

XOQDOQ Calculation

Method, Tools and Pitfalls



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October 13, 2006

XOQDOQ Purpose



- ❖ Model concentration and deposition of routine releases of radioactive effluents dispersed through the atmosphere

Definitions

X/Q χ/Q Chi/Q X/Q XOQ

- ❖ Average effluent concentration normalized by source strength
- ❖ Function of distance and sector from source
- ❖ Units are seconds per cubic meter

D/Q DOQ

- ❖ Average relative deposition per unit area
- ❖ Function of distance and sector from source
- ❖ Units are per square meter

XOQDOQ Inputs - Releases

A release describes the characteristics of the vent, building characteristics, and the decay properties of the release.

❖ Vent

- Height
- Velocity
- Diameter
- Emission rate

❖ Release type

- Elevated
- Ground
- Mixed

❖ Interference Factors

- Building height
- Building cross section

❖ Purges

- Indicator
- Number
- Duration

❖ Decays & Depletion

- Up to 3 release products
- Half-life
- Depletion indicator

XOQDOQ Inputs - Receptors



What is a receptor?

You may be one. A receptor is a location of interest around the plant, where a release may intersect with people or agricultural areas. It is defined by a direction and a distance from the vent.

- ❖ Population categories
 - Business areas
 - Population centers
 - Residences – nearest homes
- ❖ Agricultural categories
 - milk animals
 - meat animals
 - gardens or crops
- ❖ Plant boundary

XOQDOQ Inputs – Terrain & Corrections



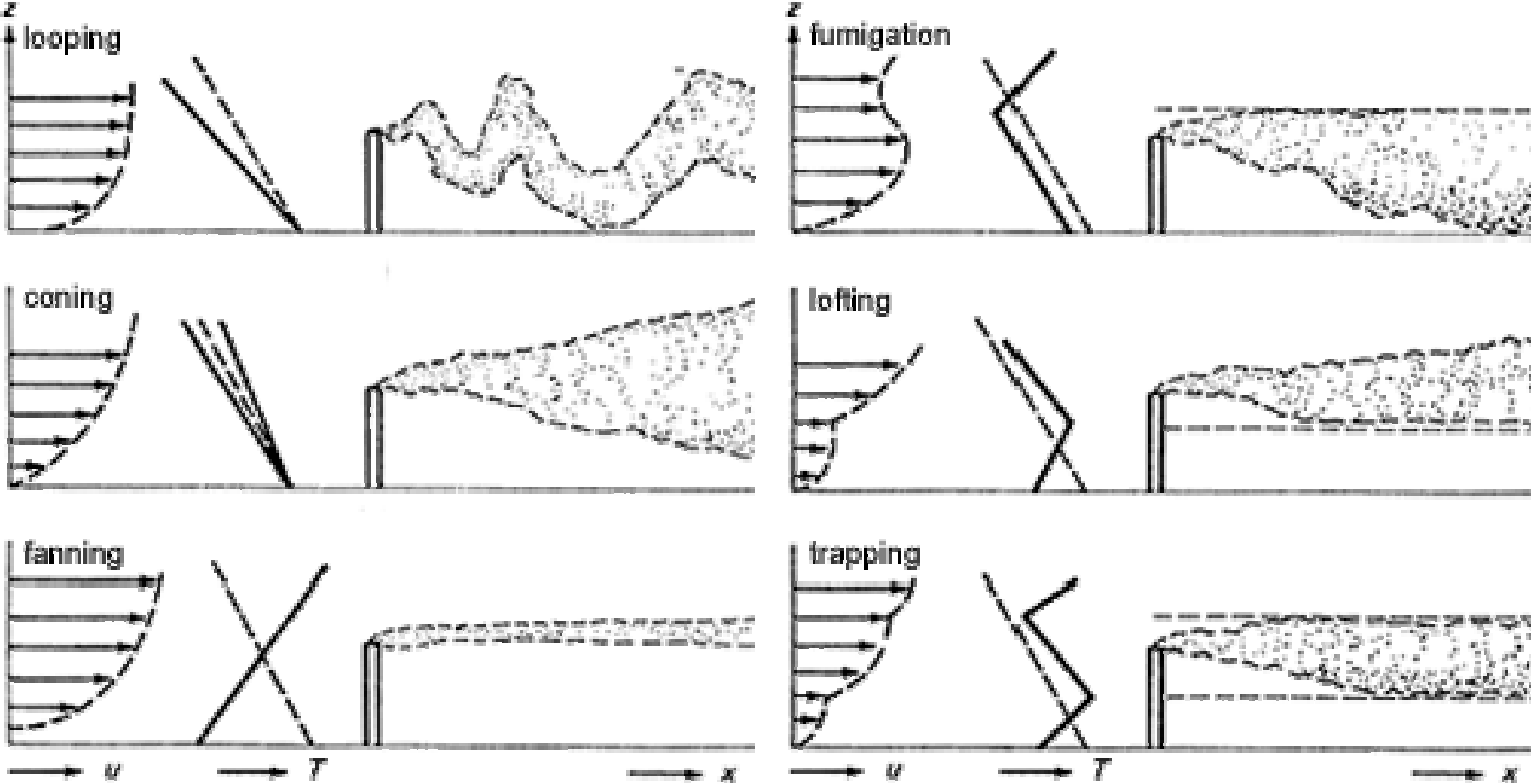
- ❖ Defaults for open terrain, standard correction curve
- ❖ Option for desert terrain
- ❖ Custom terrain
 - Distance
 - Direction
 - Elevation
- ❖ The Correction curve accounts for recirculation and stagnation
- ❖ Site specific recirculation factors
 - Distance
 - Direction
 - Multiplier
 - Requires advanced modeling techniques or site diffusion experiments

XOQDOQ Inputs – Wind Data

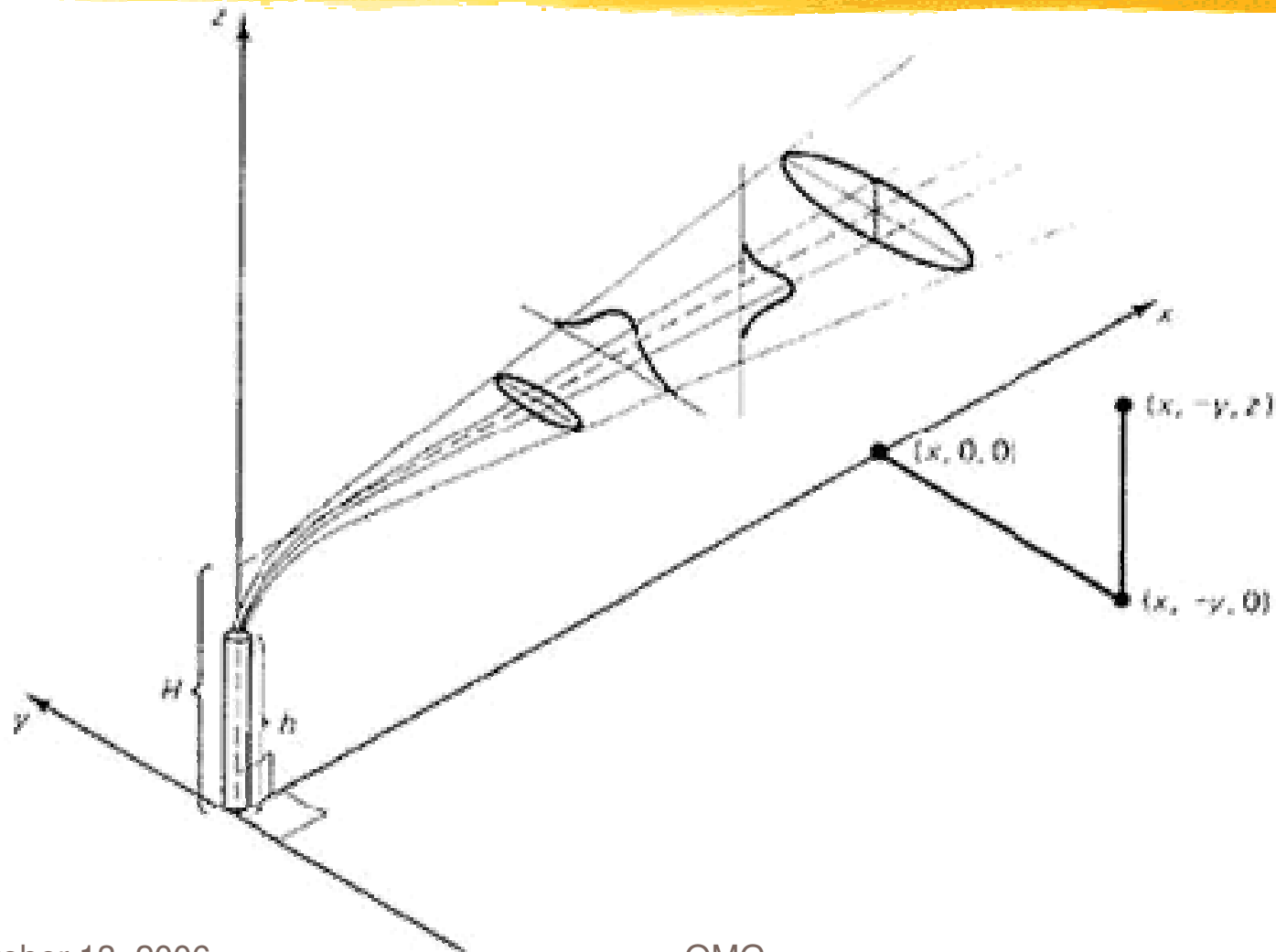


- ❖ Calms handling
- ❖ Counts or percentage
- ❖ Sectors - 22.5° sectors or option for 20° & 30°
- ❖ Velocity - number of velocity categories & maximum speed per category
- ❖ Stability - number of stability classes
- ❖ Height - sensor height of JFD data
- ❖ Units - miles/hour or meters/sec
- ❖ Joint Frequency Distribution

Plume Behaviors



Gaussian Distributions in Plume Model



Release



- ❖ Momentum (from velocity)
- ❖ Buoyancy (from high temperature)
- ❖ Downwash (from aerodynamic effects and low velocity)
- ❖ Cone out from source
- ❖ Diffusion is a function of atmospheric stability
- ❖ Building wake effects add to dispersion

Decay, Depletion & Recirculation



Materials in plumes

- ❖ Are deposited (deplete from plume)
- ❖ And decay
- ❖ Up to 3 cases per run, defaults are:
 - no decay / no depletion
 - Xe_{133m} – half life 2.26 days no depletion
 - I₁₃₁ – half life 8 days with depletion
- ❖ Recirculation & Stagnation

Method



- ❖ A Gaussian distribution is used to model plume behavior
- ❖ Allowances are made for buildings, vents, terrain and decay
- ❖ XOQ and DOQ are computed for standard distances in each of 16 sectors
- ❖ Specific locations are interpolated from the computed distributions

Computation Method

An XOQ value is computed for 22 specific distances and 16 directions from the release (352 points)

- ❖ For each wind velocity, direction and stability class category, a Gaussian distribution is computed as:

Where:

- h_e = the effective stack height at this distance
- σ_y = sigma in the horizontal (cross wind) direction
- σ_z = sigma in the vertical direction
- The σ_y and σ_z values are computed from the distance and stability class

$$\frac{e^{-\frac{1}{2} \left(\frac{h_e}{\sigma_z}\right)^2}}{(\text{wind velocity}) \sigma_y \sigma_z}$$

- ❖ The Gaussian distribution is multiplied by the fraction of the sample period represented by this wind velocity, direction, and stability class category
- ❖ Decay and depletion factors are multiplied by this value
- ❖ All of the values are summed together
- ❖ The XOQ value is computed for the point by multiplying the above result by a constant, the recirculation correction factor, and dividing by the distance
- ❖ DOQ is computed in a similar manner

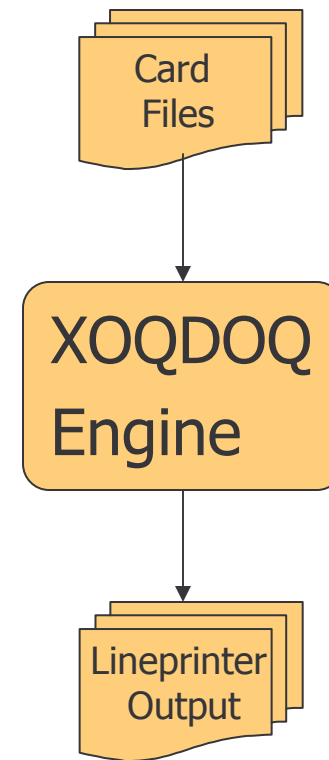
Outputs



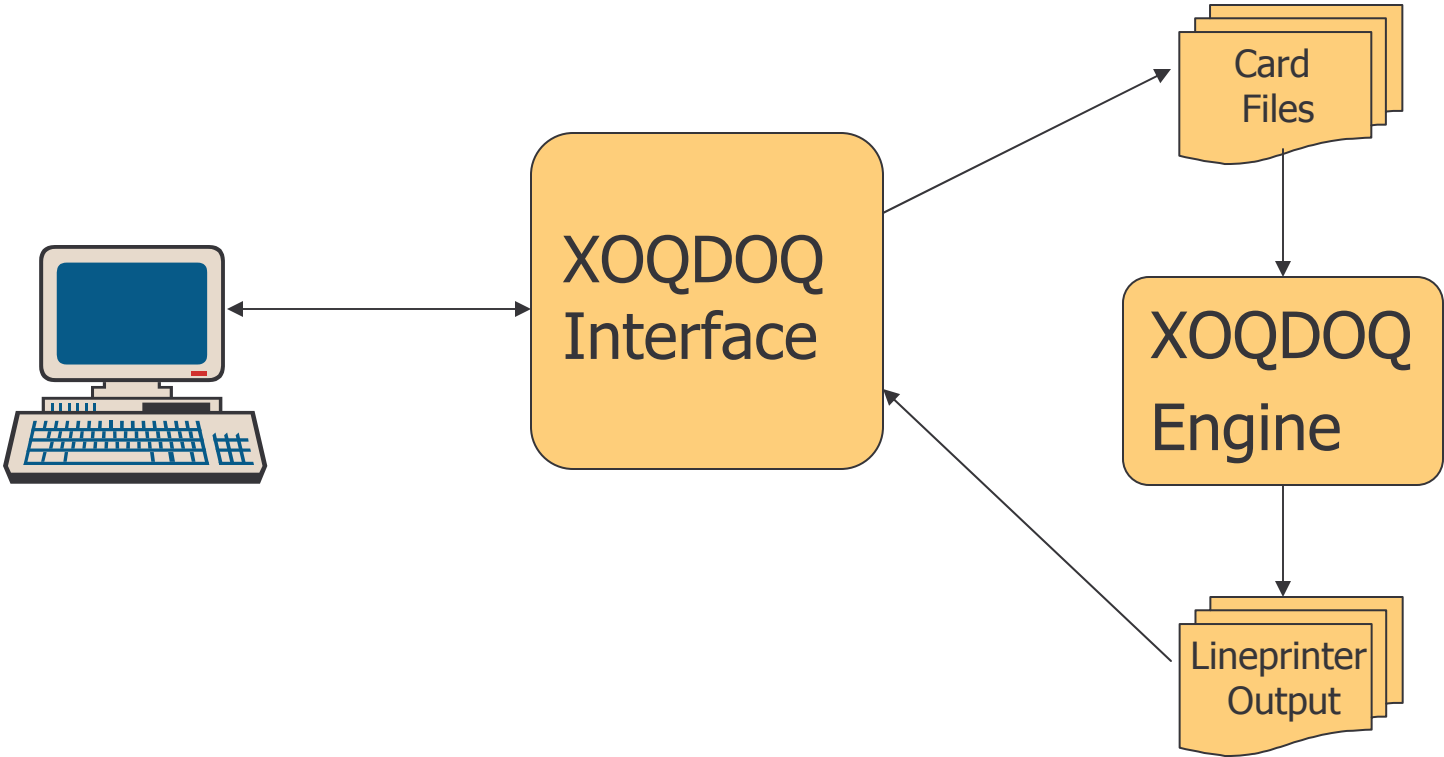
What You Will Get Out of the Program

- ❖ Input data, JFD of wind data
- ❖ For each decay/depletion case, direction, specified distance
 - Chi/Q
 - Chi/Q (specified distance ranges)
 - DOQ
 - DOQ (specified distance ranges)
- ❖ For each receptor
 - Chi/Q value for each decay/depletion case
 - DOQ
- ❖ For 100% elevated releases
 - The maximum Chi/Q value in each direction from the plant

XOQDOQ Direct Operation



NRC Dose Interface



NRC Dose Interface

The screenshot shows the 'NRC Dose Interface' software. The main window has a menu bar with 'File', 'Variables', and 'Quit'. The 'Wind Data' menu is open, showing options: 'Options...', 'Parameters...', 'Wind Data' (highlighted), 'Misc Parameters...', 'Calms Data...', and 'Joint Freq Data...'. Below the menu are buttons for 'Create Input File', 'View Output', and 'Create Alternate Met Input for GASPAR'. A 'View Alternate Met Input' button is also visible.

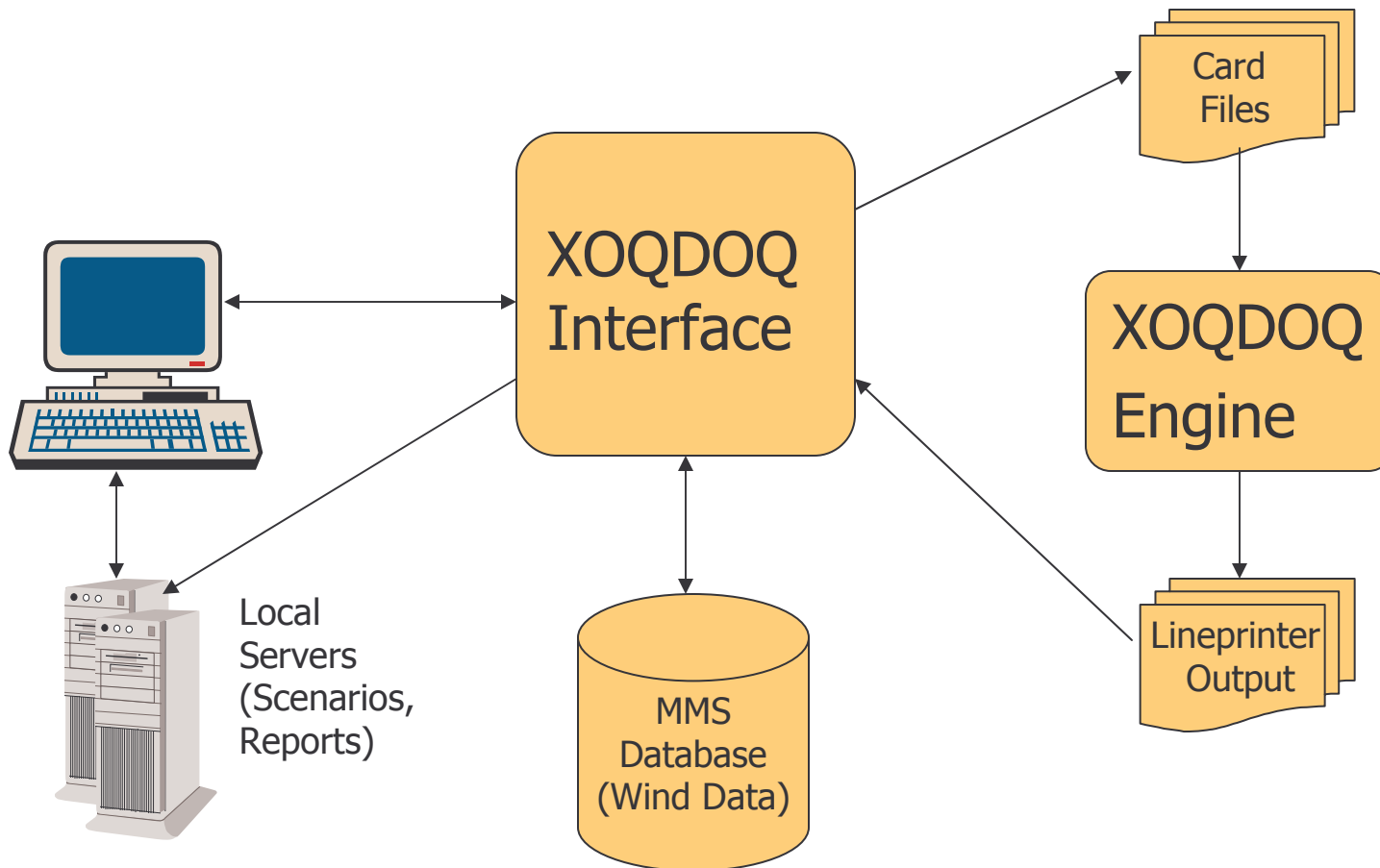
The 'Wind Speed Values' dialog box is open, showing two columns of wind speed classes and a table of wind direction values in hours.

STABILITY		WIND SPEED	
Class A		Class 2	
Class B		Class 3	
Class C		Class 4	
Class D		Class 5	
Class E		Class 6	
Class F		Class 7	
Class G			

[Hours]			
S:	0.00	N:	0.00
SSW:	0.00	NNE:	0.00
SW:	0.00	NE:	0.00
WSW:	0.00	ENE:	0.00
W:	0.00	E:	0.00
WNW:	0.00	ESE:	0.00
NW:	0.00	SE:	0.00
NNW:	0.00	SSE:	0.00

Buttons: Save, Cancel

XOQDOQ Full Interface



Scenario – Release & Receptors

MMS XQQDOQ

General Options JFD Data Historical **Scenarios** Terrain Results Help

Half Life (days)

 No Decay Decay Decay
 No Depletion No Depletion Depletion

NMP Unit #2 Stack Release

1 Release Exit Point

ID	Velocity (meters/sec)	Diameter (meters)	Height (meters)	Bldg Ht. (meters)	Cross Sect. (sq. meters)	Wind Ht. (meters)	Emis. Rate (cal/sec)	Release Type	Title
A	10.7	2.1	131	0	0	131	0	Elevated	NMP Unit #2 Stack

Delete

Unit #2 Stack Receptors

5 Receptor Types

Title	Sector	Direction	Distance (Miles)
Residences			
	14	ESE	1.1
	13	E	1.3
Milk Animals			
	14	ESE	1.6
	15	SE	2.9
Meat Animals			
	15	SE	2.6

Distance Units
 Meters
 Miles

Delete

Plant Site
 Nine Mile Point Unit #1
 Nine Mile Point Unit #2
 James A. Fitzpatrick

Select JFD Data Compute XQQDOQ

Exit

Wind Data - Selection

The screenshot shows a software window titled "Joint Frequency Distribution" with a blue title bar. The main content area is titled "Meteorological Monitoring System" and "Joint Frequency Distribution Report".

Date Range: Continuous, Seasonal

Start Date: Day of Year: 4/1, Years: 2000

End Date: Day of Year: 11/1, Years: 2005

Display: NMP Metric, NMP English, NRC Metric, Legacy XQDDQ Classes

Wind Speed/Direction Source: NMP 200', NMP 100', NMP 30', JAF 90', Inland 30'

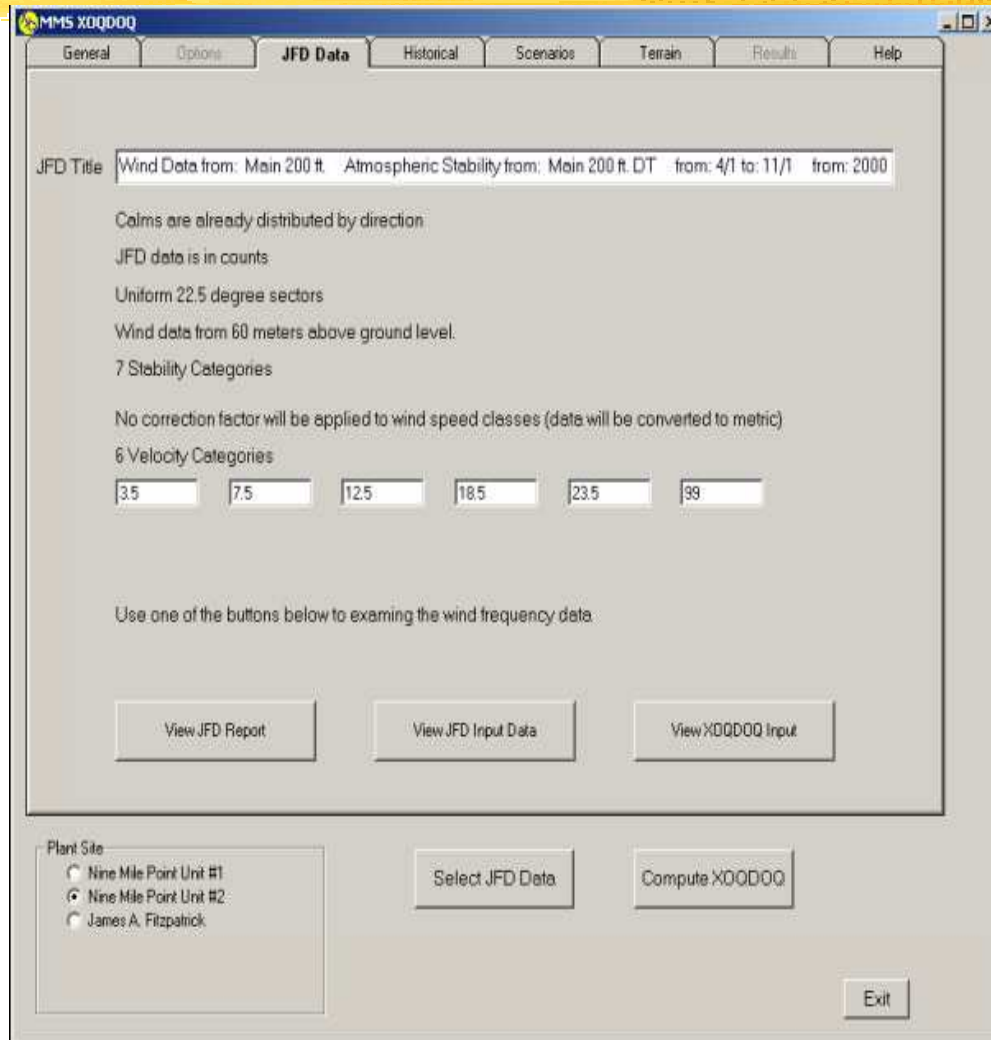
Stability Source: Sigma Theta NMP 200', Sigma Theta NMP 100', Sigma Theta NMP 30', Sigma Theta JAF 90', Sigma Theta Inland 30', Delta Temp NMP 200', Delta Temp NMP 100'

Display Valid Data Only, Include Suspect Data, Display Raw Data

Allow Data Substitution

Buttons: Compute JFD, Cancel

Wind Data



Output Viewer

KOQDQ Output File

HMP Unit #2 Stack
CORRECTED USING STANDARD OPEN TERRAIN FACTORS
SPECIFIC POINTS OF INTEREST

RELEASE ID	TYPE OF LOCATION	DIRECTION FROM SITE	DIST. (MI)	X/Q (SEC/M3) NO DECAY UNDEPLETED	X/Q (SEC/M3) 2.260 DAY DECAY UNDEPLETED	X/Q (SEC/M3) 8.000 DAY DECAY DEPLETED	D/Q (PER SQ.METER)
A	Residences	ESE	1.10	8.4E-09	8.4E-09	8.1E-09	1.0E-09
A	Residences	E	1.30	2.3E-09	2.3E-09	2.3E-09	1.6E-10
A	Milk Animals	ESE	1.60	7.6E-09	7.6E-09	7.4E-09	5.2E-10
A	Milk Animals	SE	2.90	1.3E-08	1.3E-08	1.3E-08	4.0E-10
A	Meat Animals	SE	2.60	1.4E-08	1.4E-08	1.3E-08	4.9E-10
A	Meat Animals	SSE	1.80	1.2E-08	1.2E-08	1.2E-08	6.4E-10
A	Gardens	E	1.30	2.3E-09	2.3E-09	2.3E-09	1.8E-10
A	Gardens	SE	1.40	1.6E-08	1.6E-08	1.5E-08	1.4E-09
A	Populations	E	1.40	2.4E-09	2.4E-09	2.3E-09	1.6E-10
A	Populations	SE	1.90	1.5E-08	1.5E-08	1.5E-08	8.4E-10
A	MAXIMUM CHI/Q	S	.75	2.2E-08	2.2E-08	2.2E-08	2.8E-09
A	MAXIMUM CHI/Q	SSW	.75	9.4E-09	9.4E-09	9.2E-09	1.1E-09
A	MAXIMUM CHI/Q	SW	.50	5.4E-09	5.4E-09	5.4E-09	6.7E-10
A	MAXIMUM CHI/Q	WSW	.25	9.3E-08	9.3E-08	9.3E-08	1.6E-08
A	MAXIMUM CHI/Q	W	.75	7.6E-08	7.6E-08	7.4E-08	1.1E-08
A	MAXIMUM CHI/Q	WNW	.25	6.0E-08	6.0E-08	6.0E-08	1.2E-08
A	MAXIMUM CHI/Q	NW	.25	7.6E-08	7.6E-08	7.6E-08	9.6E-09
A	MAXIMUM CHI/Q	NNW	.25	9.7E-08	9.7E-08	9.7E-08	1.0E-08
A	MAXIMUM CHI/Q	N	.25	8.0E-08	8.0E-08	8.0E-08	1.2E-08
A	MAXIMUM CHI/Q	NNE	.25	6.0E-08	6.0E-08	6.0E-08	1.0E-08
A	MAXIMUM CHI/Q	NE	.50	1.1E-08	1.1E-08	1.1E-08	1.8E-09
A	MAXIMUM CHI/Q	ENE	3.00	3.3E-09	3.2E-09	3.1E-09	5.3E-11
A	MAXIMUM CHI/Q	E	2.50	2.7E-09	2.7E-09	2.6E-09	6.6E-11
A	MAXIMUM CHI/Q	ESE	.75	1.0E-08	1.0E-08	1.0E-08	1.7E-09
A	MAXIMUM CHI/Q	SE	.50	2.5E-08	2.5E-08	2.5E-08	4.2E-09
A	MAXIMUM CHI/Q	SSE	.75	2.6E-08	2.6E-08	2.6E-08	3.2E-09

Print Close

Manage Reports -Generation Information

The screenshot displays the 'MMS XQDDQQ' application window with a 'General' tab selected. The interface includes a menu bar with 'Options', 'JFD Data', 'Historical', 'Scenarios', 'Terrain', 'Results', and 'Help'. The main content area shows the following settings:

- XQDDQQ Main Title: Demonstration for NUMUG 2006
- Options: Standard Options
- Releases: NMP Unit #2 Stack Release
- Receptors: Unit #2 Stack Receptors
- Terrain: Flat Terrain Model
- Corrections: Open Terrain Recirculation
- JFD Data: Wind Data from: Main 200 ft. Atmospheric Stability from: Main 200 ft. DT from: 4/1 to: 11/1 from: 2000 to: 2005

At the bottom, the status bar indicates 'XQDDQQ Interface: Version 1.1.0 Created 9/8/2006 1:01:26 PM'. A 'Plant Site' section contains three radio buttons: 'Nine Mile Point Unit #1', 'Nine Mile Point Unit #2' (selected), and 'James A. Fitzpatrick'. Action buttons include 'Select JFD Data', 'Compute XQDDQQ', and 'Exit'.

Manage Reports - Properties

The image shows a Windows-style dialog box titled "XOQ_OUT050824124805.rtf Properties". It has five tabs: "General", "Summary", "Statistics", "Contents", and "Custom". The "General" tab is selected. The dialog contains several text input fields and a list box. At the bottom, there are "OK" and "Cancel" buttons.

Field	Value
Title:	Seasonal Unit #1 Stack Release Test
Subject:	XOQDOQ
Author:	Meteorological Monitoring System
Manager:	Operations Management Group
Company:	Nine Mile Point - Nine Mile Point Nuclear Station
Category:	Wind Data from: Main 200 ft. Atmospheric Stat
Keywords:	NMP1
Comments:	-- NMP Unit #1 Stack Release -- Unit #1 Default Receptors -- Flat Terrain Model
Hyperlink base:	
Template:	Normal.dot

Save preview picture

Annoyances



- ❖ **Inconsistent terminology**
 - both X/Q and CHI/Q are referenced in the output report
- ❖ **Errors in the formatting of the report**

Pitfalls

❖ **Multiple previous versions –**

- XOQDOQ results may have been generated on a customized version of the XOQDOQ program
- Old input files may produce different results or even fail if rerun with the new PC program

❖ **Inconsistent use of engineering units – *e.g.***

- XOQDOQ engine expects receptor distances in meters, but reports resulting XOQ and DOQ values in miles from the source

❖ **The required format of wind data –**

- The XOQDOQ program expects data beginning with wind from the South

❖ **Arcane input options – *e.g.***

- Elevated releases are indicated by negating the Stack Height Value
- Ground Releases are specified by setting the velocity and diameter entries to 0 and wind height entry to 10 meters
- Any other combination is treated as a mixed release

❖ **Program bug -** Wind height must be set to vent height