

B.F. GOODRICH CHEMICAL COMPANY REPORT
TO U.S. ENVIRONMENTAL PROTECTION AGENCY
ON VINYL CHLORIDE AND POLYVINYL CHLORIDE
MANUFACTURING OPERATIONS

June 18, 1974

PLAINTIFF'S
EXHIBIT

RECEIVED BY: [illegible]

65-76001

I. Process and Emission Data - Avon Lake Plant

A. Brief Process Description and Flowsheet

Vinyl chloride (VCM) is unloaded from railroad tank cars or tank trucks into pressurized storage spheres. VCM, emulsifiers, and catalysts are metered into polymerization vessels wherein PVC is produced through a chemical reaction in an aqueous medium under controlled conditions of temperature and pressure. After the reaction reaches a predetermined completion, the contents are transferred to a secondary vessel wherein steam is injected and the VCM containing vapors are pumped to a recovery system. The VCM containing vapors are compressed, cooled, condensed, decanted, and recycled to the process for reuse. The stripped PVC resin water slurry is then pumped to blending tanks where the batches from multiple reaction vessels are blended for product uniformity. From the plant tanks the PVC resin water slurry is pumped to a dewatering centrifuge where approximately 90% of the water is removed and subsequently discharged to the industrial sewer system. The PVC resin wet cake is conveyed from the centrifuge to a flash dryer where essentially all the remaining water is removed. At this point, the dry resin is buoyant in an air stream and enters a two-stage collection system for separation of conveying air. The PVC resin is then screened and air conveyed to storage for bulk shipment, for compounding, or bagging.

It should be emphasized that there are numerous transfer and storage points as PVC manufacture via the suspension process consists of a batch process. Major equipment items installed at this plant for suspension resin comprise 70 polymerizer vessels of varying sizes, 24 stripper vessels, 19 blending tanks, 10 entrainment separators, four VCM receiver tanks, 10 compressors, six VCM condensers, one vent compressor and condensor, eight centrifuges, eight flash dryers, eight primary and secondary collection systems, 16 product storage bins, and 16 product storage silos.

A simplified process flowsheet showing all major equipment processing steps is attached.

The suspension resin production rate in 1973 for this plant was approximately 25,500 pounds/hour.

B. Emissions

Continuous and intermittent sources of emission to the atmosphere are shown on the accompanying flowsheet as designated by letter. Emission data are correspondingly tabulated below.

25276002

E -1

1. Emission Source (A) - Safety Relief Devices

This emission source is intermittent in nature and consists of rupture discs and pressure relief devices for numerous and varied equipment items. Also included are discharges which occur as a result of manual venting to reduce the pressure thereby preventing greater losses. Operational history has shown that atmospheric releases occur essentially only from the polymerizer vessels. In such case the emission would consist of VCM, water, PVC, or some combination thereof depending upon the stage of the VCM conversion when venting occurs. There are 70 separate relief valve equipment discharge pipes and 70 separate manual pressure relief devices associated with the polymerizer vessels. These discharge pipes are four inches in diameter and vary in height from 50 to 65 feet above grade.

2. Emission Source (B) - Poly Evacuation

This emission source is generally of a continuous nature inasmuch as the poly evacuation blower services multiple polymerizer vessels on a slightly greater frequency than two per day per vessel.

Use of this system occurs during polymerizer cleaning operations after the stripped PVC resin water slurry has been transferred to the blending stage. The purpose of this system is to insure low VCM exposure levels to workers upon entry to the vessels. The following tabulation better characterizes this source.

3 blowers, each exhausting 12 polymerizers at 1,500 scfm through a 0.83 ft. diameter vent at a height of 50 feet above grade.

1 blower exhausting 8 polymerizers at 2,500 scfm through a 1 ft. diameter vent at a height of 50 feet above grade.

1 blower exhausting 10 polymerizers at 3,500 scfm through a 1.2 ft. diameter vent at a height of 50 feet above grade.

2 blowers, each exhausting 8 polymerizers at 2,500 scfm through a 0.83 ft. diameter vent at a height of 65 feet above grade.

3. Emission Source (C) - Blending

The atmospheric emission from the blending operation results from the continuous purging of the vapor space in the atmospheric pressure blending tanks with fresh air. This practice is both a safety and health-related one aimed at maintaining VCM concentration well below the lower explosive limit and at

25276003

acceptable levels for worker exposure. The following tabulation characterizes this source.

<u>Number</u>	<u>Emission Rate</u>	<u>Vent Size</u>	<u>Vent Height</u>
1	1,200	0.67 ft. ²	16
1	1,200	0.67 ft. ²	16
4	3,500	1.0 ft. ²	55
3	4,000	1.0 ft. ²	55
4	6,000	1.0 ft. ²	55
3	4,300	1.5 ft. ²	45
1	1,660	1.0 ft. ²	40
1	1,660	1.0 ft. ²	40
1	1,660	1.0 ft. ²	40

4. Emission Source (D) - Vent Condenser

This source consists of the discharge from the VCM recovery system and contains inert gas, water vapor, and VCM. Prior to discharge, the gases are treated in a two-stage compression condensation system. The emission is intermittent in nature as required to discharge the inert gases contained in the system. There are two separate recovery systems installed. Vent pipe size for each system is .33 square feet in area discharging at an approximate height of 63 feet above grade.

5. Emission Source (E) - Steam Jets

After vessel cleaning and prior to putting such vessel into service, a vacuum is pulled on the vessel to remove any oxygen contained in the system. This discharge contains no VCM. A discharge is periodic and exhausts through a two inch in diameter vent at a height above grade of 74 feet.

6. Emission Source (M) - Secondary Dust Collection System

This emission source contains water vapor, air, VCM, and small amounts of PVC resin. Two of the secondary collectors consist of aerodynes, four are Aerotecs, and two are Dustecs. The following tabulation characterizes this source.

25270003

<u>Emission Rate</u>	<u>Vent Size</u>	<u>Vent Height</u>
6,800 scfm	1.67 ft. diameter	50 ft. above grade
8,800 scfm	1.67 ft. diameter	50 ft. above grade
9,000 scfm	1.67 ft. diameter	50 ft. above grade
9,000 scfm	1.67 ft. diameter	50 ft. above grade
24,000 scfm	1.4 ft. x 1.6 ft.	64 ft. above grade
25,000 scfm	1.9 ft. x 3.75 ft.	58 ft. above grade
16,000 scfm	1.4 ft. x 3.75 ft.	58 ft. above grade
16,000 scfm	1.4 ft. x 3.75 ft.	58 ft. above grade

7. Emission Source (Q) - Resin Transfer Discharge

The tailings from the screener operation are air conveyed to a cyclone separator where the conveying air is separated and the resin subsequently rescreened and collected for sale as off-grade product. The conveying air discharges from the cyclone at a rate of 4,000 scfm through a duct eight inches in diameter at a height above grade of 56 feet.

8. Emission Source (N) - Storage Bins

Sixteen product storage bins are utilized. Each bin is equipped with a bag type collector for separating the product conveying air from the product. The tabulation below characterizes the venting conditions from this source.

<u>Number of Bins</u>	<u>Emission Rate</u>	<u>Vent Size</u>	<u>Vent Height</u>
2	1,600 scfm	1.15 ft. dia.	50 ft.
5	1,725 scfm	1.25 ft. dia.	64 ft.
1	3,750 scfm	1 ft. dia.	57 ft.

9. Emission Source (P) - Storage Silos

Sixteen fluidized storage silos are used, each of which are all equipped with bag type dust collectors for separation of the product from the conveying air. No single discharge pipes exist for these collectors. Rather, the conveying air is exhausted via multiple discharge ports. The height of these silos vary considerably from 40 to 70 feet above grade.

25276005

Avon Lake Plant - Suspension Process
Emission Summary(1)

<u>Emission Source</u> (2)	<u>Lbs/Hour</u>	<u>Lbs/100 lb PVC</u>	<u>Number of Sources</u> (3)
A	60.8 VCM	0.24	140
A	30.4 PVC	0.12	140
B	109.8 VCM	0.43	7
C	136.1 VCM	0.54	19
D	104.0 VCM	0.41	2
M, N, P, Q	68.1 VCM	0.27	41
M, N, P, Q	119.1 PVC	0.47	41
Solid & Liquid			
Losses	356.2 PVC & VCM	1.41	-
Fugitive	682.8 PVC & VCM	2.68	-

(1) Average hourly for 1973

(2) Reference to Flowsheet

(3) Emissions stated are per total number of vents.

25276006

E-5

1. Monomer Emission Control

Monomer which is not converted to polymer is flashed from the polymer slurry and condensed after compression to suitable pressure levels. Inerts present in the system, however, will not be condensed and will be saturated with monomer. In B.F. Goodrich plants it is common practice to reduce the monomer released to the atmosphere with the inerts by passing the vent stream through a refrigerated condenser or by compressing the vent stream to higher pressures and recondensing before releasing the vents (Emission D).

The main monomer condensers are cooled either with cooling tower water (85° F. summer temperature) or with refrigerated water (40° F.) in the newer plants. The amount of monomer leaving these condensers will depend upon the inert load in the system which is quite variable. However, the concentration of monomer will be about 80% in the summer with a tower water cooled unit or about 72% with a refrigerated water cooled unit. Passing the vent stream from these condensers through a refrigerated vent condenser or raising the pressure and recondensing will reduce the monomer concentration in the vented stream by removing 80-90% of the monomer content.

Monomer concentrations in this vent depend upon the relative temperatures and pressures used, a combination of high pressure and low temperature being theoretically the best combination. There are, however, practical limitations. Since the gases emitted from suspension polymerization processes contain water vapor, operation of a refrigerated vent below 32° F. can cause ice formation on the condenser tubes, thus limiting the condensing capacity of the unit. A refrigerated vent operating at 40° F. and 40 psig will contain about 50% vinyl chloride, while at 80 psig and 40° F. the monomer concentration will be about 30%. Lower temperature can reduce the monomer concentration further if the vinyl chloride is dry enough to avoid icing.

It should be possible to decrease monomer emissions at this point even further (perhaps by 80%) by absorption in a solvent, then regenerating the monomer for reuse. The presence of water, however, introduces problems with emulsion formation. There are also problems of contamination of the solvent due to polymer formation, and control of solvent losses.

Another possible alternative is adsorption on activated carbon or another adsorbent. Polymer formation in the adsorbent with subsequent reduction in adsorbent capacity is a problem, however. Theoretically reductions of concentration of the order of 90% or better should be possible if polymer formation can be prevented.

2. Particulate Emission Control

Particulate control in B.F. Goodrich plants (Emissions M, N, P and Q) is achieved with high efficiency particle collectors. Collectors on product bins and silos are bag collectors with efficiencies of 99.9+% for

25276007

2. Particulate Emission Control (continued)

particles above 44 microns. Final collectors on driers are either bag collectors or high efficiency cyclone collectors with efficiencies in excess of 99% for particles above 44 microns.

Bag collectors represent one of the most efficient devices for removing particulates from gases. Where cyclones are used for particulate separation, wet scrubbers offer an alternate possibility for supplemental treatment of the gas streams if additional particulate removal is necessary. An effective device of this type probably would remove 90% or better of the particles escaping a high efficiency dry cyclone collector.

D. FUGITIVE EMISSIONS (General Discussion Relating to B.F. Goodrich Plants)

Fugitive emissions listed for B.F. Goodrich plants represent the difference between monomer in and polymer out of a production operation which cannot be otherwise identified. In the tabulations for B.F. Goodrich plants, fugitive emissions may be either monomer loss or polymer loss. Some plants establish "loss factors" by adjusting measured or estimated losses to reflect fugitive emissions and in these cases the fugitive emissions may appear low or to be non-existent. Fugitive emission estimates are given in tabular form for our various plants.

E. EMISSION CONTROL PROCEDURES (General Discussion Relating to B.F. Goodrich Plants)

A sincere effort is made in plant design, operation and maintenance to minimize emissions of monomer to the atmosphere. Some design features and operating practices are listed below.

1. Knock-Out Tanks

Knock-out tanks are provided in vapor recovery lines leading to monomer compressors. These permit separation of liquid entrainment which would otherwise be transferred to the compressors, causing damage and shutdown. In this way these vital pieces of equipment can be kept on stream a greater proportion of the total time.

2. Double Rupture Disc Assemblies

Polymerizers and other pressure vessels handling polymer slurry are usually equipped with rupture discs to protect the vessels against rupture due to excessive pressure caused by unusual operating conditions or exposure to fire. Occasional disc failures occur due to fatigue, incorrect installation or defective discs. In order to minimize the likelihood of these failures, the use of a double disc assembly is established practice in critical service, since the failure of two discs in series due to these causes is unlikely. Also, with the double disc assembly the discs can be mounted in the shop under close supervision, lessening the chance of a faulty field installation.

3. Vacuum Recovery

Before opening pressure vessels containing monomer vapors, a vacuum is pulled on these tanks to remove as much monomer as possible through the recovery system. By this method as much as two-thirds of the vapor remaining in the tank at atmospheric pressure can be removed before the vessel is opened.

25276008

EMISSION CONTROL PROCEDURES (continued)

4. Reduction of Residual Monomer Before Drying

Since most of the monomer remaining in the polymer will be vaporized and emitted to the atmosphere during drying, it is important to reduce the monomer content in the polymer as low as possible before this operation. Steam sparging is employed after completion of the polymerization to improve monomer removal.

5. Emergency Shortstopping

Reactions can go out of control due to loss of agitation, loss of cooling water and other unusual circumstances resulting in vented charges unless preventive measures are taken. Emergency shortstopping of the reaction can often prevent this. Some of our plants are equipped with such a system.

6. Organic Vapor Detection

Within the last year our plants have adopted a procedure of frequent checking of possible or suspected sources of leaks with an organic vapor analyzer. With this sensitive device leaks too small to be detected by odor can be located and the leaks eliminated. This is an effective procedure for reducing fugitive emissions.

25276009

CONTROL DEVICES AND ECONOMIC DATA

AVON LAKE PLANT

(Partial List)

Control Devices for Emission N (6 Units)

Fine PVC dust is removed from a 2,000 CFM air stream that is exhausted to the atmosphere from PVC storage bins. These units are Flex-Kleen Model 84-BV-25 units containing 250 sq. ft. filter area. The vendor states that these units will remove 99.9+% of particles over 44 microns. The size of the unit is 3'-4" x 3'-4" x 8'-7".

The total installed cost of these units totalled \$90,438 in 1970, when the equipment was retrofitted. Major equipment cost for this installation was \$42,600.

It is estimated that the unit will last at least 15 to 20 years. Annual operating costs consist of:

Air for Blowback	\$ 400
Maintenance	400
Bags	800
	\$1,600

Control Device for Emission D

Vent gas from the main recovery compressors is compressed from 45 psig to 85 psig into a vent condenser cooled with refrigerated water. The quantity of monomer condensed in this unit has not been measured. However, calculations show that about 75% of the monomer carried by inerts from the main condensers should be condensed in this unit.

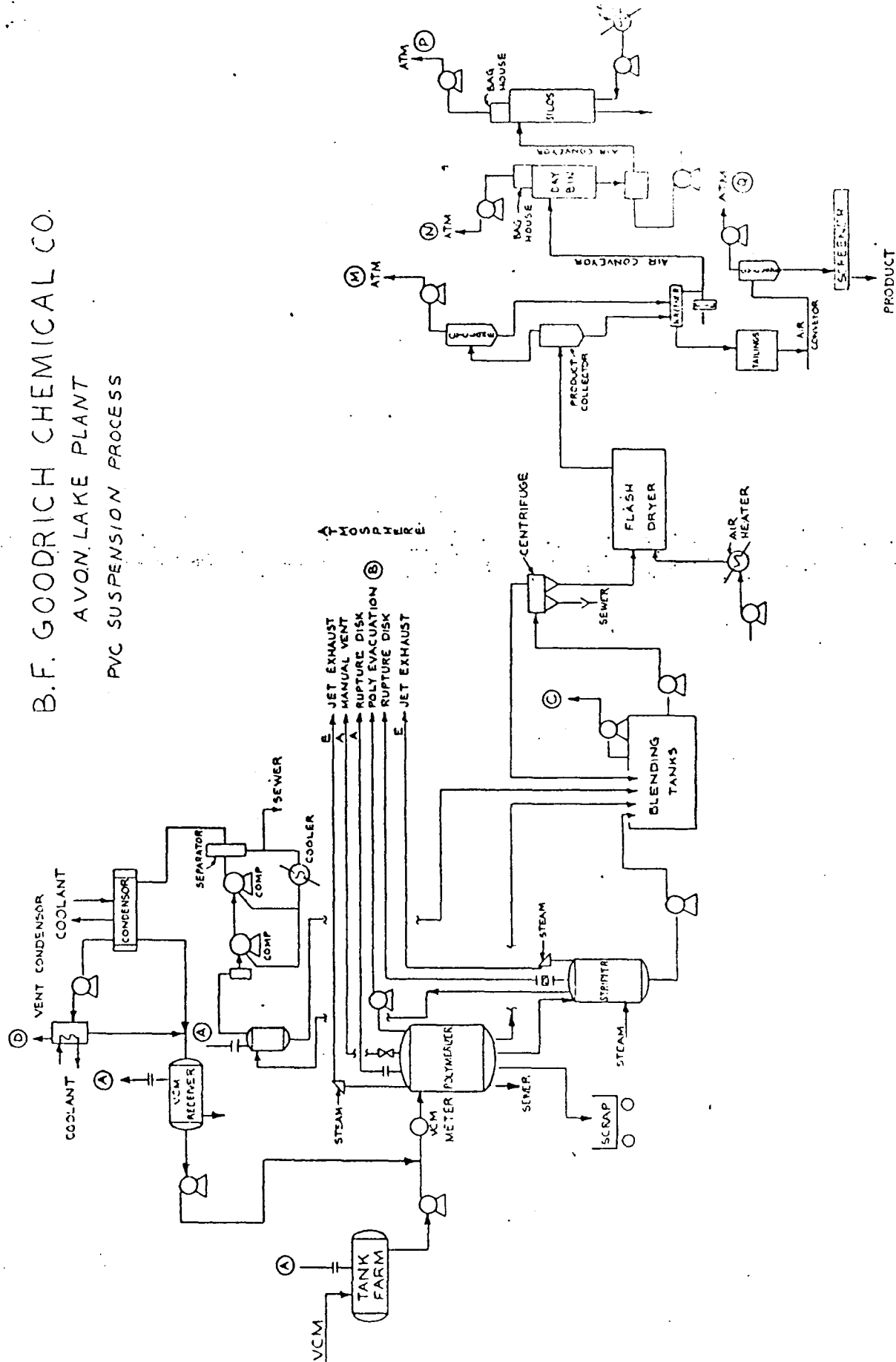
The total installed cost of compressor and vent condenser is estimated at \$17,000 in 1971. Installation was made as part of the original plant.

Maintenance costs on this system are high due to tramp polymer formation in the system. In order to reduce maintenance downtime in this area, study of alternative systems is now under way. Operating and maintenance costs are estimated as follows:

Electricity	\$4,000
Refrigerated Water	400
Maintenance, Supplies	<u>5,000</u>
and Labor	
	\$9,400

25276010

B.F. GOODRICH CHEMICAL CO.
 AVON LAKE PLANT
 PVC SUSPENSION PROCESS



17 - 10

17034222

AMBIENT SAMPLING DATA

B.F. Goodrich has conducted a limited amount of vinyl chloride grab sampling with subsequent gas chromatography analysis. This data long with the description of the sampling point locations relative to the plant and the wind vector occurring during sampling are shown on the attachments.

The gas samples were taken using metal vacuum containers, 250 milliliter glass containers, tedlar bags, or syringes. The gas was then transferred to the gas chromatography via the appropriate size injection syringe.

A typical gas chromatography used for the analysis was a Hewlett Packard Model 5710A or equivalent equipped with a 8' x 1/8" Parapak QS 50/80 mesh column. For this work, the gas chromatography was calibrated using two vinyl chloride standards of 10 and 100 parts per million. The appropriate concentration to establish a calibration curve (area under the VCM peak) down to 0.05 parts per million was obtained by dilution of the standard volumes.

In obtaining the preliminary ambient data, the sample locations A - L were placed on the wind vector occurring during sampling period rather than the prevailing wind vector. Therefore, the sample points were not stationary and no conclusions could be drawn concerning the long term effect of vinyl chloride on a specific residential area, etc. surrounding the plants. The purpose of the measurements were to determine orders of magnitudes of concentration up and down wind from which to generate future sampling requirements.

25278012

[illegible]

A	B	C	D	E	F	G	H	I	J	K
Sample Location										

High

Plant Medium /?

Name	No. Samples
...	...

0.002
0.005
0.037
0.018

	0.03	0.05	0.37	0.14	0.44	0.18	0.49	0.11	0.84	0.00
Avon Lake	0.22	0.03	0.05	0.37	0.14	0.44	0.18	0.49	0.11	0.84
Avon Lake	0.22	0.03	0.05	0.37	0.14	0.44	0.18	0.49	0.11	0.84

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100																																																																																																																																																																																		
Population	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4	18.5	18.6	18.7	18.8	18.9	19.0	19.1	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.8	21.9	22.0	22.1	22.2	22.3	22.4	22.5	22.6	22.7	22.8	22.9	23.0	23.1	23.2	23.3	23.4	23.5	23.6	23.7	23.8	23.9	24.0	24.1	24.2	24.3	24.4	24.5	24.6	24.7	24.8	24.9	25.0	25.1	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9	26.0	26.1	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.9	27.0	27.1	27.2	27.3	27.4	27.5	27.6	27.7	27.8	27.9	28.0	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	28.9	29.0	29.1	29.2	29.3	29.4	29.5	29.6	29.7	29.8	29.9	30.0	30.1	30.2	30.3	30.4	30.5	30.6	30.7	30.8	30.9	31.0	31.1	31.2	31.3	31.4	31.5	31.6	31.7	31.8	31.9	32.0	32.1	32.2	32.3	32.4	32.5	32.6	32.7	32.8	32.9	33.0	33.1	33.2	33.3	33.4	33.5	33.6	33.7	33.8	33.9	34.0	34.1	34.2	34.3	34.4	34.5	34.6	34.7	34.8	34.9	35.0	35.1	35.2	35.3	35.4	35.5	35.6	35.7	35.8	35.9	36.0	36.1	36.2	36.3	36.4	36.5	36.6	36.7	36.8	36.9	37.0	37.1	37.2	37.3	37.4	37.5	37.6	37.7	37.8	37.9	38.0	38.1	38.2	38.3	38.4	38.5	38.6	38.7	38.8	38.9	39.0	39.1

[illegible][illegible]

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

200

Long Beach*	0.20	0.19	0.20	0.90
-------------	------	------	------	------

NO COMPANY DATA AVAILABLE

[illegible][illegible]

Age Group	2006 (%)	2008 (%)
18-29	~80	~85
30-49	~65	~70
50-69	~55	~60
70+	~40	~45

Pedricktown
0.05
0.05

NO COMPANY DATA AVAILABLE

[illegible]

1. $\frac{1}{2}$

10 /

Henry

NO COMPANY DATA AVAILABLE

Louisville*

[illegible]

1

Calvert City	0.39	0.14	0.08	0.03
Calvert	0.39	0.14	0.08	0.03

COMPANY	0.27	NO COMPANY DATA AVAILABLE	0.15	0.39	0.39
COMPANY	0.27	NO COMPANY DATA AVAILABLE	0.15	0.39	0.39

[illegible]

CONTENTS

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
84

Downloaded from <http://ajphaphysocpharm.sagepub.com/> at 11:06 11 November 2014

*PPA Sampling Data Available

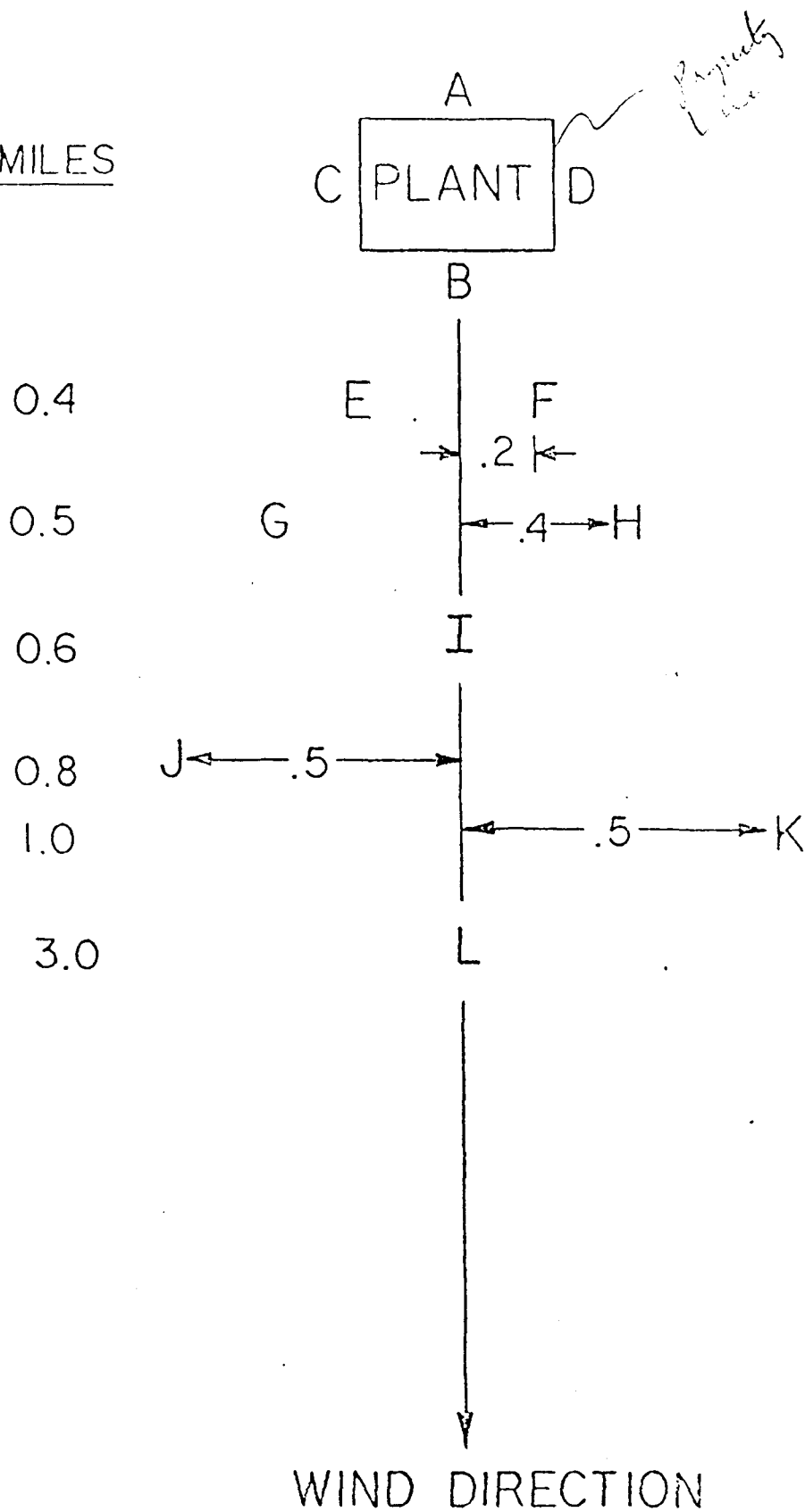
1. **Introduction**
 2. **Background**
 3. **Methodology**
 4. **Results**
 5. **Discussion**
 6. **Conclusion**
 7. **References**
 8. **Appendix**
 9. **Figure 1**
 10. **Figure 2**
 11. **Figure 3**
 12. **Figure 4**
 13. **Figure 5**
 14. **Figure 6**
 15. **Figure 7**
 16. **Figure 8**
 17. **Figure 9**
 18. **Figure 10**
 19. **Figure 11**
 20. **Figure 12**
 21. **Figure 13**
 22. **Figure 14**
 23. **Figure 15**
 24. **Figure 16**
 25. **Figure 17**
 26. **Figure 18**
 27. **Figure 19**
 28. **Figure 20**
 29. **Figure 21**
 30. **Figure 22**
 31. **Figure 23**
 32. **Figure 24**
 33. **Figure 25**
 34. **Figure 26**
 35. **Figure 27**
 36. **Figure 28**
 37. **Figure 29**
 38. **Figure 30**
 39. **Figure 31**
 40. **Figure 32**
 41. **Figure 33**
 42. **Figure 34**
 43. **Figure 35**
 44. **Figure 36**
 45. **Figure 37**
 46. **Figure 38**
 47. **Figure 39**
 48. **Figure 40**
 49. **Figure 41**
 50. **Figure 42**
 51. **Figure 43**
 52. **Figure 44**
 53. **Figure 45**
 54. **Figure 46**
 55. **Figure 47**
 56. **Figure 48**
 57. **Figure 49**
 58. **Figure 50**
 59. **Figure 51**
 60. **Figure 52**
 61. **Figure 53**
 62. **Figure 54**
 63. **Figure 55**
 64. **Figure 56**
 65. **Figure 57**
 66. **Figure 58**
 67. **Figure 59**
 68. **Figure 60**
 69. **Figure 61**
 70. **Figure 62**
 71. **Figure 63**
 72. **Figure 64**
 73. **Figure 65**
 74. **Figure 66**
 75. **Figure 67**
 76. **Figure 68**
 77. **Figure 69**
 78. **Figure 70**
 79. **Figure 71**
 80. **Figure 72**
 81. **Figure 73**
 82. **Figure 74**
 83. **Figure 75**
 84. **Figure 76**
 85. **Figure 77**
 86. **Figure 78**
 87. **Figure 79**
 88. **Figure 80**
 89. **Figure 81**
 90. **Figure 82**
 91. **Figure 83**
 92. **Figure 84**
 93. **Figure 85**
 94. **Figure 86**
 95. **Figure 87**
 96. **Figure 88**
 97. **Figure 89**
 98. **Figure 90**
 99. **Figure 91**
 100. **Figure 92**
 101. **Figure 93**
 102. **Figure 94**
 103. **Figure 95**
 104. **Figure 96**
 105. **Figure 97**
 106. **Figure 98**
 107. **Figure 99**
 108. **Figure 100**
 109. **Figure 101**
 110. **Figure 102**
 111. **Figure 103**
 112. **Figure 104**
 113. **Figure 105**
 114. **Figure 106**
 115. **Figure 107**
 116. **Figure 108**
 117. **Figure 109**
 118. **Figure 110**
 119. **Figure 111**
 120. **Figure 112**
 121. **Figure 113**
 122. **Figure 114**
 123. **Figure 115**
 124. **Figure 116**
 125. **Figure 117**
 126. **Figure 118**
 127. **Figure 119**
 128. **Figure 120**
 129. **Figure 121**
 130. **Figure 122**
 131. **Figure 123**
 132. **Figure 124**
 133. **Figure 125**
 134. **Figure 126**
 135. **Figure 127**
 136. **Figure 128**
 137. **Figure 129**
 138. **Figure 130**
 139. **Figure 131**
 140. **Figure 132**
 141. **Figure 133**
 142. **Figure 134**
 143. **Figure 135**
 144. **Figure 136**
 145. **Figure 137**
 146. **Figure 138**
 147. **Figure 139**
 148. **Figure 140**
 149. **Figure 141**
 150. **Figure 142**
 151. **Figure 143**
 152. **Figure 144**
 153. **Figure 145**
 154. **Figure 146**
 155. **Figure 147**
 156. **Figure 148**
 157. **Figure 149**
 158. **Figure 150**
 159. **Figure 151**
 160. **Figure 152**
 161. **Figure 153**
 162. **Figure 154**
 163. **Figure 155**
 164. **Figure 156**
 165. **Figure 157**
 166. **Figure 158**
 167. **Figure 159**
 168. **Figure 160**
 169. **Figure 161**
 170. **Figure 162**
 171. **Figure 163**
 172. **Figure 164**
 173. **Figure 165**
 174. **Figure 166**
 175. **Figure 167**
 176. **Figure 168**
 177. **Figure 169**
 178. **Figure 170**
 179. **Figure 171**
 180. **Figure 172**
 181. **Figure 173**
 182. **Figure 174**
 183. **Figure 175**
 184. **Figure 176**
 185. **Figure 177**
 186. **Figure 178**
 187. **Figure 179**
 188. **Figure 180**
 189. **Figure 181**
 190. **Figure 182**
 191. **Figure 183**
 192. **Figure 184**
 193. **Figure 185**
 194. **Figure 186**
 195. **Figure 187**
 196. **Figure 188**
 197. **Figure 189**
 198. **Figure 190**
 199. **Figure 191**
 200. **Figure 192**
 201. **Figure 193**
 202. **Figure 194**
 203. **Figure 195**
 204. **Figure 196**
 205. **Figure 197**
 206. **Figure 198**
 207. **Figure 199**
 208. **Figure 200**
 209. **Figure 201**
 210. **Figure 202**
 211. **Figure 203**
 212. **Figure 204**
 213. **Figure 205**
 214. **Figure 206**
 215. **Figure 207**
 216. **Figure 208**
 217. **Figure 209**

2000

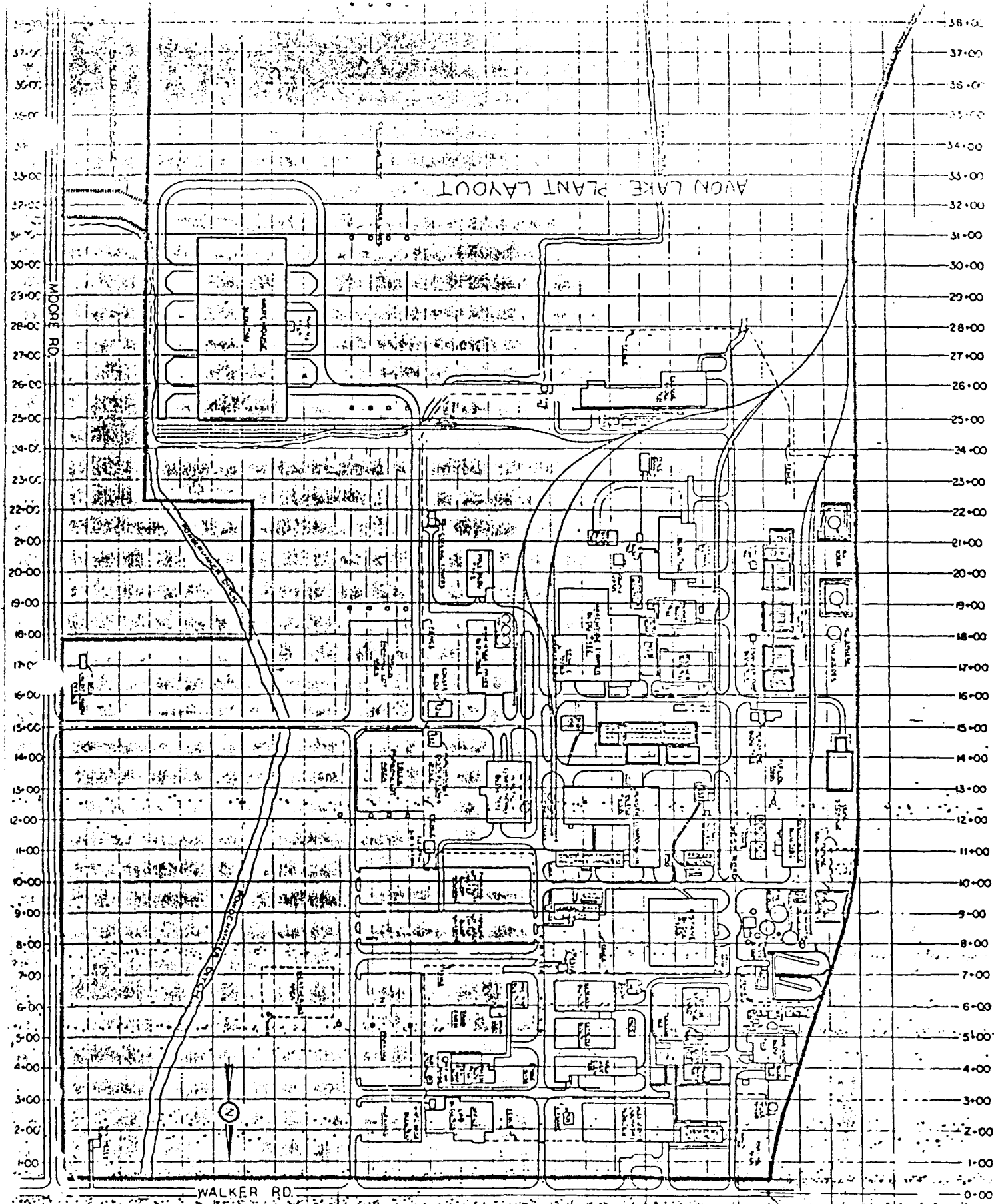
2023

SAMPLING LOCATION RELATIVE TO PLANT

MILES



25276014



25276046