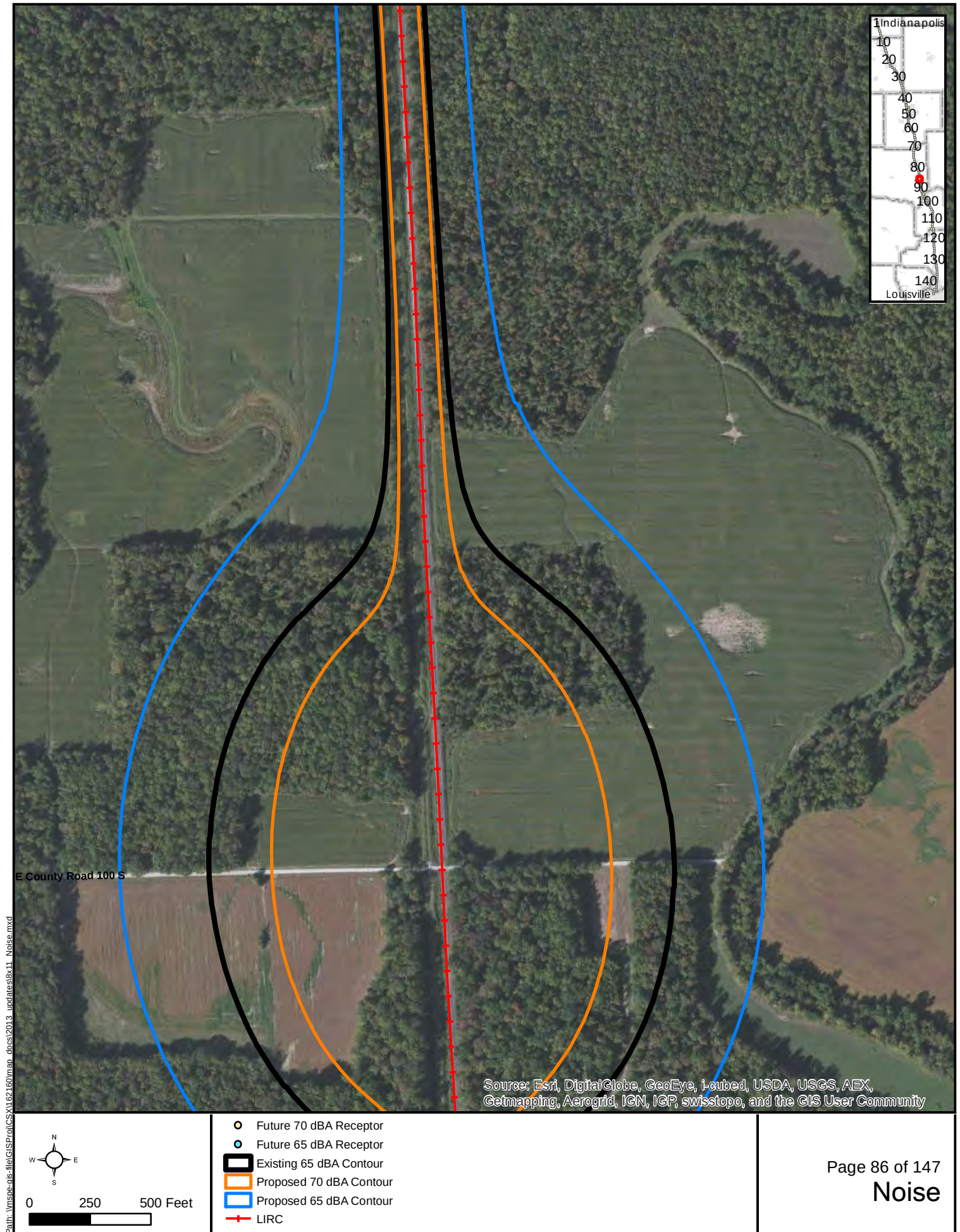


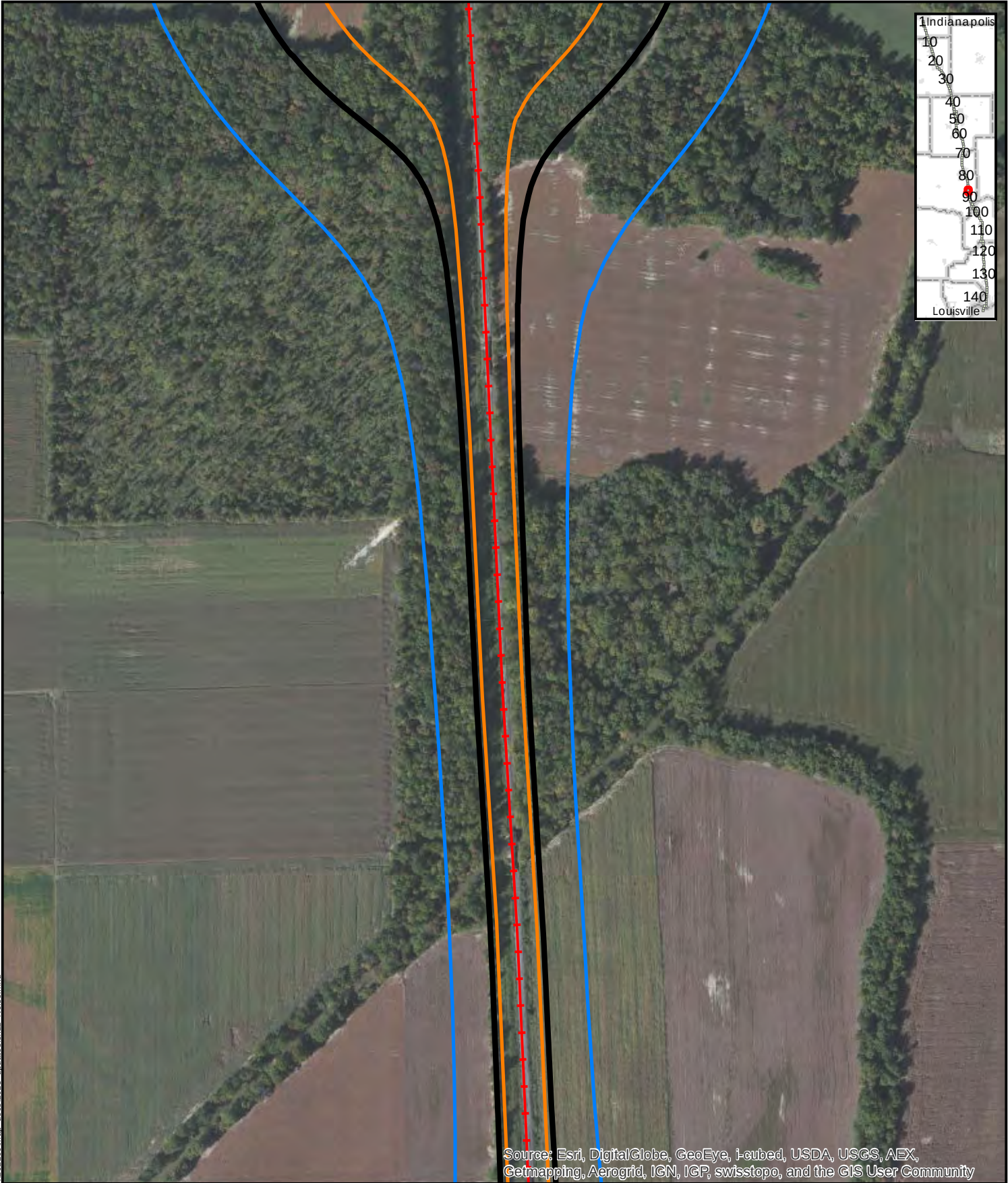












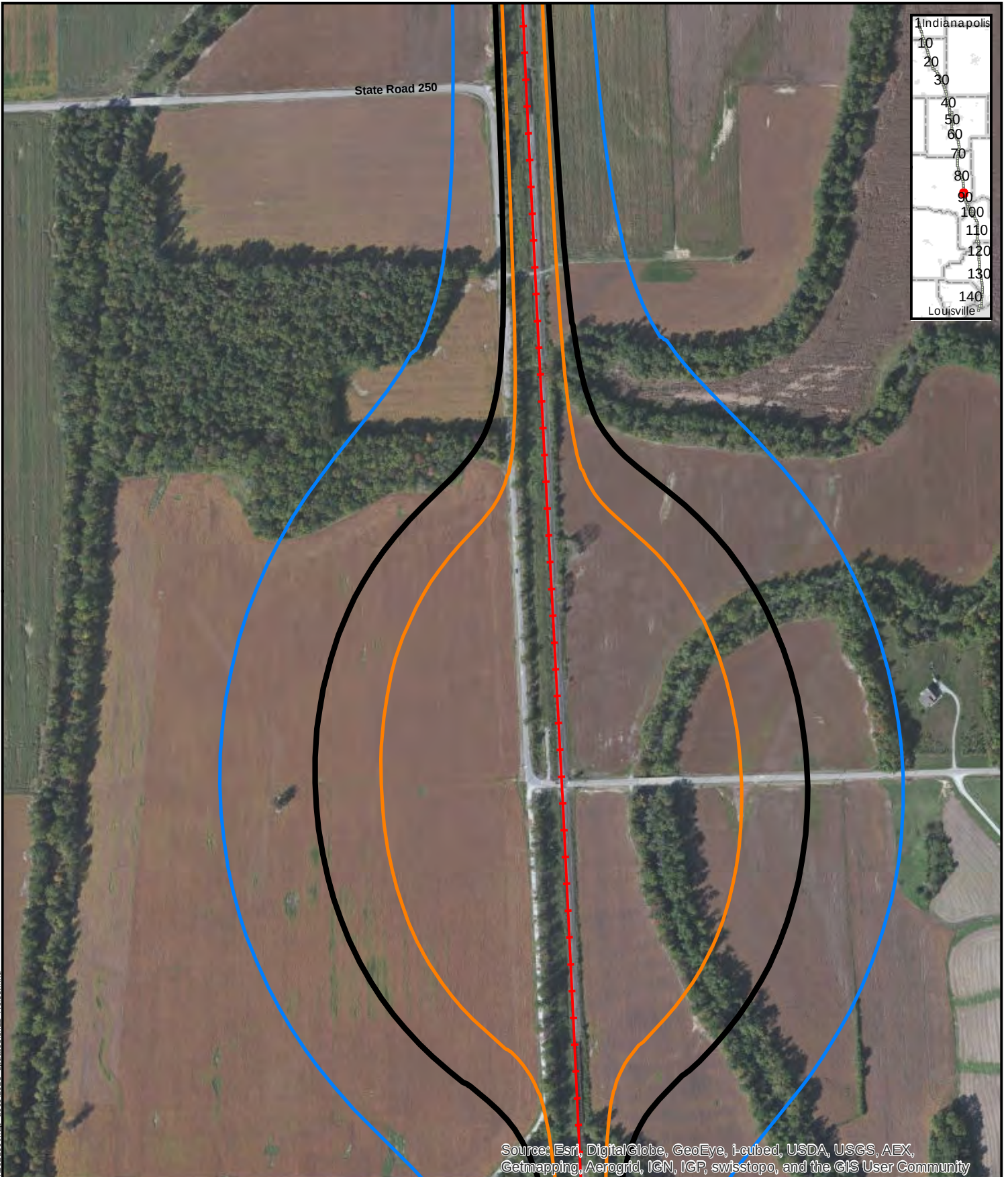
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0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- + LIRC

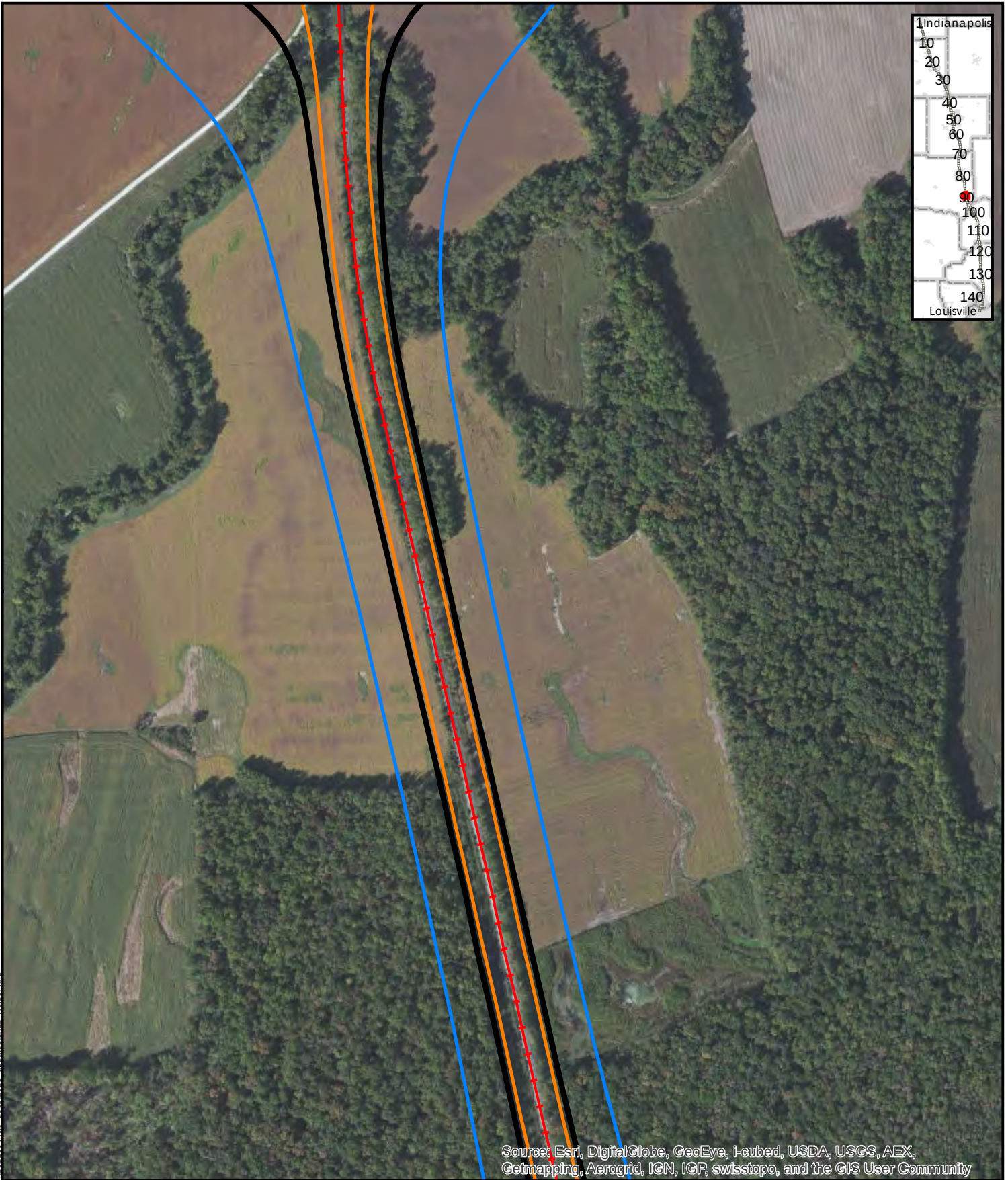


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0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- + LIRC

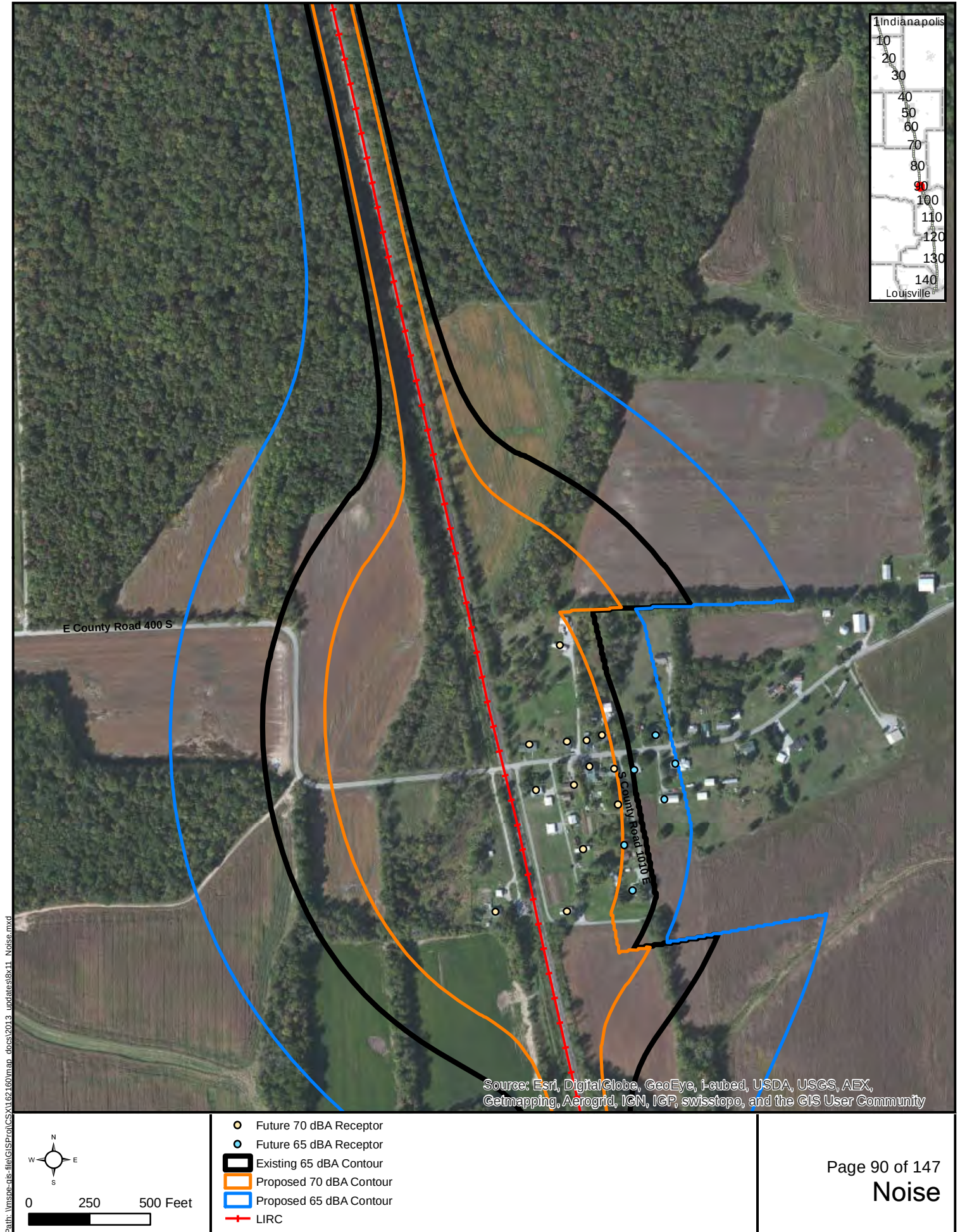


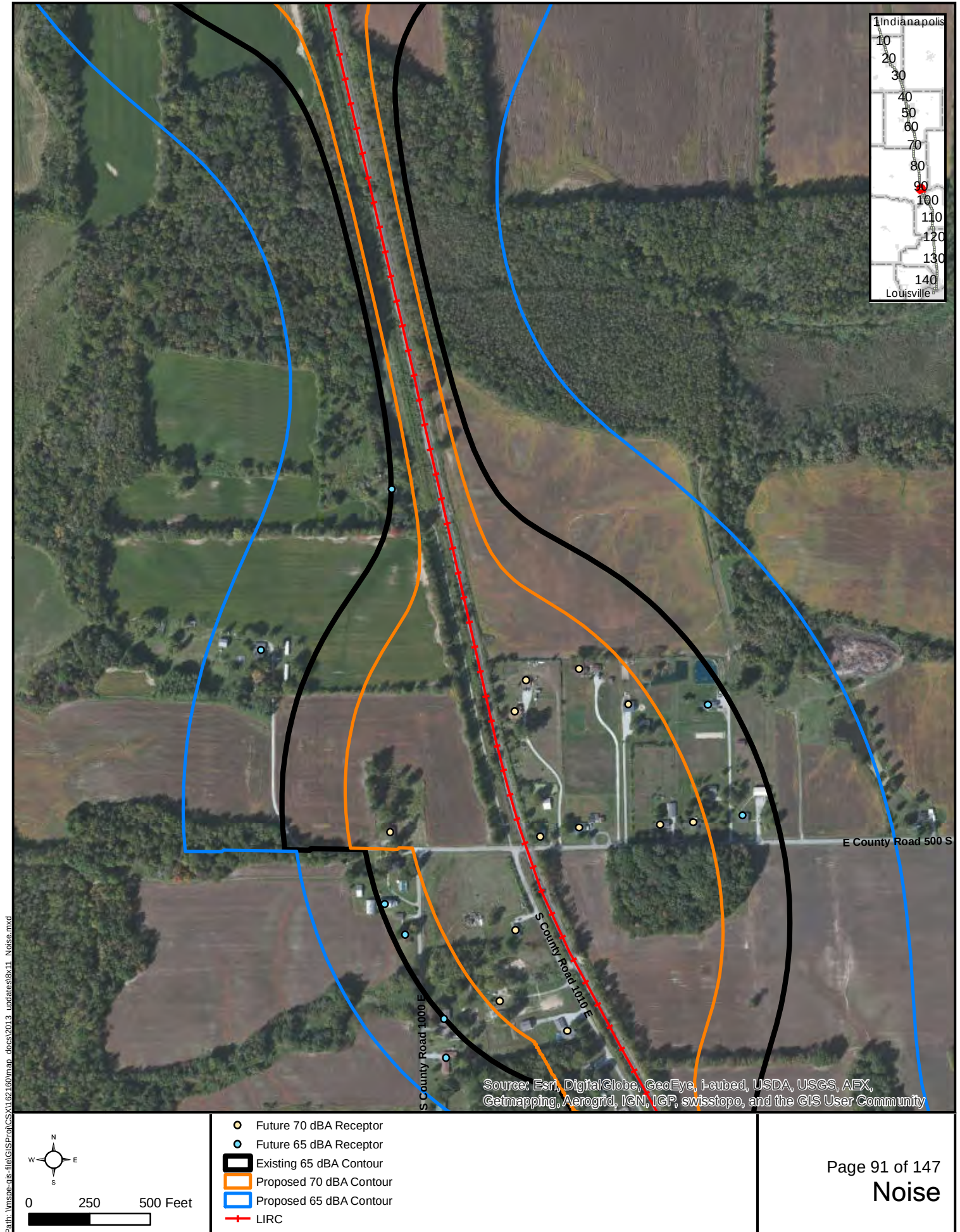
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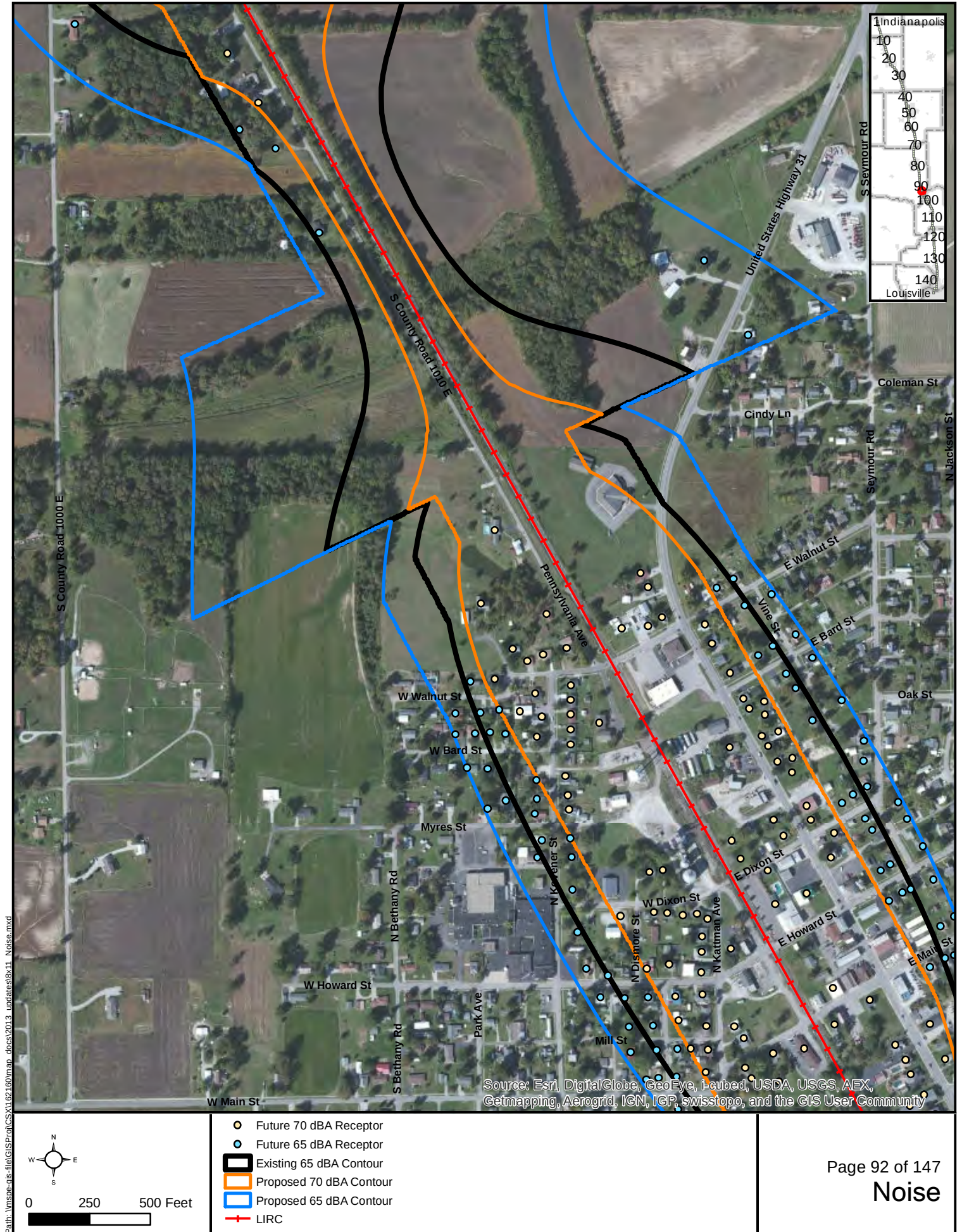


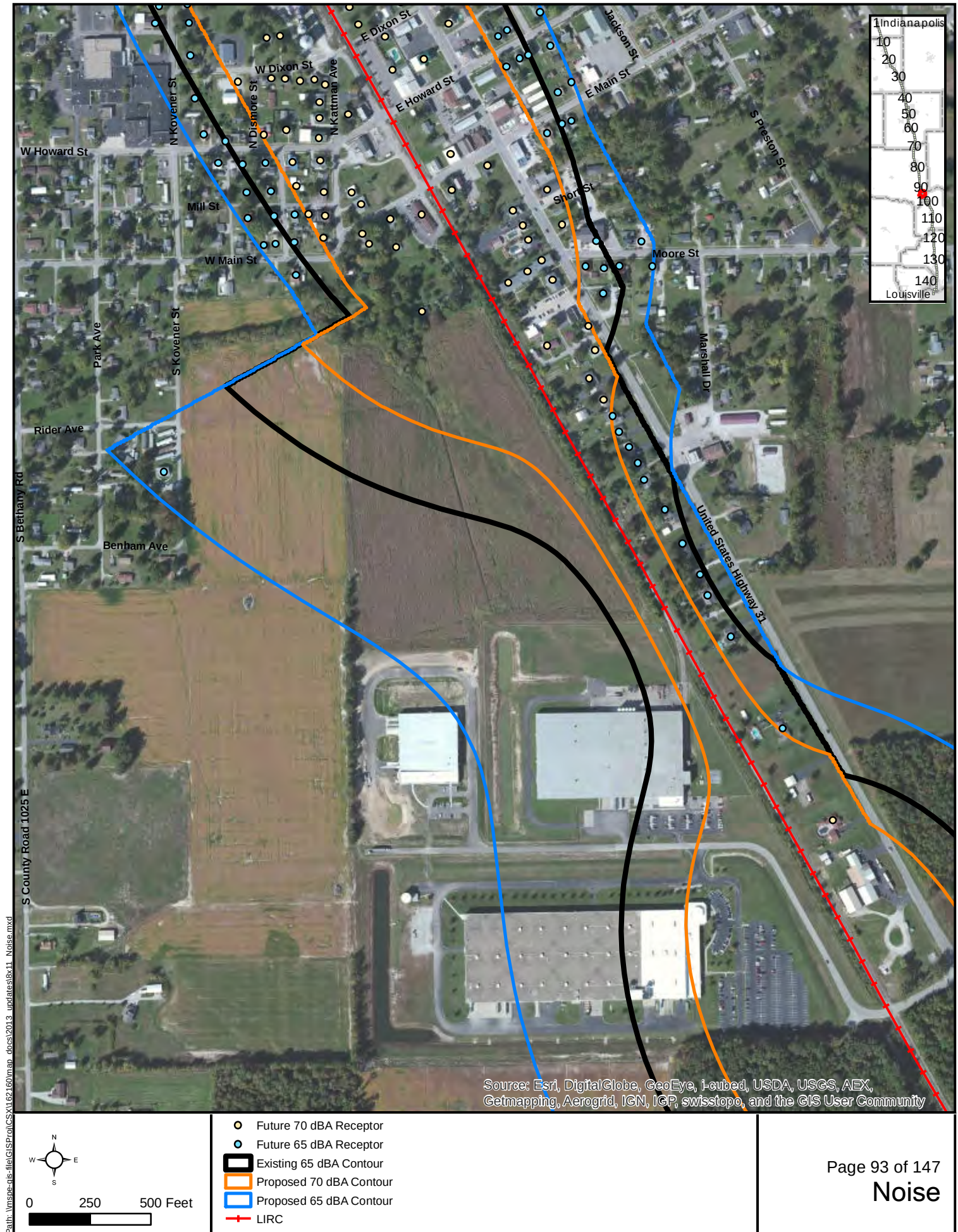
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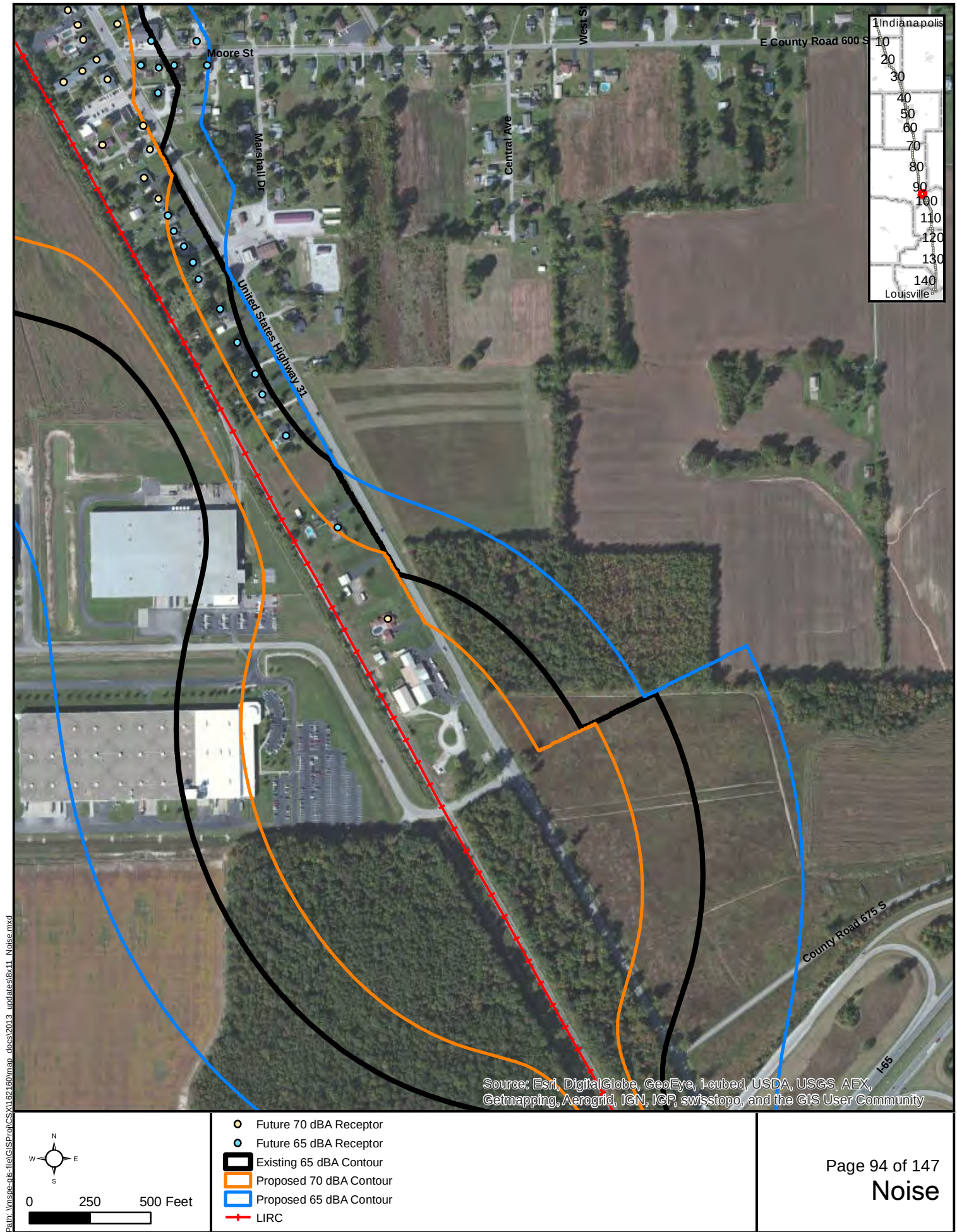
- Future 70 dBA Receptor
- Future 65 dBA Receptor
- ▬ Existing 65 dBA Contour
- ▬ Proposed 70 dBA Contour
- ▬ Proposed 65 dBA Contour
- + LIRC













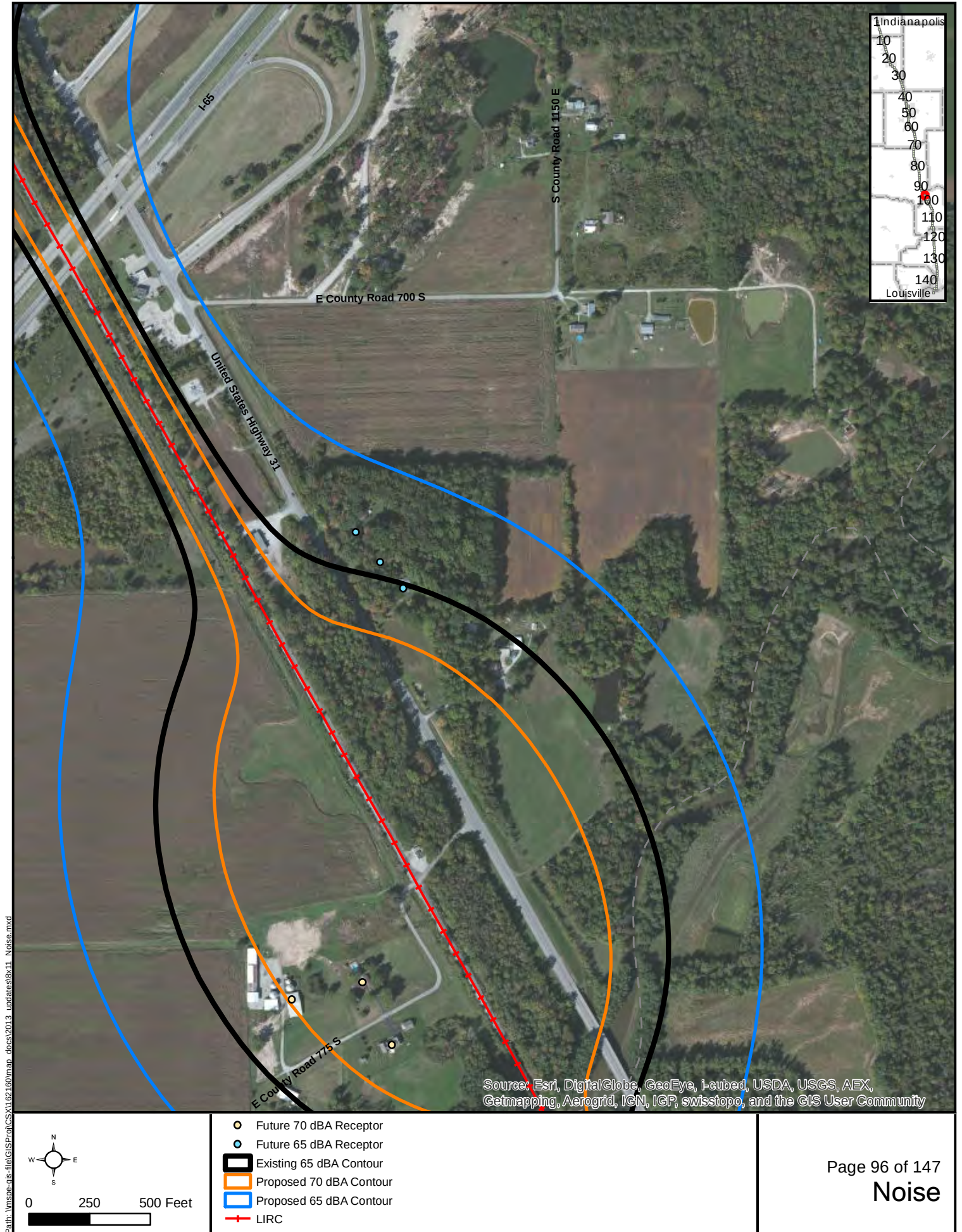
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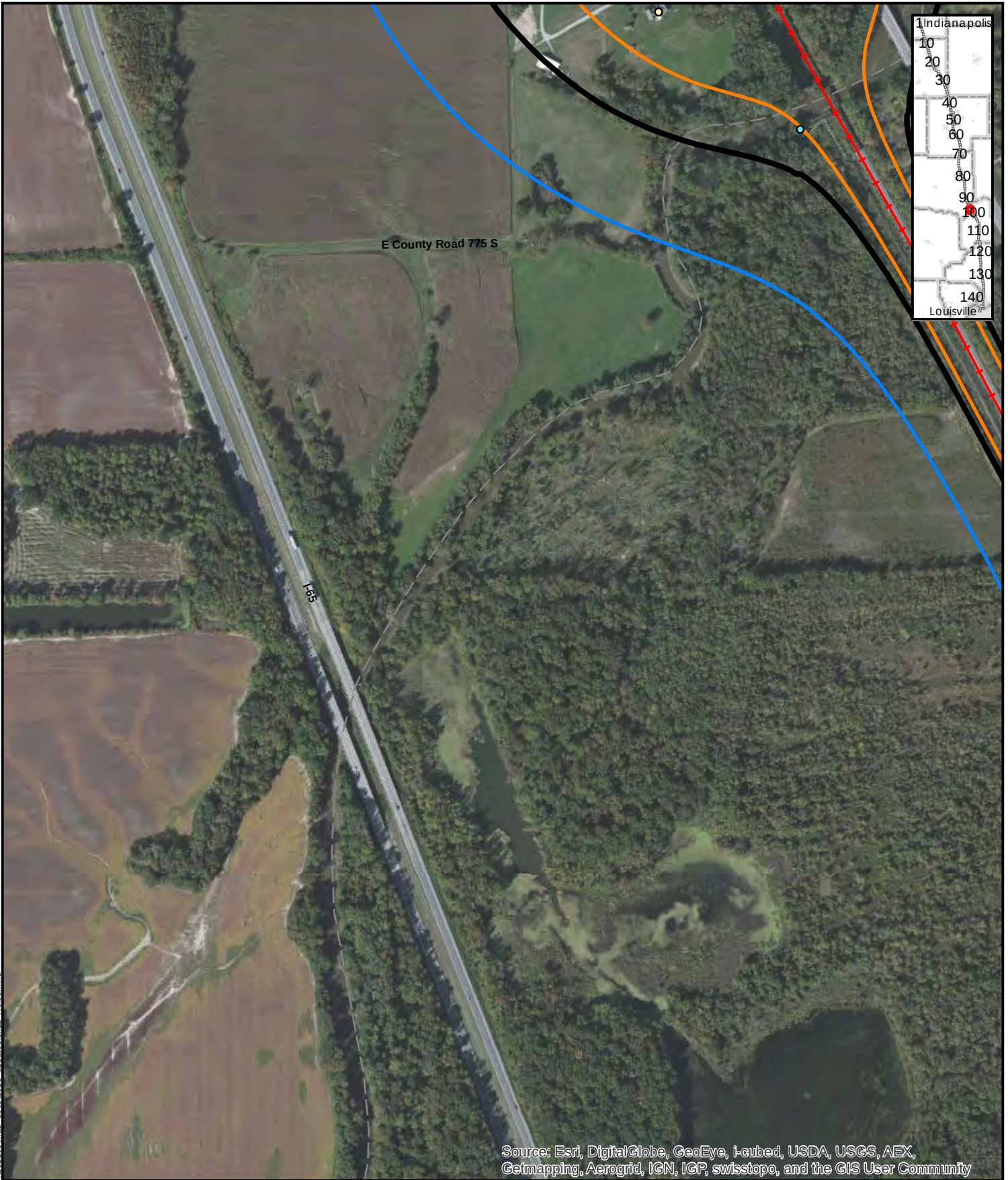
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0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- LIRC



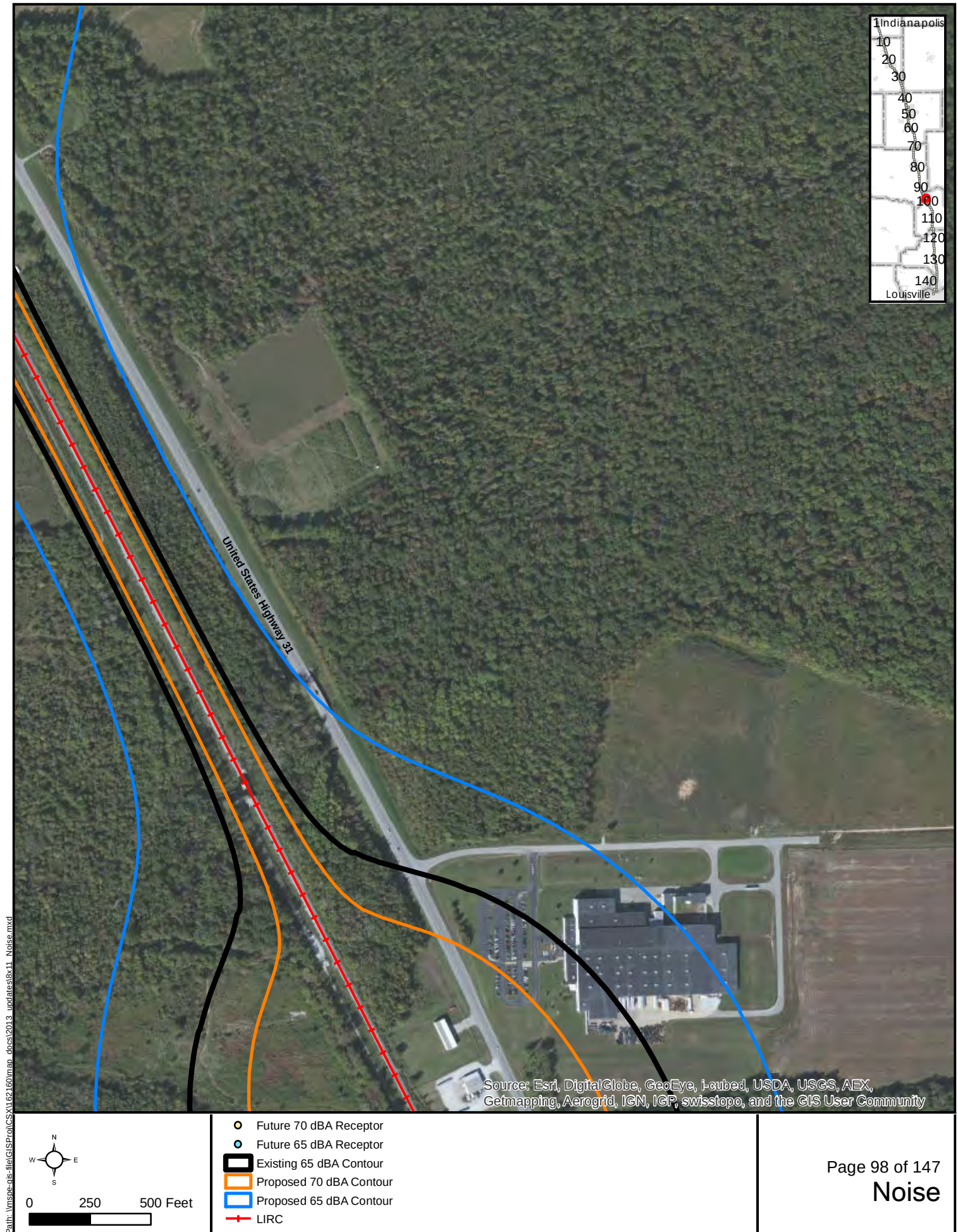


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0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- LIRC





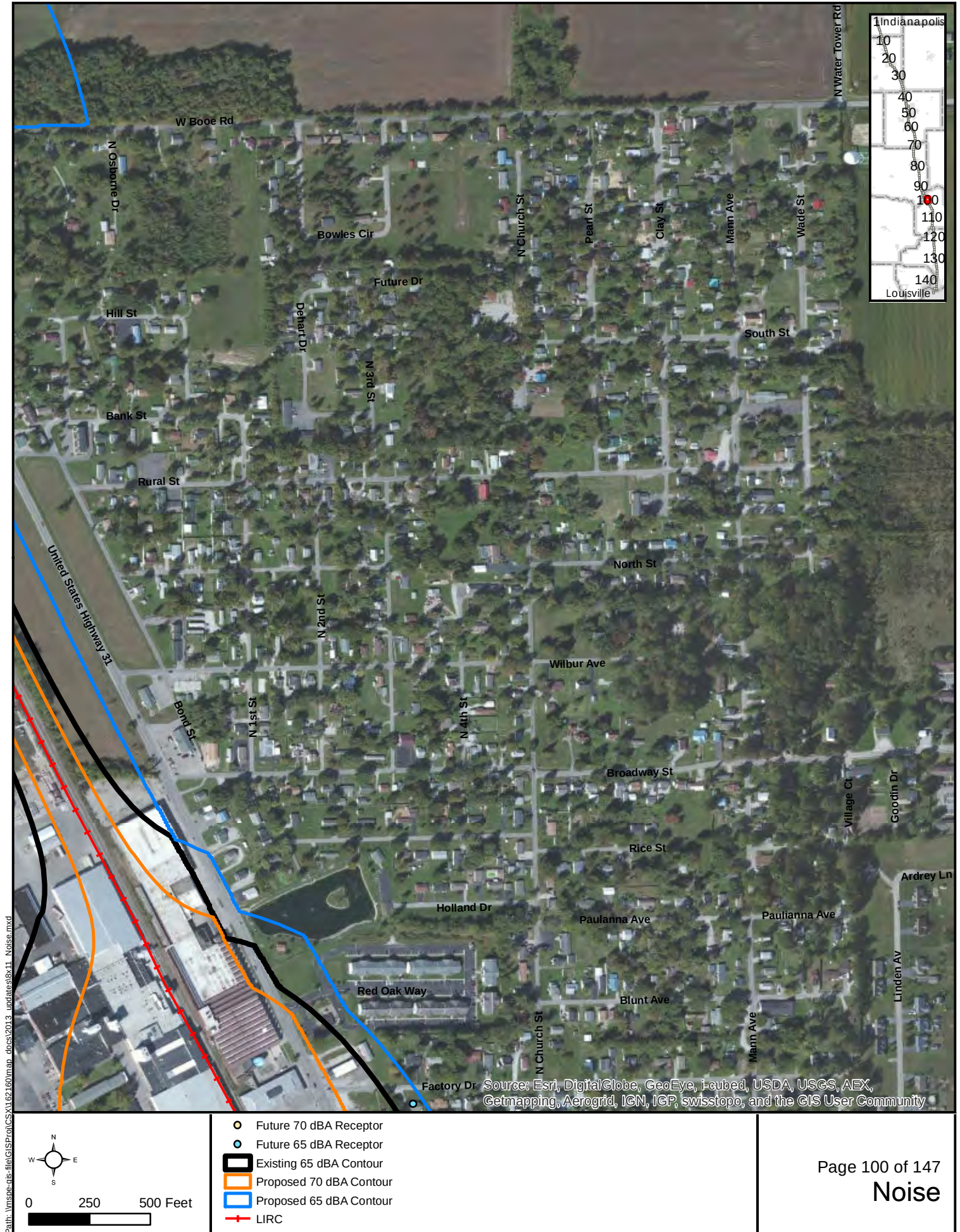
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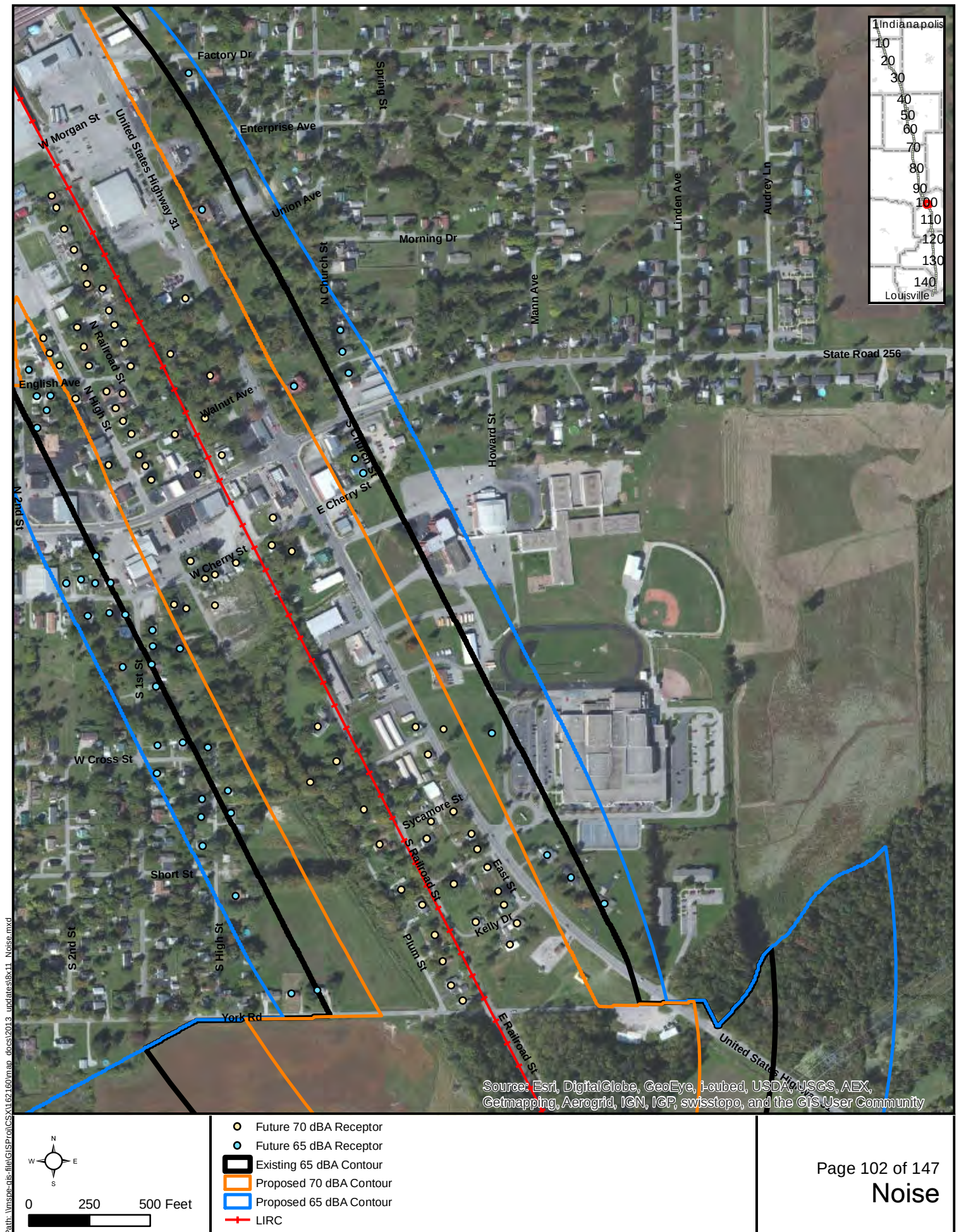


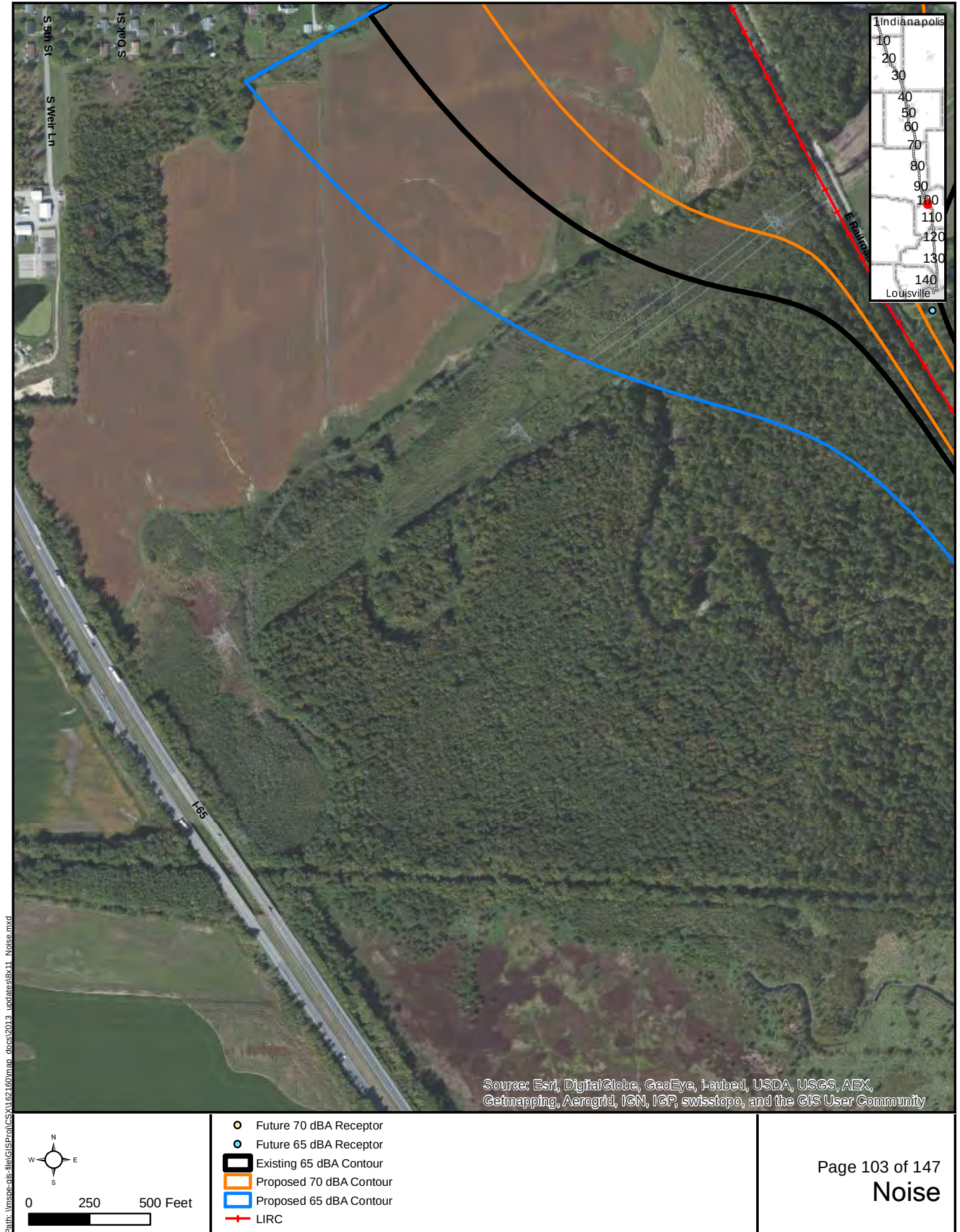
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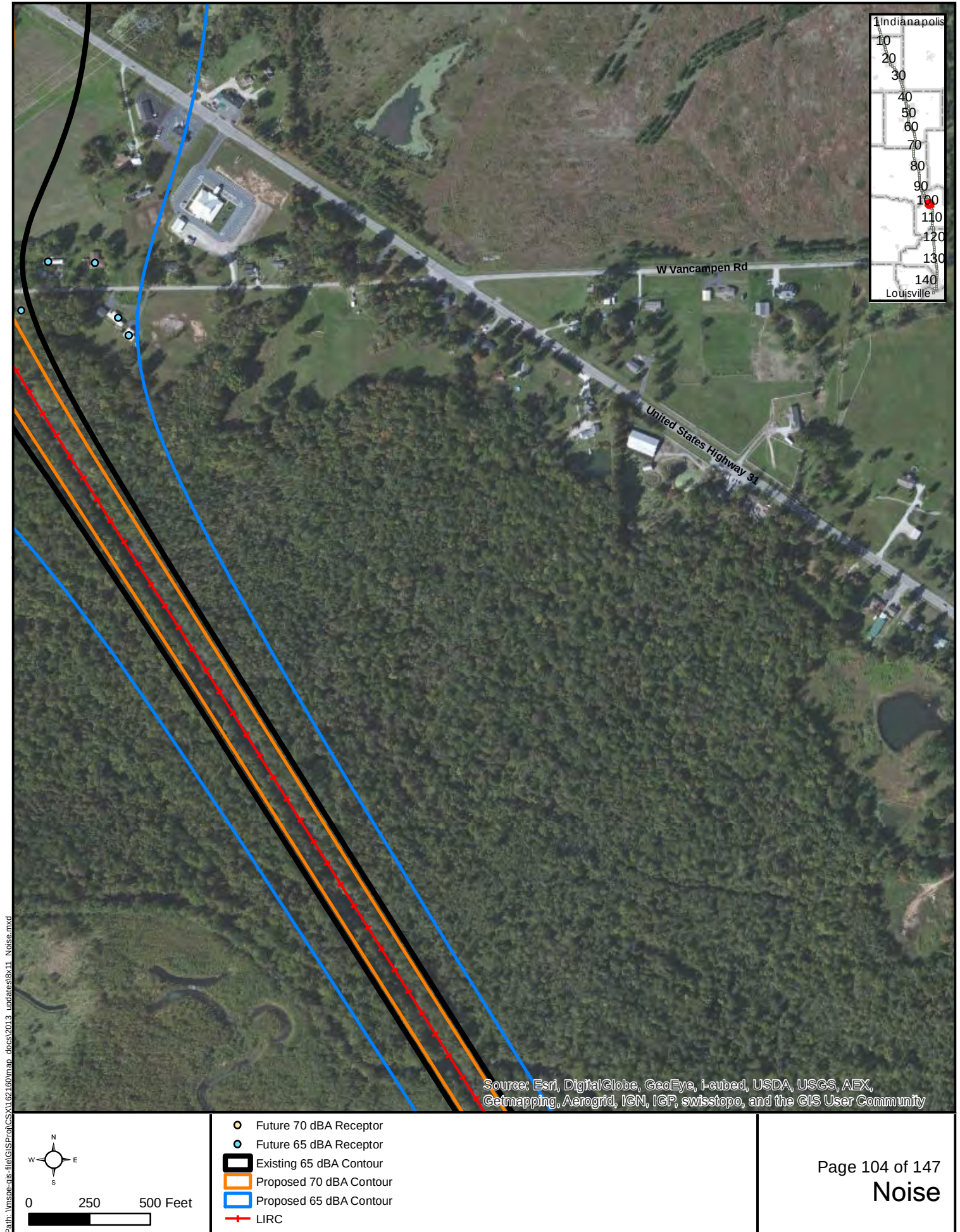
- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- + LIRC

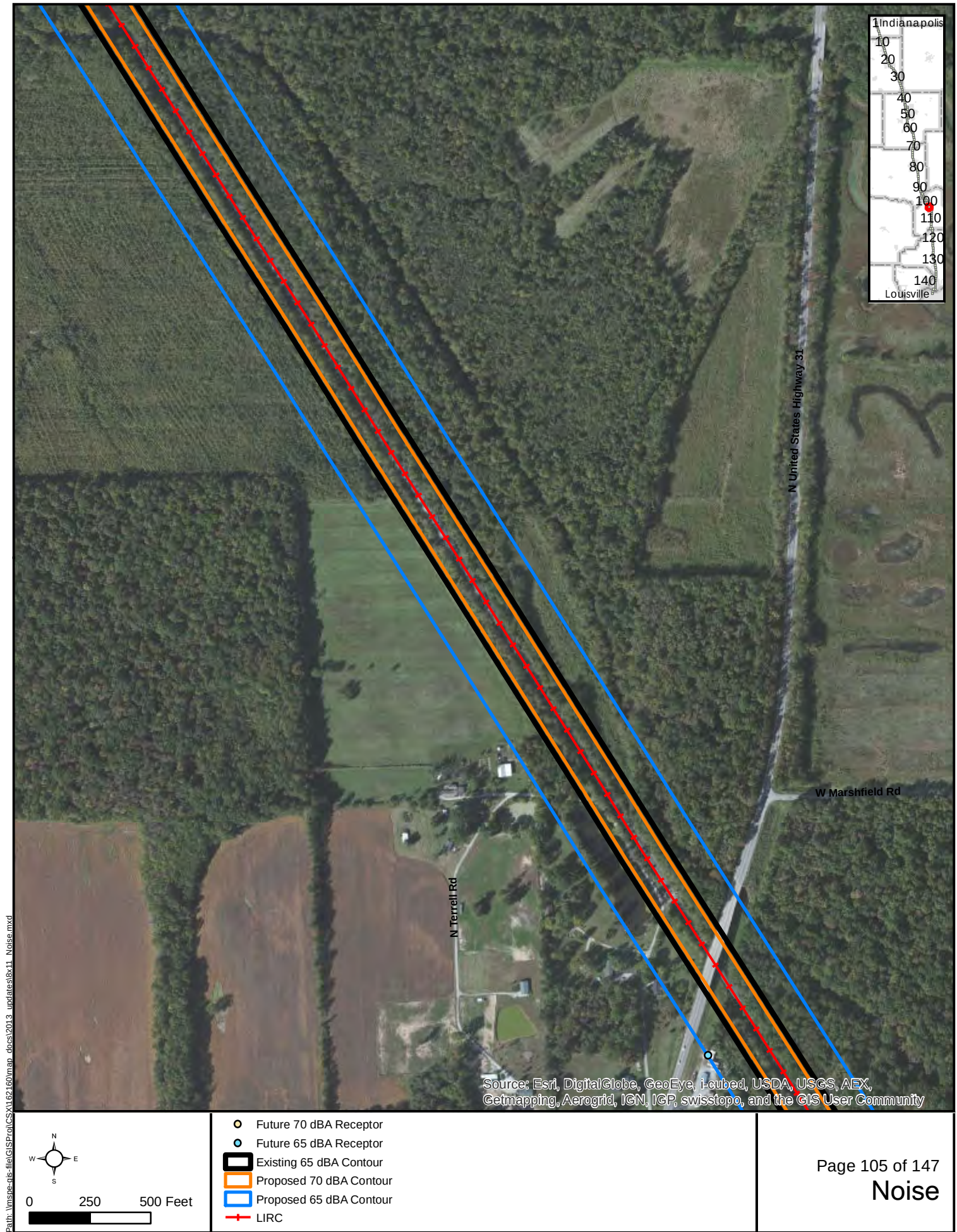


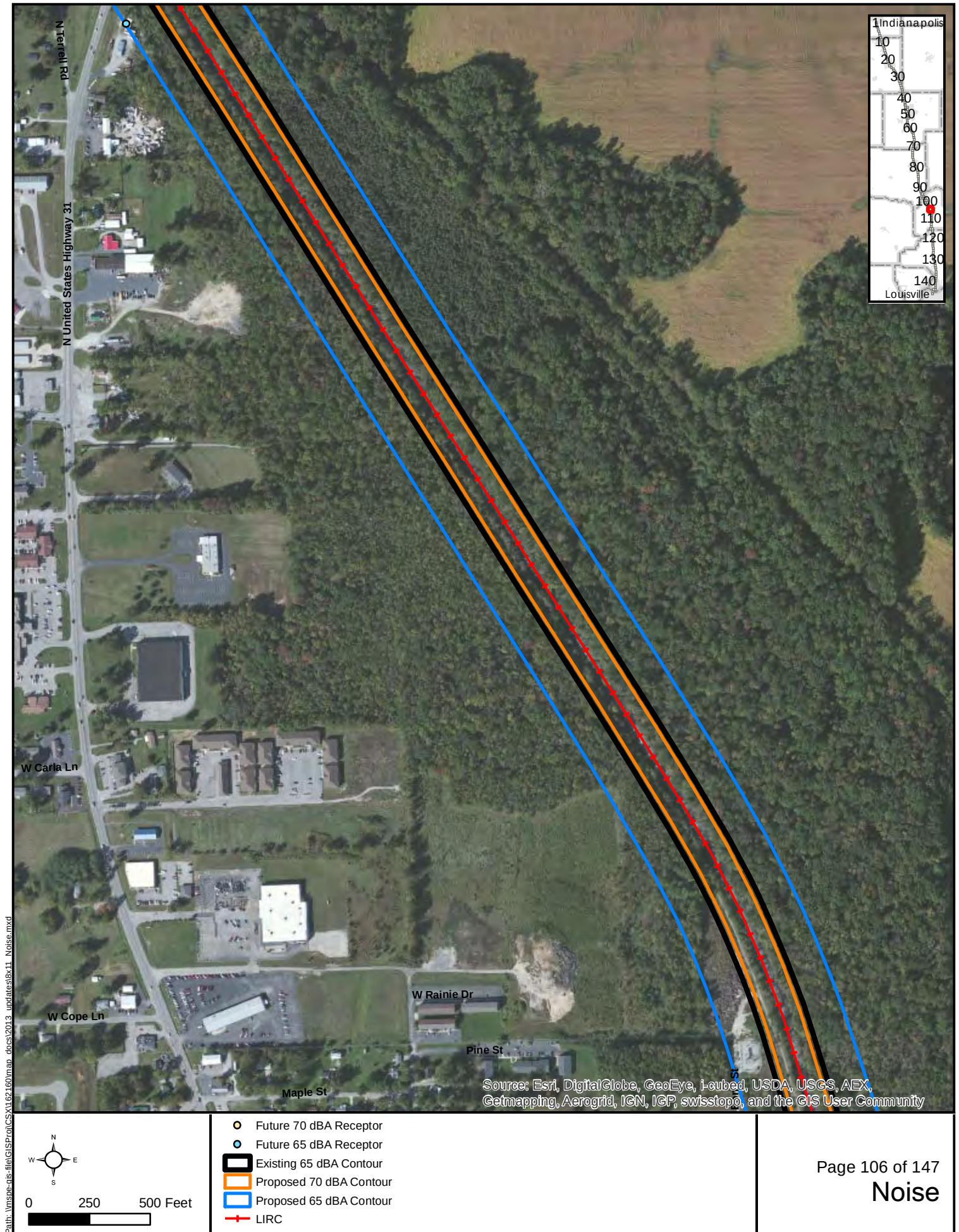


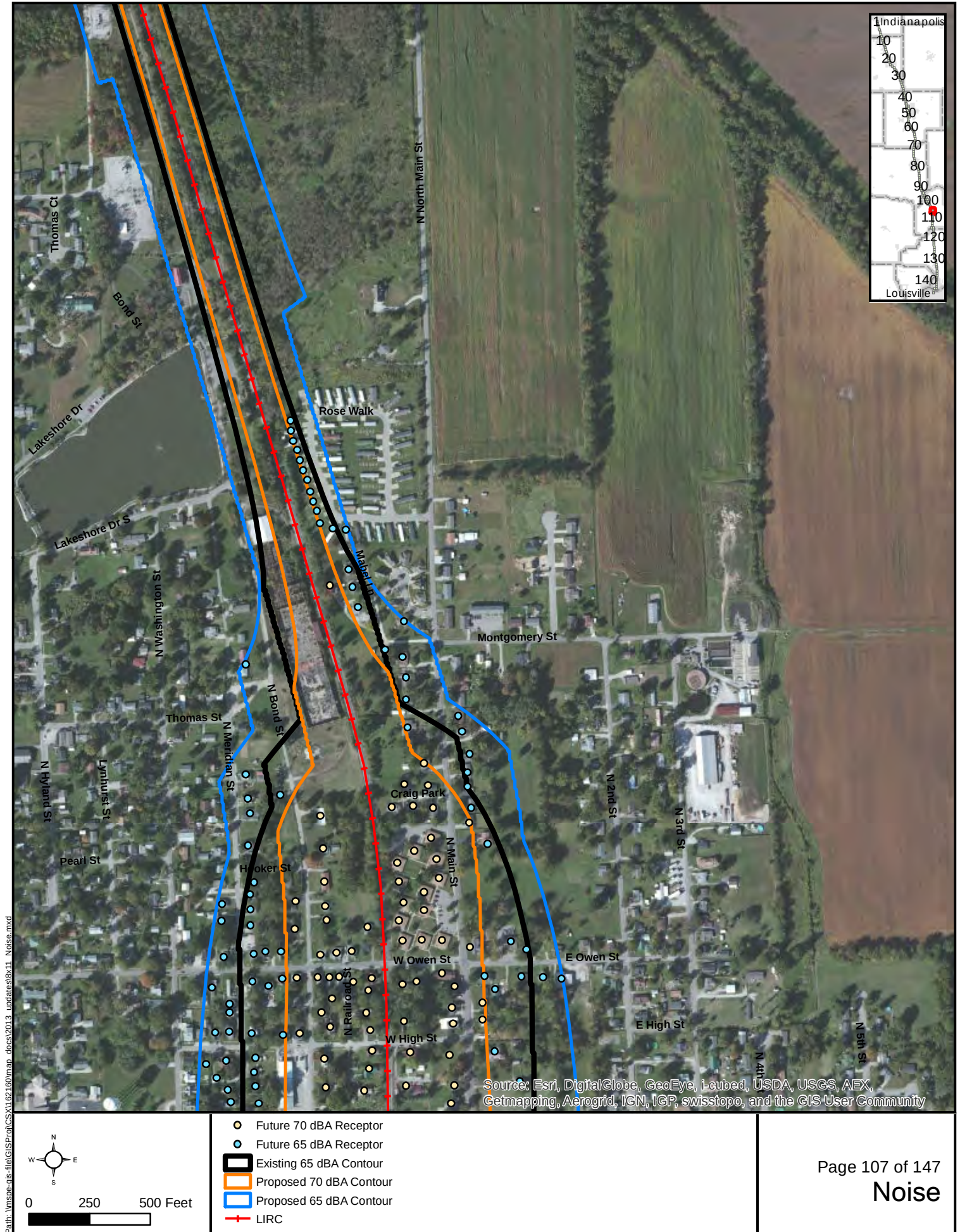


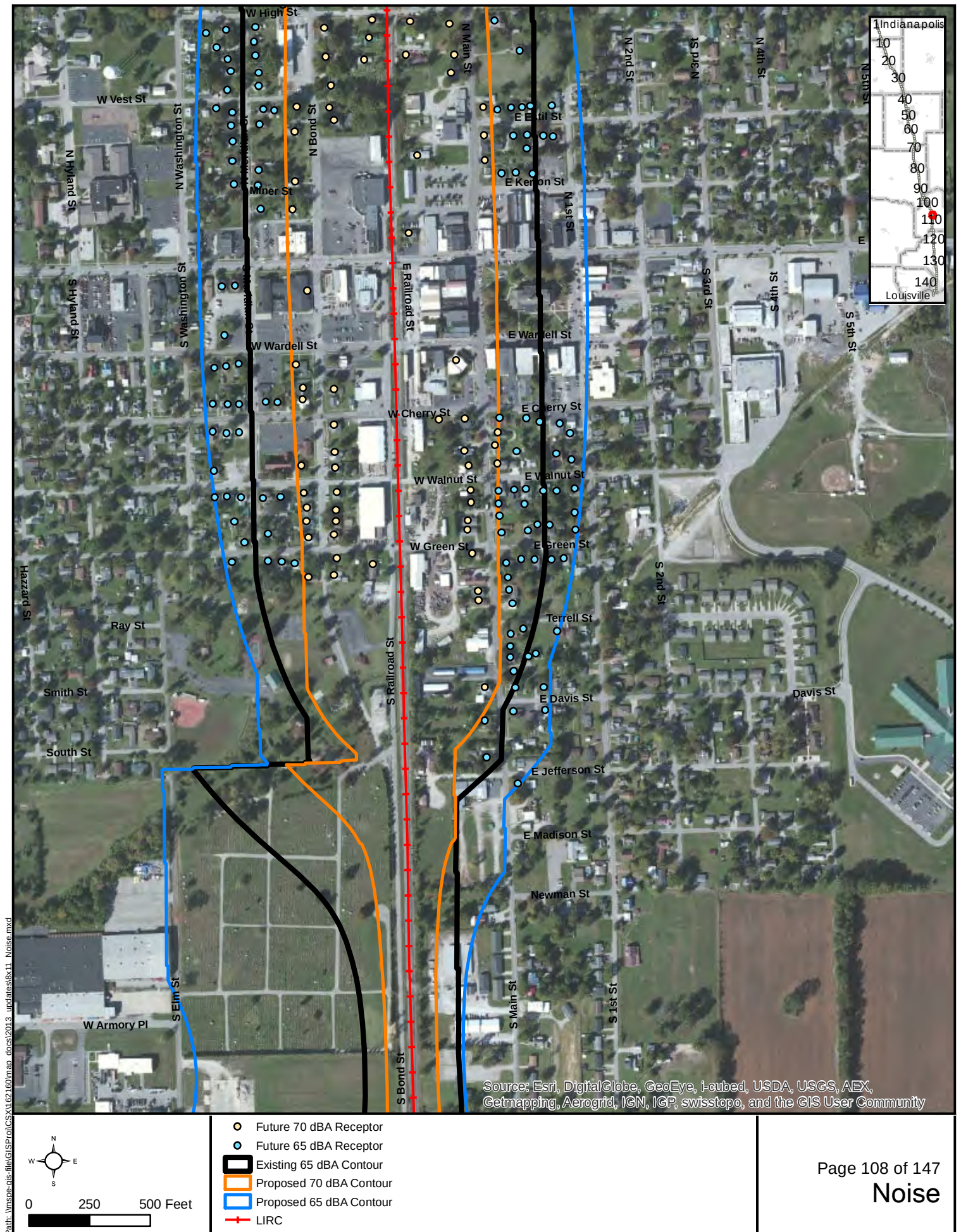


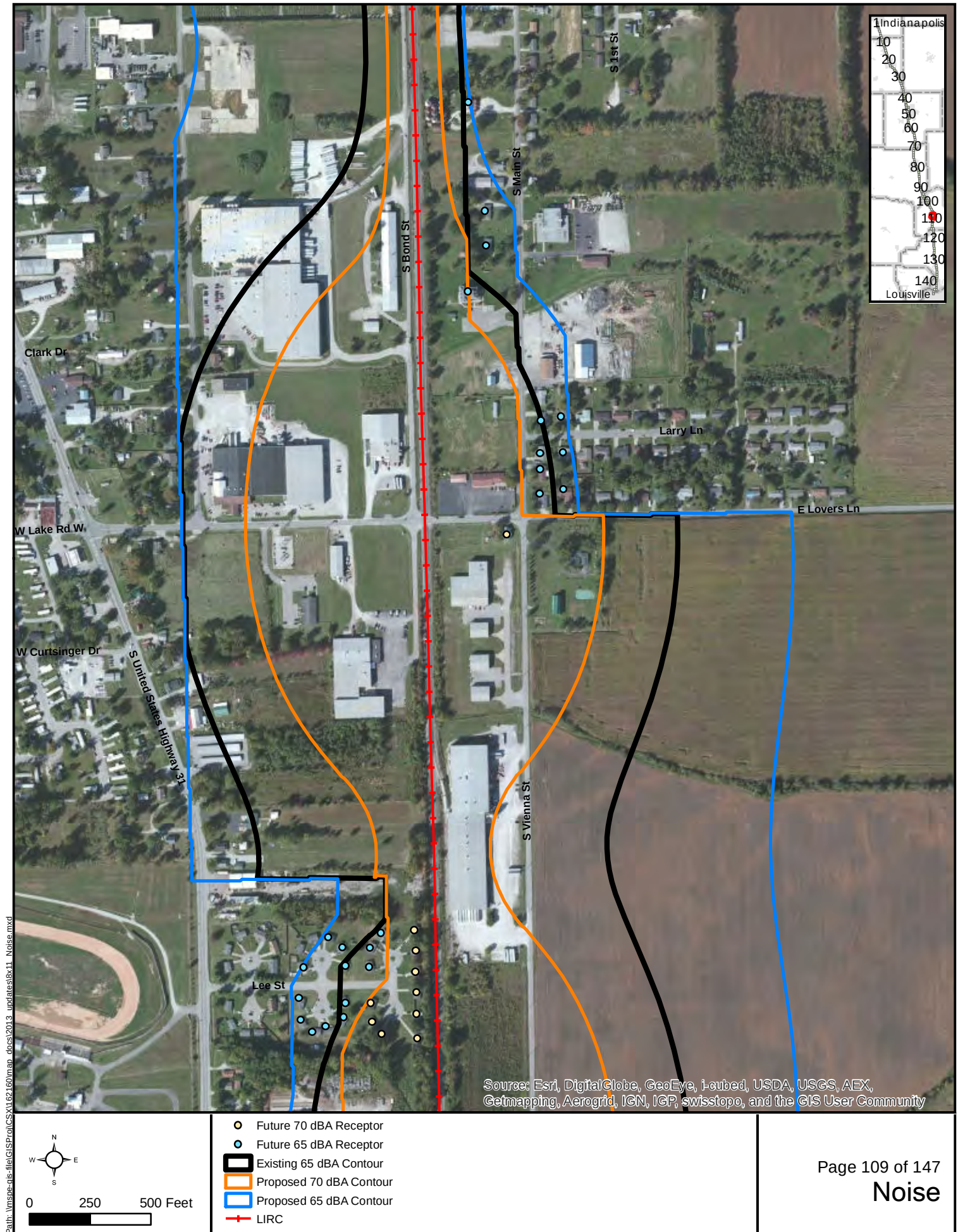


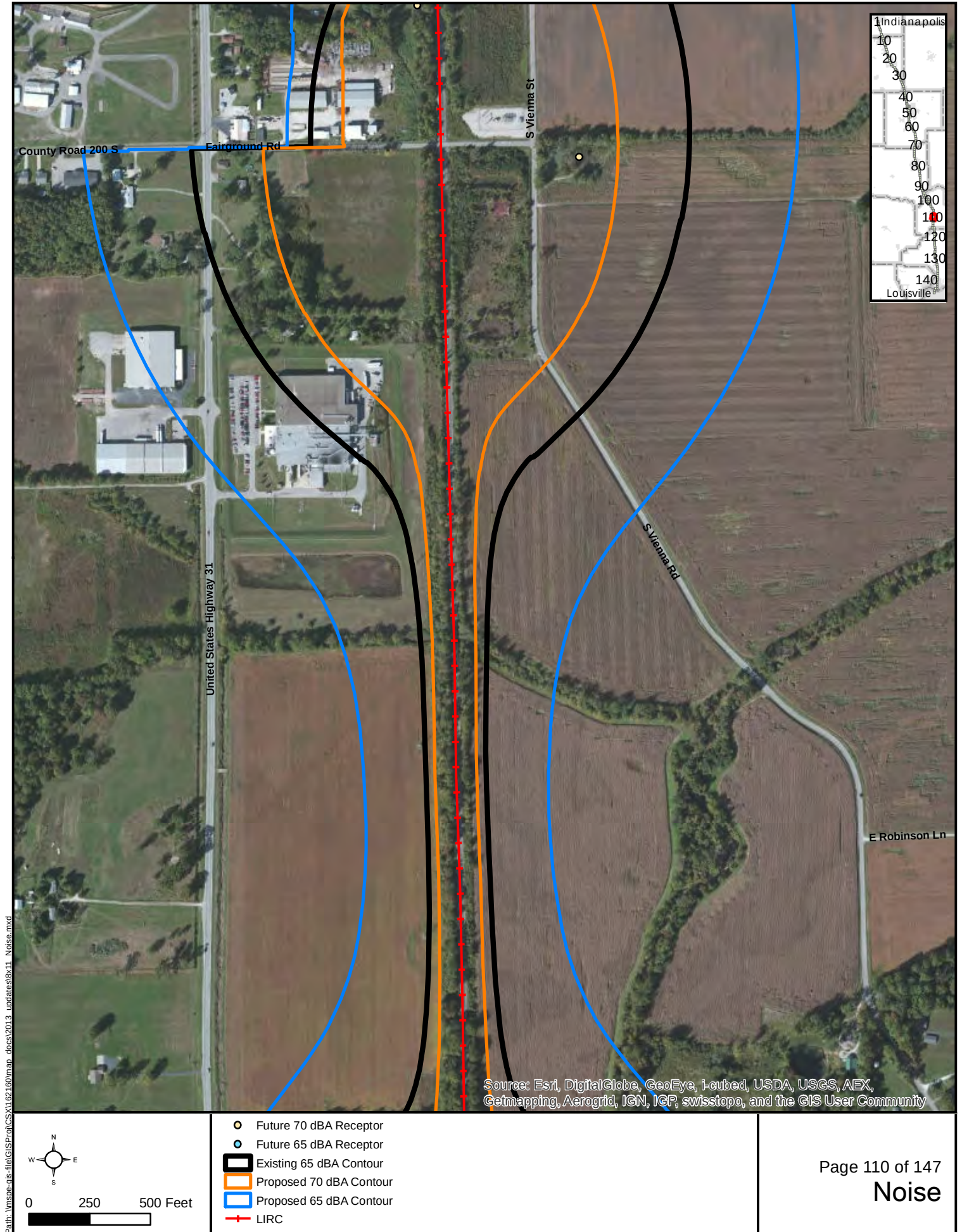


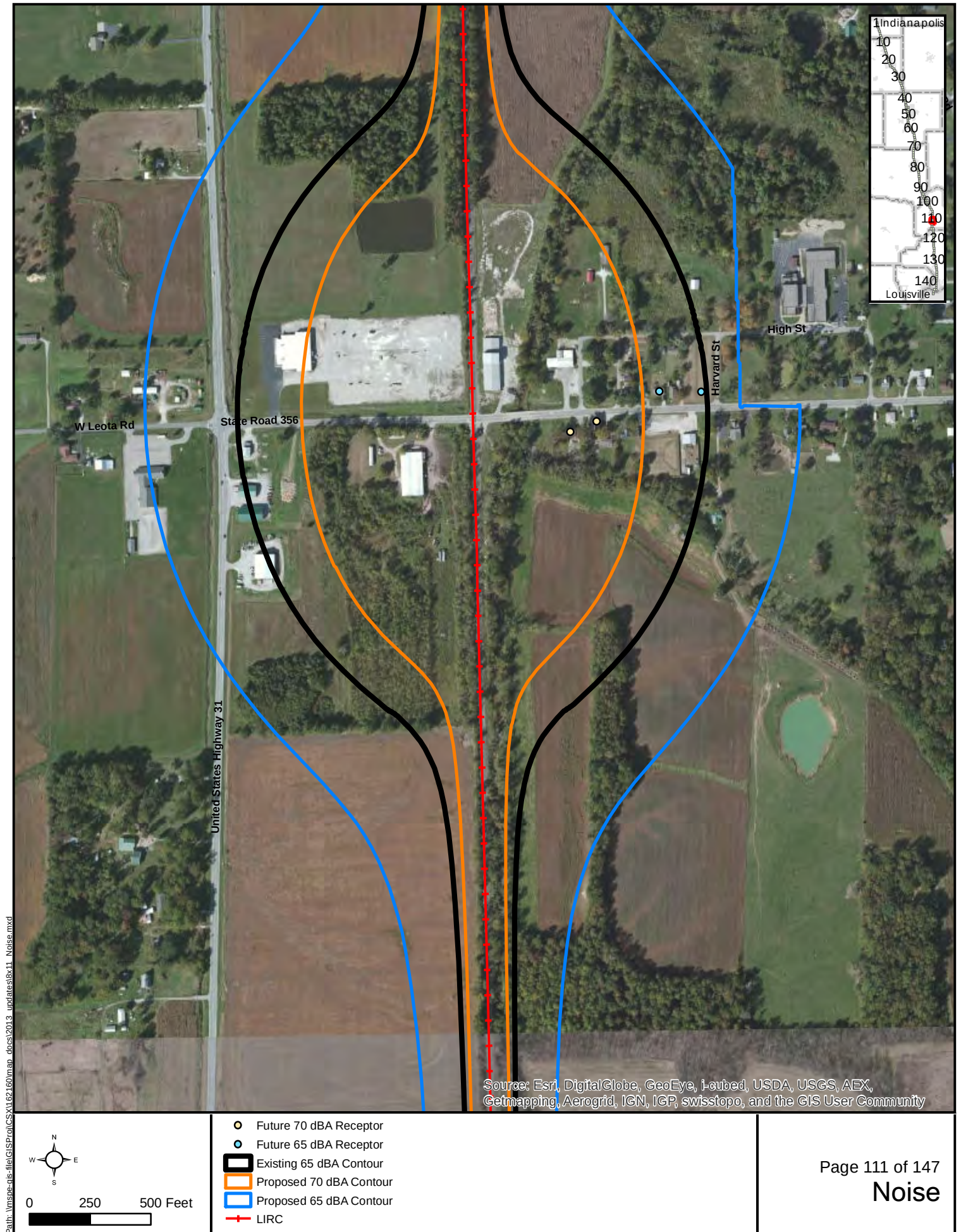


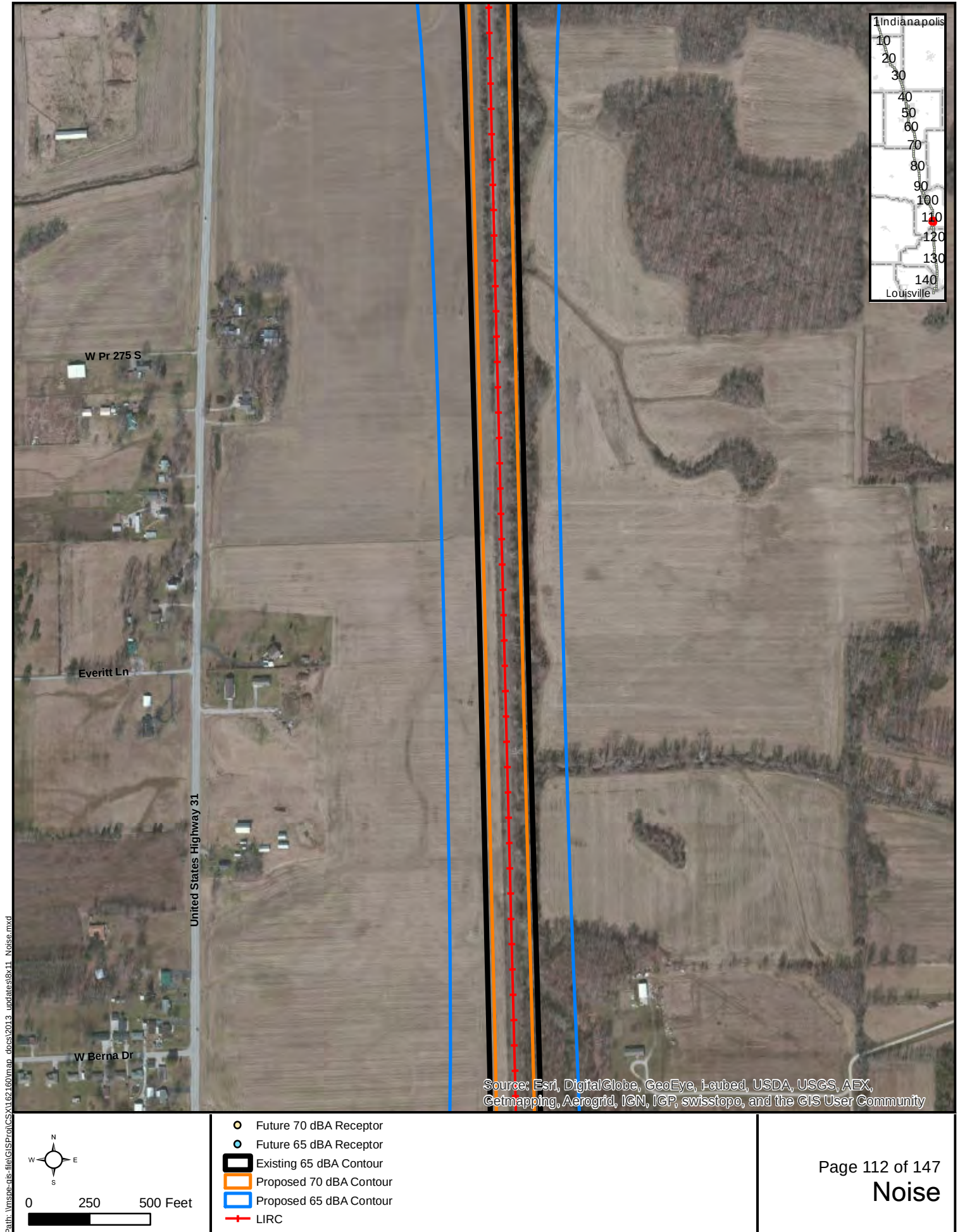


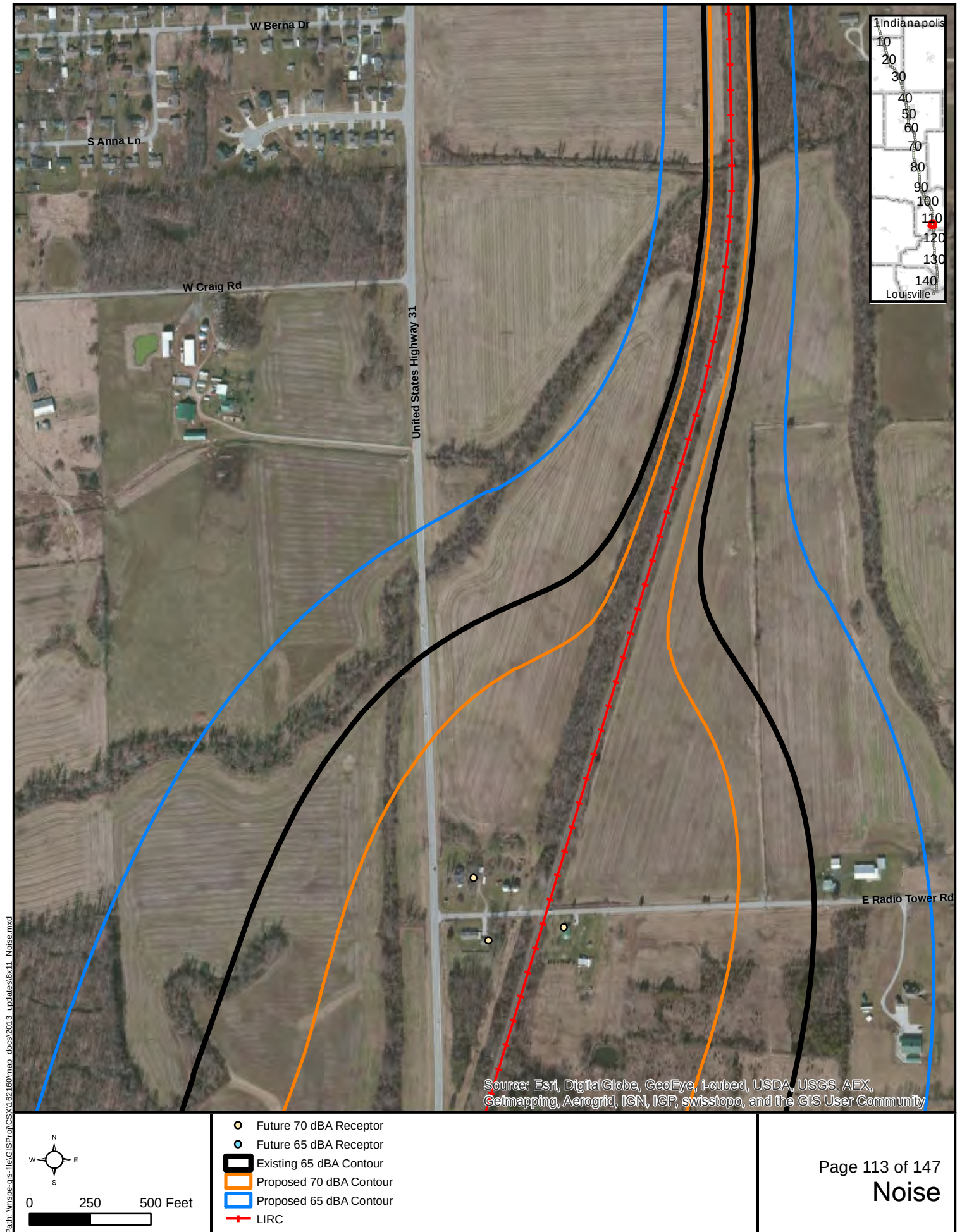


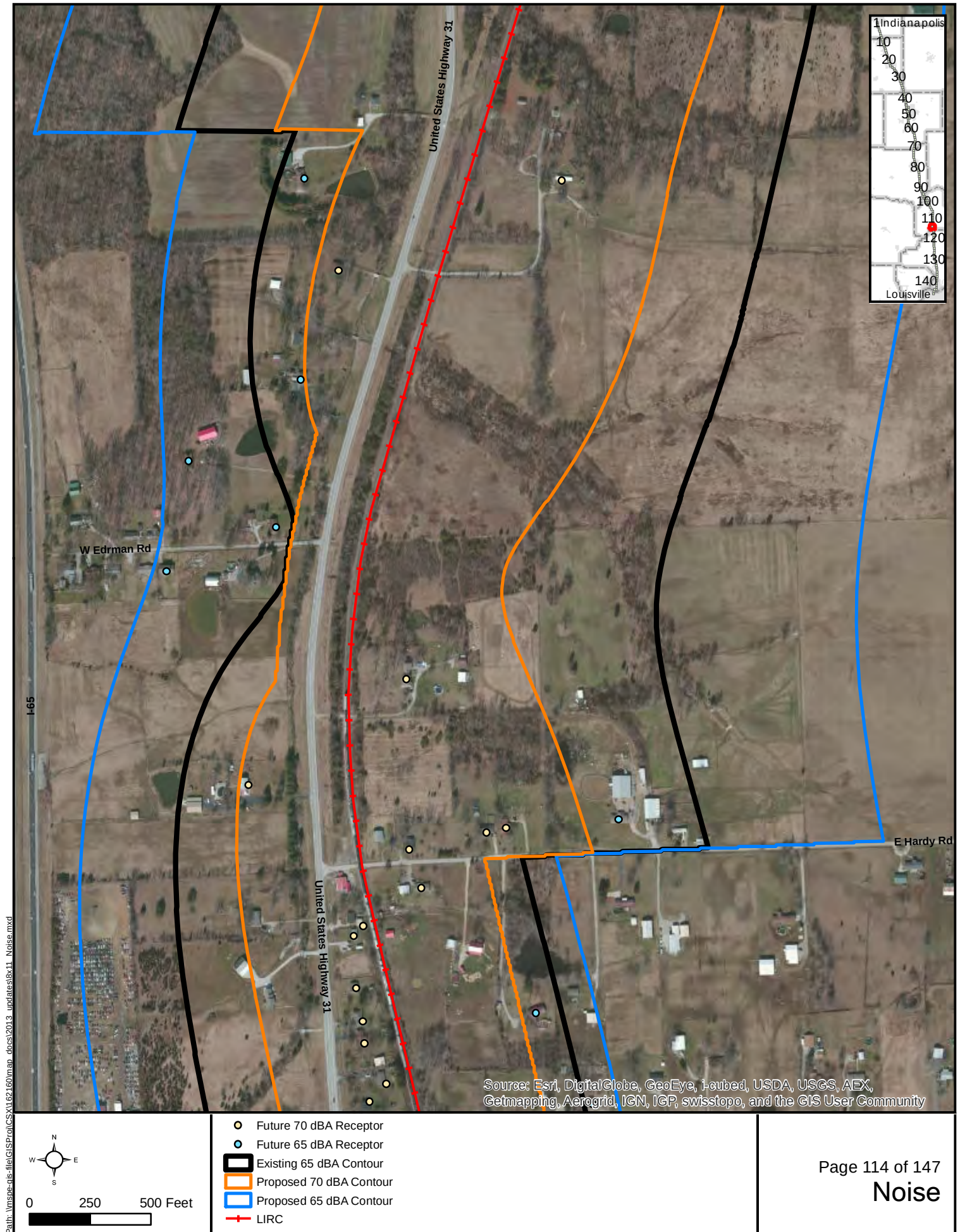












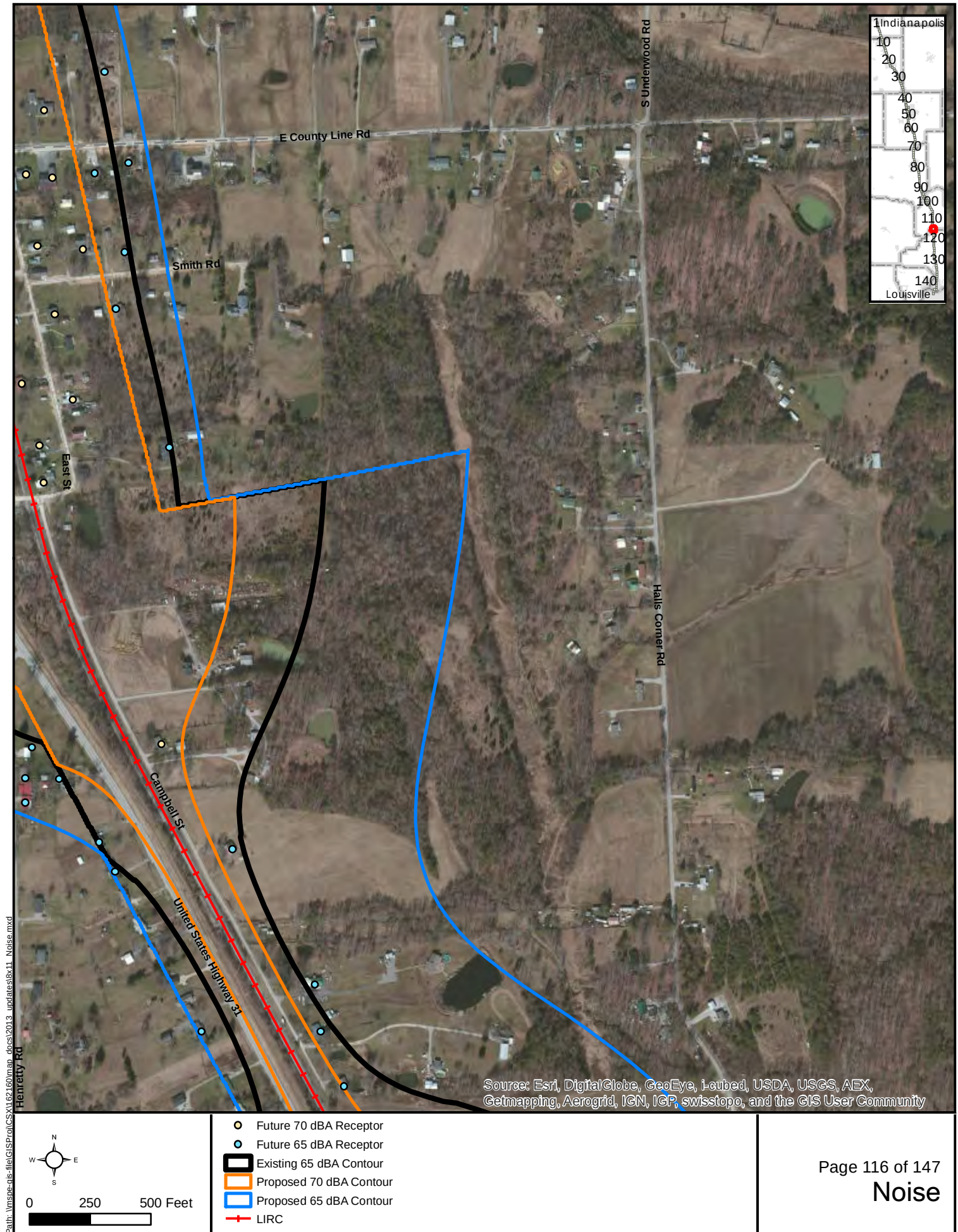


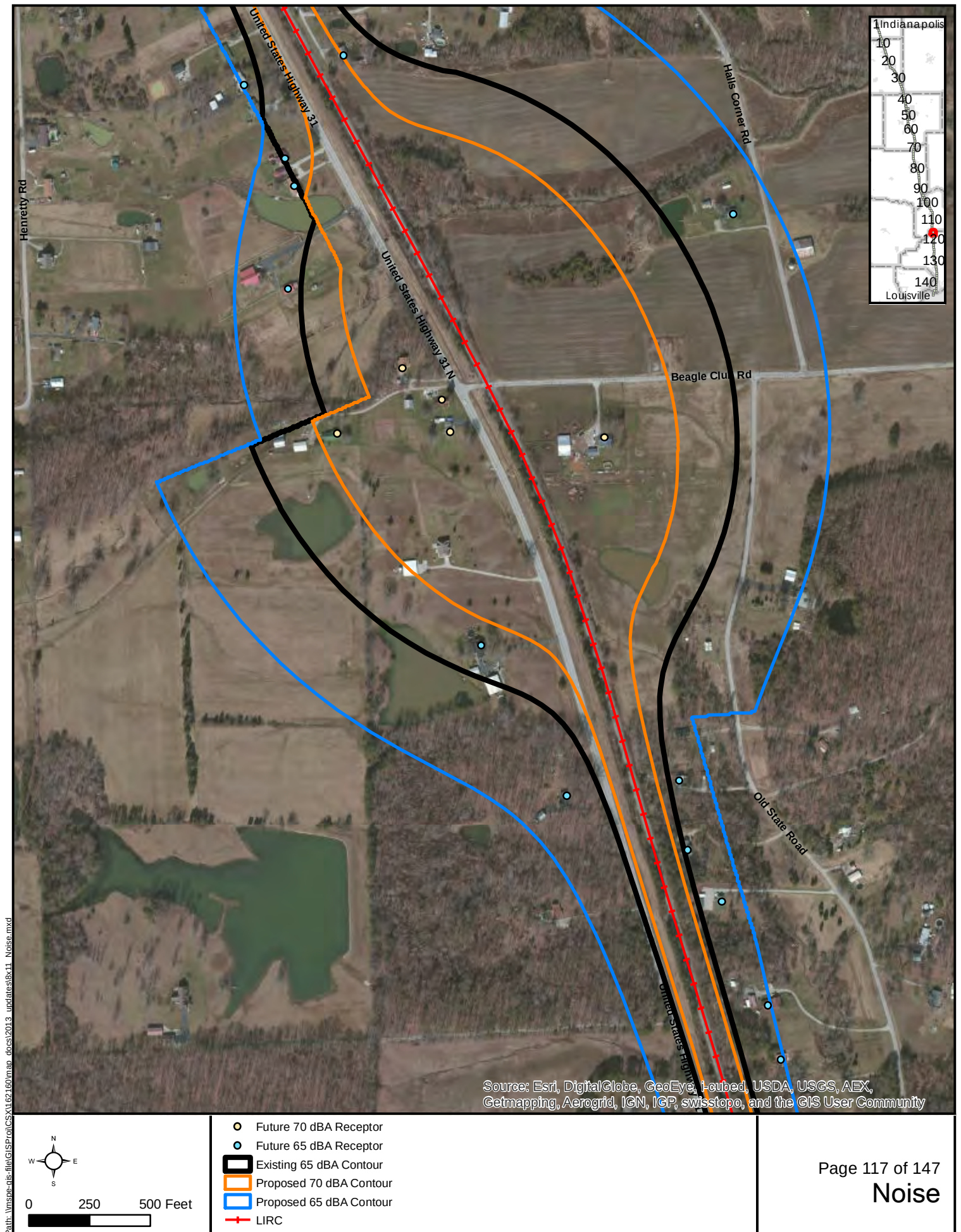
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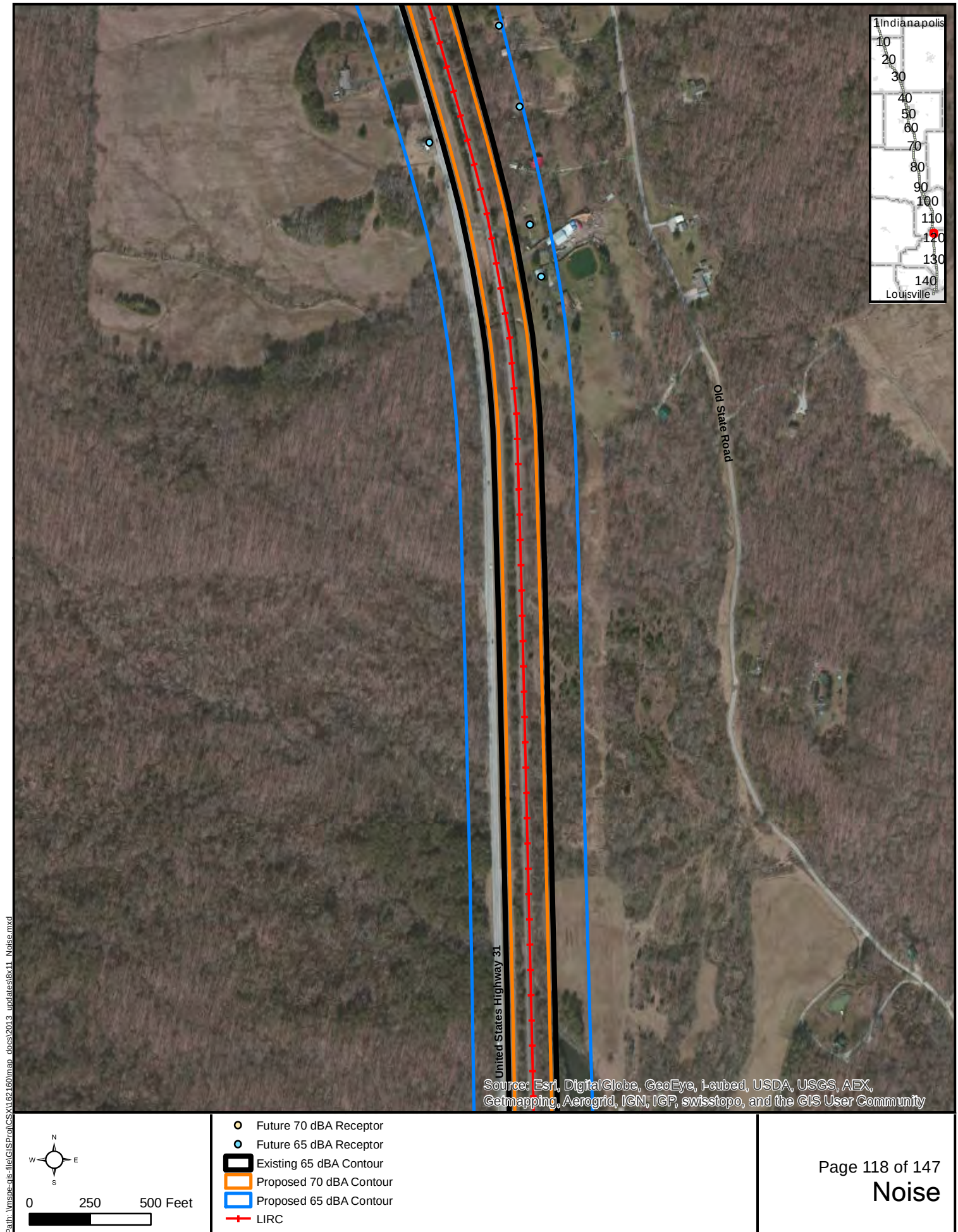


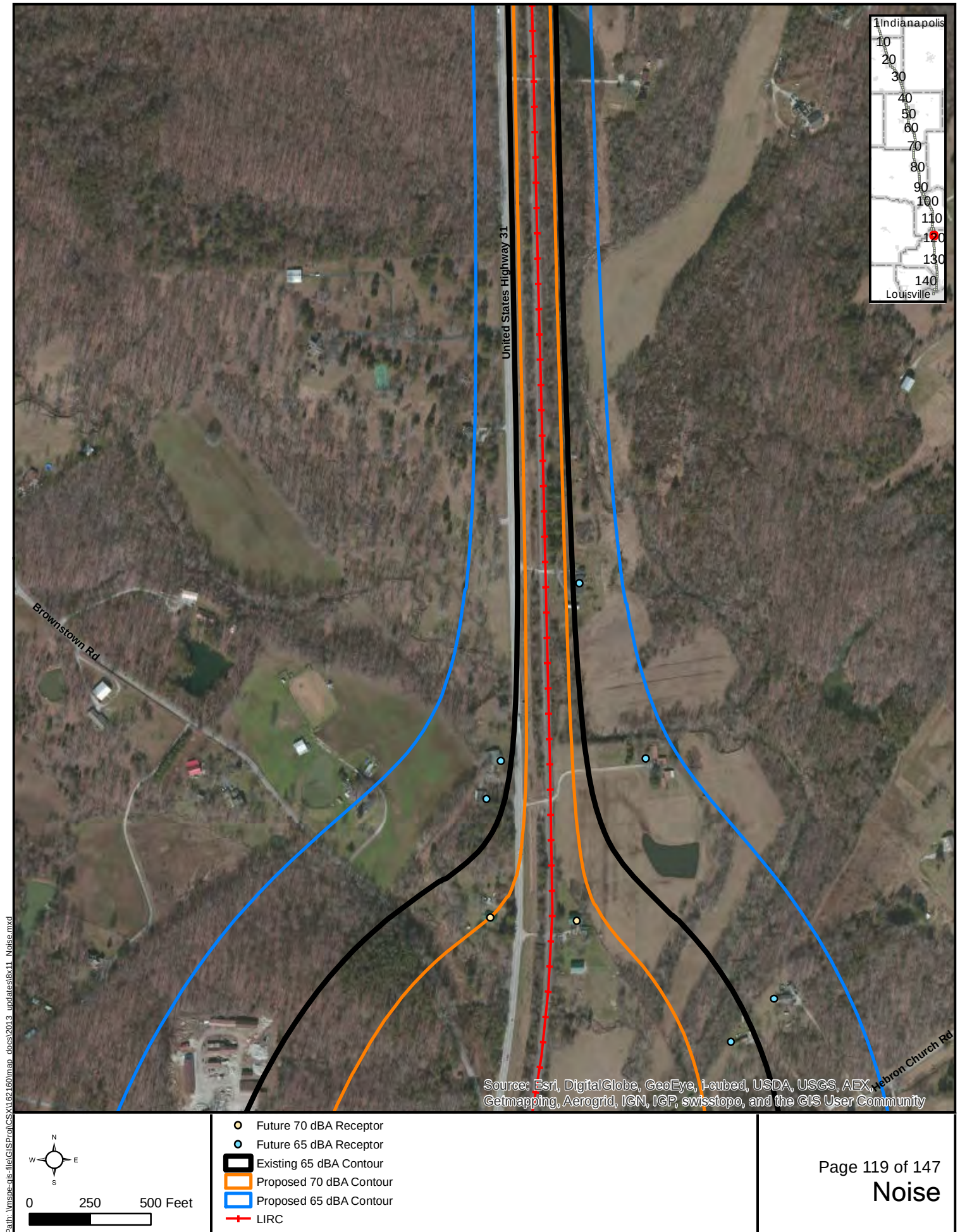
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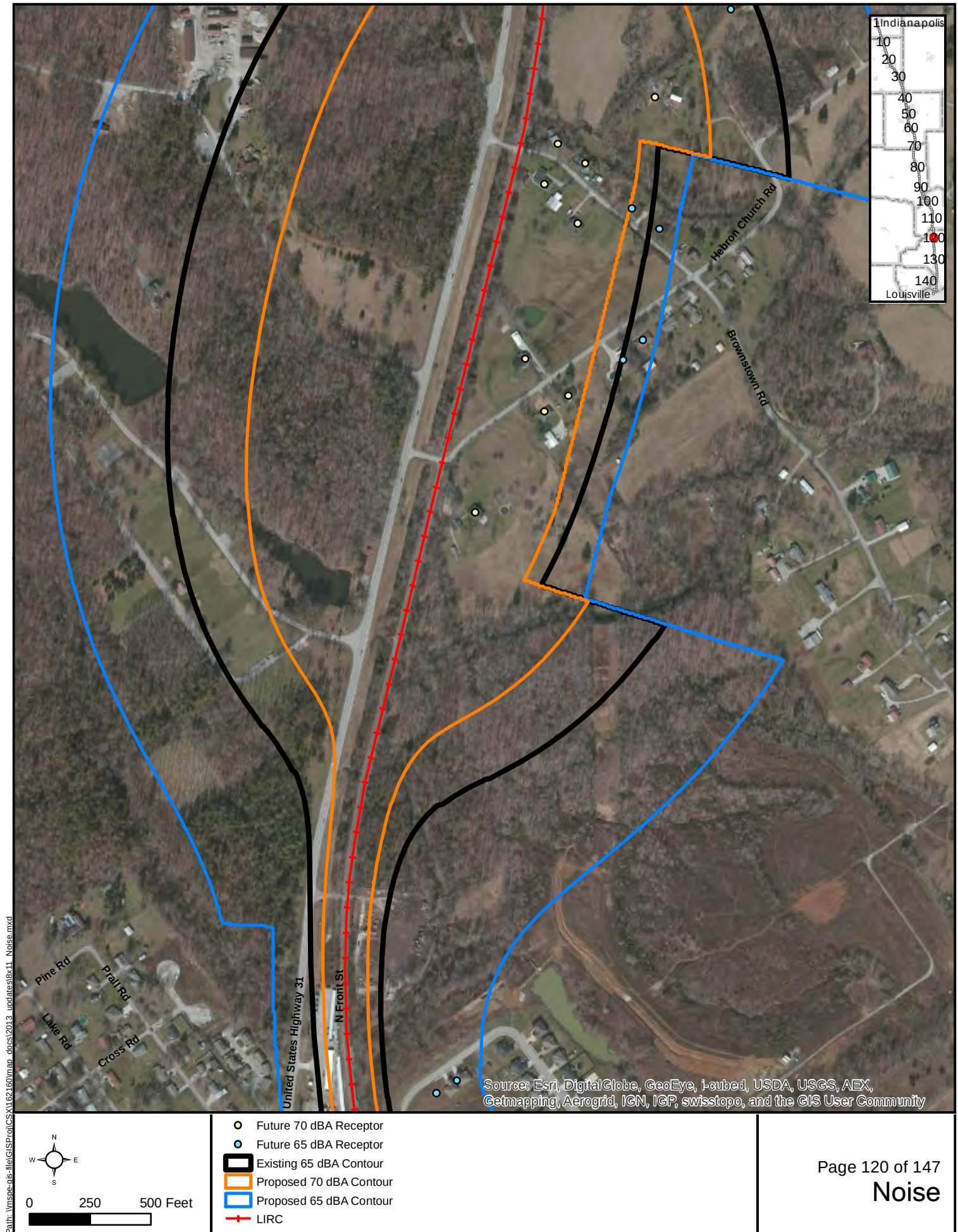
- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- LIRC

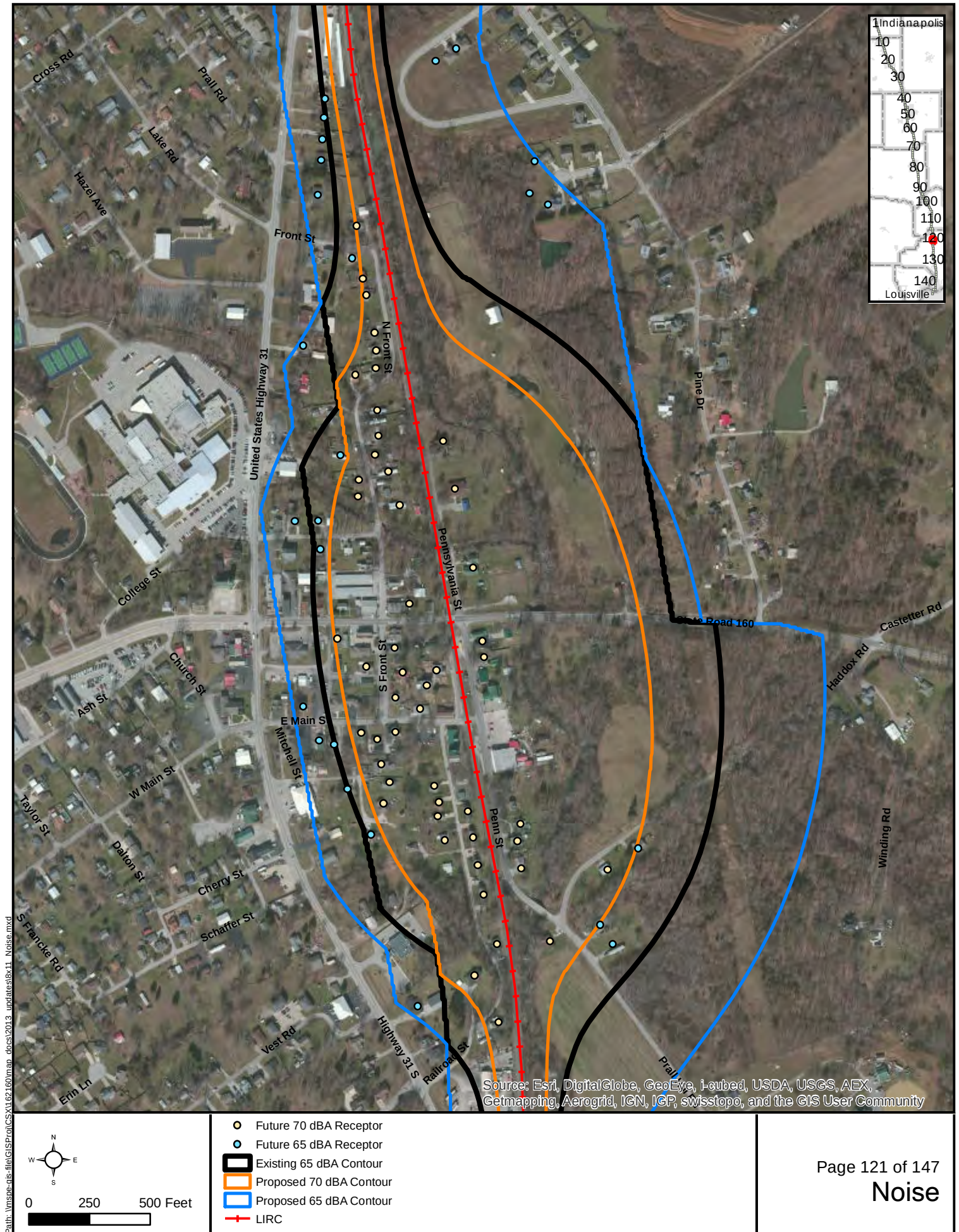


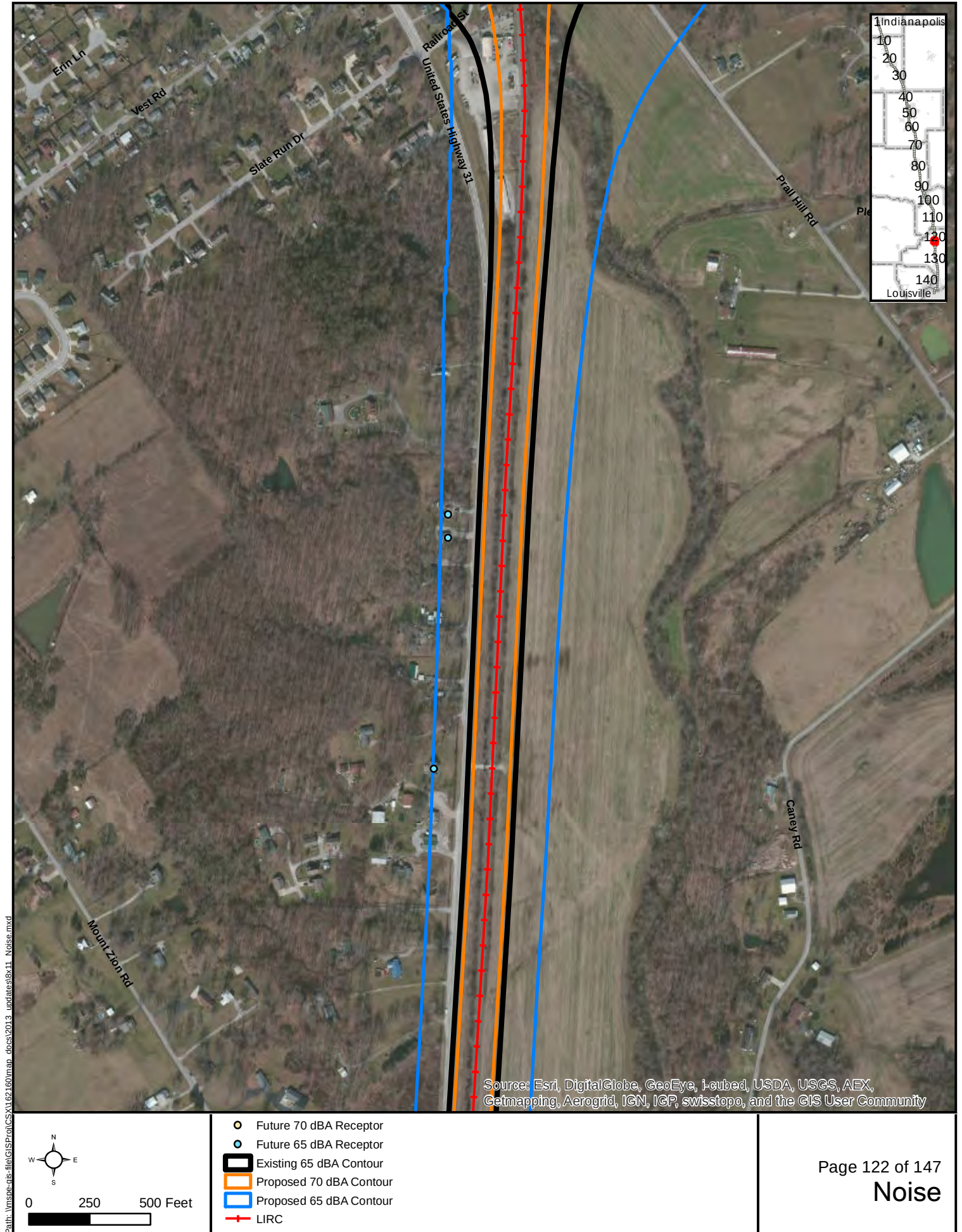


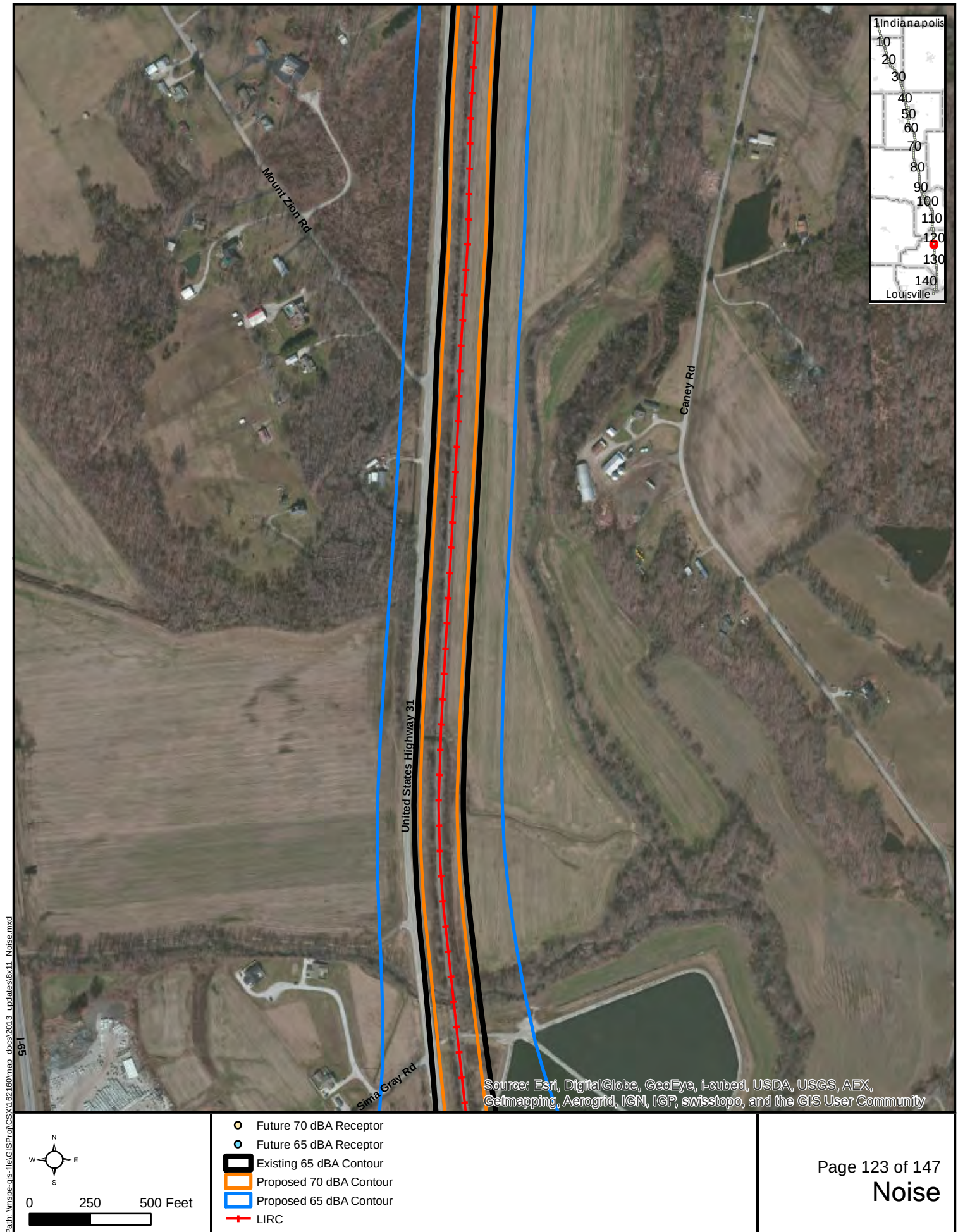


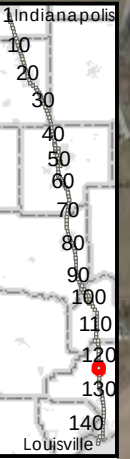
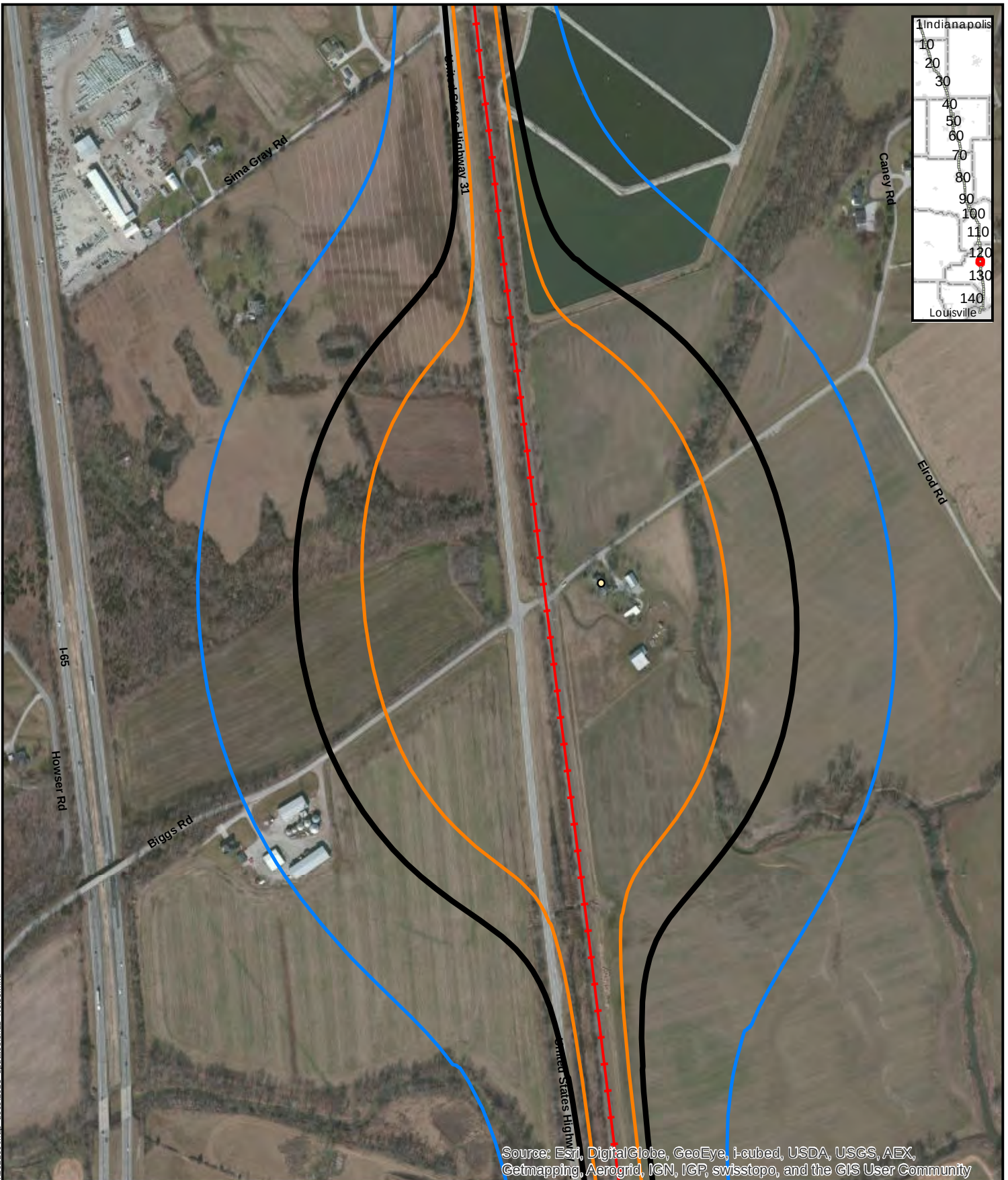






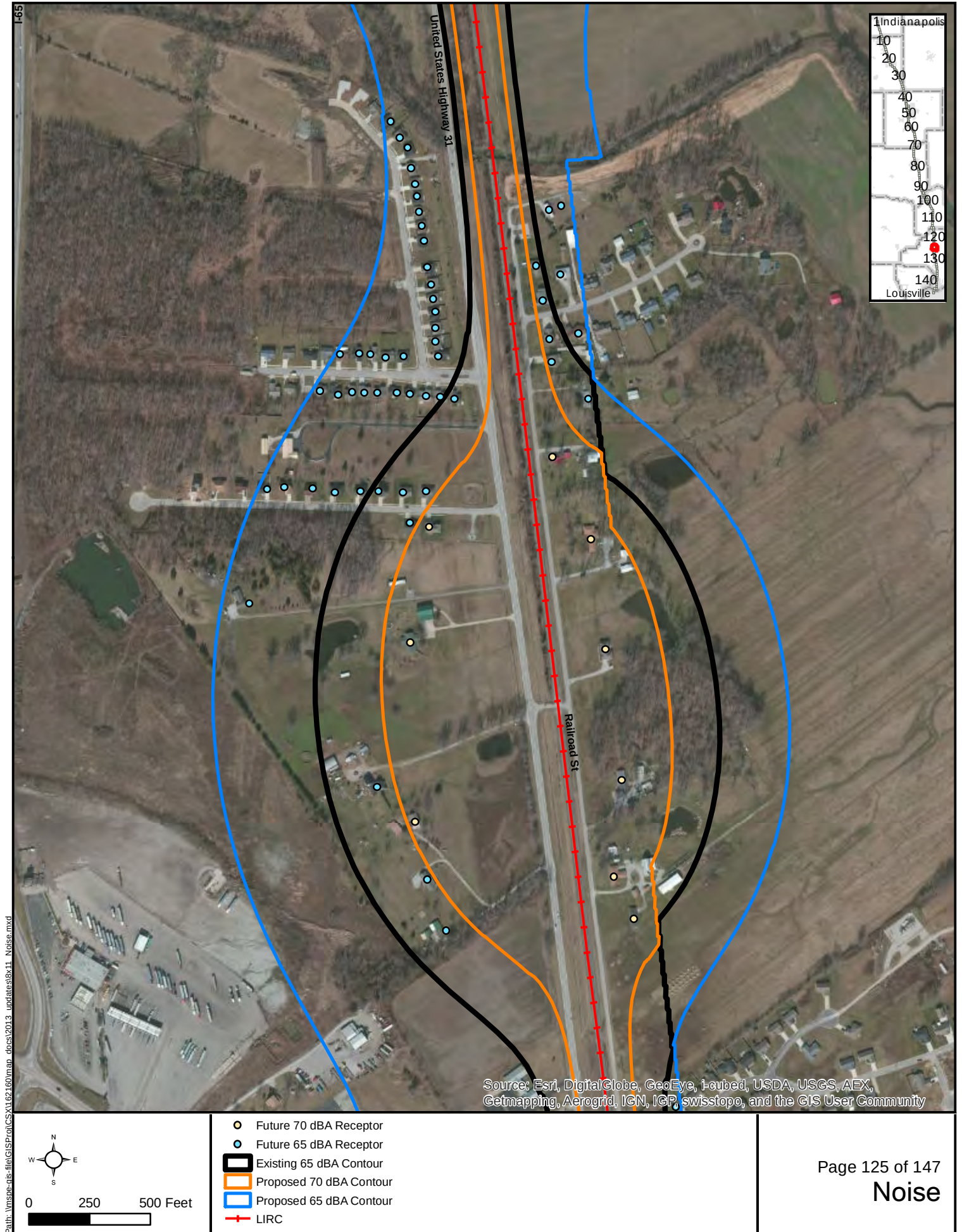


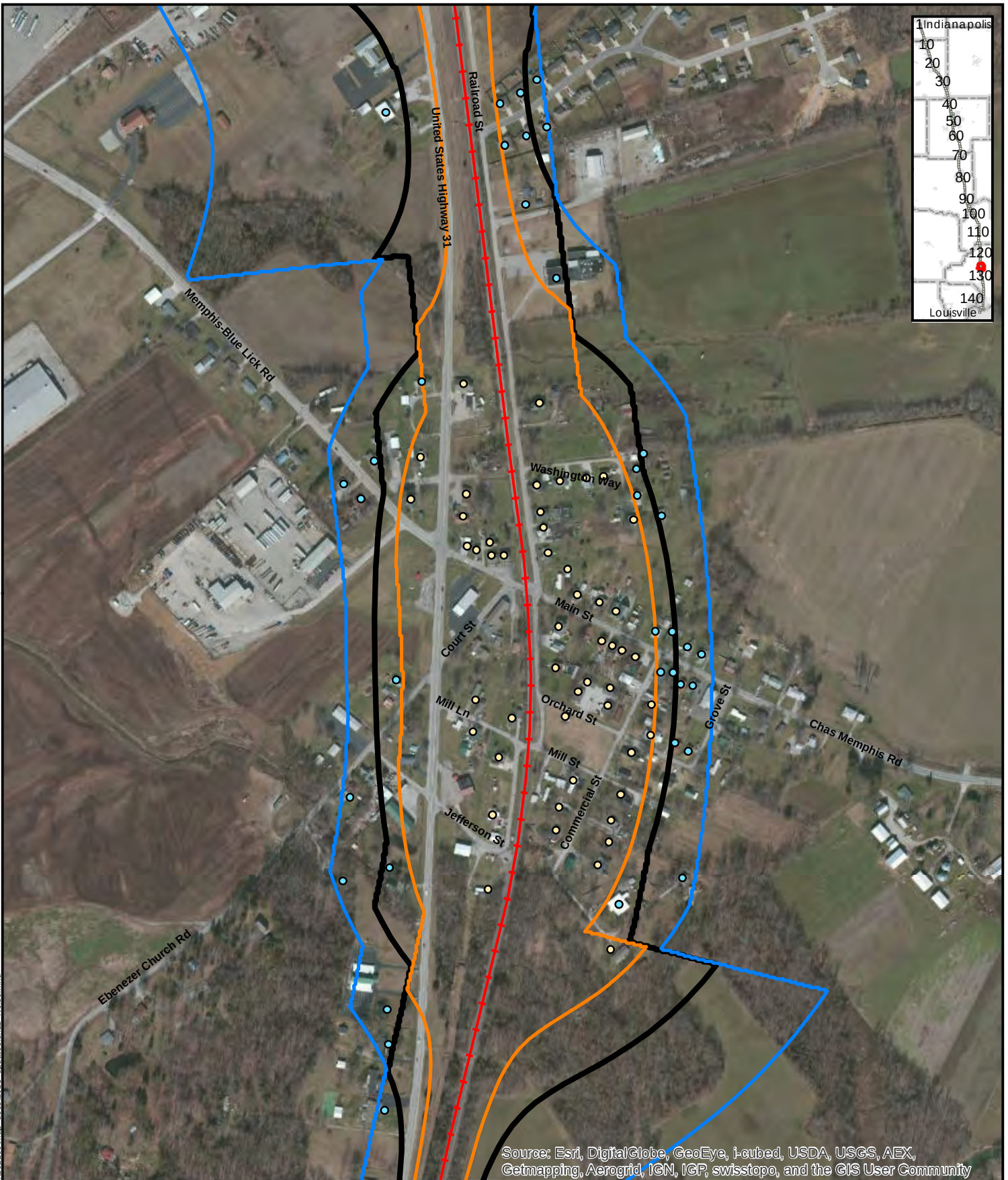




0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- +— LIRC



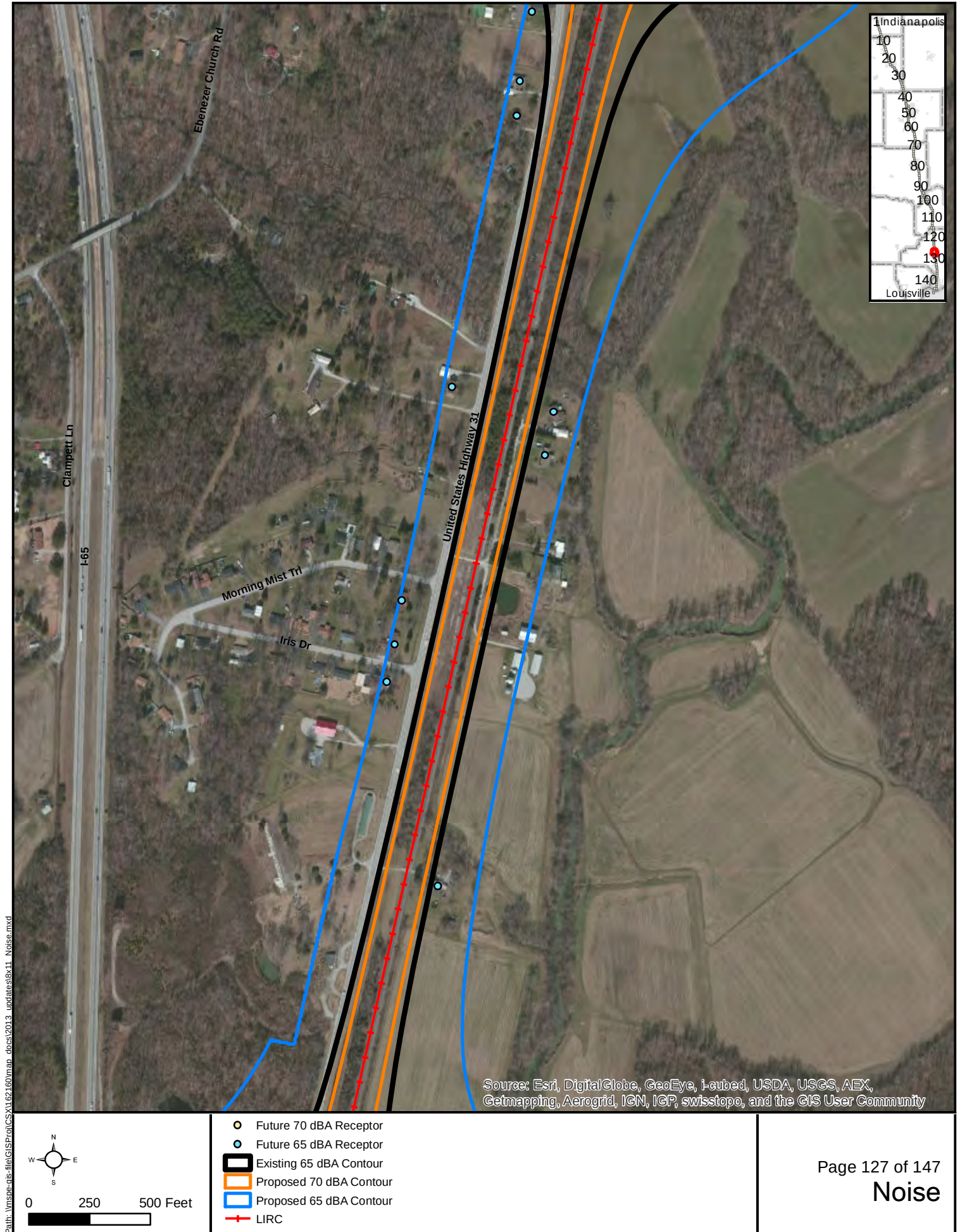


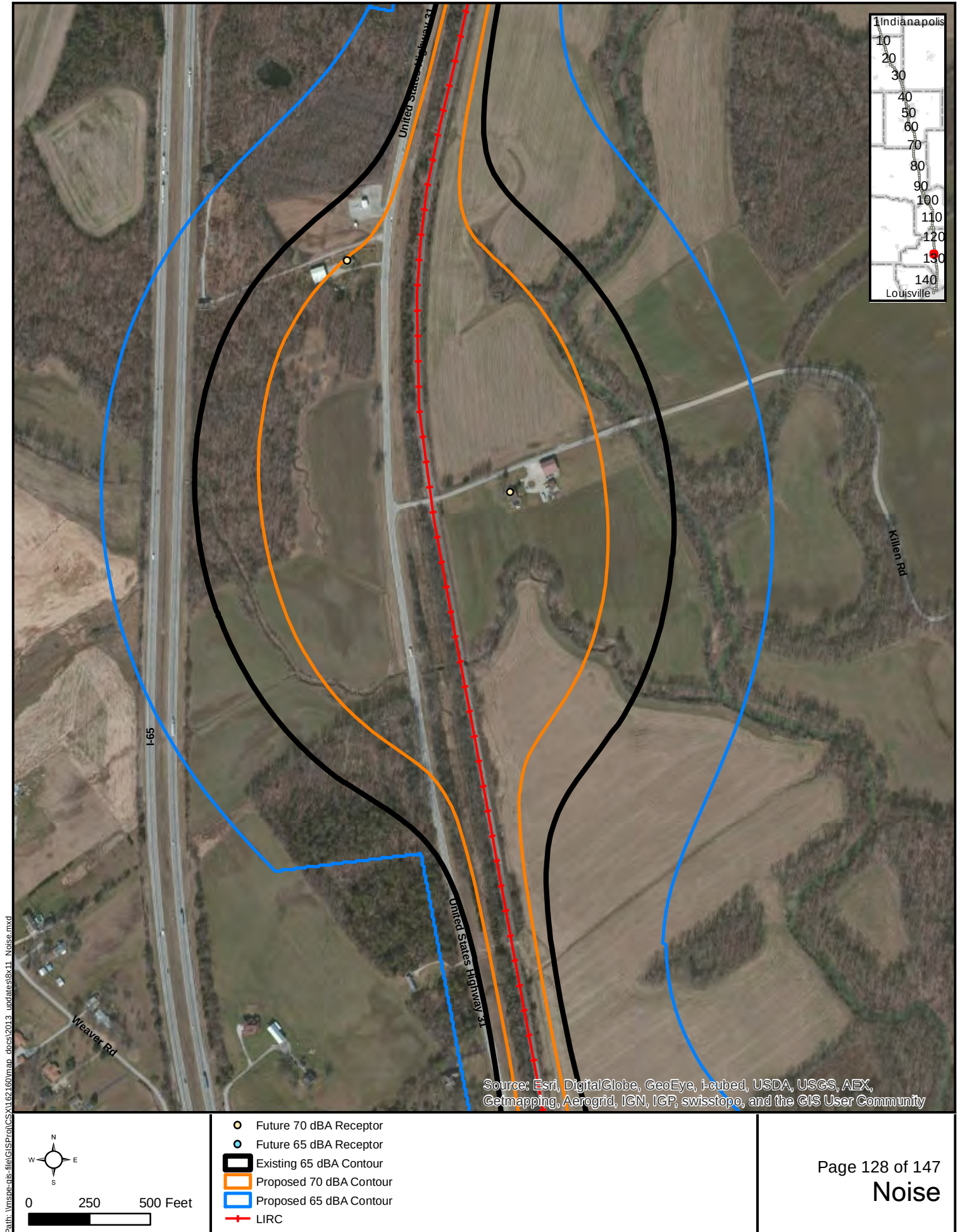
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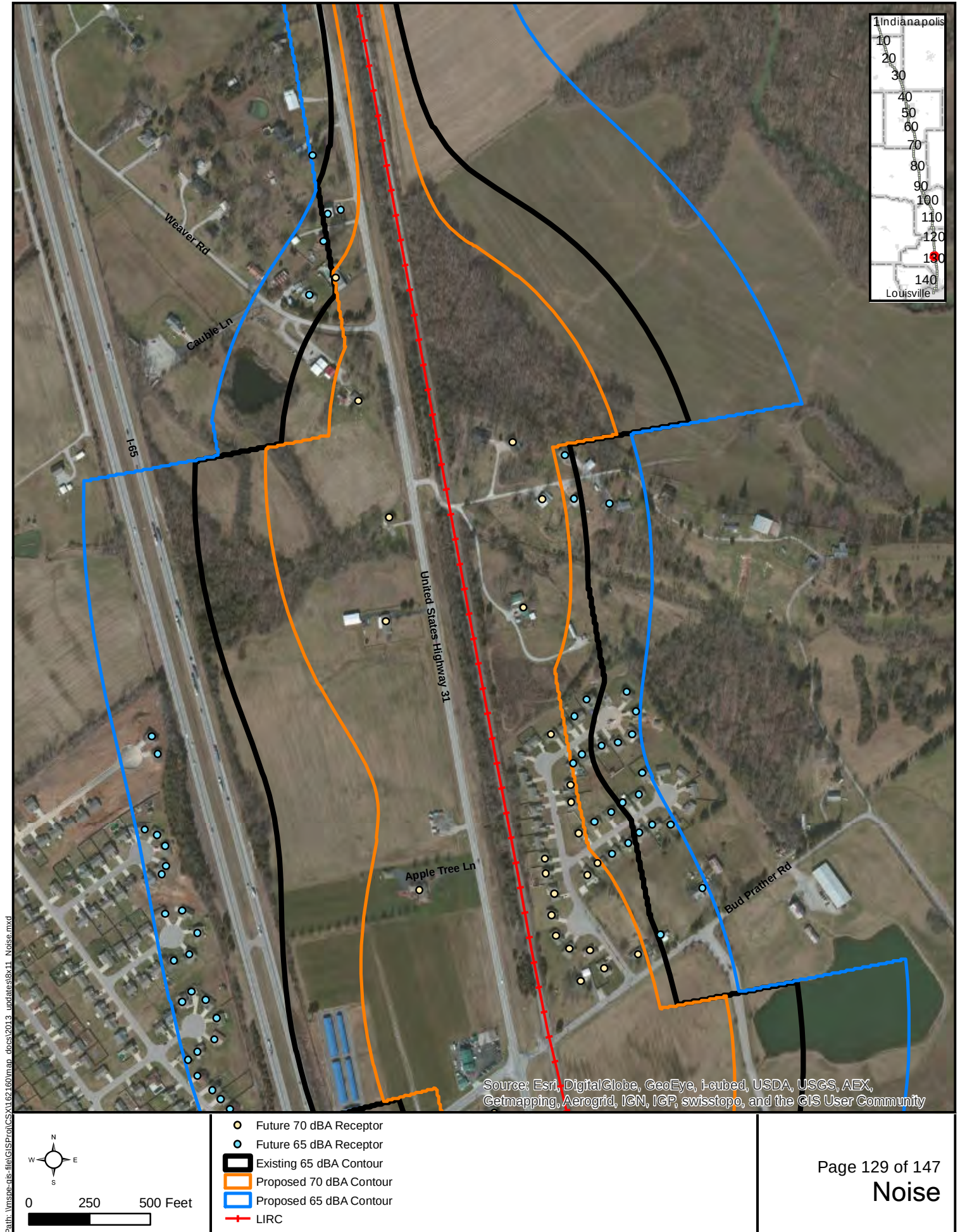


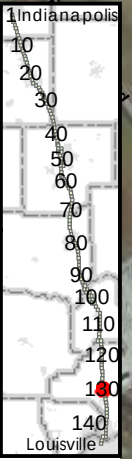
0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- ▬ Existing 65 dBA Contour
- ▬ Proposed 70 dBA Contour
- ▬ Proposed 65 dBA Contour
- + LIRC



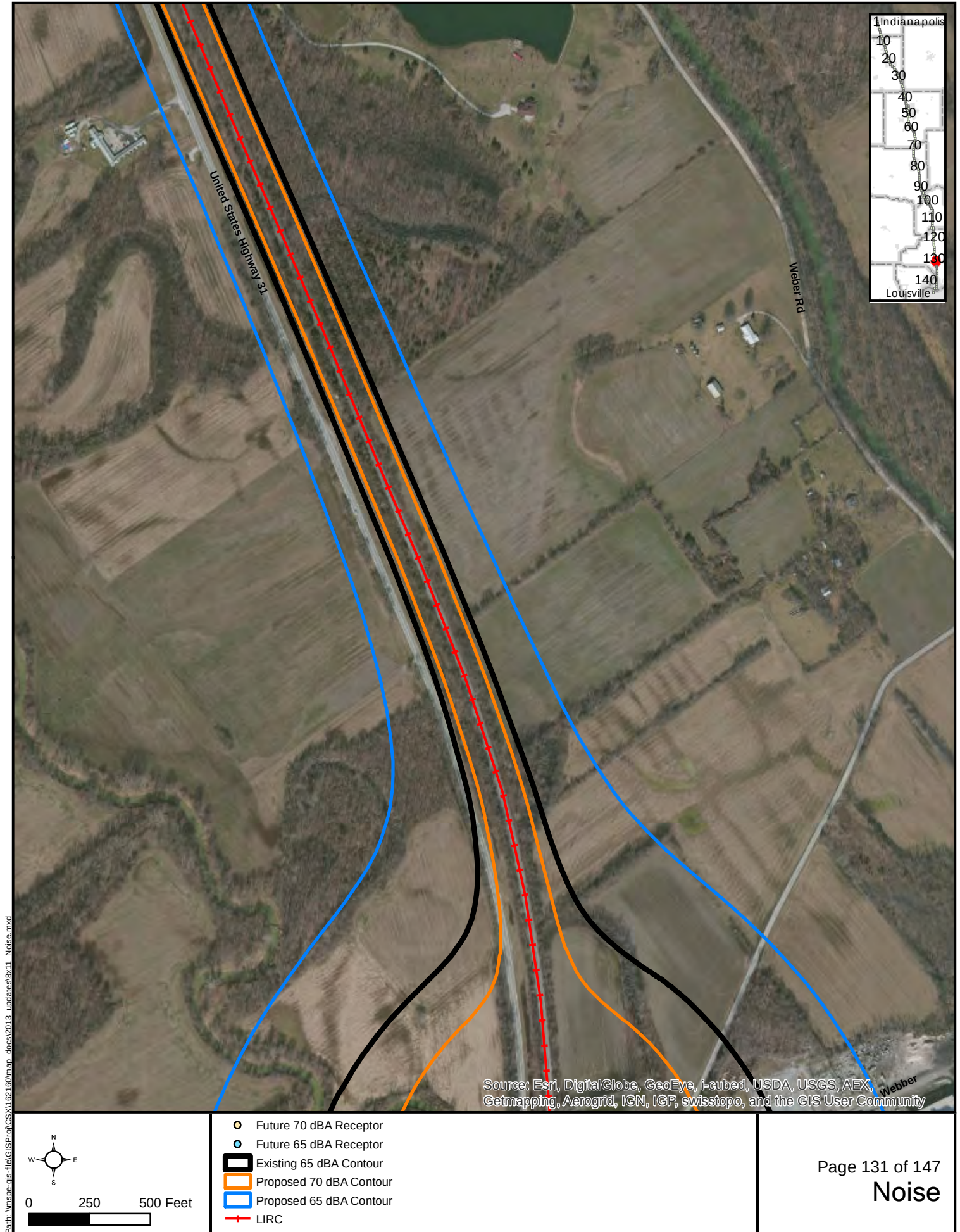


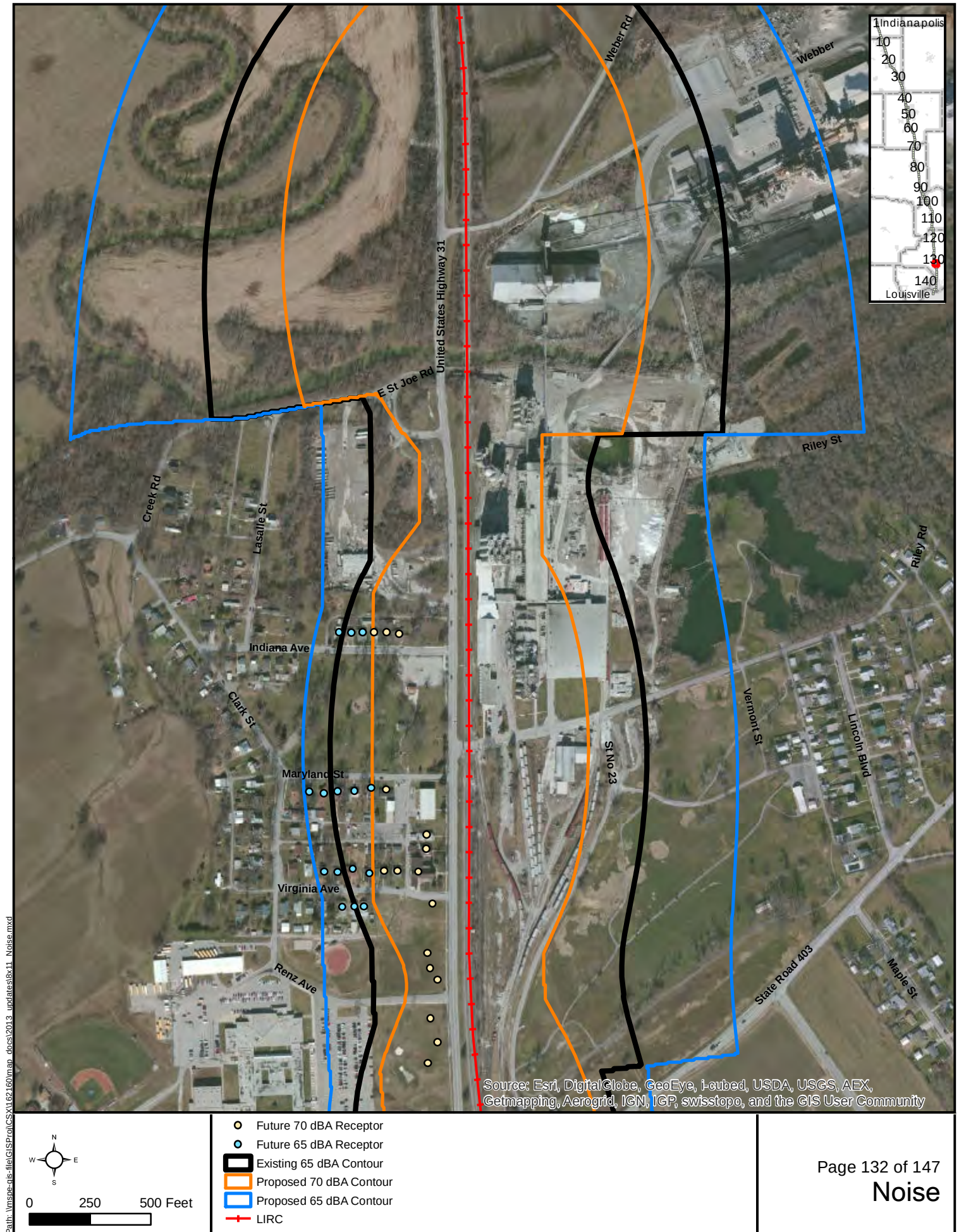


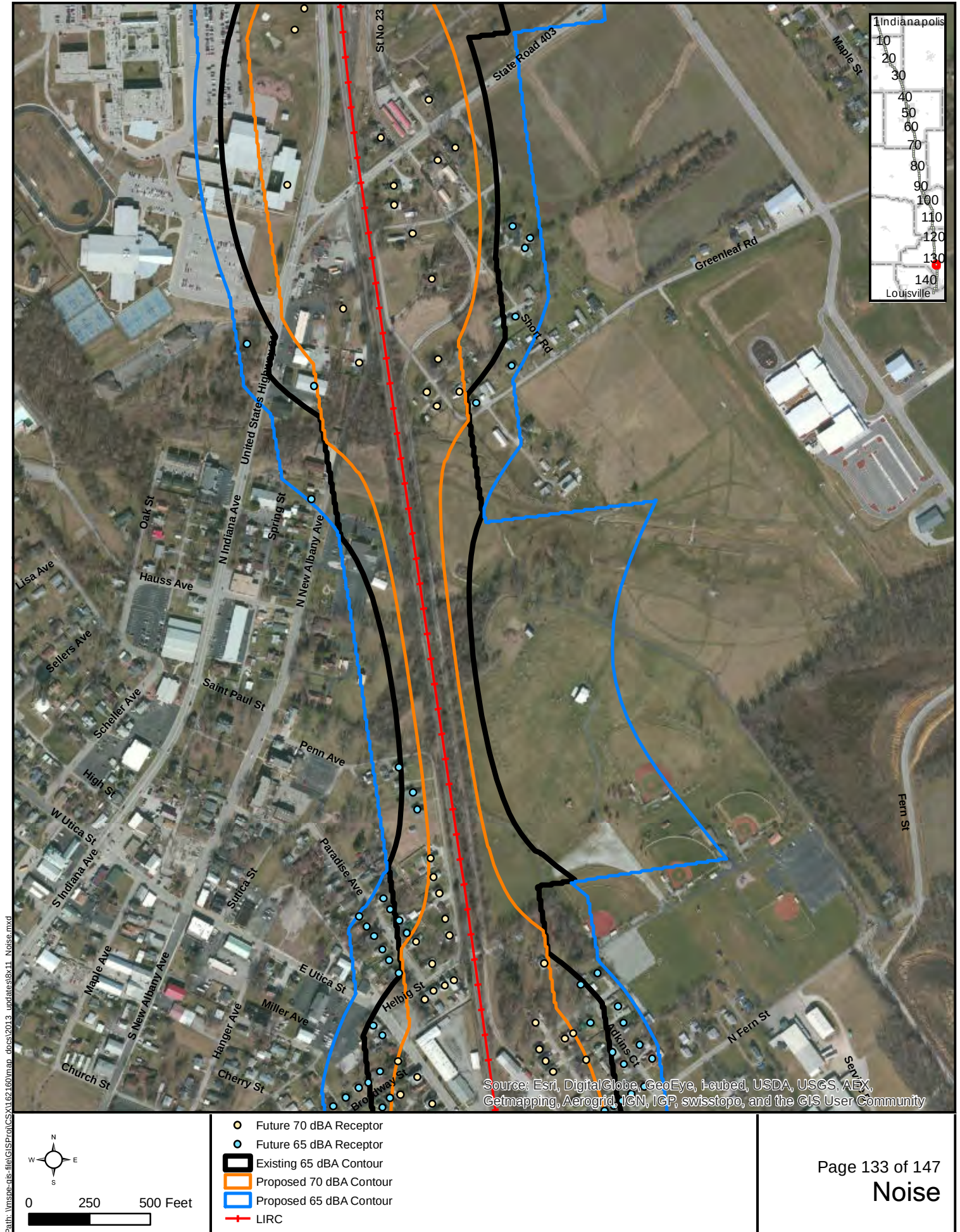


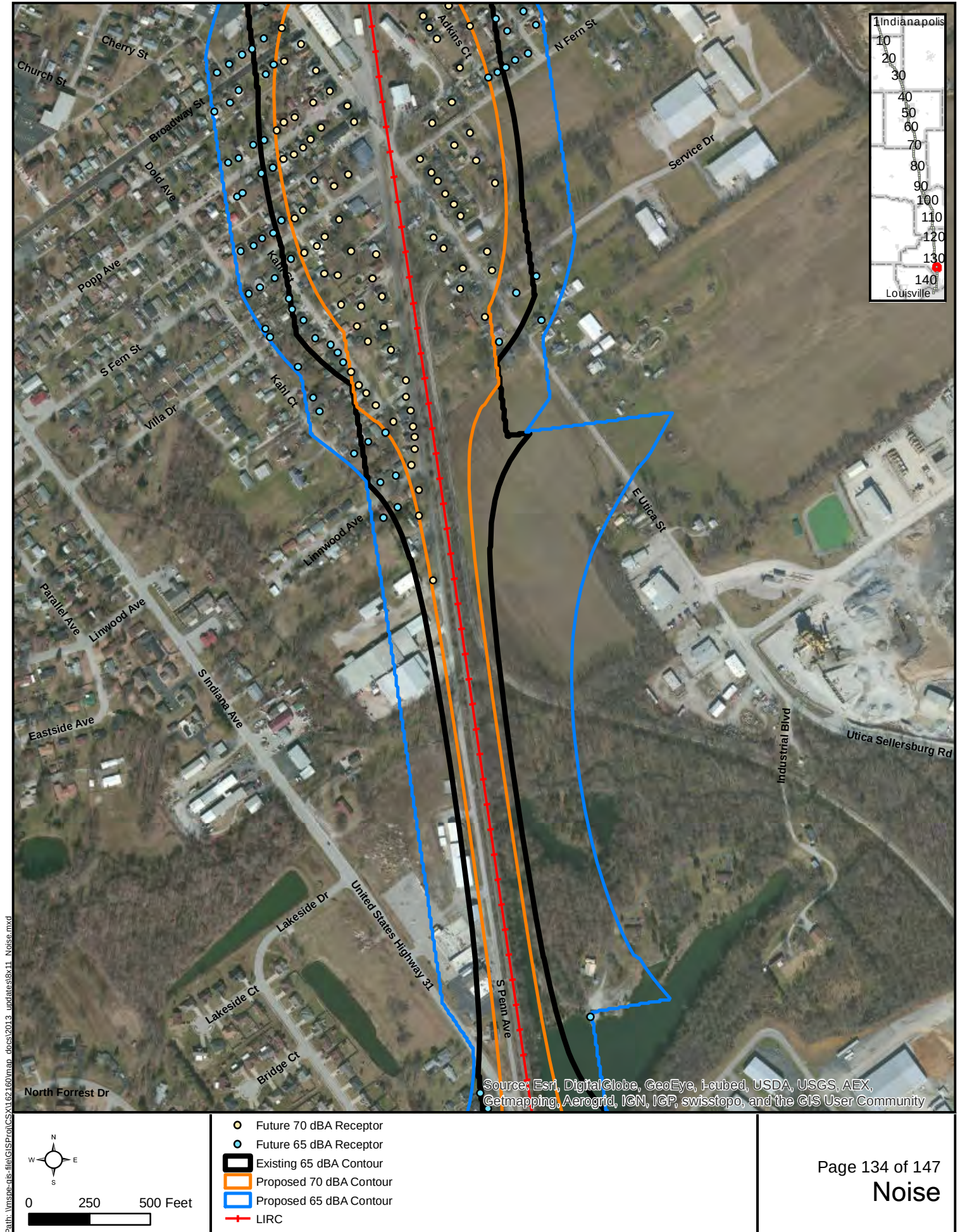
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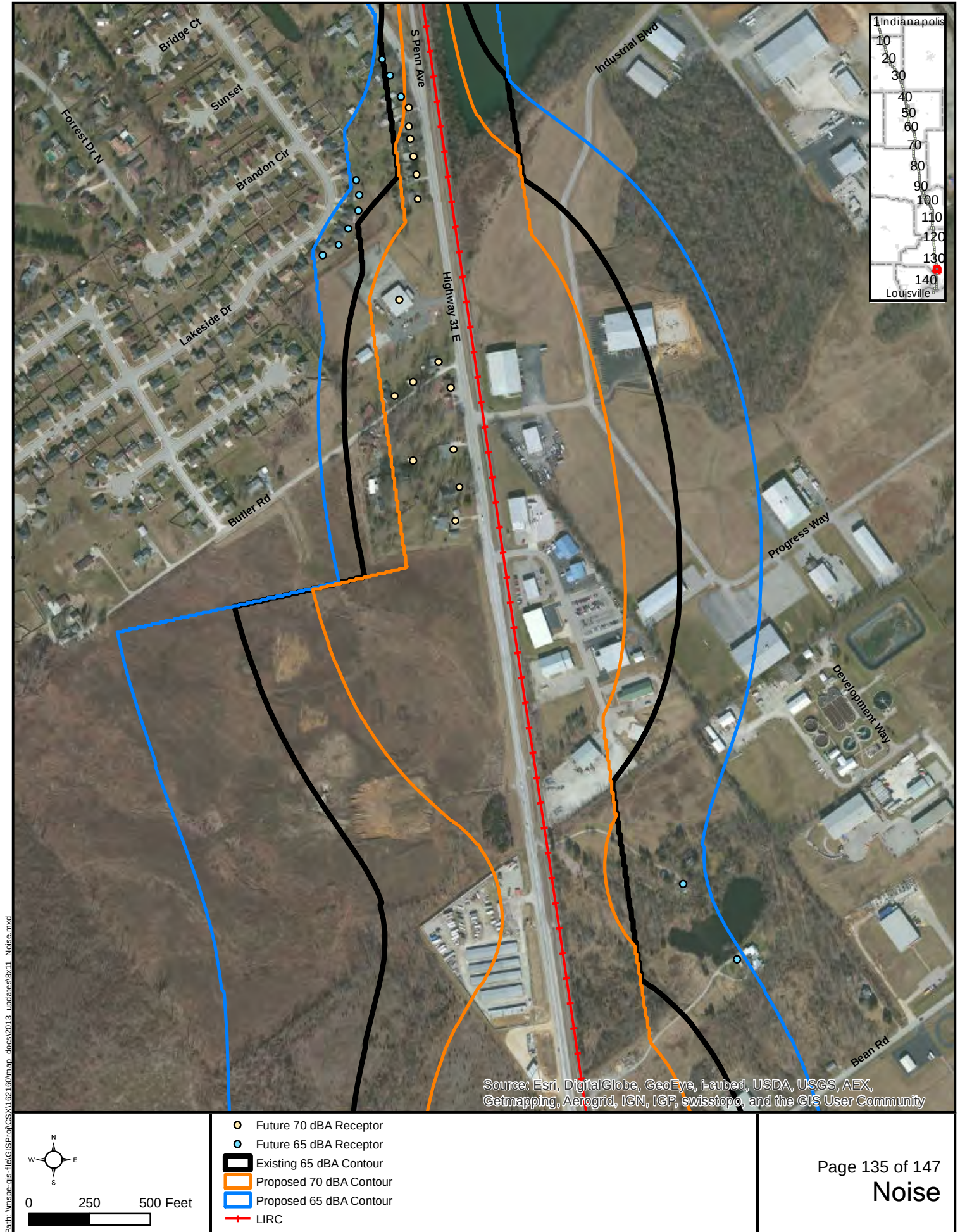
- Future 70 dBA Receptor
- Future 65 dBA Receptor
- ▬ Existing 65 dBA Contour
- ▬ Proposed 70 dBA Contour
- ▬ Proposed 65 dBA Contour
- + LIRC

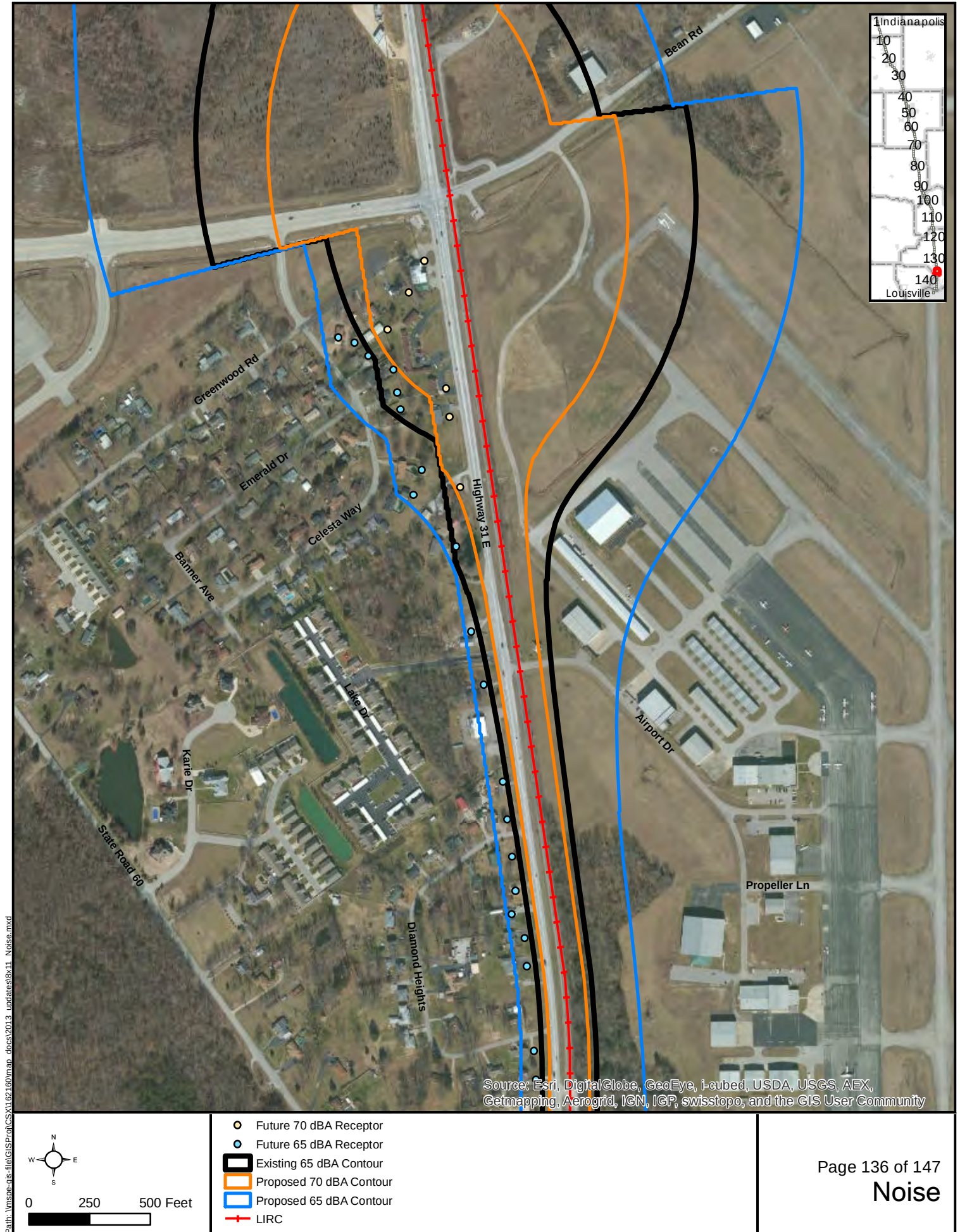


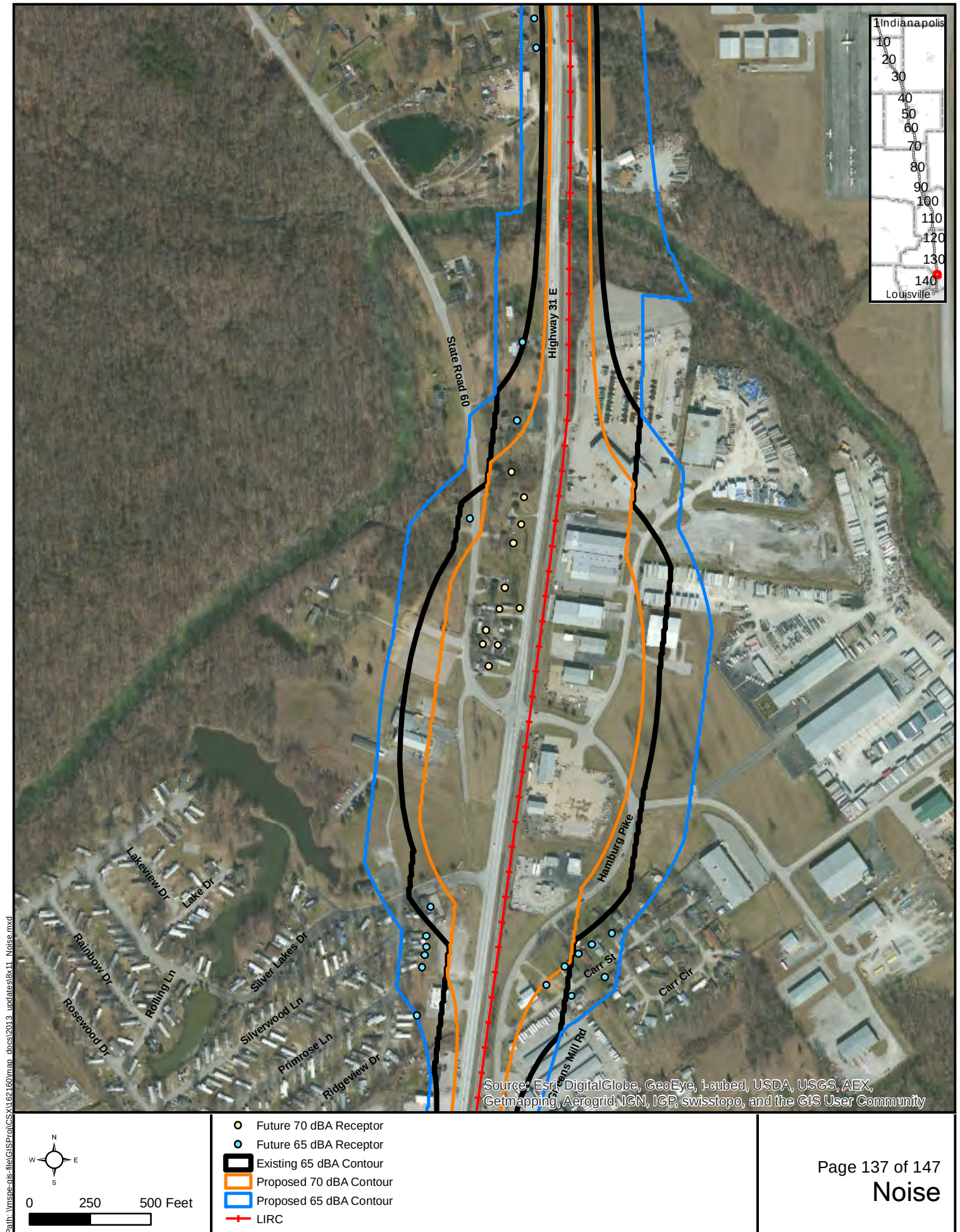


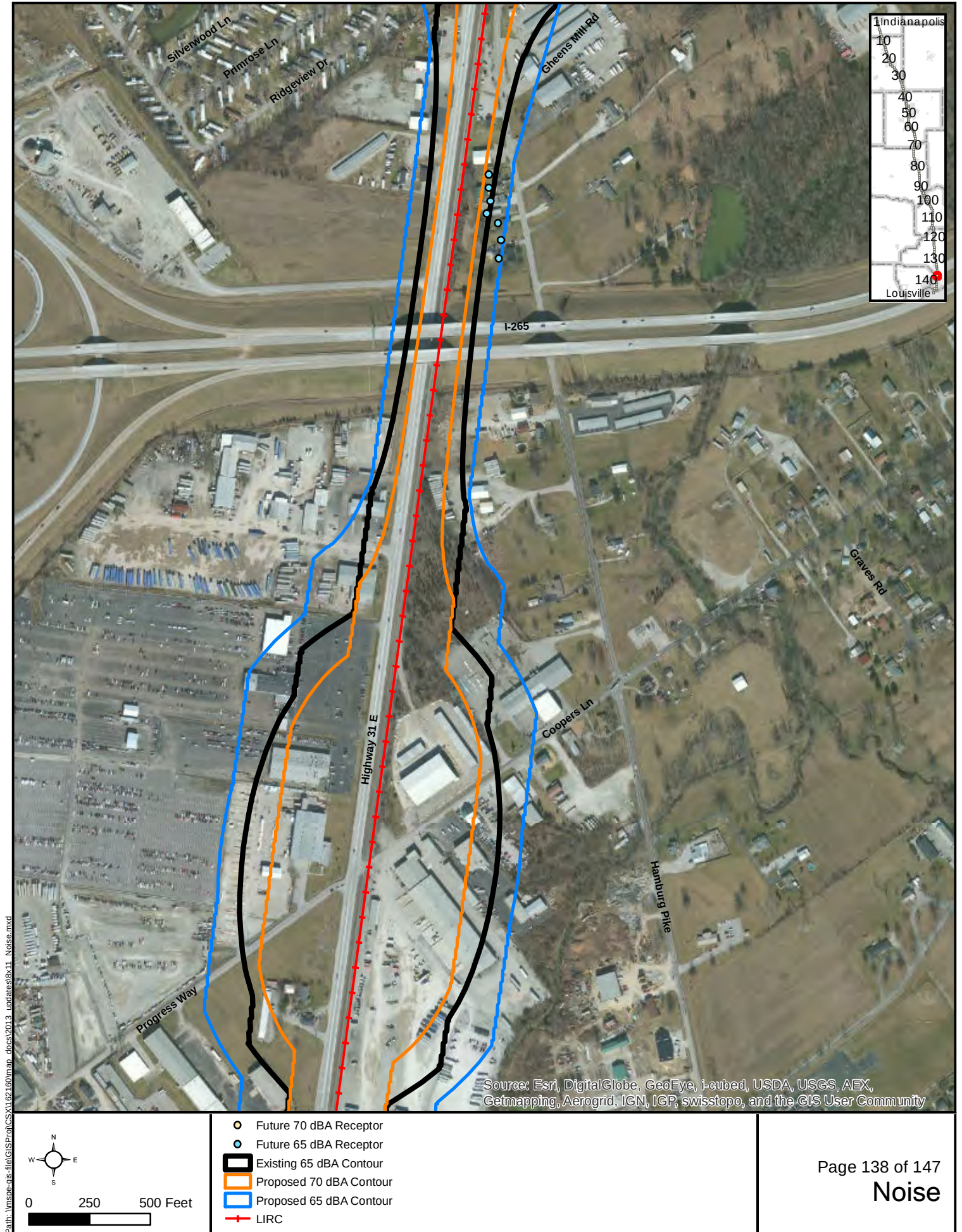


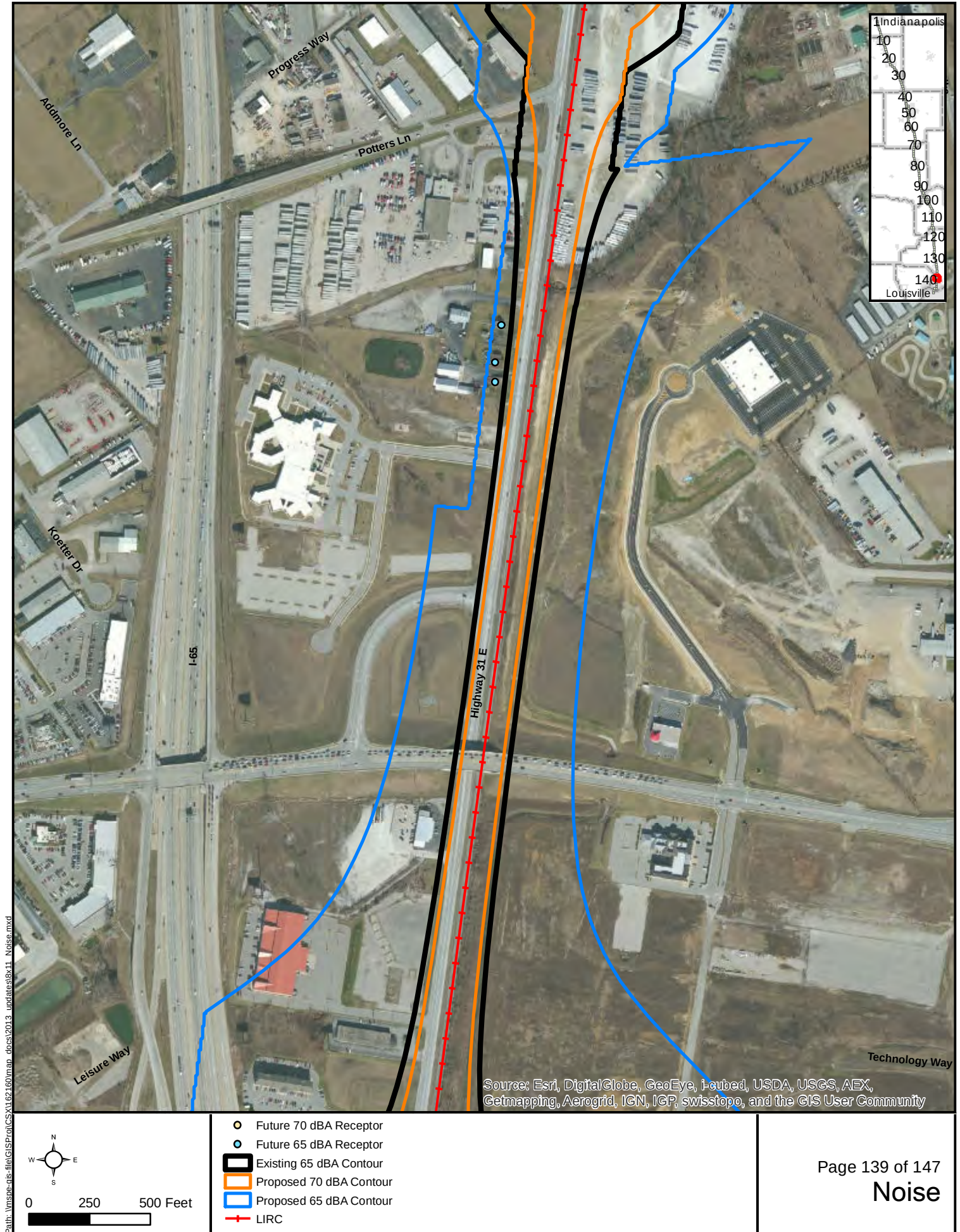


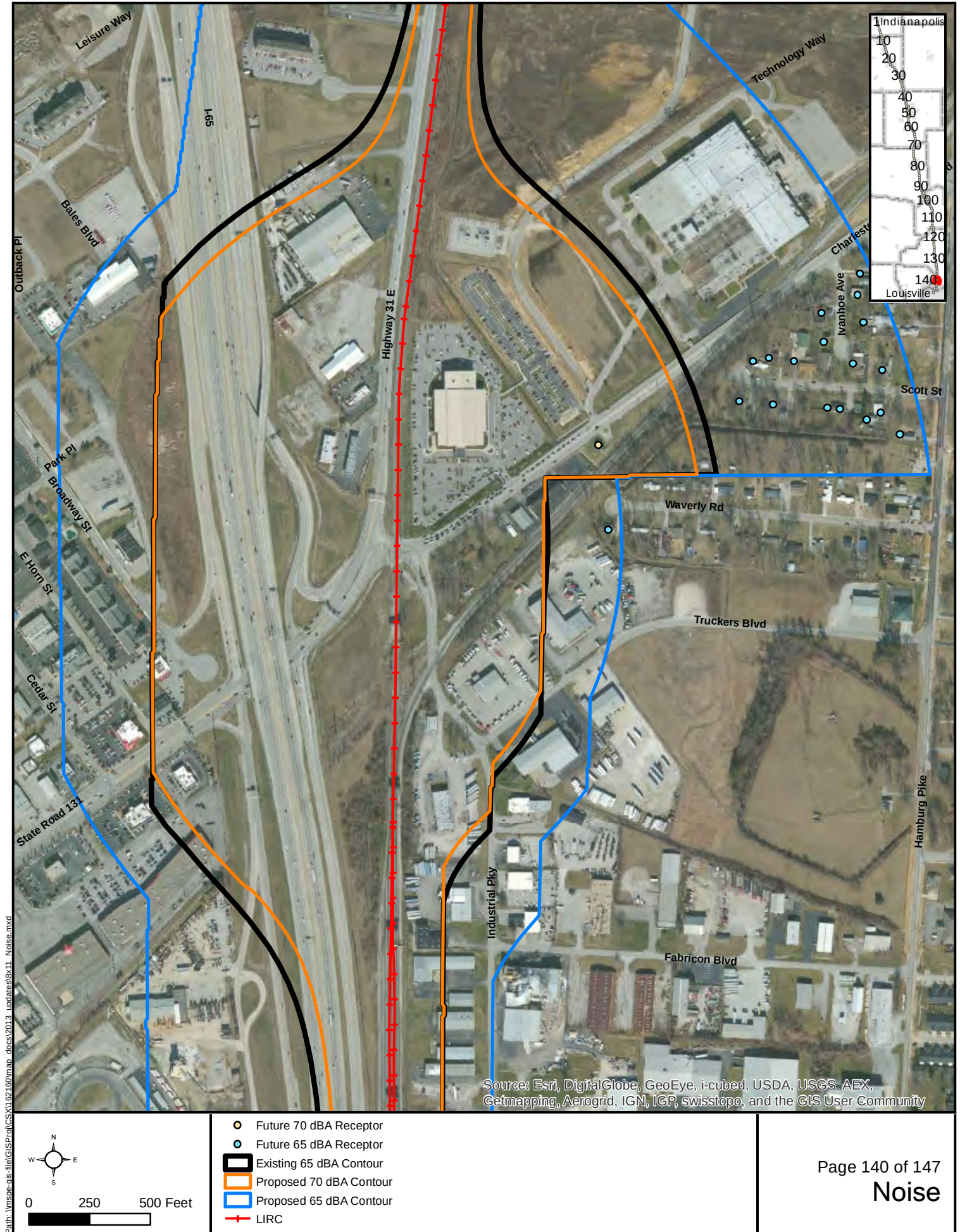


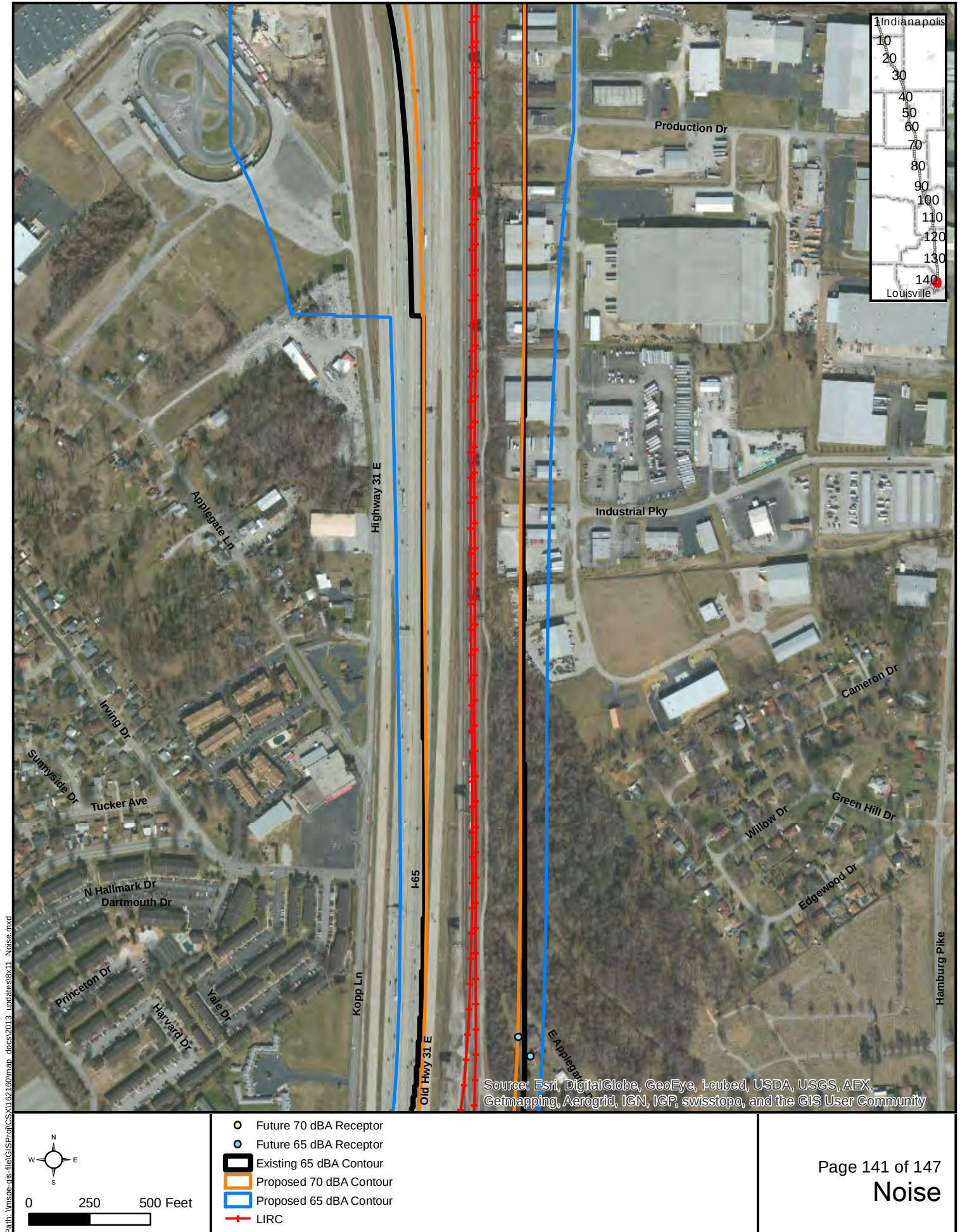


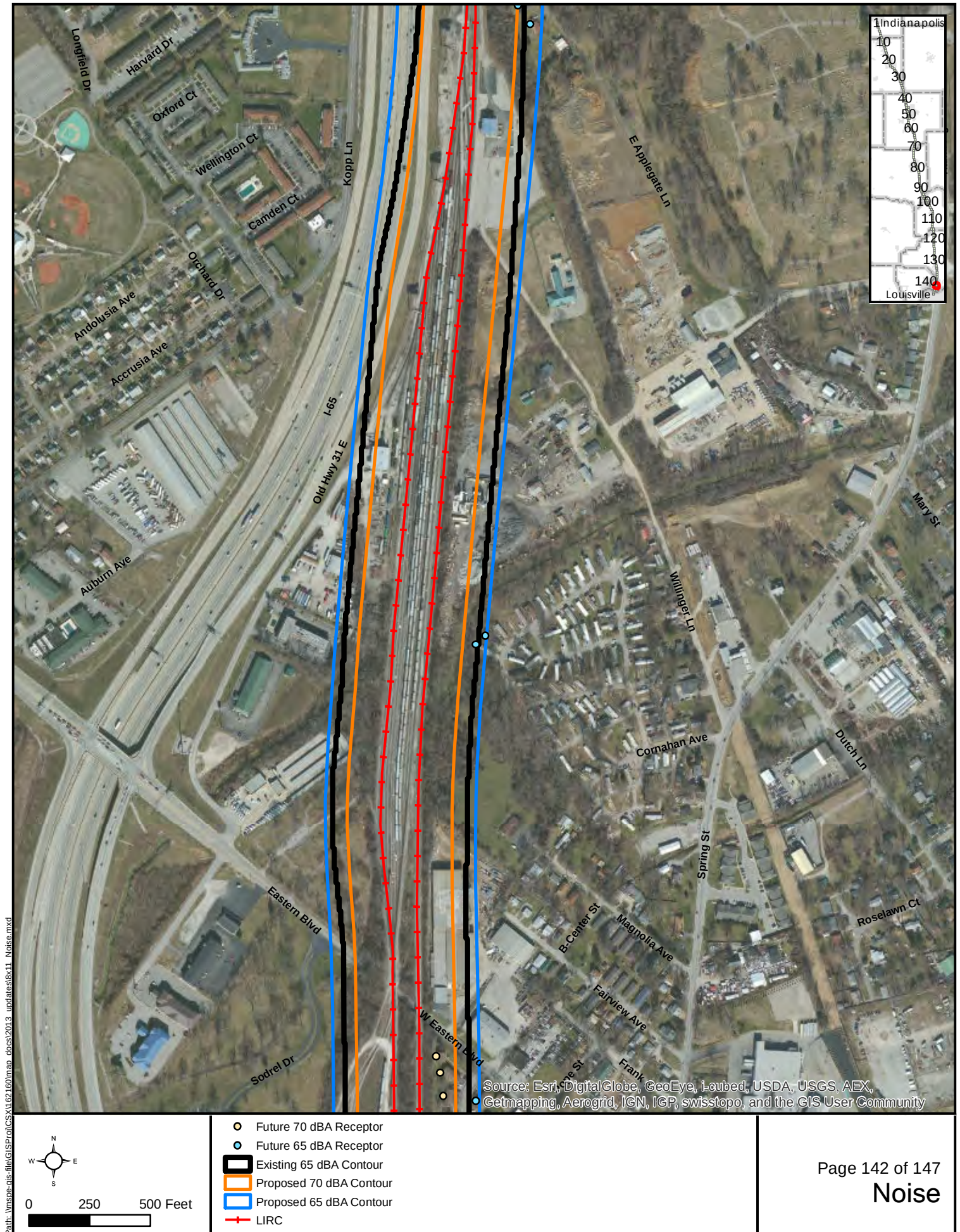


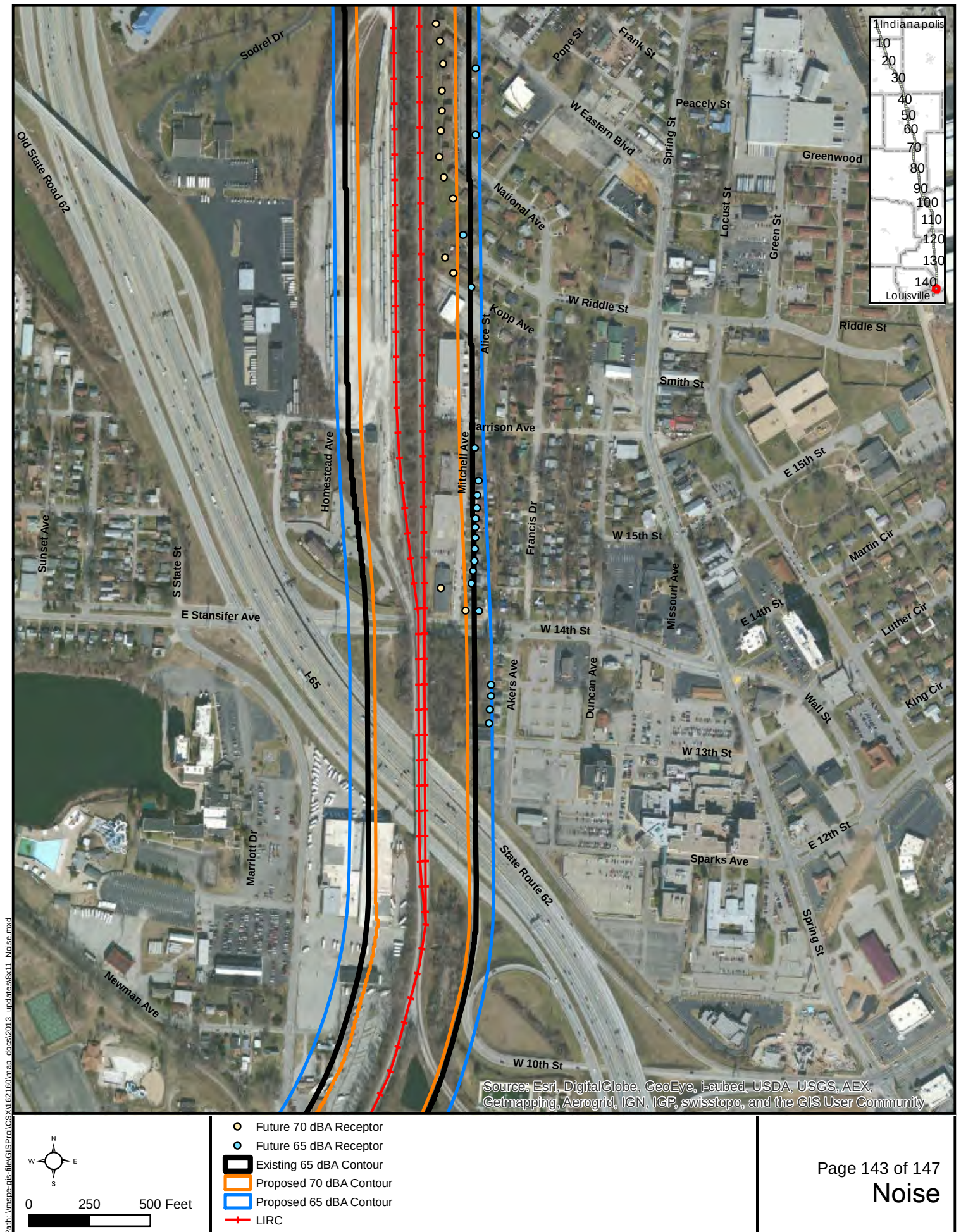


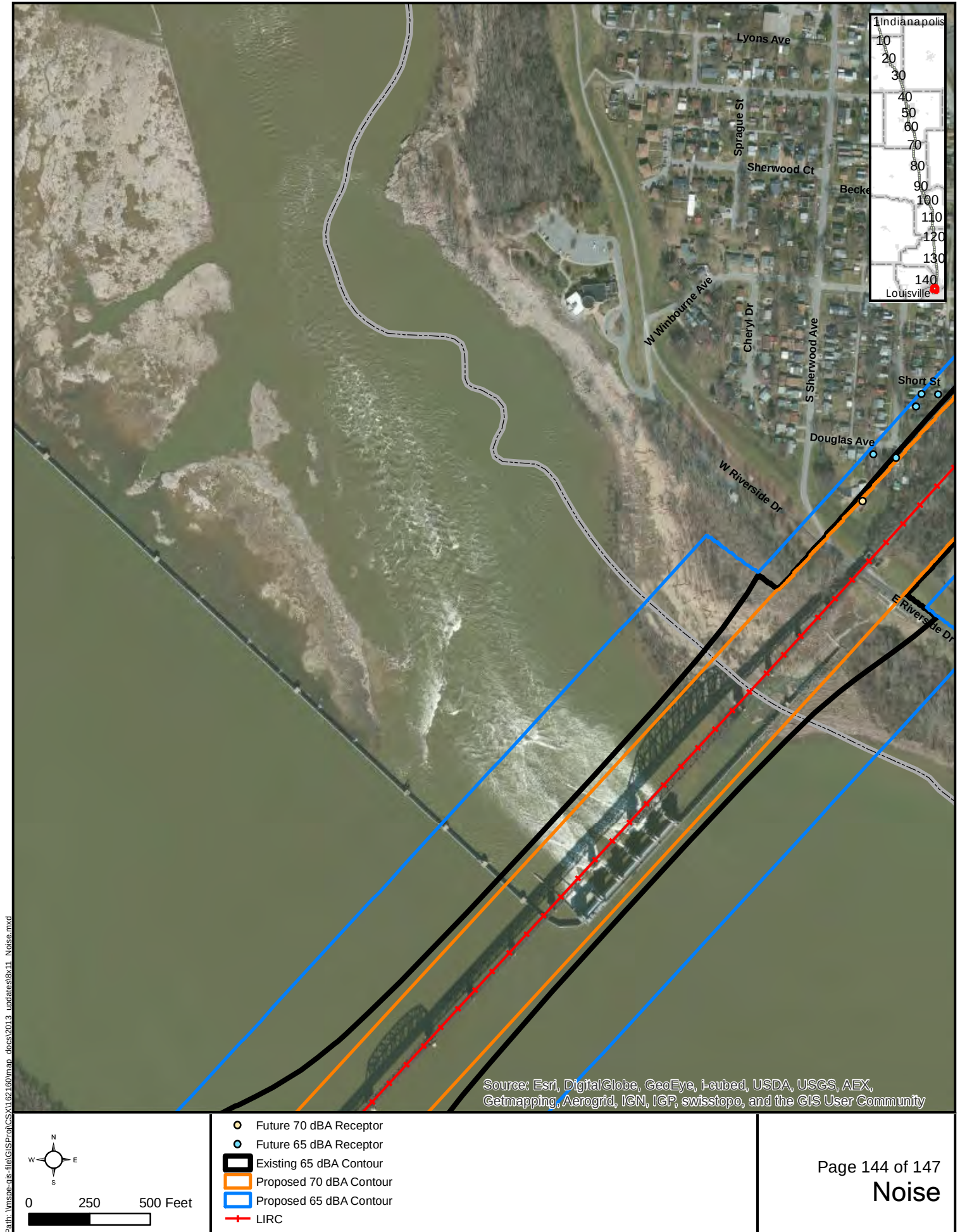














Path: \\unspc-nis-01a\GIS\Proj\CSX162160\map_docs\2013_updates\8x11_Noise.mxd



0 250 500 Feet

- Future 70 dBA Receptor
- Future 65 dBA Receptor
- Existing 65 dBA Contour
- Proposed 70 dBA Contour
- Proposed 65 dBA Contour
- + LIRC

