SeaWorld
ADVENTURE PARK
San Diego

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November 28, 2007

VIA HAND DELIVERY

John R. Odermatt
Senior Engineering Geologist
California Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, California 92123-4340

Re: *Reference No. 12-00083.01: Tentative Addendum No. 1 to Order No. R9-2005-0091, NPDES No. CA0107336; For the Discharge of Waste from Sea World Aerial Fireworks Displays to San Diego Mission Bay, San Diego*

Dear Mr. Odermatt:

This letter provides Sea World's comments on the draft Tentative Addendum No. 1 to Order No. R9-2005-0091 (herein, "draft Order"). In addition, we have enclosed a redlined version of the draft Order that contains some of our suggested changes:

1. **Recital No. 1:**

There is a typographical error in the date of December 7, 2007. It should be December 7, 2006 (see our redline of the draft Order).

2. **Recital No. 2:**

This recital does not include a description of the dimensions of the shells – generally 3-inch and 4-inch – and it does not include the mass of the fireworks used at Sea World. The average total weight of firework related materials that are used in the daily shows at Sea World is only 129 kilograms ("kg") and the annual July 4th show is only 993 kg. Our daily fireworks shows are relatively small compared to other productions in Southern California and even our

4th of July show is small compared to other 4th of July fireworks shows[1]. Our redline of the draft Order contains those additional descriptions.

3. **Recital No. 3:**

This recital includes perchlorate as a "typical fireworks constituent," even though it was not referenced that way on page 2-2 of the Report of Waste Discharge ("ROWD"). It is true that for some fireworks, potassium perchlorate is the oxidizer, but for others it is not. For example, potassium nitrate is a more common oxidizer in Sea World fireworks than potassium perchlorate. *See*, Appendix A to *An Analysis of the Fireworks Used at Sea World/San Diego,* by John Conkling (January 10, 2007) and attached to our January 18, 2007 submittal to the Regional Board (hereafter, "Conkling Report").

There is also a typographical error and the word "water" should be added in front of "quality" in the second paragraph (see our redline of the draft Order).

4. **Recital No. 4:**

In addition to the use of hand held fishnets to collect any floating firework debris after the show, there is a boom with a net off the bow of the boat that is also used to collect debris. A description of this is included in our redline of the draft Order.

5. **Recital No. 5:**

We suggest slight word changes to this recital in the attached redline of the draft Order.

6. **Discharge Prohibitions Paragraph I:**

This discharge prohibition appears to suggest that even a *de minimis* amount of "settleable material or substances" could be prohibited from being discharged. Yet, very small amounts of fireworks debris will undoubtedly be discharged into Mission Bay despite the recovery efforts of the sweeps after each show. We anticipate these discharges will be very minor in mass and consist of small particles of uncombusted paper and some deposition of the products of combusted fireworks. *See, e. g.*, the attached report prepared by Brown and Caldwell, *Air Quality Dispersion Modeling analysis of Chemical Residues from the Fireworks*

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1 Just by way of comparison, our 4th of July show is less than a tenth of the size of the Boston Pops Fourth of July show over the Charles River (at some 8,000 kg), and it is miniscule compared to the annual Macy's Fourth of July show over the East River (some 35,000 12 inch diameter-plus shells) and the Thunder over Louisville, annual Fourth of July Kentucky Derby show of some 60 tons of fireworks (around 55,000 kg).

displays at Sea World of San Diego (Sea World), California (November 20, 2007) (hereafter, the "Brown and Caldwell Dispersion Report").

We understand this prohibition to be focused on any degradation of benthic communities or aquatic life given that the monitoring program that is in the draft Order is designed to evaluate whether there is any degradation of benthic communities or aquatic life. If no such degradation is found, then we presume this condition is met even though there are small amounts of material that settle in Mission Bay.

7. **<u>Discharge Prohibitions Paragraph J</u>:**

This prohibition would limit fireworks shows to Easter through Labor Day and New Year's Eve, and not to exceed 150 days per year. Sea World already operates with a 150 day per year restriction that was part of its Master Plan approval by the City of San Diego in 2001. However, under that approval, Sea World is not limited to only evenings between Easter and Labor Day plus New Year's Eve. Sea World typically allocates some of its 150 days per year for evenings during the Spring Break time period, which generally predates Easter. There should be no different water quality impact due to firework shows before or after Easter (or Labor Day for that matter), so we request that this restriction be changed to be consistent with the provisions in the Sea World Master Plan approval, which would permit shows up to 150 days per year, but would not restrict the time of the year that those shows could take place. Our redline of the draft Order would accomplish that.

8. **<u>Monitoring and Reporting Program Paragraph F.1. (years of sampling)</u>:**

Sea World's understanding of this paragraph is that it requires a three year extensive monitoring effort for calendar years 2008, 2009 and 2010, but that the monitoring program will cease after those three years. We understand that the point of the extensive monitoring program is to further study the effects, if any, of Sea World's fireworks shows on the water quality of Mission Bay. However, if the results of this three year monitoring program demonstrate that there is no degradation of the water quality in Mission Bay, then our understanding is that this extensive monitoring program will stop. Please advise us if that understanding is incorrect.

9. **<u>Monitoring and Reporting Program Paragraph F.2. (water quality sampling locations):</u>**

Sea World's understanding of Paragraph F. 2. is that it provides a generic description of where the Regional Board wants water and sediment sampling points, but that the specific sampling locations that will satisfy this general criterion are contained in the other paragraphs of Section F. In other words, we do not read this paragraph to require any sampling locations other than those that are specified elsewhere in the draft Order. Please advise us if that understanding is incorrect.

10. Monitoring and Reporting Program Paragraph F.3. (water quality sampling locations):

This section of the draft Order identifies four water quality sampling locations, with RSW-001R being the "Reference Station." The three other sampling locations are located in reference to the "Fireworks Deposition Zone" which is defined as "the aerial extent of fireworks particles and/or debris created by a single fireworks display within the tidal influence of Mission Bay waters." The enclosed Brown and Caldwell Dispersion Report contains the results of dispersion modeling of the deposition of various firework constituents and shows that under standard meteorological conditions, most of the predicted post combustion fireworks particles will deposit on land to the northeast (Fiesta Island) and southeast (mainland along South Mission Drive) of the barge where the fireworks are shot from. Therefore, we suggest that the specific locations for all four sample points be identified, with GPS coordinates, in advance of any sampling after discussion between the Regional Board's staff, Sea World and Brown and Caldwell and that this identification be done at the beginning of each of the three calendar years, 2008, 2009, and 2010. That will allow the parties to relocate any sample point that may need to be moved based on historical experience. Note that for RSW-002, it suggests that this sampling location is to be in the "center of the deposition zone as determined after each event." Since sampling is only going to occur semiannually, there is no need to make a daily determination of the center of the deposition zone after each event and we suggest that this language be stricken from the draft Order. We have done so in the attached redline.

11. Monitoring and Reporting Program Paragraph F.4.:

The list of water quality constituents in Table X[2], as well as the list for sediment quality constituents in the next section F. 5 of the draft Order, is very long and contains many compounds that were identified only as potential and/or trace ingredients in fireworks, but were either not detected by Sea World in its water and sediment monitoring prior to submitting the ROWD, or were only detected in trace concentrations in just a few samples. Further, many of these compounds can come from multiple alternative sources other than fireworks and can be found in most water bodies located in or near developed areas. Finally, the Brown and Caldwell Dispersion Report confirms that the likely deposition of fireworks related materials will range from non-detectable to trace levels of only those firework constituents present in the highest concentrations. For these reasons, water and sediment samples should not be analyzed for certain compounds – previous water and sediment sampling has shown little or no presence of

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[2] Table X is Water Quality Monitoring Requirements and is found under section F. 4. Section F. 5. contains sediment sampling requirements and contains what appears to be an identical table but it is not labeled.

combustion; and (2) the EPA-approved Open Burn/Open Detonation Model ("OBODM") recommended by EPA for modeling the emission from ground-level explosions of lift charges or aerial propellants. Both models predict rates of deposition given model inputs about the source emissions profile, and other physical parameters.

The result of the Brown and Caldwell Dispersion Report analysis is that deposition of metals and other compounds from both elevated aerial firework displays and the ground level propelling charges range from below the threshold limits that the model can even predict to very low amounts. Just by way of example, the conservative (i.e. overestimating) ISCST3 model predicts that for a regular summer evening fireworks show, only something like a total of 9 grams of potassium perchlorate[3] would be deposited over the ground within a quarter mile radius of the center of the fireworks show (note that some of that 9 grams would be deposited upon land – either Fiesta Island or the mainland). For the metal compounds like copper, magnesium, and titanium, the conservatively predicted amounts are even less and in some cases far less reflecting the smaller amounts of metals in a fireworks show when compared to the mass of the oxidizers. The bottom line is that the model predictions of very small to immeasurable amounts of deposited fireworks residue onto land or water are consistent with the five years of data collected by SAIC from sediment and water samples, and the more recent Brown and Caldwell data indicating that one can find almost no trace of fireworks related metals or other compounds in either water or sediment in and around Mission Bay.

As a result of the already extensive data collected and modeling already completed – both of which tell a very consistent story that Sea World's aerial fireworks displays have no impact on the water quality of Mission Bay – we question why three more years of extensive water and sediment chemistry data collection and analysis should be required. The list of analytes in the draft Order contains nearly every compound referenced anywhere in the ROWD as a possible ingredient in fireworks whether or not (1) it actually exists in the fireworks used by Sea World; (2) it is only present in trace or non-detectable amounts in the fireworks debris collected; (3) has ever been found in elevated levels in water or sediments in or around the fireworks deposition area; or (4) it is believed to be a toxic pollutant. This massive data collection effort is

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[3] This was calculated by starting from Appendix A of the Conkling Report which indicated that in a typical daily show, potassium perchlorate makes up some 15.5% of the total mass of fireworks materials. Conkling estimated that the total mass of a daily fireworks show is around 284 pounds (page 2). Therefore, the total amount of potassium perchlorate in a daily fireworks show is only about 44 pounds (.155 x 284 pounds). The Brown and Caldwell Dispersion Report predicts that around .05%, or .0005 of the potassium perchlorate is deposited within a quarter mile of the source (Table 4). Therefore, only about 9 grams of potassium perchlorate is predicted to be deposited (.0005 x 44 poundsx454 grams per pound) within a quarter mile of the source in a daily show.

sediment chemistry data collection and analysis should be required. The list of analytes in the draft Order contains nearly every compound referenced anywhere in the ROWD as a possible ingredient in fireworks whether or not (1) it actually exists in the fireworks used by Sea World; (2) it is only present in trace or non-detectable amounts in the fireworks debris collected; (3) has ever been found in elevated levels in water or sediments in or around the fireworks deposition area; or (4) it is believed to be a toxic pollutant. This massive data collection effort is unwarranted given the already substantial amount of information which only confirms that the fireworks do not have even a detectable, much less adverse, effect on Mission Bay water and sediment quality.

The first category of compounds that should be deleted from both water and sediment quality monitoring are the semi-volatile organic compounds ("SVOCs"):

BIS (2-Ethylhexyl) Phthalate	Di-N-Butylphthalate
Di-N-Octylphthalate	Diethylphthalate
Dimethylphthalate	Phenol
Naphthalene	2,4-Dinitrotoluene
2,6-Dinitrotoluene	

None of these SVOCs are present in Sea World's fireworks in any substantial amounts. Appendix A to the Conkling Report makes clear that none of these compounds are present in Sea World fireworks at percentages greater than one tenth of one percent, if they are present at all. The ROWD in Appendix E, Table 2 indicated that only trace amounts of just *some* of these compounds (typically, just the BIS (2-Ethylhexyl) Phthalate and the Di-N-Butylphthalate) were found in the recovered fireworks debris and none of the grab or composite water samples taken in the fireworks deposition zone was ever found to have any of these compounds except nearly undetectable levels of BIS (2-Ethylhexyl) Phthalate found in only two composite and one grab water sample. It makes no sense to continue to collect substantial quantities of data for compounds for which there is no demonstrated nor anticipated expectation of their being present in the water or sediments[4] as a result of Sea World's fireworks shows.

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[4] Note that for the sediment samples collected as part of the ROWD, only one sample had a detectable level of one of the SVOCs, Sample SS-3, and that value was reported to be between the method detection limit and the reporting limit and therefore just barely detectable and only an estimated value.

The second category of compounds that should be deleted from water and sediment quality monitoring are the explosives:

2,6-DNT	2,4,6-Trinitrotoluene
Nitrobenzene	Tetryl
RDX	

None of the explosives are present in Sea World's fireworks in any substantial amounts as Appendix A to the Conkling Report makes clear. Further, Table 3, Appendix E to the ROWD shows that most of these explosive compounds were not detected in the fireworks debris collected after the shows. Finally, *none* of these compounds was found in *any* grab or composite water samples taken in the fireworks deposition zone after the fireworks shows, nor in any of the sediment samples taken.

The third category of compounds that should be deleted from both water and sediment quality monitoring are the following metals:

Beryllium	Cadmium
Mercury	Molybdenum
Selenium	Silver
Thallium	Tin

Again, none of these metals are present in Sea World's fireworks in any substantial amounts (reported in Appendix A to the Conkling Report), they have not been detected in any substantial concentration in the analyses of fireworks debris (reported in Table 3, Appendix E to the ROWD), nor are they standard aerial fireworks chemicals (reported in Table 2.1 of the ROWD). There is therefore no basis for testing for these metals as if they were somehow related to Sea World's fireworks. For example, if molybdenum were found in water or sediment samples, that finding could not be related to Sea World's fireworks, so there is no reason to include it in the monitoring program.[5]

Finally, and for the same reasons, "total nitrogen" should be deleted from both water and sediment quality monitoring. Nitrogen has not been identified as an ingredient in fireworks in

[5] Note that even if the monitored metals are found in water or sediment samples, that does not necessarily mean they are from Sea World's fireworks.

general, or a chemical of concern related to Sea World's fireworks in particular. There is therefore no reason to include it in the monitoring program.

Therefore, Sea World requests that the SVOCs, the explosive compounds, the identified metals, and total nitrogen be deleted from the monitoring requirements for both water quality and sediments.

12. Monitoring and Reporting Program Paragraph F.5.:

See our comments in Section 11 immediately above.

13. Monitoring and Reporting Program Paragraph F.6. (infauna monitoring):

As a general matter, there does not appear to be any basis for including the benthic infauna monitoring plan. The apparent (although not explicit) purpose of collecting this data is to test the hypothesis that deposition of chemicals from Sea World's fireworks may have adversely affected benthic infauna in Mission Bay. Yet, if that were the hypothesis, it would have to be based upon some evidence that the levels of fireworks chemical constituents are elevated in the water or sediments in the fireworks deposition zone as compared with other areas in Mission Bay. The available data do not support this assumption, as noted in Finding No. 5. While Sea World is willing to conduct some additional water and sediment sampling to confirm whether its fireworks have caused a meaningful difference in water or sediment quality, that step must be taken first before any valid study of the affect of fireworks on benthic infauna can be designed, much less conducted. If there is no material difference in water or sediment quality as a result of fireworks related chemical deposition into Mission Bay, then there would be no basis for a benthic infauna study – i.e., we would not be able to define suitable study and control areas for further comparison. Any measured difference among benthic infauna in Mission Bay would be descriptive only and could not be linked to Sea World's fireworks. On the other hand, if one or more differences are found in water or sediment quality that are believed to be caused by Sea World's fireworks, then that may serve as a basis for studying whether there are any resulting differences in the benthic infauna in those areas as well that could be related to the chemical differences.

The proposed monitoring plan in the draft Order reflects the fact that there is no basis for a study of potential affects of fireworks on benthic infauna. We presume that the requirement of sampling from ten "randomly selected" locations is intended to provide a control group to be used for comparison against the samples taken from the fireworks deposition zone. However, given the available data showing no adverse impact on sediments or water quality, it isn't clear whether any randomly selected locations would provide a valid control group for study. Accordingly, any measured difference will not necessarily be due to fireworks, and such a conclusion could not be made. Also, the locations are to be selected using the United States Environmental Protection Agency's ("USEPA") Probability Environmental Monitoring and

Assessment Program. The objectives of that program may not be sufficient to select proper control groups for answering questions regarding possible affects from fireworks. Further research and information, including the additional water and sediment sampling plan results, are necessary to identify the relevant variables, if any, that should be taken into account in the selection of control locations – a necessity for a valid study. Once that information is known, it may be necessary to alter the method for selecting sample locations to be used as controls.

For these reasons, Sea World recommends completing the three-year water and sediment quality monitoring and reporting programs set forth in Paragraphs F.4 and F.5, and then evaluating whether there is any basis for conducting a study of potential affects of fireworks on benthic infauna. Without any evidence that there is a difference in the water or sediment quality in the fireworks deposition area - which is the case today - then any measured difference in the benthic infauna in that area could not be attributed to fireworks, which defeats the purpose of doing the study in the first place. There certainly is no basis to simply have Sea World collect benthic infauna data, which is all that would be accomplished given what is currently known.

In addition to these general comments, and in the event that the Regional Board does not change the current benthic infauna monitoring in the draft Order, we offer the following specific comments to address some of the ambiguities in this part of the draft Order. The benthic infauna monitoring plan requires sampling at three locations within the fireworks deposition zone and in the "area of greatest potential impact." The text then suggests that those three locations will be sampled twice per year, but it is not completely clear that it is the same three locations. We have added clarifying language in the redline of the draft Order to avoid that ambiguity.

The benthic infauna monitoring plan further requires that ten additional locations be sampled once per year. As discussed above, while the draft Order does not state that the objective of the sampling is to compare the parameters of the benthic community in the "area of greatest potential impact" beneath the fireworks deposition zone with the ten randomly selected locations, we presume that is the intent. If so, then the ten randomly selected locations must not include the fireworks deposition zone. We have added language in the redline of the draft Order to make that clear. We have also changed the terminology of "station" to "location" for internal consistency.

Similarly, we presume that some sort of statistical analysis will be used to determine whether there is a statistically significant increase or decrease in the parameters being measured between the benthic organisms beneath the "area of greatest potential impact" and the other randomly selected locations, but that methodology is not identified in the draft Order. We presume that Sea World's technical consultants will be expected to perform the required statistical analysis using appropriate methods. If that is not the case, the methods the Regional Board intends to use should be made available for comment.

Finally, according to the draft Order, the selection of the ten locations is to be done each year by USEPA using its Probability Environmental Monitoring and Assessment Program. It is not clear from the wording of the draft Order whether the Regional Board actually intends for USEPA to undertake this effort each year. We understand from discussions with staff that the intent is for Sea World to run the program and to provide the output to the Regional Board for their approval and that we will not need to involve staff at USEPA. We have redlined the attached draft Order accordingly to make that clear.

14. Monitoring and Reporting Program Paragraph F.8.:

This section suggests that an 8 1/2 " by 11 " aerial map "shall be prepared for each sampling event." Since Sea World will only be sampling semiannually, just twice per year, it makes no sense to prepare a fireworks deposition map for every event. The Brown and Caldwell Dispersion Report provides a far more accurate prediction of the likely deposition of fireworks combustion products and should be used to help Sea World, the Regional Board staff and Brown and Caldwell to come up with a likely Fireworks Deposition Zone and related sampling locations on an annual basis as suggested above.

Very truly yours,

Andrew Fichthorn

AF/hhk
Enclosure

cc: Douglas Eberhardt, USEPA
Nancy Yoshikawa, USEPA Region IX
Kevin Carr, Sea World San Diego
Ellen Lirley, California Coastal Commission

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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN DIEGO REGION

TENTATIVE ADDENDUM NO. 1 TO
ORDER NO. R9-2005-0091, NPDES NO CA0107336
FOR THE DISCHARGE OF WASTE FROM
SEA WORLD AERIAL FIREWORKS DISPLAYS TO SAN DIEGO MISSION BAY
SAN DIEGO

The California Regional Water Quality Control Board, San Diego Region (hereinafter Regional Board) finds that:

1. On October 26, 2006, Brown and Caldwell submitted an incomplete report of waste discharge (RWD) on behalf of SeaWorld, San Diego for the discharge of waste to Mission Bay associated with their fireworks program. Additional information was requested on December 7, 2006 and received on January 19, 2007 to make the application complete.

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2. The RWD indicates that nightly displays of fireworks occur during the summer months between April and September and other times during the year. Under the current Sea World Master Plan update, approved by the California Coastal Commission in 2001, Sea World may present up to 150 fireworks shows per year, with an anticipated average between 110 and 120 shows per year.

   The fireworks are launched from a barge located in the Pacific Passage Zone of Mission Bay, between Fiesta Island and the Sea World Shorelines. The average fireworks show lasts 5 to 6 minutes and dispenses approximately 250 shells (3-inch and 4-inch); special events, such as the 4th of July and New Year's Eve, may dispense between 1,000 and 1,750 shells (mostly 3-inch and 4-inch and some larger). The average total weight of firework related materials that are used in the daily shows at Sea World is only 129 kilograms ("kg") and the annual July 4th show is only 993 kg. These shows are relatively small compared to other productions in Southern California.

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   Sea World subcontracts the logistics of fireworks, operations, transportation, setup, ignition and cleanup and currently subcontracts that to Fireworks America, a licensed pyrotechnics company based in Lakeside, CA.

3. Typical fireworks constituents include aluminum, magnesium, strontium, barium, sodium, potassium, iron, copper, sulfate, nitrate and perchlorate. These constituents have a potential to adversely impact and/or contribute to degradation of water and sediment quality within Mission Bay.

   In addition, debris from unexploded shells as well as paper, cardboard, wires and fuses from exploded shells can also adversely impact water quality within

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Mission Bay. The area affected by these debris can vary depending on wind speed and direction, size of the shells, and other environmental and anthropogenic factors.

4. After each aerial fireworks display, crews conduct sweeps to gather floating debris from spent fireworks using handheld fishnets and a boom with a net off the bow of the boat. In addition, the fireworks barge is swept immediately after each show to prevent solid waste and debris from being swept into the water by the wind. Unexploded fireworks are disposed of by the fireworks subcontractor, who is currently Fireworks America. Fireworks debris deposited on Fiesta Island mainland is collected from the shorelines each morning following the aerial fireworks display. Solid waste typically consists of paper, paperboard or cardboard shells, and marginal amounts of wires and fuses.

   Data for wet and dry debris retrieved by Sea World staff since 2002 was reviewed and it was determined that, on average, 11 pounds of fireworks related wet debris were collected each evening and 8 pounds of wet debris each morning.

5. Sea World conducted annual fireworks related monitoring of sediment and water quality parameters between 2001-2006. The final monitoring report prepared for Sea World, by Science Applications International Corporation, concluded that there were no significant spatial or temporal patterns of key firework-related metals concentrations in sea water or sediments in Mission Bay. It was also concluded that there is no indication of fireworks residue accumulation in the water or sediment of Mission Bay.

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6. This action is exempt from the provisions of the California Environmental Quality Act (Public Resources Code, Section 21100 Et seq.) in accordance with California Water Code Section 13389.

7. This Regional Board has notified the Discharger and all known interested parties of the intent to amend Order No. R9-2005-0091.

8. This Regional Board in a public meeting has heard and considered all comments pertaining to the proposed discharge from the Sea World fireworks displays to Mission Bay.

IT IS HEREBY ORDERED, that Order No. R9-2005-0091 is amended as follows:

The following shall be added to Section III Discharge Prohibitions:

H. The discharge of waste from the aerial fireworks display shall not cause or contribute to the degradation of water or sediment quality in Mission Bay.

I. The discharge of waste from the aerial fireworks display shall be free of settleable material or substances that may form sediments, which will degrade benthic communities or other aquatic life.

J. Fireworks aerial displays shall be limited to a maximum of 150 fireworks aerial displays per calendar year.

Deleted: the following dates: Easter through Labor Day and New Year's Eve of each year and shall not to exceed

The following shall be added to Attachment A-Definitions:

Fireworks Deposition Zone: The aerial extent of fireworks particles and/or debris created by a single fireworks display within the tidal influence of Mission Bay waters.

The following shall be added to Section IX of the Monitoring and Reporting Program:

F. Fireworks Related Water Quality and Benthic Monitoring

1. Beginning in April 2008, the Discharger shall implement a fireworks monitoring program that will continue until September 2010.

2. To determine the level of impact to the receiving water and underlying sediment, the monitoring program shall document conditions of the vicinity of the receiving water discharge points, at reference stations, and at areas beyond the immediate vicinity of the discharge points where discharge impacts might reasonably be expected.

3. The following shall constitute the water quality monitoring locations:

Station Number	Location
RSW-001R	Area south of crown point shore and north of Vacation Isle shore **Reference Station**
RSW-001	Pacific Passage, 20 feet from the fireworks barge and in the direction of the fireworks deposition zone
RSW-002	Pacific Passage, center of the deposition zone
RSW-003	Pacific Passage, the outermost area of the fireworks deposition zone, at a point farthest away from the barge

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4. Water quality analysis shall be conducted at all stations for the following constituents:

Table X. Water Quality Monitoring Requirements

Constituent	Units	Type of Sample	Frequency[1]
BIS (2-Ethylhexyl) Phthalate	mg/l	Grab	Semiannually
di-N Butylphthalate	mg/l	Grab	Semiannually
di-N Octylphthalate	mg/l	Grab	Semiannually
Diethylphthalate	mg/l	Grab	Semiannually
Dimethylphthalate	mg/l	Grab	Semiannually
Phenol	mg/l	Grab	Semiannually
Constituent	**Units**	**Type of Sample**	**Frequency[1]**
Naphthalene	mg/l	Grab	Semiannually
2,4-Dinitrotoluene	mg/l	Grab	Semiannually
2,6-DNT	mg/l	Grab	Semiannually
2,4,6-Trinitrotoluene	mg/l	Grab	Semiannually
Nitrobenzene	mg/l	Grab	Semiannually
Tetryl	mg/l	Grab	Semiannually
RDX	mg/l	Grab	Semiannually
Aluminum[2]	mg/l	Grab	Semiannually
Antimony[2]	mg/l	Grab	Semiannually
Arsenic[2]	mg/l	Grab	Semiannually
Barium[2]	mg/l	Grab	Semiannually
Beryllium[2]	mg/l	Grab	Semiannually
Cadmium[2]	mg/l	Grab	Semiannually
Chromium[2]	mg/l	Grab	Semiannually
Cobalt[2]	mg/l	Grab	Semiannually
Copper[2]	mg/l	Grab	Semiannually
Iron[2]	mg/l	Grab	Semiannually
Lead[2]	mg/l	Grab	Semiannually
Manganese[2]	mg/l	Grab	Semiannually
Mercury	mg/l	Grab	Semiannually
Molybdenum[2]	mg/l	Grab	Semiannually
Nickel[2]	mg/l	Grab	Semiannually
Potassium[2]	mg/l	Grab	Semiannually
Selenium[2]	mg/l	Grab	Semiannually
Silver[2]	mg/l	Grab	Semiannually
Strontium[2]	mg/l	Grab	Semiannually
Thallium[2]	mg/l	Grab	Semiannually
Tin[2]	mg/l	Grab	Semiannually
Titanium[2]	mg/l	Grab	Semiannually
Vanadium[2]	mg/l	Grab	Semiannually

Zinc[2]	mg/l	Grab	Semiannually
Perchlorate	mg/l	Grab	Semiannually
Total Nitrogen	mg/l	Grab	Semiannually
Phosphorus	mg/l	Grab	Semiannually
Sulfate	mg/l	Grab	Semiannually

[1] Samples shall be collected and analyzed in January and July of each year. Semiannually means at least once during the months of January and July.

[2] All metals shall be reported as total and dissolved. Hardness as $CaCO_3$ shall also be analyzed.

5. **Sediment Characteristics.** The Discharger shall prepare a monitoring plan that identifies the locations of sediment monitoring. A minimum of 3 locations representative of the area of greatest potential impact and within the fireworks deposition zone shall be selected ("the sediment monitoring locations"). All sediment monitoring locations shall be approved by the Regional Board.

Sediment samples for chemical analysis shall be collected from the top 2 centimeters of the grab. Samples shall be analyzed for the constituents listed in table below. Sediment chemistry ambient monitoring may be conducted using USEPA approved methods, or methods developed by NOAA's National Status and Trends for Marine Environmental Quality. For chemical analysis of sediment, samples shall be reported on a dry weight basis.

Constituent	Units	Type of Sample	Frequency[1]
BIS (2-Ethylhexyl) Phthalate	mg/kg	Core	Semiannually
di-N Butylphthalate	mg/kg	Core	Semiannually
di-N Octylphthalate	mg/kg	Core	Semiannually
Diethylphthalate	mg/kg	Core	Semiannually
Dimethylphthalate	mg/kg	Core	Semiannually
Phenol	mg/kg	Core	Semiannually
Naphthalene	mg/kg	Core	Semiannually
2,4-Dinitrotoluene	mg/kg	Core	Semiannually
2,6-DNT	mg/kg	Core	Semiannually
2,4,6-Trinitrotoluene	mg/kg	Core	Semiannually
Nitrobenzene	mg/kg	Core	Semiannually
Tetryl	mg/kg	Core	Semiannually
RDX	mg/kg	Core	Semiannually
Aluminum[2]	mg/kg	Core	Semiannually
Antimony[2]	mg/kg	Core	Semiannually
Arsenic[2]	mg/kg	Core	Semiannually

Barium[2]	mg/kg	Core	Semiannually
Beryllium[2]	mg/kg	Core	Semiannually
Cadmium[2]	mg/kg	Core	Semiannually
Chromium[2]	mg/kg	Core	Semiannually
Cobalt[2]	mg/kg	Core	Semiannually
Copper[2]	mg/kg	Core	Semiannually
Iron[2]	mg/kg	Core	Semiannually
Lead[2]	mg/kg	Core	Semiannually
Manganese[2]	mg/kg	Core	Semiannually
Mercury	mg/kg	Core	Semiannually
Molybdenum[2]	mg/kg	Core	Semiannually
Constituent	**Units**	**Type of Sample**	**Frequency[1]**
Nickel[2]	mg/kg	Core	Semiannually
Potassium[2]	mg/kg	Core	Semiannually
Selenium[2]	mg/kg	Core	Semiannually
Silver[2]	mg/kg	Core	Semiannually
Strontium[2]	mg/kg	Core	Semiannually
Thallium[2]	mg/kg	Core	Semiannually
Tin[2]	mg/kg	Core	Semiannually
Titanium[2]	mg/kg	Core	Semiannually
Vanadium[2]	mg/kg	Core	Semiannually
Zinc[2]	mg/kg	Core	Semiannually
Perchlorate	mg/kg	Core	Semiannually
Total Nitrogen	mg/kg	Core	Semiannually
Phosphorus	mg/kg	Core	Semiannually
Sulfate	mg/kg	Core	Semiannually

[1] Samples shall be collected and analyzed in January and July of each year. Semiannually means at least once during the months of January and July.

[2] All metals shall be reported as total and dissolved. Hardness as $CaCO_3$ shall also be analyzed.

6. **Infauna.** The Discharger shall prepare a monitoring plan that identifies the locations of benthic infauna monitoring. A minimum of 3 locations representative of the area of greatest potential impact and within the fireworks deposition zone shall be selected ("the infauna monitoring locations"). All infauna monitoring locations shall be approved by the Regional Board.

   For analysis of benthic infauna, two replicate samples of bottom sediment shall be collected and analyzed in January and July from the infauna monitoring locations. The benthic infaunal samples shall be collected

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using a 0.1-square meter modified Van Veen gran sampler. These grab samples shall be separated from those collected for sediment analyses. The samples shall be sieved using a 1.0 millimeter mesh screen. The benthic organisms retained on the sieve shall be fixed in 15 percent buffered formalin, and transferred to 70 percent alcohol within 2 to 7 days of storage. These organisms may be stained using Rose Bengal to facilitate sorting. Infaunal organisms, obtained during benthic monitoring shall be counted and identified to as low a taxon as possible.

a. Number of species per 0.1-square meter
b. Total number of species per station
c. Total numerical abundance
d. Benthic Response Index (BRI)
e. Swartz's 75 percent dominance index
f. Shannon-Weiner's diversity index
g. Pielou eveness (J)

In addition to the community parameters, an annual evaluation shall be performed that includes more detailed statistical comparisons including community, temporal, and spatial analyses. Methods may include, but are not limited to, various multivariates, such as cluster analysis, ordination, and regression. Additionally analyses shall also be conducted, as appropriate, to elucidate temporal and spatial trends in the data.

An additional array of 10 randomly selected locations outside of the fireworks deposition zone shall be sampled and analyzed annually for sediment chemistry and benthic fauna. The same procedures must be followed as outlined in F.5 and F.6, with the exception of the number of samples collected at each location. Only one sample is required from each of the 10 randomly selected locations. The locations shall be reselected each year by Sea World using the methods set forth in USEPA's probability-based Environmental Monitoring and Assessment Program. The area shall extend throughout the Pacific Passage. All randomly selected locations shall be approved by the Regional Board.

The random benthic sampling requirement may be suspended as part of a resource exchange agreement to allow for participation in the Southern California BIGHT Regional Monitoring Surveys at the discretion of the Executive Officer. The benthic sampling may only be canceled for the year in which the BIGHT Survey is conducted.

7. The following information shall also be recorded during each sampling event: wind direction and speed; weather (cloudy, rainy, etc); tidal

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conditions; any other noteworthy water condition.

8. An aerial 8 ½ x 11 map that clearly outlines the fireworks deposition zone shall be prepared by Sea World each year and approved by the Regional Board.

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This addendum becomes effective on the date of adoption by the Regional Board.

I, John H. Robertus, Executive Officer, do hereby certify the foregoing is a full, true and correct copy of an Addendum adopted by the California Regional Water Quality Control Board, San Diego Region, on December 12, 2007.

TENTATIVE
JOHN H. ROBERTUS
Executive Officer

Date

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November 20, 2007

BROWN AND CALDWELL

Mr. Kevin Carr, Environmental Director
Sea World Environmental
500 Sea World Drive
San Diego, CA 92109 130872-005

Subject: Air Quality Dispersion Modeling Analysis of Chemical Residues from the Fireworks Displays at Sea World of San Diego (Sea World), California

Dear Mr. Carr:

Brown and Caldwell (BC) is pleased to present Sea World of San Diego (Sea World) our summary report for the air quality dispersion modeling analysis at Sea World of San Diego, California (the "Site"). The objective of this study was to examine the fate of the principal chemical residues created by commercial aerial fireworks displays at the Site. Specifically, the air quality dispersion modeling analysis was performed to evaluate if the chemical residues are deposited in Mission Bay or on land.

Background and Project Description

Sea World holds daily fireworks displays during Spring break and the summer months, with a special display for the July 4th holiday. The bulk of the fireworks (or aerial "shells") are launched from the fireworks barge located in Mission Bay on the southwestern side of Fiesta Island. Based on review of data included in two previous reports prepared by BC and an application for waste discharge for fireworks constituents, the California Regional Water Quality Control Board (RWQCB) had questioned whether chemical residues, particularly metals, were deposited in portions of Mission Bay adjacent to the barge. As part of the second report prepared by BC, a study from pyrotechnics expert Dr. John Conkling concluded that there is minimal deposition of chemical residues in the vicinity of the barge. Based on Dr. Conkling's professional opinion, most of the residues are transported long distances by the prevailing winds. To provide more definitive and quantitative estimates of chemical residue transport or deposition in the vicinity of the barge, Sea World commissioned BC to perform air dispersion modeling for representative particulate plumes created by the fireworks shows.

Modeling Approach

Our literature search for potentially relevant or similar studies did not identify useful information in terms of prior precedents for the air dispersion modeling of fireworks displays. Thus, BC developed the following dispersion modeling approach based on our prior modeling experience and discussion with regulatory modeling experts at local and state environmental agencies and the United States Environmental Protection Agency (US EPA).

The Industrial Source Complex – Short Term (ISCST3) Model, a previously-EPA-approved air dispersion model, was chosen to simulate the deposition of metal residues from aerial shell explosions. Although the AERMOD model was originally proposed for the study, AERMOD-ready meteorological data were not available, and thus ISCST3 was selected for the study. The Open Burn/Open Detonation Model (OBODM) was recommended by EPA for modeling the emission from ground-level explosions of lift charges or aerial propellants. Both models predict rates of deposition given model inputs about the source, emissions profile, and other physical parameters.

Sources

ISCST3 Model

For each scenario – the daily show and the July 4th show – there are numerous aerial fireworks shells fired, of differing types/colors. To simplify the modeling process, the shells were grouped by height of explosion. That is, all aerials set to explode at a certain height throughout a given show were combined into one equivalent shell. As indicated in Dr. Conkling's report, an aerial display shell will travel approximately 100 feet per inch-diameter of the shell (for example, a 3-inch diameter shell is designed to burst at approximately 300 feet in the air). Thus, 4 sources were modeled for the daily show and 8 sources were modeled for the July 4th show, corresponding to the number of different shell diameter sizes present for each show.

Each source was modeled as a volume source. A volume source assumes that there is no velocity component associated with a uniform discharge of emissions from the source. Although each source was assumed to be 100 feet in diameter, ISCST3 cannot model spherical sources. Thus, each source was modeled as a square block 100 feet on each side.

OBODM

For ground-level lift charges, all explosions were modeled as a single equivalent, instantaneous explosion, since all explosions occur at ground level. However, because OBODM can only model one pollutant at a time, the model was run once for each pollutant for each show.

Emissions Data

ISCST3 Model

The air pollutants modeled consisted of the metals presented in Dr. Conkling's report, using the most inclusive definition. Thus, the metals and compounds modeled included potassium (K) in the form of potassium perchlorate ($KClO_4$) and potassium nitrate (KNO_3); barium (Ba) in the form of barium nitrate ($BaNO_3$); copper (Cu) in the form of copper(II) oxide (CuO); magnesium (Mg) and aluminum (Al) in the form of magnalium (Mg/Al), a magnesium-aluminum alloy; Al its pure metal form; strontium (Sr) in the form of strontium carbonate ($SrCO_3$); and titanium (Ti) in its pure metal form.

These emission constituents were modeled as particles as opposed to gases. It is because of this that modeling of deposition by gravitational settling (also termed dry deposition) is possible. Deposition is a function of the particle diameter, size distribution, and particle density, all of which contribute to the deposition velocity of a modeled particle.

Emissions data were taken from Dr. Conkling's report. The model's HROFDY flag was set to be "on" for 9 PM for all days and scenarios modeled. When the HROFDY flag is set to be "on," the emissions profile is assumed to occur only at the specified times (in this case, 9 PM to 10 PM) to more accurately designate the meteorological conditions the emissions profile is likely to encounter. See Attachment A for details.

OBODM

The emission modeled with OBODM consisted primarily of constituents of combustion from the propelling charge of black powder -- KNO_3, sulfur (S), and charcoal, per Dr. Conkling's report. See Attachment A for details.

Terrain and Setting

The project site is located in flat terrain in an urban setting.

Source Data

Summaries of the source input data for the two models are presented in Tables 1 through 3. The calculation of deposition requires that certain parameters such as particle density be input to the models. To simplify this calculation, for each show an overall particle density was derived by calculating the mass-emissions-weighted average of the density of the pollutants of a given emission profile. See Attachment A for details, including weighted particle density calculations for each show.

Table 1. Model Input Data for Daily Show, ISCST3

Model Run	Horiz./Vert. Dim. (ft)	Release Height (ft above grade)	KClO4 (g/s)	KNO3 (g/s)	Mg/Al (g/s)	SrCO3 (g/s)	Ba(NO3)2 (g/s)	CuO (g/s)	Al (g/s)	Ti (g/s)
3-inch Shells	100	300	0.816	1.912	0.449	0.074	0.559	0.174	0.028	0.069
4-inch Shells	100	400	1.326	1.695	0.628	0.162	0.851	0.123	0.051	0.057
5-inch Shells	100	500	1.523	1.843	0.63	0.311	0.485	0.102	0.013	0.014
6-inch Shells	100	600	1.355	0.715	0.146	0.85	0.352	0.043	0.024	1.355

Table 2. Model Input Data for July 4th Show, ISCST3

Model Run	Horiz./Vert. Dim. (ft)	Release Height (ft above grade)	KClO4 (g/s)	KNO3 (g/s)	Mg/Al (g/s)	SrCO3 (g/s)	Ba(NO3)2 (g/s)	CuO (g/s)	Al (g/s)	Ti (g/s)
3-inch "salute" Shells	100	300	1.1978	0	0.9839	0	0	0	0.2139	0
3-inch Shells	100	300	6.945	2.1607	4.1413	0.8488	3.7812	1.8006	0.2829	0.6431
4-inch Shells	100	400	3.672	1.1424	2.1896	0.4488	1.9992	0.952	0.1496	0.34
5-inch Shells	100	500	3.06	0.952	1.8247	0.374	1.666	0.7933	0.1247	0.2833
6-inch Shells	100	600	3.6975	1.1503	2.2048	0.4519	2.0131	0.9586	0.1506	0.3424
8-inch Shells	100	800	0.78	0.2427	0.4651	0.0953	0.4247	0.2022	0.0318	0.0722

Table 2. Model Input Data for July 4th Show, ISCST3

Model Run	Horiz./Vert. Dim. (ft)	Release Height (ft above grade)	KClO4 (g/s)	KNO3 (g/s)	Mg/Al (g/s)	SrCO3 (g/s)	Ba(NO3)2 (g/s)	CuO (g/s)	Al (g/s)	Ti (g/s)
10-inch Shells	100	1,000	0.5513	0.1715	0.3287	0.0674	0.3001	0.1429	0.0225	0.051
12-inch Shells	100	1,200	0.9675	0.301	0.5769	0.1183	0.5268	0.2508	0.0394	0.0896

Table 3. Model Input Data for OBODM

	KNO3 (g/s)	Sulfur (g/s)	Charcoal (g/s)
Daily Show	24,446	3,260	4,889
July 4th Show	122,895	16,386	24,579

Receptor Locations

In both ISCST3 and OBODM, a receptor grid at a node density of 500 meters was used. Coverage of the modeling domain spans approximately 3,000 to 5,000 meters in all directions from the source.

Meteorology

Meteorological data for 1993 through 1995 from the Lindbergh Field (surface data from Lindbergh, Station 23188 and upper air data from Miramar, Station 93107) were selected based on consultation (anonymous) with the San Diego Air Pollution Control District (SDAPCD's) meteorology department. Three years instead of five years of meteorological data were modeled based on the discussions with SDAPCD. SDAPCD recommended that, based on their experience, a 3-year modeling period was sufficient and acceptable for health-risk analyses submitted to the SDAPCD.

Model Results

Model results from ISCST3 and OBODM are tabulated in Tables 4 and 5, respectively. For a given pollutant, percent deposition is calculated by multiplying the area of a one-quarter-mile-radius circle by the maximum predicted rate of deposition, then dividing by the total emissions. Figures in Attachment C graphically show the deposition rates of metal compounds from aerial shells from the daily show and July 4th show, respectively, as predicted by ISCST3. Detailed sample calculations as well as model run outputs may be found in Attachment D. As the data demonstrate, deposition of metals from both elevated aerial firework displays and the ground-level propelling charges range from below model threshold limits to very low amounts. Note that these values represent a conservative upper-bound or over-estimate, as oftentimes the point of predicted maximum deposition rate falls outside of the ¼ -mile radius. Refer to Attachment D for maximum modeled deposition rates by pollutant for each show.

Table 4. Deposition within ¼-mile Radius of Source as Percent of Total Emissions by Pollutant, ISCST3

	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Daily Show	0.05%	0.06%	0.06%	0%	0.05%	0%	0%	0%
July 4th Show	0.07%	0.07%	0.07%	0.06%	0.07%	0.06%	0.14%	0.08%

Notes: (1) 0% denotes that the rate of deposition modeled is below the threshold limit of the model. (2) For a given pollutant, percent deposition is calculated by multiplying the area of a ¼-mile-radius circle by the maximum predicted rate of deposition, then dividing by the total emissions. Note that these values represent a conservative upper-bound or over-estimate, as often times the point of predicted maximum deposition rate falls outside of the ¼ mile radius.

Table 5. Deposition within ¼-mile Radius of Source as Percent of Total Emissions by Pollutant, OBODM

	KNO3	Sulfur	Charcoal
Daily Show	3.8%	1.8%	1.1%
July 4th Show	1.1%	1.0%	0.5%

Note: For a given pollutant, percent deposition is calculated by multiplying the area of a ¼-mile-radius circle by the maximum predicted rate of deposition, then dividing by the total emissions. Note that this represents a conservative upper-bound or over-estimate, as often times the point of predicted maximum deposition rate falls outside of the ¼ mile radius.

Summary

In summary, air quality dispersion modeling analysis was performed to assess if the chemical residues from Sea World's fireworks displays are deposited in Mission Bay or on land. Specifically, two models – ISCST3 and OBODM – were used to provide more definitive and quantitative estimates of transport of metals and their deposition in the vicinity of the fireworks launching barge. Conservative estimates show that very little chemical residue is deposited in the bay within a one-quarter-mile radius of the launch site.

If you have any questions, please call me at (925) 210-2453.

Very truly yours,

BROWN AND CALDWELL

Wynn Yin
Project Engineer

Jim Laughlin
Project Manager

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Attachments:
A. Mass Emission and Particle Density Calculations
B. Particle Depositon Calculations
C. Figures (1-16)
D. Sample OBODM KN_03 Daily Output (15 pages)

Limitations:

This document was prepared solely for Sea World Environmental in accordance with professional standards at the time the services were performed and in accordance with the contract between Sea World Environmental and Brown and Caldwell dated August 21, 2006. This document is governed by the specific scope of work authorized by Sea World Environmental; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Sea World Environmental and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

ATTACHMENT A

Mass Emission and Particle Density Calculations

ATTACHMENT A
Mass Emission Calculations, Daily Fireworks Show, 3" Shells, in grams

Shell Type	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Blue	520	0	195	0	0	260	0	0
Crackling	0	195	120	0	0	260	0	0
Glitter	0	0	0	0	0	0	0	0
Gold	297	536.25	110	0	407	0	99	0
Red	600	731.25	375	180	0	0	0	0
Purple	360	438.75	90	17	0	108	0	0
Kamuro	0	2518.75	0	0	0	0	0	250
Green	0	0	0	0	0	0	0	0
Silver	230	1121.25	460	0	1357	0	0	0
Yellow	301	341.25	140	70	0	0	0	0
White	0	318.75	125	0	250	0	0	0
Whistle	0	0	0	0	0	0	0	0
Brocade	630	682.5	0	0	0	0	0	0
TOTAL (g):	**2938**	**6883.75**	**1615**	**267**	**2014**	**628**	**99**	**250**
g/s (spread over 3600 s):	**0.816**	**1.912**	**0.449**	**0.074**	**0.559**	**0.174**	**0.028**	**0.069**

Notes:
KClO4 = potassium perchlorate
KNO3 = potassium nitrate
Mg/Al = magnesium/alluminum alloy ("magnalium")
SrCO3 = Strontium carbonate
Ba(NO3)2 = barium nitrate
CuO = copper(II) oxide
Al = aluminum metal
Ti = titanium metal

Mass Emission Calculations, Daily Fireworks Show, 4" Shells, in grams

Shell Type	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Blue	306	0	114.75	0	0	153	0	0
Crackling	0	90	76.5	0	0	165.75	0	0
Glitter	0	0	0	0	0	0	0	0
Gold	550.8	720	204	0	754.8	0	183.6	0
Red	1326	1170	828.75	397.8	0	0	0	0
Purple	408	360	102	132.6	0	122.4	0	0
Kamuro	0	1780.8	0	0	0	0	0	204
Green	1020	180	117.3	0	204	0	0	0
Silver	357	1260	714	0	2106.3	0	0	0
Yellow	219.3	180	102	51	0	0	0	0
White	0	0	0	0	0	0	0	0
Whistle	357	180	0	0	0	0	0	0
Brocade	229.5	180	0	0	0	0	0	0
TOTAL (g):	**4773.6**	**6100.8**	**2259.3**	**581.4**	**3065.1**	**441.15**	**183.6**	**204**
g/s (spread over 3600 s):	**1.326**	**1.695**	**0.628**	**0.162**	**0.851**	**0.123**	**0.051**	**0.057**

Notes:
KClO4 = potassium perchlorate
KNO3 = potassium nitrate
Mg/Al = magnesium/alluminum alloy ("magnalium")
SrCO3 = Strontium carbonate
Ba(NO3)2 = barium nitrate
CuO = copper(II) oxide
Al = aluminum metal
Ti = titanium metal

Mass Emission Calculations, Daily Fireworks Show, 5" Shells, in grams

Shell Type	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Blue	612	0	229.5	0	0	306	0	0
Crackling	0	0	0	0	0	0	0	0
Glitter	0	453.75	51	1	51	0	0	0
Gold	137.7	198.75	51	0	188.7	0	45.9	0
Red	1632	1590	1020	489.6	0	0	0	0
Purple	204	198.75	51	66.3	0	61.2	0	0
Kamuro	0	463.95	0	0	0	0	0	51
Green	0	0	0	0	0	0	0	0
Silver	255	993.75	510	0	1504.5	0	0	0
Yellow	219.3	198.75	102	51	0	0	0	0
White	0	550.5255	255	510	0	0	0	0
Whistle	357	198.75	0	0	0	0	0	0
Brocade	2065.5	1788.75	0	0	0	0	0	0
TOTAL (g):	**5482.5**	**6635.7255**	**2269.5**	**1117.9**	**1744.2**	**367.2**	**45.9**	**51**
g/s (spread over 3600 s):	**1.523**	**1.843**	**0.630**	**0.311**	**0.485**	**0.102**	**0.013**	**0.014**

Notes:
KClO4 = potassium perchlorate
KNO3 = potassium nitrate
Mg/Al = magnesium/alluminum alloy ("magnalium")
SrCO3 = Strontium carbonate
Ba(NO3)2 = barium nitrate
CuO = copper(II) oxide
Al = aluminum metal
Ti = titanium metal

Mass Emission Calculations, Daily Fireworks Show, 6" Shells, in grams

Shell Type	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Blue	1020	0	382.5	0	0	510	0	0
Crackling	0	292.5	255	0	0	552.5	0	0
Glitter	0	171.25	85	0	85	0	0	0
Gold	459	585	170	0	629	0	153	0
Red	1020	877.5	637.5	306	0	0	0	0
Purple	680	585	170	221	0	204	0	0
Kamuro	0	734.5	0	0	0	0	0	85
Green	1700	292.5	195.5	0	340	0	0	0
Silver	340	1170	680	0	2006	0	0	0
Yellow	0	0	0	0	0	0	0	0
White	0	0	0	0	0	0	0	0
Whistle	0	0	0	0	0	0	0	0
Brocade	1530	170	0	0	0	0	0	0
TOTAL (g):	**6749**	**4878.25**	**2575.5**	**527**	**3060**	**1266.5**	**153**	**85**
g/s (spread over 3600 s):	**1.875**	**1.355**	**0.715**	**0.146**	**0.850**	**0.352**	**0.043**	**0.024**

Notes:
KClO4 = potassium perchlorate
KNO3 = potassium nitrate
Mg/Al = magnesium/alluminum alloy ("magnalium")
SrCO3 = Strontium carbonate
Ba(NO3)2 = barium nitrate
CuO = copper(II) oxide
Al = aluminum metal
Ti = titanium metal

Mass Emission Calculations, July 4th Fireworks Show, in grams

	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
3-in salute	4312	0	3542	0	0	0	770	0
3-in	25002	7778.4	14908.6	3055.8	13612.26482	6482	1018.6	2315
4-in	13219.2	4112.64	7882.56	1615.68	7197.12	3427.2	538.56	1224
5-in	11016	3427.2	6568.8	1346.4	5997.6	2856	448.8	1020
6-in	13311	4141.2	7937.3	1626.9	7247.1	3451	542.3	1232.5
8-in	2808	873.6	1674.4	343.2	1528.8	728	114.4	260
10-in	1984.5	617.4	1183.35	242.55	1080.45	514.5	80.85	183.75
12-in	3483	1083.6	2076.9	425.7	1896.3	903	141.9	322.5
TOTAL:	**75136**	**22034**	**45774**	**8656**	**38560**	**18362**	**3655**	**6558**

Emission Rate (spread over 60 min), g/s

	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
3-in salute	1.1978	0.0000	0.9839	0.0000	0.0000	0.0000	0.2139	0.0000
3-in	6.9450	2.1607	4.1413	0.8488	3.7812	1.8006	0.2829	0.6431
4-in	3.6720	1.1424	2.1896	0.4488	1.9992	0.9520	0.1496	0.3400
5-in	3.0600	0.9520	1.8247	0.3740	1.6660	0.7933	0.1247	0.2833
6-in	3.6975	1.1503	2.2048	0.4519	2.0131	0.9586	0.1506	0.3424
8-in	0.7800	0.2427	0.4651	0.0953	0.4247	0.2022	0.0318	0.0722
10-in	0.5513	0.1715	0.3287	0.0674	0.3001	0.1429	0.0225	0.0510
12-in	0.9675	0.3010	0.5769	0.1183	0.5268	0.2508	0.0394	0.0896
Total (g/s):	**20.87**	**6.12**	**12.71**	**2.40**	**10.71**	**5.10**	**1.02**	**1.82**

Notes:
KClO4 = potassium perchlorate
KNO3 = potassium nitrate
Mg/Al = magnesium/alluminum alloy ("magnalium")
SrCO3 = Strontium carbonate
Ba(NO3)2 = barium nitrate
CuO = copper(II) oxide
Al = aluminum metal
Ti = titanium metal

Particle Density Calculations

Daily Show

	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Total Mass Emitted (g)	19,943	24,499	8,719	2,493	9,883	2,703	482	590
Density (g/cm3)	2.52	2.11	2	3.7	3.24	6	2.7	4.506
Total Mass Emitted x Density	50,257	51,692	17,439	9,225	32,022	16,217	1,300	2,659
Weighted Density (g/cm3)	**2.61**							

July 4th Show

	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Total Mass Emitted (g)	75,136	22,034	45,774	8,656	38,560	18,362	3,655	6,558
Density (g/cm3)	2.52	2.11	2	3.7	3.24	6	2.7	4.506
Total Mass Emitted x Density	189,342	46,492	91,548	32,028	124,933	110,170	9,870	29,549
Weighted Density (g/cm3)	**2.90**							

Notes:
KClO4 = potassium perchlorate
KNO3 = potassium nitrate
Mg/Al = magnesium/alluminum alloy ("magnalium")
SrCO3 = Strontium carbonate
Ba(NO3)2 = barium nitrate
CuO = copper(II) oxide
Al = aluminum metal
Ti = titanium metal

Lift/Break Charge Mass Emission Calculations, Daily Fireworks Show, 3" Shells, in grams

Shell Type	KNO3	sulfur	charcoal
Blue	633.75	84.5	126.75
Crackling	195	26	39
Glitter	0	0	0
Gold	536.25	71.5	107.25
Red	731.25	97.5	146.25
Purple	438.75	58.5	87.75
Kamuro	1218.75	162.5	243.75
Green	0	0	0
Silver	1121.25	149.5	224.25
Yellow	341.25	45.5	68.25
White	243.75	32.5	48.75
Whistle	0	0	0
Brocade	682.5	91	136.5
Sum (g):[1]	***6142.5***	***819***	***1228.5***
MassFrac:[2]	**0.75**	**0.1**	**0.15**

[1] Sum represents the total mass emissions of a given pollutant from all shell types.

[2] MassFrac, or mass fraction, represents the fractional contribution of a given pollutant compared to the sum of all lift/break charge emissions on a mass basis.

Lift/Break Charge Mass Emission Calculations, Daily Fireworks Show, 4" Shells, in grams

Shell Type	KNO3	sulfur	charcoal
Blue	270	36	54
Crackling	90	12	18
Glitter	0	0	0
Gold	720	96	144
Red	1170	156	234
Purple	360	48	72
Kamuro	720	96	144
Green	180	24	36
Silver	1260	168	252
Yellow	180	24	36
White	0	0	0
Whistle	180	24	36
Brocade	180	24	36
Sum (g):[1]	***5310***	***708***	***1062***
MassFrac:[2]	**0.75**	**0.1**	**0.15**

[1] Sum represents the total mass emissions of a given pollutant from all shell types.

[2] MassFrac, or mass fraction, represents the fractional contribution of a given pollutant compared to the sum of all lift/break charge emissions on a mass basis.

Lift/Break Charge Mass Emission Calculations, Daily Fireworks Show, 5" Shells, in grams

Shell Type	KNO3	sulfur	charcoal
Blue	596.25	79.5	119.25
Crackling	0	0	0
Glitter	198.75	26.5	39.75
Gold	198.75	26.5	39.75
Red	1590	212	318
Purple	198.75	26.5	39.75
Kamuro	198.75	26.5	39.75
Green	0	0	0
Silver	993.75	132.5	198.75
Yellow	198.75	26.5	39.75
White	397.5	53	79.5
Whistle	198.75	26.5	39.75
Brocade	1788.75	238.5	357.75
Sum (g):[1]	**6558.75**	**874.5**	**1311.75**
MassFrac:[2]	**0.75**	**0.1**	**0.15**

[1] Sum represents the total mass emissions of a given pollutant from all shell types.

[2] MassFrac, or mass fraction, represents the fractional contribution of a given pollutant compared to the sum of all lift/break charge emissions on a mass basis.

Lift/Break Charge Mass Emission Calculations, Daily Fireworks Show, 6" Shells, in grams

Shell Type	KNO3	sulfur	charcoal
Blue	877.5	117	175.5
Crackling	292.5	39	58.5
Glitter	292.5	39	58.5
Gold	585	78	117
Red	877.5	117	175.5
Purple	585	78	117
Kamuro	292.5	39	58.5
Green	292.5	39	58.5
Silver	1170	156	234
Yellow	0	0	0
White	0	0	0
Whistle	0	0	0
Brocade	1170	156	234
Sum (g):[1]	**6435**	**858**	**1287**
MassFrac:[2]	**0.75**	**0.1**	**0.15**

[1] Sum represents the total mass emissions of a given pollutant from all shell types.

[2] MassFrac, or mass fraction, represents the fractional contribution of a given pollutant compared to the sum of all lift/break charge emissions on a mass basis.

Lift/Break Charge Mass Emission Calculations, July 4th Fireworks Show, in grams

	KNO3	sulfur	charcoal
3-in salute	7507.5	1001	1501.5
3-in	45142.5	6019	9028.5
4-in	17280	2304	3456
5-in	15900	2120	3180
6-in	16965	2262	3393
8-in	6600	880	1320
10-in	5062.5	675	1012.5
12-in	8437.5	1125	1687.5
SUM:	**122895**	**16386**	**24579**
MassFrac:	**0.75**	**0.1**	**0.15**

[1] Sum represents the total mass emissions of a given pollutant from all shell types.

[2] MassFrac, or mass fraction, represents the fractional contribution of a given pollutant compared to the sum of all lift/break charge emissions on a mass basis.

ATTACHMENT B

Particle Deposition Calculations

Particle Deposition Calculations

Daily Show

	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Total Mass Emitted	19943.1	24498.5255	8719.3	2493.3	9883.3	2702.85	481.5	590
Max Deposition Rate per ISCST3 [g/m2]	0.00002	0.00003	0.00001	0	0.00001	0	0	0
Fractional Deposition in 1/4-mile radius	0.05%	0.06%	0.06%	0	0.05%	0	0	0

July 4th Show

	KClO4	KNO3	Mg/Al	SrCO3	Ba(NO3)2	CuO	Al	Ti
Total Mass Emitted	75136	22034	45774	8656	38560	18362	3655	6558
Max Deposition Rate per ISCST3 [g/m2]	0.0001	0.00003	0.00006	0.00001	0.00005	0.00002	0.00001	0.00001
Fractional Deposition in 1/4-mile radius	0.07%	0.07%	0.07%	0.06%	0.07%	0.06%	0.14%	0.08%

Notes:

[1] Max. deposition occurred in model year 1995.

[2] Fractional deposition in 1/4-mile radius computed by multiplying the area of a circle 1/4-mile in diameter by the max. deposition rate and dividing by the total mass emitted. Note that this represents an absolute upper bound, as the point at which the max. deposition rate occurs does not necessarily fall within the first 1/4 mile radius of the source.

Calculations for Particle Deposition from Lift/Break Charges

Daily Show

	KNO3	sulfur	charcoal
Total Mass Emitted	24,446	3,260	4,889
Max Deposition Rate per OBODM [ug/m2]	1833	116	106
Fractional Deposition in 1/4-mile radius	3.81%	1.81%	1.10%

July 4th Show

	KNO3	sulfur	charcoal
Total Mass Emitted	122,895	16,386	24,579
Max Deposition Rate per ISCST3 [ug/m2]	2571	322	238
Fractional Deposition in 1/4-mile radius	1.06%	1.00%	0.49%

Notes:

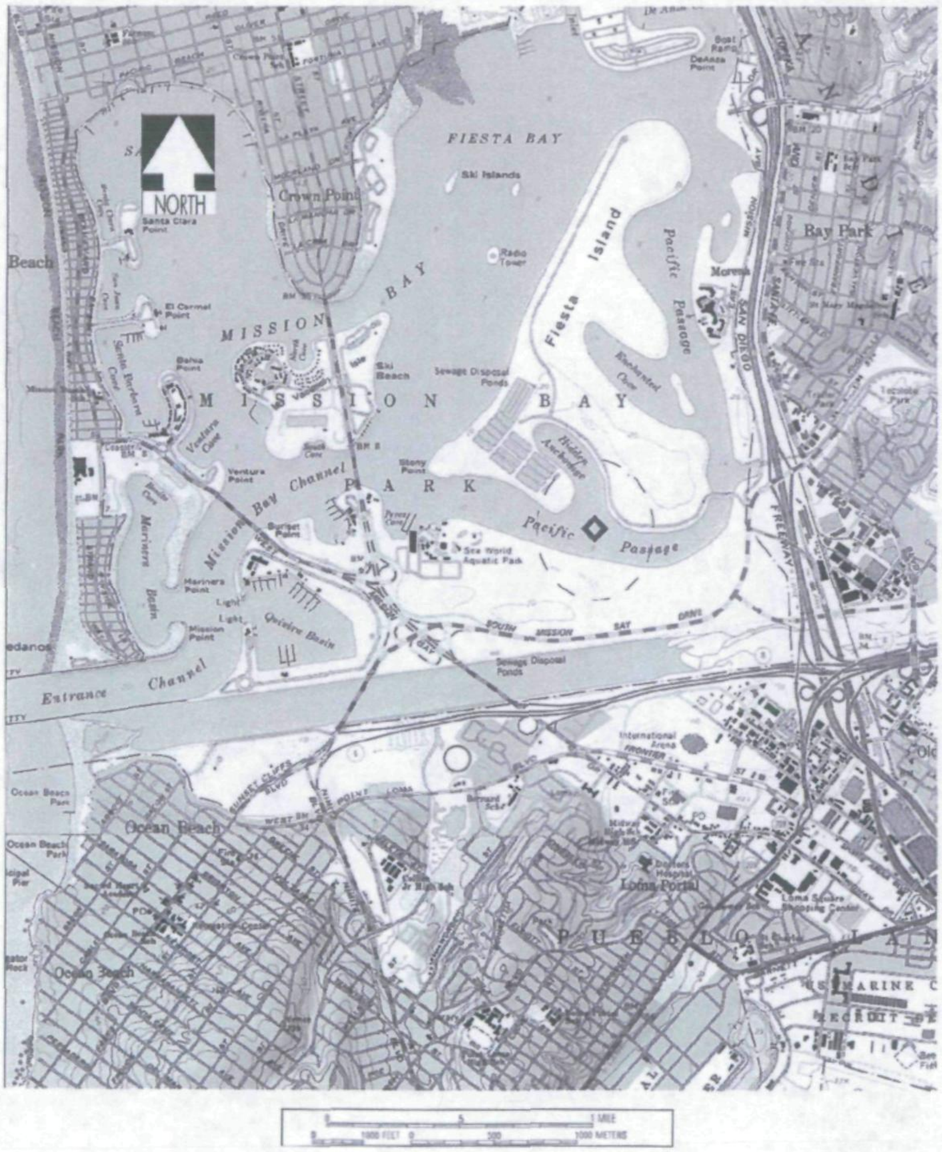
[1] Max. deposition occurred in model year 1995.

[2] Fractional deposition in 1/4-mile radius computed by multiplying the area of a circle 1/4-mile in diameter by the max. deposition rate and dividing by the total mass emitted. Note that this represents an absolute upper bound, as the point at which the max. deposition rate occurs does not necessarily fall within the first 1/4 mile radius of the source.

ATTACHMENT C

Figures 1-16

Deposition of Aluminum (Al) in g/m^2
Daily Show (Deposition Rate Below Model Limits)

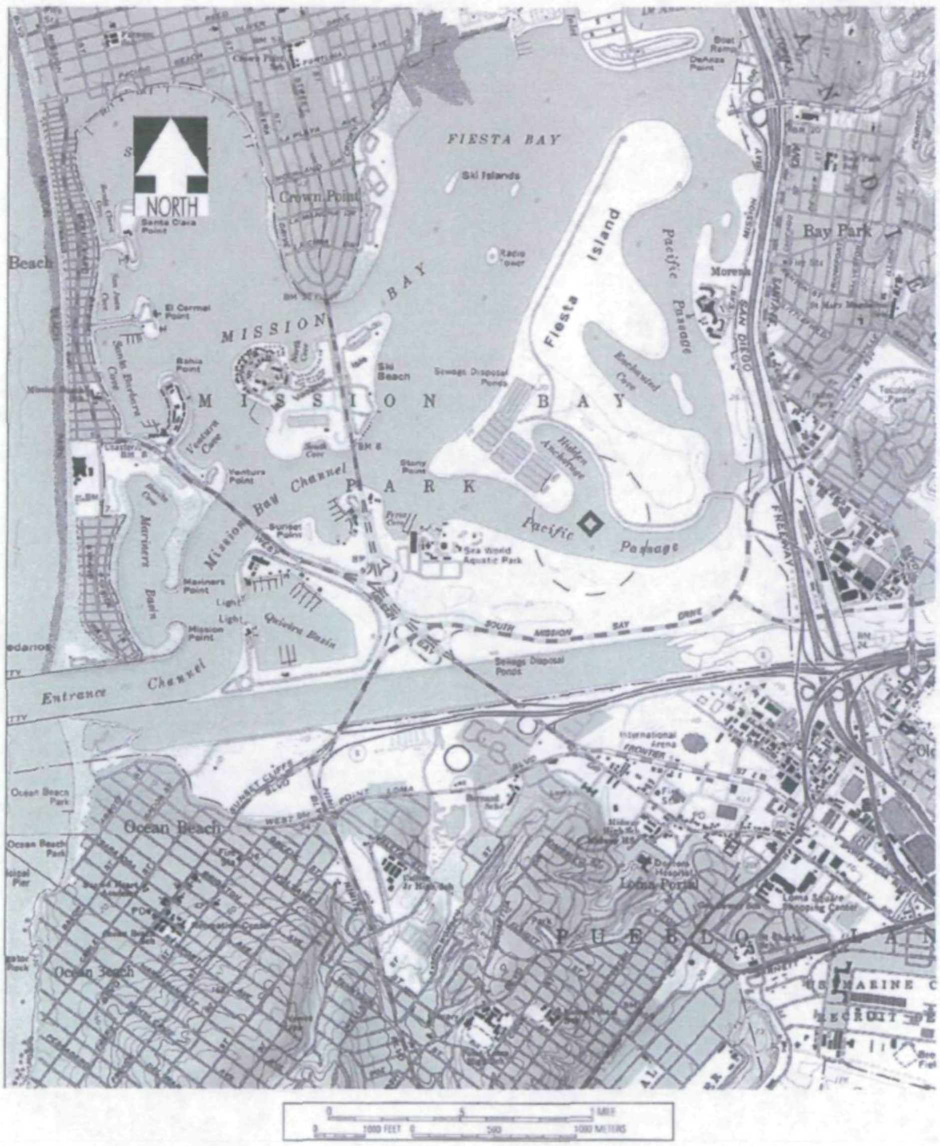


☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Barium Nitrate (Ba(NO3)2) in g/m^2
Daily Show

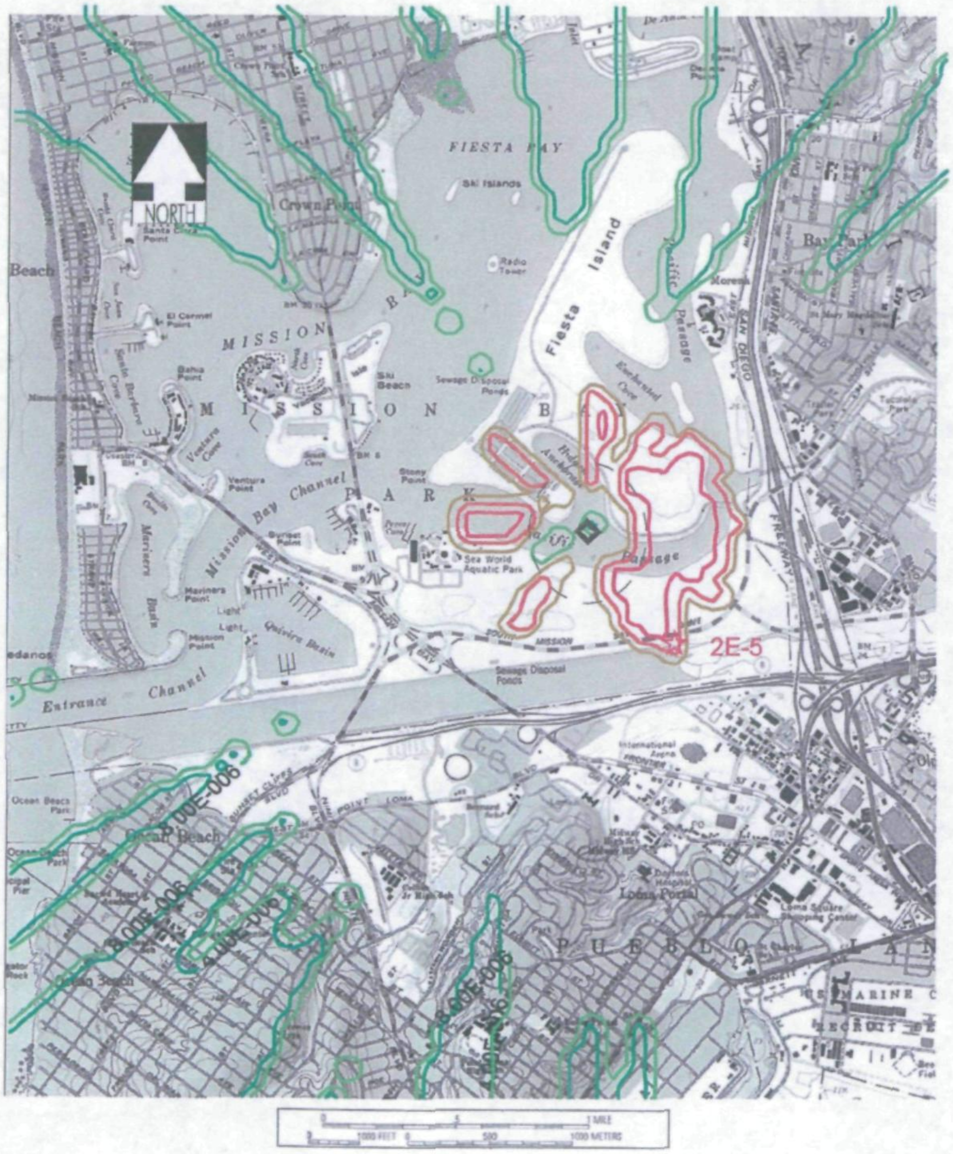
☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Copper(II) Oxide (CuO) in g/m^2
Daily Show (Deposition Rate Below Model Limits)



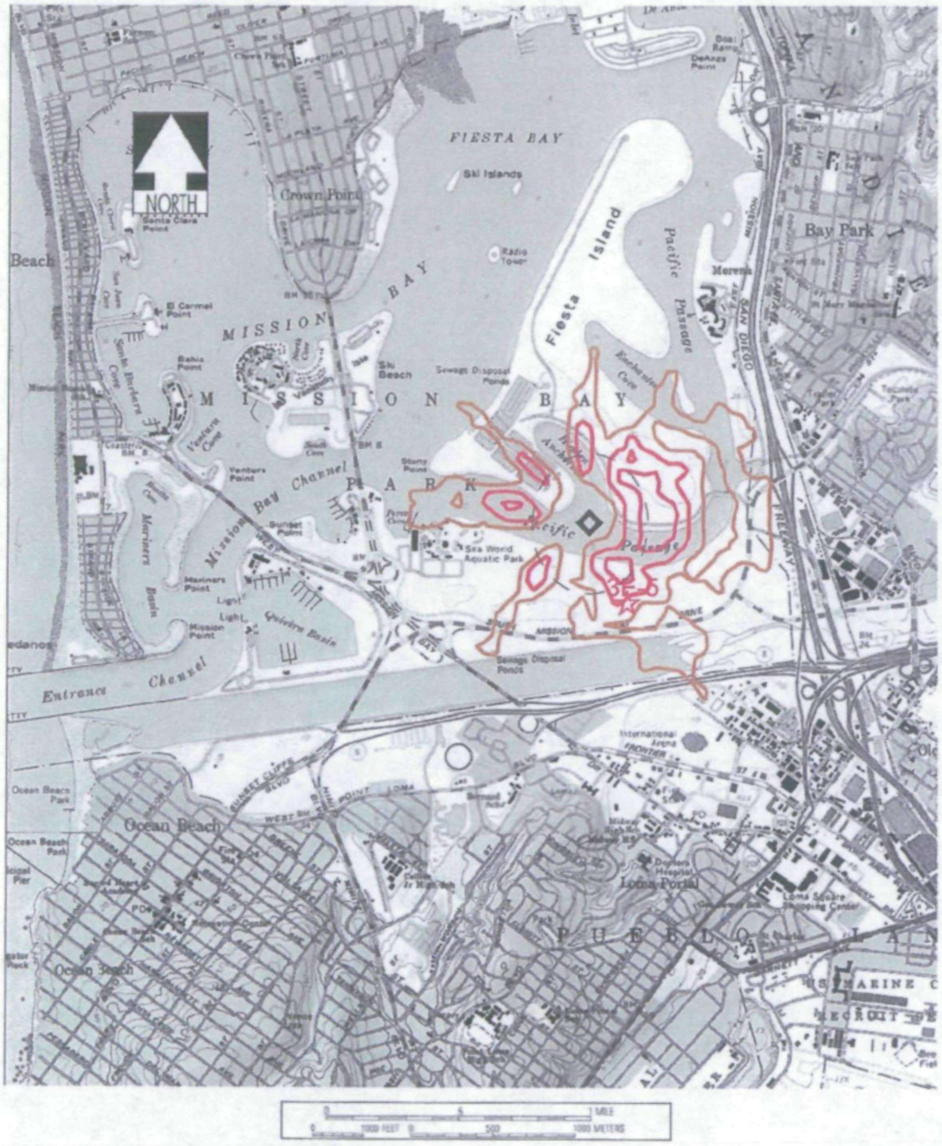
☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Potassium Perchlorate (KClO4) in g/m^2
Daily Show



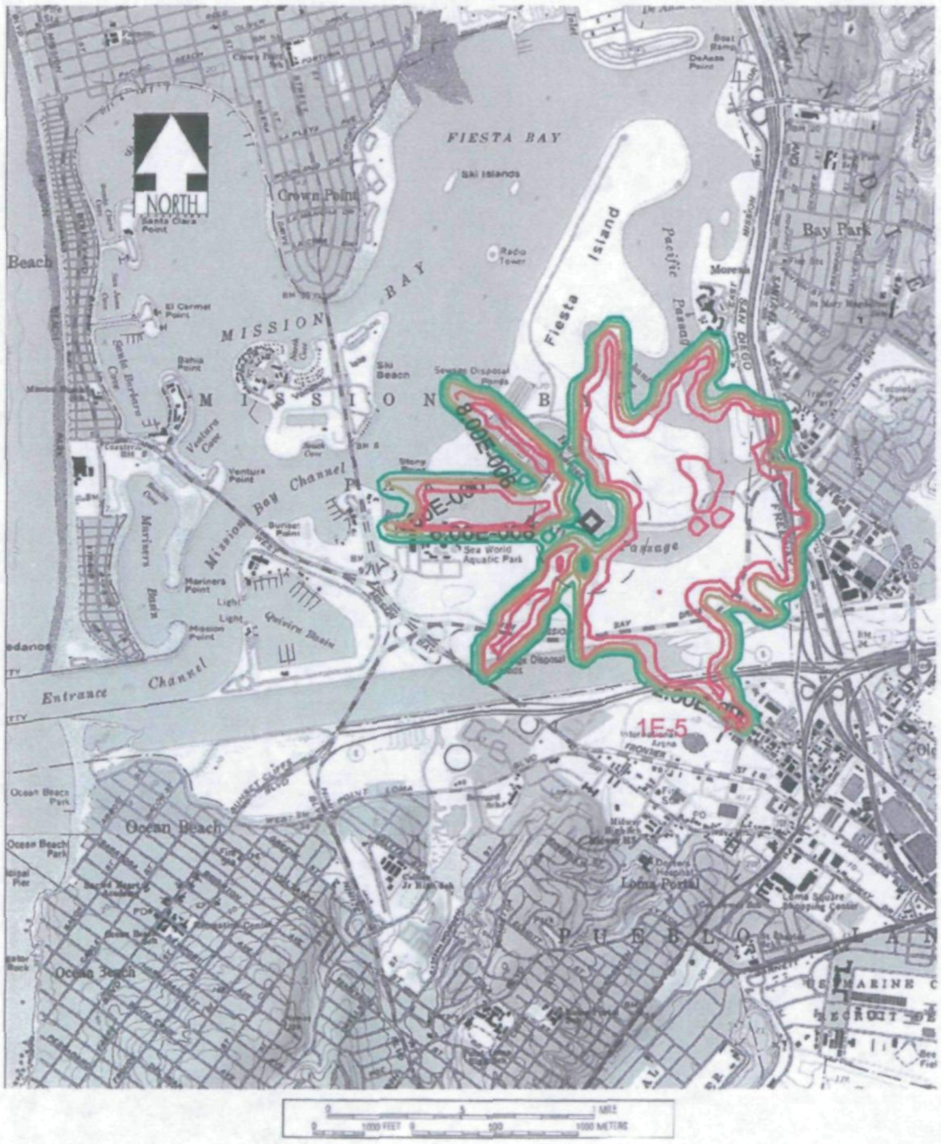
☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Potassium Nitrate (KNO3) in g/m^2
Daily Show



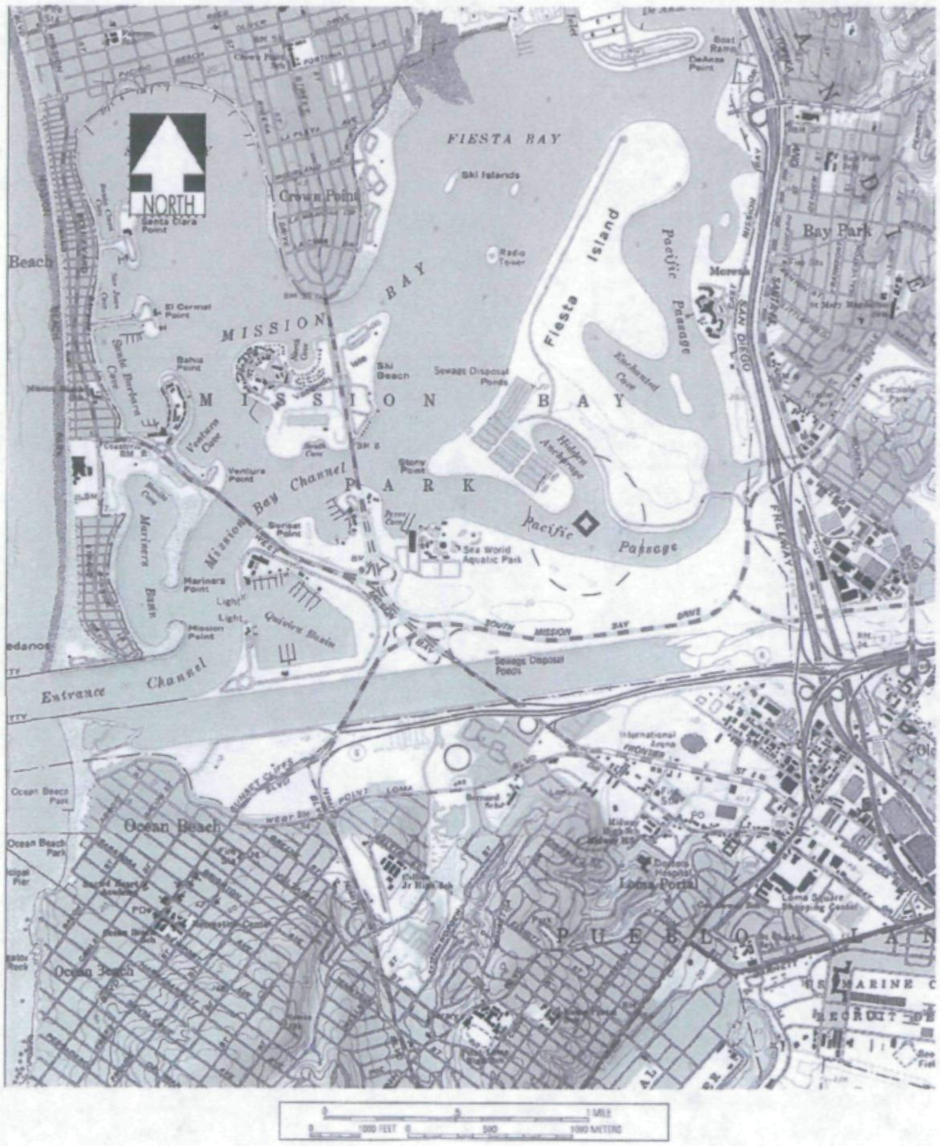
☆ Point of max. deposition ◆ Location of fireworks discharge ◯ Sphere of influence, 1/4-mile radius

Deposition of Magnalium (Mg/Al) in g/m^2
Daily Show



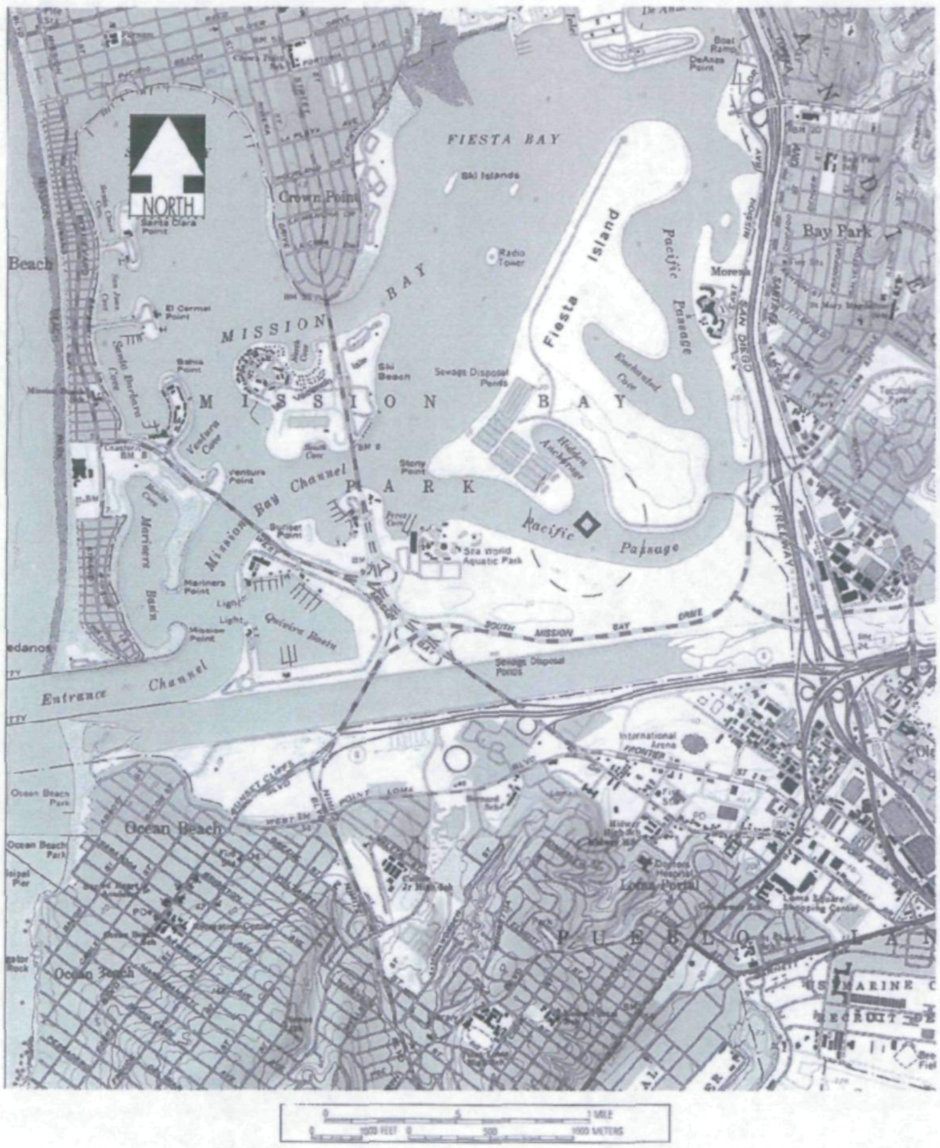
☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Strontium Carbonate ($SrCO_3$) in g/m^2
Daily Show (Deposition Rate Below Model Limits)



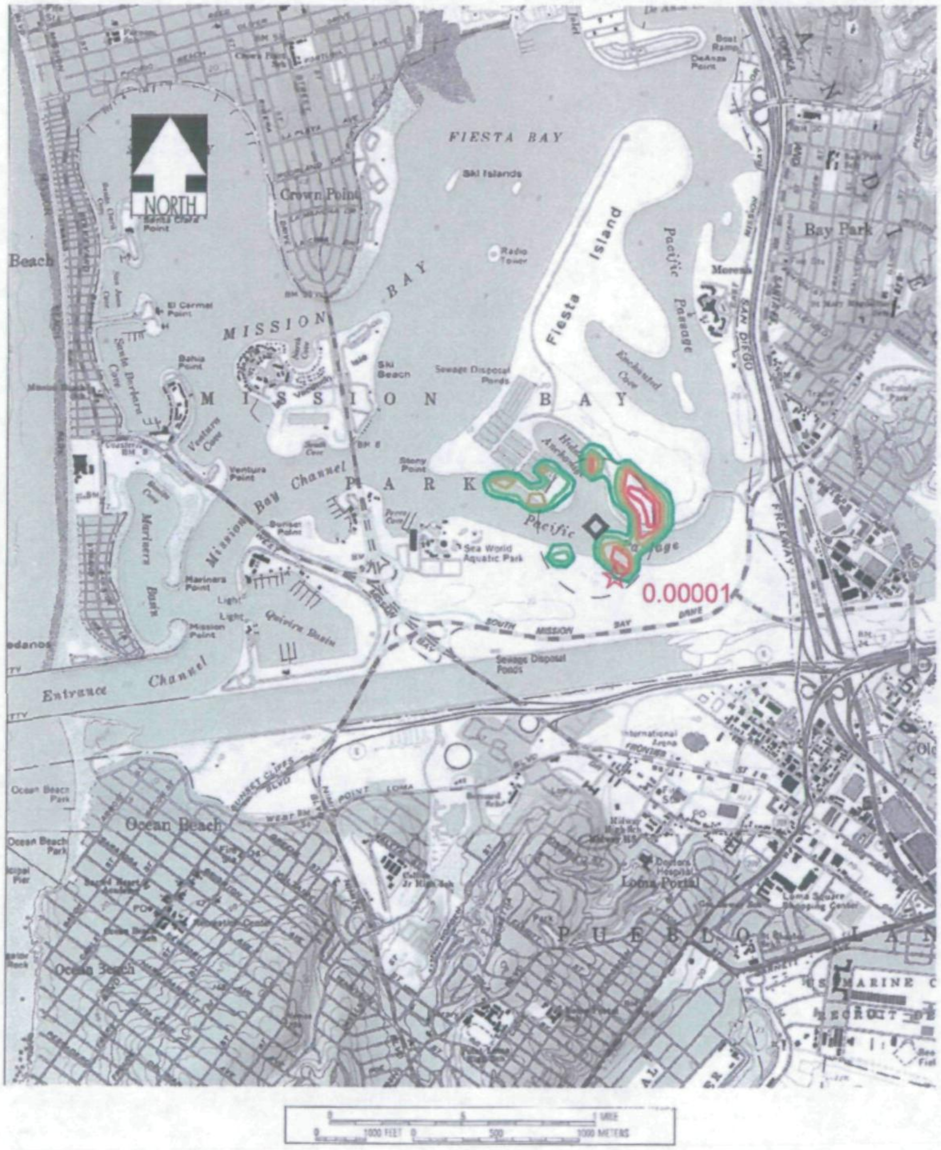
☆ Point of max. deposition ◇ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Titanium (Ti) in g/m^2
Daily Show (Deposition Rate Below Model Limits)



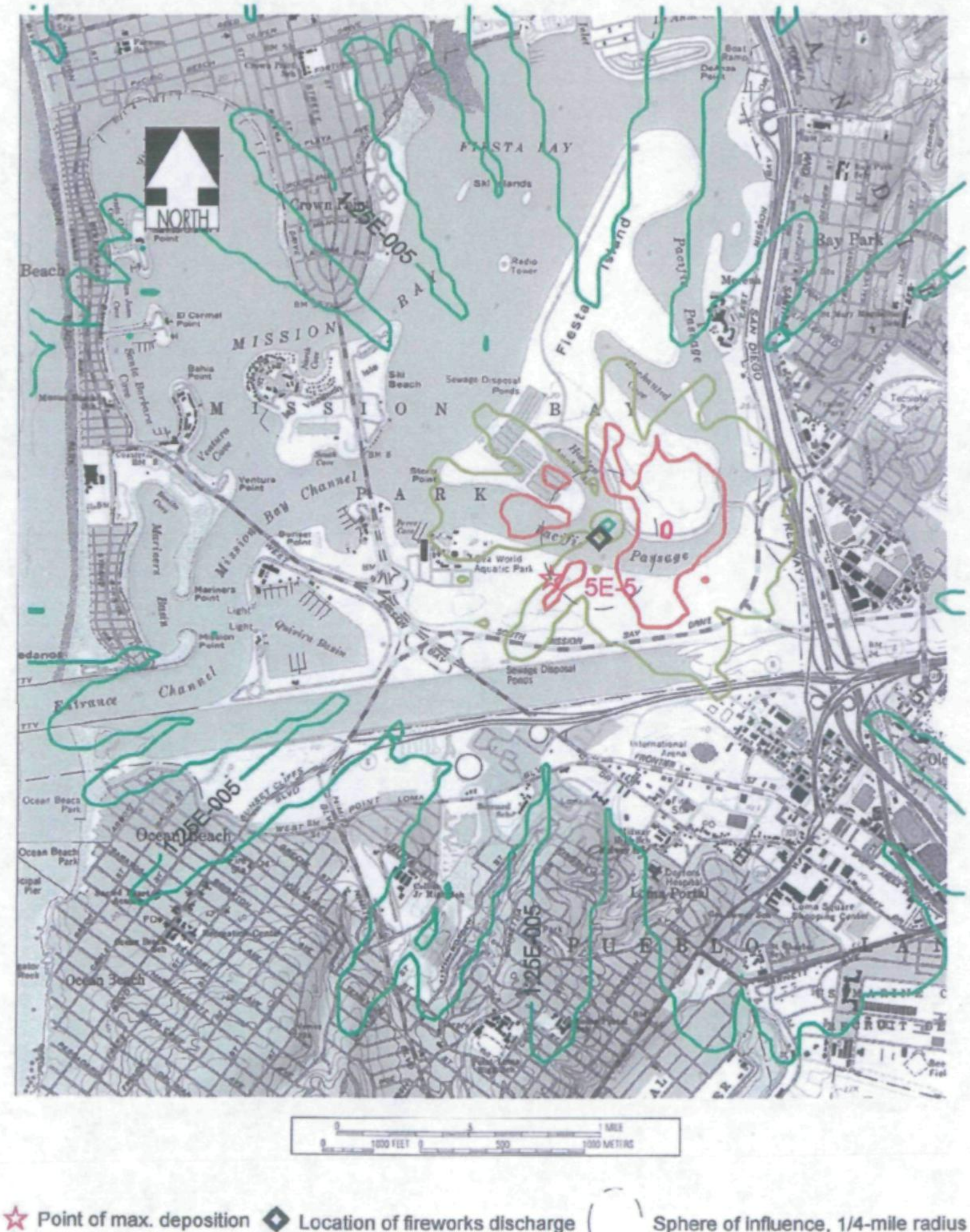
☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Aluminum (Al) in g/m^2
July 4th Show



☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

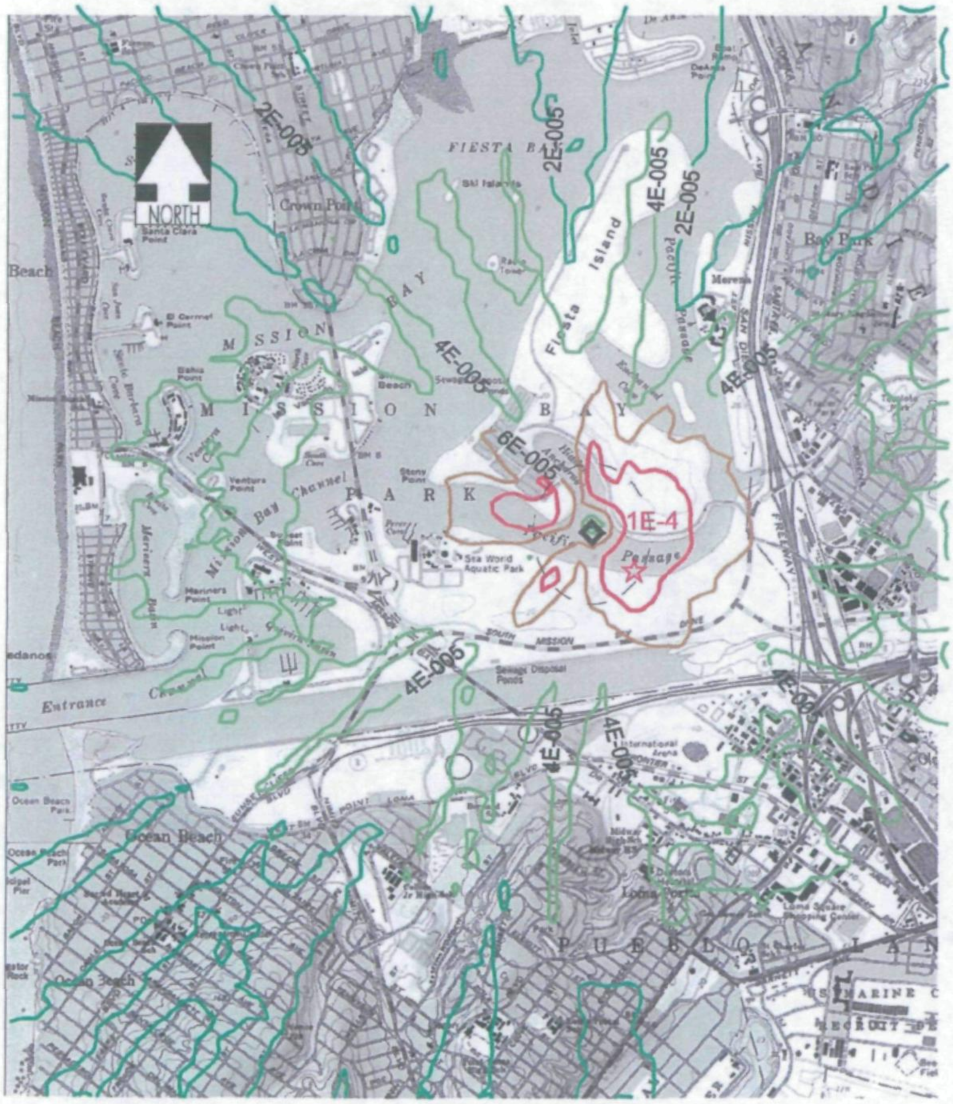
Deposition of Barium Nitrate ($Ba(NO_3)_2$) in g/m^2
July 4th Show



Deposition of Copper(II) Oxide (CuO) in g/m^2
July 4th Show

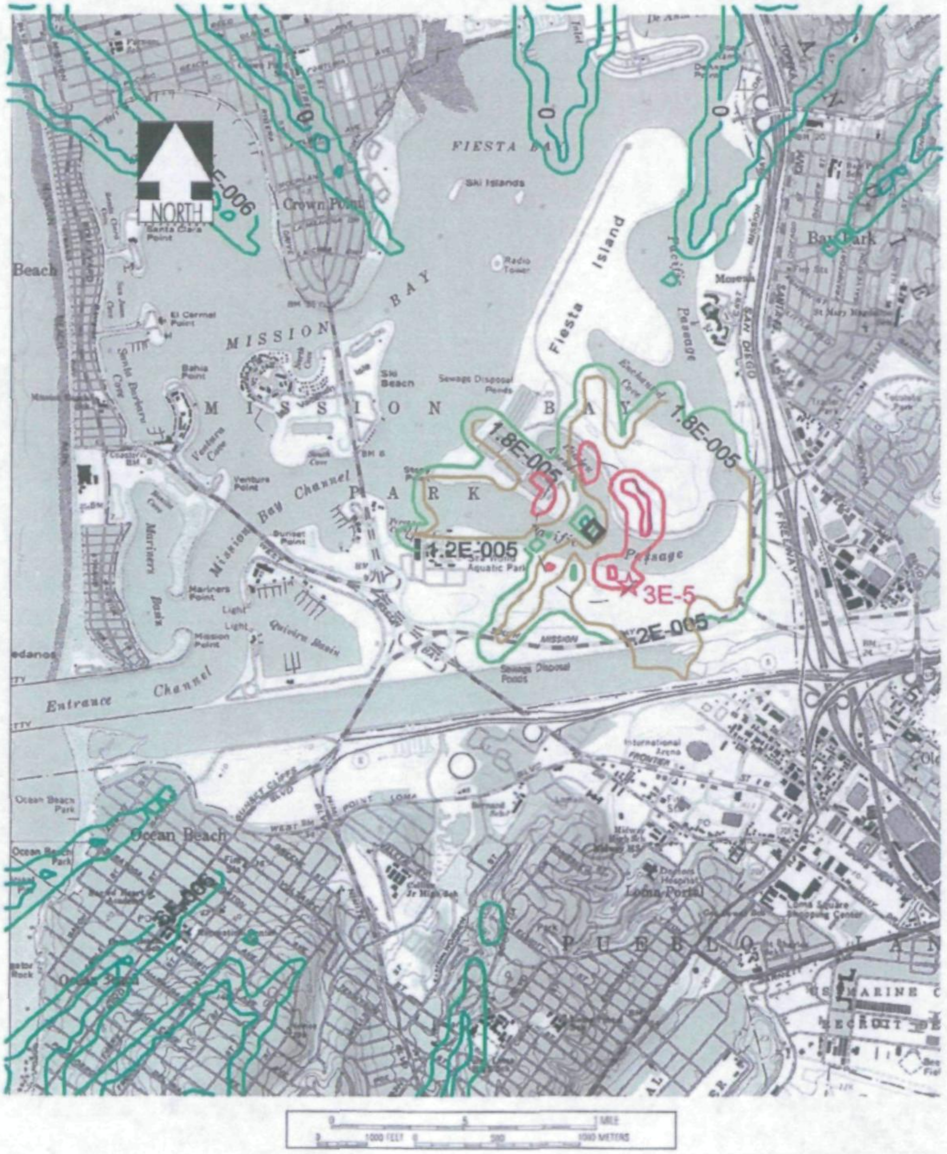
☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Potassium Perchlorate (KClO4) in g/m^2
July 4th Show



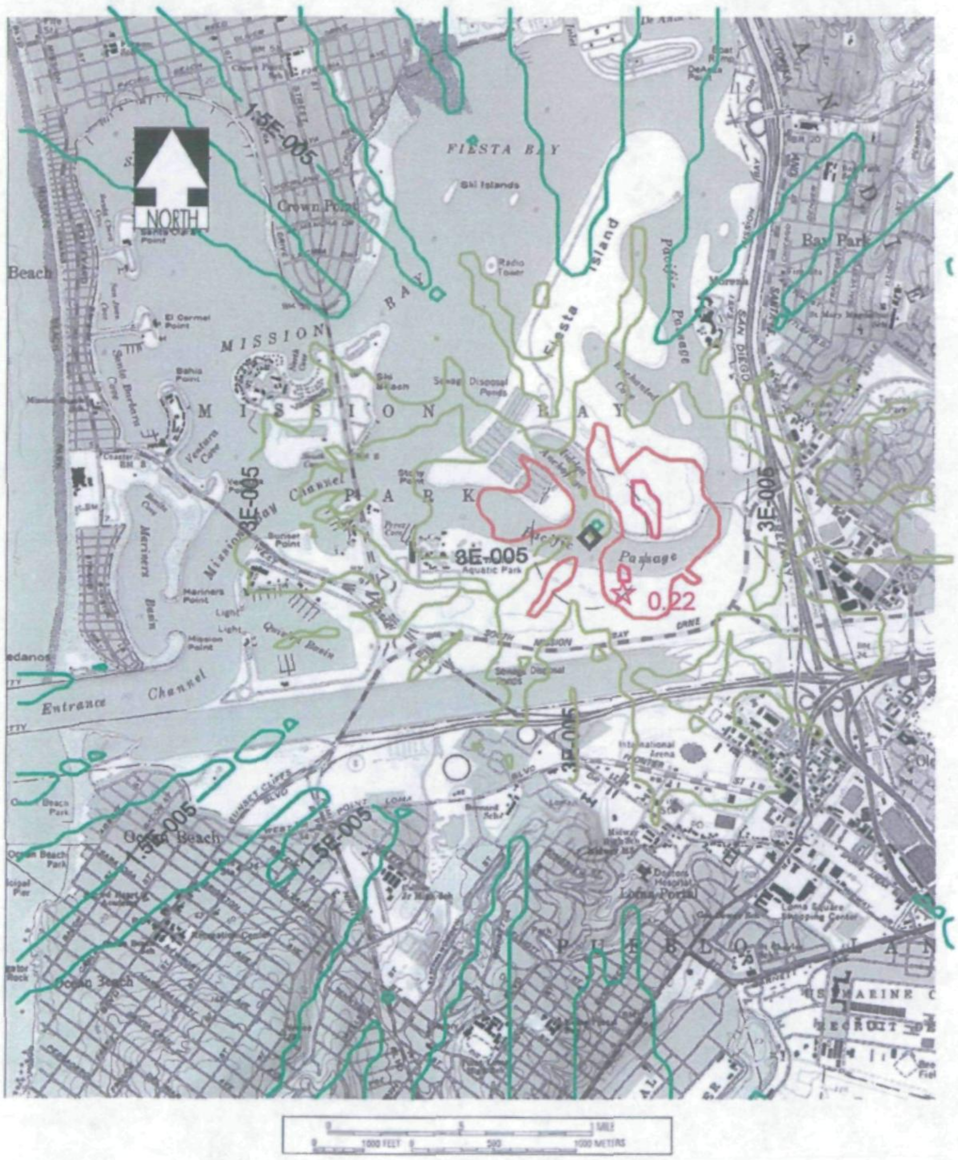
☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Potassium Nitrate (KNO3) in g/m^2
July 4th Show



☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Magnalium (Mg/Al) in g/m^2
July 4th Show

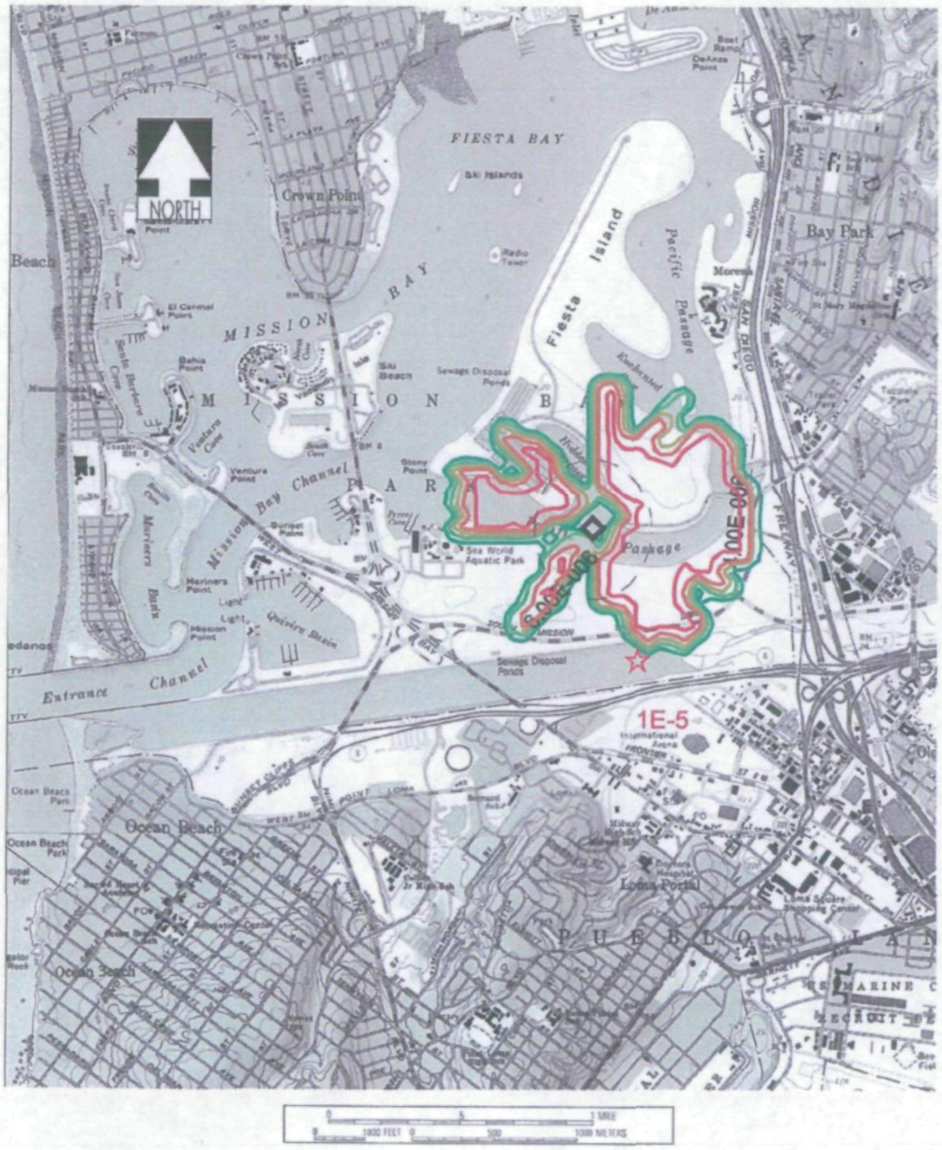


☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Strontium Carbonate ($SrCO_3$) in g/m^2
July 4th Show

☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

Deposition of Titanium (Ti) in g/m^2
July 4th Show



☆ Point of max. deposition ◆ Location of fireworks discharge ( ) Sphere of influence, 1/4-mile radius

ATTACHMENT D

Sample OBODM KNo3 Daily Output - 15 pages

Table 1

- Program Input Data -

- Program Models Selected -

- Gravitational deposition
- Using final cloud rise ht. for all calc. distances.
- Flat terrain is assumed.
- Grid system origin is not added to source rectangular coordinates
- Instantaneous sources can use both stable and adiabatic plume rise.
- Hours with calm wind speeds result in zero dispersion/deposition.
- Missing hours result in zero dispersion/deposition.
- Calculation averaging times (hrs) ---------------------------------- 1
- Grid receptor system is ------------------------------------ Polar

- Print Output Options -

- Print and save data using Summary processing mode
- Print highest and second highest at each receptor
- Print table of maximum 50 receptors
- Print deposition output units ----------------- Micrograms/Square Meters

- Receptor Grid System Geometry -

```
Grid system orientation angle (Degrees) ---------------------------      .0
Receptor X coordinate units -------------------------------------- Meters
         Y coordinate units ------------------------------------- Degrees
         Z coordinate units -------------------------------------- Meters
X origin -----------------------------------------------------        .00
Y origin -----------------------------------------------------        .00
X Axis of the grid system (Meters)-----------------        .00,     200.00,
       400.00,    600.00,    800.00,   1000.00,   1200.00,   1400.00,
      1600.00,   1800.00,   2000.00,   2200.00,   2400.00,   2600.00,
      2800.00,   3000.00,   3200.00,   3400.00,   3600.00,   3800.00,
      4000.00,   4200.00,   4400.00,   4600.00,   4800.00,   5000.00,
Y Axis of the grid system (Degrees)----------------        .00,      30.00,
        60.00,     90.00,    120.00,    150.00,    180.00,    210.00,
       240.00,    270.00,    300.00,    330.00,    360.00,
```

- Source Geometry/Emission Strength -

Material or fuel/explosive ------------------------ Fireworks Black Charge
Pollutant/species --- KNO3
Total number of sources -- 1

Source Number	Ident	Reference System	Source Type	Emission Type
1	Black Powder Charge	Polar	Volume	Instantaneous

Table 1 (cont.)

- Program Input Data -

- Source Geometry/Emission Strength -

Source Number	X Coordinate	Y Coordinate	Z Elevation	Release Height	Emission Strength
1	.0 m	.0 d	.0 m	3.8~ m	2.44460E+04 g

~ Means the value is defaulted for each hour of met. data.

Source Number	Rect. Expan. Crosswind	Dist. / Vertical/Crosswind	Reference Dist. Vertical/	/Air Entrain-ment Coeff.	/Dispersion Coeff. /Crosswind	Vertical
1	50.00 m	50.00 m	.00 m	.00 m	.640	1.000	1.000

Source Number	Fuel Heat Content	Fuel Burn Rate	Fuel Burn Time	Initial Diameter
1	1000.0 ca/g	9778.4 g/s	2.5 s	7.69~ m

~ Means the value is defaulted for each hour of met. data.

Hours in which source is burned or detonated

Source Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

- Pollutant/Species Material Characteristics -

```
Pollutant/species name -------------------------------------------------- KNO3
Pollutant/species is ---------------------------------------------  Particulate
Particle material half-life ---------------------------------------   infinite
Molecular weight (g/g-mol) ------------------------------------        101.0
Density of species ( g/cm**3) ---------------------------------         2.11
Fraction of exhaust cloud constituting pollutant/species -----              .75
Upper limits of particle diameters (um) --------   1.140,    .960,    .820,
    .690,   .580,
Lower limits of particle diameters (um) --------    .960,    .820,    .690,
    .580,   .490,
Ratio of lagrangian to eulerian time-scales ----------------------- 1.00000
Fraction of particle material for each category ----------  .07467, .24420,
   .36225, .24420, .07467,
Particle settling velocity for each category (  m/s) -------  .0001,  .0001,
    .0000,  .0000,  .0000,
Particle reflection coefficient for each category -------  .958061, .962447,
   .966339, .970007, .973247,
```


Table 1 (cont.)

- Program Input Data -

- Meteorological Data -
([#-#] min-max limits)

```
Year [1900-2099]------------------------------------------------------ 1995
Month [ 1-12]---------------------------------------------------------    7
Day [ 1-31]-----------------------------------------------------------    4
Hour (STD) [01-24]---------------------------------------------------- 2200
Minute ---------------------------------------------------------------    0
Julian day [  1-366]--------------------------------------------------  185
Surface pressure (  mb) [ 600.0-1100.0]-----------------------       870.00
Cloud cover (8ths) [0-8]--------------------------------------          .00
Cloud ceiling ( m) [     .0-20000.0]--------------------------      9999.00
```

DLYKNO3.OUT

```
Net radiation index [-2- 4]------------------------------------------  2.
Pasquill stability category [A-F]-------------------------------------- C
Wind speed reference height (m) -------------------------------    10.00
Surface roughness length (cm) [   .00-100.00]------------------     .500
Vertical grad. of pot. temp. (  C/m) [-5.000- 5.000]---------         .0
Reference wind speed (  m/s) [  1.0- 50.0]------------------------- 2.000
Minimum (at 2m) wind speed (m/s) ---------------------------------- 1.450
Air temperature ( C) [-60.0- 60.0]-----------------------------  20.000
Standard dev. of wind direction angle ( d) [ 1.0000-80.0000]------  16.0000
Standard dev. wind elevation angle ( d) [ 1.0000-50.0000]---------   6.0000
Longitudinal turbulence intensity ( d) [ 1.0000-106.4000]---------  21.2800
Measurement time for std. dev. wind dir. angle ( s) [ 2.5-3600.0]-  600.00
Air humidity (%) (  .0-100.0)--------------------------------------   50.0
Standard dev. of wind direction angle is adjusted for roughness length to
                                                ----------  8.7885 ( d)
Standard dev. of wind elevation angle is adjusted for roughness length to
                                                ----------  3.2957 ( d)
Longitudinal turbulence intensity is adjusted for roughness length to
                                                ---------- 11.6887 ( d)
Surface mixing layer height ( m) [ 1.0-20000.0]-----------------  1200.00
Wind direction (From) (deg) [    .0- 360.0]----------------------   270.0
Wind-direction shear (  d/m) [ -45.0-  45.0]---------------------     .00
Wind-speed power law exponent [ .000-5.000]----------------------      .2
Wind-speed shear (  m/s) [   .00- 20.00]--------------------------- Compute
```

- Other Required Data -

```
Days calculated -
Month           Day of Month            Month           Day of Month
     1234567890123456789012345678901         1234567890123456789012345678901
--------------------------------------------------------------------------
 Jan [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY] Feb [YYYYYYYYYYYYYYYYYYYYYYYYYYYY ]
 Mar [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY] Apr [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYY]
 May [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY] Jun [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYY]
 Jul [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY] Aug [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY]
 Sep [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYY]  Oct [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY]
 Nov [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYY]  Dec [YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY]
```


Table 1 (cont.)

- Program Input Data -

- Meteorological Data -
([#-#] min-max limits)

```
Input save data file name ------------------------------------ DLYKNO3.INP
Output save data file name ----------------------------------- DLYKNO3.INP
Print solution output file name ------------------------------ DLYKNO3.OUT
Graphics/solution input/output file -------------------------- DLYKNO3.SOL
Hourly meteorological input data file ------------------------ sdo95db.asc
Sigma plot output solution file ------------------------------- DLYKNO3.sig

Total data hours read -------------------------------------------     8760
Total data hours processed --------------------------------------     8760
Total non-excluded/non-missing data hours (calculated) ---------     7301
Total missing data hours (includes calms) -----------------------     1459
Total calm wind speed (<  1.0 m/s) hours -------------------------     1459
Total data errors (out of range) ---------------------------------       0
Total user excluded data hours (zero emissions) ------------------       0
```

Table 2
Maximum 50 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

Deposition	x (Meters)	y (Degrees)	Year	Month	Day	Julian day	Hour
1833.22	200.0	180.0	1995	01	04	004	1900
1740.32	200.0	180.0	1995	03	10	069	2300
1656.21	200.0	180.0	1995	01	04	004	2000
1636.08	200.0	210.0	1995	03	11	070	0200
1635.12	200.0	180.0	1995	03	10	069	2000
1635.12	200.0	180.0	1995	03	10	069	2400
1567.11	200.0	180.0	1995	01	04	004	1700
1543.18	200.0	180.0	1995	01	04	004	1800
1449.59	200.0	300.0	1995	01	15	015	1900
1418.43	200.0	300.0	1995	04	16	106	1500
1388.85	200.0	180.0	1995	01	04	004	1600
1372.43	200.0	300.0	1995	01	15	015	1700
1365.58	200.0	210.0	1995	03	05	064	2200
1352.49	200.0	300.0	1995	04	18	108	1600
1343.00	200.0	210.0	1995	02	14	045	0600
1339.55	200.0	300.0	1995	01	05	005	1300
1338.65	200.0	300.0	1995	03	21	080	1100
1325.92	200.0	270.0	1995	05	05	125	0200
1308.07	200.0	330.0	1995	04	22	112	1600
1307.08	200.0	210.0	1995	01	10	010	2200
1303.35	200.0	150.0	1995	01	04	004	1400
1301.69	200.0	240.0	1995	03	11	070	1300
1296.12	200.0	240.0	1995	03	11	070	1200
1293.81	200.0	240.0	1995	03	05	064	2100
1286.41	200.0	210.0	1995	03	10	069	1400
1286.41	200.0	330.0	1995	04	21	111	1700
1283.46	200.0	240.0	1995	03	11	070	1500
1283.46	200.0	300.0	1995	01	05	005	0600
1280.96	200.0	270.0	1995	01	05	005	1400
1280.96	200.0	270.0	1995	01	25	025	2200
1274.28	200.0	300.0	1995	04	16	106	1600
1269.84	200.0	300.0	1995	01	05	005	1200
1263.53	200.0	270.0	1995	04	16	106	1300
1262.65	200.0	210.0	1995	03	10	069	1900
1260.00	200.0	30.0	1995	02	19	050	1900
1259.77	200.0	300.0	1995	01	15	015	1300
1259.77	200.0	210.0	1995	02	14	045	0800
1257.74	200.0	270.0	1995	04	16	106	1100
1257.74	200.0	270.0	1995	05	06	126	1200
1256.65	200.0	90.0	1995	02	19	050	1300
1256.39	200.0	270.0	1995	01	25	025	2000
1256.39	200.0	270.0	1995	05	05	125	1200
1253.11	200.0	270.0	1995	05	05	125	0900
1247.14	200.0	270.0	1995	01	15	015	1600
1242.95	200.0	300.0	1995	01	15	015	2200
1238.76	200.0	270.0	1995	01	05	005	0100
1238.59	200.0	150.0	1995	03	11	070	0100
1235.39	200.0	300.0	1995	01	05	005	0400
1235.39	200.0	330.0	1995	03	14	073	1600

Table 2 (cont.)
Maximum 50 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

Deposition	x (Meters)	y (Degrees)	Year	Month	Day	Julian day	Hour
1235.13	200.0	240.0	1995	03	05	064	1900

Table 3
Highest 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

(Maximum = 1833.2 at x = 200.00, Y = 180.00

- X Axis (Meters) -

Y Axis (Degrees)	.000	Mo/Dy/Yr	Jdy	Hr	200.000	Mo/Dy/Yr	Jdy	Hr
	- Gravitational Deposition -							
360.000	.000000	00/00/00	000	0000	1013.41	04/23/95	113	1600
330.000	.000000	00/00/00	000	0000	1308.07	04/22/95	112	1600
300.000	.000000	00/00/00	000	0000	1449.59	01/15/95	015	1900
270.000	.000000	00/00/00	000	0000	1325.92	05/05/95	125	0200
240.000	.000000	00/00/00	000	0000	1301.69	03/11/95	070	1300
210.000	.000000	00/00/00	000	0000	1636.08	03/11/95	070	0200
180.000	.000000	00/00/00	000	0000	1833.22	01/04/95	004	1900
150.000	.000000	00/00/00	000	0000	1303.35	01/04/95	004	1400
120.000	.000000	00/00/00	000	0000	1179.39	03/11/95	070	0300
90.000	.000000	00/00/00	000	0000	1256.65	02/19/95	050	1300
60.000	.000000	00/00/00	000	0000	1150.89	12/20/95	354	1700
30.000	.000000	00/00/00	000	0000	1260.00	02/19/95	050	1900
.000	.000000	00/00/00	000	0000	1013.41	04/23/95	113	1600

- X Axis (Meters) -

Y Axis (Degrees)	400.000	Mo/Dy/Yr	Jdy	Hr	600.000	Mo/Dy/Yr	Jdy	Hr
	- Gravitational Deposition -							
360.000	631.786	04/23/95	113	1700	367.920	04/23/95	113	1700
330.000	752.777	04/22/95	112	1600	399.322	04/22/95	112	1600
300.000	790.853	01/15/95	015	1900	408.388	01/15/95	015	1900
270.000	766.725	05/05/95	125	0200	405.623	05/05/95	125	0200
240.000	745.375	03/11/95	070	1300	394.900	03/11/95	070	1200
210.000	773.528	03/11/95	070	0200	397.442	01/10/95	010	2200
180.000	885.421	01/04/95	004	1900	429.025	01/04/95	004	1900
150.000	749.843	01/04/95	004	1400	397.674	01/04/95	004	1400
120.000	661.608	03/11/95	070	0300	366.892	01/03/95	003	0600
90.000	746.436	02/19/95	050	1300	400.406	02/19/95	050	1300
60.000	704.079	12/20/95	354	1700	385.616	12/20/95	354	1700
30.000	657.502	07/16/95	197	1000	371.028	07/16/95	197	1000
.000	631.786	04/23/95	113	1700	367.920	04/23/95	113	1700

- X Axis (Meters) -

Y Axis (Degrees)	800.000	Mo/Dy/Yr	Jdy	Hr	1000.000	Mo/Dy/Yr	Jdy	Hr
	- Gravitational Deposition -							
360.000	220.242	04/23/95	113	1700	139.111	04/23/95	113	1700
330.000	226.720	04/22/95	112	1600	138.705	03/14/95	073	1600
300.000	228.384	01/15/95	015	1900	138.705	01/05/95	005	0400
270.000	230.210	01/25/95	025	2000	141.155	01/25/95	025	2000

Table 3 (cont.)
Highest 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

(Maximum = 1833.2 at X = 200.00, Y = 180.00

Y Axis (Degrees)	800.000	Mo/Dy/Yr Jdy Hr	1000.000	Mo/Dy/Yr Jdy Hr
240.000	225.357	03/05/95 064 1900	138.576	06/01/95 152 1400
210.000	225.518	01/10/95 010 2200	138.331	01/07/95 007 1300
180.000	234.338	03/10/95 069 2000	140.431	02/13/95 044 1200
150.000	225.745	01/04/95 004 1400	138.576	01/23/95 023 1300
120.000	218.315	01/03/95 003 0600	137.434	01/03/95 003 0600
90.000	228.512	02/19/95 050 1300	140.032	02/19/95 050 1300
60.000	222.973	12/20/95 354 1700	137.827	12/20/95 354 1700
30.000	218.291	07/16/95 197 1000	136.422	07/16/95 197 1000
.000	220.242	04/23/95 113 1700	139.111	04/23/95 113 1700

- X Axis (Meters) - / - Gravitational Deposition -

Y Axis (Degrees)	1200.000	Mo/Dy/Yr Jdy Hr	1400.000	Mo/Dy/Yr Jdy Hr
360.000	92.4577	04/23/95 113 1700	64.8404	05/29/95 149 0200
330.000	91.2966	08/29/95 241 1900	64.0086	03/08/95 067 2000
300.000	91.2966	01/13/95 013 1300	64.0086	03/18/95 077 1200
270.000	92.6545	08/21/95 233 1000	64.8404	02/02/95 033 1600
240.000	91.2966	04/15/95 105 1200	64.0086	05/10/95 130 0700
210.000	91.2966	01/11/95 011 1200	64.0086	01/10/95 010 0300
180.000	92.5990	01/23/95 023 1500	64.8404	04/26/95 116 0800
150.000	91.2035	01/08/95 008 1000	63.9883	01/02/95 002 0900
120.000	91.2966	12/24/95 358 0300	64.0086	01/08/95 008 2300
90.000	92.3986	02/18/95 049 0600	64.8404	02/03/95 034 0700
60.000	91.2966	01/30/95 030 1400	64.0086	10/08/95 281 1000
30.000	90.1120	02/26/95 057 1200	64.0086	02/26/95 057 1200
.000	92.4577	04/23/95 113 1700	64.8404	05/29/95 149 0200

- X Axis (Meters) - / - Gravitational Deposition -

Y Axis (Degrees)	1600.000	Mo/Dy/Yr Jdy Hr	1800.000	Mo/Dy/Yr Jdy Hr
360.000	47.4890	06/30/95 181 0300	35.7517	06/30/95 181 0300
330.000	46.8867	03/08/95 067 2000	35.2692	03/08/95 067 2000
300.000	46.8867	03/18/95 077 1200	35.2692	03/18/95 077 1200
270.000	47.4890	05/25/95 145 0600	35.7517	05/25/95 145 0600
240.000	46.8867	05/10/95 130 0700	35.2692	05/10/95 130 0700
210.000	46.8867	01/10/95 010 0300	35.2692	01/10/95 010 0300
180.000	47.4037	01/21/95 021 0700	35.6855	01/21/95 021 0700
150.000	46.8202	07/13/95 194 0200	35.2182	07/13/95 194 0200

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Table 3 (cont.)
Highest 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

(Maximum = 1833.2 at X = 200.00, Y = 180.00

Y Axis (Degrees)	1600.000	Mo/Dy/Yr	Jdy	Hr	1800.000	Mo/Dy/Yr	Jdy	Hr
120.000	46.8867	01/08/95	008	2300	35.2692	01/08/95	008	2300
90.000	47.4890	01/01/95	001	2300	35.7517	01/01/95	001	2300
60.000	46.8867	10/08/95	281	1000	35.2692	10/08/95	281	1000
30.000	46.8867	02/26/95	057	1200	35.2692	02/26/95	057	1200
.000	47.4890	06/30/95	181	0300	35.7517	06/30/95	181	0300

- X Axis (Meters) -
- Gravitational Deposition -

Y Axis (Degrees)	2000.000	Mo/Dy/Yr	Jdy	Hr	2200.000	Mo/Dy/Yr	Jdy	Hr
360.000	27.5326	06/30/95	181	0300	21.6233	06/30/95	181	0300
330.000	27.1443	03/08/95	067	2000	21.3082	03/08/95	067	2000
300.000	27.1443	03/18/95	077	1200	21.3082	03/18/95	077	1200
270.000	27.5326	05/25/95	145	0600	21.6233	05/25/95	145	0600
240.000	27.1443	05/10/95	130	0700	21.3082	05/10/95	130	0700
210.000	27.1443	01/10/95	010	0300	21.3082	01/10/95	010	0300
180.000	27.4805	01/21/95	021	0700	21.5816	01/21/95	021	0700
150.000	27.1043	07/13/95	194	0200	21.2764	07/13/95	194	0200
120.000	27.1443	01/08/95	008	2300	21.3082	01/08/95	008	2300
90.000	27.5326	01/01/95	001	2300	21.6233	01/01/95	001	2300
60.000	27.1443	10/08/95	281	1000	21.3082	10/08/95	281	1000
30.000	27.1443	02/26/95	057	1200	21.3082	02/26/95	057	1200
.000	27.5326	06/30/95	181	0300	21.6233	06/30/95	181	0300

- X Axis (Meters) -
- Gravitational Deposition -

Y Axis (Degrees)	2400.000	Mo/Dy/Yr	Jdy	Hr	2600.000	Mo/Dy/Yr	Jdy	Hr
360.000	17.2749	06/30/95	181	0300	14.0088	06/30/95	181	0300
330.000	17.0167	03/08/95	067	2000	13.7953	03/08/95	067	2000
300.000	17.0167	03/18/95	077	1200	13.7953	03/18/95	077	1200
270.000	17.2749	05/25/95	145	0600	14.0088	05/25/95	145	0600
240.000	17.0167	05/10/95	130	0700	13.7953	05/10/95	130	0700
210.000	17.0167	01/10/95	010	0300	13.7953	01/10/95	010	0300
180.000	17.2411	01/21/95	021	0700	13.9810	01/21/95	021	0700
150.000	16.9911	07/13/95	194	0200	13.7743	07/13/95	194	0200
120.000	17.0167	01/08/95	008	2300	13.7953	01/08/95	008	2300
90.000	17.2749	01/01/95	001	2300	14.0088	01/01/95	001	2300
60.000	17.0167	10/08/95	281	1000	13.7953	10/08/95	281	1000
30.000	17.0167	02/26/95	057	1200	13.7953	02/26/95	057	1200

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Table 3 (cont.)
Highest 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

(Maximum = 1833.2 at X = 200.00, Y = 180.00

- X Axis (Meters) -
- Gravitational Deposition -

Y Axis (Degrees)	2400.000	Mo/Dy/Yr	Jdy	Hr	2600.000	Mo/Dy/Yr	Jdy	Hr
.000	17.2749	06/30/95	181	0300	14.0088	06/30/95	181	0300

Y Axis (Degrees)	2800.000	Mo/Dy/Yr Jdy Hr	3000.000	Mo/Dy/Yr Jdy Hr
360.000	11.5109	06/30/95 181 0300	9.56963	06/30/95 181 0300
330.000	11.3327	03/08/95 067 2000	9.41961	03/08/95 067 2000
300.000	11.3327	03/18/95 077 1200	9.41961	03/18/95 077 1200
270.000	11.5109	05/25/95 145 0600	9.56963	05/25/95 145 0600
240.000	11.3327	05/10/95 130 0700	9.41961	05/10/95 130 0700
210.000	11.3327	01/10/95 010 0300	9.41961	01/10/95 010 0300
180.000	11.4878	01/21/95 021 0700	9.55033	01/21/95 021 0700
150.000	11.3153	07/13/95 194 0200	9.40506	07/13/95 194 0200
120.000	11.3327	01/08/95 008 2300	9.41961	01/08/95 008 2300
90.000	11.5109	01/01/95 001 2300	9.56963	01/01/95 001 2300
60.000	11.3327	10/08/95 281 1000	9.41961	10/08/95 281 1000
30.000	11.3327	02/26/95 057 1200	9.41961	02/26/95 057 1200
.000	11.5109	06/30/95 181 0300	9.56963	06/30/95 181 0300

- X Axis (Meters) - / - Gravitational Deposition -

Y Axis (Degrees)	3200.000	Mo/Dy/Yr Jdy Hr	3400.000	Mo/Dy/Yr Jdy Hr
360.000	8.03967	06/30/95 181 0300	6.81931	06/30/95 181 0300
330.000	7.91231	03/08/95 067 2000	6.71033	03/08/95 067 2000
300.000	8.56501	01/15/95 015 1900	8.29741	01/15/95 015 1900
270.000	8.03967	05/25/95 145 0600	6.81931	05/25/95 145 0600
240.000	7.91231	05/10/95 130 0700	6.71033	05/10/95 130 0700
210.000	7.91231	01/10/95 010 0300	7.15680	03/05/95 064 2200
180.000	8.42637	03/10/95 069 2000	8.18635	03/10/95 069 2000
150.000	7.90001	07/13/95 194 0200	6.69984	07/13/95 194 0200
120.000	7.91231	01/08/95 008 2300	6.71033	01/08/95 008 2300
90.000	8.03967	01/01/95 001 2300	6.81931	01/01/95 001 2300
60.000	7.91231	10/08/95 281 1000	6.71033	10/08/95 281 1000
30.000	7.91231	02/26/95 057 1200	6.71033	02/26/95 057 1200
.000	8.03967	06/30/95 181 0300	6.81931	06/30/95 181 0300

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Table 3 (cont.)
Highest 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

(Maximum = 1833.2 at X = 200.00, Y = 180.00

- X Axis (Meters) - / - Gravitational Deposition -

Y Axis (Degrees)	3600.000	Mo/Dy/Yr Jdy Hr	3800.000	Mo/Dy/Yr Jdy Hr
360.000	5.83652	06/30/95 181 0300	5.03980	06/30/95 181 0300
330.000	5.74257	03/08/95 067 2000	4.95823	03/08/95 067 2000
300.000	8.27955	01/15/95 015 1900	8.41958	01/15/95 015 1900
270.000	6.58656	01/05/95 005 1400	6.65461	01/05/95 005 1400
240.000	5.74257	05/10/95 130 0700	5.19630	03/11/95 070 1000
210.000	7.10971	03/05/95 064 2200	7.20823	03/05/95 064 2200
180.000	8.20127	03/10/95 069 2000	8.37757	03/10/95 069 2000
150.000	5.88226	03/11/95 070 0100	5.93196	03/11/95 070 0100
120.000	5.74257	01/08/95 008 2300	4.95823	01/08/95 008 2300
90.000	5.83652	01/01/95 001 2300	5.57871	02/19/95 050 1600
60.000	5.74257	10/08/95 281 1000	4.95823	10/08/95 281 1000

30.000	5.84124	02/19/95 050 1900	5.89623	02/19/95 050 1900
.000	5.83652	06/30/95 181 0300	5.03980	06/30/95 181 0300

- X Axis (Meters) -

Y Axis (Degrees)	4000.000 - Gravitational	Mo/Dy/Yr Jdy Hr	4200.000 Deposition -	Mo/Dy/Yr Jdy Hr
360.000	4.39204	06/30/95 181 0300	3.86613	06/30/95 181 0300
330.000	4.32070	03/08/95 067 2000	3.80331	03/08/95 067 2000
300.000	8.64497	01/15/95 015 1900	8.90130	01/15/95 015 1900
270.000	6.80386	01/05/95 005 1400	6.98907	01/05/95 005 1400
240.000	5.29647	03/11/95 070 1000	5.43307	03/11/95 070 1000
210.000	7.38877	03/05/95 064 2200	7.60305	03/05/95 064 2200
180.000	8.64079	03/10/95 069 2000	8.93464	03/10/95 069 2000
150.000	6.05911	03/11/95 070 0100	6.22246	03/11/95 070 0100
120.000	4.32070	01/08/95 008 2300	3.80331	01/08/95 008 2300
90.000	5.69101	02/19/95 050 1600	5.83990	02/19/95 050 1600
60.000	4.32070	10/08/95 281 1000	4.23318	02/19/95 050 1600
30.000	6.02789	02/19/95 050 1900	6.19508	02/19/95 050 1900
.000	4.39204	06/30/95 181 0300	3.86613	06/30/95 181 0300

- X Axis (Meters) -

Y Axis (Degrees)	4400.000 - Gravitational	Mo/Dy/Yr Jdy Hr	4600.000 Deposition -	Mo/Dy/Yr Jdy Hr
360.000	3.44188	06/30/95 181 0300	3.10378	06/30/95 181 0300
330.000	3.44625	04/24/95 114 1500	3.32858	04/24/95 114 1500
300.000	9.15581	01/15/95 015 1900	9.37730	01/15/95 015 1900
270.000	7.17751	01/05/95 005 1400	7.35431	01/05/95 005 1400

Table 3 (cont.)
Highest 1-hour Total KNO3 Gravitational Deposition (Micrograms/Square Meter)

(Maximum = 1833.2 at x = 200.00, Y = 180.00

- X Axis (Meters) -

Y Axis (Degrees)	4400.000 - Gravitational	Mo/Dy/Yr Jdy Hr	4600.000 Deposition -	Mo/Dy/Yr Jdy Hr
240.000	5.57879	03/11/95 070 1000	5.71919	03/11/95 070 1000
210.000	7.82068	03/05/95 064 2200	8.01427	03/05/95 064 2200
180.000	9.22458	03/10/95 069 2000	9.47871	03/10/95 069 2000
150.000	6.39184	03/11/95 070 0100	6.55251	03/11/95 070 0100
120.000	3.38620	01/08/95 008 2300	3.05410	01/08/95 008 2300
90.000	5.99657	02/19/95 050 1600	6.14639	02/19/95 050 1600
60.000	4.34243	02/19/95 050 1600	4.45112	02/19/95 050 1600
30.000	6.36779	02/19/95 050 1900	6.53130	02/19/95 050 1900
.000	3.44188	06/30/95 181 0300	3.10378	06/30/95 181 0300

- X Axis (Meters) -

Y Axis (Degrees)	4800.000 - Gravitational	Mo/Dy/Yr Jdy Hr	5000.000 Deposition -	Mo/Dy/Yr Jdy Hr
360.000	2.83938	06/30/95 181 0300	2.63825	06/30/95 181 0300
330.000	3.28499	04/24/95 114 1500	3.29911	04/24/95 114 1500
300.000	9.55458	01/15/95 015 1900	9.68172	01/15/95 015 1900

270.000	7.49736	01/05/95 005 1400	7.60388	01/05/95 005 1400
240.000	5.83705	03/11/95 070 1000	5.92829	03/11/95 070 1000
210.000	8.17249	03/05/95 064 2200	8.28915	03/05/95 064 2200
180.000	9.68501	03/10/95 069 2000	9.83726	03/10/95 069 2000
150.000	6.68480	03/11/95 070 0100	6.78524	03/11/95 070 0100
120.000	2.79479	01/08/95 008 2300	2.59801	01/08/95 008 2300
90.000	6.27086	02/19/95 050 1600	6.36619	02/19/95 050 1600
60.000	4.54556	02/19/95 050 1600	4.62115	02/19/95 050 1600
30.000	6.66606	02/19/95 050 1900	6.76862	02/19/95 050 1900
.000	2.83938	06/30/95 181 0300	2.63825	06/30/95 181 0300

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Table 4

Second Highest 1-hour Total KNO3 Gravitational Deposition
(Micrograms/Square Meter)

(Maximum = 1740.3 at X = 200.00, Y = 180.00)

- X Axis (Meters) -

Y Axis (Degrees)	.000	Mo/Dy/Yr Jdy Hr	200.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	.000000	00/00/00 000 0000	945.309	01/30/95 030 1700
330.000	.000000	00/00/00 000 0000	1286.41	04/21/95 111 1700
300.000	.000000	00/00/00 000 0000	1418.43	04/16/95 106 1500
270.000	.000000	00/00/00 000 0000	1280.96	01/25/95 025 2200
240.000	.000000	00/00/00 000 0000	1296.12	03/11/95 070 1200
210.000	.000000	00/00/00 000 0000	1365.58	03/05/95 064 2200
180.000	.000000	00/00/00 000 0000	1740.32	03/10/95 069 2300
150.000	.000000	00/00/00 000 0000	1238.59	03/11/95 070 0100
120.000	.000000	00/00/00 000 0000	1052.97	01/04/95 004 1100
90.000	.000000	00/00/00 000 0000	1199.63	02/19/95 050 1400
60.000	.000000	00/00/00 000 0000	1124.30	01/30/95 030 1300
30.000	.000000	00/00/00 000 0000	1017.02	07/16/95 197 1000
.000	.000000	00/00/00 000 0000	945.309	01/30/95 030 1700

- X Axis (Meters) -

Y Axis (Degrees)	400.000	Mo/Dy/Yr Jdy Hr	600.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	613.828	01/30/95 030 1700	354.508	01/20/95 020 0300
330.000	738.309	04/21/95 111 1700	394.169	03/14/95 073 1600
300.000	765.897	04/16/95 106 1500	394.169	01/05/95 005 0400
270.000	749.854	01/25/95 025 2000	402.994	01/25/95 025 2000
240.000	745.011	03/11/95 070 1200	394.556	03/11/95 070 1300
210.000	750.084	01/10/95 010 2200	391.016	03/10/95 069 1400
180.000	870.923	03/10/95 069 2300	429.024	03/10/95 069 2300
150.000	707.640	01/23/95 023 1300	387.612	01/23/95 023 1300
120.000	649.370	01/04/95 004 1100	363.546	01/24/95 024 2200
90.000	696.616	02/19/95 050 1700	376.659	02/19/95 050 1700
60.000	678.019	01/30/95 030 1300	373.262	01/30/95 030 1500
30.000	650.502	02/19/95 050 1900	356.012	07/16/95 197 0700
.000	613.827	01/30/95 030 1700	354.508	01/20/95 020 0300

- X Axis (Meters) -

Y Axis (Degrees)	800.000	Mo/Dy/Yr Jdy Hr	1000.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	214.705	01/20/95 020 0300	136.640	01/20/95 020 0300

330.000	225.743	03/14/95 073 1600	138.548	04/22/95 112 1600
300.000	225.743	01/05/95 005 0400	138.408	03/26/95 085 1400
270.000	230.210	05/05/95 125 1200	141.155	05/05/95 125 1200

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Table 4 (cont.)
Second Highest 1-hour Total KNO3 Gravitational Deposition
(Micrograms/Square Meter)

(Maximum = 1740.3 at X = 200.00, Y = 180.00

- X Axis (Meters) -

Y Axis (Degrees)	800.000	Mo/Dy/Yr Jdy Hr	1000.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
240.000	224.157	06/01/95 152 1400	138.576	06/16/95 167 1500
210.000	223.788	01/07/95 007 1300	138.331	03/05/95 064 1200
180.000	234.338	03/10/95 069 2400	140.282	03/10/95 069 2000
150.000	224.157	01/23/95 023 1300	138.382	01/07/95 007 0900
120.000	215.634	12/24/95 358 0300	136.871	12/24/95 358 0300
90.000	219.276	11/27/95 331 2100	138.454	11/27/95 331 2100
60.000	219.576	01/30/95 030 1500	137.222	01/30/95 030 1500
30.000	211.289	07/16/95 197 0700	133.889	04/10/95 100 0500
.000	214.705	01/20/95 020 0300	136.640	01/20/95 020 0300

- X Axis (Meters) -

Y Axis (Degrees)	1200.000	Mo/Dy/Yr Jdy Hr	1400.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	91.9476	05/29/95 149 0200	64.8404	11/17/95 321 2200
330.000	91.2596	01/27/95 027 1200	64.0086	04/29/95 119 0100
300.000	91.2966	02/07/95 038 1400	64.0086	06/21/95 172 2000
270.000	92.6545	10/11/95 284 1500	64.8404	04/17/95 107 2000
240.000	91.2596	01/25/95 025 1600	64.0086	06/01/95 152 2100
210.000	91.2966	02/13/95 044 1500	64.0086	09/15/95 258 2200
180.000	92.4577	07/28/95 209 1000	64.8404	06/25/95 176 0900
150.000	91.1497	01/24/95 024 0500	63.9883	07/24/95 205 0500
120.000	91.1556	01/03/95 003 0600	64.0086	04/22/95 112 0200
90.000	92.3986	12/18/95 352 0500	64.8404	02/19/95 050 2000
60.000	90.5634	01/30/95 030 1500	63.9468	02/20/95 051 0400
30.000	90.1120	07/16/95 197 0800	64.0086	07/16/95 197 0800
.000	91.9476	05/29/95 149 0200	64.8404	11/17/95 321 2200

- X Axis (Meters) -

Y Axis (Degrees)	1600.000	Mo/Dy/Yr Jdy Hr	1800.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	47.4890	07/14/95 195 2400	35.7517	07/14/95 195 2400
330.000	46.8867	04/29/95 119 0100	35.2692	04/29/95 119 0100
300.000	46.8867	06/21/95 172 2000	35.2692	06/21/95 172 2000
270.000	47.4890	07/28/95 209 0700	35.7517	07/28/95 209 0700
240.000	46.8867	06/01/95 152 2100	35.2692	06/01/95 152 2100
210.000	46.8867	09/15/95 258 2200	35.2692	09/15/95 258 2200
180.000	47.4037	04/02/95 092 0900	35.6855	04/02/95 092 0900
150.000	46.8202	12/13/95 347 0200	35.2182	12/13/95 347 0200

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Table 4 (cont.)
Second Highest 1-hour Total KNO3 Gravitational Deposition

(Micrograms/Square Meter)

(Maximum = 1740.3 at X = 200.00, Y = 180.00

- X Axis (Meters) -	1600.000	Mo/Dy/Yr Jdy Hr	1800.000	Mo/Dy/Yr Jdy Hr
Y Axis (Degrees)	- Gravitational Deposition -			
120.000	46.8867	04/22/95 112 0200	35.2692	04/22/95 112 0200
90.000	47.4890	01/01/95 001 2400	35.7517	01/01/95 001 2400
60.000	46.8414	02/20/95 051 0400	35.2351	02/20/95 051 0400
30.000	46.8867	07/16/95 197 0800	35.2692	07/16/95 197 0800
.000	47.4890	07/14/95 195 2400	35.7517	07/14/95 195 2400

- X Axis (Meters) -	2000.000	Mo/Dy/Yr Jdy Hr	2200.000	Mo/Dy/Yr Jdy Hr
Y Axis (Degrees)	- Gravitational Deposition -			
360.000	27.5326	07/14/95 195 2400	21.6233	07/14/95 195 2400
330.000	27.1443	04/29/95 119 0100	21.3082	04/29/95 119 0100
300.000	27.1443	06/21/95 172 2000	21.3082	06/21/95 172 2000
270.000	27.5326	07/28/95 209 0700	21.6233	07/28/95 209 0700
240.000	27.1443	06/01/95 152 2100	21.3082	06/01/95 152 2100
210.000	27.1443	09/15/95 258 2200	21.3082	09/15/95 258 2200
180.000	27.4805	04/02/95 092 0900	21.5816	04/02/95 092 0900
150.000	27.1043	12/13/95 347 0200	21.2764	12/13/95 347 0200
120.000	27.1443	04/22/95 112 0200	21.3082	04/22/95 112 0200
90.000	27.5326	01/01/95 001 2400	21.6233	01/01/95 001 2400
60.000	27.1179	02/20/95 051 0400	21.2874	02/20/95 051 0400
30.000	27.1443	07/16/95 197 0800	21.3082	07/16/95 197 0800
.000	27.5326	07/14/95 195 2400	21.6233	07/14/95 195 2400

- X Axis (Meters) -	2400.000	Mo/Dy/Yr Jdy Hr	2600.000	Mo/Dy/Yr Jdy Hr
Y Axis (Degrees)	- Gravitational Deposition -			
360.000	17.2749	07/14/95 195 2400	14.0088	07/14/95 195 2400
330.000	17.0167	04/29/95 119 0100	13.7953	04/29/95 119 0100
300.000	17.0167	06/21/95 172 2000	13.7953	06/21/95 172 2000
270.000	17.2749	07/28/95 209 0700	14.0088	07/28/95 209 0700
240.000	17.0167	06/01/95 152 2100	13.7953	06/01/95 152 2100
210.000	17.0167	09/15/95 258 2200	13.7953	09/15/95 258 2200
180.000	17.2411	04/02/95 092 0900	13.9810	04/02/95 092 0900
150.000	16.9911	12/13/95 347 0200	13.7743	12/13/95 347 0200
120.000	17.0167	04/22/95 112 0200	13.7953	04/22/95 112 0200
90.000	17.2749	01/01/95 001 2400	14.0088	01/01/95 001 2400
60.000	17.0001	02/20/95 051 0400	13.7818	02/20/95 051 0400
30.000	17.0167	07/16/95 197 0800	13.7953	07/16/95 197 0800

Table 4 (cont.)
Second Highest 1-hour Total KNO3 Gravitational Deposition
(Micrograms/Square Meter)

(Maximum = 1740.3 at X = 200.00, Y = 180.00

- X Axis (Meters) -
2400.000 Mo/Dy/Yr Jdy Hr 2600.000 Mo/Dy/Yr Jdy Hr

Y Axis (Degrees) - Gravitational Deposition -

.000	17.2749	07/14/95 195 2400	14.0088	07/14/95 195 2400

- X Axis (Meters) -

Y Axis (Degrees)	2800.000	Mo/Dy/Yr Jdy Hr	3000.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	11.5109	07/14/95 195 2400	9.56963	07/14/95 195 2400
330.000	11.3327	04/29/95 119 0100	9.41961	04/29/95 119 0100
300.000	11.3327	06/21/95 172 2000	9.41961	06/21/95 172 2000
270.000	11.5109	07/28/95 209 0700	9.56963	07/28/95 209 0700
240.000	11.3327	06/01/95 152 2100	9.41961	06/01/95 152 2100
210.000	11.3327	09/15/95 258 2200	9.41961	09/15/95 258 2200
180.000	11.4878	04/02/95 092 0900	9.55033	04/02/95 092 0900
150.000	11.3153	12/13/95 347 0200	9.40506	12/13/95 347 0200
120.000	11.3327	04/22/95 112 0200	9.41961	04/22/95 112 0200
90.000	11.5109	01/01/95 001 2400	9.56963	01/01/95 001 2400
60.000	11.3215	02/20/95 051 0400	9.41030	02/20/95 051 0400
30.000	11.3327	07/16/95 197 0800	9.41961	07/16/95 197 0800
.000	11.5109	07/14/95 195 2400	9.56963	07/14/95 195 2400

- X Axis (Meters) -

Y Axis (Degrees)	3200.000	Mo/Dy/Yr Jdy Hr	3400.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	8.03967	07/14/95 195 2400	6.81931	07/14/95 195 2400
330.000	7.91231	04/29/95 119 0100	6.71033	04/29/95 119 0100
300.000	8.11183	04/16/95 106 1500	7.84207	04/16/95 106 1500
270.000	8.03967	07/28/95 209 0700	6.81931	07/28/95 209 0700
240.000	7.91231	06/01/95 152 2100	6.71033	06/01/95 152 2100
210.000	7.91231	09/15/95 258 2200	6.71033	01/10/95 010 0300
180.000	8.42637	03/10/95 069 2400	8.18635	03/10/95 069 2400
150.000	7.90001	12/13/95 347 0200	6.69984	12/13/95 347 0200
120.000	7.91231	04/22/95 112 0200	6.71033	04/22/95 112 0200
90.000	8.03967	01/01/95 001 2400	6.81931	01/01/95 001 2400
60.000	7.90446	02/20/95 051 0400	6.70365	02/20/95 051 0400
30.000	7.91231	07/16/95 197 0800	6.71033	07/16/95 197 0800
.000	8.03967	07/14/95 195 2400	6.81931	07/14/95 195 2400

Table 4 (cont.)
Second Highest 1-hour Total KNO3 Gravitational Deposition
(Micrograms/Square Meter)

(Maximum = 1740.3 at X = 200.00, Y = 180.00

- X Axis (Meters) -

Y Axis (Degrees)	3600.000	Mo/Dy/Yr Jdy Hr	3800.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	5.83652	07/14/95 195 2400	5.03980	07/14/95 195 2400
330.000	5.74257	04/29/95 119 0100	4.95823	04/29/95 119 0100
300.000	7.81260	04/16/95 106 1500	7.93629	04/16/95 106 1500
270.000	6.58656	01/25/95 025 2200	6.65461	01/25/95 025 2200
240.000	5.74257	06/01/95 152 2100	4.95823	05/10/95 130 0700
210.000	6.47654	03/11/95 070 0200	6.61968	03/11/95 070 0200
180.000	8.20127	03/10/95 069 2400	8.37757	03/10/95 069 2400

150.000	5.73354	07/13/95 194 0200	4.95038	07/13/95 194 0200
120.000	5.74257	04/22/95 112 0200	4.95823	04/22/95 112 0200
90.000	5.83652	01/01/95 001 2400	5.03980	01/01/95 001 2400
60.000	5.73682	02/20/95 051 0400	4.95322	02/20/95 051 0400
30.000	5.74257	02/26/95 057 1200	4.95823	02/26/95 057 1200
.000	5.83652	07/14/95 195 2400	5.03980	07/14/95 195 2400

Y Axis (Degrees)	- X Axis (Meters) - 4000.000	Mo/Dy/Yr Jdy Hr	4200.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	4.39204	07/14/95 195 2400	3.86613	07/14/95 195 2400
330.000	4.32070	04/29/95 119 0100	3.80331	04/29/95 119 0100
300.000	8.14414	04/16/95 106 1500	8.38412	04/16/95 106 1500
270.000	6.80386	01/25/95 025 2200	6.98907	01/25/95 025 2200
240.000	4.32070	05/10/95 130 0700	3.80331	05/10/95 130 0700
210.000	6.84201	03/11/95 070 0200	7.09608	03/11/95 070 0200
180.000	8.64079	03/10/95 069 2400	8.93464	03/10/95 069 2400
150.000	4.31380	07/13/95 194 0200	3.79716	07/13/95 194 0200
120.000	4.32070	04/22/95 112 0200	3.80331	04/22/95 112 0200
90.000	4.39204	01/01/95 001 2400	3.86613	01/01/95 001 2400
60.000	4.31629	02/20/95 051 0400	3.81926	02/19/95 050 1900
30.000	4.32070	02/26/95 057 1200	3.80331	02/26/95 057 1200
.000	4.39204	07/14/95 195 2400	3.86613	07/14/95 195 2400

Y Axis (Degrees)	- X Axis (Meters) - 4400.000	Mo/Dy/Yr Jdy Hr	4600.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
360.000	3.44188	07/14/95 195 2400	3.10378	07/14/95 195 2400
330.000	3.42374	03/14/95 073 1600	3.31225	03/14/95 073 1600
300.000	8.62437	04/16/95 106 1500	8.83518	04/16/95 106 1500
270.000	7.17751	01/25/95 025 2200	7.35431	01/25/95 025 2200

Table 4 (cont.)

Second Highest 1-hour Total KNO3 Gravitational Deposition
(Micrograms/Square Meter)

(Maximum = 1740.3 at X = 200.00, Y = 180.00

Y Axis (Degrees)	- X Axis (Meters) - 4400.000	Mo/Dy/Yr Jdy Hr	4600.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			
240.000	3.47651	06/01/95 152 1400	3.35870	06/01/95 152 1400
210.000	7.34744	03/11/95 070 0200	7.58014	03/11/95 070 0200
180.000	9.22458	03/10/95 069 2400	9.47871	03/10/95 069 2400
150.000	3.47651	01/23/95 023 1300	3.35870	01/23/95 023 1300
120.000	3.38620	04/22/95 112 0200	3.05410	04/22/95 112 0200
90.000	3.44188	01/01/95 001 2400	3.29847	02/19/95 050 1300
60.000	3.91999	02/19/95 050 1900	4.02109	02/19/95 050 1900
30.000	3.38620	02/26/95 057 1200	3.05410	02/26/95 057 1200
.000	3.44188	07/14/95 195 2400	3.10378	07/14/95 195 2400

Y Axis (Degrees)	- X Axis (Meters) - 4800.000	Mo/Dy/Yr Jdy Hr	5000.000	Mo/Dy/Yr Jdy Hr
	- Gravitational Deposition -			

360.000	2.83938	07/14/95 195 2400	2.63825	07/14/95 195 2400
330.000	3.27528	03/14/95 073 1600	3.29636	03/14/95 073 1600
300.000	9.00529	04/16/		