Goes with Power Line's Study

ROSTAD MORTUARY CREMATORY AIR QUALITY IMPACT ANALYSIS

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1 Introduction and Summary of Results

This report provides an analysis of the air quality impacts of air pollutants from the incineration of human bodies in a CMS Millennium II cremator located at the Rostard Mortuary in Rawlins, Wyoming. A crematory is a source of criteria pollutants and toxic air contaminants. These pollutants are listed in Table 2. These pollutants are emitted into the atmosphere through an exhaust stack during the cremation process, which may have an impact on the nearby properties in the neighborhood. Since the Rostad Mortuary Crematory is surrounded by a residential area and is located within 600 meters of the nearest schools (Mountain view school and St. Joseph school), it is important to examine the potential impact of the emissions from the crematory. In order to predict the impact of the emissions, an air quality impact analysis was performed using the current version of the EPA-approved Industrial Source Complex Short Term, Version 3 air dispersion model (ISCST3).

The emissions from the crematory stack were categorized into 20 species and modeled as a point source. The major emissions from crematories are nitrogen oxides (NOx), carbon monoxide (CO), sulfur dioxide (SOx), particulate matter (PM10), mercury, hydrogen fluoride (HF), hydrogen chloride (HCl), non-methane volatile organic compounds (NMVOCs), other heavy metals, and some persistent organic pollutants (POPs) including dioxins and furans, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), etc. The detailed emission rates and stack information are described in Section 3.

Default options of ISCST3 were used along with building downwash information and one year (1994) of hourly meteorological data. Fine nested grid receptors were used to predict the impact more accurately including 25-meter spaced fine grid receptors for the area within the vicinity of the crematory.

The modeling results are shown in Table 3 and indicate that the criteria pollutants (NOx, SO, SOx, and PM10) and most of the toxic pollutants except cadmium and dioxin/furan do not exceed the National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards (WAAQS) or the preliminary remediation goal (PRG) levels (URS, 2006). However, the annual cadmium and dioxin/furan concentrations exceed the PRG significantly, by 205% and 2200%, respectively.

The modeling results show that the maximum impact is predicted to occur on the immediate vicinity of the crematory as shown in Figures 5 through 9.

2 Modeling Analysis Design

The air quality dispersion model and related options used to determine ambient impacts are described in this section, along with the receptor network employed.

2.1 Model Selection

The air quality impacts in the areas surrounding the Rostad Mortuary Crematory were determined with the latest version of the EPA ISCST3 model, which is commonly used for

regulatory analyses involving the prediction of impacts (concentration or deposition) within 50 kilometers (km) of a source. The ability of the ISCST3 model to accommodate varying source types and terrain makes it an appropriate selection for this analysis.

2.2 Model Input Defaults/Options

The ISCST3 model was run with regulatory default options. These options are:

- Stack tip downwash (except for Schulman Scire downwash);
- Buoyancy induced dispersion (except for Schulman Scire downwash);
- No gradual plume rise (except for building downwash);
- Calms processing routines;
- Upper bound concentration estimates for sources influenced by building downwash from super squat buildings;
- Default wind profile exponents; and
- Default vertical potential temperature gradients.

As noted above, the model was executed with the calms processing invoked. Periods of calm winds are identified in the meteorological data processing by defining a threshold wind speed. If the recorded wind speed is less than the threshold wind speed, then the wind speed for that given hour is reset (and wind direction adjusted) to reflect a period of calm wind. The option for modeling elevated terrain was also selected.

2.3 Rural/Urban Classification

The ISCST3 model includes rural and urban algorithm options. These options affect the wind speed profile, dispersion rates, and mixing-height formula used in calculating ground-level pollutant concentrations. A protocol was developed by the EPA to classify an area as either rural or urban for dispersion modeling purposes. The classification is based on average heat flux, land use, or population density within a 3-km radius of the modeled facility, with land use being the most definitive criterion (USEPA, 2003). The urban/rural classification scheme based on land use is as follows:

> *The land use within the total area, A0, circumscribed by a 3-km circle about the source, is classified using the meteorological land use-typing scheme proposed by Auer (1978). The classification scheme requires that more than 50% of the area, A0, be from the following land use types in order to be considered urban for dispersion modeling purposes: heavy industrial; light-moderate industrial; commercial; single-family compact residential; and multi-family compact residential. Otherwise, the use of rural dispersion coefficients is appropriate.*

Since most of area is the medium low density of residential and rural area as shown in the aerial photomap, the rural land use classification was used in this analysis.

24 Receptor Network

A receptor grid, or network, defines the locations of predicted air pollutant concentrations that are used to assess compliance with the relevant standards or guidelines. The following receptor network was used for this analysis:

- 25-m spaced receptors along the facility fence line and out to 100 m from the fenceline;
- 50-m spaced receptors from beyond 100 m to 250 m from the fence line;
- 100-m spaced receptors from beyond 250 m to 1000 m from the fence line; and
- 250-m spaced receptors from beyond 1000 m to 2000 km from the fence line.

This network is composed of Cartesian (X, Y) receptors with Universal Transverse Mercator (UTM) coordinates. For consistency with the terrain elevation data, the modeling was conducted using the North American Datum of 1927 (NAD27). Receptors were modeled with terrain elevations for each point interpolated from US Geological Survey (USGS) 7.5-minute Digital Elevation Model (DEM) data.

The near field and far field receptor networks are illustrated in Figure 1. Detailed locations of buildings, the stack, and the fenceline are shown in Figure 2 and Figure 3.

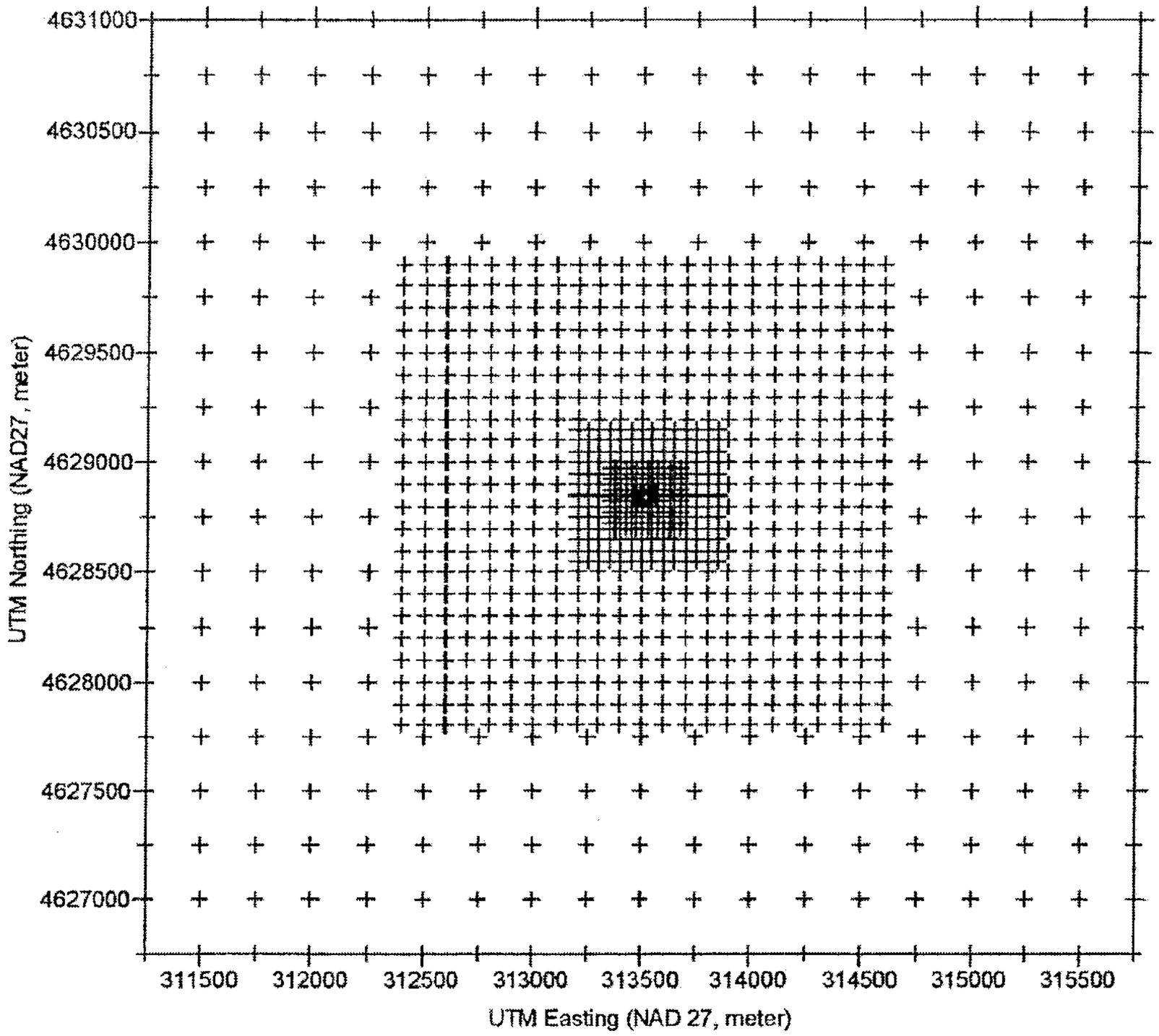

Figure 1. Near Field and Far Field Receptor Networks

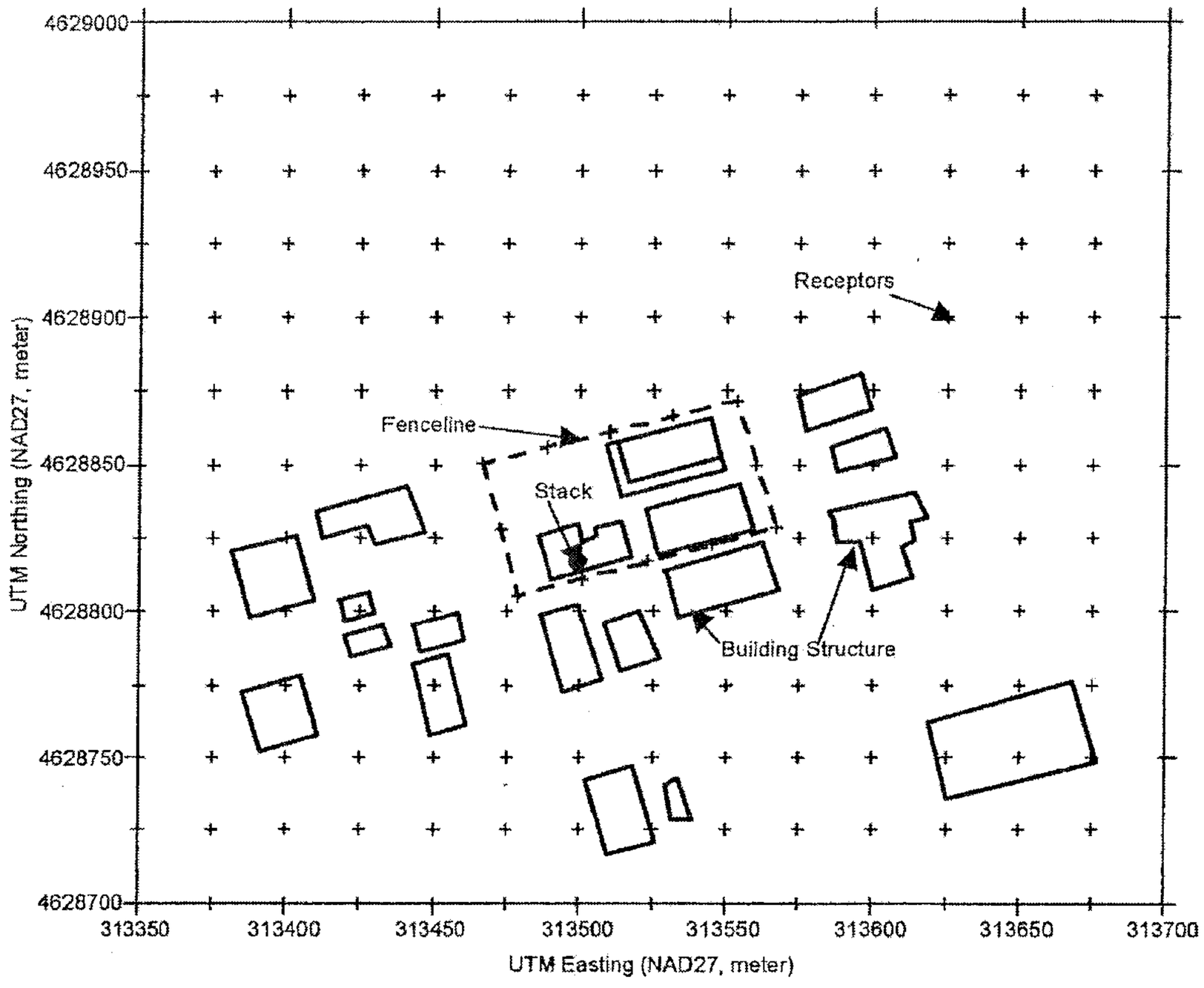

Figure 2. Location of Buildings, Stack, Property Fenceline, and Receptors

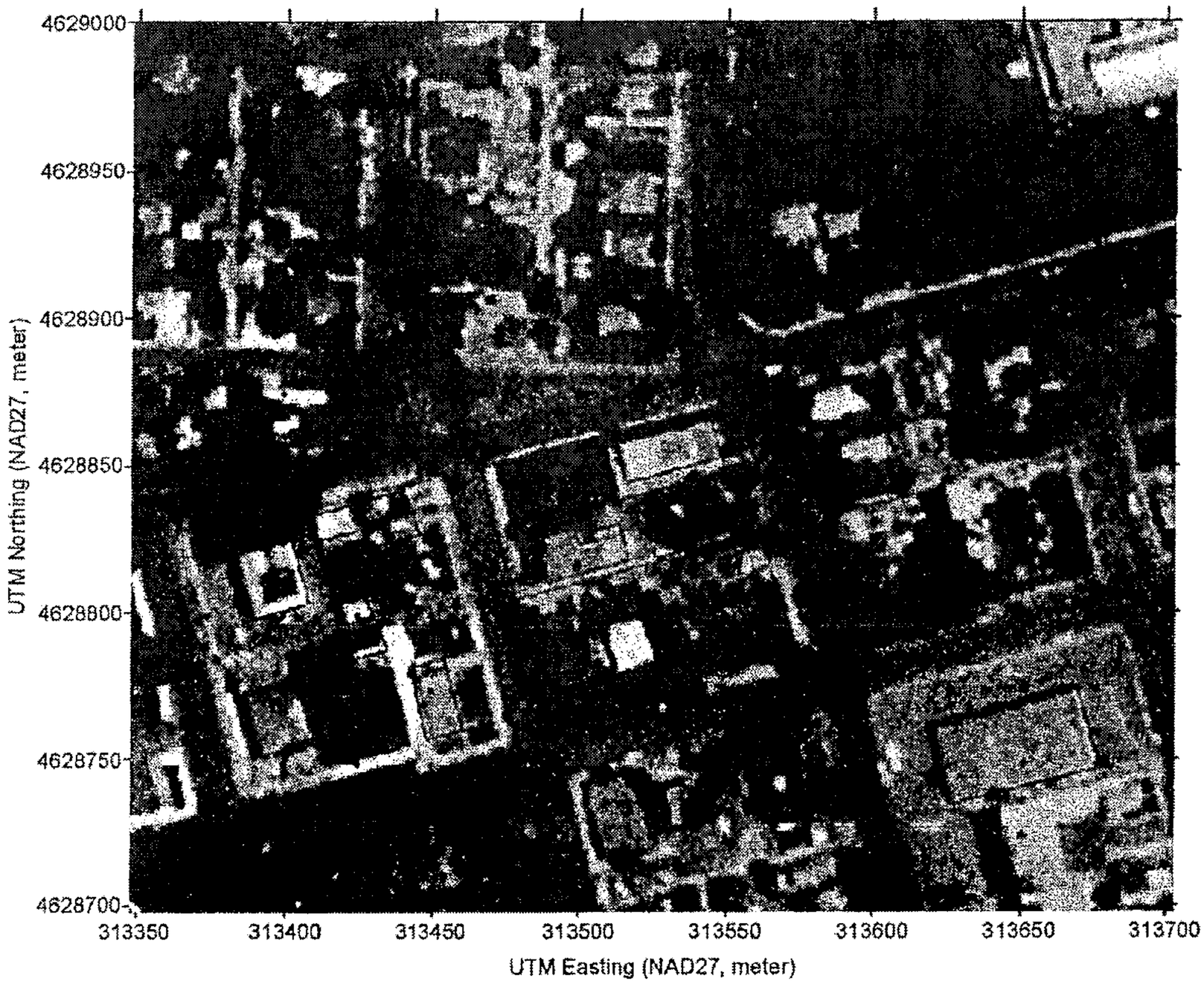

Figure 3. Location of Buildings, Stack, Property Fenceline, and Receptors on the Aerial Photomap

3 Source Data

3.1 Pollutants Emissions

The major emissions from crematories are nitrogen oxides (NOx), carbon monoxide (CO), sulfur dioxide (SOx), particulate matter (PM10), mercury, hydrogen fluoride (HF), hydrogen chloride (HCl), non-methane volatile organic compounds (NMVOCs), other heavy metals, and some persistent organic pollutants (POPs) including dioxins and furans, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), etc. The emission rates depend on the design of the crematory, combustion temperature, gas retention time, duct design, duct temperature, and any control devices (Environment Canada, 1999).

Particulates such as dust, soot, ash and other unburned particles originate from the cremation container, human remains, and other contents of the container. Carbon based organic particulates should be removed in the secondary combustion chamber and through proper adjustment and operation of the cremation equipment. Carbon monoxide results from the incomplete combustion of containers, human remains, fuel, and other contents.

Carbon monoxide may be minimized through proper adjustment and operation of the cremation equipment (Environment Canada, 1999).

Sulfur dioxide is produced from the combustion of fuel, containers, and contents. The sulfur content of natural gas and human remains is relatively lower than other fuels. Nitrogen oxides are formed by high temperature combustion processes through the reaction of the nitrogen in air with oxygen (Environment Canada, 1999).

Mercury emissions originate from the dental fillings that may contain 5 to 10 grams of mercury depending on the numbers and types used. Mercury may be removed through the use of selenium salt in the cremation chamber or scrubbers. Hydrogen fluoride and hydrogen chloride results from the combustion of plastics contained in the container and from stomach contents. NMVOCs are produced from incomplete or inefficient combustion of hydrocarbons contained in the fuel, human remains, and casket. Dioxins and furans result from the combustion of wood cellulose and chlorinated plastics in the correct temperature range (Environment Canada, 1999).

3.2 Emission Source Description

Crematory emissions exhaust from a stack, and thus it is modeled as a point source. The stack parameters are shown in Table 1.

Table 1. Source Stack Parameters (Rostad Mortuary, 2006)

Source Name	Stack Height		Stack Gas Exit Temperature		Stack Gas Exit Velocity		Stack Diameter		UTM Coordinates (NAD27) Easting/Northing	
	(ft)	(m)	(°F)	(K)	(ft/s)	(m/s)	(ft)	(m)	(m)	(m)
Stack1	15	4.572	1413	1040	16.08	4.902	2.03	0.619	313499	4628817

Emission rate for various pollutants from crematory operations are described on the basis of 100 lbs of body per hour. The emissions associated with the fuel combustion during the cremation were also included, and the fuel type was assumed to be natural gas. All emission rates are shown in Table 2, and the maximum emission rate was chosen conservatively as a model input emission rate among various references.

Table 2. Source Emission Rates

Reference	Established Emission Factors Note1	Stack Test Data Note 2	Keaton's Mortuary Note 3	US EPA Note 4	US EPA 1996 Note 5	CANA, 1993 Note 6	Canada 1996	US EPA/CANA Woodlawn Crematory Test 1999 Note 7	Max Emission Rate	
Pollutant	Emission Rate (lb/hr)	Emission Rate (lb/hr)	Emission Rate (lb/hr)	Emission Rate (lb/hr)	Emission Rate (lb/hr)	Emission Rate (lb/hr)	Emission Rate (lb/hr)	Emission Rate (lb/hr)	Max (lb/hr)	Max (g/sec)
PM10	2.6619E-05	0.276	0.171233		3.902E-05	3.445E-01		0.283	3.445E-01	**4.340E-02**
NOX	0.323809524		0.32911		4.746E-01	9.791E-02		0.43	4.746E-01	**5.980E-02**
SOX	0.057142857		0.05		8.374E-02	7.003E-01		0.148	7.003E-01	**8.824E-02**
CO	4.74286E-10	0.064	0.160616		2.163E-01	3.263E-01		0.0099	3.263E-01	**4.111E-02**
VOC	0.147619048								1.476E-01	**1.860E-02**
ARSENIC					1.689E-08				1.689E-08	**2.128E-09**
CADMIUM					4.780E-09			0.000161	1.609E-04	**2.028E-05**
LEAD					2.862E-08			0.00097	9.700E-04	**1.222E-04**
CHROMIUM					1.298E-08				1.298E-08	**1.635E-09**
MERCURY					1.438E-06			0.000573	5.732E-04	**7.222E-05**
NICKEL					1.654E-08				1.654E-08	**2.084E-09**
COPPER					1.186E-08				1.186E-08	**1.495E-09**
COBALT					2.512E-09				2.512E-09	**3.165E-10**
DIOXIN				8.14335E-13	3.574E-11			8.12E-08	8.12E-08	**1.023E-08**
FURAN				8.14335E-13	4.669E-11			8.12E-08	8.12E-08	**1.023E-08**
HCL						2.446E-02	7.077E-02	0.39	0.39	**4.914E-02**
HF					2.882E-07				2.882E-07	**3.631E-08**
Fluoranthene					9.072E-11				9.072E-11	**1.143E-11**
Benzo[a]-pyrene					1.591E-11				1.591E-11	**2.004E-12**
Benzo[a]-anthracene					5.812E-12				5.812E-12	**7.323E-13**

Note:

1) According to NCDENR-DAQ, these emission factors were developed from testing performed by the California Air Resources Board. The test results are published in the October 29, 1992 report entitled "Evaluation Test on Two Propane Fired Crematories at Camellia Memorial Lawn Cemetery". A full copy of the report is generally unavailable. However, the report is based on testing of 2 propane-fired crematories (max. capacity 1.4 MMBTU/hr each). The minimum process rate (hr/case) for the similar crematory (see Note 2 below) is used to convert from lb/case to lb/hr.
2) The emission rates were obtained from "Air Compliance Test Report" for a crematory incinerator at Haisley-Hobbs Funeral Home in Fort Pierce, FL (attached). The average emission rates have been converted to lb/hr for presentation and comparison.
3) Engineering Evaluation Report Keaton's Mortuary Plant Number 14968, Application Number 6416. Emission Factors for PM10, SO2, NOx, CO, and POC are taken from AP-42, 1/95, Table 1.4-1, and 1.4-3. Based on the Emission factors from AP-42, Pathological Waste Combustion was added. Operating schedule: 16hrs/day, 7days/wk, 52wks/yr
4) Source of Dioxins and Furans in Australia:Air Emissions May 2002, Page 38 Chapter 6.1.9. Crematoria
5) Emission Factors are for 1 55 to 70 kg body, about 65kg on average, No emission control devices were present in the creation of the emission factors. US-EPA emission factors include a 2 kg cardboard and 1kg wood container.
6) CANA emission factors averaged from test data in report for cardboard, cloth covered and finished wood containers.
7) Maximum outlet emission rate was used among the average values of 3 sets of 3 various runs.

4 Building Downwash Analysis

Stack exhaust has the potential to be influenced by building wakes, which in effect "wash down" the plume, causing increased ground-level concentrations. The EPA Building Profile Input Program (BPIP), adapted for use with ISCST3, was used to determine the direction-dependent building input parameters (USEPA, version 04274, 2004). This program was also used to calculate the Good Engineering Practice (GEP) stack height for each source location. The crematory stack height was not greater than the calculated GEP stack height; therefore, building downwash was considered.

Figure 2 shows the structures (purple solid line) that could influence the stack gas exhaust and are included in the downwash analysis. These structures were input to the BPIP program. Inspection of the BPIP output showed that some of these structures were of sufficient stature to cause some downwash of the stack exhaust.

5 Meteorological Data

ISCST3 model-ready meteorological data were obtained from the State of Wyoming Department of Environmental Quality (WDEQ). The meteorological data were collected near Rawlins, Wyoming and summarized into hourly averaged values for 1994. The anemometer height used to collect the wind data was 10 meters. According to the State Department of Environmental Quality, the average background NO_2 concentration for this area is 10 micrograms per cubic meter ($\mu g/m^3$) (State of Wyoming, 2006).

A wind rose for the 1994 data set is shown in Figure 4. The prevailing wind directions are from the Southwest.

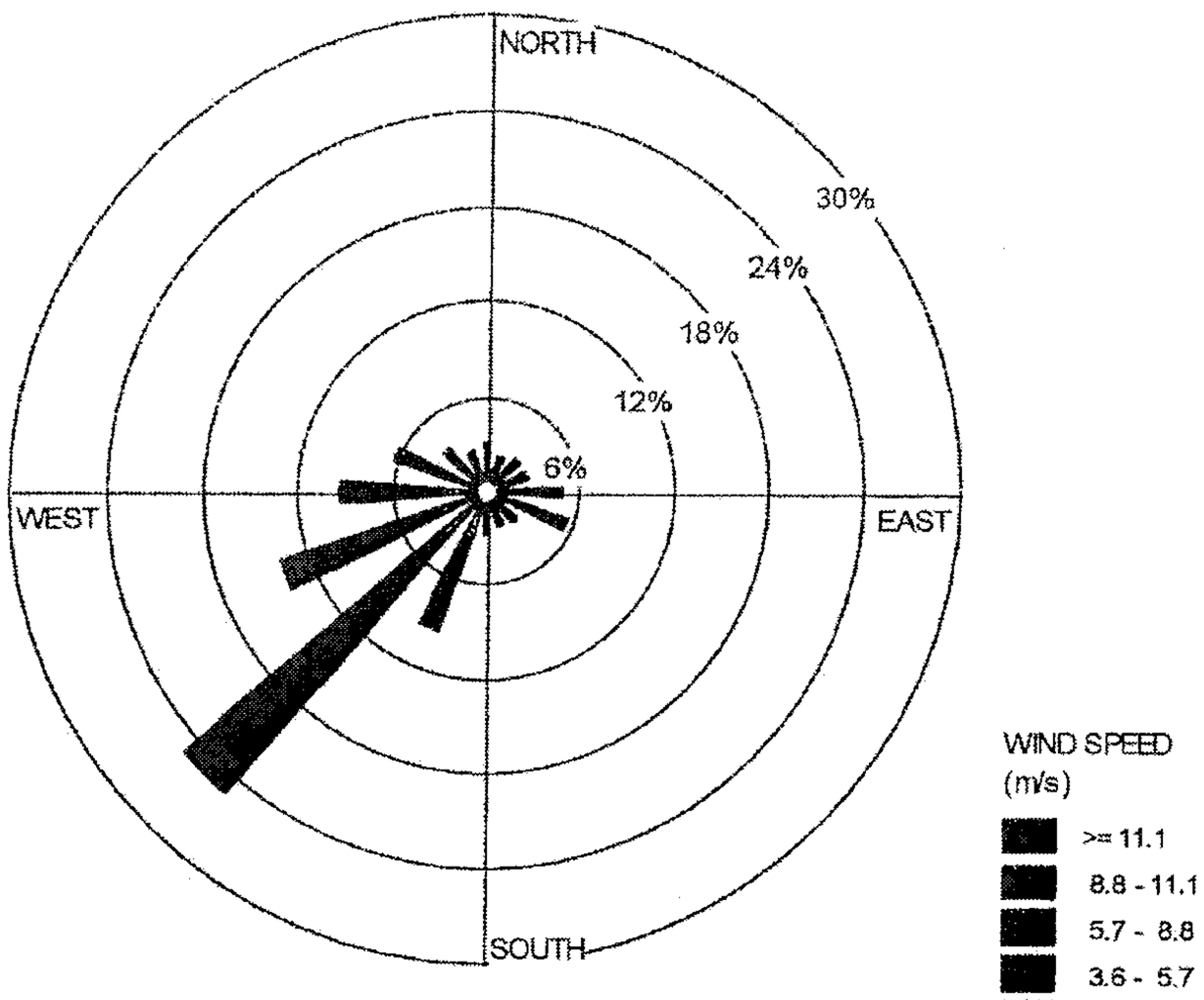

Figure 4. Rawlins Wind Rose

6 Modeling Results

The dispersion modeling was conducted to assess if all the estimated pollutant emissions listed in Table 2 from the crematory source would result in local concentrations that exceed the NAAQS and Wyoming AAQS. PM10, NOx, SOx, and CO were modeled for the various averaging periods compatible with the averaging period of the NAAQS and Wyoming AAQS. There is not a Wyoming AAQS for 1-hour NOx and 1-hour SOx, so the corresponding California AAQS were used for comparison. All other toxics and chemicals were modeled on 1-hour and annual averaged periods. The maximum impact of each pollutant is shown in Table 3 with the NAAQS and Wyoming AAQS.

The maximum 1-hour averaged impact of all the pollutants was predicted to occur to the east of the crematory stack, on the south central portion of the fenceline. Figure 5 shows the 1-hour averaged emission concentration isopleth for mercury. Figure 6 shows the 1-hour averaged emission concentration isopleth for NOx, and the maximum impact points

are indicated as a red star symbol on both figures. The trend of the isopleths for 1-hour averaged concentrations of all pollutants is similar to what is shown in Figures 5 and 6.

The maximum 3-hour averaged impact of SOx occurred north of the crematory stack, at the northwest portion of the fenceline on W. Walnut St. Figure 8 shows the 3-hour averaged emission concentration isopleth for SOx and the maximum impact points are indicated as a red star symbol.

The maximum annual averaged impact of all the pollutants occurred northeast of the crematory stack, at the northeast portion of the fenceline on W. Walnut St. Figure 7 shows the annual averaged emission concentration isopleth for NOx, Figure 9 shows the annual averaged emission concentration isopleth for cadmium, and the maximum impact points are indicated as a red star symbol on both figures. The trend of the isopleths for the annual averaged concentrations of all pollutants is similar to what is shown in Figures 7 and 9. The maximum 24-hour averaged impact of PM10 and SOx also occurred at the same location that the maximum annual averaged impact occurred.

For the toxic pollutants such as arsenic, cadmium, chromium, mercury, nickel, dioxin/furan and HCl, the annual averaged concentrations were predicted and compared with the annual preliminary remediation goal (PRG) for ambient air for EPA Region 9.

The 1-hour averaged concentrations of arsenic, chromium, nickel, and dioxin/furans were predicted by the model, but the annual averaged concentrations of these pollutants were not quantified because they were less than the model's minimum calculation limit of 0.00001 (0.1E-05). Even though the annual averaged concentration is shown as 0.00000 in the model output, this value is not actually zero. Therefore, the annual averaged concentrations of these pollutants were extrapolated from the 1-hour averaged concentrations. The ratio of the other pollutants' 1-hour average to their annual average was found to be 30. By applying this ratio to the 1-hour averaged concentration of arsenic, chromium, nickel, and dioxin/furans, the annual concentrations were found to be 3.33E-07 $\mu g/m^3$, 3.33E-07 $\mu g/m^3$, 3.33E-07 $\mu g/m^3$, 1.0E-06 $\mu g/m^3$ rather than 0.00000 $\mu g/m^3$ respectively.

Annual Cadmium and Dioxin/Furan concentrations exceed the PRG significantly by 205% and 2200%, respectively.

Table 3. Comparison of Maximum Predicted Impact of crematory emissions with the NAAQS, Wyoming AAQS, and Annual Preliminary Remediation Goal of EPA Region 9

Pollutant	Avg. Period	Primary NAAQS	Secondary NAAQS	Wyoming AAQS	Annual Preliminary Remediation Goal (EPA Region 9)	Model Predicted Impact	Percent of Model Predicted Impact to Standard
Unit	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(%)
PM10	24-hour	150	150	150		16.07	10.71%
	Annual	50	50	50		4.84	9.68%
NOX	1-hour	NA	NA	470 (California AAQS)		203.70	43.34%
	Annual	100	100	100		6.67	6.67%
SOX	1-hour	NA	NA	655 (California AAQS)		300.56	45.89%
	3-hour	NA	1300	1300		138.81	10.68%
	24-hour	365	NA	260		30.67	11.80%
	Annual	80	NA	60		9.85	16.42%
CO	1-hour	40000	NA	40000		140.05	0.35%
	8-hour	10000	NA	10000		35.73	0.36%
VOC	1-hour					63.36	
ARSENIC	Annual				0.00045	3.33E-07 (Estimated Value from Annual)	0.07%
	1-hour				NA	0.00001	*2.22% (Annual Standard Applied)*
CADIMUM	Annual				0.0011	0.00226	*205%*
	1-hour				NA	0.06908	*6280% (Annual Standard Applied)*
LEAD	Annual				NA	0.01364	
	1-hour				NA	0.41624	
CHROMIUM	Annual				0.000023	3.33E-7 (Estimated Value from Annual)	1.44%
	1-hour				NA	0.00001	*43.48% (Annual Standard Applied)*
MERCURY	Annual				0.31	0.00806	2.6%
	1-hour				NA	0.246	*79.35% (Annual Standard Applied)*
NICKEL	Annual				0.008	3.33E-7 (Estimated Value from Annual)	0.004%
	1-hour				NA	0.00001	*0.13% (Annual Standard Applied)*
COPPER	Annual				NA	0.00001	
HCL	Annual				21	5.48468	26.12%
	1-hour				NA	167.38	*797.05% (Annual Standard Applied)*
HF	Annual				NA	0.00012	
Dioxin/Furan	Annual				14 4.5E-08	1.0E-06 (Estimated Value from Annual)	2200%
	1-hour				NA	0.00003	66667% *(Annual Standard Applied)*

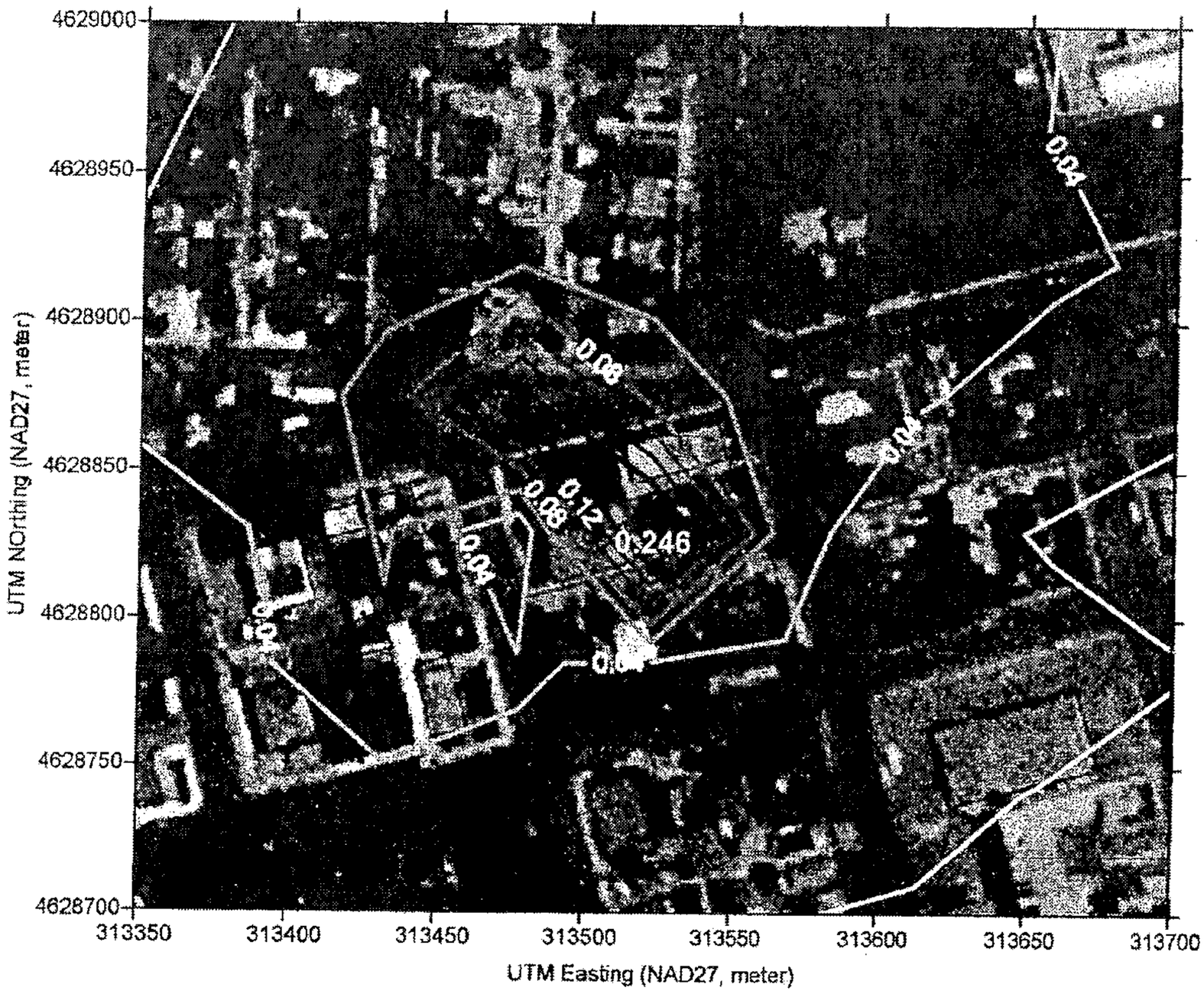

Figure 5. Isopleth of 1-hour averaged Mercury Impact (Max: 0.246 $\mu g/m^3$)

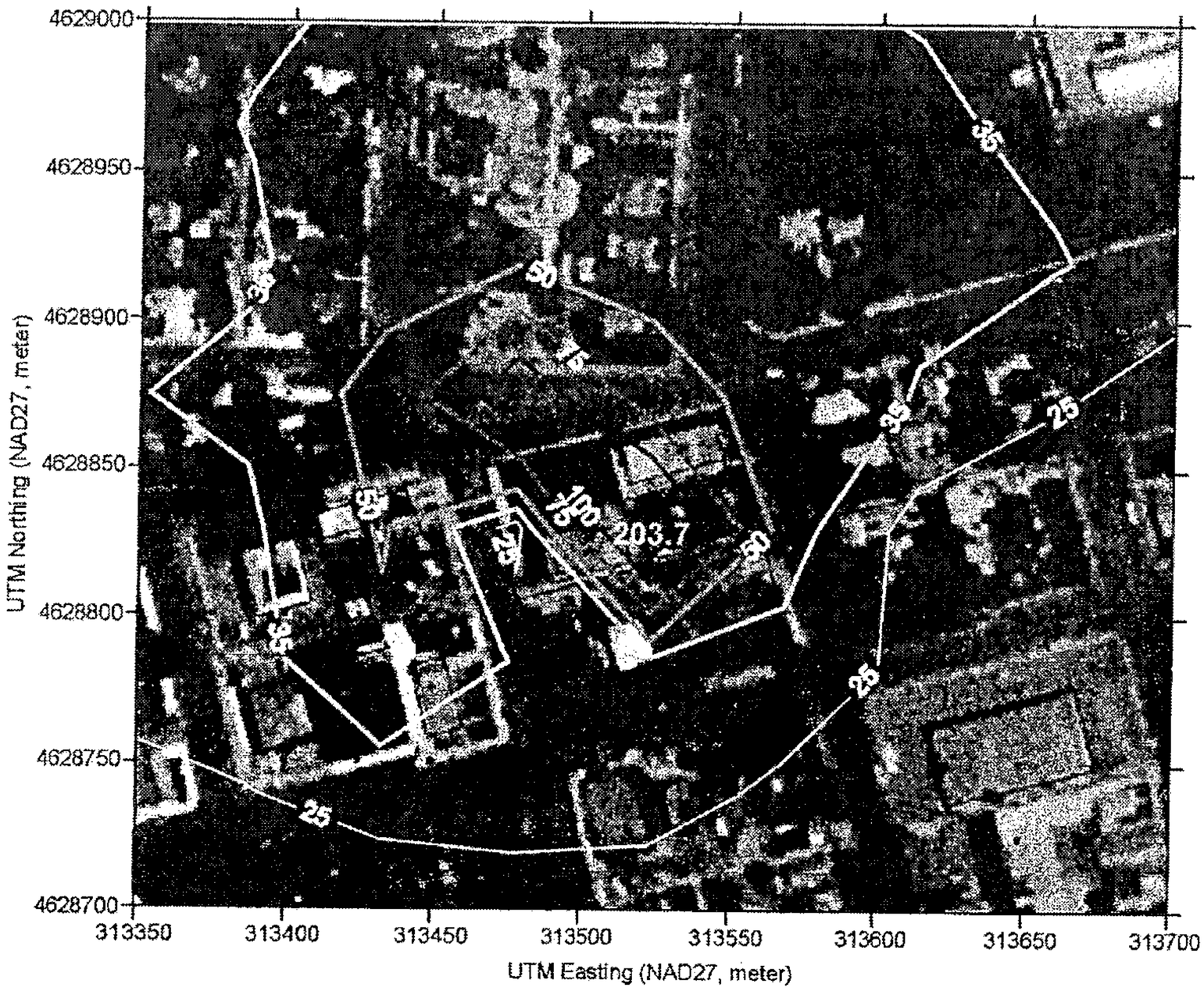

Figure 6. Isopleth of 1-hour averaged NOx Impact (Max: 203.7 $\mu g/m^3$)

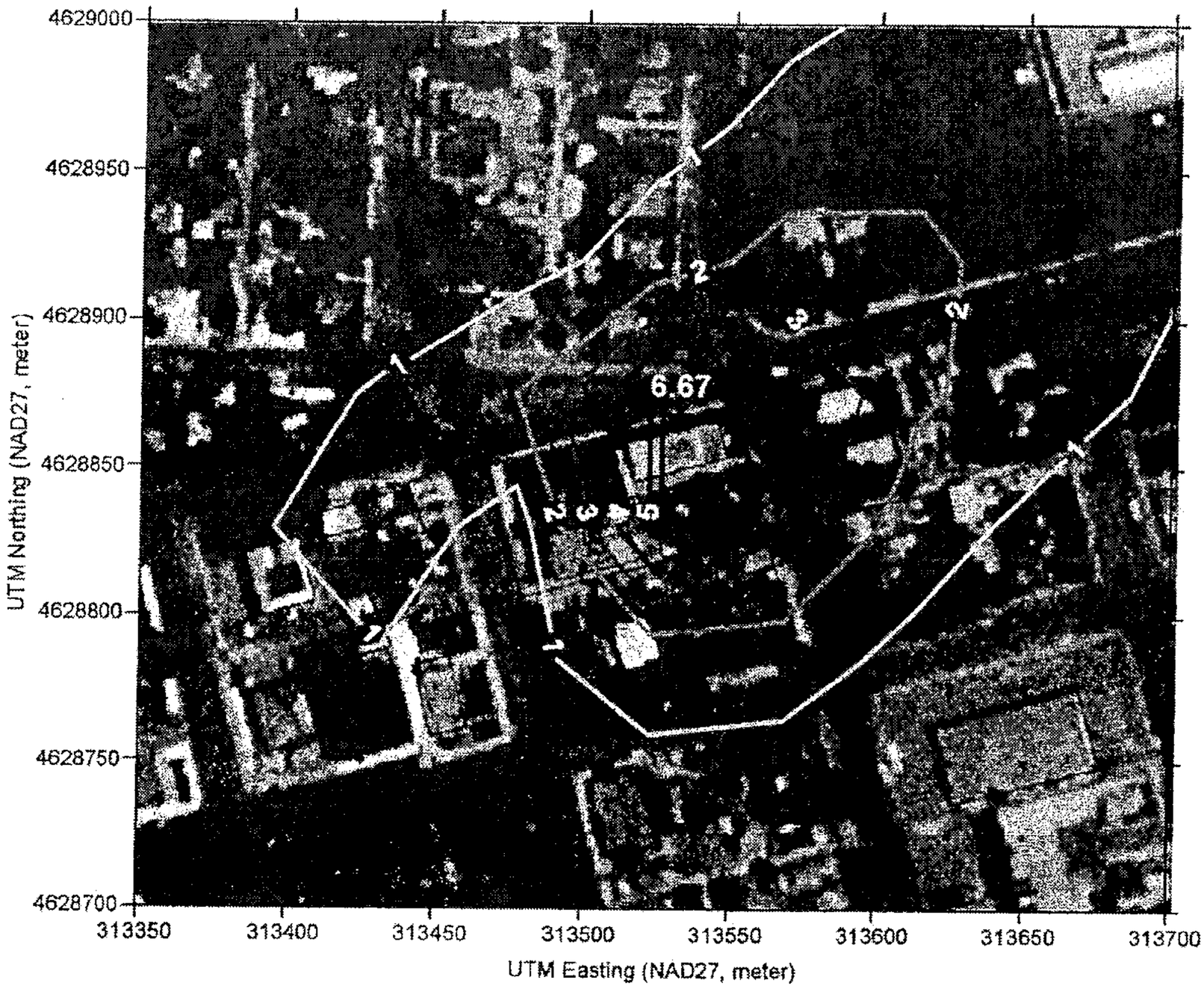

Figure 7. Isopleth of Annual Averaged NOx Impact (Max: 6.67 $\mu g/m^3$)

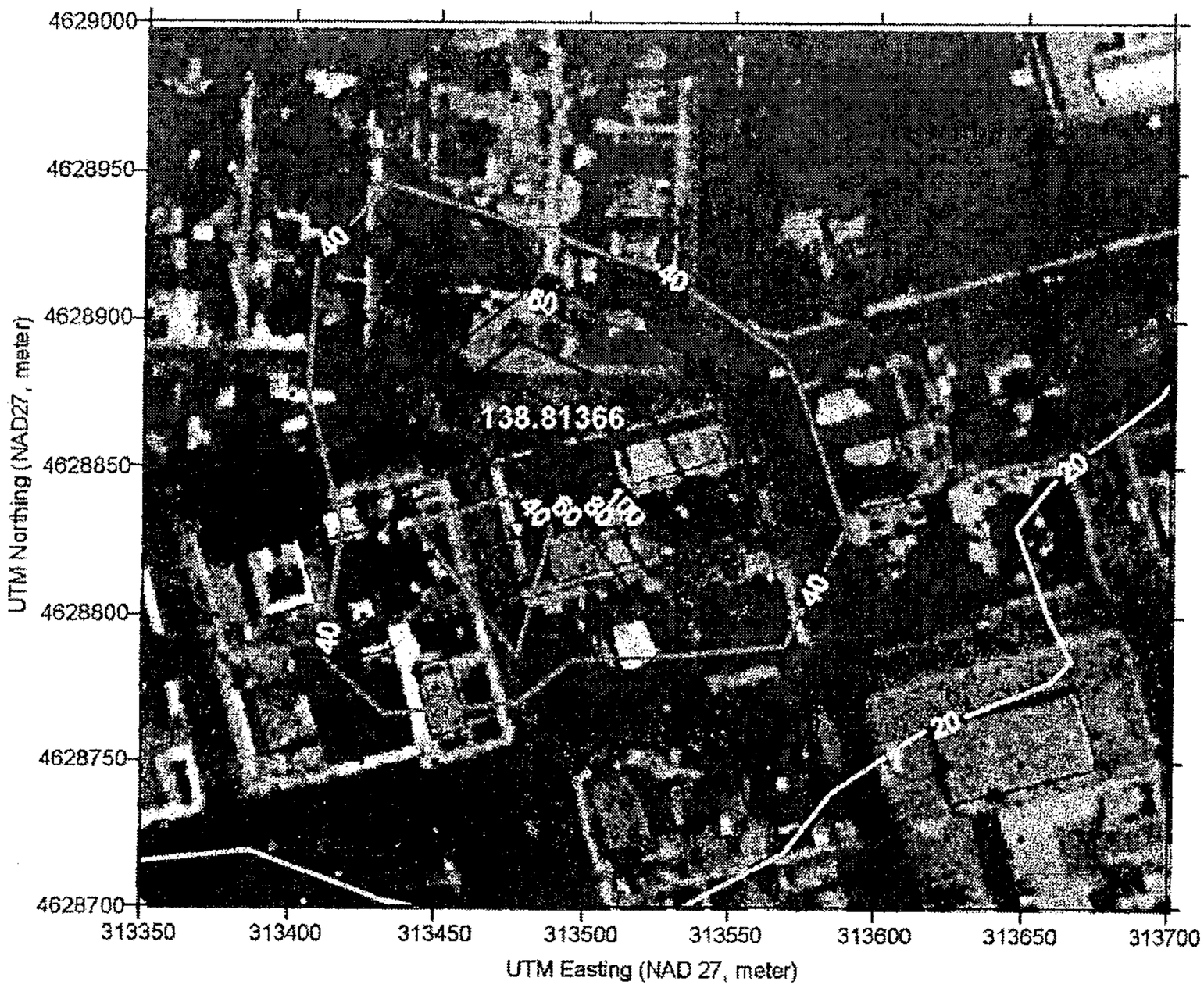

Figure 8. Isopleth of 3-hour Averaged SOx Impact (Max: 138.81 μg/m^3)

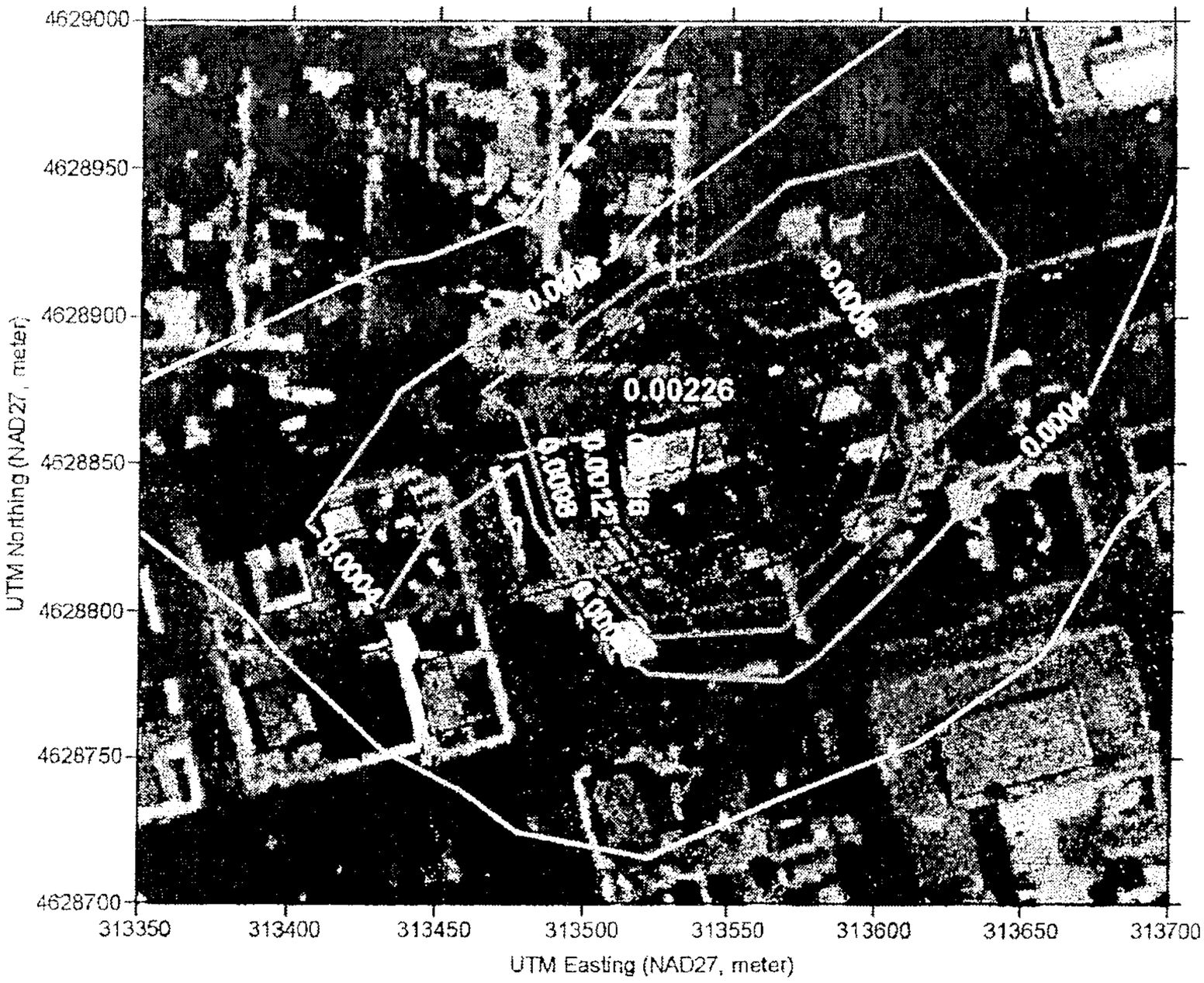

Figure 9. Isopleth of Annual Averaged Cadmium Impact (Max: 0.00226 μg/m^3)

7 References

1. Environment Canada, Emission Inventory Guidebook-Cremation Activity 090901, September 1999

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