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SITE CHARACTERISTICS

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification of Location

Columbia Generating Station (CGS) is located in the southeast area of the U.S. Department of Energy's (DOE) Hanford Site in Benton County, Washington. The site is approximately 3 miles west of the Columbia River at River Mile 352, approximately 10 miles north of north Richland, 18 miles northwest of Pasco, and 21 miles northwest of Kennewick (Figures 2.1-1 and 2.1-2).

The reactor is located at 46° 28' 18" north latitude and 119° 19' 58" west longitude. The approximate Universal Transverse Mercator coordinates are 5,148,840 meters north and 320,930 meters east.

2.1.1.2 Site Area Map

The CGS site area is that real estate over which Energy Northwest has the legal right to control access. It is the area enclosed by the exclusion area boundary plus the plant property lines as shown in Figure 3-1 of the Offsite Dose Calculation Manual (ODCM). The property line and nearby industrial facilities are shown in Figure 2.1-3. Industrial facilities located in the site area are the H. J. Ashe Substation and Energy Northwest's Nuclear Projects 1 and 4 (WNP-4 was terminated in January 1982, and WNP-1 was terminated in May 1994). Highway and railway facilities located within the site area are shown in Figure 2.1-3. The relative locations of the plant structures are shown in Figure 1.2-1.

The boundary of the exclusion area is a circle with its center at the reactor and a radius of 1950 m. Ownership and control of the land outside the CGS property line but within the site exclusion area are discussed in Section 2.1.2.

The site is situated near the middle of the relatively flat, essentially featureless plain, which is best described as a shrub steppe with sagebrush interspersed with perennial native and introduced annual grasses extending in a northerly, westerly, and southerly direction for several miles. The plain is characterized by slight topographic relief of approximately 20 ft across the plant site.

The dominant topographic features in the area are the Rattlesnake Hills, 13 to 15 miles west southwest, 3200 ft above the elevation of the plant site; Gable Mountain, approximately

10 miles northwest of the site and about 670 ft above the site grade; and the steep river cut bluffs forming the east bank of the Columbia River, approximately 3.5 miles east of the site (Figure 2.1-1).

2.1.1.3 Boundaries for Establishing Effluent Release Limits

The boundary for establishing effluent release limits (unrestricted area boundary as defined in 10 CFR Part 20) is the site area boundary as shown in the ODCM, Figure 3-1. The site area is the area enclosed by the exclusion area boundary and the plant property lines that fall outside the exclusion area. All area within the site area boundary is considered a controlled area as defined by 10 CFR 20.1003.

A number of restricted areas (as defined in 10 CFR 20.1003) are associated with CGS. The primary CGS restricted area is located within the plant security fence which also is the boundary of the protected area (as defined in 10 CFR 73.2). This is shown as the double fence line in Figure 1.2-1. Unescorted access to the protected area is controlled by CGS security staff. Other restricted areas include the Independent Spent Fuel Storage Installation, stormwater pond, Plant Support Facility calibration laboratory, Warehouse No. 5, the cooling tower sediment disposal area, and Building 167 on the WNP-4 site. Access to these secondary restricted areas is controlled by locks and fences. Temporary restricted areas may be established and removed as dictated by activities at CGS.

2.1.2 EXCLUSION AREA AUTHORITY AND CONTROL

2.1.2.1 Authority

Energy Northwest leased 1089 acres from the DOE, within the DOE Hanford Site, to be used for CGS. A letter from the DOE Richland Operations office to the Managing Director of Energy Northwest (Reference 2.1-1) advises that the DOE has the authority to sell or lease land on the Hanford Site and the letter further states

> This Authority is contained in Section 120 of the Atomic Energy Community Act of 1955, as amended, and Section 161g of the Atomic Energy Act of 1954, as amended. There is also general federal disposal authority available under the Federal Property Administrative Services Act of 1949, as amended.

The 1950-m radius exclusion area extends beyond the CGS property lines and overlaps DOE lands as well as the additional land leased by Energy Northwest for the construction of the WNP-1 and WNP-4 projects (see Figure 2.1-3 and ODCM Figure 3-1). All land outside the Energy Northwest leased property but within the exclusion area is managed by the DOE.

In recognition of the requirement specified in 10 CFR 100.3(a) that a licensee have control over access to the exclusion area, the following terms have been incorporated as Article 7 of the site property lease agreement between Energy Northwest and the DOE (as modified in 1975):

> Nothwithstanding any provisions of this lease to the contrary, the Administration [Energy Research and Development Administration -- now DOE] agrees that the Supply System [now Energy Northwest] has the authority to determine all activities within the exclusion area within the meaning of 10 CFR Section 100.3 (a), including the authority to remove all personnel and property from the area. The Supply System agrees that it will exercise such authority in a manner so as not to preclude the Administration from undertaking any action or activity within the exclusion area that is permissible under the provisions of 10 CFR Section 100.3 (a). As used herein, the term "exclusion area" includes both the leased and nonleased portions of the exclusion area.

Therefore, any actions such as public access and actions concerning mineral rights and easements taken within the exclusion area but outside the leased property are under the control of the DOE with the provision that Energy Northwest has the legal right to control access of individuals to the exclusion area if necessary. All rail shipments on the track which traverses the property (Figure 2.1-3) are also under control of the DOE and are also subject to the above provision and controls imposed by Energy Northwest Security.

The only paved roads that traverse the exclusion area of CGS are the CGS, WNP-1, and WNP-4 facility access roads shown in Figure 2.1-3. Access by land from outside of the Hanford Site to the plant site is over DOE roads. Travel within the exclusion area on the access roads will be under the authority of Energy Northwest.

In the event that evacuation or other control of the exclusion area should become necessary, appropriate notice will be given to the DOE-Richland Operations Office for control of non-Energy Northwest originated activities.

The above provisions provide the necessary assurance that the exclusion area is properly controlled. If Energy Northwest should decide that an easement would be useful in ensuring continued control, there is a provision in Article 5(b) of the lease as follows:

> Subject to the provisions of Section 161g of the Atomic Energy Act of 1954, as amended, the Commission has authority to grant easements for rights-of-way for roads, transmission lines and for any other purpose, and agrees to negotiate with Energy Northwest for such rights-of-way over the Hanford Operations Area as are necessary to service the Leased Premises.

Pursuant to this provision Energy Northwest could obtain an easement over the exclusion area in question from the DOE, which would ensure that no permanent structures or other activities inconsistent with the exclusion area would be carried on therein.

2.1.2.2 Control of Activities Unrelated to Plant Operation

In accordance with, and as defined by 10 CFR 100.3, Energy Northwest has the authority to determine all activities within the exclusion area, including the authority to remove all personnel and property from the area. The following activities unrelated to plant operation are permitted within the exclusion area:

2.1.2.2.1 Industrial Development Complex

Energy-Northwest is conducting site restoration and economic development (such as leasing of excess facilities for office space and manufacturing) activities at the WNP-1 and WNP-4 sites (the WNP-1 and WNP-4 sites are also leased from the DOE and controlled by Energy Northwest). The number of personnel at the WNP-1 and WNP-4 sites varies. However, coordination of activities within the exclusion area is under the control of Energy Northwest and the CGS emergency plan. This includes notification and evacuation considerations in the event of an emergency at CGS.

2.1.2.2.2 618-11 (Wye) Waste Burial Ground

The 618-11 site is a DOE waste burial ground, encompassing an eight-acre parcel directly adjacent to Energy Northwest leased land (see Figure 2.1-3) and located wholly within the CGS exclusion area. The DOE and its site contractor are approved to perform non-intrusive surveillance and characterization activities to obtain data and information necessary for planning future intrusive activities and remediation strategies. These activities are necessary to meet the 618-11 site remediation and closeout milestone of September 2018 as delineated in the Hanford Federal Facility Agreement and Consent Order. All 618-11 site activities are controlled by DOE in accordance with 10 CFR Chapter III. DOE has responsibility for the 618-11 site documented safety analysis (DSA) in accordance with 10 CFR 830.204. The currently approved DSA and its associated technical safety requirements (TSR) establish the safety basis and assess the environmental impact of the non-intrusive activities within the site. The soil overburden covering the caissons and vertical pipe units at the 618-11 site is identified as a passive design feature that serves a mitigative function. Existing soil overburden shall not be removed.

A memorandum of understanding (MOU) has been established between the DOE 618-11 site contractor and Energy Northwest for communication and mutual support for the non-intrusive activities at the site. The MOU delineates the requirements for the site contractor to inform Energy Northwest of plans, schedules, manning, and other matters pertaining to the non-intrusive site activities. In addition, the MOU defines Energy Northwest requirements for contractor notification of CGS events with the potential to affect the 618-11 site operation and/or personnel. Communication includes notification and evacuation considerations in the event of an emergency at CGS.

In the event of a 618-11 site emergency, including the 618-11 site design basis event, the 618-11 site is subject to control by the DOE. Control includes notifications, implementation of required actions, and communication of recommendations to protect the health and safety of CGS personnel and the public within and beyond the Hanford reservation boundaries.

The non-intrusive activities, analyzed 618-11 site events, and the design basis event associated with the non-intrusive activities, have been assessed and approved by DOE. In addition, Energy Northwest has performed an evaluation of the 618-11 site releases that would occur from the postulated design basis event. The evaluation, using NRC radionuclide transport methodology and CGS meteorological data, has confirmed that the potential 618-11 site releases will not adversely impact Structures, Systems, and Components or credited operator actions. Implementation of DOE approved non-intrusive activities at the 618-11 site will not affect the operation of CGS, and thus, will not result in a significant hazard to the health and safety of the public from CGS's operation.

2.1.2.3 Arrangements for Traffic Control

The only roads within the exclusion area are the Energy Northwest access roads. These roads are normally used only by employees and visitors associated with the CGS, WNP-1, and WNP-4 facilities, DOE, and DOE contractors. The security force, with offsite assistance as required, controls traffic during emergencies.

2.1.2.4 Abandonment or Relocation of Roads

There were no public roads transversing the exclusion area that had to be abandoned or relocated as a result of the construction of CGS.

2.1.3 POPULATION DISTRIBUTION

Table 2.1-1 presents the compass sector population estimates for 1980 and the forecasts for the same compass sectors by decade from 1990 to 2030.[*] Cumulative totals are also shown in Table 2.1-1. This table may be keyed to Figures 2.1-4 and 2.1-5, which show the sectors and major population centers within 10 and 50 miles of the site. As can be seen in Figure 2.1-6, population centers, within 50 miles of the site include the Tri-Cities area of Richland, Pasco, and Kennewick; Moses Lake; Hermiston; and the communities lying along the Yakima River

[*] Population estimates out to 50 miles were derived to serve the licensing requirements of WNP-1, CGS, and WNP-4. Therefore, estimates were made relative to the centroid of the triangle formed by the three reactors. This point is located 2800 ft east of CGS and has coordinates longitude 119° 19' 18" west, latitude 46° 28' 19" north. This shift does not affect the overall accuracy or applicability of the population distribution projections.

from Prosser to Toppenish. Figure 2.1-4 shows that there are no towns located within 10 miles of the site, with the exception of a small part of Richland.

The 1990 to 2030 forecasts presented here (Reference 2.1-2) are based on

a. 1979 population figures provided by the Washington State Office of Financial Management,

b. Benton and Franklin County Traffic Analysis Zone population distributions,

c. Computed annual average area growth rates from 1975 through 1979 which were utilized to obtain the total 1980 population estimated for each area, and

d. County forecasts prepared by the Bonneville Power Administration. (References 2.1-3 and 2.1-4).

Table 2.1-2 presents the compass sector population estimates for 2000 based on U.S. Census Bureau data (Reference 2.1-5). See also Figures 2.1-4 and 2.1-5. When this table is compared with Table 2.1-1, it is seen that estimates based on the more recent census data are generally less than the projections based on 1979 data, although the 30-mile cumulative totals are very close (approximately 207,000).*

2.1.3.1 Population Within Ten Miles

In 2000, an estimated 2945 people were living within 10 miles of the site. The nearest inhabitants occupy farms which are located east of Columbia River and are thinly spread over five compass sectors. There are no permanent inhabitants located within 3 miles of the site.

No significant changes in land use within five miles are anticipated. The Hanford Site is expected to remain dedicated primarily to industrial use without private residences. No change in the use of the land east of the Columbia River is expected since it currently is irrigated to about the maximum amount practicable. The primary increase in population within the 10-mile radius is expected to be in the area south and south-southwest of the plant (see Figure 2.1-4).

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* The estimates in Table 2.1-2 are centered on the plant, whereas Table 2.1-1 is centered on a point about 0.5 mile to the east. This introduces a minor amount of variation.

2.1.3.2 Population Between Ten and Fifty Miles

As indicated in Table 2.1-2, about 357,000 people were estimated to be living within a 50-mile radius of CGS in 2000. Projections for the 10-50 mile region are shown in Table 2.1-1 which is based on earlier (1979-1980) population counts.

2.1.3.3 Transient Population

The transient population consists of agricultural workers needed for harvesting crops produced in the region, industrial and construction workers, and sportsmen engaged in hunting, fishing, and boating. A description of the transient population is discussed in Section 5.6 of the CGS Emergency Plan.

2.1.3.4 Low Population Zone

The low population zone (LPZ) [see 10 CFR 100.3(b)] for CGS is defined as all land within a 3-mile radius of the reactor. This LPZ was selected on the basis that it is not expected to have a large population in the future and that effective protective measures could be established. As shown in Table 2.1-2, no permanent residents are located within a 3-mile radius of the reactor, and none are anticipated in the future.

There are no public facilities or institutions such as schools and hospitals within a 3-mile radius of the plant. The transportation facilities and topographic features of the LPZ are shown in Figure 2.1-7.

2.1.3.5 Population Center

The nearest population center is the City of Richland, 12 miles to the south.

2.1.3.6 Population Density

In 2000, the population densities within the 10, 20, and 30-mile radii were 9, 96, and 73 people per square miles, respectively. In 2030, the densities out to the same distances are estimated to be 13, 123, and 84, respectively, based on the projections in Table 2.1-1.

2.1.4 REFERENCES

2.1-1 Letter from Atomic Energy Commission, Richland Operations Office, to Managing Director of the Supply System, Washington Public Power Supply System, Subject: Appendix 2P, November 25, 1970.

2.1-2 Yandon, K. E., Projections and Distributions of Populations Within a 50-Mile Radius of Washington Public Power Supply System Nuclear Projects Nos. 1, 2, and 4 by Compass Direction and Radii Intervals, 1970-2030, October 1980.

2.1-3 Bonneville Power Administration, U.S. Department of Energy, Washington, Subject: Population, Employment and Household Projections to 2000 by County, July 1979.

2.1-4 Bonneville Power Administration, U.S. Department of Energy, Oregon Population, Employment and Household Projections to 2000 by County.

2.1-5 J. P. Chasse, Energy Northwest, personal communication with M. Mohrman, Washington Office of Financial Management, December 4, 2002, and J. P. Chasse, Energy Northwest, Updated 50-Mile Population Estimate, personal communication with J. D. Arbuckle, Energy Northwest, July 29, 2003.

Table 2.1-1

Projected Population Distribution by Compass Sector and Distance from the Site

Distance Cumulative (miles)	Direction (compass segment)	1980 Number	1980 Cumulative Total	1990 Number	1990 Cumulative Total	2000 Number	2000 Cumulative Total	2010 Number	2010 Cumulative Total	2020 Number	2020 Cumulative Total	2030 Number	2030 Cumulative Total
0-3	All	0	0	0	0	0	0	0	0	0	0	0	0
3-5	N-NNE	0	0	0	0	0	0	0	0	0	0	0	0
	NE	10	10	35	35	48	48	52	52	55	55	86	86
	ENE	22	32	43	78	56	104	60	112	63	118	64	150
	E	22	54	43	121	56	160	60	172	63	181	64	214
	ESE	22	76	43	164	56	216	60	232	63	244	64	278
	SE	4	80	6	170	9	225	11	243	11	255	12	290
	SSE-NNW	0	80	0	170	0	225	0	243	0	255	0	290
5-10	N	26	106	58	228	77	302	83	326	87	342	88	378
	NNE	83	189	126	354	152	454	162	488	170	512	172	550
	NE	155	344	198	552	224	678	240	728	252	764	254	804
	ENE	114	458	157	709	177	855	190	918	200	964	202	1006
	E	135	593	200	909	257	1112	276	1194	290	1254	293	1299
	ESE	168	761	276	1185	341	1453	366	1560	385	1639	389	1688
	SE	190	951	406	1591	536	1989	575	2135	604	2243	610	2298
	SSE	45	996	253	1844	308	2297	330	2465	347	2590	350	2648
	S	50	1046	272	2116	483	2780	518	2983	544	3134	550	3198
	SSW	235	1281	535	2651	809	3589	867	3850	911	4045	920	4118
	SW	25	1306	25	2676	25	3614	27	3877	28	4073	29	4147
	WSW-NNW	0	1306	0	2676	0	3614	0	3877	0	4073	0	4147
10-20	N	332	1638	371	3047	398	40112	427	4304	449	4522	454	4601
	NNE	328	1966	371	3418	397	4409	426	4730	447	4969	452	5053
	NE	399	2365	562	3980	588	4997	630	4360	662	5631	669	5722
	ENE	792	3157	835	4815	855	5852	917	6277	964	6595	974	6696
	E	461	3618	479	5294	544	6396	583	6860	613	7208	619	7315
	ESE	192	3810	430	5724	576	6972	618	7478	650	7858	657	7972
	SE	4155	7965	5221	10945	5821	12793	6242	13720	6561	14419	6627	14599
	SSE	49178	57143	63483	74428	70917	83710	76043	89763	79932	94351	80734	95333
	S	28943	86086	37672	112100	45434	129144	48717	138480	51208	145559	51722	147055
	SSW	1592	87678	1772	113872	1922	131066	2061	140541	2166	147725	2188	149243
	SW	3106	90784	3597	117469	894	134960	4175	144716	4389	152114	4433	153676
	WSW	950	91734	1048	118517	1108	136068	1188	145904	1248	153362	1260	154936
	W	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936
	WNW	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936
	NW	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936
	NNW	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936

Table 2.1-1

Projected Population Distribution by Compass Sector and Distance from the Site (Continued)

Distance Cumulative (miles)	Direction (compass segment)	1980 Number	1980 Cumulative Total	1990 Number	1990 Cumulative Total	2000 Number	2000 Cumulative Total	2010 Number	2010 Cumulative Total	2020 Number	2020 Cumulative Total	2030 Number	2030 Cumulative Total
20-30	N	1501	93235	1837	120354	2055	138123	2203	148107	2316	155678	2339	157275
	NNE	5759	98994	6487	126841	7123	145246	7638	155745	8029	163707	8110	165385
	NE	2015	101009	2174	129015	2274	147520	2438	158183	2563	166270	2589	167974
	ENE	1717	102726	1760	130775	1786	149306	1915	160098	2013	168283	2033	170007
	E	151	102877	194	130969	220	149526	236	160334	248	168531	250	170257
	ESE	153	103030	240	131209	305	149831	327	160661	344	168875	348	170605
	SE	6138	109168	6512	137721	6738	156569	7225	167886	7594	176469	7670	178275
	SSE	24116	133284	32559	170280	36360	192929	38987	206873	42032	218501	42454	220729
	S	187	133471	678	170958	975	193904	1045	207918	1098	219599	1109	221838
	SSW	875	134346	1218	172176	1426	195330	1529	209447	1607	221206	1623	223461
	SW	6165	140511	7147	179323	7737	203067	8296	217743	8720	229926	8808	232269
	WSW	1626	142137	1799	181122	1908	204975	2046	219789	2151	232077	2173	234442
	W	1191	143328	1325	182447	1429	206404	1532	221321	1610	233687	1626	236068
	WNW	185	143513	280	182727	297	206701	318	221639	334	234021	338	236406
	NW	40	143553	44	182771	48	206749	51	221690	54	234075	55	236461
	NNW	182	143735	200	182971	218	206967	234	221924	246	234321	249	236710
30-40	N	980	144715	1096	184065	1127	208094	1208	223132	1270	235591	1283	237993
	NNE	3198	147913	3663	187728	3983	212077	4271	227403	4490	240081	4536	242529
	NE	650	148563	800	188528	745	212822	799	228202	846	240927	850	243379
	ENE	421	148984	447	188975	475	213297	509	228711	535	241462	540	243919
	E	128	149112	136	189111	141	213438	152	228863	160	241622	162	244081
	ESE	167	149279	176	189287	182	213620	195	229058	205	241827	208	244289
	SE	464	149743	484	189771	497	214117	533	229591	560	242387	566	244855
	SSE	592	150335	844	190615	955	215072	1023	230615	1076	243463	1087	245942
	S	4680	155015	5653	196268	6368	221440	6828	237442	7172	250635	7250	253192
	SSW	256	155271	424	196692	529	221969	567	238009	596	251231	602	253794
	SW	473	155744	661	197353	786	222755	842	238851	885	252116	894	254688
	WSW	21871	177615	24729	222082	26890	249645	28833	267684	30362	282478	30665	285353
	W	3578	181193	3949	226031	4273	253918	4582	272266	4816	287294	4864	290217
	WNW	1399	182592	1459	227490	1579	255497	1693	273959	1780	289074	1798	292015
	NW	703	183295	770	228260	836	256333	896	274855	942	290016	952	292967
	NNW	1575	184870	1738	229998	1899	258232	2036	276891	2140	292156	2161	295128
40-50	N	17872	202742	19730	249728	21572	279804	23130	300021	24312	316468	24556	319684
	NNE	893	203635	1019	250747	1121	280925	1202	301223	1263	317731	1275	320959
	NE	926	204561	1139	251886	1275	282200	1367	302590	1437	319168	1451	322410
	ENE	213	204774	243	252129	375	282575	402	302992	423	319591	427	322837
	E	241	205015	258	252387	268	282843	287	303279	302	319893	305	323142
	ESE	864	205879	925	253312	961	283804	1030	304309	1083	320976	1095	324237

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Table 2.1-1

Projected Population Distribution by Compass Sector and Distance from the Site (Continued)

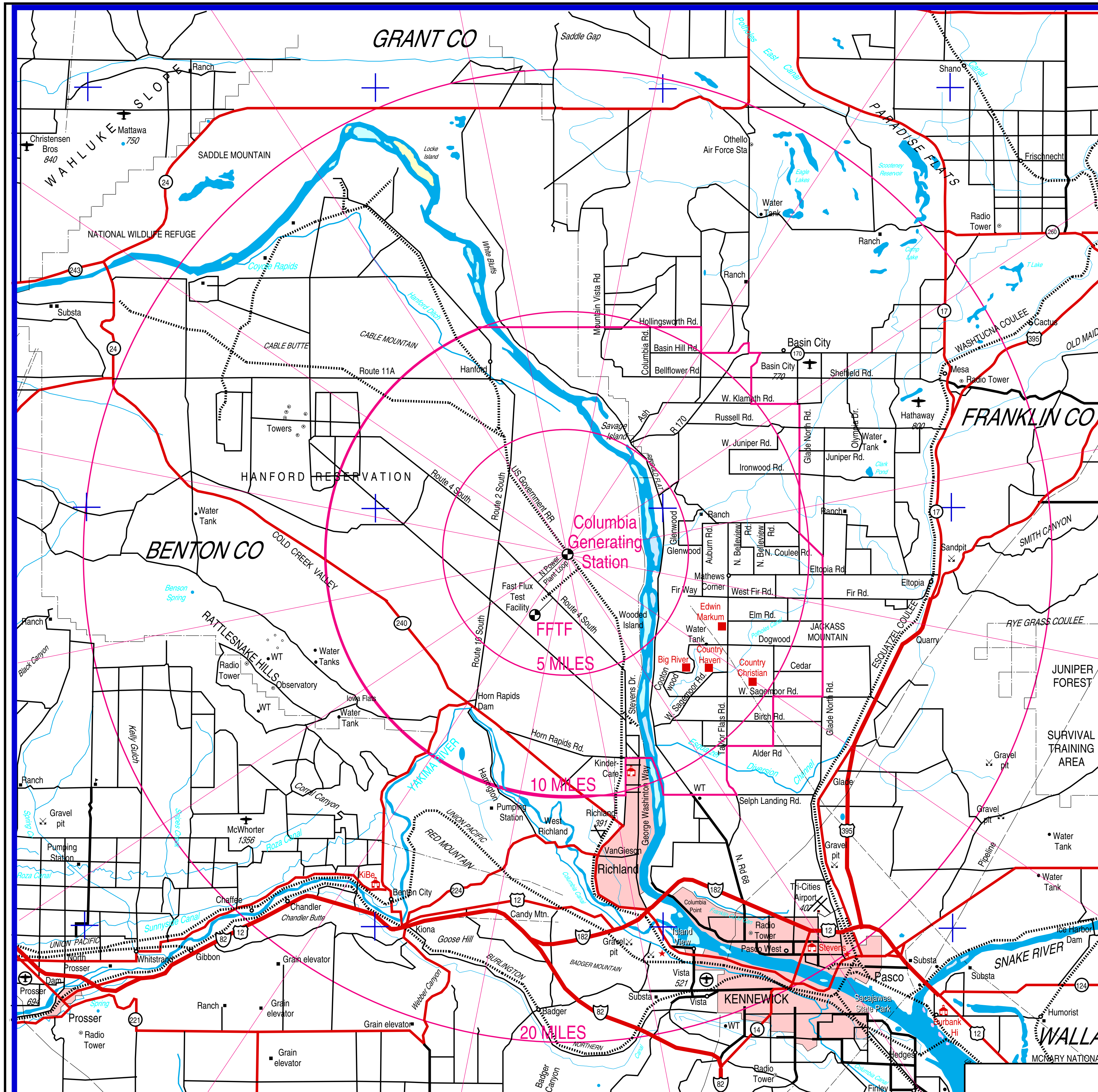
Distance Cumulative (miles)	Direction (compass segment)	1980		1990		2000		2010		2020		2030	
		Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total
40-50 (cont.)	SE	2084	207963	2245	25557	2349	286153	2518	306827	2646	323622	2673	326910
	SSE	1740	209703	1920	257477	2072	288225	2222	309049	2336	325958	2359	329269
	S	16540	226243	16406	273883	17708	305933	18987	328036	19958	345916	20158	349427
	SSW	2610	228853	2895	276778	2972	308905	3186	331222	3349	349265	3428	352855
	SW	421	229274	443	277221	476	309381	509	331731	535	349800	541	353396
	WSW	809	230083	892	278113	965	310346	1035	332766	1088	350888	1099	354495
	W	18515	248598	20481	298594	22176	332525	23780	356546	24996	375884	25247	379742
	WNW	1742	250340	1903	300497	2043	334568	2191	358737	2303	378187	2326	382068
	NW	812	251152	859	301356	905	335473	970	359707	1020	379207	1030	383098
	NNW	532	251684	587	301943	642	336115	688	360395	723	379930	730	383828

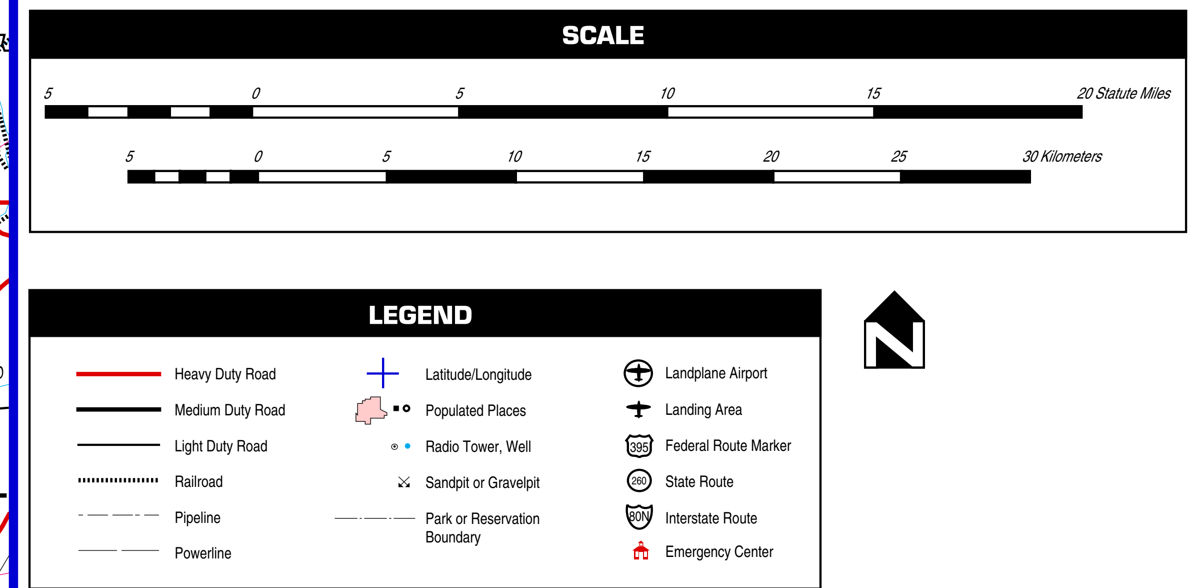
Table 2.1-2

2000 Population Distribution by Compass Sector and Distance from the Site

Distance (miles)	Direction (compass segment)	2000 Population	Distance (miles)	Direction (compass segment)	2000 Population	Distance (miles)	Direction (compass segment)	2000 Population
0-3	ALL	0	5-10	N	33	10-20	N	169
			5-10	NNE	71	10-20	NNE	680
3-4	NNE	0	5-10	NE	294	10-20	NE	1,535
3-4	ENE	2	5-10	ENE	281	10-20	ENE	912
3-4	E	4	5-10	E	312	10-20	E	567
3-4	ESE	3	5-10	ESE	369	10-20	ESE	479
3-4	SE-NNW	0	5-10	SE	471	10-20	SE	13,147
			5-10	SSE	118	10-20	SSE	65,247
4-5	N-NNE	0	5-10	S	391	10-20	S	27,095
4-5	NE	12	5-10	SSW	481	10-20	SSW	6,517
4-5	ENE	25	5-10	SW	17	10-20	SW	1,426
4-5	E	31	5-10	WSW-NW	0	10-20	WSW	21
4-5	ESE	24	5-10	NNW	3	10-20	WNW	0
4-5	SE	3				10-20	NNW	8
4-5	SSE-NNW	0						
0-5	TOTAL	104	0-10	TOTAL	2,945	0-20	TOTAL	120,748
20-30	N	1,158	30-40	N	1,077	40-50	N	30,168
20-30	NNE	10,663	30-40	NNE	3,643	40-50	NNE	713
20-30	NE	502	30-40	NE	251	40-50	NE	733
20-30	ENE	3,089	30-40	ENE	370	40-50	ENE	179
20-30	E	74	30-40	E	143	40-50	E	92
20-30	ESE	424	30-40	ESE	959	40-50	ESE	215
20-30	SE	14,781	30-40	SE	366	40-50	SE	2,915
20-30	SSE	42,124	30-40	SSE	408	40-50	SSE	3,876
20-30	S	841	30-40	S	5,494	40-50	S	19,644
20-30	SSW	143	30-40	SSW	186	40-50	SSW	3,857
20-30	SW	9,560	30-40	SW	1,398	40-50	SW	209
20-30	WSW	1,561	30-40	WSW	36,199	40-50	WSW	3,801
20-30	W	81	30-40	W	954	40-50	W	20,934
20-30	WNW	210	30-40	WNW	3,861	40-50	WNW	8
20-30	NW	531	30-40	NW	1,870	40-50	NW	577
20-30	NNW	406	30-40	NNW	3,290	40-50	NNW	1,707
0-30	TOTAL	206,896	0-40	TOTAL	267,365	0-50	TOTAL	356,993

Table based on April 2000 Census Bureau counts.

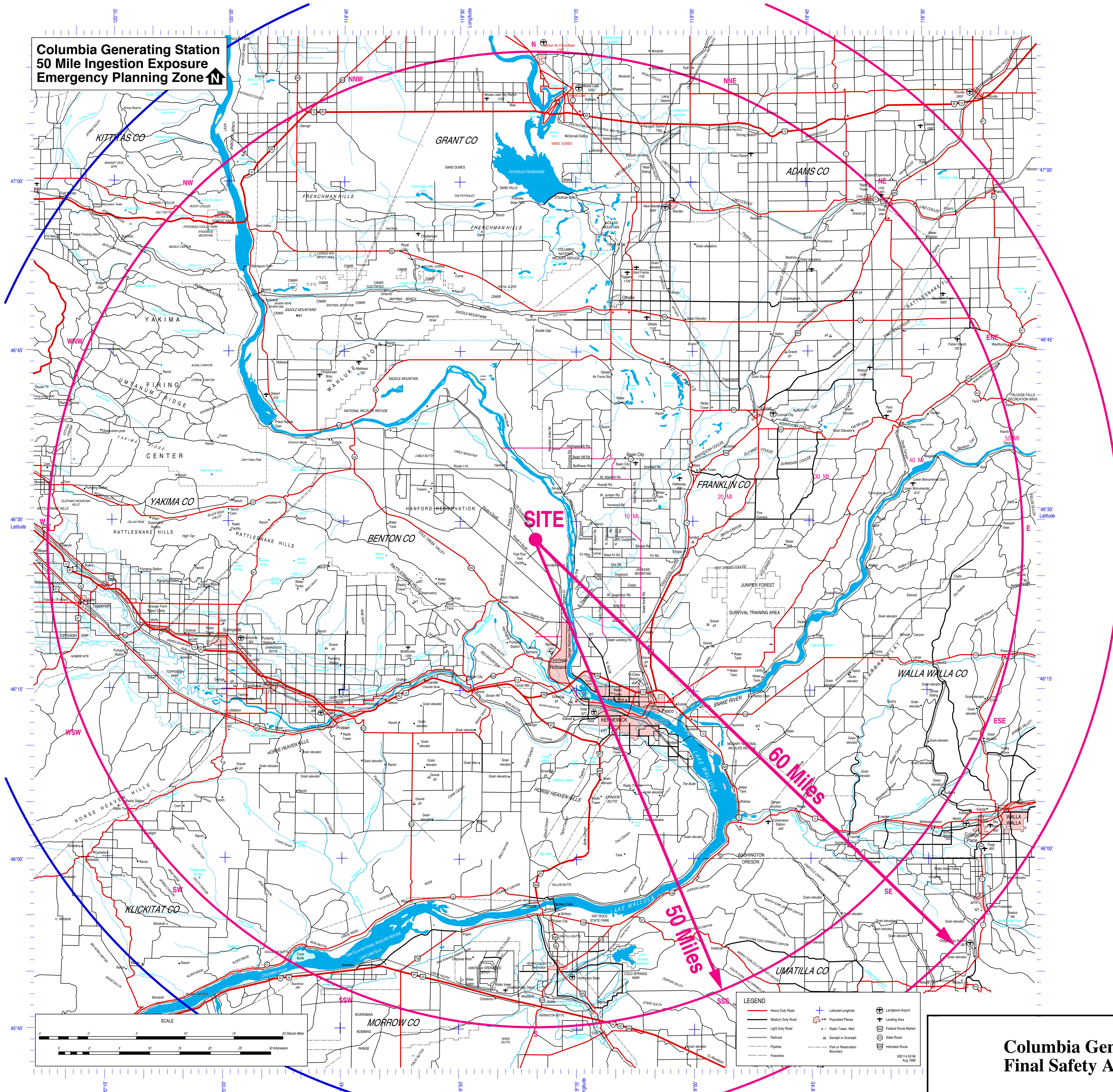




Columbia Generating Station
Final Safety Analysis Report

General Area, 0 - 20 Miles

Draw. No.	990306.20	Rev.		Figure	2.1-1

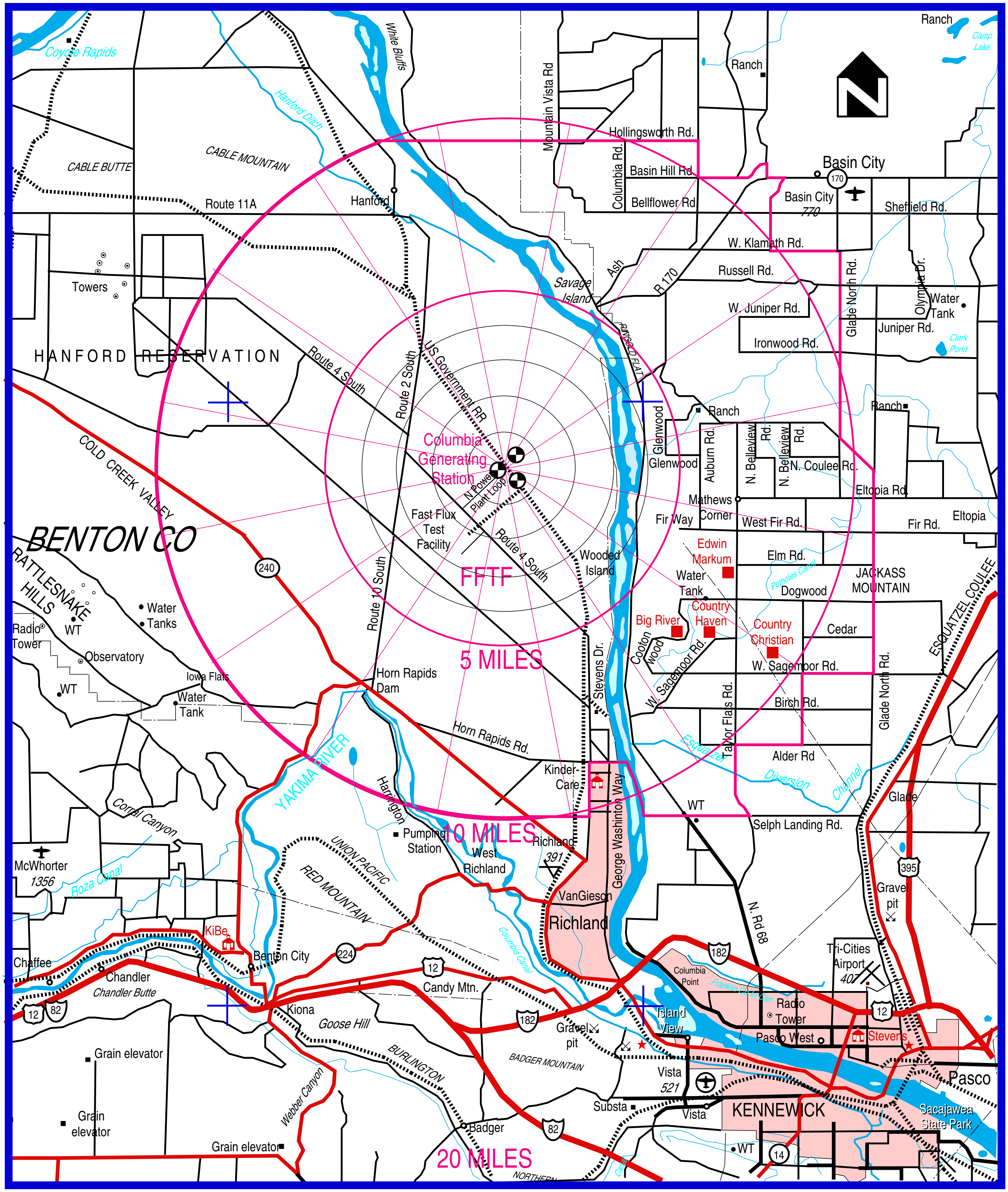


Columbia Generating Station
Final Safety Analysis Report

General Area, 0 - 50 Miles

Draw. No. 990306.60	Rev.	Figure 2.1-2

Figure Not Available For Public Viewing



5 0 5 10

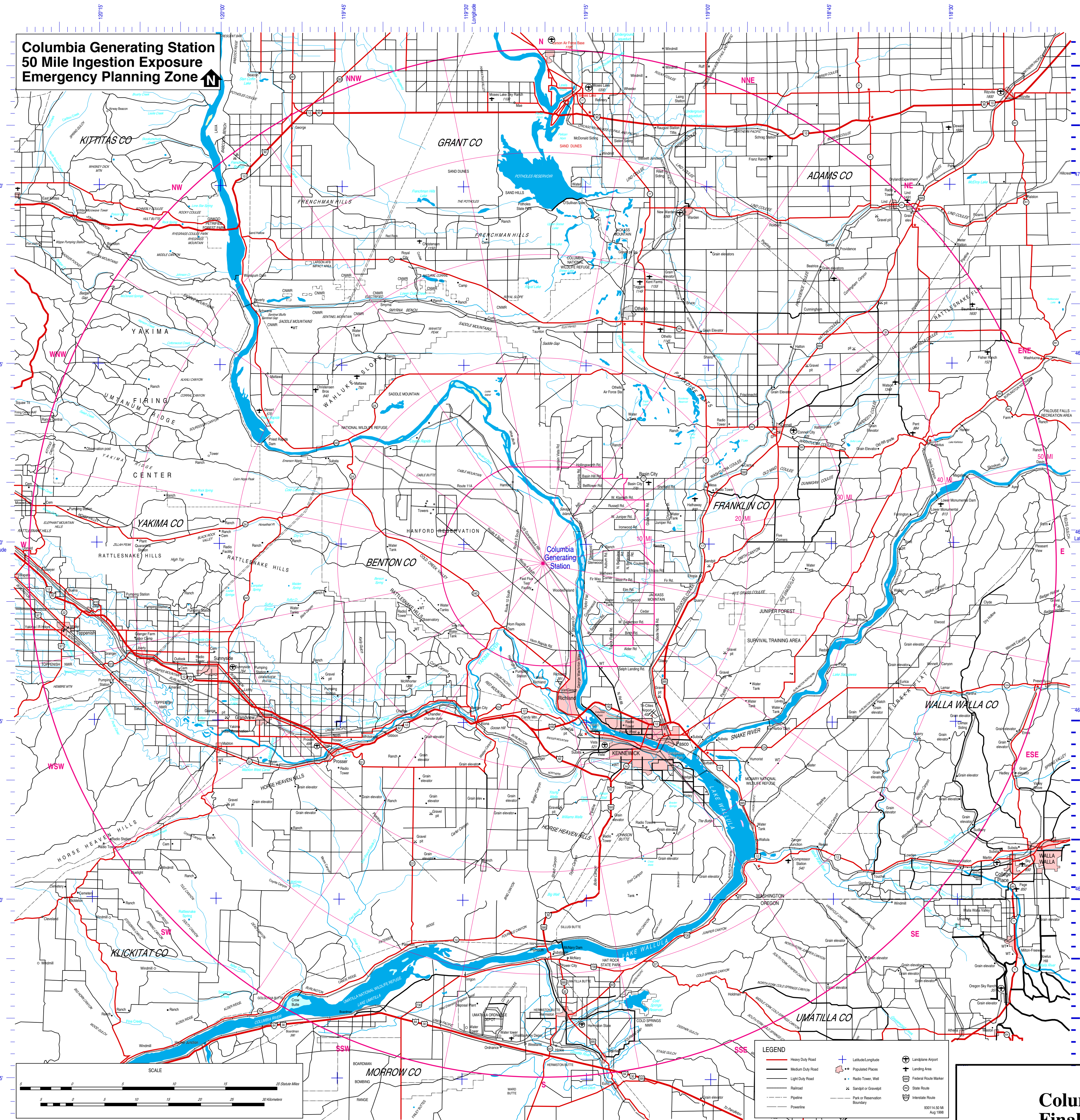
Scale in Miles

Project Area Map - 10 Mile Radius

Columbia Generating Station
Final Safety Analysis Report

Draw. No. 990306.10	Rev.	Figure 2.1-4

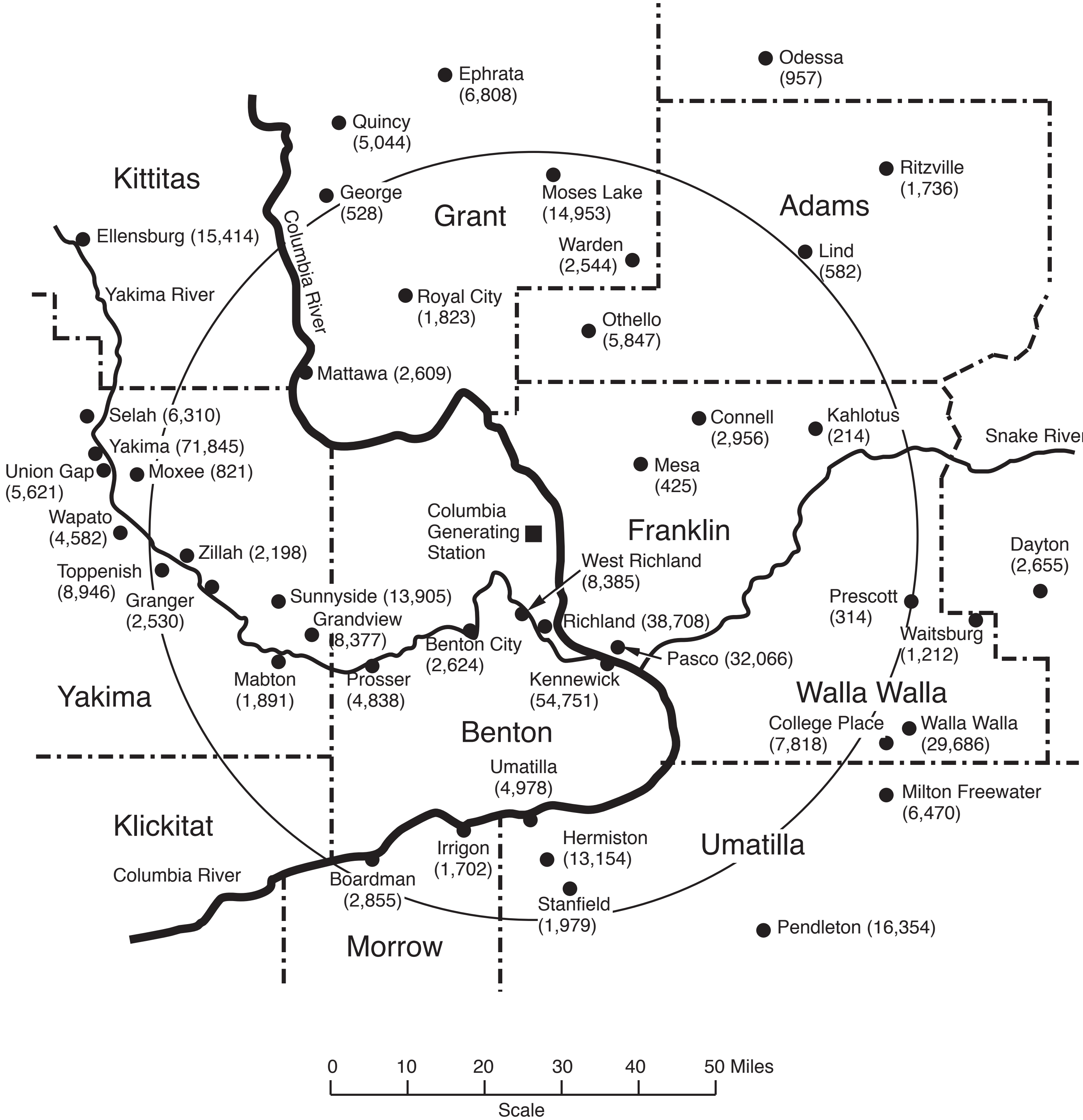
Form No. 960690



Columbia Generating Station
Final Safety Analysis Report

Project Area Map - 50 Mile Radius

Draw. No. 990306.50	Rev.	Figure 2.1-5

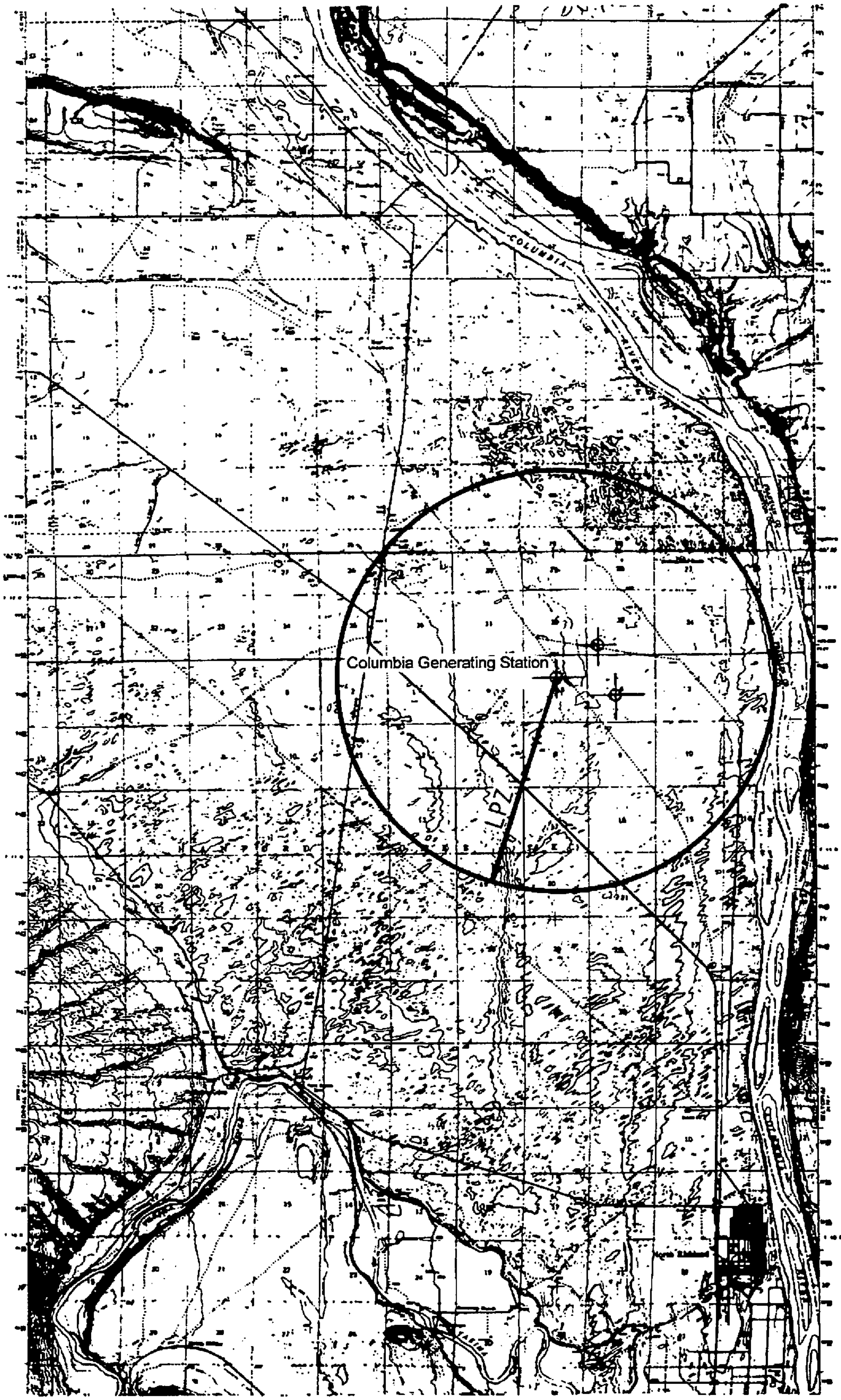


Columbia Generating Station
Final Safety Analysis Report

2000 Population in Communities Around Site

Draw. No. 970187.14	Rev.	Figure 2.1-6

Form No. 960690
LDCN-03-023



Transportation and Topographic Features of Low Population Zone

Draw. No. 020361.01 | Rev. | Figure 2.1-7

2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

This section describes the industrial, transportation, and military installations and operations in the vicinity of the site which may have a potential effect on the safe operation of Columbia Generating Station (CGS).

2.2.1 LOCATION AND ROUTES

There are no military bases, missile sites, manufacturing plants, chemical plants, commercial chemical storage facilities, or airports within a 5-mile radius of the site. A security barrier completely surrounds the station and its major supporting facilities to keep unauthorized vehicles a safe distance from critical structures.

According to the Richland Operations Office of the Department of Energy (DOE) (Reference 2.2-1), there are no plans for petrochemical storage facilities, airports, oil and gas pipelines, or petrochemical tank farms on the Hanford Site. Plans for modifications to or new radiological material treatment or storage facilities are discussed in Section 2.2.2.

As shown in Figure 2.1-3, the following facilities are located at or near the CGS site:

- Energy Northwest Plant Engineering Center,
- H. J. Ashe Substation,
- DOE Fast Flux Test Facility (FFTF),
- WNP-1 and WNP-4 sites,
- DOE 618-11 (Wye) radioactive waste burial ground,
- Permanent meteorological tower,
- Independent Spent Fuel Storage Installation (ISFSI), and
- Hydrogen Storage and Supply Facility.

Other facilities that are located within a 5-mile radius of the site include:

- The Plant Support Facility/Emergency Operation Facility which is located 0.75 miles southwest of CGS on Energy Northwest property,

- The Benton Substation which is located 3 miles east-southeast of CGS on DOE property,

- The Laser Interferometer Gravitational-Wave Observatory (LIGO) which is located approximately 3.3 miles west-southwest of CGS on DOE property, and

- The DOE 618-10 (300 North) radioactive waste burial ground which is located approximately 3.5 miles south of CGS on DOE property.

Transportation needs of CGS can be met by existing barge, rail, and highway facilities. Barges of up to 3000 tons capacity can be accommodated on the Columbia River within the Hanford Site. A barge unloading facility 9 miles south of the plant was used for delivery of large construction items for the DOE FFTF and Energy Northwest nuclear projects. These materials were transported by truck or rail to the construction sites from the Port of Benton landing.

The CGS site is serviced by a two-lane paved access road connected to Hanford Site Route 4, which is a paved four-lane major artery located 1.6 miles west of the station. Route 4 is part of the DOE road system. The DOE-owned road system connects the areas of the Hanford Site with paved two-lane and four-lane primary roads, secondary gravel roads, and unimproved roads. State Highway 240 traverses the Hanford Site from the southeast to the northwest. The highway passes within about 7 miles of CGS in the southwest quadrant. The highway connects into State Highway 24, which goes west to Yakima, Washington, and across the Vernita Bridge on the Columbia River 22 miles to the northwest (see Figure 2.2-1).

The Hanford Site (DOE) railroad system (see Figure 2.2-2) connects with commercial rail systems in Richland and Kennewick, Washington. Railroad operations that pass through CGS property are restricted to only those trains that have been authorized by Energy Northwest Security. The rail line is physically blocked at the two points where the plant vehicle barrier crosses the tracks.

Heavy barge traffic north of the Port of Benton dock is not feasible because the river channel is too shallow and the current is too swift. The environmental impact and economic cost of constructing a new barge slip at some upstream location and channeling the river cannot presently be justified with the availability of land transportation between the Port of Benton facility and the Hanford Site.

Making the Columbia River navigable for barges from north of Richland to Wenatchee would result in barge traffic past the CGS site at River Mile 352. However, this situation would not likely occur. Locks or other lift facilities would have to be constructed at the Priest Rapids, Wanapum, and Rock Island Dams. Furthermore, in 2000, a presidential executive order created the Hanford Reach National Monument, protecting the 51-mile Hanford Reach of the Columbia River (Reference 2.2-2). The protected area includes a ¼-mile-wide corridor on the west side of the river in the vicinity of CGS.

Airports, military facilities, low-level Federal airways, and airport instrument approaches in the vicinity of CGS are discussed in Section 3.5.1.6 and shown in Figure 2.2-3.

An explosives and ordinance test site operated by Pacific Northwest National Laboratory approximately 13 miles northwest of the site was abandoned in mid-1975 (Reference 2.2-3). Explosives for operations such as quarrying or seismic studies on the Hanford Site are brought to the blasting site as needed and unused quantities are removed. Normally the only explosives stored on the Hanford Site are small arms ammunition for use by the security patrols. A small arms firing range used for training by the DOE security patrol is located 8 miles due south of the plant (Reference 2.2-3). Another range, used by Energy Northwest security personnel, is located 1.5 miles east-northeast of CGS on Energy Northwest lease property.

2.2.2 DESCRIPTIONS

2.2.2.1 Description of Facilities

Energy Northwest's Plant Engineering Center is located west of the CGS turbine generator building as shown in Figure 1.2-1. It is a two-story, 100,000 ft^2 facility designed to house approximately 470 CGS plant staff personnel.

The H. J. Ashe Substation is located approximately 0.5 mile north of CGS and is operated by the Bonneville Power Administration as part of its transmission system.

The Energy Northwest permanent meteorological tower is located less than 0.5 mile west of the plant site. The tower is automated so that the only personnel at the tower are those required to make adjustments to the instruments or to perform repairs to the system. There are no permanent personnel at the facility.

The ISFSI is located immediately north-northwest of the plant. Confinement of all radioactive materials at the ISFSI is provided by the required use of NRC certified spent fuel storage casks listed in 10 CFR 72.214. The ISFSI storage cask system consists of an inner stainless steel multi-purpose canister (MPC) and an outer storage overpack. The MPC contains the spent fuel. It is a welded pressure vessel with no bolted closure or mechanical seals. Primary closure welds are examined and leakage tested to ensure their integrity. The MPC redundant closures are designed to maintain confinement integrity during normal conditions of storage, and off-normal and postulated accident conditions. The outer storage overpack is fabricated from concrete and structural steel components that are classified as important to safety.
A fully loaded spent fuel storage cask weighs approximately 185 tons. The spent fuel loaded storage casks are located within the Energy Northwest ISFSI protected area which is surrounded by a fence and topped with barbed wire. The ISFSI access gates are locked except when in use.

The Hydrogen Storage and Supply Facility is located 0.6 miles south-southeast of the plant site. The facility is part of a hydrogen water chemistry system to prevent and mitigate intergranular stress corrosion cracking in reactor internal structures and piping welds. The facility consists of a fenced gravel yard with concrete pads constructed to accommodate a liquid hydrogen tank, nitrogen tank, gaseous hydrogen tubes, and all supporting piping and equipment necessary to supply CGS with gaseous hydrogen. The liquid and compressed gases are delivered to the facility by truck.

Within the exclusion area radius of 1950 m is Energy Northwest's 1250-MWe WNP-1 project. Construction of the PWR plant, located 1500 m (4925 ft) east-southeast of CGS, was suspended in April 1982. In May 1994 the Energy Northwest Board of Directors voted to terminate WNP-1. The construction of twin unit WNP-4, located 1250 m (4100 ft) east-northeast of CGS, was terminated in January 1982. These projects have a separate access road that ties into the Hanford Site Route 4, 1.6 miles south of the CGS access road. Support activities at either the WNP-1 or WNP-4 sites do not interfere with operation of CGS. These may include activities associated with site restoration and economic development (such as leasing of excess facilities for office space and manufacturing). Within the exclusion area, Energy Northwest has the authority to determine all activities within the meaning of 10 CFR 100.3(a), including the authority to remove all personnel and property from the area.

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is located approximately 3.3 miles west-southwest from the plant site. The mission of this research facility is to observe gravitational waves of cosmic origin. The facility houses laser interferometers, consisting of mirrors suspended at each of the corners of an L-shaped vacuum system measuring 2.5 miles on a side. The materials and activities at this facility do not impact the operation of CGS.

The Umatilla Chemical Depot (UMCD), formerly known as Umatilla Army Depot, is located in northeastern Oregon in parts of Umatilla and Morrow Counties approximately 43 miles south of CGS. In 1962, the UMCD began storing chemical weapons and stored approximately 12% (3717 tons) of the nation's original chemical weapons. The weapons consisted of various munitions and ton containers containing GB (Sarin), VX, or HD (Mustard) agents. Beginning in 1990, the UMCD shipped all conventional ammunition and supplies to other installations and only chemical weapons remained pending disposal. The Umatilla Chemical Agent Disposal Facility was completed in 2001 and uses high temperature incineration to destroy the weapons. The Army began weapons disposal in 2004 and has destroyed all GB and VX nerve agent chemical weapons. In June, 2009, the Army began the HD blister agent disposal campaign which is expected to take between one and two years to complete. Upon completion, the facility will be dismantled and the UMCD will be closed.

As discussed in Section 2.1.1 and shown in Figure 2.1-1, CGS is located on the DOE Hanford Site. In reviewing the plant site and the vicinity for potential external hazards or hazardous material, the Hanford facilities currently operating, recently operating, or with the potential for operating were screened. The facilities discussed below are those believed to pose the most risk to the safe operations of CGS. The safety analysis reports and accident analysis prepared for those facilities were reviewed to determine possible hazards. No accidents evaluated present a physical challenge to the CGS buildings. Releases with the potential to impact the operation of CGS were radioactive particulate that would be effectively mitigated within General Design Criterion (GDC) 19 limits by the control room high-efficiency particulate air (HEPA) filters. Considered but not included were the 200 East Burial Grounds, the Critical Mass Laboratory, the Liquid Effluent Retention Facility, and the Effluent Treatment Facility in the 200 East Area. In the 200 West Area, the T Plant, U Plant, Reduction-Oxidation Plant, and the 222-S Laboratory were considered but not included. These facilities have insufficient radiological or toxicological inventories in a dispersible form to represent a risk to CGS operation. The specific facilities included are discussed in Table 2.2-1.

Three DOE facilities are located within a 5-mile radius of the plant site. These are the Fast Flux Test Facility (FFTF) and two radioactive waste burial grounds. The specific hazards associated with these facilities are summarized in Table 2.2-1 and the specific activities are listed below:

- The FFTF is a deactivated sodium cooled breeder reactor located approximately 3 miles southwest of CGS. All fuel has been removed and shipped to the Idaho National Laboratory. All sodium has been removed, solidified, and is stored on-site. The facility has been placed in a long-term, low-cost surveillance and maintenance condition.

- The 618-10 (300 North) Waste Burial Ground is approximately 3.5 miles south of CGS. DOE has initiated surveillance and characterization activities at the site to obtain data and information for planning remediation strategies.

- The 618-11 (Wye) Waste Burial Ground is directly west of CGS, outside of Energy Northwest leased land, but within its 1950-meter exclusion area radius and security perimeter. The site received low- to high-activity waste, fission products, some plutonium-contaminated waste, and non-radiological hazardous waste from March 1962 to December 1967 from the Hanford 300 Area. The waste is buried in 3 trenches, 50 Vertical Pipe Units (VPUs), and 3 to 5 caissons. The site was covered with an overburden of soil when it was closed. The surface was stabilized in 1982 with an additional 2 ft of soil. Since surface stabilization, activities at the site have been limited to monitoring and surveillance. DOE will initiate non-intrusive surveillance and characterization activities at the site in 2011 to obtain data information and information for planning intrusive characterization activities.

The DOE 300, 200 East, and 200 West Areas are located within a 10-mile radius of the site. The current waste management activities (storage, disposal, and treatment) conducted in these areas are discussed in Table 2.2-1. The 300 Area is approximately 7 miles southeast of CGS. The only hazard presented to CGS from this site is from the spent nuclear fuel and other radioactive material stored there. There is an unknown quantity of miscellaneous reactor fuel material in the 300 Area. This quantity is not publicly available information.

The DOE 200 East and 200 West Areas are approximately 10 miles northwest of CGS. Originally these facilities were constructed to support the extraction of weapons grade plutonium for the defense program. However, as the Hanford mission has changed from production to environmental cleanup, so has the purpose of the facilities discussed. This change in mission has, in some cases, resulted in a change in the hazards presented to CGS plant site and personnel.

A private (non-DOE) low-level radioactive waste disposal area is adjacent to 200 East Area. There are also plans to build private waste vitrification facilities adjacent to 200 East. These facilities are also discussed in Table 2.2-1.

Several plutonium production reactor facilities are located approximately 20 miles north-northwest of CGS. All of the reactors were water cooled, graphite moderated. The last operating reactor, the N Reactor, was permanently shut down in 1991. The N Reactor also provided steam for the Energy Northwest Hanford Generating Station until 1987. The fuel has been removed from the reactors for storage or treatment. The current activities at these reactor sites are also discussed in Table 2.2-1.

The nearest petroleum product storage tanks are located 22 miles southeast of the site: approximately 23 million gal capacity at the Chevron Pipeline Company and approximately 20 million gal capacity at the Tidewater Barge Lines.

2.2.2.2 Description of Products and Materials

The existing Hanford Site railroad track (owned by the DOE and operated by a private contractor in support of the Hanford Operations), and the CGS, the WNP-1, WNP-4, and the FFTF railroad spurs all run within the exclusion area of the plant site. Shipments of large quantities of hazardous materials on this track that existed during initial licensing of CGS are no longer made (Reference 2.2-4).

The DOE has no plans for railroad shipments of explosives in the foreseeable future. However the DOE's Richland Operations Office has agreed to notify Energy Northwest prior to transporting any explosive shipments of more than 1800 lb past CGS (Reference 2.2-5). Energy Northwest will provide an analysis to the NRC of the potential consequences prior to the start of such shipping (Reference 2.2-6).

Hazardous material is also transported on Hanford Route 4 by DOE. Chlorine is the only material of concern transported on Route 4 with the potential for impacting CGS operation. Section 6.4.4.2.1 provides additional information on control room habitability assessments for CGS.

The Yakima Training Center, a sub-installation of Fort Lewis, is 30 miles northwest of the site. The center consists of 327,000 acres. The center provides training facilities and logistical support and it is used for firing of all types of ordnance, both in a direct mode and by indirect artillery and mortars. Weapons to 155mm are fired. This type firing occurs frequently. Other types of live ordnance use at the center include aerial delivery by high performance aircraft of ordnance to include 2,000-lb bombs, helicopter weapons which include automatic weapons and

2.75-in. folding fin rockets, and anti-aircraft missiles. These latter activities are significant as to occurrence. The majority of the ordnance impacts a 20,000-acre area which is generally located in the central portion of the center. All activities are confined to the geographical limits of the center and/or its restricted air space unless special arrangements are made with affected agencies. Mechanized units (i.e., tanks and armored personnel carriers) from Fort Lewis and reserve components conduct extensive maneuvers on all accessible areas of the Training Center and use specially designed ranges to practice firing their weapons. Infantry and engineer units that support the mechanized units also train at the center. Training activity is greatest from March to November. War games sometimes involve troop and equipment deployment at the Richland Airport and along Highway 243 west of Vernita Bridge. Helicopters may fly near the Hanford Site, or military vehicles may travel over Highway 240 (Reference 2.2-7).

2.2.2.3 Pipelines

There are no commercial oil or gas pipelines in the vicinity of CGS. The nearest major natural gas transmission pipeline to the site is about 12 miles. A 20-in. gas transmission line of the Northwest Pipeline Corporation is located east and essentially parallel to U.S. Highway 395 between Pasco and Ritzville, Washington. A second pipeline system consisting of parallel 36-in. and 42-in. lines, owned by Pacific Gas Transmission Company, passes through Wallula, approximately 24 miles from the site (Reference 2.2-8). These distances eliminate any potential hazard to plant operations due to a natural gas fire or explosion. The Energy Northwest Hydrogen Storage and Supply Facility is located 0.6 miles south-southeast of the plant and is connected to the plant with a 2-in NPS gas pipeline. The pipeline runs north from the facility approximately 400 ft east of the plant and then turns and runs west approximately 400 feet north of the plant then south approximately 200 ft west of the plant to its connection point on the west side of the Turbine Building. Fire and explosion risks to the plant involving this pipeline are discussed in Appendix F and Section 3.5.1.5.

2.2.2.4 Waterways

Makeup water inlet structures are located in the Columbia River 315 ft from the shoreline at low river flow (36,000 cfs; el. 341.73 ft) at river mile 351.75.

A significant amount of Columbia River barge traffic moves as far upstream as the Ports of Pasco and Kennewick. Also, a docking facility established by the Port of Benton in North Richland (approximately 9 miles downstream of the CGS site) is accessible by barges with a maximum 16 ft of draft (normally 2500 to 3000 tons). The first use of this facility was in April 1973 when the FFTF reactor vessel was off-loaded. Traffic to the North Richland dock is very infrequent in comparison to that in Pasco and Kennewick due to the lack of large industrial concerns in the region between Richland and Priest Rapids Dam. This facility is most often used to off-load dismantled nuclear components. On several occasions in the past, lightly loaded barges have transported material to the vicinity of the Hanford Site. This required maintenance of an adequate flow from Priest Rapids Dam during the transit period.

2.2.2.5 Airports

Three commercial airports are within 20 miles of CGS. The closest is Richland Airport 11 miles south of the plant. This general aviation airport has two 4000-ft runways, one with a 010°/190° orientation and the other with a 070°/250° orientation. Visual flight rule landings are standard for Federal Aviation Administration (FAA) non-control-tower airports.

The Tri-Cities Airport 17 miles southeast near Pasco is the largest airport within 40 miles. The FAA operates the air traffic tower and airport radar approval control facility. The airport has two 7700-ft crossing runways with 120°/300° and 030°/210° orientations. The latter has a 4430-ft parallel runway. Runway 30 has a very high frequency omnirange (VOR) instrument approach and Runway 21R has an instrument landing system and is an instrument approach runway.

The Vista Airport operated by the Port of Kennewick is a general aviation airport located 18 miles south-southeast. It has a 4000-ft runway with a 20°/200° orientation. All operations are under visual flight rules.

Information relative to the flight paths and activity at these three commercial airports, the Yakima Training Center, and the nearby private airstrips is discussed in Section 3.5.1.6.

2.2.2.6 Projection of Industrial Growth

There is no projected growth of waterway traffic nor plans for oil and gas pipelines within 10 miles of CGS.

2.2.3 EVALUATION OF POTENTIAL ACCIDENTS

2.2.3.1 Determination of Design Basis Events

Energy Northwest has investigated the resistance of plant structures to explosions. The reactor building is a reinforced-concrete structure up to the refueling floor and is designed to withstand the worst probable combination of wind velocity and associated pressure drop due to a design basis tornado. A differential pressure of 3 psi between the exterior and interior of the building is also considered in the design. At its nearest point, the railroad is 510 ft from the reactor building.

From the above criteria, it has been determined that the reactor building can resist an explosion of 20,000 lb of dynamite on a railway car 510 ft from the reactor building. The performance of the reactor building structure for this blast loading condition will be similar to that for the original design basis tornado loading condition based on the 3 psi differential pressure used in the original tornado analysis.

In the unlikely event of an explosion or fire on the railroad affecting the 115-kV shutdown power supply, the 230-kV power supply or the diesel generators would fulfill that function.

It is extremely unlikely that an explosion or fire on the mainline railroad would compromise the safe shutdown of the facility. As noted in Section 2.2.2.2, DOE has no plans to ship explosives on the railroad, and the agency will notify Energy Northwest prior to the shipment of explosives in a quantity greater than 1800 lb. Energy Northwest Security controls access to the rails that pass near the plant. The only explosives on the Hanford Site are small arms munitions. As described in Section 2.2.2.2, this represents no hazard to the operation of CGS. The Yakima Training Center does not endanger the site. Hydrogen gas stored in the gas bottle storage building and in a trailer parked adjacent to the gas bottle storage building will not pose any fire or explosion problem because of the light weight properties and dispersal qualities of the gas and the distances (approximately 400 ft) between the storage areas and any safety-related equipment. Hydrogen gas stored at the Hydrogen Storage and Supply Facility (HSSF) and transported to the plant by pipeline does not pose a significant fire or explosion risk to the plant as discussed in Appendix F and Section 3.5.1.5. Habitability considerations for the control room and quantities of hydrogen gas stored in/adjacent to the gas bottle storage building and at the HSSF are discussed in Section 6.4.4.2.3.

Table 2.2-1 summarizes the potential events at the Hanford Site facilities that could present a radiological or chemical hazard or hazardous situation to the continued safe operation of CGS. The cesium and strontium capsules stored at the Waste Encapsulation and Storage Facility (WESF), the fuel stored at the K Basins, and the high level waste stored in the tank farms present contributions to risk at CGS due to presence of ^{137}Cs, ^{90}Sr, and ^{241}Am. However, based on consideration of the radionuclide inventory at risk, the ability to transport this inventory, and the proximity of the storage facility, the risk is dominated by the inventory stored at WESF. The probability of the loss of cooling in the capsule storage pool is extremely low, but the potential dose to unprotected CGS personnel due to the release is significant. Any required evacuations would be performed as discussed in the Emergency Plan. The design basis accident at WESF would not result in a condition at CGS which would challenge the criteria established in 10 CFR 100.

In each event evaluated, the radiological dose resulting from particulate releases would be adequately filtered by the control room HEPA filters, mitigating any challenge to the habitability of the control room. None of the facilities present a chemical exposure risk to CGS. Radiological exposures for postulated events on the Hanford Site are characterized by the contribution from gaseous radionuclides because of the short half-life of ^{131}I and because the other noble gases were released during the spent fuel processing.

The Yakima Training Center, discussed in Section 2.2.2.2, is used for military maneuvers and weapons training and is the only significant military activity in the vicinity of the Hanford Site. The only weapon currently in use at the Yakima Training Center known to present a hazard to the Hanford Site is the multiple launch rocket system (MLRS). With a range in excess of 25 miles, the MLRS could potentially impact the CGS site. However, the MLRS is only fired from the perimeter of the Yakima Training Center into a centrally located impact zone and is only fired with dummy warheads. Given this information, additional safety features, and the administrative controls in place at the Yakima Training Center, a weapons accident having an impact on CGS is very improbable.

The Umatilla Chemical Depot, discussed in Section 2.2.2.1, is used to store chemical weapons. As part of the program to demilitarize chemical weapons, an incinerator has been constructed at the Depot for disposal of the weapons. Risks associated with weapons disposal operations at the Umatilla Chemical Depot have been quantified in a Phase 1 Quantitative Risk Assessment (QRA) prepared for the U.S. Army. The QRA examined risks associated with storing munitions at the Depot, transporting munitions from the storage igloos to the incinerator, and processing munitions within the incinerator. Although not directly transferable to the assessment of effects at CGS, the risk estimates provide some inferences regarding the risks to plant operation. A review of the assessment concluded that the risk to persons in the 60 to 100 km distance range due to chemical munitions disposal are very small. It should also be recognized that operations at the Depot would be within the scope of a comprehensive emergency preparedness program that includes offsite notification. Furthermore, pursuant to Regulatory Guide 1.78, chemicals stored or situated at distances greater than 5 miles from CGS need not be considered because, if a release were to occur, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for control room operators to take appropriate action. In addition, the probability of a plume remaining within a given sector for a long period of time is quite small (Reference 2.2-9).

As stated in Section 2.2.2.1, confinement of all radioactive materials at the ISFSI is provided by the required use of NRC certified spent fuel storage casks listed in 10 CFR 72.214. Pursuant to the 10 CFR 72.212 report, evaluations performed in support of the ISFSI have demonstrated the reactor site-specific parameters are bounded by the safety analysis for the generically approved cask. Accordingly, activities associated with the facility do not adversely impact operation of CGS (Reference 2.2-10).

Brush fires have occurred on the Hanford Site and have presented no potential hazard to existing facilities. Areas adjacent to CGS major buildings and auxiliary facilities are maintained to prevent weed growth by landscaping, gravel, ground cover, and weed control spraying. The Hydrogen Storage and Supply Facility (HSSF) is landscaped with gravel beyond the perimeter of the site, exceeding the code required clearance distance, to keep the area free from dry vegetation and combustible materials. These or similar methods of weed control minimize brush fire hazards to CGS facilities.

The potential effects of fires that involve materials used in the operation of the plant are discussed in Appendix F.

The formation of unconfined vapor clouds caused by the accidental release of flammable or toxic liquids or vapors stored at the plant site is discussed in Section 6.4 and addressed by the Emergency Plan.

The non-safety-related makeup water intake consists of two sets of paired perforated pipe sections. One set is capable of supplying the full makeup water requirements of the plant. Extreme low river flow (36,000 cfs) will provide about 0.5 ft of water over the top of the intake pipes. The probability of damage to both sets of intakes as a result of a pleasure boat or barge accident is extremely remote given the infrequency of both extreme low flows and large boat and barge traffic. In the unlikely event that such an accident might occur, destruction of the makeup water intake structure would be comparable in effect to loss of offsite power to the makeup water pumps. The Seismic Category I spray ponds provide for 30-day cooling without makeup. This is ample time to restore makeup from either the river or wells.

There are no upstream industrial facilities for which waterborne deliveries of significant quantities of petroleum products, corrosive chemicals, or other hazardous materials are expected. Fuel oil, diesel oil, acids, and caustics are stored at the N-Reactor site. The oil storage facilities are protected by dikes, and the chemical storage facilities are far enough from the river to avoid direct discharge. Thus, there is no possible hazard to the plant due to spillage of such materials into the river. There are no upstream releases which may be corrosive, cryogenic, or coagulant.

2.2.3.2 Effects of Design Basis Events

As discussed in Section 2.2.3.1, the activities of nearby industrial, transportation, and military facilities will have no adverse effect on the plant.

2.2.4 REFERENCES

2.2-1 Holmes, D. B., Energy Northwest, personal communication with Steve Burnam, Site Infrastructure Division, Department of Energy, July 31, 1998.

2.2-2 Presidential Proclamation 7319, Establishment of the Hanford Reach National Monument, 65 FR 37253, June 9, 2000.

2.2-3 Chasse, J. P., Energy Northwest, personal communication with B. J. Rokkan, Safeguards and Security Division, DOE, Richland Operations Office, December 6, 1977.

2.2-4 Note, D. A. Marsh, Westinghouse Hanford, to D. E. Larson, Supply System, dated January 22, 1993.

2.2-5 Memorandum, C. A. Hansen, Assistant Manager for Waste Management, DOE-RL to Alice Q. Murphy et al., 98-WPD-032, February 20, 1998.

2.2-6 NUREG 0892, Safety Evaluation Report Related to the Operation of WPPSS Nuclear Project No. 2, Section 2.2.1, March 1982.

2.2-7 Arbuckle, J. D., Energy Northwest, personal communication with J. Reddick, Executive Officer, Yakima Training Center, July 29, 2003.

2.2-8 Hosler, A. G., Contact with Local Organizations to Support CSB SAR Chapter 1 (Memo 042AGH.96 to Canister Storage Building Report File), Science Applications International Corporation, May 6, 1998.

2.2-9 Holmes, D. P and Chasse, J. P., Energy Northwest, White Paper -- Applicability of the Chemical Stockpile Disposal Program at the Umatilla Army Depot to the WNP-2 FSAR, December 1997.

2.2-10 Energy Northwest, Independent Spent Fuel Storage Installation 10 CFR 72.212 Evaluation, Docket Number 72-35, Revision 1, September 2002.

Table 2.2-1

Hanford Site Nuclear Facilities

Facility	Description	Hazard	Design Basis Event	Impact on CGS
Fast Flux Test Facility (FFTF) Ref: Surveillance and Maintenance Plan for FFTF, Rev. 0, DOE/RL-2009-26	Deactivated sodium cooled breeder reactor	Activated solid sodium	1) 180,000 lb sodium spill - 2-hr dose at 1.5 mi = 0.015 mrem, 24-hr dose at 4.5 mi = 0.26 mrem	Particulate release, effectively mitigated by distance
DOE 618-10 (300 North) Waste Burial Ground Ref: 618-10 and 618-11 Waste Burial Grounds Basis for Interim Operation, Rev. 1, WCH-183	Disposal site with broad spectrum of low- to high-level solid radioactive wastes buried in caissons or pipe	Radioactive waste	Caisson penetration with fire — unmitigated dose at 5 km = 10.2 mrem	Particulate release, effectively mitigated by distance (> 5 km)
DOE 618-11 (Wye) Waste Burial Ground Ref: 618-10 and 618-11 Waste Burial Grounds Basis for Interim Operation, Rev. 1, WCH-183	Disposal site with broad spectrum of low- to high-level solid radioactive wastes and non-radiological hazardous materials buried in caissons or pipe	Radioactive waste inventories, primarily Cs-137, Sr-90, and Pu-239 and non-radiological hazardous materials bounded by beryllium	Caisson penetration with fire and explosion: control room doses are less than 0.1 rem; beryllium oxide concentration of 4.6 x 10^{-3} mg/m^3 at 100 m from 618-11 site boundary	Particulate release, effectively mitigated by credited 618-11 Waste Burial Ground project controls. The soil overburden covering the VPUs and caissons in the 618-11 Waste Burial Ground is credited for reducing releases and is designated as a passive design feature. No missiles are postulated for this event.

Table 2.2-1

Hanford Site Nuclear Facilities (Continued)

Facility	Description	Hazard	Design Basis Event	Impact on CGS
B Plant Ref: B Plant Basis for Interim Operation, March 6, 1997, HNF-SD-BIO-003	Process to remove cesium and strontium from radioactive waste, deactivated, currently in surveillance and maintenance mode	Residual radionuclide inventories on cell filters (^{137}Cs, ^{90}Sr, and ^{241}Am)	Flooding cell 291-B HEPA filters - 0.368 rem max. public dose	Particulate release effectively mitigated by distance
Plutonium-Uranium Extraction Facility (PUREX). PUREX End State Basis for Interim Operation (BIO) 1997, HNF-SD-CP-15B-004 (Draft)	Currently shut down, in preparation for decommissioning and decontamination	Residual plutonium and uranium contamination	Design basis earthquake, dose @ 100 m - 1.9 rem; 12 km - 7.4 x 10^{-4} rem	Particulate release, mitigated by distance
Plutonium Finishing Plant (PFP) Ref: Plutonium Finishing Plant Final Safety Analysis Report, 1995, WHC-SD-CP-SAR-021	Receipt and storage of SNM, reactive material stabilization, radioactive and mixed waste handling	Stored SNM, and residual plutonium contamination	Design basis earthquake, 8-hr dose of 15.2 rem @550 m 24-hr dose of 0.31 rem @12,500 m	Particulate release, mitigated by distance
Tank Waste Remediation System (TWRS) Facilities Ref: Tank Waste Remediation System Basis for Interim Operation, 1997, HNF-SD-WM-BIO-00, Revision 0	Mixed radioactive and chemical wastes storage in 149 single shell tanks (SST) and 28 double shell tanks (DST) in 12 tank farms Associated support facility: 242-A-Evaporator	SSTs contain combinations of sludge, saltcake, and interstitial and pooled liquids DSTs contain liquid and slurry waste with small amounts of sludge		

Table 2.2-1

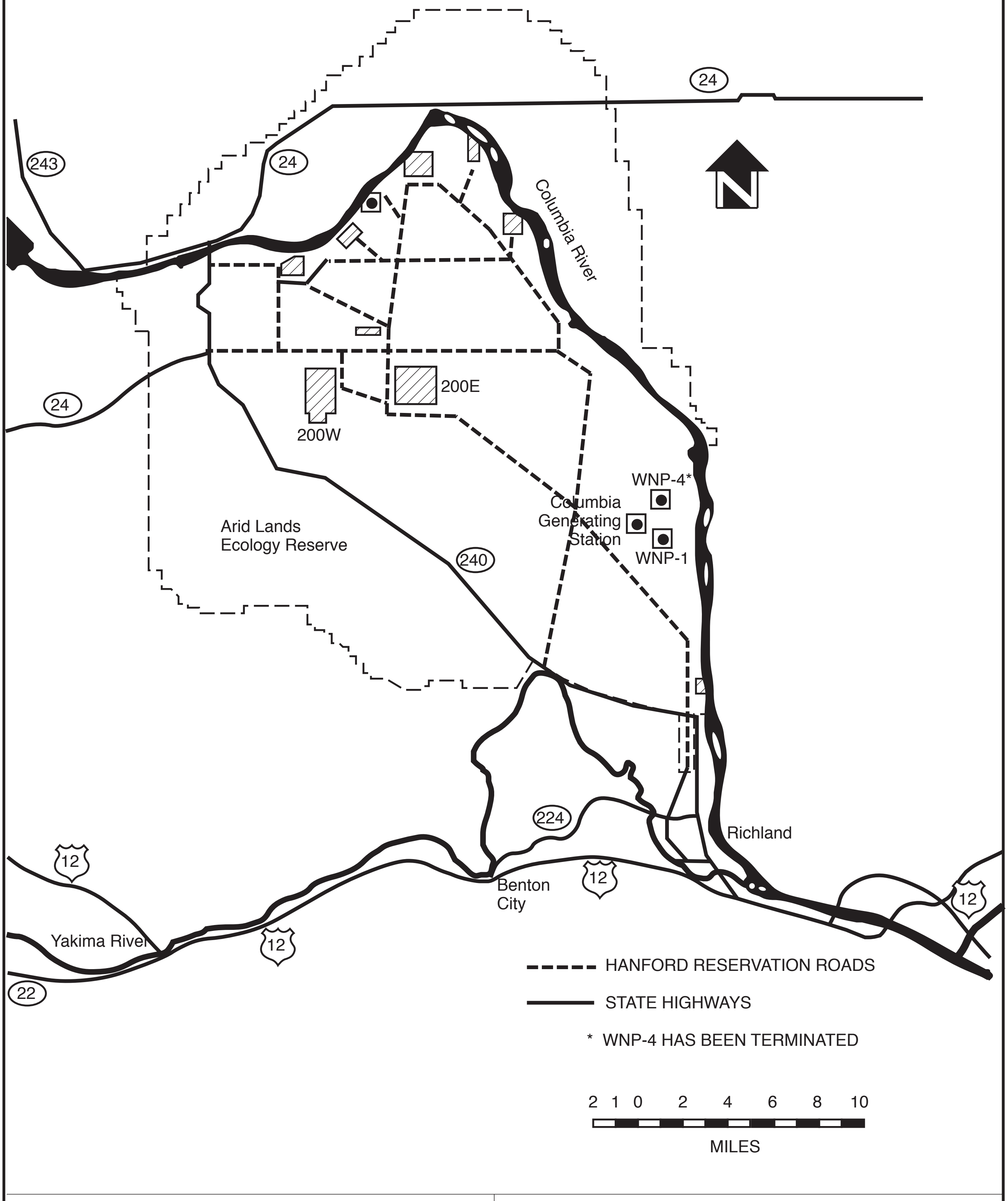
Hanford Site Nuclear Facilities (Continued)

Facility	Description	Hazard	Design Basis Event	Impact on CGS
Tank Waste Remediation System- Project (TWRS-P) (private facilities, proposed for construction in 2000) Ref: DOE/RL-96-0006	Vitrify low level, high level, and transuranic mixed waste	High level radioactive waste	Requirements for authorization limit to less than 25 rem/event in an accident. Releases are projected to be airborne particulate.	HEPA filter system would protect CGS control room operators, in accordance with the limits of GDC 19
Waste Encapsulation and Storage Facility (WESF) Ref: Waste Encapsulation and Storage Facility Basis for Interim Operation, 1997, HNF-SD-WM-BIO-002	Conversion process for cesium and strontium has halted	Cesium chloride and strontium fluoride salts, encapsulated in double-walled metal containers stored in water-filled cooling basin	Capsule rupture following loss of water from storage pool - 24 hr exposure to public, 9 rem	Control room exposure mitigated by HEPA filters; potential evacuation of other personnel
Low-Level Waste Disposal Site (Private)	Buried storage of low-level radioactive waste in lined containers	Low-level buried waste, monitored as required by NRC license	No credible event	None
Canister Storage Building (CSB) Ref: Letter; DOE to H. J. Hatch, Flour Daniel Hanford, 28 May 97	Storage of spent nuclear fuel (SNF) from the K Basins in sealed multi-canister overpacks (MCO)	2100 metric tons of spent fuel, from production reactors	Requirements for authorization limit to less than 5 rem/event in an accident. Releases are projected to be airborne particulate	HEPA filter system would protect CGS control room operators, in accordance with the limits of GDC 19
Cold Vacuum Drying Facility (CVDS) Ref: Letter; DOE to H. J. Hatch, Flour Daniel Hanford, 28 May 97	Draining and vacuum drying to remove water from MCOs in preparation for interim storage at CSB	Spray release	Requirements for authorization limit to less than 5 rem/event in an accident. Releases are projected to be airborne particulate.	HEPA filter system would protect CGS control room operators, in accordance with the limits of GDC 19

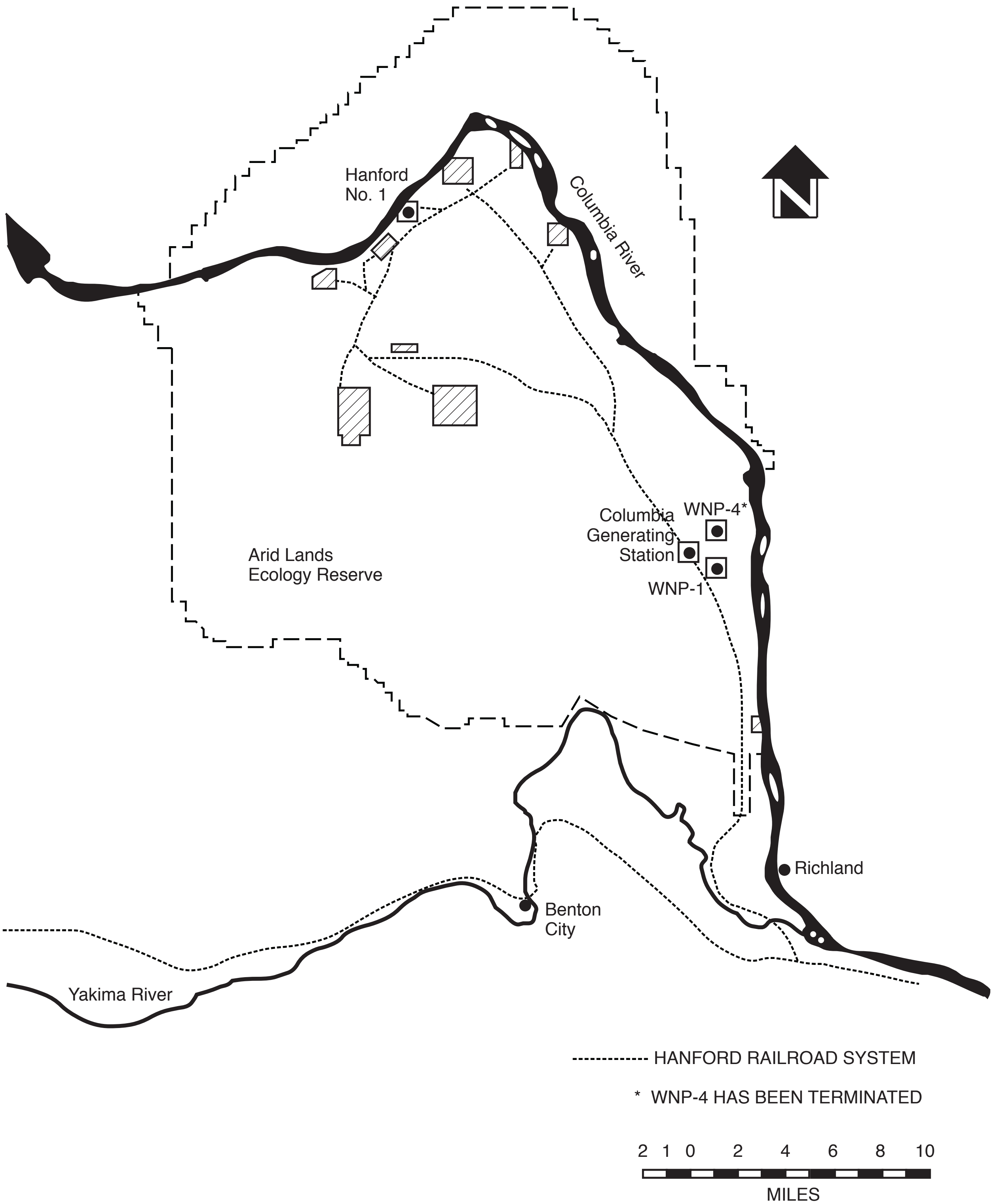
Table 2.2-1

Hanford Site Nuclear Facilities (Continued)

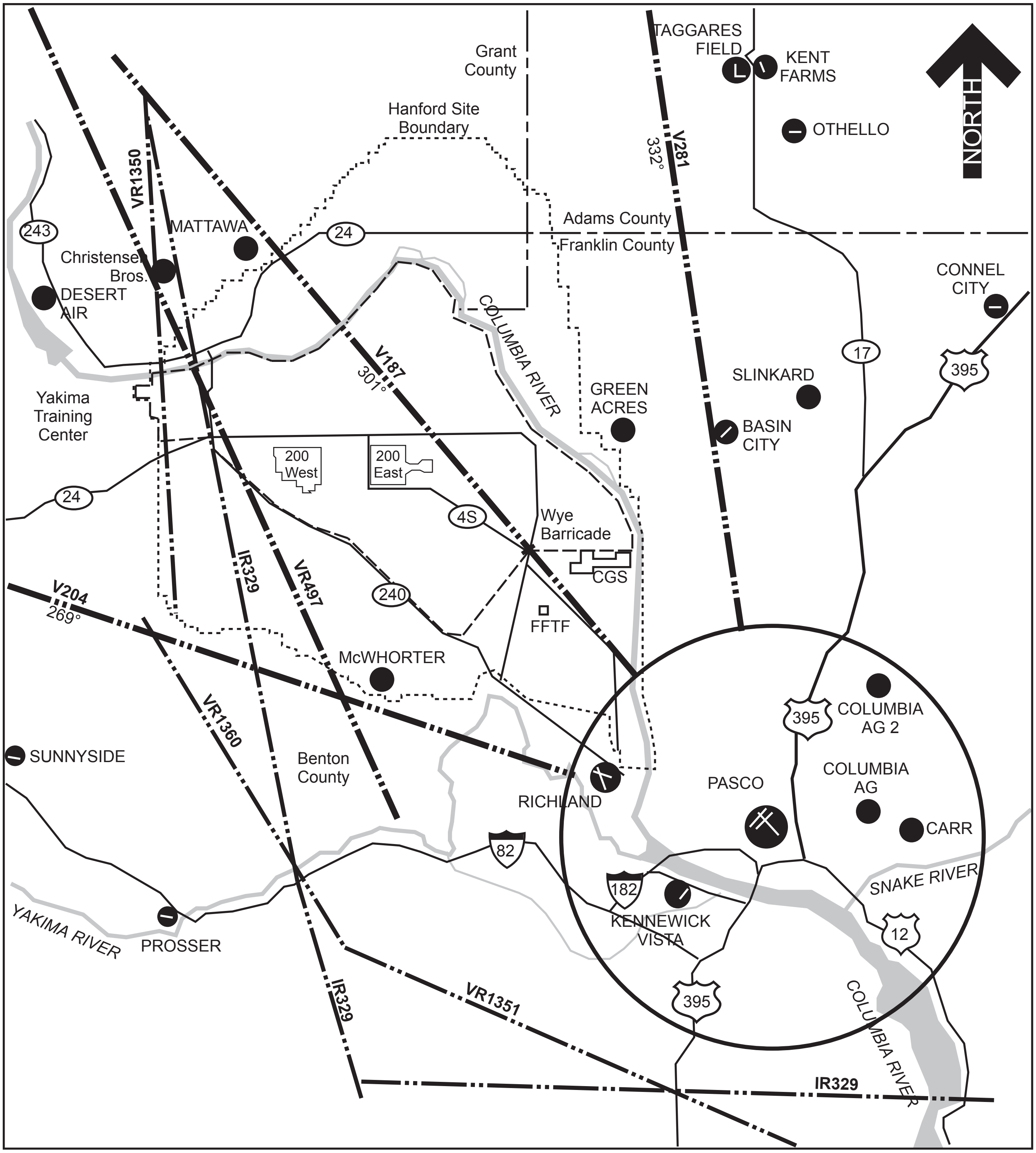
Facility	Description	Hazard	Design Basis Event	Impact on CGS
B, C, D, DR, F, and H Reactors (shutdown since 1969) Ref: WHC-EP-0619, Vol. 1.	Single-pass, water-cooled, graphite-moderated reactors	The onsite hazards involve personnel injury, primarily falls and electric shock. No significant offsite risks	No credible event	None
K East and West reactors (shutdown since 1971) Ref: WHC-EP-0619, Vol. 1.	Single-pass, water-cooled, graphite-moderated reactors	The onsite hazards involve personnel injury, primarily falls and electric shock. No significant offsite risks	No credible event	None
K East and West Basins Ref: WHC-EP-0619, Vol. 1.	Storage basins for spent fuel, some severely degraded	Approximately 2100 metric ton inventory of irradiated reactor fuel	Dropping and overturning of a transfer cask containing reactor fuel. (Bounding event; but transfer is administratively prohibited)	None
N reactor (shutdown since 1987) and N Basin Ref: WHC-EP-0619, Vol. 1. and BHI-00866, Rev 0	A pressure tube, water-cooled, graphite-moderated reactor with fuel assemblies removed for decontamination and decommissioning	The onsite hazards involve personnel injury, primarily falls and electric shock. No significant offsite risks	No credible event	None



Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Road System
	Draw. No. 990306.15 · Rev. · Figure 2.2-1



Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Railroad System		
	Draw. No. 990306.16	Rev.	Figure 2.2-2



Columbia Generating Station Final Safety Analysis Report	Federal Airways and Instrument Approaches/Departures
	Draw. No. 900547.96 / Rev. / Figure 2.2-3

2.3 METEOROLOGY

The italicized information, including associated tables and figures, is historical and was provided to support the application for an operating license.

2.3.1 REGIONAL CLIMATOLOGY[*]

2.3.1.1 General Climate

The site is located in a mid-latitude semi-arid (steppe) climatic region in the Lower Columbia Basin which is the lowest elevation of any part of central Washington. A major factor influencing this climatological region is its location in the continent, well away from the windward coast and protected to the west by the 4,000 to 7,000-ft average elevation Cascade Mountains. Dominant air masses affecting the region are of maritime polar origin as modified by the presence of these mountains. Modified continental tropical and polar air masses also periodically affect the climate. In winter, there is a succession of cyclones as the westerlies and the polar front prevail in these latitudes. The mountain barriers commonly induce these storms to occlude by delaying air mass movement. Fewer frontal passages occur during the summer months since subtropical oceanic high cells reach their highest latitudes thereby diverting cyclonic storms poleward. Along the eastern margin of the Pacific anticyclone, an out-flow of stable subsiding air brings distinctly drier conditions to the North American Pacific coast.

The regional temperatures, precipitation, and winds are greatly affected by the presence of the mountain barriers. The Rocky Mountains and ranges in Southern British Columbia are effective in protecting the inland basin from the more severe winter storms and associated cold polar air masses moving southward across Canada. Occasionally, an outbreak of cold air will pass through the Basin and result in low temperatures or a damaging spring or fall frost. Maritime polar air traveling eastward from the coastal zone cools as it rises along the western slope of the Cascade Range. These orographic effects cause heavy precipitation on the windward and light precipitation on the leeward slopes. The prevailing westerly. winds are normally strongest during winter and spring due to the presence of cyclonic scale disturbances and associated frontal activity. During those months, foehn or chinook winds (a warm dry

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[*] *This section is based on records kept at the Hanford Meteorology Station (14 miles northwest of the site, elevation 733 ft MSL) from 1945 to 1980 (2) and 100-N area sites (1) (supplemented with precipitation and temperature data taken by U.S. Weather Bureau cooperative observers at a site about 25 miles north of the present station location during the period from 1912 to 1944 (2,3) and regional climatological data gathered during the period from 1931 to 1960). (4) Other references are as indicated.*

wind on the lee side of a mountain range; the warmth and dryness of the air is due to adiabatic compression upon descending the mountain slopes) occur whenever cyclonic circulation is sufficiently strong and deep to force air completely across the cascades in a short period of time. At other times during the winter, warm front occlusions can force moist air over the Cascade Range. The mixing of this moist air with relatively cooler air in the Basin results in considerable cloudiness and fog. The percent of possible sunshine ranges from 20 to 30 percent in winter, 50 to 60 percent in spring and fall, and 80 to 85 percent in mid-summer.

Because the site is in the rain shadow of these mountains, annual average precipitation decreases from about 100 inches near the summit of the Cascades to about 6 or 7 inches in the Basin. Approximately 70 percent of the annual total precipitation occurs from November through April and about 10 percent occurs during July through September. Rainfall amounts are normally light in the summer and gradually increase in late fall, reaching a peak of about one inch each month in midwinter due to cyclonic storm and frontal activity. Rainfall amounts decrease in Spring, increase somewhat in June, and again sharply decrease in July. During mid-summer, it is not uncommon to have 3- to 6-week periods with trace rainfall. There are only two occurrences per year of 24-hour amounts of 0.50 inch or more, while occurrences of 24-hour amounts of 1.00 inch or more number only four in the entire 25 years of record (1946 to 1970). One of these was the record storm of October 1 through 2, 1957, in which rainfall totaled 1.08 inches in three hours, 1.68 inches in six hours, and 1.88 inches in twelve hours. At the other extreme, there have been 81 consecutive days without measurable rain (June 22 through September 10, 1967), 139 days with only 0.18 inch (June 22 through November 7, 1967), and 172 days with only 0.32 inch (February 24 through August 13, 1968).

About 45 percent of all precipitation during the months of December, January, and February is in the form of snow. Regional annual total snowfall amounts have ranged from less than 1/2 inch in 1957 to 1958 to 56.1 inches for the winter of 1992-1993; the annual average total is about 14 inches.

Snow rarely remains on the ground longer than two to four weeks or reaches a depth at any time in excess of four to six inches, as rapid melting, which often contributes to local stream flooding, can occur from rain or Chinook winds. The record greatest depth of 24.5 inches occurred in February 1916.

Thunderstorms have been observed in the area in every month except November. Although severe ones are rare, lightning strikes have occasionally ignited grass fires which burned thousands of acres of the Hanford Reservation and resulted subsequently in considerable wind erosion of soil. The most notable of these occurrences were in August 1961, July 1963, and July 1970, and August 1984.

The continental-type climate not only affects precipitation in the Basin but also results in wide ranges and variations in annual temperature conditions. While the regional annual average temperature is about 53°F, the coldest month, January, has a mean of about 29°F; the *warmest month, July, has a mean of about 76°F. Although the presence of the cascades contributes to the wide differences in monthly average temperatures, other mountain ranges shield the area from many of the arctic surges, and half of all winters are free of temperatures as low as 0°F. However, six winters in 58 of record have contributed a total of 16 days with temperatures of -20°F or below; and in January to February 1950, there were four consecutive such days. There are ten days of record when even the maximum temperature failed to rise above zero. At the other extreme, in the winter of 1925 to 1926, the lowest temperature all season was +22°F.*

Although winter minima have varied from -27°F to +22°F, summer maxima have varied only from 100°F to 115°F. However, there is considerable variation in the frequency of such maxima. In 1954, for example, there was only one day with a maximum as high as 100°F. On the other hand, there have been two summers (1938 and 1967) when the temperature went to 100°F or above for 11 consecutive days.

Although temperatures reach 90°F or above on about 56 days a year, there are only about seven annual occurrences of overnight minima 70°F or above. The usual cool nights are a result of gravity winds.

The channeling of air by the Cascade Mountains and surrounding terrain produces a prevailing WNW and NW regional flow. Local topographic features can cause other channeling effects and formation of local diurnal wind circulation systems which produce a greater degree of variability in winds at locations within the Basin. For example, the Columbia Generating Station (CGS) site experiences a bimodal wind direction distribution from approximately south and also northwest; at the Hanford Meteorological Station (HMS) about 14 miles northwest, the direction distribution displays a single peak at approximately WNW to NW (refer to 2.3.2).

Drainage (gravity) winds channeled by topographic features produce a marked effect on diurnal range of wind speed and cause the highest monthly average speeds of about 9 mph to occur during the summer months. In July, for example, hourly average speeds range from a low of 5.2 mph from 9 to 10 a.m. to a high of 13.0 mph from 9 to 10 p.m. In contrast, the corresponding speeds in January are 5.5 and 6.3 mph. These warm season diurnal winds, resulting from relatively cold air draining from the Cascade Mountains, occur in response to pressure gradients created between surface-heated warm, dry basin air and cooler air situated over the mountains and coastal region. This favors an outbreak of stronger winds during the afternoon and evening hours. Although the gravity wind occurs with regularity in summer, it is never strong unless reinforced by frontal activity. In June, the month of highest average speed, there are fewer instances of hourly averages exceeding 31 mph than in December, the month of lowest average speed. A complete summary of the monthly averages and extremes of climatic elements at the Hanford Reservation appears in Table 2.3-1.

2.3.1.2 Regional Meteorological Conditions for Design and Operating Bases

2.3.1.2.1 Severe Weather Phenomena

2.3.1.2.1.1 Heavy Rain, Snow, and Ice. Glaze is a coating of ice, generally clear and smooth, but with some air pockets. It is formed on exposed objects by the freezing of super-cooled drizzle or rain drops. Glaze is denser, harder, and more transparent than either rime or hoar frost. Although the record shows an average of seven glaze days per year, many of these cause little or no inconvenience to the public. Two outstanding exceptions occurred on February 11 to 12, 1954, and on November 23 to 24, 1970. There was serious disruption to Hanford traffic in each instance although there was no known damage to transmission lines. In each instance, rising temperatures soon melted the ice.

Precipitation frequency (rain and snow), intensity, and quantity statistics are presented in Figures 2.3-1 and 2.3-2 and Tables 2.3-2 and 2.3-3. For the winter of 1992-93, the following snowfall records were set: greatest winter snowfall (56.1 inches); most days with greater than 1, 6, and 12 inches on the ground (71, 41, and 9, respectively); and greatest 24-hour snowfall (10.2 inches) on February 18 and 19. Probable maximum precipitation is given in 2.4.3.1.

2.3.1.2.1.2 Thunderstorms and Hail. Thunderstorms may occur during any month of the year at Hanford. A thunderstorm day is one in which thunder is heard. If a thunderstorm should begin in late evening and last past midnight, it is counted as two thunderstorm days even though only one storm event occurred. Similarly, should there be two or more distinct thunderstorms in a day - and this sometimes happens - it is counted as a single thunderstorm day. The table below shows the monthly frequency of thunderstorms.

HMS THUNDERSTORM DAYS: 1945-1970

	J	F	M	A	M	J	J	A	S	O	N	D	SUM
Total	0	1	7	18	53	64	46	54	24	5	0	0	272
Average	0	#	#	1	2	3	2	2	1	#	0	0	11
% of Total	0	#	3	7	19	23	17	20	9	2	0	0	100

 # = Less than 0.5

Although the table above shows 0 for the months of November through January, a thunderstorm occurred at HMS on December 22, 1971. In Richland, one occurred on January 18, 1953. However, the thunderstorm season essentially includes only the months of April through September. Although the average is eleven days per year, the number has varied from three to twenty-three. In June 1948, there were eight thunderstorm days during the month; and this record was repeated in August 1953. The records show that cold fronts probably constitute the greatest single cause of thunderstorms at HMS. During the years of 1947 to 1955, 43 percent of all thunderstorm days during the months of May through August *were directly associated with cold frontal passages. On several occasions (notably on August 7, 1953), lightning has struck the HMS tower.*

Peak gust data are not available for the 50-, 200-, and 400- ft levels prior to 1952. Of the 185 thunderstorm days occurring during the period of 1952 to 1970, the speed classification of peak gusts on these days is as follows:

	Number of Cases			% of Total		
mph	*50 ft*	*200 ft*	*400 ft*	*50 ft*	*200 ft*	*400 ft*
< 21	*18*	*9*	*5*	*10*	*5*	*3*
21 -30	*75*	*45*	*42*	*40*	*24*	*23*
31 -40	*63*	*80*	*73*	*34*	*43*	*39*
41 -50	*23*	*34*	*46*	*12*	*19*	*25*
51 -60	*4*	*11*	*12*	*2*	*6*	*8*
61 -70	*1*	*4*	*5*	*1*	*2*	*3*
> 70	*1*	*2*	*2*	*1*	*1*	*1*
	185	*185*	*185*	*100*	*100*	*100*

Precipitation was not measured during 1945 and 1946 in which 26 thunderstorm days occurred. During the period of 1947 to 1970, 246 thunderstorm days were recorded. The daily precipitation distribution during these days was as follows:

Amount - Inches	*Number of Cases*	*% of Total*
None or trace	*110*	*45*
0.01 - 0.10	*87*	*35*
0.11 - 0.25	*29*	*12*
0.26 - 0.50	*15*	*6*
> 0.50	*5*	*2*
	246	*100*

Precipitation intensities are defined in Reference 2.3-5.

The record for rainfall intensity during a thunderstorm is 0.55 inch in 20 minutes (1.65 inches per hour) on June 12, 1969. This storm included hailstones of 1/4-inch diameter.

Hail was reported on fourteen, or 5 percent, of the total thunderstorm days. Blowing dust or dust was reported on sixteen thunderstorm days and both hail and blowing dust or dust on six days.

Hail is a rare phenomenon at Hanford. For all years of record, hail has not occurred more than twice in any year. Of the 272 thunderstorm days from 1945 to 1970, hail was reported on fourteen or 5 percent of these days. Hail was also reported on two days without occurrence *of either a cold frontal passage or a thunderstorm on the same day. The distribution by months of days on which hail occurred is as follows:*

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Number	0	1	1	4	2	1	2	2	1	0	0	0	14
% of Total	0	7	7	30	14	7	14	14	7	0	0	0	100

Where size was reported, all except two reports indicated sizes in the 0.2- to 0.3-inch range. The exceptions were May 26, 1954, and July 1, 1955, when the size reported was 0.4 inch.

There is no known case of local damage from hail.

2.3.1.2.1.3 Tornadoes

The State of Washington experiences, on the average, less than one tornado each year. Within a one hundred mile radius of the site, only fourteen tornadoes have been reported since 1916. These tornadoes are listed in Table 2.3-4. Of these fourteen recorded tornadoes, only five had any damage associated with them. A more extensive survey of tornadoes in the three northwestern states (Washington, Oregon, and Idaho) was performed by Fujita (6). His results indicate that tornadoes and hailstorms in this area occur primarily in "alleys". The locations of these "alleys" are shown in Figure 2.3-3 along with locations of tornadoes which have been recorded in the tri-state area during the twenty-year period from 1950 to 1969.

Jaech (7) has analyzed the data of Fujita (6) to determine the probability of a tornado striking the Jersey Nuclear Company Fuel Facility (now Siemens Power Corporation), which is located about eight miles from the site. His analysis estimates the probability of occurrence of a tornado in the vicinity of the Exxon site as six chances in a million during any given year or about one chance in four thousand during a forty-year plant life.

The peak tornado wind velocity estimated for the site is 214 mph (Reference 2.3-7). This includes an estimated maximum rotational and translational wind velocities (at a 95-percent confidence level). Daubek (Reference 2.3-8) estimates the maximum translational velocity to be 30 mph. The maximum pressure drop in the center of the tornado relative to the environment is estimated to be up to 1.5 psi (Reference 2.3-6).

These values are equal to or less than those tornado parameters listed for a Class III region (which includes the site location) in Regulatory Guide 1.76, issued April 1974. Prior to the issuance of this guide, CGS was designed to withstand some of the most stringent NRC tornado criteria presented for a site located within a Class I region.

A comparison between criteria used for CGS and those applicable to Class I and III regions are given below:

Design Basis Tornado Characteristics

	Maximum Wind Speed (mph)	Rotational Speed (mph)	Translational Speed (mph) Maximum	Translational Speed (mph) Minimum
Class I Region	360	290	70	5
Class III Region	240	190	50	5
CGS	360	300	60	-

	Radius of Maximum Rotational Speed (ft)	Pressure Drop (psi)	Rate of Pressure Drop (psi/sec)
Class I Region	150	3.0	2.0
Class III Region	150	1.5	0.6
CGS	264 - 880	3.0	1.0

Wind and tornado loading criteria used in the CGS structural design are discussed in Section 3.3.

2.3.1.2.1.4 Strong Winds. *The Hanford region experiences high wind speeds due to squall lines, frontal passages, strong pressure gradients and thunderstorms.** *The Hanford Reservation has experienced only one recorded tornado (June 1948) and has not been known to be affected by typhoons. No complete statistics are readily available which present frequency of occurrence of high winds produced or accompanied by a particular meteorological event. However, the highest winds produced by any cause are tabulated for HMS in Tables 2.3-5 and 2.3-6. Figure 2.3-4 indicates the return probability of any peak wind gust, again due to any cause.*

The speed-direction summary (Table 2.3-6) shows that daily peak gusts of at least 40 mph have occurred from all but four of the sixteen compass points indicated. The SW octant, however, accounts for 65 percent of such cases. The SSW octant accounts for 83 percent of daily peak gusts of 50 mph or over and 100 percent of those 60 mph or over. Since WNW and NW are the most frequently observed directions at HMS, they account for almost half of all daily peak gusts. However, less than 3 percent of these are at speeds of 40 mph or more. By contrast, 23 percent of daily peak gusts from the SSW and SW attain this speed. Although the winter season has a lower average wind speed than any other, it also has the greatest frequency of days with peak gusts 40 mph or over (10 percent). This compares with 8 percent for spring, 7 percent for fall, and 5 percent for summer. However, reflecting the frequent periods of stagnation in winter, this season also has the highest frequency of days with peak gusts under

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Peak wind gust data associated with thunderstorm activity are given in 2.3.1.2.1.2.

10 mph (16 percent). This compares with 10 percent for fall and 1 percent for spring. In summer, such days are virtually non-existent with only one being tabulated in 1,102 days of record. About 60 percent of the days from May through August experience drainage winds of at least 13 mph from the west direction for at least two hours daily during the period of 1600 to 2400 PST.

The annual extreme fastest mile of wind speed* for a given region has been commonly used as the best available measure of wind for design purposes (Reference 2.3-9). The standard reference speed level is normally chosen at the 30-ft elevation, and wind speed is assumed to vary with the one-seventh power of height.

All CGS structures have been designed to withstand a basic wind (fastest mile) velocity, including gusts of 100 mph at an elevation of 30 ft above the site grade. *This design speed value is conservative for the CGS site since the 100 year return period peak gust as shown in Figure 2.3-4 at HMS is 86 mph at an elevation of 50 ft (as given in Tables 2.3-5 and 2.3-6 at that level peak gusts have not exceeded 80 mph during the period 1945 to present). The 100 year return period fastest mile of wind would be less than 86 mph since by definition gust velocity divided by an appropriate gust factor provides the velocity of the fastest mile of wind.* Although not recorded in historical records the 100 year fastest mile of wind can be expected to be in the range of 66 to 78 mph. These values are based on the application of gust factors of 1.3 and 1.1 (Reference 2.3-10) for gusts of one and 10 sec durations** respectively to the estimated historical value of 86 mph.

2.3.1.2.1.5 High Air Pollution Potential (APP) and Dust Storm Potential. Larson (11) has concluded that "consideration of the general weather parameters indicates a significantly high average annual APP over southeastern Washington." Holzworth (12) has estimated that the mean maximum January mixing depth in the Hanford area is about 250 meters, which is nearly the lowest in the contiguous United States, and for July about 2,000 meters. Hosler (13) has indicated a significantly high frequency of low-level inversion in winter over this area - on the order of 43 percent with bases below 150 meters. The occurrence of very stable and moderately stable conditions between the surface and 60 meters in winter at the Hanford Meteorology Tower is 66.5 percent.

Stagnation is defined by Huschke (14) as "the persistence of a given volume of air over a region, permitting an abnormal buildup of pollutants from sources within the region". Defining the establishment of stagnation as an uninterrupted period of daily average wind speed of 5.0 miles per hour or less and/or a peak gust of 15 miles per hour or less, Jenne (15)

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* Fastest mile of wind is generally defined as either the fastest speed associated with 1 mile of passing wind or fastest observed 1 minute wind speed.

** According to Huschke (Glossary of Meteorology, 1959), the duration of a gust is usually less than 20 seconds.

compiled a 15-year summary of Hanford stagnation periods covering the months of November through February (1947-48 through 1961-62).

Both of the two most notable Hanford stagnation periods experienced during this time occurred in November and December 1952. The first period was from November 15 to December 3 (19 days). Then, after five days of ventilation, stagnation set in again December 9 and lasted through December 28 (20 days). Average wind speeds during the two periods were respectively, 2.6 and 2.9 miles per hour. Eleven days during the first period and eight during the second had peak gusts under 10 miles per hour. One day during the first period and two during the second had average speeds less than 1.0 miles per hour with peak "gusts" of 4 miles per hour. There were 13 days of fog in each period.

Although stagnation lasting for 20 days can be expected only one season in twenty, a 10-day stagnation period can be expected every other season. Only one season in three will fail to produce a stagnation period of at least eight days.

Air quality in the Hanford area, in terms of sulfur dioxide, nitrogen dioxide, and suspended particulates, is routinely measured by the Hanford Environmental Health Foundation. (18,29)

For the year 1971, SO2 measurement in Richland averaged less than 0.02 ppm. At other sampling stations, the concentrations were below the detection limit of 0.01 ppm. In 1974, all 24 hour sequential samples of SO2 measured in the vicinity of Richland, North Richland, and Hanford 300 Area had concentrations below the detection limit of 0.005 ppm which is 25% of the annual average ambient air standard of 0.02 ppm. The 1971 and 1974 measurements for NO2 and suspended particulates are shown below:

Air Quality Measurements-Annual Averages for 1971 and 1974 (18, 29[*])
(these data are based on 24 hour integrated samples)

	NO2 (pom)			
Location	*No. of Samples*	*Max.*	*Min.*	*Avg.*
Richland (747 Building)	*49*	*6.8*	*0.06*	*0.86*
Opposite Richland	*170*	*0.019*	*<.001*	*0.005*
(Hobkirk Ranch)	*(78)*	*(0.022)*	*(0.001)*	*(0.006)*
Opposite N. Richland	*157*	*3.0*	*<.001*	*0.024*

[*] *Concentrations in parentheses are for 1974.*

[**] *High value due to a local dust storm.*

(Gilliam Ranch)	*(130)*	*(0.020)*	*(0.001)*	*(0.006)*
Opposite 300 Area	*170*	*0.025*	*0.001*	*0.005*
(Sullivan Ranch)	*(77)*	*(0.014)*	*(0.001)*	*(0.005)*
Ringold (Keys Ranch)	*166*	*0.028*	*0.001*	*0.006*
White Bluffs (McLane Ranch)	*149*	*0.028*	*0.001*	*0.006*

	Suspended Particulate ($\mu g/m+3$)			
Location	*No. of Samples*	*Max.*	*Min.*	*Avg.*
Richland (747 Building)	*42*	*440*	*25*	*120*
	(125)	*(572)*****	*(8)*	*(57)*
Opposite Richland (Hobkirk Ranch)	-	-	-	-
Opposite N. Richland (Gilliam Ranch)	-	-	-	-
Opposite 300 Area (Sullivan Ranch)	-	-	-	-
Ringold (Keys Ranch)	-	-	-	-
White Bluffs (McLane Ranch)	-	-	-	-

The major cause of air pollution in the Hanford area is dust occurring during windy periods. The most significant sources are cultivated fields in the surrounding area. A limited amount of information is available regarding atmospheric dust loading in the Hanford area. Hilst and Nickola (16) conducted limited dust investigations over a range of wind speeds and to heights of 400 feet in the Hanford area. A portion of their findings is presented in Figure 2.3-5. Other investigations which have been made in the Hanford area and reported by Sehmel and Lloyd (17) demonstrate the dependence of airborne concentrations on wind speed as shown in Figure 2.3-6.

Measurements of the particulate burden in air at a specific observation point in the 200 Areas at Hanford showed values of around 100 micrograms per cubic meter of air when the wind was less than 8 mph. The particulate content increased when higher winds were present, averaging 1,000 micrograms per cubic meter with winds of 12 mph, and 3,000 micrograms per cubic meter with winds of 16 mph.

Additional considerations regarding the August 11, 1955 and January 11, 1972 dust storms shown in Figures 2.3-5 and 2.3-6 and other climatological dust storm characteristics at Hanford are contained in the following paragraphs.

2.3.1.2.1.5.1 Evaluation of August 11, 1955 and January 11, 1972 Dust Storms at Hanford. The wind speeds at 1.25 ft., 50 ft. and 400 ft. heights for the August 11, 1955 observation period were 14, 24, 31 mph respectively. Figure 2.3-5 represents atypical conditions for the site region. The case was originally selected for study as a situation with considerable airborne dust conditions compared to average conditions.

A Hanford climatological summary of dust storms is given in Table 2.3-40 for 1953-1970 (30). Dust dependence on wind speed and direction (50 ft.) at the Hanford Meteorological Station is given in Table 2.3-41 for the same period (30). Approximate values of dust concentrations are computed based on an empirical relationship using visibility observations (31). The relationship is

$$C6 = \frac{56}{v1.25} mg/m^3$$

where V is horizontal visibility in km. This is based on data from the Great Plains with visibilities 7 to 9 miles and wind speeds greater than 12 mph. Hourly weather observations at the Hanford Meteorological Station were used as input criteria to define a wind resuspension or dust storm period. Hours satisfying dust storm criteria at Hanford (1953-1970) had either visibilities less than 7 miles and dust reported, or visibilities between 7-14 miles, wind speeds greater than 5.8 m/s, and relative humidities less than 70%. Since the above empirical concentration - visibility relationship was based on observed dust concentrations at approximately 5-6 feet above the surface, any measured dust data should be interpolated to that height when comparing the measurements to the calculated 1953-1970 results of Table 2.3-41. (30)

The frequency of the hourly data satisfying the dust storm criteria at Hanford is given in Table 2.3-42. (30)

The August 11, 1955 dust storm has an interpolated 5-ft value of 17 mg/m^3 compared with the climatological average of about 7 mg/m^3. Further inspection of the climatological values in Table 2.3-41, supports a conclusion that the storm is an example of the more severe type of dust storm that occurs in this region.

Care must be taken in interpretation of Tables 2.3-40 to 2.3-42 to allow for certain limitations. Estimates based on visibilities and/or wind speeds outside the range used in formulation of Equation 1 are of unknown reliability. The average visibilities within each wind speed class were within the range of empirical validity except for the high wind cases. Another source of errors is the fact that the visibility observations are taken at specific times and are not hourly averages. Considering these limitations Tables 2.3-40 to 2.3-42 may be taken to represent overall aspects of the Hanford dust storm climatology. Individual values must be considered approximate estimates - particularly those based on only a few data points.

The extreme value in Table 2.3-41 in the 53 to 66 mph class (988 mg/m^3) represents a single observation of 0-1/16 miles visibility for a few minutes. Typically at the onset of a dust storm very low visibilities with high winds occur for a few minutes. The very limited visibility and high winds for such a period were coded for the data for that hour. The station log reveals that five minutes after the onset of this dust storm, the winds had dropped to 37 mph and visibility was 3/8 mile. The phenomenon was generated by a thunderstorm passing close to the station. Hence, the extreme value in Table 2.3-41 represents an occurrence of very short duration which was the onset of a dust storm that had a duration of about one hour. Qualitative observation indicates that this is not an atypical scenario. Over the 40 minute duration of the storm, the average calculated average dust concentration was 60 mg/m^3. It should be noted, however, that the onset concentration (988 mg/m^3) is of unknown validity because it is calculated from a visibility value for which the empirical model has not been validated.

The visibility during the January 11, 1972 storm was initially less than one mile, changing to four miles during the last half hour of the reported episode. The January 11, 1972 dust storm had winds at 50' WSW in the range 31 to 43 mph. Wind storms with peak gusts recorded at 50' on the Hanford Tower during this period have a three to four year return period at Hanford.

Actual particulate loading depends on other factors such as surface conditions and atmospheric stability. Hence, the wind gust return period does not necessarily apply to particulate loading although it is reasonable to assume the return period is not less than that for wind.

Detailed estimates of the particulate size and total mass concentrations cannot be accurately made for the January 11, 1972 dust storm as a result of the lack of any particle size distribution data. In addition, only one height of mass concentration datum (189 mg/m^3 at 0.2m) was made in the steep gradient region of the vertical profile. An indication of size distribution and mass loading profiles can be obtained from other data collected at Hanford. Sehmel (32) reports an April 1972 storm which has mass loadings near the surface which are similar to the January 11, 1972 storm. Although adjacent meteorological observations are not available for this episode, the fact that the mass loadings at the lower levels are of the same order as the January 11, 1972 dust storm provides a basis for comparison of the storms. The April 1972 storm has well documented mass loading profiles as a function of particle size. The table shown below contains the profiles of airborne soil concentrations as a function of particle diameter for the dust storm. These are based on optical measurements for smaller particles (.16 to 5 μm) at 0.9m and, impacter-cowl measurements for larger particles (1 to 230 μm) at the indicated heights. The mass loading is dominated by the larger particle data.

Soil Mass Loading for the April 1972 Dust Storm (mg/m^3)

Particle Diameter Range (μm)	*Height (m)*					
	0.3	*1.0*	*2.0*	*3.0*	*10.*	*32.*
0.9 - 5.0	*0.21*	*0.11*	*	*	*0.058*	*.0038*
5 - 20	*0.83*	*0.28*	*0.26*	*.25*	*0.070*	*.0056*
20 - 60	*14.*	*4.4*	*2.9*	*1.5*	*.81*	*.29*
60 - 240	*220.*	*6.6*	*2.8*	*1.3*	*.19*	*.11*
Total	*235*	*11.4*	*~6.0*	*~3.1*	*1.13*	*0.41*

Comparison of the dust loading of 6.0 mg/m^3 at 2 meters with the climatological summaries in Tables 2.3-41 and 2.3-42 indicates that this is a typical dust storm for the region.

The particle size distribution for the August 11, 1955 storm is shown in the following table for comparison.

Airborne Dust Loadings of Particles Greater Than 0.9μ For August 11, 1955 Dust Storm (mg/m^3)

Particle Diameter Range (μm)	*Height (m)*			
	0.38	*2.0*	*15.2*	*30.5*
0.9 - 5.0	*0.015*	*0.012*	*0.012*	*0.0079*
5 - 20	*0.39*	*0.32*	*0.23*	*0.17*
20 - 60	*3.1*	*2.2*	*1.1*	*0.77*
60 - 240	*18.*	*12.0*	*2.3*	*0.78*
Total	*22.*	*14.5*	*3.7*	*1.7*

The April 1972 dust storm has higher mass loadings near the surface in all size ranges. The August 11, 1955 dust storm had higher dust loadings above 1 to 2 m heights in the ranges greater than 5μ diameter. One interpretation of these profiles is that the 1972 storm had a source nearby and the 1955 data represents advection of airborne dust from more remote sources (33).

2.3.1.2.1.5.2 Hanford Dust Storm Climatology for Design and Operating Bases. *The Hanford climatological study of dust storms for 1953-1970 (30) (discussed in the previous subsection) was re-examined for the purpose of establishing the "worst case" dust storm which may have occurred during that period (33).* The worst case dust storm, i.e., that storm which had the largest calculated time integrated dust loading (mg-hr/m^3), is considered to be

* *No value in reference.*

160 mg-hr/m^2, duration of 18 hr, and average dust loading of 8.9 mg/m^3 at a height of 5 to 6 ft. The design basis dust storm is bounded by a postulated volcanic ashfall event (see Section 2.5.1.2.6) in the evaluation of the design and performance of HVAC systems and diesel generators. *Results of this worst case dust storm investigation are listed below. As mentioned above, these loadings would apply for a height of 5 to 6 feet above the ground.*

Detailed Estimates of the Dust Loadings for the Six Worst Storms Based on Surface Observations of the Hanford Meteorology Station, 1953-1970

Storm Number	*Total Dust Loading (mg-hr/m^3)*	*Actual Duration (hr)*	*Average Dust Loading (mg/m^3)*
1	*40**	*0.67*	*60*
2	*100*	*1.0*	*100*
3	*160*	*18***	*8.9*
4	*44*	*2.6*	*17*
5	*90*	*3.1*	*29*
6	*80*	*7*	*11*

The worst storm of these was storm No. 3. While it was also shown in this study that once a given dust storm terminated, there existed a 5% probability that another one would occur within 10 hours and a 50% probability that another one would occur within 30 days, none of the above six worst case dust storms had occurred within 30 days of each other. Most had occurred in different years during the 1953-1970 study period.

The dust loading for storm No. 3 is conservative in terms of its being considered as the worst case storm for use in plant design evaluations. As a result of the shorter storm durations of the measured August 11, 1955, January 11, 1972, and April 1972 dust storms, their time integrated dust loadings at 5-6 feet above the ground are not worse than that computed for storm No. 3 (33).

2.3.1.2.2 Design Snow Load

The American National Standards Institute (ANSI) in "Building Code Requirements for minimum Design Loads in Buildings and other Structures" (19) provides weights of 100-year return period ground level snow packs for the site region. The ANSI (Reference 2.3-19) value

* *Value is less than actual dust loading as a result of less than 1 hour duration.*

** *The detailed investigation yielded 18 hours as opposed to a range of 1-16 hours given in Table 2.3-40 of 2.3.1.2.1.5.1 for the range in duration of dust storms using the same 1953-1970 data.*

of 20 lb/ft^2 was used as the design snow load for all CGS structures.* Assuming a specific gravity of 0.1 or snow density 6.24 lb/ft^3, this design value corresponds to a snow depth of 3.2 ft. *The above snow load is conservative for the site as snow depth seldom exceeds six inches, and the greatest depth of 24.5 inches was recorded in February 1916. (4) The weight of the 48-hour probable maximum winter precipitation can be determined from the data presented in Table 2.3-3. Since the greatest snowfall in 24 hours was 10.2 inches (February 1993) and a record depth of approximately 12 inches lasted four days (December 1964) these depths would correspond to snow loads of 5.3 and 6.24 lb/ft^2 respectively.*

2.3.1.2.3 Meteorological Data Used for Evaluation of Ultimate Heat Sink

The ultimate heat sink is evaluated in Section 9.2.5.

The meteorological data presented in Figure 2.3-7 and Tables 2.3-1, 2.3-5, and 2.3-7a-7h was used to evaluate the performance of the CGS spray ponds in 9.2.5 with respect to (1) maximum evaporation and drift loss and (2) minimum water cooling. In accordance with Regulatory Guide 1.27, Rev. 1 "Ultimate Heat Sink for Nuclear Power Plants", the worst one-day and 30-day periods of meteorological record which resulted in minimum heat transfer to the atmosphere were established. The worst recorded 30-day period (30-day average) of maximum difference between dry-bulb and dewpoint temperature and highest simultaneously recorded wind speeds which resulted in the maximum evaporation and drift loss were also established.

Climatological moisture and temperature data presented as a function of time of day for each month in Figure 2.3-7, and wind statistics given in Table 2.3-5 were used to establish the maximum initial pond temperature for the ultimate heat sink analyses in 9.2.5. It was determined in 9.2.5 using these meteorological data, solar radiation formulas contained in ASHRAE Handbook of Fundamentals, and techniques outlined in the John Hopkins University Report "Cooling Water Studies" (Edison Electric Institute Research Report No. 5, Project RP-49, November 1969) that the month of July contained the worst average meteorological data which resulted in the maximum initial pond temperature.

The worst day meteorological data was considered to be the given combination of meteorological parameters in a particular consecutive twenty-four hour period which resulted in the worst pond thermal performance. The following recorded episodes of extreme wet bulb temperatures experienced at the CGS and/or HMS sites were evaluated in 9.2.5 to establish the worst pond thermal performance:

1) August 7-9, 1972 at CGS and HMS, presented in Table 2.3-7a (20),

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* Ice loading is included in this CGS estimate.

2) July 4-12, 1975 at CGS, presented in Tables 2.3-7b to 2.3-7e from the onsite FSAR meteorological monitoring program,

3) August 4, 1961 at HMS, presented in Table 2.3-7f (21).

The meteorological conditions which occurred on July 10, 1975 at CGS resulted in the worst pond thermal performance as determined in 9.2.5.

The following worst month meteorological data were used in 9.2.5 to establish the second through thirtieth day worst pond thermal performance and worst 30-day drift loss and evaporation (Reference 2.3-21):

a) July 9 - August 8, 1961 at HMS, presented in Table 2.3-7a (minimum heat transfer)

b) July 2 - August 1, 1960 at HMS, presented in Table 2.3-7h (maximum evaporation and drift loss)

Diurnal variations in dry bulb and wet bulb temperatures for both 30-day periods assumed that the hourly temperature variation approximated a sine wave of one cycle in 24 hours (Reference 2.3-21). The average wind speeds during both 30-day periods was approximately 5.5 mph. The root mean square average of the hourly wind speed data for the 30-day mass loss period is 6.91 mph.

For conservatism in the thermal analysis, the worst day data for thermal performance was assumed to repeat in the analysis until pond temperature peaked (three days repetition). For conservatism in the mass loss analysis, an upper bound curve was fit to the drift loss data taken during spray pond testing. The drift loss value was obtained from this curve. See 9.2.5 for details.

2.3.2 LOCAL METEOROLOGY

2.3.2.1 Data Comparisons

The local meteorology prior to CGS plant operation at the CGS site can be described from FSAR meteorological data procured during the period April 1, 1974 to March 31, 1976 from the permanent onsite 7-ft and 245-ft meteorological towers. Data collected from the 245-ft CGS tower had been used for the short-term (accident) and long-term (routine) diffusion estimates. Onsite meteorological data were also obtained from a temporary 23-ft tower which commenced operation in April 1972 for the purpose of determining optimum cooling tower geometric orientation for performance during high wet bulb periods. The 23-ft meteorological tower data were also used with other regional data to establish the potential impact of proposed mechanical draft cooling tower atmospheric releases in the vicinity of CGS

(Reference 2.3-22). The permanent tower data have been compared where appropriate and possible, with simultaneously recorded and historical data obtained from the Hanford Meteorological Station (HMS) for the purpose of documenting the representativeness of the two years of onsite meteorological measurements. For the months of April through August 1974, comparisons have also been made with data from the onsite temporary tower; this tower and instrumentation were dismantled in September 1974. Monthly and annual average comparisons between simultaneously recorded and historical data for all the aforementioned meteorological tower sites have indicated that agreement between the data sources is reasonably good.

When comparing sources of data, it should be recognized that at any given time, significant differences can exist between the reported meteorological conditions at the CGS and HMS sites (see, for example, Table 2.3-7a). Differences in the frequencies of occurrence of various meteorological conditions at a given site can also exist from year to year or from one elevation to another elevation at a site for coincident observation times. Any discrepancies between summarized data sources can also be attributed (in addition to site separation and instrument height above ground) to differences in types and accuracies of instrumentation used and procedures considered for acquiring, processing, and analyzing raw meteorological data. Details regarding the onsite meteorological measurement program are presented in 2.3.3.

For the following data comparisons, the following definitions are used:

CGS[*]	*Data obtained from the permanent 7' and 245' towers at the CGS site; summarized here for April 1, 1974 - March 31, 1976.*
CGS (temp).	*Data obtained from the temporary 23' tower at the CGS site; summarized here for April 1, 1974 - August 31, 1975.*
HMS:	*Data obtained from the Hanford Meteorological Station; used here for April 1, 1974 - March 31, 1976.*
HMS (hist):	*Data obtained from the Hanford meteorology tower at the Hanford Meteorological Station, used here for various periods identified in the data comparison listings. The source is AEC Research and Development Report "Climatography of the Hanford Area", June 1972, BNWL-1605.*
Wind Variable:	*At CGS an hour of data which contains less than 15 minutes of any one direction sector; at Hanford, the same but for 20 minutes.*

[*]Data obtained at the 33 foot (10 meter) elevation is presented since these data have been subsequently used in the site diffusion studies for postulated ground-level release cases.

Wind Calm: *At CGS, an hour of data for which the average speed is 0.22 miles per hour or less; at Hanford, average speed less than 1 mph (as decided by weather observer, corresponds to no motion of strip-chart recorded pen).*

Sense of Delta T: *Positive values imply relative stability, negative values imply relative instability.*

The first annual cycle of CGS onsite meteorological data which covered the period April 1, 1974 through March 31, 1975 has been presented in detail. Local meteorological data collected during the second annual cycle (April 1, 1975 through March 31, 1976) generally portrayed the same characteristics as indicated by comparison with the first annual cycle data. Except for the high wet bulb episode experienced at CGS during July 1975 (refer to 2.3.1.2.3 and 2.3.2.3), no monitored onsite data proved to be more severe in terms of the design and operation of CGS than those data presented in 2.3.1.2. Hence, only the second annual cycle monthly averages have been presented in Table 2.3-8a which summarizes the two years of monitored on-site data with concurrently measured and historical HMS data. Any significant differences noted between first and second annual cycle onsite data and concurrently measured CGS and HMS data are discussed in 2.3.2.1. Otherwise, conclusions stated herein for the first annual cycle of data similarly apply to the second annual cycle data. It is observed in Table 2.3-8a that any year to year differences in the summarized monthly mean meteorological data at tend to parallel the differences in the means summarized for the HMS site for corresponding months during the two year monitoring period.

Summaries of joint frequency distributions of wind direction and wind speed by atmospheric stability class and results from accident and routine diffusion estimates for both annual cycles of CGS onsite meteorological data are presented in subsequent sections.

Magnetic tape files of the two years of hourly onsite data have been transmitted to the NRC.

2.3.2.1.1 Winds

Table 2.3-8b presents monthly and annual CGS joint wind speed and direction data for the first annual cycle of monitoring. Similar data for the HMS site are given in Table 2.3-9. The CGS data presented in the above tables were collected at an elevation of 33 feet above local grade for the one year period of record whereas the HMS historical data were collected at an elevation of 50 feet above local grade during the period 1955 through 1970 (HMS is approximately 280 feet higher in elevation than the CGS site). Additional wind direction frequency statistics are presented in Table 2.3-10.

The CGS 33 ft and CGS (temp) 23 ft wind direction data given in Table 2.3-10 have similar distributions of direction frequency and show a bimodal wind direction distribution from approximately South and also Northwest. These distributions differ from that given for the HMS site where the direction distribution displays a single peak at approximately West

Northwest to Northwest. Further, the wind direction distribution at the CGS site is much more uniform around the compass than it is at the HMS site. The differences in these distributions may be attributed to the influence of terrain features, causing variability of air flow at the CGS site. This conclusion is strengthened by the observation that the CGS monthly wind frequency distributions are similar through-out the period of data acquisition.

Tables 2.3-11 and 2.3-12 provide the 20 longest occurrences of wind direction persistence at CGS for an elevation of 33 feet. Table 2.3-11 shows persistence in one (22.5 degree) sector while Table 2.3-12 shows persistence within two (45 degrees) adjoining sectors; the corresponding stability class distributions and average wind speed within each stability class are also provided.

It is noted that the majority of the periods of high direction persistence at CGS are associated with unstable, neutral, and moderately stable atmospheric conditions and moderate to strong wind speeds. These represent relatively good diffusion conditions. Table 2.3-12a summarizes the longest persistences of wind direction in one and two sectors at CGS measured during the first and second annual cycles. The annual frequency and duration of episodes of high wind direction persistence at CGS depend upon the frequency and intensity of weather systems which result in regional large scale gradient flow. For example, during the first annual cycle, the longest persistence in one and two sectors lasted 14 hours (NW) and 26 hours (NW, NNW) respectively. During the second annual cycle, the longest persistence in one and two sectors lasted 33 hours (NNE) and 35 hours (N, NNE) respectively. Whereas the longest persistence in one sector during the first annual cycle lasted 14 hours, the duration of the first three longest persistences in one sector during the second annual cycle (33 hours from NNE, 20 hours from SSW, and 16 hours from NW) exceeded that longest duration.

Table 2.3-13 presents monthly frequency distributions and averages of wind speed measured at the CGS and HMS sites. Considering site separation, elevation of sensors, and instrumentation and procedural differences, the CGS wind data appear meteorologically reasonable and demonstrate consistency among data sources.

2.3.2.1.2 Moisture and Temperature

Diurnal variation and averages of dry-bulb, wet-bulb, and dew-point temperatures for the first annual cycle of monitoring at the CGS and HMS sites are given in Tables 2.3-14 to 2.3-16. Tables 2.3-17 to 2.3-19 present frequency distributions of dry-bulb, wet-bulb, and dewpoint temperatures, summarized for the first year of CGS site observations. Table 2.3-20 contains additional climatological summaries of monthly normals and extreme values of temperature and humidity measured at HMS.

Considering the 280 ft difference between the CGS and HMS sites and assuming a dry adiabatic lapse rate of 5.48°F/1000 ft, one can expect a temperature difference of about 1.5°F between the dry-bulb temperature data measured at both sites.

Higher monthly average wet-bulb and dewpoint temperatures occurred at CGS since the CGS site experienced air of slightly higher moisture content than the HMS site. The higher moisture content may be attributed to Columbia River proximity and irrigation of the fields in the vicinity of CGS. This conclusion is strengthened by the fact that moisture enhancement at CGS was at a minimum for the months of January, February, and March during the first annual cycle of CGS site observations.

During the second annual cycle of monitoring, it was observed that the CGS site experienced air of essentially the same moisture content as did the HMS site. The absence of the moisture enhancement at CGS, which was noted during the first annual cycle, may be attributed to reduced evaporation from the proximate river and irrigated fields. The periodic occurrences (during the second annual cycle) of cooler dry-bulb temperatures and precipitation deficits when high dry-bulb temperatures prevailed may have resulted in reduced evaporation.

2.3.2.1.3 Monthly Precipitation

Diurnal variation of precipitation intensity at CGS and monthly total precipitation at CGS and HMS for the first annual cycle of monitoring are given in Table 2.3-21. Frequency of occurrence of precipitation intensity data from April 1974 through March 1975 at CGS are presented in Table 2.3-22. Frequency of occurrence of wind speed and direction versus precipitation intensity for the same year of data is given in Table 2.3-22a. The data show that the CGS site experienced less precipitation than did the HMS site. The difference can be attributed to site separation and the incidence of precipitation falling in the form of showers of quite limited spatial extent. The precipitation deficit at CGS may also result from a rain shadow effect from Rattlesnake Mountain. A precipitation gradient is known to exist along the slope of this terrain feature.

2.3.2.1.4 Fog

Fog data are unavailable for the site. Although fog has been observed in every month of the year at HMS, it is essentially a seasonal phenomenon with 95 percent of it observed during the months of November through February. Inclusion of March and October fog would increase this percentage to 99.7. Tables 2.3-23 and 24 summarize the duration and persistence statistics for fog occurrences at HMS. Because of the relative proximity of the site to the Columbia River, it is expected that the frequency of occurrence, intensity and duration of fog would be somewhat greater than these data indicate (refer also to 2.3.2.1.5).

Most fog in the Hanford region is of the radiation type and hence occurs mostly in conjunction with light wind, inversion or stable atmospheric conditions. The occurrence of fog at the site can therefore be considered as one visual indicator of poor atmospheric diffusion conditions. Advection and frontal fogs occur occasionally at both HMS and the Tri-City stations of Richland and Pasco. In addition, at Richland and Pasco, there are occasional occurrences of *steam fog from the Columbia River. These are not usually deep and many would be classified as ground fog.*

Statistics on fog persistence are limited to those at HMS. Although most dense (visibility 1/4 mile or less) fogs do not last longer than 3 hours, a few run for much longer periods as shown in Table 2.3-23. After a period of fog, there frequently follows a period of atmospheric stagnation with a low stratus overcast and light winds. Such conditions may persist for many days.

2.3.2.1.5 Stability Summaries

For the purposes of comparison, the t Δ (temperature difference) and sigma theta (standard deviation of the horizontal wind direction fluctuations) stability classifications which are used in diffusion studies at Hanford are given below with the t Δ"Pasquill" and sigma theta classes identified in NRC Regulatory Guide 1.23:

REGULATORY GUIDE 1.23

Pasquill Class		Δt/ΔZ (°F/200 FT)	Sigma* Theta
Extremely unstable	A	Less than -2.1	25.0
Moderately unstable	B	-2.1 to -1.9	20.0
Slightly unstable	C	-1.9 to -1.6	15.0
Neutral	D	-1.6 to -0.6	10.0
Slightly stable	E	-0.6 to 1.6	5.0
Moderately stable	F	1.6 to 4.4	2.5
Extremely stable	G	greater than 4.4	1.7

HANFORD RESERVATION CLASSIFICATION

Pasquill Class	Δt/ΔZ (°F/200 FT)	Sigma Theta Groupings** (Degrees)
Very unstable	Less than -2.5	greater than 22.5
Unstable	-2.5 to -1.5	25.5 to 17.5
		17.5 to 12.5

* *Period of 15 minutes to 1 hour.*

** *Note that these sigma theta groupings do not necessarily correspond to any particular Hanford Stability Class on the left, i.e., there can be a maximum of 35 group combinations of Δt/ΔZ and sigma theta although some combinations are unlikely to occur.*

Neutral	*-1.5 to 0.5*	*12.5 to 7.5*
		7.5 to 3.75
Moderately Stable	*0.5 to 3.5*	*3.75 to 2.1*
Very Stable	*greater than 3.5*	*less than 2.1*

Joint frequency distributions of wind speed and direction by atmospheric stability class (temperature difference and sigma theta combinations) for the first and second annual cycles of monitoring are presented in Section 2.3.3. Percent frequency of occurrence of stability (Δt distribution) at CGS and HMS are given in Table 2.3-25. Although the heights over which Δt was measured are similar for both sites, it is observed in Table 2.3-25 that CGS experiences air of greater thermal stability than HMS. This discrepancy between site stabilities may be accounted for because of terrain differences. The CGS site serves as a drainage basin for relatively cool air (especially at night), resulting in strong thermal low-level stratification and the formation of persistent temperature inversions. This conclusion is strengthened by the observation that the difference between the sites is much more pronounced during July, August, September and October than during all other months. It is during these months that pooling of relatively cool air is at a maximum due, partly, to minimum cloudiness and therefore, enhanced nocturnal cooling occurs at the ground. It is noted in Table 2.3-25 that the percent frequencies of stability types for both annual cycles of monitoring at CGS are very similar.

Frequencies of occurrence of Δt and sigma theta versus time of day for the first year of onsite meteorological measurements are given in Table 2.3-26 and 2.3-27. Although frequency of occurrence and duration of inversion conditions were not analyzed for the site, stagnation and inversion information contained in 2.3.1.2.1.5 and 2.3.2.1.5 for HMS should be representative for the site (except for the fact that the above data indicates that CGS experiences a greater frequency of surface-based inversions than does HMS). Figure 2.3-8 shows probabilities of inversion persistence at HMS from 1952-1969 (2).

2.3.2.2 Potential Influence of the Plant and Its Facilities on Local Meteorology

The shapes and sizes of the buildings erected on the plant site will produce a disturbed air flow which alters the initial distribution pattern and diffusion rates of plant release airborne contaminants. In the diffusion calculations this effect is considered.

Electrical power generation by steam turbines requires dissipation of large quantities of low grade thermal energy. Waste heat produced from the operation of CGS is dissipated by means of six circular mechanical draft cooling towers. These evaporative cooling towers release waste heat directly to the atmosphere in the form of sensible and latent heat. An extended visible plume consisting of liquid water droplets can occur principally during the winter months when periods of cold weather and high relative humidity prevail. Fogging is defined as occurring if visible plumes intersect the ground, buildings, or other elevated structures.

Fog occurs naturally in this region, and any cooling tower fog is an extension of the naturally occurring phenomenon. When air temperatures of 0°C or lower prevail, the additional potential exists for icing on these surfaces. At times, small cumulus clouds could form above or remote from the plant, depending on the atmospheric temperature and moisture conditions in the first several thousand feet above the cooling towers. No significant environmental or atmospheric impacts arising from CGS cooling tower operation have been observed or are foreseen based on dispersion meteorological studies performed by Battelle Northwest Laboratories (Reference 2.3-22). Details covering potential environmental impacts arising from CGS cooling tower operation are given in the CGS Environmental Report.

2.3.2.3 Local Meteorological Conditions for Design and Operating Bases

The regional long term meteorological conditions provided in Section 2.3.1.2 are applicable for use in establishing the plant design and station operating bases. Except for the high wet bulb episode experienced at CGS during July 1975 (refer to 2.3.1.2.3), none of the local short term meteorological data presented in 2.3.2.1 proved to be more severe in terms of the design and operation of CGS than those presented in 2.3.1.2. Data collected since January 1, 1984 form the revised long-term design and operating basis for dispersion calculation.

2.3.2.4 Topographic Description

As shown in Figures 2.1-1 and 2.1-2, the plant is located at a grade elevation of 441 feet MSL in a basin area formed by the Saddle Mountains to the northwest, bluffs and hills rising to about 900 feet MSL to the north and east, the Horse Heaven Hills to the south and the Rattlesnake Hills and Yakima, Umtanum and Manastach ridges to the west. Topographic cross-sections plotted out to 10 kilometers by sector from the plant are given in Figure 2.3-9. Except for the cliffs toward the east across the Columbia River, the region within this circumference is basically flat and featureless and slopes gradually toward the Columbia River. Additional details regarding the regional topography and geology are given in 2.5. The effects of regional topography on local meteorology are discussed in 2.3.1.1, 2.3.2.1.1 and 2.3.2.1.5. The need to consider plume height relative to land elevations has been obviated by the assumption of a ground-level release for the accident and routine station release cases which are presented in 2.3.4 and 2.3.5.

2.3.3 ONSITE METEOROLOGICAL MEASUREMENT PROGRAM

The permanent onsite meteorological data collection system in use since January 23, 1974 consisted of a 240 ft main tower, an auxiliary seven ft instrument mast, sensors with associated *electronics and recording devices, and a meteorological shelter.** *A 23 ft onsite temporary tower was also used during the period April 1, 1972 through August 31, 1974.*

The Battelle Memorial Institute, Pacific Northwest Laboratories, had been conducting a continuing two year program of acquisition, processing, and analysis of meteorological data for Energy Northwest Columbia Generating Station in a contractual arrangement with Burns and Roe, Inc.

The first and second annual cycles of reliable meteorological data were collected during the periods April 1, 1974 through March 31, 1975 and April 1, 1975 through March 31, 1976, respectively. The accuracy of these data had been established primarily through calibrations conducted at quarterly intervals as required through a formal program of quality assurance. The data were examined for meteorological reasonableness, after corrections were applied per the calibration Reports, through computer edit programs. No data were found to be unreasonable. The annual summaries were compared with the monthly summaries and all were found to be consistent. The computer summarization programs (identical for monthly and annual purposes) were tested at quarterly intervals by application to dummy data per the quality assurance program. (23) The computer calculation programs for x/Q were similarly tested. Comparisons between CGS meteorological data and concurrently measured and historical HMS data have been presented in 2.3.2.1.

2.3.3.1 Permanent Onsite Meteorological Tower and Instrumentation Characteristics

The meteorological tower, which is located approximately 2,500 feet west of the CGS plant site with its base at 455' MSL, consists of a 240 ft high primary tower with a five ft mast extending above it. The primary tower is triangular in shape and of open lattice construction to minimize tower interference with meteorological measurements. Wind and temperature measurements were made at the top of the mast and at the 33 ft level. The dewpoint temperature was measured at the 33 ft level. At the lower level the instruments were mounted on an eight ft horizontal boom extending southwest of the tower. Wind and temperature measurements were also made at the top of a seven ft mast which was located approximately 80 feet southwest of the 245 ft tower.

Wind speed measurements were made using conventional cup anemometers (Climet Instruments, Model 011-1 Wind Speed Transmitter) which have a response threshold of about 0.6 mph and a distance constant of less than five feet. Over a calibrated range of 0.6 to 90 mph the accuracy of these instruments is ± 1% or 0.15 mph (whichever is greater).

**Data collection on the 240 foot and seven foot towers was terminated on June 1, 1976 subsequent to the collection of two years of reliable tower data ending March 31, 1976, required for the CGS FSAR. Data collection on the Primary and backup towers began on July 1, 1984.*

Wind direction measurements were made using lightweight vanes (Climet Instruments, Model 012-10 Wind Direction Transmitter).

The response threshold of these vanes is about 0.75 mph, and their damping ratio and distance constant are approximately 0.4 and 3.3 feet, respectively. Dual potentiometers in the Wind Direction Transmitter produce an electrical signal covering 540° in azimuth with an accuracy of ±3°. In addition, electronics had been included to provide signals which were proportional to the standard deviation of the wind direction fluctuations at each level.

Temperature instrumentation had been installed to provide measurements of both the ambient air temperature at the 245, 33 and 7 ft levels, as well as the temperature differences between these levels. The ambient air temperature and the temperature difference measurement systems were independent of each other to provide for reliability. Atmospheric stability delta - T classes were determined solely on the basis of the data from the electronic differencing bridge and not by subtracting the ambient air temperature measurements. All temperature measurements for both systems were made in aspirated radiation shields (Climet Instruments Model 016-1 or -2) using platinum resistance temperature detectors (Rosemount Engineering Co., Model 104 MB6ABCA). These instruments provided an ambient temperature range from -30°F to ±130°F and a temperature difference range of ±15°F. The accuracy of the instruments is ±.09°F in the measurement of temperatures and ±0.18°F in the measurement of temperature differences.

The dewpoint temperature was measured at the 33 ft level of the tower using a lithium chloride dewpoint sensor (Climet Instruments, Model 015-12) housed in an aspirated radiation shield (Climet Instruments Model 016-2). Precipitation was measured at ground level using a tipping bucket rain gage (Meteorology Research Incorporated, Model 302) located about 40 feet west of the main tower. This instrument is accurate to within 1% at rainfall rates up to 3 in./hr and has a resolution of 0.01 in. The instrument building provided a semi-controlled environment near the tower to house the instrument electronics and record the data. Analog strip chart and digital magnetic tape recorders were used to provide redundant data recording capability. The primary data recording system was a seven-track digital magnetic tape recorder (Kennedy, Model 1600) which used 1/2 inch tape. Logarithmically time-averaged wind speed, wind direction, temperature, temperature difference and dewpoint temperature signals were recorded at five minute intervals. The time constant of the averaging process was five to ten minutes. The standard deviation of wind direction fluctuations during the preceding five minutes at each level and the total precipitation were recorded along with the wind and temperature information. All data, except the wind direction standard deviations, were also recorded on strip charts which provided a backup data record to enhance data retrievability. In addition, since the strip charts contained an essentially instantaneous record of the signal from each instrument, they provided a rapid means of identifying instrument malfunctions and were useful in system calibration. These strip charts and magnetic tapes were changed weekly.

In summary, the total system accuracies for the measured meteorological parameters meet or exceed the following specifications:

air temperature	*±0.5°C*
temperature difference	*±0.2°C*
humidity (dew point)	*±2.8°C*
wind speed	*±0.5 mph from 0.5 to 5 mph, ±10% of reading above 5 mph per RG 1.97, Rev. 3.*
wind direction	*±5°*

These are verified by the end-to-end calibrations. Data recovery was better than 90%.

2.3.3.2 Quality Assurance Program

To ensure the quality of the meteorological data collected by the monitoring system, an extensive quality assurance program had been instituted. This program covered all phases of meteorological monitoring from the initial instrument acquisition through the analysis of data. Periodic checks and calibration of the instrument systems and individual components had been instituted. These periodic checks ranged from daily inspection of the strip charts to semiannual calibration of the complete system. All checks, calibrations and maintenance were fully documented, including traceability of test and calibration equipment to the National Bureau of Standards where necessary. Once collected, the data were protected from loss to the maximum extent possible; the digital tapes were examined to identify possible instrumentation malfunctions; and the data were then copied onto two master tapes. The original weekly tape and one master tape were stored in vaults for safekeeping while the second master tape was used in the preparation of data summaries. Finally, to ensure proper operation of computer hardware and software, all computer programs used to summarize or analyze the data were checked quarterly using a standard data input. The computer output from these tests was then saved to document computer operation.

The various phases of the quality assurance program pertaining to the two years of permanent onsite meteorological monitoring and data processing are discussed in the following subsections.

2.3.3.2.1 Data Recovery During April 1, 1974 - March 31, 1976

The meteorological data acquisition system was put into operation during January 1974. Outages in the digital system precluded an initiation date for the acquisition of reliable data prior to April 1, 1974 because the processing of an inordinate amount of data from strip charts *would have been required. The data utilized in the production of the monthly and annual summaries have been obtained exclusively with the primary data recording equipment (magnetic tape digital system) since August 1, 1974.*

Recourse to data recorded on strip charts was required at times prior to August 1974 to assure, as viewed at the time, a recovery rate of 90% representative data as required by Nuclear Regulatory Guide 1.23. The percentages of monthly data read from strip charts is listed below:

April 1974 - 23.3%

May 1974 - 8.3%

June 1974 - 49.5% (W/S 33' - 59.1%)

July 1974 - 1.6%

From routine and anticipated causes (system maintenance and calibration) modest data losses were experienced on the order of 2% and 1.2% for the first and second annual cycles of onsite data collection respectively. A comparable amount, for some of the meteorological quantities, was caused by circumstances beyond Battelle's control (power outages, delay in receipt of spare parts, etc.). The percentages of missing annual data for various meteorological quantities are listed below:

	April 1, 1974- March 31, 1975	*April 1, 1975 March 31, 1976*
Wind Speed 33'	*4.0%*	*2.7%*
Wind Direction 33'	*4.0%*	*1.5%*
Dry Bulb Temperature 33'	*2.5%*	*1.2%*
Wet Bulb, Dewpoint Temperature 33'	*2.7%*	*1.2%*
Differential Temperature 33' - 245'	*3.1%*	*1.5%*

These percentages are representative of missing data for all meteorological quantities except precipitation. During the first annual cycle of monitoring, data recovery for precipitation was 100%. Precipitation data recovery was complete during the second annual cycle of monitoring, except possibly during December 1975 when a sand plug was discovered in the rain gauge funnel. As a result, it was estimated that less than 0.1 inch of precipitation was not recorded during that month. For the first annual cycle of monitoring, the data recovery rate was 96% or better for all meteorological quantities; this rata was 97% or better during the second annual cycle of monitoring.

2.3.3.2.2 Maintenance and Calibration

Assurance of quality data rests primarily with the calibrations performed at quarterly intervals and reported for July and October 1974; January, April, July and October 1975; and January and April 1976.

All evidence to date obtained through formal calibrations and routine daily and weekly inspection had demonstrated that the meteorological system remained electronically stable in terms of obtaining data of sufficient quality to meet the requirements in Regulatory Guide 1.23. The calibration corrections required are tabulated in the response to NRC question 6.4 on the FER. The calibrations established any system inaccuracies by comparisons to standards. These inaccuracies were corrected by appropriately adjusting the data at the data processing stage as opposed to adjusting the system electronics. The calibrations before and after each calibration period were used to determine if corrections were required to account for drift or if offset had occurred. No drift corrections were required. The offsets were discussed in the FER response. For corrections that were not constant throughout the range of a given parameter, a calibration table or curve was used to correct the data. Calibration corrections were applied as part of the computer programs used to edit and translate the data from the original raw-data tapes to a master file of hourly values.

2.3.3.2.3 Data Processing and Analysis

For the two years (1974-1976) of onsite FSAR meteorological monitoring at CGS, all data (magnetic tape and strip chart where required) were run through computer edit programs. No data were found to be unreasonable except for known causes as documented in Nonconformance Reports. Data corrections, per the Calibration Reports, were applied in the computer programs. Summarization of data has been accomplished only at such times as calibration information was available to bracket in time the acquired data.

The data for each hour is represented by an average of the data for the last 30 minutes in the hour. The averaging period of 30 minutes was selected for consistency with 1) the data used to formulate the Hanford Diffusion Model used for routine and accident dose calculations, 2) the recommendations in Regulatory Guide 1.23, and 3) computational economy. The only exception was wind direction which was averaged over one-hour to facilitate the formulation of wind direction persistence summaries.

One thirty-minute period per hour is considered adequate for climatological summaries consisting of averages of many hours. In addition, x/Qs based on thirty-minute averages will be conservative for estimates of the one-hour averages. All data products were based on these "hourly" averages.

Wet bulb from the permanent tower was obtained from standard psychrometric formulas presented in the Smithsonian Meteorological Tables, 1971 issue.

The above descriptions relate to data collected and used in FSAR submittals through Amendment #36. Data collection and processing since July 1, 1983 is described in 2.3.3.2.4. The Kennedy Tape Recorder has been replaced with a floppy disk recorder for increased reliability.

In several of the monthly summary reports, the computer programs as applied to dummy data have been compiled as called for in the Quality Assurance Manual (Reference 2.3-23) for the purpose of documenting proper programming and proper computer performance.

These computer computations have been verified with hand calculations made with the dummy data. The computational programs for x/Q were similarly tested.

2.3.3.2.4 Meteorological Monitoring Program During Plant Operation

The meteorological tower, which is located approximately 2500 ft west of the CGS plant site with its base at 455 ft msl consists of a 240-ft high primary tower with a 5-ft mast extending above it. This tower is triangular in shape and of open lattice construction to minimize tower interference with meteorological measurements. Wind and temperature measurements are made at the top of the mast and at the 33-ft elevation by duplicate sets of instruments. One set of instruments is the primary measurement system and the other set constitutes the backup instrumentation. The lower elevation wind speed/direction instruments are mounted on a horizontal boom, extending southwest of the tower.

Wind speed and wind direction measurements are made with a single instrument package that combines a wind speed propeller on the leading (upwind) end of the instrument and a wind direction vane, or tail, on the opposite end. Wind speed measurement range is 0.5 to 90 mph with a threshold sensitivity of about 1 mph. The wind direction measurements are made by the wind passing over the wind vane portion of the instrument. In addition, electronic modules process the data from these instruments and provide output data which is proportional to the standard deviation of the wind direction fluctuations over 15 minutes.

Temperature instrumentation provides measurements of the ambient air temperature at the 245 and 33-ft elevations. Temperature measurements are made in aspirated radiation shields using platinum RTDs. These instruments provide an ambient temperature range from -50°F to +150°F. Each set of RTDs (one from 33 ft level and one from 245 ft level) are calibrated together in the same temperature bath and electronic modules process the data from these instruments to provide a temperature difference range of ±15°F.

The relative humidity is measured at the 33-ft elevation of the tower using an intercap sensor with a range of 0 to 100% RH housed in an aspirated radiation shield. Precipitation is measured at ground level using a tipping bucket rain gauge located about 40-ft west of the main tower. The barometric pressure is measured by a pressure transmitter located inside the

Met Tower building. The Met Tower building provides a semi-controlled environment near the tower to house the instrument electronics. Signal conditioning is provided in the Met Tower by two GE FANUC PLC controllers, one for the primary instrumentation and one for the backup instrumentation. The primary controller feeds data to the Supervisory System and the PDIS via the LAN. The backup controller feeds data only to the PDIS via the LAN. Information will be available to all locations for both the primary and backup instruments on the LAN. The backup system does not provide data for the barometric pressure or the rain gauge. Wind speed, wind direction, temperature, temperature difference and relative humidity signals are averaged by the controllers using a 15 minute time constant device before sending the information to the control room. In the control room are three recorders which record 245-ft and 33-ft wind speed, wind direction, delta temperature, and ambient temperature at 33-ft elevation. The system accuracies for the measured meteorological parameters are demonstrated to meet or exceed the following specifications by performance of instrument loop calibrations:

Air temperature	±0.5°C (±0.9°F)
Temperature difference	±0.2°C (±0.36°F)
Humidity (dew point)	±2.8°C (±5.0°F)
Wind speed	±0.50 mph from 0.5 to 5 mph, ±10% of reading above 5 mph per RG 1.97, Rev. 3.
Wind direction	±5.0°

This data is processed by the Supervisory System which forms the primary communication vehicle for the meteorological system. The supervisory system located at the meteorological tower building and the control room digitizes and multiplexes the data to the control room where it is restored to analog format and sent to recorders and the PPCRS, as required, on a real-time basis. The data input to the supervisory system is 15-minute average analog values. Longer period averages will also be computed for trend analysis and report generation. These data are routed to satisfy display and processing requirements of the onsite technical support centers (TSC) and the emergency operations facility (EOF). The primary meteorological tower data is stored by the plant data acquisition system. Instrument calibrations and maintenance procedures meet the data recovery and system accuracy requirements of Regulatory Guide 1.23 except as noted above.

The Emergency Dose Projection system provides redundant data communication paths with remote access and redundant power sources as required for routine or emergency preparedness support. The near real time access to both the primary and backup meteorology systems, via the supervisory system or the LAN, thus satisfies the emergency preparedness requirements of Regulatory Guide 1.23.

These two systems are designed to meet or exceed data unavailability statements of Regulatory Guide 1.23. If offsite meteorological data is needed, data can be obtained from a network of meteorological towers located on the Hanford Site using methods described in the Emergency

Preparedness Plan. The accuracy, calibration, and reliability of all data not directly controllable by Energy Northwest is determined by the private/governmental controlling agency.

2.3.3.3 Other Meteorological Measurement Programs Considered for the Data Comparisons

2.3.3.3.1 CGS Temporary Tower

A temporary 23-ft onsite tower was used during the period April 1, 1972, through August 31, 1974, to obtain data input for CGS environmental studies and to provide a comparative overlap with the initially measured permanent tower data.

The temporary tower was located in the vicinity of the permanent towers with its base at approximately 448 ft msl. Wind data from the temporary tower were obtained at the 23-ft level while temperature data were acquired at the 3-ft level. Wet bulb data from the temporary tower were established from techniques and data contained in the U.S. Department of Commerce, Weather Bureau Office Document, Relative Humidity and Dewpoint Table. As a special quality assurance program was not initiated for the temporary tower installation, it is not possible to assert that this tower's data complied with the requirements contained in Regulatory Guide 1.23.

2.3.3.3.2 Hanford Meteorological Station

The Hanford Site maintains a network of meteorological towers, which can be accessed for data by telephone or electronic form.

2.3.3.4 Joint Stability - Wind Frequency Summaries

Joint frequencies of wind direction and wind speed by atmospheric stability class (sigma theta by Δt classes), collected at the 33 ft level of the permanent tower during the period from January 1, 1984 to December 31, 1989 are presented in Table 2.3-28.

The sigma theta/Δt stability classification approach (see 2.3.2.1.5) has been used by Battelle to maintain consistency with the longer term HMS data to which existing data is compared and to satisfy the data requirements of the Hanford Diffusion Model (HDM) the HDM requires joint measurements of sigma theta and Δt for the more restrictive stable diffusion cases and utilizes the Sutton method with locally derived parameters for neutral and unstable cases (21). The HDM differs from the standard NRC diffusion models as a result of the incorporation of empirically derived diffusion coefficients based on historical experiments performed at Hanford. As a result of the extensive experimental data that were used in deriving the HDM, it is appropriate to consider this model when performing diffusion analysis at the Hanford Reservation.

In 2.3.2.1, comparisons between measured CGS onsite data and simultaneously recorded and historical HMS data illustrated the following differences between sites:

a. *The CGS site experienced a small air moisture enhancement during the first annual cycle of monitoring. During the second annual cycle, the CGS site experienced air of essentially the same moisture content as did the HMS site.*

b. *The CGS site experiences a biomodal wind direction distribution from approximately south and also northwest. At HMS, the direction distribution displays a single peak at approximately west northwest to northwest.*

c. *The CGS site experiences air of greater thermal stability than does HMS.*

Reasons for these differences were given in 2.3.2.1.

2.3.4 SHORT TERM DIFFUSION ESTIMATES

2.3.4.1 Objective

In this section brief descriptions of the sources, the receptors, and the methodologies used to calculate the air dispersion factors, χ/Q, for the Exclusion Area Boundary (EAB), the Low Population Zone (LPZ), and the control room are presented.

2.3.4.2 Exclusion Area Boundary

The EAB is located at a distance of 1950 m (approximately 1.2 miles) from the site. The χ/Qs were calculated using site-specific meteorological data from 1996 to 1999, (Reference 2.3-38). The Joint Frequency Distributions (JFDs), Table 2.3-28, were used as an input to the computer code PAVAN, (Reference 2.3-25) and the χ/Q results are presented in Table 2.3-37.

The χ/Q values at the EAB are calculated for each hour of data. The cumulative probability distribution of these values are determined for each of the wind direction sectors. Two distributions are calculated, Pasquill-Gifford (P-G) with meander sigmas and desert sigmas (includes meander). The distributions represent the annual probabilities that the given χ/Q values will be exceeded in each wind direction sector at the exclusion area distance. Table 2.3-34 incorporates the P-G meander effect and Table 2.3-33 has desert sigmas. From each of the sixteen sector distributions, the χ/Q value which is exceeded 0.5 percent of the total time was selected. This value was selected based on the percentage of total observations rather than the percentage of observations that the wind direction is within the appropriate sector. These 16 sector χ/Q values are given in Tables 2.3-33 through 2.3-34. The highest of these sixteen values is defined as the maximum sector χ/Q value.

2.3.4.3 Low Population Zone

The LPZ is located at a distance of 4827 m (approximately 3 miles) from the site. The χ/Qs were calculated using site specific meteorological data from 1996 to 1999, (Reference 2.3-38), the JFDs, Table 2.3-28, were used as an input to the computer code PAVAN, (Reference 2.3-25) and the χ/Q results are presented in Table 2.3-37.

The sector χ/Q values at the LPZ have been estimated for various fixed time intervals of a 30-day period. These time intervals are 0 - 2 hours, 2 - 8 hours, 8 - 24 hours, and 1 - 30 days. The estimates for these time periods are made by interpolation on a log-log plot of the two-hour and annual average values as described by Regulatory Guide 1.145. These interpolations are carried out for the value which is exceeded 5 percent of the time, and 0.5 percent of the time. The interpolations are displayed in Tables 2.3-35 (Desert) through 2.3-36 (P-G, meander). For these interpolations the 2-hour values are assumed equivalent to the 1-hour values. These depictions and interpolation schemes are identical to those specified in Regulatory Guide 1.145.

2.3.4.4 Control Room

The control room air dispersion factors χ/Q were calculated using the 1996 to 1999 site-specific hourly meteorological data, (Reference 2.3-37). The meteorological data and the input parameters were used as input to the computer code ARCON96, (Reference 2.3-36), and the χ/Q results are presented in Table 2.3-37.

2.3.4.5 Description of Sources

There are 4 sources at CGS that could release radioactivity to the environment following an accident. These sources are described below:

a. The roofline source is a vent (short stack) on top of the reactor building at a height of 70 m (approximately 229 ft) above the ground through which routine releases take place. Following an accident, the exhaust air from the reactor building passes through the SGT filtration system before exiting through the roofline stack. This source is treated as a ground level point source in the χ/Q calculations.

b. The reactor building railroad bay doors are located at the ground level on the eastside wall of the reactor building. It is assumed that some leakage to the environment takes place through these doors.

c. The reactor building walls from the 606 ft level to the 670 ft level (top of reactor building) are made of metal sheets and therefore they are assumed to be a diffuse source capable of leaking radioactive materials to the atmosphere, this source is also treated as a ground level release source.

d. The Turbine Building Exhaust System (TBES) is a set of four circular vents (short stacks) located on top of the radwaste building roof. Air from the turbine building is exhausted to the atmosphere through these 4 vents.

2.3.4.6 Control Room Intakes

There are three intakes at CGS which draw air into the control room during normal operation as well as post accident. A description of these intakes is given below:

a. Local intake point: The local intake point is a vent located on the west side of the radwaste building wall at an elevation of 527 ft (26.5 m above the ground).

b. Remote intakes: there are two ground level remote intake points which are approximately 180 degrees from each other. One remote intake is located to the north-west side of the turbine building and is labeled remote-1, the other is located to the south-east side of the reactor building and is labeled remote-2.

2.3.4.7 Calculations

Formulations for calculating short term χ/Q values have been developed for licensing of nuclear power plants and are described in Regulatory Guide 1.145, (Reference 2.3-26) "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." For the CGS configuration, it is assumed that accidental releases are made at ground level. This assumption provides a conservative estimate of downwind χ/Q values. NRC code PAVAN (Reference 2.3-25) is used to produce dispersion estimates with the desert sigma option enabled.

Based on the guidance given in Regulatory Guide 1.145 the χ/Q values are calculated using three separate equations. The particular equation which is used depends upon the existing meteorological conditions. The equations are:

(1) $$\chi / Q = \frac{1}{U_{10}(\pi\sigma y\sigma z + A/2)}$$

(2) $$\chi / Q = \frac{1}{U_{10}(3\pi\sigma y\sigma z)}$$

(3) $$\chi / Q = \frac{1}{U_{10}\pi\Sigma y\sigma z}$$

Where χ/Q is relative concentration (sec/m^3)

π is 3.14159

U_{10} is the wind speed at the 10 meter level (m/sec)

σy is the horizontal desert diffusion parameter (m) determined from downwind distance and stability category.

σz is the vertical desert diffusion parameter (m) determined from downwind distance and stability category.

ΣY represents plume meander and building wake effects (m) and is a function of stability category, wind speed, and downwind distance.

A is the smallest vertical plane cross-sectional area of the reactor building (m^2).

During neutral or stable atmospheric stability conditions, the results of all three equations are used to determine dosages. The values from Equations (1) and (2) are compared and the larger is selected. This value is compared with that computed in Equation 3 and the lower value is selected as the appropriate χ/Q value.

During all other meteorological conditions (unstable and/or wind speeds of 6 m/sec or more), only equations (1) and (2) are considered. The appropriate χ/Q value is the larger of the two.

Values of σY and σz, the horizontal and vertical diffusion parameters are taken from Regulatory Guide 1.145 for the applicable stability category and downwind distance. For extremely stable condition (Category G), the following equations are applied:

$$\sigma Y(G) = 2/3\ \sigma Y(F)$$

$$\sigma z(G) = 3/5\ \sigma z(F)$$

2.3.5 LONG-TERM (ROUTINE) DIFFUSION ESTIMATES

2.3.5.1 Objectives

The joint wind direction and wind speed by atmospheric stability class data presented in Subsection 2.3.3 was used to assess annual average normalized concentrations, X/Q, for 16 radial sectors extending from the site boundary to a distance of 50 miles from the source. Tables 2.3-38 provides X/Q and D/Q concentrations for a mix mode release assuming desert *sigmas no decay, no plume depletion, recirculation, and a building wake (building height - 70.4 m). D/Q is normalized deposition.*

2.3.5.2 Calculations

The calculational techniques used are consistent with the guidance provided in Regulatory Guide 1.111 "Methods for Estimating Atmospheric Transport and Dispersions of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors". The joint frequency data presented in Subsection 2.3.3 were used in conjunction with the following equation to obtain X/Q values at appropriate downwind distance in each of the 16 sectors.

$$\frac{X(x,\kappa)}{Q} = \frac{2.032\Sigma_{ij} f_{ij\kappa} \exp\left[{-h_e^2}\Big/{2\sigma_{zj}^2(x)}\right] R_{fx}(x)}{x\overline{u}_i(x)\left[\sigma_{zj}^2(x) + \frac{0.5D^2}{\pi}\right]^{1/2}}$$

Where:

$\frac{X(x,\kappa)}{Q}$ = *average effluent concentration in Ci/m³ normalized by source release rate (Ci/sec) at distance x and direction k.*

x = *downwind distance from release point.*

$\overline{u_i}$ = *midpoint value of ith wind speed class.*

h_e = *effective plume height.*

$\sigma_{zj}(x)$ = *vertical standard desert deviation of effluent spread at distance x for the jth stability class.*

R_{fx} = *factor to account for air recirculation and stagnation.*

f_{ijk} = *joint probability of the ith wind speed class, jth stability, class, and kth wind direction.*

π = *3.1416*

D = *maximum building height of adjacent buildings (D = 70.4 m)*

The building wake correction Equation 1 must not reduce the X/Q estimate by more than a factor of 3 or

$$\left(\sigma^2 xj\ (x) + \frac{0.5D^2}{\pi}\right) 1/2 \leq \left(3\sigma^2 zj(x)\right) 1/2$$

Equation 1 assumes a long-term continuous release whose effluent is distributed evenly across a 22.5° sector. The release was assumed to be ground level (i.e., he = 0 in Equation 1). Computer code X0QD0Q, with the Desert sigma option enabled described in NUREG-0324, was used to make two sets of calculations.

The nearest residences where maximum individual doses with single sector contributions occur at distances of 4.0 miles ENE (Ringold) and 4.2 miles ESE (Taylor Flats) of CGS. The annual average χ/Q values for these locations are calculated in Table 2.3-38c, 38f and 39c, 39f. The Columbia bluffs rise to an elevation of 878 ft just south of Taylor Flat. If it is considered that the low level sigma Z is less than 100 m out to 6 km for the P-G stability classes D-G, which are prevalent most of the winters and that low-level winds deflect either north or south near the bluffs (Reference 2.3-2), it is estimated that the total doses for these locations may be once again as large due to contributions of favorably oriented wind sectors.

The total dose in the channeling area of the Columbia River should include contributions from four other sectors with deflected winds and other channeling effects. The individual doses in that location could be twice as large as for the single sector, constant wind computations. The drift from the cooling towers should remove some of the effluent and deposit it on the site with the salts and counteract the bluff effect. The mechanical draft cooling towers should entrain part of the effluent, lift it with the plume and thus also make the χ/Q values over-predictive. Reasons for these differences were given in Subsection 2.3.2.1.

The results reported by Start and Wendell ("Regional Effluent Dispersion Calculation Considering spatial and Temporal Meteorological Variation," Preprint volume, Symposium on Atmospheric Diffusion and Air Pollution of the American Meteorological Society, September 9-13, 1974) indicate an average value at these distances of about 0.65 and a minimum single point value of about 1.75. If these factors are multiplied by the fraction of plume remaining at the distances in question, about 0.75, to account for the conservatism of the nondepleting model used to arrive at the dose estimates provided in 5.2 of the CGS Environmental Report, it is found that the most critical dose of 9.2 mrem to a child's thyroid (at Taylor Flat) is still within the 10 CFR Part 50 Appendix I design objective limit of 15 mrem. For example, 1.75 x 0.75 x 9.2 = 12.1 mrem. This value would still be conservative because the above recirculation factors do not account for the existence of a bluff line immediately downwind of Taylor Flat which will under the more stable conditions turn the plume before it reaches Taylor Flat. This effect would further reduce the effective recirculation factor.

At the nearest point of the nearest population center, about 9 miles, the average recirculation factor value from Start and Wendell, 1974, appears to be about 0.3 with the maximum single point value about 0.8. In addition to this effect, the effect of topographic channeling has been evaluated by conservatively hypothesizing that under stable conditions that winds blowing anywhere from the east to west (through north) sector might end up in the four sectors containing the majority of the population, SE through WSW (Pasco through Benton City). Including the effects due to channeling results in an estimated maximum factor of approximately 1.6. Applying the factors for recirculation and fraction of plume remaining after deposition results in a maximum effective factor of (1.6 x 0.8 x 0.67 = 0.86) less than one.

It therefore appears reasonable to conclude that the methodology employed to estimate doses is sufficiently conservative for the subject site to ensure that the doses to individuals and the general population have not been substantially underestimated due to the inherent assumptions.

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Table 2.3-1

Averages and Extremes of Climatic Elements at Hanford
(Based on all Available Records to and Including the Year 1980)

TEMPERATURE (°F) — 1912-1980 Averages; 1912-1980 Extremes (Daily Maximum, Daily Minimum)

Month	Daily Maximum	Daily Minimum	Monthly	Highest Monthly	Year	Lowest Monthly	Year	Daily Max: Record Highest	Year	Daily Max: Record Lowest	Year	Daily Min: Record Highest	Year	Daily Min: Record Lowest	Year
Jan	36.6	21.9	29.3	42.5	1953	12.1	1950	72	1971	-2	1950	53	1971	-23	1934
Feb	45.4	27.3	36.3	44.5	1958	21.4	1929	71	1924	-3	1950	55	1932	-23	1950
Mar	56.5	33.7	45.1	49.8	1926	39.4	1955	83	1960	24	1960	54	1942	6	1955
Apr	66.2	40.0	53.1	59.6	1934	47.5	1955	95	1934	41	1945	60	1956	12	1935
May	75.5	47.8	61.7	68.8	1947	56.6	1933	103	1936+	49	1918	70	1956	23	1954
June	83.2	55.3	69.3	75.4	1922	63.0	1953	110	1912	55	1966	81	1924	33	1933
July	91.8	61.0	76.4	81.8	1960	72.4	1963	115	1939	59	1966	82	1925	39	1979
Aug	89.3	59.2	74.3	81.5	1967	69.8	1964	113	1961	63	1920	81	1961+	40	1918
Sept	79.6	50.8	65.2	71.7	1967	58.8	1926	102	1976+	52	1934	72	1955	25	1926
Oct	65.4	40.6	53.0	59.0	1952	48.8	1930	90	1933	31	1935	60	1945+	6	1935
Nov	48.4	31.3	39.8	46.0	1954	31.3	1955	75	1975	14	1955	52	1959+	-1	1955
Dec	39.4	26.0	32.7	38.5	1957	18.5	1919	69	1980	-3	1919	56	1975	-27	1919
Year	64.8	41.2	53.0	81.8	July 1960	12.1	Jan 1950	115	July 1939	-3	Feb 1950+	82	July 1925	-27	Dec 1919

DEGREE DAYS (BASE 65°F) — Heating 1945-1980 Totals; Cooling 1960-1980 Totals

Month	Heating: Mean Monthly	Maximum Monthly	Year	Minimum Monthly	Year	Cooling: Mean Monthly	Maximum Monthly	Year	Minimum Monthly	Year
Jan	1104	1640	1950	694	1953	0	0	------	0	------
Feb	781	1147	1956	576	1958	0	0	------	0	------
Mar	638	794	1955	476	1947	0	0	------	0	------
Apr	381	522	1955	253	1977	2	24	1977	0	1978+
May	156	258	1977	36	1947	43	94	1971	3	1962
June	35	90	1953	3	1938	183	310	1969	57	1980
July	4	22	1955	0	1975+	384	518	1960	232	1963
Aug	6	32	1960	0	1979+	323	508	1967	171	1964
Sept	70	179	1972	10	1979+	102	216	1967	27	1970
Oct	376	479	1946	200	1952	2	10	1971	0	1977+
Nov	758	1008	1955	567	1954	0	0	------	0	------
Dec	990	1224	1964	822	1957	0	0	------	0	------
Year	5299	1640	Jan 1950	0	Aug 1979+	1039	518	July 1960	0	Apr 1978+

PRECIPITATION (INCHES) — 1912-1980 Totals; Snow, Ice Pellets (Sleet)

Month	Mean Monthly	Maximum Monthly	Year	Minimum Monthly	Year	Max. in 24 Hours	Year	Snow: Mean Monthly	Maximum Monthly	Year	Max. in 24 Hours	Year	Maximum Depth	Year
Jan	0.92	2.47	1970	0.08	1977	1.08	1948	5.3	23.4	1950	7.1	1954	12.0	1969
Feb	0.60	3.08	1940	T	1967	1.24	1916	2.3	26.0	1916	18.0	1916	24.5	1916
Mar	0.37	1.86	1957	0	1942+	0.59	1949	0.3	4.2	1951	2.2	1957	2.3	1957
Apr	0.39	1.22	1969	0	1933+	0.58	1980	T	T	1968+	T	1968+	0	------
May	0.48	2.03	1972	0	1931	1.39	1972	T	T	1960	T	1960	0	------
June	0.54	2.92	1950	0	1919	1.50	1934	0	0	------	0	------	0	------
July	0.15	0.81	1966	0	1939+	1.25	1942	0	0	------	0	------	0	------
Aug	0.24	1.36	1977	0	1955+	0.89	1977	0	0	------	0	------	0	------
Sept	0.31	1.34	1947	T	1976+	0.82	1947	0	0	------	0	------	0	------
Oct	0.56	2.72	1957	0	1917+	1.91	1957	T	1.5	1973	1.5	1973	1.5	1973
Nov	0.85	3.05	1926	T	1976+	0.78	1966	1.4	12.7	1955	8.3	1978	9.1	1978
Dec	0.89	2.53	1931	0.11	1976+	1.00	1958	3.9	19.1	1964	5.4	1965	12.1	1964
Year	6.30	3.08	Feb 1940	0	Aug 1955+	1.91	Oct 1957	13.2	26.0	Feb 1916	18.0	Feb 1916	24.5	Feb 1916

WIND (mph) — 1945-1980 Averages; Peak Gusts

Month	Prevailing Direction	Mean Monthly Speeds	Highest Monthly	Year	Lowest Monthly	Year	Peak Gusts: Speed	Direction	Year
Jan	NW	6.4	10.3	1972	3.1	1955	80	SW	1972
Feb	NW	7.1	10.8	1976	4.6	1963	65	SW	1971
Mar	WNW	8.5	10.7	1977+	5.9	1958	70	SW	1956
Apr	WNW	9.0	11.1	1972+	7.4	1958	73	SSW	1972
May	WNW	8.9	10.5	1965+	5.8	1957	71	SSW	1948
June	WNW	9.2	10.7	1949	7.7	1950+	72	SW	1957
July	WNW	8.7	9.6	1963	6.8	1955	69	WSW	1979
Aug	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961
Sept	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953
Oct	WNW	6.6	9.1	1946	4.4	1952	63	SSW	1950
Nov	NW	6.1	8.2	1977	2.9	1956	64	SSW	1949
Dec	NW	6.1	8.3	1968	3.9	1963+	71	SW	1955
Year	WNW	7.7	11.1	Apr 1972+	2.9	Nov 1956	80	SW	Jan 1972

RELATIVE HUMIDITY (%) — 1946-1980 Averages; 1946-1980 Extremes

Month	Mean	Highest Monthly	Year	Lowest Monthly	Year	Highest	Year	Lowest	Year
Jan	76.4	88.8	1960	60.0	1963	100	1980+	13	1963
Feb	70.7	86.9	1963	54.0	1967	100	1980+	14	1962
Mar	55.9	65.9	1950	44.0	1965	100	1979+	12	1965+
Apr	46.9	64.5	1963	36.9	1966	100	1978+	9	1954
May	43.0	61.9	1948	31.2	1966	100	1978+	7	1953
June	39.7	53.5	1950	30.0	1949	100	1977+	10	1964+
July	32.2	40.5	1955	21.9	1959	99	1972	6	1951
Aug	35.6	47.8	1976	24.5	1967	100	1972+	7	1951
Sept	41.6	55.5	1977	33.2	1974	100	1978+	10	1962+
Oct	56.8	74.2	1962	42.5	1952	100	1980+	10	1952+
Nov	73.6	88.7	1979	62.8	1976	100	1980+	16	1976+
Dec	80.0	90.5	1950	69.0	1968	100	1980+	26	1972
Year	54.3	90.5	Dec 1950	21.9	July 1959	100	Dec 1980+	6	July 1951

SKY COVER (SCALE 0-10) — 1946-1980 Averages (Sunrise to Sunset); **SOLAR RADIATION (LANGLEYS)*** — 1953-1980 Averages Daily Totals; 1953-1980 Extreme Daily Totals

Month	Sky: Monthly	Highest Monthly	Year	Lowest Monthly	Year	Solar Avg: Monthly	Highest Monthly	Year	Lowest Monthly	Year	Solar Extreme: Highest Monthly	Year	Lowest Monthly	Year
Jan	7.9	9.2	1978	4.3	1949	116	136	1973	78	1978	277	1969	16	1976+
Feb	7.6	9.3	1980	5.9	1964	194	238	1970	128	1980	422	1958	21	1976
Mar	6.8	8.5	1978	4.9	1965	335	388	1965	293	1978	542	1968	44	1979
Apr	6.4	8.1	1963	3.7	1951	469	535	1973	374	1963	704	1972	75	1974
May	5.9	7.7	1977+	4.5	1945	569	634	1970	472	1980	838	1977	67	1962
June	5.3	7.0	1950	2.8	1961	627	698	1960	537	1980	821	1971	112	1965
July	2.9	4.7	1976	0.9	1953	650	714	1973	588	1955	808	1974	118	1972
Aug	3.4	5.9	1968	0.6	1955	548	613	1955	475	1968	721	1957	107	1959
Sept	4.1	6.7	1978	1.4	1975	415	463	1975	326	1977	591	1970	61	1957
Oct	5.8	8.0	1975	3.9	1952	262	303	1976	216	1975	434	1973	33	1974
Nov	7.7	9.1	1972	6.2	1957	130	180	1957	97	1979+	295	1971	14	1969
Dec	8.1	9.2	1962	6.4	1978	89	116	1970	57	1980+	196	1972	9	1973
Year	6.0	9.3	Feb 1980	0.6	Aug 1955	367	714	July 1973	57	Dec 1980+	838	May 1977	9	Dec 1973

* CALORIES/cm^2
+ALSO ON EARLIER YEARS

EXTREME AVERAGES OR TOTALS AND YEAR OR SEASON OF OCCURRENCE

1912-1980 TEMPERATURE AVERAGES (°F)

HIGHEST ANNUAL	56.2	(1958+)
LOWEST ANNUAL	50.2	(1929)
HIGHEST WINTER (D-J-F)	41.1	(1933-34)
LOWEST WINTER	24.2	(1948-49)
HIGHEST SPRING (M-A-M)	58.2	(1947)
LOWEST SPRING	48.0	(1955)
HIGHEST SUMMER (J-J-A)	78.2	(1958)
LOWEST SUMMER	70.2	(1980)
HIGHEST FALL (S-O-N)	56.6	(1963)
LOWEST FALL	49.5	(1978)

1912-1980 PRECIPITATION TOTALS (IN.)

GREATEST ANNUAL	11.45	(1950)
LEAST ANNUAL	2.99	(1976)
SNOW, ICE PELLETS (SLEET) GREATEST SEASONAL	43.6	(1915-16)
LEAST SEASONAL	0.3	(1957-58)

1945-1980 WIND SPEED AVERAGE (MPH)

HIGHEST ANNUAL	8.3	(1968+)
LOWEST ANNUAL	6.3	(1957)

1945-1980 RELATIVE HUMIDITY AVERAGE (%)

HIGHEST ANNUAL	58.9	(1978)
LOWEST ANNUAL	49.4	(1967)

1945-1980 SKY COVER AVERAGES (SUNRISE TO SUNSET, SCALE 0-10)

HIGHEST ANNUAL	6.6	(1978+)
LEAST ANNUAL	5.1	(1949)

1953-1980 SOLAR RADIATION AVERAGE DAILY TOTAL (LANGLEYS)

HIGHEST ANNUAL	390	(1973)
LOWEST ANNUAL	324	(1980)

Table 2.3-1

Averages and Extremes of Climatic Elements at Hanford (Based on all Available Records to and Including the Year 1980) (Continued)

	NUMBER OF DAYS (1954-1980)										
	CLEAR					PTLY CLDY	CLOUDY				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan	3	7	1963	0	1955+	5	22	28	1978	17	1963
Feb	4	9	1968+	0	1980+	5	19	26	1980+	12	1964
Mar	6	12	1979+	1	1978+	8	17	23	1977	9	1979+
Apr	6	12	1962	1	1963	9	15	21	1979+	6	1956
May	8	14	1973	1	1977	11	12	19	1977+	6	1958
June	10	21	1961	5	1972+	10	10	15	1980+	5	1979+
July	19	26	1960	13	1976+	7	5	12	1976	0	1967
Aug	18	30	1955	9	1978	7	6	13	1968	0	1969+
Sept	15	27	1975	6	1978	7	8	16	1977	1	1975
Oct	10	14	1980+	1	1975	7	14	22	1973	9	1970
Nov	4	10	1957	1	1973+	5	21	25	1973+	15	1961
Dec	3	9	1978	1	1980+	5	23	28	1962	17	1978
Year	106	30	Aug 1955	0	Feb 1980+	86	172	28	Jan 1978+	0	Aug 1969+

	NUMBER OF DAYS (1945–1980) *																			
	THUNDERSTORMS					HEAVY FOG (VIS. 1/4 MI. OR LESS)					PRECIPITATION 0.10 INCH OR MORE					SNOW 1.0 INCH OR MORE				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MONTHLY MEAN	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan	0	0	------	0	------	6	15	1976	0	1949	3	8	1970	0	1977+	2	10	1950	0	1977+
Feb	#	1	1972+	0	1980+	3	11	1963	0	1977	2	5	1980+	0	1979+	1	4	1975+	0	1979+
Mar	#	1	1969+	0	1980+	1	5	1951	0	1980+	2	8	1957	0	1980+	#	2	1957+	0	1980+
Apr	1	3	1979+	0	1977+	#	1	1975+	0	1980+	1	5	1948	0	1977+	0	0	------	0	------
May	2	7	1956	0	1977+	#	1	1958	0	1980+	2	4	1980+	0	1979+	0	0	------	0	------
June	2	8	1972+	0	1963+	#	1	1971	0	1980+	2	8	1950	0	1979+	0	0	------	0	------
July	2	7	1975	0	1973+	0	0	------	0	------	1	3	1974+	0	1980+	0	0	------	0	------
Aug	2	8	1953	0	1974+	#	1	1959	0	1980+	1	4	1976+	0	1980+	0	0	------	0	------
Sept	1	4	1959	0	1976+	#	1	1977	0	1980+	1	5	1977+	0	1978+	0	0	------	0	------
Oct	#	2	1976	0	1980+	1	7	1980	0	1978+	2	8	1950	0	1978+	1	1	1973	0	1980+
Nov	0	0	------	0	------	6	13	1965	0	1960	3	10	1973	0	1976+	1	6	1955	0	1980+
Dec	#	1	1971	0	1980+	8	17	1950	2	1968+	3	9	1964	0	1976+	2	6	1964	0	1976+
Year	10	8	June 1972+	0	------	25	17	Dec 1950	0	------	23	10	Nov 1973	0	Aug 1980+	6	10	Jan 1950	0	------

	NUMBER OF DAYS (1945-1980)										NUMBER OF DAYS (1912 – 1980)				
	3" OR MORE SNOW ON GND.					PEAK GUST 40 MPH OR GREATER					MAX. TEMP 90 OR ABOVE				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan	5	23	1969	0	1977+	3	11	1972	0	1979+	0	0	------	0	------
Feb	3	16	1950	0	1978+	2	10	1976	0	1978+	0	0	------	0	------
Mar	0	0	------	0	------	3	9	1956	0	1978	0	0	------	0	------
Apr	0	0	------	0	------	3	7	1972	0	1979+	#	4	1926	0	1980+
May	0	0	------	0	------	2	6	1971+	0	1977	3	11	1924	0	1980+
June	0	0	------	0	------	2	6	1973	0	1980+	9	20	1940+	0	1980+
July	0	0	------	0	------	1	4	1979+	0	1977+	20	29	1941	8	1963
Aug	0	0	------	0	------	1	5	1951	0	1980+	18	29	1915	7	1948
Sept	0	0	------	0	------	1	4	1946	0	1980+	5	16	1938	0	1977+
Oct	0	0	------	0	------	2	8	1967	0	1979+	#	1	1933	0	1980+
Nov	1	12	1978	0	1980+	2	5	1973+	0	1979+	0	0	------	0	------
Dec	2	14	1955	0	1980+	3	8	1957+	0	1969+	0	0	------	0	------
Year	11	23	Jan 1969	0	------	25	11	Jan 1972	0	------	55	29	July 1941	0	------

	NUMBER OF DAYS (1912 – 1980)																			
	MAX. TEMP 100 OR ABOVE					MAX. TEMP. 32 OR BELOW					MIN. TEMP. 32 OR BELOW					MIN. TEMP 0 OR BELOW				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLYY	YEAR
Jan	0	0	------	0	------	11	30	1979	0	1967+	27	31	1980+	9	1953	2	14	1950	0	1977+
Feb	0	0	------	0	------	3	15	1956	0	1976+	21	28	1944+	5	1958	1	9	1929	0	1980+
Mar	0	0	------	0	------	#	2	1960	0	1980+	15	25	1944+	6	1968+	0	0	------	0	------
Apr	0	0	------	0	------	0	0	------	0	------	5	15	1935	0	1974+	0	0	------	0	------
May	#	1	1966+	0	1980+	0	0	------	0	------	#	3	1938	0	1980+	0	0	------	0	------
June	2	9	1970	0	1980+	0	0	------	0	------	0	0	------	0	------	0	0	------	0	------
July	7	16	1971+	0	1963+	0	0	------	0	------	0	0	------	0	------	0	0	------	0	------
Aug	4	16	1942	0	1980+	0	0	------	0	------	0	0	------	0	------	0	0	------	0	------
Sept	#	2	1955+	0	1980+	0	0	------	0	------	#	4	1933+	0	1980+	0	0	------	0	------
Oct	0	0	------	0	------	#	2	1935	0	1980+	5	12	1916	0	1962+	0	0	------	0	------
Nov	0	0	------	0	------	2	15	1955	0	1976+	17	30	1936	4	1949	#	1	1955+	0	1980+
Dec	0	0	------	0	------	8	19	1914	0	1974+	25	31	1978+	14	1933	1	14	1919	0	1980+
Year	13	16	July 1971+	0	------	24	30	Jan 1979	0	------	115	31	Jan 1980+	0	------	4	14	Jan 1950+	0	------

REFERENCE NOTES

* PRECIPITATION OBSERVATIONS NOT BEGUN UNTIL 1946

\# LESS THAN 1/2

\+ ALSO ON EARLIER YEARS

LOCATION AND HISTORY

PRESENT LOCATION 25 MILES NW OF RICHLAND, WASHINGTON

LATITUDE 46°34'N; LONGITUDE 119°36'W, ELEVATION 733 FEET

OBSERVATIONS FROM 1912 TO 1944 WERE BY UNITED STATES WEATHER BUREAU COOPERATIVE OBSERVERS AT A SITE ABOUT 10 MILES ENE OF PRESENT LOCATION. SINCE 1944, OBSERVATIONS HAVE BEEN MAINTAINED ON A 24 HOUR-A-DAY BASIS BY THREE DIFFERENT DOE CONTRACTORS.

NUMBER OF DAYS

CLEAR (0-3 TENTHS SKY COVER, SR TO SS)		
GREATEST ANNUAL (1954-80)	121	1960
LEAST ANNUAL (1954-80)	80	1977
CLOUDY (9-10 TENTHS SKY COVER, SR TO SS)		
GREATEST ANNUAL (1954-80)	193	1978
LEAST ANNUAL (1954-80)	85	1966
THUNDERSTORMS		
GREATEST ANNUAL (1945-80)	23	1948
LEAST ANNUAL (1945-80)	3	1949
HEAVY FOG (VIS. 1/4 MILE OR LESS)		
GREATEST SEASONAL (1945-80)	42	1950-51
LEAST SEASONAL (1945-80)	9	1948-49
PRECIPITATION 0.10 INCH OR MORE		
GREATEST ANNUAL (1946-80)	39	1950
LEAST ANNUAL (1946-80)	10	1965
SNOW 1.0 INCH OR MORE		
GREATEST SEASONAL (1946-80)	15	1955-56
LEAST SEASONAL (1946-80)	0	1976-77
3 IN. OR MORE SNOW ON GROUND		
GREASTEST SEASONAL (1946-80)	40	1978-79+
LEAST SEASONAL (1946-80)	0	1976-77
PEAK GUST 40 MPH OR GREATER		
GREATEST ANNUAL (1945-80)	41	1961
LEAST ANNUAL (1945-80)	10	1978
MAX. TEMPERATURE 90 OR ABOVE		
GREATEST ANNUAL (1912-80)	85	1940+
LEAST ANNUAL (1912-80)	29	1980
MAX. TEMPERATURE 100 OR ABOVE		
GREATEST ANNUAL (1912-80)	32	1942
LEAST ANNUAL (1912-80)	1	1954
MAX. TEMPERATURE 32 OR BELOW		
GREATEST SEASONAL (1912-80)	53	1955-56
LEAST SEASONAL (1912-80)	1	1937-38
MIN. TEMPERATURE 32 OR BELOW		
GREATEST SEASONAL (1912-80)	141	1916-17
LEAST SEASONAL (1912-80)	75	1957-58
MIN. TEMPERATURE 0 OR BELOW		
GREATEST SEASONAL (1912-80)	18	1949-50
LEAST SEASONAL (1912-80)	0	1976-77

Table 2.3-2

Average Return Period (R) and Existing Record (ER) for Various Precipitation Amounts and Intensity During Specified Time Periods at Hanford
(Based on Extreme Value Analysis of 1947-1969 Records)

	Amount (Inches)							Intensity (Inches per Hour)						
	Time Period							Time Period						
R (YEARS)	20 MIN	60 MIN	2 HRS	3 HRS	6 HRS	12 HRS	24 HRS	20 MIN	60 MIN	2 HRS	3 HRS	6 HRS	12 HRS	24 HRS
2	0.16	0.26	0.30	0.36	0.48	0.62	0.72	0.49	0.26	0.15	0.12	0.08	0.052	0.030
5	0.24	0.40	0.48	0.55	0.77	0.95	1.06	0.72	0.40	0.24	0.18	0.13	0.079	0.044
10	0.37	0.50	0.59	0.67	0.96	1.17	1.28	1.1	0.50	0.30	0.22	0.16	0.098	0.053
25	0.47	0.62	0.74	0.83	1.21	1.45	1.56	1.4	0.62	0.37	0.28	0.20	0.121	0.065
50	0.53	0.72	0.85	0.96	1.40	1.66	1.77	1.6	0.72	0.42	0.32	0.23	0.138	0.074
100	0.60	0.81	0.96	1.07	1.59	1.87	1.99	1.8	0.81	0.48	0.36	0.27	0.156	0.083
250	0.68	0.93	1.11	1.22	1.82	2.13	2.26	2.0	0.93	0.55	0.41	0.30	0.177	0.094
500	0.73	1.02	1.22	1.33	2.00	2.34	2.47	2.2	1.02	0.61	0.44	0.33	0.195	0.103
1000	0.80	1.11	1.33	1.45	2.20	2.55	2.68	2.4	1.11	0.67	0.48	0.37	0.212	0.112

* No records have been kept for time periods of less than 60 minutes. However, the rain gage chart for 6-12-69 shows that 0.55 inch occurred during a 20-minute period from 1835 to 1855 PST. An additional 0.01 inch occurred between 1855 and 1910 to account for the record 60-minute amount of 0.59 inch.

Table 2.3-3

Miscellaneous Snowfall Statistics
(1946 Through 1970)

	Oct	Nov	Dec	Jan	Feb	Mar	Season
Average number of days with depth at 0400 PST							
1" or more	0	1	5	10	5	#	21
3" or more	0	1	2	5	3	0	11
6" or more	0	0	1	3	1	0	5
12" or more	0	0	#	#	0	0	#
Record greatest number of days with depth at 0400 PST							
1" or more	0	(1955) 11	(1964+) 17	(1969) 31	(1950) 17	(1951) 3	(1955-56) 54
3" or more	0	(1955) 10	(1955) 14	(1969) 23	(1950) 16	0	(1949-50) 38
6" or more	0	0	(1964) 12	(1965) 23	(1969+) 8	0	(1949-50) 23
12" or more	0	0	(1964) 4	(1969) 1	0	0	(1964-65) 4
Record greatest depth	(1957) 0.3	(1946) 5.1	(1964) 12.1	(1969) 12.0	(1969) 10.0	(1957) 2.3	(Dec 1964) 12.1
Greatest in 24 hours	(1957) 0.3	(1955) 4.8	(1965) 5.4	(1954) 7.1	(1959) 5.2	(1957+) 2.2	(Jan. 1954) 7.1
Average % of water equivalent of all precipitation	2	14	46	48	29	14	26

( ) Denotes year of occurrence

\+ Denotes also in earlier years

# Denotes less than 1/2 day

Table 2.3-4

Tornado History Within 100 Miles of CGS

Date	Location
June 26, 1916	Walla Walla, Washington
April 15, 1925	Condon, Oregon
September 2, 1936	Walla Walla, Washington
May 20, 1948	Yakima, Washington
May 29, 1948	Yakima, Washington
June 11, 1948	Ephrata, Washington
June 16, 1948	Hanford Reservation
May 9, 1956	Kennewick, Washington
April 12, 1957	Ione, Oregon
April 30, 1957	Yakima, Washington
May 6, 1957	Harrington, Washington
April 24, 1958	Walla Walla, Washington
June 26, 1958	Wallula Junction, Washington
March 14, 1966	Little Goose Dam, Washington

Note: No major damage or loss of life was associated with any of the tornadoes.

Table 2.3-5

Monthly and Annual Prevailing Directions, Average Speeds, and
Peak Gusts: 1945-1970 at HMS
(50 ft level)

Month	Prev Den	Avg Speed	Highest Avg	Year	Lowest Avg	Year	Peak Gust Speed	Peak Gust Den	Peak Gust Year
Jan	NW	6.4	9.6*	1953	3.1	1955	65**	S	1967
Feb	NW	7.0	9.4	1961	4.6	1963	63	SW	1965
Mar	WNW	8.4	10.7	1964	5.9	1958	70	SW	1956
Apr	WNW	9.0	11.1	1959	7.4	1958	60	WSW	1969
May	WNW	8.8	10.5	1965+	5.8	1957	71	SSW	1943
June	WNW	9.2	10.7	1949	7.7	1950+	72	SW	1957
July	WNW	8.6	9.6	1963	6.8	1955	55	WSW	1963
Aug	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961
Sept	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953
Oct	WNW	6.7	9.1	1946	4.4	1952	63	SSW	1950
Nov	NW	6.2	7.9	1945	2.9	1956	64	SSW	1949
Dec	NW	6.0	8.3	1968	3.9	1963+	71	SW	1955
Year	WNW	7.6	8.3	1968+	6.3	1957	72**	SW	June 1957

* The average speed for January, 1972, was 10.3 mph

** On January 11, 1972, a new all-time record peak gust of 80 mph was established

Table 2.3-6

Speed and Direction of Daily Peak Gusts*

Direction	Speed Class (mph)									Extreme High and Date of Occurrence **	
	Under 10	10-19	20-29	30-39	40-49	50-59	60-69	70 or over	Total	mph	Date
NNE	0.2	0.8	1.3	0.2	0.1	0	0	0	2.6	47	Feb. 5, 1948
NE	0.3	1.0	1.0	0.2	0	0	0	0	2.5	38	July 10, 1951
ENE	0.2	0.6	0.3	0.1	0	0	0	0	1.2	37	May 27, 1947
E	0.2	0.7	0.2	0.1	#	0	0	0	1.2	44	June 11, 1950
ESE	0.1	0.4	0.1	0	0	0	0	0	0.6	26	June 2, 1958
SE	0.7	2.0	0.4	#	#	#	0	0	3.1	53	Aug. 29, 1947
SSE	0.7	1.8	0.5	0.1	0.1	#	0	0	3.2	52	Dec. 4, 1952
S	0.3	0.8	1.0	0.7	0.3	0.2	#	0	3.3	58	Dec. 23, 1957
SSW	0.1	0.9	1.5	1.4	0.8	0.4	0.1	#	5.2	71	May 26, 1948
SW	0.2	0.7	3.6	3.4	1.7	0.4	0.1	0.1	10.2	72	June 5, 1957
WSW	0.2	1.5	2.7	2.4	1.1	0.2	0	0	8.1	58	Nov. 3, 1958 L
W	0.3	2.2	2.1	1.0	0.3	#	0	0	5.9	52	Nov. 4, 1958 L
WNW	1.0	9.6	8.0	5.4	0.6	#	0	0	24.6	50	July 19, 1953
NW	1.5	9.6	6.8	5.1	0.8	0	0	0	23.8	49	April 6, 1952

Table 2.3-6

Speed and Direction of Daily Peak Gusts* (Continued)

Direction	Speed Class (mph) Under 10	10-19	20-29	30-39	40-49	50-59	60-69	70 or over	Total	Extreme High and Date of Occurrence ** mph	Date
NNW	0.4	0.8	0.3	#	0	0	0	0	1.5	38	May 8, 1955
N	0.2	1.1	1.4	0.2	0.1	0	0	0	3.0	46	Aug. 27, 1951
Summary	6.6	34.5	31.2	20.3	5.9	1.2	0.2	0.1	100.0	---	---

* Based on 12 years of observations (1947–58). Tabular values under speed classes denote percent of all daily observations made during the period.

L Denotes the latest of several occurrences.

# Denotes less than .05%.

** A new record was set on January 11, 1972, when a peak gust of 80 mph was recorded at the 50 foot level at the Hanford Meteorology Station. Reference Document BNWL-1640 “The Hanford Wind Storm of January 11, 1972.” dated February 1972, issued by Battelle Pacific Northwest Laboratories.

Table 2.3-7a

CGS and HMS Hourly Meteorological Data, August 7-9, 1972 (Ultimate Heat Sink Studies)

Day/Hour	CGS Site Wind Direction (degrees)	CGS Site Wind Speed (mph)	CGS Site Dry Bulb (°F)	CGS Site Relative Humidity (percent)	CGS Site Wet Bulb (°F)	HMS Tower Site Wind Direction (degrees)	HMS Tower Site Wind Speed (mph)	HMS Tower Site Dry Bulb (°F)	HMS Tower Site Wet Bulb (°F)
Elevation	23 feet	23 feet	3 feet	3 feet	3 feet	50 feet	7 feet	7 feet	7 feet
7/1	30	5	76	35	60	220	6	78	57
7/2	50	5	72	36	58	270	6	76	56
7/3	160	5	71	44	59	300	5	78	57
7/4	80	5	69	48	58	270	5	74	54
7/5	50	5	65	51	55	180	4	72	55
7/6	70	4	61	64	54	110	2	67	53
7/7	100	5	61	64	54	300	1	76	57
7/8	70	4	59	68	53	320	5	81	60
7/9	70	4	67	66	59	320	3	85	61
7/10	100	5	77	54	65	Variable	1	92	64
7/11	130	5	85	46	69	40	3	93	64
7/12	140	5	91	38	71	Variable	3	98	66
7/13	360	6	96	35	73	90	5	102	68
7/14	80	8	99	32	74	110	5	104	68
7/15	110	8	102	30	76	90	4	105	69
7/16	110	9	106	28	77	Variable	4	107	69
7/17	90	9	107	25	77	90	8	108	69
7/18	60	9	108	24	77	90	8	106	68
7/19	50	12	106	23	75	110	7	103	67
7/20	50	12	106	23	75	90	8	97	64
7/21	40	8	103	22	73	130	7	90	62
7/22	60	6	96	22	69	220	6	84	60
7/23	100	5	89	26	66	300	8	82	58
7/24	30	4	85	34	66	270	5	81	58
8/1	360	6	79	36	63	270	4	78	57
8/2	130	5	72	39	58	270	4	77	57
8/3	40	5	70	42	58	200	4	78	57
8/4	20	7	71	46	59	240	1	71	53
8/5	40	6	71	46	59	200	4	70	53
8/6	80	5	67	46	56	300	5	69	53
8/7	100	5	65	52	55	320	5	79	60
8/8	140	4	62	54	53	20	3	85	63
8/9	130	5	67	56	57	140	2	87	63
8/10	130	5	77	53	64	110	3	91	65
8/11	120	7	85	46	69	110	4	93	65
8/12	70	7	90	40	71	60	4	97	67
8/13	70	6	95	37	73	90	4	103	69
8/14	40	6	98	34	74	90	4	104	69
8/15	60	7	101	32	76	130	4	106	70
8/16	70	7	104	30	77	110	6	108	70
8/17	30	8	106	28	77	220	10	108	70
8/18	30	8	108	27	78	270	16	106	68
8/19	90	8	106	26	77	300	20	102	70
8/20	110	8	106	25	76	300	21	96	66
8/21	320	19	108	26	78	300	21	91	66
8/22	320	21	100	26	73	300	22	90	63
8/23	320	15	95	28	71	300	16	87	64
8/24	320	15	91	28	68	270	16	85	63
9/1	320	17	90	32	69	270	9	83	63
9/2	320	10	89	32	68	240	6	82	61
9/3	180	7	84	34	65	300	7	78	60
9/4	Variable	5	77	35	61	240	6	80	62
9/5	150	6	72	46	60	270	11	82	63
9/6	140	5	70	54	59	240	10	82	63
9/7	160	5	71	57	61	240	8	82	63
9/8	200	7	68	58	59	220	6	87	65
9/9	190	7	73	60	63	240	10	89	65
9/10	200	8	81	56	68	320	9	94	65
9/11	180	6	89	50	72	320	6	96	66
9/12	170	5	94	44	74	220	5	99	67
9/13	190	7	98	38	76	220	10	101	68
9/14	200	10	100	34	76	220	15	101	67
9/15	160	8	100	30	74	220	15	101	67
9/16	300	13	102	30	76	240	13	103	68
9/17	250	13	104	28	76	300	16	102	68
9/18	300	17	104	26	75	300	20	97	67
9/19	310	14	104	27	76	300	20	93	65
9/20	320	20	102	26	74	300	17	88	63
9/21	320	22	96	27	71	300	16	83	61
9/22	320	17	93	29	70	300	18	80	60
9/23	320	13	87	30	66	300	19	79	60
9/24	320	16	84	30	64	300	14	78	60

Table 2.3-7b

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
4/1	3.56	66.13	53.17	58.41
4/2	3.66	64.91	54.85	58.86
4/3	1.71	64.16	53.92	58.07
4/4	4.88	62.69	53.41	57.22
4/5	2.96	61.87	53.57	56.99
4/6	2.76	65.60	55.20	59.30
4/7	5.21	72.51	55.95	62.22
4/8	3.33	77.12	54.84	63.26
4/9	6.02	81.71	55.52	65.16
4/10	5.97	83.95	57.71	67.00
4/11	12.36	90.00	55.57	67.88
4/12	9.67	94.48	57.09	69.99
4/13	9.55	97.15	57.97	71.21
4/14	8.89	99.57	58.00	71.93
4/15	6.28	102.37	56.77	72.17
4/16	5.85	103.49	54.77	71.63
4/17	6.13	104.27	52.40	70.88
4/18	3.55	104.77	51.20	70.56
4/19	3.41	103.68	49.57	69.61
4/20	5.64	95.64	59.28	71.39
4/21	3.88	91.49	57.55	69.30
4/22	3.61	86.72	56.56	67.32
4/23	3.97	83.92	58.68	67.50
4/24	4.81	79.60	57.84	65.66
5/1	4.96	76.83	57.17	64.37
5/2	3.90	74.83	55.47	62.79
5/3	3.30	71.68	55.41	61.64
5/4	6.61	70.93	54.56	60.92
5/5	6.06	71.15	55.57	61.54
5/6	5.00	72.99	55.89	62.36
5/7	5.28	77.84	57.41	64.84
5/8	2.94	81.95	58.51	66.78
5/9	4.87	87.01	57.89	68.07
5/10	8.24	92.11	56.24	68.85
5/11	5.82	96.69	54.80	69.61
5/12	5.69	98.96	57.68	71.60
5/13	6.13	100.80	60.27	73.36
5/14	4.74	103.79	54.99	71.81
5/15	7.52	105.36	54.77	72.18
5/16	6.43	105.81	55.09	72.44
5/17	4.65	104.53	53.25	71.31
5/18	6.93	103.48	52.80	70.80
5/19	6.48	101.04	57.15	71.97
5/20	6.79	96.64	57.79	70.97
5/21	5.25	93.63	57.23	69.80
5/22	6.05	89.23	56.43	68.05
5/23	3.95	87.41	57.25	67.88
5/24	6.34	83.80	58.84	67.55
6/1	2.68	81.71	59.17	67.05
6/2	6.15	79.55	59.15	66.33
6/3	4.87	76.13	59.73	65.54
6/4	6.08	73.41	59.47	64.49
6/5	5.55	72.83	59.39	64.24
6/6	2.14	74.56	61.28	65.91
6/7	2.35	80.99	63.33	69.16
6/8	4.21	85.01	61.95	69.61
6/9	2.96	86.61	63.65	71.04
6/10	5.10	89.49	61.49	70.70
6/11	13.07	86.75	62.85	70.63
6/12	12.58	83.84	63.47	70.10
6/13	6.00	87.87	60.85	69.87
6/14	4.56	88.69	61.47	70.45
6/15	5.09	91.49	60.59	70.83
6/16	6.27	94.56	59.57	71.21
6/17	9.89	92.59	60.03	70.87

Table 2.3-7c

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)*
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
6/18	7.70	93.44	59.81	71.00
6/19	3.03	92.59	59.17	70.43
6/20	5.58	90.53	59.57	70.02
6/21	12.41	87.60	60.93	69.83
6/22	8.22	82.43	58.69	67.03
6/23	3.64	79.72	56.40	64.94
6/24	3.82	79.49	55.65	64.48
7/1	8.39	75.23	54.69	62.52
7/2	7.41	73.55	54.69	61.94
7/3	8.64	72.88	53.95	61.31
7/4	7.31	72.67	53.68	61.10
7/5	7.31	71.28	53.36	60.43
7/6	8.75	74.37	55.44	62.61
7/7	10.86	76.77	57.23	64.38
7/8	8.77	79.63	58.96	66.26
7/9	10.34	83.07	59.71	67.77
7/10	12.46	86.32	60.35	69.13
7/11	9.95	89.15	61.49	70.60
7/12	10.70	90.61	60.37	70.45
7/13	6.33	92.80	59.71	70.76
7/14	3.98	95.65	59.57	71.53
7/15	8.95	95.01	58.67	70.90
7/16	12.70	96.85	59.31	71.76
7/17	5.17	96.51	59.49	71.75
7/18	3.60	97.15	58.72	71.56
7/19	8.61	96.40	57.76	70.88
7/20	5.68	91.52	58.85	69.94
7/21	4.75	86.08	61.33	69.58
7/22	4.06	84.35	55.89	66.22
7/23	8.93	81.39	59.31	67.02
7/24	16.32	81.47	60.35	67.62
8/1	10.89	80.08	58.21	66.01
8/2	10.13	79.65	56.69	65.07
8/3	11.19	78.05	55.33	63.83
8/4	9.25	76.72	54.43	62.91
8/5	8.42	74.67	54.53	62.25
8/6	8.80	76.45	55.55	63.40
8/7	14.06	79.23	56.88	65.03
8/8	13.55	80.37	57.60	65.79
8/9	M	M	M	M
8/10	M	M	M	M
8/11	M	M	M	M
8/12	M	M	M	M
8/13	M	M	M	M
8/14	M	M	M	M
8/15	M	M	M	M
8/16	5.38	101.23	59.09	72.92
8/17	5.44	102.03	58.00	72.64
8/18	3.66	102.16	56.56	72.02
8/19	3.50	100.85	55.28	71.07
8/20	6.68	97.09	56.61	70.54
8/21	7.28	92.64	56.40	69.09
8/22	9.70	89.25	55.25	67.49
8/23	9.48	87.49	53.71	66.21
8/24	6.22	83.73	54.29	65.24

*M – Missing data

Table 2.3-7d

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)*
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
9/1	7.99	81.52	55.81	65.25
9/2	5.26	79.12	56.45	64.76
9/3	3.95	74.91	58.32	64.35
9/4	4.58	73.12	58.69	63.94
9/5	3.78	72.37	57.92	63.25
9/6	4.00	75.28	59.49	65.12
9/7	4.67	79.79	60.16	66.98
9/8	9.88	83.38	60.06	68.06
9/9	12.03	85.49	60.00	68.69
9/10	10.18	88.13	61.28	70.18
9/11	8.76	92.13	62.85	72.20
9/12	5.78	95.52	64.40	74.02
9/13	7.10	99.49	63.17	74.46
9/14	4.77	102.61	62.72	75.01
9/15	5.17	106.40	58.77	74.23
9/16	5.12	108.03	55.28	73.15
9/17	3.24	109.47	55.49	73.65
9/18	6.10	109.15	53.07	72.58
9/19	6.18	107.44	52.35	71.79
9/20	7.80	101.47	57.87	72.42
9/21	13.30	99.31	53.15	69.69
9/22	25.82	94.16	61.36	72.01
9/23	17.04	94.61	59.49	71.19
9/24	11.05	92.37	57.57	69.58
10/1	8.36	90.91	58.03	69.35
10/2	12.16	85.92	59.17	68.39
10/3	9.19	84.24	57.28	66.88
10/4	5.08	80.61	56.21	65.14
10/5	1.56	80.24	58.48	66.21
10/6	6.53	78.27	59.55	66.15
10/7	7.10	83.25	62.99	69.65
10/8	4.15	86.77	62.91	70.67
10/9	3.89	90.64	61.09	70.83
10/10	5.12	92.64	62.00	71.90
10/11	3.77	95.23	63.36	73.38
10/12	5.74	98.32	62.40	73.73
10/13	5.89	100.91	59.41	72.98
10/14	5.27	103.09	59.39	73.58
10/15	5.30	105.20	58.91	73.96
10/16	5.90	105.71	56.00	72.80
10/17	9.37	104.93	54.11	71.78
10/18	12.21	102.48	55.88	71.81
10/19	8.55	101.15	56.05	71.50
10/20	5.54	98.27	56.13	70.68
10/21	4.26	96.21	56.59	70.27
10/22	3.14	90.72	60.53	70.57
10/23	7.36	91.33	57.68	69.31
10/24	12.76	91.49	60.48	70.77
11/1	7.86	89.61	61.65	70.83
11/2	12.03	86.81	62.03	70.20
11/3	14.22	88.56	61.48	70.42
11/4	6.62	87.60	59.81	69.25
11/5	8.70	85.47	60.11	68.74
11/6	7.13	85.28	60.37	68.82
11/7	12.45	82.37	61.23	68.39
11/8	M	M	M	M
11/9	10.14	83.96	62.40	69.53
11/10	12.86	83.57	62.53	69.49
11/11	14.68	82.51	63.97	70.00

*M – Missing data

Table 2.3-7e

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)*
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
11/12	13.48	84.13	64.96	71.06
11/13	11.16	87.73	62.91	70.96
11/14	11.36	87.76	63.12	71.08
11/15	8.17	89.92	61.81	71.00
11/16	4.60	94.72	59.97	71.46
11/17	4.39	96.19	59.89	71.85
11/18	4.27	96.16	58.85	71.33
11/19	11.57	89.28	64.05	72.05
11/20	9.70	84.99	61.07	69.10
11/21	8.24	83.01	60.69	68.28
11/22	6.89	82.00	61.09	68.20
11/23	10.12	81.97	59.39	67.25
11/24	10.69	78.83	57.81	65.38
12/1	10.37	77.65	57.01	64.57
12/2	7.69	76.64	56.85	64.14
12/3	3.17	75.87	56.32	63.59
12/4	2.34	75.71	56.99	63.89
12/5	5.74	73.92	58.64	64.18
12/6	6.75	70.51	56.51	61.81
12/7	6.57	73.07	57.71	63.38
12/8	4.62	76.88	59.63	65.73
12/9	4.23	79.71	60.93	67.38
12/10	4.51	82.69	61.44	68.61
12/11	5.53	84.13	61.01	68.81
12/12	5.53	86.43	61.65	69.86
12/13	5.93	88.75	62.40	70.98
12/14	6.81	90.69	62.93	71.85
12/15	10.87	91.31	61.73	71.37
12/16	12.07	87.20	60.19	69.32
12/17	15.02	86.96	62.24	70.36
12/18	12.21	87.39	61.36	70.00
12/19	15.39	83.63	62.45	69.46
12/20	13.48	81.47	60.80	67.87
12/21	8.45	81.76	58.77	66.86
12/22	7.23	81.36	54.43	64.51
12/23	9.74	79.41	44.32	59.39
12/24	5.68	77.73	43.97	58.63

Table 2.3-7f

24 Hour HMS Meteorological Profile for August 4, 1961

Hour	Dry Bulb Temp °F	Wet Bulb Temp °F	Dew Pt °F	Wind (mph) °F
0	82.0	61.0	45.0	4
1	84.0	62.0	46.0	5
2	86.0	63.0	48.0	5
3	85.0	63.0	49.0	5
4	85.0	63.0	48.0	5
5	85.0	62.0	46.0	3
6	86.0	61.0	43.0	8
7	91.0	63.0	42.0	7
8	92.0	63.0	42.0	6
9	96.0	64.0	41.0	6
10	99.0	65.0	42.0	7
11	103.0	67.0	44.0	6
12	107.0	69.0	45.0	6
13	110.0	70.0	46.0	5
14	112.0	71.0	48.0	6
15	112.0	71.0	48.0	5
16	113.0	72.0	49.0	5
17	110.0	70.0	45.0	8
18	108.0	68.0	43.0	14
19	100.0	66.0	45.0	19
20	98.0	66.0	45.0	20
21	96.0	66.0	46.0	18
22	94.0	65.0	46.0	16
23	93.0	64.0	45.0	12

24 Hour Average:

Dry Bulb = 96.96 °F
Wet Bulb = 65.62 °F
Dew Point = 45.29 °F
Wind = 8.37 mph

Table 2.3-7g

Diurnal Variation in Dry Bulb and Wet Bulb Temperature for Use in Analyzing Second Through Thirtieth Day Pond Thermal Performance (Based On July 9 - August 8, 1961 Hourly Hanford Meteorological Station Data)

Hour	Dry Bulb (°F)	Wet Bulb (°F)
1	70.2	56.5
2	68.8	56.0
3	68.3	55.8
4	68.8	56.0
5	70.2	56.5
6	72.5	57.3
7	75.6	58.4
8	79.0	59.6
9	82.8	61.0
10	86.6	62.3
11	90.1	63.6
12	93.1	64.7
13	95.4	65.5
14	96.8	66.0
15	97.3	66.2
16	96.8	66.0
17	95.4	65.5
18	93.1	64.7
19	90.1	63.6
20	86.6	62.3
21	82.8	61.0
22	79.0	59.6
23	75.6	58.4
24	72.5	57.3
Daily Average and Variation	82.8 ± 14.5°F	61.0 ± 5.2°F

Table 2.3-7h

Diurnal Variation in Dry Bulb and Wet Bulb Temperature for Use in Analyzing First Through Thirtieth Day Maximum Mass Loss (Based On July 2 - August 1, 1960 Hourly Hanford Meteorological Station Data)

Hour	Dry Bulb (°F)	Wet Bulb (°F)
1	69.4	53.3
2	67.8	52.6
3	67.3	52.4
4	67.8	52.6
5	69.4	53.3
6	71.9	54.3
7	75.1	55.7
8	78.9	57.3
9	82.9	59.0
10	86.9	60.7
11	90.7	62.3
12	93.9	63.7
13	96.4	64.7
14	98.0	65.4
15	98.5	65.6
16	98.0	65.4
17	96.4	64.7
18	93.9	63.7
19	90.7	62.3
20	86.9	60.7
21	82.9	59.0
22	78.9	57.3
23	75.1	55.7
24	71.9	54.3
Daily Average and Variation	82.9 ± 15.6°F	59.0 ± 6.6°F

Table 2.3-8a

Summary of CGS Onsite Meteorological Data Collected During the First and Second Annual Cycles as Compared to Corresponding Hanford Meteorological Station Data (Historical HMS Data Indicated for Each Month)

		April '74	April '75	May '74	May '75	June '74	June '75	July '74	July '75	August '74	August '75	September '74	September '75	October '74	October '75
	Site and Sensor Elevation														
1.	Prevailing Wind Direction														
	CGS 33'	WNW	SSW	SSW	NW	WNW	NW	S	S	S	S	N	N	WNW	S
	HMS 50'	WNW	N/A	WNW	N/A	WNW	N/A	WNW	N/A	WNW	N/A	NW	N/A	NW	NW
	HMS (hist) 50' (1955-1970)	WNW		WNW		WNW		WNW		WNW		NW		WNW	
2.	Mean Wind Speed (mph)														
	CGS 33'	9.8	8.0	8.4	8.7	8.5	9.3	7.2	7.6	6.8	7.9	6.5	5.7	4.8	7.2
	HMS 50'	10.3	9.0	9.0	9.6	9.0	10.5	8.1	8.5	7.5	9.0	7.1	6.8	5.6	7.1
	HMS (hist) 50' (1955-1970)	9.0		8.8		9.2		8.6		8.0		7.5		6.7	
3.	Mean Dry Bulb Temp. (°F)														
	CGS 33'	52.2	47.6	57.4	59.6	72.5	66.1	73.6	78.7	74.7	70.3	66.9	66.2	51.7	52.1
	HMS 3'	52.5	48.4	57.9	60.7	73.3	67.3	74.8	80.0	76.3	71.2	68.3	67.9	52.0	52.3
	HMS (hist) 3' (1950-1970)	52.5		61.8		69.9		77.5		75.3		67.0		53.2	
4.	Mean Wet Bulb Temp. (°F)														
	CGS 33'	44.7	39.7	47.2	48.2	56.0	52.7	57.4	61.5	58.0	55.7	52.6	52.0	43.8	45.3
	HMS 3'	43.9	40.0	46.5	49.0	54.5	54.0	56.3	62.0	57.0	56.0	52.0	52.0	42.0	45.0
	HMS (hist) 3' (1950-1970)	42.8		49.1		54.5		57.9		57.3		52.6		45.4	
5.	Mean Dew Point Temp. (°F)														
	CGS 33'	36.6	29.8	36.6	36.9	43.0	40.8	44.9	50.2	45.6	44.2	39.9	39.5	35.0	38.2
	HMS 3'	33.3	30.0	34.0	38.6	38.2	42.4	41.0	50.1	43.2	44.6	38.9	38.2	31.0	37.2
	HMS (hist) 3' (1950-1970)	30.4		36.0		41.2		42.3		42.8		39.5		36.9	
6.	Total Precipitation (inches)														
	CGS	.55	.53	.44	.47	.06	.46	.45	.09	0.0	1.17	.06	0.0	.10	.74
	HMS	.46	.42	.28	.38	.12	.14	.71	.32	Trace	1.16	.01	.03	.21	.87
	HMS (hist) 1946-1970 Mean Total	.44		.50		.66		.16		.21		.30		.61	

N/A - Not Available

Table 2.3-8a

Summary of CGS Onsite Meteorological Data Collected During the First and Second Annual Cycles as Compared to Corresponding Hanford Meteorological Station Data (Historical HMS Data Indicated for Each Month) (Continued)

Site and Sensor Elevation		November '74	November '75	December '74	December '75	January '75	January '76	February '75	February '76	March '75	March '76	First Annual Cycle April '74– March '75	Second Annual Cycle April '75– March '76
1. Prevailing Wind Direction													
CGS	33'	SSW	S	S	NW	NNW	NW	NW	SSW	NNW	SSW	NW	NW
HMS	50'	NW	NW	NW	NW	NW SW	NW	NW	NW SW	WNW	NW SW	N/A	N/A
HMS (hist) 50' (1955-1970)		NW		NW		NW		NW		WNW		NW ('55 –'70)	
2. Mean Wind Speed (mph)													
CGS	33'	5.8	7.8	6.4	7.1	6.4	5.0	7.8	10.4	8.7	9.1	7.2	7.8
HMS	50'	5.5	7.7	5.9	7.2	6.4	4.9	7.5	10.8	8.9	9.6	9.1	10.1
HMS (hist) 50' (1955-1970)		6.2		6.0		6.4		7.0		8.4		7.6 ('55 – '70)	
3. Mean Dry Bulb Temp. (°F)													
CGS	33'	42.1	39.5	36.8	34.2	32.3	32.4	33.8	37.7	41.9	40.8	53.1	52.1
HMS	3'	42.1	39.3	35.7	34.5	32.0	31.5	33.6	37.3	42.0	40.6	53.4	52.6
HMS (hist) 3' (1950-1970)		40.1		33.4		30.3		37.5		44.0		53.5 ('50 – '70)	
4. Mean Wet Bulb Temp. (°F)													
CGS	33'	39.3	35.5	34.5	31.9	30.0	30.6	30.9	32.9	36.2	34.4	44.3	43.4
HMS	3'	38.0	35.0	33.0	32.0	30.0	30.0	31.0	33.0	36.0	35.0	43.4	43.6
HMS (hist) 3' (1950-1970)		36.4		31.2		27.9		33.6		37.3		43.8 ('50 – '70)	
5. Mean Dew Point Temp. (°F)													
CGS	33'	36.3	30.6	31.4	28.9	26.3	28.1	26.5	25.4	27.9	24.8	35.9	34.8
HMS	3'	33.9	30.0	29.2	28.1	26.0	27.6	25.5	25.5	26.0	25.0	33.4	34.8
HMS (hist) 3' (1950-1970)		31.1		27.5		23.2		27.4		27.3		33.8 ('50 – '70)	
6. Total Precipitation (inches)													
CGS		.56	.70	.67	.03	.93	.08	.67	.11	.52	.16	4.92	4.54
HMS		.71	.60	.97	.70	1.43	.56	.98	.36	.33	.23	6.21	5.87
HMS (hist) 1946-1970 Mean Total		.80		.81		.97		.58		.38		6.53 ('46 – '70)	

N/A - Not Available

Table 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975)

APRIL
SPEED CLASS (MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	5	8	6	0	0	0	0	19
NE	0	2	15	4	0	0	0	1	22
ENE	0	1	2	0	0	0	0	0	3
E	0	3	3	0	0	0	0	0	6
ESE	0	6	4	1	0	0	0	0	11
SE	0	4	12	6	1	0	0	0	23
SSE	0	4	26	21	0	0	0	3	54
S	0	8	18	19	12	0	0	7	64
SSW	0	4	16	29	30	2	0	13	94
SW	0	4	18	9	15	4	0	6	56
WSW	0	3	10	12	5	3	1	7	41
W	0	3	14	16	17	4	1	8	63
WNW	0	7	19	26	40	21	8	2	123
NW	0	5	23	15	9	11	3	1	67
NNW	0	5	17	5	1	0	0	2	30
N	0	3	14	5	1	0	0	0	23
VAR	0	2	5	0	0	0	0	0	7
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	14	14
TOTAL	0	69	224	176	131	45	13	64	720

MAY
SPEED CLASS (MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	5	11	0	0	0	0	0	16
NE	0	7	3	3	0	0	0	0	13
ENE	0	1	6	2	0	0	0	0	9
E	0	8	6	0	0	0	0	0	14
ESE	0	6	9	0	0	0	0	0	15
SE	0	1	16	1	0	0	0	0	18
SSE	0	9	38	13	0	0	0	0	60
S	0	10	27	45	10	0	0	0	92
SSW	0	5	30	49	16	4	2	0	106
SW	0	3	15	18	13	3	0	0	52
WSW	0	6	19	30	13	1	0	0	69
W	0	3	23	35	13	5	0	0	79
WNW	0	11	24	34	17	10	0	0	96
NW	0	4	14	10	13	4	2	0	47
NNW	0	3	13	7	0	0	0	0	23
N	0	4	7	1	0	0	0	0	12
VAR	0	7	8	0	0	0	0	0	15
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	8	8
TOTAL	0	93	269	248	95	27	4	8	744

JUNE
SPEED CLASS (MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	5	12	1	0	0	0	0	18
NE	0	7	9	4	0	0	0	1	21
ENE	0	6	16	9	0	0	0	0	31
E	0	3	14	7	0	0	0	0	24
ESE	0	4	16	6	0	0	0	0	26
SE	0	4	23	10	0	0	0	0	37
SSE	0	7	34	11	0	0	0	0	52
S	0	4	20	18	10	2	0	1	55
SSW	0	6	20	12	12	1	0	0	51
SW	0	3	11	6	4	5	0	0	29
WSW	0	3	15	5	3	1	1	0	28
W	0	2	18	14	13	2	3	0	52
WNW	0	2	24	19	10	10	2	0	67
NW	0	3	15	20	8	5	2	0	53
NNW	0	6	17	3	0	0	0	0	26
N	0	6	11	1	0	0	0	0	18
VAR	0	0	4	0	1	0	0	0	5
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	10	38	26	9	0	0	44	127
TOTAL	0	81	317	172	70	26	8	46	720

Table 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975) (Continued)

JULY
SPEED CLASS (MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	3	13	2	0	0	0	0	18
NE	0	11	12	1	0	0	0	0	24
ENE	0	3	9	6	0	0	0	0	18
E	0	10	14	6	0	0	0	0	30
ESE	0	6	18	1	0	0	0	0	25
SE	0	10	26	4	0	0	0	0	40
SSE	0	3	37	16	1	0	0	0	57
S	0	6	27	32	5	0	0	0	70
SSW	0	9	16	18	9	2	0	0	54
SW	0	7	22	14	6	0	1	0	50
WSW	0	6	12	11	3	1	2	0	35
W	0	7	14	19	9	0	0	0	49
WNW	0	5	18	18	17	5	0	0	63
NW	0	11	18	21	13	4	0	0	67
NNW	0	10	25	4	2	0	0	0	41
N	0	8	22	5	0	0	0	0	35
VAR	0	5	24	3	0	0	0	0	32
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	36	36
TOTAL	0	120	327	181	65	12	3	36	744

AUGUST
SPEED CLASS (MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	16	21	11	0	0	0	0	48
NE	0	12	19	6	3	2	0	0	42
ENE	0	9	6	0	0	0	0	0	15
E	0	10	4	4	0	0	0	0	18
ESE	0	12	9	0	0	0	0	0	21
SE	0	6	25	1	0	0	0	0	32
SSE	0	8	39	16	0	0	0	0	63
S	0	7	33	28	4	3	0	0	75
SSW	0	11	24	17	13	1	0	0	66
SW	0	8	16	8	0	1	0	0	33
WSW	0	9	18	1	0	0	0	0	28
W	0	4	13	6	3	0	0	0	26
WNW	0	8	19	13	22	10	1	0	73
NW	0	12	27	12	8	8	0	0	67
NNW	0	4	35	10	0	0	0	0	49
N	0	15	32	10	0	0	0	0	57
VAR	0	12	5	1	0	0	0	0	18
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	13	13
TOTAL	0	163	345	144	53	25	1	13	744

SEPTEMBER
SPEED CLASS (MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	19	29	10	11	0	0	0	69
NE	0	21	11	5	2	0	0	0	39
ENE	0	20	20	0	0	0	0	0	40
E	0	17	7	0	0	0	0	0	24
ESE	0	15	11	1	0	0	0	0	27
SE	0	7	11	3	0	0	0	0	21
SSE	0	1	13	7	0	0	0	0	21
S	0	8	22	25	4	0	0	0	59
SSW	0	5	18	11	3	1	0	0	38
SW	0	12	11	3	3	0	0	0	29
WSW	0	8	5	3	1	0	0	0	17
W	0	12	10	10	4	0	0	0	36
WNW	0	9	12	17	12	5	1	0	56
NW	0	9	19	24	8	4	1	0	65
NNW	0	12	29	14	3	0	1	0	59
N	0	15	38	28	12	0	0	0	93
VAR	0	10	8	1	0	0	0	0	19
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	8	8
TOTAL	0	200	274	162	63	10	3	8	720

Table 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975) (Continued)

OCTOBER
SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	26	15	1	0	0	0	0	42
NE	0	26	17	0	0	0	0	0	43
ENE	0	26	22	1	0	0	0	0	49
E	0	20	4	0	0	0	0	0	24
ESE	0	15	2	0	0	0	0	0	17
SE	0	15	19	2	0	0	0	0	36
SSE	0	16	21	8	0	0	0	0	45
S	0	13	25	13	0	0	0	0	51
SSW	0	15	21	6	0	0	0	0	42
SW	0	12	13	1	0	0	0	0	26
WSW	0	15	11	2	0	0	0	0	28
W	0	12	9	10	5	1	0	0	37
WNW	0	21	11	15	11	6	0	0	64
NW	0	17	17	12	7	0	0	0	53
NNW	0	29	20	9	2	0	0	0	60
N	0	37	24	3	0	0	0	0	64
VAR	0	16	4	0	0	0	0	0	20
CALM	1	0	0	0	0	0	0	0	1
UNKNO	0	0	0	0	0	0	0	42	42
TOTAL	1	331	255	83	25	7	0	42	744

NOVEMBER
SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	18	14	4	0	0	0	2	38
NE	0	10	13	2	0	0	0	1	26
ENE	0	13	10	7	0	0	0	1	31
E	0	6	2	0	0	0	0	0	8
ESE	0	12	3	0	0	0	0	0	15
SE	0	14	13	7	0	0	0	0	34
SSE	0	7	28	15	3	0	0	0	53
S	0	12	29	29	5	0	0	0	75
SSW	0	11	32	14	19	1	0	0	77
SW	0	12	20	6	8	4	0	0	50
WSW	0	9	6	5	2	2	0	0	24
W	0	12	14	3	1	2	0	3	35
WNW	0	22	14	7	5	1	0	2	51
NW	0	27	34	12	0	1	0	1	75
NNW	0	24	34	2	0	0	0	0	60
N	0	30	17	3	0	0	0	0	50
VAR	0	11	2	0	0	0	0	0	13
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	5	5
TOTAL	0	250	285	116	43	11	0	15	720

DECEMBER
SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	12	3	2	0	0	0	0	17
NE	0	9	5	2	0	0	0	0	16
ENE	0	5	4	0	0	0	0	0	9
E	0	6	1	0	0	0	0	0	7
ESE	0	8	1	1	0	0	0	0	10
SE	0	9	6	5	1	0	0	0	21
SSE	0	5	26	25	3	1	0	0	60
S	0	11	39	35	14	1	0	0	100
SSW	0	14	23	29	9	4	3	0	82
SW	0	14	11	9	2	0	0	0	36
WSW	0	16	17	6	3	2	1	0	45
W	0	20	15	7	3	3	4	0	52
WNW	0	27	25	21	6	1	1	0	81
NW	0	17	59	11	3	0	0	1	91
NNW	0	29	27	6	0	0	0	0	62
N	0	21	12	0	1	0	0	0	34
VAR	0	8	3	1	0	0	0	0	12
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	9	9
TOTAL	0	231	277	160	45	12	9	10	744

Table 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975) (Continued)

JANUARY
SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	11	17	6	0	0	0	0	34
NE	0	13	11	4	0	0	0	0	28
ENE	0	10	12	5	0	0	0	6	33
E	0	5	10	1	0	0	0	2	18
ESE	0	15	5	2	0	0	0	1	23
SE	0	10	14	1	0	1	0	1	27
SSE	0	13	17	15	2	1	0	0	48
S	0	10	14	16	6	0	0	0	46
SSW	0	6	18	10	15	3	0	0	52
SW	0	15	14	5	7	4	2	1	48
WSW	0	13	16	4	3	6	3	0	45
W	0	8	8	8	4	0	0	0	28
WNW	0	23	14	13	0	0	0	1	51
NW	0	20	37	19	3	0	0	10	89
NNW	0	29	47	22	0	0	0	4	102
N	0	11	17	15	0	0	0	1	44
VAR	0	7	3	1	0	0	0	0	11
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	17	17
TOTAL	0	219	274	147	40	15	5	44	744

FEBRUARY
SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	15	15	2	0	0	0	0	32
NE	0	8	8	0	0	0	0	0	16
ENE	0	5	8	0	0	0	0	0	13
E	0	4	2	0	0	0	0	0	6
ESE	0	5	5	1	0	0	0	0	11
SE	0	6	10	3	1	0	0	0	20
SSE	0	14	20	13	4	1	0	0	52
S	0	14	11	18	8	2	0	0	53
SSW	0	9	8	10	9	18	1	0	55
SW	0	4	9	3	9	4	4	0	33
WSW	0	9	7	3	7	4	1	0	31
W	0	4	11	6	1	1	1	0	24
WNW	0	7	14	9	2	2	1	0	35
NW	0	12	54	45	10	3	2	0	126
NNW	0	14	45	24	14	0	0	0	97
N	0	16	19	19	1	0	0	0	55
VAR	0	5	2	1	0	0	0	0	8
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	5	5
TOTAL	0	151	248	157	66	35	10	5	672

MARCH
SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	6	8	5	2	0	0	0	21
NE	0	5	4	1	0	0	0	0	10
ENE	0	4	4	1	0	0	0	0	9
E	0	6	2	2	0	0	0	0	10
ESE	0	9	5	1	0	0	0	0	15
SE	0	2	6	7	3	0	0	0	18
SSE	0	5	24	22	3	0	0	0	54
S	0	3	28	35	13	0	0	0	79
SSW	0	1	15	24	16	6	0	0	62
SW	0	5	9	14	31	14	0	0	73
WSW	0	4	7	12	8	6	0	0	37
W	0	1	12	2	0	1	0	0	16
WNW	0	6	21	19	2	0	4	0	52
NW	0	13	32	27	6	1	4	0	83
NNW	0	9	37	23	12	5	0	0	86
N	0	11	18	6	9	0	0	0	44
VAR	0	7	5	0	0	0	0	0	12
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	63	63
TOTAL	0	97	237	201	105	33	8	63	744

Table 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS
33-ft Level (1974-1975) (Continued)

ANNUAL
SPEED CLASS (MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	141	166	50	13	0	0	2	372
NE	0	131	127	32	5	2	0	3	300
ENE	0	103	119	31	0	0	0	7	260
E	0	98	69	20	0	0	0	2	189
ESE	0	113	88	14	0	0	0	1	216
SE	0	88	181	50	6	1	0	1	327
SSE	0	92	323	182	16	3	0	3	619
S	0	106	293	313	91	8	0	8	819
SSW	0	96	241	229	151	43	6	13	779
SW	0	99	169	96	98	39	7	7	515
WSW	0	101	143	94	48	26	9	7	428
W	0	88	161	136	73	19	9	11	497
WNW	0	148	215	211	144	71	18	5	812
NW	0	150	349	228	88	41	14	13	883
NNW	0	174	346	129	34	5	1	6	695
N	0	177	231	96	24	0	0	1	529
VAR	0	90	73	8	1	0	0	0	172
CALM	1	0	0	0	0	0	0	0	1
UNKNO	0	10	38	26	9	0	0	264	347
TOTAL	0	2005	3332	1945	801	258	64	354	8760

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970)

JANUARY

SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.8	1.2	0.2	0.3	0.2					4.7	4.3
NNE	2.0	0.8	0.4	0.1	0.1	#				3.4	4.6
NE	1.8	0.7	0.2	0.1	0.1	#				2.9	4.4
ENE	1.3	0.5	0.1	#	#					1.9	3.0
E	1.8	0.6	0.1	#						2.4	3.0
ESE	1.8	0.7	0.2	0.1	#					2.8	3.4
SE	2.7	1.5	0.4	0.2	#	#				4.8	4.0
SSE	1.6	0.8	0.3	0.1	0.1					2.9	5.4
S	1.4	0.9	0.4	0.5	0.2	0.1	0.1	#		3.6	7.7
SSW	1.2	1.0	0.6	1.0	0.6	0.3	0.1	#		4.8	11.5
SW	1.4	1.4	1.4	1.6	0.7	0.3	#			6.8	10.7
WSW	1.4	1.5	1.7	0.8	0.4	0.2	#			6.0	8.9
W	1.8	2.3	1.3	10.6	0.1					6.1	6.3
WNW	2.4	5.6	5.1	0.9	#	#				14.0	7.1
NW	3.6	7.8	6.6	1.2	0.1	#				19.3	6.9
NNW	3.0	2.8	0.6	0.1	#					6.5	4.2
VAR	1.3	0.1								1.4	1.8
CALM	5.4									5.4	
TOTAL	38.7	30.1	19.6	7.6	2.6	0.9	0.2	#		100.0	6.2

# DENOTES LESS THAN 0.05%

FEBRUARY

SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.6	1.6	0.4	0.2	#	#				4.8	4.5
NNE	1.8	1.3	0.8	0.4	0.1	0.1				4.5	6.3
NE	2.2	0.9	0.2	0.2	#					3.5	3.8
ENE	1.3	0.6	0.1							1.9	3.3
E	1.3	0.7	#							2.0	3.0
ESE	1.3	0.7	0.1							2.1	3.3
SE	1.9	1.1	0.3	0.1						3.4	4.0
SSE	1.2	0.8	0.4	0.2	#					2.6	5.2
S	1.3	0.7	0.4	0.3	0.1	0.1				2.9	6.6
SSW	1.0	1.0	0.8	0.6	0.5	0.2	0.1	#		4.2	10.5
SW	1.0	1.6	1.3	1.8	1.1	0.5	0.1	#		7.4	12.6
WSW	0.9	2.1	2.1	1.4	0.5	0.3	0.1	#		7.4	10.5
W	1.6	3.4	2.9	1.1	0.2	0.1				9.3	7.8
WNW	1.9	4.9	6.8	1.5	0.3	0.1				15.5	8.3
NW	3.3	6.9	6.4	1.5	0.2	0.1				18.4	7.3
NNW	2.3	2.5	0.8	0.1	#					5.7	4.8
VAR	1.3	0.2	#							1.5	1.8
CALM	2.4									2.4	
TOTAL	30.6	31.0	23.8	9.4	3.0	1.5	0.3			100.0	7.1

# DENOTES LESS THAN 0.05%

MARCH

SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.9	1.8	1.0	0.2	#					4.9	5.4
NNE	1.4	1.6	0.9	0.6	#	#				4.5	6.8
NE	1.7	1.2	0.3	0.2	0.1	#				3.5	4.8
ENE	0.7	0.8	0.1	#	#	#				1.6	5.0
E	0.9	0.8	0.2	#	#					1.9	4.2
ESE	1.0	1.1	0.2	0.1						2.4	4.4
SE	1.4	1.7	0.5	0.1	#					3.7	5.0
SSE	0.6	1.1	0.8	0.3	#					2.8	7.1
S	1.0	1.4	0.7	0.4	0.2	#				3.7	7.4
SSW	0.6	1.3	1.1	1.2	0.7	0.3	0.1			5.3	12.1
SW	0.8	2.0	2.0	2.5	1.5	0.8	0.2	#	#	9.8	13.5
WSW	0.8	2.5	3.0	2.5	1.0	0.4	0.2			10.4	11.7
W	1.1	3.9	3.1	1.2	0.2	0.1				9.6	8.2
WNW	1.1	4.4	5.8	2.2	0.8	0.1				14.4	9.5
NW	1.5	4.4	5.3	1.8	0.6	0.1				13.7	8.9
NNW	1.4	2.4	1.1	0.2	#					5.1	5.6
VAR	1.3	0.2	#							1.5	2.1
CALM	0.7									0.7	
TOTAL	19.9	32.6	26.1	13.5	5.1	1.8	0.5			100.0	8.6

# DENOTES LESS THAN 0.05%

APRIL

SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.6	1.6	0.7	0.3	#					4.2	5.5
NNE	1.0	1.3	0.6	0.3	0.1	#				3.3	6.8
NE	1.4	1.2	0.4	0.2	#	#				3.2	5.3
ENE	0.6	1.0	0.2	0.1						1.9	5.2
E	0.8	1.0	0.5	#						2.3	5.0
ESE	0.8	1.0	0.2	#						2.0	4.5
SE	1.0	1.5	0.5	0.1						3.1	5.2
SSE	0.5	1.0	0.8	0.2						2.5	6.8
S	0.7	1.4	0.7	0.3	0.1	#				3.2	6.7
SSW	0.7	1.5	1.1	0.9	0.4	0.1				4.7	9.6
SW	0.7	2.3	2.1	2.1	1.6	0.6	0.1			9.5	12.7
WSW	0.8	2.6	3.8	2.5	1.1	0.4	0.1			11.3	11.4
W	1.1	4.2	4.3	1.7	0.5	0.1	#			11.9	8.8
WNW	0.8	3.9	6.0	4.2	1.3	0.3				16.5	11.0
NW	1.2	3.7	4.2	3.2	1.5	0.4	#			14.2	11.0
NNW	0.9	1.9	0.6	0.2	#					3.6	5.8
VAR	1.6	0.5								2.1	2.7
CALM	0.5									0.5	
TOTAL	16.7	31.6	26.7	16.3	6.6	1.9	0.2			100.0	9.1

# DENOTES LESS THAN 0.05%

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970) (Continued)

MAY
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.2	1.7	0.9	0.1						3.9	5.7
NNE	0.6	1.4	0.7	0.3	#					3.0	6.7
NE	1.0	1.5	1.0	0.1	0.1					3.7	6.4
ENE	0.8	1.1	0.3	0.1						2.3	5.0
E	0.9	1.2	0.3	#						2.4	4.7
ESE	0.9	1.0	0.3	#						2.2	4.6
SE	1.0	1.5	0.6	0.1						3.2	5.4
SSE	0.6	1.3	0.6	0.2	#					2.7	6.4
S	0.6	1.7	0.5	0.1	#					2.9	5.6
SSW	0.7	1.3	0.8	0.4	0.1	#				3.3	7.4
SW	0.6	2.4	1.7	1.1	0.5	0.1	#			6.4	9.6
WSW	0.9	2.7	3.5	1.8	0.7	0.2	#			9.8	10.1
W	1.2	4.0	4.4	1.6	0.2	#				11.4	8.3
WNW	0.8	3.9	6.7	4.7	1.7	0.2	#			18.0	11.2
NW	1.2	3.6	4.9	4.4	2.6	0.5	#			17.2	12.0
NNW	1.0	1.8	0.7	0.1						3.6	5.5
VAR	1.9	1.3	#							3.2	3.2
CALM	0.6									0.6	
TOTAL	16.5	33.4	27.9	15.1	5.9	1.0	#			100.0	8.7

# DENOTES LESS THAN 0.05%

JUNE
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	0.9	2.0	0.9	0.2						4.0	6.0
NNE	0.6	1.8	0.8	0.4	#					3.6	7.1
NE	0.8	1.4	0.8	0.5	0.1	#				3.6	7.5
ENE	0.4	1.0	0.4	0.1	#	#				1.9	6.5
E	0.5	1.3	0.3	#	#					2.1	5.6
ESE	0.6	1.3	0.3	#						2.2	5.0
SE	0.7	1.6	0.4	#						2.7	5.2
SSE	0.5	1.1	0.4	0.1	#					2.1	5.8
S	0.6	1.7	0.3	0.1						2.7	5.5
SSW	0.4	1.5	0.7	0.2	0.1	#				2.9	7.3
SW	0.7	2.5	2.0	1.0	0.3	#				6.5	8.8
WSW	0.6	2.5	3.5	1.5	0.4	0.1	#			8.6	9.7
W	0.7	4.1	4.4	1.6	0.3	#				11.1	8.8
WNW	0.6	3.5	6.9	6.2	2.1	0.4	#			19.7	12.1
NW	0.7	3.7	5.1	5.4	3.4	0.7	#			19.0	13.0
NNW	0.6	2.0	0.8	0.1	#	#				3.5	6.3
VAR	1.6	1.7	#							3.3	3.4
CALM	0.3									0.3	
TOTAL	11.8	34.7	28.0	17.4	6.7	1.2				100.0	9.3

# DENOTES LESS THAN 0.05%

JULY
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.1	2.6	0.6	0.1						4.4	5.3
NNE	0.7	2.1	0.8	0.2	#					3.8	6.0
NE	0.9	2.1	0.5	0.2	#					3.7	5.7
ENE	0.5	1.2	0.2	#						1.9	5.0
E	0.7	1.5	0.3							2.5	4.9
ESE	0.7	1.3	0.3	#						2.3	4.9
SE	0.9	1.7	0.3	#						2.9	4.9
SSE	0.4	1.0	0.4	#	#	#				1.8	5.6
S	0.7	1.5	0.2	0.1	#	#				2.5	5.3
SSW	0.5	1.3	0.5	0.2	0.4	#				2.5	6.5
SW	0.8	2.3	1.7	1.0	0.4	0.1	#			6.3	9.1
WSW	0.7	3.0	2.8	1.4	0.1	0.2	#			8.5	9.5
W	1.0	4.4	3.5	0.9	1.8	#				9.9	7.7
WNW	0.7	4.2	7.7	4.8	3.0	0.2				19.4	11.2
NW	0.9	3.8	5.6	5.1	#	0.5				18.9	12.4
NNW	0.8	2.0	0.7	0.1						3.6	5.8
VAR	2.6	1.8	#							4.4	3.3
CALM	0.4									0.4	
TOTAL	15.0	37.8	26.1	14.1	5.7	1.0				100.0	8.6

# DENOTES LESS THAN 0.05%

AUGUST
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.3	2.5	0.4	0.1						4.3	5.0
NNE	1.0	1.8	0.5	0.1						3.4	5.1
NE	1.3	1.6	0.3	0.1	#					3.3	4.4
ENE	0.7	1.1	0.1	#						1.9	4.3
E	0.9	1.3	0.2	#						2.4	4.5
ESE	0.8	1.6	0.3							2.7	4.7
SE	1.1	1.8	0.5	#						3.4	4.8
SSE	0.7	1.1	0.6	#	#					2.4	5.5
S	0.8	1.4	0.3	#						2.5	4.8
SSW	0.6	1.6	0.7	0.2	0.1					3.2	6.6
SW	1.0	2.7	1.6	0.8	0.2	0.1	#			6.4	8.1
WSW	0.9	3.2	2.9	1.4	0.1	0.1				8.6	8.5
W	1.3	5.1	4.1	0.7	#					11.2	7.5
WNW	0.9	4.1	7.6	4.1	1.3	0.2				18.2	10.6
NW	1.2	3.8	5.1	4.5	2.3	0.5				17.4	11.8
NNW	1.0	2.3	0.5	0.1	#					3.9	5.4
VAR	2.8	1.3								4.1	3.0
CALM	0.6									0.6	
	18.9	38.3	25.7	12.1	4.0	0.9	#			100.0	7.9

# DENOTES LESS THAN 0.05%

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970) (Continued)

SEPTEMBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.9	2.4	0.9	0.3	#	#				5.5	5.3
NNE	1.5	1.8	1.0	0.4	0.1	#				4.8	6.4
NE	1.8	1.8	0.6	0.3	0.1	#				4.6	5.6
ENE	1.3	0.9	0.1	0.1						2.4	3.9
E	1.6	1.1	0.2	#						2.9	3.7
ESE	1.2	1.5	0.2							2.9	4.1
SE	1.4	2.1	0.4	#						3.9	4.6
SSE	0.9	1.3	0.5	0.1						2.8	5.3
S	0.9	1.3	0.3	0.1	#					2.6	5.2
SSW	0.8	1.6	0.5	0.2	0.1	0.1				3.3	7.0
SW	0.8	2.1	1.3	1.0	0.5	0.3	#			6.0	9.9
WSW	1.0	3.0	2.7	1.3	0.6	0.1	#			8.7	9.4
W	1.3	4.9	3.7	0.8	0.3	0.1				11.1	7.6
WNW	1.2	4.0	5.6	2.9	0.9	0.1				14.7	9.8
NW	1.4	3.6	4.9	3.3	1.4	0.2				14.8	10.5
NNW	1.3	2.6	0.9	0.2	#					5.0	5.7
VAR	2.0	0.6								2.6	2.6
CALM	1.2									1.2	
TOTAL	23.5	36.6	23.8	11.0	4.0	0.9				100.0	7.5

# DENOTES LESS THAN 0.05%

OCTOBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.6	1.7	0.4	0.1						4.8	3.9
NNE	2.1	1.1	0.3	0.1						3.6	3.9
NE	2.4	0.8	0.2	0.1	#					3.5	3.5
ENE	1.4	0.7	0.1	#	#					2.2	3.6
E	1.8	0.9	0.1							2.8	3.1
ESE	1.8	1.4	0.1							3.3	3.6
SE	2.5	1.9	0.6	0.1						5.1	4.2
SSE	1.0	1.5	0.7	0.1	#					3.3	5.7
S	1.1	1.4	0.5	0.3	0.2	#				3.5	6.7
SSW	1.0	1.4	0.7	0.7	0.5	0.2	#	#		4.5	9.7
SW	1.0	2.0	1.5	1.4	1.0	0.4	#			7.3	11.3
WSW	1.0	2.8	3.0	1.6	0.6	0.1	#			9.1	9.5
W	1.7	4.6	3.6	0.7	0.1	#				10.7	7.1
WNW	1.7	4.7	5.0	1.4	0.4	#				13.2	8.1.
NW	2.4	4.4	4.0	1.6	0.4	0.1	#			12.9	8.0
NNW	2.1	2.5	0.6	0.1	#	#				5.3	4.7
VAR	1.6	0.1	#							1.7	1.8
CALM	2.7									2.7	
TOTAL	31.9	33.9	21.4	8.3	3.2	0.8	#	#		100.0	6.7

# DENOTES LESS THAN 0.05%

NOVEMBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.7	1.3	0.4	0.2						4.6	4.0
NNE	2.2	0.7	0.4	0.2	#					3.5	4.0
NE	1.9	0.5	0.1	#						2.5	2.8
ENE	1.8	0.4	#							2.2	2.5
E	1.9	0.6	#							2.5	2.6
ESE	2.0	1.0	0.1							3.1	3.1
SE	2.5	1.4	0.3	0.1						4.3	3.9
SSE	1.4	1.2	0.4	0.2	0.1	#				3.3	5.3
S	1.7	1.2	0.5	0.5	0.3	#				4.2	6.8
SSW	1.4	1.2	0.8	0.9	0.7	0.2	0.1			5.3	9.9
SW	1.6	1.6	1.4	1.5	0.8	0.3	0.1	#		7.3	10.5
WSW	1.3	2.1	1.9	1.3	0.4	0.1	#	#		7.1	9.1
W	2.1	3.4	1.9	0.6	0.1	0.1	#			8.2	6.8
WNW	2.5	4.6	4.9	1.0	0.3	0.1				13.4	7.5
NW	3.6	5.9	4.7	0.7	0.1	0.1	#			15.1	6.6
NNW	3.0	2.8	1.0	0.2						7.0	4.6
VAR	1.4	0.1								1.5	1.6
CALM	4.7									4.7	
TOTAL	39.7	30.0	18.8	7.4	2.8	0.9	0.2	#		100.0	6.1

# DENOTES LESS THAN 0.05%

DECEMBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.7	1.0	0.3	0.2						4.2	3.5
NNE	1.6	0.6	0.2	#						2.4	3.6
NE	1.7	0.5	#	#						2.2	2.6
ENE	1.5	0.5	#							2.0	2.4
E	1.6	0.6	0.1	#	#					2.3	2.9
ESE	1.9	0.7	0.2	0.1	#					2.9	3.6
SE	2.6	1.2	0.4	0.1	#					4.3	3.6
SSE	1.7	1.2	0.2	0.2	0.1					3.4	4.7
S	1.7	0.8	0.4	0.4	0.2	0.1	#			3.6	6.7
SSW	1.3	0.7	0.6	0.8	0.5	0.4	0.1	#		4.4	11.1
SW	1.5	1.3	1.2	1.4	1.0	0.5	0.1	#	#	7.0	11.8
WSW	1.6	1.8	1.7	1.1	0.4	0.1	#			6.7	8.6
W	2.1	2.7	1.5	0.5	0.1	#				6.9	6.0
WNW	2.9	5.7	5.3	0.8	0.1	#				14.8	6.9
NW	3.8	7.3	6.0	1.0	0.1					18.2	6.7
NNW	2.9	2.4	0.9	0.1						6.3	4.3
VAR	1.5	0.1								1.6	1.7
CALM	6.8									6.8	
TOTAL	41.4	29.1	19.0	6.7	2.5	1.1	0.2	#	#	100.0	5.9

# DENOTES LESS THAN 0.05%

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970) (Continued)

COMPOSITE OF ALL MONTHS

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.0	1.8	0.6	0.2	#	#				4.6	4.9
NNE	1.4	1.4	0.6	0.3	#	#				3.7	5.7
NE	1.6	1.2	0.4	0.2	#	#				3.4	4.9
ENE	1.0	0.8	0.2	#	#	#				2.0	4.1
E	1.2	1.0	0.2	#	#					2.4	3.9
ESE	1.2	1.1	0.2	#	#					2.5	4.0
SE	1.6	1.6	0.4	0.1	#	#				3.7	4.5
SSE	0.9	1.1	0.5	0.1	#	#				2.0	5.7
S	1.0	1.3	0.4	0.2	0.1	#	#	#		3.0	6.4
SSW	0.9	1.3	0.7	0.6	0.3	0.2	#	#		4.0	9.5
SW	1.0	2.0	1.6	1.4	0.8	0.3	0.1	#	#	7.2	10.9
WSW	1.0	2.5	2.7	1.6	0.5	0.2	#	#		8.5	9.9
W	1.4	3.9	3.2	1.0	0.2	#	#			9.7	7.7
WNW	1.5	4.5	6.1	2.9	0.9	0.1	#			16.0	9.7
NW	2.1	4.9	5.2	2.8	1.3	0.3	#			16.6	9.6
NNW	1.7	2.3	0.8	0.1	#	#				4.9	5.1
VAR	1.7	0.7	#							2.4	2.7
CALM	2.2									2.2	
TOTAL	25.4	33.4	23.8	11.5	4.1	1.1	0.1	#	#	100.0	7.6

# DENOTES LESS THAN 0.05%

Table 2.3-10

Percent Frequency of Occurrence of Wind Direction
at the Hanford Reservation*

WIND DIRECTION

MONTH/YEAR/SITE/ELEVATION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VARI-ABLE	CALM
4/74 CGS 33'	2.64	3.06	0.42	0.83	1.53	3.19	7.50	8.89	13.06	7.78	5.69	8.75	17.08	9.31	4.17	3.19	0.97	0.00
4/74 CGS (temp) 23'	2.64	3.61	1.11	1.81	3.75	4.72	6.81	10.42	6.11	4.31	4.72	10.28	16.11	7.50	2.36	2.92	3.19	0.00
4/74 HMS 50'	1.53	2.36	1.25	1.53	1.94	2.64	2.50	1.81	3.61	6.81	15.28	13.19	22.08	17.08	2.78	1.53	1.67	0.42
April (1955-1970) HMS (hist) 50'	3.2	3.2	2.0	2.3	2.0	3.1	2.5	3.2	4.7	9.5	11.2	11.8	16.6	14.3	3.7	4.2	2.1	0.4
5/74 CGS 33'	2.15	1.75	1.21	1.88	2.02	2.42	8.06	12.37	14.25	6.99	9.27	10.62	12.90	6.32	3.09	1.61	2.02	0.00
5/74 CGS (temp) 23'	0.94	2.69	0.94	2.82	2.28	4.57	8.20	11.83	9.14	6.32	7.53	8.20	8.06	5.24	2.55	1.48	6.05	0.13
5/74 HMS 50'	1.88	1.34	0.81	1.75	3.36	1.88	1.75	2.15	4.70	8.47	14.92	14.25	21.24	13.31	1.75	1.88	3.90	0.67
May (1955-1970) HMS (hist) 50'	3.1	3.7	2.3	2.4	2.2	3.3	2.7	2.8	3.3	6.4	9.8	11.4	18.1	17.2	3.6	3.9	3.2	0.6
6/74 CGS 33'	2.50	2.92	4.31	3.33	3.61	5.14	7.22	7.64	7.08	4.03	3.89	7.22	9.31	7.36	3.61	2.50	0.69	0.00
6/74 CGS (temp) 23'	3.06	4.72	3.75	4.44	7.22	7.50	7.78	6.67	6.53	5.42	3.61	4.86	10.0	10.0	4.72	2.22	7.50	0.00
6/74 HMS 50'	1.94	2.92	2.22	2.50	3.75	4.03	2.64	2.36	3.06	4.44	7.22	6.25	24.03	19.58	4.72	2.36	5.56	0.42
June (1955-1970) HMS (hist) 50'	3.6	3.7	2.0	2.2	2.2	2.8	2.1	2.6	3.0	6.5	8.5	11.2	19.6	18.9	3.5	3.9	3.3	0.4
7/74 CGS 33'	2.42	3.23	2.42	4.03	3.36	5.38	7.66	9.41	7.26	6.72	4.70	6.59	8.47	9.01	5.51	4.70	4.30	0.00
7/74 CGS (temp) 23'	3.63	4.30	3.49	3.09	5.51	5.78	8.60	9.14	10.22	3.36	3.76	4.30	5.65	12.50	5.78	3.76	6.99	0.13
7/74 HMS 50'	2.82	1.88	2.96	2.55	3.90	3.76	2.69	3.76	2.96	5.11	12.50	12.90	16.53	11.96	2.96	2.42	8.33	0.00
July (1955-1970) HMS (hist) 50'	3.8	3.8	2.0	2.5	2.3	2.9	1.9	2.5	2.5	6.3	8.4	9.9	19.5	18.9	3.5	4.5	4.4	0.4
8/74 CGS 33'	6.45	5.65	2.02	2.42	2.82	4.30	8.47	10.08	8.87	4.44	3.76	3.49	9.81	9.01	6.59	7.66	2.42	0.00
8/74 CGS (temp) 23'	6.72	8.87	4.03	4.03	3.76	5.38	10.48	10.62	5.51	3.49	2.42	2.69	7.39	8.74	7.12	3.49	4.30	0.40
8/74 HMS 50'	5.65	3.49	2.55	2.42	2.69	2.55	2.55	2.96	3.49	3.36	7.12	10.62	16.80	16.13	5.65	4.97	6.18	0.81
August (1955-1970) HMS (hist) 50'	3.4	2.9	2.0	2.4	2.7	3.4	2.4	2.5	3.2	6.4	8.6	11.3	18.3	17.4	3.9	4.4	4.2	0.6
9/74 CGS 33'	9.58	5.42	5.56	3.33	3.75	2.92	2.92	8.19	5.28	4.03	2.36	5.00	7.78	9.03	8.19	12.92	2.64	0.00
9/73 CGS (temp) 23'	4.72	6.11	3.61	4.86	3.75	5.42	7.92	8.47	5.28	4.72	2.36	3.75	7.36	6.94	7.08	8.47	9.17	0.00
9/73 HMS 50'	7.36	4.86	1.67	3.75	2.50	2.50	2.64	2.92	3.61	4.58	8.61	6.81	15.28	15.97	7.22	4.03	3.06	2.64
September (1955-1970) HMS (hist) 50'	4.9	4.6	2.4	2.9	2.8	3.9	2.7	2.8	3.4	6.0	8.8	11.0	14.7	14.8	4.9	5.6	2.6	1.2
10/74 CGS 33'	5.65	5.78	6.59	3.23	2.28	4.84	6.05	6.85	5.65	3.49	3.76	4.97	8.60	7.12	8.06	8.60	2.69	0.13
10/73 CGS (temp) 23'	3.76	4.70	2.69	4.30	3.63	6.85	9.68	11.96	7.53	5.51	1.75	4.84	7.12	6.85	4.97	3.23	8.20	0.27
10/73 HMS 50'	2.42	3.76	2.15	1.75	3.23	3.63	2.96	3.23	5.65	10.89	11.16	9.27	14.78	11.42	4.84	2.82	1.48	4.57
October (1955-1970) HMS (hist) 50'	3.5	3.6	2.3	2.8	3.3	5.1	3.4	3.5	4.5	7.4	9.2	10.7	13.2	12.9	5.4	4.7	1.8	2.7

* For some months, when concurrent measurements are not available for all sites shown; previous year data is given.

Table 2.3-10

Percent Frequency of Occurrence of Wind Direction at the Hanford Reservation* (Continued)

WIND DIRECTION

MONTH/YEAR/SITE/ELEVATION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VARI-ABLE	CALM
11/74 CGS 33'	5.28	3.61	4.31	1.11	2.08	4.72	7.36	10.42	10.69	6.94	3.33	4.86	7.08	10.42	8.33	6.94	1.81	0.00
11/73 CGS (temp) 23'	2.22	4.86	1.81	1.53	4.44	8.19	9.72	8.19	5.42	2.22	2.22	5.69	16.25	8.06	3.75	2.92	3.61	0.28
11/73 HMS 50'	3.33	1.67	1.81	1.81	3.61	6.11	3.06	5.00	6.25	7.50	4.86	5.42	13.89	19.31	5.97	4.44	0.56	5.42
November (1955-1970) HMS (hist) 50'	3.4	2.6	2.3	2.5	3.1	4.4	3.3	4.2	5.2	7.4	7.1	8.4	13.4	15.1	7.0	4.6	1.4	4.6
12/74 CGS 33'	2.28	2.15	1.21	0.94	1.34	2.82	8.06	13.44	11.02	4.84	6.05	6.99	10.89	12.23	8.33	4.57	1.61	0.00
12/73 CGS (temp) 23'	2.28	5.38	2.28	2.82	3.76	7.53	9.95	10.62	5.24	3.09	2.02	4.30	9.41	10.48	4.84	2.82	7.93	0.67
12/73 HMS 50'	2.02	1.48	2.15	2.28	2.28	3.49	3.49	4.30	4.70	7.12	8.20	9.54	13.84	20.02	4.57	1.75	2.15	6.59
December (1955-1970) HMS (hist) 50'	2.5	2.3	1.9	2.3	2.8	4.2	3.4	3.5	4.4	7.1	6.8	6.9	14.8	18.2	6.3	4.2	1.6	6.8
1/75 CGS 33'	4.57	3.76	4.44	2.42	3.09	3.63	6.45	6.18	6.99	6.45	6.05	3.76	6.85	11.96	13.71	5.91	1.48	0.00
1/74 CGS (temp) 23'	2.28	1.88	1.08	1.88	3.09	4.97	7.12	13.17	17.34	8.20	3.23	3.23	5.51	6.32	3.49	1.88	4.70	1.61
1/74 HMS 50'	2.69	3.09	2.02	1.34	2.55	4.57	4.03	4.03	5.24	16.67	13.04	7.66	7.53	9.81	4.30	3.09	1.21	4.70
January (1955-1970) HMS (hist) 50'	3.4	2.9	1.9	2.4	2.8	4.7	3.1	3.6	4.9	6.7	6.0	6.1	14.2	19.5	6.4	4.6	1.4	5.4
2/75 CGS 33'	4.76	2.38	1.93	0.89	1.64	2.98	7.74	7.89	8.18	4.91	4.61	3.57	5.21	18.76	14.43	8.18	1.19	0.00
2/74 CGS (temp) 23'	1.04	1.79	1.34	1.64	4.32	7.44	9.08	13.54	13.39	6.25	7.14	5.21	8.33	5.65	2.38	1.34	8.93	0.19
2/74 HMS 50'	2.08	2.68	2.08	1.19	4.17	4.46	2.83	5.36	8.63	10.57	12.95	10.86	10.12	10.71	4.91	2.38	2.23	1.79
February (1955-1970) HMS (hist) 50'	4.4	3.5	1.9	2.1	2.2	3.4	2.7	2.9	4.2	7.5	7.4	9.3	15.4	18.4	5.8	5.0	1.5	2.4
3/75 CGS 33'	2.82	1.34	1.21	1.34	2.02	2.42	7.26	10.62	8.33	9.81	4.97	2.15	6.99	11.16	11.56	5.91	1.61	0.00
3/74 CGS (temp) 23'	1.61	2.55	2.02	2.82	1.61	6.59	6.72	10.08	10.08	7.66	4.84	5.65	6.72	6.72	4.57	3.23	9.41	1.08
3/74 HMS 50'	1.75	2.69	2.02	1.61	1.21	4.84	3.76	4.30	7.12	15.05	10.75	9.01	11.16	13.04	5.65	2.82	2.82	0.40
March (1955-1970) HMS (hist) 50'	4.5	3.5	1.7	2.0	2.3	3.7	2.8	3.8	5.4	9.9	10.4	9.6	14.4	13.7	5.0	5.1	1.5	0.7
April 1974-March 1975 CGS 33'	4.25	3.42	2.97	2.16	2.47	3.73	7.07	9.35	8.89	5.88	4.89	5.67	9.27	10.08	7.93	6.04	1.96	0.01
1955-1970 HMS (hist) 50'	3.7	3.4	2.0	2.4	2.6	3.7	2.8	3.2	4.1	7.2	8.5	9.8	16.0	16.6	4.9	4.5	2.4	2.2

* For some months, when concurrent measurements are not available for all sites shown; previous year data is given.

Table 2.3-11

Persistence of Wind Direction in One Sector (22.5 Degrees)
from 4/74 through 3/75 at 33-ft Level
(Stability Based On Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIR	HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
400	22	NW	14	0	V UNS	.00
				0	UNSTA	.00
				3	NEUTR	10.30
				11	M STA	11.08
				0	V STA	.00
				0	UNKNO	.00
171	10	S	10	1	V UNS	16.00
				7	UNSTA	18.14
				2	NEUTR	15.00
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
295	15	NNW	10	0	V UNS	.00
				1	UNSTA	19.57
				2	NEUTR	21.18
				7	M STA	9.98
				0	V STA	.00
				0	UNKNO	.00
327	14	NW	10	0	V UNS	.00
				0	UNSTA	.00
				5	NEUTR	3.81
				5	M STA	4.06
				0	V STA	.00
				0	UNKNO	.00
425	6	NNW	10	0	V UNS	.00
				1	UNSTA	5.53
				7	NEUTR	5.84
				2	M STA	6.81
				0	V STA	.00
				0	UNKNO	.00
134	7	SSW	9	0	V UNS	.00
				1	UNSTA	23.78
				8	NEUTR	19.54
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
219	17	WNW	9	0	V UNS	.00
				2	UNSTA	17.34
				2	NEUTR	22.97
				5	M STA	16.69
				0	V STA	.00
393	2	NW	9	0	V UNS	.00
				0	UNSTA	.00
				9	NEUTR	#999.0 (missing data)
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
404	2	NNW	9	0	V UNS	.00
				0	UNSTA	.00
				1	NEUTR	13.63
				8	M STA	11.18
				0	V STA	.00
				0	UNKNO	.00

Table 2.3-11

Persistence of Wind Direction in One Sector (22.5 Degrees) from 4/74 through 3/75 at 33-ft Level (Continued) (Stability Based on Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIR	HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
407	5	SSW	9	0	V UNS	.00
				0	UNSTA	.00
				2	NEUTR	17.20
				7	M STA	20.64
				0	V STA	.00
				0	UNKNO	.00
102	13	WNW	8	0	V UNS	.00
				5	UNSTA	16.67
				1	NEUTR	19.07
				2	M STA	16.91
				0	V STA	.00
				0	UNKNO	.00
132	13	WNW	8	0	V UNS	.00
				6	UNSTA	22.17
				1	NEUTR	22.06
				1	M STA	17.06
				0	V STA	.00
				0	UNKNO	.00
244	11	NNE	8	0	V UNS	.00
				7	UNSTA	15.35
				1	NEUTR	12.87
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
271	16	NW	8	0	V UNS	.00
				1	UNSTA	18.52
				2	NEUTR	16.92
				5	M STA	11.63
				0	V STA	.00
				0	UNKNO	.00
363	10	S	8	0	V UNS	.00
				0	UNSTA	.00
				5	NEUTR	13.70
				3	M STA	13.80
				0	V STA	.00
				0	UNKNO	.00
396	21	NW	8	0	V UNS	.00
				0	UNSTA	.00
				4	NEUTR	9.10
				4	M STA	8.16
				0	V STA	.00
				0	UNKNO	.00
401	12	NNW	8	0	V UNS	.00
				0	UNSTA	.00
				5	NEUTR	12.80
				3	M STA	11.49
				0	V STA	.00
				0	UNKNO	.00
402	6	N	8	0	V UNS	.00
				0	UNSTA	.00
				7	NEUTR	9.04
				1	M STA	9.99
				0	V STA	.00
				0	UNKNO	.00
426	14	SW	8	0	V UNS	.00
				2	UNSTA	18.58
				3	NEUTR	16.88
				3	V STA	15.28
				0	V STA	.00
				0	UNKNO	.00
430	8	NNW	8	0	V UNS	.00
				6	UNSTA	10.54
				1	NEUTR	10.68
				1	M STA	7.82
				0	V STA	.00
				0	UNKNO	.00

Table 2.3-12

Persistence of Wind Direction in Two Sectors (45 Degrees) from 4.74 through 3/75 at CGS for 33-ft Level (Stability Based on Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIRECTIONS		HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
400	22	NW	NNW	26	0	V UNS	.00
					0	UNSTA	.00
					8	NEUTR	11.80
					15	M STA	11.05
					3	V STA	6.23
					0	UNKNO	.00
379	12	NW	NNW	23	0	V UNS	.00
					0	UNSTA	.00
					6	NEUTR	3.73
					17	M STA	3.78
					0	V STA	.00
					0	UNKNO	.00
399	23	NW	NNW	22	0	V UNS	.00
					0	UNSTA	.00
					7	NEUTR	15.79
					15	M STA	12.65
					0	V STA	.00
					0	UNKNO	.00
424	21	NW	NNW	20	0	V UNS	.00
					2	UNSTA	4.20
					8	NEUTR	5.88
					10	M STA	7.18
					0	V STA	.00
					0	UNKNO	.00
102	1	NNW	NW	19	0	V UNS	.00
					8	UNSTA	18.20
					2	NEUTR	28.03
					9	M STA	21.20
					0	V STA	.00
					0	UNKNO	.00
400	17	WNW	NW	19	0	V UNS	.00
					0	UNSTA	.00
					3	NEUTR	10.30
					16	M STA	11.44
					0	V STA	.00
					0	UNKNO	.00
244	5	N	NNE	18	0	V UNS	.00
					7	UNSTA	15.35
					7	NEUTR	15.01
					4	M STA	9.66
					0	V STA	.00
					0	UNKNO	.00
404	2	NNW	N	18	0	V UNS	.00
					0	UNSTA	.00
					9	NEUTR	11.56
					9	M STA	10.83
					0	V STA	.00
					0	UNKNO	.00
431	10	NW	NNW	18	0	V UNS	.00
					5	UNSTA	17.79
					5	NEUTR	17.77
					8	M STA	8.45
					0	V STA	.00
					0	UNKNO	.00
171	3	S	SSW	17	1	V UNS	16.00
					8	UNSTA	18.37
					5	NEUTR	16.60
					3	M STA	13.33
					0	V STA	.00
					0	UNKNO	.00
224	17	NNW	NW	17	0	V UNS	.00
					4	UNSTA	10.07
					3	NEUTR	14.39
					10	M STA	12.00
					0	V STA	.00
					0	UNKNO	.00

Table 2.3-12

Persistence of Wind Direction in Two Sectors (45 Degrees) from 4.74 through 3/75 at CGS for 33-ft Level (Continued)
(Stability Based on Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIRECTIONS		HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
401	21	NNW	N	17	0	V UNS	.00
					0	UNSTA	.00
					7	NEUTR	9.04
					3	M STA	8.95
					7	V STA	6.78
					0	UNKNO	.00
406	21	SSW	SW	17	0	V UNS	.00
					0	UNSTA	.00
					2	NEUTR	17.20
					15	M STA	21.52
					0	V STA	.00
					0	UNKNO	.00
438	1	SSE	S	17	0	V UNS	.00
					2	UNSTA	7.67
					2	NEUTR	5.47
					7	M STA	7.21
					6	V STA	8.80
					0	UNKNO	.00
396	17	WNW	NW	16	0	V UNS	.00
					0	UNSTA	.00
					10	NEUTR	8.80
					6	M STA	7.94
					0	V STA	.00
					0	UNKNO	.00
423	8	NW	NNW	16	0	V UNS	.00
					0	UNSTA	.00
					10	NEUTR	7.61
					6	M STA	5.58
					0	V STA	.00
					0	UNKNO	.00
98	11	WNW	NW	15	0	V UNS	.00
					3	UNSTA	15.67
					4	NEUTR	14.00
					8	M STA	11.62
					0	V STA	.00
					0	UNKNO	.00
253	15	WNW	NW	15	0	V UNS	.00
					0	UNSTA	.00
					2	NEUTR	16.41
					9	M STA	11.59
					4	V STA	7.27
					0	UNKNO	.00
293	11	W	WNW	15	0	V UNS	.00
					4	UNSTA	16.25
					3	NEUTR	18.27
					8	M STA	9.39
					0	V STA	.00
					0	UNKNO	.00
355	6	WSW	W	15	0	V UNS	.00
					0	UNSTA	.00
					7	NEUTR	25.65
					8	M STA	15.14
					0	V STA	.00
					0	UNKNO	.00

Table 2.3-12a

Longest Persistence of Wind Direction in One (22.5 Degrees) and Two (45 Degrees) Sectors
During First and Second Annual Cycles at 33-ft Level
(Stability Based on Temperature Difference)

First Annual Cycle (April '74 – March '75)						Second Annual Cycle (April '75 – March '76)					
MONTH	WIND DIRECTION	HOURS OF PERSISTENCE	HOURS OF EACH STABILITY		AVERAGE WIND SPEED	MONTH	WIND DIRECTION	HOURS OF PERSISTENCE	HOURS OF EACH STABILITY		AVERAGE WIND SPEED
January	NW	14	0	V UNS	.00	February	NNE	33	0	V UNS	.00
			0	UNSTA	.00				3	UNSTA	30.22
			3	NEUTR	10.30				10	NEUTR	29.04
			11	M STA	11.08				20	M STA	23.15
			0	V STA	.00				0	V STA	.00
			0	UNKNO	.00				0	UNKNO	.00
January	NW, NNW	26	0	V UNS	.00	January	N, NNE	35	0	V UNS	.00
			0	UNSTA	.00				3	UNSTA	30.22
			8	NEUTR	11.86				10	NEUTR	29.04
			15	M STA	11.05				22	M STA	21.84
			3	V STA	6.23				0	V STA	.00
			0	UNKNO	.00				0	UNKNO	.00

Table 2.3-13

Percent Frequency of Occurrence of Wind Speed
at the Hanford Reservation (1)

Wind Speed Range, mph [(2)]

Month/Year/Site/Elevations	Calm	1-3	4-7	8-12	13-18	19-24	25-Up	Average Speed (mph)
4/74 CGS 33'	0.00	9.58	31.11	24.17	18.19	6.25	1.81	9.8
4/74 CGS (temp) 23'	0.00	13.19	37.50	23.47	17.78	4.72	0.42	8.7
4/74 HMS 50'	0.42	9.72	26.11	33.33	19.72	7.64	3.06	10.3
April (1955-1970) HMS (hist) 50'		16.8	31.6	26.6	16.2	6.6	2.2	9.0
5/74 CGS 33'	0.00	12.50	36.16	33.33	12.77	3.63	0.54	8.4
5/74 CGS (temp) 23'	0.13	14.11	38.17	28.23	11.96	2.55	0.67	7.9
5/74 HMS 50'	0.67	12.63	30.11	32.66	18.15	5.38	0.40	9.0
May (1955-1970) HMS (hist) 50'		16.6	33.3	27.9	15.1	6.0	1.1	8.8
6/74 CGS 33'	0.00	11.25	44.03	23.89	9.72	3.61	1.11	8.5
6/74 CGS (temp) 23'	0.00	21.67	47.64	18.06	9.03	3.06	0.56	6.9
6/74 HMS 50'	0.42	13.61	35.42	26.11	15.69	7.64	1.11	9.0
June (1955-1970) HMS (hist) 50'		11.7	34.6	28.1	17.4	6.8	1.4	9.2
7/74 CGS 33'	0.00	16.13	43.95	24.33	8.74	1.61	0.40	7.2
7/74 CGS (temp) 23'	0.13	25.40	45.30	19.89	8.06	1.21	0.00	6.4
7/74 HMS 50'	0.00	16.26	38.44	27.28	13.44	4.57	0.00	8.1
July (1955-1970) HMS (hist) 50'		15.0	37.8	26.2	14.2	5.8	1.0	8.6
8/74 CGS 33'	0.00	21.91	46.37	19.35	7.12	3.36	0.13	6.8
8/74 CGS (temp) 23'	0.40	27.82	46.24	17.20	6.85	1.21	0.00	6.0
8/74 HMS 50'	0.81	16.53	43.28	26.21	7.53	5.11	0.54	7.5
August (1955-1970) HMS (hist) 50'		18.9	38.2	25.6	12.3	4.2	0.8	8.0
9/74 CGS 33'	0.00	27.78	38.06	22.50	8.75	1.39	0.42	6.5
9/73 CGS (temp) 23'	0.00	26.67	42.08	22.50	7.50	1.25	0.00	6.2
9/73 HMS 50'	2.64	20.42	36.25	28.33	8.75	3.19	0.42	7.1
September (1955-1970) HMS (hist) 50'		23.6	36.8	23.8	10.9	4.1	0.8	7.5

[(1)] For some months, when, concurrent measurements are not available for all sites shown; previous year data is given.

[(2)] HMS (hist) 50' calm values are included in the 1-3 mph range group.

Table 2.3-13

Percent Frequency of Occurrence of Wind Speed
at the Hanford Reservation (1) (Continued)

Month/Year/Site/Elevation	Calm	1-3	4-7	8-12	13-18	19-24	25-Up	Average Speed (mph)
10/74 CGS 33'	0.13	44.49	34.27	11.16	3.36	0.94	0.00	4.8
10/73 CGS (temp) 23'	0.27	30.91	40.99	16.80	8.87	2.15	0.00	6.2
10/73 HMS 50'	4.57	25.81	34.95	23.39	7.53	3.23	0.54	6.7
October (1955-1970) RMS (hist) 50'		32.1	34.0	21.3	8.3	3.3	1.0	6.7
11/74 CGS 33'	0.00	34.72	39.58	16.11	5.97	1.53	0.00	5.8
11/73 CGS (temp) 23'	0.28	17.92	37.08	21.53	7.78	2.36	0.00	7.1
11/73 HMS 50'	5.42	19.86	33.89	26.67	6.81	5.28	2.08	7.5
November (1955-1970) HMS (hist) 50'		39.7	30.1	18.9	7.5	2.7	1.1	6.2
12/74 CGS 33'	0.00	31.05	37.23	21.51	6.05	1.61	1.21	6.4
12/73 CGS (temp) 23'	0.67	41.53	31.72	15.86	8.74	1.21	0.27	5.7
12/73 HMS 50'	6.59	25.13	31.05	23.79	9.95	3.09	0.40	6.7
December (1955-1970) HMS (hist) 50'		41.4	29.2	18.9	6.7	2.5	1.3	6.0
1/75 CGS 33'	0.00	29.44	36.83	19.76	5.38	2.02	0.67	6.4
1/74 CGS (temp) 23'	2.02	29.97	24.46	15.46	16.40	7.80	3.90	8.7
1/74 HMS 50'	4.70	21.10	26.48	21.24	13.31	7.66	5.51	9.3
January (1955-1970) HMS (hist) 50'		38.8	30.2	19.5	7.6	2.7	1.2	6.4
2/75 CGS 33'	0.00	22.47	36.90	23.36	9.82	5.21	1.49	7.8
2/74 CGS (temp) 23'	1.19	26.64	29.17	22.17	15.03	4.46	1.34	7.6
2/74 HMS 50'	1.79	20.09	33.63	23.66	15.63	4.61	0.60	8.0
February (1955-1970) HMS (hist) 50'		30.8	31.0	23.9	9.3	3.2	1.7	7.0
3/75 CGS 33'	0.00	13.04	31.85	27.02	14.11	4.44	1.08	8.7
3/74 CGS (temp) 23'	1.08	28.90	31.32	18.68	12.77	3.36	3.36	7.8
3/74 HMS 50'	0.40	16.94	33.33	25.81	13.04	7.66	2.82	9.1
March (1955-1970) HMS (hist) 50'		20.0	32.6	26.1	13.5	5.4	2.4	8.4
April 1974 – March 1975 CGS 33'	0.01	22.89	38.04	22.20	9.14	2.95	0.73	7.2
1955-1970 HMS (hist) 50'		25.4	33.3	23.9	11.6	4.4	1.4	7.6

Table 2.3-14

Diurnal Variation of 33-ft Elevation Dry Bulb Temperature (°F) at CGS and Monthly Average Dry Bulb Temperature (°F) at the Hanford Reservation

Hour	April 1974	May 1974	June 1974	July 1974	August 1974	September 1974	October 1974	November 1974	December 1974	January 1975	February 1975	March 1975	Annual Average (April 1974 – March 1975)
	Month/Year												
01	46.7	51.0	63.7	66.5	66.8	58.2	45.6	40.3	35.3	30.9	30.6	37.5	47.9
02	46.1	49.8	62.1	64.5	64.6	57.1	44.7	40.1	35.3	30.8	30.5	36.6	46.9
03	44.9	48.3	60.3	62.2	63.0	56.3	43.3	39.6	35.1	30.4	30.1	35.9	45.9
04	44.4	46.9	58.1	60.8	61.2	55.3	42.6	39.5	35.0	30.6	30.2	35.0	45.1
05	43.3	45.8	57.5	59.7	60.0	54.1	41.3	39.0	34.9	30.1	30.1	34.9	44.3
06	43.6	47.0	59.6	61.0	59.6	53.0	40.8	38.7	34.1	30.0	29.8	34.7	44.4
07	45.3	50.9	63.8	65.3	63.6	53.9	40.4	38.3	33.8	29.4	29.6	35.1	45.8
08	49.2	54.4	68.0	69.3	68.8	58.9	43.4	38.3	33.8	29.5	29.3	37.4	48.4
09	51.8	56.8	72.7	73.0	72.9	64.8	48.3	39.9	34.4	30.3	31.3	40.6	51.2
10	54.2	59.0	75.3	75.1	76.4	68.6	52.7	41.6	35.8	31.7	33.9	42.9	54.3
11	56.2	61.3	78.0	77.3	79.1	72.0	56.4	43.8	37.9	33.0	35.6	45.2	56.2
12	57.9	63.1	80.5	79.4	81.6	75.2	59.5	45.4	39.6	34.9	37.6	46.9	58.4
13	59.3	64.9	82.3	81.3	84.0	77.8	62.0	46.7	41.0	35.7	38.6	48.6	60.1
14	60.5	66.3	83.8	83.2	86.2	79.8	63.7	47.4	41.7	36.5	39.3	49.4	61.6
15	60.9	67.5	85.1	84.7	87.5	81.0	64.8	47.6	41.5	37.2	39.7	50.3	62.4
16	60.9	67.7	84.6	85.2	88.4	81.6	65.1	46.9	40.5	36.7	39.5	50.8	62.3
17	60.3	67.4	85.1	85.2	88.4	81.2	63.7	45.0	38.8	35.2	38.7	50.0	61.7
18	58.8	66.2	84.1	84.7	87.1	78.4	60.0	43.5	37.7	33.9	36.8	47.9	60.4
19	56.1	63.9	81.9	82.7	83.7	73.6	56.4	42.7	36.8	32.9	35.3	44.9	57.7
20	53.6	60.3	77.8	78.7	79.6	69.4	53.5	42.1	36.8	32.1	34.4	42.7	55.2
21	51.8	57.7	73.7	75.5	75.7	67.1	51.3	41.6	36.8	31.5	33.8	41.2	53.3
22	50.3	56.0	70.7	73.0	73.6	64.5	49.4	41.0	36.1	31.1	32.8	40.1	51.7
23	48.9	54.2	68.0	70.8	71.0	62.3	48.2	40.2	35.2	31.0	32.4	39.2	50.2
24	47.7	52.7	66.0	68.9	69.0	60.4	46.4	40.0	35.1	30.8	31.6	38.1	49.0
Monthly Average Dry Bulb Temperature (°F)* (Site, Elevation)													
CGS 33'	52.2	57.4	72.5	73.6	74.7	66.9	51.7	42.1	36.8	32.3	33.8	41.9	53.1
CGS 7'	52.7	58.3	73.0	74.3	75.0	66.3	50.6	41.9	36.1	32.2	33.9	42.2	53.1
CGS (temp) 3'	53.3	59.6	74.2	75.3	76.3	(65.0)	(51.2)	(39.7)	(37.8)	(29.0)	(40.7)	(45.4)	Not Computed
HMS 3'	52.5	57.9	73.3	74.8	76.3	68.3	52.0	42.1	35.7	32.0	33.6	42.0	53.4
1950-1970 HMS (hist) 3'	52.5	61.8	69.9	77.5	75.3	67.0	53.2	40.1	33.4	30.3	37.5	44.0	

*For some months, when concurrent measurements are not available for all sites shown, former year data is given in parentheses.

Table 2.3-15

Diurnal Variation of 33-ft Elevation Wet Bulb Temperature (°F) at CGS and Monthly Average Wet Bulb Temperature (°F) at the Hanford Reservation

	Month/Year												
Hour	April 1974	May 1974	June 1974	July 1974	August 1974	September 1974	October 1974	November 1974	December 1974	January 1975	February 1975	March 1975	Annual Average (April 1974 – March 1975)
01	41.9	44.4	52.1	54.7	54.9	49.1	40.7	38.0	33.5	29.0	28.9	34.0	41.8
02	41.5	43.8	51.6	54.1	54.1	48.6	40.1	38.0	33.6	29.0	28.7	33.4	41.4
03	40.9	43.3	50.9	53.1	53.5	48.0	39.3	37.6	33.5	28.7	28.5	32.9	40.9
04	40.7	42.6	50.1	52.6	52.8	47.6	38.9	37.6	33.4	28.9	28.4	32.3	40.6
05	40.2	41.9	50.0	52.3	52.5	47.0	38.0	37.3	33.2	28.5	28.3	32.2	40.2
06	40.5	42.7	51.2	53.4	52.3	46.4	37.8	37.1	32.7	28.4	28.0	32.1	40.3
07	41.9	44.9	53.3	55.4	54.5	47.1	37.5	36.8	32.4	27.9	27.8	32.4	41.0
08	44.2	46.1	54.9	56.9	56.8	49.7	39.5	36.9	32.2	27.8	27.6	34.3	42.3
09	45.5	47.5	56.8	57.9	58.2	52.6	42.7	38.2	32.6	28.4	29.5	36.1	43.8
10	46.6	48.1	57.7	58.5	59.7	54.2	44.9	39.3	34.0	29.6	31.2	37.1	45.3
11	47.1	49.1	58.8	59.0	60.6	55..4	46.7	40.8	35.4	30.6	32.1	38.3	46.1
12	47.8	49.7	59.6	59.7	61.2	56.5	48.0	41.6	36.4	31.8	33.2	39.0	47.0
13	48.2	50.3	60.0	60.2	61.7	57.4	49.1	42.3	37.3	32.3	33.9	39.5	47.7
14	48.6	50.7	60.3	60.4	62.2	57.9	49.7	42.6	37.6	32.8	34.2	40.0	48.2
15	48.7	51.0	60.7	60.9	62.4	58.2	50.2	42.8	37.6	33.2	34.5	40.4	48.4
16	48.6	50.9	60.1	61.1	62.6	58.3	50.3	42.4	36.9	32.9	34.4	40.6	48.3
17	48.5	50.8	60.5	61.0	62.6	58.0	49.8	41.4	35.8	31.9	34.0	40.1	48.0
18	48.0	50.4	60.3	60.8	62.0	57.0	48.4	40.5	35.1	30.9	32.9	39.2	47.2
19	46.8	49.7	59.6	60.1	60.9	55.4	46.4	40.0	34.4	30.4	32.0	37.8	46.2
20	45.8	48.5	58.4	59.0	59.6	53.6	44.8	39.6	34.4	29.7	31.4	36.8	45.2
21	44.8	47.4	56.5	58.0	58.0	52.4	43.4	39.0	34.4	29.4	31.1	35.9	44.3
22	43.8	46.6	54.9	57.2	57.3	51.4	42.4	38.5	34.1	29.0	30.5	35.2	43.5
23	43.1	45.8	54.1	56.2	56.6	50.5	41.8	37.8	33.5	29.0	30.3	34.6	42.8
24	42.5	45.1	53.1	55.6	55.8	49.7	41.1	37.7	33.5	28.8	29.6	34.0	42.3
Monthly Average Wet Bulb Temperature (°F)* (Site, Elevation)													
CGS 33'	44.7	47.2	56.0	57.4	58.0	52.6	43.8	39.3	34.5	30.0	30.9	36.2	44.3
CGS (temp) 3'	45.9	49.8	60.0	61.0	62.6	(54.6)	(45.5)	(37.8)	(36.4)	(26.4)	(36.6)	(39.3)	Not Calculated
HMS 3'	43.9	46.5	54.5	56.3	57.0	52.0	42.0	38.0	33.0	30.0	31.0	36.0	43.4
1950-1970 HMS (hist) 3'	42.8	49.1	54.5	57.9	57.3	52.6	45.4	36.4	31.2	27.9	33.6	37.3	

*For some months, when concurrent measurements are not available for all sites shown, former year data is given in parentheses.

Table 2.3-16

Diurnal Variation of 33 ft Elevation Dew Point Temperature (°F) at CGS and Monthly Average Dew Point Temperature (°F) at the Hanford Reservation

	Month/Year												
Hour	April 1974	May 1974	June 1974	July 1974	August 1974	September 1974	October 1974	November 1974	December 1974	January 1975	February 1975	March 1975	Annual Average (April 1974 – March 1975)
01	36.5	37.3	42.0	45.1	45.4	40.5	35.0	35.4	31.2	26.0	26.1	28.6	35.8
02	36.5	37.5	42.5	45.4	45.6	40.6	34.6	35.5	31.4	26.1	26.0	28.6	35.9
03	36.6	37.8	42.7	45.5	45.8	39.9	34.4	35.4	31.4	25.9	25.9	28.3	35.9
04	36.8	37.9	43.1	45.7	45.9	40.1	34.6	35.6	31.4	26.0	25.4	28.4	36.0
05	36.7	37.7	43.3	46.2	46.3	40.1	34.0	35.4	31.0	26.0	25.4	28.4	35.9
06	37.0	38.1	44.1	47.2	46.4	39.8	34.2	35.3	30.8	25.8	25.2	28.2	36.1
07	38.3	38.6	44.6	47.5	47.3	40.4	34.0	35.1	30.5	25.5	24.9	28.5	36.3
08	38.8	37.3	44.3	47.5	47.8	41.0	35.0	35.2	30.0	25.1	24.9	30.0	36.5
09	38.8	37.8	44.4	46.7	47.3	41.8	36.3	36.4	30.3	25.4	26.8	29.6	36.8
10	38.8	37.2	44.2	46.0	47.7	41.7	36.3	36.7	31.7	26.4	27.1	28.8	37.1
11	37.8	36.7	44.2	45.7	47.4	41.4	36.2	37.4	32.2	26.9	26.9	28.3	36.8
12	37.3	36.2	43.8	45.3	46.7	40.9	36.0	37.5	32.3	27.0	26.8	27.6	36.5
13	36.8	35.5	43.3	44.4	46.0	40.4	35.6	37.4	32.5	27.2	27.0	27.2	36.1
14	36.4	35.1	42.6	43.3	45.3	39.7	35.3	37.3	32.1	27.5	27.0	26.6	35.7
15	35.9	34.6	42.3	43.1	44.5	39.4	35.1	37.7	32.4	27.4	27.0	26.3	35.5
16	35.8	34.0	41.5	43.1	44.0	39.0	35.1	37.4	32.1	27.4	27.2	26.3	35.2
17	36.0	34.1	41.9	42.7	44.0	38.5	35.5	37.4	31.8	27.0	27.2	25.9	35.2
18	36.6	34.5	42.4	42.9	43.7	38.6	36.1	37.1	31.5	26.4	27.1	26.7	35.4
19	37.0	35.2	42.8	42.6	44.1	39.4	35.3	37.0	31.1	25.9	27.2	27.6	35.5
20	37.3	36.3	43.5	43.5	44.5	39.2	34.8	36.7	31.0	26.0	27.1	28.3	35.7
21	37.1	36.6	42.7	44.4	44.4	38.8	34.0	36.2	31.3	25.8	27.2	28.3	35.6
22	36.8	36.8	41.7	44.7	44.6	38.9	33.8	35.5	31.2	25.6	27.1	27.9	35.4
23	36.7	37.1	42.4	44.5	45.2	39.2	34.2	35.1	31.1	25.6	27.2	27.9	35.6
24	36.6	37.1	42.1	44.9	45.3	39.5	34.7	35.0	31.2		26.6	27.9	35.6
Monthly Average Dew Point Temperature (°F) (Site/Elevation)													
CGS 33'	36.6	36.6	43.0	44.9	45.6	39.9	35.0	36.3	31.4	26.3	26.5	27.9	35.9
HMS 3'	33.3	34.0	38.2	41.0	43.2	38.9	31.0	33.9	29.2	26.0	25.5	26.0	33.4
1950-1970 HMS (hist) 3'	30.4	36.0	41.2	42.3	42.8	39.5	36.9	31.1	27.5	23.2	27.4	27.3	

Table 2.3-17

Frequency of Occurrence, Dry Bulb Temperature (°F) Versus Time of Day from 4/74 through 3/75 for 33-ft Level

		TIME OF DAY																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
	-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-20	-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-15	-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-10	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	15	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	5
15	20	2	2	3	3	7	5	7	8	4	3	3	2	1	1	1	1	1	1	1	2	3	3	3	2	69
20	25	11	11	13	13	14	13	17	14	10	7	5	4	4	3	3	3	4	6	7	9	9	9	9	10	208
25	30	22	26	27	29	30	37	28	27	25	17	13	9	9	9	9	8	9	11	10	8	9	11	13	20	416
30	35	44	46	43	44	42	41	41	31	26	26	25	21	12	14	11	14	20	19	29	37	41	40	47	45	759
35	40	42	39	45	46	48	44	46	39	24	27	31	30	32	21	23	26	28	32	37	35	34	45	40	38	852
40	45	40	45	48	54	57	57	45	36	35	28	28	31	28	37	36	34	26	34	35	35	38	33	43	46	929
45	50	51	52	48	46	48	43	42	38	38	37	35	32	34	29	29	29	41	36	33	29	34	39	37	39	919
50	55	33	30	34	40	31	38	28	28	34	35	33	32	32	33	36	39	25	23	26	41	40	34	32	35	792
55	60	31	33	32	31	33	28	34	30	17	24	33	34	33	30	25	21	24	30	31	27	27	26	29	29	692
60	65	27	29	32	32	29	30	28	28	24	20	20	27	22	22	24	24	24	23	21	19	21	33	28	26	613
65	70	25	26	25	21	20	23	25	28	30	31	25	19	27	32	26	24	24	17	25	27	29	23	24	35	611
70	75	26	20	11	3	2	2	18	22	18	33	31	26	27	24	26	27	25	29	16	30	23	26	30	20	515
75	80	7	2	1	0	0	0	2	17	16	18	29	37	20	22	26	24	21	19	31	17	27	23	20	12	391
80	85	0	0	0	0	0	0	0	1	16	15	15	18	37	34	20	17	22	27	16	22	19	14	5	4	302
85	90	0	0	0	0	0	0	0	0	1	10	16	19	12	17	31	30	26	19	23	16	8	2	1	0	231
90	95	0	0	0	0	0	0	0	0	0	1	5	9	20	20	16	21	20	18	13	8	0	0	0	0	151
95	100	0	0	0	0	0	0	0	0	0	0	0	1	3	9	14	14	16	13	7	0	0	0	0	0	77
100	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	2	1	0	0	0	0	0	11
105	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UNKNO		3	3	3	3	4	4	4	18	47	33	18	14	12	8	7	6	6	6	3	3	3	3	3	3	217
TOTAL		365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Table 2.3-18

Frequency of Occurrence, Wet Bulb Temperature (°F) Versus Time of Day from 4/74 through 3/75 for 33-ft Level

TIME OF DAY

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
	-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-20	-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-15	-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-10	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	15	2	2	2	1	1	1	1	2	1	1	1	0	0	0	0	0	0	1	1	1	1	2	2	2	25
15	20	1	2	4	7	9	8	9	8	5	3	3	3	3	3	2	2	2	1	1	3	4	2	2	1	88
20	25	14	15	18	14	14	16	18	15	9	8	8	6	6	6	6	5	7	8	10	9	8	10	9	12	251
25	30	35	33	35	42	41	43	41	34	30	24	14	10	7	7	7	10	11	14	18	18	23	26	35	39	597
30	35	44	51	46	47	50	45	42	37	32	33	39	43	33	26	24	28	31	35	41	48	47	55	47	44	968
35	40	54	51	58	57	60	67	60	51	44	41	45	39	50	49	51	50	50	52	48	46	48	44	56	49	1220
40	45	73	73	65	65	61	56	53	55	52	51	52	50	45	53	51	51	48	44	48	50	62	56	57	65	1336
45	50	43	44	52	54	51	47	51	47	39	49	51	54	52	50	52	48	47	49	52	55	43	52	44	52	1178
50	55	48	50	49	48	51	51	38	39	43	42	39	44	49	49	52	51	51	43	42	49	55	48	49	44	1124
55	60	39	33	27	23	18	23	39	41	36	38	49	50	50	52	47	46	44	51	46	39	45	46	48	44	974
60	65	8	6	5	3	4	3	8	18	23	33	39	43	46	47	45	44	45	44	41	35	22	19	11	9	601
65	70	0	1	0	0	0	0	0	0	3	5	6	8	12	15	21	24	23	17	14	9	4	1	1	0	164
70	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UNKNO		4	4	4	4	5	5	5	18	48	37	19	15	12	8	7	6	6	6	3	3	3	4	4	4	234
TOTAL		365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

LDCN-99-000

Table 2.3-19

Frequency of Occurrence, Dew Point Temperature (°F) Versus Time of Day from 4/74 through 3/75 for 33-ft Level

TIME OF DAY

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
	-40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-40	-35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-35	-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-30	-25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-25	-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-20	-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-15	-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-10	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	5	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	10
5	10	1	2	1	2	2	3	2	1	1	1	2	3	1	3	3	2	2	2	1	1	1	1	1	1	40
10	15	4	2	5	4	4	2	3	2	3	4	3	3	4	2	3	4	3	4	5	4	2	2	2	3	77
15	20	12	14	12	13	13	16	16	16	8	5	7	10	11	11	11	10	11	13	11	10	12	13	16	13	284
20	25	23	22	24	22	28	23	23	22	17	18	21	20	20	23	25	26	28	24	22	25	26	30	24	28	564
25	30	45	47	44	46	43	44	46	48	48	48	44	44	48	47	48	49	49	45	47	47	45	43	49	48	1112
30	35	74	70	74	67	65	68	60	48	47	45	53	56	59	69	66	66	66	74	76	73	76	76	70	73	1571
35	40	86	77	74	77	81	77	78	81	70	74	87	89	90	80	78	90	92	86	86	88	91	91	88	78	1991
40	45	67	77	73	73	65	66	64	59	56	65	56	66	67	73	78	73	69	71	74	70	68	62	65	67	1626
45	50	38	38	42	44	48	46	42	44	47	48	54	47	42	40	38	30	29	24	27	30	28	33	35	40	934
50	55	7	8	9	10	6	11	21	20	16	15	15	9	8	6	6	7	6	9	10	10	6	8	7	6	238
55	60	3	3	2	2	4	2	4	4	4	5	4	3	3	2	1	1	3	3	3	3	4	1	3	4	71
60	65	1	1	1	1	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	13
65	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UNKNO		4	4	4	4	5	5	5	18	47	36	18	14	11	8	7	6	6	6	3	3	3	4	4	4	229
TOTAL		365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Table 2.3-20

Monthly Averages of Psychrometric Data Based on Period of Record (1950-1970)

AVERAGES

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
DRY BULB	30.3	37.5	44.0	52.5	61.8	69.9	77.5	75.3	67.0	53.2	40.1	33.4	53.5
WET BULB	27.9	33.6	37.3	42.8	49.1	54.5	57.9	57.3	52.6	45.4	36.4	31.2	43.8
REL HUM.	76.0	69.7	55.0	46.4	41.8	39.4	31.5	34.9	39.9	57.7	72.6	80.8	53.8
DEWPOINT	23.2	27.4	27.3	30.4	36.0	41.2	42.3	42.8	39.5	36.9	31.1	27.5	33.8

MONTHLY AVERAGE EXTREMES

		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
DRY BULB	HIGHEST	43.0	44.0	48.7	56.2	68.7	75.5	82.8	82.5	72.0	59.1	45.8	38.8	56.3
	YEAR	1953	1958	1968	1956	1958	1969	1960	1967	1967	1952	1954	1953	1953
	LOWEST	12.9	25.8	39.6	48.3	57.2	64.2	73.2	70.6	61.6	50.3	32.3	26.5	51.0
	YEAR	1950	1956	1955	1955	1962	1953	1963	1964	1970	1968	1955	1964	1955+
WET BULB	HIGHEST	39.3	40.7	40.8	45.1	54.6	58.6	61.2	61.1	56.5	47.7	42.3	35.8	46.5
	YEAR	1953	1958	1963	1962	1958	1958	1958	1961	1963	1962	1954	1966	1958
	LOWEST	12.4	23.4	32.9	39.3	45.4	51.4	55.6	54.9	48.3	42.4	29.6	25.0	41.8
	YEAR	1950	1956	1955	1955	1959	1954	1954	1964	1970	1970	1955	1964	1955
REL HUM.	HIGHEST	89	87	66	64	*52	54	40	44	55	74	80	90	58
	YEAR	1960	1963	1950	1963	1962+	1950	1955	1968	1969	1962	1956	1950	1950+
	LOWEST	60	54	44	37	31	34	22	24	34	42	64	69	49
	YEAR	1963	1967	1965	1966	1966	1960	1959	1967	1952	1952	1963+	1968	1967
DEWPOINT	HIGHEST	34.4	36.7	34.0	37.1	43.8	47.5	46.6	46.9	45.4	43.5	38.3	34.3	37.7
	YEAR	1953	1958	1961	1963	1957	1958	1958	1961	1963	1962	1954	1950	1958
	LOWEST	6.5	17.3	20.8	26.2	30.4	37.5	35.4	38.4	33.8	32.1	24.0	21.0	31.5
	YEAR	1950	1956	1965+	1955	1964	1954	1959	1955	1970	1970	1959	1951	1955

+Also in Earlier Years
*Although not included in these tables, an average of 63% was recorded in 1948

Table 2.3-21

Diurnal Variation of Precipitation Intensity (Inches/Hour) at CGS and Monthly Total Precipitation (Inches) at the Hanford Reservation

HOUR	APRIL 1974	MAY 1974	JUNE 1974	JULY 1974	AUGUST 1974	SEPTEMBER 1974	OCTOBER 1974	NOVEMBER 1974	DECEMBER 1974	JANUARY 1975	FEBRUARY 1975	MARCH 1975	AVERAGE FOR HOUR (APRIL 1974 – MARCH 1975)
01	0.000	0.136	0.000	0.168	0.000	0.000	0.000	0.000	0.016	0.000	0.032	0.040	0.071
02	0.000	0.016	0.000	0.040	0.000	0.000	0.000	0.016	0.040	0.000	0.032	0.000	0.029
03	0.016	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.032	0.020	0.000	0.000	0.026
04	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.020	0.016	0.000	0.000	0.018
05	0.016	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.064	0.000	0.000	0.030
06	0.000	0.048	0.000	0.016	0.000	0.000	0.000	0.000	0.016	0.072	0.000	0.000	0.045
07	0.000	0.072	0.000	0.032	0.000	0.000	0.000	0.016	0.016	0.020	0.016	0.016	0.026
08	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.024	0.024	0.048	0.029
09	0.000	0.088	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.024	0.016	0.032	0.039
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.000	0.072	0.024	0.036
11	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.056	0.040	0.028	0.034
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.024	0.016	0.024	0.022
13	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.036	0.016	0.024	0.032
14	0.032	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.020	0.024	0.000	0.000	0.024
15	0.016	0.000	0.032	0.000	0.000	0.064	0.000	0.032	0.036	0.032	0.000	0.000	0.033
16	0.016	0.000	0.000	0.016	0.000	0.000	0.000	0.036	0.024	0.048	0.024	0.000	0.029
17	0.024	0.000	0.000	0.056	0.000	0.000	0.000	0.040	0.032	0.040	0.064	0.000	0.038
18	0.016	0.000	0.000	0.000	0.000	0.000	0.016	0.028	0.000	0.032	0.036	0.000	0.026
19	0.020	0.000	0.000	0.024	0.000	0.000	0.000	0.052	0.040	0.032	0.000	0.000	0.034
20	0.000	0.000	0.000	0.000	0.000	0.000	0.064	0.028	0.000	0.020	0.024	0.048	0.032
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.024	0.016	0.088	0.040
22	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.021
23	0.080	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.024	0.048	0.020	0.016	0.040
24	0.036	0.048	0.000	0.000	0.000	0.000	0.016	0.000	0.048	0.024	0.032	0.080	0.038
MONTHLY TOTAL PRECIPITATION (INCHES)													
CGS	0.55	0.44	0.06	0.45	0.00	0.06	0.10	0.56	0.67	0.93	0.67	0.52	4.92
HMS	0.46	0.28	0.12	0.71	trace	0.01	0.21	0.71	0.97	1.43	0.98	0.33	6.21
HMS (hist) 1946-1970 Mean Total	0.44	0.50	0.66	0.16	0.21	0.30	0.61	0.80	0.81	0.97	0.58	0.38	6.53

Table 2.3-22

Frequency of Occurrence, Precipitation (Inches/Hour) Versus Time of Day
from 4/74 through 3/75 at CGS

Time of Day

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
016	6	5	7	4	5	5	8	5	6	4	5	5	6	6	8	7	9	8	7	8	4	3	8	10	149
050	2	0	0	0	1	1	1	0	2	1	1	0	1	0	2	0	2	1	1	1	1	0	2	1	21
100	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.3-22a

Annual Frequency of Occurrence of Wind Direction and Wind Speed Versus Precipitation Intensity

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .016 INCHES PER HOUR

	SPEED CLASS (MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	2	2	0	0	0	0	0	4
NE	0	2	3	0	0	0	0	0	5
ENE	0	2	1	0	0	0	0	0	3
E	0	1	4	0	0	0	0	0	5
ESE	0	7	2	0	0	0	0	0	9
SE	0	1	1	2	1	0	0	0	5
SSE	0	4	6	4	4	1	0	0	21
S	0	3	3	5	0	0	0	0	11
SSW	0	3	3	4	3	1	0	0	14
SW	0	1	3	4	1	0	0	0	9
WSW	0	1	2	1	0	1	0	0	5
W	0	0	3	2	0	0	1	0	6
WNW	0	0	5	7	0	0	0	0	12
NW	0	5	10	5	1	0	0	0	21
NNW	0	2	10	2	0	0	0	0	14
N	0	0	1	0	0	0	0	0	1
VAR	0	2	1	0	0	0	0	0	3
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	1	1
TOTAL	0	36	60	36	10	3	1	1	149

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .050 INCHES PER HOUR

	SPEED CLASS (MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	1	1	0	0	0	0	0	2
NE	0	1	0	0	0	0	0	0	1
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	1	0	0	0	0	1
SSE	0	0	0	3	2	0	0	0	5
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	2	0	0	0	0	2
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	1	0	0	0	0	1
W	0	0	0	1	0	0	0	0	1
WNW	0	0	2	0	0	0	0	0	2
NW	0	0	1	3	0	0	0	0	4
NNW	0	0	1	1	0	0	0	0	2
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	2	5	12	2	0	0	0	21

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .100 INCHES PER HOUR

	SPEED CLASS (MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	1	0	0	0	0
SSE	0	0	0	0	0	0	0	0	1
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0
WNW	0	0	1	0	0	0	0	0	1
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	1	0	0	0	0	1
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	1	1	0	0	0	3

Table 2.3-22a

Annual Frequency of Occurrence of Wind Direction and Wind Speed Versus Precipitation Intensity (Continued)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .250 INCHES PER HOUR

	SPEED CLASS (MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .500 INCHES PER HOUR

	SPEED CLASS (MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0

Table 2.3-23

Statistic on Fog at the Hanford Meteorology Station (Based on 1945-1970 Data)*

	All Fog (viz 0-6 Miles)						Dense Fog (viz 1/4 Mile or Less)						Greatest No. of Hours of Persistence	
	No. of Days			No. of Hours			No. of Days			No. of Hours			(9)	(10)
	Avg	Greatest	Least	Avg	Greatest	Least	Avg	Greatest	Least	Avg	Greatest	Least	AF	DF
J	9	19	0	68.3	193.4	0	6	14	0	20.4	52.4	0	58.1	15.0
F	6	20	0	36.4	206.2	0	3	11	0	12.7	86.7	0	58.0	16.7
M	1	6	0	4.4	20.6	0	1	5	0	1.8	7.8	0	12.2	5.0
A	#	1	0	0.3	2.8	0	#	1	0	0.1	1.8	0	2.8	0
M	#	3	0	0.3	2.7	0	#	1	0	0.1	1.6	0	2.7	1.6
J	#	1	0	#	0.5	0	0	0	0	0	0	0	0.5	0
J	#	1	0	#	0.7	0	0	0	0	0	0	0	0.7	0
A	#	1	0	#	1.0	0	#	1	0	#	1.0	0	0.7	0.7
S	#	1	0	0.3	5.5	0	#	1	0	0.1	3.2	0	2.6	1.4
O	2	9	0	7.6	63.6	0	1	6	0	3.1	35.2	0	39.0	15.8
N	8	14	1	55.4	148.0	1.0	5	13	0	21.1	71.4	0	65.4	20.6
D	12	20	2	105.4	193.8	6.5	8	17	2	42.0	119.8	1.3	72.3	47.0
		(1)	(2)		(3)	(4)		(5)	(6)		(7)	(8)		
Y	33	57	22	278.4	462.5	147.7	24	42	2	101.4	201.5	24.3	72.3	47.0

\# Less than 1/2
1. Greatest number of days in a season -- occurred in 1969-70
2. Least number of days in a season -- occurred in 1948-49
3. Greatest number of hours in a season -- occurred in 1964-65
4. Least number of hours in a season -- occurred in 1948-49
5. Greatest number of days in a season -- occurred in 1950-51
6. Least number of days in a season -- occurred in 1948-49
7. Greatest number of hours in a season -- occurred in 1962-63
8. Least number of hours in a season -- occurred in 1948-49
9. AF denotes all fog (viz 0-6 miles)
10. DF denotes dense fog (viz 1/4 mile or less). Records for persistence of dense fog did not begin until 1953.

*Summation for the year does not necessarily reflect the summation of individual months.

Table 2.3-24

Percent Frequency Distribution of Wind Speeds During Hourly Observations of Fog at Pasco (1966-1970) and at HMS (1960-1970)

	Speed Class*					
Station	Calm	1-3	4-7	8-12	12	Total
HMS[1]	29	44	25	2	0	100
Pasco[2]	61	8	24	6	1	100

* Speed classes are in units of mph for HMS, and in units of knots for Pasco.

(1) Statistics for HMS are only for hourly observations of fog restricting visibility to 1/2 mile or less.

(2) Statistics for Pasco are for all hourly observations of fog (visibility 0-6 miles).

Table 2.3-25

Percent Frequency of Occurrence of Stability (ΔT Distribution)
at the Hanford Reservation (1)

Month/Year/Site	Very Unstable Less Than -2.5	Unstable -2.5 to -1.5	t Range (°F/200 ft) Neutral -1.5 to -0.5	Moderately Stable -0.5 to +3.5	Very Stable Greater Than 3.5
4/74 CGS	0.14	15.69	27.78	43.33	12.36
4/74 HMS	3.61	25.28	26.94	40.83	3.19
APRIL 1955-1970 HMS (hist)	5.10	20.88	30.22	39.19	4.61
5/74 CGS	0.27	23.39	30.51	35.89	8.06
5/74 HMS	6.18	33.20	26.34	32.39	1.88
MAY 1955-1970 HMS (hist)	8.33	22.56	30.18	34.71	4.22
6/74 CGS	1.25	35.42	17.36	30.42	5.42
6/74 HMS	7.36	33.33	24.72	31.39	3.19
JUNE 1955-1970 HMS (hist)	8.60	26.25	30.75	31.45	2.95
7/74 CGS	0.00	28.23	25.81	27.02	14.11
7/74 HMS	6.72	30.78	28.90	30.51	3.09
JULY 1955-1970 HMS (hist)	8.74	26.31	27.69	33.42	3.84
8/74 CGS	0.00	28.09	20.83	23.79	25.54
8/74 HMS	8.20	32.12	18.28	33.74	7.66
AUGUST 1955-1970 HMS (hist)	7.33	23.73	26.55	37.65	4.74
9/74 CGS	0.00	21.67	20.83	21.25	35.14
9/74 HMS	6.94	25.69	17.64	33.06	16.67
SEPTEMBER 1955-1970 HMS (hist)	5.05	19.90	25.11	40.89	9.05
10/74 CGS	0.00	14.38	18.15	25.81	38.98
10/74 HMS	3.36	20.16	17.74	41.26	17.47
OCTOBER 1955-1970 HMS (hist)	2.23	11.82	27.03	48.87	10.06
11/74 CGS	0.00	4.58	28.06	52.22	14.44
11/74 HMS	0.00	5.00	30.42	57.22	5.83
NOVEMBER 1955-1970 HMS (hist)	0.76	6.82	31.74	53.37	7.30
12/74 CGS	0.00	1.75	22.72	56.18	18.15
12/74 HMS	0.13	5.24	22.72	60.89	11.02
DECEMBER 1955-1970 HMS (hist)	0.40	4.35	36.53	50.98	7.74

[(1)] Δt at CGS is computed from 33 to 245 foot levels; at HMS, Δt is computed from 50 to 250 foot level.

Table 2.3-25

Percent Frequency of Occurrence of Stability (ΔT Distribution) at the Hanford Reservation (1) (Continued)

			t Range (°F/200 ft)		
Month/Year/Site	Very Unstable Less Than -2.5	Unstable -2.5 to -1.5	Neutral -1.5 to -0.5	Moderately Stable -0.5 to +3.5	Very Stable Greater Than 3.5
1/75 CGS	0.00	2.55	30.51	53.90	10.62
1/74 HMS (1975 Not Available)	0.13	5.65	29.30	59.54	5.11
JANUARY 1955-1970 HMS (hist)	0.34	4.73	34.78	52.23	7.91
2/75 CGS	0.00	8.78	30.51	49.40	10.57
2/74 HMS (1975 Not Available)	0.30	14.43	26.93	51.19	7.14
FEBRUARY 1955-1970 HMS (hist)	1.51	9.29	28.24	52.05	8.90
3/75 CGS	0.13	20.03	17.34	42.07	11.96
3/74 HMS (1975 Not Available)	1.48	19.09	26.34	47.04	6.05
MARCH 1955-1970 HMS (hist)	3.49	15.84	28.22	45.25	6.61
April 1974 - March 1975 CGS	0.14	17.17	24.25	38.21	17.17
1955-1970 HMS (hist)	4.32	16.04	29.80	41.84	6.49
April 1975 - March 1976 CGS	0.59	21.31	21.85	37.20	17.51

[1] Δt at CGS is computed from 33 to 245 foot levels; at HMS, Δt is computed from 50 to 250 foot level.

Table 2.3-26

Frequency of Occurrence ΔT (°F/200 ft) Versus Time of Day from 4/74 through 3/75
at CGS between 245 and 33 ft Levels

Time of Day

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
LT-2.5	0	0	0	0	0	0	0	0	0	0	3	2	2	1	2	1	1	0	0	0	0	0	0	0	12
GE-2.5 LT-1.5	0	0	0	0	0	0	3	43	98	137	156	175	213	217	196	148	90	27	1	0	0	0	0	0	1504
GE-1.5 LT-0.5	17	16	16	16	18	37	97	137	134	150	168	158	123	123	145	168	181	167	111	52	33	21	18	18	2124
GE-0.5 LT-3.5	216	202	193	197	187	188	177	131	76	40	20	16	14	14	14	42	85	156	203	236	235	242	238	225	3347
GE-3.5	124	141	148	143	150	133	84	36	9	5	1	1	1	1	1	0	2	8	41	71	91	95	102	116	1504
UNKNO	8	6	8	9	10	7	4	18	48	33	17	13	12	9	7	6	6	7	9	6	6	7	7	6	269
TOTAL	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Average for Hour

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
2.899	3.008	3.226	3.261	3.227	2.714	1.499	.243	-.654	-1.104	-1.303	-1.432	-1.521	-1.502	-1.441	-1.240	-.835	-.155	.762	1.656	2.144	2.228	2.383	2.685	.883

Table 2.3-27

Frequency of Occurrence, Sigma (°) Versus Time of Day from 4/74 through 3/75
at CGS for 33 ft Level

Time of Day

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
GE22.5	111	110	105	104	104	112	96	117	124	139	144	152	152	153	137	109	62	44	52	51	79	88	107	98	2550
LT22.5 GE17.5	30	33	32	38	33	32	34	29	32	35	39	44	33	36	46	39	32	20	21	28	36	26	27	41	790
LT17.5 GE12.5	43	48	54	52	52	47	54	48	46	58	70	55	68	60	50	59	50	36	34	39	43	51	47	41	1205
LT 12.5 GE7.5	104	91	87	74	94	97	112	114	81	79	71	79	83	80	94	107	144	151	113	112	105	96	98	88	2354
LT7.5 GE3.75	60	61	64	75	62	56	58	31	31	18	19	17	13	23	27	39	65	92	121	112	90	86	68	77	1365
LT3.75 GE2.1	0	5	7	5	4	6	1	0	0	0	1	0	0	0	0	1	1	11	13	8	5	8	5	6	87
LT2.1	8	8	8	7	5	5	0	2	0	0	0	0	0	0	0	0	0	0	3	7	5	2	4	5	69
UNKNO	9	9	8	10	11	10	10	24	51	36	21	18	16	13	11	11	11	11	8	8	8	8	9	9	340
TOTAL	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Average for Hour

22.406 23.575 22.421 23.031 27.390 27.768 28.298 21.895 14.198 14.656 18.667 20.997
23.638 22.506 22.794 21.730 27.378 28.124 28.874 27.136 17.011 15.285 17.978 20.985 22.384

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction

PLANT NAME: COLUMBIA GENERATING STATION — METEOROLOGICAL INSTRUMENTATION
DATA PERIOD: JFD 1996-1999 — WIND SENSORS HEIGHT: 10.0 METER
TYPE OF RELEASE: GROUND LEVEL RELEASE — DELTA-T HEIGHTS: 10 - 75 METERS
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS A

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.029	.035	.027	.021	.024	.022	.025	.014	.024	.017	.013	.016	.013	.020	.022	.024	.348
1.01	1.01	.101	.123	.095	.073	.085	.079	.088	.051	.085	.060	.044	.057	.047	.070	.079	.085	1.223
2.03	2.03	.231	.190	.161	.114	.095	.123	.247	.180	.224	.155	.098	.063	.095	.098	.155	.269	2.497
3.02	3.02	.190	.145	.130	.035	.032	.095	.158	.247	.209	.107	.073	.054	.028	.054	.085	.171	1.811
4.00	4.00	.168	.117	.060	.022	.016	.028	.139	.262	.180	.107	.076	.038	.035	.016	.060	.085	1.410
5.03	5.03	.114	.088	.035	.006	.013	.013	.070	.114	.196	.117	.073	.025	.025	.019	.013	.098	1.018
6.01	6.01	.051	.028	.016	.003	.000	.003	.019	.047	.180	.079	.035	.013	.016	.019	.016	.054	.578
8.02	8.02	.079	.057	.032	.000	.000	.000	.003	.022	.196	.092	.066	.041	.028	.035	.019	.035	.705
10.04	10.04	.003	.003	.006	.000	.000	.000	.000	.006	.063	.016	.035	.025	.022	.019	.013	.000	.212
13.03	13.03	.000	.006	.000	.000	.000	.000	.000	.003	.022	.006	.003	.009	.009	.022	.009	.003	.095
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003	.000	.000	.000	.000	.000	.003	.006
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		.96	.79	.56	.27	.26	.36	.75	.95	1.38	.76	.52	.34	.32	.37	.47	.83	9.90

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS B

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.007	.008	.001	.005	.007	.005	.006	.006	.005	.005	.003	.003	.004	.003	.008	.012	.092
1.01	1.01	.022	.025	.003	.016	.022	.016	.019	.019	.016	.016	.009	.009	.013	.009	.025	.038	.278
2.03	2.03	.063	.041	.035	.013	.019	.035	.038	.025	.070	.057	.051	.028	.028	.025	.038	.063	.629
3.02	3.02	.085	.057	.047	.013	.009	.016	.063	.076	.095	.025	.032	.016	.016	.022	.028	.070	.670
4.00	4.00	.047	.057	.032	.006	.006	.022	.038	.085	.076	.047	.022	.019	.019	.022	.038	.032	.569
5.03	5.03	.035	.032	.025	.003	.000	.006	.009	.051	.092	.047	.032	.013	.019	.019	.016	.025	.424
6.01	6.01	.019	.006	.003	.003	.000	.000	.006	.019	.047	.041	.016	.000	.028	.022	.013	.009	.234
8.02	8.02	.013	.006	.006	.009	.000	.000	.009	.013	.066	.060	.051	.006	.032	.016	.006	.013	.307
10.04	10.04	.003	.000	.000	.000	.000	.000	.000	.003	.009	.025	.025	.013	.003	.006	.003	.000	.092
13.03	13.03	.000	.006	.000	.000	.000	.000	.000	.000	.000	.013	.025	.000	.013	.013	.000	.000	.070
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		.29	.24	.15	.07	.06	.10	.19	.30	.48	.34	.27	.11	.17	.16	.18	.26	3.36

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS C

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.007	.011	.009	.005	.003	.004	.005	.002	.007	.008	.008	.003	.003	.003	.003	.007	.088
1.01	1.01	.019	.032	.025	.016	.009	.013	.016	.006	.019	.022	.022	.009	.009	.009	.009	.019	.256
2.03	2.03	.076	.060	.035	.013	.019	.009	.025	.047	.044	.057	.028	.044	.022	.028	.051	.054	.613
3.02	3.02	.079	.057	.035	.028	.022	.003	.063	.098	.082	.044	.028	.019	.028	.038	.054	.079	.759
4.00	4.00	.054	.047	.009	.003	.006	.013	.035	.076	.092	.044	.044	.022	.025	.009	.022	.051	.553
5.03	5.03	.051	.035	.016	.000	.000	.006	.022	.057	.063	.047	.047	.035	.022	.022	.022	.035	.480
6.01	6.01	.022	.009	.009	.000	.000	.000	.003	.035	.063	.057	.022	.016	.022	.022	.013	.022	.316
8.02	8.02	.022	.006	.006	.000	.000	.000	.016	.016	.047	.063	.054	.028	.032	.016	.009	.028	.345
10.04	10.04	.000	.006	.000	.000	.000	.000	.000	.000	.019	.032	.041	.044	.013	.028	.022	.003	.209
13.03	13.03	.000	.000	.000	.000	.000	.000	.000	.000	.006	.019	.009	.003	.003	.025	.000	.003	.070
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		.33	.26	.14	.07	.06	.05	.19	.34	.44	.39	.30	.22	.18	.20	.21	.30	3.69

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS D

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.035	.025	.020	.018	.012	.010	.021	.018	.025	.015	.031	.019	.027	.030	.028	.031	.363
1.01	1.01	.142	.101	.082	.073	.051	.041	.085	.073	.101	.060	.126	.079	.111	.123	.114	.126	1.489
2.03	2.03	.332	.215	.168	.104	.117	.101	.205	.322	.322	.243	.136	.123	.158	.158	.471	.405	3.581
3.02	3.02	.420	.231	.171	.079	.073	.092	.193	.401	.338	.212	.168	.149	.092	.202	.468	.455	3.742
4.00	4.00	.218	.186	.126	.060	.057	.082	.218	.395	.398	.205	.161	.079	.101	.202	.414	.408	3.312
5.03	5.03	.193	.101	.107	.019	.016	.022	.133	.303	.326	.281	.142	.054	.126	.149	.310	.265	2.547
6.01	6.01	.130	.047	.051	.000	.000	.016	.051	.136	.228	.240	.107	.082	.092	.171	.231	.149	1.729
8.02	8.02	.032	.038	.013	.006	.000	.003	.013	.120	.335	.370	.202	.155	.107	.326	.161	.155	2.035
10.04	10.04	.003	.025	.019	.000	.000	.000	.003	.009	.123	.215	.142	.133	.057	.161	.088	.047	1.027
13.03	13.03	.003	.003	.013	.000	.000	.000	.000	.000	.041	.120	.101	.035	.016	.057	.051	.009	.449
18.04	18.04	.000	.000	.006	.000	.000	.000	.000	.000	.006	.022	.016	.000	.006	.006	.006	.009	.079
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.51	.97	.78	.36	.33	.37	.92	1.78	2.24	1.98	1.33	.91	.89	1.59	2.34	2.06	20.35

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS E

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.037	.029	.019	.021	.018	.013	.025	.029	.051	.043	.045	.043	.051	.074	.066	.045	.607
1.01	1.01	.142	.111	.073	.082	.070	.051	.095	.111	.196	.168	.174	.164	.196	.284	.253	.174	2.342
2.03	2.03	.370	.291	.199	.095	.070	.098	.247	.411	.490	.392	.281	.307	.310	.446	.651	.676	5.332
3.02	3.02	.307	.250	.171	.085	.060	.063	.288	.544	.484	.288	.228	.218	.256	.480	.762	.540	5.022
4.00	4.00	.161	.104	.145	.025	.016	.079	.348	.670	.484	.196	.199	.142	.272	.455	.610	.414	4.320
5.03	5.03	.079	.032	.047	.028	.000	.038	.247	.525	.553	.250	.164	.107	.136	.509	.487	.234	3.436
6.01	6.01	.035	.013	.009	.016	.000	.006	.101	.288	.430	.316	.199	.104	.136	.442	.389	.107	2.592
8.02	8.02	.025	.041	.019	.003	.003	.000	.070	.224	.424	.518	.224	.120	.130	.477	.354	.180	2.813
10.04	10.04	.009	.041	.022	.000	.000	.000	.003	.009	.076	.348	.196	.038	.038	.202	.098	.066	1.147
13.03	13.03	.003	.000	.003	.000	.000	.000	.000	.000	.025	.133	.082	.019	.019	.063	.032	.013	.392
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.006	.025	.016	.000	.000	.006	.000	.000	.054
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.17	.91	.71	.36	.24	.35	1.42	2.81	3.22	2.68	1.81	1.26	1.54	3.44	3.70	2.45	28.06

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS F

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.075	.055	.037	.016	.016	.014	.020	.035	.055	.041	.049	.057	.065	.070	.083	.072	.759
1.01	1.01	.272	.199	.136	.057	.057	.051	.073	.126	.202	.149	.177	.209	.237	.256	.303	.262	2.765
2.03	2.03	.531	.446	.221	.095	.044	.076	.209	.512	.629	.455	.303	.265	.322	.442	.733	.670	5.954
3.02	3.02	.307	.205	.126	.051	.025	.032	.174	.604	.733	.389	.205	.183	.164	.319	.512	.528	4.558
4.00	4.00	.041	.025	.070	.032	.006	.013	.269	.582	.578	.288	.117	.088	.142	.326	.442	.177	3.195
5.03	5.03	.006	.003	.009	.009	.000	.006	.111	.414	.297	.120	.051	.051	.101	.171	.161	.073	1.583
6.01	6.01	.009	.000	.000	.000	.000	.000	.028	.092	.130	.107	.032	.016	.051	.088	.063	.013	.629
8.02	8.02	.000	.000	.000	.000	.000	.000	.013	.066	.104	.085	.032	.016	.006	.044	.006	.013	.386
10.04	10.04	.000	.000	.000	.000	.000	.000	.000	.006	.009	.047	.003	.000	.003	.000	.000	.000	.070
13.03	13.03	.000	.000	.000	.000	.000	.000	.000	.000	.006	.009	.006	.003	.000	.000	.000	.000	.025
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.24	.93	.60	.26	.15	.19	.90	2.44	2.75	1.69	.97	.89	1.09	1.72	2.31	1.81	19.92

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION ATMOSPHERIC STABILITY CLASS G

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.113	.111	.068	.030	.020	.022	.027	.054	.059	.047	.067	.061	.067	.071	.094	.134	1.046
1.01	1.01	.332	.326	.199	.088	.060	.063	.079	.158	.174	.139	.196	.180	.196	.209	.275	.392	3.066
2.03	2.03	.860	.787	.335	.092	.019	.019	.139	.357	.408	.335	.237	.120	.171	.307	.667	.796	5.648
3.02	3.02	.281	.237	.180	.044	.003	.000	.114	.493	.496	.155	.082	.051	.047	.139	.395	.405	3.123
4.00	4.00	.025	.025	.060	.019	.003	.000	.028	.307	.313	.111	.047	.019	.041	.044	.221	.101	1.365
5.03	5.03	.000	.000	.009	.006	.000	.000	.009	.136	.085	.025	.000	.013	.016	.016	.019	.003	.338
6.01	6.01	.000	.000	.000	.003	.000	.000	.000	.032	.028	.019	.000	.003	.000	.000	.006	.000	.092
8.02	8.02	.000	.000	.000	.000	.000	.000	.000	.006	.009	.003	.000	.000	.000	.000	.000	.000	.019
10.04	10.04	.000	.000	.000	.000	.000	.000	.000	.003	.006	.000	.000	.000	.000	.000	.000	.000	.009
13.03	13.03	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003	.000	.000	.000	.000	.000	.000	.003
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003	.000	.000	.000	.000	.000	.003
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.61	1.49	.85	.28	.11	.10	.40	1.55	1.58	.84	.63	.45	.54	.79	1.68	1.83	14.71

WIND MEASURED AT 10.0 METERS

WIND SPEED CORRECTED TO THE RELEASE HEIGHT OF 10.0 METERS.

OVERALL WIND DIRECTION FREQUENCY

WIND DIRECTION:	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
FREQUENCY:	7.1	5.6	3.8	1.7	1.2	1.5	4.8	10.2	12.1	8.7	5.8	4.2	4.7	8.3	10.9	9.5

OVERALL WIND SPEED FREQUENCY AS MEASURED ON THE TOWER:

MAX. WIND SPEED (M/S):	.425	1.006	2.034	3.018	4.001	5.029	6.013	8.024	10.036	13.031	18.038	44.704
WIND SPEED FREQUENCY:	3.30	11.42	24.25	19.68	14.73	9.83	6.17	6.61	2.77	1.10	.14	.00

BUILDING AND RELEASE CHARACTERISTICS:

RELEASE HEIGHT: 10.00 METERS

MIXING VOLUME COEFFICIENT: 0.50

BUILDING CROSS-SECTIONAL AREA: 2861.00 SQUARE METERS

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

TABLE 2.3-29
THROUGH
TABLE 2.3-32

DELETED

Table 2.3-33

Exclusion Area Boundary Accident χ/Q Desert Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWWIND SECTOR
S	1950.	1.68E-04	1.08E-04	8.69E-05	5.39E-05	2.71E-05	1.17E-05	38.6	S
SSW	1950.	1.61E-04	1.02E-04	8.16E-05	5.00E-05	2.48E-05	1.05E-05	389.5	SSW
SW	1950.	1.13E-04	7.01E-05	5.51E-05	3.27E-05	1.55E-05	6.20E-06	22.0	SW
WSW	1950.	5.62E-05	3.38E-05	2.63E-05	1.51E-05	6.88E-06	2.62E-06	10.4	WSW
W	1950.	2.88E-05	1.80E-05	1.42E-05	8.52E-06	4.09E-06	1.67E-06	7.6	W
WNW	1950.	3.14E-05	1.94E-05	1.53E-05	9.06E-06	4.29E-06	1.72E-06	7.5	WNW
NW	1950.	7.22E-05	4.41E-05	3.45E-05	2.02E-05	9.39E-06	3.67E-06	10.0	NW
NNW	1950.	1.19E-04	7.70E-05	6.20E-05	3.87E-05	1.97E-05	8.64E-06	20.3	NNW
N	1950.	1.30E-04	8.49E-05	6.86E-05	4.32E-05	2.23E-05	9.87E-06	23.5	N
NNE	1950.	1.09E-04	6.85E-05	5.45E-05	3.31E-05	1.62E-05	6.73E-06	17.9	NNE
NE	1950.	1.20E-04	7.40E-05	5.81E-05	3.44E-05	1.62E-05	6.46E-06	23.8	NE
ENE	1950.	1.14E-04	6.94E-05	5.41E-05	3.16E-05	1.46E-05	5.66E-06	22.7	ENE
E	1950.	1.25E-04	7.65E-05	6.00E-05	3.53E-05	1.65E-05	6.50E-06	25.1	E
ESE	1950.	1.39E-04	8.76E-05	6.94E-05	4.20E-05	2.04E-05	8.41E-06	27.9	ESE
SE	1950.	1.59E-04	1.04E-04	8.44E-05	5.34E-05	2.77E-05	1.24E-05	34.5	SE
SSE	1950.	1.81E-04	1.18E-04	9.52E-05	5.98E-05	3.07E-05	1.36E-05	43.7	SSE
MAX χ/Q		1.81E-04				TOTAL HOURS AROUND SITE:		724.9	
SRP 2.3.4	1950.	1.69E-04	1.12E-04	9.06E-05	5.76E-05	3.01E-05	1.36E-05		
SITE LIMIT		1.69E-04	1.12E-04	9.06E-05	5.76E-05	3.01E-05	1.36E-05		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Table 2.3-33a

Exclusion Area Boundary χ/Q Values
Desert Sigmas w/ Meander

Direction From Site	0.5% Level[a] (10^{-4} sec/m^3)	5% Level[b] (10^{-4} sec/m^3)
S	1.68	2.04
SSW	1.61	2.26
SW	1.13	2.13
WSW	0.562	2.20
W	0.288	2.19
WNW	0.314	1.93
NW	0.722	1.17
NNW	1.19	1.18
N	1.30	1.17
NNE	1.09	1.18
NE	1.20	1.74
ENE	1.14	2.03
E	1.25	2.00
ESE	1.39	1.58
SE	1.59	1.52
SSE	1.81	1.86

[a] Exceeded 0.5% of the total time.

[b] Exceeded 5% of the time that wind blows into the individual sector.

Table 2.3-34

Exclusion Area Boundary Accident χ/Q P-G Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWWIND SECTOR
S	1950.	1.67E-04	8.92E-05	6.53E-05	3.32E-05	1.25E-05	3.82E-06	38.9	S
SSW	1950.	1.59E-04	8.36E-05	6.06E-05	3.01E-05	1.10E-05	3.23E-06	385.6	SSW
SW	1950.	1.15E-04	5.89E-05	4.21E-05	2.04E-05	7.20E-06	2.01E-06	21.0	SW
WSW	1950.	5.48E-05	2.81E-05	2.01E-05	9.75E-06	3.45E-06	9.65E-07	8.6	WSW
W	1950.	2.52E-05	1.39E-05	1.03E-05	5.39E-06	2.12E-06	6.80E-07	6.1	W
WNW	1950.	2.85E-05	1.54E-05	1.13E-05	5.80E-06	2.22E-06	6.87E-07	6.3	WNW
NW	1950.	7.40E-05	3.92E-05	2.85E-05	1.43E-05	5.29E-06	1.57E-06	9.2	NW
NNW	1950.	1.30E-04	7.05E-05	5.20E-05	2.68E-05	1.04E-05	3.24E-06	22.8	NNW
N	1950.	1.38E-04	7.60E-05	5.65E-05	2.97E-05	1.18E-05	3.81E-06	25.5	N
NNE	1950.	1.08E-04	5.86E-05	4.31E-05	2.22E-05	8.56E-06	2.67E-06	17.2	NNE
NE	1950.	1.09E-04	5.81E-05	4.24E-05	2.15E-05	8.07E-06	2.44E-06	19.9	NE
ENE	1950.	1.01E-04	5.32E-05	3.87E-05	1.94E-05	7.19E-06	2.14E-06	18.9	ENE
E	1950.	1.10E-04	5.87E-05	4.29E-05	2.17E-05	8.18E-06	2.47E-06	20.7	E
ESE	1950.	1.24E-04	6.83E-05	5.07E-05	2.65E-05	1.05E-05	3.37E-06	23.2	ESE
SE	1950.	1.59E-04	8.86E-05	6.61E-05	3.51E-05	1.41E-05	4.63E-06	35.2	SE
SSE	1950.	1.77E-04	9.68E-05	7.16E-05	3.72E-05	1.45E-05	4.59E-06	43.7	SSE
MAX χ/Q		1.77E-04				TOTAL HOURS AROUND SITE:		702.8	
SRP 2.3.4	1950.	2.86E-04	1.45E-04	1.03E-04	4.91E-05	1.70E-05	4.63E-06		
SITE LIMIT		1.65E-04	9.16E-05	6.82E-05	3.59E-05	1.43E-05	4.63E-06		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Table 2.3-34a

Exclusion Area Boundary χ/Q Values
Pasquill-Gifford Sigmar w/ Meander and Building Wake Credit

Direction From Site	0.5% Level[a] (10^{-4} sec/m^3)	5% Level[b] (10^{-4} sec/m^3)
S	1.67	1.99
SSW	1.59	2.18
SW	1.15	2.02
WSW	0.548	1.96
W	0.252	1.93
WNW	0.285	1.71
NW	0.740	1.14
NNW	1.30	1.29
N	1.38	1.25
NNE	1.08	1.17
NE	1.09	1.53
ENE	1.01	1.80
E	1.10	1.77
ESE	1.24	1.38
SE	1.59	1.52
SSE	1.77	1.82

[a] Exceeded 0.5% of the total time.

[b] Exceeded 5% of the time that wind blows into the individual sector.

Table 2.3-35

Low Population Zone Accident χ/Q Desert Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWNWIND SECTOR
S	4827.	8.35E-05	4.58E-05	3.39E-05	1.76E-05	6.92E-06	2.20E-06	39.1	S
SSW	4827.	7.96E-05	4.33E-05	3.19E-05	1.64E-05	6.36E-06	1.99E-06	364.8	SSW
SW	4827.	5.52E-05	2.92E-05	2.12E-05	1.06E-05	3.94E-06	1.17E-06	22.2	SW
WSW	4827.	2.18E-05	1.16E-05	8.48E-06	4.28E-06	1.61E-06	4.85E-07	9.8	WSW
W	4827.	7.98E-06	4.64E-06	3.54E-06	1.97E-06	8.46E-07	3.02E-07	7.0	W
WNW	4827.	8.94E-06	5.13E-06	3.89E-06	2.13E-06	8.96E-07	3.11E-07	7.2	WNW
NW	4827.	2.94E-05	1.57E-05	1.15E-05	5.81E-06	2.19E-06	6.61E-07	9.1	NW
NNW	4827.	5.22E-05	2.93E-05	2.20E-05	1.17E-05	4.78E-06	1.59E-06	18.0	NNW
N	4827.	5.78E-05	3.26E-05	2.45E-05	1.31E-05	5.38E-06	1.80E-06	21.1	N
NNE	4827.	5.01E-05	2.71E-05	1.99E-05	1.03E-05	3.95E-06	1.23E-06	16.7	NNE
NE	4827.	5.49E-05	2.92E-05	2.12E-05	1.07E-05	3.98E-06	1.19E-06	22.7	NE
ENE	4827.	5.04E-05	2.66E-05	1.93E-05	9.60E-06	3.53E-06	1.04E-06	21.6	ENE
E	4827.	5.66E-05	2.99E-05	2.17E-05	1.09E-05	4.02E-06	1.19E-06	23.7	E
ESE	4827.	6.26E-05	3.39E-05	2.50E-05	1.28E-05	4.94E-06	1.54E-06	25.3	ESE
SE	4827.	7.62E-05	4.27E-05	3.20E-05	1.70E-05	6.91E-06	2.29E-06	33.4	SE
SSE	4827.	8.91E-05	4.95E-05	3.69E-05	1.95E-05	7.81E-06	2.55E-06	43.7	SSE
MAX χ/Q		8.91E-05					TOTAL HOURS AROUND SITE:	685.7	
SRP 2.3.4	4827.	7.96E-05	4.51E-05	3.39E-05	1.83E-05	7.54E-06	2.55E-06		
SITE LIMIT		7.96E-05	4.51E-05	3.39E-05	1.83E-05	7.54E-06	2.55E-06		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Table 2.3-36

Low Population Zone Accident χ/Q P-G Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWNWIND SECTOR
S	4827.	7.65E-05	3.43E-05	2.30E-05	9.64E-06	2.77E-06	6.01E-07	38.9	S
SSW	4827.	7.30E-05	3.21E-05	2.13E-05	8.74E-06	2.43E-06	5.08E-07	379.7	SSW
SW	4827.	5.16E-05	2.22E-05	1.46E-05	5.85E-06	1.57E-06	3.16E-07	20.9	SW
WSW	4827.	2.17E-05	9.52E-06	6.31E-06	2.59E-06	7.19E-07	1.50E-07	9.2	WSW
W	4827.	8.35E-06	4.05E-06	2.83E-06	1.29E-06	4.19E-07	1.06E-07	6.5	W
WNW	4827.	9.39E-06	4.48E-06	3.10E-06	1.39E-06	4.38E-07	1.07E-07	6.7	WNW
NW	4827.	3.16E-05	1.42E-05	9.49E-06	3.97E-06	1.14E-06	2.46E-07	9.1	NW
NNW	4827.	5.63E-05	2.59E-05	1.76E-05	7.56E-06	2.25E-06	5.13E-07	21.4	NNW
N	4827.	6.01E-05	2.81E-05	1.92E-05	8.42E-06	2.58E-06	6.05E-07	24.0	N
NNE	4827.	4.77E-05	2.18E-05	1.48E-05	6.32E-06	1.87E-06	4.21E-07	16.8	NNE
NE	4827.	4.98E-05	2.23E-05	1.49E-05	6.22E-06	1.78E-06	3.84E-07	21.1	NE
ENE	4827.	4.56E-05	2.03E-05	1.35E-05	5.62E-06	1.59E-06	3.40E-07	20.1	ENE
E	4827.	5.08E-05	2.28E-05	1.52E-05	6.37E-06	1.82E-06	3.94E-07	22.1	E
ESE	4827.	5.64E-05	2.61E-05	1.78E-05	7.71E-06	2.32E-06	5.36E-07	23.6	ESE
SE	4827.	7.21E-05	3.38E-05	2.31E-05	1.02E-05	3.12E-06	7.35E-07	34.6	SE
SSE	4827.	8.17E-05	3.74E-05	2.53E-05	1.08E-05	3.21E-06	7.24E-07	43.7	SSE
MAX χ/Q		8.17E-05					TOTAL HOURS AROUND SITE:	698.5	
SRP 2.3.4	4827.	1.15E-04	4.99E-05	3.28E-05	1.33E-05	3.61E-06	7.35E-07		
SITE LIMIT		7.53E-05	3.50E-05	2.39E-05	1.04E-05	3.16E-06	7.35E-07		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

LDCN-05-009

Table 2.3-37

Control Room, Exclusion Area Boundary and Low Population Zone χ/Qs (S/m^3)

	Control Room[1]									
	Filtered				Unfiltered				LPZ[2]	EAB[2]
	SGT Roofline	Railway Bay doors SC Leakage	RBW SC Leakage	Turbine Building	SGT Roofline	Railway Bay doors SC Leakage	RBW SC Leakage	Turbine Building		
0 - 2 hrs	1.43E-04	3.65E-04	1.99E-04	8.81E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03	4.95E-05	1.81E-04
2 - 8 hrs	1.05E-04	2.89E-04	1.44E-04	3.75E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03	4.95E-05	
8 - 24 hrs	4.14E-05	1.18E-04	5.73E-05	1.93E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03	3.69E-05	
1 - 4 days	3.52E-05	9.83 E-05	5.00E-05	1.50E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04	1.95E-05	
4 - 30 days	3.03E-05	8.61E-05	4.18E-05	1.44E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04	7.81E-06	

(1) Reference 2.3-37
(2) Reference 2.3-38

NOTE:
EAB = Exclusion Area Boundary
LPZ = Low Population Zone
SGT = Standby Gas Treatment
SC = Secondary Containment
RBW = Reactor Building Wall

Table 2.3-38a

CGS Calculation, Terrain Features, Desert Sigmas

CGS TURBINE AND RADWASTE BLDGS
NO DECAY, UNDEPLETED
CORRECTED USING STANDARD OPEN TERRAIN FACTORS

ANNUAL AVERAGE CHI/Q (SEC/METER CUBED) — DISTANCE IN MILES FROM THE SITE

SECTOR	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	1.170E-04	4.880E-05	2.943E-05	1.612E-05	7.145E-06	4.144E-06	2.767E-06	2.013E-06	1.551E-06	1.246E-06	1.031E-06
SSW	8.738E-05	3.691E-05	2.243E-05	1.234E-05	5.502E-06	3.204E-06	2.146E-06	1.565E-06	1.208E-06	9.718E-07	8.058E-07
SW	5.041E-05	2.119E-05	1.282E-05	7.028E-06	3.117E-06	1.808E-06	1.207E-06	8.781E-07	6.766E-07	5.432E-07	4.497E-07
WSW	2.672E-05	1.129E-05	6.851E-06	3.769E-06	1.679E-06	9.761E-07	6.527E-07	4.753E-07	3.666E-07	2.945E-07	2.439E-07
W	1.743E-05	7.139E-06	4.257E-06	2.314E-06	1.015E-06	5.849E-07	3.886E-07	2.817E-07	2.164E-07	1.733E-07	1.431E-07
WNW	3.424E-05	1.390E-05	8.233E-06	4.450E-06	1.936E-06	1.109E-06	7.331E-07	5.293E-07	4.053E-07	3.237E-07	2.667E-07
NW	5.972E-05	2.452E-05	1.463E-05	7.962E-06	3.496E-06	2.014E-06	1.337E-06	9.689E-07	7.440E-07	5.955E-07	4.917E-07
NNW	1.094E-04	4.499E-05	2.691E-05	1.468E-05	6.471E-06	3.738E-06	2.487E-06	1.805E-06	1.388E-06	1.112E-06	9.193E-07
N	1.148E-04	4.680E-05	2.783E-05	1.514E-05	6.639E-06	3.821E-06	2.536E-06	1.836E-06	1.409E-06	1.128E-06	9.305E-07
NNE	9.052E-05	3.669E-05	2.171E-05	1.174E-05	5.115E-06	2.930E-06	1.937E-06	1.399E-06	1.071E-06	8.551E-07	7.045E-07
NE	7.851E-05	3.196E-05	1.896E-05	1.029E-05	4.493E-06	2.578E-06	1.706E-06	1.233E-06	9.443E-07	7.543E-07	6.216E-07
ENE	7.545E-05	3.053E-05	1.805E-05	9.773E-06	4.260E-06	2.442E-06	1.615E-06	1.167E-06	8.935E-07	7.136E-07	5.881E-07
E	8.001E-05	3.243E-05	1.917E-05	1.038E-05	4.517E-06	2.585E-06	1.708E-06	1.232E-06	9.420E-07	7.514E-07	6.185E-07
ESE	1.238E-04	5.040E-05	2.986E-05	1.617E-05	7.040E-06	4.029E-06	2.662E-06	1.920E-06	1.469E-06	1.172E-06	9.644E-07
SE	1.508E-04	6.203E-05	3.703E-05	2.016E-05	8.853E-06	5.097E-06	3.383E-06	2.449E-06	1.879E-06	1.503E-06	1.241E-06
SSE	1.535E-04	6.378E-05	3.835E-05	2.097E-05	9.262E-06	5.358E-06	3.569E-06	2.593E-06	1.995E-06	1.600E-06	1.323E-06

ANNUAL AVERAGE CHI/Q (SEC/METER CUBED) — DISTANCE IN MILES FROM THE SITE

SECTOR	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	8.745E-07	4.911E-07	3.377E-07	2.095E-07	1.494E-07	1.150E-07	9.290E-08	7.760E-08	6.641E-08	5.789E-08	5.121E-08
SSW	6.840E-07	3.859E-07	2.662E-07	1.658E-07	1.186E-07	9.147E-08	7.402E-08	6.191E-08	5.304E-08	4.628E-08	4.097E-08
SW	3.812E-07	2.140E-07	1.471E-07	9.121E-08	6.504E-08	5.005E-08	4.042E-08	3.376E-08	2.889E-08	2.518E-08	2.227E-08
WSW	2.068E-07	1.162E-07	7.994E-08	4.960E-08	3.536E-08	2.721E-08	2.197E-08	1.835E-08	1.570E-08	1.368E-08	1.209E-08
W	1.211E-07	6.750E-08	4.618E-08	2.846E-08	2.021E-08	1.550E-08	1.249E-08	1.041E-08	8.897E-09	7.744E-09	6.841E-09
WNW	2.252E-07	1.245E-07	8.474E-08	5.184E-08	3.662E-08	2.799E-08	2.249E-08	1.870E-08	1.595E-08	1.386E-08	1.222E-08
NW	4.159E-07	2.313E-07	1.580E-07	9.714E-08	6.883E-08	5.272E-08	4.242E-08	3.532E-08	3.014E-08	2.621E-08	2.314E-08
NNW	7.782E-07	4.434E-07	2.973E-07	1.832E-07	1.301E-07	9.973E-08	8.032E-08	6.692E-08	5.714E-08	4.927E-08	4.390E-08
N	7.867E-07	4.368E-07	2.979E-07	1.827E-07	1.292E-07	9.881E-08	7.940E-08	6.604E-08	5.630E-08	4.892E-08	4.314E-08
NNE	5.948E-07	3.285E-07	2.234E-07	1.364E-07	9.622E-08	7.345E-08	5.895E-08	4.898E-08	4.172E-08	3.623E-08	3.193E-08
NE	5.248E-07	2.900E-07	1.972E-07	1.204E-07	8.490E-08	6.478E-08	5.196E-08	4.316E-08	3.675E-08	3.189E-08	2.810E-08
ENE	4.965E-07	2.744E-07	1.866E-07	1.140E-07	8.045E-08	6.141E-08	4.929E-08	4.095E-08	3.489E-08	3.029E-08	2.670E-08
E	5.217E-07	2.872E-07	1.947E-07	1.184E-07	8.330E-08	6.343E-08	5.080E-08	4.214E-08	3.584E-08	3.108E-08	2.736E-08
ESE	8.135E-07	4.479E-07	3.038E-07	1.849E-07	1.301E-07	9.912E-08	7.942E-08	6.590E-08	5.607E-08	4.863E-08	4.282E-08
SE	1.049E-06	5.821E-07	3.970E-07	2.435E-07	1.722E-07	1.317E-07	1.059E-07	8.809E-08	7.511E-08	6.527E-08	5.757E-08
SSE	1.120E-06	6.263E-07	4.294E-07	2.653E-07	1.886E-07	1.448E-07	1.168E-07	9.740E-08	8.325E-08	7.248E-08	6.405E-08

Table 2.3-38b

CGS Calculation, Terrain Features, Desert Sigmas

CGS TURBINE AND RADWASTE BLDGS
NO DECAY, UNDEPLETED
CHI/Q (SEC/METER CUBED) FOR EACH SEGMENT

DIRECTION FROM SITE	SEGMENT BOUNDARIES IN MILES FROM THE SITE									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.782E-05	7.806E-06	2.832E-06	1.567E-06	1.037E-06	5.081E-07	2.113E-07	1.153E-07	7.771E-08	5.794E-08
SSW	2.117E-05	6.000E-06	2.195E-06	1.220E-06	8.099E-07	3.989E-07	1.671E-07	9.172E-08	6.199E-08	4.631E-08
SW	1.211E-05	3.404E-06	1.236E-06	6.834E-07	4.521E-07	2.214E-07	9.199E-08	5.019E-08	3.381E-08	2.520E-08
WSW	6.468E-06	1.831E-06	6.680E-07	3.702E-07	2.451E-07	1.202E-07	5.001E-08	2.729E-08	1.837E-08	1.369E-08
W	4.034E-06	1.113E-06	3.982E-07	2.186E-07	1.439E-07	6.994E-08	2.873E-08	1.555E-08	1.043E-08	7.751E-09
WNW	7.812E-06	2.127E-06	7.518E-07	4.096E-07	2.682E-07	1.292E-07	5.239E-08	2.809E-08	1.873E-08	1.387E-08
NW	1.386E-05	3.830E-06	1.370E-06	7.517E-07	4.944E-07	2.397E-07	9.809E-08	5.290E-08	3.538E-08	2.624E-08
NNW	2.549E-05	7.081E-06	2.548E-06	1.402E-06	9.242E-07	4.498E-07	1.849E-07	1.001E-07	6.703E-08	4.976E-08
N	2.640E-05	7.275E-06	2.599E-06	1.424E-06	9.356E-07	4.528E-07	1.845E-07	9.915E-08	6.615E-08	4.897E-08
NNE	2.061E-05	5.617E-06	1.986E-06	1.082E-06	7.085E-07	3.410E-07	1.379E-07	7.372E-08	4.906E-08	3.626E-08
NE	1.800E-05	4.929E-06	1.749E-06	9.543E-07	6.251E-07	3.009E-07	1.217E-07	6.502E-08	4.323E-08	3.193E-08
ENE	1.715E-05	4.677E-06	1.656E-06	9.030E-07	5.914E-07	2.848E-07	1.152E-07	6.164E-08	4.103E-08	3.032E-08
E	1.821E-05	4.961E-06	1.751E-06	9.521E-07	6.221E-07	2.982E-07	1.198E-07	6.368E-08	4.221E-08	3.111E-08
ESE	2.834E-05	7.730E-06	2.730E-06	1.484E-06	9.699E-07	4.651E-07	1.870E-07	9.951E-08	6.602E-08	4.868E-08
SE	3.509E-05	9.967E-06	3.466E-06	1.899E-06	1.247E-06	6.035E-07	2.459E-07	1.322E-07	8.823E-08	6.534E-08
SSE	3.628E-05	1.013E-05	3.656E-06	2.015E-06	1.330E-06	6.485E-07	2.677E-07	1.453E-07	9.755E-08	7.255E-08

Table 2.3-38c

CGS Calculation, Terrain Features, Desert Sigmas

CGS TURBINE AND RADWASTE BLDGS – SPECIFIC POINTS OF INTEREST

RELEASE ID	TYPE OF LOCATION	DIRECTION FROM SITE	DISTANCE (MILES)	DISTANCE (METERS)	X/Q (SEC/CUB.METER) NO DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 2.260 DAY DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 8.000 DAY DECAY DEPLETED	D/Q (PER SQ.METER)
A	PROTECTED ARE	SE	6.40	10298.	7.2E-07	6.8E-07	5.1E-07	2.6E-10
A	PROTECTED ARE	ESE	3.90	6275.	1.2E-06	1.2E-06	9.3E-07	7.0E-10
A	PROTECTED ARE	ESE	4.00	6436.	1.2E-06	1.1E-06	8.9E-07	6.6E-10
A	PROTECTED ARE	ESE	4.10	6597.	1.1E-06	1.1E-06	8.5E-07	6.3E-10
A	PROTECTED ARE	ESE	4.20	6758.	1.1E-06	1.0E-06	8.1E-07	6.0E-10
A	PROTECTED ARE	ESE	4.30	6919.	1.0E-06	1.0E-06	7.8E-07	5.7E-10
A	PROTECTED ARE	ESE	4.40	7080.	1.0E-06	9.6E-07	7.5E-07	5.4E-10
A	PROTECTED ARE	ESE	4.50	7241.	9.6E-07	9.2E-07	7.2E-07	5.1E-10
A	PROTECTED ARE	ESE	3.00	4827.	1.9E-06	1.9E-06	1.5E-06	1.3E-09
A	PROTECTED ARE	ESE	3.10	4988.	1.8E-06	1.8E-06	1.4E-06	1.2E-09
A	PROTECTED ARE	ESE	3.21	5159.	1.7E-06	1.7E-06	1.3E-06	1.1E-09
A	PROTECTED ARE	ESE	3.30	5310.	1.6E-06	1.6E-06	1.3E-06	1.0E-09
A	PROTECTED ARE	ESE	3.40	5471.	1.5E-06	1.5E-06	1.2E-06	9.6E-10
A	PROTECTED ARE	ESE	3.50	5632.	1.5E-06	1.4E-06	1.1E-06	9.0E-10
A	PROTECTED ARE	ESE	3.60	5792.	1.4E-06	1.4E-06	1.1E-06	8.4E-10
A	PROTECTED ARE	SE	15.00	24135.	2.4E-07	2.1E-07	1.5E-07	6.0E-11
A	LPZ (4828)	SE	4.80	7723.	1.1E-06	1.1E-06	8.3E-07	4.9E-10
A	LPZ (4828)	ESE	4.20	6758.	1.1E-06	1.0E-06	8.1E-07	6.0E-10
A	LPZ (4828)	ENE	4.10	6597.	6.9E-07	6.5E-07	5.2E-07	3.7E-10
A	LPZ (4828)	NNE	4.30	6918.	7.6E-07	7.3E-07	5.7E-07	5.1E-10
A	LPZ (4828)	ESE	0.10	160.	4.1E-04	4.1E-04	4.0E-04	8.4E-07
A	LPZ (4828)	SE	9.59	15437.	4.2E-07	3.9E-07	2.8E-07	1.3E-10
A	LPZ (4828)	SE	8.29	13346.	5.1E-07	4.7E-07	3.5E-07	1.7E-10
A	LPZ (4828)	NE	4.30	6919.	6.7E-07	6.3E-07	5.0E-07	3.7E-10
A	EAB (1950 M)	S	1.21	1950.	1.1E-05	1.1E-05	9.4E-06	7.9E-09
A	EAB (1950 M)	SSW	1.21	1950.	8.4E-06	8.3E-06	7.2E-06	5.5E-09
A	EAB (1950 M)	SW	1.21	1950.	4.8E-06	4.7E-06	4.1E-06	3.5E-09
A	EAB (1950 M)	WSW	1.21	1950.	2.6E-06	2.5E-06	2.2E-06	1.4E-09
A	EAB (1950 M)	W	1.21	1950.	1.6E-06	1.5E-06	1.3E-06	1.3E-09
A	EAB (1950 M)	WNW	1.21	1950.	3.0E-06	2.9E-06	2.6E-06	2.5E-09
A	EAB (1950 M)	NW	1.21	1950.	5.4E-06	5.3E-06	4.6E-06	5.2E-09
A	EAB (1950 M)	NNW	1.21	1950.	9.9E-06	9.8E-06	8.5E-06	1.1E-08
A	EAB (1950 M)	N	1.21	1950.	1.0E-05	1.0E-05	8.8E-06	1.3E-08
A	EAB (1950 M)	NNE	1.21	1950.	7.9E-06	7.8E-06	6.8E-06	1.0E-08
A	EAB (1950 M)	NE	1.21	1950.	6.9E-06	6.8E-06	5.9E-06	7.3E-09
A	EAB (1950 M)	ENE	1.21	1950.	6.6E-06	6.5E-06	5.6E-06	6.7E-09
A	EAB (1950 M)	E	1.21	1950.	7.0E-06	6.9E-06	6.0E-06	7.0E-09
A	EAB (1950 M)	ESE	1.21	1950.	1.1E-05	1.1E-05	9.3E-06	1.1E-08
A	EAB (1950 M)	SE	1.21	1950.	1.4E-05	1.3E-05	1.2E-05	1.2E-08
A	EAB (1950 M)	SSE	1.21	1950.	1.4E-05	1.4E-05	1.2E-05	1.1E-08

Table 2.3-38d

CGS Calculation, Terrain Features, Desert Sigmas

CGS REACTOR BLDG
NO DECAY, UNDEPLETED
CORRECTED USING STANDARD OPEN TERRAIN FACTORS
ANNUAL AVERAGE CHI/Q (SEC/METER CUBED) DISTANCE IN MILES FROM THE SITE

SECTOR	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	3.983E-07	5.147E-07	4.459E-07	2.855E-07	1.417E-07	8.546E-08	6.007E-08	4.723E-08	3.955E-08	3.450E-08	3.085E-08
SSW	3.015E-07	3.460E-07	2.917E-07	1.836E-07	8.972E-08	5.399E-08	3.809E-08	3.012E-08	2.537E-08	2.223E-08	1.996E-08
SW	2.241E-07	2.226E-07	1.853E-07	1.175E-07	5.986E-08	3.986E-08	3.227E-08	2.901E-08	2.518E-08	2.229E-08	2.000E-08
WSW	9.654E-08	7.983E-08	7.694E-08	5.258E-08	2.801E-08	1.857E-08	1.473E-08	1.300E-08	1.120E-08	9.892E-09	8.868E-09
W	3.448E-08	7.360E-08	7.682E-08	5.380E-08	2.883E-08	1.888E-08	1.476E-08	1.283E-08	1.088E-08	9.460E-09	8.362E-09
WNW	7.411E-08	1.508E-07	1.476E-07	1.017E-07	5.532E-08	3.697E-08	2.952E-08	2.619E-08	2.256E-08	1.990E-08	1.781E-08
NW	2.513E-07	3.020E-07	2.641E-07	1.670E-07	8.155E-08	4.940E-08	3.530E-08	2.826E-08	2.409E-08	2.133E-08	1.931E-08
NNW	7.930E-07	7.233E-07	5.856E-07	3.550E-07	1.649E-07	9.701E-08	6.783E-08	5.335E-08	4.477E-08	3.913E-08	4.183E-08
N	1.124E-06	8.905E-07	6.762E-07	4.031E-07	1.877E-07	1.113E-07	7.839E-08	6.206E-08	5.232E-08	4.585E-08	4.113E-08
NNE	1.049E-06	7.337E-07	5.603E-07	3.353E-07	1.577E-07	9.422E-08	6.677E-08	5.308E-08	4.498E-08	3.965E-08	4.297E-08
NE	6.008E-07	4.702E-07	3.787E-07	2.340E-07	1.123E-07	6.758E-08	4.829E-08	3.883E-08	4.067E-08	4.490E-08	8.482E-08
ENE	4.892E-07	5.305E-07	4.710E-07	3.229E-07	2.809E-07	3.180E-07	3.667E-07	5.692E-07	1.128E-06	1.019E-06	8.387E-07
E	5.015E-07	5.031E-07	4.747E-07	3.390E-07	3.184E-07	3.702E-07	4.232E-07	6.426E-07	1.325E-06	1.054E-06	8.662E-07
ESE	9.120E-07	7.571E-07	6.975E-07	4.987E-07	4.778E-07	5.635E-07	6.623E-07	1.026E-06	1.950E-06	1.650E-06	1.356E-06
SE	6.666E-07	6.348E-07	5.775E-07	3.846E-07	2.045E-07	1.394E-07	1.150E-07	1.046E-07	2.207E-07	7.638E-07	6.314E-07
SSE	4.473E-07	5.728E-07	5.291E-07	3.498E-07	1.780E-07	1.089E-07	7.782E-08	6.216E-08	5.287E-08	4.674E-08	4.227E-08

ANNUAL AVERAGE CHI/Q (SEC/METER CUBED) DISTANCE IN MILES FROM THE SITE

SECTOR	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	2.814E-08	2.023E-08	1.577E-08	3.200E-07	2.287E-07	1.764E-07	1.428E-07	1.195E-07	1.024E-07	8.938E-08	7.915E-08
SSW	1.825E-08	1.646E-08	1.027E-08	2.576E-07	1.846E-07	1.427E-07	1.156E-07	9.686E-08	8.309E-08	7.259E-08	6.433E-08
SW	1.814E-08	1.472E-08	6.195E-08	1.393E-07	9.960E-08	7.682E-08	6.218E-08	5.202E-08	4.458E-08	3.891E-08	3.446E-08
WSW	8.058E-09	6.624E-09	2.853E-08	7.526E-08	5.376E-08	4.145E-08	3.353E-08	2.804E-08	2.402E-08	2.096E-08	1.856E-08
W	7.499E-09	4.948E-09	3.627E-09	4.242E-08	3.020E-08	2.323E-08	1.876E-08	1.567E-08	1.341E-08	1.169E-08	1.034E-08
WNW	1.613E-08	1.203E-08	1.269E-08	7.524E-08	5.333E-08	4.089E-08	3.294E-08	2.746E-08	2.346E-08	2.042E-08	1.805E-08
NW	1.778E-08	1.734E-08	1.283E-08	1.423E-07	1.011E-07	7.760E-08	6.258E-08	5.221E-08	4.463E-08	3.888E-08	3.437E-08
NNW	4.509E-08	2.990E-08	2.199E-08	2.697E-07	1.919E-07	1.474E-07	1.190E-07	9.930E-08	8.493E-08	7.401E-08	6.544E-08
N	3.754E-08	4.858E-08	4.276E-07	2.625E-07	1.860E-07	1.425E-07	1.148E-07	9.564E-08	8.168E-08	7.108E-08	6.278E-08
NNE	4.676E-08	4.163E-07	3.178E-07	1.945E-07	1.376E-07	1.053E-07	8.473E-08	7.055E-08	6.022E-08	5.238E-08	4.625E-08
NE	2.656E-07	4.104E-07	2.789E-07	1.705E-07	1.205E-07	9.214E-08	7.408E-08	6.164E-08	5.259E-08	4.572E-08	4.035E-08
ENE	7.075E-07	3.901E-07	2.653E-07	1.623E-07	1.148E-07	8.786E-08	7.067E-08	5.884E-08	5.021E-08	4.367E-08	3.855E-08
E	7.296E-07	4.000E-07	2.710E-07	1.650E-07	1.163E-07	8.872E-08	7.121E-08	5.918E-08	5.043E-08	4.380E-08	3.862E-08
ESE	1.143E-06	6.275E-07	1.652E-07	2.594E-07	1.830E-07	1.398E-07	1.123E-07	9.334E-08	7.958E-08	6.915E-08	6.099E-08
SE	5.345E-07	2.974E-07	2.034E-07	3.525E-07	2.499E-07	1.916E-07	1.544E-07	1.287E-07	1.099E-07	9.568E-08	8.452E-08
SSE	3.896E-08	3.642E-08	2.261E-08	3.975E-07	2.834E-07	2.181E-07	1.762E-07	1.473E-07	1.261E-07	1.099E-07	9.728E-08

Table 2.3-38e

CGS Calculation, Terrain Features, Desert Sigmas

CGS REACTOR BLDG
NO DECAY, UNDEPLETED
CHI/Q (SEC/METER CUBED) FOR EACH SEGMENT

	SEGMENT BOUNDARIES IN MILES FROM THE SITE									
DIRECTION FROM SITE	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	3.899E-07	1.486E-07	6.171E-08	3.982E-08	3.093E-08	2.000E-08	2.118E-07	1.769E-07	1.196E-07	8.944E-08
SSW	2.557E-07	9.471E-08	3.914E-08	2.553E-08	2.000E-08	1.411E-08	1.702E-07	1.431E-07	9.698E-08	7.264E-08
SW	1.635E-07	6.378E-08	3.299E-08	2.517E-08	1.999E-08	3.647E-08	1.045E-07	7.704E-08	5.209E-08	3.894E-08
WSW	6.676E-08	2.927E-08	1.506E-08	1.122E-08	8.872E-09	1.668E-08	5.532E-08	4.156E-08	2.808E-08	2.098E-08
W	6.588E-08	2.996E-08	1.509E-08	1.090E-08	8.368E-09	4.928E-09	2.837E-08	2.330E-08	1.569E-08	1.170E-08
WNW	1.279E-07	5.746E-08	3.018E-08	2.258E-08	1.781E-08	1.324E-08	5.160E-08	4.103E-08	2.750E-08	2.044E-08
NW	2.294E-07	8.625E-08	3.624E-08	2.423E-08	1.934E-08	1.543E-08	9.519E-08	7.785E-08	5.228E-08	3.891E-08
NNW	5.137E-07	1.770E-07	6.982E-08	4.507E-08	4.224E-08	2.976E-08	1.801E-07	1.479E-07	9.945E-08	7.407E-08
N	6.024E-07	2.016E-07	8.063E-08	5.264E-08	4.120E-08	2.146E-07	2.652E-07	1.430E-07	9.579E-08	7.115E-08
NNE	4.988E-07	1.690E-07	6.861E-08	4.526E-08	4.339E-08	2.904E-07	1.966E-07	1.057E-07	7.066E-08	5.243E-08
NE	3.347E-07	1.195E-07	4.965E-08	4.175E-08	1.400E-07	3.198E-07	1.723E-07	9.247E-08	6.174E-08	4.576E-08
ENE	4.184E-07	3.067E-07	4.347E-07	9.267E-07	8.436E-07	4.052E-07	1.641E-07	8.817E-08	5.893E-08	4.371E-08
E	4.207E-07	3.460E-07	4.968E-07	1.027E-06	8.714E-07	4.159E-07	1.669E-07	8.906E-08	5.928E-08	4.385E-08
ESE	6.224E-07	5.205E-07	7.813E-07	1.572E-06	1.364E-06	5.365E-07	2.045E-07	1.403E-07	9.350E-08	6.922E-08
SE	5.045E-07	2.156E-07	1.174E-07	3.944E-07	6.347E-07	3.083E-07	2.738E-07	1.923E-07	1.289E-07	9.576E-08
SSE	4.591E-07	1.855E-07	7.985E-08	5.319E-08	4.237E-08	3.085E-08	2.635E-07	2.188E-07	1.475E-07	1.100E-07

Table 2.3-38f

CGS Calculation, Terrain Features, Desert Sigmas

CGS REACTOR BLDG, SPECIFIC POINTS OF INTEREST

RELEASE ID	TYPE OF LOCATION	DIRECTION FROM SITE	DISTANCE (MILES)	DISTANCE (METERS)	X/Q (SEC/CUB.METER) NO DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 2.260 DAY DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 8.000 DAY DECAY DEPLETED	D/Q (PER SQ.METER)
B	PROTECTED ARE	SE	6.40	10298.	3.7E-07	3.5E-07	3.4E-07	3.2E-10
B	PROTECTED ARE	ESE	3.90	6275.	1.7E-06	1.6E-06	1.3E-06	7.0E-10
B	PROTECTED ARE	ESE	4.00	6436.	1.7E-06	1.6E-06	1.3E-06	6.6E-10
B	PROTECTED ARE	ESE	4.10	6597.	1.6E-06	1.5E-06	1.2E-06	6.4E-10
B	PROTECTED ARE	ESE	4.20	6758.	1.5E-06	1.5E-06	1.2E-06	6.0E-10
B	PROTECTED ARE	ESE	4.30	6919.	1.5E-06	1.4E-06	1.1E-06	5.7E-10
B	PROTECTED ARE	ESE	4.40	7080.	1.4E-06	1.3E-06	1.1E-06	5.5E-10
B	PROTECTED ARE	ESE	4.50	7241.	1.4E-06	1.3E-06	1.0E-06	5.2E-10
B	PROTECTED ARE	ESE	3.00	4827.	1.0E-06	9.9E-07	8.1E-07	1.2E-09
B	PROTECTED ARE	ESE	3.10	4988.	1.2E-06	1.2E-06	9.6E-07	1.2E-09
B	PROTECTED ARE	ESE	3.21	5159.	1.5E-06	1.5E-06	1.2E-06	1.1E-09
B	PROTECTED ARE	ESE	3.30	5310.	1.8E-06	1.8E-06	1.5E-06	1.0E-09
B	PROTECTED ARE	ESE	3.40	5471.	1.9E-06	1.8E-06	1.5E-06	9.4E-10
B	PROTECTED ARE	ESE	3.50	5632.	1.8E-06	1.8E-06	1.4E-06	8.9E-10
B	PROTECTED ARE	ESE	3.60	5792.	1.8E-06	1.7E-06	1.4E-06	8.3E-10
B	PROTECTED ARE	SE	15.00	24135.	3.5E-07	3.1E-07	2.9E-07	7.6E-11
B	LPZ (4828)	SE	4.80	7723.	5.7E-07	5.5E-07	5.5E-07	5.9E-10
B	LPZ (4828)	ESE	4.20	6758.	1.5E-06	1.5E-06	1.2E-06	6.0E-10
B	LPZ (4828)	ENE	4.10	6597.	9.8E-07	9.3E-07	7.7E-07	3.8E-10
B	LPZ (4828)	NNE	4.30	6918.	4.1E-08	4.1E-08	3.9E-08	1.8E-10
B	LPZ (4828)	ESE	0.10	160.	3.1E-06	3.1E-06	3.1E-06	4.0E-08
B	LPZ (4828)	SE	9.59	15437.	2.1E-07	2.0E-07	1.9E-07	1.6E-10
B	LPZ (4828)	SE	8.29	13346.	2.6E-07	2.5E-07	2.4E-07	2.0E-10
B	LPZ (4828)	NE	4.30	6919.	6.8E-08	6.6E-08	6.6E-08	1.3E-10
B	EAB (1950 M)	S	1.21	1950.	1.9E-07	1.9E-07	1.8E-07	1.6E-09
B	EAB (1950 M)	SSW	1.21	1950.	1.2E-07	1.2E-07	1.2E-07	1.0E-09
B	EAB (1950 M)	SW	1.21	1950.	7.9E-08	7.9E-08	7.6E-08	5.7E-10
B	EAB (1950 M)	WSW	1.21	1950.	3.8E-08	3.8E-08	3.6E-08	1.9E-10
B	EAB (1950 M)	W	1.21	1950.	3.8E-08	3.7E-08	3.7E-08	2.4E-10
B	EAB (1950 M)	WNW	1.21	1950.	7.2E-08	7.1E-08	7.0E-08	4.8E.10
B	EAB (1950 M)	NW	1.21	1950.	1.1E-07	1.1E-07	1.1E-07	9.0E-10
B	EAB (1950 M)	NNW	1.21	1950.	2.3E-07	2.3E-07	2.2E-07	2.0E-09
B	EAB (1950 M)	N	1.21	1950.	2.6E-07	2.6E-07	2.5E-07	2.8E-09
B	EAB (1950 M)	NNE	1.21	1950.	2.2E-07	2.2E-07	2.1E-07	2.5E-09
B	EAB (1950 M)	NE	1.21	1950.	1.6E-07	1.6E-07	1.5E-07	1.8E-09
B	EAB (1950 M)	ENE	1.21	1950.	2.7E-07	2.7E-07	2.6E-07	1.8E-09
B	EAB (1950 M)	E	1.21	1950.	2.9E-07	2.9E-07	2.9E-07	1.5E-09
B	EAB (1950 M)	ESE	1.21	1950.	4.4E-07	4.4E-07	4.3E-07	2.4E-09
B	EAB (1950 M)	SE	1.21	1950.	2.7E-07	2.7E-07	2.6E-07	2.0E-09
B	EAB (1950 M)	SSE	1.21	1950.	2.4E-07	2.4E-07	2.3E-07	1.9E-09

TABLE 39 (a through f)

DELETED

Table 2.3-40

Frequency of Wind Resuspension
Periods at Hanford (1953-1970)

Total Dust Hours	476
Total Dust Days	142
Number of Dust Storms	150
Average Dust Hr/Yr.	26.4
Average Dust Days/Yr.	7.9
Average Dust Storms Per Year	8.3
Range in Duration of Dust Storms (hr.)	1-16
Average Duration of Dust Storms (hr.)	3.2
Average Dust Storm Concentration (from Table 2) mg/m^3	6.77

Table 2.3-41

Dust Concentration Dependency on Wind Speed and Direction at Hanford 1953-1970 Predicted Concentration From Visibility, mg/m^3

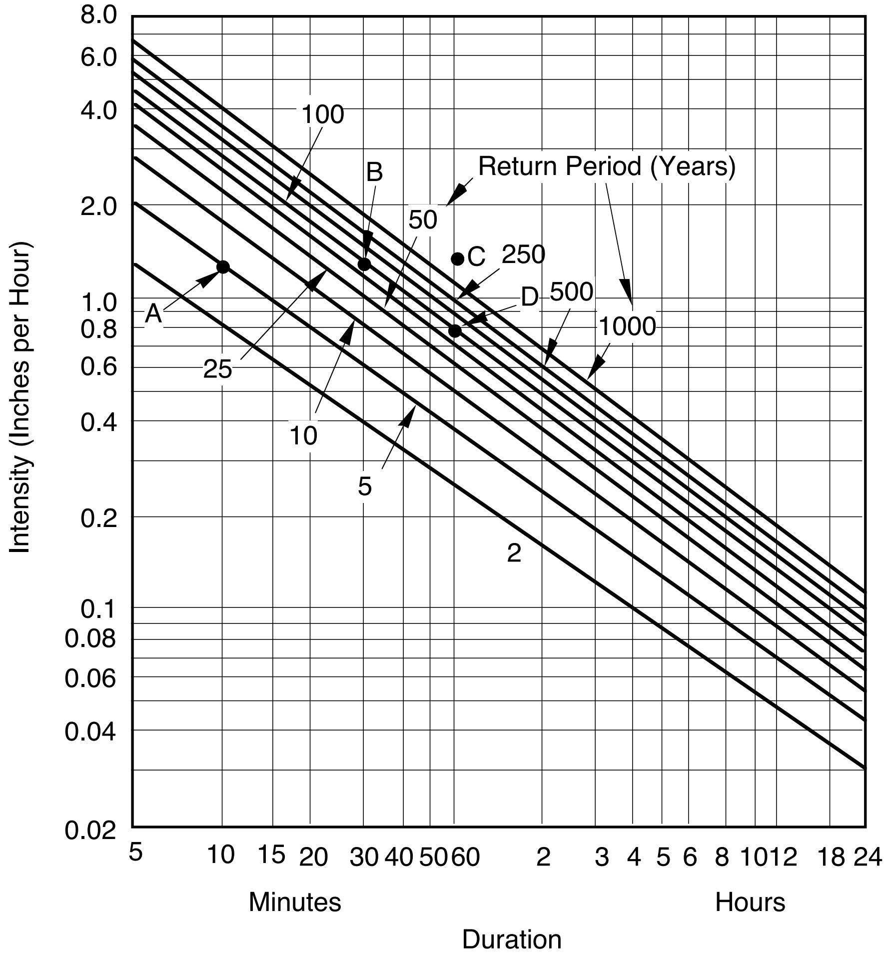
WIND DIRECTION	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47-54	55-63	64-UP	OVERALL AVERAGE
	WIND SPEED CLASS (MPH)											
SE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SSE	.00	.00	.00	2.71	1.38	1.25	.00	.00	.00	.00	.00	1.78
S	.00	.00	7.83	1.62	1.38	5.70	15.92	.00	.00	.00	.00	7.17
SSW	.00	.00	.00	2.48	1.62	2.21	3.86	4.13	.00	.00	.00	2.95
SW	.00	.00	2.71	6.34	3.54	2.75	8.83	13.87	.00	988.88*	.00	19.40
WSW	.00	.00	1.74	1.81	4.96	4.13	12.95	48.31	.00	.00	.00	7.67
W	.00	1.74	1.74	1.83	2.89	5.37	2.71	.00	.00	.00	.00	3.54
WNW	.00	.00	3.49	2.64	1.77	1.99	3.29	4.13	.00	.00	.00	2.39
NW	.00	3.29	1.88	2.58	1.50	1.98	2.23	.00	.00	.00	.00	2.08
NNW	.00	2.02	2.60	2.58	4.80	.00	.00	.00	.00	.00	.00	2.77
N	.00	3.29	2.92	3.50	5.06	12.99	.00	.00	.00	.00	.00	3.81
NNE	.00	1.74	3.38	3.41	6.08	7.04	7.83	.00	.00	.00	.00	4.77
NE	.00	4.38	4.60	3.38	4.54	2.81	.00	.00	.00	.00	.00	3.84
ENE	.00	.00	.00	3.05	2.19	.00	.00	.00	.00	.00	.00	2.48
E	.00	.00	3.29	2.44	3.60	2.71	.00	.00	.00	.00	.00	2.78
ESE	.00	2.71	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.71
OVERALL** AVERAGE	.00	2.84	3.00	3.15	4.15	3.71	8.57	22.22	.00	988.88	.00	6.77

.00 NO DATA
*VISIBILITY 0 TO 1/16 MILE DUE TO ONE-HOUR DUSTSTORM
**WEIGHTED AVERAGE BASED ON TABLE 2.3-42

Table 2.3-42

Hours Satisfying Dust Storm Criteria at Hanford (1953-1970)
Hours With (1) Visibility 7 Mile and Dust Reported or (2) Visibility
7 to 14 Miles, Windspeed 5.8 M/Sec: RH 70% Dust Assumed

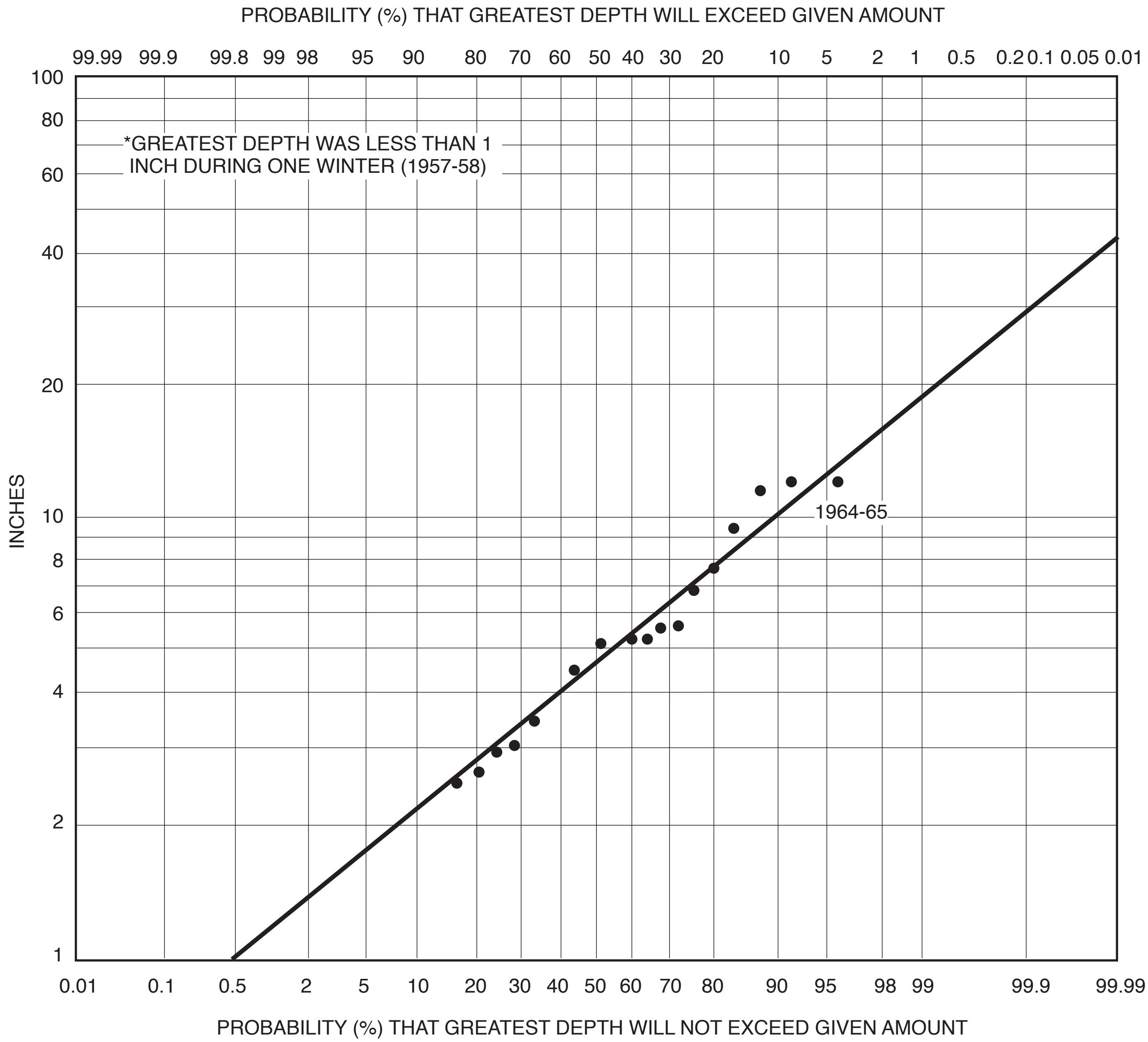
WIND DIRECTION	WIND SPEED CLASS (MPH) 1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47-54	55-63	64-UP	TOTAL HOURS
SE	0	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	1	1	1	0	0	0	0	0	3
S	0	0	1	3	1	3	3	0	0	0	0	11
SSW	0	0	0	4	3	11	13	2	0	0	0	33
SW	0	0	1	3	13	24	26	6	0	1	0	74
WSW	0	0	1	7	17	39	13	4	0	0	0	81
W	0	1	1	3	5	7	1	0	0	0	0	18
WNW	0	0	5	5	11	6	1	1	0	0	0	29
NW	0	1	6	4	3	5	2	0	0	0	0	21
NNW	0	2	8	6	2	2	0	0	0	0	0	18
N	0	1	12	34	10	1	0	0	0	0	0	58
NNE	0	1	3	31	23	7	1	0	0	0	0	66
NE	0	2	3	19	15	5	0	0	0	0	0	44
ENE	0	0	0	3	6	0	0	0	0	0	0	9
E	0	0	1	6	2	1	0	0	0	0	0	10
ESE	0	1	0	0	0	0	0	0	0	0	0	1
TOTAL HOURS	0	9	42	129	112	110	60	13	0	1	0	476



To use this chart, select any desired rainfall intensity and duration and read from the diagonal lines the expected frequency of such intensity and duration. For example, rainfall intensity of 1.3 inches per hour for 10 minutes can be expected to occur, on average, once every five years (point A). However, such intensity can be expected for 30 minutes duration only about once in 100 years (point B). The return period for intensity for 60 minutes duration is greater than 1000 years (point C).

There are, of course, variations in use of the chart. Suppose, for example, it is desired to find the "100-year storm" for 60 minutes. This is 0.8 inch (point D).

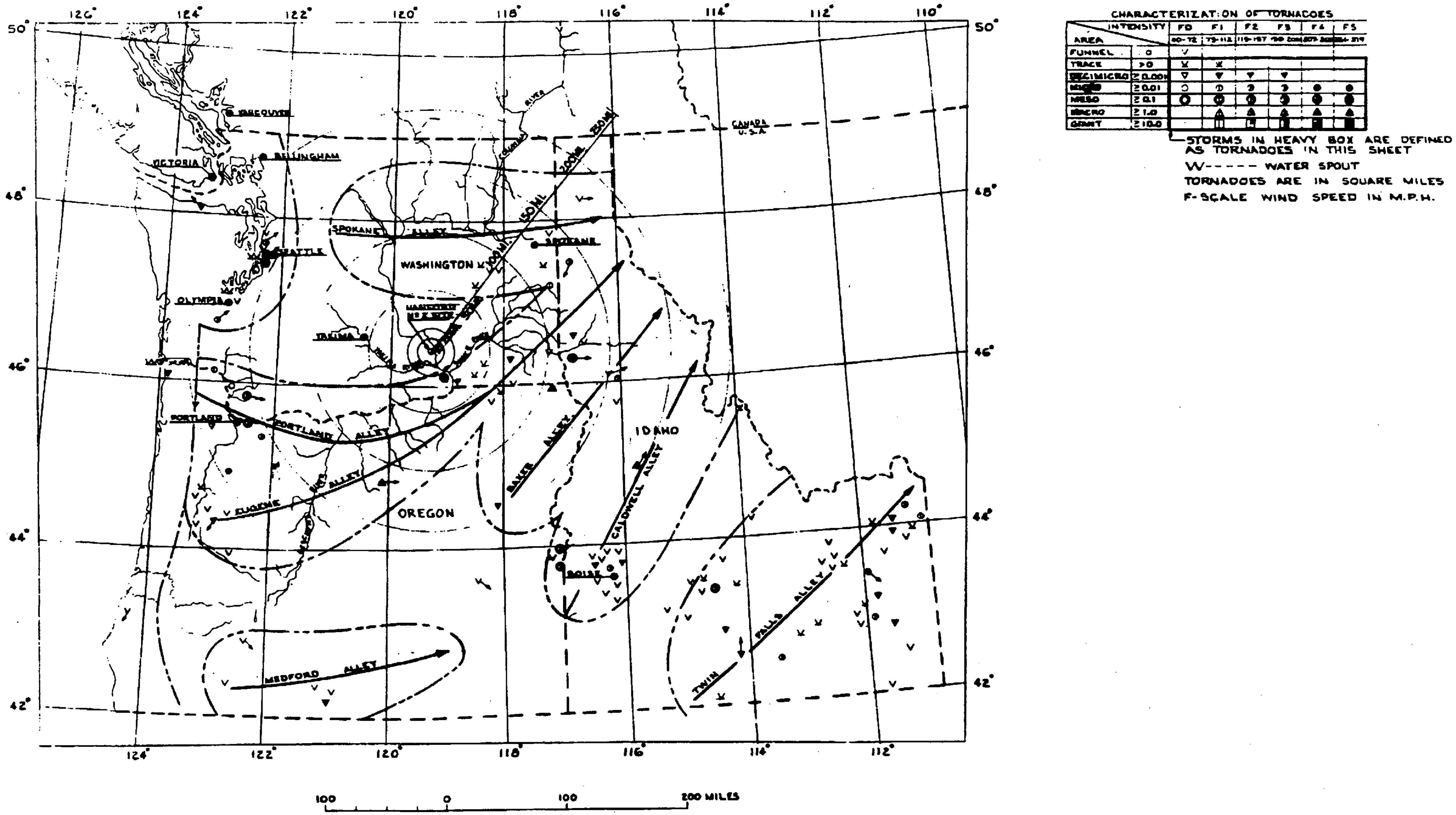
Rainfall Intensity, Duration, and Frequency Based on the Period 1947-69 at Hanford



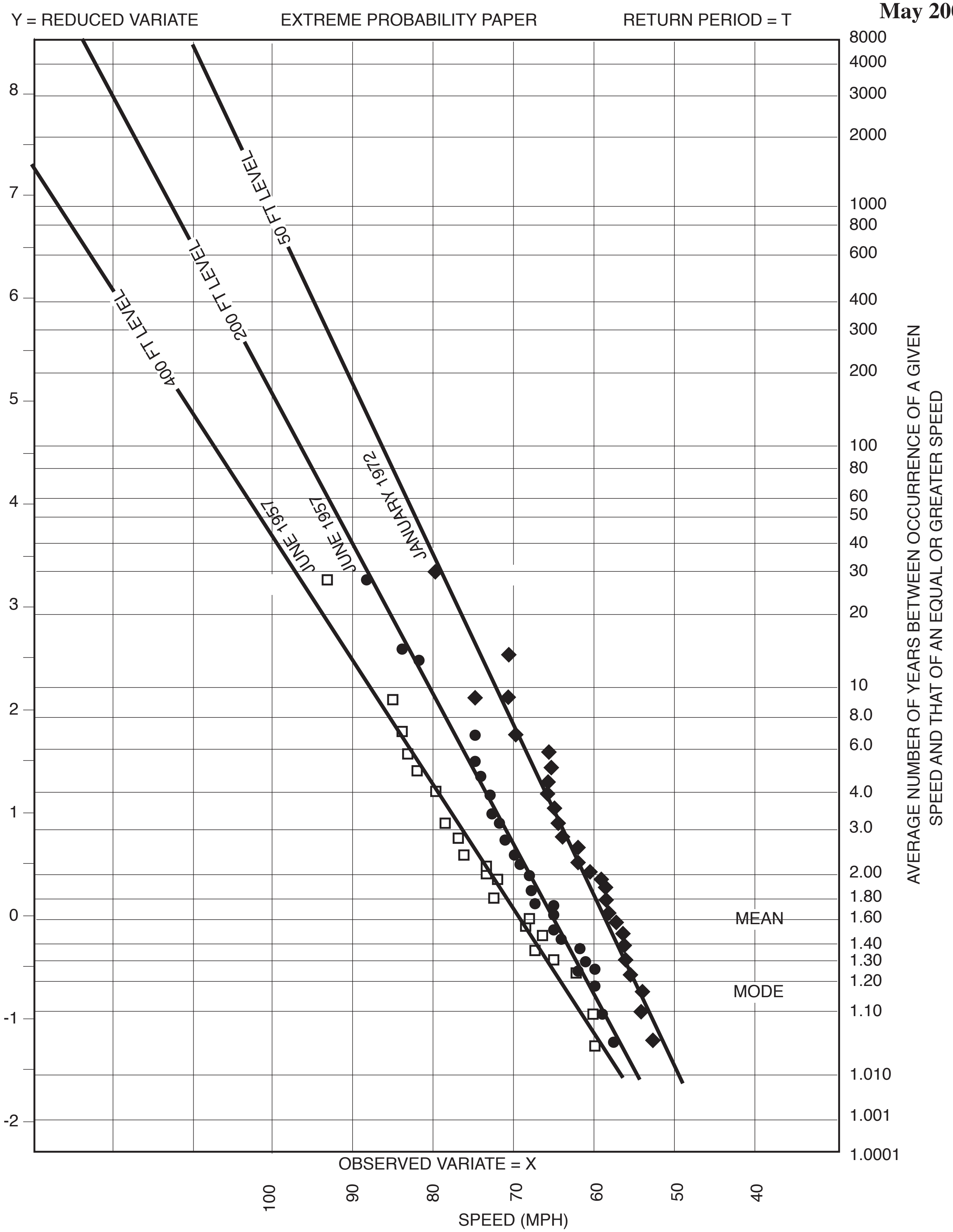
Columbia Generating Station
Final Safety Analysis Report

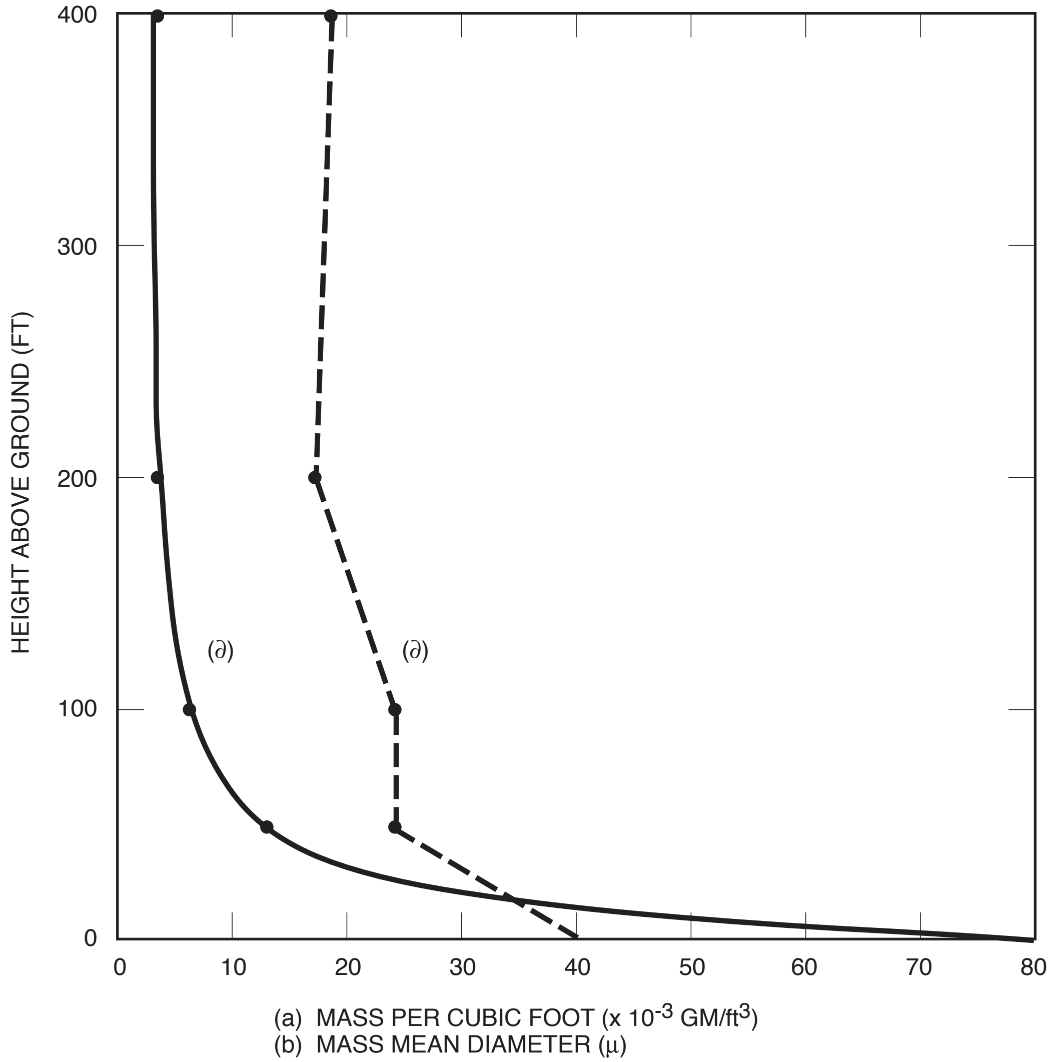
Greatest Depth of Snow on Ground During 24 of 25 Winters of Record at Hanford (1946-47 through 1969-70)

Draw. No. 990306.14	Rev.	Figure 2.3-2



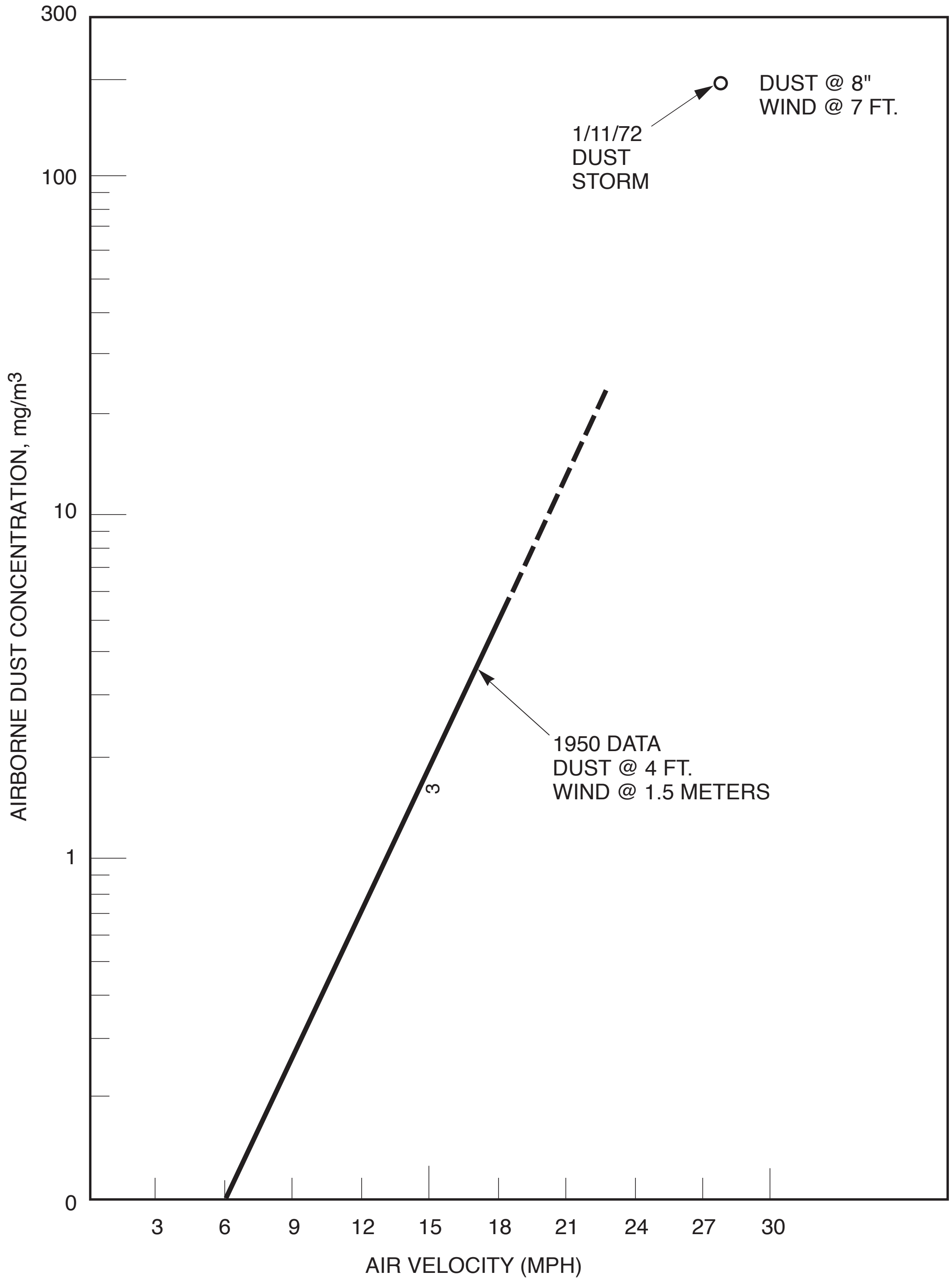
Columbia Generating Station Final Safety Analysis Report	Distribution of Characterized Tornadoes in 20-Year Period (1950-1969)
	Draw. No. 020552.01 / Rev. / Figure 2.3-3


Y = REDUCED VARIATE
EXTREME PROBABILITY PAPER
RETURN PERIOD = T
8
7
6
5
4
3
2
1
0
-1
-2
8000
4000
3000
2000
1000
800
600
400
300
200
100
80
60
50
40
30
20
10
8.0
6.0
4.0
3.0
2.00
1.80
1.60
1.40
1.30
1.20
1.10
1.010
1.001
1.0001
MEAN
MODE
400 FT LEVEL
200 FT LEVEL
50 FT LEVEL
JUNE 1957
JUNE 1957
JANUARY 1972
AVERAGE NUMBER OF YEARS BETWEEN OCCURRENCE OF A GIVEN SPEED AND THAT OF AN EQUAL OR GREATER SPEED
OBSERVED VARIATE = X
100
90
80
70
60
50
40
SPEED (MPH)



(a) AVERAGE MASS OF DUST PER FOOT^3, AND
(b) MASS MEAN DIAMETER OF DUST PARTICLES.
METEOROLOGY TOWER, HAPO. AUGUST 11, 1955

Dust Occurrences Per Wind Speeds to 400 ft Heights



Columbia Generating Station
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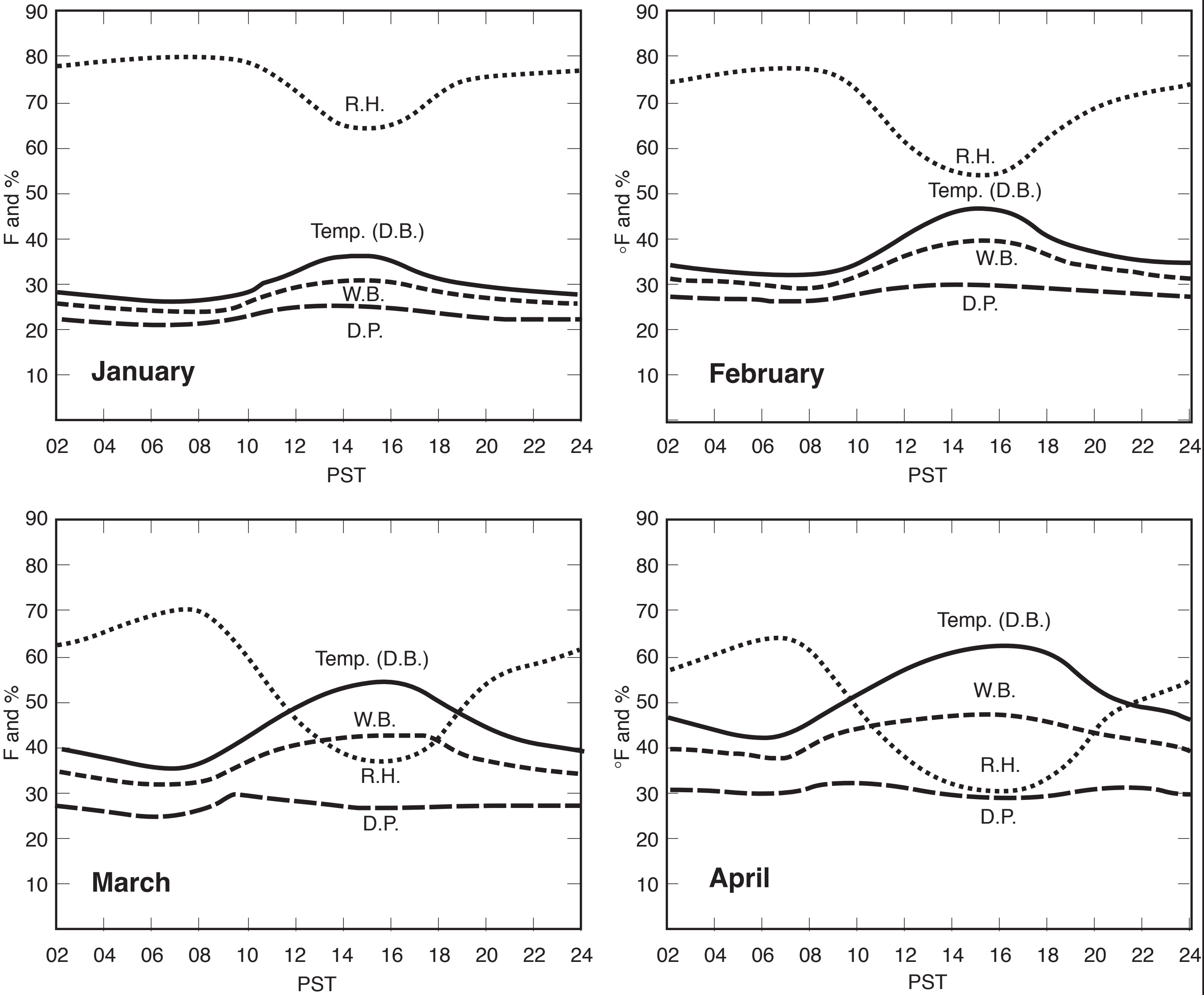
Near-Surface Airborne Dust Concentration as a Function of Average Air Velocity

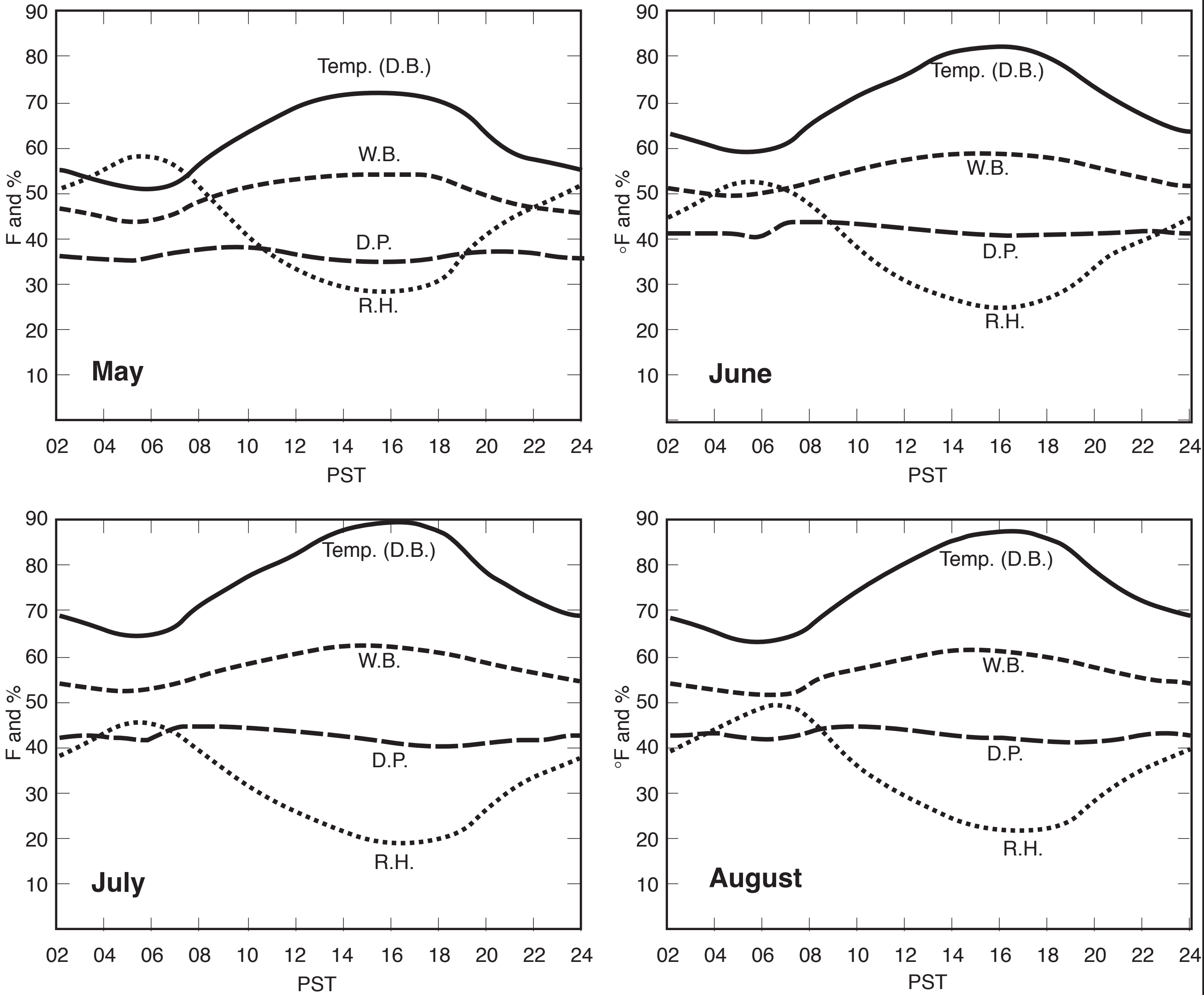
Draw. No. 990306.19 | Rev. | Figure 2.3-6

Monthly and annual hourly averages of Dry Bulb (D.B.) and Wet Bulb (W.B.) Temperature Relative Humidity (R.H.) and temperature of the dew point (D.P.) (1957 - 1970)



Monthly Hourly Average of Temperature and Relative Humidity - January thru April

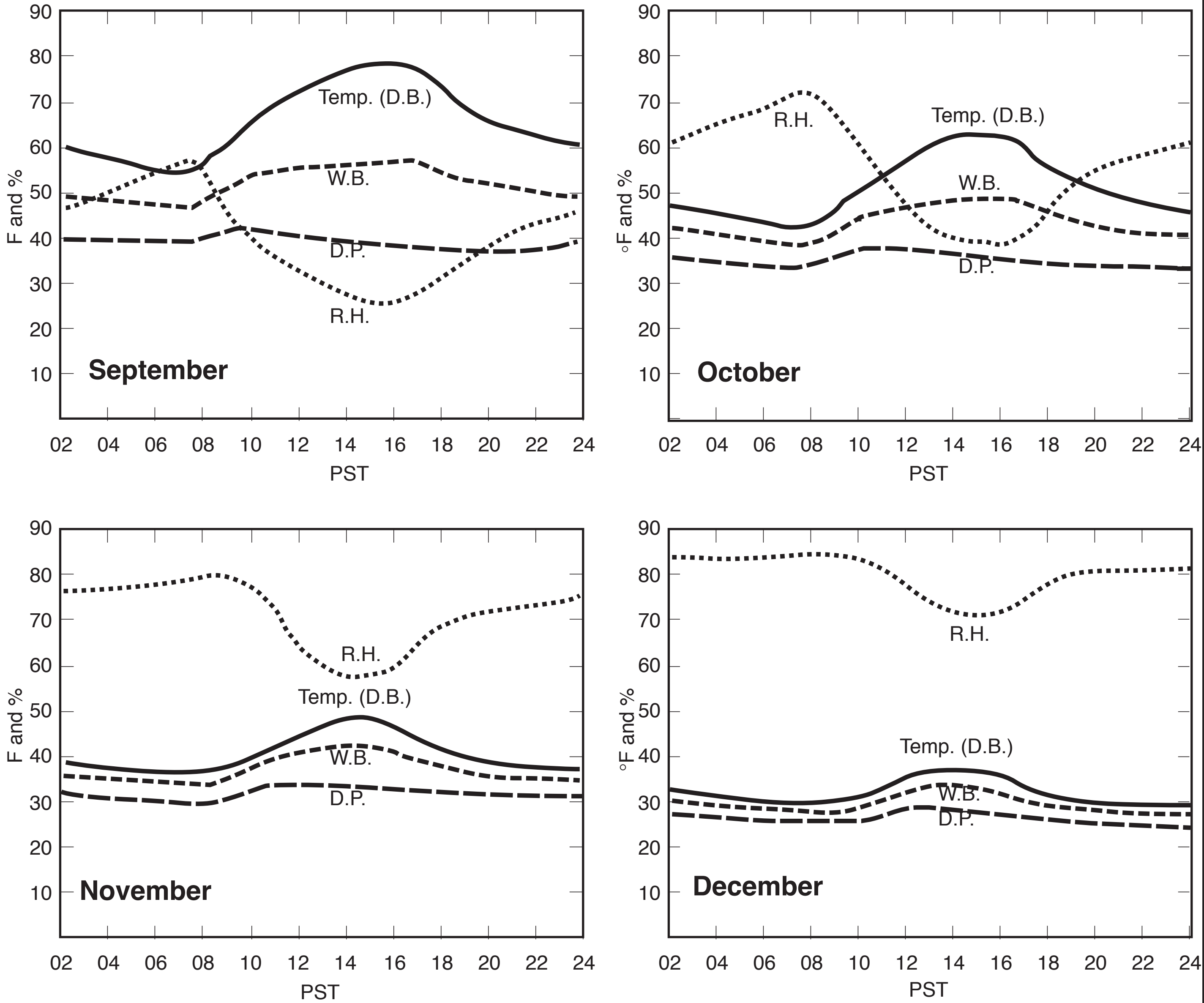
Draw. No. 990306.21	Rev.	Figure 2.3-7.1



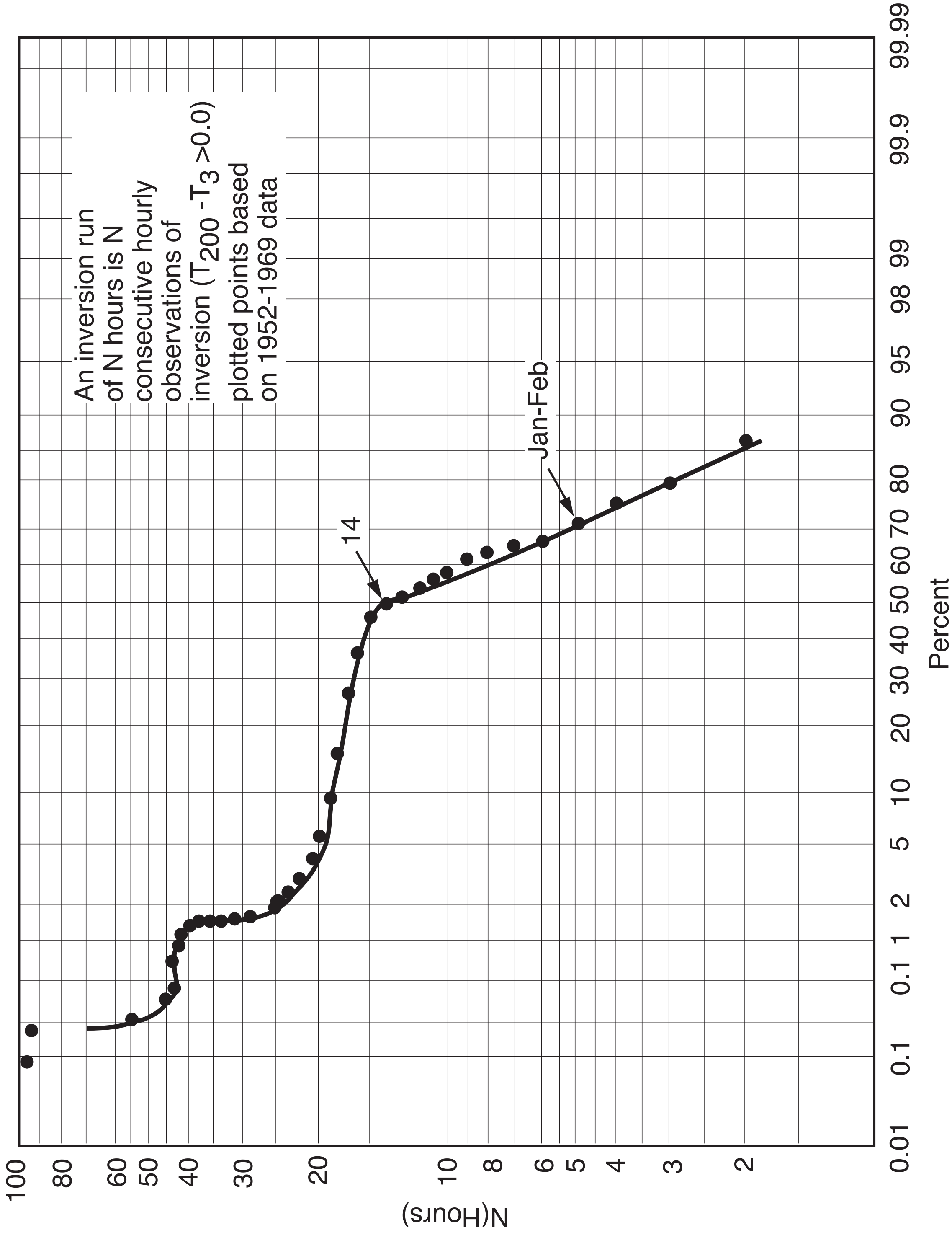
Monthly Hourly Average of Temperature and Relative Humidity - May thru August

Draw. No.	990306.40	Rev.		Figure	2.3-7.2

Monthly and annual hourly averages of Dry Bulb (D.B.) and Wet Bulb (W.B.) Temperature
Relative Humidity (R.H.) and temperature of the dew point (D.P.)
(1957-1970)



Columbia Generating Station Final Safety Analysis Report	Monthly Hourly Average of Temperature and Relative Humidity - September thru December
	Draw. No. 990306.22 Rev. Figure 2.3-7.3



Columbia Generating Station
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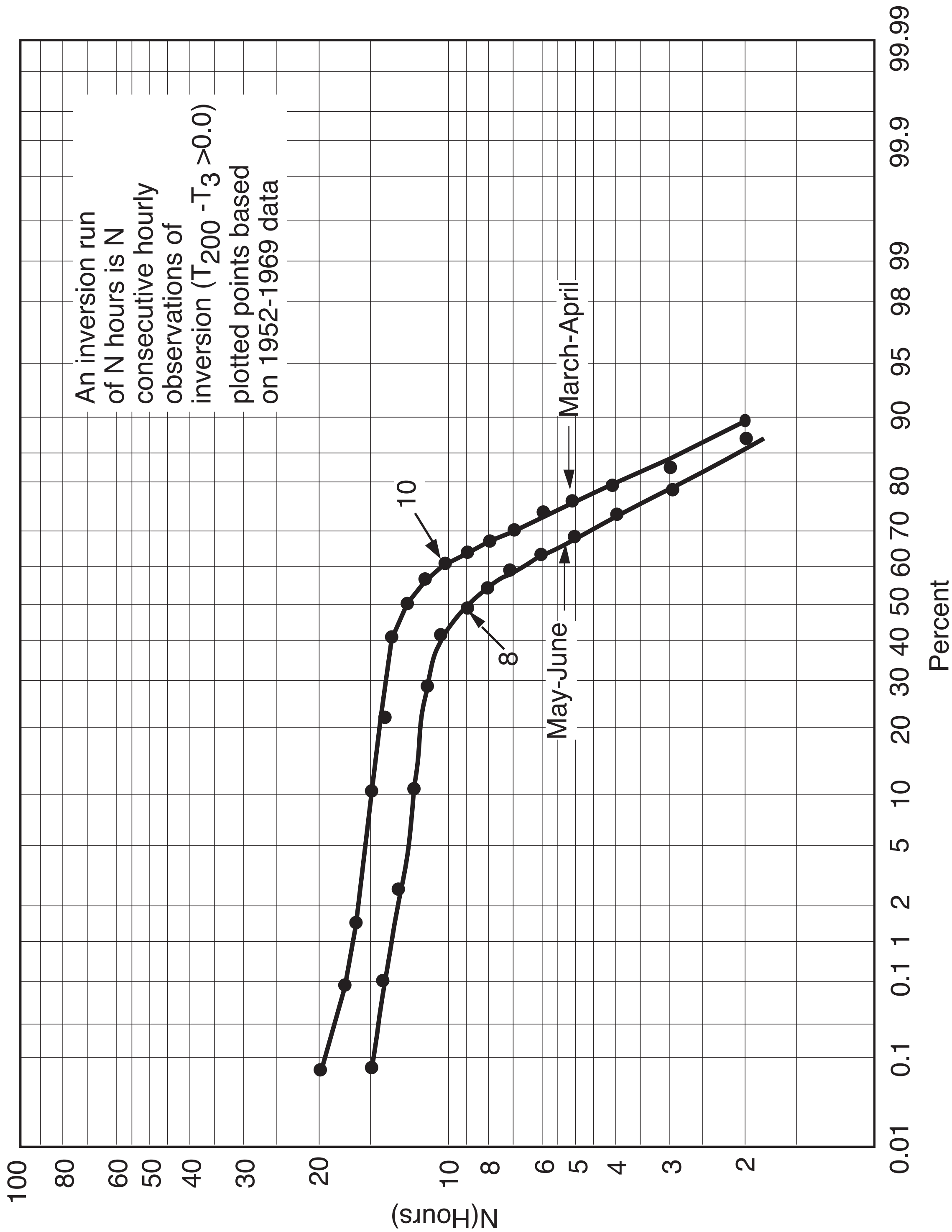
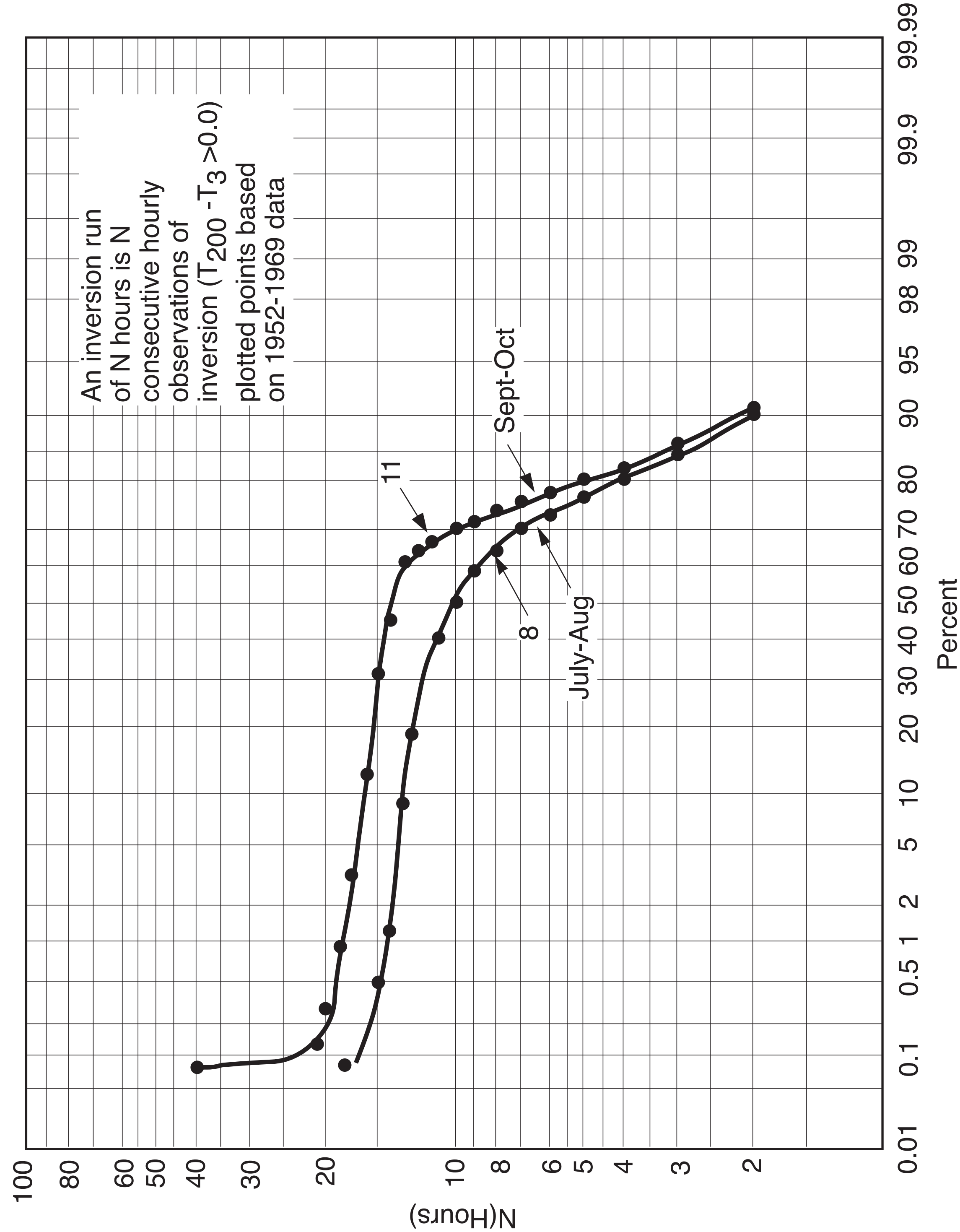
Probability (%) that the First Hourly Observation of an Inversion will Mark the Beginning of an Inversion Run of N Hr

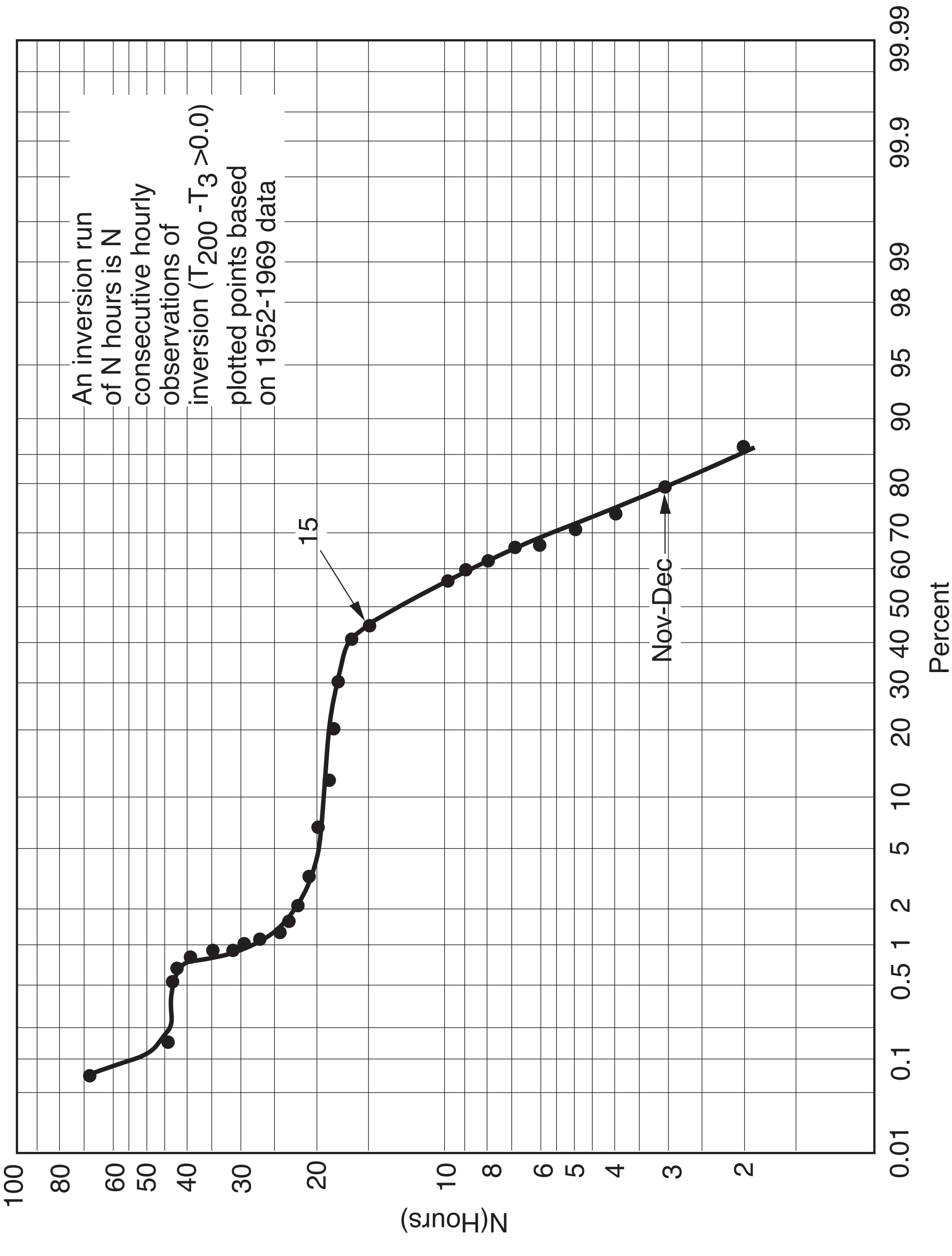
Draw. No. 990306.03 | Rev. | Figure 2.3-8.1



Probability (%) that the First Hourly Observation of an Inversion will Mark the Beginning of an Inversion Run of N Hr



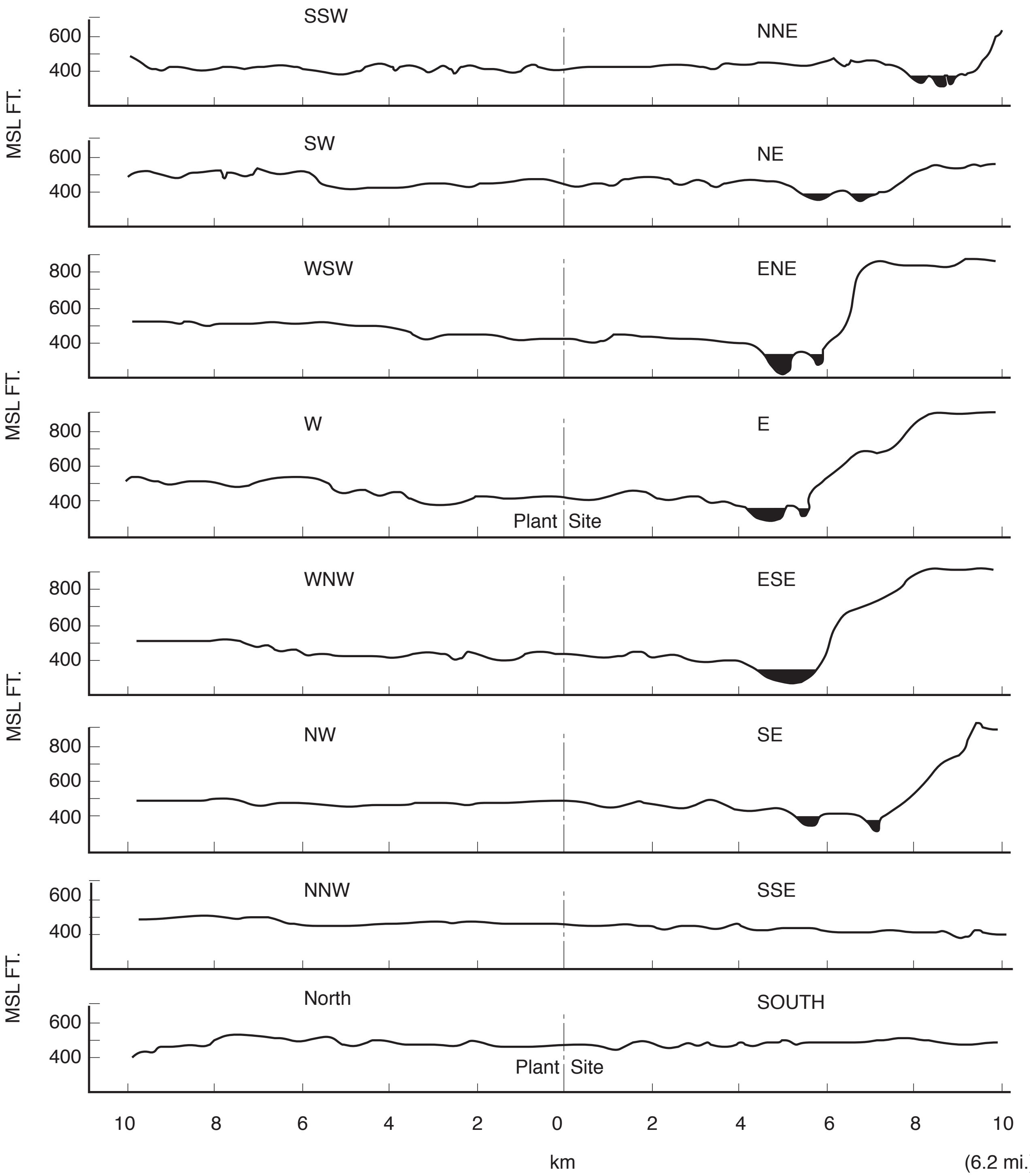
Columbia Generating Station Final Safety Analysis Report	Probability (%) that the First Hourly Observation of an Inversion will Mark the Beginning of an Inversion Run of N Hr		
	Draw. No. 990306.04	Rev.	Figure 2.3-8.3



Columbia Generating Station
Final Safety Analysis Report

Probability (%) that the First Hourly Observation of an Inversion will Mark the Beginning of an Inversion Run of N Hr

Draw. No. 990306.05	Rev.	Figure 2.3-8.4

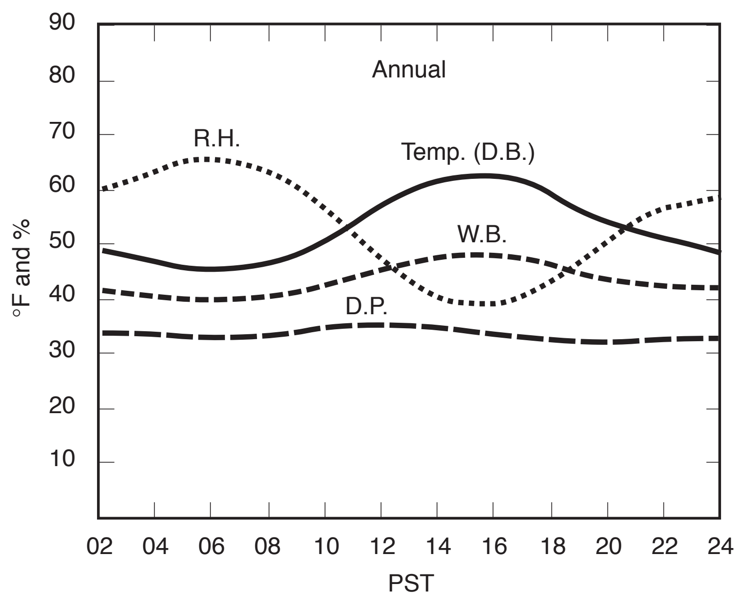


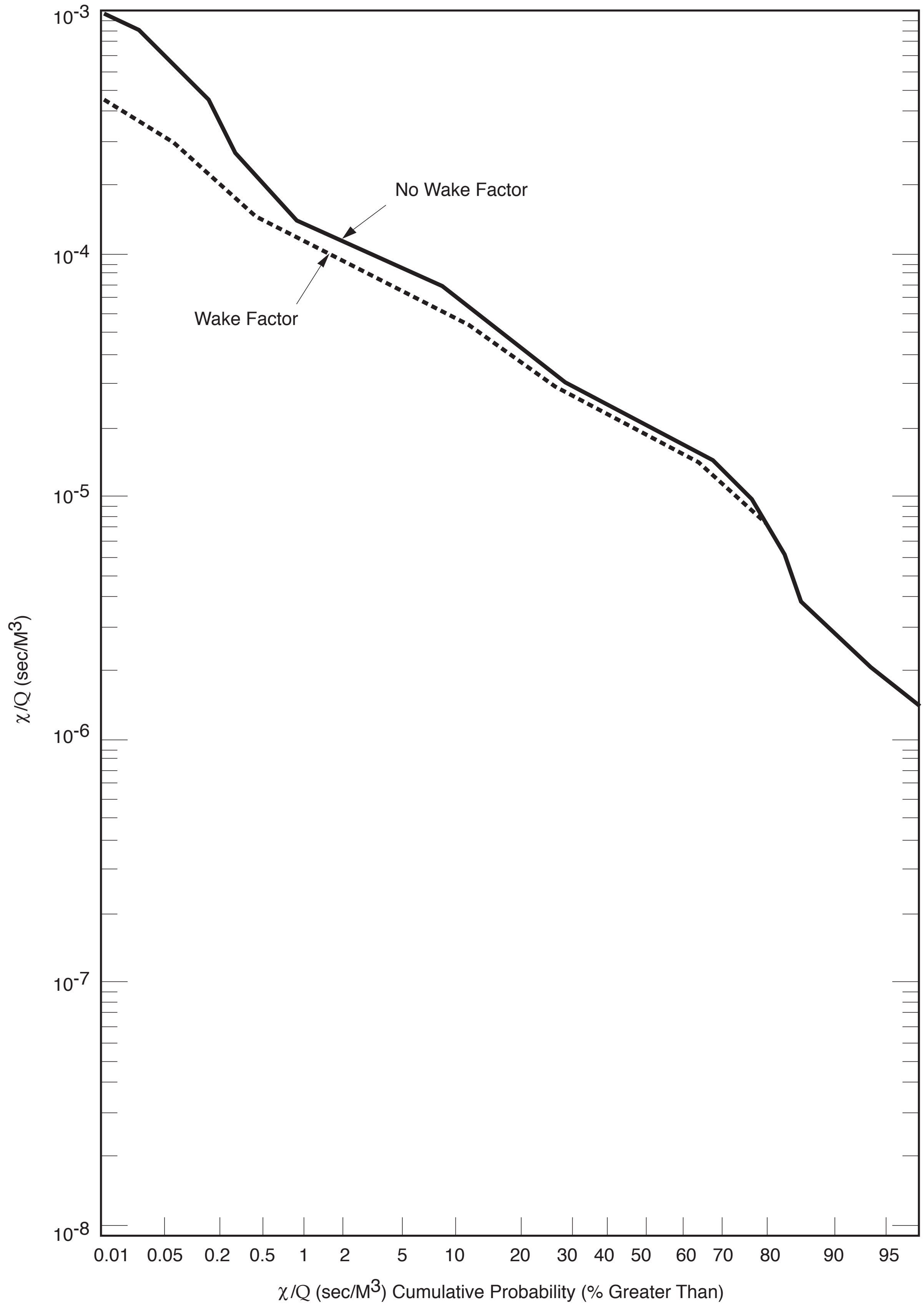
Columbia Generating Station
Final Safety Analysis Report

Topographic Cross Sections of Region Surrounding Site

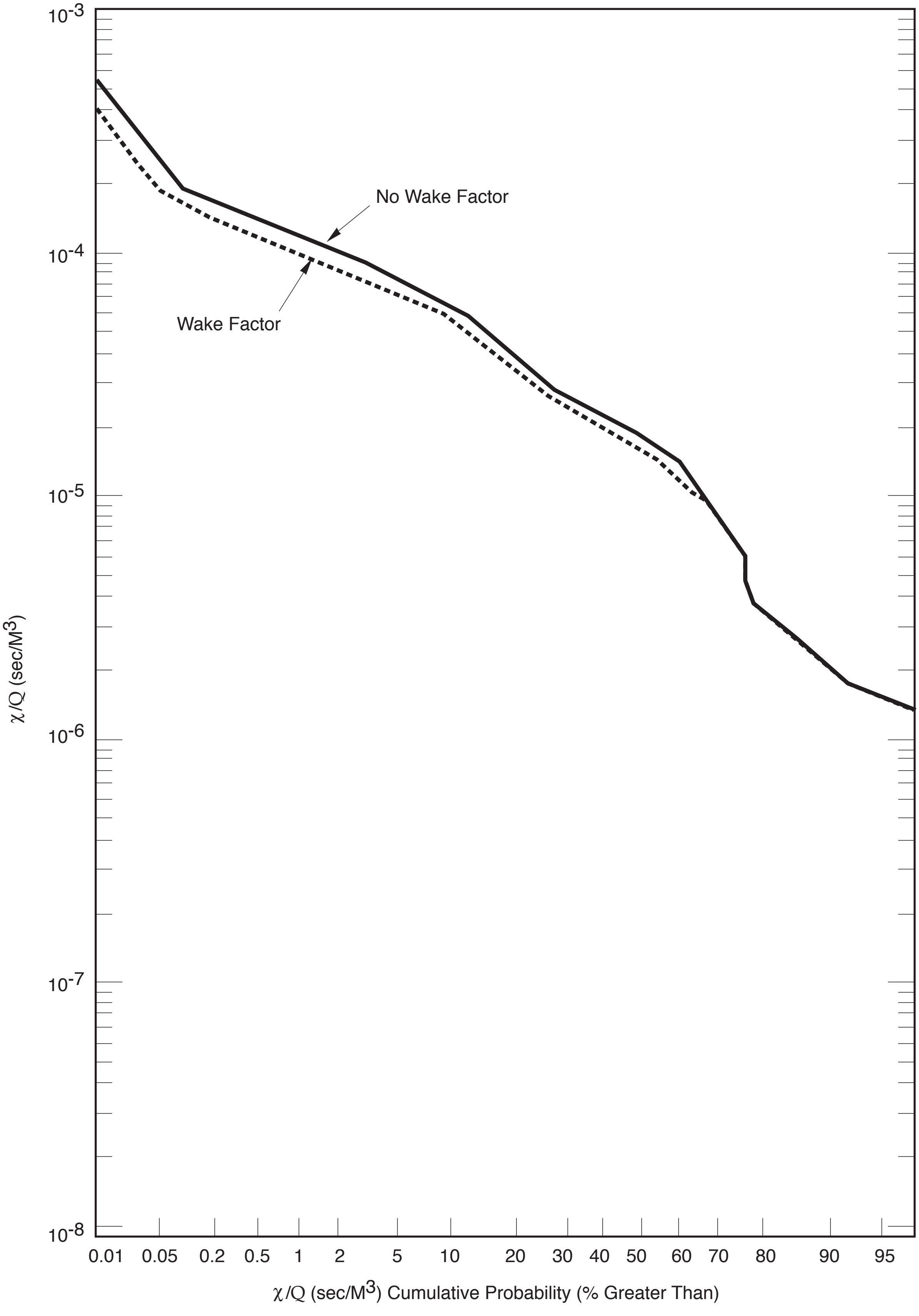
Draw. No. 990306.23 | Rev. | Figure 2.3-9

Monthly and annual hourly averages of Dry Bulb (D.B.) and Wet Bulb (W.B.) Temperature
Relative Humidity (R.H.) and temperature of the dew point (D.P.)
(1957-1970)





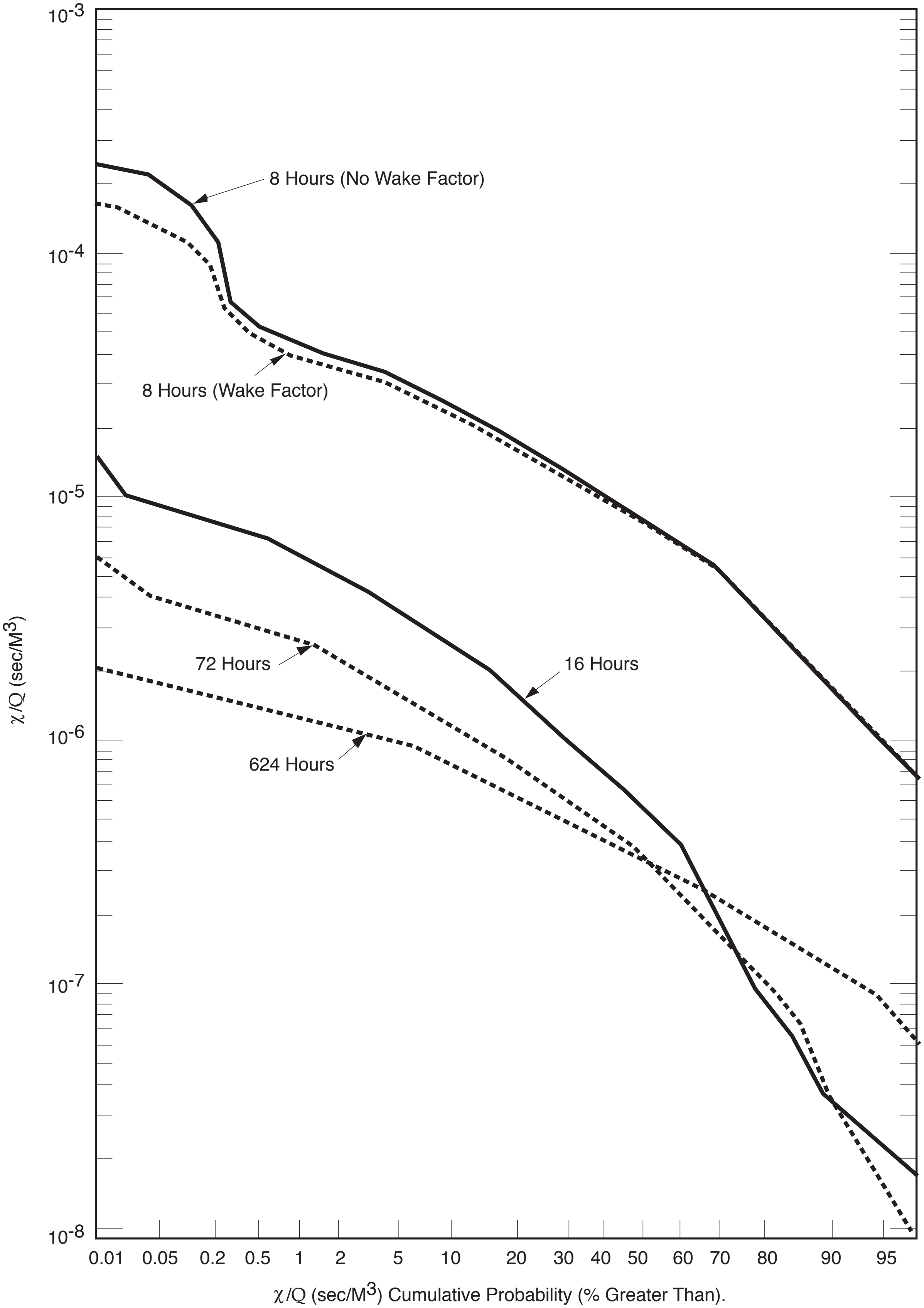
Columbia Generating Station Final Safety Analysis Report	Cumulative (%) Frequency of Hourly Centerline (χ/Q at Site Boundary Circular Distance of 1.212 Miles From Source (April 1974-March 1975)
	Draw. No. 990306.25 · Rev. · Figure 2.3-11



Columbia Generating Station
Final Safety Analysis Report

Cumulative (%) Frequency of Hourly Centerline (χ/Q at Site Boundary Circular Distance of 1.212 Miles From Source (April 1975-March 1976)

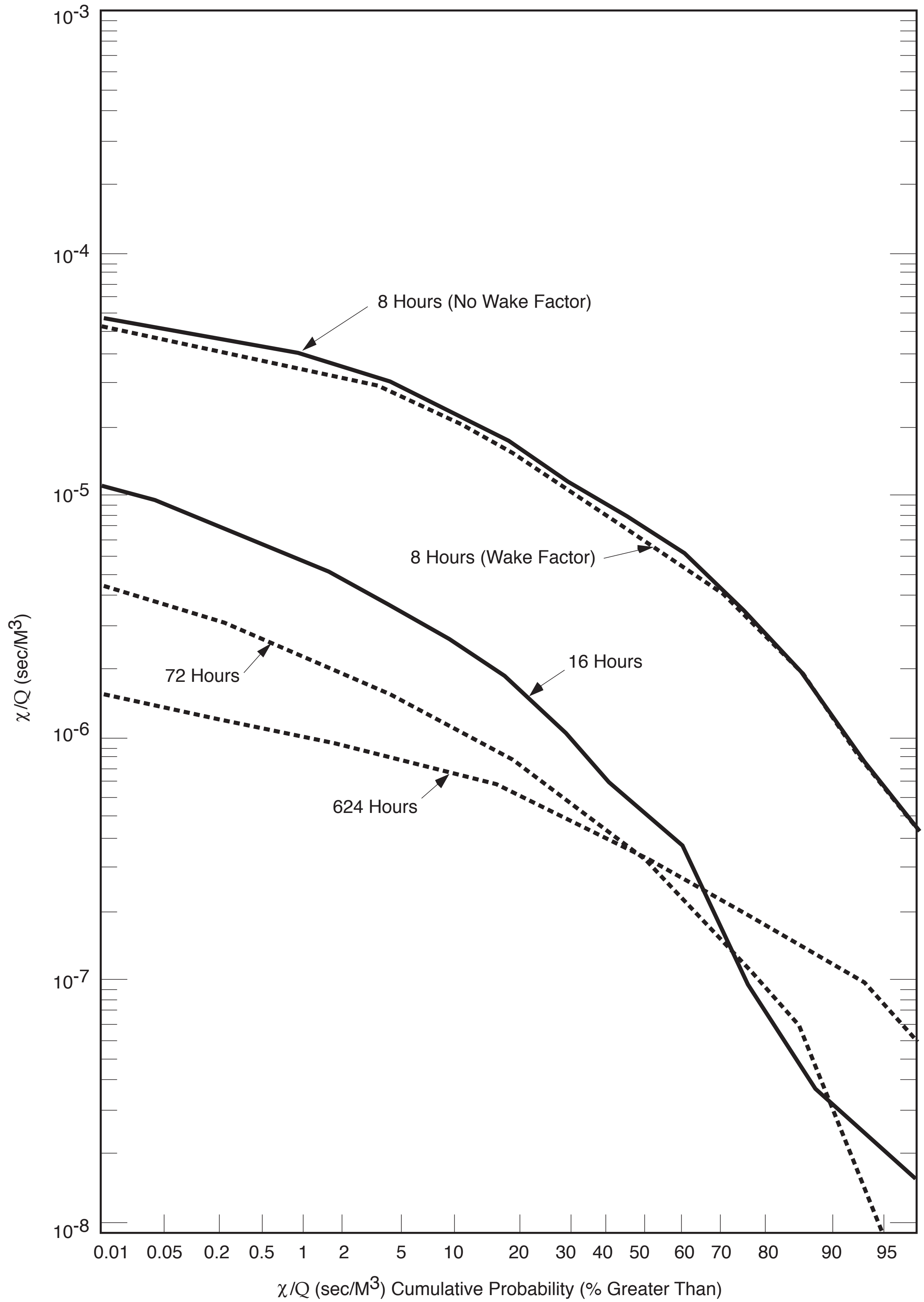
Draw. No. 990306.26 | Rev. | Figure 2.3-12



Columbia Generating Station
Final Safety Analysis Report

Cumulative (%) Frequency of Occurrence of (χ/Q for Postulated Accidents of 8, 16, 72, and 624 Hr at Outer Boundary of Low Population Zone (3.0 Miles from Source) (April 1974-March 1975)

Draw. No. 990306.27	Rev.	Figure 2.3-13

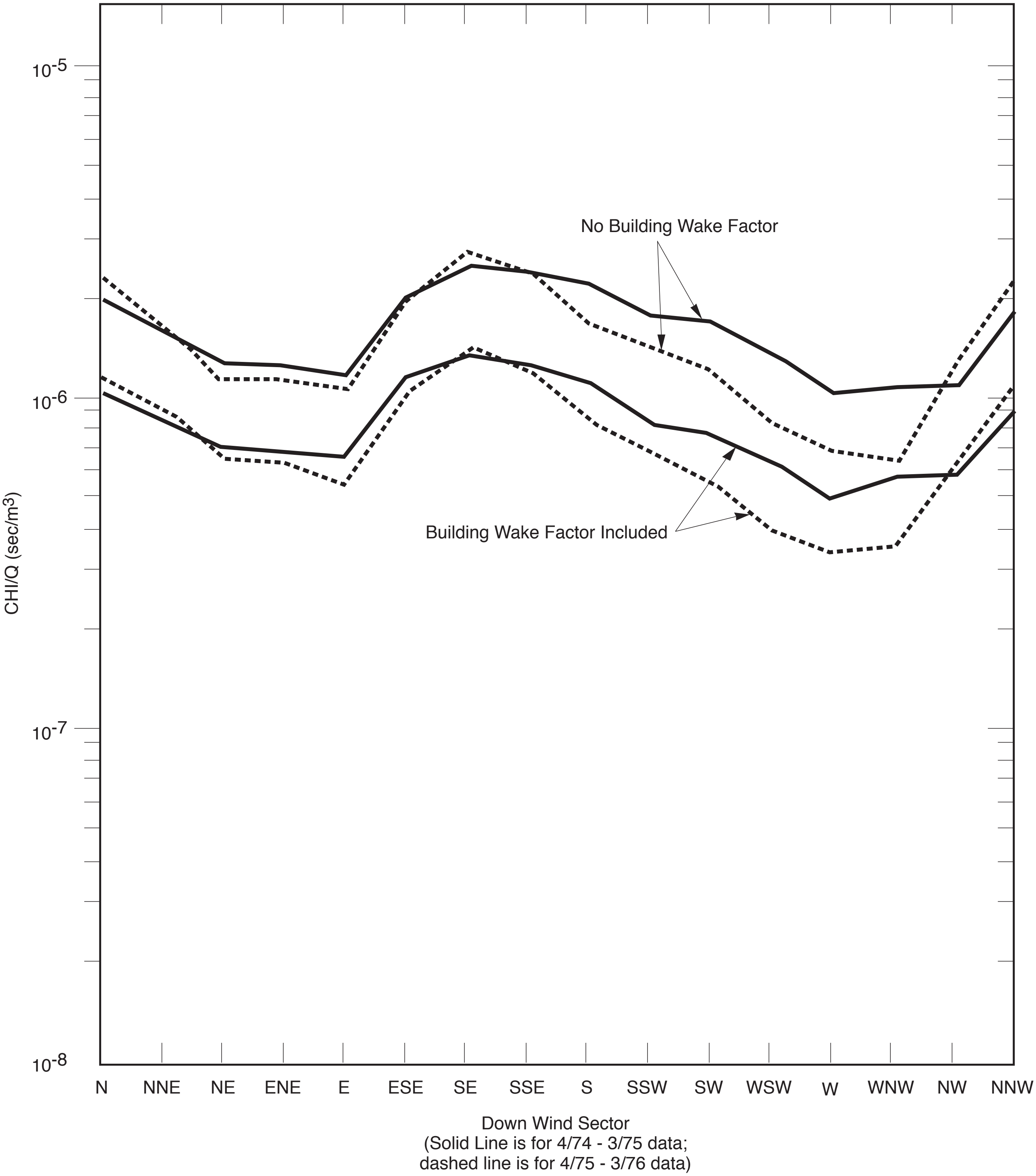


Columbia Generating Station
Final Safety Analysis Report

Cumulative (%) Frequency of Occurrence of (χ/Q for Postulated Accidents of 8, 16, 72, and 624 Hr at Outer Boundary of Low Population Zone (3.0 Miles from Source) (April 1975-March 1976)

Draw. No. 990306.28	Rev.	Figure 2.3-14

Form No. 960690



Columbia Generating Station Final Safety Analysis Report	Annual Average χ/Q by Sector at the Site Boundary for First and Second Annual Cycle Data	
	Draw. No. 990306.29 Rev.	Figure 2.3-15

2.4 HYDROLOGY ENGINEERING

The italicized information is historical and was provided to support the application for an operating license.

2.4.1 HYDROLOGIC DESCRIPTION

2.4.1.1 Site and Facilities

Columbia Generating Station (CGS) is located in the Hanford Site within Benton County, Washington, approximately 3 miles west of the Columbia River at river mile (RM) 352, 10 miles north of Richland and 45 miles downstream from Grant County PUD Priest Rapids Dam. The site coordinates are approximately 46° 28' North Latitude and 119° 20' West Longitude.

The Columbia River is the predominant hydrologic feature of the area and provides principal drainage for the surrounding area. The riverbed is clearly marked in the terrain and at the proximity of the site the river flows between high banks. The Columbia River approximate riverbed elevation is 328 ft above mean sea level (msl); the ground elevation at the site is approximately 440 ft. Another hydrologic feature of the area is the Yakima River, which at its closest approach flows within 8 miles of the plant site. The river system is shown in the hydrographic map, Figure 2.4-1. Figures 2.1-1 and 2.1-2 show the major hydrologic features of the area.

All Seismic Category I structures are located above maximum postulated flood elevations. For flood elevations refer to Sections 2.4.3 and 2.4.4.

Water for cooling tower makeup water and other plant requirements is withdrawn from the Columbia River. The intake system is designed for a maximum capacity of 25,000 gpm (55.7 cfs). The non-safety-related makeup water intake system is approximately 3 miles east of the plant and is made up of two offshore perforated pipe inlets, two lead-in pipes, and pump house structure.

A topographic map and contour map of the region surrounding the site are shown in Figures 2.4-2 and 2.4-3. The natural drainage features of the surrounding area have not been changed by the construction of CGS.

2.4.1.2 Hydrosphere

The Columbia River, the largest river flowing into the Pacific Ocean from North America, is one of this world's greatest sources of hydroelectric power. Its annual discharge of 18,000,000 acre ft (1 acre-ft = 43,560 ft^3) is exceeded in the North American continent only by the Mississippi, Mackenzie and St. Lawrence Rivers.

The Columbia River drains an area of approximately 258,000 square miles, lying to the west of the Continental Divide in the northwestern part of the U.S. (85%) and southwestern part of Canada (15%). Major tributaries are the Kootenay, Snake, Pend Oreille, Spokane, Okanogan, Yakima, and Willamette Rivers.

In determining the Standard Project Flood (SPF) the drainage area was divided into subbasins. These subbasins can be grouped into six general areas with similar hydrometeorological characteristics.

The six areas are: (1) upper Columbia, which includes the drainage of the area in Canada and the northern part of the United States above Chief Joseph Dam; (2) Middle Columbia, which includes the area between Pasco and Chief Joseph Dam; (3) Upper and Middle Snake River; (4) Lower Snake River, the area between Weiser and Ice Harbor Dam; (5) Lower Columbia, including the area between Bonneville Dam and Pasco; (6) the Columbia below Bonneville Dam, including the Willamette River.

The river basin has five outstanding physical features: the Rocky Mountain System, the Columbia Plateau, the Columbia River Gorge, the Cascade Range and Puget Trough.

The Rocky Mountain System is the major range with elevations from 2000 to over 12,000 ft. There are permanent glaciers and extensive snow fields at higher elevations and deep valleys that provide the principal drainage for the head-waters of the Columbia, Kootenay and other rivers.

The Columbia Plateau is a great, generally treeless, semiarid plateau covering over 100,000 square miles in the central portion of the basin. This plateau is in an area between the Cascade Range and the Rocky Mountains. The plateau was formed by successive flows of lava and filled to a general thickness of approximately 4000 ft. The Columbia River flows 1214 miles from its source in Columbia Lake (el. 2700 ft) in British Columbia, near the crest of the Rockies, to the Pacific Ocean at Astoria, Oregon. It sweeps around the north and northwesterly sides of the Columbia Plateau to central Washington to be joined by the Snake River. The Columbia River flows directly across the axis of the Cascades in a narrow gorge to the Pacific.

The Columbia Gorge is the gateway from the Pacific Ocean to the intermountain Columbia Plateau. Tide flows 140 miles up-river. For most of its length the river flows in deep valleys and canyons.

High flows occur in late spring and early summer with melting of snow on the mountainous watershed. Low flows occur in autumn and winter.

The Columbia River has been regulated by dams and reservoirs over the past 35 years. A large portion of the main stream and major tributaries is developed to meet various *functional requirements, such as flood control, hydroelectric power, irrigation, municipal and industrial supply, etc. The regulation of Columbia River floods is accomplished by use of reservoir storage space provided primarily for irrigation or for hydroelectric power utilization. The volume of usable reservoir storage space is on the order of 20% to 25%.*

There are seven dams upstream and four dams downstream of the site on the main stream of the Columbia River within the U.S. These dams are listed in Table 2.4-1. The Columbia River flow in the reach of CGS is controlled by regulation of the upstream reservoir projects, which have a total usable storage capacity of approximately 35 million acre-ft. Some control of flow in the immediate vicinity of the site is by regulation of the nearest upstream hydroelectric projects, Priest Rapids Dam, at RM 397, containing about 45,000 acre-ft of active storage, and Wanapum Dam, at RM 415, containing about 161,000 acre-ft of active storage. Some minimal effect on the river flow in the vicinity of the site is caused by McNary Dam, at RM 292, approximately 60 RM downstream from the site area.

Flows in the Columbia River during the summer, fall, and winter vary from a low of 36,000 ft^3*/sec to as much as 160,000 ft*^{3}*/sec. During spring runoff high flows ranging from 250,000 ft*^{3}*/sec to 450,000 ft*^{3}*/sec have been recorded. The average annual flow is 120,000 ft*^{3}*/sec; during low flow periods flows may average about 60,000 ft*^{3}*/sec (see Figure 2.4-4).*

The Grand Coulee and Bonneville dams were put into operation prior to World War II and several dams were built after the war. The four downstream dams include large locks to permit the passage of river vessels. Several of the dams provide emergency floodwater storage. Grand Coulee, the largest and most complex of the dams, augments the low winter flows for the entire system from its 9,402,000 acre-ft of available storage (of which approximately 5,100,000 acre-ft is active storage) and also pumps water to the Columbia River Irrigation Project.

The river channel near the CGS site varies between 400 and 600 yards in width for low water and normal high water level, respectively. The depth varies from about 25 ft to 45 ft for normal high water and flood high water levels, respectively. Velocities vary from 3 ft/sec to over 11 ft/sec depending on section and flow. Average water temperature is 51°F. Temperatures may reach a low of 32°F and a high of 68°F. (See Table 2.4-2 and Figure 2.4-4.)

A list of water usage downstream of CGS, obtained from records of the Department of Ecology, State of Washington, for water rights as of February 1980, is presented in Table 2.4-3. The closest municipal surface water user is the City of Richland with an intake approximately 12 miles downstream. *The location of local groundwater users is discussed in Section 2.4.13.2.*

2.4.2 FLOODS

2.4.2.1 Flood History

Floods in the Columbia River Basin are grouped as:

a. *The interior basin east of the Cascades, caused by melting snowpack and occurring from May through June;*

b. *The Willamette and other basins, west of the Cascades, caused by direct runoff from intense winter rain occasionally augmented by snowmelt.*

There is some overlapping effect within these two groupings. At certain elevations, basins in the interior Columbia drainage area occasionally have significant flood flows resulting from winter rain or snowmelt. These are local floods and do not usually contribute sufficient flow to cause flooding of the main Columbia River. Major floods in the Columbia River Basin result from rapid spring melting of the snowpack over a wide area, generally augmented by rain or by above-normal precipitation in May, accompanied by a major chinook wind which causes rapid area temperature rise. The annual spring snowmelt flood of the main interior basin is characterized by relatively uniform distribution over the basin. The snowfall and individual snow storms may vary, but the integration of all storms over the winter period smoothes the irregularities, with the result that the distribution of the flood runoff is reasonably constant from year to year.

The maximum historical flood of record is that of June 7, 1894, which resulted from a combination of hydrometeorologic conditions, including heavy snowpack and rapid melt plus rainfall. The peak discharge at CGS was 740,000 ft^3/sec for the Columbia River, as estimated from high water marks at Wenatchee, Washington (Reference 2.4-1). *The largest recent flood, occurring in 1948, had an observed peak discharge of 690,000 ft^3/sec at Hanford. These floods were spring floods resulting from the melt of a large snowpack combined with the spring rains (Reference 2.4-2).* Water surface profiles for the Columbia River in the vicinity of the site as derived by the Corps of Engineers (Reference 2.4-2) are given in Figure 2.4-5.

The plant site is located approximately three miles west of the Columbia River at RM 352 with reactor floor elevation of 441 ft msl, which is 68 ft above the water level estimated for the largest historical flood (approximately 373 ft msl). There is no record of flooding in the immediate site area.

2.4.2.2 Flood Design Considerations

Flood protection of safety-related components is based on the highest calculated flood water level including wave effects, resulting from intense local precipitation. Several different probable maximum events were considered, including the Corps of Engineers design-project flood considered to be "the most severe reasonably possible." Wave action caused by storm winds, the effects of failure of upstream dam surge flooding, and ice flooding were also considered.

The results of these analyses (described in Section 2.4.3) indicate that the CGS site is safe from floods and that no flood protection measures are required. The Hydrogen Storage and Supply Facility located 0.6 miles south-southeast of the plant is subject to flooding due to the PMP flood discussed in Section 2.4.3.1. Equipment storing liquid and gaseous hydrogen has been analyzed for the effects of this flood (Section 2.4.2.3). As discussed in sections that follow, plant safety-related structures are located above high water elevations associated with Columbia River flooding (Sections 2.4.2.1 and 2.4.3), intense local precipitation (Sections 2.4.3.5 and 2.4.3.6), and upriver dam failures (Section 2.4.4).

2.4.2.3 Effects of Local Intense Precipitation

Intense local summer thunder storms can produce short duration rains which have the potential for causing serious flood. Winter precipitation may occur as rain or snow and would be less intense than the worst summer thunderstorm. The probable maximum precipitation (PMP) event for the CGS site has been determined using the methodology developed by the U.S. Weather Bureau and reported in Hydrometeorological Report No. 43, "Probable Maximum Precipitation, Northwest States" (Reference 2.4-3).

The plant area slopes easterly to a broad channel which is adequate to store and drain the PMP. Construction contours of the site are shown in Figure 2.4-28. The reactor building and the spray ponds are located at elevations that are safe from the effect of any flood resulting from the maximum precipitation event.

Winter precipitation may occur as rain or snow. The winter season snowfall has ranged from less than 0.5 in. to a maximum of 12 in. in December 1964. There is no ice accumulation at the site.

To accommodate surface drainage during severe climatic conditions such as rainfall and rapid snow melts, a system of catch basins and dry wells is provided with inlet elevations a minimum of 6 in. lower than the nearest road and a minimum of 12 in. lower than the finished floor elevation of the nearest building(s).

Runoff from the PMP event is accommodated by designing the roadways such that the high point of the road is 6 in. to 1 ft below the finished floor elevation of the adjacent safety-related building(s). Runoff from this event is from the northwest to the southeast across the site plateau to the low area southeast of the plant site. The general plant site is nominally 9 ft above the maximum calculated water surface elevation resulting from the postulated PMP (Section 2.4.3.3). Therefore, the site grading precludes the potential flooding of safety-related structures. The Hydrogen Storage and Supply Facility is subject to the PMP event flooding.

The elevation of the facility is 420 ft msl and the PMP flood level is 431.1 ft msl (Section 2.4.3.5). See Section 10.4.10 for more discussion.

Roofs of buildings are designed to take, with adequate drainage, any instantaneous or local intense precipitation. Discharge from roof drains is carried by means of a storm sewer system to a manhole located southeast of the reactor building. From that point a pipeline with a northeast alignment transfers the discharge to a low point of disposal about 1500 ft away from the plant site.

The roofs of safety-related buildings (diesel generator building, radwaste/control building, standby service water pump house) are concrete beam and slab construction except the high roof of the reactor building, which is metal deck on steel framing. The minimum roof slope for all structures is 1/8 in. per ft for adequate drainage and the roof areas are encompassed by curbs or parapet walls up to 3 ft 6 in. high. Roof plans, including details of roof drains and overflow scuppers, are provided in Figure 2.4-6. Assuming that the roof drains are completely blocked during the PMP event, overflow scuppers limit the depth of water to within the design load carrying capability of the roofs. Those safety-related structures that do not have this relief capability structurally can carry the entire PMP accumulations.

2.4.3 PROBABLE MAXIMUM FLOOD ON STREAMS AND RIVERS

Analyses for probable maximum flood (PMF) and SPF on the Columbia River (Reference 2.4-2) are consistent with the requirements of Regulatory Guide 1.59, Revision 2. The SPF for the Mid-Columbia Reach of the highly developed and regulated Columbia River is defined as 570,000 ft^3/sec (Reference 2.4-4). The unregulated SPF for the same reach is 740,000 ft^3/sec. The unregulated PMF at the site is estimated to be 1,600,000 ft^3/sec (References 2.4-2, 2.4-4, and 2.4-5).

Adjustment of the flood profiles for the Hanford region reported in Reference 2.4-4, results in a regulated PMF of 1,440,000 ft^3/sec and a water level of 390 ft at the Seismic Category II makeup water structure. This structure is not designed to function throughout the PMF but is designed for the SPF (unregulated) of 740,000 ft^3/sec.

Although assumed to exist for the purpose of flood hydrograph calculations, Ben Franklin Dam is not a federally authorized project. As originally planned it would have been a low head dam with only a negligible effect on extreme flood flows (Reference 2.4-6).

The design basis flood for the CGS site area results from the PMP event on the adjacent drainage basin and not from flooding of the Columbia River.

2.4.3.1 Probable Maximum Precipitation

The PMP event which was presented in the CGS PSAR was subsequently reevaluated in the preparation of the PSAR for WPPSS Nuclear Project No. 1 (Docket 50-460). The analysis presented here is consistent with the latter document.

Precipitation in the vicinity of the site has been classified by the U.S. Weather Bureau, Reference 2.4-3, as convergence precipitation, orographic precipitation, and thunderstorm precipitation. The methodology for predicting the total amount of precipitation from each of these events, as given in Reference 2.4-3, requires the adding together of the convergence PMP and the orographic PMP to obtain a single precipitation for a general storm. A separate analysis is then required for thunderstorms. Thunderstorms in the vicinity of the site can be locally very intense for short periods of time and hence, have the potential for causing serious flooding. The PMP for both a general storm and a thunderstorm were analyzed as given in Chapters 6 and 5, respectively, of Reference 2.4-3 for a 38.5 $mile^2$ basin at the site. This basin is shown in Figure 2.4-8 and is described in Section 2.4.3.3. The calculated general storm PMP results in a 24-hr and 48-hr precipitation of 7.9 in. and 10.1 in., respectively. A thunderstorm PMP yields 9.2 in. in a 5-hr period. Therefore, the thunderstorm is considerably more severe. The thunderstorm PMP hydrograph is

Time (hr)	Rain (in.)
1	0.6
2	1.6
3	5.2
4	0.9
5	0.5
6	0.4
Total	9.2

2.4.3.2 Precipitation Losses

Infiltration losses have been estimated in the vicinity of the sites as 1.5 in./hr (Reference 2.4-7). However, for the analysis below, an average antecedent moisture condition (Condition II as defined in Reference 2.4-8) was assumed. As explained in the following section, the 60-minute retention loss rate is 0.15 in./hr.

2.4.3.3 Runoff and Stream Course Models

The drainage basin common to the reactor building and spray ponds is shown in Figure 2.4-8. The entire area drains to a broad channel that extends in a north-south direction for about 7 miles, and ranges from about 2000 ft to over a mile wide. All plant structures are located on high ground to the west of the channel. At a point about 2.8 miles south of the reactor site, the four-lane Department of Energy (DOE) highway crosses the drainage basin. The area above this section is 33.2 $miles^2$.

To evaluate the effect of the PMP event on the plant area, the peak discharge at the highway crossing, 2.8 miles downstream of the plant, was calculated using the U.S. Bureau of Reclamation procedure for computing design floods on ungauged basins from thunderstorm rainfall in the western U.S. (Reference 2.4-8). Important assumptions used in the triangular hydrograph procedure of Reference 2.4-8 are

a. Hydrologic soil group B,

b. Land use and treatment class - poor pasture or range,

c. Thunderstorm cover-index is brush-sage-grass combination with 50% or less cover density, and

d. Thunderstorm minimum 15-minute retention loss rate of 0.06 in./15 minutes and 60-minute retention loss rate of 0.15 in./hr.

Additionally, no credit was taken in the hydrograph analysis for potential storage in the stream channel or upstream sub-basins.

The time of concentration, T_c, for the watershed above the highway crossing was computed to be 7.5 hr. The PMF hydrograph is shown in Figure 2.4-7 for the 33.2 $mile^2$ drainage basin. A peak discharge of 21,400 ft^3/sec was determined.

Based on this PMF, an upstream water surface profile was determined using the Corps of Engineers HEC Standard-Step Procedure (Reference 2.4-9). A total of eleven cross sections were used (seven downstream, one at the plant, and three upstream as shown in Figure 2.4-3). Details of the channel cross sections are shown in Figure 2.4-9. The Manning roughness coefficient was conservatively taken as n=0.035 in the main channel sections, and n=0.05 in the overbank areas.

Using the computational procedure of Reference 2.4-9, it was determined that the channel restrictions at cross sections 5 and 7 (Figure 2.4-3) do not control the flow. The stillwater elevation at the plant site (cross section 8) was determined to be 431.1 ft msl. The water surface profile is shown in Figure 2.4-10.

2.4.3.4 Probable Maximum Flood Flow

The PMF runoff hydrograph produced by the PMP at cross section 1 (Figure 2.4-3) is shown in Figure 2.4-7. The peak discharge at this location is 21,400 ft^3/sec.

2.4.3.5 Water Level Determinations

As discussed in Section 2.4.3.3, the water elevation of a flood at the plant site generated by the PMP event is 431.1 ft msl. This flood condition has a higher estimated elevation than any flood of the Columbia River.

2.4.3.6 Coincident Wind Wave Activity

Procedures published by the Corps of Engineers (References 2.4-10 and 2.4-11 were used to determine the wind wave activity. The effective fetch for the predominant July wind direction (north) is 3450 ft (0.65 miles). The effective fetch diagram is shown in Figure 2.4-11. The calculated extreme 2-year over water wind for the north-to-south direction, based on area data, is 63.5 mph. This wind results in a maximum wave height of 4.0 ft, with the assumption of a water depth of 12 ft (the average depth in cross sections 8, 9, and 10). The other potential wind directions ENE and ESE were evaluated but found to be less severe.

The wind setup has been computed to be 0.3 ft, and the maximum wave runup is 1.9 ft on a smooth, 1 on 8 slope of compacted naturally occurring sands and gravels. Therefore, the design water surface elevation is 433.3 ft msl. This is less than the east spray pond wall elevation of 435.0 ft msl.

2.4.4 POTENTIAL DAM FAILURES, SEISMICALLY INDUCED

Analyses of floods resulting from potential dam failures were investigated by the Corps of Engineers for the Columbia River. These studies are consistent with Regulatory Guide 1.59, Revision 2. The flood resulting from the breaching of Grand Coulee Dam is considered in lieu of a seismically induced flood.

In 1951, the Seattle District Corps of Engineers made a confidential study (now declassified) to determine artificial flood hydrographs and the flood profile in the Columbia River Valley resulting from breaching the Grand Coulee Dam by enemy attack. The studies covered a spectrum of conditions in terms of breach openings and hydrologic conditions that might prevail at the time of attack. A postulated seismic failure of Grand Coulee Dam could result in displacement of part of the structure, but it would still act as a restriction or weir and minimize the hydraulic failure. For this reason, the explosion-induced artificial flood represents an upper limit to seismically induced failures. The failure of Grand Coulee Dam would initiate a catastrophic flood, which would be augmented by the failure of the earth portions of downstream dams and subsequent release of the storage pools. Figure 2.4-5 shows water surface profiles for RM 323 to RM 358 for various river flows, including Artificial Flood No. 1. This flood provides a “limiting case” assessment of the conservatism of CGS elevation. This flood would have an outfall peak of 8,800,000 ft^3/sec at Grand Coulee Dam at the moment of breaching and a peak discharge at RM 338 (Richland) of 4,800,000 ft^3/sec.

A base flow of 50,000 ft^3/sec was assumed above the mouth of the Snake for this flood (Reference 2.4-12).

An arbitrarily assumed dramatic failure of Arrow and/or Mica Dams in Canada could result in greater releases of storage in terms of volume than that from the Grand Coulee Dam, but the effects of such postulated releases are mitigated by a combination of valley storage and critical (flow limiting) valley cross sections. The Corps of Engineers states (Reference 2.4-13) that the river channel restrictions at Trail, British Columbia, would restrict river flow to about 3.1 x 10^6 cfs, regardless of the postulated dam failure. A major failure upstream would result in this maximum flow for many days causing overtopping of Grand Coulee Dam. An analysis by the Bureau of Reclamation (Reference 2.4-14) concluded that overtopping which might result from the failure of upstream dams will not cause failure of either the Grand Coulee Dam or the Forebay Dam.

Various studies (References 2.4-12, 2.4-15, 2.4-16 and 2.4-17) made by the Corps of Engineers, and others, since 1951 have considered that breaching of Grand Coulee Dam would represent the worst catastrophic event for downstream Columbia River occupants. Although these studies bear no relationship to flooding from natural causes, they have been used as the basis for a very conservative, limiting case approach.

Figure 2.4-5 shows water surface profiles for RM 323 to RM 395 for artificial and real stage flows, one of which corresponds to Artificial Flood No. 1 noted earlier, which has been established (Reference 2.4-18) as conservative (limiting case) criteria for Columbia River flooding. Since the base flow used to develop these curves was 50,000 ft^3/sec, an additional 570,000 ft^3/sec is added to account for simultaneous occurrence of the regulated SPF.

2.4.4.1 Dam Failure Permutations

The effect of potential dam failure on the water levels at the site is determined using the following assumptions:

a. The Columbia River is at flood stage, with a SPF (570,000 ft^3/sec regulated);

b. The reservoirs in each storage pool are full;

c. A massive hydraulic failure occurs at Grand Coulee Dam, releasing 8,800,000 ft^3/sec;

d. Following the above assumed failure, all downstream dams between CGS site and Grand Coulee Dam suffer some degree of failure and release their storage reservoirs to the flood. [The result of a stability analysis (Reference 2.4-15) showed that all mass concrete portions of the dams will resist sliding and overturning with the possible exception of part of Rock Island Dam.];

e. The explosion-induced failure of Grand Coulee Dam represents a more severe failure than any seismic event because of the failure mechanism;

f. Failure of Arrow and/or Mica Dam could result in greater release of storage volume than Grand Coulee Dam; however, the peak flow is limited to 3,100,000 ft^3/sec due to channel restrictions at Trail, British Columbia; and

g. Overtopping of Grand Coulee Dam would occur with failure of Arrow and/or Mica Dams in Canada. The failure of Grand Coulee, as a result of overtopping, is not considered to be a credible event in view of its concrete construction and rock abutments.

2.4.4.2 Unsteady Flow Analysis of Potential Dam Failures

The flood hydrographs developed by the Corps of Engineers are based on the results of extensive studies of the physical characteristics of the flood route (References 2.4-12 and 2.4-15). Subsequent studies made by the Corps of Engineers verify these results (Reference 2.4-17). Water levels following such a flood would depend on the status of reservoir storage upstream from Grand Coulee Dam but, without regulation of some dams, would approximate the natural seasonal flow conditions.

2.4.4.3 Water Level at Plant Site

The water elevations associated with limiting case flood (LCF) levels are shown in Figure 2.4-5. RM 350 provides the control for backwater flow to the plant area which is sheltered by higher ground east of WNP-1 and WNP-4.

Elevation at RM 350 (dam breach flood 4,800,000 ft^3/sec plus SPF, 570,000 ft^3/sec)	=	422 ft msl
Allowance for simultaneous wind and wave action	+	2 ft
Elevation:		424 ft msl = LCF

An adequate margin exists between the resultant flood elevation and the plant elevation of 441 ft msl.

2.4.5 PROBABLE MAXIMUM SURGE AND SEICHE FLOODING

The location of the CGS site is not close to any water body which experiences seiche flooding. Thus the site is not vulnerable to such flooding.

2.4.6 PROBABLE MAXIMUM TSUNAMI FLOODING

The location of the CGS site is in south-central Washington and it is not adjacent to any coastal area. It is not, therefore, vulnerable to tsunami flooding.

2.4.7 ICE EFFECTS

Historically, the Columbia River has never experienced complete flow stoppage or significant flooding due to ice blockage. Periodic ice blocking has caused reduced flows and limited flooding for only relatively short periods of time. *The most significant icing in recent recorded history occurred during the winter of 1936-37 prior to the construction of the upstream regulating dams. A relatively thick sheet of ice formed across the river. The minimum flow recorded near the Priest Rapids Dam site during this winter was 20,000 cfs. However, the ice forming on the river was caused primarily by the low flow rather than the reverse. The deltaic mouths of many of the tributaries to the Columbia River are frequently blocked by ice causing backup of flood waters. No instance of complete stoppage is known to have occurred.*

Ice blockage is most likely to occur when water temperatures are already low, when flows are small, and when a significant cold spell occurs. With the completion of Grand Coulee and other dams on the Columbia River main stream, the seasonal temperature and flow cycles have drastically changed. These changes will further aid to reduce the intensity and timing of the conditions which may contribute to potential ice blockage and flooding situations. Also average river flow rates, during the winter months, have been increased significantly. The water temperatures have shown a shift in time such that the peak temperatures occur 30-45 days later than formerly. In addition, the low extreme temperatures measured have risen over the years.

The long term trends of temperatures in the Columbia River been studied (Reference 2.4-19) using a 37 year record of measured temperatures. The trends for the maximum, average and minimum temperatures are shown in Figure 2.4-12. The erection of dams on the upper Columbia River has caused the extreme high and low river temperatures measured at Rock Island Dam (Columbia RM 453, 101 miles above the CGS site) to converge toward the average. Winter water temperatures are considerably warmer and summer temperatures cooler with a slightly lowered average of less than 1°F occurring during the 37 years.

On the basis of these studies and the recorded observation of 25 years of operation of the Hanford plutonium production plants, it is concluded that the potential for ice blockage or the combination of blockage and flooding behind ice dams is so low as to be considered insignificant. The erection of Mica, Arrow, and Libby Dams in the Columbia River Basin headwaters is expected to further raise winter water flows and also to increase winter water temperatures somewhat.

In any event, ice flooding will not effect the capability to shut down the reactor in a safe and orderly manner. Also, the daily fluctuating stage of the river at the intake location will discourage formation of sheet ice as well as ice jams. Ice flows, should they occur, will normally pass over intake structure due to relatively high winter discharge in the river.

2.4.8 COOLING WATER CANALS AND RESERVOIRS

There are no cooling water canals. The two spray ponds located southeast of the reactor building designed as Seismic Category I structures, have reinforced concrete side walls, and reinforced concrete base mats at el. 420 ft msl. The finished grade at the spray ponds is approximately at el. 434 ft msl and have top of wall elevations of 435 ft msl. The spray ponds are the ultimate heat sink for normal reactor cooldown and for emergency cooling.

The spray ponds are a part of the standby service water system which is discussed in Section 9.2.7. See also Section 2.4.11.6.

During normal reactor operation, the cooling water necessary for the plant is supplied from the cooling tower basins.

2.4.9 CHANNEL DIVERSIONS

The Columbia River flow in the Hanford reach is controlled to a large extent by regulation of the upstream reservoir projects. The riverbed in the vicinity of the site is well defined and it is very unlikely that the riverbed would be diverted from its present location by natural causes. Any possible effect on water supply to the makeup water pump house from riverbed changes would come from extremely slow changes which can be corrected if and when they occur.

As discussed in Section 2.4.7, the river has not frozen over in Hanford reach during at least the past 25 years, and icing on the river has not been a problem at pump house or outfall structures associated with the plutonium production plants.

2.4.10 FLOODING PROTECTION REQUIREMENTS

The design considerations of safety-related facilities to withstand floods and flood waves are described in Section 2.4.2.2. The PMF is discussed in Section 2.4.3.

All safety-related facilities are housed in Seismic Category I structures protected from flooding and designed to withstand the static and dynamic forces of all postulated floods. Flood considerations are described in Section 3.4 and the design of Seismic Category I structures, for all conditions including flood, is described in Section 3.8.

In the event of a flood at the site, it will be possible to place the plant in a safe shutdown condition.

All non-safety-related facilities with the exception of the makeup water pump house, are above the LCF elevation. The flooding of the makeup water pump house would not affect safety-related equipment and would not affect the safe shutdown of the plant. The approximate finished grade at all Seismic Category I structures except the spray ponds is at elevation 440 ft msl. The finished grade of the spray ponds is 434 ft msl.

The PMF elevation of the Columbia River (described in Section 2.4.3), at the site, is estimated to be 390 ft msl.

Seismic Category I structures are designed to withstand the static and dynamic forces which could result from a flood due to a breach of Grand Coulee Dam. Since this represents the LCF, the structures are also considered secure against the forces due to the lower PMF.

The access openings to all seismic Category I structures are located well above all flood water elevations, including that due to wind and wave action.

2.4.11 LOW WATER CONSIDERATIONS

As described in Section 2.4.1.1, plant water needs are supplied through an intake structure in the Columbia River. The top of the makeup water intake screens (at RM 352) are set below the water surface elevation that would be associated with the minimum allowable flow (36,000 cfs) at the federally licensed Priest Rapids Dam (at RM 397). Water levels at the CGS intake are not influenced by backwater from the downstream McNary Dam (RM 292). The Columbia River Basin upstream of CGS has in excess of 35 million acre-ft of usable reservoir storage capacity. Because of this storage and highly regulated river flows, it is improbable that flows below the licensed minimum will occur. Based on data for 1961 through 1994, 7-day low flow with a recurrence interval of 100 years has been estimated at 44,500 cfs.

Even if some event (e.g., very severe drought) caused the makeup water system to be inoperable, the loss of water would not compromise the safe shutdown of the plant. As is discussed in Sections 9.2.5 and 9.2.7, shutdown cooling water is supplied by the ultimate heat sink which contains a 30-day supply of water in two spray ponds. The only scenario in which the makeup water pump house is called on to supply water in an emergency situation is when a tornado removes a significant quantity of spray pond water (see Section 9.2.5.3). Therefore, the low river water condition is not a situation requiring safety-related features and procedures.

2.4.11.1 Low Flow in Streams

Reservoir projects on the Columbia River Basin upstream of the proposed site have a total usable storage capacity in excess of 35 million acre-ft. This capacity is sufficient to maintain a flow in the Columbia River, at the proximity of CGS, of 36,000 ft^3/sec for over 1 year with absolutely no inflow from other sources. Because of this regulation, the anticipated minimum *and maximum monthly mean flow rates will be 60,000 and 260,000 ft^3/sec in the vicinity of the site. It is improbable that minimum flows below that administratively set for dam operation (36,000 ft^3/sec) will occur due to drought conditions. Columbia River storage measurements have been extrapolated down to 25,000 cfs and are shown in Figure 2.4-13. The river elevation at RM 352, site of the CGS makeup water pump house, is 341.73 ft msl and has a corresponding flow of 36,000 ft^3/sec.*

2.4.11.2 Low Water Resulting From Surges, Seiches, or Tsunami

There exists no possibility of low water conditions resulting from meteorological or geoseismic generated surges, seiches, or tsunami unless such natural phenomena effected rapid closure of the Priest Rapids Dam, which is located 45 miles upstream from the proposed site. Rapid closure of the dam would cause a negative surge to be generated downstream.

A complete stoppage of flow is an unlikely event because of the redundant equipment and operational procedure in place at the dam. Provisions to guard against an accidental shut off of Priest Rapids Dam include:

a. A gate actuation button in the control room of the Dam which is used to maintain at least minimum licensed flow from the facility in the event of one or more turbine shutdowns.

b. Independent motors on each gate which have redundant wiring and power supplies.

c. Electrical heating on four of the gates to prevent ice buildup which might interfere with gate operation.

d. Multiple offsite power sources in addition to an on-site diesel generator power backup for gate operation.

In the event of a rapid and complete stoppage of flow over Priest Rapids Dam the effect of the negative surge would pass the site in a few hours. Since the Priest Rapids Dam is a run of the river dam with low storage capacity, it is unlikely that its closure can restrict the Columbia River flow for a significant period of time before being topped.

2.4.11.3 Historical Low Water

Historical records of the U.S. Geological Survey gauging station (RM 394.5) located 2.6 miles downstream from Priest Rapids Dam show low daily averaged flows of 20,000 ft^3/sec (January 31, 1937) and low monthly averaged flows of 20,900 ft^3/sec (February 1937). An instantaneous low flow of 4120 ft^3/sec occurred February 10, 1932, due to activities connected with dam regulation of the river near Wenatchee, Washington, before construction of Priest

Rapids Dam. After completion of the Dam in 1956, the minimum flow rate of the Columbia River at RM 352, approximate location of the CGS makeup water pump house site, is 36,000 ft^3/sec. The flow is maintained by the Grant County PUD as operator of the Priest Rapids Dam (RM 397) under FPC license which states:

> *"The licenses shall so regulate the flow from the Project 2114 that it will not result in flows of less than 36,000 cfs of water at the Hanford Works of the Atomic Energy Commission except when conditions are beyond the licensee's control."*

In eighteen years of operation the flow has not dropped below the specified minimum.

The annual average flow of the Columbia River below Priest Rapids Dam is in the range of 115,000 cfs. The effect of use of upstream water for irrigation development on the stream flow has been taken into account and the modified mean monthly discharge variations for the period 1928-58 are shown in Table 2.4-4 and Figure 2.4-14. The discharge for the base period of 1929-58 was adjusted to reflect 1970 levels of water utilization, including water consumption due to activities of flood control, power generation and irrigation. Figure 2.4-15 shows the exceedance frequency for annual low flows for the period 1929 through 1958 with 1970 conditions measured at the gauging station (RM 394.5) immediately below Priest Rapids Dam. Because of the flow regulation on the Columbia River, the anticipated minimum and maximum monthly mean flow rates will approximate 60,000 and 260,000 cfs in the vicinity of the CGS site. The variations of the river flow in this reach are due not only to seasonal fluctuations, but also to the daily regulation of the power producing Priest Rapids Dam. Flow rates during the late summer, fall and winter may vary from a low of 36,000 cfs to 160,000 cfs each day.

The dependable yield for flows in the Columbia River below Priest Rapids Dam for periods of one year through 10 years, as well as the 30-year period 1929-58 is illustrated in Table 2.4-5. The flow duration curve resulting from a plot of Table 2.4-4 is shown by Figure 2.4-14 (Reference 2.4-20). This figure illustrates the percentage of time equaled or exceeded for different amounts of flows below Priest Rapids Dam on a monthly and on an annual basis.

2.4.11.4 Future Controls

Flows in the Columbia River at Hanford are required to be maintained above 36,000 ft^3/sec. This is the licensed minimum flow of Priest Rapids Dam and, as such, is a parameter closely monitored and controlled by the Grant County PUD. The State of Washington has administratively set higher average daily minimum flows (greater than 40,000 ft^3/sec) and will attempt to have the FERC licenses for the dams modified to insure the minimums (Reference 2.4-21).

2.4.11.5 Plant Requirements

All cooling water is supplied to the plant cooling towers via the circulating water system, the plant service water system, or the standby service water system described in Sections 9.2.1.2 and 10.4.5. In the event of an incident rendering the cooling towers inoperative, cooling water is supplied from the spray ponds by the standby service water system, described in Section 9.2.7. These are closed loop systems and the only water loss is through evaporative cooling.

Makeup to the plant cooling towers and spray ponds comes from the Columbia River. Should this capability be lost, the cooling load is taken over by the spray ponds. These ponds have sufficient capacity to provide shutdown cooling water for 30 days without makeup. Other sources of water are available to provide makeup after the initial 30-day period (see Section 9.2.5). Therefore, variation in river flow will not have any adverse affect on the capability to shut down the reactor in a safe and orderly manner.

2.4.11.6 Heat Sink Dependability Requirements

At the minimum river flow of 36,000 ft^3/sec described in Section 2.4.11.3, there is still sufficient submergence at the makeup water pumps to provide full makeup water requirements at full power operation. Sump level indication and low level alarms are provided in the main control room. Should the sump water elevation fall below the minimum submergence level for the makeup pumps, due either to low river flow or blocked inlets, the plant would be shut down if the situation could not be readily corrected with the safety-related standby service water coming from the spray ponds.

Section 9.2.5 discusses the design bases used in designing the two spray ponds which serve as the ultimate heat sink for CGS. Design of the CGS ultimate heat sink is in compliance with the guidelines presented in Regulatory Guide 1.27 Rev. 1, "Ultimate Heat Sink for Nuclear Power Plants," dated March 1974. The CGS spray ponds serve as the suction source and discharge point for the standby service water system. This system is discussed in Section 9.2.7 and identifies the uses and quantities of water drawn from the ultimate heat sink.

2.4.12 DISPERSION, DILUTION, AND TRAVEL TIMES OF ACCIDENTAL RELEASES OF LIQUID EFFLUENTS IN SURFACE WATERS

Small amounts of liquid radioactive wastes, processed within the plant and containing traces of radioactive nuclides, are discharged ultimately to the Columbia River via the plant blowdown line as discussed in Section 11.2.2.2.6 (see Figure 2.4-16). *In the vicinity of CGS, the Columbia River is wide, relatively shallow, and fast flowing. Field measurements have shown river velocities near the CGS discharge to be about 3 ft/sec for minimum flows (Reference 2.4-22) and 4.5 ft/sec for average flows (Reference 2.4-23). At the point of discharge the river is about 5 ft deep at minimum flow. Based on a dye dispersion study (Reference 2.4-22), the local eddy diffusivity at low flow has been conservatively estimated to* *be 4 ft^2/sec (Reference 2.4-24). With a combination of minimum river flow and maximum blowdown, it is estimated that an effluent would be diluted by a factor of about 60 at a distance of 300 ft and a factor of 200 at 3000 ft.* Dilution factors and travel times for calculating doses to downstream water users are discussed in the CGS Offsite Dose Calculation Manual (ODCM).

Downstream surface water users are listed in Section 2.4.1.2. The travel time to the nearest withdrawal which could be affected by an accidental release is approximately 1 hr. At that point a radioactive release would be essentially completely mixed with the river resulting in a dilution factor of 1:200,000. It is concluded that water users are sufficiently removed from the release point, and the Columbia River is sufficiently dispersive to preclude adverse impacts due to accidental releases. The dispersion characteristics of the river and the effects of routine releases are discussed in Sections 5.1 and 5.2 of the Environmental Report - Operating License Stage.

2.4.13 GROUNDWATER

2.4.13.1 Description and Onsite Use

Subsurface soil conditions, across the site, have been classified as follows:

a. *Loose to medium dense, fine to coarse sand with scattered gravel (glaciofluvial sediments).*

b. *Very dense, sandy gravel with interbedded sandy and silty layers (Ringold Formation, Middle Member).*

c. *Very dense, interbedded layers of sandy gravel silt and soft sandstone (Ringold Formation, Lower Member).*

d. *Basalt bedrock which forms the bedrock beneath the area.*

The lithologic character and water bearing properties of the geologic units occurring in the Hanford region are summarized in Table 2.4-6. In general, groundwater in the surficial sediments occurs unconfined, although locally confined zones exist. Water in the basalt bedrock occurs mainly under confined conditions. Occasionally, the lower zone of the Ringold Formation occurs as a confined aquifer, separated from the overlying unconfined aquifer by thick clay beds which possess a distinct hydraulic potential.

The unconfined aquifer consists of both glaciofluvial sand and gravel deposits and the Ringold silts, clays, and gravels. Since these materials are very heterogeneous, often greater lithologic differences occur within a given bed than between beds. In the vicinity of CGS the water table is below the top of the Ringold Formation (see Figures 2.5-64 and 2.5-65). The unconfined *aquifer bottom is the basalt bedrock in some areas and silt/clay zones of the Ringold Formation in other areas. Clearly the bottom of the unconfined aquifer is not a continuous lithologic surface.*

The Hanford Reservation contains over 2200 wells constructed from pre-Hanford work days to the present). Approximately 600 of these wells are used for groundwater monitoring (Reference 2.4-25). Figure 2.4-17 identifies the well locations in the Hanford Reservation as of September 1975. Figure 2.4-18 shows the December 1975 groundwater contour map. In general, the groundwater gradient resulting from groundwater flowing under the Reservation is the highest in the southwestern area toward Rattlesnake Mountain, and slopes toward the Hanford 200 Areas near the center of the reservation. From the 200 Areas the general slope in the gradient is toward northeast and southeast.

A groundwater contour map based on the potential construction of the Ben Franklin Dam at approximately RM 348 is illustrated by Figure 2.4-19. The CGS design basis groundwater level is based on the possible construction of the Ben Franklin Dam and is taken to be 420 ft msl, whereas the most recent study indicates that the water table would be about 405 ft msl (Reference 2.4-26). The feasibility of constructing Ben Franklin Hydroelectric Dam has been extensively studied. Its proposal was strongly contested by local groups and individuals concerned with environmental protection and preservation. Additionally, the matter of the impact such a facility would have on the DOE Hanford Reservation was believed by some to preclude its construction. Finally, the cost/benefit ratio was believed by many to be too low to make the project viable. The combination of the unresolved impediments to the project has effectively, though not conclusively, relegated it to a very low priority status. Planning studies for the project by the Corps of Engineers were suspended in 1969 and reinitiated in October 1979 as part of the development of a management plan for the Hanford reach. The most recent studies were terminated in November 1981.

Impermeable groundwater boundaries are the Rattlesnake Hills, Yakima Ridge, and Umtanum Ridge on the west and southwest sides of the Hanford Reservation. Gable Mountain and Gable Butte also impede the groundwater flow, as well as other small areas of basalt outcrop above the water table. The Yakima River recharges the unconfined aquifer along its reach from horn Rapids to Richland. The Columbia River forms a hydraulic potential boundary which is a discharge boundary for the aquifer. The major source of natural recharge is precipitation on Rattlesnake Hills, Yakima Ridge, and Umtanum Ridge.

Minor changes would be expected in the groundwater elevations during the summer months because of the charging stage of the Columbia River, which historically reaches peak flood stage in June. Because CGS is located about three miles from the river and because of the permeability characteristics and enormous volume of the Ringold Formation, there is a substantial time lag in changing water levels. For the same reasons, the range in water table fluctuations is very small.

Natural recharge due to precipitation over the lowlands of the Hanford Reservation is not measurable as the evaporation potential during the summer months greatly exceeds total precipitation. Data on migration of moisture from natural precipitation in deep soils (below 30 ft) show movement rates less than 1/2-in./yr at one measurement site (References 2.4-27, 2.4-28 and 2.4-29). The major artificial recharge of ground water to the unconfined aquifer occurs near the Hanford 200 East and 200 West Areas. The large volume of process water (1.35 x 1011 gal) discharged to ground during 1944-1973 has caused the formation of significant groundwater mounds in the water table (Figures 2.4-20 and 2.4-26). Other local groundwater mounds formerly existed along the Columbia River. The present Hanford 100-N Area mound is the only one of these remaining. A minor recharge mound also exists at the Hanford 300 Area.

The unconfined aquifer is characterized by its hydraulic conductivity, the storage coefficient, and the effective porosity. The hydraulic conductivity relates the water flow quantity to the hydraulic potential gradient, while the effective porosity gives the fraction of porous media volume that is available to transmit ground water flow. The storage coefficient relates a change in the water table elevation to a change in the volume of water contained in the aquifer per unit horizontal area. In the limit of no delayed yield, the storage coefficient is equal to the effective porosity of the soil through which the water table moves. These parameters vary widely over the Hanford Reservation.

Qualitatively the hydraulic conductivity, storage coefficient, and effective porosity distributions are a function of the different geologic formations in the unconfined aquifer. Ancestral Columbia River channels which incised in the Ringold Formation are now filled with more permeable glaciofluvial sediments. These channels have been identified extending eastward along the northern and southern flanks of Gable Mountain and extending southeastward from the 200 East Area to the Columbia River (see Figure 2.4-21). These permeable channels are reflected in the groundwater flow pattern of the region.

Quantitative measurements of the hydraulic conductivity of the unconfined aquifer have been made on the Hanford Reservation using a variety of techniques: pumping tests, specific capacity tests, and tracer tests. The most common method has been the pumping tests. Values obtained for the Ringold Formation range between 10 to 650 ft/day with a median of about 130 ft/day. In sharp contrast are the very large hydraulic conductivities of glaciofluvial sediments, ranging from 1,200 to 12,000 ft/day (Reference 2.4-30).

The storage coefficient is much more difficult to measure in the field and estimates are, therefore, less common. For the unconfined aquifer, estimates of the storage coefficient have ranged from 0.01 to 0.1 (Reference 2.4-30). An areal estimate of 0.11 has been provided for the 200 West Area based on the growth of groundwater mounds (References 2.4-30 and 2.4-31). The median specific yield (effective porosity) has been estimated by various researchers at Hanford to range from 4.8% to 11%; most commonly it is assumed to be 10% (Reference 2.4-32).

The unconfined groundwater aquifer is characterized by the contour map of the hydraulic potential or water table. The map for December 1975 appears in Figure 2.4-18. The depth to the water table varies greatly from place to place, depending chiefly on local topography which ranges from less than 1 to more than 300 ft below the land surface. Beneath most of the Hanford 200 Area disposal sites the depth of the water table averages about 250 ft. The current estimate of the maximum saturated thickness of the unconfined aquifer is approximately 230 ft.

The chemical quality of the groundwater in the unconfined aquifer is measured at seven locations. Sodium, calcium, and sulfate ions are measured as well as pH. Chromium and fluoride ions associated with fuel manufacturing operations are analyzed from Hanford 300 Area wells. Nitrate ion, which is a waste product from the manufacturing and chemical separation operations, is monitored over the entire Hanford Reservation. Annual maps of the nitrate ion concentration near the surface of the unconfined aquifer are published (Reference 2.4-33). The map showing nitrate concentration for December 1975 appears in Figure 2.4-22.

The radiological status of the groundwater near the surface of the unconfined aquifer is monitored regularly (Reference 2.4-34) and reported annually. Plots of gross beta (ruthenium) plumes and the tritium plumes are shown in Figures 2.4-23 and 2.4-24 for December 1975 (Reference 2.4-33). Since the nitrate ion is not adsorbed in the soil it can be used as a tracer for groundwater movement. The extent of movement of waste water containing radionuclides can thus be plotted. Respective tritium and nitrate ion concentrations under the CGS site are currently ranging from 30 to 300 pci/ml and 4.5 to 45 mg/l depending on the sampling location. Concentration guide for drinking water is 3,000 pci/ml for tritium and the recommended drinking water standard is 10 mg/l for nitrate ions. Gross beta concentrations do not extend to the site.

From the research that has been done to date, it appears that there are a number of confined aquifers underlying the Hanford Reservation. Relatively impermeable confining beds commonly include the individual basalt flows and the silts and clays of the lower part of the Ringold Formation.

Within the basalt sequence, groundwater is transmitted primarily in the interflow zones, either in sedimentary beds or in the scoria and breccia zones forming the tops and bottoms of the flows (References 2.4-35 and 2.4-36). Basalt flows in the Pasco Basin have been eroded particularly in the anticlinal ridges. In some locations the basalts are highly jointed and contain breccia, pillow and plagonite complexes through which groundwater can move. Consequently, hydraulic potential differences between water bearing zones in the upper part of the basalt sequence are small over hundreds of feet of depth. The lowermost Ringold Formation silts and clays are of variable thickness. Distinct hydraulic potential differences have been observed between aquifers below the silts and clays and the unconfined aquifer.

Groundwater flow in the uppermost confined aquifer is also to the southeast with possible discharge into the Columbia River somewhere below Lake Wallula. However, the flow rates are regarded as quite small due to the low transmissivity range of this water bearing zone. Groundwater in the lower confined aquifers does not appear to cross the major anticlinal divides that define the Pasco Basin.

The piezometric or hydraulic potential map for the confined zones above the basalt (Figure 2.4-25) was based on measurements made in 1970. In general, the hydraulic potential observed in the confined aquifer zones above the basalt is greater than in the overlying unconfined aquifer. The main exception is in the vicinity of the Hanford 200 Area recharge mounds which have raised the potential in the unconfined aquifer.

One recharge area that has been identified is from the Yakima River at Horn Rapids. The piezometric map in Figure 2.4-25 also suggests recharge from the upper Cold Creek Valley with flow toward a potential trough under the Columbia River. The Columbia Basin Irrigation Project to the northeast and east, and the Columbia River behind Priest Rapids and Wanapum Dams to the northwest are other probable recharge sites in both these areas the basalt is exposed and is covered by perennially saturated unconsolidated deposits. A site of possible minor recharge exists adjacent to Gable Butte and Gable Mountain anticline near the center of the Reservation.

Only 90 wells on the Hanford Reservation have been drilled to basalt. Thus data on the confined aquifers in the basalt flows are limited and more would have to be gathered to fully characterize the confined aquifers.

The plant is located on glaciofluvial outwash sands and gravels which are about 50 ft thick. Below this layer occurs very dense gravel. Sandy gravel occurs in a sequence approximately 200 ft thick which is assumed to be the middle member of the Ringold Formation. The lower member of the Ringold Formation consists of a very compact, interbedded gravel, sand, silt, and clay and extends down to a depth of about 500-525 ft. Basaltic bedrock underlies the lower Ringold member, at approximately 550 ft depth.

The water table is about 60 ft below the ground surface level at CGS. The water table elevation is about 378 ±4 ft msl and appears to be stable. The effective bottom of the unconfined aquifer is assumed to be at about 220-260 ft msl at the top of the lower Ringold Formation. Groundwater potentials from the lower Ringold and from the basalt water bearing zones are about 25 ft higher than that of the unconfined aquifer. Test borings down to 925 ft reveal there are water bearing zones in the lower basalt flows and sedimentary interbeds at CGS. Piezometric level in basalt is 10 ft above unconfined water table and hence artesian.

Under the CGS site the unconfined groundwater is moving easterly toward the Columbia River, the nearest discharge boundary. Studies of the uppermost confined aquifer indicate that the *potential gradients at the proposed site are oriented in the same general direct ion as those of the unconfined aquifer.*

Three water supply wells are located on the site. Two shallow wells were constructed in the unconfined aquifer (at approximately 240 ft deep) and a third well penetrates a confined aquifer in the underlying basalt flows (at approximately 695 ft deep). Normal water supply is from the river, and the deep well is maintained in the standby mode to provide supplemental makeup water for the potable and demineralized water system as needed. Pumping capability is about 250 gpm. The two shallow wells were used during construction.

2.4.13.2 Sources

Regional use of the unconfined aquifer occurs at two nearby locations. The first is at the DOE's 400 Area located about 3 miles southwest of the CGS site as shown in Figure 2.1-3. *Groundwater to this construction site is supplied from two wells and is used for sanitary and operation purposes. Maximum expected usage rate is between 2 million and 2.5 million gal/month. No data is available on drawdown tests performed on the FFTF water supply wells 699-SO-7 and SO-8.* The second location of ground water use is the WNP-1/4 site about 1 mile east of CGS. Water is drawn from two wells for sanitary and potable water requirements. *Usage rate is approximately 250,000 gal/month.*

The two onsite wells which drew from the unconfined aquifer (699-13-1A and 1B) are 234 and 244 ft deep. Drawdown tests for each well showed 22 and 91 ft of drawdown respectively, at pumping rates of 250 gpm and test durations of about 25 hr. These wells are no longer used. The third well (695 ft deep) is sealed from the unconfined aquifer and draws from confined water in the basalt. Drawdown on this well was 163 ft at a pumping rate of 275 gpm with a test duration of 25 hr.

Water table contours in the vicinity of CGS can be seen in Figure 2.4-26. The aquifer is assumed to be isotropic, therefore, flow occurs along instantaneous streamlines perpendicular to the equipotential contours. The groundwater flow is toward the discharge boundary at the Columbia River to the east of the site. The hydraulic potential gradient in this area is about 8-10 ft/mile in the unconfined aquifer. As described in Section 2.4.13.1, recharge and discharge of riverbank storage occur along the Columbia River with daily fluctuations superimposed on the seasonal variations in river stage. Hydrographs of wells in the vicinity of the plant site (Figure 2.4-27) show that riverbank storage is not detectable even in years of extreme spring runoff at the two wells that are about one mile from the riverbank. Thus no seasonal reversability of the gradients driving the groundwater flow occurs. In other areas of the Hanford Reservation, the seasonal fluctuations of groundwater levels from riverbank recharge can be detected 3-4 miles inland from the riverbank.

During early studies of groundwater in the area (References 2.4-37 and 2.4-31) little information was obtained on specific features at the plant site. The water table for 1944 *(pre-Hanford Work conditions) was interpolated using 1948-1952 observation well data (Figure 2.4-20) and showed a water table elevation of about 370 ft msl under the site. The potential gradient was interpolated (References 2.4-31 and 2.4-38) to be about 5-6 ft per mile toward the Columbia River.*

The earliest wells in the vicinity (699-2-3 and 17-5) were drilled in 1950. Their hydrographs, presented in Figure 2.4-27, show the gradual rise of the water table to approximately 15 ft above pre-Hanford Operations elevations. The peak rise in 1972 for well 699-2-3 shown on Figure 2.4-27 is believed to be a measurement error. Other wells were drilled in 1958, 1961, 1962 and 1966. Their hydrographs appear in Figure 2.4-27. Wells 669-14-E6-T and -20-E5T also show the gradual rise of the water table at their respective locations. Smaller apparent water table changes at the site between 1944- 1974 (see 2.4.13.1 and Figure 2.4-27, well 699-14-E6-T and 699-20-E5-T) indicated a zone of relatively lower hydraulic conductivity in this area.

Well 699-9-E2 is a deep well perforated in both the unconfined and lower confined aquifer zones. Its historical hydrograph (Figure 2.4-27) reflects a composite of confined and unconfined potentials with discontinuities caused by sanding in an subsequent maintenance operations. The 1962 peak of the hydrograph of well 699-20-E12 (Figure 2.4-27) is due to the influence of the high confined aquifer potential before the installation of piezometer tubes in this deep well. The 1972 peak, could be bank recharge from the high river stage of that year but the lack of previous response to river stage makes the measurement suspicious. Well 699-10-E12, also located within one mile of the river, does not show seasonal bank recharge (Figure 2.4-27). Over the past two years, a decrease in the rate of rise is evident.

Soil test borings and water supply wells drilled in conjunction with the CGS construction site, confirmed the present contouring interpretation of the water table. Recent data from boring at WNP-1 and WNP-4 are not reflected in the water table maps shown in Figures 2.4-18, 2.4-19, 2.4-26, and 2.4-25.

The historical well hydrographs for the uppermost confined aquifer in the vicinity of the plant site are given in Figure 2.4-27. Well number 699-20-E12-P shows a rather rapid rise of the confined aquifer potential in 1962-65. It has been postulated that this rise reflects recharge to the confined zones from irrigation across the river in the Columbia Basin Irrigation Project. The hydraulic potential in the uppermost confined aquifer near the plant site is presently about 390 ft msl, which is about 25 ft higher than the potential of the overlying unconfined aquifer.

The effects of the groundwater withdrawal at the site have been estimated to be local. No drawdown has been detected in the nearest observation wells, numbers 699-17-5 and 699-9-E2. The latter well is perforated over multiple aquifers so it does not give a representative measurement of the water table elevation. The radius of influence (defined to be the radius at which a 0.1 ft drawdown exists) of the CGS wells has been estimated to be about 3500-4500 ft. This is based on the ten months of high rate of withdrawal during compaction *operations taking into account the ambient water table gradient. The subsequent reduction in withdrawal flow rate to 25% of the early value would shrink the radius of influence considerably.*

There is no groundwater recharge area within the influence of the plant. The 60-ft depth from the land surface to the water table and the arid condition of sediments above the water table make it virtually impossible to detect any recharge from precipitation over this area.

2.4.13.3 Accidental Effects

An evaluation of a possible radioactive liquid release is postulated due to the rupture of a 700-gal decontamination solution concentrator waste tank within the radwaste building (see Figure 11.2-1). The released effluent was then assumed to reach the soil environment outside the building and to percolate to the water table unimpeded. On entering the groundwater, the postulated radwaste release is dispersed, sorbed, decayed, and diluted along the potential groundwater pathway from the plant towards the Columbia River.

In the unconfined (water table) aquifer, there are no down gradient groundwater users between CGS and the Columbia River. However, the construction water needs at WNP-1/4 are supplied by the two deep wells that withdraw groundwater from the uppermost confined aquifer downgradient from the CGS radwaste building. During operation of WNP-1/4, these wells will be maintained in a standby mode. The uppermost screens in these wells are about 240 ft below the ground surface in the lower Ringold Formation. The effective bottom of the unconfined aquifer is generally assumed to be at the top of the lower Ringold Formation or about 200 ft below the surface. Thus, in all likelihood, any liquid radioactive spill to the groundwater beneath the CGS radwaste building would travel through the unconfined aquifer towards the Columbia River. However, for conservatism, analyses of postulated radionuclide movement assume that the WNP-1/4 wells draw from the unconfined aquifer. The remainder of this subsection provides estimates of travel times of critical radionuclides to move from the postulated spill to receptors and the corresponding concentration reduction factors.

For an assumed one-dimensional groundwater movement, the groundwater travel time, t, is the path length, L, divided by the groundwater velocity (seepage velocity), u. The groundwater velocity is the Darcy (apparent) velocity divided by the effective porosity, $u = Ki/n_e$*, where K is the lateral permeability (hydraulic conductivity) of the aquifer, i is the hydraulic gradient, and ne is the effective porosity of the aquifer material.*

For computational purposes, a conservative value for lateral permeability of 500 ft/day was selected to represent the unconfined aquifer located in the Ringold Formation beneath CGS (see Figure 2.4-21). From 2.4.13.1, effective porosity is taken 0.10. From Figure 2.4-26, the gradient in the water table aquifer between the plant and the Columbia River is about 8 or 9 ft/mile, and is taken conservatively as 10 ft/mile.

Using the above parameter values, groundwater velocities were computed to be 10 ft/day. With path lengths of 3.4 miles to the river and 1.0 mile to the WNP-1/4 wells, the respective travel times are estimated to be 5.2 years and 1.5 years.

Generally, the critical radionuclides of concern for a postulated liquid radwaste spill are ^{3}H, ^{90}Sr, *and* ^{137}Cs. *These three radionuclides are fairly representative in terms of sorption characteristics, of those found in liquid radwaste tanks, since tritium does not sorb onto soil particles at all, strontium is an intermediate sorber, and cesium strongly sorbs to soil particles. The half-life of tritium is 12.3 years, whereas those of* $^{90}S_r$ *and* $^{137}C_s$ *are 29.0 and 30.1 years, respectively.*

The travel time, t_i, *for a particular radionuclide moving through groundwater depends upon the velocity,* u_i, *of the radionuclide*

$$t_i = l/u_i$$

where the radionuclide velocity is

$$u_i = r_f u$$

in which r_f *is the velocity reduction factor attributable to sorption*

$$r_f = 1/1 + \frac{\rho b}{n} k_d$$

In this equation, ρb *is the bulk density of the aquifer material, n is the total porosity, and* K_d *is the equilibrium distribution coefficient for a particular radionuclide. The bulk density and total porosity are further related physically as*

$$b = R_s (1 - n)$$

where R_s *is the real specific gravity or particle density of the solid particles in the aquifer media.*

The particle density, R_s, *for Hanford soils is usually taken to be constant at 2.65 gm/cm*^{3}, *(Reference 2.4-39). The bulk density* ρb, *of Hanford soils has been determined to range from about 1.5 gm/cm*^{3} *to about 1.75 gm/cm*^{3}, *with a median value of about 1.65 gm/cm*^{3}, *(Reference 2.4-40). For the median value of bulk density, the corresponding total porosity is about 0.377.*

Using the above value for bulk density and total porosity, radionuclide travel time, ti, through the groundwater beneath WNP-1/4 can be expressed as

$$t_i = (1 + 4.4\,K_d)\,t$$

The following summarizes radionuclide travel times (in years) to the WNP-1/4 wells (1.0 miles) and to the Columbia River (3.4 miles):

Nuclide	*Half-life, years*	K_d	t_i *@ 1.0 miles*	t_i *@ 3.4 miles*
^{3}H	*12.3*	*0*	*1.5*	*5.2*
^{90}Sr	*29.0*	*10*	*67.0*	*230.0*
^{137}Cs	*30.1*	*100*	*660.0*	*2300.0*

The radionuclide concentration at the point of water use will be determined by the amount of decay, dispersion, and sorption on the aquifer media. The minimum concentration reduction factor, CRF_{min}*, along the centerline of the contaminant plume from an instantaneous point source is given by (Reference 2.4-41)*

$$CRF_{min} = \frac{C_o}{C} = \frac{(4\pi t)^{3/2}\ (K_x K_y K_z)^{1/2}}{2V}$$

for an effluent volume, V, with a specific gravity of 1.0 and an initial concentration, C_o*, released to soil with dispersion coefficients,* K_x*,* K_y*,* K_z*, in the x, y, and z directions, respectively. This expression neglects the phenomena of sorption and decay which will be considered later.*

It is generally accepted that the dispersion coefficients are proportional to groundwater velocity for unidirectional flow, i.e.,

$$K_{x,y,z} = \alpha_{x,y,z} u$$

where $\propto_{x,y,z}$*, are constants called dispersivities which are a function of the nonhomogeneity of the material. The range in dispersivities in homogeneous granular aquifers may approach 1000 cm (33 ft) (Reference 2.4-42). Substituting this relationship into the above expression for concentration reduction, and noting that travel time is determined by path length and velocity, results in*

$$CRF_{min} = \frac{(4\pi L)^{3/2}\ (\propto_x \propto_y \propto_z)^{1/2}}{2V}$$

For the conservative condition of $\alpha_x = \alpha_y = \alpha_z = 1.0$*, then*

$$CRF_{min} = \frac{(4\pi L)^{3/2}}{2V}$$

The concentration reduction factors at the WNP-1/4 wells and at the bank of the Columbia River, due only to dispersion, are 9.1 x 10^4 and 5.7 x 10^5, respectively, for the 700-gal concentrated waste tank. When sorption and decay are included, the concentration reduction is given by (Reference 2.4-42)

$$CRF = \frac{(4\pi L)3 / 2 \, (\propto_x \propto_y \propto_z)^{1/2}}{2V} e^{\lambda t_i}$$

in which λ is the radionuclide decay constant defined in terms of the half-life, T1/2, of a particular radionuclide as

$$\lambda = \frac{1n\ 2}{T_{1/2}}$$

The concentration reduction factor can be expressed as

$$CRF = CRF_{min} \, (e \, \lambda \, t_i)$$

The exponential term accounts for the effects of sorption and decay. The only effect of sorption on concentration reduction is to increase the travel time, thus allowing more time for decay. Concentration reduction factors (CRF) for the radionuclides listed were calculated for path lengths of 1.0 mile (to WNP-1/4 wells) and 3.4 miles (to Columbia River):

Nuclide	CRF (1.0 mile)	CRF (3.4 mile)
^{3}H	1.0 x 10^5	7.7 x 10^5
^{90}Sr	4.5 x 10^5	1.8 x 10^8
^{137}Cs	3.7 x 10^{11}	5.8 x 19^{28}

The above factors, derived through the application of conservative parameters, are used in Section 15.7.3 to evaluate concentrations offsite. *The consideration of the WNP-1/4 wells is especially conservative. Groundwater contamination from the 200 Areas which reached CGS over six years ago (see Section 2.4.13.1) has not been detected at WNP-1/4. This substantiates that the WNP-1/4 wells do not draw from the unconfined aquifer or, alternatively, the hydraulic conductivities are much less than assumed.*

It should also be noted that if Ben Franklin Dam were ever constructed, the concentration reduction factors at the river bank would be even larger than those noted above. This would be true, because the groundwater gradient (thus, the groundwater velocity) would be decreased as shown in Figure 2.4-19.

2.4.13.4 Monitoring or Safeguard Requirements

Plant water systems result in releases to the ground at a number of locations. Sanitary wastewater is routed to a central treatment system comprised of lined aeration lagoons and stabilization ponds. This treatment plant also receives wastes from the Plant Support Facility, WNP-1 and WNP-4, and the DOE's 400 Area.

Periodically the treated effluent is discharged to percolation beds. As discussed in Section 2.4.2.3, the storm water drainage system discharges to an unlined depression northeast of the plant (see additional description in Section 9.3.3.2.3.1). Such sources as water treatment filter backwashes, heating, ventilating, and air conditioning (HVAC) air wash units, and some building sumps and floor drains (see Section 9.3.3.2.3) also contribute to flow in the storm water system. Periodic testing and flushing of the fire protection system and cleaning of the cooling towers and standby service water ponds result in localized discharges of water to the ground.

Monitoring of groundwater and plant-related discharges to ground is performed as described in the ODCM.

2.4.13.5 Design Bases for Subsurface Hydrostatic Loadings

CGS does not employ permanent dewatering systems. Site groundwater conditions are presented in Section 2.5.4.6 and the design bases for subsurface hydrostatic loadings are given in Section 3.4.

The design-basis groundwater elevation used for subsurface hydrostatic loadings is 420 ft msl and was predicated on the possible future construction of Ben Franklin Dam at RM 348. As noted in Section 2.4.13.1, planning for the dam has been terminated. The same section notes that the water table beneath CGS would rise to less than 405 ft msl if the dam were to be completed. The actual water table beneath the project is about 385 ft msl (see Sections 2.4.13.1 and 2.5.4.6). The design-basis groundwater level is adequate to account for seepage from the ultimate heat sink spray ponds or the rupture of any Seismic Category I or nonseismic pipe. As discussed in Section 3.8.4.1.5, the two, 250-ft^2 reinforced-concrete spray ponds are designed to Seismic Category I requirements and are designed to mitigate any possible water leakage. The bottom of the spray ponds are at 417 ft msl and the ponds are designed for external hydrostatic loading to 420 ft msl. The maximum combined leakage from the two ponds during the initial filling sequences was 120 gpm. It may be inferred from previous studies (Reference 2.4-7) that continued leakage cannot affect the groundwater level beneath the ponds or other safety-related structures, the closest of which (500+ ft away) is the diesel generator building with a foundation at 434 ft msl. These early CGS hydrologic studies evaluated the effect of cooling pond leakage and cooling tower blowdown at the project site. Equivalent leakage/discharge rates used in these studies were very much greater than leakage from the spray ponds. For example, the continuous discharge of 2700 gpm of cooling tower blowdown to the depression just east of CGS was estimated to raise the water table about 20 ft beneath the point of discharge (Reference 2.4-7). Based on these previous studies, it can be concluded that the minimal amount of spray pond leakage will have no influence on the design-basis groundwater elevation of 420 ft msl.

With respect to a pipe break, the 144-in. circulating water system pipe on the discharge side of the condenser would produce the maximum release of water. The maximum quantity of water released from such a rupture is 199,180 ft^3. This discharge would have a negligible (less than 1 in.) and temporary effect on the groundwater level. Failure of the pipe at its closest proximity to a safety-related building may result in temporary saturation of the backfill. This material has been recompacted to a minimum relative density of 75% and an average relative density of 85%. As discussed in Section 2.5.4.8, these densities are not susceptible to liquefaction for motions associated with the safe shutdown earthquake, and as discussed in Section 2.5.4.10, temporary saturation would not significantly reduce the bearing capacity of the densely compacted backfill. A continuous but undetected leak from any major pipe would not influence the groundwater level enough to affect plant structures. This may be deduced from the time factors and water table rises predicted from a number of scenarios in the above mentioned hydrologic studies (Reference 2.4-7).

2.4.14 TECHNICAL SPECIFICATIONS AND EMERGENCY OPERATION REQUIREMENTS

The worst hydrological condition, as discussed in this section, is a flood caused by a postulated PMP event. This flood does not create an adverse hydrological condition on safety-related equipment. Emergency flood protection procedures are therefore unnecessary.

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Table 2.4-1

Major Columbia River Basin Dams

Location	Dams	River	River Miles from Site	Usable Storage 10^3 ac-ft
Upstream	Mica	Columbia (Can)	666	12,000
	Duncan	Duncan		1,400
	Arrow	Columbia (Can)	429	7,090
	Libby	Kootenai	642	5,000
	Hungry Horse	South Fork Flathead		3,160
	Kerr	Clark Fork		1,219
	Albeni Falls	Pend Oreille	483	1,153
	Grand Coulee	Columbia	245	5,200
	Chief Joseph	Columbia	193	--
	Wells	Columbia	164	117
	Chelan	Chelan	152	677
	Rocky Reach	Columbia	122	120
	Rock Island	Columbia	101	--
	Wanapum	Columbia	64	389[a]
	Priest Rapids	Columbia	45	170[a]
Downstream	McNary	Columbia	60	
	John Day	Columbia	136	
	The Dalles	Columbia	160	
	Bonneville	Columbia	206	

[a] Storage not available for flood regulation.

Table 2.4-2

Columbia River Temperatures Near Columbia Generating Station

MONTHLY AVERAGE WATER TEMPERATURE,
IN °C, AT RICHLAND, WA

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1965	6.1	5.4	6.3	9.1	11.0	14.2	17.3	19.8	18.5	16.4	12.6	8.4	12.1
1966	6.9	6.2	6.8	10.3	12.1	13.5	16.2	18.8	19.4	15.6	12.6	9.5	12.2
1967	7.4	7.0	6.6	8.8	12.0	13.9	17.0	20.2	19.4	16.1	12.0	7.8	12.4
1968	5.7	5.0	6.0	8.8	12.8	14.3	17.0	18.7	18.3	15.0	11.4	7.4	11.7
1969	2.7	1.9	4.3	8.0	11.4	15.3	17.9	19.3	18.6	15.2	11.7	7.0	11.1
1970	5.3	4.9	5.7	7.9	11.7	15.4	19.0	19.9	17.5	14.9	10.6	5.9	11.6
1971	4.2	3.4	3.8	7.0	11.1	12.9	16.4	19.5	17.8	15.0	10.7	6.2	10.7
1972	3.3	2.2	3.7	7.0	11.0	13.3	15.5	18.1	16.9	14.0	10.5	6.1	10.1
1973	3.2	3.0	4.7	7.8	12.9	15.6	18.3	19.6	18.3	15.0	9.9	7.6	11.3
1974	3.2	3.2	5.2	8.2	11.3	13.7	17.4	19.4	18.8	15.4	11.5	7.9	11.3
Average 1965-1974	4.7	4.2	5.3	8.3	11.7	14.2	17.2	19.3	18.4	15.3	11.4	7.4	11.4
Minimum Daily	0.2	0.7	2.4	5.1	8.6	11.2	14.2	17.3	14.6	11.1	7.7	2.4	--
Maximum Daily	8.3	8.3	8.6	12.8	15.0	17.7	20.4	21.5	21.1	18.5	15.9	11.3	--

Records since June 1964.

MONTHLY AVERAGE WATER TEMPERATURE,
IN °C, AT PRIEST RAPIDS DAM, WA

1961	5.4	4.7	4.7	7.4	10.4	13.7	17.3	18.9	17.8	14.9	10.4	6.6	11.0
1962	4.1	3.6	3.6	6.5	10.0	13.7	16.1	17.4	17.1	14.8	11.9	8.9	10.6
1963	5.3	3.8	4.6	6.5	10.4	14.0	16.6	18.4	18.3	16.3	11.9	7.7	11.2
1964	5.5	4.6	4.7	7.2	9.7	12.8	15.3	17.1	16.3	14.6	10.8	6.3	10.4
1965	4.4	3.3	4.1	6.6	10.0	13.3	16.1	18.4	17.3	15.3	11.9	7.8	10.7
1966	4.8	4.1	4.5	7.8	10.6	12.4	15.3	17.5	17.5	14.6	11.6	8.4	10.8
1967	5.9	5.7	5.0	6.8	10.1	13.3	16.1	18.5	18.2	15.4	11.3	7.2	11.1
1968	4.6	3.3	4.6	7.1	11.1	13.4	16.1	17.5	17.2	14.2	10.9	6.8	10.6
1969	2.4	1.5	3.4	7.2	10.8	14.6	17.1	18.2	17.7	14.8	11.5	7.6	10.6
1970	4.3	4.1	4.8	6.8	10.9	14.8	18.0	19.2	17.5	15.2	10.6	6.2	11.0
1971	4.0	3.5	3.6	6.6	10.7	12.6	15.3	18.4	17.2	15.2	11.3	6.8	10.4
1972	3.6	1.9	4.0	7.2	10.6	12.9	15.2	17.3	16.8	15.4	11.3	7.3	10.3
1973	2.3	2.9	4.8	7.7	12.5	15.4	17.6	18.8	17.8	15.2	10.3	7.7	11.1
1974	4.0	3.0	4.9	7.7	10.8	13.6	17.2	18.7	18.4	15.5	11.8	8.6	11.2
Average 1965-1974	4.0	3.3	4.4	7.2	10.8	13.6	16.4	18.3	17.6	15.1	11.3	7.4	10.8
Minimum Daily	0.3	0.3	2.2	4.3	7.5	10.6	13.1	16.6	15.3	12.2	7.7	2.3	--
Maximum Daily	7.6	6.2	6.9	10.1	14.6	17.1	19.3	20.2	20.0	18.7	14.4	10.5	--

Records since August 1960. Recorded values adjusted by computer-simulation to compensate for measurement errors and missing data.

Table 2.4-3

Downstream Surface Water Users

Name	Location of Diversion Township	Range	Section	Approximate Miles Downstream	Quantity (cfs)	Type Use[a]
Energy Northwest	11	28	2	--	90	IN
Peter Kewit and Sons	11	28	2	--	1	I
L. L. Bailey	11	28	24	4	2	I
H. D. Loyd	11	28	24	4	0.99	D,I
Central Premix Concrete Company	11	28	27	4	2	IN
Battelle Memorial Institute	10	28	14	8	4.4	I
University of Washington	10	28	23	9	1.75	I
City of Richland	10	28	24	9	0.67	D
City of Richland	10	28	25	12	31	D
City of Richland	10	28	25	12	23.25	D
City of Richland	10	28	25	12	31	D
City of Richland	10	28	35	12	93	D
E. C. Watts	9	28	1	13	0.31	D,I
H. S. Petty	9	28	1	13	0.48	I
N. H. and M. E. Ketchersid	9	28	1	13	1.66	I
G. C. Walkley	9	28	1	13	2.32	I
R. T. Justesen, et al.	9	28	12	15	2.54	I
Central Premix Concrete Company	9	28	12	15	1.10	IN
City of Richland	9	28	13	17	2.0	I
Benton County	9	29	28	19	1.0	I
City of Kennewick	9	30	31	23	55.7	D
City of Pasco	9	30	31	23	35.0	D
F. J. Henckel	8	30	14	27	0.015	I
Allied Chemical	8	30	14	27	3.55	IN
Chevron Chemical	8	30	23	28	3.77	IN
Chevron Chemical	8	30	23	28	40	IN
Phillips Pacific Chemical Company	8	30	24	28	82	IN
Phillips Pacific Chemical Company	8	30	24	28	20	IN
Boise Cascade Corporation	7	31	10	34	24.5	IN
L. D. Hoyte, et al.	7	31	14	35	179.8	I
D. Howe	7	31	23	36	6.4	I
Crawford and Sons	6	30	27	47	32.8	I
Barbarosa Farms	6	30	27	47	20	I
Crawford and Sons	6	30	27	47	7.6	I
Rainier National Bank	6	30	27	47	9.4	I
Anderson and Coffin	5	29	5	49	242	I
Horse Heaven Farms	5	29	6	50	82	I
Horse Heaven Farms	5	29	6	50	550	I
Horse Heaven Farms	5	29	6	50	290	I
Anderson and Coffin	5	29	6	50	242	I

[a] D - Domestic or municipal uses
I - Irrigation and other agricultural uses
IN - Industrial
Includes only those water rights for which a permit or certificate has been issued

Table 2.4-4

Mean Discharges in CFS of
Columbia River Below Priest Rapids Dam,
Modified to 1970 Conditions

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1928										224000	109900	90900	
1929	82300	78400	101100	103000	108000	72600	85200	62000	71300	87600	97000	94300	86900
1930	87900	89800	102700	93500	90700	83100	72500	81700	90200	98800	97600	92700	90100
1931	86800	89600	100000	82200	90800	88400	74500	81700	104000	102200	99400	85800	90400
1932	87400	88700	102000	95000	109200	77800	90700	157500	156700	74600	97800	90600	102300
1933	89600	69700	102700	128800	167100	97900	118900	185900	196600	180300	121900	100200	130000
1934	100600	104200	128000	139600	203400	196700	243100	221200	168800	104500	100000	101000	150900
1935	82000	72400	109200	132100	132000	111300	117600	147500	156900	131100	99300	96900	115700
1936	90200	86200	107900	119400	79800	80400	81500	160500	123300	83400	93200	89400	99600
1937	87600	87500	105400	96600	100600	84400	63500	70400	76900	87800	102500	91500	87900
1938	89300	83100	88700	111000	124100	86800	110700	142400	146800	154100	90400	89200	109700
1939	83400	77100	91700	127200	90400	83000	108500	100000	112400	95500	96900	90800	96400
1940	85800	85400	90500	133200	98000	89200	110700	89700	101700	94100	96000	91600	97200
1941	84300	79600	92500	99400	92200	87900	137400	76900	73200	84000	91500	88700	90600
1942	96000	82700	91400	114100	119000	84600	115900	105300	148400	101400	102000	88300	104100
1943	87900	65800	86800	105600	150600	116000	132400	202600	134300	147700	101300	88900	118300
1944	81300	77200	96800	99300	110600	78700	88200	88000	69100	81200	94600	84400	87400
1945	90100	90900	103600	88500	94000	86500	77800	112800	67800	88800	99300	87400	90600
1946	86200	85700	92500	95600	117700	90800	112200	178100	170900	134500	94400	91100	112500
1947	79600	81300	93100	116000	137800	135200	155900	184400	163400	136300	89900	85500	121500
1948	94700	96000	113900	113200	202800	166700	137700	193400	257600	194700	122900	101900	149600
1949	88000	83600	97700	126000	114000	80000	123000	166400	181600	82700	92200	87800	110200
1950	79000	69500	106800	123300	155200	145400	136400	197500	200200	211900	114800	96200	136400
1951	91800	87900	102600	115400	223400	186200	195600	188800	171300	174300	110300	91700	144900
1952	94200	98800	112200	126500	155200	113300	134600	172400	135800	145100	88700	85900	121900
1953	85500	83900	103900	95500	124800	87800	98700	174000	168300	141400	99000	89200	112700
1954	83600	89800	110300	122100	153600	135200	124200	191200	224900	228400	163600	114400	145100
1955	98700	103400	126600	132400	143900	102700	110500	104300	181800	193300	111900	91000	125000
1956	95700	94500	97000	108100	206500	200600	173500	245800	212600	200400	103600	90700	152400
1957	87400	82900	109400	132100	145100	101200	113600	182700	176500	120900	89000	86900	119000
1958	77500	75200	83300	120200	123700	107300	125000	172800	172900				
Mean	87800	84700	101700	113200	132100	108600	119000	147900	147200	132800	102400	91800	114100

Table 2.4-5

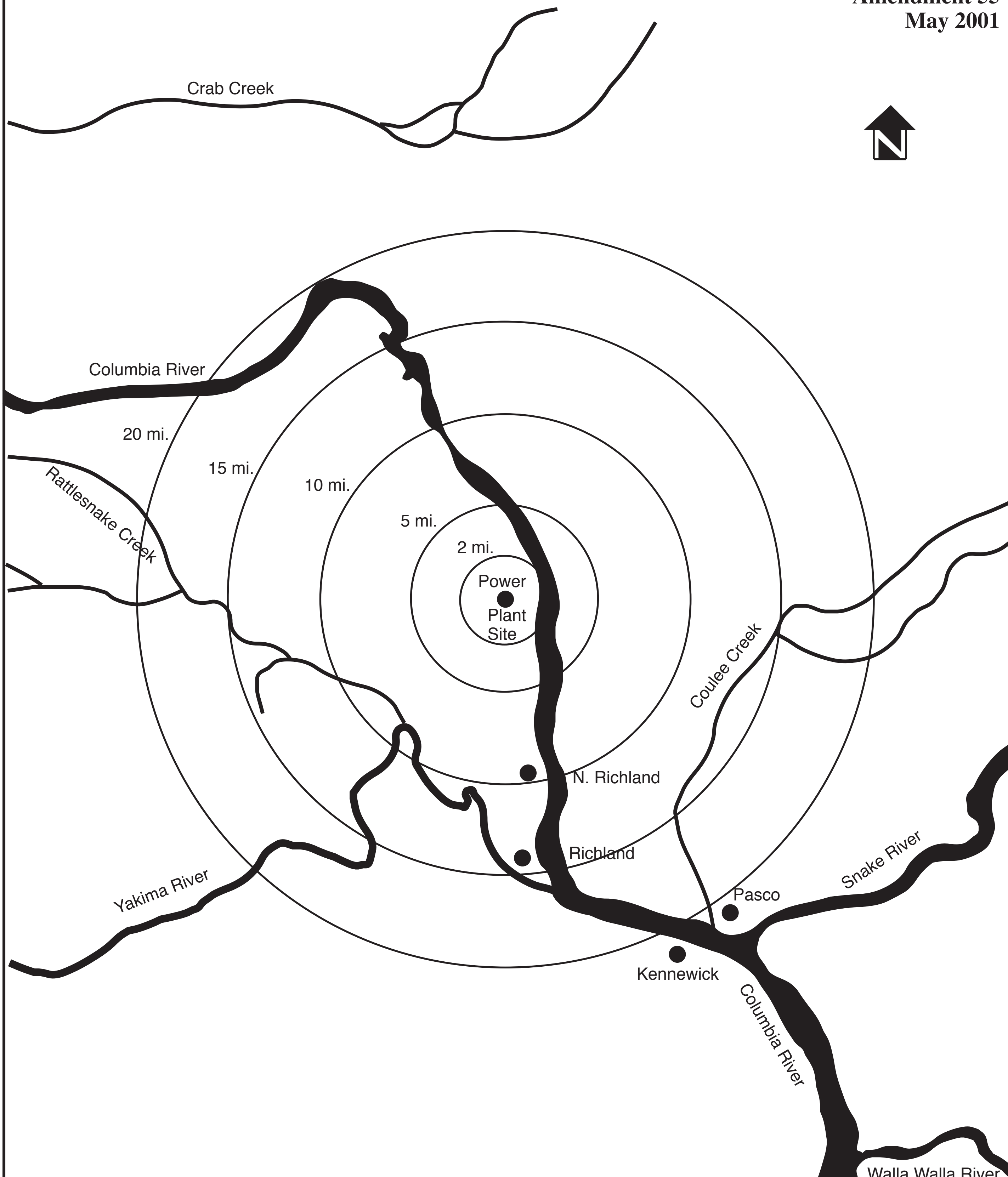
Dependable Yield, Columbia River Below
Priest Rapids Dam, Washington

Consecutive Years of Lowest Mean Flow	Inclusive Years	Lowest Mean Flow (cfs)	Percent of 1929-1958 Mean
1	1937	86,600	75.9
2	1930-31	89,900	78.8
3	1929-31	92,900	81.4
4	1929-32	95,800	84.0
5	1937-41	96,400	84.5
6	1937-42	97,300	85.3
7	1936-42	98,400	86.2
8	1937-44	99,000	86.8
9	1937-45	97,900	85.8
10	1936-45	98,600	86.4
11	1929-58	114,100	100.0

Table 2.4-6

Major Geologic Units in the Hanford Region
and Their Water-Bearing Properties

System	Series	Geologic Unit	Material	Water-Bearing Properties
		Fluviatile and glaciofluviatile sediments and the Touchet formation (0-200 ft thick)	Sands and gravels occurring chiefly as glacial outwash. Unconsolidated, tending toward coarseness and angularity of grains, essentially free of fines.	Where below the water table, such deposits have very high permeability and are capable of storing vast amounts of water. Highest permeability value determined was 12,000 ft/day.
	Pleistocene	Palouse soil	Wind deposited silt.	Occurs everywhere above the water table.
Quaternary		Ringold formation (200-1200 ft thick)	Well-bedded lacustrine silts and sands and local beds of clay and gravel. Poorly sorted, locally semi-consolidated or cemented. Generally divided into the lower "blue clay" portion which contains considerable sand and gravel, the middle conglomerate portion, and the upper silts and fine sand portion.	Has relatively low permeability; values range from 1 to 200 ft/day. Storage capacity correspondingly low. In very minor part, a few beds of gravel and sand are sufficiently clean that permeability is moderately large; on the other hand, some beds of silty clay or clay are essentially impermeable.
	Miocene and Pliocene	Columbia River basalt series (10,000 ft thick)	Basaltic lavas with interbedded sedimentary rocks, considerably deformed. Underlie the unconsolidated sediments.	Rocks are generally dense except for numerous shrink-age cracks, interflow scoria zones, and interbedded sediments. Permeability of rocks is small (e.g., 0.002 to 9 ft/day) but transmissivity of a thick section may be considerable (70 to 700 ft^2/day)



Columbia Generating Station
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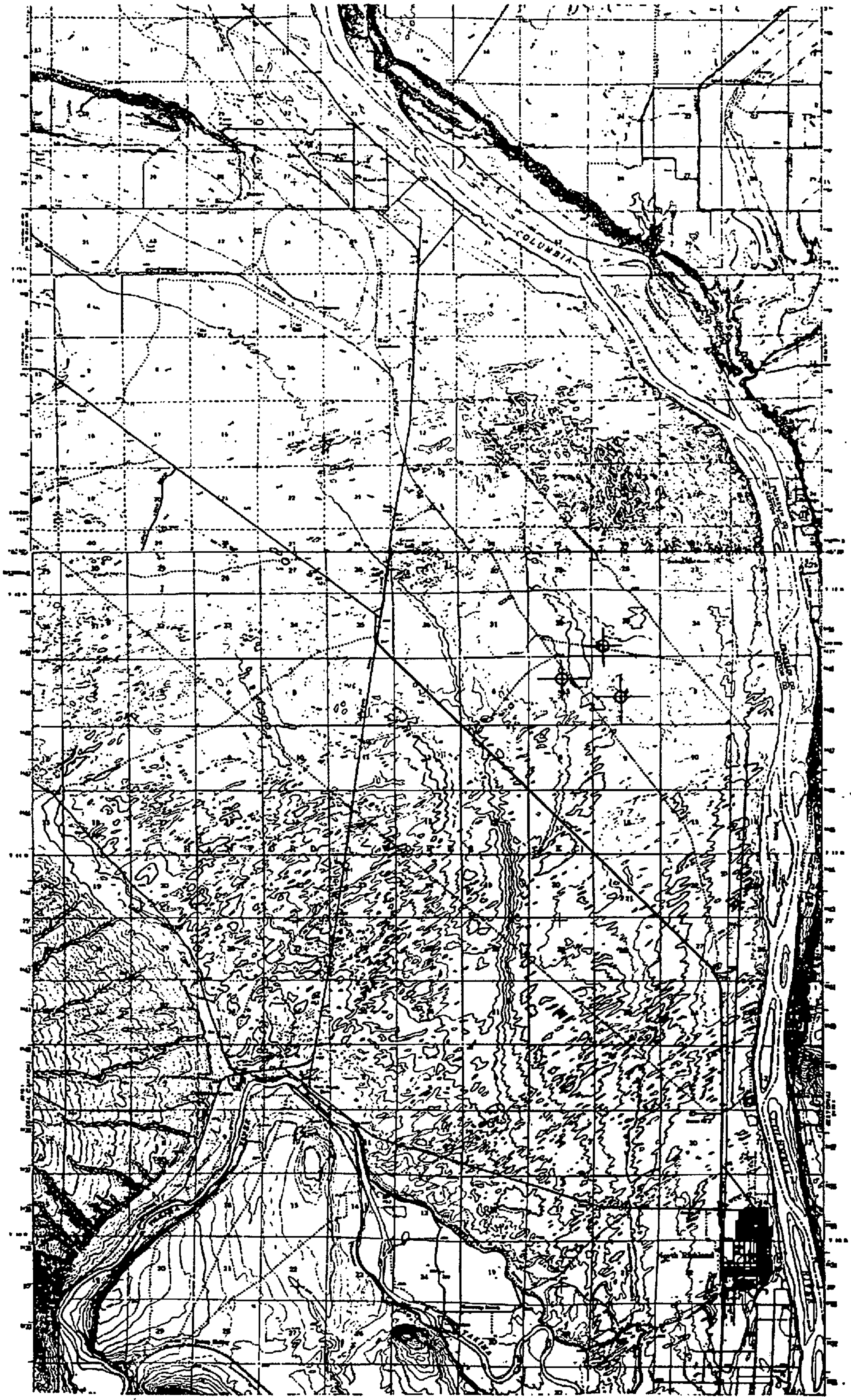
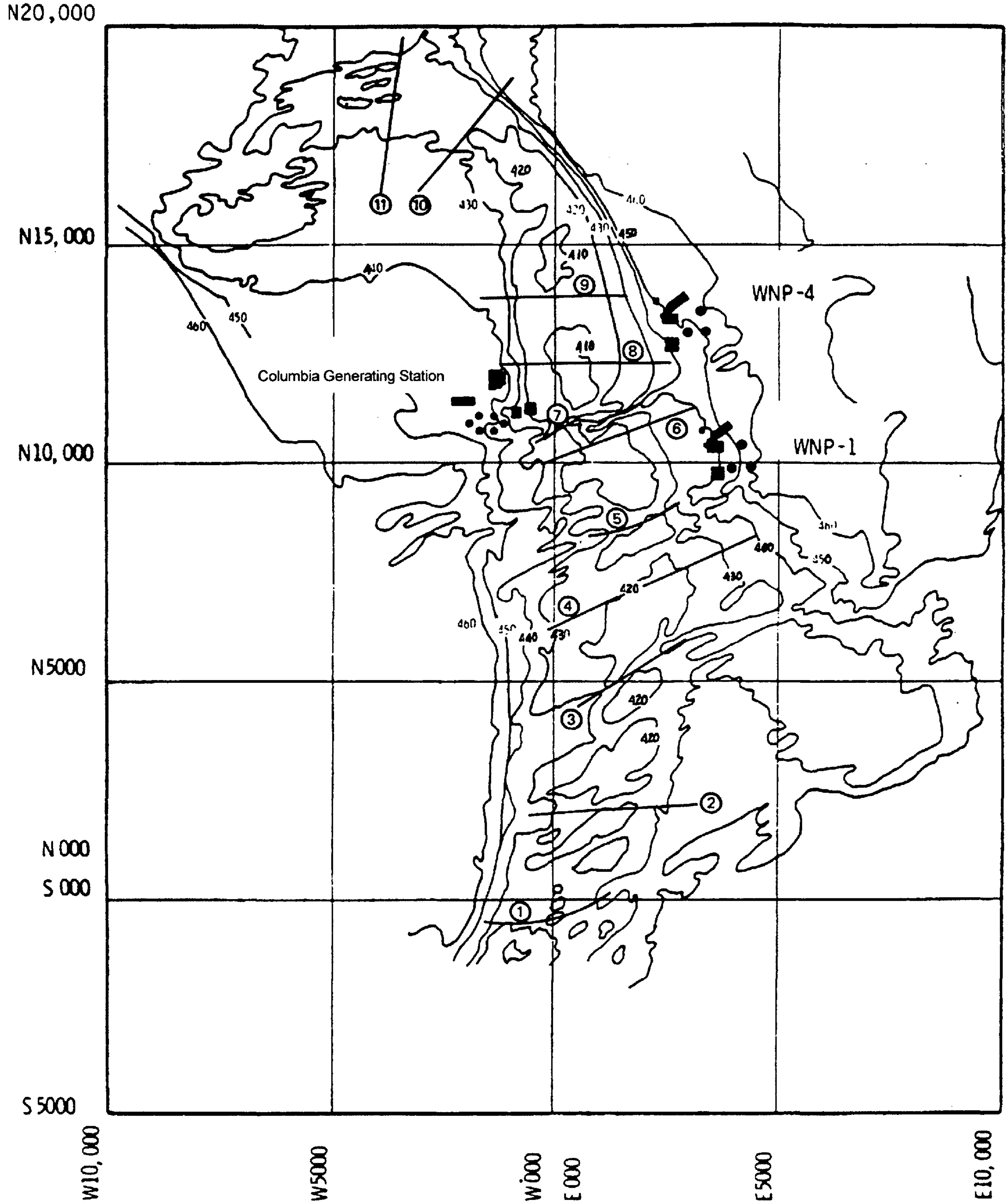
Hydrographic Map

Draw. No. 990306.30 | Rev. | Figure 2.4-1



Topographic Map of Site and Sounding Area

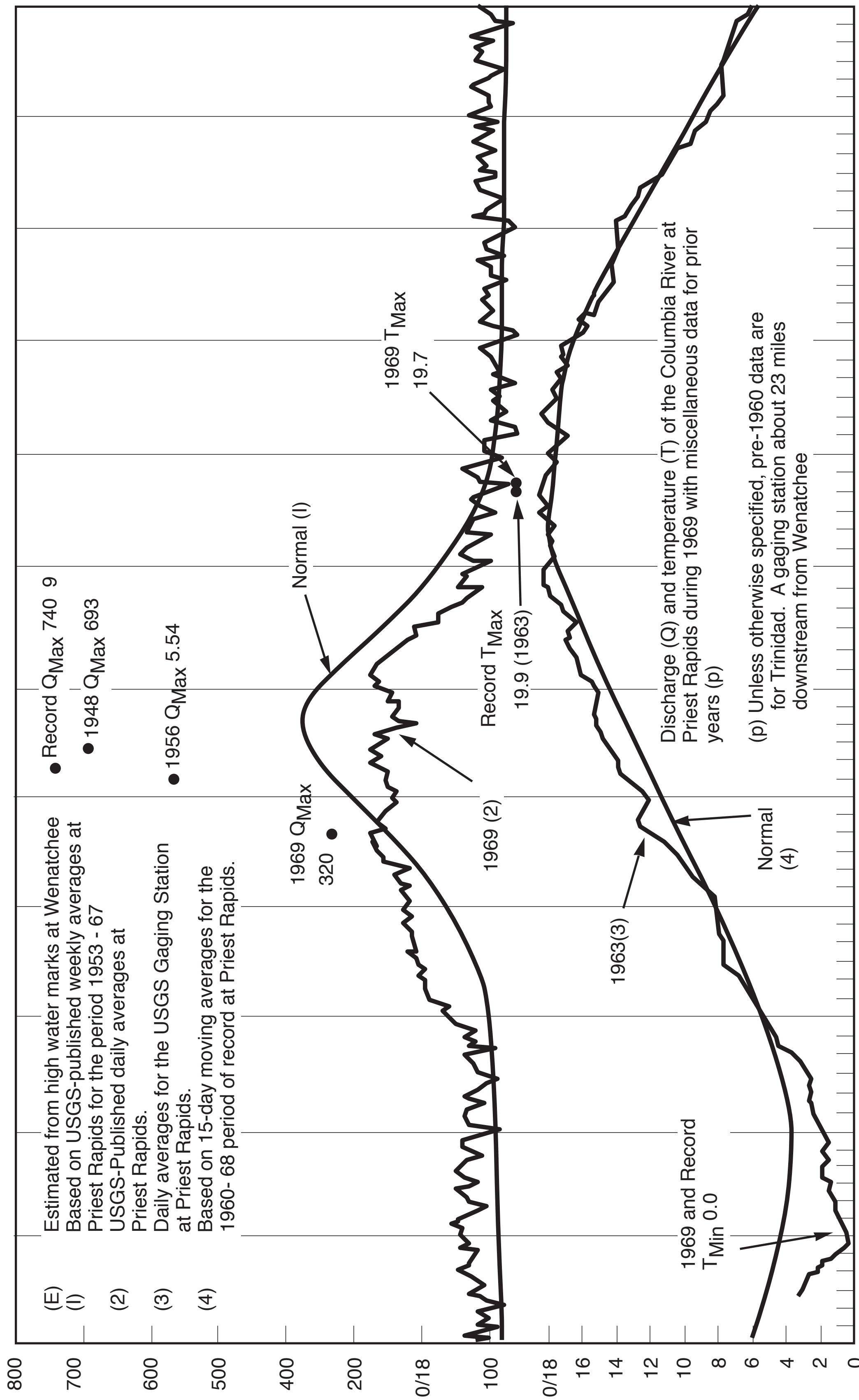
Draw. No. 020361.02 | Rev. | Figure 2.4-2



Columbia Generating Station
Final Safety Analysis Report

Detailed Countours Near the Site

Draw. No. 020361.03 | Rev. | Figure 2.4-3



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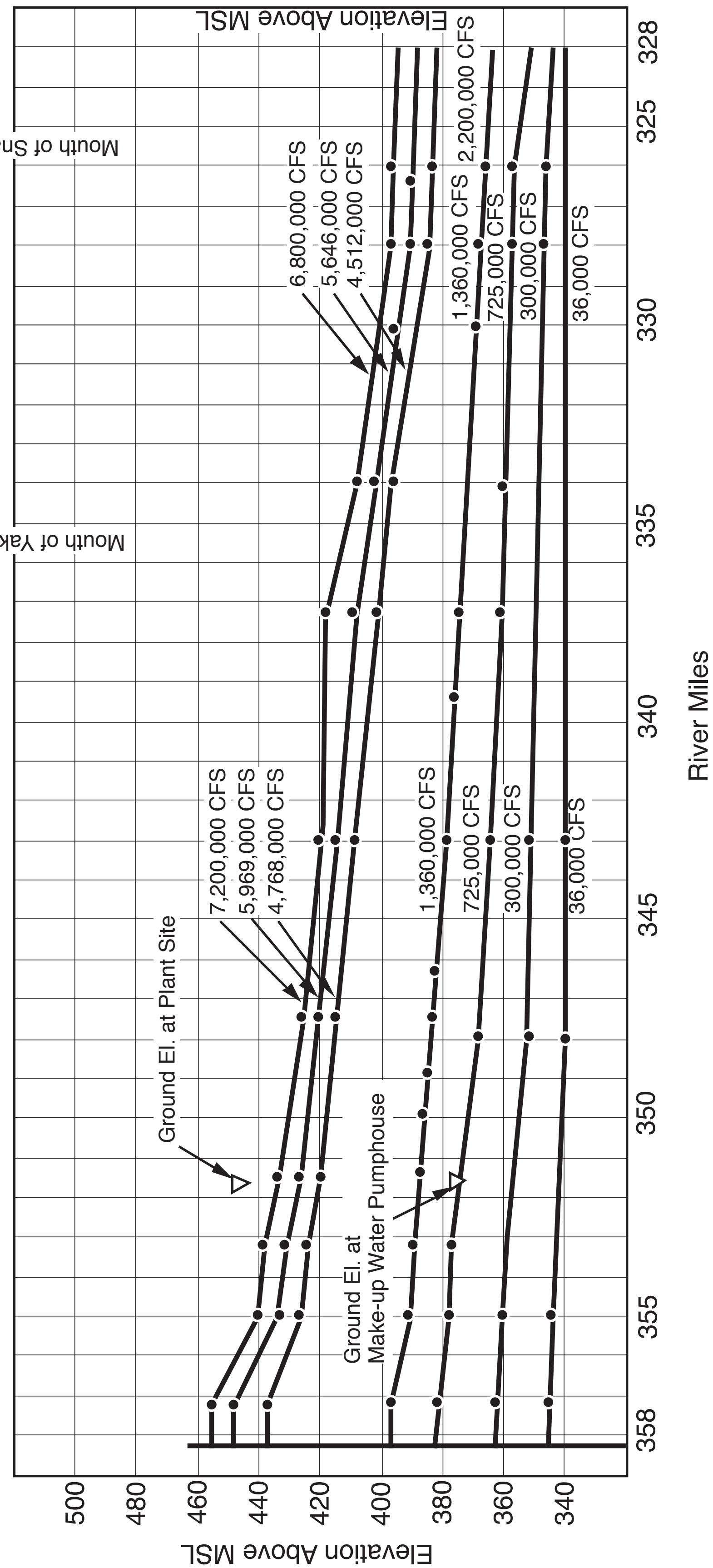
Discharge and Temperature of the Columbia River at Priest Rapids

Draw. No. 990306.06 | Rev. | Figure 2.4-4



Columbia Generating Station Final Safety Analysis Report	Columbia River Water Surface Profiles River Miles 323 to 358
	Draw. No. 990306.07 | Rev. | Figure 2.4-5

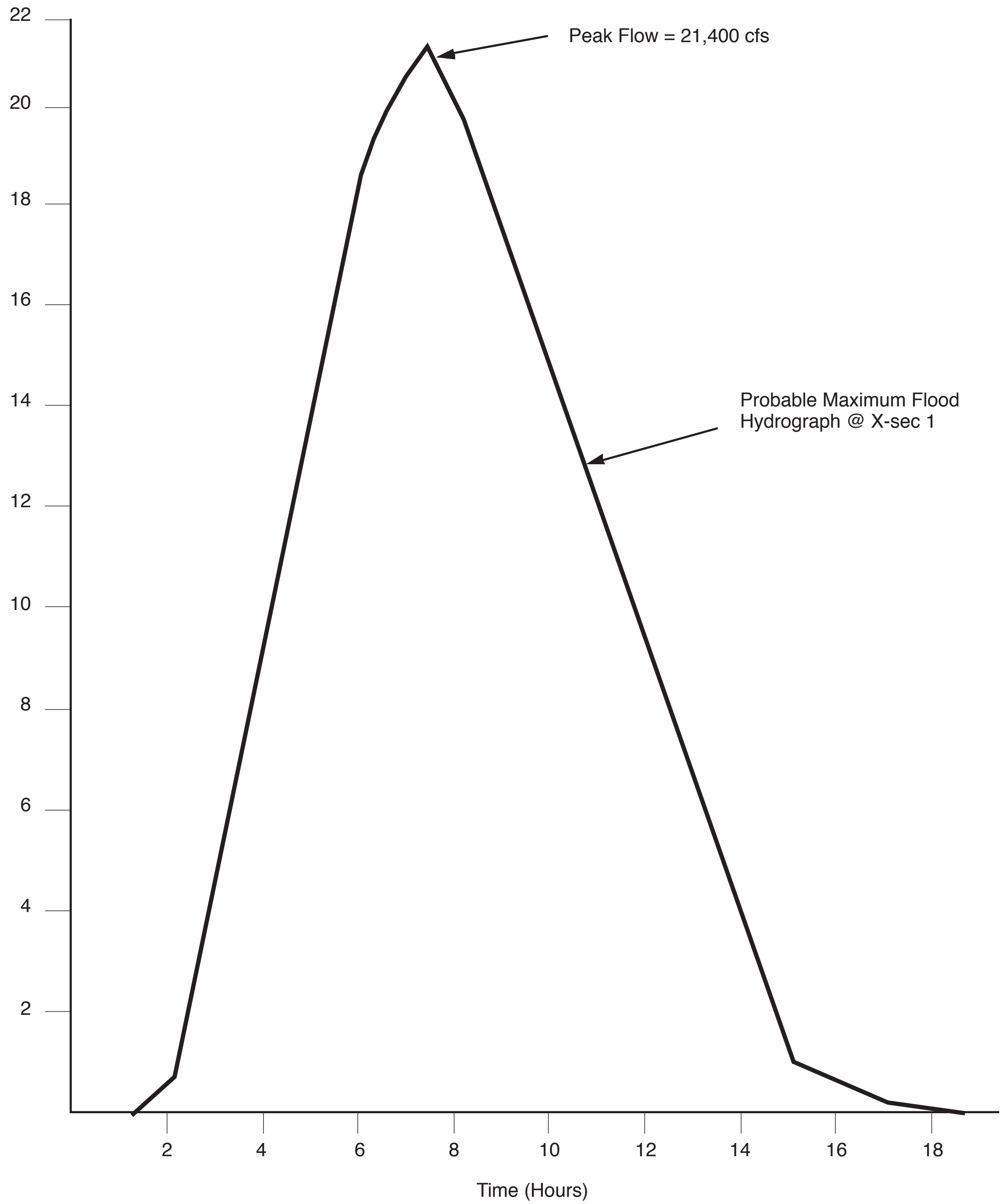
Figure Not Available For Public Viewing

Figure Not Available For Public Viewing

Figure Not Available For Public Viewing

Figure Not Available For Public Viewing

Figure Not Available For Public Viewing

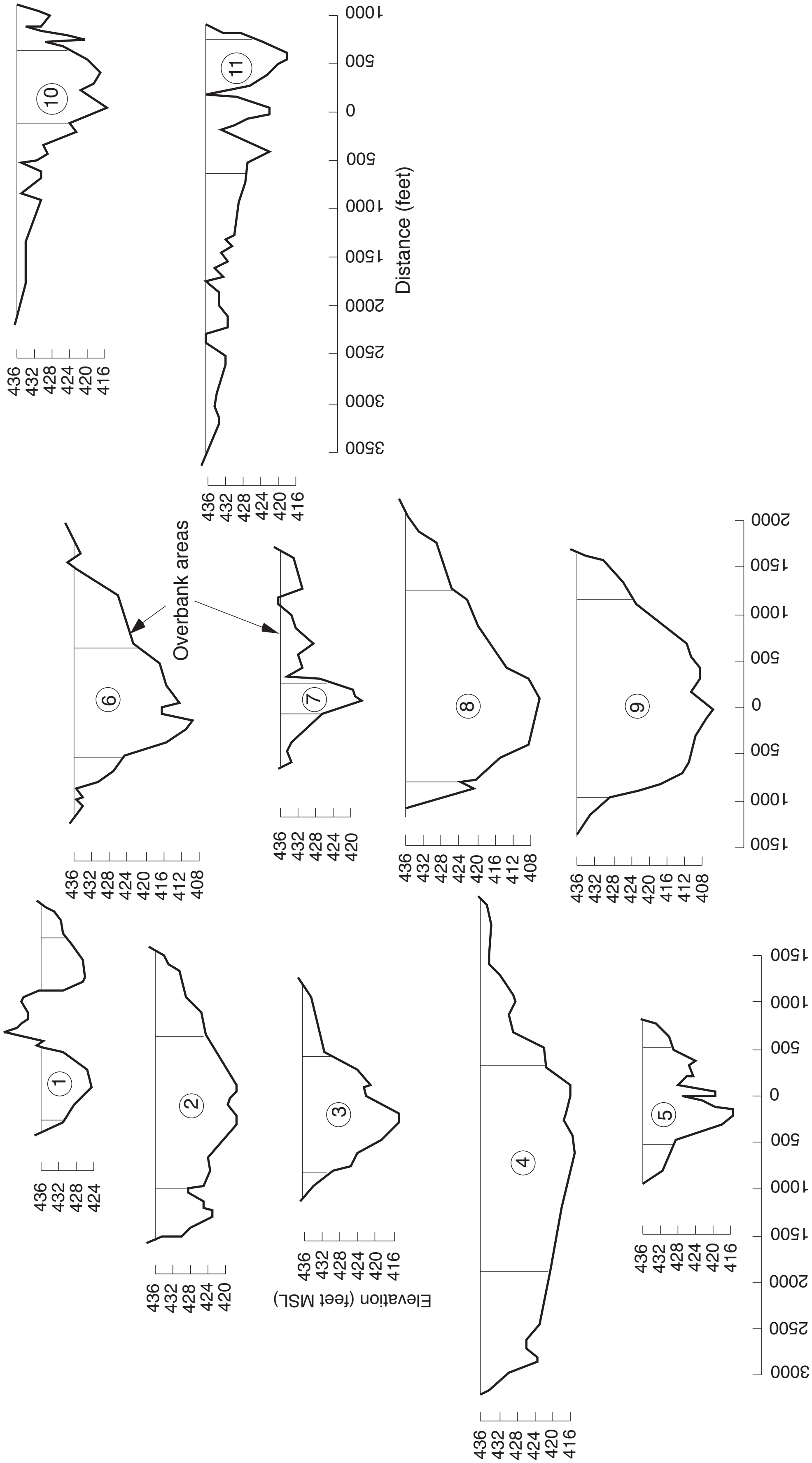


Columbia Generating Station
Final Safety Analysis Report

PMF Hydrograph Due to Thunderstorm PMP

Draw. No. 990306.31	Rev.	Figure 2.4-7

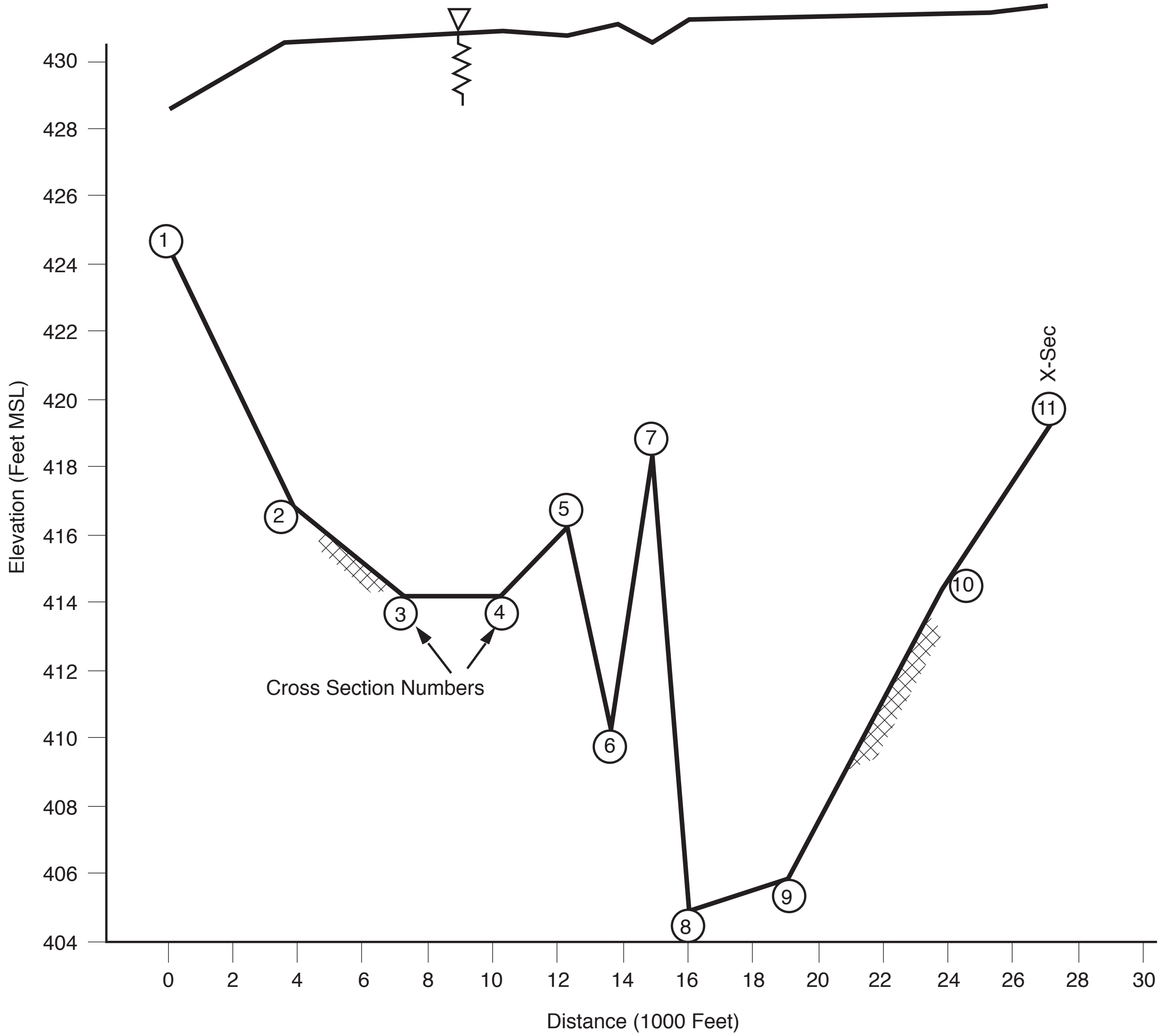
Columbia Generating Station Final Safety Analysis Report	Probable Maximum Precipitation Drainage Basin		
	Draw. No. 020361.04	Rev.	Figure 2.4-8



Columbia Generating Station
Final Safety Analysis Report

Probable Maximum Precipitation Channel Cross Sections

Draw. No. 990306.08	Rev.	Figure 2.4-9

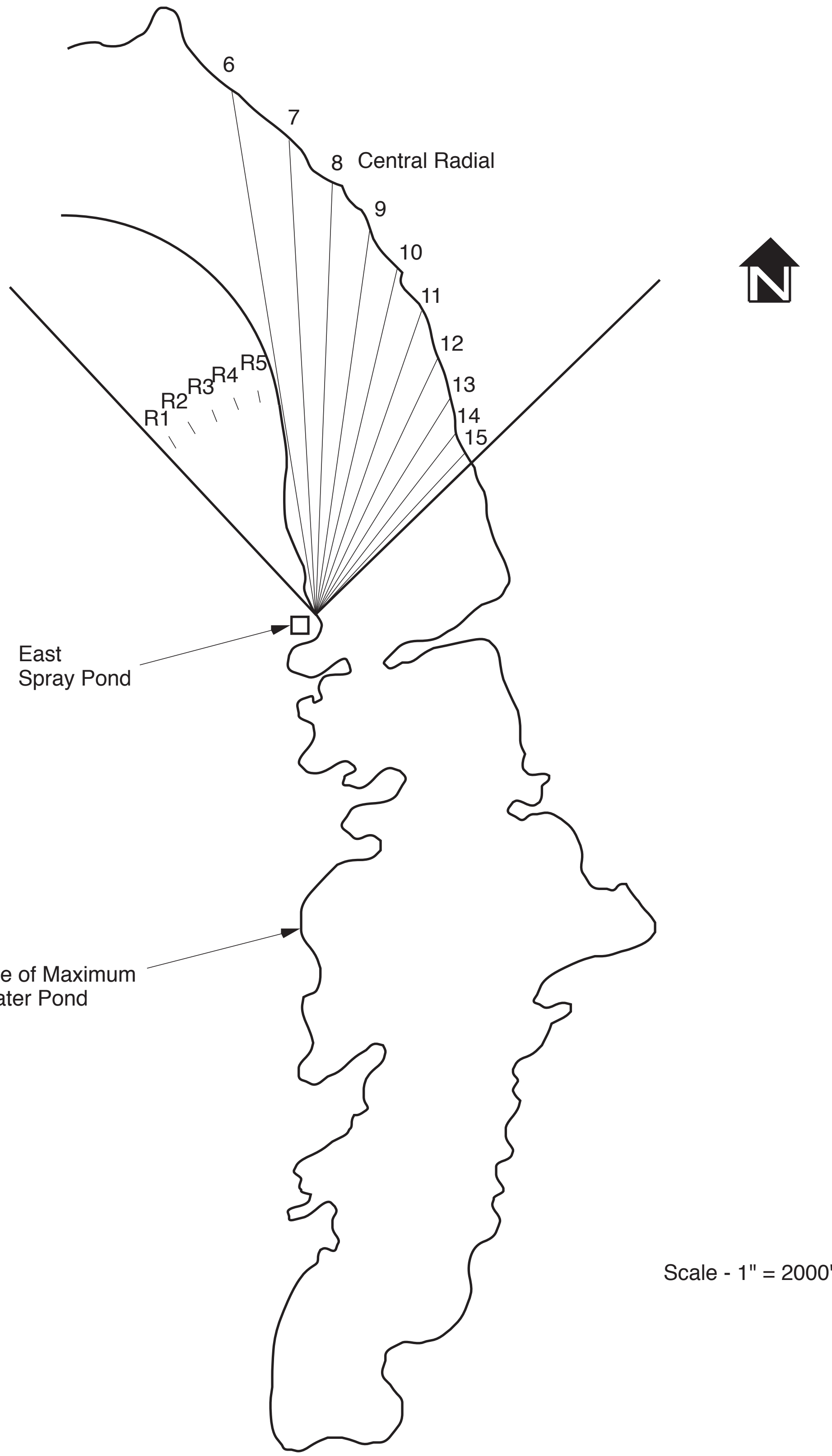


Columbia Generating Station
Final Safety Analysis Report

Water Surface Profile

Draw. No. 990306.32 | Rev. | Figure 2.4-10

Form No. 960690



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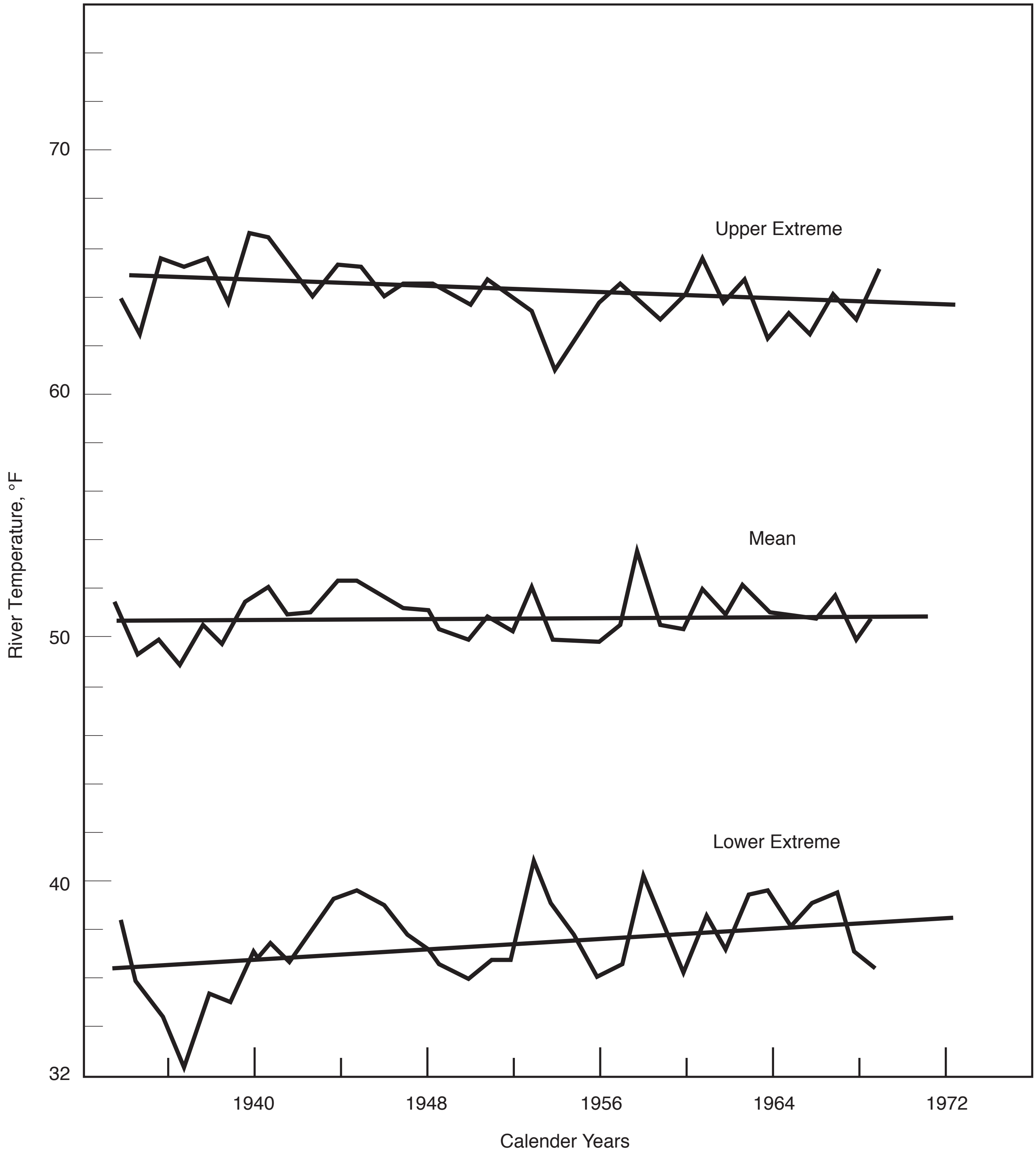
Effective Fetch Diagram

Draw. No. 990306.33	Rev.	Figure 2.4-11



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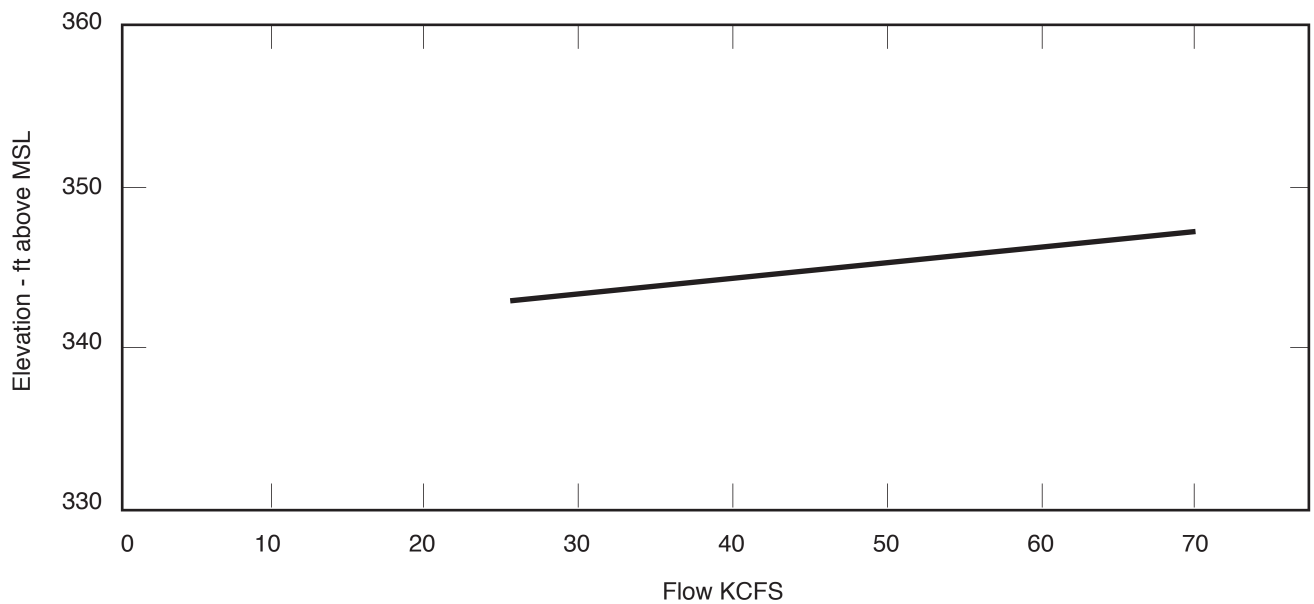
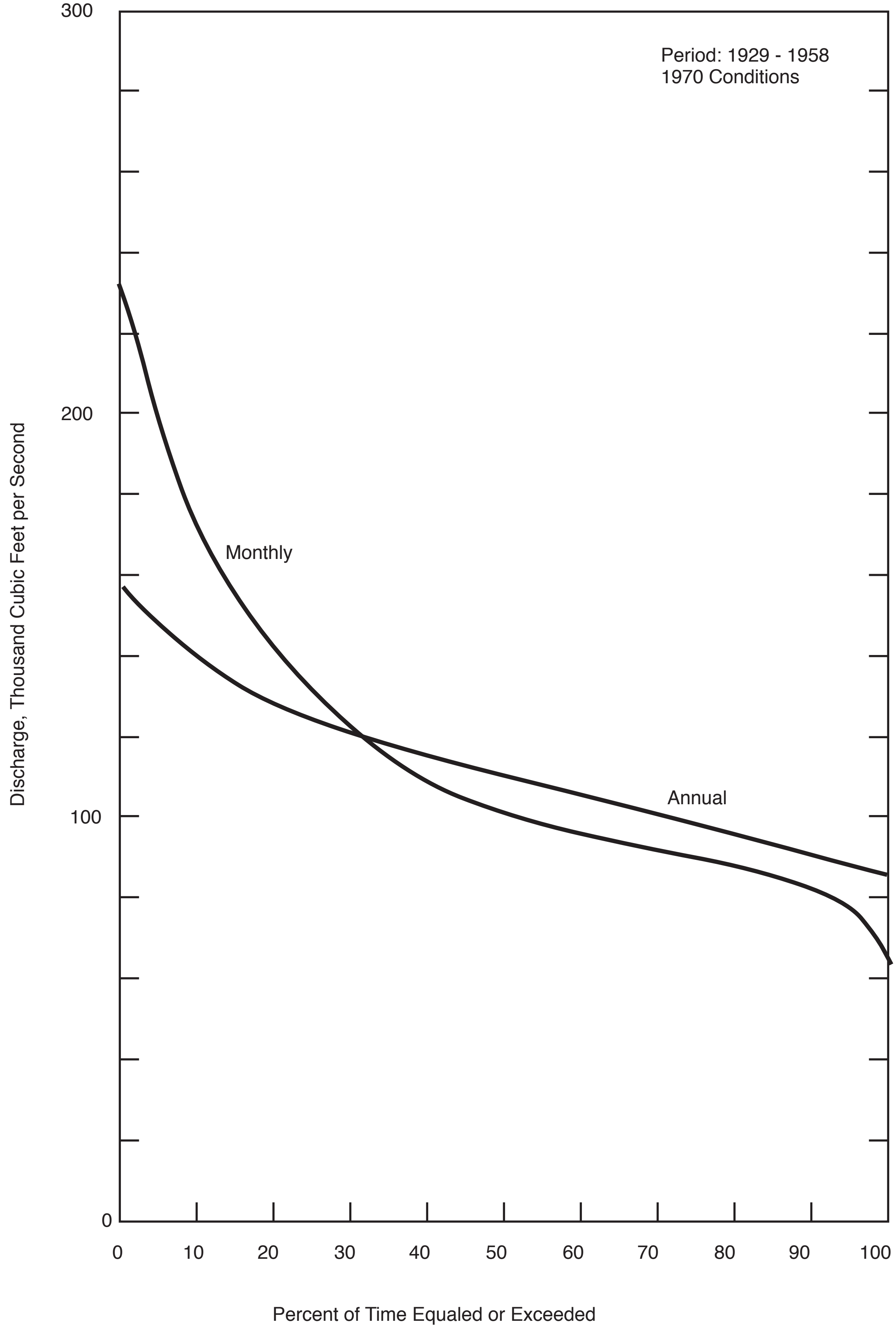
Computed Long-Term Temperature Trends on the Columbia River at Rock Island Dam (1938 - 1962)

Draw. No. 990306.34 | Rev. | Figure 2.4-12



River Elevation at Low Flows - River Mile 352

Draw. No. 990306.35 | Rev. | Figure 2.4-13



Columbia Generating Station
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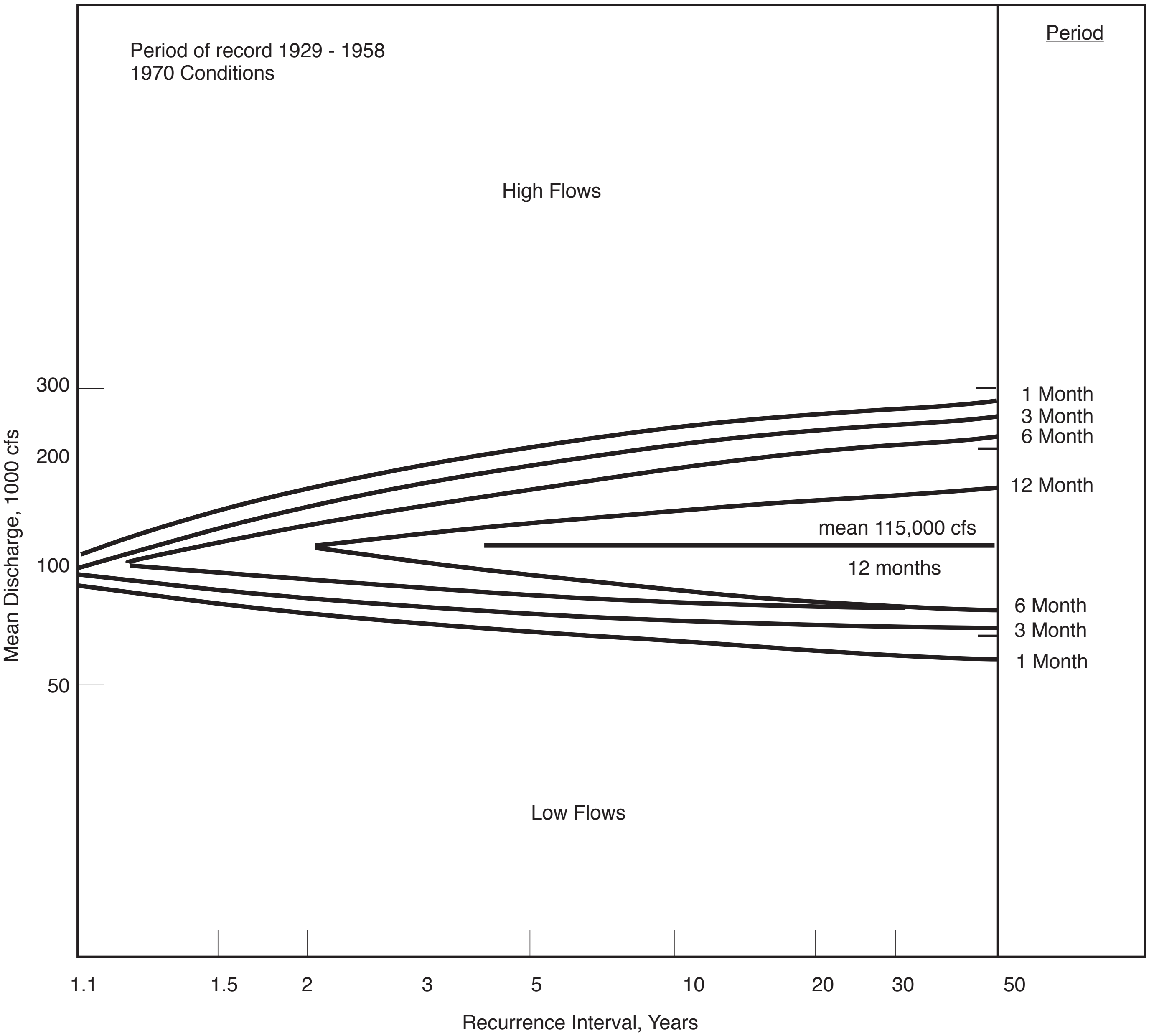
Duration Curves Columbia River, Priest Rapids Dam

Draw. No. 990306.36	Rev.	Figure 2.4-14



Columbia Generating Station
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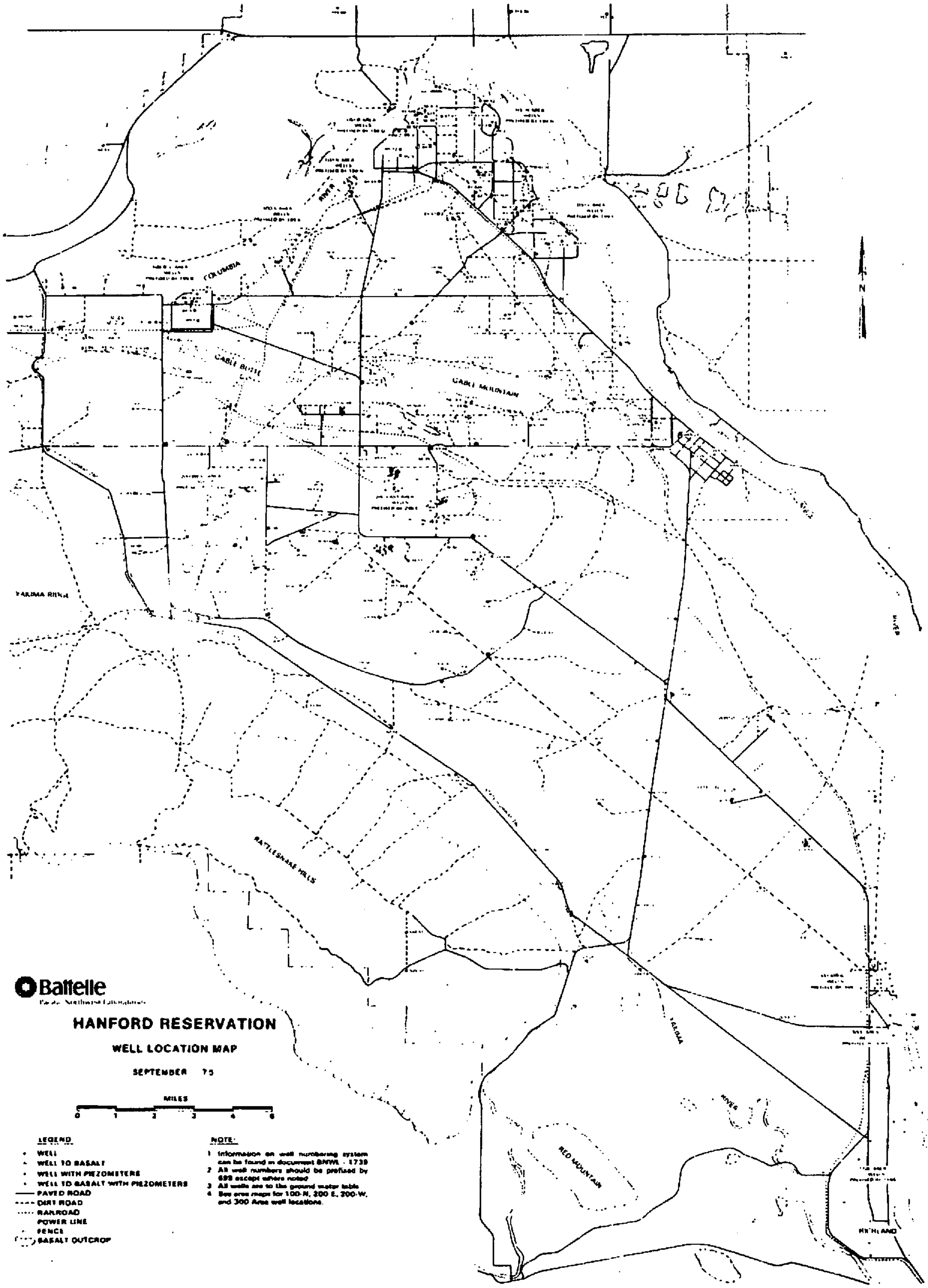
Frequency Curves of High and Low Flows for the Columbia River Below Priest Rapids Dam

Draw. No. 990306.37	Rev.	Figure 2.4-15

Figure Not Available For Public Viewing



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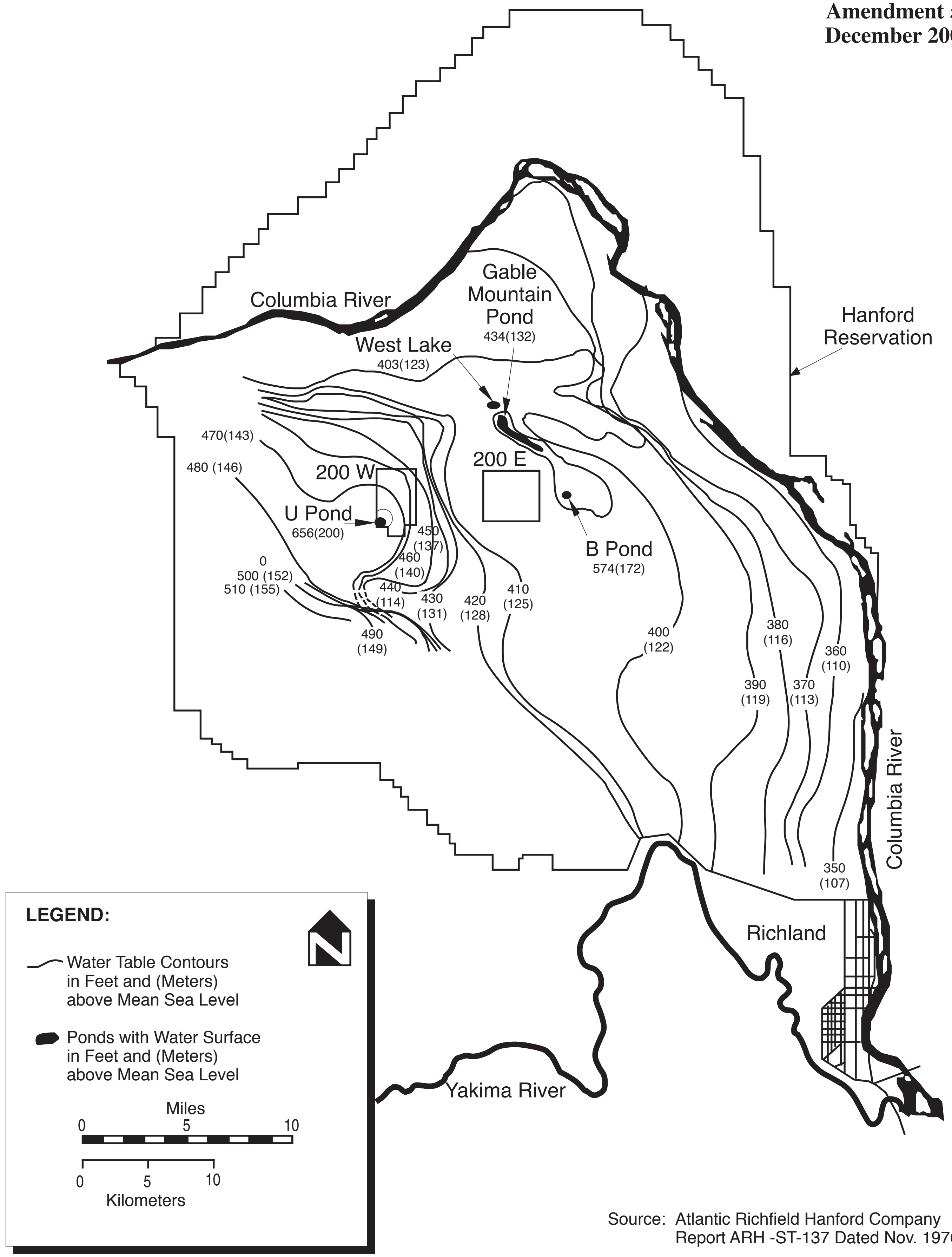
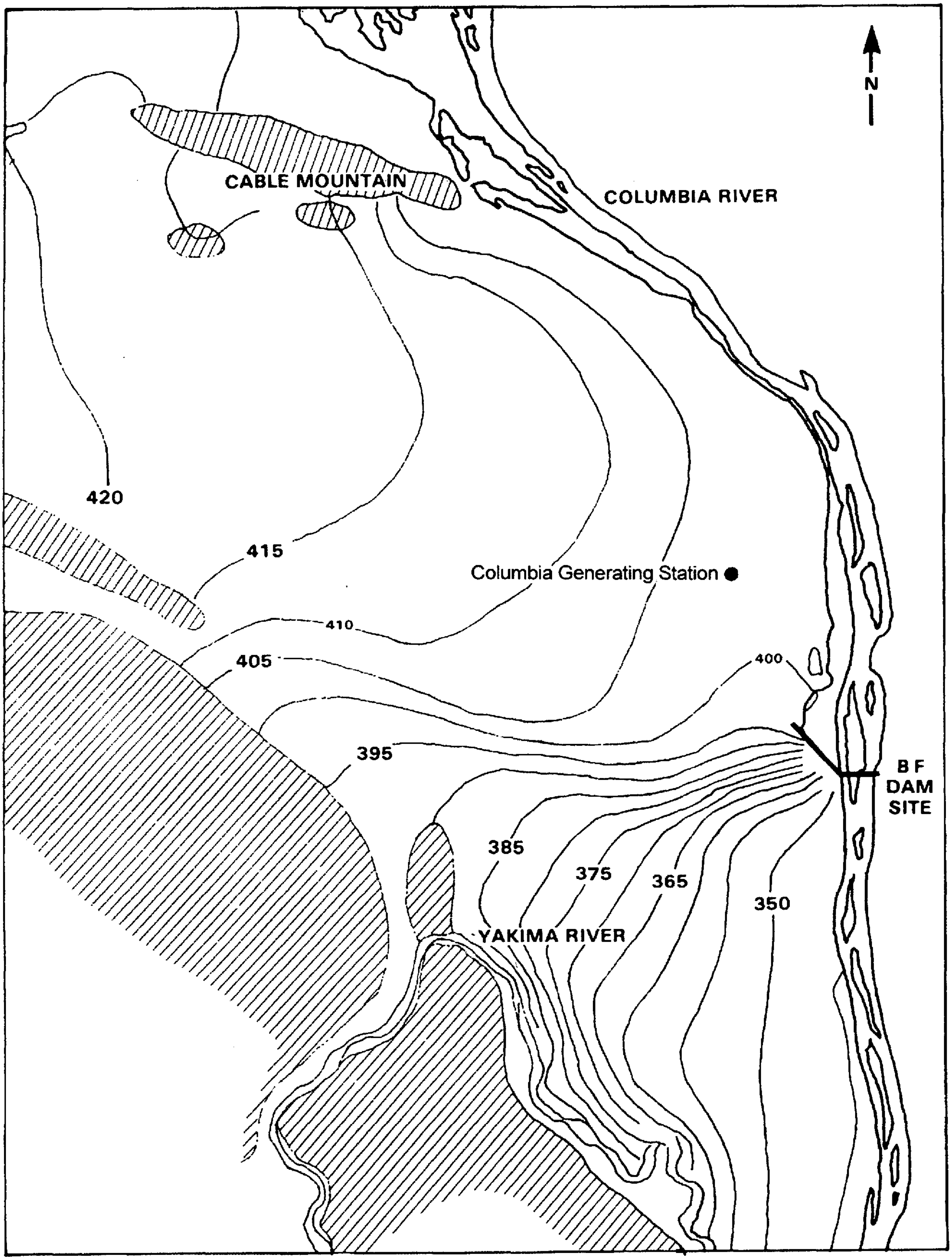
Monitoring Well Locations (September 1975)

Draw. No. 020361.05 | Rev. | Figure 2.4-17

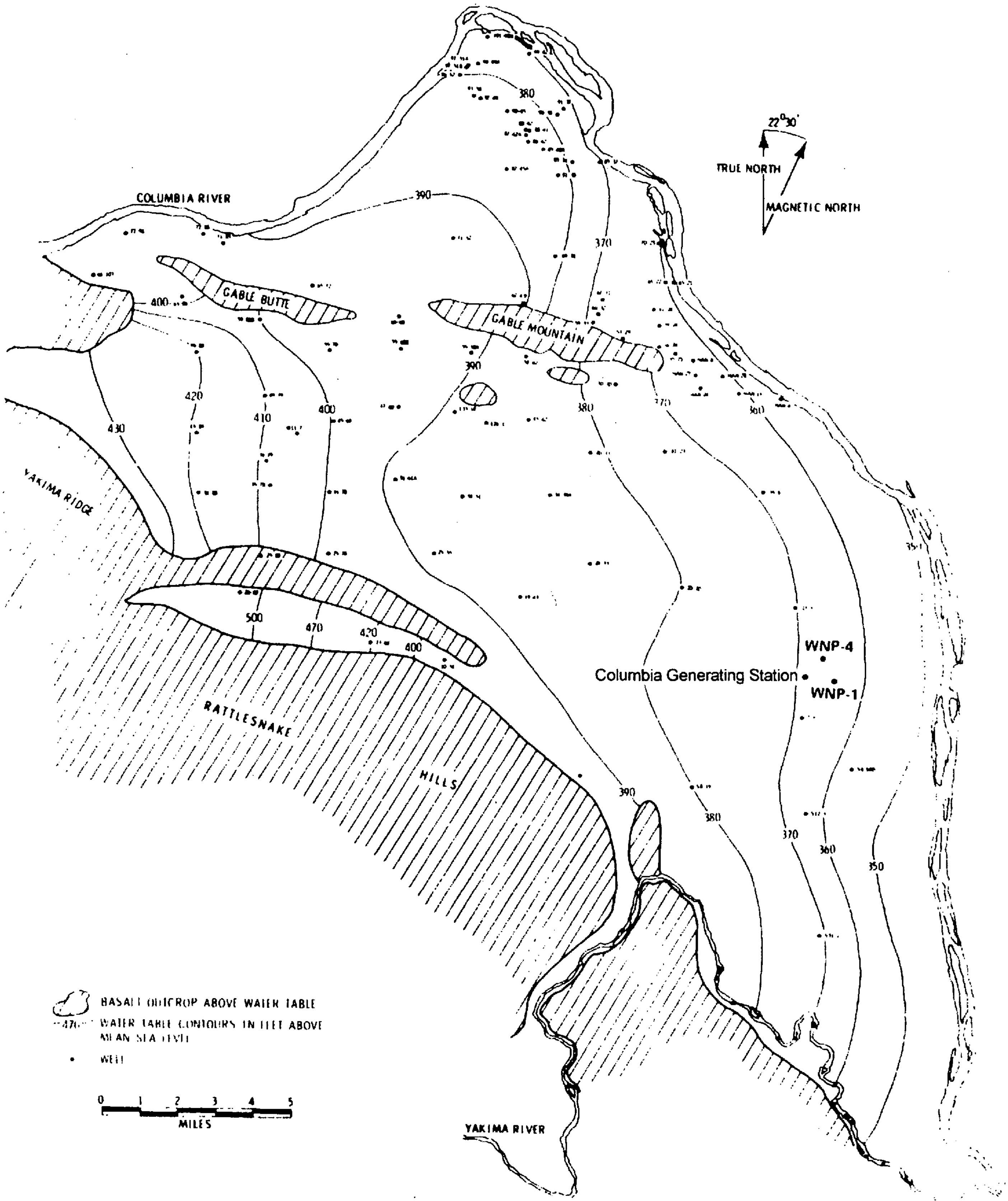


Source: Atlantic Richfield Hanford Company Report ARH -ST-137 Dated Nov. 1976

Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Water Table Map (December 1975)		
	Draw. No. 010126.53	Rev.	Figure 2.4-18



Columbia Generating Station **Final Safety Analysis Report**	**Groundwater Contours Assuming Construction of the Ben Franklin Dam** Draw. No. 020361.06 | Rev. | Figure 2.4-19



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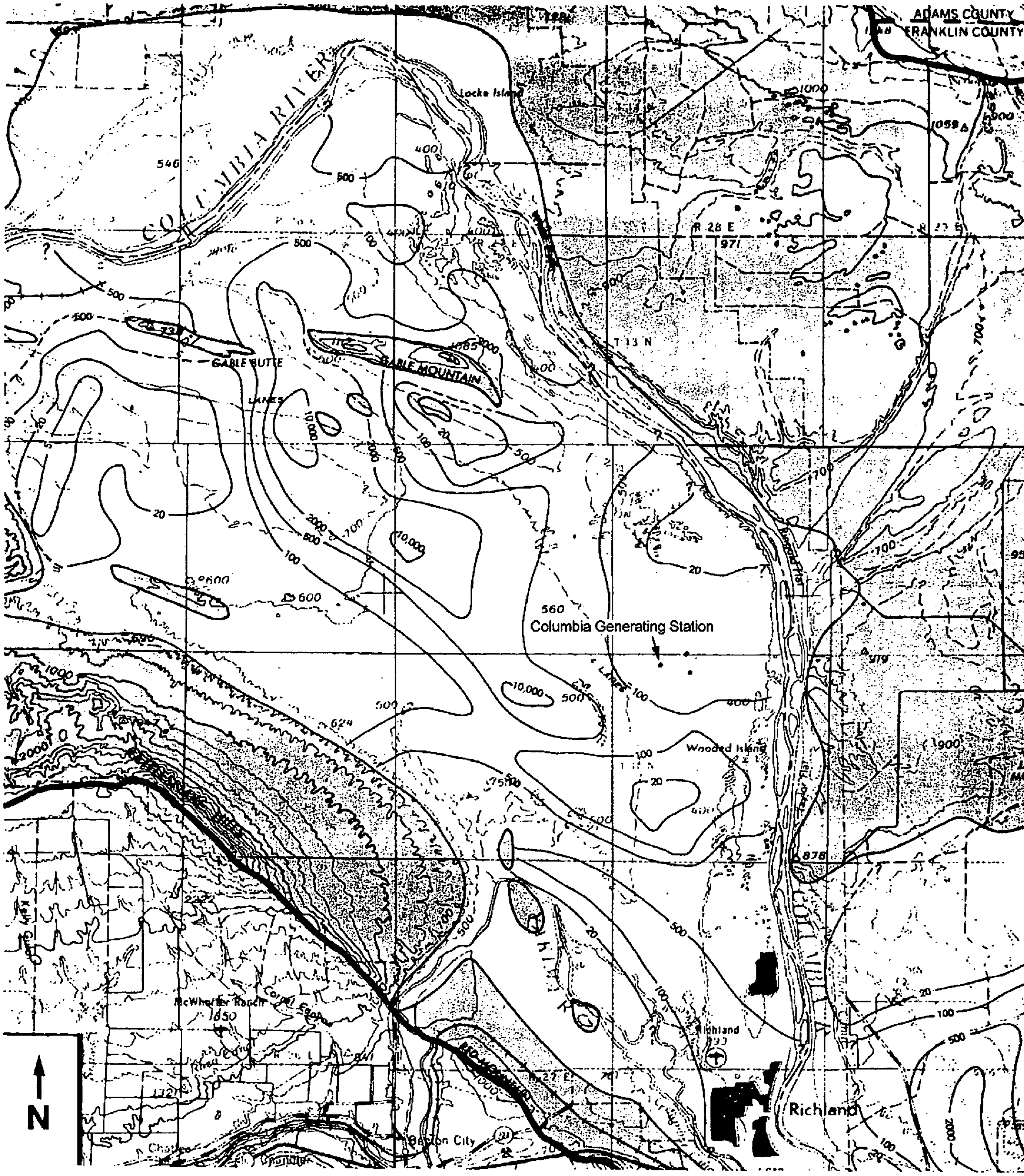
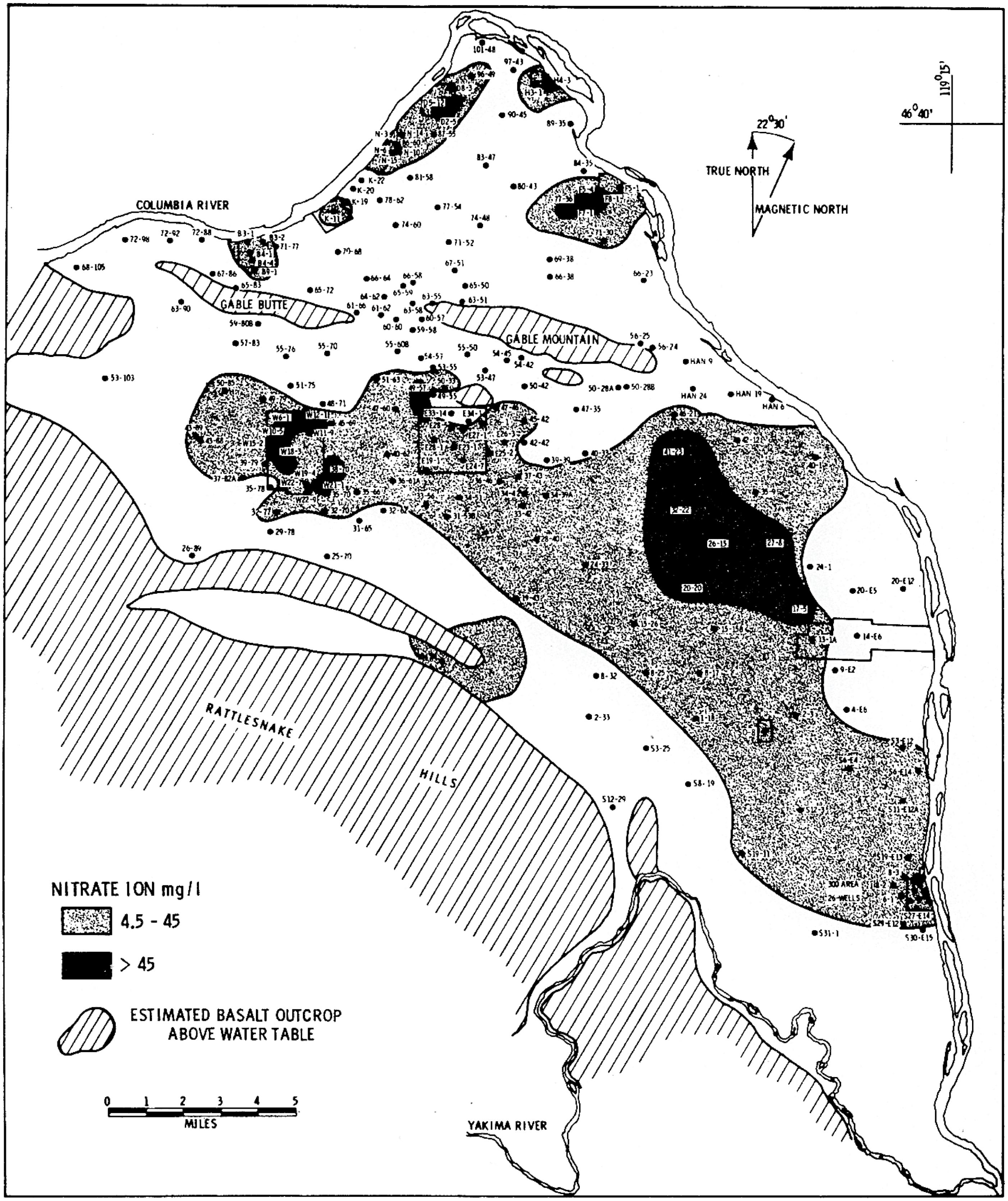
Hanford Reservation Water Table Map (January 1944)

Draw. No. 020361.07	Rev.	Figure 2.4-20



HYDRAULIC CONDUCTIVITY ISOPETHS IN FEET PER DAY
SOURCE: PLATE III-5 FROM REFERENCE 2.4-39

Columbia Generating Station Final Safety Analysis Report	Hydraulic Conductivities in the Unconfined Aquifer		
	Draw. No. 020361.08	Rev.	Figure 2.4-21



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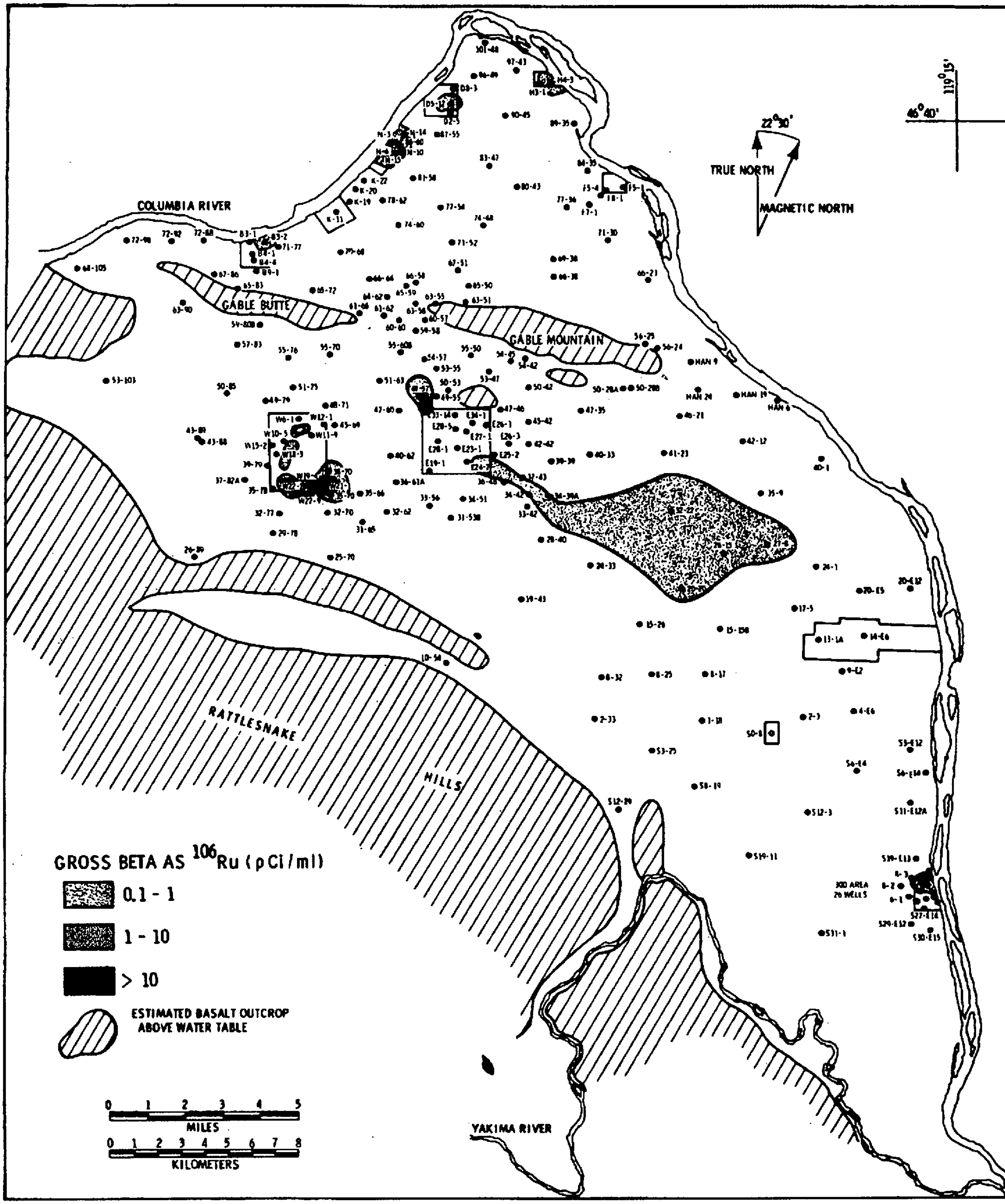
Nitrate (NO3) Concentrations (December 1976)

Draw. No. 020361.09 | Rev. | Figure 2.4-22



Gross Beta Concentrations (December 1976)

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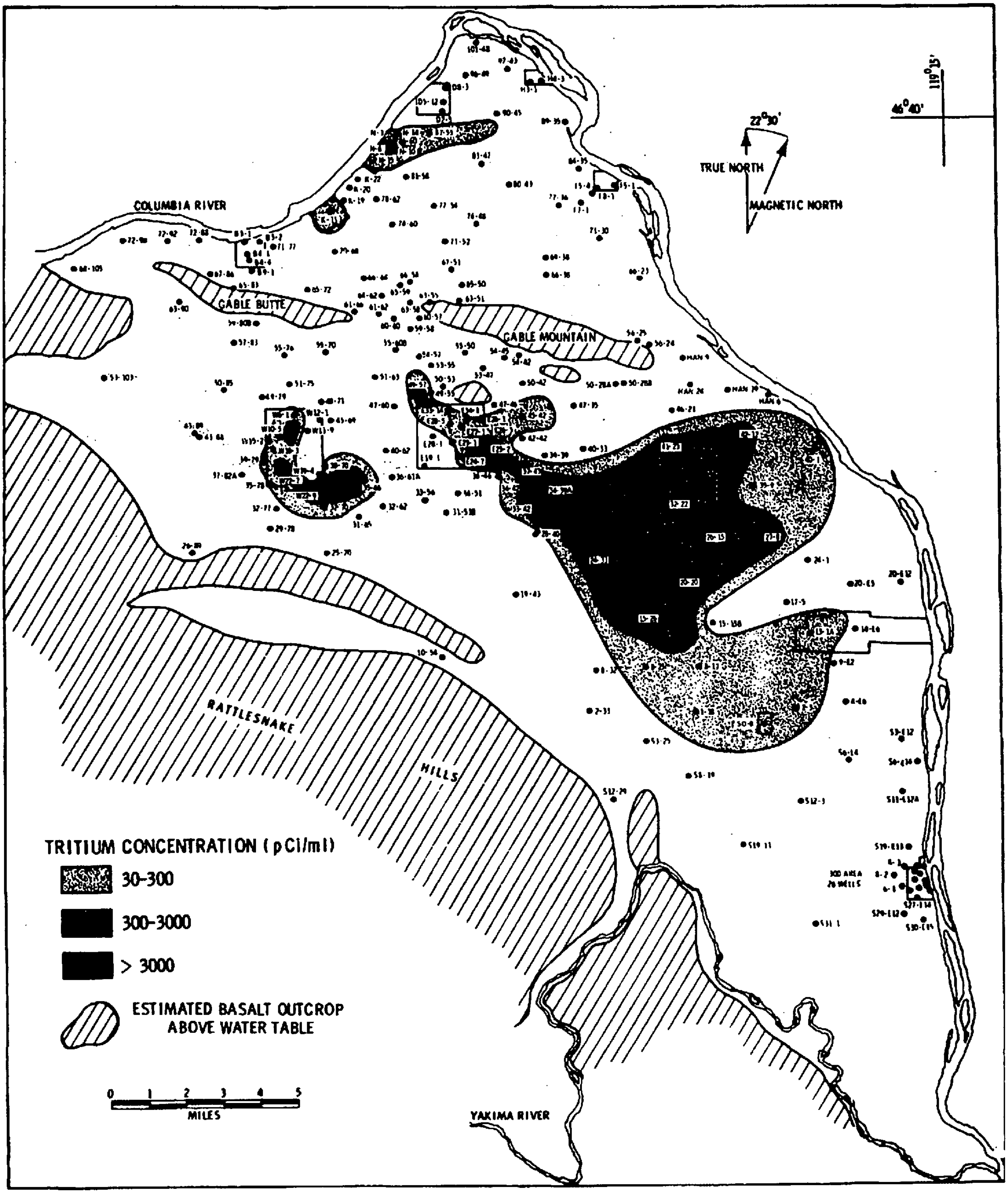
Draw. No. 020361.10 | Rev. | Figure 2.4-23



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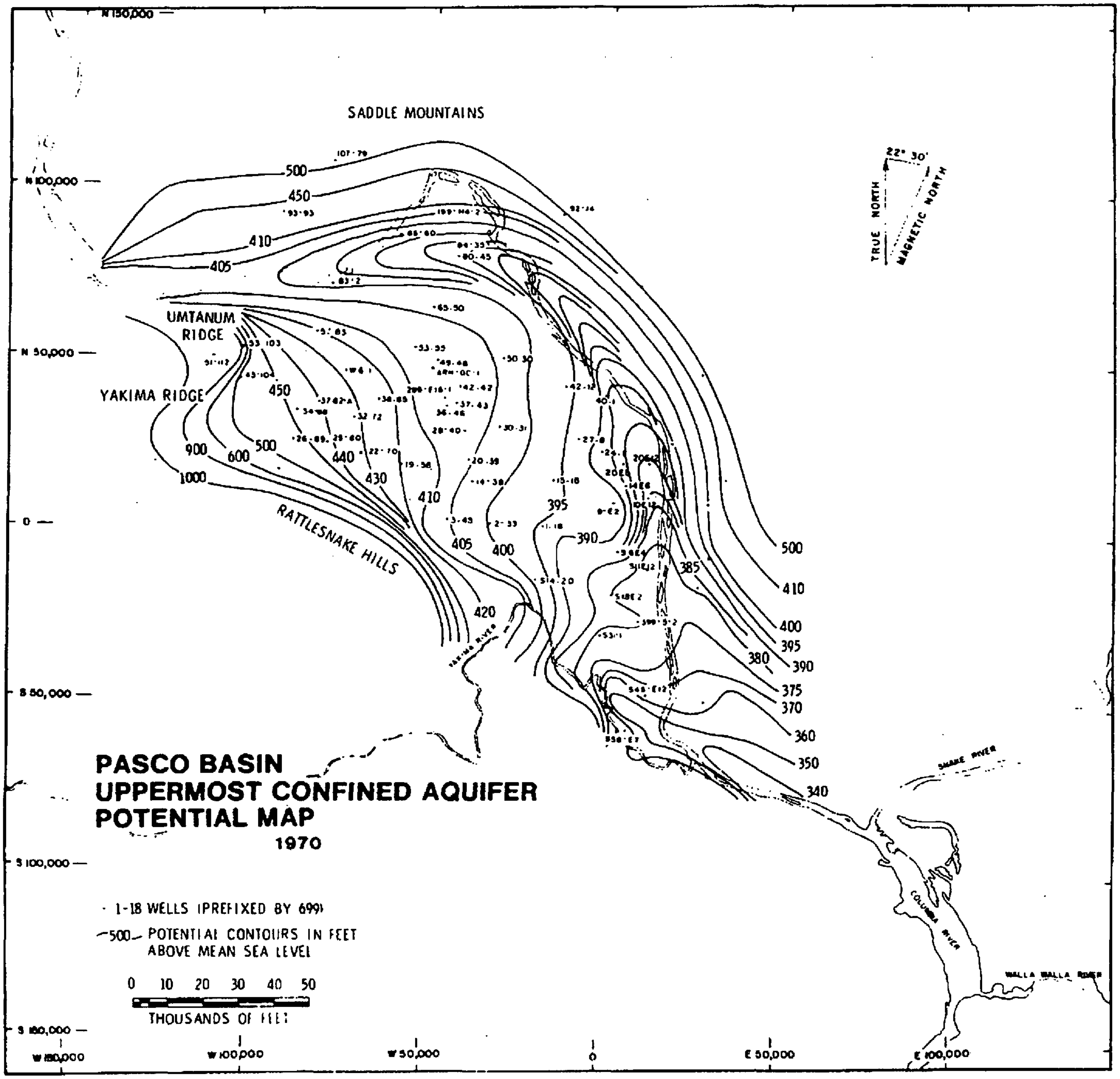
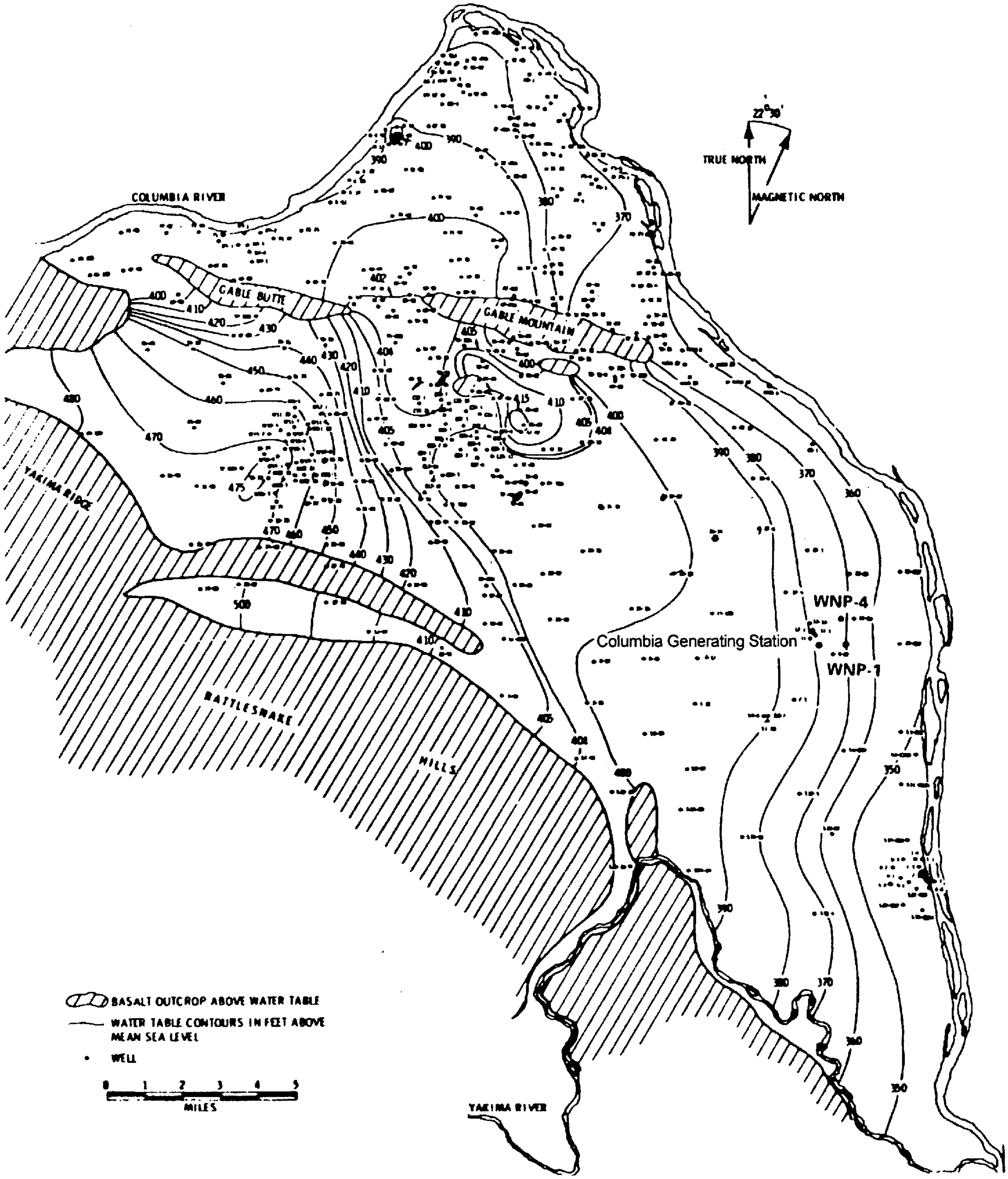
Tritium (^3H) Concentrations (December 1976)

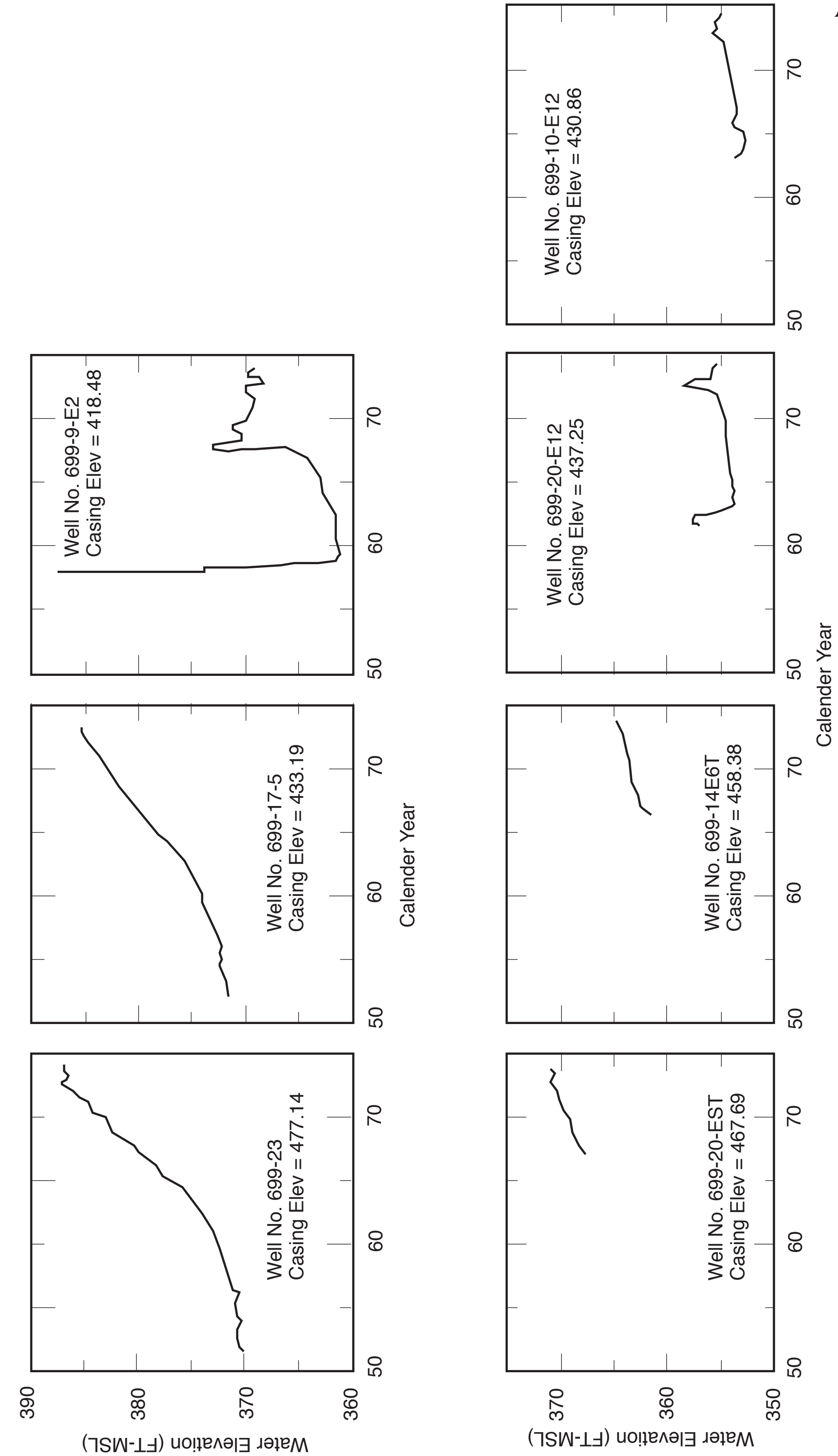
Draw. No. 020361.11 | Rev. | Figure 2.4-24


N 150,000
N 100,000
N 50,000
0
S 50,000
S 100,000
S 150,000
W 150,000
W 100,000
W 50,000
0
E 50,000
E 100,000
SADDLE MOUNTAINS
UMTANUM RIDGE
YAKIMA RIDGE
RATTLESNAKE HILLS
TRUE NORTH
MAGNETIC NORTH
22° 30'
500
450
410
405
900
600
1000
440
430
420
400
395
390
385
380
375
370
360
350
340
PASCO BASIN
UPPERMOST CONFINED AQUIFER
POTENTIAL MAP
1970
· 1-18 WELLS (PREFIXED BY 699)
500 POTENTIAL CONTOURS IN FEET ABOVE MEAN SEA LEVEL
0 10 20 30 40 50
THOUSANDS OF FEET



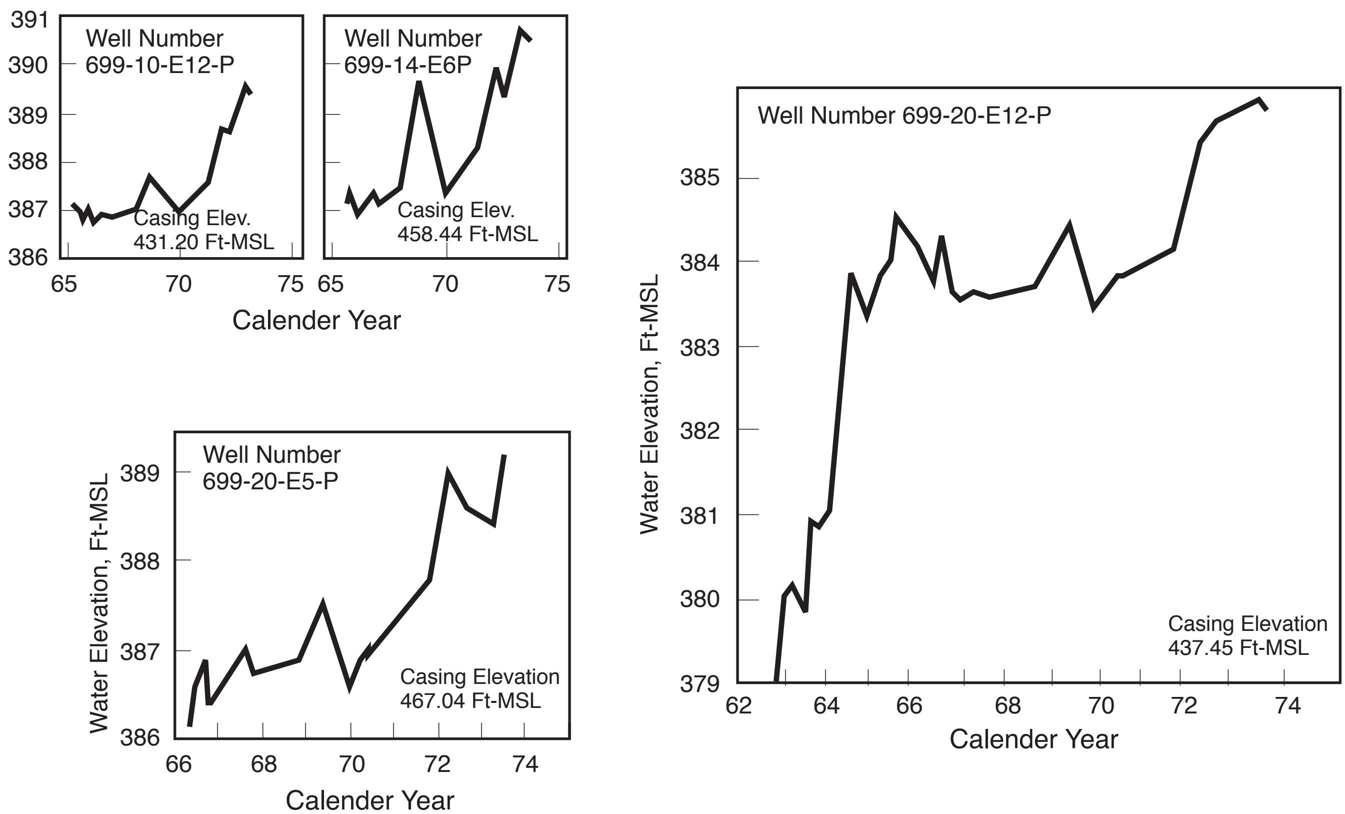
Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Water Table Map (September 1973)		
	Draw. No. 020361.13	Rev.	Figure 2.4-26

Amendment 55
May 2001

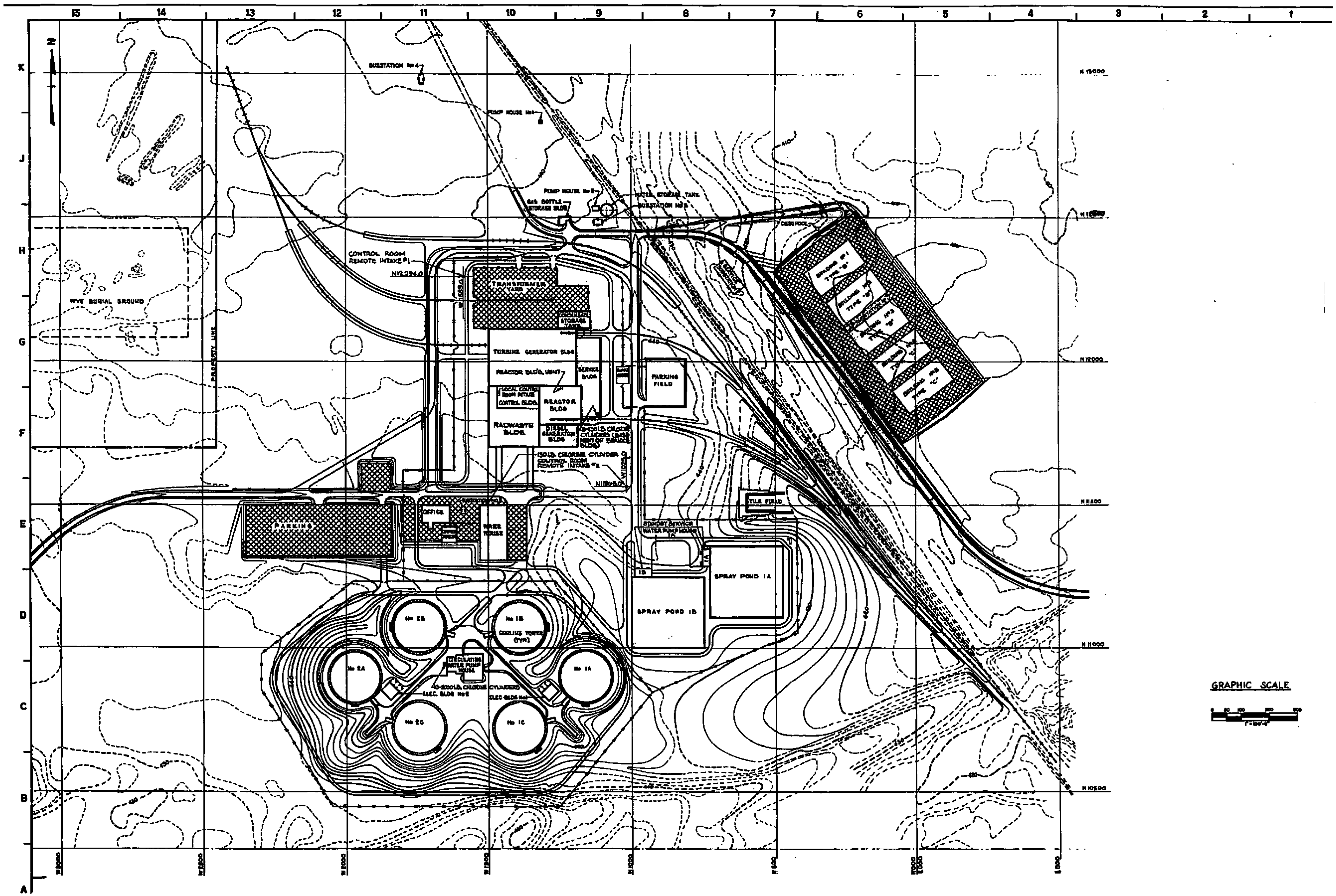


Columbia Generating Station Final Safety Analysis Report	Well Hydrographs
	Draw. No. 990306.09	Rev.	Figure 2.4-27.1

Form No. 960690



Columbia Generating Station **Final Safety Analysis Report**	**Well Hydrographs**
	Draw. No. **990306.39** | Rev. | Figure **2.4-27.2**



Columbia Generating Station
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Site Topographic Map

Draw. No. SS053 | Rev. 0 | Figure 2.4-28

2.5 GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING

The information discussing the geology, seismology, and geotechnical engineering is contained in a technical memorandum, TM-2143, "Geology, Seismology, and Geotechnical Engineering Report." This report is incorporated by reference into the FSAR and as such is subject to the same controls as the FSAR.