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MEMORANDUM

To: Michael Pelan and Timothy Weible

From: Stephen Zemba, Ph.D., P.E.

Subject: Project update – Potential impact of Joppa facility expansion on threatened and endangered species

Date: March 24, 2006
Revised April 11, 2006 to add new Figures 6–10
Further revised May 18, 2006 per discussion with U.S. EPA Region 5

I write to provide a sense of the preliminary findings of the screening-level assessment of potential impacts to threatened and endangered wildlife species associated with the proposed expansion of Lafarge's Joppa facility. At this point, my summary is sketchy, but I would like to convey the sense that I anticipate being able to demonstrate that there are no significant risks to threatened and endangered species. To this point, I have conducted some very conservative screening-level calculations that, even under extreme assumptions, indicate no potential adverse impacts should result from increased emissions from the proposed facility stacks for most contaminants. There are a few contaminants that fail the simple screening-level tests, but I expect that refined modeling and consideration will be able to demonstrate insignificant risks for those chemicals also.

The following text and tables describe my preliminary calculations.

Threatened and endangered species

There are four federally-listed threatened and endangered species for Massac County, Illinois, in which Lafarge's Joppa facility is located, and a fifth has been recommended for inclusion, also. These species are:

- Pink mucket pearly mussel (Ohio River) ;
- Fat pocketbook pearly mussel (Wabash River) ;
- Least tern (Sterna antillarum);
- Spectacle case mussel (Ohio River); and
- Orange-footed pearly mussel (Ohio River).[1]

[1] The orange-footed pearly mussel is not a listed Threatened and Endangered species for Massac County, but it is listed in neighboring Pulaski County, and the U.S. Fish and Wildlife Service requested that it be included in the evaluation.

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In addition, the Indiana bat (Myotis sodalis) is a listed species in all of the counties that border Massac County. As you know, this species received considerable attention in the Prairie States consultation, and I would anticipate the need to consider it in the evaluation of Lafarge's proposed expansion.

The four mussel species suggest the need to evaluate impacts to rivers. For this purpose, I have considered potential impacts to both surface water and sediment. Additionally, the least tern feeds on small fish and nests on open beach areas, and hence consideration of the river environment (as its food supply) is appropriate for this species, also. The Indiana bat, however, feeds on insects in either a terrestrial or aquatic habitat. As a media-based screening, I have developed a simple model of potential impacts to soil to evaluate potential risks to the bat (as well as other terrestrially-based species) in addition to the aquatic screening analyses of sediment and surface water.

Emission rates

I have built on the Ecological Screening Assessment (ESA) emission spreadsheet that you provided, making a number of minor corrections and adjustments discussed by e-mail. Hazardous air pollutant (HAP) emissions are estimated with emission factors and clinker production volumes. The basic list of HAPs is derived from the U.S. EPA's AP42 emission factor database (AP42 Table 11.6-9), with several additional HAPs presumably based on data and/or testing of other cement production facilities (antimony, nickel, and polycyclic aromatic compounds [PACs]). HAP emission rates are calculated on a net increase basis by estimating the maximum future potential emissions of the expanded facility (at full projected capacity) and subtracting the present actual emissions based on the last few years of production data. Table 11.6-9 provides emission factors for cement kilns equipped with both fabric filters and electrostatic precipitators (ESPs). In cases for which emission factors for both control devices are provided for the same HAP, net emissions differentiate future emissions (with all three kilns utilizing fabric filters) from present emissions (in which one kiln is equipped with a fabric filter and the other with an ESP). In several cases for which the ESP-based emission factor is substantially higher than that of the fabric filter-based value, emissions are projected to decrease for the expanded facility despite the increase in production capacity.

A number of HAPs have AP42 emission factors for a single air pollution control device option (i.e., for either a fabric filter or an ESP, but not both). All of these HAPs are considered, including those based on ESP control (even though the updated facility will solely use fabric filter control, potentially limiting the relevance of ESP-based emission factors). In cases for which only a single emission factor is available (fabric filter or ESP), the increase in HAP

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emissions is proportional to the potential change in production volume (future potential less present actual).

Additionally, AP42 Section 11.6 includes some dated information on polychlorinated dibenzo(*p*)dioxin and furan (PCDD/PCDF) emissions from cement kilns. Emission factors for one specific congener (1,2,3,4,6,7,8-HeptaCDD) and four classes of congeners, are reported on a total basis not weighted by toxic equivalency factors (total HeptaCDD, total OctaCDD, total PentaCDD, and total PentaCDF). The AP42 data appear to have been developed prior to the now common treatment of PCDD/PCDF on a toxic equivalency (TEQ) basis, and hence reflect incomplete test data (excepting 1,2,3,4,6,7,8-HeptaCDD and the singular OctaCDD). Data on individual congeners are not provided, and I suspect that congener classes without positive detections were not reported as emission factors. The U.S. EPA's dioxin reassessment work provides more recent and complete information on PCDD/PCDF emissions from cement kilns. These data are provided in Table 1 along with toxic equivalency (TEQ) weighting factors derived for ecological receptors. Total TEQ emission factors are calculated as the summed products of the congener-specific emission factors and the receptor-specific TEQs. The highest overall TEQ emission factor is 1.076 ng TEQ/kg clinker (2.15×10^{-9} lb/ton), estimated for birds, is used to derive screening-level emission estimates.

The present actual and future potential production volumes for the four kilns at the Joppa facility are those provided in your spreadsheet. The present production values of 484,666 and 628,340 tons/year for existing Kilns 1 and 2, respectively, are based on recent production levels. Projected production volumes for Kilns 1, 3, and 4 are 209,437, 1,377,875, and 1,377,875 tons/year, respectively. Note that the proposed expansion ceases operation of Kiln 2, but the future emissions from Kiln 1 will be rerouted to the present Kiln 2 fabric filter. Table 1 lists the projected increases in HAP emissions based on the supporting emission factors and calculations contained in the ESA emissions spreadsheet.

Surface water concentrations

The screening-level model to estimate worst-case concentrations in surface water assumes that all stack emissions are mixed within the Ohio River. Concentrations are calculated by dividing the emission rate of each HAP by the gaged flow rate of the river. The closest gaging station to Lafarge's Joppa facility is a short distance upstream at Metropolis, Illinois. The average discharge (flow) rate is used to estimate long-term average concentrations. This flow rate of 277,000 ft^3/s is reported by the U.S. Geological Survey as the long-term average over a period of 75 years (1928-2003). (http://il.water.usgs.gov/annual_report/data/disc2003/03611500.htm). Surface water concentrations of contaminants calculated by the model are provided in Table 2.

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Sediment concentrations

Sediment concentrations are estimated under the assumption that all stack emissions mix into the Ohio River and blend with the existing solids suspended in the river. In this way, the concentrations of contaminants in any settling solids is assumed equivalent to the modeled worst-case concentration in the overlying water column. A suspended sediment load of 113,000 tons/day is assumed based on data collected from 1998 to 2003 at the Ohio River Lock and Dam 53 near Grand Chain, Illinois (http://il.water.usgs.gov/annual_report/data/chem1998/03612500.htm). Sediment concentrations of contaminants calculated by the model are provided in Table 2.

Air concentrations

The U.S. EPA's ISCST3 model is used to estimate the dispersion of emissions from the kilns, and net impacts are estimated as the predicted concentrations from potential future emissions less those due to present actual emissions. Stack parameters for the present and proposed future configuration of the plant are taken from the screening-level model files that you provided. These parameters are provided in Table 3. Three years of meteorological data from the Paducah, KY airport, as downloaded from the U.S. EPA's Support Center for Regulatory Air Modeling (SCRAM) website, are modeled (1989 through 1991). Explicit receptor elevations are considered at an extensive monitoring network centered about the facility location. Building downwash is also considered as appropriate. Each source is modeled using a unitized (1 g/s) emission rate. The ISCST3 model predictions for each of the five sources are averaged over the three model years at each receptor, and the results weighted by kiln emission rates (future positive, existing negative) to provide estimates of net concentration impacts. The maximum (at any receptor) net concentration values are provided in Table 4. For the sake of comparison, Table 4 also includes estimates of background concentrations for pollutants that are considered in the U.S. EPA's 1996 National Air Toxics Study (modeled estimates) and Illinois' 2004 ambient monitoring program. For contaminants with available background concentration estimates, Table 4 indicates that all of the modeled worst-case increases in concentration in air due to the Lafarge facility are smaller than background.

The several contaminants for which there are projected decreases in net emissions (future potential less present actual) also have projected decreases in ambient concentrations. Hence, the negative values in Table 4 reflect the smallest decreases that are projected to occur. One HAP – cadmium – has a projected decrease in ambient concentrations at all receptors despite a projected increase in net emissions, a condition that results from a change in source

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configuration (specifically, eliminating emissions from a presently-used shorter stack). This same phenomenon also occurs for all of the criteria pollutant emissions excepting carbon monoxide – Table 4 has been expanded to reflect these projected decreases.

Several figures are provided to depict the nature of the ISCST3 model predictions (patterns are similar for most contaminants). Figure 1 depicts the air modeling receptor grid. Figures 2 – 4 provide projected annual average impacts of sulfur dioxide (SO_2), independently for the future and existing facility configurations (Figures 2 and 3, respectively), and superposed (Figure 4) to depict the pattern of net anticipated impacts (future potential less present actual). Note that the Figure 3 impacts are depicted as negative values to reflect the decreases that will result from the discontinued present emissions. Note further that net impacts (Figure 4) are negative at all receptors, indicating anticipated decreases in overall SO_2 concentrations (despite small expected increases in overall emissions). Figure 5 depicts the predicted pattern of net annual average impacts for benzene, for which concentrations are expected to decrease at locations very close to the Lafarge facility, and increase at more distant locations.

Figures 6 – 8 plot a sequence of NO_x (nitrogen oxides) impacts similar to those of SO_2, with Figures 6 and 7 plotting the annual average model predictions for actual present and potential future emissions, respectively. Figure 6 contours are plotted as negative values to reflect the decreases that will result from the elimination of present emissions, and similar to SO_2, the net impacts depicted in Figure 8 (Figures 6 and 7 combined) indicate net decreases in annual average NO_x concentrations at all receptors (as reflected by the negative contour levels).

Figures 9 and 10 depict net changes in carbon monoxide concentrations, plotting the highest net increase in 1-hour (Figure 9) and 8-hour (Figure 10) averaging periods. In each case, the highest modeled increases are well below Significant Impact Levels.

Soil concentrations

Concentrations of HAPs in soil are estimated with a simple mixing model that assumes that HAPs deposit from the atmosphere over a period of thirty years of facility operation and remain within a shallow (1 cm, bulk density 1.5 g/cm^3) layer near the surface. The soil deposition/concentration model is that recommended in the U.S. EPA's multi-pathway risk assessment protocol guidance for untilled soils. A high-end deposition velocity of 1 cm/s is used to estimate deposition based on modeled ground-level concentrations in air. Predicted worst-case contaminant concentrations in soil are listed in Table 2 based on the highest net projected impacts to ambient air.

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Table 5 compares the modeled concentrations of inorganic contaminants in soil with background levels in Illinois soils (where available). In all cases, the predicted increases in contaminant concentrations are smaller than background levels. The predicted increases for most chemicals are smaller than 0.1%, and only for two metals are the increases greater than 1% (copper at 10%, selenium at 19%).

Benchmark concentrations

Per the suggestion of U.S. EPA Region 5, the following sources of screening-level ecological benchmarks were searched to identify region-appropriate values for the chemicals of interest:

- the Illinois Water Quality Criteria for aquatic life for surface water benchmarks (http://www.ipcb.state.il.us/documents/dsweb/Get/Document-33354/);
- the U.S. EPA Ecological Soil Screening Levels (SSLs) for soil benchmarks (http://mountain.epa.gov/ecotox//ecossl/); and
- the U.S. EPA Region 5, RCRA Ecological Screening Levels (ESLs) for surface water, soil, and sediment benchmarks (see http://www.epa.gov/reg5rcra/ca/edql.htm).

Ecological benchmark concentrations for other combinations of chemicals and environmental media are obtained from the Risk Assessment Information System (RAIS) developed and supported by the Oak Ridge National Laboratory (ORNL). The RAIS has compiled media-based ecological benchmarks from a number of regulatory databases and sources that collectively cover a wide variety of potential ecological endpoints. A search of the RAIS was conducted to identify the lowest (and hence most protective) ecotoxicity benchmark from any of the data sources contained in the RAIS. This conservative, non-selective method is designed to identify the lowest ecotoxicity benchmark established by regulatory authorities under any conditions, and is therefore not necessarily relevant to the specific threatened and endangered species of concern in the vicinity of Lafarge's Joppa facility. The lowest benchmark concentrations identified by this method for the surface water, sediment, and soil media are listed in Table 2. In many cases, benchmark concentrations are not available.

Screening-level ecotoxicity hazard ratios

The final three columns of Table 2 provide simple hazard quotients, calculated as the ratios of the predicted contaminant concentrations in environmental media divided by their corresponding benchmark concentrations. Most hazard quotients are smaller than one, indicating that, even

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using very simple, highly conservative models, adverse impacts to ecological receptors of all kinds (including threatened and endangered species) would not be anticipated.

Because some contaminants are ubiquitous chemicals in soil, Table 5 calculates hazard ratios for the combined sum of background and modeled increases in soil. Some of the hazard ratios in Table 5 are quite large, indicating in most cases that the conservative screening-level benchmark concentrations are well below natural background levels.

A handful of hazard quotients exceed one, as indicated in boldface in Table 2. These calculations may require additional work to demonstrate insignificant risks, but based on some simple preliminary considerations, I would anticipate that refined modeling and consideration would yield ratios smaller than one. The sediment and surface water models are quite conservative, assuming that all plume emissions mix into the Ohio River water and sediment (which are also considered separately in whole, without consideration of partitioning between bound and dissolved phases). Hence, the hazard ratios of 2.4 for PCDD/PCDF in surface water and 3.1 for benzene in sediment are likely overestimated simply due to the nature of the "mix it all in" screening models.

Four of the six hazard ratios exceeding one are estimated for soil. A gross conservatism in the soil model is the assumption that all contaminants deposit from the air at a deposition velocity of 1 cm/s. Based on experience, particle emissions from the Lafarge facility will likely be very small in diameter, in the so-called fine particulate range (aerodynamic diameters of the order of 1 μm). These particles settle and deposit very slowly from the atmosphere. A deposition velocity of 0.1 cm/s or even lower is more appropriate for small particles under most atmospheric conditions (G. Sehmel, *Deposition and Resuspension*, Chapter 12 in *Atmospheric Science and Power Production*, U.S. Department of Energy, OE/TIC-27061, 1984). Thus, contaminants bound to particles, which would include most metals and a substantial portion of PCDD/PCDFs, would likely deposit at rates more than ten times smaller than estimated in the soil model. Consequently, the preliminary hazard ratios for PCDD/PCDF and selenium for soil would likely be lower than one upon deposition modeling refinement.

A similar observation holds for the gaseous species benzene and naphthalene for which preliminary estimates of soil hazard ratios are greater than one. Based on previous assessments for Indeck and ExxonMobil, the fate-and-transport properties of benzene (and naphthalene, by analogy) are such that its tendencies are to remain airborne and resist deposition. The modeled benzene concentration in air is 0.015 $\mu g/m^3$ at the worst-case location, a small fraction of typical background levels of about 1 $\mu g/m^3$ (see Table 4). The modeled concentration of benzene in soil is 9.7 mg/kg (Table 2) based on this modeled air concentration of 0.015 $\mu g/m^3$. If, as one would expect, background benzene in air deposited to soil in the same manner as that modeled for the

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Lafarge emissions, one would anticipate the background soil concentration of benzene to be (by ratio) 9.7 mg/kg times (1 ÷ 0.015) = 650 mg/kg! Clearly, widespread benzene contamination of this sort does not exist due to its background presence in air. Typically, benzene is not even detectable in soils except in cases in which petroleum products have been spilled directly into soil. Since the detection limit for benzene is of the order of 0.001 mg/kg, it would appear that modeling benzene with the simple deposition model may overpredict concentrations by more than five orders of magnitude. Hence, there is probably very little reason for concern over the preliminary hazard ratio of 38 calculated for benzene in soil.

Similar arguments apply for naphthalene. Background concentrations of naphthalene in the greater Chicago area have been measured to be about 0.1 $\mu g/m^3$ (see http://www.epa.state.il.us/air/ohare/ohare-toxic-report.pdf), more than 50 times the worst-case modeled estimate due to Lafarge facility emissions (0.0018 $\mu g/m^3$, as indicated in Table 4). Extrapolating the modeled soil concentration of 1.1 mg/kg in soil for naphthalene (Table 2), one would anticipate background concentrations of naphthalene in soil of 50 mg/kg to be present ubiquitously in the environment. Again, given naphthalene is not known to be present in soils even at concentrations orders of magnitude lower, the preliminary hazard ratio of 11 for naphthalene in soil (Table 2) is likely to be grossly overstated.

The conservative nature of the screening-level hazard ratios may also be influenced by the benchmark concentrations. As an example, the selenium benchmark concentration of 0.028 mg/kg in soil is more than ten times smaller than the typical background level of 0.37 mg/kg of selenium in soil (Table 5), suggesting the benchmark concentration to be unrealistically conservative. In fact, the projected increases in the concentrations of all inorganic contaminants are smaller than background levels in Illinois soils – the projected incremental impacts for many contaminants are only small fractions of existing background (Table 5). Even for organic contaminants such as PCDD/PCDF, the benchmark concentration of 0.2 ng/kg in soil (Table 2) is considerably lower than the U.S. EPA's estimates of background levels in urban and rural soils (12 ng/kg and 3 ng/kg, respectively – see p. 3-191 of the U.S. EPA's draft dioxin reassessment:
http://www.epa.gov/ncea/pdfs/dioxin/nas-review/pdfs/part1_vol2/dioxin_pt1_vol2_ch03_dec2003.pdf).

The PCDD/PCDF assessment is also influenced by the choice of the avian species TEFs in constructing the TEQ emission factor (Table 1). If either the mammalian-based or the fish-based TEQ emission factor is considered instead of the avian-based value, the screening-level hazard indices decrease by at least a factor of 3.5, making all of the PCDD/PCDF screening-level hazard ratios smaller than one. This choice is potentially important, as the avian-based TEQ emission factor may be relevant only to the least tern.

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Table 1 Polychlorinated dibenzo(*p*)dioxin and furan (PCDD/PCDF) emission factors expressed on a toxic equivalency (TEQ) basis

PCDD/PCDF Congener	Emission factor (ng/kg clinker) (EPA, 2003a)		Toxic Equivalency (TEQ) Factor (EPA, 2003b)			TEQ Emission Factor (ng TEQ/kg clinker)		
	ND=0	ND=1/2 DL	Mammals	Birds	Fish	Mammals	Birds	Fish
2,3,7,8-TCDD	0.01	0.02	1	1	1	0.02	0.02	0.02
1,2,3,7,8-PeCDD	0.03	0.04	1	1	1	0.04	0.04	0.04
1,2,3,4,7,8-HxCDD	0.03	0.04	0.1	0.05	0.5	0.004	0.002	0.02
1,2,3,6,7,8-HxCDD	0.04	0.05	0.1	0.01	0.01	0.005	0.0005	0.0005
1,2,3,7,8,9-HxCDD	0.04	0.06	0.1	0.1	0.01	0.006	0.006	0.0006
1,2,3,4,6,7,8-HpCDD	0.39	0.39	0.01	0.001	0.001	0.0039	0.00039	0.00039
OCDD	0.64	0.64	0.0001	0.0001	0.0001	6.4E-05	6.4E-05	6.4E-05
2,3,7,8-TCDF	0.73	0.73	0.1	1	0.05	0.073	0.73	0.0365
1,2,3,7,8-PeCDF	0.1	0.11	0.05	0.1	0.05	0.0055	0.011	0.0055
2,3,4,7,8-PeCDF	0.22	0.23	0.5	1	0.5	0.115	0.23	0.115
1,2,3,4,7,8-HxCDF	0.17	0.18	0.1	0.1	0.1	0.018	0.018	0.018
1,2,3,6,7,8-HxCDF	0.05	0.06	0.1	0.1	0.1	0.006	0.006	0.006
1,2,3,7,8,9-HxCDF	0.01	0.02	0.1	0.1	0.1	0.002	0.002	0.002
2,3,4,6,7,8-HxCDF	0.08	0.08	0.1	0.1	0.1	0.008	0.008	0.008
1,2,3,4,6,7,8-HpCDF	0.13	0.14	0.01	0.01	0.01	0.0014	0.0014	0.0014
1,2,3,4,7,8,9-HpCDF	0	0.02	0.01	0.01	0.01	0.0002	0.0002	0.0002
OCDF	0.22	0.24	0.0001	0.0001	0.0001	2.4E-05	2.4E-05	2.4E-05
Totals	1.71	1.81				0.308	1.076	0.274

(1) EPA/600/P-00/001Cb, December 2003 Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds National Academy Sciences (NAS) Review Draft www.epa.gov/ncea, Table 5-3.

(2) EPA/630/P-03/002A, June 2003, External Review Draft, Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans and Biphenyls in Ecological Risk Assessment

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Table 2 Preliminary screening-level modeling estimates and comparisons to conservative benchmarks

Chemical	Net emission rate (tons/year)	Screening-level concentration			Screening-level benchmark concentration			Screening-level hazard ratio		
		Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water	Sediment	Soil
Polychlorinated dioxins and furans (PCDD/PCDF, expressed as 2,3,7,8-TCDD toxic equivalents)	2.0E-06	7.3E-09	4.9E-08	5.1E-07	3.0E-9	1.2E-07	2.0E-07	**2.4E+00**	4.0E-01	**2.5E+00**
C3 Benzenes (a)	2.4E-03	8.8E-06	5.9E-05	6.1E-04	8.6E+02	1.4E-01	2.6E-01	1.0E-08	4.1E-04	2.4E-03
C4 Benzenes (a)	5.6E-03	2.0E-05	1.4E-04	1.4E-03	8.6E+02	1.4E-01	2.6E-01	2.4E-08	9.5E-04	5.5E-03
C6 Benzenes (a)	8.5E-04	3.1E-06	2.1E-05	2.2E-04	8.6E+02	1.4E-01	2.6E-01	3.6E-09	1.5E-04	8.5E-04
Acenaphthylene	1.1E-01	4.1E-04	2.7E-03	2.8E-02	4.8E+03	5.9E-03	6.8E+02	8.4E-08	4.6E-01	4.1E-05
Acetone	3.4E-01	1.3E-03	8.4E-03	8.7E-02	1.7E+03	9.9E-03	2.5E+00	7.4E-07	8.4E-01	3.5E-02
Benzaldehyde (b)	2.2E-02	8.2E-05	5.4E-04	5.7E-03	NoBench	NoBench	3.0E-01	NoBench	NoBench	1.9E-02
Benzene	1.8E+01	6.6E-02	4.4E-01	9.7E+00	8.6E+02	1.4E-01	2.6E-01	7.7E-05	**3.1E+00**	**3.8E+01**
Benzo(a)anthracene	4.0E-05	1.5E-07	9.7E-07	1.0E-05	2.5E-02	1.1E-01	5.2E+00	5.8E-06	9.0E-06	1.9E-06
Benzo(a)pyrene	1.2E-04	4.4E-07	2.9E-06	3.1E-05	1.4E-02	1.5E-01	1.5E+00	3.2E-05	2.0E-05	2.0E-05
Benzo(b)fluoranthene	5.2E-04	1.9E-06	1.3E-05	1.3E-04	9.1E+00	1.0E+01	6.0E+01	2.1E-07	1.2E-06	2.2E-06
Benzo(g,h,i)perylene	7.2E-05	2.7E-07	1.8E-06	1.8E-05	7.6E+00	1.7E-01	1.2E+02	3.5E-08	1.0E-05	1.5E-07
Benzo(k)fluoranthene	1.4E-04	5.1E-07	3.4E-06	3.5E-05	NoBench	2.4E-01	1.5E+02	NoBench	1.4E-05	2.4E-07
Benzoic Acid	3.2E+00	1.2E-02	7.9E-02	8.2E-01	4.0E+01	6.5E-01	NoBench	3.0E-04	1.2E-01	NoBench
Biphenyl	5.6E-03	2.1E-05	1.4E-04	1.4E-03	1.0E+01	1.1E+00	6.0E+01	2.1E-06	1.2E-04	2.4E-05
Bis(2-ethylhexyl)phthalate	8.8E-02	3.2E-04	2.1E-03	2.2E-02	3.0E-01	1.8E-01	9.2E-01	1.1E-03	1.2E-02	2.4E-02

Table 2 Preliminary screening-level modeling estimates and comparisons to conservative benchmarks

Chemical	Net emission rate (tons/year)	Screening-level concentration			Screening-level benchmark concentration			Screening-level hazard ratio		
		Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water	Sediment	Soil
Bromomethane	4.0E-02	1.5E-04	9.7E-04	1.0E-02	1.6E+01	1.4E-03	2.4E-01	9.1E-06	7.1E-01	4.3E-02
Carbon Disulfide	1.0E-01	3.7E-04	2.5E-03	2.6E-02	1.5E+01	2.4E-02	9.4E-02	2.5E-05	1.0E-01	2.8E-01
Chlorobenzene	1.5E-02	5.4E-05	3.6E-04	3.8E-03	4.7E+01	2.9E-01	1.3E+01	1.2E-06	1.2E-03	2.9E-04
Chloromethane	3.5E-01	1.3E-03	8.6E-03	8.9E-02	5.5E+03	NoBench	1.0E+01	2.3E-07	NoBench	8.6E-03
Chrysene	1.5E-04	5.4E-07	3.6E-06	3.8E-05	7.0E+00	1.7E-01	4.7E+00	7.8E-08	2.2E-05	8.0E-06
Di-n-butylphthalate	3.8E-02	1.4E-04	9.3E-04	9.7E-03	5.0E+00	2.2E+00	1.5E-01	2.8E-05	4.2E-04	6.4E-02
Dibenz(a,h)anthracene	5.8E-04	2.1E-06	1.4E-05	1.5E-04	4.0E+00	3.3E-02	1.8E+01	5.4E-07	4.3E-04	8.1E-06
Ethylbenzene	1.8E-02	6.5E-05	4.3E-04	4.5E-03	1.4E+01	1.8E-01	5.2E+00	4.6E-06	2.5E-03	8.7E-04
Fluoranthene	8.1E-03	3.0E-05	2.0E-04	2.1E-03	1.9E+00	4.2E-01	1.2E+02	1.6E-05	4.7E-04	1.7E-05
Fluorene	1.8E-02	6.5E-05	4.3E-04	4.5E-03	1.9E+01	7.7E-02	1.2E+02	3.4E-06	5.5E-03	3.7E-05
Formaldehyde	4.3E-01	1.6E-03	1.0E-02	1.1E-01	NoBench	NoBench	3.0E-01	NoBench	NoBench	3.6E-01
Freon 113	4.6E-02	1.7E-04	1.1E-03	1.2E-02	4.1E+02	NoBench	NoBench	4.1E-07	NoBench	NoBench
Indeno(1,2,3-cd)pyrene	8.1E-05	3.0E-07	2.0E-06	2.0E-05	4.3E+00	2.0E-01	1.1E+02	6.9E-08	9.8E-06	1.9E-07
Methyl Ethyl Ketone	2.8E-02	1.0E-04	6.8E-04	7.1E-03	2.2E+03	4.2E-02	9.0E+01	4.6E-08	1.6E-02	7.9E-05
Methylene Chloride	4.5E-01	1.7E-03	1.1E-02	1.2E-01	9.4E+02	1.6E-01	4.0E+00	1.8E-06	7.0E-02	2.8E-02
Methylnaphthalene (c)*	3.9E-03	1.4E-05	9.5E-05	9.9E-04	3.3E+02	2.0E-02	3.2E+00	4.3E-08	4.7E-03	3.1E-04
Naphthalene	1.9E+00	7.1E-03	4.7E-02	1.1E+00	1.3E+01	1.8E-01	9.9E-02	5.5E-04	2.7E-01	**1.1E+01**
PACs (d)	1.0E-02	3.7E-05	2.5E-04	2.6E-03	NoBench	1.6E+00	1.0E+00	NoBench	1.5E-04	2.6E-03
Phenanthrene	3.6E-01	1.3E-03	8.8E-03	9.2E-02	3.6E+00	2.0E-01	4.6E+01	3.7E-04	4.3E-02	2.0E-03

Table 2 Preliminary screening-level modeling estimates and comparisons to conservative benchmarks

Chemical	Net emission rate (tons/year)	Screening-level concentration			Screening-level benchmark concentration			Screening-level hazard ratio		
		Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water	Sediment	Soil
Phenol	1.0E-01	3.7E-04	2.5E-03	2.6E-02	1.8E+02	4.9E-02	1.2E+02	2.1E-06	5.1E-02	2.2E-04
Pyrene	4.1E-03	1.5E-05	9.9E-05	1.0E-03	3.0E-01	2.0E-01	7.8E+01	5.0E-05	5.1E-04	1.3E-05
Styrene	1.4E-03	5.1E-06	3.4E-05	3.5E-04	3.2E+01	2.5E-01	4.7E+00	1.6E-07	1.3E-04	7.5E-05
Toluene	1.8E-01	6.5E-04	4.3E-03	4.5E-02	6.0E+02	1.2E+00	5.4E+00	1.1E-06	3.5E-03	8.2E-03
Xylenes	1.2E-01	4.4E-04	2.9E-03	3.1E-02	3.6E+02	4.3E-01	1.0E+01	1.2E-06	6.8E-03	3.1E-03
Aluminum	1.2E+01	4.4E-02	2.9E-01	3.1E+00	7.0E+01	5.8E+04	5.0E+01	6.3E-04	5.1E-06	6.1E-02
Ammonia	9.3E+00	3.4E-02	2.3E-01	2.4E+00	1.47E+03 (e)	NoBench	NoBench	2.3E-05	NoBench	NoBench
Ammonium	1.0E+02	3.7E-01	2.5E+00	2.6E+01	1.47E+03 (e)	NoBench	NoBench	2.5E-04	NoBench	NoBench
Antimony	1.3E-03	4.8E-06	3.2E-05	3.3E-04	8.0E+01	2.0E+00	2.7E-01 (M)	6.0E-08	1.6E-05	1.2E-03
Arsenic	1.1E-02	4.0E-05	2.7E-04	2.4E-03	1.9E+02	9.8E+00	4.3E+01 (A)	2.1E-07	2.7E-05	5.5E-05
Barium	4.5E-01	1.7E-03	1.1E-02	2.9E-03	2.2E+02	NoBench	3.3E+02 (I)	4.3E-04	NoBench	8.9E-06
Beryllium	6.1E-04	2.2E-06	1.5E-05	1.6E-04	3.6E+00	NoBench	2.1E+01 (M)	4.2E-06	NoBench	7.4E-06
Cadmium	5.6E-04	2.1E-06	1.4E-05	Net Decrease	1.3E+00 (f)	9.9E-01	Net Decrease	1.6E-04	1.4E-05	Net Decrease
Calcium	2.2E+02	8.2E-01	5.4E+00	5.7E+01	1.2E+05	NoBench	NoBench	7.0E-06	NoBench	NoBench
Chloride	−1.6E+02	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease

Table 2 Preliminary screening-level modeling estimates and comparisons to conservative benchmarks

Chemical	Net emission rate (tons/year)	Screening-level concentration			Screening-level benchmark concentration			Screening-level hazard ratio		
		Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water	Sediment	Soil
Chromium	1.6E-01	5.9E-04	3.9E-03	1.0E-01	2.4E+02 (f)	4.3E+01	2.6E+01 (A)	7.0E-05	9.1E-05	4.0E-03
Copper	4.9E+00	1.8E-02	1.2E-01	1.2E+00	1.4E+01 (f)	3.2E+01	5.4E+00	8.8E-02	3.8E-03	2.3E-01
Fluoride	8.3E-01	3.1E-03	2.0E-02	2.1E-01	1.2E-01	NoBench	NoBench	2.5E-02	NoBench	NoBench
Iron	1.6E+01	5.8E-02	3.8E-01	4.0E+00	1.0E+01	2.0E+04	2.0E+02	5.8E-03	1.9E-05	2.0E-02
Hydrogen Chloride (HCl) (g)	1.5E+02	5.6E-01	3.7E+00	7.5E+01	2.3E+05 (g)	NoBench	NoBench	2.4E-06	NoBench	NoBench
Lead	9.3E-02	3.4E-04	2.3E-03	2.4E-02	2.5E+01 (f)	3.6E+01	1.1E+01 (A)	9.7E-04	6.3E-05	2.1E-03
Manganese	8.0E-01	2.9E-03	1.9E-02	2.0E-01	8.0E+01	4.6E+02	1.0E+02	3.7E-05	4.2E-05	2.0E-03
Mercury	−2.5E-02	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease
Nickel	3.0E-03	1.1E-05	7.2E-05	7.5E-04	5.8E+00 (f)	2.3E+01	1.4E+01	2.2E-06	3.2E-06	5.5E-05
Nitrate	4.3E+00	1.6E-02	1.0E-01	1.1E+00	NoBench	NoBench	NoBench	NoBench	NoBench	NoBench
Potassium	1.7E+01	6.1E-02	4.1E-01	4.2E+00	5.3E+04	NoBench	NoBench	1.2E-06	NoBench	NoBench
Selenium	2.0E-01	7.2E-04	4.8E-03	7.0E-02	5.0E+00	NoBench	2.8E-02	7.2E-04	NoBench	**2.5E+00**
Silver	5.6E-04	2.1E-06	1.4E-05	1.4E-04	1.2E-01	5.0E-01	4.0E+00	1.7E-04	2.8E-05	3.6E-05
Sodium	3.5E+01	1.3E-01	8.6E-01	8.9E+00	6.8E+05	NoBench	NoBench	1.9E-07	NoBench	NoBench
Sulfate	−4.0E+01	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease
Sulfuric Acid Mist (H_2SO4)	−5.5E+00	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease	Net Decrease
Thallium	5.0E-03	1.8E-05	1.2E-04	1.3E-03	1.0E+01	NoBench	5.7E-02	2.3E-05	NoBench	2.2E-02

Table 2 Preliminary screening-level modeling estimates and comparisons to conservative benchmarks

Chemical	Net emission rate (tons/year)	Screening-level concentration			Screening-level benchmark concentration			Screening-level hazard ratio		
		Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water (µg/l)	Sediment (mg/kg)	Soil (mg/kg)	Surface water	Sediment	Soil
Titanium	3.4E-01	1.3E-03	8.4E-03	8.7E-02	NoBench	NoBench	1.0E+03	NoBench	NoBench	8.7E-05
Zinc	2.7E-01	9.8E-04	6.5E-03	3.2E-02	2.5E+01 (f)	1.2E+02	6.6E+00	4.9E-05	5.4E-05	4.8E-03

Values highlighted in pink are recommended U.S. EPA Ecological Soil Screening Levels (http://mountain.epa.gov/ecotox/ecossl/). The lowest value among mammalian (M), avian (A), or soil invertebrate (I) endpoints is selected.

Values highlighted in yellow are Illinois Water Quality Standards based on the protection of aquatic organisms. The chronic standards are taken from Section 302.208 (e) of the general use water quality standards (Title 35, Subtitle C, Chapter I of the Illinois Environmental Regulations. Available at: http://www.ipcb.state.il.us/documents/dsweb/Get/Document-33354/

Values highlighted in blue are U.S. EPA Region 5 RCRA Ecological Screening Levels (ESLs) available at http://www.epa.gov/reg5rcra/ca/edql.htm

Notes:
- (a) Benzene used as a chemical surrogate
- (b) Formaldehyde used as a chemical surrogate
- (c) Values selected for 2-Methylnaphthalene
- (d) PACs are polycyclic aromatic compounds. The category of total PAHS (polycyclic aromatic hydrocarbons) was selected from the RAIS to identify benchmarks.
- (e) Value obtained from Section 302.212 of the general use water quality standards for Illinois. Value may not be specific to ecological receptors of concern, and is applied to both ammonia and ammonium as a screening-level evaluation.
- (f) Values based on a hardness of 119 mg/l (the average of measurements at Ohio River Lock and Dam 53 near Grand Chain, Illinois in 2005, available at http://il.water.usgs.gov/annual_report/data/sw_q2005/03612500.htm) and reflect total water column concentrations (dissolved phase adjustment factors not included)
- (g) Evaluated as chloride

Table 3 Modeling parameters for kiln emission sources

Kiln	Clinker Production (tons/year, Present Actual or Future Potential)	Stack coordinates (UTM m)		Stack Parameters			
		Easting	Northing	Height (m)	Diameter (m)	Exit temperature (K)	Exit velocity (m/s)
Existing 1 (ESP)	484,666	332972	4120358	45.72	3.90	385	5.47
Existing 2	628,340	332965	4120322	69.01	2.59	461	16.2
Future 1	209,437	332965	4120322	68.88	2.59	464	22.8
Future 3	1,377,875	333171	4120842	134.1	2.90	385	16.5
Future 4	1,377,875	333194	4120482	134.1	2.90	385	16.5

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Table 4 Maximum net increases in ambient concentrations (annual average basis)

Contaminant (Italics indicate POM and boldface indicates 7-PAH group)	Maximum net increase in annual average concentration due to Lafarge facility expansion (μg/m^3)	Average modeled concentrations (μg/m^3), U.S. EPA's National Air Toxics Assessment (NATA), County-average estimates for 1996		Measured concentrations in air, 2004 Illinois EPA monitoring program (μg/m^3)
		Massac County	Cook County	
NO_x (nitrogen oxides)	−1.18E-01			30 to 54
SO_2 (sulfur dioxide)	−4.22E-02			5 to 18
CO (carbon monoxide)	2.19E+00			
VOCs (Volatile organic compounds)	−2.08E-03			
PM (TSP) (total particulate matter)	−1.28E-03			
PM_{10} (particulate matter smaller than 10 μm diameter)	−3.48E-03			17 to 38
PCDD/PCDF	8.03E-10			
C3 Benzenes	9.71E-07			
C4 Benzenes	2.24E-06			
C6 Benzenes	3.43E-07			
Acenaphthylene	4.48E-05			
Acetone	1.38E-04			
Benzaldehyde	8.96E-06			
Benzene	1.53E-02	7.15E-01	2.19E+00	1.0 to 1.3
Benzo(a)anthracene	1.61E-08			
Benzo(a)pyrene	4.85E-08			
Benzo(b)fluoranthene	2.09E-07			
Benzo(g,h,i)perylene	2.91E-08			
Benzo(k)fluoranthene	5.60E-08			
Benzoic Acid	1.31E-03			
Biphenyl	2.28E-06			
Bis(2-ethylhexyl)phthalate	3.55E-05			
Bromomethane	1.61E-05			
Carbon Disulfide	4.11E-05			
Chlorobenzene	5.97E-06			

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Table 4 Maximum net increases in ambient concentrations (annual average basis)

Contaminant (Italics indicate POM and boldface indicates 7-PAH group)	Maximum net increase in annual average concentration due to Lafarge facility expansion (μg/m^3)	Average modeled concentrations (μg/m^3), U.S. EPA's National Air Toxics Assessment (NATA), County-average estimates for 1996		Measured concentrations in air, 2004 Illinois EPA monitoring program (μg/m^3)
		Massac County	Cook County	
Chloromethane	1.42E-04			
Chrysene	5.97E-08			
Di-n-butylphthalate	1.53E-05			
Dibenz(a,h)anthracene	2.35E-07			
Ethylbenzene	7.09E-06			
Fluoranthene	3.29E-06			
Fluorene	7.09E-06			
Formaldehyde	1.72E-04	5.99E-01	2.29E+00	0.7 to 1.7
Freon 113	1.87E-05			
Indeno(1,2,3-cd)pyrene	3.25E-08			
Methyl Ethyl Ketone	1.12E-05			
Methylene Chloride	1.83E-04			
Methylnaphthalene	1.57E-06			
Naphthalene	1.78E-03			
*PACs**	4.11E-06	2.68E-01	9.24E-02	
Phenanthrene	1.46E-04			
Phenol	4.11E-05			
Pyrene	1.64E-06			
Styrene	5.60E-07			
Toluene	7.09E-05			2.3 to 3.0
Xylenes	4.85E-05			
Aluminum	4.85E-03			
Ammonia	3.73E-03			
Ammonium	4.11E-02			1.5 to 1.6
Antimony	5.23E-07			
Arsenic	3.76E-06	6.13E-05	1.57E-04	0.001 to 0.007
Barium	4.66E-06			

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Table 4 Maximum net increases in ambient concentrations (annual average basis)

Contaminant (Italics indicate POM and boldface indicates 7-PAH group)	Maximum net increase in annual average concentration due to Lafarge facility expansion (μg/m^3)	Average modeled concentrations (μg/m^3), U.S. EPA's National Air Toxics Assessment (NATA), County-average estimates for 1996		Measured concentrations in air, 2004 Illinois EPA monitoring program (μg/m^3)
		Massac County	Cook County	
Beryllium	2.46E-07	4.88E-06	2.80E-05	
Cadmium	−1.03E-07	1.56E-04	7.62E-04	<0.001 to 0.003
Calcium	8.96E-02			
Chloride	−1.58E-02			
Chromium	1.63E-04	3.43E-04	4.60E-03	<0.001 to 0.011
Copper	1.98E-03			
Fluoride	3.36E-04			
Iron	6.35E-03			0.2 to 3.1
Hydrogen Chloride (HCl)	1.18E-01			
Lead	3.73E-05	1.49E-03	1.76E-02	0.010 to 0.060
Manganese	3.21E-04	6.54E-04	1.64E-03	0.008 to 0.174
Mercury	−4.14E-06	1.81E-03	1.96E-03	0.002 to 0.002
Nickel	1.19E-06	2.04E-04	4.41E-03	<0.001 to 0.010
Nitrate	1.72E-03			2.0 to 3.0
Potassium	6.72E-03			
Selenium	1.11E-04			
Silver	2.28E-07			
Sodium	1.42E-02			
Sulfate	−4.37E-03			2.5 to 3.0
Sulfuric Acid Mist (H_2SO_4)	−1.75E-03			
Thallium	2.02E-06			
Titanium	1.38E-04			
Zinc	5.03E-05			
7 Polycyclic Aromatic Hydrocarbons (PAHs)	4.82E-07	6.75E-03	1.87E-03	
Polycyclic Organic Matter (POM)	1.99E-03	2.68E-01	9.24E-02	

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Table 5 Comparison of modeled concentrations in soil to background levels for inorganic contaminants (http://www.ilga.gov/commission/jcar/admincode/035/03500742ZZ9996agR.html)

Contaminant	Maximum modeled increase in soil (mg/kg)	Illinois background (mg/kg)	Screening-level soil benchmark (mg/kg)	Total hazard ratio (sum background plus increment divided by benchmark)	Percent increase in background due to increment
Aluminum	3.1	9,200	50	180	0.03%
Ammonia	2.4		NoBench		
Ammonium	25.9		NoBench		
Antimony	0.00033	3.3	0.27	12	0.01%
Arsenic	0.00237	11.3	43	0.3	0.02%
Barium	0.00294	122	330	0.4	0.002%
Beryllium	0.00016	0.56	21	0.03	0.03%
Cadmium	-0.00007	0.5	0.36	1.4	Net decrease
Calcium	56.5	5525	NoBench		1%
Chloride	-9.9				Net Decrease
Chromium	0.1	13	26	0.5	0.8%
Copper	1.2	12	5.4	2.5	10%
Fluoride	0.2		NoBench		
Iron	4.0	15,000	200	75	0.03%
Hydrogen Chloride (HCl)	74.5		NoBench		
Lead	0.02	20.9	11	1.9	0.1%
Manganese	0.2	630	100	6.3	0.03%
Mercury	-0.0026	0.05	0.1	0.5	Net Decrease
Nickel	0.0008	13	14	1.0	0.006%
Nitrate	1.1		NoBench		
Potassium	4.2	1,100	NoBench		0.4%
Selenium	0.07	0.37	0.028	16	19%
Silver	0.00014	0.5	4	0.1	0.5
Sodium	8.9	130	NoBench		7%
Sulfate	-2.8	110	2	55	Net Decrease
Sulfuric Acid Mist (H_2SO_4)	-1.1				Net Decrease
Thallium	0.0013	0.42	0.057		0.3%
Titanium	0.09		1000		
Zinc	0.03	60.2	6.6	9	0.05%

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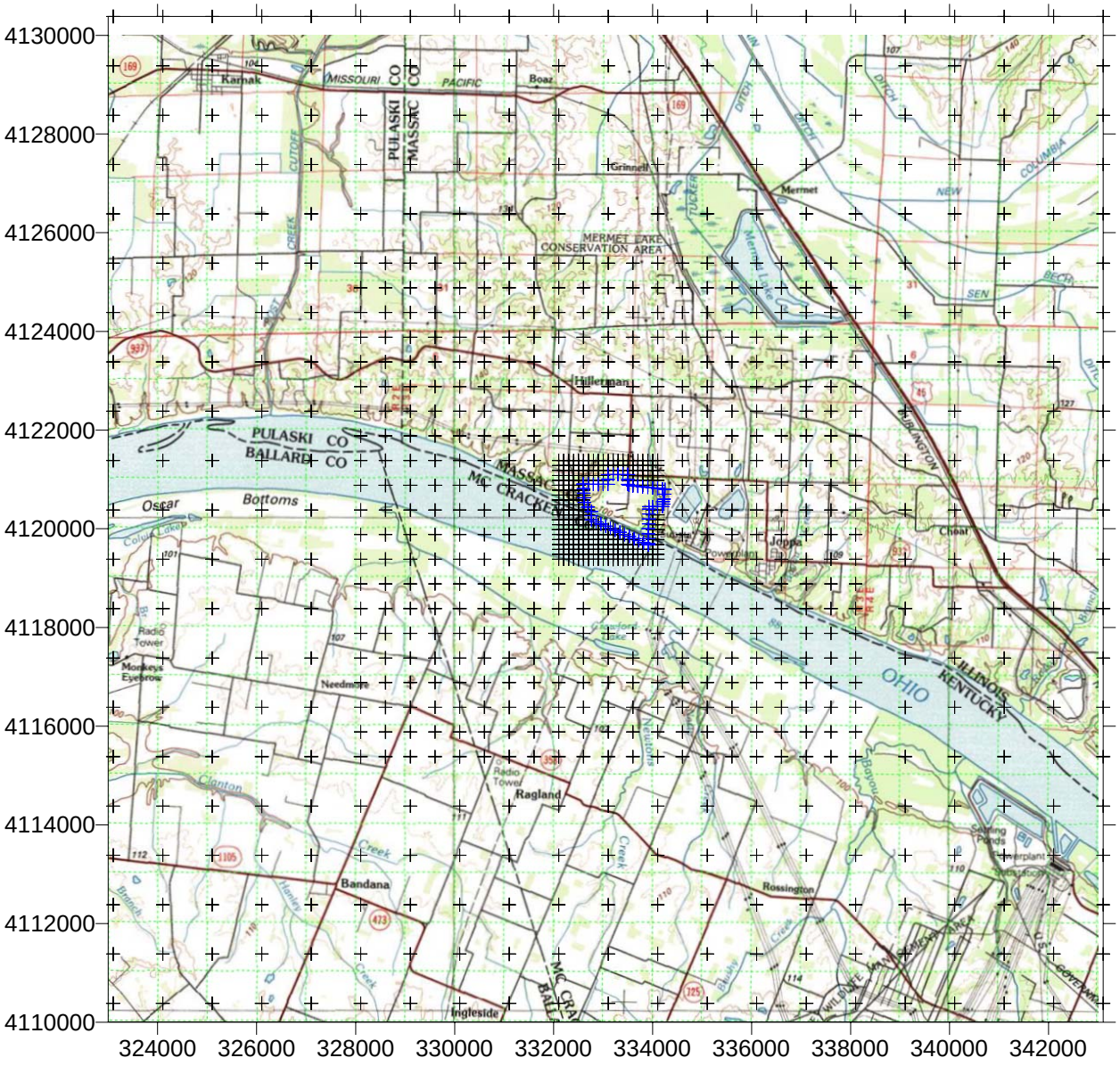

Figure 1 ISCST3 Receptor Modeling Grid. Fenceline receptors indicated in blue.

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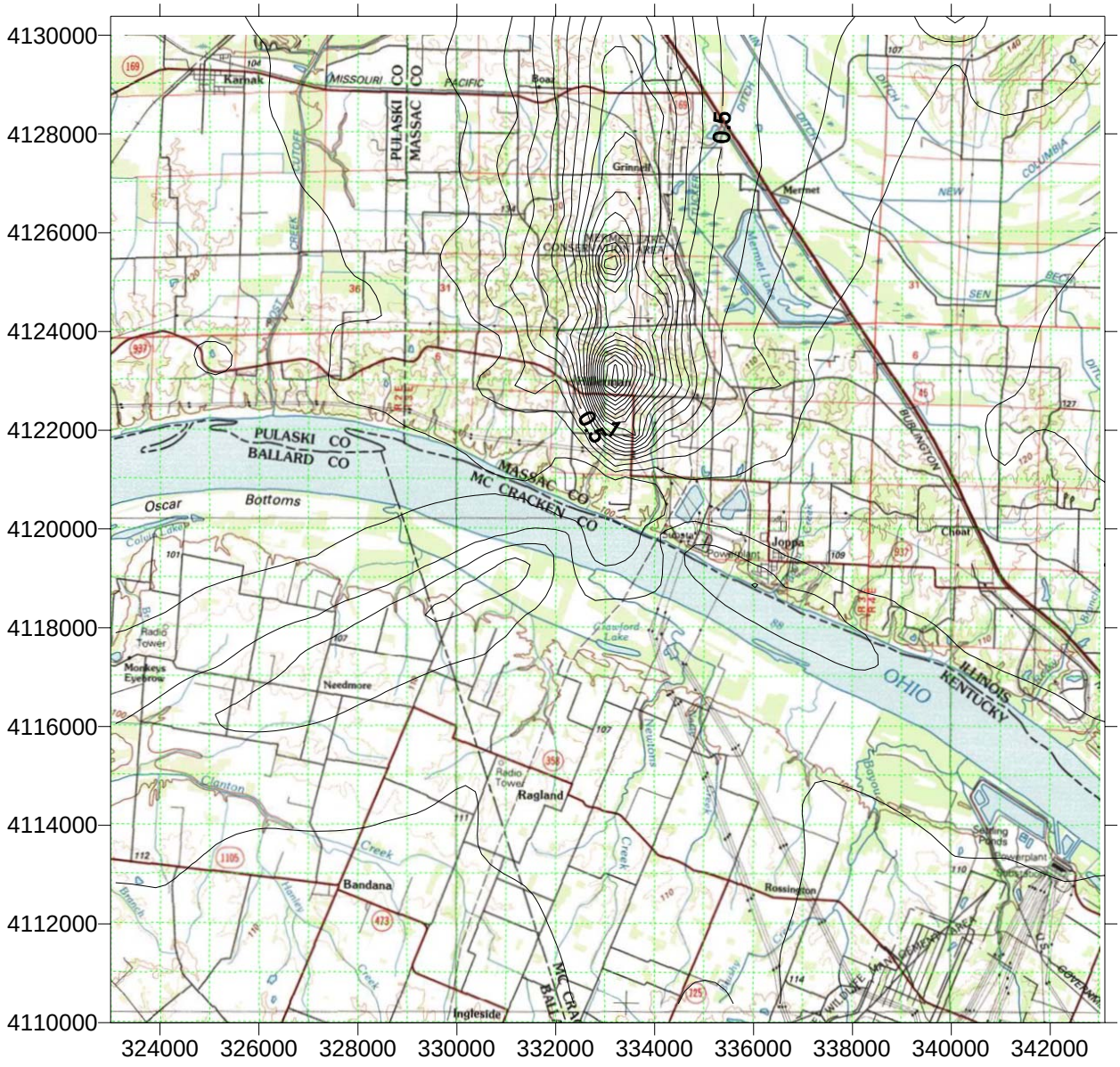

Figure 2 Modeled SO_2 ground-level annual average concentrations ($\mu g/m^3$) for the proposed facility modification at maximum emission rates. The contour interval is 0.1 $\mu g/m^3$ and the peak contour is 2 $\mu g/m^3$.

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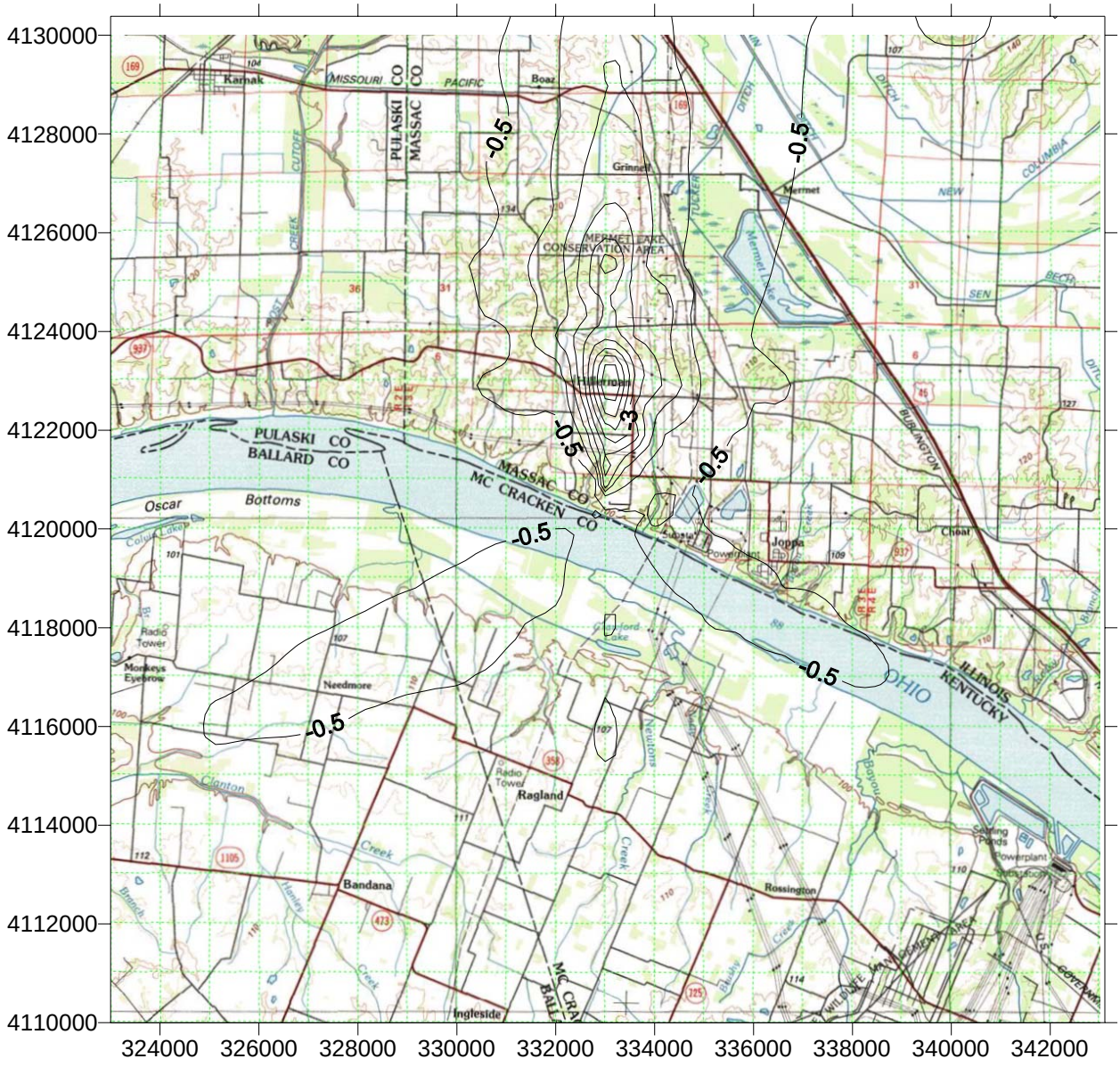

Figure 3 Modeled SO_2 ground-level annual average concentrations ($\mu g/m^3$) for the existing facility at actual emission rates. The contour interval is –0.5 $\mu g/m^3$ and the peak contour is –5.5 $\mu g/m^3$. Negative values are used to allow superposition with Figure 2.

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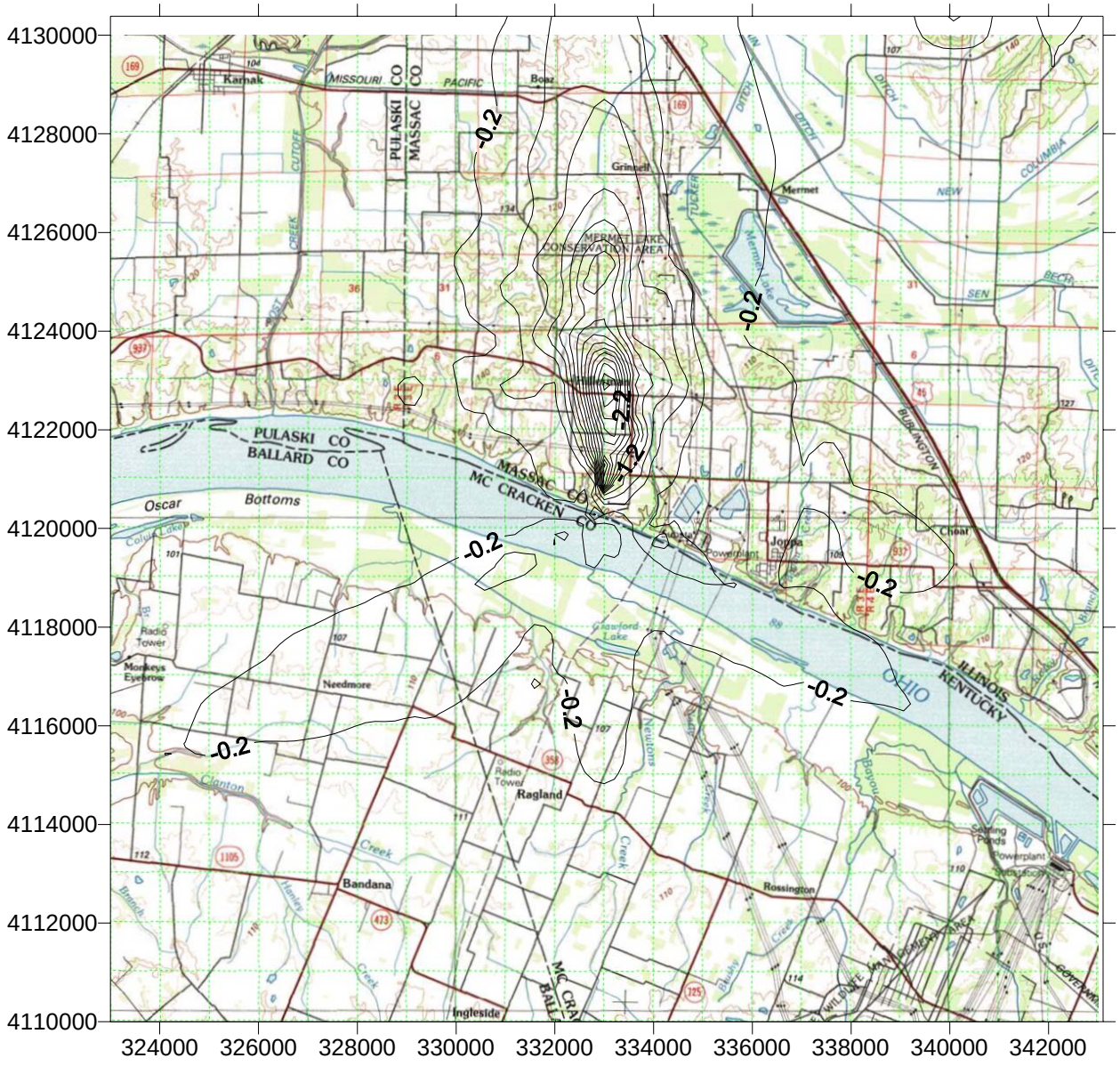

Figure 4 Modeled net SO_2 ground-level annual average concentrations ($\mu g/m^3$) for the proposed facility modification, calculated as maximum potential emission rate impacts less present actual emission rate impacts. The contour interval is –0.2 $\mu g/m^3$ and the peak contour is –3.2 $\mu g/m^3$. Impacts are the superposed values of Figures 2 and 3.

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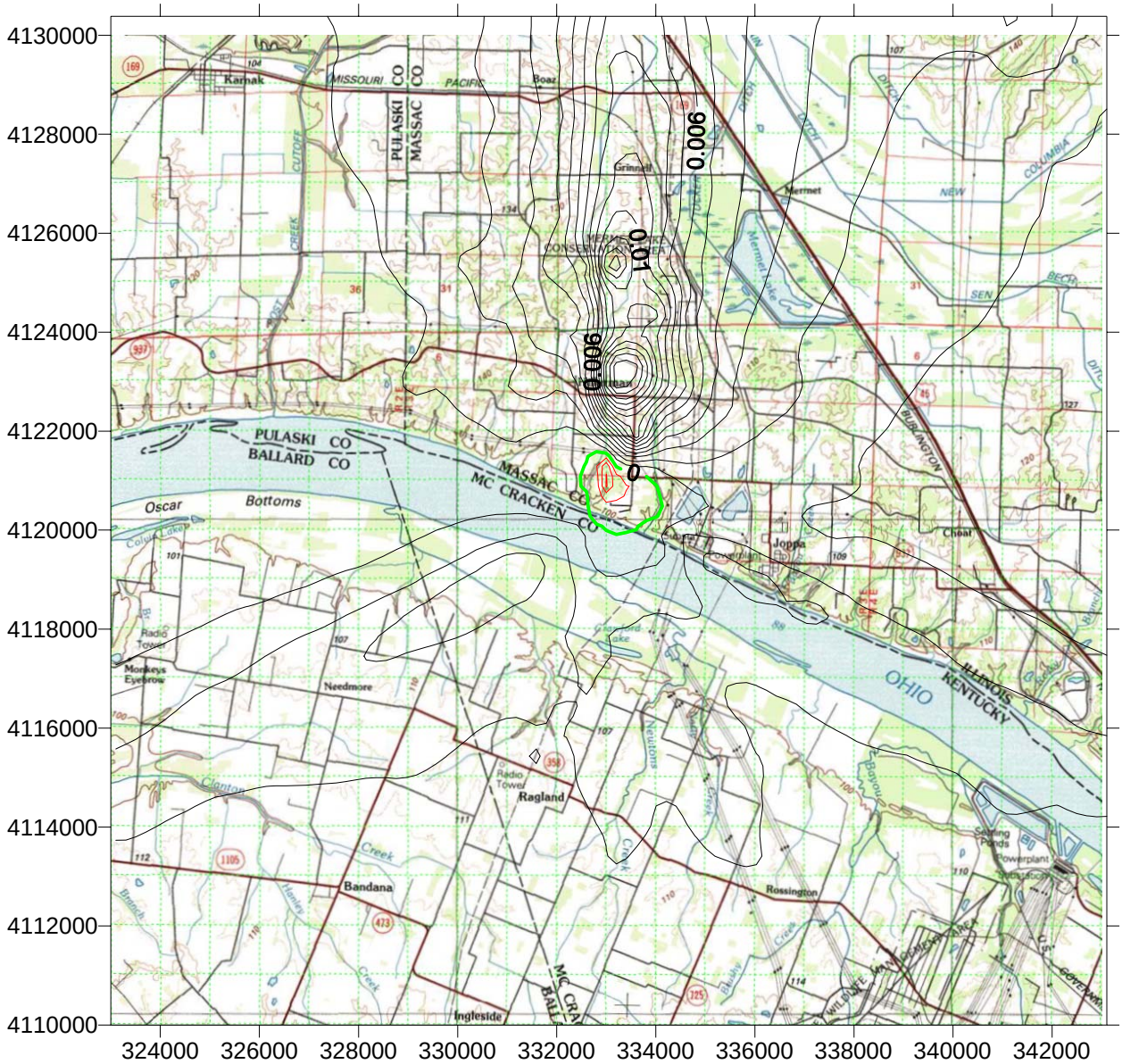

Figure 5 Modeled net benzene ground-level annual average concentrations ($\mu g/m^3$) for the proposed facility modification, calculated as maximum potential emission rate impacts less present actual emission rate impacts. The contour interval is 0.001 $\mu g/m^3$ and the minimum and maximum contours are –0.004 $\mu g/m^3$ and 0.015 $\mu g/m^3$, respectively. Negative contours are indicated in red (near the facility) and the green contour indicates zero (no net impact).

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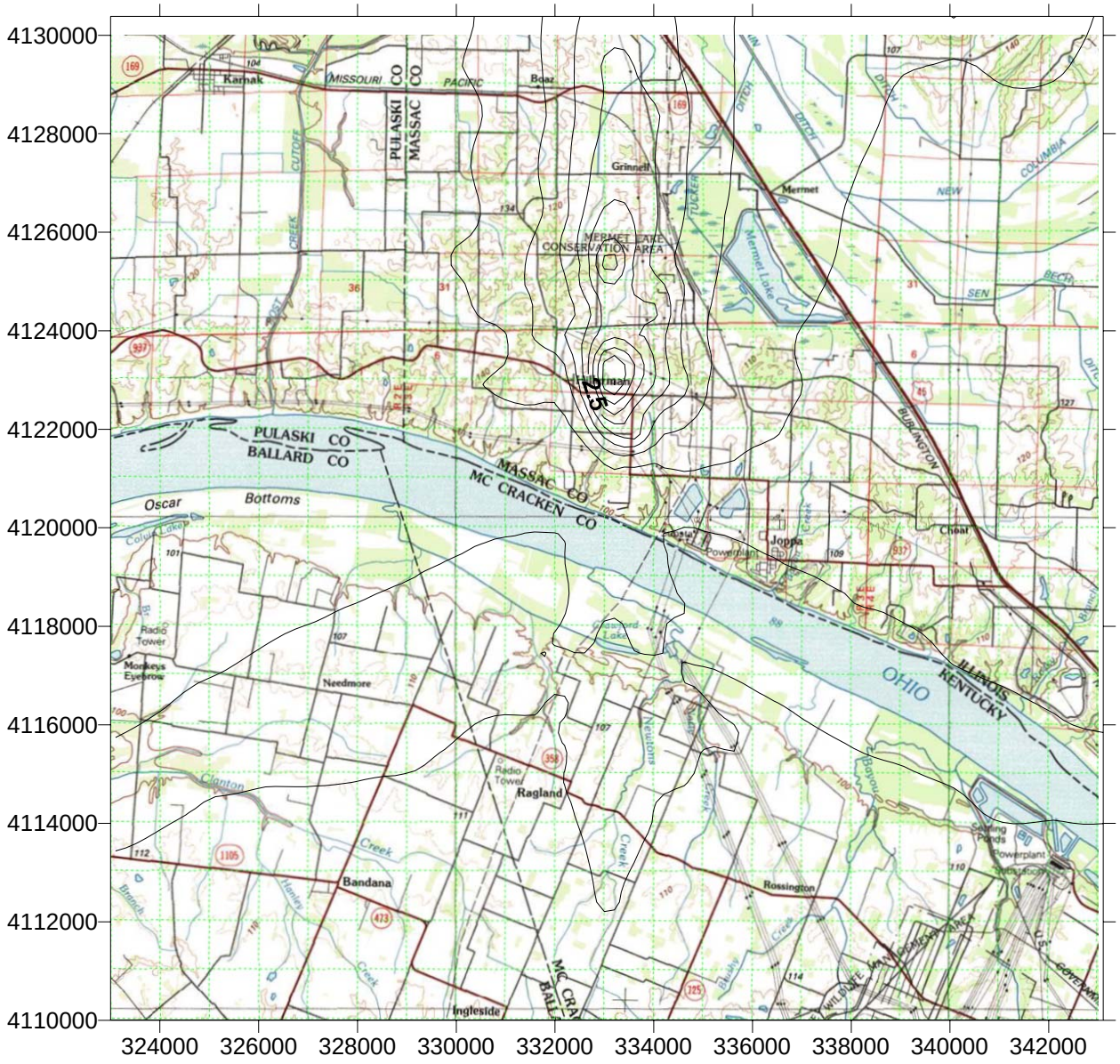

Figure 6 Modeled NO_x (as NO_2) ground-level annual average concentrations ($\mu g/m^3$) for the proposed facility modification at maximum emission rates. The contour interval is 0.5 $\mu g/m^3$ and the peak contour is 4.5 $\mu g/m^3$.

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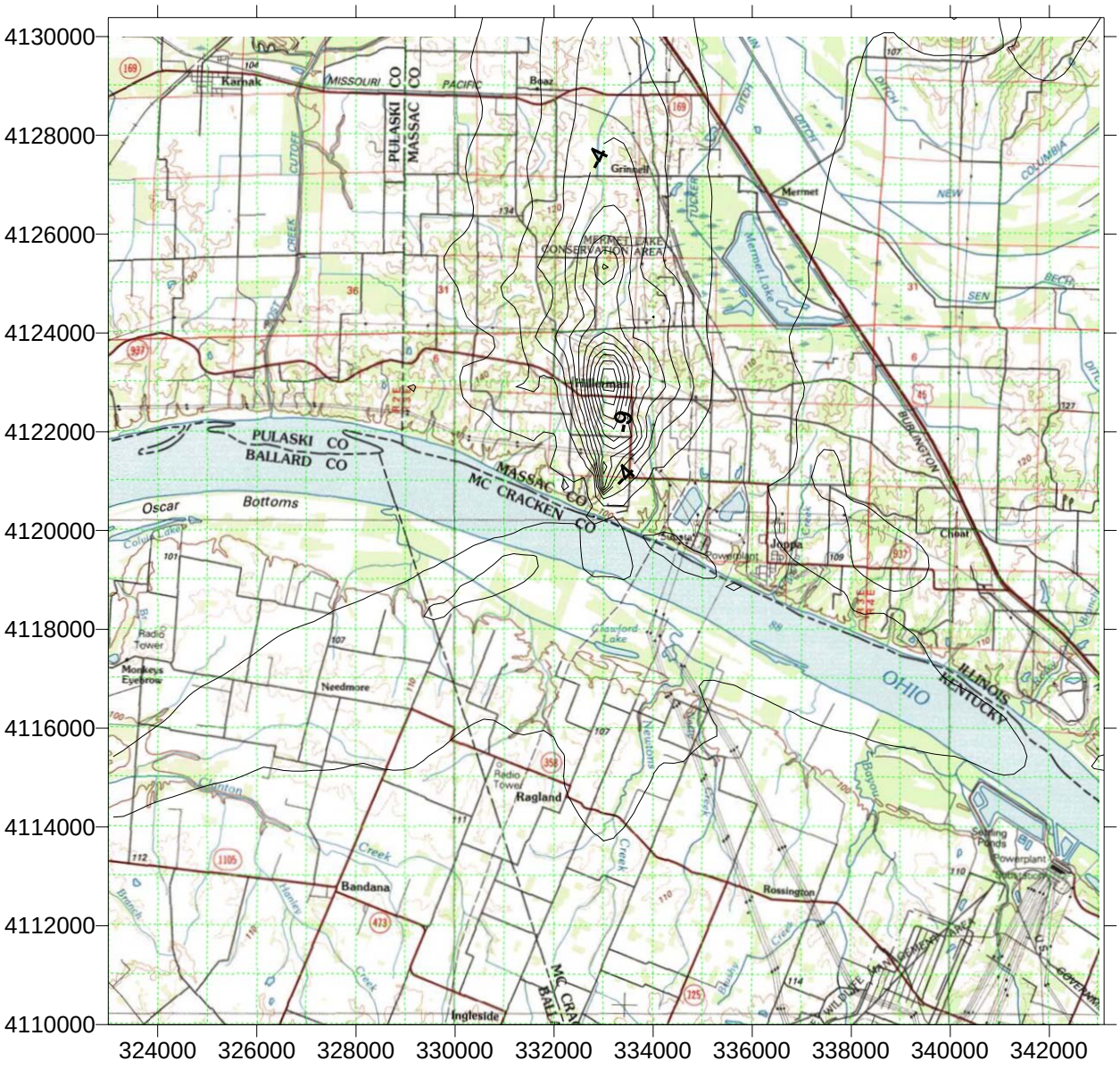

Figure 7 Modeled NO_x (as NO_2) ground-level annual average concentrations ($\mu g/m^3$) for the existing facility at actual emission rates. The contour interval is –1 $\mu g/m^3$ and the peak contour is –14 $\mu g/m^3$. Negative values are used to allow superposition with Figure 6.

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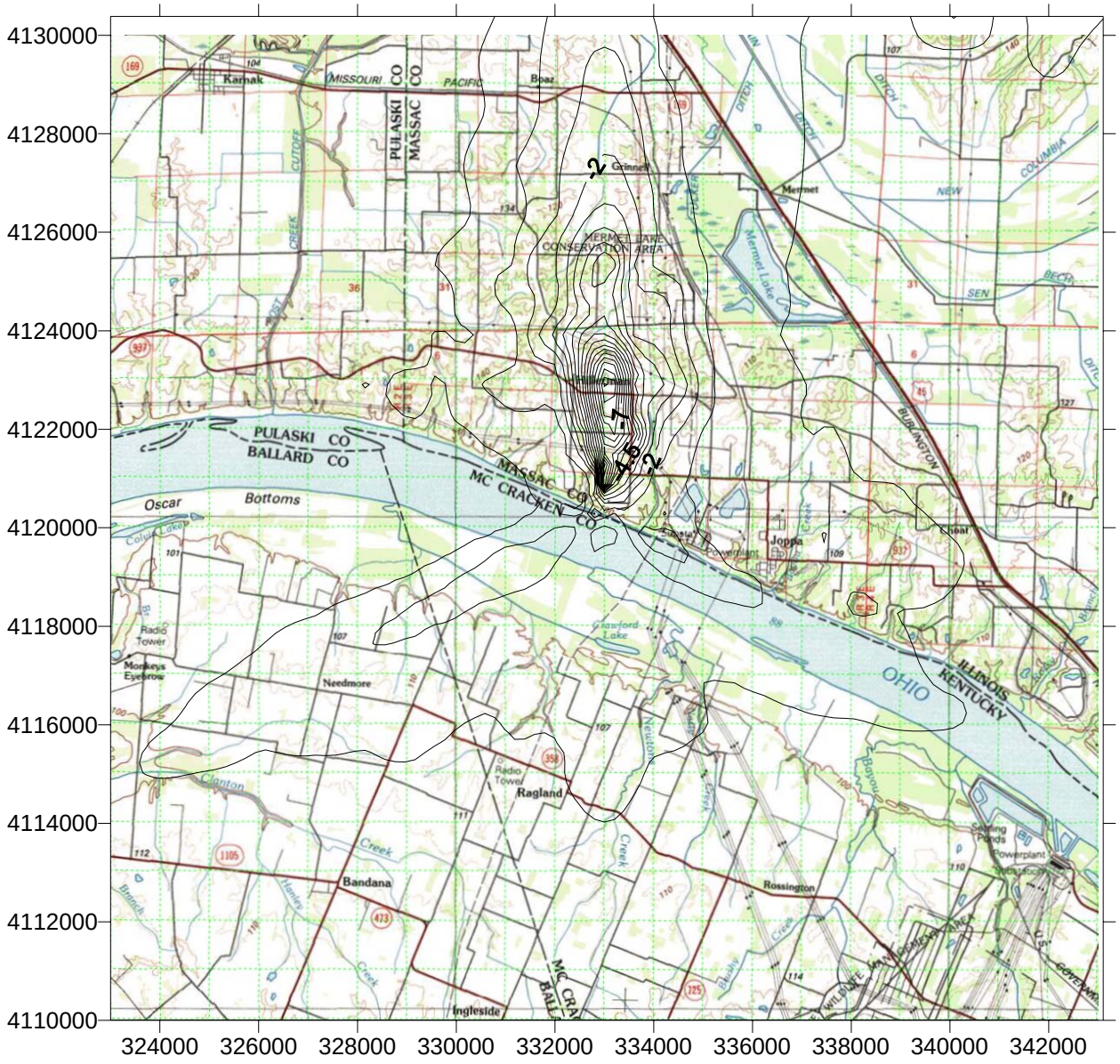

Figure 8 Modeled net NO_x (as NO_2) ground-level concentrations ($\mu g/m^3$) for the proposed facility modification, calculated as maximum potential emission rate impacts less present actual emission rate impacts. The contour interval is –0.5 $\mu g/m^3$ and the peak contour is –9.5 $\mu g/m^3$. Impacts are the superposed values of Figures 6 and 7.

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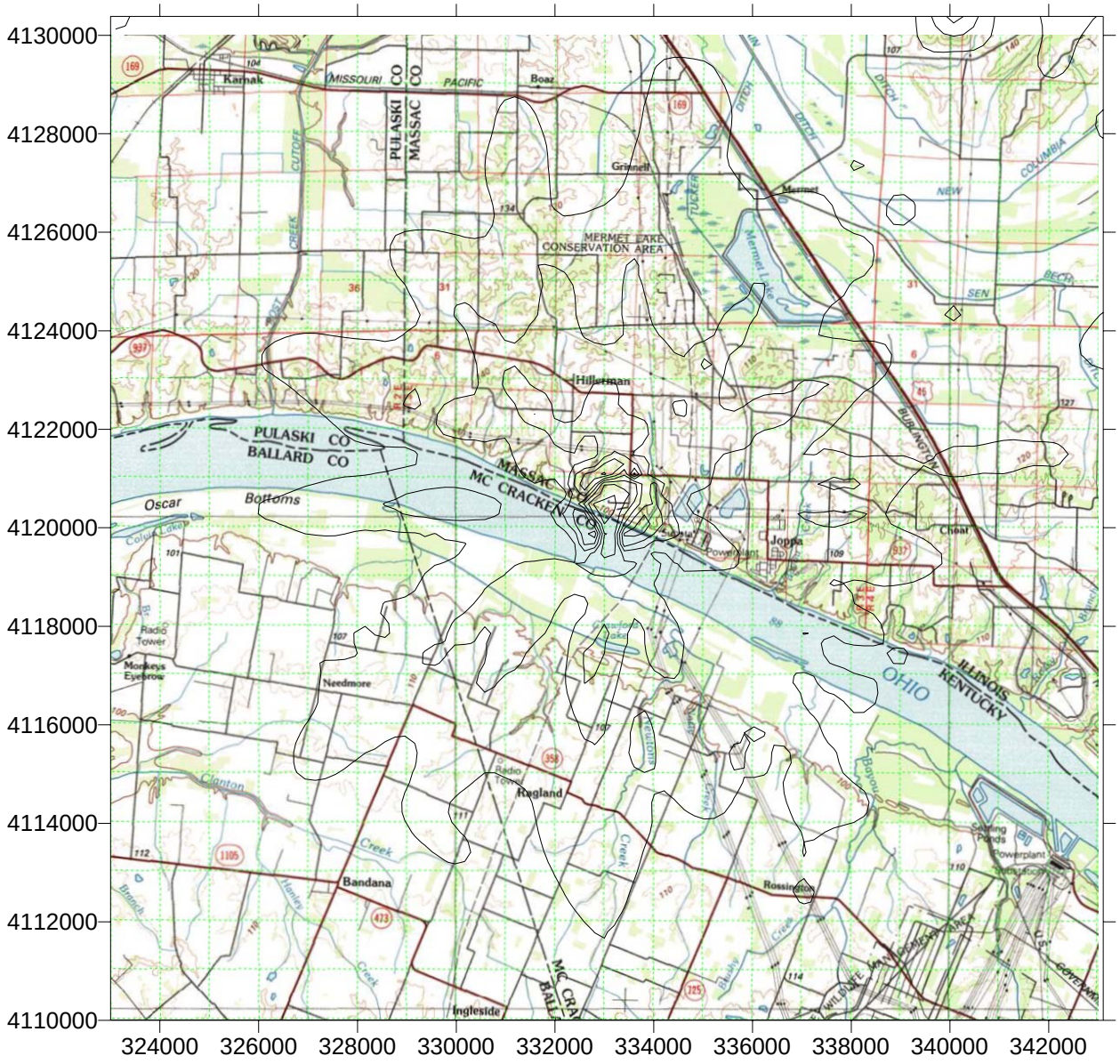

Figure 9 Modeled maximum net carbon monoxide (CO) ground-level 1-hour average concentrations ($\mu g/m^3$) for the proposed facility modification, calculated as maximum potential emission rate impacts less present actual emission rate impacts. The contour interval is 20 $\mu g/m^3$ and the peak contour is 140 $\mu g/m^3$. All values are below the Significant Impact Level (SIL) of 2,000 $\mu g/m^3$.

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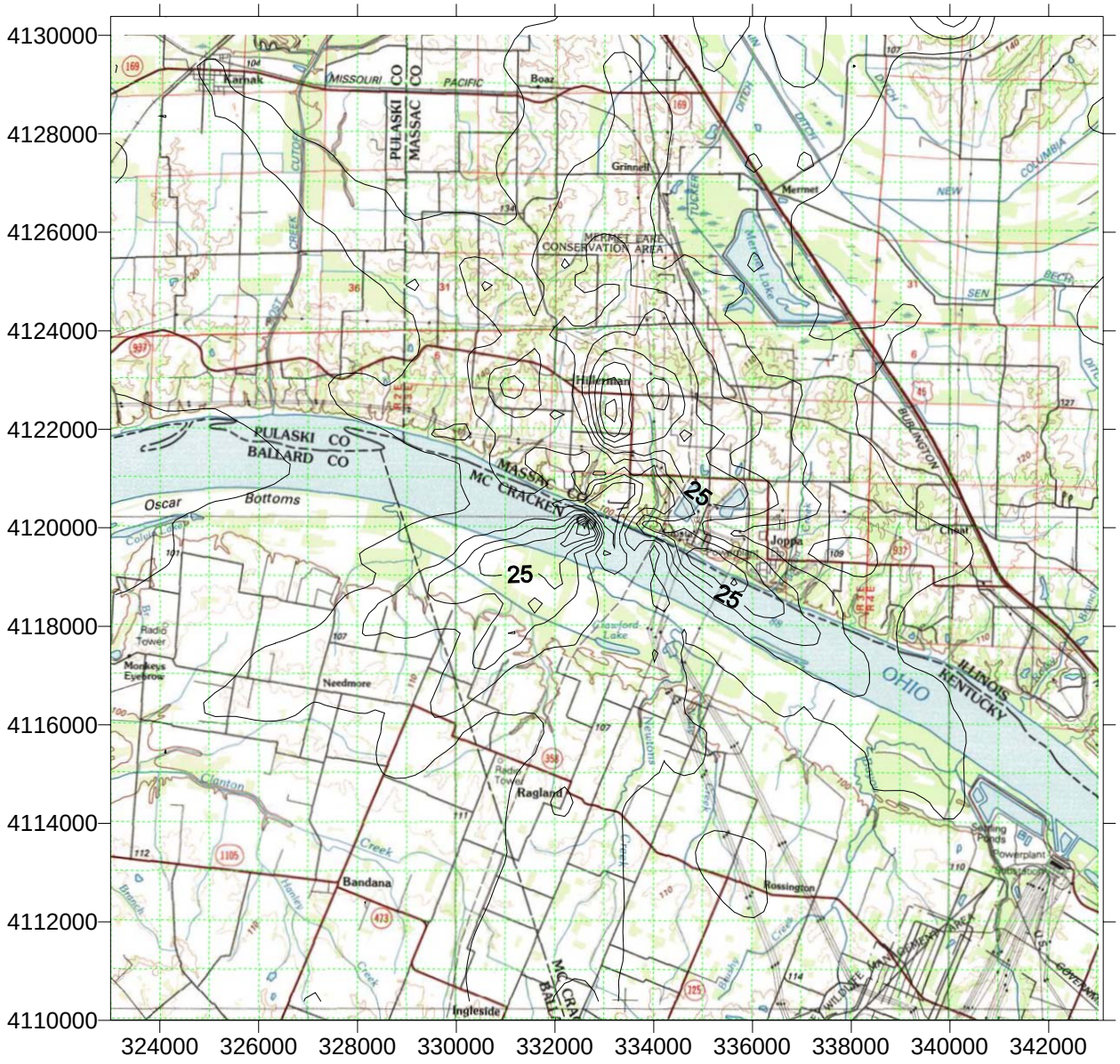

Figure 10 Modeled maximum net carbon monoxide (CO) ground-level 8-hour average concentrations ($\mu g/m^3$) for the proposed facility modification, calculated as maximum potential emission rate impacts less present actual emission rate impacts. The contour interval is 5 $\mu g/m^3$ and the peak contour is 45 $\mu g/m^3$. All values are below the Significant Impact Level (SIL) of 500 $\mu g/m^3$.

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