PLG-0913

# CALCULATION OF X/Q VALUES FOR THE CONTROL ROOM INTAKES

Prepared for

D.C. COOK PLANT

by

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February 1993

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# CALCULATION OF X/Q VALUES FOR THE CONTROL ROOM INTAKES

## 1.0 INTRODUCTION AND SUMMARY

The purpose of this study was to calculate the 5% probable dispersion coefficients (X/Q) at the D.C. Cook plant control room intakes due to containment leakage after an accident. Four release-receptor combinations were evaluated for each of the 16 wind directions. Releases from both containment structures were evaluated and concentrations at each of the control room intakes were determined.

The study involved two major efforts. First, Dr. James Halitsky prepared estimates of direction-dependent concentration coefficients ($K_{c,avg}$) that are used along with wind speed to determine dilution due to turbulence around the plant structures. Dr. Halitsky's report is included as Attachment A. In this effort, Dr. Halitsky actually built a scale model of the plant to serve as a basis for his estimates. Dr. Halitsky is a well-known aerodynamicist who has worked with wind tunnels and has participated in field studies for many years. Use of generic factors is not appropriate for the Cook Plant due to the complex geometry of the plant structures involved. Second, values of X/Q were calculated for each weather category using site specific joint frequency weather data combined with the concentration coefficients.

The X/Q values were then rank ordered and summed to determine the 5% probable X/Q value for each release-receptor combination.

The maximum 5% X/Q value was 7.85E-4 (sec/$m^3$). Results for all combinations are given in Table 1.

## 2.0 BACKGROUND

During the design review in the licensing process, the U.S. NRC evaluates control room doses following an accident. This requires estimation of the dispersion (expressed as values of X/Q) that occurs as radionuclides released from the containment travel to the control room intake. Established NRC guidelines suggest that a conservative dispersion value should be used, such that concentrations at the intakes would not be exceeded more than 5% of the time. This is defined as the 5% probable X/Q value. Once the dilution factor is known, dose calculations to control room occupants can be made. The X/Q values computed in this study are appropriate for the first 8 hours following an accident. Values for longer time periods would be lower.

## 3.0 INPUT DATA

This study required use of two types of site/plant specific data as discussed below:

### 3.1 Meteorology

A 60m meteorological tower instrumented at two levels is in continuous operation at the plant site. For this report, joint frequency tables were generated for a 3-year period of record from January 1989 through

December 1991. Wind speed and direction measurements from the 33 ft level and delta temperature between 197 and 33 ft were used. The data recovery averaged better than 98% over the three year period. The concentration coefficients ($K_{c,avg}$) provided by Dr. Halitsky were to be used with wind speeds at the average plant structure height of 60 ft. Therefore, the wind speed taken from the 33 ft level was adjusted to 60 ft. Table 2 provides all seven joint frequency tables followed by a "totals" table for all stabilities.

3.2 Plant Parameters

The physical characteristics of the site were taken from drawings provided by AEP as shown in Figure 1 of Attachment A. The heights in Figure 1 are approximate as derived from the drawings. A scale model of the plant was constructed and used to visualize the plant complex. A simplified tracer study was run by Dr. Halitsky using the model to assist in visualizing the effect of the building cavities.

The plant grade averaged about 608 ft above sea level. The average release height of 60 ft above grade was used for all calculations. This height was about midway between plant grade of 608 ft and the top of the containment at about 720 ft. The reference area of the containment used in all calculations was $1685m^2$.

## 4.0 CALCULATION OF 5% X/Q VALUES

An EXCEL® spreadsheet was developed to compute the X/Q values for each of the control room intakes given a diffuse release at either of the containments at the D.C. Cook Nuclear Plant. The X/Q values were computed using K-factors provided by Dr. James Halitsky as described in Attachment A. When the user selects a particular combination of source unit and control room intake, the X/Q value for each combination of direction, wind speed, and stability is computed and tabulated using:

$$X/Q = K_{c,avg}/u_{60}A \qquad (1)$$

where $K_{c,avg}$ is the Halitsky K-factor, $u_{60}$ is the wind speed (m/s) at 60 ft (the average elevation of the complex above grade) and A is the reference area ($m^2$) of the containment. The wind speed is adjusted for elevation using:

$$u_{60} = (60/h_m)^n \qquad (2)$$

where the exponent n is 0.25 for unstable conditions (Pasquill-Gifford A, B, and C stability), 0.33 for neutral conditions (D stability), and 0.50 for stable conditions (E, F, G stability), and where $h_m$ is the measurement height (33 ft) of the meteorological data. A total of sixteen directions, six wind speeds and seven stability classes were used. Each wind speed category in the joint frequency tables was assigned a wind speed approximating the average speed in the category.

The assumed wind speed in each joint frequency speed category (33 ft level) was as follows:

| Wind Speed Category | Assumed Average Speed (mph) |
|---|---|
| 1-3 | 2.00 |
| 4-7 | 5.50 |
| 8-12 | 10.00 |
| 13-18 | 15.50 |
| 19-24 | 21.25 |
| 25 + | 27.00 |

## 5.0 5% PROBABLE X/Q RESULTS

The resulting table of X/Q values, their corresponding meteorological conditions and the frequency of these meteorological conditions, is sorted in order of descending X/Q. The cumulative frequency is then computed, and the desired X/Q value is the largest one for which the cumulative frequency exceeds 5%. Tables 1 through 4 provide numerical values of X/Q and their frequencies for the highest 5% of the categories in the joint frequency weather tables. Complementary cumulative distribution functions for all X/Q values and all release-receptor combinations are computed and plotted as shown in Figures 1 through 4.

TABLE 1. 5% PROBABLE CONTROL ROOM INTAKE X/Q VALUES FOR THE COOK NUCLEAR PLANT

| Release from | Unit 1 | Unit 1 | Unit 2 | Unit 2 |
|---|---|---|---|---|
| Receptor at | Intake 1 | Intake 2 | Intake 1 | Intake 2 |
| X/Q Value (sec/m$^3$) | 7.85E-4 | 2.45E-4 | 3.43E-4 | 7.07E-4 |

TABLE 2. JOINT FREQUENCY TABLE OF WIND SPEED AND DIRECTION VERSUS STABILITY CATEGORY FROM THE COOK METEOROLOGICAL TOWER FOR THE PERIOD OF JANUARY 1, 1989 THROUGH DECEMBER 31, 1991

TABLE 2. JOINT FREQUENCY TABLE OF WIND SPEED AND DIRECTION VERSUS STABILITY CATEGORY FROM THE COOK METEOROLOGICAL TOWER FOR THE PERIOD OF JANUARY 1, 1989 THROUGH DECEMBER 31, 1991

| Stability Class: A | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | Wind Speed(Mph) | | | | | | Total |
| | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | |
| N | 12 | 261 | 215 | 16 | 0 | 0 | 504 |
| NNE | 4 | 21 | 32 | 5 | 0 | 0 | 62 |
| NE | 8 | 29 | 32 | 8 | 2 | 0 | 79 |
| ENE | 3 | 54 | 50 | 9 | 0 | 0 | 116 |
| E | 5 | 63 | 50 | 7 | 0 | 0 | 125 |
| ESE | 4 | 83 | 39 | 5 | 0 | 0 | 131 |
| SE | 5 | 68 | 54 | 2 | 0 | 0 | 129 |
| SSE | 16 | 110 | 80 | 13 | 0 | 0 | 219 |
| S | 10 | 87 | 193 | 48 | 2 | 1 | 341 |
| SSW | 3 | 23 | 64 | 30 | 2 | 0 | 122 |
| SW | 6 | 119 | 172 | 28 | 0 | 0 | 325 |
| WSW | 9 | 162 | 204 | 32 | 2 | 0 | 409 |
| W | 5 | 194 | 123 | 10 | 3 | 0 | 335 |
| WNW | 19 | 210 | 68 | 2 | 1 | 0 | 300 |
| NW | 24 | 247 | 73 | 1 | 0 | 0 | 345 |
| NNW | 17 | 353 | 160 | 5 | 0 | 0 | 535 |
| Total | 150 | 2084 | 1609 | 221 | 12 | 1 | 4077 |

Periods of Calm(Hours) : 0

TABLE 2 (continued)

| Stability Class: B | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | Total |
| N | 14 | 77 | 54 | 8 | 0 | 0 | 153 |
| NNE | 4 | 19 | 18 | 3 | 0 | 0 | 44 |
| NE | 3 | 36 | 21 | 9 | 3 | 0 | 72 |
| ENE | 12 | 31 | 33 | 5 | 0 | 0 | 81 |
| E | 7 | 44 | 32 | 5 | 0 | 0 | 88 |
| ESE | 5 | 34 | 19 | 2 | 0 | 0 | 60 |
| SE | 6 | 40 | 20 | 1 | 0 | 0 | 67 |
| SSE | 6 | 23 | 32 | 3 | 1 | 0 | 65 |
| S | 6 | 43 | 66 | 34 | 2 | 0 | 151 |
| SSW | 3 | 13 | 43 | 20 | 0 | 0 | 79 |
| SW | 2 | 55 | 77 | 22 | 0 | 0 | 156 |
| WSW | 3 | 76 | 71 | 12 | 2 | 0 | 164 |
| W | 8 | 66 | 47 | 9 | 9 | 0 | 139 |
| WNW | 6 | 44 | 30 | 5 | 0 | 0 | 85 |
| NW | 20 | 43 | 23 | 4 | 0 | 0 | 90 |
| NNW | 8 | 89 | 30 | 1 | 0 | 0 | 128 |
| Total | 113 | 733 | 616 | 143 | 17 | 0 | 1622 |

Periods of Calm(Hours) : 0

TABLE 2 (continued)

| Stability Class: C | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | Wind Speed(Mph) | | | | | | Total |
| | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | |
| N | 13 | 99 | 54 | 16 | 0 | 0 | 182 |
| NNE | 7 | 25 | 40 | 3 | 0 | 0 | 75 |
| NE | 9 | 35 | 28 | 6 | 2 | 0 | 80 |
| ENE | 6 | 45 | 29 | 11 | 1 | 0 | 92 |
| E | 10 | 54 | 26 | 8 | 0 | 0 | 98 |
| ESE | 8 | 28 | 19 | 5 | 0 | 0 | 60 |
| SE | 17 | 36 | 18 | 0 | 0 | 0 | 71 |
| SSE | 14 | 51 | 30 | 4 | 0 | 0 | 99 |
| S | 5 | 42 | 70 | 28 | 3 | 0 | 148 |
| SSW | 3 | 19 | 51 | 36 | 6 | 0 | 115 |
| SW | 5 | 49 | 79 | 23 | 2 | 0 | 158 |
| WSW | 4 | 57 | 61 | 37 | 11 | 0 | 170 |
| W | 6 | 41 | 80 | 23 | 3 | 0 | 153 |
| WNW | 6 | 62 | 69 | 17 | 2 | 0 | 156 |
| NW | 6 | 48 | 42 | 9 | 0 | 0 | 105 |
| NNW | 16 | 81 | 54 | 16 | 0 | 0 | 167 |
| Total | 135 | 772 | 750 | 242 | 30 | 0 | 1929 |

Periods of Calm(Hours) : 0

TABLE 2 (continued)

| Stability Class: D | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | Wind Speed(Mph) | | | | | | Total |
| | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | |
| N | 63 | 353 | 195 | 39 | 1 | 0 | 651 |
| NNE | 35 | 166 | 108 | 25 | 4 | 0 | 338 |
| NE | 35 | 170 | 136 | 43 | 5 | 0 | 389 |
| ENE | 38 | 150 | 121 | 13 | 4 | 0 | 326 |
| E | 41 | 135 | 111 | 26 | 3 | 0 | 316 |
| ESE | 43 | 113 | 105 | 13 | 0 | 0 | 274 |
| SE | 49 | 129 | 95 | 11 | 0 | 0 | 284 |
| SSE | 48 | 146 | 98 | 36 | 0 | 0 | 328 |
| S | 49 | 259 | 343 | 126 | 10 | 2 | 789 |
| SSW | 18 | 157 | 401 | 162 | 17 | 2 | 757 |
| SW | 37 | 147 | 336 | 117 | 10 | 0 | 647 |
| WSW | 25 | 134 | 284 | 112 | 13 | 1 | 569 |
| W | 30 | 176 | 294 | 113 | 12 | 0 | 625 |
| WNW | 66 | 230 | 329 | 50 | 0 | 0 | 675 |
| NW | 71 | 255 | 176 | 50 | 0 | 0 | 552 |
| NNW | 78 | 360 | 180 | 67 | 3 | 1 | 689 |
| Total | 726 | 3080 | 3312 | 1003 | 82 | 6 | 8209 |

Periods of Calm(Hours) : 0

TABLE 2 (continued)

| Stability Class E | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | Wind Speed (Mph) | | | | | | Total |
| | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | |
| N | 97 | 183 | 58 | 10 | 1 | 1 | 350 |
| NNE | 76 | 144 | 35 | 3 | 1 | 0 | 259 |
| NE | 77 | 139 | 80 | 0 | 0 | 0 | 296 |
| ENE | 62 | 170 | 34 | 0 | 0 | 0 | 266 |
| E | 92 | 157 | 56 | 2 | 5 | 0 | 312 |
| ESE | 89 | 174 | 34 | 1 | 0 | 0 | 298 |
| SE | 96 | 179 | 50 | 5 | 0 | 0 | 330 |
| SSE | 122 | 225 | 83 | 10 | 2 | 0 | 442 |
| S | 108 | 505 | 294 | 41 | 3 | 0 | 951 |
| SSW | 56 | 271 | 270 | 56 | 1 | 0 | 654 |
| SW | 50 | 178 | 153 | 19 | 0 | 0 | 400 |
| WSW | 45 | 125 | 78 | 11 | 2 | 0 | 261 |
| W | 59 | 113 | 56 | 6 | 0 | 0 | 234 |
| WNW | 83 | 96 | 26 | 1 | 4 | 0 | 210 |
| NW | 55 | 58 | 15 | 2 | 0 | 0 | 130 |
| NNW | 78 | 110 | 13 | 6 | 0 | 0 | 207 |
| Total | 1245 | 2827 | 1335 | 173 | 19 | 1 | 5600 |

Periods of Calm(Hours) : 0

TABLE 2 (continued)

| Stability Class: F | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | Wind Speed(Mph) | | | | | | Total |
| | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | |
| N | 38 | 17 | 5 | 1 | 0 | 1 | 62 |
| NNE | 49 | 10 | 5 | 0 | 0 | 0 | 64 |
| NE | 86 | 37 | 5 | 1 | 0 | 0 | 129 |
| ENE | 110 | 60 | 7 | 8 | 0 | 0 | 185 |
| E | 130 | 68 | 5 | 0 | 0 | 0 | 203 |
| ESE | 129 | 57 | 3 | 0 | 0 | 0 | 189 |
| SE | 106 | 61 | 8 | 0 | 0 | 0 | 175 |
| SSE | 188 | 176 | 8 | 0 | 0 | 0 | 372 |
| S | 153 | 260 | 16 | 2 | 0 | 0 | 431 |
| SSW | 61 | 77 | 9 | 1 | 0 | 0 | 148 |
| SW | 37 | 51 | 10 | 0 | 0 | 0 | 98 |
| WSW | 15 | 28 | 6 | 3 | 0 | 0 | 52 |
| W | 34 | 16 | 1 | 3 | 0 | 0 | 54 |
| WNW | 28 | 16 | 3 | 0 | 0 | 0 | 47 |
| NW | 36 | 7 | 3 | 0 | 0 | 0 | 46 |
| NNW | 26 | 6 | 3 | 0 | 0 | 0 | 35 |
| Total | 1226 | 947 | 97 | 19 | 0 | 1 | 2290 |

Periods of Calm(Hours) : 0

TABLE 2 (continued)

| Stability Class G | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | Wind Speed (mph) | | | | | | Total |
| | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | |
| N | 17 | 4 | 1 | 0 | 0 | 0 | 22 |
| NNE | 24 | 2 | 0 | 0 | 0 | 0 | 26 |
| NE | 65 | 8 | 1 | 0 | 0 | 0 | 74 |
| ENE | 155 | 16 | 2 | 0 | 0 | 0 | 173 |
| E | 224 | 28 | 0 | 0 | 0 | 0 | 252 |
| ESE | 188 | 9 | 0 | 0 | 0 | 0 | 197 |
| SE | 255 | 14 | 0 | 0 | 0 | 0 | 269 |
| SSE | 345 | 64 | 0 | 0 | 0 | 0 | 409 |
| S | 245 | 94 | 3 | 0 | 0 | 0 | 342 |
| SSW | 57 | 34 | 0 | 0 | 0 | 0 | 91 |
| SW | 28 | 10 | 1 | 0 | 0 | 0 | 39 |
| WSW | 25 | 6 | 0 | 0 | 0 | 0 | 31 |
| W | 30 | 2 | 0 | 0 | 0 | 0 | 32 |
| WNW | 19 | 5 | 0 | 0 | 0 | 0 | 24 |
| NW | 20 | 2 | 0 | 0 | 0 | 0 | 22 |
| NNW | 21 | 7 | 0 | 0 | 0 | 0 | 28 |
| Total | 1718 | 305 | 8 | 0 | 0 | 0 | 2031 |

Periods of Calm(Hours) : 0

TABLE 2 (continued)

| Stability Class: All | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind Direction | Wind Speed(Mph) | | | | | | Total |
| | 1-3 | 4-7 | 8-12 | 13-18 | 19-24 | >24 | |
| N | 254 | 994 | 582 | 90 | 2 | 2 | 1924 |
| NNE | 199 | 387 | 238 | 39 | 5 | 0 | 868 |
| NE | 283 | 454 | 303 | 67 | 12 | 0 | 1119 |
| ENE | 386 | 526 | 276 | 46 | 5 | 0 | 1239 |
| E | 509 | 549 | 280 | 48 | 8 | 0 | 1394 |
| ESE | 466 | 498 | 219 | 26 | 0 | 0 | 1209 |
| SE | 534 | 527 | 245 | 19 | 0 | 0 | 1325 |
| SSE | 739 | 795 | 331 | 66 | 3 | 0 | 1934 |
| S | 576 | 1290 | 985 | 279 | 20 | 3 | 3153 |
| SSW | 201 | 594 | 838 | 305 | 26 | 2 | 1966 |
| SW | 165 | 609 | 828 | 209 | 12 | 0 | 1823 |
| WSW | 126 | 588 | 704 | 207 | 30 | 1 | 1656 |
| W | 172 | 608 | 601 | 164 | 27 | 0 | 1572 |
| WNW | 227 | 663 | 525 | 75 | 7 | 0 | 1497 |
| NW | 232 | 660 | 332 | 66 | 0 | 0 | 1290 |
| NNW | 244 | 1006 | 440 | 95 | 3 | 1 | 1789 |
| Total | 5313 | 10748 | 7727 | 1801 | 160 | 9 | 25758 |

Periods of Calm(Hours) : 0
Hours of Missing Data : 522

TABLE 3. CUMULATIVE X/Q VALUES AT UNIT 1 CONTROL ROOM INTAKE BASED ON UNIT 1 RELEASE

| All Directions | | | | | |
|---|---|---|---|---|---|
| Stability Class | Wind Speed | Wind Direction | Chi/Q s/m^3 | # of Hours | Cumul. Freq. |
| G | 1.21 | ESE | 7.853E-4 | | 5.09% |
| A | 1.04 | NE | 2.112E-3 | 8 | 0.03% |
| B | 1.04 | NE | 2.112E-3 | 3 | 0.04% |
| C | 1.04 | NE | 2.112E-3 | 9 | 0.08% |
| D | 1.09 | NE | 2.012E-3 | 35 | 0.21% |
| E | 1.21 | NE | 1.816E-3 | 77 | 0.51% |
| F | 1.21 | NE | 1.816E-3 | 86 | 0.85% |
| G | 1.21 | NE | 1.816E-3 | 65 | 1.10% |
| A | 1.04 | WNW | 1.027E-3 | 19 | 1.17% |
| A | 1.04 | NW | 1.027E-3 | 24 | 1.27% |
| B | 1.04 | WNW | 1.027E-3 | 6 | 1.29% |
| B | 1.04 | NW | 1.027E-3 | 20 | 1.37% |
| C | 1.04 | WNW | 1.027E-3 | 6 | 1.39% |
| C | 1.04 | NW | 1.027E-3 | 6 | 1.41% |
| D | 1.09 | WNW | 9.790E-4 | 66 | 1.67% |
| D | 1.09 | NW | 9.790E-4 | 71 | 1.95% |
| A | 1.04 | ESE | 9.133E-4 | 4 | 1.96% |
| B | 1.04 | ESE | 9.133E-4 | 5 | 1.98% |
| C | 1.04 | ESE | 9.133E-4 | 8 | 2.01% |
| E | 1.21 | WNW | 8.835E-4 | 83 | 2.33% |
| E | 1.21 | NW | 8.835E-4 | 55 | 2.55% |
| F | 1.21 | WNW | 8.835E-4 | 28 | 2.66% |
| F | 1.21 | NW | 8.835E-4 | 36 | 2.80% |
| G | 1.21 | WNW | 8.835E-4 | 19 | 2.87% |
| G | 1.21 | NW | 8.835E-4 | 20 | 2.95% |
| D | 1.09 | ESE | 8.702E-4 | 43 | 3.11% |
| A | 1.04 | N | 8.562E-4 | 12 | 3.16% |
| B | 1.04 | N | 8.562E-4 | 14 | 3.21% |
| C | 1.04 | N | 8.562E-4 | 13 | 3.27% |
| D | 1.09 | N | 8.158E-4 | 63 | 3.51% |
| E | 1.21 | ESE | 7.853E-4 | 89 | 3.86% |
| F | 1.21 | ESE | 7.853E-4 | 129 | 4.36% |
| G | 1.21 | ESE | 7.853E-4 | 188 | 5.09% |
| A | 2.86 | NE | 7.680E-4 | 29 | 5.20% |
| B | 2.86 | NE | 7.680E-4 | 36 | 5.34% |
| C | 2.86 | NE | 7.680E-4 | 35 | 5.47% |
| A | 1.04 | NNE | 7.420E-4 | 4 | 5.49% |
| A | 1.04 | SE | 7.420E-4 | 5 | 5.51% |
| B | 1.04 | NNE | 7.420E-4 | 4 | 5.52% |
| B | 1.04 | SE | 7.420E-4 | 6 | 5.55% |
| C | 1.04 | NNE | 7.420E-4 | 7 | 5.57% |
| C | 1.04 | SE | 7.420E-4 | 17 | 5.64% |
| E | 1.21 | N | 7.363E-4 | 97 | 6.02% |
| F | 1.21 | N | 7.363E-4 | 38 | 6.17% |
| G | 1.21 | N | 7.363E-4 | 17 | 6.23% |
| D | 3.00 | NE | 7.318E-4 | 170 | 6.89% |

TABLE 4. CUMULATIVE X/Q VALUES AT UNIT 1 CONTROL ROOM INTAKE BASED ON UNIT 2 RELEASE

| All Directions | | | | | |
|---|---|---|---|---|---|
| Stability Class | Wind Speed | Wind Direction | Chi/Q s/m^3 | # of Hours | Cumul. Freq. |
| E | 1.21 | N | 2.454E-4 | | 5.35% |
| A | 1.04 | NE | 3.996E-4 | 8 | 0.03% |
| B | 1.04 | NE | 3.996E-4 | 3 | 0.04% |
| C | 1.04 | NE | 3.996E-4 | 9 | 0.08% |
| D | 1.09 | NE | 3.807E-4 | 35 | 0.21% |
| E | 1.21 | NE | 3.436E-4 | 77 | 0.51% |
| F | 1.21 | NE | 3.436E-4 | 86 | 0.85% |
| G | 1.21 | NE | 3.436E-4 | 65 | 1.10% |
| A | 1.04 | ENE | 3.425E-4 | 3 | 1.11% |
| A | 1.04 | E | 3.425E-4 | 5 | 1.13% |
| B | 1.04 | ENE | 3.425E-4 | 12 | 1.18% |
| B | 1.04 | E | 3.425E-4 | 7 | 1.20% |
| C | 1.04 | ENE | 3.425E-4 | 6 | 1.23% |
| C | 1.04 | E | 3.425E-4 | 10 | 1.27% |
| D | 1.09 | ENE | 3.263E-4 | 38 | 1.41% |
| D | 1.09 | E | 3.263E-4 | 41 | 1.57% |
| E | 1.21 | ENE | 2.945E-4 | 62 | 1.81% |
| E | 1.21 | E | 2.945E-4 | 92 | 2.17% |
| F | 1.21 | ENE | 2.945E-4 | 110 | 2.60% |
| F | 1.21 | E | 2.945E-4 | 130 | 3.10% |
| G | 1.21 | ENE | 2.945E-4 | 155 | 3.70% |
| G | 1.21 | E | 2.945E-4 | 224 | 4.57% |
| A | 1.04 | N | 2.854E-4 | 12 | 4.62% |
| B | 1.04 | N | 2.854E-4 | 14 | 4.67% |
| C | 1.04 | N | 2.854E-4 | 13 | 4.72% |
| D | 1.09 | N | 2.719E-4 | 63 | 4.97% |
| E | 1.21 | N | 2.454E-4 | 97 | 5.35% |
| F | 1.21 | N | 2.454E-4 | 38 | 5.49% |
| G | 1.21 | N | 2.454E-4 | 17 | 5.56% |
| A | 1.04 | NNE | 2.283E-4 | 4 | 5.57% |
| A | 1.04 | ESE | 2.283E-4 | 4 | 5.59% |
| B | 1.04 | NNE | 2.283E-4 | 4 | 5.61% |
| B | 1.04 | ESE | 2.283E-4 | 5 | 5.63% |
| C | 1.04 | NNE | 2.283E-4 | 7 | 5.65% |
| C | 1.04 | ESE | 2.283E-4 | 8 | 5.68% |
| D | 1.09 | NNE | 2.176E-4 | 35 | 5.82% |
| D | 1.09 | ESE | 2.176E-4 | 43 | 5.99% |
| E | 1.21 | NNE | 1.963E-4 | 76 | 6.28% |
| E | 1.21 | ESE | 1.963E-4 | 89 | 6.63% |
| F | 1.21 | NNE | 1.963E-4 | 49 | 6.82% |
| F | 1.21 | ESE | 1.963E-4 | 129 | 7.32% |
| G | 1.21 | NNE | 1.963E-4 | 24 | 7.41% |
| G | 1.21 | ESE | 1.963E-4 | 188 | 8.14% |
| A | 1.04 | SE | 1.712E-4 | 5 | 8.16% |
| A | 1.04 | SSE | 1.712E-4 | 16 | 8.22% |
| B | 1.04 | SE | 1.712E-4 | 6 | 8.25% |

TABLE 5. CUMULATIVE X/Q VALUES AT UNIT 2 CONTROL ROOM INTAKE
BASED ON UNIT 1 RELEASE

| All Directions | | | | | |
|---|---|---|---|---|---|
| Stability Class | Wind Speed | Wind Direction | Chi/Q s/m^3 | # of Hours | Cumul. Freq. |
| B | 1.04 | ENE | 3.425E-4 | | 5.04% |
| A | 1.04 | SE | 7.420E-4 | 5 | 0.02% |
| A | 1.04 | SSE | 7.420E-4 | 16 | 0.08% |
| B | 1.04 | SE | 7.420E-4 | 6 | 0.10% |
| B | 1.04 | SSE | 7.420E-4 | 6 | 0.13% |
| C | 1.04 | SE | 7.420E-4 | 17 | 0.19% |
| C | 1.04 | SSE | 7,420E-4 | 14 | 0.25% |
| D | 1.09 | SE | 7.071E-4 | 49 | 0.44% |
| D | 1.09 | SSE | 7.071E-4 | 48 | 0.63% |
| E | 1.21 | SE | 6.381E-4 | 96 | 1.00% |
| E | 1.21 | SSE | 6.381E-4 | 122 | 1.47% |
| F | 1.21 | SE | 6.381E-4 | 106 | 1.88% |
| F | 1.21 | SSE | 6.381E-4 | 188 | 2.61% |
| G | 1.21 | SE | 6.381E-4 | 255 | 3.60% |
| G | 1.21 | SSE | 6.381E-4 | 345 | 4.94% |
| A | 1.04 | ENE | 3.425E-4 | 3 | 4.95% |
| A | 1.04 | S | 3.425E-4 | 10 | 4.99% |
| B | 1.04 | ENE | 3.425E-4 | 12 | 5.04% |
| B | 1.04 | S | 3.425E-4 | 6 | 5.06% |
| C | 1.04 | ENE | 3.425E-4 | 6 | 5.09% |
| C | 1.04 | S | 3.425E-4 | 5 | 5.11% |
| D | 1.09 | ENE | 3.263E-4 | 38 | 5.25% |
| D | 1.09 | S | 3.263E-4 | 49 | 5.44% |
| E | 1.21 | ENE | 2.945E-4 | 62 | 5.68% |
| E | 1.21 | S | 2.945E-4 | 108 | 6.10% |
| F | 1.21 | ENE | 2.945E-4 | 110 | 6.53% |
| F | 1.21 | S | 2.945E-4 | 153 | 7.12% |
| G | 1.21 | ENE | 2.945E-4 | 155 | 7.73% |
| G | 1.21 | S | 2.945E-4 | 245 | 8.68% |
| A | 1.04 | ESE | 2.854E-4 | 4 | 8.69% |
| B | 1.04 | ESE | 2.854E-4 | 5 | 8.71% |
| C | 1.04 | ESE | 2.854E-4 | 8 | 8.74% |
| D | 1.09 | ESE | 2.719E-4 | 43 | 8.91% |
| A | 2.86 | SE | 2.698E-4 | 68 | 9.17% |
| A | 2.86 | SSE | 2.698E-4 | 110 | 9.60% |
| B | 2.86 | SE | 2.698E-4 | 40 | 9.76% |
| B | 2.86 | SSE | 2.698E-4 | 23 | 9.85% |
| C | 2.86 | SE | 2.698E-4 | 36 | 9.99% |
| C | 2.86 | SSE | 2.698E-4 | 51 | 10.18% |
| D | 3.00 | SE | 2.571E-4 | 129 | 10.68% |
| D | 3.00 | SSE | 2.571E-4 | 146 | 11.25% |
| E | 1.21 | ESE | 2.454E-4 | 89 | 11.60% |
| F | 1.21 | ESE | 2.454E-4 | 129 | 12.10% |
| G | 1.21 | ESE | 2.454E-4 | 188 | 12.83% |
| E | 3.33 | SE | 2.320E-4 | 179 | 13.52% |
| E | 3.33 | SSE | 2.320E-4 | 225 | 14.40% |

TABLE 6. CUMULATIVE X/Q VALUES AT UNIT 2 CONTROL ROOM INTAKE BASED ON UNIT 2 RELEASE

| All Directions | | | | | |
|---|---|---|---|---|---|
| Stability Class | Wind Speed | Wind Direction | Chi/Q s/m^3 | # of Hours | Cumul. Freq. |
| D | 1.09 | ESE | 7.071E-4 | | 5.11% |
| A | 1.04 | S | 1.313E-3 | 10 | 0.04% |
| B | 1.04 | S | 1.313E-3 | 6 | 0.06% |
| C | 1.04 | S | 1.313E-3 | 5 | 0.08% |
| D | 1.09 | S | 1.251E-3 | 49 | 0.27% |
| E | 1.21 | S | 1.129E-3 | 108 | 0.69% |
| F | 1.21 | S | 1.129E-3 | 153 | 1.29% |
| G | 1.21 | S | 1.129E-3 | 245 | 2.24% |
| A | 1.04 | W | 1.027E-3 | 5 | 2.26% |
| B | 1.04 | W | 1.027E-3 | 8 | 2.29% |
| C | 1.04 | W | 1.027E-3 | 6 | 2.31% |
| D | 1.09 | W | 9.790E-4 | 30 | 2.43% |
| A | 1.04 | E | 9.704E-4 | 5 | 2.45% |
| B | 1.04 | E | 9.704E-4 | 7 | 2.47% |
| C | 1.04 | E | 9.704E-4 | 10 | 2.51% |
| D | 1.09 | E | 9.246E-4 | 41 | 2.67% |
| E | 1.21 | W | 8.835E-4 | 59 | 2.90% |
| F | 1.21 | W | 8.835E-4 | 34 | 3.03% |
| G | 1.21 | W | 8.835E-4 | 30 | 3.15% |
| E | 1.21 | E | 8.344E-4 | 92 | 3.51% |
| F | 1.21 | E | 8.344E-4 | 130 | 4.01% |
| G | 1.21 | E | 8.344E-4 | 224 | 4.88% |
| A | 1.04 | ESE | 7.420E-4 | 4 | 4.90% |
| B | 1.04 | ESE | 7.420E-4 | 5 | 4.91% |
| C | 1.04 | ESE | 7.420E-4 | 8 | 4.95% |
| D | 1.09 | ESE | 7.071E-4 | 43 | 5.11% |
| E | 1.21 | ESE | 6.381E-4 | 89 | 5.46% |
| F | 1.21 | ESE | 6.381E-4 | 129. | 5.96% |
| G | 1.21 | ESE | 6.381E-4 | 188 | 6.69% |
| A | 1.04 | ENE | 6.279E-4 | 3 | 6.70% |
| B | 1.04 | ENE | 6.279E-4 | 12 | 6.75% |
| C | 1.04 | ENE | 6.279E-4 | 6 | 6.77% |
| D | 1.09 | ENE | 5.983E-4 | 38 | 6.92% |
| E | 1.21 | ENE | 5.399E-4 | 62 | 7.16% |
| F | 1.21 | ENE | 5.399E-4 | 110 | 7.59% |
| G | 1.21 | ENE | 5.399E-4 | 155 | 8.19% |
| A | 1.04 | SE | 5.137E-4 | 5 | 8.21% |
| B | 1.04 | SE | 5.137E-4 | 6 | 8.23% |
| C | 1.04 | SE | 5.137E-4 | 17 | 8.30% |
| D | 1.09 | SE | 4.895E-4 | 49 | 8.49% |
| A | 2.86 | S | 4.774E-4 | 87 | 8.82% |
| B | 2.86 | S | 4.774E-4 | 43 | 8.99% |
| C | 2.86 | S | 4.774E-4 | 42 | 9.15% |
| D | 3.00 | S | 4.549E-4 | 259 | 10.16% |
| E | 1.21 | SE | 4.418E-4 | 96 | 10.53% |
| F | 1.21 | SE | 4.418E-4 | 106 | 10.94% |

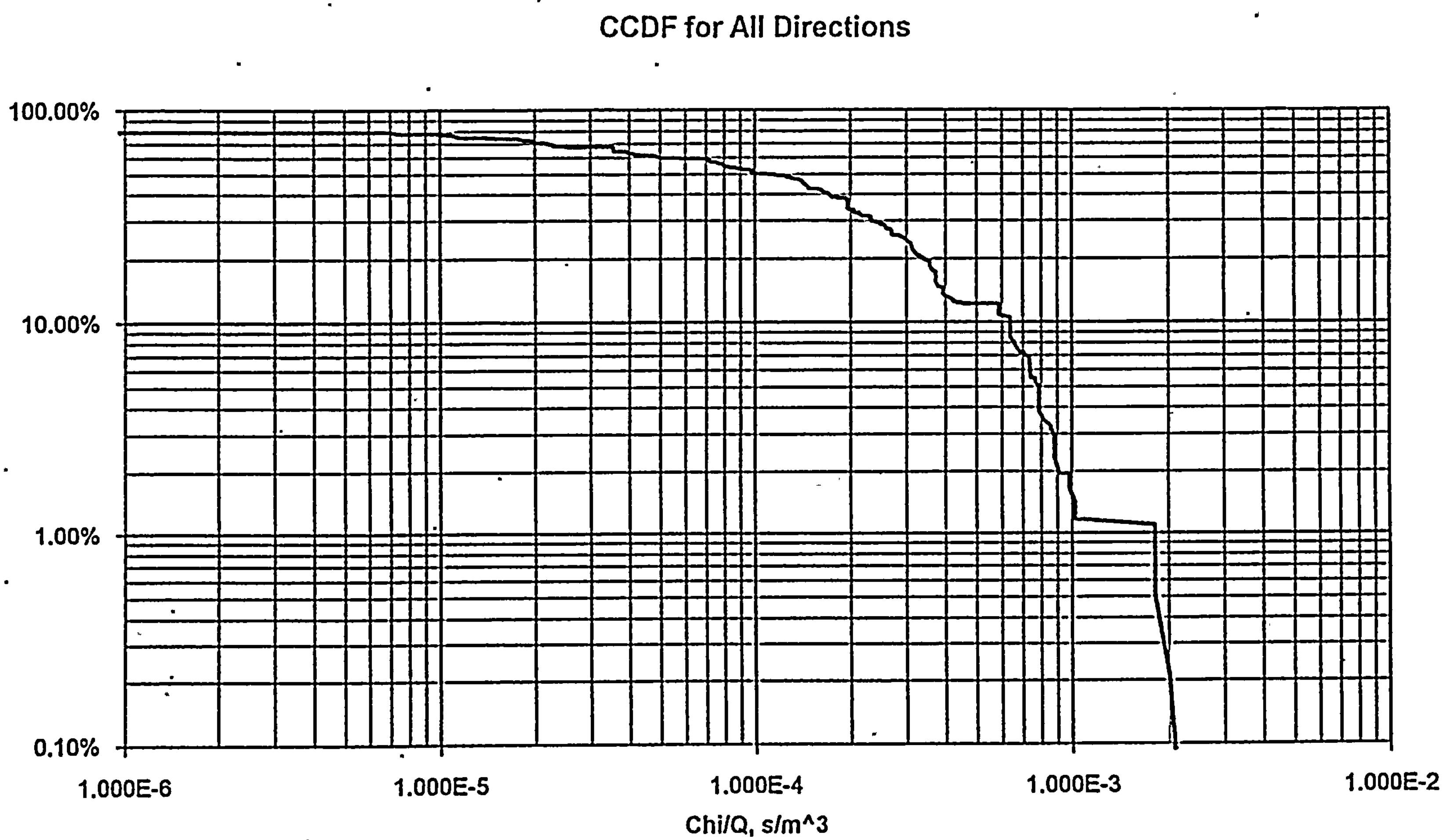


FIGURE 1. CUMULATIVE PLOTS OF DIRECTION INDEPENDENT X/Q VALUES AT UNIT 1 CONTROL ROOM INTAKE BASED ON UNIT 1 RELEASE

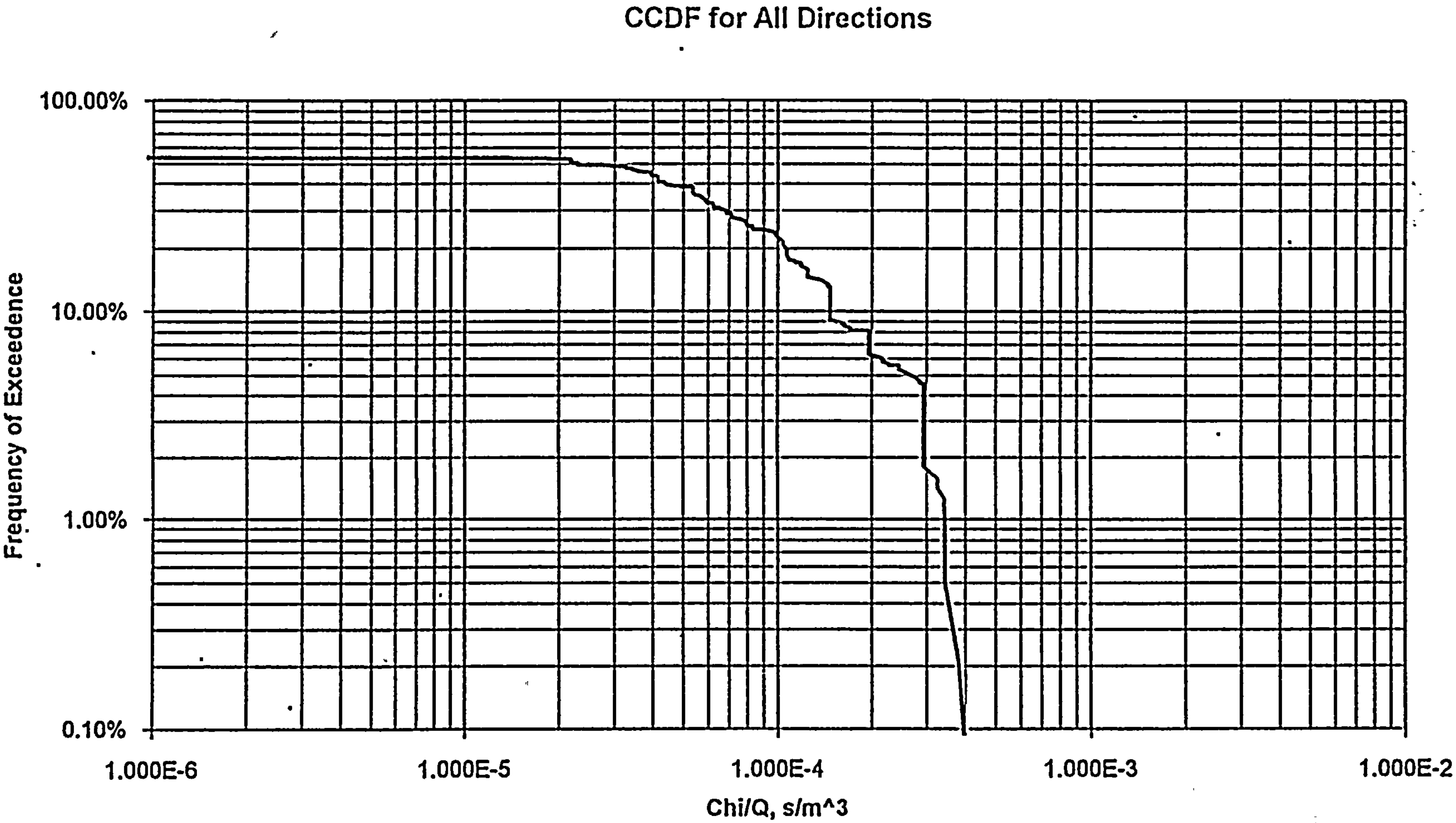


FIGURE 2. CUMULATIVE PLOTS OF DIRECTION INDEPENDENT X/Q VALUES AT UNIT 1 CONTROL ROOM INTAKE BASED ON UNIT 2 RELEASE

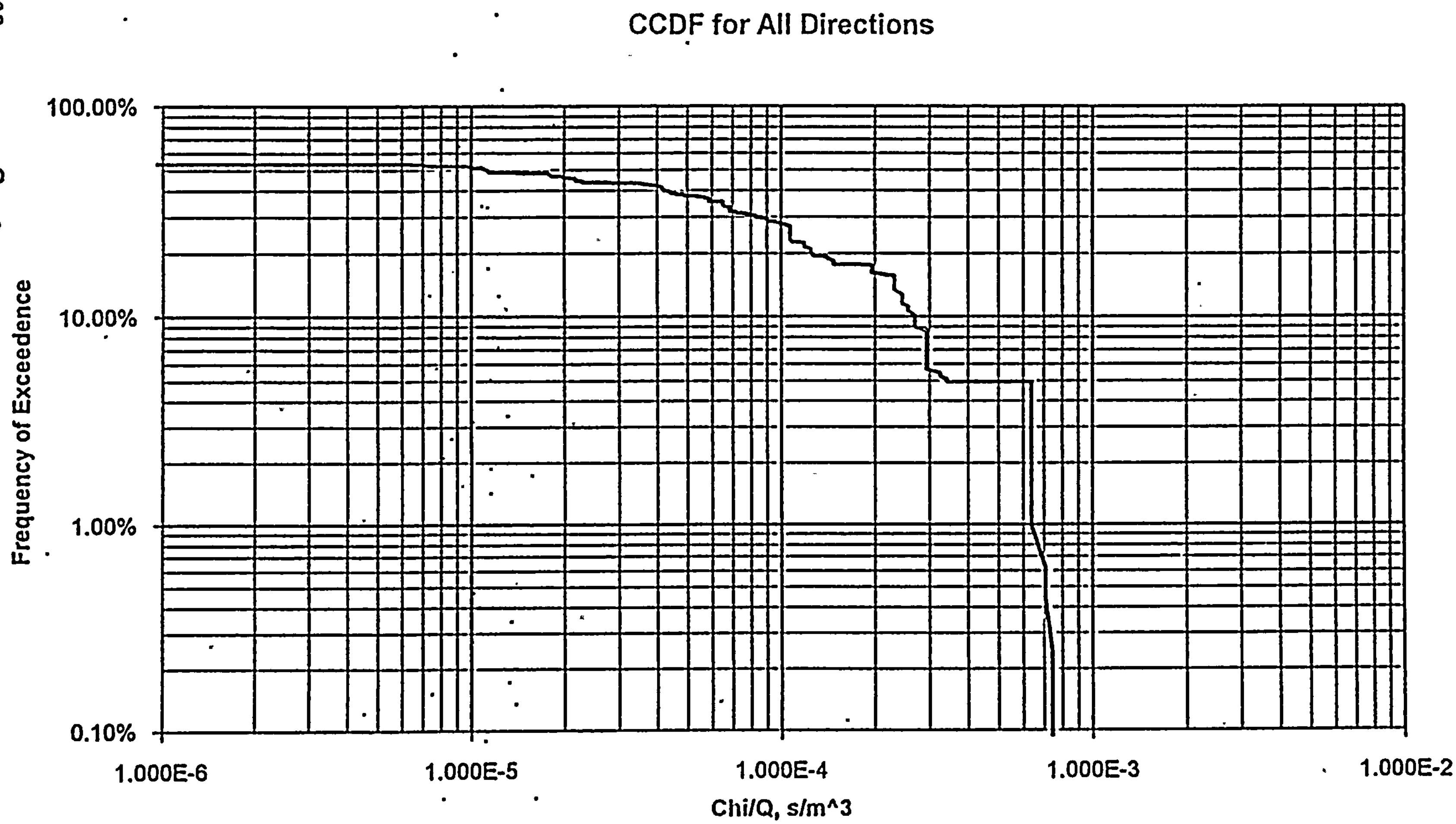


FIGURE 3. CUMULATIVE PLOTS OF DIRECTION INDEPENDENT X/Q VALUES AT UNIT 2 CONTROL ROOM INTAKE BASED ON UNIT 1 RELEASE

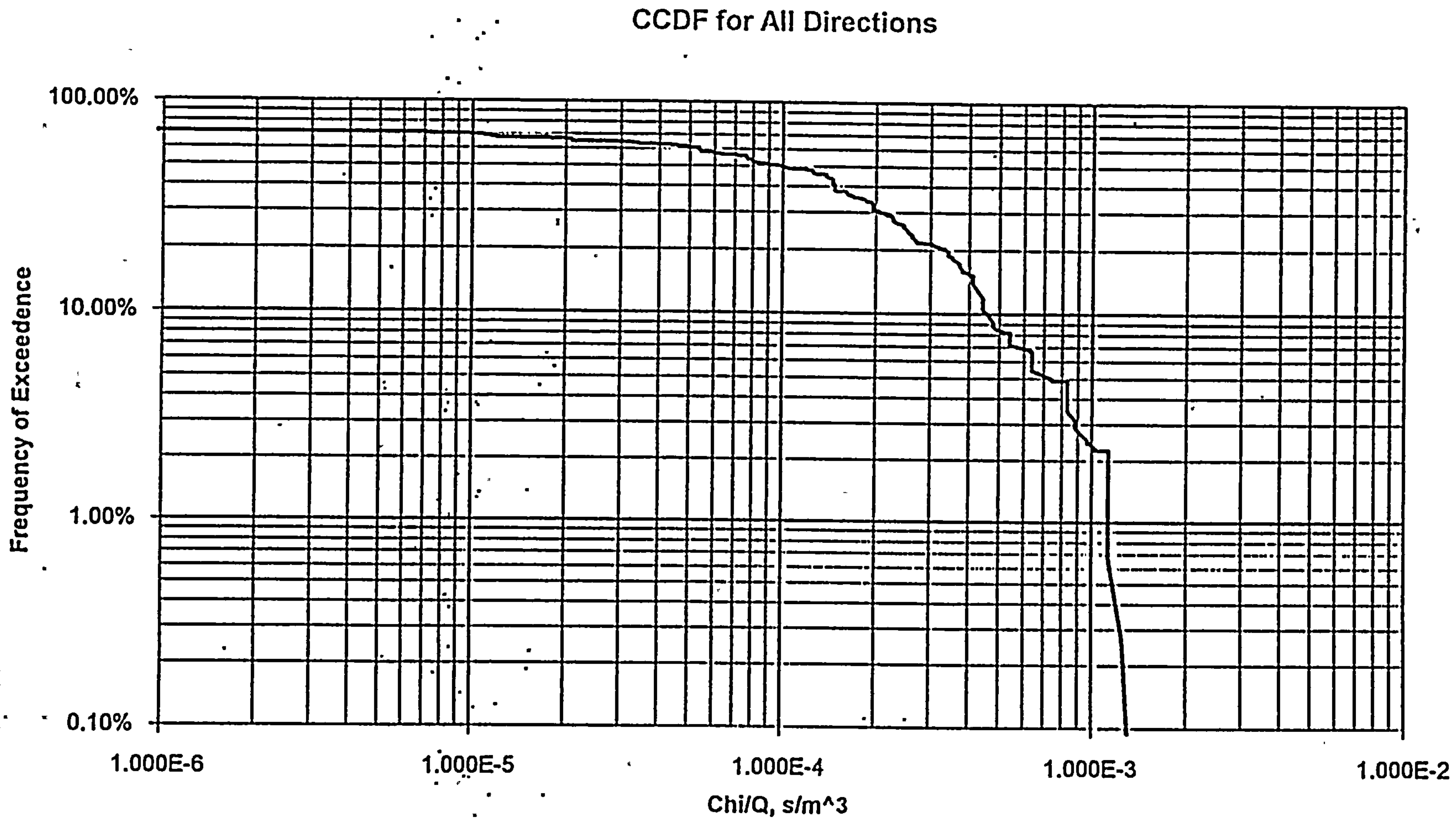


FIGURE 4. CUMULATIVE PLOTS OF DIRECTION INDEPENDENT X/Q VALUES AT UNIT 2 CONTROL ROOM INTAKE BASED ON UNIT 2 RELEASE

ATTACHMENT A

0 0 1 0 0 0 1 0 0 7 6

# ESTIMATION OF CONCENTRATION COEFFICIENTS AT THE CONTROL ROOM INTAKES FOR DIFFUSE RELEASES FROM THE UNITS 1 AND 2 CONTAINMENT STRUCTURES AT THE DONALD C. COOK NUCLEAR PLANT

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7478A020193

0 0 1 0 0 5 0 0 0 7 8

# TABLE OF CONTENTS

## 1. Introduction

This report contains a determination of values of the concentration coefficient $K_{c,avg}$ at the Unit 1 and Unit 2 control room intakes of the Donald C. Cook Nuclear Plant for diffuse releases through the Unit 1 and Unit 2 containment building surface.

The $K_{c,avg}$ determinations were made in sixteen conventional wind directions referred to true north. An equation is provided for combining a $K_{c,avg}$ value with a wind velocity at an elevation of 10m on the meteorological tower to obtain a value of the concentration factor X/Q for each of four release-intake combinations.

The $K_{c,avg}$ values were obtained by applying a Gaussian plume model to each of nine point source releases distributed uniformly on the surface of one containment building, converting the predicted X/Q values to $K_c$ values for each release, and averaging the nine $K_c$ values to yield $K_{c,avg}$ for the diffuse release. The Gaussian model included provisions for initial plume enlargement due to entrapment in the direction-specific building cavities, and employed plume expansion rates corresponding to PG-C stability in an adaptation of the Halitsky jet plume model (Reference 1) for short travel distances, as applied to building wake plumes.

## 2. Building Arrangement

Physical site characteristics were extracted from a set of plans, elevation and vertical section drawings dated 5/1/89, provided by AEP.

Figure 1 shows all significant buildings, roof elevations indicated by numbers within the building outline, and locations of the control room intakes. The topography is flat at elevation 608 ft over most of the plant area, but descends to lake elevation 580 ft, over a distance of about 300 ft in a north-south strip at the west edge of the plant.

A 1:360 scale (1 in equals 30 ft) cardboard model of the plant was constructed as an aid in visualizing the building complex and for use with a visual tracer (water mist from an ultrasonic room humidifier) in an air stream to detect and/or confirm the existence of cavities and local plume trajectories. Figures 2 and 3 show photographs of the model and the flow study set-up.

## 3. Procedure for Estimating $K_{c,avg}$

a. Divide containment surface area into nine patches of equal area and replace each patch with a single point release. The nine release points correspond to those used in the EBR-II wind tunnel test and are identified by the following symbols:

BU = bottom upwind
BL = bottom left side
BR = bottom right side
BD = bottom downwind
MU = mid-height upwind

ML = mid-height left side
MR = mid-height right side
MD = mid-height downwind
T = top

b. The total gas release rate is Q; the release rate at each of the release points is:

$$Q_i = Q/9 \quad (1)$$

c. The concentration field near a building is given generally by:

$$X = K_c Q/Au \quad (2)$$

For multiple releases, each release makes the contribution:

$$X_i = K_{c,i} Q_i/Au \quad (3)$$

and the total concentration, for equal values of $Q_i$, becomes:

$$X = \sum_{i=1}^{9} X_i = \sum_{i=1}^{9} (K_{c,i} Q_i/Au) = \frac{1}{Au} \sum_{i=1}^{9} K_{c,i} \frac{Q_i}{9} = \frac{\sum_{i=1}^{9} Q_i}{Au} \frac{\sum_{i=1}^{9} K_{c,i}}{9} = \frac{Q}{Au} K_{c,avg} \quad (4)$$

where,

$$K_{c,avg} = \frac{\sum_{i=1}^{9} K_{c,i}}{9} \quad (5)$$

d. The value of $K_{c,i}$ must be determined separately for each combination of wind direction, point source release location and intake location. This was done by first sketching the wind field in the building complex with cavity zones, streamlines and wakes determined by a combination of the information in Hosker (Reference 2), personal experience, and observations of a visual tracer moved about the model in the windstream. $K_{c,i}$ was then either calculated or estimated by analytical methods described in Section 4. Tables 1 and 2 show the individual values of $K_{c,i}$ for each of the 16X9X4 = 576 combinations, and the values of $K_{c,avg}$.

e. To combine the $K_{c,avg}$ values with wind frequency data, use:

$$X/Q\ (\text{sec/m}^3) = \frac{K_{c,avg}}{Au_t} \quad (6)$$

where,

A = projected area of containment = 1685m$^2$

$u_t$ = wind speed at an average elevation for the complex or about 60 ft above grade (m/s).

4. Calculation of $K_{c,i}$

$K_{c,i}$ in Equation 5 is obtained from Equation 3 after $X_i$ is determined by an independent calculation using the Gaussian plume model outlined in Table 1. This model includes provisions for partial division of some released material from the plume (Fq), ground reflection ($F_r$), entrapment of released material in a building cavity with resulting establishment of a Gaussian wake plume having initial dimensions $\sigma_{z,0}$ and $\sigma_{y,0}$ and plume sigma growth according to the Halitsky jet plume model for PG stability C. The choice of PG-C was based on a comparison of predicted values of $K_{c,i}$ using the model in Table 1 against observed values of $K_{c,i}$ in the EBR-II wind tunnel model tests.

The 16 figures in Appendix I show drawings of the wind flow patterns for each wind direction used to determine values of $K_{c,i}$.

Table 2 provides a summary of $K_{c,avg}$ values.

5. References

1. Halitsky, J. (1989): A Jet Plume Model for Short Stacks, JAPCA J. v 39, No. 6, pp. 856-858.

2. Hosker, R.P., Jr. (1984): Flow and Diffusion Near Obstacles. Chapter 7 in Atmospheric Science and Power Production, D. Randerson, ed., U.S. DOE Pub. DE84005177, NTIS DOE/TIC-27601.

TABLE 1. PLUME MODEL FOR $K_{c,i}$ DETERMINATION

$$K_{c,i} = A \frac{X_i u}{Q_i} = A \frac{F_q F_r}{2\pi\sigma_y\sigma_z} e^{-\frac{(y/\sigma_y)^2}{2}}$$

$A$ = containment projected area = 18,137 ft$^2$ (1685m$^2$)

$u$ = wind speed at 60 ft above ground

$Q_i$ = release rate at each release location

$F_q$ = fraction of source entering plume

$F_r$ = ground reflection = 2 for flat ground
= 3 for flat ground plus small vertical wall

$\sigma_y$ = $\sigma_{y,0} + 0.66\ F_t\ X^{0.92}$

$\sigma_z$ = $\sigma_{z,0} + 0.82\ F_t\ X^{0.80}$

$F_t$ = $e^{0.08\ (T-30)}$

$T$ = Turbulence class factor = 15.1 for PG-C stability

Therefore,

$F_t$ = $e^{0.08\ (15.1-30)} = 0.304$

$\sigma_y$ = $\sigma_{y,0} + (0.66)(.304)\ X^{0.92}$

$\sigma_z$ = $\sigma_{z,0} + (0.82)(.304)\ X^{0.80}$

$\frac{A}{2\pi}$ = $18{,}137 / 2\pi = 2{,}887$

$\sigma_{y,0}$ = $\sigma_{z,0} = 0$ for direct plume impingement on intake

and

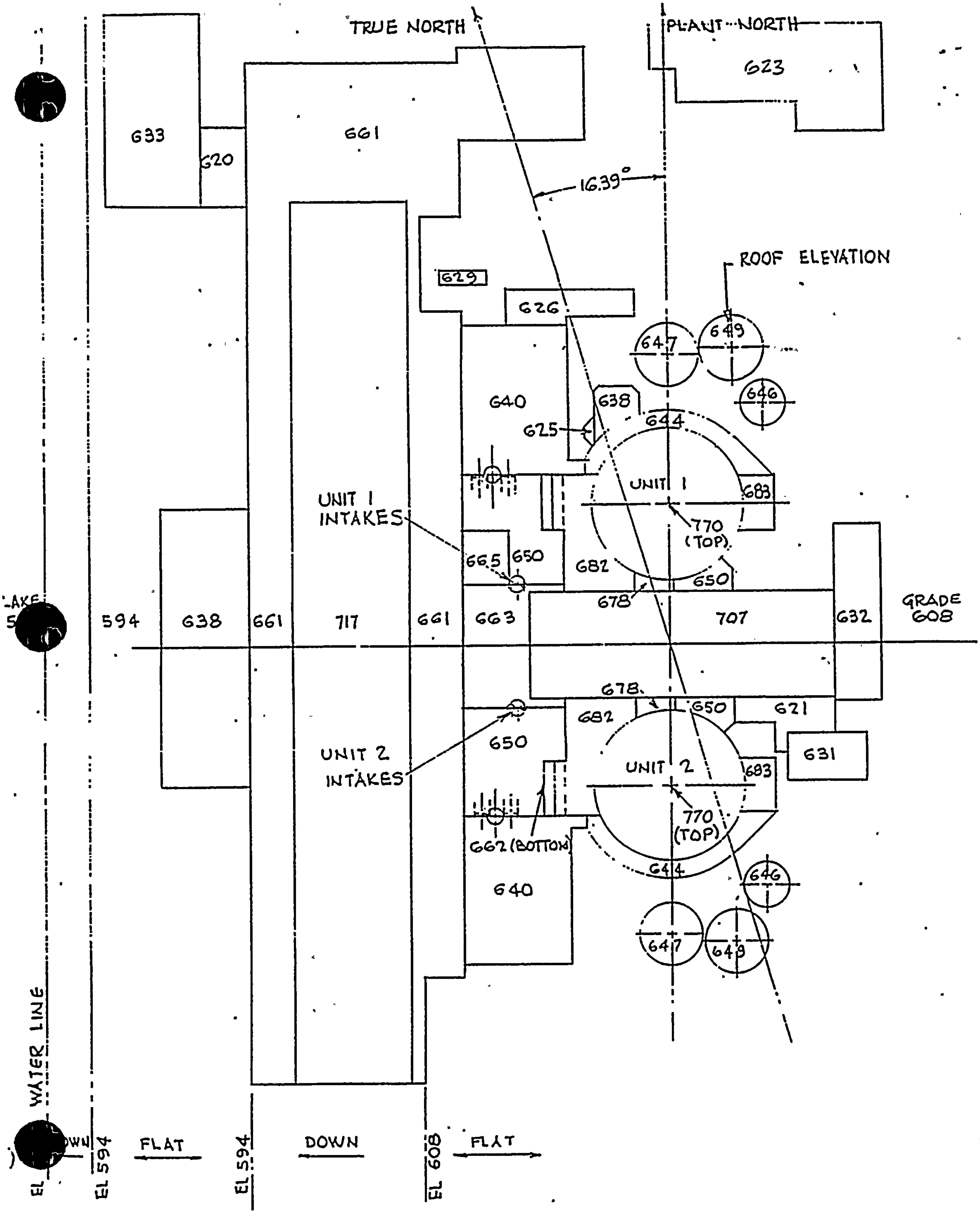
$\sigma_{y,0}$ = $\sigma_{z,0}$ are estimated independently for each wind direction according to building configuration

All dimensions in feet.

TABLE 2. $K_{c,avg}$ APPROXIMATION FOR A DIFFUSE LEAK FROM THE COOK NUCLEAR PLANT CONTAINMENT STRUCTURES WITH RECEPTORS AT THE CONTROL ROOM INTAKES

| | Values of $K_{c,avg}$ | | | |
|---|---|---|---|---|
| Release from | Unit 1 | Unit 1 | Unit 2 | Unit 2 |
| Receptor at | Intake 1 | Intake 2 | Intake 1 | Intake 2 |
| Wind Direction (degrees from) | | | | |
| 000 | 1.5 | 0.5 | 0 | 0 |
| 022.5 | 1.3 | 0.4 | 0 | 0.4 |
| 045 | 3.7 | 0.7 | 0 | 0.5 |
| 067.5 | 0.8 | 0.6 | 0.6 | 1.1 |
| 090 | 1.2 | 0.6 | 0.4 | 1.7 |
| 112.5 | 1.6 | 0.4 | 0.5 | 1.3 |
| 135 | 1.3 | 0.3 | 1.3 | 0.9 |
| 157.5 | 0.4 | 0.3 | 1.3 | 0.3 |
| 180 | 0.2 | 0 | 0.6 | 2.3 |
| 202.5 | 0.1 | 0 | 0.1 | 0 |
| 225 | 0 | 0 | 0 | 0 |
| 247.5 | 0 | 0 | 0 | 0.1 |
| 270 | 0.7 | 0 | 0.2 | 1.8 |
| 292.5 | 1.8 | 0.2 | 0 | 0.7 |
| 315 | 1.8 | 0.2 | 0 | 0.7 |
| 337.5 | 0 | 0 | 0 | 0 |

0 0 1 0 0 0 1 0 0 8 3




SCALE: 1 IN = 100 FT

100

FIGURE 1. D.C. COOK NUCLEAR PLANT

J. HALITSKY
12 NOV. 1992
REV. 18 JAN 1993

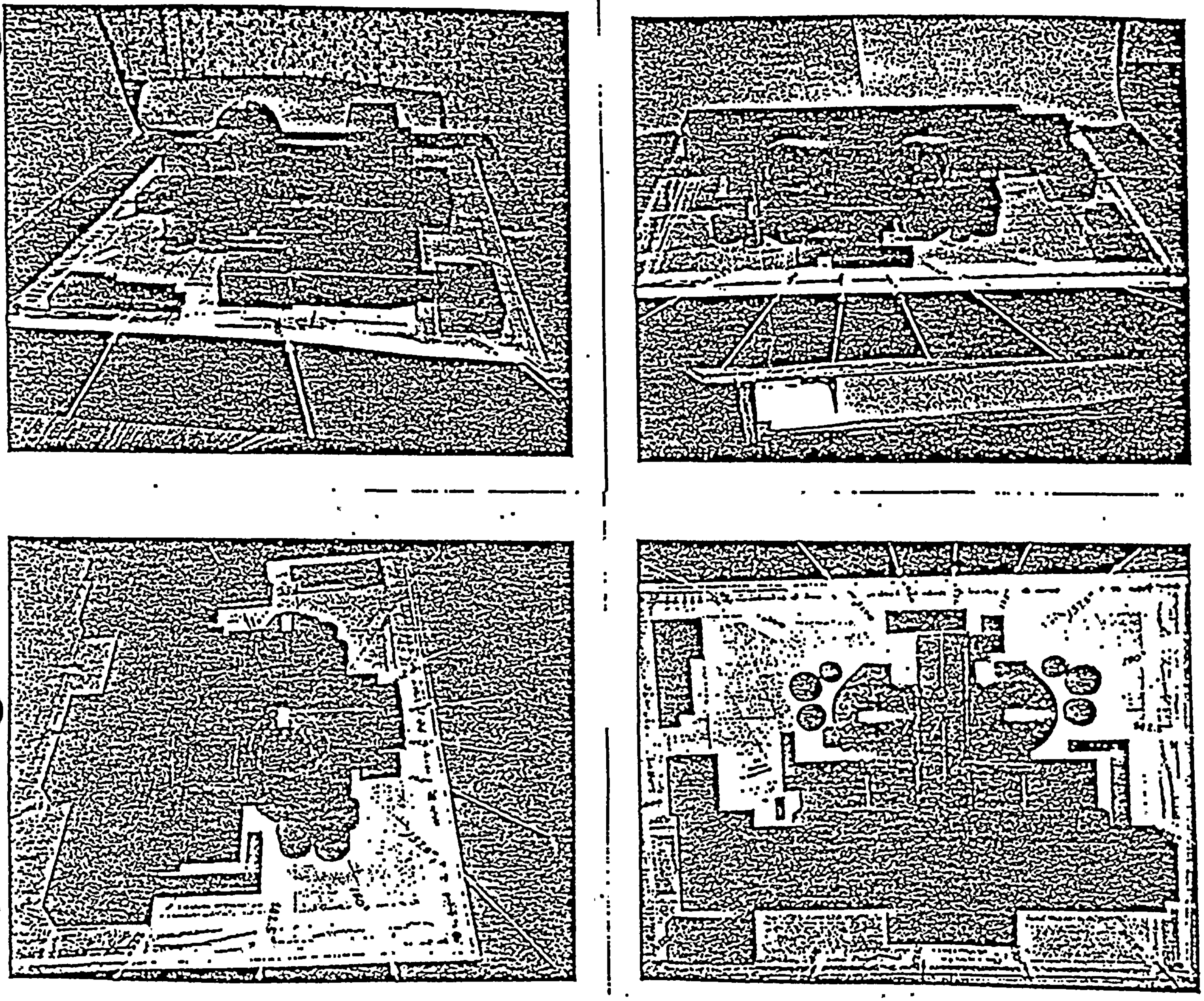
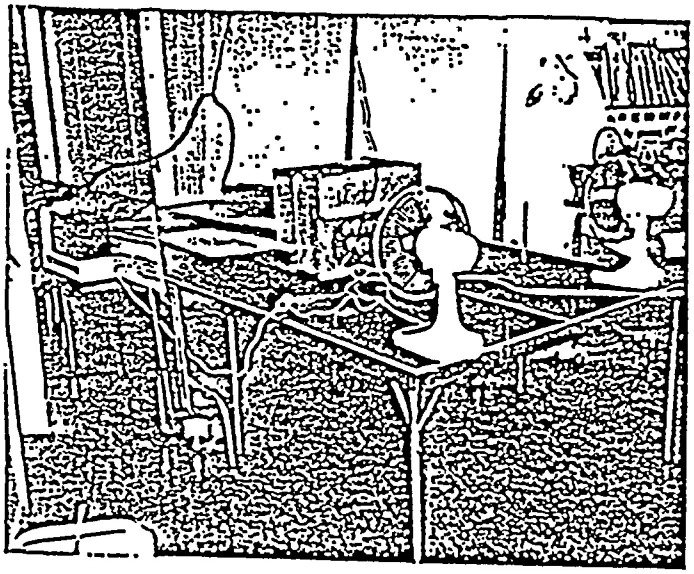


FIGURE 2. PHOTOGRAPHS OF SCALE MODEL



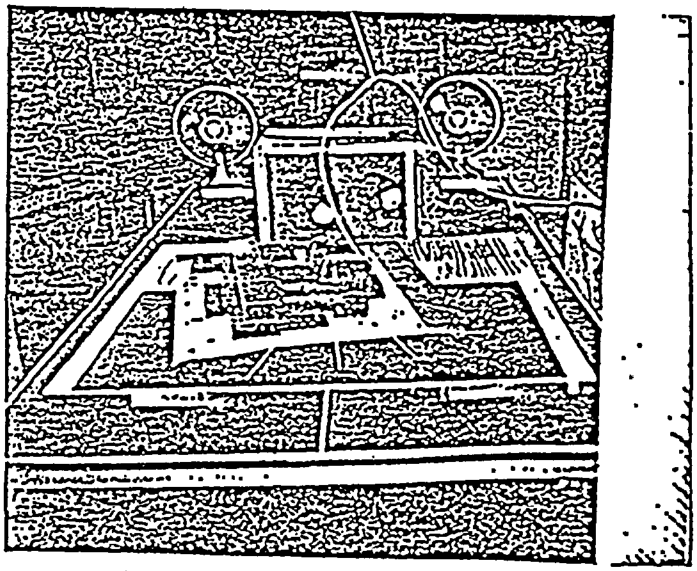
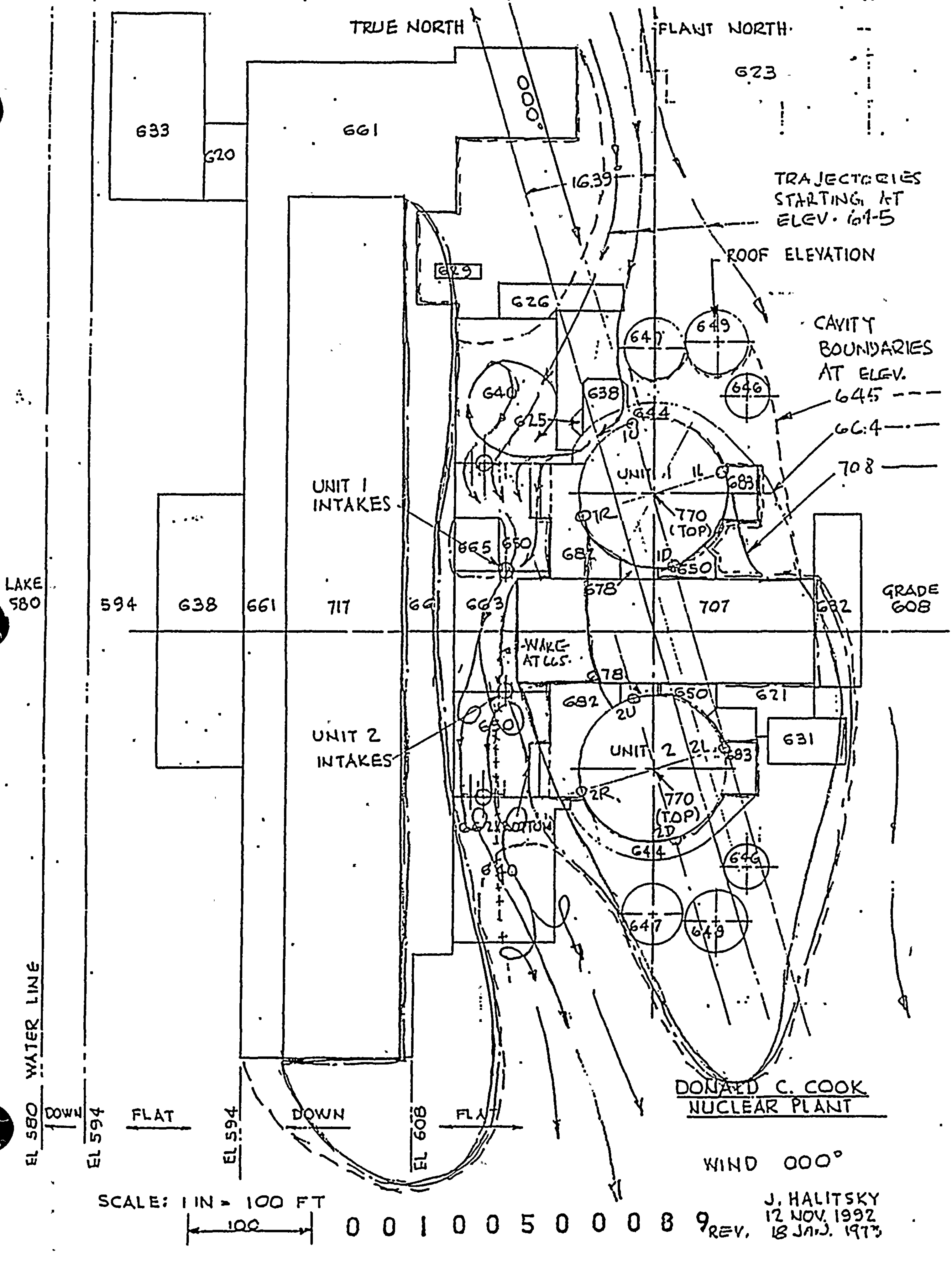


FIGURE 3. PHOTOGRAPHS OF SCALE MODEL IN WIND STREAM

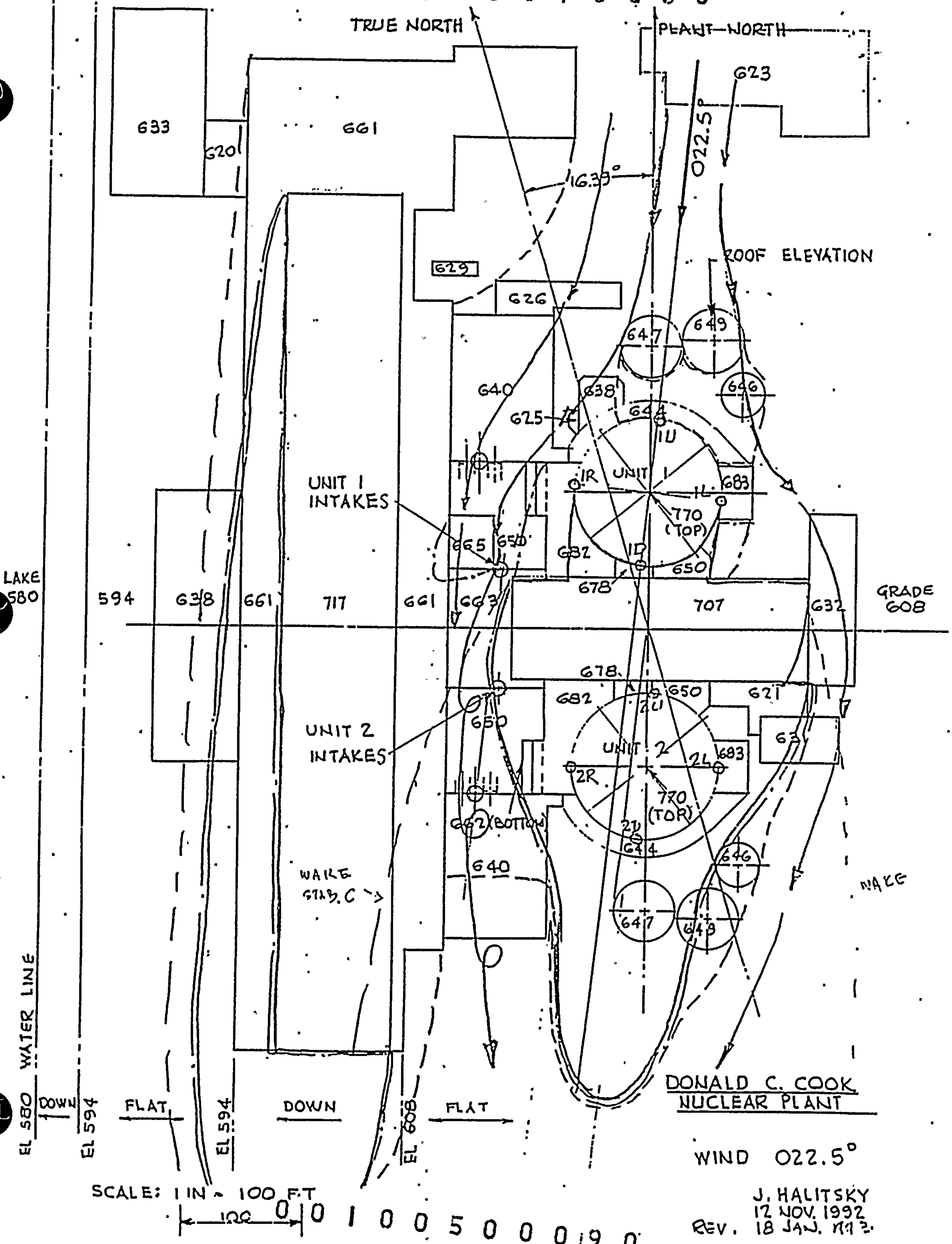
# APPENDIX I

## WIND PATTERNS USED TO ESTIMATE $K_{c,i}$ VALUES

0 0 1 0 0 0 1 0 0 0 1

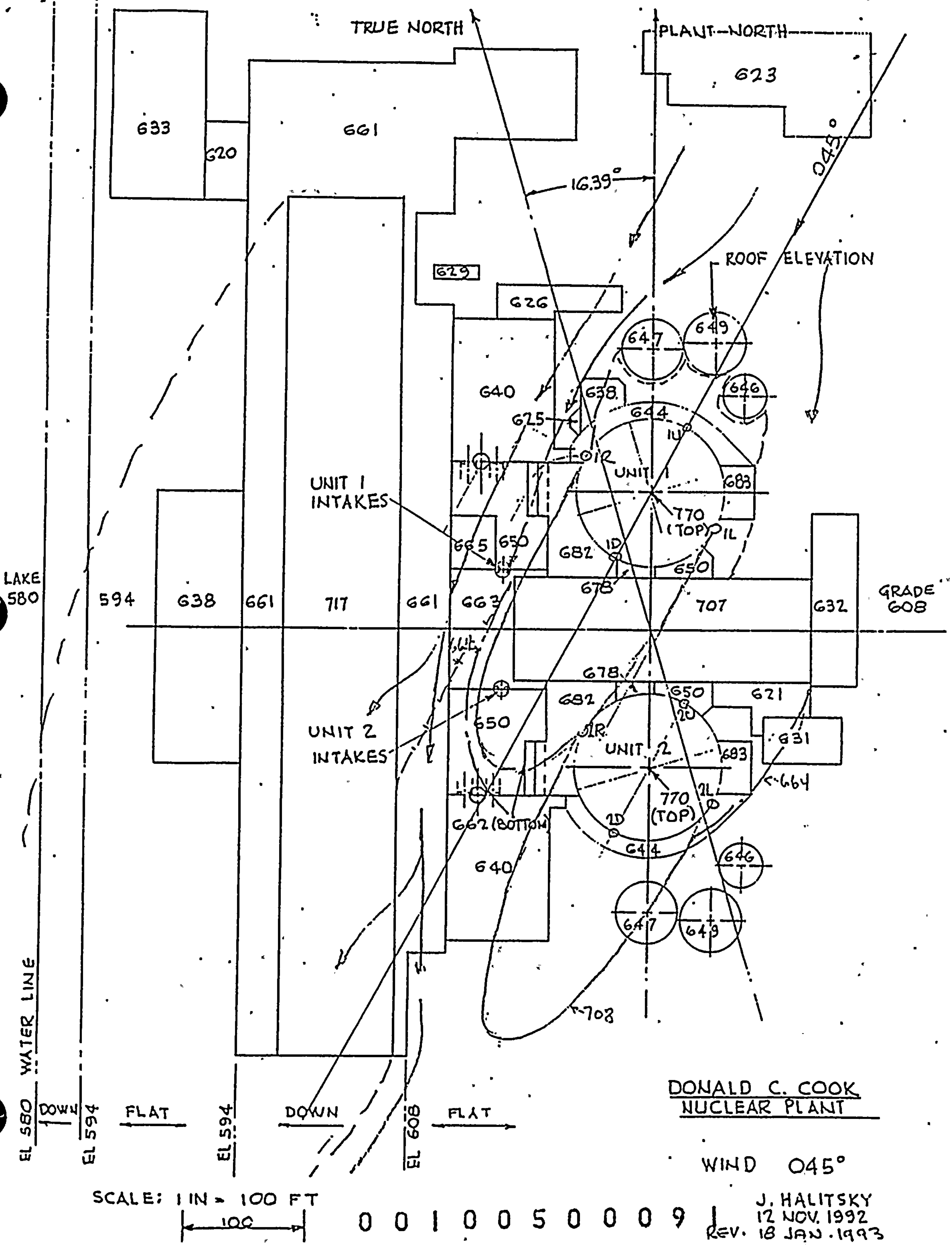


0 0 1 0 0 0 1 0 0 8 8




0 0 1 0 0 5 0 0 0 9 0

0 0 1 0 0 0 1 0 0 0 9



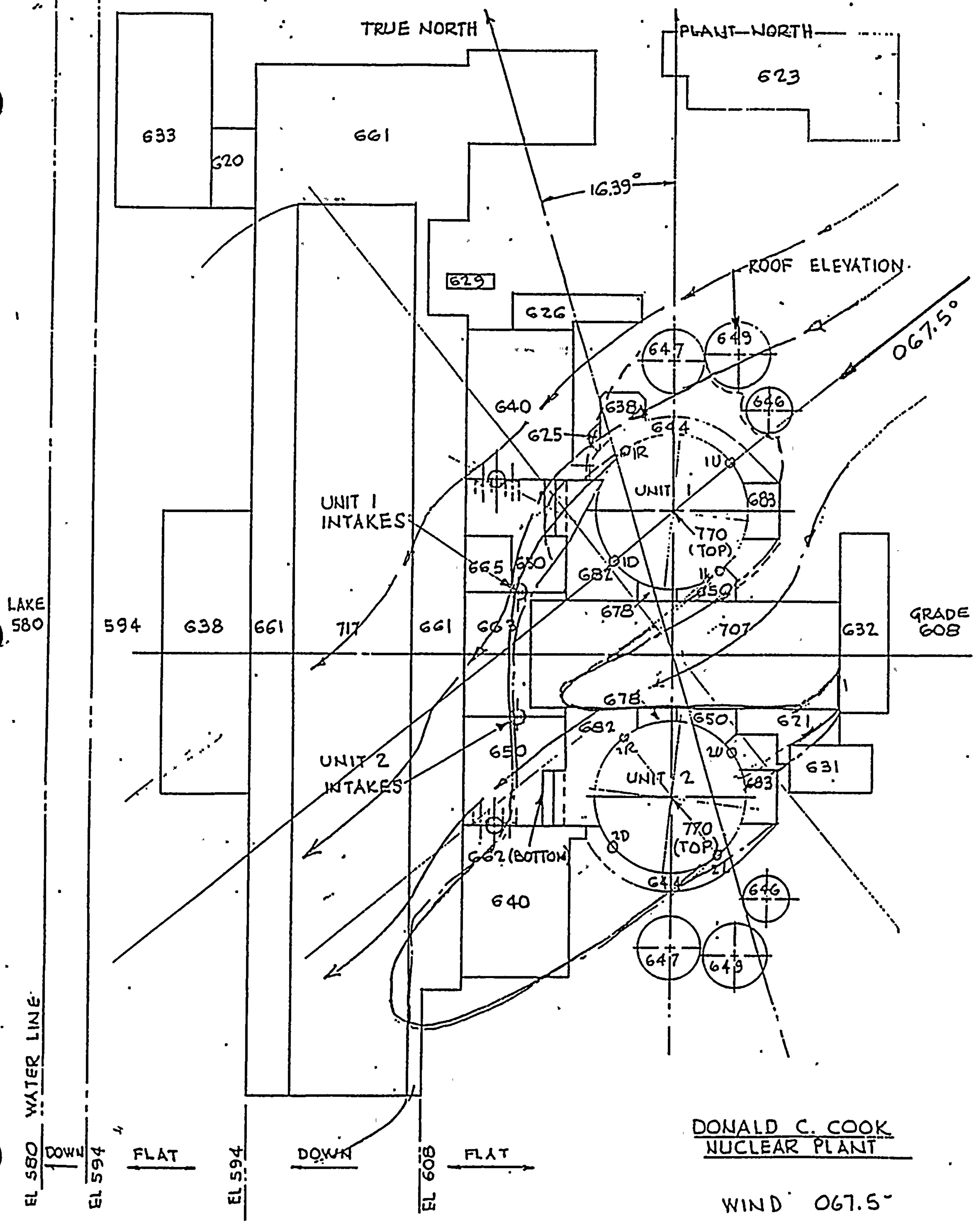

DONALD C. COOK
NUCLEAR PLANT

WIND 045°

J. HALITSKY
12 NOV. 1992
REV. 18 JAN. 1993

0 0 1 0 0 5 0 0 0 9

0 0 1 0 0 0 1 0 0 9 0



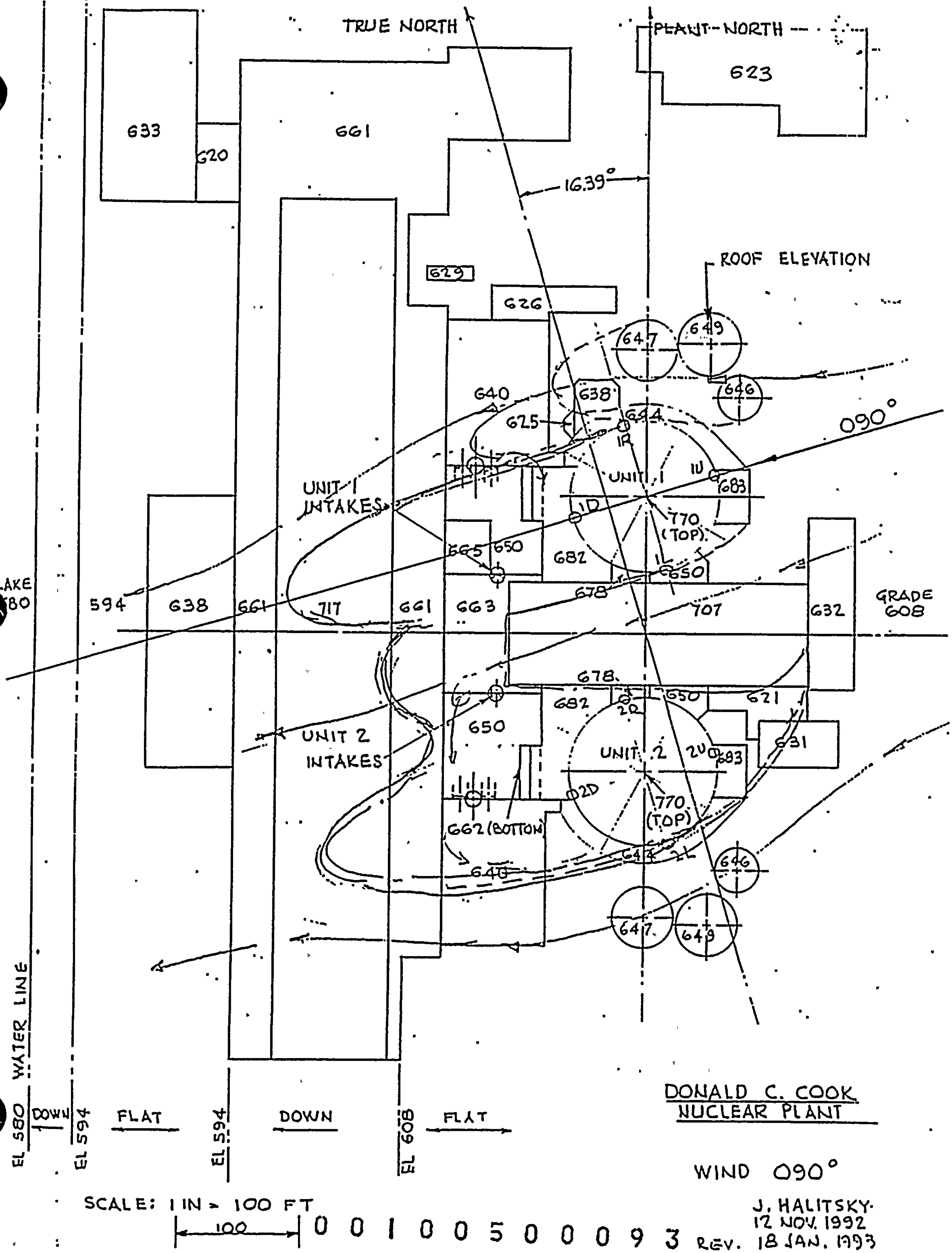

DONALD C. COOK
NUCLEAR PLANT

WIND 067.5°

SCALE: 1 IN = 100 FT
100

J. HALITSKY
12 NOV. 1992
REV. 18 JAN 1993

0 0 1 0 0 5 0 0 0 9 2

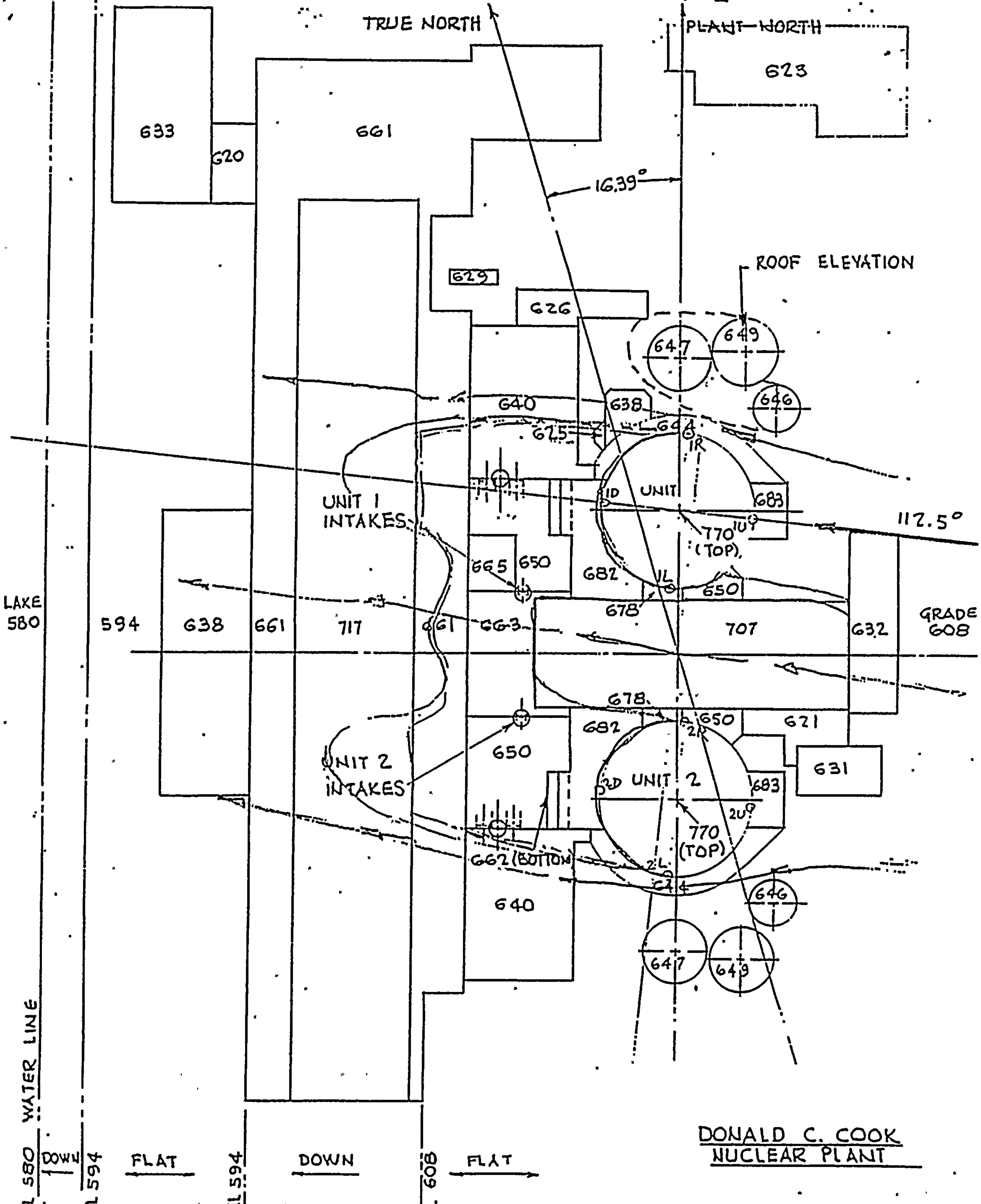



DONALD C. COOK NUCLEAR PLANT

WIND 090°

J. HALITSKY
12 NOV. 1992
REV. 18 JAN. 1993

0010001 0092



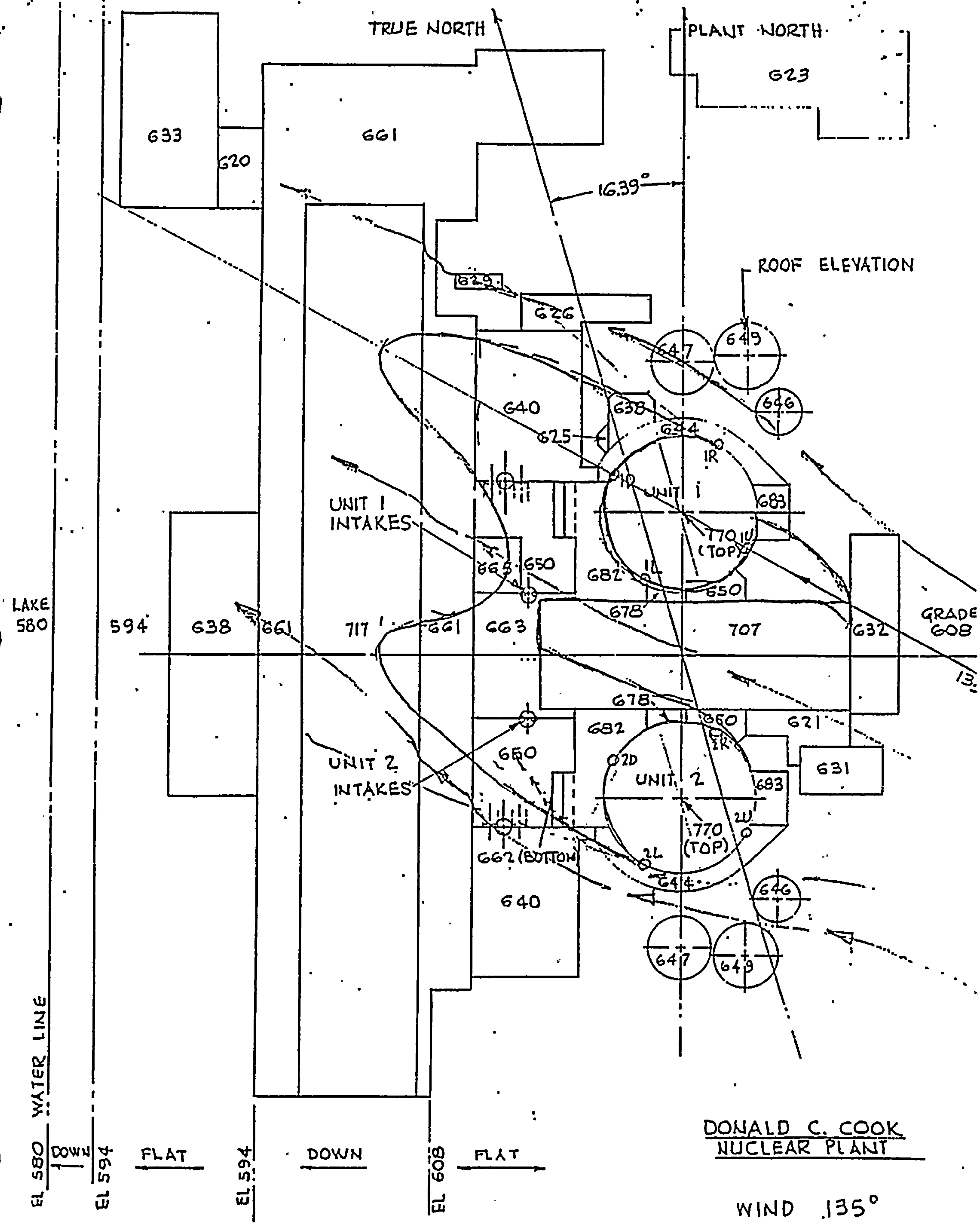

DONALD C. COOK
NUCLEAR PLANT

WIND 112.5°

SCALE: 1 IN = 100 FT

J. HALITSKY
12 NOV. 1992
REV. 18 JAN. 1993

0010050 0094




DONALD C. COOK
NUCLEAR PLANT

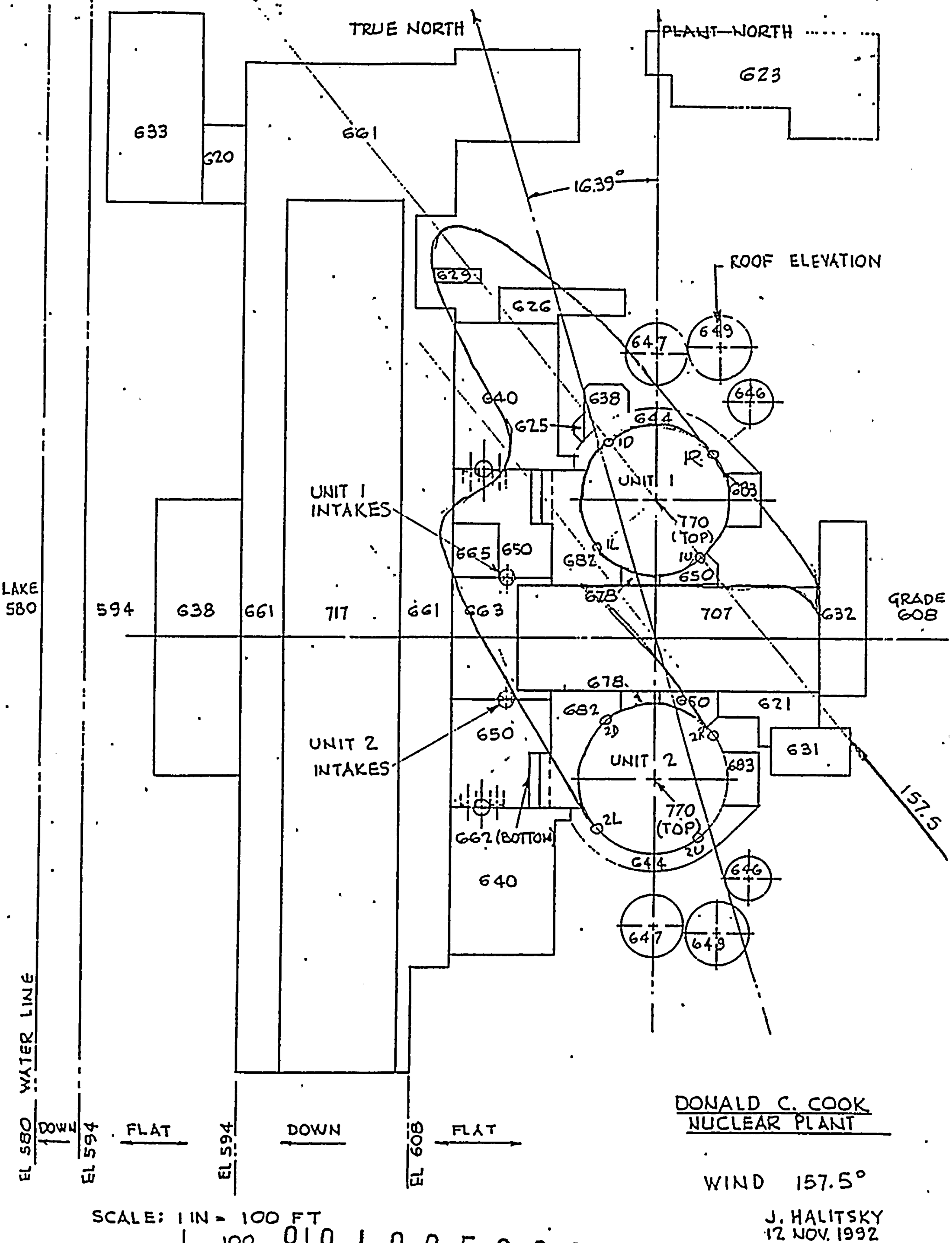
WIND 135°

SCALE: 1 IN = 100 FT

100

J. HALITSKY
12 NOV. 1992
REV. 18 JAN. 1993

0010001 0094

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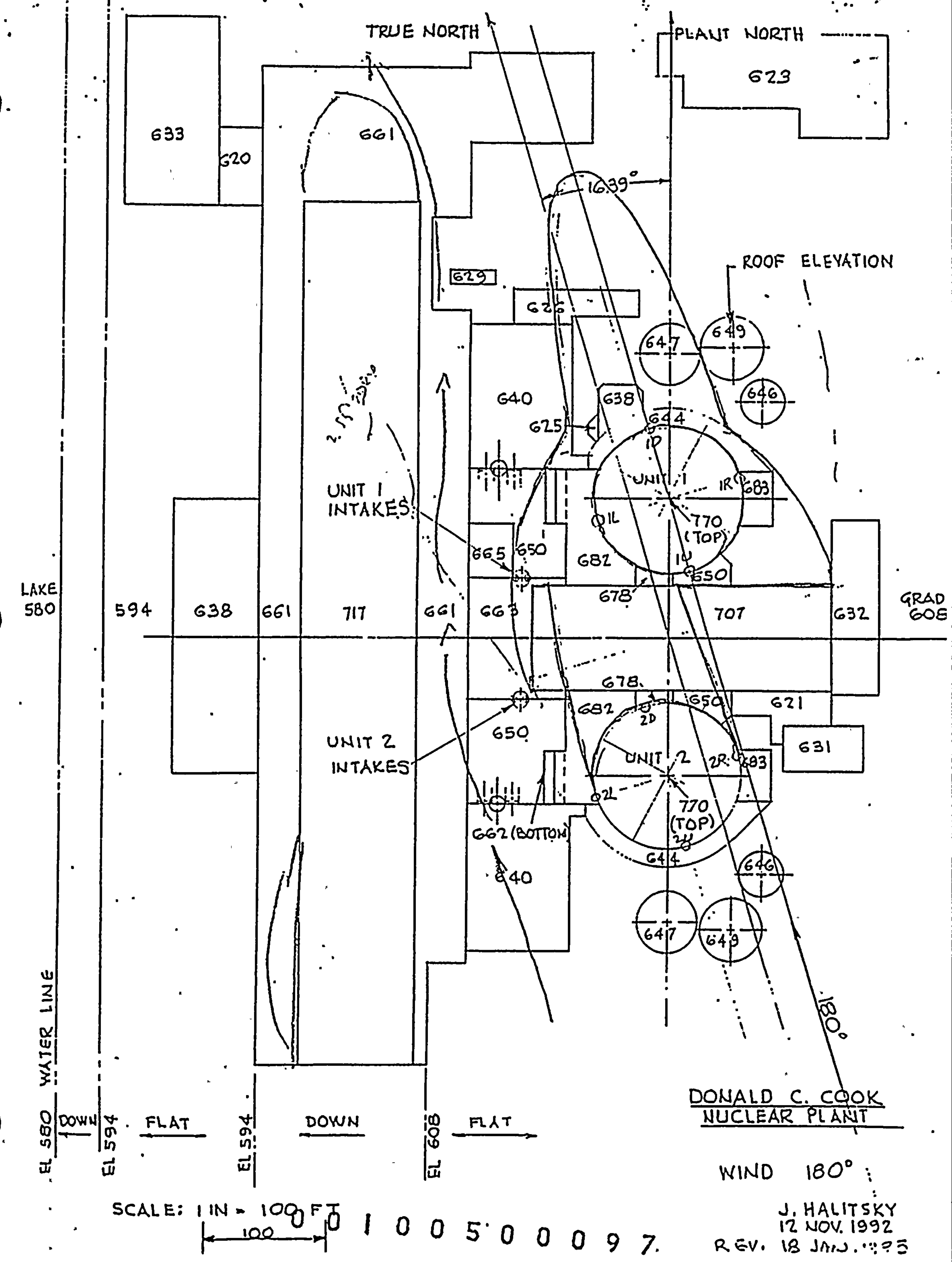
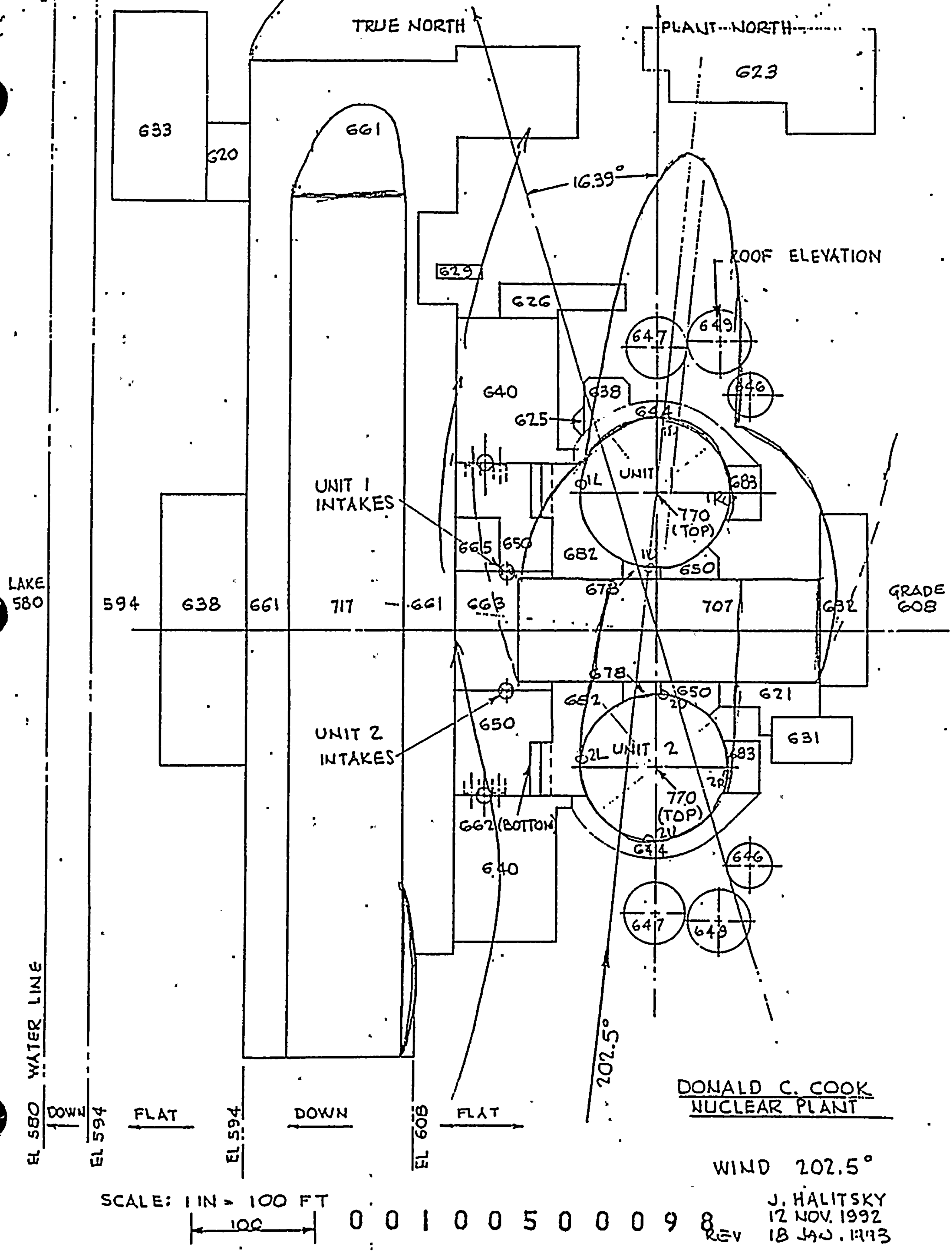

TRUE NORTH
PLANT NORTH
623
633
620
661
629
626
163.9°
ROOF ELEVATION
647
649
646
640
638
644
625
1D
UNIT 1
1R
683
1L
770 (TOP)
UNIT 1 INTAKES
665
650
682
1U
650
678
LAKE 580
594
638
661
717
661
663
707
632
GRAD 608
678
650
621
682
2D
650
631
UNIT 2 INTAKES
UNIT 2
2R
683
2L
770 (TOP)
662 (BOTTOM)
2U
644
646
640
647
649
180°
WATER LINE
EL 580
DOWN
EL 594
FLAT
EL 594
DOWN
EL 608
FLAT
DONALD C. COOK NUCLEAR PLANT
WIND 180°
SCALE: 1 IN = 100 FT
100
J. HALITSKY
12 NOV. 1992
REV. 18 JAN. 1993

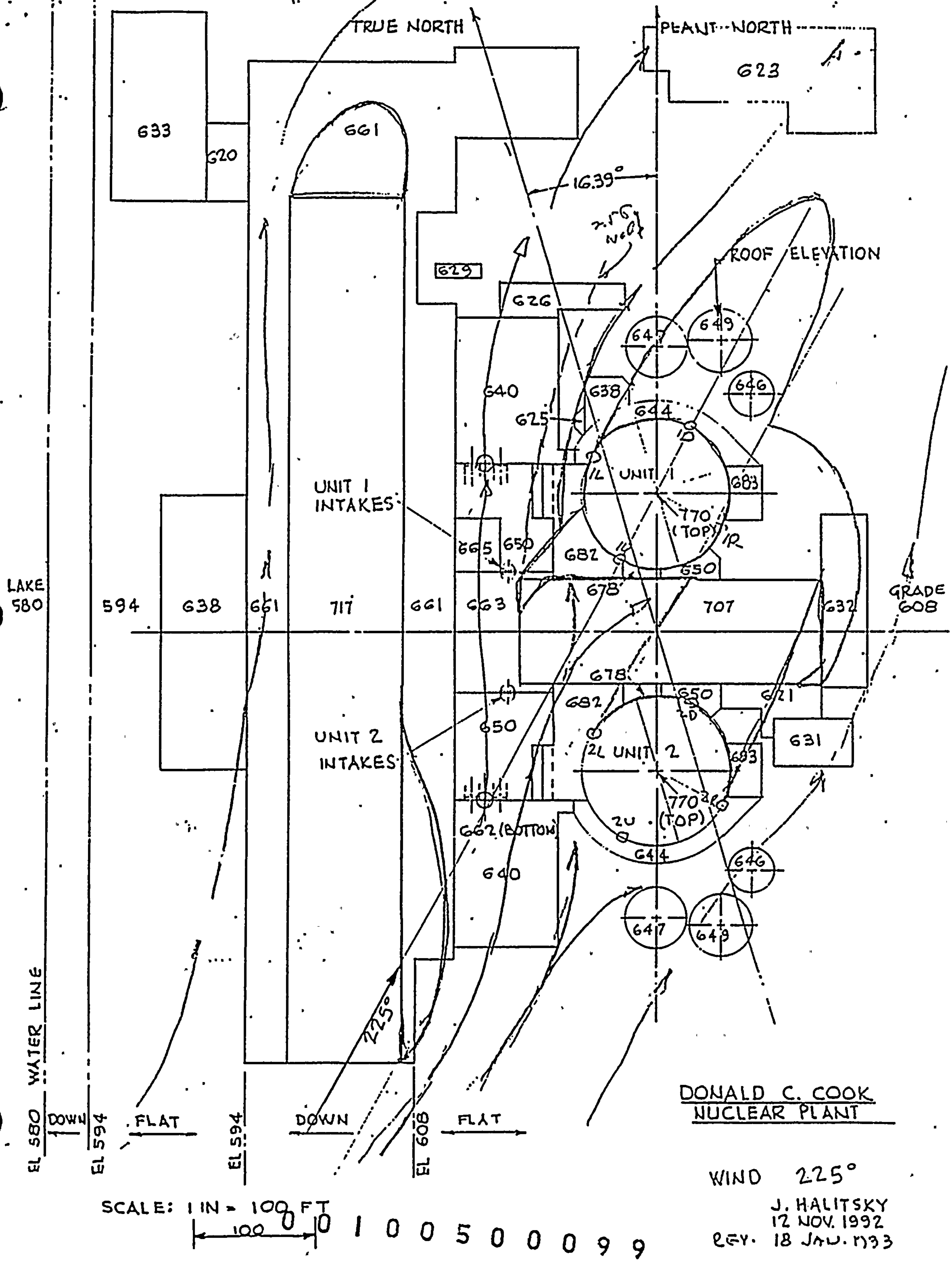
0 1 0 0 5 0 0 0 9 7

0 0 1 0 0 0 1 0 0 9 6




0 0 1 0 0 5 0 0 0 9 8

9210010097




0100500099

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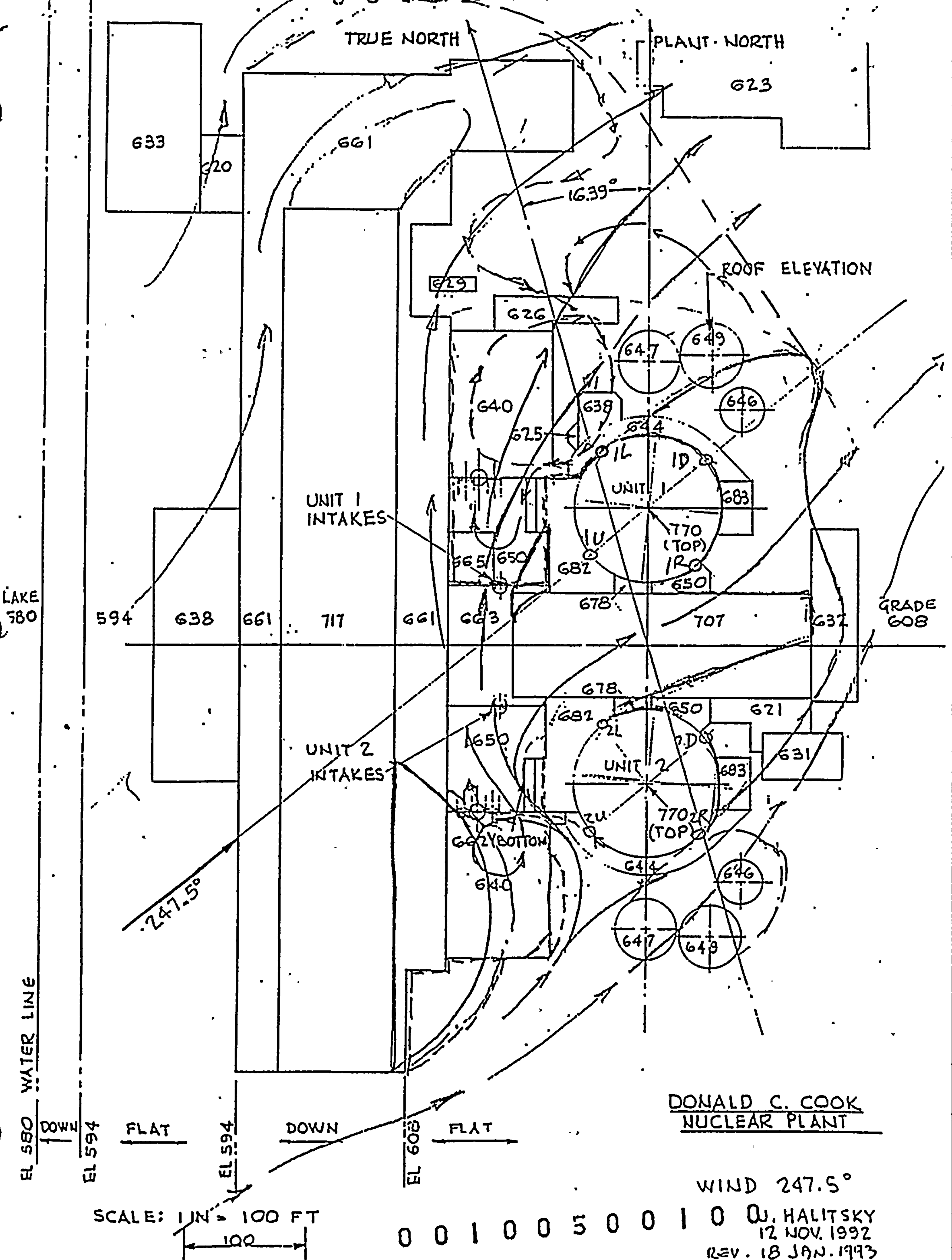
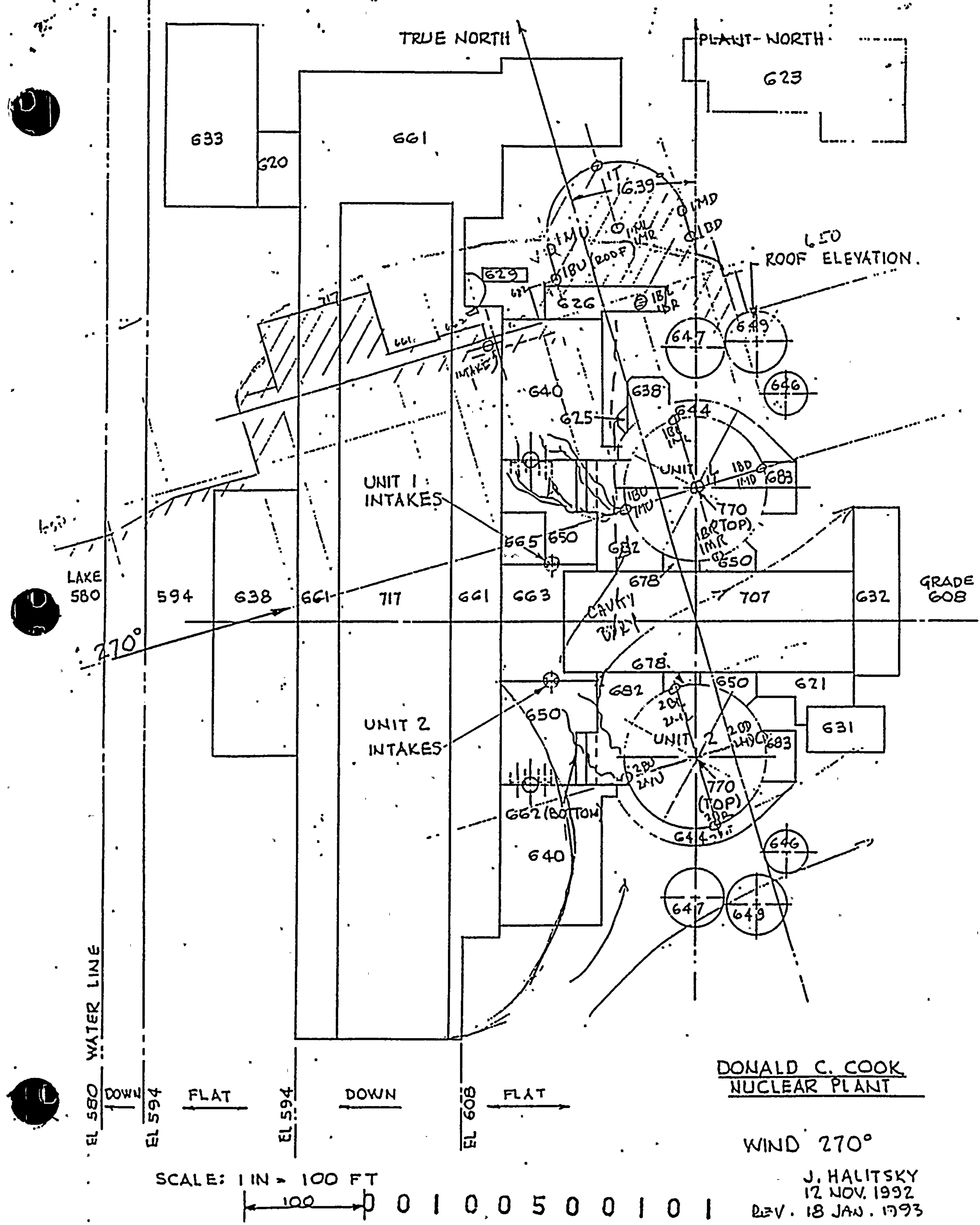



DONALD C. COOK
NUCLEAR PLANT

WIND 247.5°

D. HALITSKY
12 NOV. 1992
REV. 18 JAN. 1993

0 0 1 0 0 5 0 0 1 0 0



TRUE NORTH
PLANT NORTH
623
633
620
661
650
ROOF ELEVATION.
629
626
647
649
646
638
640
625
644
UNIT 1
683
770
(TOP)
665
650
682
678
UNIT 1
INTAKES
LAKE
580
594
638
661
717
661
663
707
632
GRADE
608
270°
678
682
650
621
631
UNIT 2
INTAKES
650
UNIT 2
683
770
(TOP)
662 (BOTTOM)
644
646
640
647
649
WATER LINE
EL 580
DOWN
EL 594
FLAT
EL 594
DOWN
EL 608
FLAT
DONALD C. COOK
NUCLEAR PLANT
WIND 270°
SCALE: 1 IN = 100 FT
100
J. HALITSKY
12 NOV. 1992
REV. 18 JAN. 1993


0 1 0 0 5 0 0 1 0 1