INSTRUCTIONS

The following is furnished as a guide for insertion of Amendment 1 sheets into the WNP-3 Environmental Report - Operating License Stage. After inserting Amendment 1, place the transmittal letter and instruction sheets in the front of the Environmental Report to maintain a record of the changes. Several unrevised pages (Sections 2.2 and 5.3 in particular) are included because of pagination errors in approximately half the distributed copies.

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2.1.2.1 Population Within Ten Miles

The 1980 population and projections by decade through the year 2030 for each of the sectors within ten miles of the plant site are listed in Table 2.1-2 which may be keyed to sectors shown in Figure 2.1-3.

The nearest incorporated communities with population exceeding 1,000 are the City of Elma, located approximately four miles northeast of the site with a 1980 population of 2,720, and the City of Montesano, located six miles west-northwest with a 1980 population of 3,247 people.(1) Of the 80 sectors (22.5^{o} x 1 radial mile areas) within a 5-mile radius of the site, 42 were uninhabited in 1980; it is anticipated that they will continue to remain uninhabited during the period through 2030.(13,14)

2.1.2.2 Population Between Ten and Fifty Miles

Population estimates and projections by decade through the year 2030 for each 22.5^{o} sector between the ten and fifty-mile radii are presented in Table 2.1-2. The 50-mile radius encompasses a ten-county region. The counties vary from a low rural population density to a high urban population density. The economic basis of the rural counties is primarily the forest products industry. These counties include Grays Harbor, Pacific, Lewis, Wahkiakum, Mason, Cowlitz, and Jefferson. Most of these counties have experienced a stable or moderate population growth for the last 30-40 years with the exception of the last decade in which higher growth rates have occurred. In the future, it is expected that these recent trends will continue as the rural counties expand their economic base.(15)

The urban counties of Pierce, Thurston, and Kitsap have high population densities and diversified economic bases. A substantial portion of industrialized Pierce County is located within the 50-mile radius. Pierce County has grown faster than most of the rural counties during the last ten years and it is projected to continue to grow at a substantial rate. Thurston County is the location of the State capital. During the last ten years, this county has experienced rapid growth in response to increased government employment. It is projected that growth in Thurston County will continue to respond to activity in the State government.

Kitsap County is less populated than Thurston or Pierce Counties, although it is still considered an urban region. Only a small portion of the county falls within the 50-mile radius of the plant. During the last ten years the county has grown rapidly as a result of construction of the Trident Submarine Support Base. It is expected that Kitsap County will grow at a moderate rate in the future; although probably not to the extent it has in the past decade. |1

2.1.2.3 Transient Population

The transient population within ten miles is composed primarily of teachers and students at public schools, nursing home residents, employees in logging operations and at industrial facilities, and area hunters and fishermen.

Public facilities and institutions within 10 miles of the site where people may work or reside temporarily are listed in Table 2.1-3.[16-19] Also listed is the Mark E. Reed Memorial Hospital in McCleary which is slightly outside the 10-mile radius. In 1981 this institution was licensed for 26 beds and had an anverage occupancy of 50% in 22 beds.[18]

1 Excepting the Cities of Elma and Montesano and the public facilities listed in Table 2.1-3, the four largest employers in the vicinity of WNP-3 are:

Employer	Employees July 1981	Employees Peak	Location
Elma Plywood	25	120	8 mi NE
Ventron Corporation	50	75	5 mi ENE
Anderson Logging Company	35	50	5 mi ENE
Elma Cedar Products	20	40	5 mi ENE

Logging activity can vary considerably from area to area. The approximately 100,000 acres of commercial forest within the 10-mile radius are shown in Figure 2.1-6. Table 2.1-4 illustrates the number of employees which could be employed in each sector based upon an annual yield estimate. Since one logging operation employs approximately 10 persons, it could be assumed that approximately 12 different logging operations (or about 120 persons) could be employed during the course of one year within this 10-mile radius.

Fishing and hunting are also contributors to transient populations. Figure 2.1-5 shows the estimated seasonal totals of big games and upland bird hunters within 10 miles of the site. The Chehalis River and its tributaries, the Satsop and Wynoochee Rivers, provide a number of public swimming, boating, hunting and fishing areas. Table 2.1-5 provides estimates of peak numbers of fishermen for areas with 10 miles of the plants. In addition, a total of 1600 waterfowl hunters may use the 25-mile segment of the Chehalis River Valley over the course of the hunting season.[20] All of these sportsmen cannot plausibly be expected to be in the area at the same time.

Table 2.1-6 lists county and state camping and fishing facilities located within 10 miles of the site. Camp Delezene, a year-round Boy Scout camp, is located at three miles southeast of WNP-3 on Delezene Creek Road. The

TABLE 2.1-2
(SHEET 3 OF 4)
POPULATION WITHIN 50 MILE RADIUS OF WNP-3/5
BY RADII AND COMPASS SECTORS

DISTANCE (MILES)	DIRECTION (COMPASS SECTOR)	1980 NUMBER	1980 CUMULATIVE TOTAL	1986 NUMBER	1986 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	
10-20	N	410	15,575	445	16,637	469	17,384	522	19,828	561	22,333	602	25,[illegible]	636	27,739	
	NNE	499	16,074	544	17,184	574	17,958	637	20,465	675	23,008	716	25,719	744	28,483	
	NE	1,902	17,976	2,005	19,189	2,173	20,131	2,501	22,966	2,824	25,832	3,177	28,896	3,540	32,023	
	ENE	2,292	20,268	2,453	21,642	2,560	22,691	2,817	25,783	3,107	28,939	3,423	32,319	3,725	35,748	
	E	406	20,674	430	22,072	446	23,137	468	26,251	496	29,435	526	32,845	547	36,295	
	ESE	2,491	23,105	2,783	24,855	2,979	26,116	3,322	29,573	3,557	32,992	3,816	36,661	4,029	40,324	
	SE	1,789	24,954	2,012	26,867	2,160	28,276	2,683	32,256	3,323	36,315	3,621	40,282	5,095	45,419	
	SSE	440	25,394	442	27,309	444	28,720	447	32,703	454	36,769	463	40,745	474	45,893	
	S	562	25,956	562	27,871	562	29,282	562	33,265	562	37,331	562	41,307	562	46,455	
	SSW	811	26,767	818	28,689	824	30,106	838	34,103	854	38,185	871	42,178	888	47,343	
	SW	436	27,203	438	29,127	440	30,546	440	34,543	451	38,636	458	42,636	465	47,808	
	WSW	147	27,350	160	29,287	168	30,714	189	34,732	213	38,849	239	42,875	266	48,074	
	W	30,073	57,423	30,758	60,045	31,215	61,929	33,125	67,857	34,731	73,080	36,109	78,984	37,371	85,445	
	WNW	1,107	58,530	1,143	61,188	1,167	63,096	1,259	69,116	1,341	74,421	1,420	80,404	1,490	86,935	
	NW	430	58,960	444	61,632	453	63,549	486	69,602	518	74,939	549	80,953	576	87,511	1
	NNW	50	59,010	55	61,687	58	63,607	60	69,662	75	75,014	85	81,038	96	87,607	
20-30	N	42	59,052	42	61,729	42	63,649	42	69,704	42	75,056	42	81,080	42	87,649	
	NNE	1,019	60,071	1,110	62,839	1,172	64,821	1,301	71,005	1,379	76,435	1,448	82,528	1,506	89,155	
	NE	8,680	68,751	9,461	72,300	9,982	74,803	11,080	82,085	11,745	88,180	12,450	94,978	12,948	102,103	
	ENE	26,535	95,286	32,903	105,203	37,149	111,952	44,579	126,664	49,483	137,663	55,421	150,399	60,963	163,066	
	E	34,920	130,206	43,300	148,503	48,888	160,840	58,666	185,330	65,119	202,782	72,934	223,333	80,227	243,293	
	ESE	6,231	136,437	6,978	155,481	7,477	168,317	8,224	193,554	8,717	211,499	9,240	232,573	9,610	252,903	
	SE	13,210	149,647	15,191	170,672	16,512	184,829	20,145	213,699	21,354	232,853	22,635	255,208	23,5[illegible]0	276,443	
	SSE	638	150,285	676	171,348	702	185,531	758	214,457	803	233,656	851	256,059	885	277,328	
	S	444	150,729	444	171,792	444	185,975	444	214,901	444	234,100	444	256,503	444	277,772	
	SSW	1,919	152,648	1,976	173,768	2,014	189,989	2,074	216,975	2,198	236,298	2,330	258,833	2,423	280,195	
	SW	4,128	156,776	4,462	178,230	4,685	192,674	4,690	221,665	4,961	241,259	5,259	264,092	5,469	285,664	
	WSW	684	157,460	745	178,975	785	193,459	870	222,541	947	242,206	1,031	265,123	1,096	286,760	
	W	3,937	161,397	4,059	183,034	4,143	197,602	4,462	227,003	4,745	246,951	5,014	270,137	5,254	292,014	
	WNW	869	162,266	907	183,941	933	198,535	1,029	228,032	1,119	248,070	1,210	271,347	1,296	293,310	
	NW	667	162,933	695	184,636	714	199,249	790	228,891	859	248,929	929	272,276	995	294,305	
	NNW	145	163,078	146	184,782	146	199,395	148	229,040	148	249,077	148	272,424	148	294,453	
30-40	N	18	163,096	18	184,800	18	199,413	18	229,058	18	249,095	18	272,442	18	294,471	
	NNE	1,577	164,673	2,088	186,888	2,429	201,842	3,158	232,216	3,505	252,600	3,926	276,368	4,319	298,790	
	NE	5,334	170,007	7,062	193,950	8,214	210,056	10,678	242,894	11,853	264,453	13,275	289,643	14,603	313,393	
	ENE	13,321	183,328	18,116	212,066	21,314	231,370	27,708	270,602	30,756	295,209	34,447	324,090	37,891	351,284	
	E	34,345	217,673	46,709	258,775	54,952	286,322	71,438	342,040	79,296	374,505	88,812	412,902	97,693	448,977	
	ESE	2,760	220,433	3,174	261,949	3,450	289,772	4,209	346,249	4,462	378,967	4,730	417,632	4,919	453,896	
	SE	12,560	232,993	1,444	263,393	15,700	305,472	19,154	365,403	20,303	399,270	21,521	439,153	22,382	476,278	
	SSE	1,465	234,458	1,553	264,946	1,612	307,084	1,741	367,144	1,845	401,115	1,956	441,109	2,034	478,312	
	S	396	234,854	396	265,342	396	307,480	396	367,540	396	401,511	396	441,505	396	478,708	
	SSW	269	235,123	277	265,619	282	307,762	290	367,830	307	401,818	325	441,830	338	479,046	1
	SW	1,056	236,179	1,141	266,760	1,198	308,960	1,310	369,140	1,389	403,207	1,472	443,302	1,531	480,577	
	WSW	1,596	237,775	1,815	268,575	1,962	310,922	2,450	371,590	2,683	405,890	3,738	447,040	4,574	485,151	
	W	4,075	241,850	4,702	273,277	5,173	316,095	6,717	378,307	8,617	414,507	10,987	458,027	13,883	499,034	
	WNW	2,255	244,105	2,630	275,907	2,914	319,009	3,853	382,160	5,035	419,542	6,532	464,559	8,402	507,436	
	NW	46	244,151	49	275,956	51	319,060	58	382,218	63	419,605	68	464,627	73	507,509	
	NNW	695	244,846	753	276,709	794	319,854	930	383,148	1,075	420,680	1,235	465,862	1,406	508,915	

TABLE 2.1-2
(SHEET 4 OF 4)
POPULATION WITHIN 50 MILE RADIUS OF WNP-3/5
BY RADII AND COMPASS SECTORS

DISTANCE (MILES)	DIRECTION (COMPASS SECTOR)	1980 NUMBER	1980 CUMULATIVE TOTAL	1986 NUMBER	1986 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	
40-50	N	3	244,849	3	276,712	3	319,857	3	383,151	3	420,683	3	465,865	3	508,918	
	NNE	1,817	246,666	2,364	279,076	2,750	322,607	3,575	386,726	3,968	424,651	4,444	470,309	4,888	513,806	
	NE	15,247	261,913	20,186	299,262	23,480	346,087	30,524	417,250	33,882	458,533	37,948	508,257	41,743	555,549	
	ENE	223,901	485,814	249,835	549,097	267,125	613,212	302,535	719,785	335,814	794,348	376,112	884,369	413,723	969,272	
	E	11,299	497,113	12,395	561,492	13,125	626,337	14,375	734,160	15,238	809,586	16,152	900,521	16,798	986,070	
	ESE	2,438	499,551	2,584	564,076	2,682	629,019	2,897	737,057	3,071	812,657	3,255	903,776	3,385	989,455	
	SE	6,619	506,170	7,015	571,091	7,280	636,299	7,862	744,919	8,334	820,991	8,834	912,610	9,187	998,642	
	SSE	2,741	508,911	2,905	573,996	3,015	639,314	3,256	748,175	3,451	824,442	3,658	916,268	3,805	1,002,447	
	S	1,111	510,022	1,135	575,131	1,144	640,453	1,184	749,359	1,208	825,650	1,214	917,482	1,263	1,003,718	1
	SSW	1,349	511,371	1,458	576,589	1,531	641,989	1,670	751,029	1,770	827,420	1,876	919,361	1,951	1,005,669	
	SW	2,213	513,584	2,391	578,980	2,511	644,500	2,750	753,779	2,915	830,335	3,090	922,451	3,214	1,008,883	
	WSW	0	513,584	0	578,980	0	644,500	0	753,779	0	830,335	0	922,451	0	1,008,883	1
	W	0	513,584	0	578,980	0	644,500	0	753,779	0	830,335	0	922,451	0	1,008,883	
	WNW	73	513,657	81	579,061	87	644,587	107	753,886	135	830,470	169	922,620	209	1,009,092	
	NW	749	514,406	854	579,915	932	645,519	1,185	755,071	1,489	831,959	1,860	924,480	2,302	1,011,394	
	NNW	548	514,954	594	580,509	627	646,145	733	755,804	847	832,806	973	925,453	1,108	1,012,502	

TABLE 2.1-3

PUBLIC FACILITIES WITHIN 10 MILES OF WNP-3

Type of Facility	Name of Facility	Direction	Distance (Miles)	Average Number of Users (1981)	
Schools	Satsop School District #104: Satsop Elementary	NNW	3	62 Students; 6 Staff	
	Elma School District #68:	NE	4	31 Staff	
	Elma Elementary	NE	4	810 Students; 62 Staff	1
	Elma Secondary (Jr.-Sr. High)	NE	4	924 Students; 76 Staff	
	Montesano School District #66:	WNW	7	101 Staff	
	Simpson Avenue Elementary	WNW	7	38C Students	
	Beacon Avenue Elementary	WNW	7	425 Students	
	Montesano Jr.-Sr. High	WNW	7	673 Students	
Hospitals	Mark E. Reed Hospital	NE	11	55 Staff; 11 Patients	
Nursing Homes	Beechwood Nursing Home	NE	4	35 Patients; 20-23 Staff	
	Oakhurst Convalescent Center	NE	4	180 Patients; 148 Staff	
	Woodland Terrace Nursing Home	WNW	7	30 Patients; 35 Staff	
	Edgewood Manor Nursing Home	WNW	7	37 Patients; 22-24 Staff	
Penal Institutions	Grays Harbor County Jail	WNW	7	41 Prisoners; 12 Staff	
Other Facilities	Elma Air Field (Washington State Aeronautics Commission)	NE	3-1/4	N/A	
	Grays Harbor Youth Home Elma (Grays Harbor County Juvenile Dept.)			10 Residents; 7 Staff	

TABLE 2.1-4

TIMBER PRODUCTION EMPLOYEES[a] WITHIN 10 MILES OF WNP-3

Sector	Primary Ownership	Acres	Average Annual Yield (10^3 bf)[b]	Employees[c]
N	Private	3,840	2,070	4.53
NNE	"	6,080	3,277	7.17
NE	"	320	172	.37
ENE	"	640	345	.76
E	State (Capital Forest)	1,920	1,035	2.27
ESE	Private/State	3,520	1,897	4.15
SE	"	8,320	4,484	9.82
SSE	"	12,480	6,727	14.73
S	"	12,800	6,899	15.11
SSW	"	12,160	6,554	14.35
SW	"	11,200	6,037	13.22
WSW	"	11,520	6,209	13.60
W	"	640	345	.76
WNW	Private/Local Government	2,560	1,380	3.02
NW	Private	9,600	5,174	11.33
NNW	"	3,520	1,897	4.15
TOTAL		101,120	54,502	119.36

Source: Reference 2.1-20

1 (a)Possible employment estimated from average annual yields.

(b)Acres X 1976 Grays Harbor Co yield/acre (0.539 thousand board feet)

(c)Average annual yield X number of employees/10^6 board feet (2.19)

2.2 ECOLOGY

2.2.1 Terrestrial Ecology

General descriptions and data collected before 1975 on flora and fauna found in the vicinity of WNP-3 are described in Section 2.7 of the Environmental Report-Construction Permit Stage.(1) The following discussions of the terrestrial ecology focuses on data collected from 1975 through 1980.

2.2.1.1 Vegetation

The vegetation communities surrounding the site can be divided into three topographic areas: upland areas, river terraces, and riparian areas along the Chehalis River and creek bottoms. In general, the site area is forested with some pasture and agriculture usage along the river (Figure 2.2-1). The upper creek bottoms and terraces are populated by conifers | 1
and stands of second growth hardwood dominated by red alder (Alnus rubra). Mixed stands of hardwoods and conifers are found on the river terraces. On the steep upper slopes, Douglas fir (Pseudotsuga menziesii) is the dominant timber and above the 300-foot contour, nearly pure stands of conifers have developed. Bigleaf maple (Acer macrophyllum), vine maple (Acer circinatum), willow (Salix sp.), black cottonwood (Populas trichocarpa), cascara (Rhamnus purshiana), western hemlock (Tsuga heterophylla) and western red cedar (Thuja plicata) are the common species in the area. Forests in this area are generally managed so that they maintain the earlier stages of succession, because red alder is used for pulpwood and the Douglas fir for saw timber. The WNP-3 site is approximately 800 acres and in the past supported coniferous vegetation. However, most of the vegetation on the site was harvested once before and represented second growth.

Table 2.2-1 presents a representative list of 219 plant species identified near the site, representing 165 genera and 65 families. The understories in forested areas are dominated by a dense growth of shrubs, herbaceous species, ferns and bryophytes. The principal shrub is salal (Gaultheria shallon). This straggling plant forms dense tangles in many areas. Red huckleberry (Vaccinium parvifolium), oregon grape (Berberis nervosa), and sword fern (Polystichum munitum) are also common. | 1

The approach of the Terrestrial Ecology programs in 1978 through 1980 was to use intensive sampling within four small watersheds as a basis for evaluating potential impacts. The watersheds were selected to be representative of the two major habitat types surrounding the site (i.e., maturing second-growth coniferous forests and recent clearcuts). They were selected in matched pairs so that areas adjacent to the plant site could be compared with areas outside the influence of the plant. Two forested watersheds (called treatment and control) near WNP-3 were sampled in 1978 (Figure 2.2-2).(1) The dominant species were similar in both forested areas. Sword fern (Polystichum munitum) covered 32 and 17 percent of the treatment and control forest plots, respectively. Salal was second to sword fern in cover dominance, with values of about 10 percent in both forests. Deer fern (*Blechnum spicant*) was third in dominance at over 6 percent in the treatment forest, but covered less than 1 percent in the control forest. Foamflower (*Tiarella trifoliata*) had a mean coverage of 5 percent in both forests, ranking third in dominance in the control forest and fourth in the treatment forest. Both salal and foamflower were widely distributed in the forested watersheds. Although low in coverage, Pacific brome grass (*Bromus pacificus*) and immature grass plants were well-distributed only in the control forest. Seedlings of western red-cedar and western hemlock yielded low coverage and frequency values in both forests, but only the control forest contained seedlings of Douglas fir.

Two clearcut watersheds (called treatment and control) near WNP-3 were sampled 1978-1980 (Figure 2.2-2).[2,3,4] The treatment and control clearcut watersheds were similar in plant species coverage and frequency in 1978 through 1980. In 1980, 39 and 41 vascular plant species were
1| found in sampled areas of the control and treatment clearcuts, respectively. Approximately 75 percent of the plants were common to both watersheds. Pacific blackberry (*Rubus ursinus*) was the dominant cover species, with coverage of 40.7 and 28.3 percent in the treatment and control clearcuts, respectively. Other species with relatively high cover values in both watersheds were bracken fern (*Pteridium aquilinum*) and common velvet-grass (*Holcus anatus*). In the treatment clearcut, 13 species had cover values exceeding 2 percent. Predominant among these species were thimbleberry (*Rubus parviflorus*), Oregon grape, pearly-everlasting (*Anaphalis margaritacea*), and Douglas fir seedlings. In the control clearcut, 12 species had cover values exceeding 2 percent; predominant among these were hairy cat's-ear (*Hypochaeris radicata*), fireweed (*Epilobium augustifolium*), and seedlings of Douglas fir, vine maple and bitter cherry (*Prunus emarginata*).

In summary, vegetation near the site can be described as follows: (1) within the study site vegetation is highly diverse and is no longer representative of the former climax vegetation of the Western Hemlock Zone; (2) much of the vegetation diversity can be attributed to timber and agricultural practices; (3) the dominant vegetation in the lower elevation and
1| moist areas is red alder and on the upper steep slopes and level uplands Douglas fir is the dominant species; (4) the forest land produces high-quality timber; (5) forest management techniques (e.g., natural and artificial seeding, thinning, fertilization, etc.) are used to maintain vegetation in a state of intermediate forest succession so yields of the commercially valuable Douglas fir can be sustained; and (6) the early successional stages on the upper terraces and along the creeks result in
1| an interspersion of cover types ideal for some wildlife species.

2.2.1.2 Wildlife

Visual observations and consultations with State game biologists indicate that the characteristic wildlife species of the region are well represented in the vicinity of the site. Forest management and agricultural practices often keep areas in early stages of succession, which is conducive to many desirable species of wildlife. The open hardwoods are important feeding areas for wildlife. The conifer areas provide cover and protection from severe weather conditions. Generally, most game animals thrive in areas of new growth which follow logging activity. Extensive pure stands of conifers are less desirable for wildlife production than mixed wood or hardwood forests.

Mammals

Forty-nine species of mammals representing 7 orders and 17 families are known to occur in the Satsop area (Table 2.2-2). Twelve species have been identified by sightings or other signs of activity, while an additional 37 species have not been observed but their range is thought to include the site environs. 1

The black-tailed deer (*Odocoileus hemionus columbianus*) is one of the most significant species in the area, both from an economic and a recreational viewpoint. Studies performed near the site in the 1950s indicated populations of 26 to 48 deer per square mile.(5) Recent estimates for the Wynooche-Satsop Game Management Unit project the population at about 21 per square mile.(6) Estimates in 1980 for two Washington Game Department Management units near WNP-3 ranged from 12 to 15 deer per square mile.(6) 1

Pellet-group counting was used to estimate deer population densities on forested and clearcut watersheds in the vicinity of WNP-3 (see Figure 2.2-2). Studies were performed during the spring and fall in 1978 through 1980 and densities ranged from 0 to 9 deer per square mile.(4) The fall survey actually represents the late spring-summer-early fall period; the spring survey represents the late fall through early spring period. The control clearcut watershed had the highest deer densities each year. Deer use of both clearcuts in the summer has tended to increase each year from 1978, while deer use of the clearcuts in the winter has been relatively stable. Deer densities in the forested watersheds were low for all seasons of 1978 through 1980. Deer populations are expected to continue to increase in both clearcuts during the initial years of plant succession and to remain low in the two forested watersheds. This relationship exists because second-growth forests (i.e., the forested watersheds) characteristically have low deer forage production while forage production in clearcuts typically increases during the early years of plant succession.(5) 1

The elk (*Cervus canadensis*) density for the Satsop area in 1980 was estimated at 2.4 individuals per square mile.(6) However, no elk pellets were found in 1978 through 1980 in the watersheds studied near the WNP-3 site.

Another important big game animal in Washington is the black bear (*Ursus americanus*). Black bear have been infrequently sighted near the site.

The density for the Satsop game management unit in 1980 was estimated at 0.88 bear per square mile.[6] This is close to the one bear per square mile of available black bear habitat projected for the entire state by Poelker and Hartwell in 1973.[7]

Other terrestrial and aquatic mammals that occur near the site, but for which there is little specific information, are mountain beaver (Aplodontia rufa), beaver (Castor canadensis), muskrat (Ondatra zibethica), raccoon (Procyon lotor), striped skunk (Mephitis mephitis), coyote (Canis latrans), long-tailed weasel (Mustela frenata) and red fox (Vulpes fulva).[1]

1 Small mammals (mice and shrews) were surveyed during 1978 using live-trapping and multiple mark-and-recapture methods.[2] A grid of 169 trap stations was established in each of four watersheds (Figure 2.2-2). Baited Sherman live traps were checked daily for four consecutive days. The mark-and-recapture method provided relative abundance and density estimates for deer mice (Peromyscus maniculatus), Pacific jumping mice (Zapus trinotatus), shrews (Sorex spp.), Townsend's chipmunk (Eutamias townsendii), northern flying squirrel (Glaucomys sabrinus) and short-tailed weasel (Mustela erminea) (Table 2.2-3).

Amphibians and Reptiles

Amphibians and reptiles observed and known to occur in Grays Harbor County are listed in Table 2.2-4. The most abundant amphibians observed near the site are the Pacific Northwest newt (Tarica granulosa) and the Western wood frog (Rana aurora). Only one species of reptile, the dusky garter snake (Thamnophis elegans), was observed near WNP-3.

Birds

Birds are ecologically and aesthetically important components of the ecosystem surrounding WNP-3. A list of the species found near WNP-3 and the habitat in which they are found is presented in previous documents.[1,8,9] Bird studies performed in 1978 through 1980[2,3,4] near WNP-3 include: 1) breeding and winter surveys of watersheds and roadsides close to the site, 2) ruffed (Bonasa umbellas) and blue (Dendragapus obscurus) grouse surveys during the breeding season in forested and clearcut watersheds, and 3) aquatic bird surveys of the Chehalis River.

Overall, 124 bird species were encountered in the study area during 1979-80 compared to 111 in 1978-79.[4] Results of the 1978-79 and 1979-80 surveys were quite similar. One hundred species were recorded in common for both survey periods. An additional 24 new species were encountered in 1979-80.

1 Forty-six bird species were identified in the experimental watersheds (Figure 2.2-2) during the 1980 breeding season. This compares to 47 and 44 species encountered in 1978 and 1979, respectively. The number of

species observed in the treatment and control forests were similar from 1978 through 1980. Twenty-eight species in the control forest and 25 in the treatment forest were identified as breeders or visitors to the watersheds. The winter wren (Troglodytes troglodytes) was the most abundant species in both watersheds, while the golden-crowned kinglet, (Regulus satrapa), chestnut-backed chickadee (Parus rufescens), Wilson's warbler (Wilsonia pusil . and western flycatcher (Empidonax difficilis) were common.

During 1978 and 1979, the species diversity of breeding birds was similar between the control and treatment clearcuts. In 1980 the control clearcut had more breeding bird species than the treatment clearcut. Twenty-five species were observed in the control clearcut and 18 in the treatment clearcut. The white-crowned sparrow (Zonotrichia leucophrys) and dark-eyed junco (Junco hyemalis) were the predominant species observed in both watersheds 1978-1980. During these three years, the American goldfinch (Spinus tristis), song sparrow (Melospiza melodia), and rufous-sided towhee (Pipilo erythrophthalmus) were also common in the clearcut areas. The total density of birds in breeding territories was substantially higher in both clearcuts in 1980 than reported in previous years.

Winter bird surveys of the four watersheds were also conducted during 1978-1979 and 1979-1980. During both surveys, species diversity and abundance of birds were greatest in the forest watersheds. These values were particularly high in the control forest. The golden-crowned kinglet and winter wren were consistently the most abundant species observed in the forested watersheds. In the clearcut watersheds, species diversity and relative abundance were generally highest in the treatment watershed during both survey periods. In the two clearcuts, the darkeyed junco was the predominant species recorded during the 1979-1980 surveys, while the golden-crowned sparrow (Zonotrichia atricapilla) was the predominant species in the 1978-1979 winter survey.

The results of the 1979 and 1980 roadside breeding bird surveys were similar. Eighty-eight species were observed in 1979 and 1980. Of these, 74 species were recorded in both years. While the species' richness was comparable between years, the mean number (478) of birds recorded during the 1978 surveys was 15 percent below that recorded in 1979.

The American robin (Turdus migratorius) and song sparrow were the most abundant and most frequently observed species. Other species abundantly present during both survey periods were the common crow, (Corvus brachyrhynchos), Swainson's thrush (Catharus ustulatus), savannah sparrow (Passerculus sandwichensis), and American goldfinch.

The principal forest game birds are ruffed and blue grouse. A minimum of five grouse surveys were performed during the spring of 1979 and 1980 at 15 roadside stations near the plant site (i.e., treatment route) and at 15 stations outside the influence of the plant (i.e., control route) (Figure 2.2-3).

The mean densities (number counted per survey) for the adult male ruffed
grouse along treatment and control survey routes were similar in 1979 (2.2
vs 2.0).[2] However, in 1980 the control route had densities four times
1 greater than the treatment route (2.8 vs 0.7).[3]

Adult blue grouse were also more abundant along the control route than the
treatment route in both 1979 and 1980. The control route yielded means of
3.8 and 4.7 while the treatment means were 1.0 and 0.7 for 1979 and 1980
respectively.[2,3] The differences between control and treatment routes
are probably due in part to higher noise levels near WNP-3 and to reduced
coniferous habitat along the treatment route.

Previous studies[1] describe the birds using the aquatic habitat near WNP-3 and important migratory waterfowl common to the area. An update of this information is provided by aquatic bird surveys of the Chehalis River performed monthly, November 1978 through December 1980.[2,3]

During these surveys the green-winged teal (*Anas carolinensis*), American wigeon (*Mareca americana*), mallard (*Anas platyrhynchos*), scaup species (*Aythya* spp.) and the common (*Mergus merganser*) and hooded mergansers (*Lophodytes cucullatus*) were the most numerous waterfowl. The most commonly observed nonwaterfowl were the killdeer (*Charadrius vociferus*), great blue heron (*Ardea herodias*), gulls (*Larus* spp.), double-crested cormorant (*Phalacrocorax auritus*), belted kingfisher (*Megaceryle alcyon*), spotted sandpiper (*Actitis maculaira*) and green heron (*Butorides virescens*).

Many avian predators are common to the site and the surrounding area.
Hawks and falcons, which hunt during the day, are represented by at least
1 ten species. The red-tailed hawk (*Buteo jamaicensis*) and American kestrel
(*Falco sparverius*) are most commonly seen. The bald eagle (*Haliaeetus
leucocephalus*), marsh hawk (*Circus cuaneus*), and osprey (*Pandion
haliaetus*) have also been observed. Seven species of owl, which are noc-
turnal predators, are known to occur in the area. These generally nest in
trees, wooded and bushy areas, or man-made structures. The largest of the
1 owls is the great-horned owl (*Bubo virginianus*).

2.2.1.3 Threatened and Endangered Species

Two federally listed threatened or endangered animal species may occur
near WNP-3, the bald eagle and peregrine falcon (*Falco peregrinus*).[11]
Bald eagles were observed along the Chehalis River during the 1978-1980
1 aquatic bird surveys.[2,3,4] In 1979 through 1980 a single bald eagle
was observed in November, March through May, July, August and October.[4]
No active eagle nests were seen along the river in the three survey years.
Peregrine falcons were not observed during bird surveys performed near the
1 site during 1978 through 1980.[2,3,4] The construction and operation of
WNP-3 is not expected to result in the damage or loss of individuals of
any species presently regarded as threatened or endangered.

2.2.2 Aquatic Ecology

The physical and chemical characteristics of the Chehalis River in the vicinity of WNP-3 are presented in Section 2.4. Studies concerned with various aquatic organisms in the Chehalis River, relating mainly to construction and preoperational phases of WNP-3, were conducted in 1973 through 1980.[1-4,12-17] Sampling locations for the 1980 program are shown in Figure 2.2-4. The following paragraphs summarize the essential characteristics of the major aquatic communities. |1

2.2.2.1 Phytoplankton and Macrophytes

Phytoplankton studies were performed July through October 1973.[1] Samples were examined to determine species composition and relative abundance. Nineteen diatom genera were identified. Sampling in the Chehalis River at Fuller Bridge showed a predominance of Navicula, Nitzschia, Cocconeis, and Melosira.

Qualitative surveys of macrophytes in the Chehalis River were performed April through September 1976 at three sampling areas.[12] During spring and early summer, macrophyte growth was sparse; most species appeared only during July through October. Twelve species were widely dispersed and occurred in relatively small groups in the river. Potamogeton spp., Elodea canadensis and Fontinalis antipyretica were the predominant species collected.

Many characteristics of the Chehalis River are thought to limit the productivity of aquatic macrophytes. The banks along pool sections drop abruptly off to deeper water a short distance from shore. High turbidity of the river during many months inhibits macrophyte growth in deeper waters. Bank erosion is considerable, and in many areas riparian vegetation overhangs the river, providing shade. The shade and erosion discourage the establishment of emergent and submergent aquatic vegetation. During the winter, virtually the entire river bottom is scoured due to high sediment loads and current velocities. |1

In the lotic environment of the Chehalis River both phytoplankton and macrophyte contributions to the food web are limited because of low production and little grazing by herbivores.

2.2.2.2 Periphyton

Periphyton, algae that attaches to substrates, were sampled from 1976 through 1980 in the Chehalis River.[2,3,4,12,13] Since the Chehalis River is moderately fast flowing, primary production is probably limited to the attached forms of diatoms, blue-green algae and green algae. From 1978 through 1980 when periphyton were sampled on standard glass slide substrates, diatoms and blue-green algae were by far the most numerous algal groups in terms of cells counted. The most abundant diatom genera collected during this period were Cocconeis, Achnanthes, Cymbella, | 1

Gomphonema, Synedra and Navicula; Chamaesiphon and Lyngbya were the
1 dominant blue-green genera. Biomass (ash-free dry weight) averages for
July and September collections in 1979 and 1980 were 1.0 and 1.2 g/m^2,
respectively. Cell density from artificial substrates collected during
July and September averaged approximately 14,000, 37,000 and 15,000
cells/mm^2 during 1978, 1979 and 1980, respectively.[4] The greater
density in 1979 was due to an increase in blue-green algae.

2.2.2.3 Zooplankton

Zooplankton were sampled along the shoreline of the Chehalis River in June
and July 1973.[1] Zooplankton densities were consistently low and seldom
averaged more than 300 individuals per sweep net station. Canthocamptus
and Cyclops were the dominant copepod genera and were consistently more
abundant than cladocerans in all samples. Dipterans (Tendipedidae) were
1 the most abundant noncrustaceans collected in zooplankton samples. The
paucity of zooplankton in the lower Chehalis River is probably related to
high river velocity, natural siltation and unavailability of suitable
littoral habitat.

1 2.2.2.4 Benthic Macroinvertebrates

Chehalis River macroinvertebrates were sampled from 1976 through 1980
using either or both natural and artificial substrates.[3,4,12,13]
Generally, natural substrate samples were collected monthly, from March
through September. At least two stations were sampled, including the in-
take and discharge areas. On dates when both artificial and natural sub-
1 strates were sampled the number of benthic taxa and densities were greater
for artificial substrates.[17] Midges (Chironomidae) were numerically
dominant in most samples. Other abundant groups in the vicinity of WNP-3
include scuds (Gammarus sp.), true flies (Diptera), may-flies (Ephemerop-
tera), caddisflies (Trichoptera), stoneflies (Plecoptera) and beetles
1 (Coleoptera), snails (Gastropoda), and worms (Oligochaeta). The mean
densities of macroinvertebrates collected on artificial substrates (i.e.,
multiple plate samples) range from approximately 1000 to 3000 individuals
per sample in 1977 through 1979. Densities were generally highest in the
1 spring and lowest for the autumn exposure period. Statistical tests (on
natural substrate data) reveal that densities were lowest in 1976 and 1978
and highest in 1977 and 1979.[17] The low densities may be the result
of floods which preceded the 1976 and 1978 sampling programs.

1 2.2.2.5 Chehalis River Fish

A complete list of fish species in the Chehalis River Basin and fish life
history information is presented in other documents.[1-4,12,13,18]
Twenty-five fish species (Table 2.2-5) were captured by electrofishing and
beach seining near WNP-3 from 1977 to 1979.[2,3,13] Anadromous three-
spine stickleback (Gasterosteus aculeatus), redside shiner (Richardsonius
balteatus), northern squawfish (Ptychocheilus oregonensis) and largescale
1 sucker (Catostomus macrocheilus) were in terms of numbers the four most

abundant fish, comprising 59 percent of the fish collected between 1977 and 1979. Salmon (i.e., chinook, chum, coho) and trout (rainbow and cutthroat) represented approximately 10 and 3 percent of the catch, respectively.

Of the fish found in the Chehalis River study area, various species of salmonids have the highest commercial and recreational value. Because of the value of chinook and coho salmon and rainbow/steelhead trout, concern for maintaining their populations is high. In recognition of this concern, the State of Washington maintains an extensive fisheries management program for these species. Chinook, coho and steelhead trout are stocked in numerous rivers and streams throughout the state and help to maintain the Pacific Northwest recreational and commercial fishery. In addition to their significance in terms of natural resource value, these salmonid species are highly sensitive to such environmental variables as water 1
temperature and water quality.

There are marked similarities between the life histories of different anadromous salmonids in the Chehalis River (see Figure 2.2-5). The adults spend one or more years in salt water, migrate into freshwater and spawn in suitable gravel beds where waters are cool and well oxygenated. The eggs develop from fall through spring, depending on the species, and hatch from late winter to late spring. The young usually remain in the gravel until the egg sac is absorbed. Young salmonids emerge from the gravel between late winter and early summer and, again depending on the species, reside in fresh water from several days to several years before migrating to salt water. Before entering salt water, salmonids undergo a transformation called smoltification. This process is the physiological and morphological adjustment necessary to accommodate the osmotic changes produced by movement from fresh to salt water. Details of salmonid life cycles in the Chehalis River Basin are presented below together with descriptions of abundance and distribution in the study area. The following subsections focus on chinook and coho salmon and rainbow/steelhead trout, and their life histories, distribution and abundance in the Chehalis River study area. Estimates of the sizes of important Chehalis 1
River salmonid runs are given in Table 2.2-7.

<u>Chinook Salmon (Oncorhynchus tshawytscha)</u>

Chinook salmon originate from many of the rivers that drain into the North Pacific and support an important ocean sport fishery. In addition, chinook support a commercial troll fishery from central California through southeastern Alaska. As they return to fresh water to spawn, chinook are often caught in estuaries and rivers by commercial and sport fisher- 1
men.[19] Of all the Pacific salmon, chinook are the most highly regarded for the fresh fish trade. Chinook are categorized into three distinct spawning runs: fall, spring and summer. In the Chehalis River 1
the fall run predominates, but spring chinook also occur.

Fall chinook matured between 3 and 5 years of age. Their weight at maturity averages between 15 and 20 pounds.[20] Fall chinook spend from 3 to 5 months in freshwater and from 2 to 5 years in the ocean. Adults migrate upstream from August to November. Downstream migration of young chinook takes place from January to August.

Spring chinook reach maturity at 4 to 6 years of age and weigh an average of 15 pounds (range 10 to 20 pounds). They spend about one year in freshwater before migrating to the sea, and then remain in the ocean for 2 to 5 years. Adults migrate to the spawning grounds from March to early June and spawning occurs from August to mid-October. Young spring chinook, which average 5 to 6 inches, migrate downstream the second spring (1 + age-class) after the parent spawning run.[20]

The spawning patterns of the two races of chinook are distinct. Springrun chinook usually travel to upstream areas and spend the summer in resting holes before spawning in late summer; fall-run chinook usually travel shorter distances and spawn shortly thereafter.

The population density and distribution of juvenile chinook is controlled by numerous factors including availability of food, and chinook social behavior.[21] Juvenile chinook reside in waters with velocity and depth in proportion to their body size. As they grow, they shift to faster and deeper waters. Young chinook often move downstream from tributaries and remain in large streams during winter.[22]

The distribution and abundance of chinook salmon in the study area are
consistent with the knowledge of the life history of these fish as
described above. Only a small number of adult chinook (37 adults) were
1| captured during five years of sampling. This indicates that upstream
migrants spend relatively little time in this stretch of the Chehalis
during the months of sampling.

Most of the chinook captured in the study area during the monitoring programs were 0 + age-class fish. It was concluded that these fish were juvenile downstream migrants from the fall spawning run. These juvenile out-migrants have been present in the study area from January to October, with peak abundance occurring April to June. Rearing spring-run juveniles were not present in the study area in significant numbers during the monitoring programs.

Young-of-the-year Chinook salmon (age 0+) comprised 43, 48, 83 and 77 percent of all juvenile salmon captured during 1976, 1977, 1978 and 1979, respectively.[3] From 1976 through 1979 the mean fork length ranged from 47 to 59 mm, 51 to 59 mm and 67 to 73 mm for April, May and June, respectively. Mean 1979 condition factors ranged from 0.84 in March to 1.18 in August.

In summary, while the Satsop River and upstream locations on the Chehalis River are the sites of early fall spawning runs, the study area is not a spawning area for chinook. The study area is used for upstream passage of migrating adults, downstream passage of juvenile out-migrants, and some rearing of spring-run juveniles. Within the study area, young chinook appear to prefer sheltered, slow-moving waters such as are found in parts of the holding area (Figure 2.2-4). As they grow, the young chinook move to more rapidly moving water.

Coho Salmon (Oncorhynchus kisutch)

The coho is an important sport and commercial fish along the Northern Pacific coast.[23] Like the chinook, coho are anadromous, spending one to two years in fresh water and two years or more in the ocean. Coho reach maturity at three years of age; adults weigh an average of eight pounds (range from 5 to 20 pounds).

Adult coho generally migrate to fresh water from September to January. In coastal Washington, adult migration peaks in October and November. Spawning occurs from mid-October to March with the peak period from November to January. After emerging from the gravel of spawning streams, coho fry remain close to the shoreline in shallow water to conserve energy.[24] They often establish territories near fast currents because the current brings them food in the form of drifting terrestrial and aquatic insects. During downstream migration, which begins from March to July of their second year, the young coho form schools and move into swifter currents. Before and during this time they undergo smoltification. Both the Chehalis and Satsop Rivers provide suitable habitats for coho salmon. In fact, coho are the most important salmon species in these rivers in terms of commercial and sport harvest.

Significant numbers of yearling coho have been captured in the study area, 1
mostly in April, May and June. Underyearlings have been present in all months sampled; the period of peak underyearling abundance has varied within the spring to fall sampling period.

Juvenile coho salmon were the fifth most abundant salmonid in catches during 1979, second in 1978 and 1976, and first in 1977. Representative scale analysis shows the downstream migrants to be 1+ years of age with a 1
fork length of 68 to 203 mm. Mean condition factor for those individuals ranged from 1.02 in January to 1.35 in May 1979, whereas those for 0+ coho salmon ranged from 0.98 in April to 1.17 in September 1979.

Juvenile coho have exhibited slight distributional preferences. The greatest sample densities have generally occurred in the Satsop River and at the holding area (Figure 2.2-4). Large numbers of juvenile coho have also been found at the intake area. Within the discharge area (see Subsection 3.4.4), greater densities of juvenile coho have been found upstream of, rather than at the diffuser itself.

Waters in the discharge area appear to be utilized by adult coho only for migration passage. Jack coho and migrating adults (3 + age-class) have been sampled during the fall at Chehalis River locations downstream of the Satsop River, including the discharge area. No signs of coho spawning or egg incubation have been found in the discharge area during the ecological sampling programs.

Coho salmon have shown definite patterns of movement while migrating upstream through the WNP-3 diffuser area.(14) Fish movements tend to be associated with the deeper water. From approximately 550 m downstream of the diffuser, fish travel near the deeper area of the south bank. Just upstream of the diffuser, fish appear to cross into the deeper water of the northern bank. A sonic tracking program revealed that the majority (60%) of migrating coho whose movements were monitored passed the diffuser location during darkness.

1

Rainbow/Steelhead Trout (Salmo gairdneri)

Two varieties of this species exist. Trout that are strictly freshwater residents are commonly called rainbow trout, while the anadromous, or sea-run, variety is known as steelhead trout. Both varieties are highly prized as sport fish throughout the Pacific Northwest. Although significant numbers of juvenile Salmo gairdneri have been collected in the
1 study area, few mature rainbow trout have been captured there. This strongly suggests that most representatives of this species in the study area are anadromous.

Steelhead mature at 3 to 6 years of age, reaching an adult weight of 5 to 30 pounds. They spend from 1 to 3 years in freshwater and 1 to 4 years in the ocean. The period of adult migration for summer-run steelhead is June to early August; that of winter-run fish is December through April. The actual spawning for both runs takes place from February to June; egg incubation occurs from February to July. Many steelhead spawn more than once. In fact, up to 31 percent of winter-run fish may spawn a second time.(23) Downstream migration of young steelhead occurs from March to June.

While in streams, juvenile steelhead remain out of the main current to conserve energy. They usually remain close to the substratum from which they make forays into the overlying currents to capture drifting food.
1 Steelhead trout in freshwater feed on bottom living and terrestrial insects, amphipods, oligochaetes, frogs, fish, cladocerans, stoneflies, caddisflies, and mayflies.(21)

1 Steelhead comprised the fourth and third most frequently captured salmonid species in 1979-1980 and 1978, respectively. The highest densities of 0+
1 steelhead trout occurred in Satsop River catches beginning in August for 1976, 1977 and 1978. Extremely low river levels prevented Satsop River
1 sampling in 1979. Young-of-the-year (age 0+) steelhead trout from other sampling areas generally increased in mean fork length from 32 mm in May to 77 mm in October 1979. Mean condition factors for these fish ranged from 0.85 in May to 1.20 in September 1979. Similar lengths and condition factors were recorded in 1980.

1

Most of the juvenile steelhead encountered were of the 0 + age class. This age class is common in the study area from June to October with peak abundance occurring in June and July. A smaller number of yearlings and older steelhead have been captured in the study area, most often from 1
March through May. The 1+ and 2+ age class trout use areas in both the Satsop and Chehalis Rivers above the discharge area.

No seasonal peak in 1+ age class and older trout could be detected; nor were any spawning fish sampled. Washington Department of Game statistics indicate that the winter steelhead run in the Chehalis is larger than the summer run.

No distributional preferences have been observed for juvenile steelhead in the study area. Yearling and older trout have shown some preference for fast water areas with gravel substrate, as in sections of the holding area.

White Sturgeon (Acipenser transmontanus, Richardson)

White sturgeon is another species of commercial and sport value to the Grays Harbor region. Although some can be found in the ocean and ascend rivers to spawn, the species is not truly anadromous. White sturgeon utilize upper Grays Harbor and the lower Chehalis River during the entire year with the greatest abundance occurring from late September through early April when high river flows and low salinities prevail.[26] The greatest numbers in the river are found below Montesano (RM 14);[27] a survey revealed that the reach below Montesano was the section most often 1
fished by sturgeon fishermen.[28] Although not substantiated by field studies, adults may spawn in the Chehalis River during spring and early summer as gravid fish are occasionally noted in catches.[26] No sturgeon have been sampled in five years of preoperational studies and no critical habitat has been identified in the vicinity of the site.

Commercial white sturgeon landings in Grays Harbor between 1952 and 1975 have ranged from 8,200 (1952) to 81,300 lbs. (1962) and averaged 28,300 lbs.[28] Nearly 80 percent of the poundage is taken in September through November.[26]

2.2.2.6 Stream Fish 1

Fish communities in tributary streams near WNP-3 were studied from 1976 through 1980.[2-4,12,13] Fish were collected by using an electro-shocker. Initially, 15 stations were sampled,[12] whereas in 1979 1
through 1980 eight of the original locations were sampled.[3,4] The eight stations included three on Workman and Fuller Creeks and one each on Stein and Ein Creeks.

Electroshocking and mark-recapture methods were used from 1977 to 1980[2-4,13,15] to estimate fish populations and other fishery characteristics (e.g., species composition) at each sampling location. Each sampling station was 200 m in length; to isolate the sample

populations, block nets were placed at both ends of the sampling station. Two passes were made at each station. Sampling was performed in August 1980 and 1979, from August to October in 1978, and from December 1977 through February 1978. Thirteen fish species were collected from 1977 through 1979 and sculpins (79.6%), trout (6.7%), lampreys (5.0%), and
1| salmon (4.2%) comprised 95.5 percent (by numbers) of the 6,158 fish sampled.

Surveys of salmonid spawning potential have been conducted on Fuller, Workman, Elizabeth and Hyatt Creeks since 1968.[15] Methods of assessing potential spawning areas were adopted from Burner.[25] At least two surveys were conducted on each stream November 1977 through January 1978.[15] Six biweekly surveys were made of Fuller Creek and at least one in each of the other streams November 1978 through January 1979, and October 1979 through January 1980.[2-4]

The purpose of the spawning surveys was to estimate the potential spawning area available to salmonids in site streams and to document the presence or absence of spawning adults or redds. Table 2.2-6 presents the estimated potential spawning area for each stream. It is important to note that, prior to the start of construction of WNP-3, no potential spawning areas were available in any site stream sections directly affected by construction runoff except Fuller Creek.[12] A total loss of three coho or steelhead redds was estimated due to construction activities before 1978.[15] Subsequent surveys have not revealed any reduction in potential spawning areas as a result of construction activities.[4]

2.2.2.8 Threatened and Endangered Species

No federally listed threatened or endangered aquatic organisms are known to occur in the Chehalis River in the vicinity of WNP-3.[11] Consequently, the construction and operation of WNP-3 is not expected to result in the damage or loss of any aquatic species presently regarded as threatened or endangered.

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TABLE 2.2-1

PLANTS FOUND NEAR WNP-3

Type / Family / Species	Common Name
Trees (Conifer)	
Pinaceae (Pine)	
Abies grandis	Grand fir
Picea sitchensis	Sitka spruce
Pseudotsuga menziesii	Douglas-fir
Tsuga heterophylla	Western hemlock
Cupressaceae (Cypress)	
Thuja plicata	Western red cedar
Trees (hardwood)	
Aceraceae (Maple)	
Acer macrophyllum	Bigleaf maple
Acer circinatum	Vine maple
Betulaceae (Birch)	
Alnus rubra	Red alder
Corylus californica	California hazel
Cornaceae (Dogwood)	
Cornus Nuttallii	Pacific dogwood
Cornus occidentalis	Western dogwood
Fagaceae (Beech)	
Quercus garryana	Oregon white oak
Oleaceae (Olive)	
Fraxinus latifolia	Oregon white ash
Rhamnaceae (Buckthorn)	
Rhamnus purshiana	Cascara
Rosaceae (Rose)	
Prunus emarginata	Bitter cherry
Sorbus sitchensis	Mountain Ash
Salicaceae (Willow)	
Populus trichocarpa	Black cottonwood
Salix lasiandra	Western black willow
Salix piperi	Piper's willow
Salix scouleriana	Scouler's willow
Shrubs (woody plants)	
Aquifoliaceae (Holly)	
Ilex aquifolium	English Holly
Araliaceae (Genseng)	
Oplopanix horridum	Devil's club
Berberidaceae (Barberry)	
Berberis nervosa	Dull leaved Oregon grape
Caprifoliaceae (Honeysuckle)	
Linnaea americana	Twin flower
Sambucus callicarpa	Red elderberry
Sambucus glauca	Tree elderberry
Symphoricarpos albus	Snowberry
Celastraceae (Staff Tree)	
Euonymus occidentalis	Western wahoo

TABLE 2.2-1 (contd.)

Type Family Species	Common Name
Ranunculaceae (Buttercup)	
Actaea arguta	Baneberry
Aquilegia formosa	Columbine
Aruncus sylvester	Goat's beard
Coptis laciniatus	Western gold thread
Ranunculus acris	Tall field buttercup
Ranunculus bongardi	Bongard's buttercup
Ranunculus macouni	Macoun's buttercup
Ranunculus repens	Creeping buttercup
Rosaceae (Rose)	
Geum macrophyllum	Large leaved avens
Potentilla pacifica	Pacific silverweed
Potentilla palustris	Marsh Cinquefoil
Rubiaceae (Madder)	
Galium aparine	Bedstraw
Galium triflorum	Fragrant bedstraw
Saxifragaceae (Saxifrage)	
Mitella caulenscens	Leafy stemmed mitre wort
Tellima grandiflora	Large fringe cup
Tiarella trifoliata	Three leaved coolwort
Tolmiea menziesii	Bristle flower
Scrophulariaceae (Figwort)	
Digitalis purpurea	Foxglove
Glechoma hederacea	Ground ivy
Linaria vulgaris	Butter and eggs
Mimulus guttatus	Common monkey flower
Veronica americana	American speedwell
Solanaceae (Potato)	
Solanum dulcamara	Bittersweet nightshade
Sparganiaceae (Bur-reed)	
Sparganium simplex	Simple-stemmed but reed
Typhaceae (Cat-tail)	
Typha latifolia	Common cat-tail
Umbelliferae (Parsley)	
Daucus carota	Wild carrot
Heracleum lanatum	Cow parsnip
Oenanthe sarmentosa	Wooly head parsnip
Urticaceae (Stinging Nettle)	
Urtica lyallii	Stinging nettle
Violaceae (Violet)	
Viola glabella	Smooth woodland violet
Viola sempervirens	Evergreen violet
Berberidaceae (Barberry)	
Aclys triphylla	Vanilla leaf
Vancouveria hexandra	Inside-out-flower

TABLE 2.2-2

MAMMALS FOUND NEAR WNP-3

Family / Order / Species	Common Name
Marsupialia	Pouched Mammals
Didelphiidae	Opossums
Didelphis marsupialis	Opossum
Insectivora	Insect-Eaters
Soricidae	Shrews
Sorex bendirei	Pacific Water Shrew
Sorex cinereus	Masked Shrew
Sorex obscurus	Dusky Shrew
Sorex palustris	Northern Water Shrew
Sorex towbridgei	Towbridge Shrew
Sorex vagrens	Vagrant Shrew
Talpidae	Moles
Neuretrichus gibbsi	Shrew-Mole
Scapanus orarius	Pacific Mole
Scapanus townsendi	Townsend Mole
Chiroptera	Bats
Vespertilonidae	Plainnose Bats
Myotis californicus	California Myotis
Myotis evotis	Long-eared Myotis
Myotis lucifungus	Little Brown Myotis
Myotis volans	Hairy Winged Myotis
Myotis vumanensis	Yuma Myotis
Lasionverteris noctivagans	Silver Haired Bat
Lasiurus cinereus	Hoary Bat
Eptesicus fucus	Big Brown Bat
Plecotus townendi	Western Big-Eared Bat
Carnivora	Carnivores
Ursidae	Bears
Ursus americanus	Black Bear
Procyonidae	Racoons
Procyon lotor	Raccoon
Mustelidae	Weasels, Skunks, etc.
Martes americana	Marten
Mustela pennanti	Fisher
Mustela erminea	Shorttail Weasel
Mustela frenata	Longtail Weasel
Mustela vison	Mink
Lutra canadensis	River Otter
Mephitis mephitis	Striped Skunk
Spilogale putorius	Spotted Skunk

TABLE 2.2-2 (contd.)

Family Order Species	Common Name
Canidae	Dogs, Wolves and Foxes
Canus latrans	Coyote
Vulpes fulva	Red Fox
Felidae	Cats
Felis concolor	Mountain Lion
Lynx rufus	Bobcat
Rodentia	Gnawing Mammals
Aplodontiidae	Aplondontia
Aplondontia rufa	Mountain Beaver
Sciuridae	Squirrels
Eutamias townsendi	Townsend Chipmunk
Tamiasciurus douglasi	Chickaree
Glaucomys sabrinus	Northern Flying Squirrel
Castoridae	Beaver
Castor canadensis	Beaver
Cricetidae	Mice, Rats and Voles
Peromyscus maniculatis	Deer Mouse
Neotoma cinerea	Bushy tailed Woodrat
Microtus oregoni	Oregon Vole
Microtus longicandus	Longtail Vole
Microtus townsendi	Townsend Vole
Ondatra zibethica	Muskrat
Zapodidae	Jumping Mice
Zapus trinotatus	Pacific Jumping Mouse
Erethizontidae	Porcupines
Erethizon dorasatum	Porcupine
Lagomorpha	Hares and Rabbits
Leporidae	Hares and Rabbits
Lepus americanus	Snowshoe Hare
Artiodactyla	Even-Toed Hoofed Mammals
Cervidae	Deer
Cervus canadensis	Elk
Odocoileus hermionus columbianus	Black-tailed Deer

TABLE 2.2-3

NUMBER AND RELATIVE ABUNDANCE OF
SMALL MAMMALS COLLECTED NEAR WNP-3, 1978

		TCW[a]		CCW		TFW		CFW	
Common Name	Scientific Name	No.	R.A.[b]	No.	R.A.	No.	R.A.	No.	R.A.
Deer Mouse	*Peromyscus maniculatus*	122	98.4	73	97.3	15	53.6	20	48.8
Pacific jumping mouse	*Zapus trinotatus*	1	0.8	0	-	1	3.6	10	24.4
Shrews[c]	*Sorex* spp.	0	-	0	-	10	35.7	11	26.8
Townsend's chipmunk	*Eutamias townsendi*	0	-	0	-	1	3.6	0	-
Northern flying squirrel	*Glaucomys sabrinus*	0	-	0	-	1	3.6	0	-
Short tailed weasel	*Mustela erminea*	1	0.8	2	2.7	0	-	0	-
TOTAL		124	100.0	75	100.0	28	100.1	41	100.0

(a) TCW = treatment clearcut Watershed
CCW = Control Clearcut Watershed
TFW = Treatment Forested Watershed
CFW = control forested Watershed

(b) Relative abundance is given in percent

(c) Shrews are difficult to positively identify without examination of skulls; most individuals were probably Trowbridge shrews (*Sorex trowbidgei*) and vagrant shrews (*Sorex vagrans*).

TABLE 2.2-4

AMPHIBIANS AND REPTILES WHICH OCCUR IN GRAYS HARBOR COUNTY

Order Species	Common Name
Urodela	
Taricha granulosa granulosa	Pacific Northwest Newt[a]
Dicamptodon ensatus	Pacific Giant Salamander
Rhyacotriton olympicus olympicus	Olympic Mountain Salamander
Ambystoma gracile gracile	Northwestern Salamander
Ambystoma macrodactylum	Long-toed Salamander
Plethodon vandykei	Washington Salamander
Plethodon vehiculum	Western Red-Backed Salamander
Ensatina eschscholtzi oregonensis	Oregon Red Salamander
Anura	
Ascaphus truei	American Ribbed Toad
Bufo boreas boreas	Northwestern Toad
Hyla regilla	Pacific Tree Frog
Rana aurora aurora	Western Wood Frog[a]
Rana cascada	Washington Frog
Rana catesbieana	Bullfrog
Lacertilia	
Gerrhonotus coeruleaus principis	Northern Alligator Lizard
Serpentes	
Thamnophis ordinoides	Puget Garter Snake
Thamnophis elegans nigrescens	Dusky Garter Snake
Thamnophis sirtalis trilineata	Puget Sound Garter Snake
Thamnophis sirtalis fitchi	Northwestern Garter Snake

(a) Observed in the site area.

1

TABLE 2.2-5

FISH SPECIES SAMPLED IN CHEHALIS AND SATSOP RIVERS, 1977-1979

Scientific Name	Common Name
Oncorhynchus tshawytscha	Chinook Salmon
Oncorhynchus keta	Chum Salmon
Oncorhynchus kisutch	Coho Salmon
Salmo gairdneri	Rainbow Trout
Salmo clarki	Cutthroat Trout
Prosopium williamsoni	Mountain Whitefish
Pomoxis nigromaculatus	Black Crappie
Micropterus salmoides	Largemouth Bass
Rhinichthys cataractae	Longnose Dace
Rhinichthys osculus	Speckled Dace
Mylocheilus caurinus	Peamouth
Ptychocheilus oregonensis	Northern Squawfish
Richardsonius balteatus	Redside Shiner
Cyprinidae	Minnow (Unidentified)
Cyprinidae	Minnows (Peamouth & Redside Shiner)
Perca flavescens	Yellow Perch
Alosa sapidissima	American Shad
Catostomus macrocheilus	Largescale Sucker
Cottus asper	Prickly Sculpin
Cottus rhotheus	Torrent Sculpin
Cottus bairdi	Mottled Sculpin
Cottus aleuticus	Coastrange Sculpin
Gasterosteus aculeatus	Anadromous Stickleback
Gasterosteus aculeatus	Resident Stickleback
Gasterosteus aculeatus	Hybrid Stickleback
Petromyzontidae	Lamprey
Entosphenus tridentatus	Pacific Lamprey
Lampetra ayresi	River Lamprey
Lampetra richardsoni	Western Brook Lamprey
Platichthys stellatus	Starry Flounder

TABLE 2.2-6

POTENTIAL SPAWNING AREAS FOR SITE STREAMS

Year	1968-1968[a]		1976 [b]		1977-1978[b]		1978-1979		1979-1980		1980-1981	
	Number of Potential Coho Salmon or Steelhead		Number of Potential Coho Salmon or Steelhead		Number of Potential Coho Salmon or Steelhead		Number of Potential Coho Salmon or Steelhead		Number of Potential Coho Salmon or Steelhead		Number of Potential Coho Salmon or Steelhead	
Stream	Area (yd^2)	Redds	Area (yd^2)	Redds	Area (yd^2)	Redds	Area (yd^2)	Redds	Area (yd^2)	Redds	Area (yd^2)	Redds
Workman	--[c]	--	0[d]	0	1,246	89	1,179	84	1,303	93	1,091	78
Fuller	250	18	140	10	98	7	105	7	176[g]	12[g]	173[g]	12[g]
Hyatt	--	--	0	0	0	0	--	--	0[f]	0[f]	0[f]	0[f]
Elizabeth	660	47	290	21	70	5	42[e]	3[e]	56[e]	4[e]	63[e]	4[e]

(a) Washington Department of Fisheries, 1969.
(b) Reference 2.2-15.
(c) --denotes no survey was conducted.
(d) Upper stretch of Workman not surveyed in 1976. This was the region where spawning was found in 1977-78.
(e) Potential in rechannelized portion only.
(f) Gravel present in upper areas but high culvert at mouth in 1979-80 and dam in 1980-81 eliminates all potential anadromous spawning.
(g) Maximum estimated during all surveys.

TABLE 2.2-7

SALMONID MOVEMENTS ON THE CHEHALIS RIVER SYSTEM[a]

Species/Race	Mean Number/Year	Range/Year
Upstream (Adults)		
Chinook[b]		
Fall-wild	4200 (1970-1977)	1300 (1976) - 7400 (1970)
Spring-wild	850 (1970-1980)	550 (1980) - 1700 (1977)
Coho[b]		
Normal-wild	11670 (1972-1980)	2700 (1976) - 29200 (1974)
Normal-hatchery	5390 (1970-1980)	100 (1978) - 17300 (1975)
Late-wild	6350 (1970-1980)	200 (1972) - 18900 (1974)
Late-hatchery	480 (1970-1980)	100 (1973) - 1400 (1972)
Steelhead[c]	13,850	
Downstream (Juveniles)		
Chinook[d]		
Fall-wild		1,210,000 - 5,500,000
Spring-wild		123,000 - 390,000
Coho[d]		
wild	790,000	
hatchery	3,500,000	
Chum[d]		1,225,000 - 2,625,000
Steelhead smolts[c]		
wild	277,000	
hatchery	50,000	

(a) Except as indicated, estimated fish movements are past WNP-3.
(b) Based on estimates by D. Stone, Wash. Dept. of Fisheries, in personal communication with B. Stables, Supply System, October 1982. Fall chinook and coho estimates include escapement to Wynoochee River (see Figure 2.4-1).
(c) Estimates by G. Fenton, Wash. Dept. of Game, in personal communication with J. Mudge, Supply System, October 6, 1982.
(d) Estimates based on escapement goals furnished by R. Brix, Wash. Dept. of Fisheries, in personal communication with B. Stables, Supply System, November 16, 1982.

Olympia is the closest offsite weather station with long-term wind data available for comparison. The frequency distribution of annual winds (in knots) is given in Table 2.3-10 which shows prevailing winds are from SSW-SW. Average wind speed at Olympia is about 3 m/sec.

2.3.2.3 Atmospheric Stability

Stability classification of the onsite data is based on vertical temperature difference. Pasquill stability categories were assigned according to the delta-T ranges described in Regulatory Guide 1.23.(6) The categories are defined in Table 2.3-11. Table 2.3-12 is an annual summary of stability versus time-of-day. Class E is the most frequent in all hours and averages 62.9 percent occurrence. Classes D, F, and G average 17.9, 12.5, and 6.5 percent, respectively.

Joint frequencies of wind speed and direction for the various stability categories are shown in Tables 2.3-13a through 2.3-13g. The prevailing winds during neutral (Class D) and slightly stable (Class E) conditions are from the SSW. Winds are fairly uniformly distributed during moderately stable (Class F) conditions, although the southwesterly winds are least frequent. Under extremely stable (Class G) conditions, the northerly component predominates with the southwesterly winds occurring least frequently.

Regional atmospheric stability (and general diffusion potential) is indicated by mixing heights compiled by Holzworth(7) for locations throughout the United States. The station nearest the site for which data were used in the summary. Although not as representative as onsite data, these summaries depict the general nature of air pollution at coastal locations in the northwestern United States. The mean seasonal and annual mixing heights and wind speeds for Seattle are presented in Table 2.3-14. The diurnal variation apparent in these data is less than would be experienced generally at a continental location.

2.3.2.4 Precipitation

The WNP-3 site area receives about 75 percent of the annual precipitation in the 6-month period between mid-October and mid-April. Average monthly precipitation at various stations in the area is listed in Table 2.3-15. 1
The monthly maximums and minimums at Elma are included for comparison. The decrease in precipitation with distance from the ocean is evident. Precipitation at the site and Elma are compared for each month of a 12-month period in Table 2.3-16. The two locations have the same pattern with the plant site recording slightly less rainfall in most months. Elma averages about 180 days per year with measurable precipitation. Measurable precipitation occurred onsite about 16 percent of the time during the 24-month monitoring program.

Precipitation wind roses, composited by month, for the onsite data are given in Tables 2.3-17a through 2.3-17l. Tables 2.3-18a and 2.3-18b provide comparison of the precipitation wind roses for the two heights of measurement. The frequency distribution of rainfall intensities measured onsite is given by Table 2.3-19.

2.3.3 Topography

As shown in Figure 2.1-2, WNP-3 is located on a ridge about 300 ft above the Chehalis River valley. Figures 2.3-1 and 2.3-2 present topographic profiles out to 10 miles and 50 miles, respectively. The Chehalis valley to the north and Willapa Hills to the south are the dominant features near the plant. At distances beyond 10 miles, the Pacific Ocean to the west and the Olympic Mountains to the north are important topographic features.

TABLE 2.3-19

RAINFALL RATE DISTRIBUTION AT THE WNP-3 SITE[a]

Rate (in/hr)	Rate (mm/hr)	Frequency (Percent) (All Observations)	Frequency (Percent) (Precipitation Cases)
0.00	0.00	83.24	
0.01-0.02	0.1-0.5	8.67	51.71
0.03-0.04	0.6-1.0	2.95	17.59
0.05-0.08	1.1-2.0	2.68	15.97
0.09-0.12	2.1-3.0	1.23	7.31
0.13-0.15	3.1-4.0	0.50	3.00
0.16-0.19	4.1-5.0	0.42	2.51
0.20-0.23	5.1-6.0	0.18	1.10
0.24-0.31	6.1-8.0	0.11	0.67
0.32-0.39	8.1-10.0	0.01	0.04
0.40	10.0	0.02	0.11

[a] October 1979 - September 1981

2.4 HYDROLOGY

2.4.1 Surface Water

The WNP-3 project is located on a ridge 1.4 miles south of the confluence of the Chehalis and Satsop Rivers, and approximately 21 river miles (RM) upstream of the Chehalis River's confluence with Grays Harbor. Nominal plant grade is 390 ft mean sea level (MSL), about 370 ft above the Chehalis River floodplain. Makeup water for the Circulating Water System is supplied from induced infiltration of surface waters and groundwater within the Chehalis River by Ranney collector wells located slightly more than three miles downstream from the Satsop River confluence. Blowdown from the natural-draft cooling tower is discharged to the Chehalis River through a submerged multiport diffuser located 0.5 miles downstream from the confluence (see Section 3.4). The Chehalis River watershed is shown in Figure 2.4-1, and principal hydrologic features of the site vicinity are shown in Figure 2.4-2.

2.4.1.1 Chehalis River Hydrology and Physical Characteristics

The Chehalis River basin is a major river basin draining west-central Washington. The river heads in the Willapa Hills in southwestern Washington, flows generally northeastward to Grand Mound, and enters into Grays Harbor at Aberdeen. The higher portions of the river basin, where the river has an average slope of about 16 feet per mile, are rugged and densely forested. The slope flattens to about 3 feet per mile near the city of Chehalis and then 2 feet per mile near Satsop. The river and its tributaries have a drainage area of about 2,115 sq mi; the total area draining to the site is about 1,765 sq mi, of which approximately 300 sq mi is drainage area of the Satsop River.

A stream gage for the Chehalis River was installed and operated at the site by the United States Geological Survey (USGS) in 1977 using temporary facilities; permanent facilities were constructed in 1981. There are no other long-term gaging station records for the lower reach of the Chehalis River. However, long-term records are available for USGS gaging stations on the Chehalis at Grand Mound (1929-present) (RM 59.9), Porter (1952-1972; 1972-1979)(RM 33.3) and on the Satsop River near Satsop
(1929-present)(RM 2.3 upstream from mouth). River flows near the dis-
charge diffuser are estimated by adding the Satsop River flow to the flow 1
in the Chehalis River at Porter or Grand Mound adjusted to the site by drainage area ratio.

The annual mean flow near the diffuser is 6,630 cubic feet per second 1
(cfs); the monthly mean flow ranges from 730 cfs in August to 14,865 cfs in January. The minimum monthly flow, 432 cfs, occurred in August 1951, while the maximum monthly flow, 40,876 cfs, occurred in December 1934.
Estimated monthly average flows in the Chehalis River just below the con-
fluence of the Satsop are shown in Table 2.4-1. As indicated in the 1
table, the flow in the river is quite variable and reflects the seasonal rainfall distribution within the basin. Also listed in Table 2.4-1 are the record minimum daily flows for each month.

The lowest daily flows in the site vicinity are normally expected in August and September. The one percent non-exceedence flows for these two months are 500 and 460 cfs, respectively. The once-in-10-year, 7-day duration low flow for the Chehalis River downstream of the Satsop confluence is 530 cfs based on recorded flow data for the period 1930-1981 (WNP-3 FSAR Appendix 2.4A). The 7-day low-flow frequency curve is shown on Figure 2.4-3.

Floods occur in the region primarily in December and January, but damaging floods may occur as early as the beginning of November and as late as the end of April. The estimated momentary maximum flood flow in the Chehalis
1| River below the Satsop, 97,100 cfs, occurred on December 21, 1933. The annual momentary maximum flows from 1930 to 1979 are listed in Table 2.4-2, and a frequency analysis of flood flow data is presented in Figure 2.4-4.

The Chehalis River channel at the site is approximately 250 feet wide and varies in depth from a few feet during low flow to greater than 30 feet during flooding conditions when the entire flood plain is inundated. Channel geometry varies considerably in the site vicinity. Figure 2.4-5 shows river cross-sections in the vicinity of the blowdown diffuser (see Subsection 3.4.4). River bed elevations near the site are variable, ranging from mean sea level just downstream of the Satsop confluence to approximately 19 feet below MSL just upstream of the confluence. The channel gradient or slope from about 10 miles upstream of the site to Grays Harbor (21 miles downstream of the site), is approximately 0.04 percent. The Satsop River exhibits a much steeper slope which ranges from approximately one percent in the vicinity of its confluence with the Chehalis River to nearly 15 percent at its head waters in the Olympic Mountains.

The velocity of the Chehalis River is quite variable. During low-flow conditions (< 200 cfs) upstream of the Satsop confluence, velocities of less than 0.2 fps are experienced. For the reach of river downstream of the Satsop confluence, velocities increase to approximately 0.4 fps during low-flow conditions (~ 400 cfs) due to the Satsop River inflow. During flood conditions ($> 30,000$ cfs) channel velocities reach 6 to 7 fps.

River flow in the site vicinity may also be influenced by tidal action. The degree of tidal effect depends on the river flow and the height of the ocean tide. The influence is most noticeable during spring high tides and low river flows, which in combination reduce and sometimes reverse the current velocity. During periods of high streamflow, the tidal effects on the river stage and flow are considerably less pronounced. Natural bathymetric features also affect river flow and tidal propagation in the river; a riffle area (approximately River Mile 19) reduces the effect of tidal propagation near the site area. In a 1975 field survey, the daily average flow ranged from 1,040 to 1,610 cfs; no reversals were observed during high tides above the riffle area, although current velocity at the riffle was reduced to about 10 percent of its steady flow velocity.[1] In 1977, when the daily average flow was 570 cfs, the velocity at River Mile 20.5 was decreased to 15 percent of the steady flow speed during peak high tide.[2] In mid-September and again a month later, current velocity was reduced to stagnation for at least one-half hour. The stagnations coincided with perigee spring high tides and river flows of 1,070 to 1,370 cfs. The steady flow velocity ranges from 0.44 fps when the river flow is 570 cfs to 2.8 fps when the river flow is 7500 cfs. Conductivity measurements indicate salinity at the site is representative of freshwater, and the saline estuarine zone does not extend upstream as far as the intake structure during flow reversals (see Subsection 2.4.1.3).

2.4.1.2 Site Hydrology

The plant is located on a ridge that divides the drainage basins of several streams none of which flow through the plant area; there are no ponds or wetlands in the immediate area. Five streams drain at least some portion of the site: Workman, Purgatory, Fuller, Hyatt, and Elizabeth Creeks. Stein Creek, a tributary to Workman Creek, and Purgatory and Fuller Creeks are within site boundaries. All are relatively short intermittent/permanent streams originating at elevations between 300 to 400 feet (90 to 120 meters) in hills south of Montesano and Elma. Both Purgatory Creek and Hyatt Creek flow through high culverts near their mouths which are only passable to salmon and trout when the Chehalis River floods.[3]

In general, site streams flow over bedrock composed of sandstone and siltstone. The lower portions of the streams are enclosed primarily by trenchlike banks composed of mud and clay. Streambeds within the lower sections are composed primarily of fine sand and silt created from erosion of the soft bedrock. Most streams exhibit a pool to riffle ratio favorable to salmonid spawning, however many lack significant reaches of spawning gravel necessary for successful propagation and two streams (Purgatory and Hyatt Creeks) are not accessible to upstream migrants. All are characteristically shallow with average depths ranging from approximately 2 to 12 inches during summer and fall.[3]

Total drainage areas for the site streams and the percent actually included in the plant construction zone are presented in Table 2.4-3. The watersheds of the site streams have been significantly affected by recent and past logging activities near the headwaters. The percentage of site stream watershed area clearcut since 1965 ranges from 48 percent for Hyatt Creek to 11 percent for Stein Creek.

Streamflows in Purgatory and Fuller Creeks were significantly altered by site erosion control runoff treatment measures during the construction phase. During early phases of construction water from these streams was pumped to project sedimentation ponds, treated with flocculant and subsequently discharged into the Chehalis River. Other streams which were directly influenced by plant construction are Hyatt Creek, which runs parallel to the existing Bonneville Power Administration corridor and the route of the transporter/west access road, and Elizabeth Creek, approximately 250 yards of which was rechanneled.

Figure 2.4-6 shows the post-construction drainage pattern. Storm runoff will drain to Fuller, Purgatory, and Workman Creeks. Runoff from an area of approximately 35 acres formerly drained by Stein Creek has been diverted to Fuller and Purgatory Creeks as a result of the site grading. This change will have no effect on any safety or environmental concerns, since the drainage area of the Workman Creek tributary is decreased by only 10%, and those of Fuller and Purgatory Creeks increased by only 5% and 3%, respectively.

2.4.1.3 Water Quality Characteristics

Pollution in the Chehalis River at the site is quite limited and is the result of agricultural runoff and municipal waste discharge from the small communities located along the Chehalis River. The total biochemical oxygen demand (BOD) loading of the Chehalis River as it passes Montesano has been estimated at 13,200 lbs BOD/day at a flow rate of 2,230 cfs or, assuming a completely mixed river, a concentration of approximately 1 mg/l. Although this BOD loading does not adversely affect the quality of the river at the site and is not considered a problem considerable pollution loading is added near the mouth of the river (16 miles downstream of the site) and in Grays Harbor. Under adverse tide (flood tide) and water temperature ($>21^{o}C$) conditions, the loading may cause depressed dissolved oxygen (<6 mg/l) levels. The depressed oxygen levels and other possible quality problems (pH and toxicity) in turn affect the fisheries resources of the river system as well as its aesthetic values. This has been demonstrated to some extent by the Department of Fisheries findings which have shown the survival of hatchery coho to be much lower in the Chehalis system, where outmigrants must pass through inner Grays Harbor, than in the nearby Humptulips River(4).

Water quality data specific to the site vicinity has been collected through monitoring programs since 1977.(5,6) Data from these studies are summarized in Table 2.4-4.

The Chehalis River is influenced by several physical, chemical and biological processes which result in the cyclic variation of some important water quality parameters. Maximum pH levels (approx. 7.6) occur July through September and minimum values (approx. 6.5) occur from January through March. This seasonal variation may reflect longer residence time in the soil during the dry summer months. During the summer months the soil provides more buffering action for water infiltrating through the acidic organic material on the surface. Dissolved oxygen (DO) levels respond inversely with water temperature such that maximums (approx. 12.0 mg/l DO) occur in the winter and minimums (approx. 8.8 mg/l DO) occur in summer. Chehalis River stations upstream of the Satsop River confluence had slightly lower DO levels than downstream stations. This reflects the contribution of the oxygen-rich Satsop River.

Metals were the focus of a one-year study,(6) the results of which are included in Table 2.4-4. In general, the concentrations of all heavy metals in the Chehalis were low compared to other surface waters(7) and

1|

to EPA water quality criteria.[8] Though metal concentrations show some seasonal fluctuation, the fluctuations are small and indistinct. As an example, Figure 2.4-7 shows the variation in copper. Iron, which is more abundant in the soil and rock of the drainage basin, responds more than other metals to precipitation and runoff events. The variation of iron is shown in Figure 2.4-8. Whereas iron had a relatively strong correlation with flow (r=0.83) and turbidity (r=0.85), copper showed a weak relationship with flow (r=0.37) and turbidity (r=0.38).[6]

The concentrations of dissolved minerals such as calcium, magnesium, potassium, and sodium are related to streamflow and the concentrations in groundwater. The concentrations are often greater in the groundwater than the surface water (see Table 2.4-4). During low-flow periods, the groundwater contributes significantly to streamflow, and, hence, concentrations are high. During high flow periods, most of the streamflow is from surface runoff which does not have sufficient contact time with the soil to become as mineralized as groundwater.[6]

Turbidity and suspended sediment correlate strongly with periods of intense rainfall and resultant peak runoff. The Chehalis River downstream of the Satsop River typically carries high sediment loads. Approximately 75 percent of this load is derived from the Satsop and Wynoochee Rivers, which represent 40 percent of the total drainage area of the lower basin. Transport of suspended sediment in the Chehalis River and its tributaries is highest during periods of high runoff which most frequently occur between November and January. On most of the streams in the Chehalis River basin, peak suspended sediment concentrations coincide with peak runoff. However, in the Chehalis River at Porter, peak suspended sediment concentrations generally precede the runoff peak by 24 hours.[9] Figure 2.4-9 shows the average particle size class distribution of suspended sediment and Figure 2.4-10 shows the relation between water discharge and suspended sediment for the Chehalis River near Grand Mound and the Satsop River at Satsop.

In the reach of the Chehalis River influenced by tides, salinities may vary from nearly ocean water concentrations in Grays Harbor to essentially zero at the confluence with the Satsop River. The salt front moves upriver and downriver in response to freshwater inflow to the estuary, tidal action and winds. For a freshwater flow of 10,000 cfs, the zero mean salinity point along the river occurs at approximately 14.5 miles and 20.5 miles downstream from the site at high- and low-water slack, respectively. With a river flow of 500 cfs, the salt wedge is located 7 miles downstream for both high and low-water slacks.

River water temperature near the site reflects the combined temperatures and flows of the Satsop and Chehalis Rivers upstream of the site. The monthly mean temperature ranges from 42°F (5.6°C) for the USGS stations in January to 60°F (15.6°C) at Satsop and 67°F (19.4°C) at Porter in July. Since the site is downstream from the confluence of these two rivers, weighted mean water temperatures were calculated based on both the flows and temperatures at the Satsop and Porter Stations. The weighted mean monthly temperatures in the vicinity of the site range from a low of $42^{\circ}F$ ($5.6^{\circ}C$) in January to a high of $65^{\circ}F$ ($18.3^{\circ}C$) in August. Table 2.4-5 summarizes mean and extreme monthly temperatures.

2.4.2 Groundwater

The nature and occurrence of groundwater in the Chehalis River Basin and site vicinity is determined by the geology of the area which is detailed in Section 2.5 of the Final Safety Analysis Report (FSAR). The geologic processes and groundwater resources have also been summarized by Eddy.[11]

2.4.2.1 Groundwater Sources

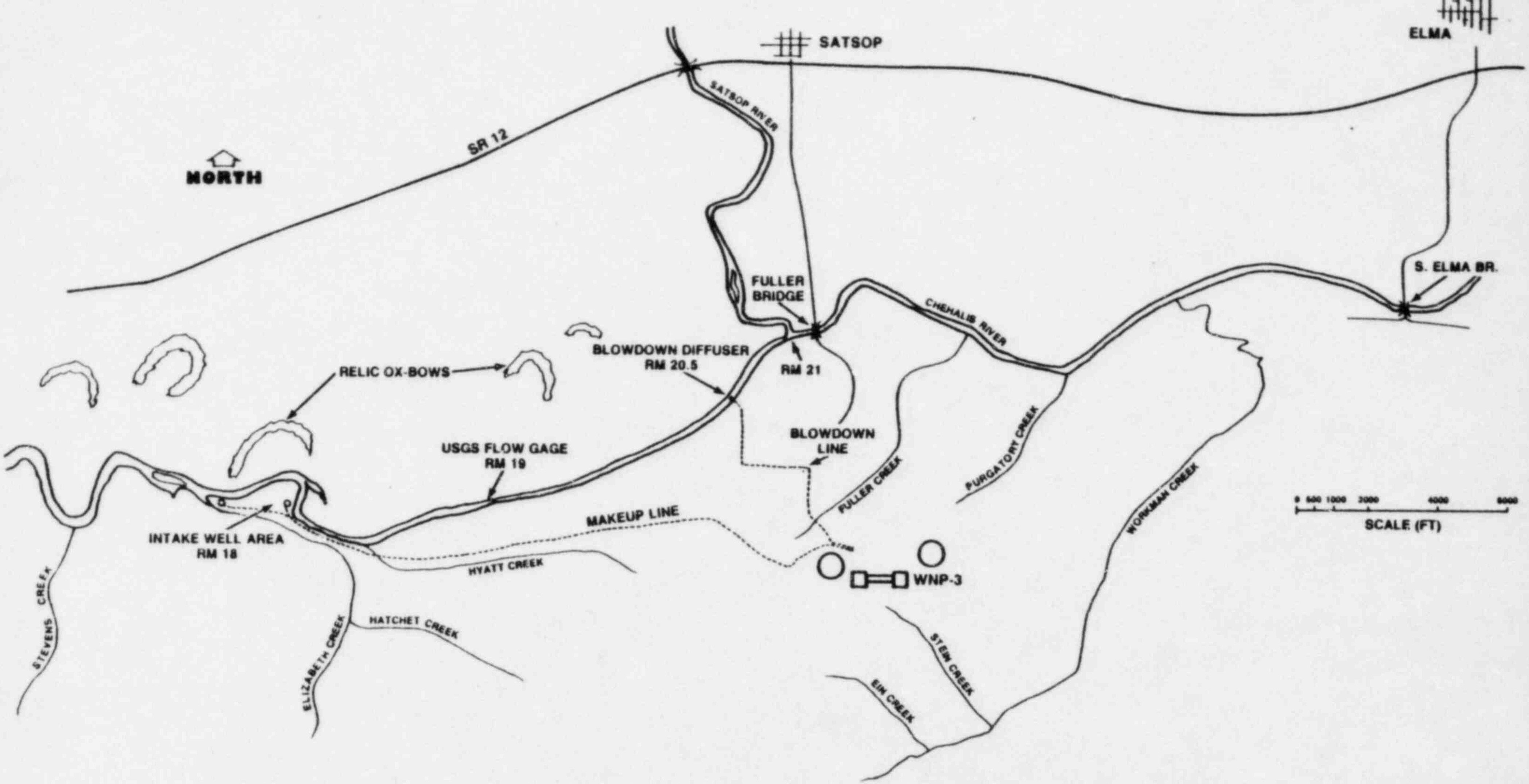
Groundwater at the plant site occurs in the alluvial valleys of the Chehalis, Satsop and tributary rivers The Chehalis River alluvial aquifer generally is confined by flood deposits of silt averaging about 11 feet thick in the site area. The piezometric surface is within 10 to 20 feet of the ground surface.[12] Groundwater also occurs in a discontinuous manner in the unconsolidated terrace deposits in the northern area of the site, where three domestic wells were developed in small perched aquifers. Recharge to the terrace deposits is from precipitation on the watersheds and from the Chehalis River.

The southern portion of the site is situated on Tertiary sandstone sediments which contain little groundwater. There are no known producing wells located in the Tertiary formation in the area. Any recharge to the Tertiary sandstone formation is derived from rainfall and snowmelt. The very low permeability of the Astoria formation permits small amounts of recharge and minimal groundwater movement.

The aquifer in the Chehalis River Valley is horizontally limited by the
occurrence of Teritiary sandstone sediments along the southern side of the
Chehalis River. The southern edge of the Olympic Mountains serves as a
boundary along the north side of the valley. The alluvial aquifer is con-
1 fined (locally) and extends two miles across the Chehalis River Valley,
about 14 miles downsteam to Grays Harbor and about 15 miles upstream to
the eastern limit of Grays Harbor County. The glacial till and outwash
varies from 45 to 190 feet in thickness with a saturated zone averaging
about 110 feet.

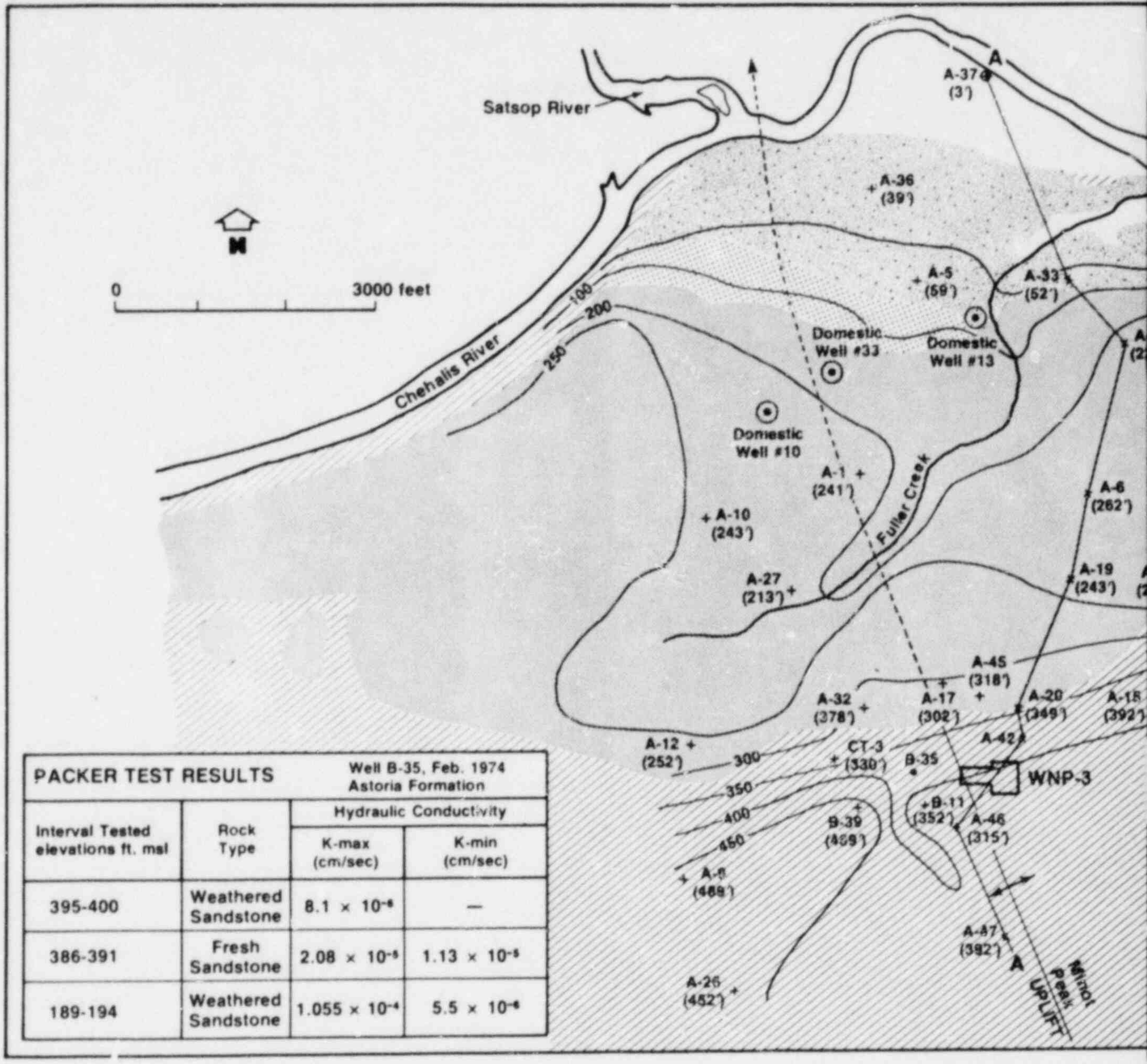
The groundwater table beneath the plant area follows the topography of the ridge and terraces and is parallel to the weathered and unweathered zones of the Astoria sandstone formation. The groundwater level slopes northward toward the Chehalis River. The level varies from 15 to 50 feet beneath the ground surface in the terrace deposits.

The range of water elevations in all plant area borings indicates only
small seasonal fluctuations in groundwater. Site groundwater fluctuations
during construction and the plant's permanent dewatering system are pre-
sented in Subsection 3.4.1.2 of the FSAR. Post-construction piezometric
1 surfaces are shown in Figure 2.4-11. Piezometric contours and a geologic
cross-section are shown in Figure 2.4-13.

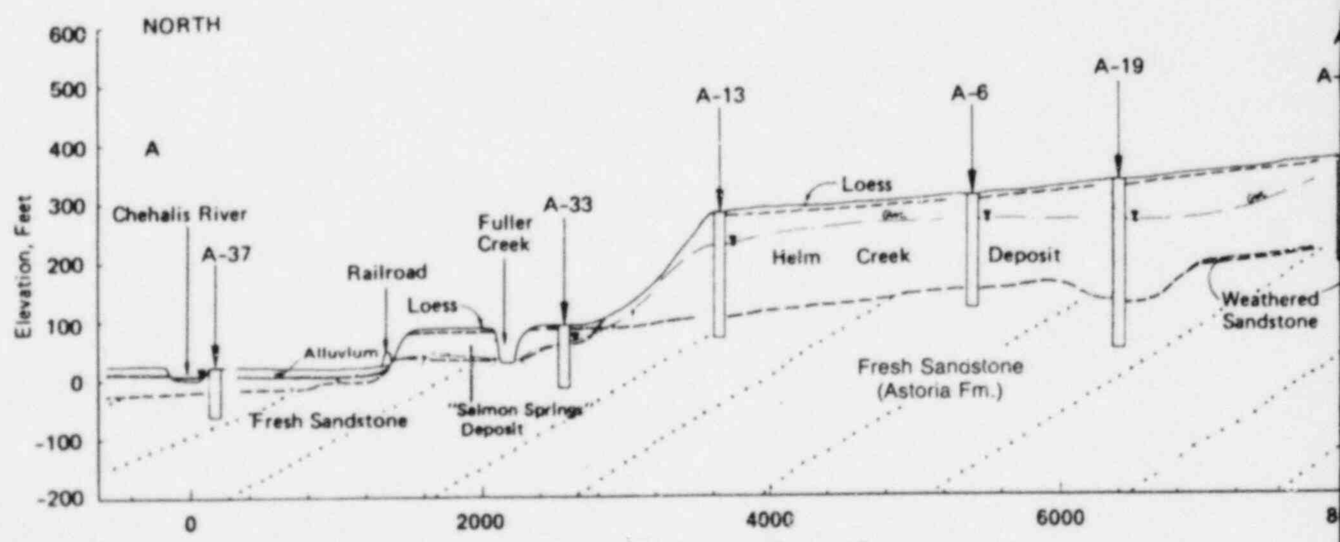


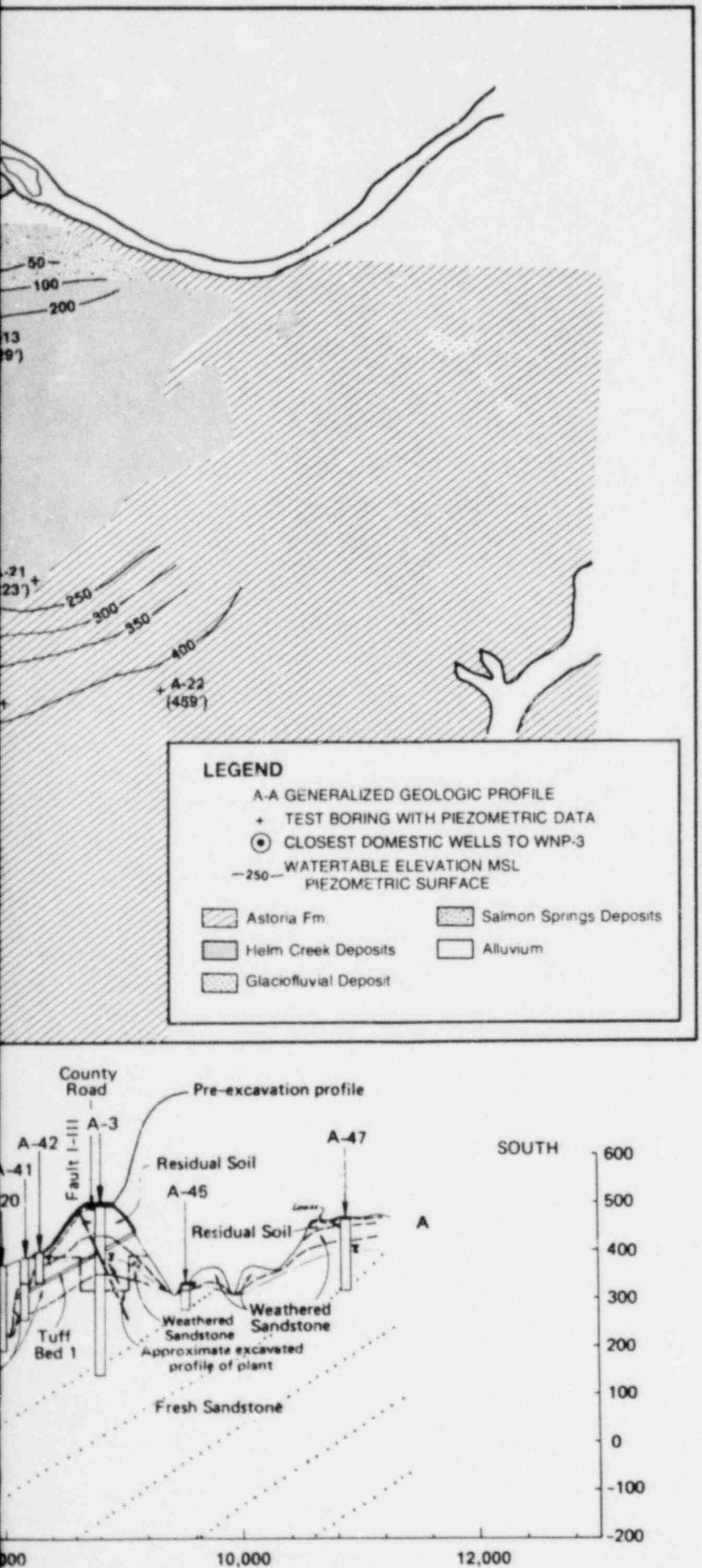
Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	HYDROLOGIC FEATURES NEAR WNP-3	FIGURE 2.4-2



PACKER TEST RESULTS		Well B-35, Feb. 1974 Astoria Formation	
Interval Tested elevations ft. msl	Rock Type	Hydraulic Conductivity	
		K-max (cm/sec)	K-min (cm/sec)
395-400	Weathered Sandstone	8.1×10^{-6}	—
386-391	Fresh Sandstone	2.08×10^{-5}	1.13×10^{-5}
189-194	Weathered Sandstone	1.055×10^{-4}	5.5×10^{-6}





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Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
WNP-3 ER-OL

PIEZOMETRIC SURFACE AND GEOLOGIC PROFILE OF WNP-3 SITE

FIGURE 2.4-13

The water droplets separate from the air flow within the drift eliminator and collect and fall back to the fill surface. The drift eliminator system is guaranteed to limit the drift loss to 0.003 percent of the design flow. Table 3.4-2 lists the design parameters of the cooling tower. Figure 3.4-3 presents the tower performance under design conditions.

The concentration of dissolved solids within the circulating water system is controlled by continuous blowdown (at an annual average rate of 3.7 x 10^6 gpd) from the cooling tower basin. Blowdown flow will be determined by daily analyses of the circulating water chemistry; the flow will be adjusted by a remotely operated butterfly valve. A continuous makeup supply is provided to the system from the Ranney collectors for the loss due to evaporation, blowdown and cooling tower drift.

3.4.3 Supplemental Cooling System

Supplemental cooling of the blowdown water is provided by a countercurrent heat exchanger and associated control and monitoring equipment (see Figure 3.4-1). The heat exchanger uses plant makeup water as the cooling medium and is sized for a 3°F approach to the makeup (well water) temperature. The supplemental cooling system is constructed primarily of Type 304 stainless steel tubing with a total exposure of approximately 26,000 sq ft.

The thermal monitoring system for the circulating water system blowdown consists of temperature sensors for the river, makeup well water, and blowdown; and there are also flow sensors for the makeup and blowdown. The temperature control of the discharge (to Chehalis River) will be controlled by using a variable bypass around the heat exchanger. Discharge temperature will be controlled within the limits of the NPDES Permit (see Appendix A). The heat exchanger can be completely bypassed if the blowdown temperature falls within the acceptable limits.

3.4.4 Blowdown Diffuser

After passing through the supplemental cooling system, the blowdown water will be conveyed through a piping system consisting of approximately 6,900 ft of 21-inch reinforced concrete pipe, 1,200 ft of 20-inch carbon steel/fiberglas pipe; and 275 ft of 18-inch carbon steel pipe. The pipe runs to the Chehalis River at River Mile 20.5 (below the confluence with the Satsop River). The pipeline will extend north and under the river bed approximately 150 feet from the south bank of the river and includes a 30-foot long multiport diffuser (see Figures 3.4-4 and 3.4-7). The 30-foot diffuser is a 18-inch diameter pipe perforated with 46 discharge ports which are 2 inches in diameter and spaced at 8-inch intervals. The diffuser is located so that the projecting ports are one foot above the river bottom and direct the discharge downstream at a 12 degree angle above the horizontal. This orientation will minimize bottom scouring. Average discharge jet velocity will be about 6.25 fps. The discharge rate and temperature are tabulated by month on Table 3.4-1. 1

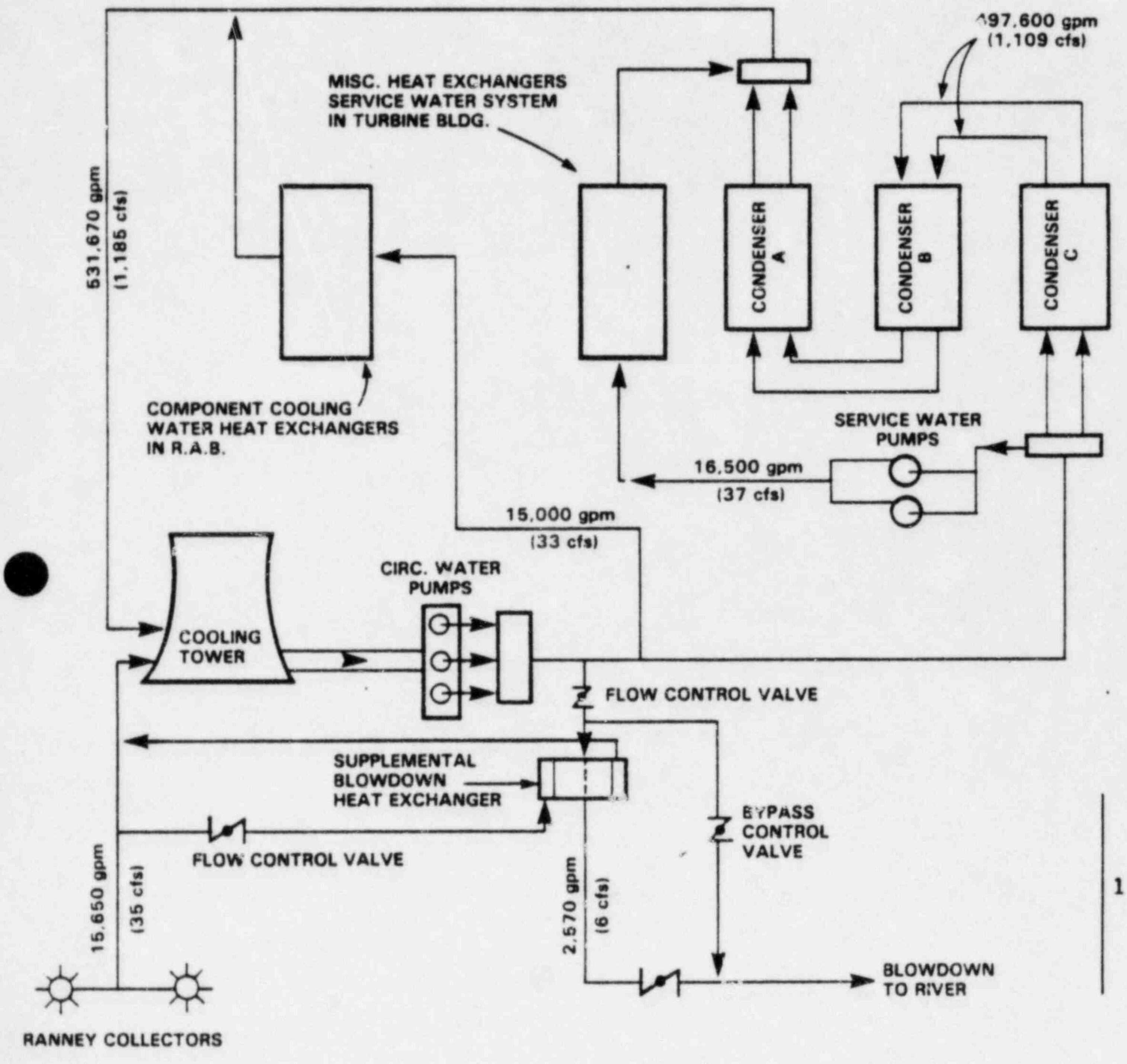
3.4.5 Makeup Water Intake

The makeup water system consists of two Ranney Collectors located on the south bank of the Chehalis River at about River Mile 18 (see Figure 3.4-5). (Three collector wells were planned to support operation of both WNP-3 and WNP-5). In general, each collector consists of a circular reinforced concrete caisson, a concrete plug near the base of the caisson, a series of horizontal screen laterals radiating from the base of the caisson, piping, valves, an extension stem and guide, and floor boxes with valve operating devices. The upper portion of the caisson holds the pumphouse. Figure 3.4-6 shows these major components.

The maximum makeup water requirement for WNP-3 is approximately 18,000 gpm and a single collector well is capable of supplying this amount on a continuous basis.

Water withdrawal through the Ranney collectors will induce the river water to flow from the river bottom and bank through the permeable aquifer to the collectors. With this type of groundwater system, extreme high summer water temperatures and extreme low winter water temperatures are moderated. Seasonal groundwater temperatures are expected to range from 50 to 58^{o}F, with water temperatures lagging those of the river by about two months. The minimum water temperature is expected to occur during March while the maximum water temperature will occur in late September or early October (see Figure 2.4-12).

The advantages of this type of intake are the reduction of maintenance problems and elimination of entrainment of fish, organisms, and debris. The high permeability and transmissibility coefficients of the unconfined aquifer indicate that the aquifer reacts much like a reservoir. The aquifer accepts surface water for storage during high river flow until the underground storage is full. The permeable aquifer discharges readily into streams and rivers during periods of low flow. Any silt buildup on the riverbed of the Chehalis River will be minimal and will have little or no effect on the capacity of the groundwater collector system.



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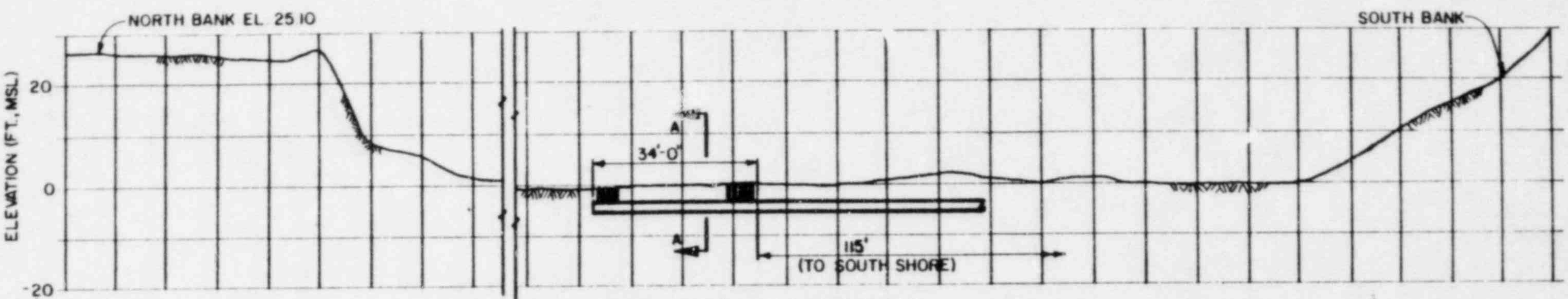
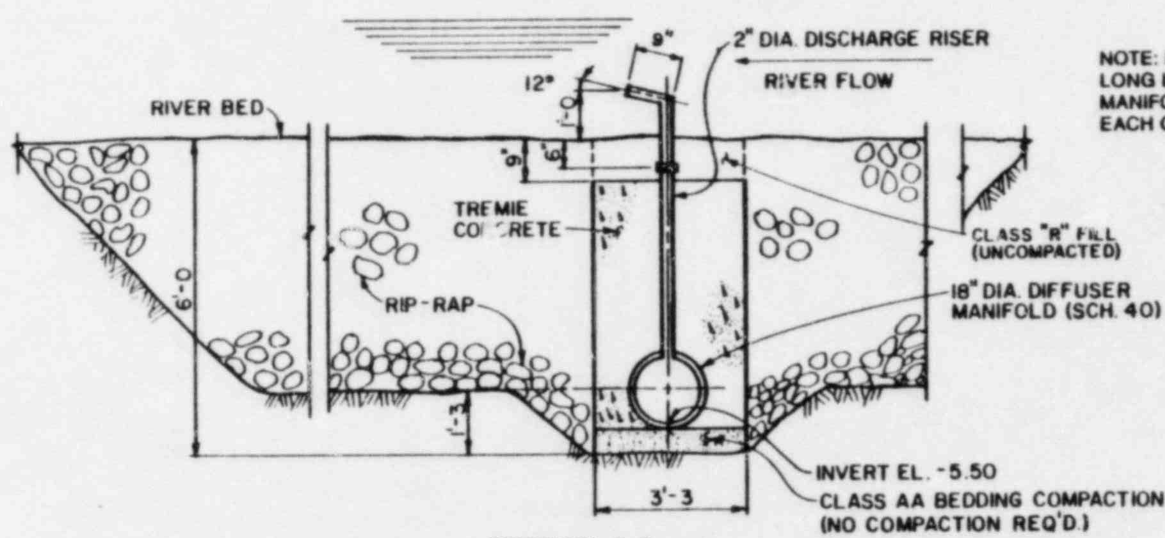
Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	SCHEMATIC DIAGRAM OF CIRCULATING COOLING WATER SYSTEM	FIGURE 3.4-1



CHEHALIS RIVER CROSS-SECTION

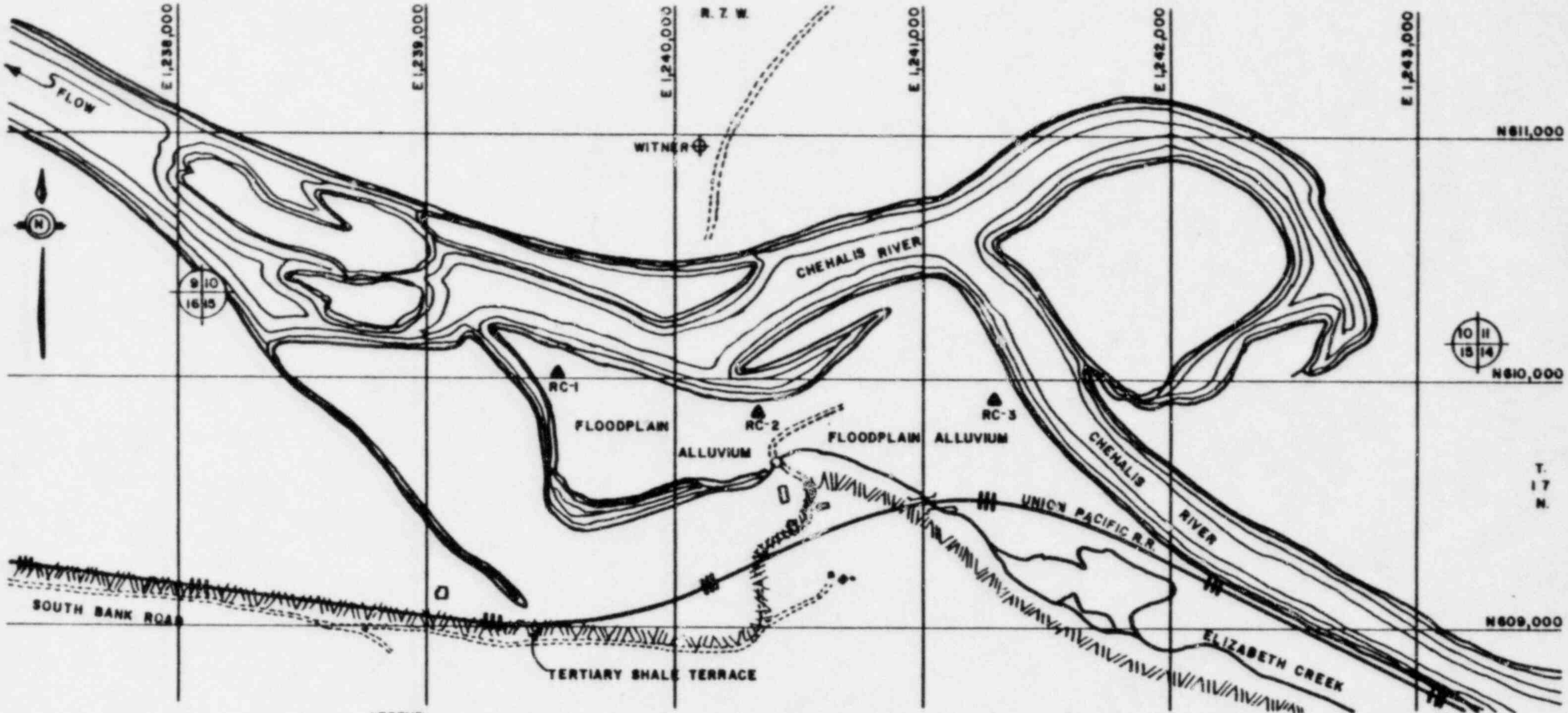


SECTION A-A

NOTE: DIFFUSER INSTALLATION MODULE IS 34 FT LONG INCLUDING 30-FT DIFFUSER SECTION AND MANIFOLD EXTENSIONS OF 1 FT AND 3 FT AT EACH OF THE ENDS. 1

Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	SCHEMATIC CROSS-SECTIONS OF DIFFUSER	FIGURE 3.4-4



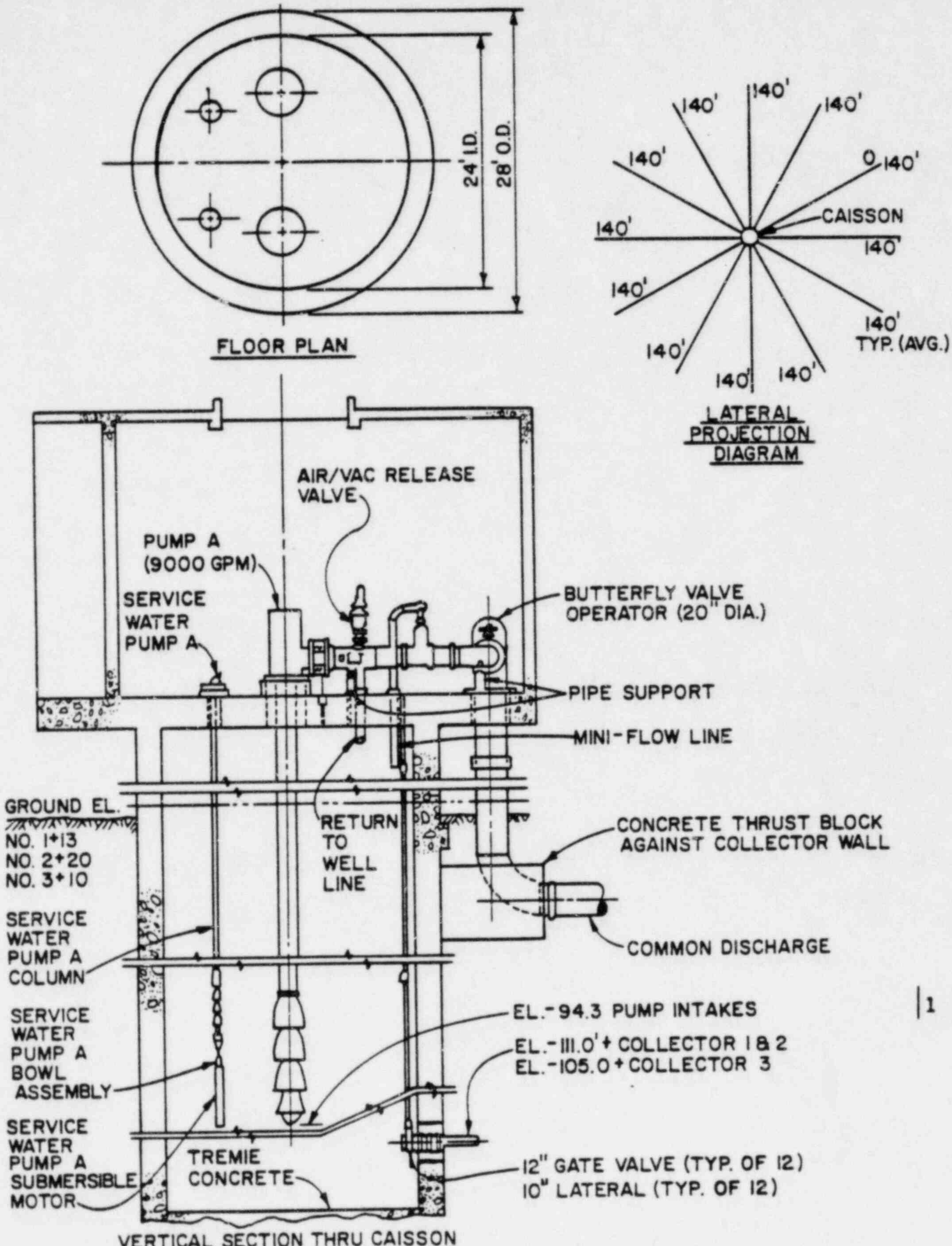
LEGEND

⊕ EXISTING FARM WELL

▲ RANNEY COLLECTOR (RC)
(RC-1 and RC-3 to be completed for WNP-3) |1

Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	LOCATION OF INTAKES (RANNEY COLLECTORS)	FIGURE 3.4-5



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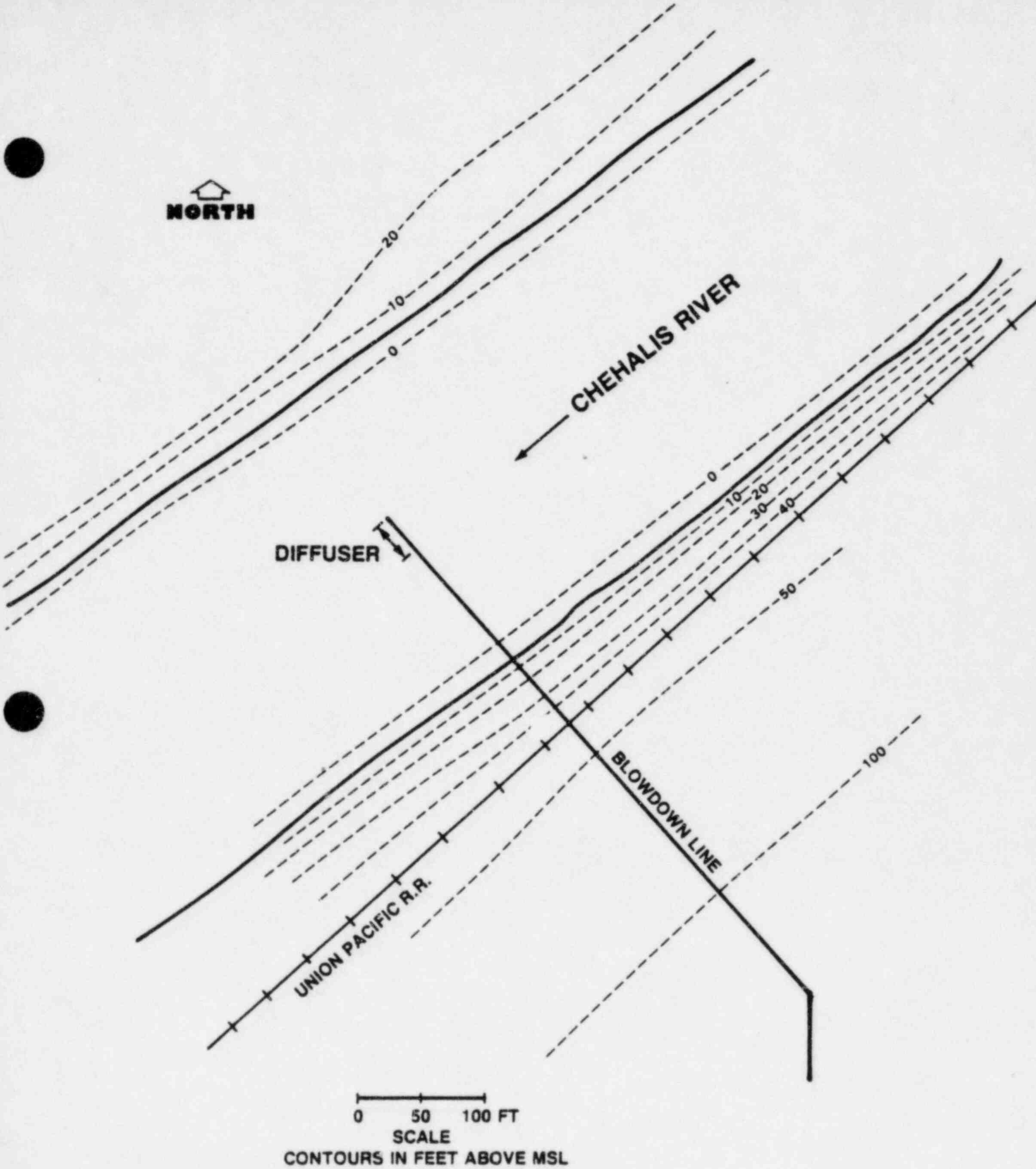
Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	RANNEY GROUNDWATER COLLECTOR	FIGURE 3.4-6



Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	PLAN VIEW OF DISCHARGE DIFFUSER	FIGURE 3.4-7

3.5.1.3 Fuel Pool System

The Fuel Pool System is designed to remove decay heat and the soluble and insoluble foreign matter from the spent fuel pool. Figure 3.5-1 presents a simplified block flow diagram of the Fuel Pool System. The detailed piping and instrument diagram is presented in Section 9.1 of the FSAR, along with the principal component design data. The radionuclide concentrations in the fuel pool during plant operations and refueling are listed in Table 3.5-4.

The values presented in Table 3.5-4 are based on the assumption that, upon shutdown for refueling, the Reactor Coolant System (RCS) is cooled for approximately two days. During this period, the primary coolant is let down through the purification filter, purification ion exchanger, and letdown strainer prior to return to the suction of the low-pressure safety injection pumps. When continuous degassification of primary coolant is desired, the letdown flow is diverted to the gas stripper and then to the VCT prior to return to the RCS. This serves two purposes: removal of noble gases in the gas stripper to avoid large releases of radioactivity to the Reactor Building following reactor vessel head removal, and reduction of dissolved fission and corrosion products in the coolant by ion exchange and filtration. At the end of about two days, the coolant above the reactor vessel flange is partially drained. The reactor vessel head is unbolted and the refueling water cavity is filled with a minimum of 470,000 gallons of water from the refueling water tank. The remaining reactor coolant volume containing radioactivity is then mixed with water in the refueling cavity and the Fuel Pool System. After refueling, the Fuel Pool System is isolated and the water in the refueling cavity is returned to the refueling water tank. This series of events determines the total activity to the Fuel Pool System. The specific activities of the radionuclides given in Table 3.5-4 are based upon a volume of 260,000 gallons. These values will be reduced by decay during refueling as well as by operation of the Fuel Pool System.

The Fuel Pool System has two basic parts: a cooling subsystem and a cleanup subsystem. The cooling subsystem of the Fuel Pool System is a closed-loop system consisting of two full-capacity pumps and heat exchangers. Water is withdrawn from the fuel pool near the surface and is circulated by pumps through a exchanger that rejects heat to the Component Cooling Water System. From the outlet of the fuel pool heat exchanger, the cooled water is returned to the bottom of the fuel pool through a distribution header.

The clarity and purity of the water in the fuel pool, refueling canal, and refueling water tank are maintained by the cleanup subsystem of the Fuel Pool System. The cleanup loop consists of two parallel trains of equipment, which include cleanup pump, ion exchanger, filter, strainers and surface skimmer. Most of the cleanup flow is drawn from the bottom of the fuel pool while a small fraction is drawn through the surface skimmer. A basket strainer is provided in the cleanup suction line to remove any relatively large particulate matter. The fuel pool water is circulated through a filter that removes particulates larger than five microns, then through an ion exchanger to remove ionic material, and finally through a strainer, which prevents resin beads from entering the fuel pool in the unlikely event of a failure of an ion exchanger retention element.

1 The refueling water tanks hold a maximum of approximately 970,000 gallons. At the time of refueling a minimum of 470,000 gallons of water are used to fill the reactor canal, fuel transfer canal, and refueling water cavity.

The release rates of radioactive materials in gaseous effluents due to evaporation from the surface of the fuel pool and refueling canals during refueling and normal operation are presented in Table 3.5-4.

3.5.1.4 Ventilation System Exhausts

Liquid and steam leakage from various coolant and process streams can result in small quantities of radioactive gases entering the building atmospheres. These systems are described in detail in Subsection 3.5.3.1.

3.5.2 Liquid Radwaste System

3.5.2.1 System Description

The Liquid Radwaste System (LRS) collects all primary and secondary side radioactive liquid wastes and processes the wastes to permit its reuse or recycle within the plant. Differences in primary and secondary system water chemistry must be considered prior to reusing liquids. Untreatable radioactive process wastes, residues and concentrates are sent to the Solid Waste System (SWS) for disposal.

The LRS is divided into five subsystems. The subsystems and the sources of the water processed in each are:

Floor Drain System (FDS)

1) Radioactive floor drains
2) Component cooling water (if radioactive)
3) Decontamination area drains (no detergents)
4) Hot chemical lab drains
5) Primary sampling panel drains

Detergent Waste System (DWS)

1 1) Hot shower drains
2) Decontamination area drains (detergent solutions)

Secondary High Purity Waste System (SHP)

1) Turbine Building drains (high purity equipment)
2) Low dissolved solids (low particulate) waste

Secondary Particulate Waste System (SPWS)

1) Low dissolved solids (high particulate) waste
2) Turbine Building drains (floor drains)

Inorganic Chemical Waste System (ICW)

1) Demineralizer regeneration chemicals
2) Cold chemical lab drains
3) Secondary sampling panel drains

Radioactive liquid wastes are collected from the above subsystems and segregated based on their composition and process requirements. The LRS is capable of processing the design and anticipated off-standard system loads without affecting normal operation or plant availability. This includes leakage or spillage due to equipment malfunction or failure. The waste quanitities that must be processed by the five subsystems are shown in Table 3.5-5. The subsystems are discussed in the following paragraphs; more detail is included in Section 11.2 of the FSAR.

Floor Drain System (FDS)

Figure 3.5-2 presents a simplified flow diagram of the FDS. The floor drain tanks accumulate that which is collected in the containment, Reactor Auxiliary Building and Fuel Handling Building floor drain sumps. Additional sources of input to the FDS include the Detergent Waste System, the chemical labs, the Decontamination Sample Tank, and the Component Cooling Water System. This water is processed using filtration, organic scavenging, evaporation and ion exchange. Holdup is provided to store waste accumulation for an average of 14 days. The processed water is monitored and used as reactor makeup water. If the water quality does not meet the standards for reactor makeup, the water will be further processed. The radioactive concentrate produced during processing of this water is handled by the Solid Waste System.

Detergent Waste System (DWS)

Figure 3.5-3 presents a simplified block flow diagram of the DWS. The detergent waste tanks collect water from the hot shower and hot sink drains. In addition, the detergent waste tanks collect water that has been diverted from the decontamination sample tank. This water is processed by filtration and blended with the regenerative waste solutions from the Inorganic Chemical Waste System. 1

Inorganic Chemical Waste System (ICWS)

Figure 3.5-4 presents a simplified block flow diagram of the ICWS. The ICWS accumulates wastes from chemical lab drains and chemicals used to regenerate resins of the steam generator blowdown demineralizers and the condensate polishers. Additionally, the ICWS is used to transfer contents of ICW waste tanks to the neutralizing pond provided the tank contents are not radioactive as described in FSAR Subsection 9.2.3.2. The ICWS provides means to adjust pH to expedite processing and to sample contents of ICW tanks for radioactivity. The ICWS processes water accumulated in the inorganic chemical waste drain tanks when the waste is radioactive or when processing by the low-volume waste treatment system (see Subsection 3.6.6) is undesirable. Processing is accomplished by filtration, evaporation, and ion exchange. Water which satisfies chemical criteria is transferred to the secondary makeup water system. Water that does not satisfy these criteria will be processed further. The ICWS minimizes the volume of wastes that are handled by the SWS.

Secondary High Purity Waste System (SHP)

Figure 3.5-5 presents a simplified block flow diagram of the SHP. The SHP collects and processes water from the secondary side drains which contain low dissolved solids and particulates. The SHP also accumulates rinse water from the condensate polisher and steam generator blowdown demineralizer. This water is processed by filtration and ion exchange and, after processing, is used as secondary makeup water if chemical criteria are satisfied. If the criteria are not satisfied the water will be processed further. The system provides approximately three days storage capacity.

Secondary Particulate Waste System (SPWS)

Figure 3.5-6 presents a simplified block flow diagram of the SPWS. The SPWS accumulates water which normally has a high concentration of particulates including backflush water from the condensate polishers, steam generator blowdown demineralizers, steam generator blowdown electromagnetic filters, water sent to the Turbine Building drains after being collected in an oil separator or sump and monitored for chemical and radiochemical contamination. Water from secondary particulate waste tanks are processed using filtration and organic scavenging. Water which meets chemical criteria is used as secondary makeup water. Water which does not meet chemical criteria is reprocessed using the secondary high purity demineralizer. The system provides approximately two days storage capacity.

3.5.2.2 Radionuclide Releases

Releases to the environs of liquid radwastes are controlled and monitored to meet the concentration limits of 10 CFR Part 20 and the as low as is reasonably achievable (ALARA) criterion and the numerical guidelines of 10 CFR Part 50, Appendix I. The design release limits are based on normal operation of the nuclear power plant, including anticipated operational occurrences. Specifically, the provisions to treat the liquid radioactive waste are such that:

a) The calculated annual total quantity of all radioactive material released from the reactor during normal operation including anticipated operational occurrences at the site to unrestricted areas does not result in an estimated annual dose or dose commitment from liquid effluents for any individual in an unrestricted area from all pathways of exposure in excess of 3 mrem to the total body or 10 mrem to any organ.

b) The concentrations of radioactive materials in liquid effluents released during operation at design base fuel leakage (i.e., leakage from fuel producing one percent of the reactor power) to an unrestricted area does not exceed the limits in 10 CFR Part 20, Appendix B, Table II, Column 2.

c) The Liquid Radwaste System includes all items of reasonably demonstrated technology that when added to the system sequentially and in order of diminishing cost-benefit return, can, for a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor.

d) In addition, the LRS has sufficient waste holding capacity, equipment and process stream redundancy and the capability to upgrade liquid radwastes to process makeup water quality so that there will be no intentional release of liquid radwaste to the environment under normal operating conditions.

Table 3.5-6 presents the calculated hypothetical radionuclide releases in the liquid effluents using the assumptions listed in Table 3.5-7. For the purpose of estimating hypothetical releases it is assumed that 10 percent of all processed liquid waste is discharged to cooling tower blowdown. This analysis was performed using the NRC GALE code.[1]

The analysis and demonstration of compliance with Appendix I to 10 CFR 50, including a cost-benefit analysis, was submitted as testimony at the June 1975 Environmental Hearings. Additional material was supplied in Supplement No. 6 to the Environmental Report-Construction Permit Stage (ER-CP). A review of the plant design and the site usage characteristics revealed that no major changes have occurred since these submittals. Therefore, a reanalysis of compliance with the cost-benefit requirements of Appendix I to 10 CFR 50 is not warranted. In addition, as demonstrated by those original analyses, the individual dose criteria of Appendix I are by far limiting. An evaluation of compliance with these criteria is included in Section 5.2.

3.5.3 Gaseous Radwaste System

3.5.3.1 System Description

This section describes the systems which collect, process and store gaseous wastes. Section 11.3 of the FSAR provides additional detail. The principal sources of gaseous waste are the Gaseous Waste Management System, the Gas Collection Header, and the Building Ventilation and Exhaust Systems.

Gaseous Waste Management System (GWMS)

A block flow diagram of the GWMS is presented in Figure 3.5-7. Waste gases which are routed to the GWMS are segregated according to source. The GWMS is divided into two subsystems, the retention subsystem and the recycle subsystem.

In the retention subsystem the gas surge header collects radioactive gases
1| from the volume control tank, gas stripper, and refueling failed fuel detector. The refueling failed fuel detector effluent is normally directed to the gas collection header; however, if the radioactivity is above a preset level, the effluent is directed to the gas surge header.

Gases from the gas surge header flow into the gas surge tank where they are collected. The gases remain in the gas surge tank until the pressure builds to a point which actuates a single waste gas compressor. The waste gas compressor feeds a preselected gas decay tank until the pressure in the gas surge tank drops to a point where the waste gas compressor stops. A second waste gas compressor will start if the pressure in the gas surge tank increases above a certain level. This automatic operation of the waste gas compressors continues until a gas decay tank is observed to approach its upper operating pressure. At this point another gas decay tank is manually lined up to receive the compressor discharge and the first tank is isolated. The filled gas decay tank is analyzed for hydrogen and oxygen content. Grab samples can also be taken for a radioactivity analysis.

After a gas decay tank has been sampled and analyzed it is then lined up to the gas recombiner system for processing. The processing is essentially a controlled reaction between hydrogen and oxygen to produce water. The influent hydrogen gas is diluted with nitrogen to maintain a 3 to 6 percent hydrogen mixture. This mixture is then preheated and oxygen is added to produce a stoichiometric mixture of hydrogen and oxygen. The addition of oxygen is controlled by analysis of either the influent or effluent
1| hydrogen and oxygen content. The entire gas stream is then passed over a catalyst bed. Recombination of hydrogen and oxygen occurs on the surface of the catalyst. The gas stream is then a mixture of nitrogen, steam and noble gases. The steam is condensed and separated out as water. The effluent is essentially nitrogen and noble gases.

The gas recombiner system effluent is then returned to the gas surge header where it reenters the system again through the gas surge tank and waste gas compressors. The gas recombiner will process until the gas decay tank pressure reaches a predetermined low level. The gas decay tank which is currently lined up to the waste gas compressors will collect the normal influents plus the hydrogen free gas recombiner effluent. When this gas decay tank is filled the process is repeated.

The gas which is in the isolated gas decay tank is allowed to decay for a period of time to reduce the activity of the gas. Source term generation was conservatively based on a 90-day holdup. |1

The GWMS provides a means to control the discharge of gaseous waste. The operator in the WMS control room discharges the gas decay tanks through a flow meter and recorder, and a radiation monitor, which automatically terminates discharge flow on high activity. The Main Control Room operator must give permission to discharge activity and has overriding switches to terminate the discharge if required. The release of radioactive gases from the GWMS is controlled by the WMS operator by manually lining up the proper gas decay tank to the discharge header after sampling the tank for activity. If the activity released exceeds a predetermined setpoint, the process flow monitor automatically shuts two valves to terminate the release. The procedure of sampling the gas decay tank prior to release and continuous monitoring of the release protects against operator error such as sampling one tank and lining up a different tank for discharge. The procedure for sampling and monitoring also protects against radiation monitor malfunction since the sample prior to discharge will be representative of tank contents.

The gases which are routed to the recycle subsystem are the nitrogen cover gases in the equipment drain tank (EDT) and the reactor drain tank (RDT). These tanks contain an initial nitrogen cover at a preset positive pressure. When liquid leakage enters either or both tanks it will raise the pressure of the cover gas. When the pressure reaches a specified upper limit the recycle compressor is actuated. The compressor discharges to the nitrogen recycle tank until the pressure in the equipment drain tank and reactor drain tank reduces to the normal operating pressure. Conversely when liquid is removed from either or both tanks, the cover gas pressure will drop to a lower limit. A pressure regulator valve then opens allowing nitrogen to flow into either or both tanks from the nitrogen recycle tank. The nitrogen recycle tank is periodically sampled by the gas analyzer. In the event of hydrogen or oxygen instrusion into the cover gas, the nitrogen recycle tank can be manually lined up with the gas recombiner system. The nitrogen recycle tank gas flows through a regulator valve into the gas recombiner system. The effluent, essentially nitrogen, from the gas recombiner system is returned by the gas recombiner compressor into the nitrogen recycle tank.

Gas Collection Header (GCH)

The GCH receives low activity gases containing oxygen from aerated tanks, ion exchangers, and concentrators. Detail on the sources and volumes to the GCH is provided in Table 11.3-6 of the FSAR.

Ventilation and Exhaust Systems

The major sources of building ventilation and exhaust include:

a) Reactor Building Heating, Ventilation, Air Conditioning (HVAC) System
b) Reactor Auxiliary Building HVAC System
c) Turbine Building HVAC System
d) Fuel Handling Building HVAC System.
e) Exhaust from the Steam Generator Blowdown System, Condenser Vacuum System and Gland Seal System

The Reactor Building HVAC System includes an internal containment recirculation system, known as the Airborne Radioactivity Removal System (ARRS). The ARRS includes two separate systems, each with a 12,500 cubic feet per minute (cfm) capacity. The system is designed to reduce airborne particulate and iodine activity within the Reactor Building and reduce discharge rates at times of purging the Reactor Building. The ARRS includes HEPA and charcoal filter beds.

During plant operation, the Reactor Building will be isolated or vented via eight-inch lines. Airborne activity can accumulate due to primary coolant leakage. Leak rates from the coolant to the Reactor Building atmosphere of 1.0 percent per day of the noble gases and 0.001 percent per day of the iodines are assumed.[1] Some of the activity will be released to the environment at times when the Reactor Building is vented. Such venting is assumed to be continuous at 2500 cfm. It is also assumed that during venting the Reactor Building atmosphere is passed through the ARRS continuously. During venting the release passes through HEPA and charcoal filters prior to discharge to the plant vent stack.

During shutdown, the containment is assumed to be continually purged through 48-inch purge lines. The radionuclide release rate from purging during shutdown is processed through HEPA and charcoal filters prior to discharge to the plant vent stack.

The HVAC exhaust from the RAB is discharged through the RAB exhaust filters. The Turbine Building and the Fuel Handling Building HVAC exhaust are normally released unfiltered due to their very small potential for contamination from radioactivity. Capability for filtration of Fuel Handling Building exhaust, in the event of an accident, is provided.

Thus, the SWS has provisions for controlling process flows and waste mixtures prior to solidification operations. Process flows and volumes are also controlled for solidification operations by adjusting the cement metering pumps. Controlled conditions of mixing assure that the liquids have been combined into a matrix that solidifies into a monolithic mass. Remote viewing is available to monitor for any excess water at the top of the liner (drum). Since several months storage space exists, any excess liquid could be allowed to evaporate with volatile radioactivity removed by ventilation systems. Additional solidification agent may also be added to solidify any free-standing liquid. The waste and solidification agent are processed through a fill station into disposable liners or 55-gallon drums. The containers, after monitoring for solidification, are capped and transferred to the Filled Liner Storage Area for temporary storage.

Prior to transporting the liners to an offsite burial facility, the containers and the vehicle are monitored for spreadable radioactivity and decontaminated as required for offsite shipment. The radioactive content of the containers is determined and additional packaging used, if necessary, to allow shipment and burial in accordance with 49 CFR Parts 170-179, 10 CFR Part 20, and 10 CFR Part 71. The expected volumes of solid waste to be shipped offsite are given in Table 3.5-16. The expected volumes of wastes to be shipped were calculated using the inputs to the SWS and a ratio of two volumes of waste to one volume of solidification material. The associated curie content, including a listing by principal nuclides is given in Table 3.5-17 for spent resins with six months decay, Table 3.5-18 for filter cartridges with six months decay, and Table 3.5-19 for precoat and particulate slurries, detergent concentrate and ICW concentrate. The basis for the activities is the radionuclide removals from the liquid processing streams.

The radioactive liner storage area can accommodate 60 liners. This is sufficient space for six months storage. This storage capability could be used to allow decay of short-lived isotopes before shipment; however, most of the drummed isotopes are long-lived and decay slowly. Therefore, the radioactive liner storage area capacity primarily provides flexibility in scheduling the offsite shipment of radwaste. The drums filled with compacted waste are stored in the 55-gallon drum storage area which can accommodate 50 to 100 drums, or at least one full offsite shipment.

3.5.5 Process and Effluent Radiological Monitoring

The Process and Effluent Monitoring and Sampling Systems provide the means for monitoring the liquid and gaseous effluents which could contain significant radioactivity. These systems are designed to give early warning of a malfunction which may lead to an unsafe condition, and to continually indicate and record radiation levels. To perform these tasks, radiation monitors are permanently installed, or specific sampling and analyses routines are established, to allow the evaluation of plant equipment performance and to measure, indicate, and record the radiation levels in the

process and effluent streams during normal operation and anticipated operational occurrences. The overall system is designed to assist the plant operator in evaluating and controlling releases of radioactive materials to the environment to insure that the requirements of 10 CFR Part 20 and 10 CFR Part 50, Appendix I are maintained. Table 3.5-20 identifies the principal radiological process and effluent monitors. The Process and
1 Effluent Monitoring Systems are discussed in detail in FSAR Section 11.5.

TABLE 3.5-4

RADIONUCLIDE CONCENTRATIONS AND SOURCE TERMS FOR THE FUEL POOL SYSTEM

Nuclide	Specific Activity at 70° F (uCi/cc)	Refueling Releases (Ci/20 days)	Normal Releases (Ci/yr)
H-3	4.4(-1)[a]	2.44(1)	1.30(3)
Kr-83m	2.0(-12)	4.04(-12)	2.26(-12)
Kr-85m	1.4(-7)	1.08(-6)	3.00(-7)
Kr-85	1.3(-4)	1.72(-1)	3.80(-1)
Kr-87	2.4(-15)	1.32(-15)	1.62(-15)
Kr-88	4.7(-9)	1.49(-8)	6.45(-9)
I-131	1.4(-3)	1.52(-5)	1.08(-5)
I-132	7.1(-10)	2.58(-10)	4.84(-12)
I-133	4.9(-4)	3.28(-6)	2.35(-6)
I-135	1.1(-5)	3.19(-8)	2.70(-8)
Xe-131m	8.6(-5)	7.68(-2)	1.20(-2)
Xe-133m	1.2(-4)	2.24(-2)	3.34(-3)
Xe-133	1.3(-2)	5.70(0)	6.80(-5)
Xe-135	1.5(-5)	3.07(-4)	6.80(-5)

[a] Parentheses denote power of 10.

Assumptions:

1. All noble gases in pool water are immediately released to the Fuel Handling Building atmosphere and vented.
2. Iodines, particulates and tritium enter the Fuel Handling Building atmosphere via evaporation processes.
3. Evaporation rate of 750 lbs/hr.
4. Partition factor = 0.001 for iodines and particulates and 1.0 for noble gases.
5. pH = 4.5 to 10.2.
6. Temperature = 130°F.
7. Iodine Concentration = 10^{-11} moles/liter. |1
8. Activity in pool declines exponentially via decay, evaporation and pool cleanup.
9. Cleanup Flow = 300 gpm; DF = 10 for all isotopes except tritium and noble gases.

TABLE 3.5-5

LIQUID RADWASTE SYSTEM INFLUENT STREAMS

	System	Source	Volume[a] gal/yr	Volume[a] gpd	Activity Fraction[a] of RCS
	Floor Drain System	Containment Sump	14,600	40	1.0
		Reactor Auxiliary Building	73,000	200	0.1
		Cask washdown	36,500	100	0.01
		Fuel Handling Bldg	36,500	100	0.1
		Pumps, valve leak drains, resin sluicing	60,225	165	0.1
		Hot Radio-Chem Lab drains	36,500	100	0.002
		Refueling	50,600	1,265[b]	0.1
		Reactor Containment Cooling System	365,000	1,000	0.001
1		Spent Fuel Pool liner leakage	256,000	700	0.001
		Decontamination Drains	133,000	3,000[b] 40[c]	0.01
	Secondary Particulate Waste	High Particulate Turbine Bldg drains	4,560,000 2,628,000	12,500 7,200	NA[e] Condenser Hot-well Activity
1	Secondary High Purity Waste	Low particulate	840,000	2,300	NA
	Detergent Waste System	Laundry, hot showers, hand wash	197,000 117,000	500 3,900[d]	NA

TABLE 3.5-5 (contd.)

LIQUID RADWASTE SYSTEM INFLUENT STREAMS

System	Source	Volume[a] gal/yr	Volume[a] gpd	Activity Fraction[a] of RCS	
Inorganic Chemical Waste	Inorganic chemical waste	840,000	2,300	NA	1
	Water analysis lab drains	525,600	1,440	Steam Generator Activity	

(a) In agreement with Reference 3.5-2.
(b) During 40-day shutdown only.
(c) During remaining 325 days.
(d) 30 days of shutdown operations.
(e) NA = Not Applicable

TABLE 3.5-6

LIQUID SOURCE TERMS FOR NORMAL OPERATIONS[a]

Nuclide	Boron RS (Ci/Yr)	Misc Wastes (Ci/Yr)	Secondary (Ci/Yr)	Turb Bldg (Ci/Yr)	Total LWS (Ci/Yr)	Adjusted[b] Total (Ci/Yr)	Deter-gent Wastes (Ci/Yr)	Total (Ci/Yr)
Corrosion and Activation Products								
Cr-51	2.50E-07[c]	3.19E-04	2.59E-05	1.84E-06	3.47E-04	6.90E-04	0.	6.90E-04
Mn-54	4.55E-08	5.34E-05	6.57E-06	4.12E-07	6.04E-05	1.20E-04	1.00E-04	2.20E-04
Fe-55	2.37E-07	2.76E-04	2.66E-05	1.65E-06	3.05E-04	6.06E-04	0.	6.10E-04
Fe-59	1.38E-07	1.70E-04	1.82E-05	1.23E-06	1.89E-04	3.76E-04	0.	3.80E-04
Co-58	2.26E-06	2.73E-03	2.51E-04	1.64E-05	3.00E-03	5.97E-03	4.00E-04	6.40E-03
Co-60	2.96E-07	3.45E-04	2.99E-05	1.86E-06	3.77E-04	7.50E-04	8.70E-04	1.60E-03
Np-239	5.18e-08	1.51E-04	1.20E-05	1.11E-06	1.64E-04	3.26E-04	0.	3.30E-04
Fission Products								
Br-83	3.94E-10	1.98E-05	7.27E-06	1.30E-06	2.83E-05	5.63E-05	0.	5.60E-05
Rb-86	1.22E-08	1.41E-05	1.97E-05	1.03E-07	3.39E-05	6.74E-05	0.	6.70E-05
Rb-88	3.83E-28	2.75E-08	1.02E-03	8.36E-12	1.02E-03	2.03E-03	0.	2.00E-03
Sr-89	4.86E-08	5.96E-05	6.13E-06	4.10E-07	6.62E-05	1.32E-05	0.	1.30E-04
Sr-91	1.61E-09	2.46E-05	3.58E-06	2.33E-07	2.84E-05	5.64E-05	0.	5.60E-05
Y-91M	1.04E-09	1.59E-05	1.43E-06	1.50E-07	1.74E-05	3.47E-05	0.	3.50E-05
Y-91	9.63E-09	1.15E-05	9.41E-07	6.24E-08	1.26E-05	2.50E-05	0.	2.50E-05
Zr-95	8.45E-09	1.02E-05	1.25E-06	8.21E-08	1.16E-05	2.30E-05	1.40E-04	1.60E-04
Nb-95	7.53E-09	8.67E-06	1.32E-06	8.23E-08	1.01E-05	2.00E-05	2.00E-04	2.20E-04
Mo-99	4.28E-06	1.11E-02	8.11E-04	7.54E-05	1.20E-02	2.38E-02	0.	2.40E-02
Tc-99M	4.08E-06	9.93E-03	5.22E-04	5.94E-05	1.05E-02	2.09E-02	0.	2.10E-02
Ru-103	6.13E-09	7.62E-06	5.99E-07	4.10E-08	8.27E-06	1.64E-05	1.40E-05	3.00E-05
Rh-103M	6.13E-09	7.64E-06	4.76E-07	4.09E-08	8.17E-06	1.62E-05	0.	1.60E-05
Ru-106	1.47E-09	1.72E-06	1.32E-07	8.24E-09	1.87E-06	3.71E-06	2.40E-04	2.40E-04
Ag-110M	0.	0.	0.	0.	0.	0.	4.40E-05	4.40E-05
Te-127M	4.03E-08	4.80E-05	3.20E-06	2.06E-07	5.15E-05	1.02E-04	0.	1.00E-04
Te-127	4.17E-08	6.84E-05	6.49E-06	4.17E-07	7.54E-05	1.50E-04	0.	1.50E-04
Te-129M	1.88E-07	2.36E-04	1.77E-05	1.23E-06	2.55E-04	5.08E-04	0.	5.10E-04
Te-129	1.20E-07	1.52E-04	1.22E-05	7.89E-07	1.65E-04	3.29E-04	0.	3.30E-04

TABLE 3.5-9 (contd.)

	Release Rate (Ci/yr)			
	Waste Gas	Building Ventilation		
Nuclide	System	Reactor	Auxiliary	Total
Airborne Particulate				
Mn-54	4.5E-05	2.2E-04	1.8E-04	4.5E-04
Fe-59	1.5E-05	7.4E-05	6.0E-05	1.5E-04
Co-58	1.5E-04	7.4E-04	6.0E-04	1.5E-03 |1
Co-60	7.0E-05	3.3E-04	2.7E-04	6.7E-04
Sr-89	3.3E-06	1.7E-05	1.3E-05	3.3E-05
Sr-90	6.0E-07	2.9E-06	2.4E-06	5.9E-06
Cs-134	4.5E-05	2.2E-04	1.8E-04	4.5E-04
Cs-137	7.5E-05	3.7E-04	3.0E-04	7.5E-04

(a) At 0.12% failed fuel as derived from Reference 3.5-1.

(b) The actual gas release point is the waste gas decay tanks.

(c) 0. indicates release is less than 1.0 Ci/yr for noble gas, 0.0001 Ci/yr for iodine.

TABLE 3.5-10

ASSUMPTIONS USED TO CALCULATE
GASEOUS RADIOACTIVITY RELEASES

Continuous stripping of full letdown flow		
Flow rate through gas stripper (gpm)		74.0135
Holdup time for Xenon (days)		90
Holdup time for Krypton (days)		90
Fill time of decay tanks for the gas stripper (days)		90
Primary coolant leak to Auxiliary Bldg (lb/day)		160
Auxiliary Building leak	Iodine partition factor	0.0075
Gas Waste System	Particulate release fraction	0.0100
Auxiliary Building	Iodine release fraction	0.1000
	Particulate release fraction	0.0100
Containment volume (10^6 cuft)		3.450
Frequency of primary coolant degassing (times/yr)		2
Primary to secondary leak rate (lb/day)		100
There is a kidney filter		
Containment atmosphere cleanup rate (thousand cfm)		11.5
Cleanup filter efficiency	Iodine	0.9000
	Particulate	0.9900
Cleanup time of containment (hours)		16
Iodine partition factor (gas/liquid) in steam generator		0.0100
Frequency of containment high-volume purge (times/yr)		4
Containment high-vol purge	Iodine release fraction	0.1000
	Particulate release fraction	0.0100
Containment low-volume purge rate (cfm)		2500
	Iodine release fraction	0.1000
	Particulate release fraction	0.0100
Steam leak to Turbine Bldg (lb/hr)		1700
Fraction of Iodine released from blowdown tank vent		0.0
Fraction of Iodine released from main condenser ejector		0.1
No cryogenic off-gas system		

TABLE 3.5-17

SOLID WASTE SYSTEM EFFLUENTS (CURIES/YEAR)
FROM SPENT RESIN[a]

Nuclide	Half Life	Activity	
H-3	12.3y	1.13E+01	
Br-84	31.8m	***	
I-129	$1.6x10^7$y	***	
I-131	8.06d	2.18E-03	
I-132	2.28h	***	
I-133	20.8h	***	
I-134	52.3m	***	
I-135	6.7h	***	
Rb-88	17.7m	***	
Rb-89	15.2m	***	
Sr-89	50.8d	9.27E+00	
Sr-90	28.9y	1.93E+01	
Sr-91	9.67h	***	
Y-90	64.0h	***	
Y-91	58.8d	6.54E+01	
Zr-95	65.5d	***	
Mo-99	66.6h	***	
Ru-103	39.8d	6.12E+00	
Ru-106	386 d	8.79E+01	
Te-129	34.1d	1.14E+01	1
Te-132	78h	***	
Te-134	43m	***	
Cs-134	2.06y	4.41E+03	
Cs-136	13d	2.40E-02	
Cs-137	30.26y	2.34E+03	
Cs-138	32.2m	***	
Ba-140	12.8d	2.59E-03	
La-140	40.2h	***	
Pr-143	13.6d	3.88E-03	
Ce-144	284 d	1.77E+02	

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[a] Based on 6-months decay of influent activities.

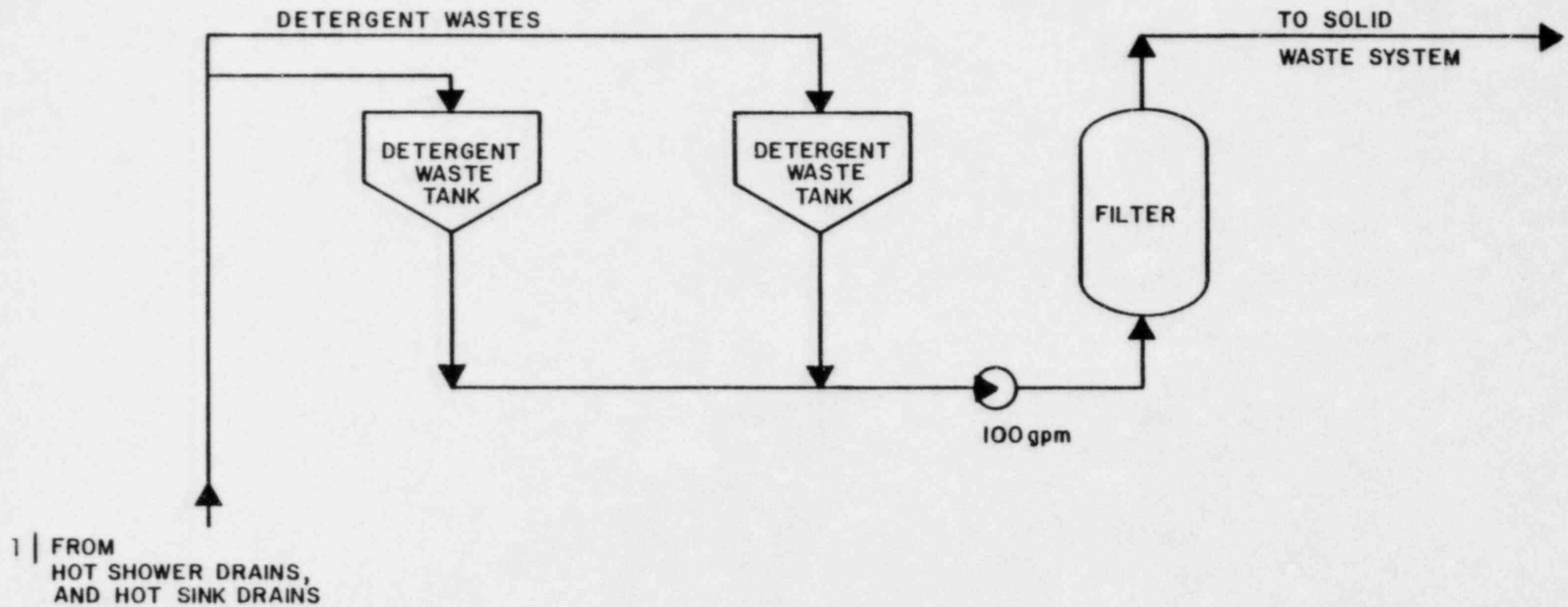
*** Denote nuclide activity less than 1.0E-04 curies/year.

TABLE 3.5-18

SOLID WASTE SYSTEM EFFLUENTS (CURIES/YEAR)
FROM FILTER CARTRIDGES[a]

Nuclide	Half Life	Activity
Cr-51	27.8d	7.11E-01
Mn-54	291 d	5.04E+00
Co-58	71 d	5.20E+01
Co-60	5.27y	9.23E+01
Fe-59	45 d	7.73E-02
Zr-95	65 d	2.20E-01

[a]Based on 6 months decay of input activities.



Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	DETERGENT WASTE SYSTEM BLOCK FLOW DIAGRAM	FIGURE 3.5-3

3.6 CHEMICAL AND BIOCIDE SYSTEMS

This section discusses the sources and treatment of chemical wastes resulting from plant operation. The anticipated water quality of the makeup and discharge is described in Table 3.6-1 and water treatment additives used in plant systems are listed in Table 3.6-2. The applicable discharge limitations are stipulated by the NPDES Permit included in Appendix A.

3.6.1 Makeup Demineralizer System

The Makeup Demineralizer System processes raw water from the plant Makeup Water System to produce high quality demineralized water. The demineralized water is required for Primary and Secondary System makeup and other miscellaneous plant uses.

The Makeup Demineralizer System consists of two cross-connected demineralizer trains, each with a normal capacity of 250 gpm and a maximum capacity of 375 gpm. Each demineralizer train consists of a cation exchange unit, an anion exchange unit, and a mixed-bed ion exchange unit. The cation exchange units are followed by a forced-draft deaerator.

The demineralizer trains are regenerated on the basis of ionic exhaustion or throughput. Each train is expected to have a throughput of about 280,000 gallons. The resins are first backflushed to remove suspended material. Cation resin is regenerated with dilute sulfuric acid (2 to 4 weight percent). Anion resin is regenerated with dilute sodium hydroxide (4 weight percent). After regeneration the resins are rinsed to remove excess regenerant solution. The backflush water, spent regenerant solution, and rinse water are transferred to the low volume waste treatment system. The waste will contain suspended material, ionic inpurities originating from the plant makeup water and excess regeneration reagents. The low-volume waste treatment system is described in Subsection 3.6.7 below.

3.6.2 Condensate Demineralizer System

The Condensate Demineralizer System processes secondary system feedwater to remove suspended material and ionic impurities. The system consists of 12 mixed-bed demineralizer units with 10 in service and 2 in standby as spares. The demineralizer units are removed from service based on throughput, pressure drop across the beds, or ionic exhaustion. The resins are transferred to a separate facility for regeneration. In the cation regeneration tank the resins are first backflushed to remove suspended matter. The anion resin is separated from the cation resin by classification and transferred to the anion regeneration tank for regeneration. The cation resin is regenerated with dilute sulfuric acid, and the anion resin is regenerated with dilute sodium hydroxide. The resins are then rinsed to remove excess regenerant solution. The anion resin is additionally treated with dilute ammonium hydroxide to prevent sodium ion leakage during service. Following regeneration the resins are transferred to the resin mixing tank where they are mixed and stored until required.

The waste will contain suspended material, consisting primarily of corrosion products from plant heat transfer surfaces, excess regenerants and rinse water. The waste is normally transferred to the low-volume waste treatment system for treatment and subsequent disposal. During normal operations portions of the waste including the backflush and the rinse water, can be processed in the SHP and SPWS (see Subsection 3.5.2.1) for reuse in the plant. Additionally, when primary to secondary system leakage occurs resulting in radioactive contamination of the condensate demineralizer system the waste is processed in the radwaste system.

3.6.3 Corrosion Control

Hydrazine is used in several plant systems to remove residual oxygen and as a corrosion inhibitor. During normal operation the concentration of hydrazine in the Secondary System feedwater is maintained in the range of 10 to
1 50 ppb. Hydrazine reacts with oxygen to yield nitrogen and water. Hydrazine decomposes to nitrogen and ammonia at higher temperatures. Essentially all of the hydrazine reacts or decomposes such that only trace quantities are released from the system.

Hydrazine is similarly used in the Primary System and the Auxiliary Boiler. The hydrazine concentration in the primary coolant is maintained in the range of 30 to 50 ppm at any time the temperature of the coolant is less than $150^{\circ}F$.

Most of the hydrazine utilized in the above applications decomposes or is oxidized. Any hydrazine released from these systems as a result of leakage or other mode of release is removed by subsequent treatment in the radwaste or secondary high purity waste treatment systems. Since hydrazine is a strong reducing agent its residual time is limited.

Ammonia is used to control pH in the Secondary Feedwater System, the Component Cooling Water System and the Auxiliary Boiler. The corrosion rate for steel is less at higher pH. In the Auxiliary Boiler System, ammonia provides the required conductivity for proper operation. As with hydrazine, any leakage from these systems is removed by subsequent treatment.

3.6.4 Biocide Control

Biocide control for the plant circulating water systems is provided by the addition of sodium hypochlorite. Sodium hypochlorite solution is injected at the intake to the circulating water pumps to produce a maximum concentration of 3 ppm (as chlorine) in the circulating water. Treatment periods vary from 20 to 30 minutes in duration. The treatment may be repeated up to twice daily depending on the biological activity in the cooling tower and the circulating water system. The maximum daily requirements for sodium hypochlorite will be approximately 800 pounds (as chlorine). The estimated average daily requirements will be less than 200 pounds (as chlorine).

TABLE 3.6-1

WATER QUALITY PARAMETERS - INTAKE AND DISCHARGE

	Intake Well[a]		Total Combined Discharge[b]		
	Ave	Max	Ave	Max	
	mg/l		mg/l		
Calcium	12.0	13.1	72.0	97.1	
Magnesium	4.3	4.8	25.8	35.4	
Sodium	6.0	6.5	36.0	164	
Potassium	0.70	0.77	4.08	5.67	
Chloride	4.2	4.2	25.2	31.7	
Fluoride	0.113	0.122	0.68	0.90	
Sulfate	2.8	2.8	300	560	
Phosphorus	0.142	0.240	0.85	1.66	
Ammonia N	0.014	0.028	0.08	0.19	
NO_3 and NO_2 N	0.51	0.54	3.06	4.02	
Oil and Grease	<1.0	<1.0	<1.0	1.0	
Chlorine (tot. residual)				0.05	
Alkalinity (as $CaCO_3$)	56	64	76	86	
Hardness (as $CaCO_3$)	54	60	324	360	
TDS	96[c]		735	941	1
TSS	1		6	8	
pH	6.9	7.5	7.1	8.5	
	ug/l		ug/l		
Barium	4.0	12.0	24.0	78.2	
Cadmium	<0.1	0.2	0.6	1.4	
Chromium	0.6	1.2	23.1	28.4	
Copper	<1.0	7.0	21.5	61.3	
Iron	16.0	90	183	655	
Lead	<1.0	<1.0	< 6.0	7.5	
Manganese	1.0	4.0	8.2	27.8	
Mercury	<0.2	0.7	1.2	4.5	
Nickel	<1.0	10.0	18.6	74.1	
Zinc	<5.0	7.0	31.2	56.9	

[a] Compiled from Environmental Monitoring Program reports 1978-1980 (References 2.2-2, 2.2-3, and 2.2-4) and Metals Monitoring Program report (Reference 2.4-6.)

[b] Includes concentrated makeup water, corrosion products, treatment additives, and low-volume waste.

[c] From Table 2.5-10 of ER-CP (Reference 2.2-1)

TABLE 3.6-2

WATER TREATMENT ADDITIVES

Additive	Systems Served	Purpose	Annual Quantities (lbs/yr) Ave	Max
Hydrazine (As 35 wt % solution)	Primary Coolant Condensate and Feedwater Component Cooling Water Auxiliary Boiler System	Oxygen Scaverging and Corrosion Inhibitor	10,000	16,000
Ammonia (As 29 wt % solution)	Condensate and Feedwater Component Cooling Water Auxiliary Boiler	pH Control and Corrosion Inhibitor	300,000	400,000
Sodium Hydroxide (As 50 wt % solution)	Makeup Demineralizer Condensate Polishing Low Volume Waste Treatment Chemical and Volume Control Radwaste System	Resin Regeneration pH Control and Adjustment	175,000	250,000
Sulfuric Acid (As 93 wt % solution)	Makeup Demineralizer Condensate Polishing Circulating Water System Storm and Construction Runoff	Resin Regeneration pH Control and Adjustment	2,700,000	3,000,000
Polyelectrolyte (Magnafloc 573C liquid)	Storm and Construction Runoff	Flocculation and Sodimentation	20,000	42,000
Sodium Hypochlorite (As 15 wt % solution)	Circulating Water Potable Water	Biocide Treatment	160,000	250,000
Sulfur Dioxide (Compressed Gas)	Circulating Water	Chlorine Neutralization	10,000	12,000
Hydrogen (Liquefied Gas)	Primary System Turbine-Generator	Oxygen Scavenger Coolant	3,000	4,000
Nitrogen (Liquefied Gas)	Chemical and Volume Control Gaseous Waste System	Cover Gas Purge Gas	15,000	20,000
Carbon Dioxide (Liquefied Gas)	Turbine-Generator Fire Protection	Purge Gas Fire Retardant	4,000	6,000
Boric Acid (Crystalline Powder)	Primary Coolant	Chemical Shim	1,000	2,000

3.7 SANITARY AND OTHER WASTE SYSTEMS

3.7.1 Sanitary Waste Treatment

The Sanitary Waste Treatment System consists of two packaged sewage treatment plants, a drainfield and all necessary forwarding (lift) stations. The sewage treatment units utilize the extended aeration - activated sludge process. One unit has a nominal capacity of 20,000 gpd; the other unit has a nominal capacity of 30,000 gpd. The units were sized in this manner to provide adequate treatment during the construction phase of the plant and for the greatly reduced loadings expected to occur later during plant operation. The design basis for sanitary waste treatment facility is 40 gallons per capita day and 0.07 pounds per capita day of 5-day BOD.

Sanitary waste is transferred from its sources to the sewage treatment plants by gravity and by wet pit type lift stations. Five lift stations have been provided for this purpose and will be used as required during plant operation.

In the sewage treatment plant the waste is first processed through a comminuter where the larger solids are reduced in size by maceration. The effluent from the comminuter section is course screened and discharged to the effluent basin. From the influent basin the waste is transferred via the surge tank to the aeration tank. The influent basin and surge tank provide a means of flow equalization and control.

The aeration tank provides a minimum of 24 hours waste retention time under aerated conditions. Air for mixing, biological treatment, and air operated components is supplied by two positive displacement air blowers (per unit). Air is supplied to the aeration tank to maintain the solids in suspension and provide a dissolved oxygen concentration of approximately 2.0 mg/l. The aeration tank is also equipped with a surface froth and foam control system.

Effluent from the aeration tank is processed through a grease trap and discharged to the clarifier tank. The clarifier tank provides a minimum retention period of three hours, adequate to allow effective sludge separation and removal. A portion of the sludge, sufficient to produce the required purification in the available aeration time, is returned to the aeration tank. The remaining sludge is transferred to the digester tank (aerated sludge holding tank).

One digester tank serves both sewage treatment units. The digester has a capacity of approximately 3000 gallons. The digester tank design includes a cover and flame arresting gas vent. Air diffusers are provided to promote mixing and to supply air for sludge digestion. Supernatent liquid is returned to the clarifier through an overflow pipe. Accumulated sludge (about 3500 gallons) is removed for off-site disposal once every three months (construction phase experience with less frequent removal expected during operation phase).

Overflow from the clarifier tank flows by gravity to a forwarding station and is pumped to the drain field for disposal. The drainfield consists of three separate component drainfields each capable of handling 16,000 gpd, all dosed in sequence to provide rest periods. The drainfield design includes the capability to isolate component drainfields during low-flow periods. Each field consists of twenty-seven 100-foot laterals in groups of nine and served by distribution boxes which provide equal flow.

3.7.2 Emergency Diesel Engines Exhaust

The emergency diesel engines are tested on a monthly basis. During the test, each engine is operated for approximately two hours. Two 7600-kw emergency diesel engines and one diesel driven fire pump has been provided for the plant. With a full-load fuel consumption rate of about 500 gal/hr, each of the emergency diesel engines will emit pollutants at the following rates: NO_x - 210 lbs/hr, SO_2 - 40 lbs/hr, particulate - 7 lbs/hr. With test durations totaling about 60 hours, the plant emissions on an annual
1 basis are as follows: NO_x - 12,600 lbs/yr, SO_2 - 2400 lbs/yr, particulates - 420 lbs/yr.

Since the diesel units are operated infrequently throughout the year, their operation will not contribute to atmospheric pollution problems.

ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM

The heat dissipation system is described in Section 3.4. This section discusses the physical and biological effects of system operation.

5.1.1 Effluent Limitations and Water Quality Standards

The Water Quality Standards of the State of Washington[1] classify the reach of the Chehalis River in the vicinity of the plant as "Class A (Excellent)". The standards specify that the increase in water temperature outside a specified mixing zone shall not exceed $t = 28/(T + 7)$, where t is the permissible increase and T is the existing water temperature in ^{o}C. When the ambient water temperature exceeds $18.0^{o}C$ the maximum permissible increase is $0.3^{o}C$.

Discharges from WNP-3 are controlled to comply with the National Pollutant Discharge Elimination System (NPDES) Permit (see Appendix A) issued by the State of Washington in compliance with Chapter 155, laws of 1973 (RCW 90.48), as amended, and the Clean Water Act (PL 95-217), as amended. This permit incorporates the Water Quality Standards and establishes a dilution zone with longitudinal boundaries 50 feet upstream and 100 feet downstream from the diffuser and lateral boundaries 25 feet from the midpoint of the diffuser. Vertically, the dilution zone extends from the surface to the river bottom. Consistent with the applicable guideline of 40 CFR Part 432, the permit limits the temperature of the blowdown to the lowest temperature of the recirculated cooling water prior to the addition of makeup water. In addition, the permit specifies that when ambient river temperatures are $20^{o}C$ or less, the discharge temperature shall be $20^{o}C$ or less and shall not exceed the ambient temperature by more than $15^{o}C$; and when the ambient river temperatures are greater than $20^{o}C$, the discharge temperature shall be equal to or less than the ambient temperature. No discharge is permitted when downstream velocities are less than 0.3 feet per second (fps).

5.1.2 Physical Effects

The thermal dispersion characteristics of the multiport blowdown diffuser were studied using a hydraulic model with a scale of 1:12.[2] The studies were conducted to support the dilution zone definition in the NPDES Permit and, consequently, focused on abnormal conditions. These conditions included minimum recorded daily flowrates for the Chehalis River and temperatures which are exceeded 99 percent of the time. These conditions are shown in Tables 2.4-1 and 2.4-5 and may be compared with the average data listed in the same tables. It should be noted that the summer low flows which were used are less than the once-in 10-yr, 7-day low flow of 530 cfs reported in Figure 2.4-3. The plant operating parameters that were modelled are shown in Table 3.4-1.

Additional conservatism is provided by the fact that the above-mentioned model tests were conducted primarily for two-unit (both WNP-3 and WNP-5) operation. Some results are shown in Figures 5.1-1 through 5.1-3. Figures 5.1-1 and 5.1-2 are for two-unit operation in January and August, respectively. Figure 5.1-2 can be compared with Figure 5.1-3 which depicts the August isotherms with only a single unit operating. A critical period for meeting water quality standards is expected to be October when the flows are low and the initial temperature differences are greatest. However, as shown in Table 5.1-1, dilution zone boundary temperatures are predicted to meet water quality standards in every month.

The river reach in the vicinity of the discharge is subject to flow stagnation and reversal during the infrequent coincidence of low river flow and extreme high tides. Several cases (e.g., river flow @ 440 cfs, Aberdeen tide @ 5.6 ft MSL) resulting in the stagnation or reversal phenomena were studied using the hydraulic model. However, the results are not discussed here because, as noted in Subsection 5.1.1, the NPDES Permit prohibits discharges when downstream river velocities go under 0.3 fps.

The unidirectional flow examples discussed above provide predictions of the seasonal variation of blowdown plume temperatures under severe conditions (low river flow, large initial temperature differences). The near- and intermediate-field temperatures of the dilution zone are seen to comply with water quality standards (see Table 5.1-1). Bulk river temperatures in the far-field will be increased no more than 0.05°C in any season due to the maximum incremental addition of approximately 10,000 Btu/sec of heat in the blowdown from WNP-3.

5.1.3 Biological Effects

5.1.3.1 Intake Structure Effects

Two subsurface infiltration-type intake structures (Ranney collector wells) located on the south bank of the Chehalis River near River Mile 18 will supply makeup water for WNP-3. Impingement and entrainment of aquatic organisms is precluded by the use of the collector wells.[3] Loss of aquatic habitat and benthic macroinvertebrates due to drawdown of the river channel (0.1 ft or less in an area with tidal fluctuations of 2 or more ft) will be negligible. Nearby Elizabeth Creek may become dry in the fall blocking the stream to both anadromous and resident fish. The number of annual juvenile coho and chum that would be lost as a result of this blockage was estimated to be 0.1% of the total run and is considered an acceptable loss.[3] The actual impact on coho and chum is probably less than previously estimated because of clearcutting in the upper Elizabeth Creek watershed during 1973 to 1976.[4] This has increased siltation, and along with numerous other obstacles (eg. fallen trees), has decreased the spawning potential from approximately 65 redds in 1968-1969 to 15 in
1 | 1977-1978, at the most recent estimate.[5]

5.1.3.2 Effects of Thermal Effluents

Thermal effects of the WNP-3 blowdown discharge are expected to be negligible from either a temperature increase or from "cold shock". Thermal effects involve two factors: (1) the change in water temperature above or below ambient and (2) the duration of exposure of the organisms to the change in temperature. Temperature, because of its direct and/or indirect effects, is a principal factor determining the suitability of a habitat for aquatic organisms. The introduction of heated water into an aquatic ecosystem may cause some biological changes that will affect metabolism, development, growth, reproduction, and mortality. These effects are documented in the literature.[6-8] The tolerance of organisms to any temperature change is species specific and depends on the magnitude of the change and the duration of the exposure, as well as previous temperature acclimation.

Periphyton and Phytoplankton

The compositions of the periphyton and phytoplankton communities in the Chehalis River are typically at a subclimax level of growth because of the turbulent river flow, seasonal low water temperature and high turbidity. The periphyton and phytoplankton population in the Chehalis River is dominated by diatoms and blue-green algae, particularly in the warm summer months. Table 5.1-2 shows data on the thermal tolerance limits of several periphyton and phytoplankton taxa. 1 As shown in Figure 5.1-2, under an extremely low river flow, the temperature rise above ambient will be less than 1.0°C within a few feet of the diffuser ports. This rapid dilution of the discharge ensures that species inhabiting the area near the diffuser will not be affected. Nor will there be a significant long-term effect on the periphyton and phytoplankton community of the river. These organisms are abundant throughout the river system and their rate of productivity is high. Thus, losses, if any, would probably be rapidly compensated by upstream sources with no measurable effect on the entire ecosystem.

Benthic Macroinvertebrates

The upper temperature limits for the majority of benthic organisms reported to occur in the Chehalis River appear to be in the range of 29.0 to 34.5°C, with tolerance somewhat dependent on the species, stage of development, and acclimation temperature. Data on the thermal tolerance of several types of benthic macroinvertebrates appears in Table 5.1-3. 1 Curry[13] found the upper thermal tolerance of several families of aquatic dipterans to be in the range of 30 to 33°C. Caddisfly larvae, and stonefly and mayfly nymphs acclimated to 10°C had a 96-hour median tolerance to temperatures ranging from 21.1 to 30.5°C, with mayflies being the most sensitive.[14] Becker[15] reported that caddisfly larvae acclimated to a river temperature of 19.5°C had a 50% mortality after a 68-hour exposure to a 10°C increment, whereas, mortality at 7.5 C above ambient was insignificant. Becker also reported that stepped thermal increases up to a differential of 10°C resulted in well-defined increases in growth for all of the species tested.[15]

The ecological consequences of thermal discharges on benthic macroinvertebrates are expected to be negligible with the potential for lethal effects being restricted to sessile organisms in the immediate area at the diffuser. Any sublethal effects [16,17], if they occur, will probably occur within the isotherms with a delta-T ≥ 0.6°C. Even with two units operating, these isotherms would cover an area of less than 0.012 acres. The magnitude of these changes should have no measureable effect on the benthic community and thus no impact on the fish resources.

Fish

Temperature is one of the important parameters influencing the fishery resources in the Chehalis River. Anadromous fish, particularly salmonids, have the greatest sport and commercial value. A review of the tolerance and thermal requirements of fish [18] indicates that, in the Chehalis River, salmonids are the species most sensitive to thermal discharges. Thus, protecting one of the most thermally sensitive group of species (i.e., juvenile salmonids) in the Chehalis River should adequately protect the remaining fish as well. Tables 5.1-4 and 5.1-5 provide data on thermal stress limits for juvenile salmonids.

No salmonid spawning has been documented in the vicinity of the WNP-3 discharge.[19] Thus, there will be no effect of the thermal discharges on salmonid embryogenesis and early development. Juvenile salmon and trout
1| do migrate downstream through the discharge area. Peak movement occurs March through July. During this time, river currents are greater than 1 fps in the discharge area.[19] In general, juvenile salmonids cannot maintain their position in currents greater than 1 fps. Therefore, the juvenile salmonids would probably be passively swept through the dilution zone, and would be exposed to elevated temperatures in the mixing zone for less than two minutes. (This assumes the fish passively drift through the area at 1 fps.) Based on the short exposures to elevated temperatures and the thermal stress limits shown in Table 5.1-4 and 5.1-5, no adverse effect to juvenile outmigrant salmonids is expected.

Adults salmonids migrate upstream through the discharge area. Thermal tolerances of adult salmonids are similar to or greater than juveniles; therefore, the adults are not expected to suffer any adverse effects from the discharge temperature. Site-specific ultrasonic tracking studies by Thorne et. al.[20] show that the adult upstream migrants tend to travel near the river bank rather than midstream where the discharge is located. In addition, adult salmonids are expected to avoid the thermal plume. Cherry et. al.[21] reported that adult rainbow trout avoided temperatures of 19°C. Also, ambient water temperatures which exceed 21.1°C are reported to impede or block adult salmonid migration.[22,23] As noted previously in Subsection 5.1.1, when ambient river temperatures are greater than 20°C, the discharge temperature will be equal to or less than ambient and therefore will not add any additional thermal stress to the fish.

Non-salmonid fish populations in the Chehalis River consist largely of suckers, sticklebacks, scupins, whitefish, shiners, and minnows. Field-measured upper preference temperatures for these species at other locations were in the range of 23 to 36°C.[18] Based on this information, it is judged that these species will not be affected by the WNP-3 thermal discharge. 1

The discharge limitations described in Subsection 5.1.1, which are based on extreme ambient Chehalis River temperatures and physiological thermal limits for juvenile salmonids, will insure that no acute mortality or other significant adverse chronic effects will occur as a result of the thermal discharge.

Cold Shock

Cold shock is an additional concern at some power plants, particularly those using natural bodies of water for once-through cooling. Cold shock problems stem from the sudden cessation of thermal discharge when the plant is shut down. Since the thermal plume attracts certain aquatic organisms, particularly fish, these organisms become acclimated to the elevated temperatures and, in fact, dependent on them for survival. Fish mortalities have occurred at a few facilities following shutdowns and much effort has recently gone into devising ways to eliminate these fish kills. Cold shock is never expected to occur at WNP-3 because during the months when it is a potential problem (i.e., winter) river flow will be high enough to prohibit prolonged occupation in the discharge area. For fish to become acclimated to the warmer temperatures of the plume, they would have to occupy these waters for several days, which is not expected to happen in the strong river currents. Fish populations downstream from the mixing zone, where the river has become thermally homogenous, will experience temperatures that are essentially natural.

The benthic community is the only other aquatic community that might be continuously exposed to the effluent and thus become acclimated to the higher temperatures. However, any impact on the benthic population from cold shock would be minimal in terms of the aquatic community in the vicinity of the site because the potentially affected area is so small (i.e., area with a $T \geq 0.6^{\circ}C$ is < 0.012 acres).

5.1.3.3 Effects on Water Quality and Aquatic Habitat

The effects of changes in water quality parameters other than temperature on the aquatic biota have also been considered. Included are dissolved oxygen, nutrients and suspended sediments. (The effects of chemical discharges are considered in Section 5.3).

The dissolved oxygen concentration in the Chehalis River should not be decreased by operation of the proposed plant. Temperature affects the solubility of oxygen; the warmer the water, the less soluble is the oxygen. Although the slightly warmer discharge may have a slightly lower oxygen concentration than the receiving water, its small volume coupled with rapid mixing induced by the diffuser should not result in any measurable change in the oxygen concentration of the river.

During normal plant operation, little or no nutrients will be added and no effect on the aquatic ecosystem will occur.

Little siltation or bottom scouring will result from the diffuser discharge because of the low volumes of water involved and because of the diffuser design (i.e., individual ports 1 ft above the bottom and oriented downstream and upward). Any siltation will stabilize and will have no long-term impact.

The thermal discharge is not expected to have any significant impact on aquatic wildlife habitat. The volume of the dilution zone is very small (Figure 5.1-1). Since the diffuser will be located approximately 100 feet from either river bank, this zone will have no effect on the shoreline. Therefore, wildlife such as amphibians, aquatic mammals, wading birds or migratory fowl that might use these areas will not be adversely affected by the discharge.

5.1.4 Atmospheric Effects

As noted in Section 3.4, the closed-cycle cooling system will dissipate approximately 8.7×10^9 Btu/hr of waste heat at full load. This rejected heat is transferred to the atmosphere both as sensible heat (by raising the temperature of air drawn through the cooling tower) and as latent heat (by evaporating water into the air). This process results in saturation of the exhausted air and subsequent formation of visible plumes. The air drawn through the tower will also entrain drops of cooling water which will be deposited near the site as drift. The effects of these phenomena are discussed in this subsection.

5.1.4.1 Plume and Fog Formation

The condensation of emitted water vapor results in the formation of tiny water droplets which have a negligible fall velocity and are effectively suspended in the air and transported with the wind as they evaporate. The nature and degree of nuisances caused by this plume depend, to a large extent, on whether it remains elevated or interacts with the ground.

At operating power plants in the 500 MWe to 2500 MWe range, the observed visible plumes may extend 5 km downwind under extreme conditions.(25-28) These observations have been used to characterize both the height and the downwind extension of visible plumes.

Results of plume model calculations (Subsection 6.1.3.2) for two units (WNP-3 and WNP-5) are presented in Table 5.1-6. The table shows the amount of time in any one year during which the plume lengths are greater

than or equal to the indicated distances. Note that plume lengths will be less than 1 km for roughly 46 percent of the time. No lengths greater 1
than 7 km (4.3 mi) were determined in this analysis. Plume lengths tend to be the longest during the fall and shortest during the summer. Plumes also tend to be longest when conditions are near saturation (i.e., during cloudy weather). The cloud cover will substantially reduce the visual impact of the plume.

The effects of the plume interacting with the ground (fogging and icing) are not expected to be a problem with the cooling tower plume from WNP-3. The vapor plume exits the tower at about 870 ft MSL. The nearest commercial highway, SR 12, is about 2.6 miles north at an elevation less than 50 ft MSL. Residential areas are at approximately the same elevations. The elevation difference (800 to 850 ft) and the momentum and buoyancy of the plume will combine to keep the plumes well removed from populated areas and commercial activities. Furthermore, the plume should not result in significant biological impacts.

Operations from the Elma Airport (3 mi NE) may suffer minimal disruption as takeoffs and landings are parallel both to valley air flow and to valley ridges upon which the cooling towers are sited. However, the occurence of stratus/stratocumulus is so common to the Elma area that elevated clouds are normally encountered during aircraft operations. Although air traffic could possibly be disrupted, the extent and duration will be localized and extremely limited. As shown in Table 5.1-6, visible plumes longer than 4 km (2.5 mi) are expected to occur only 17 hrs/yr in the NNE and NE sectors.

Plume buoyancy and elevation of release make plume-related impacts to 1
terrestrial biota very unlikely. As noted above, the plume length frequencies of Table 5.1-6 do not characterize an incremental impact of WNP-3 because the area is subject to persistent fog and low-lying clouds, especially in winter. The cooling tower plume will not significantly affect the quantity or quality of incoming solar radiation available to vegetation nor will it result in increased incidence of ice damage.

5.1.4.2 Drift Deposition

In addition to the water vapor exhausted to the atmosphere, the cooling towers will lose a small fraction (0.003 percent, see Subsection 3.4.2) of the recirculating cooling water as drift. The water droplets become mechanically separated from the recirculating water and are entrained into the tower's updraft. This drift contains the dissolved solids, or salts, which are normally carried by the cooling water. (In contrast, the normal plume droplets are composed of pure water resulting from evaporation and condensation of the cooling water in the towers.) A large percentage of the drift droplets have a measurable fall velocity such that they fall to the ground immediately surrounding the plant. In dry weather, the drift droplets may actually evaporate in the atmosphere, leaving crystals of salts which will essentially disperse or fall to the surface, depending on their size.

The deposition of these salts on the surrounding landscape depends greatly on the local atmospheric conditions and the concentration of salts in the droplets. The onsite meteorological data and the methods identified in Subsection 6.1.3.2 were used to estimate the average annual deposition patterns around the site. Figure 5.1-4 presents the mean annual salt deposition from the cooling tower assuming year-round, full-power operation. Deposition rates within 1500 feet of the tower are quite uncertain, but beyond this distance, maximum total deposition is expected to be below about 45 lb/acre-yr. Heaviest deposition rates are expected in the west-southwest and east-northeast sectors. Beyond 1 mile from tower the estimated deposition is below 16 lb/acre-yr and beyond 2 miles it drops below 1 lb/acre-yr.

Cooling tower drift is not expected to affect terrestrial biota. As shown in Figure 5.1-4 and noted above, the predicted drift deposition rates, even with the assumption of year-round, full-power operation are very low
1 beyond the immediate vicinity of the cooling tower. With the high annual precipitation (66 inches) and permeable soils, it is unlikely that drift constituents would be retained on vegetation or in the soil. Bulk precipitation samples collected on study plots near WNP-3 (see Subsection 6.1.4.3) revealed an average deposition rate of 8.2 lb/acre-month of combined sodium, calcium, sulfate, and chloride from all sources (e.g., rainfall, aerosols, dustfall) from March 1978 through February 1980 (References 6.1-10,-11,-12). Deposition attributable to the cooling tower will be indistinguishable from the nearly 100 lb/acre-yr of background material. Such has been a conclusion based on seven years of preoperational and post-operational data collected at the Trojan Nuclear Plant.(29) This plant also has a natural draft tower and is located in an area with climate and terrestrial biota very similar to the WNP-3 site.

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TABLE 5.1-1

PREDICTED DILUTION ZONE BOUNDARY TEMPERATURES VS. WATER QUALITY STANDARD

	Temperatures (°C)			
Month	River	Discharge	Dilution Zone[a]	WQS[b]
January	0.0	10.3	0.9	4.0
February	1.1	9.7	1.9	4.3
March	3.9	8.6	4.3	6.5
April	5.0	8.9	5.3	7.3
May	10.0	10.8	10.1	11.6
June	11.1	13.1	11.3	12.5
July	14.4	16.1	14.6	15.7
August	15.6	17.5	15.8	16.8
September	11.7	18.3	12.4	13.2
October	5.0	17.5	6.1	7.3
November	4.4	15.3	5.4	6.9
December	0.6	12.8	1.7	4.3

(a) Two units operating. Peak surface temperature 100 ft downstream from diffuser, from Reference 5.1-2.

(b) Water quality standards from Reference 5.1-1. See Subsection 5.1.1.

TABLE 5.1-2

THERMAL TOLERANCE OF PERIPHYTON AND PHYTOPLANKTON 1

Organism	Maximum or Optimum Temperature or Range	Miscellaneous Temperature Response	Reference
Cocconeis schlettum	Range 34°C - 36°C		(9)
Diatoms Green Algae Blue-Green Algae	Most abundant at 20°-30°C Most abundant at 30°-35°C Most prolific at 35°C		(10)
Stigoclonium tenius	Maximum temperature for living = 27°C		(9)
Nitzschia filiformis Gomphonema paruulum	Optimum growth between 22°-26°C Maximum 31°-35°C		(9)
Phytoplankton	An increase in temperature of approximately 8° C stimulated photosynthesis when natural water temparature was 16°C or cooler and inhibited photosynthesis when water was 20°C or warmer		(11)
Algae		Not injured passing through condensers if temperature does not exceed 34°-34.5°C	(9)
Nitzschia, Oscillatoria, Ankistrodesmus		Incubated microecosystems for 20 weeks at 26°C then cooled to 12°C at 1-5 day intervals. No significant difference in species present between 26 and 12°C.	(12)

1 TABLE 5.1-3

THERMAL TOLERANCE OF AQUATIC INVERTEBRATES

Organism	Range or Optimum	Upper-Lethal	Misc. Temperature Response
Coelenterata			
Hydra littoralis			Animals acclimated to 5°C were twice as large as those acclimated to 21°C
Annelida			33°C - Optimum temperature for activity of choline-acetyl-transferase in nervous tissue
Hirudo medicinales			
Arthropoda Crustacea			Eggs developed most rapidly between 14°C to 20°C
Cyclops scutiper			
Cyclops abyssorum			Egg rate development doubled every 5°C between 5° and 25°C
Cladocerans		The least resistant species Eurycercus and Chydorus perished at 35.0° to 35.5°C	
Eurycercus lamellatus			
Chydorous globosus			
Gammarus pseudolimnaeus		24-hr lethal temp - 29.9°C	
Astacus		35°C lethal temperature	
Insecta			
Diptera Tendipedidae Chironomus			Increased larval maturation rate when temperature was raised from 21°C to 31°C
Chironomus Plumosus	Largest number of emerging adults 23°C		
Chironomous hiparius			Adult midge larger when larvae raised @ 10°C than @ 20°C
Chironomidae		Most die at 35° C after an exposure of 13 to 16 hrs.	
Tendipedidae		Upper limit of 30°C to 33°C	

TABLE 5.1-5

ACCEPTABLE PHYSIOLOGICAL LIMITS FOR
REPRESENTATIVE THERMALLY SENSITIVE SPECIES[a]

Acclimation Temperature (°C)	Upper Acceptable Physiological Limit (°C)	Lower Acceptable Physiological Limit (°C)
5	20.5	1.2
10	21.6	2.7
15	22.1	5.7
20	22.7	7.5
23	22.8	8.3

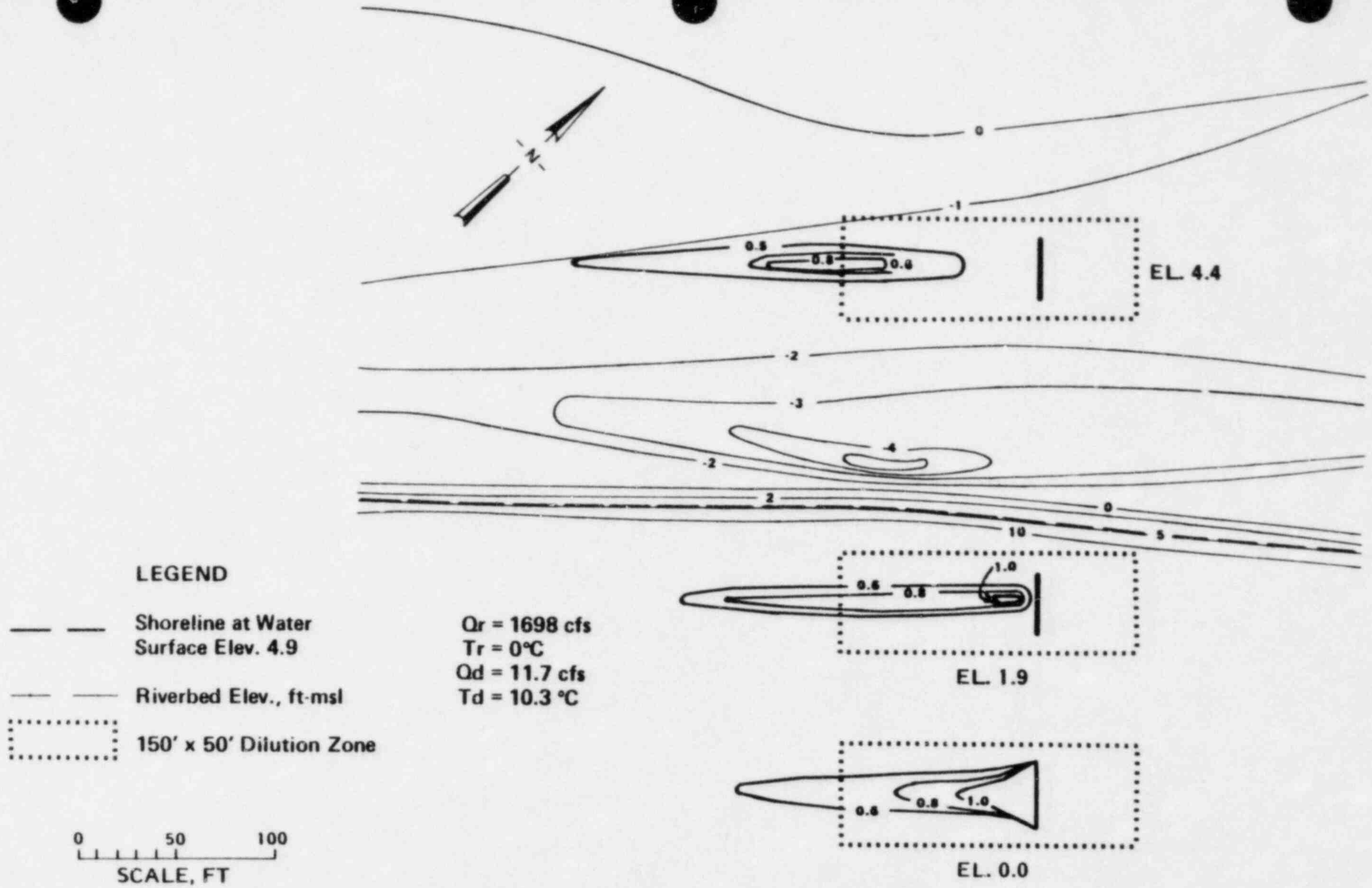
(a) Acceptable physiological limit is defined as the temperature at which no mortalities or other significant adverse effects would be expected in the dilution zone. To obtain these limits, a 1°C safety margin was applied to the upper or lower lethal limit of the least tolerant of the three species (chinook, coho, chum) at each acclimation temperature in Table 5.1-4. 1

TABLE 5.1-6

FREQUENCY OF COOLING TOWER PLUME LENGTHS VS. DIRECTION[(a)]

Direction From Tower	Distances (km) from Towers 1	2	3	4	5	6	7
S	66	43	22	8	6	2	0
SSW	92	48	27	14	8	3	0
SW	273	159	84	33	18	7	0
WSW	650	312	108	41	14	7	0
W	414	182	77	33	18	5	0
WNW	329	133	60	27	12	2	0
NW	389	132	66	24	13	2	0
NNW	226	84	42	19	11	3	0
N	436	137	48	18	10	3	0
NNE	460	115	34	10	5	3	0
NE	414	83	23	7	5	1	0
ENE	562	132	40	8	6	1	0
E	283	73	32	11	7	1	0
ESE	69	33	19	9	6	1	0
SE	57	26	10	3	3	1	0
SSE	50	27	13	5	2	1	0
Total Hrs	4,770	1,719	705	270	144	43	0

(a) Frequency (hr/yr) that a visible vapor plume equals or exceeds indicated distance.



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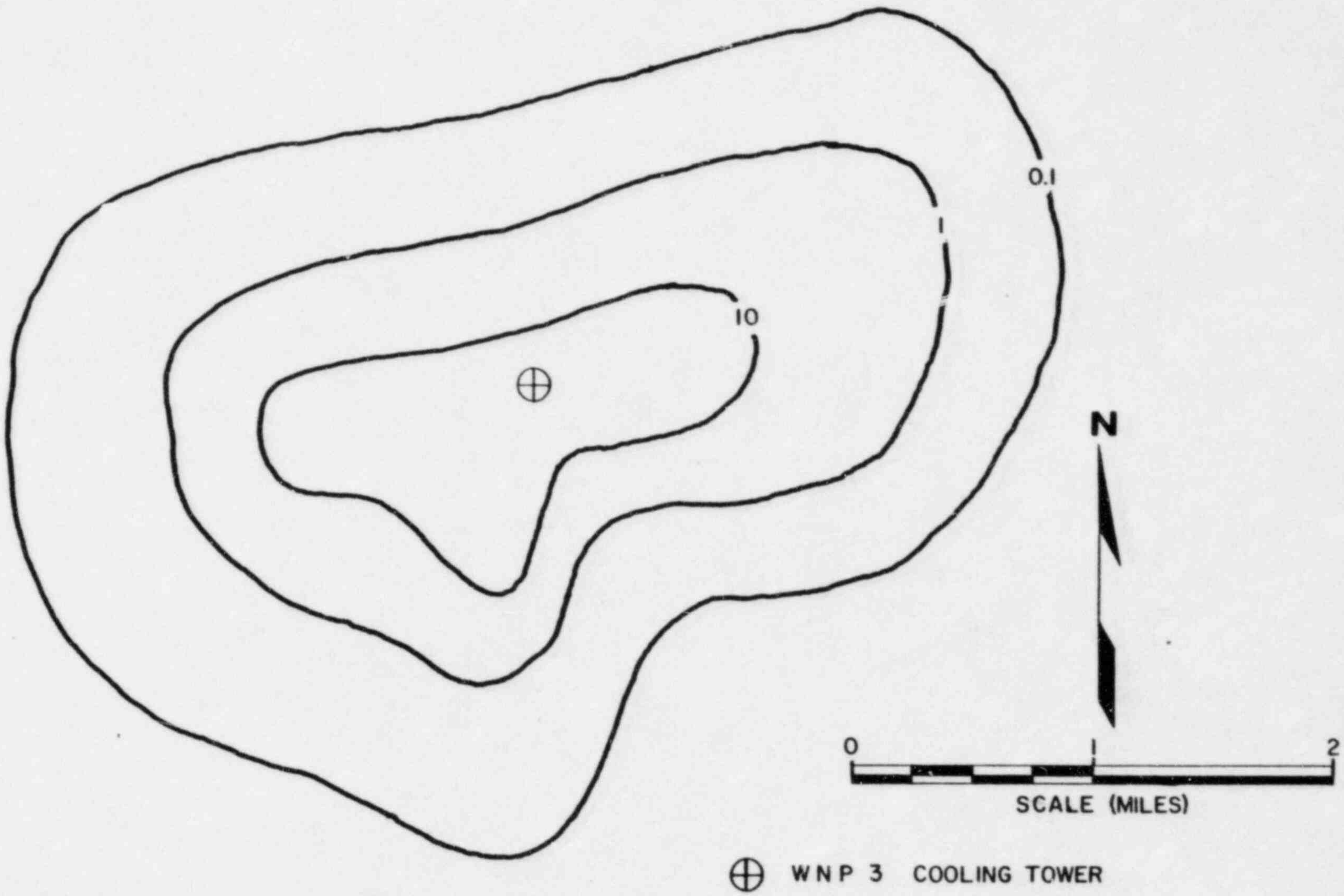
Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	BLOWDOWN PLUME ISOTHERMS (^{O}C) IN JANUARY WITH TWO-UNIT OPERATION	FIGURE 5.1-1



Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	PREDICTED COOLING TOWER DRIFT DEPOSITION PATTERN (LB/ACRE-YR)	FIGURE 5.1-4

5.2.4 Dose Rate Estimates For Man

Estimated doses to the population within 50 miles of WNP-3 and to individuals subject to maximum exposure because of their place of residence or life-style were calculated using the methodology of Regulatory Guides 1.109[6] and 1.111,[1] and NRC Codes XOQDOQ,[2] LADTAP[3] and GASPAR.[7] Detail on the calculation model input parameters is included in Appendix B. These input parameters are summarized in Tables 5.2-6 and 5.2-7 for the liquid and gaseous pathways, respectively. Table 5.2-8 summarizes the annual radiation doses to an individual from WNP-3 effluents included in Tables 5.2-1 and 5.2-2. Table 5.2-9 provides the estimates of doses to the general population.

5.2.4.1 Liquid Pathways

People may be exposed to the radioactive material in the liquid effluent by drinking water, eating fish, eating irrigated farm products and by participating in recreational activities on or along the Chehalis River.

Although there is no drinking water withdrawal downstream, it was assumed, for calculation purposes, that a household located 2 miles downstream of the discharge withdraws drinking water from the Chehalis River. The postulated doses are listed in Table 5.2-8 and were obtained using the LADTAP Code.[3]

Because fish will concentrate most radionuclides from the water they inhabit, the potential radiation dose from consumption of fish harvested downstream of the site was estimated for both an individual and the general population within 50 miles of the plant. The dose to an individual by this pathway is included in Table 5.2-8. The dose potentially received from consumption of waterfowl which had consumed contaminated fish or aquatic plants is considered negligible. | 1

Swimming, boating, and picnicking along the shores of the Chehalis River downstream of the site could result in very small doses to the local population. Doses to individuals from these activities and the irrigated foodstuff pathway are included in Table 5.2-8.

5.2.4.2 Gaseous Pathways

People may be exposed to radioactive material released to the atmosphere via inhalation, external radiation and ingestion of farm products. The maximum ground level concentration at the nearest residence offsite is approximately 1.0 mile from the plant in the north sector.

An individual living at the nearest resident (1.0 mi N) would potentially receive a very small dose due to inhalation of tritium, radioiodines and particulates as well as absorption of tritium through the skin. This dose is included in Table 5.2-8. All other dose estimates to people offsite would be less than this estimate.

External radiation from the plume or ground contamination would contribute an additional very small dose to the individual as shown in Table 5.2-8.

Radiation doses potentially received from ingestion of foodstuffs contaminated with radionuclides deposited on the soil or foliage were calculated using the GASPAR Code.[7] Food products considered in the analysis were vegetables, meat, cow milk and goat milk. Factors necessary to calculate the transfer of radionuclide from air to ground or foliage, foliage to animal, and animal to meat or milk are given in Appendix B. The individual dose potentially received from farm products is included in Table 5.2-8.

5.2.4.3 Direct Radiation From Facility

Direct radiation from the reactor facilities to individuals beyond the site boundary is extremely low and does not add measurably to doses estimated in Subsections 5.2.4.1 and 5.2.4.2. The nearest residences are one mile from the plant in the N and NNW sections. The nearest significant public facilities are in Elma about four miles northwest.

5.2.4.4 Annual Population Doses From Liquid and Gaseous Effluents

Using the GASPAR and LADTAP computer codes, the population total body and thyroid doses to the people living within an approximate 50-mile radius were calculated for several pathways. The population distribution for the year 2000 (see Table 2.1-2) was used in the calculations. Other input parameters are shown in Appendix B. Table 5.2-9 lists the calculated annual thyroid and total body doses to the population within 50 miles of the site. Dose received by the population beyond 50 miles would be an immeasurable increment to the dose already received from natural background radiation. Table 5.2-10 compares the population dose from WNP-3 with doses attributable to other sources.

5.2.5 Summary of Annual Radiation Doses

The estimated individual and population doses attributable to the operation of WNP-3 are given in Tables 5.2-8 and 5.2-9, respectively. Individual doses are within the design objectives of 10 CFR Part 50, Appendix I, shown in Table 5.2-11.

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TABLE 5.2-1

LIQUID RADIONUCLIDE RELEASES

	Radionuclide	WNP-3 Annual Release (Ci/yr)	Concentration (uCi/ml) at: Discharge Point[a]	Chehalis River[b]
	H-3	1.1E+02	2.0E-05	1.9E-08
	Cr-51	6.7E-04	1.2E-10	1.1E-13
	Mn-54	2.2E-04	4.1E-11	3.7E-14
	Fe-55	5.9E-04	1.1E-10	1.0E-13
	Fe-59	3.6E-04	6.7E-11	6.1E-14
1	Co-58	6.2E-03	1.2E-09	1.1E-12
	Co-60	1.6E-03	3.0E-10	2.7E-13
	Zr-95	1.6E-04	3.0E-11	2.7E-14
	Nb-95	2.2E-04	4.1E-11	3.7E-14
	Np-239	3.1E-04	5.8E-11	5.2E-14
	Br-83	4.0E-05	7.4E-12	6.8E-15
	Rb-86	5.0E-05	9.3E-12	8.5E-15
	Sr-89	1.3E-04	2.4E-11	2.2E-14
	Sr-91	5.5E-05	9.3E-12	8.5E-15
	Y-91M	3.0E-05	5.6E-12	5.1E-15
	Y-91	2.0E-05	3.7E-12	3.4E-15
	Mo-99	2.3E-02	4.3E-09	3.9E-12
	Tc-99M	2.1E-02	3.9E-09	3.6E-12
	Ru-103	3.0E-05	5.6E-12	5.1E-15
	Rh-103M	2.0E-05	3.7E-12	3.4E-15
	Ru-106	2.4E-04	4.5E-11	4.1E-14
	Ag-110M	4.0E-05	7.5E-12	6.8E-15
	Te-127M	1.0E-04	1.9E-11	1.7E-14
	Te-127	1.4E-04	2.6E-11	2.4E-14
	Te-129M	5.0E-04	9.3E-11	8.5E-14
	Te-129	3.2E-04	6.0E-11	5.5E-14
	I-130	2.2E-04	4.1E-11	3.7E-14
	Te-131M	5.0E-04	9.3E-11	8.5E-14
	Te-131	9.0E-05	1.7E-11	1.5E-14
	I-131	9.1E-02	1.7E-08	1.5E-11
	Te-132	7.6E-03	1.4E-09	1.3E-12
	I-132	8.6E-03	1.6E-09	1.5E-12
	I-133	6.2E-02	1.2E-08	1.0E-11
	I-134	2.0E-02	3.7E-09	3.3E-12
1	Cs-134	2.3E-02	4.2E-09	3.9E-12
	I-135	9.7E-03	1.8E-09	1.6E-12
	Cs-136	7.0E-03	1.3E-09	1.2E-12
	Cs-137	1.8E-02	3.4E-09	3.0E-12
	Ba-137M	1.5E-02	2.8E-09	2.5E-12

TABLE 5.2-1 (contd.)

Radionuclide	WNP-3 Annual Release (Ci/yr)	Concentration (uCi/ml) at: Discharge Point[a]	Chehalis River[b]
Ba-140	7.0E-05	1.3E-11	1.2E-14
La-140	6.0E-05	1.1E-11	1.0E-14
Ce-141	2.0E-05	3.7E-12	3.4E-15
Pr-143	2.0E-05	3.7E-12	3.4E-15
Ce-144	5.3E-04	9.9E-11	9.0E-14
Pr-144	1.0E-05	1.9E-12	1.7E-15

(a) Average discharge flow of 6 cfs.

(b) River dilution factor of 1:1100 based on average river flow of 6600 cfs.

TABLE 5.2-2

GASEOUS RADIONUCLIDE RELEASES

	Radionuclide	WNP-3 Annual Release (Ci)	Concentration (uCi/cc)(a) Restricted Area Boundary	Vegetable Garden	Milk Cow	Milk Goat	Meat Cattle	North Resident
	H-3	1.4E+03	1.8E-10	1.4E-10	1.4E-10	6.2E-11	1.2E-10	1.3E-10
	C-14	8.0E+00	1.0E-12	7.9E-13	7.9E-13	3.5E-13	7.1E-13	7.6E-13
	Ar-41	2.5E+01	3.2E-12	2.5E-12	2.5E-12	1.1E-12	2.2E-12	2.4E-12
	Kr-83m	2.0E+00	2.5E-13	2.0E-13	2.0E-13	8.7E-14	1.8E-13	1.9E-13
	Kr-85m	1.7E+01	2.2E-12	1.7E-12	1.7E-12	7.5E-13	1.5E-12	1.6E-12
	Kr-85	2.7E+02	3.4E-11	2.7E-11	2.7E-11	1.2E-11	2.4E-11	2.6E-11
	Kr-87	5.0E+00	6.3E-13	4.9E-13	4.9E-13	2.2E-13	4.4E-13	4.7E-13
	Kr-88	2.6E+01	3.3E-12	2.6E-12	2.6E-12	1.2E-12	2.3E-12	2.5E-12
	Xe-131m	5.0E+00	6.3E-13	4.9E-13	4.9E-13	2.2E-13	4.4E-13	4.7E-13
1	Xe-133m	2.7E+01	3.4E-12	2.7E-12	2.7E-12	1.2E-12	2.4E-12	2.6E-12
	Xe-133	1.3E+03	1.6E-10	1.3E-10	1.3E-10	5.8E-11	1.2E-10	1.2E-10
	Xe-135	6.5E+01	8.2E-12	6.4E-12	6.4E-12	2.9E-12	5.8E-12	6.2E-12
	Xe-138	3.0E+00	3.8E-13	2.9E-13	2.9E-13	1.3E-13	2.7E-13	2.8E-13
	I-131	5.8E-02	7.3E-15	5.7E-15	5.7E-15	2.6E-15	5.1E-15	5.5E-1[illegible]
	I-133	6.7E-02	8.5E-15	6.6E-15	6.6E-15	3.0E-15	5.9E-15	6.4E-15
	Mn-54	4.4E-04	5.6E-17	4.3E-17	4.3E-17	1.9E-17	3.9E-17	4.2E-17
	Fe-59	1.5E-04	1.9E-17	1.8E-17	1.8E-17	6.6E-18	1.3E-17	1.4E-17
	Co-58	1.5E-03	1.9E-16	1.8E-16	1.3E-16	6.6E-17	1.3E-16	1.4E-16
	Co-60	6.7E-04	8.5E-17	6.6E-17	6.6E-17	3.0E-17	5.9E-17	6.4E-17
	Sr-89	3.3E-05	4.2E-18	3.2E-18	3.2E-18	1.5E-18	2.9E-18	3.1E-18
	Cs-134	4.4E-04	5.6E-17	4.3E-17	4.3E-17	1.9E-17	3.9E-17	4.2E-17
	Cs-137	7.4E-04	9.4E-17	7.2E-17	7.2E-17	3.3E-17	6.5E-17	7.0E-17
	Sr-90	5.9E-06	7.5E-19	5.8E-19	5.8E-19	2.6E-19	5.2E-19	5.6E-19

(a) Based on X/Q values:

Restricted area boundary - 4.0E-06 sec/m^3
1 Vegetable garden - 3.1E-06 sec/m^3
Milk cow - 3.1E-06 sec/m^3
Milk goat - 1.4E-06 sec/m^3
Meat cattle - 2.8E-06 sec/m^3
Resident (north) - 3.0E-06 sec/m^3

TABLE 5.2-6

PARAMETERS TO CALCULATE MAXIMUM INDIVIDUAL DOSE FROM LIQUID EFFLUENTS

Drinking Water

River Dilution:	1100		
River Transit Time:[a]	1 hr		
Water Treatment and Delivery Time:	24 hrs		
Usage Factors:	Adult = 730 l/yr	Teenager = 510 l/yr	
	Child = 510 l/yr	Infant = 370 l/yr	1

Aquatic Foods

Dilution:	River - 1100, Harbor - 11000, Ocean - 110000		1
Time to Consumption:	24 hours		
Usage Factors, Fish:	Adult = 21 kg/yr	Teenager = 16 kg/yr	
	Child = 7 kg/yr	Infant = 0	
Usage Factors, Invertebrate:	Adult = 5.0 kg/yr	Teenager = 3.8 kg/yr	1
	Child = 1.7 kg/yr	Infant = 0	

Recreation

River Dilution:	1:1100		
Shoreline Width Factor:	0.2		
Usage Factors:	Shoreline Activities:	Adult	= 12 hr/yr
		Teenager	= 67 hr/yr
		Child	= 14 hr/yr
		Infant	= 0
	Swimming:	Adult	= 40 hr/yr
		Teenager	= 40 hr/yr
		Child	= 40 hr/yr
	Boating[b]:	Adult	= 200 hr/yr
		Teenager	= 40 hr/yr
		Child	= 40 hr/yr
		Infant	= 0

Irrigated Foodstuffs

River Dilution:	1100
River Transit Time:	12 hours

	Vegetables	Milk	Meat	Leafy Vegetable	
Food Delivery Time:	24 hours	24 hours	24 hours	24 hours	
Usage Factors:					
Adult	520 kg/yr	310 l/yr	110 kg/yr	64 kg/yr	
Teenager	630 kg/yr	400 l/yr	65 kg/yr	42 kg/yr	
Child	520 kg/yr	330 l/yr	41 kg/yr	26 kg/yr	
Infant	0	330 l/yr	0	0	
Monthly Irrigation Rate:	110 l/m^2	110 l/m^2	110 l/m^2	110 l/m^2	
Annual Yield:	0.[illegible] kg/m^2	4.0 kg/m^2	4.0 kg/m^2	2.0 kg/m^2	
Annual Growing Period:	70 days	180 days	180 days	70 days	1
Annual Production[c]:	[illegible].5E+06 kg	9.5E+06 l	3.5E+06 kg	2.2E+03 kg	

(a) Two miles downstream
(b) Assumed to be used for fishing
(c) Downstream irrigated production

TABLE 5.2-7

PARAMETERS TO CALCULATE INDIVIDUAL AND POPULATION DOSES FROM GASEOUS EFFLUENTS

Meteorology

GASPAR (Reference 5.2-7) meteorological input from XOQDOQ (Reference 5.2-2) is shown in Tables 5.2-3 and 5.2-4.

Source Terms

GALE-Gaseous (Reference 3.5-1) output data shown in Table 5.2-2.

Demography

As shown in Table 2.1-2.

Usage Factors

Usage factors used in GASPAR code are listed in Table 5.2-6.

Transfer Factors

As given in Reference 5.2-7.

Dose Factors

Dose factors used in GASPAR code are as listed in Reg. Guide 1.109.

Foodstuff Production Within 50 Miles

Vegetation (Leafy Vegetables Included) 2.6E+07 kg/yr
Milk 1.5E+08 liters/yr
Meat 8.9E+06 kg/yr

TABLE 5.2-8

ESTIMATED MAXIMUM ANNUAL DOSE TO AN INDIVIDUAL FROM WNP-3

Pathway	Annual Exposure	Location	Dilution Factor	Annual Dose (mRem) to an Adult: Skin	Total Body	GI-LLI	Thyroid	Bone
Liquid								
Drinking Water	730 l	2.0 mile downstream	1/1100		2.3E-03	2.0E-03	2.1E-02	3.9E-04
Fish	21 kg	2.0 mile downstream	1/1100		3.0E-02	2.2E-03	9.4E-03	2.1E-02
Shoreline	12 hr	2.0 mile downstream	1/1100	2.3E-05	2.0E-05	2.0E-05	2.0E-05	2.0E-05
Food Products								
Vegetables	520 kg	2.0 mile downstream	1/1100		1.4E-03	1.3E-03	1.3E-03	1.1E-04
Leafy Vegetation	64 kg	2.0 mile downstream	1/1100		1.7E-04	1.6E-04	1.6E-04	1.3E-05
Milk	310 l	2.0 mile downstream	1/1100		9.5E-04	7.6E-04	3.4E-03	1.5E-04
Meat	110 kg	2.0 mile downstream	1/1100		2.9E-04	3.0E-04	3.5E-04	1.7E-05
Invertebrate Seafood	5 kg	2.0 mile downstream[b]	1/11000		1.3E-04	4.5E-03	1.9E-04	1.4E-03
Swimming	40 hr	2.0 mile downstream	1/1100		2.3E-06	2.3E-06	2.3E-06	2.3E-06
Boating	200 hr	Downstream	1/1100		5.8E-06	5.8E-06	5.8E-06	5.8E-06
			Total[a]	2.3E-05	3.5E-02	1.1E-02	3.6E-02	2.3E-02
Air								
Submersion	8766 hr	1.0 mile N	3.0E-06	1.6E-01	5.2E-02	5.2E-02	5.2E-02	5.2E-02
Inhalation	8000 m^3	1.0 mile N	3.0E-06	1.7E-01	1.7E-01	1.7E-01	2.4E-01	2.7E-04
Ground Contamination	8766 hr	1.0 mile N	3.0E-06	5.0E-03	4.3E-03	4.3E-03	4.3E-03	4.3E-03
Food Products								
Vegetables	520 kg	1.5 mile NNE	3.1E-06	5.0E-01	5.0E-01	5.0E-01	6.0E-01	6.5E-01
Cow Milk	310 l	1.5 mile NNE	3.1E-06	1.9E-01	2.0E-01	1.9E-01	9.4E-01	2.9E-01
Infant[d]	330 l	1.5 mile NNE	3.1E-06	9.7E-01	9.8E-01	9.7E-01	6.6E+00	2.6E+00
Goat Milk	310 l	1.7 mile NE	1.4E-06	1.5E-01	1.5E-01	1.5E-01	5.2E-01	1.3E-01
Infant[d]	330 l	1.7 mile NE	1.4E-06	6.4E-01	6.4E-01	6.4E-01	2.8E+00	1.2E+00
Meat	110 kg	1.6 mile NNE	2.8E-06	1.0E-01	1.0E-01	1.0E-01	1.2E-01	2.4E-01
			Total[c]	1.1E-00	1.0E-01	1.0E-00	2.0E+00	1.2E-00

(a) Person assumed to drink Chehalis River water, eat fish caught in the river, consume crab caught in Grays Harbor, eat food grown with river irrigation, and use the river for recreation.
(b) Harvested in Grays Harbor.
(c) Adult cumulative dose from all pathways, excluding goat milk.
(d) Consumption of goat milk by an infant is assumed to be the same as the consumption of cow milk. It is also assumed that infant milk consumption is the same as child consumption.

1

TABLE 5.2-9

ESTIMATED ANNUAL POPULATION DOSES FROM WNP-3

	Pathway	Thyroid Dose (thyroid-rem)	Total Body Dose (man-rem)
	Air		
	Submersion	1.4E-01	1.4E-01
	Ground Contamination	8.7E-03	8.7E-03
	Inhalation	1.5E+00	1.1E+00
	Farm Products		
	Milk	2.1E+00	1.0E+00
	Meat	1.3E-01	1.2E-01
	Vegetation	6.1E-01	4.7E-01
	Total:	4.6E+00	2.9E+00
	Water		
	Drinking Water	1.4E-05	1.1E-06
	Aquatic Foods [a]		
1	Fish	7.4E-03	3.9E-02
	Invertebrates	6.5E-05	5.5E-05
	Water Recreation[b]	4.6E-05	4.6E-05
	Farm Products		
	Milk	1.2E-01	3.0E-02
	Meat	1.2E-02	9.4E-03
1	Vegetation[c]	6.6E-03	7.0E-03
	Total:	1.5E-01	8.6E-02

(a) Sport and commercial fishing.
(b) Shoreline activities, swimming and boating combined.
(c) Vegetation and leafy vegetables combined.

TABLE 5.2-10

TOTAL BODY DOSES FROM TYPICAL SOURCES OF RADIATION

Source	Individual Dose (mrem)	Population Dose (man-rem)
Natural Background Radiation in Vicinity of WNP-3	100	75,580[a]
Typical Per Capita Medical Dose in U.S. (G.I. dose)	72	54,418[a]
Transcontinental U.S. Commercial Jet Flight	5	3,779[a]
WNP-3 Operation	0.004[b]	3.0[c]

(a) Total 50-mile population of 755,800 in the year 2000 multiplied by average individual doses for this source.

(b) Cumulative dose from all pathways in Table 5.2-9 divided by the total population.

(c) Cumulative dose from all pathways in Table 5.2-9.

TABLE 5.2-11

SUMMARY OF ANNUAL DOSES

	Individuals	WNP-3	App I 10CFR50
	Air Pathway		
	Total Body (mrem/yr)	1.0	5
1	Skin (mrem/yr)	1.1	15
	Any Organ (mrem/yr)	2.0	15
	Gamma Air Dose (mrad/yr)	0.08	10
	Beta Air Dose (mrad/yr)	0.2	20
	Liquid Pathway		
	Total Body (mrem/yr)	0.035	3
	Any Organ (mrem/yr)	0.036	10

	Population	
1	Total Body, liquid pathway	0.1 man-rem/yr
	Total Body, gaseous pathway	2.9 man-rem/yr
	Thyroid, radioiodines and particulates, gaseous pathway	4.6 thyroid-rem/yr

5.3 EFFECTS OF LIQUID CHEMICAL AND BIOCIDAL DISCHARGES

The expected impacts of chemical and biocidal discharges at the construction permit stage were presented in the ER-CP in Subsections 5.4.3 and 5.4.4 and in the NRC Final Environmental Statement (FES). Since that time additional water quality data have been collected and are presented in Sections 2.4 and 3.6. The expected chemical releases to the Chehalis River via the cooling tower blowdown are described in Section 3.6 and summarized in Table 3.6-1. This section covers the effects of such discharges on aquatic life.

Table 5.3-1 presents the potential discharge concentrations and changes in concentration of chemical constituents in the Chehalis River at the downstream mixing zone boundary (see Subsection 5.1.1) for the low river flow condition.[a] The table shows that the expected discharge concentrations are less than the effluent limitation guidelines (40 CFR Part 423) and the NPDES Permit limitations. An exception is the maximum value for nickel which results primarily from a high concentration (10 μg/l) in the makeup water (see Table 3.6-1).

A comparison between the present Environmental Protection Agency (EPA) water quality criteria[1,2] and the chemical concentrations at the edge of the mixing zone reveals that all parameters for which criteria exist are less than the criteria with the exception of average values (at 440 cfs river flow) for cadmium, lead and mercury and the maximum value for copper. In regard to the concentration of cadmium, lead and mercury, operation of WNP-3 does not include the chemical addition of these parameters; however, they may be present due to concentration of the makeup water. Moreover, the average upstream ambient Chehalis River values for these metals may exceed water quality criteria (Table 5.3-1). In fact, the concentrations of average cadmium, lead and mercury at the edge of the mixing zone are all less than 0.2 μg/l above ambient levels upstream of the discharge.

5.3.1 Copper

Some of the WNP-3 auxiliary heat exchangers (totaling 90,000 sq ft) are made with copper and nickel alloy tubes. Therefore, copper and nickel releases in the discharge come from two sources: the makeup water, and corrosion and/or erosion of the heat-exchange tubes. Copper levels in the Chehalis River upstream of the intake wells range from 1.0 to 8.0 μg/l(see Section 2.4). The discharge level for copper may range from 21.5 to 61.3 μg/l (Table 5.3-1). The copper concentrations at the edge of the mixing zone are greatly reduced by dilution; the concentration ranges from 3.9 to 13.3 μg/l at the edge of the mixing zone with the river at the very low flow of 440 cfs.

(a) Thermal and chemical dilution studies assumed a once-in-10-yr, 7-day low flow of 440 cfs as reported in Subsection 2.5.1 of the ER-CP. Reanalysis, including the most recent flow data for the site area, has shown this flow to be 530 cfs as noted in Subsection 2.4.1.1.

A literature review on the biological effects of copper in aquatic environments was prepared in 1978 by Chu et.al.[3] In assessing the impacts of chemical discharges the salmonids are the most important species economically and recreationally. A review of copper toxicity data indicates that the salmonids, particularly steelhead/rainbow trout (<u>Salmo gairdneri</u>), are among the most sensitive and most frequently tested species.[3]

Most toxicity studies on salmonids have been performed with the early life stages, ranging from egg to juvenile. However, the discharge plume from the WNP-3 cooling tower blowdown does not intersect any known spawning areas. Therefore, the discharge is not expected to affect the incubation success of salmonids in the Chehalis River. Nevertheless, the toxicity studies of the early life stages are described below.

Shaw and Brown[4] observed that rainbow trout eggs could hatch after
fertilization in a solution containing 1000 ug/l copper; however, this ex-
posure level increased time to hatching. Grande[5], in studying the effects
of copper sulfate on eggs and fry in the yolk-sac stage for rainbow trout,
brown trout (<u>Salmo trutta</u>), and Atlantic salmon (<u>Salmo salar</u>), found that cop-
per reduced egg hatching. Furthermore, copper inhibited egg development at
1| about the same concentration as was toxic to fry--40 to 60 ug/l at 21 days.
Concentrations as low as 20 ug/l appeared to have a sublethal effect (i.e.,
unwillingness to feed). In another study that compared eggs and yolk-sac fry,
Hazel and Meith[6] concluded that eggs were more resistant than fry to the
1| toxic effects of copper. From a continuous-flow bioassay using chinook
salmon, the authors reported that copper concentrations of 80 ug/l had little
effect on the hatching success of eyed eggs; acute toxicity to fry was
observed at 40 ug/l, while increased mortality and inhibition of growth was
shown at 20 ug/l.

Chapman[7], also using a continuous-flow bioassay method, tested the relative resistance to copper, zinc, and cadmium of newly-hatched alevins, swim-up fry, parr and smolts of chinook salmon and steelhead trout. Chapman found that steelhead trout were consistently more sensitive to these metals than were chinook salmon. His results are summarized in Table 5.3-2.

Finlayson and Verrue[8] determined an 83-day LC_{10} (lethal concentration to 10 percent of the organisms) of 64 ug/l copper for chinook salmon eggs, alevins and swim-up fry. Similar studies by Finlayson and Ashuckian[9] determined a 60-day LC_{10} of 33 ug/l copper for steelhead trout eggs, alevins, and swim-up fry.

A number of studies have demonstrated that copper toxicity is related to water hardness and alkalinity. In general, copper toxicity is roughly inversely proportional to water hardness[6,10-13]. The work of Lloyd and Herbert[14] illustrates the relationship between lethality and total hardness or alkalinity (see Figure 5.3-1). When hardness increases over a range of 15 to 320 mg/l, a corresponding increase in the LC_{50} is observed with rainbow trout and chinook salmon.

Based upon the rapid dilution of the discharge, the minimal increases in copper predicted at the edge of the dilution zone, the hardness of the river water, and the absence of the early life stages near the discharge, no chronic mortalities are expected. |1

Because of size-related swimming speed limitations, juvenile salmonids may be passively carried through the plume and therefore may be exposed to copper concentrations higher than ambient. Assuming the fish are passively carried through the plume with the downstream velocity (0.7 and 0.3 feet per second at average and minimum river flow rates), they would be exposed to copper concentrations greater than 1.9 ug/l above ambient for less than 6 minutes under low-flow conditions. Under these conditions, 20 percent or less of the cross-sectional surface area in the 100 feet downstream of the discharge may have copper concentrations above ambient. Juveniles most likely to be exposed to these concentrations are salmon and steelhead trout migrating downstream. Studies performed on other river systems have shown that most 0-age chinook salmon migrating downstream are found near shore;[15] however, some may pass center stream through the plume.[16] Other studies indicate migrating juvenile spring chinook, sockeye (*Oncorhynchus nerka*) and coho salmon (*Oncorhynchus kisutch*) and steelhead trout are more abundant in deeper water.[17,18] |1

A few studies have been performed on short exposures (1-30 minutes) of fish to higher copper concentrations (200 to 1000 ug/l). Holland et. al.[10] studied juvenile chinook salmon and reported that, after 24 hours of exposure to cupric nitrate, 0, 21 and 46 percent mortality occurred at ionic copper concentrations of 178, 563 and 1,000 ug/l, respectively. Unpublished data by Chapman[19] indicate that the 90-minute LC_{10} for juvenile salmonids exposed to copper is approximately forty times the 96-hour LC_{50} (19.3 ug/l), or a total copper concentration of 770 ug/l. Under the most extreme conditions, the highest copper concentration predicted for the discharge is 61.3 ug/l (Table 5.3-1). Based on this information, no direct mortality is predicted for salmonids that would passively drift through the WNP-3 discharge plume.

Larger juvenile and adult salmonids have the swimming ability to maintain their position in the river and thus the potential exists for their presence in or near the discharge plume for longer periods (i.e., greater than 2 minutes). However, avoidance of copper by salmonids has been observed in both laboratory and field situations.[20-22] Chapman[22] observed that eighty percent of the nonacclimated juvenile steelhead trout he tested avoided copper at 10 to 20 ug/l. Laboratory tests have demonstrated olfactory response of Atlantic salmon parr to both copper and zinc in a continuously flowing system.[20] Strength of avoidance was measured by the relative length of time in both control waters and waters modified by the metal. An avoidance threshold of 2.3 ug/l was estimated for copper; 53 ug/l for zinc; and 0.42 ug/l copper plus 6.1 ug/l of zinc in a mixture.

The probability of adult salmonids encountering the WNP-3 discharge plume is low because chinook salmon and steelhead trout naturally migrate close to shore and would thereby pass the mid-river discharges unaffected.[23] Other tracking studies confirm this natural shoreline movement.[24-28]

In addition to fish, the sessile, benthic biota may be affected by copper discharges. The maximum area of river bottom potentially exposed to copper concentrations greater than or equal to 1.9 ug/l above ambient is approximately 5,000 square feet (50 ft wide by 100 ft long = 0.1 acres). Resistant organisms can be expected to survive within this area, but the more sensititive will not be protected. However, the 0.1 acres potentially impacted is a relatively small area compared to the total available habitat within the Chehalis River. Consequently, such a change should have no measurable effect on the abundance and composition of benthic organisms.

5.3.2 Nickel

The concentration of nickel discharged from WNP-3 may range from 18.6 to 74 ug/l (see Table 5.3-1). As a result of dilution, the concentrations at the edge of the mixing zone are reduced to 2.7 to 20.0 ug/l. Limited data exist for the biological effects of nickel in aquatic environments. Anderson et. al.[29], using rainbow trout, found that the 96-hour LC_{50} for nickel ranged from 22,000 to 24,000 ug/l and that zero mortality occurred at concentrations from 4,000 to 8,500 ug/l.[30] Hale,[31] using rainbow trout, found that the 96-hour LC_{50} for nickel nitrate was 35,500 ug/l. Brown and Dalton[32] found, for nickel sulfate in hard groundwater (total hardness = 240 mg/l), that the 48-hour LC_{50} to juvenile rainbow trout was 32,000 ug/l. It is unlikely that nickel discharged from WNP-3 will have any measurable impact because the nickel concentrations and duration of exposure are less than those reported to have any direct lethal effect.

5.3.3 Chlorine

Chlorine (from sodium hypochlorite) is the biocide used in the treatment of the WNP-3 circulating water. As described in Subsection 3.6.4, a dechlorination system is used to remove residual chlorine. The fresh water quality criteria for total residual chlorine (TRC) is 0.002 mg/l.[1] With a river flow of 440 cfs and a discharge less than 0.05 mg/l (detectable level), the TRC concentration in the plume will be reduced to 0.002 mg/l in 22 minutes at a distance 400 feet downstream from the discharge. Figure 5.3-2, adapted from Mattice and Zittel[33], shows that all aquatic life traveling through the
1| plume will not be affected.

The area of the river bottom potentially exposed to chlorine concentrations greater than 0.002 mg/l is approximately 0.5 acres. In this area, not all benthic organisms will be protected, although the more resistant organisms can be expected to survive. Also, this area is small relative to the total benthic habitat and therefore the aquatic community will not be adversely affected.

5.3.4 Sulfates

Sulfates occur in the WNP-3 discharge as a result of concentration of river water, dechlorination with sulfur dioxide, and the use of sulfuric acid to regenerate ion exchange resins and to neutralize alkaline water. Sulfate concentrations in the Chehalis River average 4.0 mg/l with maximums near 5 mg/l (Table 5.3-1). At the edge of the mixing zone, maximum sulfate levels are estimated to be about 60 mg/l. Becker and Thatcher[34] have compiled data on the toxicity of certain sulfates to aquatic life, and state that sulfates exhibit low toxicity to aquatic organisms. Based on comparison of research to date[34] and the expected WNP-3 mixing zone concentrations, no significant impact on Chehalis River biota is predicted.

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TABLE 5.3-2

LETHAL CONCENTRATIONS OF COPPER AND ZINC FOR VARIOUS LIFE STAGES OF STEELHEAD TROUT AND CHINOOK SALMON[(a)]

		Copper (ug/l)			Zinc (ug/l)		
		LC50		LC10	LC50		LC10
Species	Life Stage	96 hr	200 hr	200 hr	96 hr	200 hr	200 hr
Steelhead Trout	Alevin	28	26	19	815	555	256
	Swim-up	17	17	9	93	93	54
	Parr	18	15	8	136	120	61
	Smolt	29	21	7	651	278	84
Chinook Salmon	Alevin	26	20	15	661	661	364-661
	Swim-up	19	19	14	97	97	68
	Parr	38	30	17	463	395	268
	Smolt	26	26	18	701	367	170

(a)From Reference 5.3-7

b. In the Reactor Auxiliary Building, salvage the equipment as practicable, raze the structural walls and block the entrances. The disposition of other auxiliary structures will depend upon the future use to be made of the site. |1

c. In the containment and fuel storage area, remove all fuel, control rods and accessories, and salvage the cranes and other equipment. For these buildings, detailed plans will have to be established immediately preceding the decommissioning to allow maximum reuse of site land areas while eliminating any radioactive hazard. The degree and method of building demolition, the extent of practicable decontamination, the possible reuse of certain equipment or structures, and the subsequent use to be made of the site must be evaluated in establishing these plans.

In the above operations, equipment would be decontaminated where necessary and practicable or transported with suitable precautions.

5.8.3 Decommissioning Program

An overall work plan, including cost estimates, will be prepared near the end of the reactor's useful life. The decommissioning operations would be conducted in accordance with detailed procedures, specifications and schedules. The specifications would define the scope, methods and sequence of accomplishing major tasks. Where detailed work procedures are required to supplement the specifications they would be developed to meet the existing field conditions, state-of-the-technology, and shipping and burial ground requirements.

Prior to decommissioning, certain preparatory work would be initiated. This includes:

a. Preparation of detailed plans and accumulation of tools and equipment.

b. Selection and qualification (if required) of necessary personnel.

c. Maintaining security precautions to keep out unauthorized personnel.

d. Construction of an enlarged change room and personnel decontamination area.

e. Establishing storage areas for contaminated and uncontaminated wastes.

f. Establishing personnel and area radioactivity monitoring procedures for the additional personnel and areas involved.

All spent fuel will be withdrawn and transported to a licensed nuclear fuel processing plant or permanent storage site. Steam generators and other components contaminated by "detectable radioactivity" would be decontaminated, cut if necessary, or shipped whole with protective coverings. Shipments of radioactive materials would be governed by applicable NRC and DOT regulations. Radioactive components would be cut, with monitoring, within containment. Immediate work areas would be enclosed within a contamination control envelope to prevent release of activity to the environment.

Tanks, machines and other components capable of being decontaminated would be decontaminated and shipped to salvage dealers. Solid wastes would be packaged in approved containers which would be sealed and thoroughly surveyed for external contamination before they were removed. The sub-grade levels of all buildings would be decontaminated and sealed to prevent inleakage of ground water.

Typical plant systems which would be kept activated during decommissioning are: demineralizer, gaseous waste disposal, fuel element storage pool, ventilation, air conditioning and heating, service water, emergency electrical, service air and plant communication systems, as well as radwaste treatment systems.

After program completion, a thorough radiation survey of the plant site would be made to verify that residual radioactivity does not represent a source of contamination and is within established regulatory limits. The plant would be inspected as needed to insure that the buildings remain sealed.

5.8.4 Costs of Decommissioning

The plant decommissioning costs occur at the end of the project life, currently estimated to be 40 years. Cost calculations if made now, would be highly speculative. Certain pieces of equipment, such as water tanks and pumps, if only slightly radioactive, could probably be decontaminated and sold for a price covering their costs of removal. Other equipment, more radioactive, would probably be shipped to the closest burial ground, the cost of removal and delivery being a total loss. Demolition of concrete buildings is a significant cost. Shipping and burial of concrete, if necessary, would contribute additional costs.

5.8.5 Environmental Impacts of Decommissioning

Decommissioning the plant would have many of the same impacts on the environment as the original site preparation and station construction, but the degree of impact would be less. Automobile, truck, rail traffic and associated noise would increase. Some land would be used temporarily for laydown area and additional land may be required for permanent

During early phases of construction in late summer and fall of 1977, record rainfall caused erosion of site soils and above normal turbidity and concentrations of suspended sediment in the site streams and the Chehalis River. A study was undertaken from August 1977 through March 1978 to determine the effects of the increased turbidity and suspended sediment on the aquatic environment of the site streams and Chehalis River.[19] The specific objectives of this study were: 1) to determine if any short-term or long-term impacts to the Chehalis River aquatic resources had occurred; 2) to estimate the number of sport-fishing days lost; 3) to estimate the effects on salmonid spawning potential of the site streams; and 4) to estimate the number of rearing salmonids in the site streams that were lost or displaced, as well as any long-term effects on rearing potential.

The water temperature regime at the discharge area reflects the combined temperatures and flows of the Satsop and Chehalis Rivers upstream of the site. Extensive water temperature data have been collected by the U.S. Geographical Survey at the Satsop monitoring station and at the Porter station on the Chehalis River upstream of the confluence. Daily measurements at Porter were initiated in 1959 and terminated in 1972, providing a 12-year record (with some gaps). Measurements have been taken at irregular intervals at Satsop since 1960. The 12-year Porter record was analyzed statistically for the 1 and 99 percentile temperatures and used as extreme river temperatures in the aforementioned hydrothermal model studies (see also Subsections 2.4.1 and 5.1.2). In addition, temperatures were monitored continuously _in situ_ near the discharge from June to October 1978.

6.1.1.2 Aquatic Ecological Parameters

The major task of the aquatic ecological program was to monitor periphyton, benthic macroinvertebrates, and fish in site streams and the Chehalis and Satsop Rivers.

Periphyton

Periphyton communities are generally good indicators of water quality. Beginning in 1973, periphyton communities were sampled to establish baseline values and to monitor the impacts resulting from plant construction. Intensive studies began in 1976 and continued through 1980 (Table 6.1-3). The program has characterized the composition, density and seasonal abundance of periphyton near WNP-3.[8-12] Starting in 1978, samples were collected using both artificial and natural substrates. Natural substrates consisted of replicate groups of rocks each between 3 and 6 cm in diameter collected by SCUBA divers. Samples of periphyton were scrapped from the rocks into prelabeled vials for mounting and identification. Artificial substrate samples consisted of ten glass slides mounted in a wood and plastic frame. |1

Stations that have been sampled through the years include the Discharge Area, Intake Area, Upstream Discharge Area, Holding Area and Greenbanks (see Figure 6.1-1). At each station two samples were generally taken, one on the north side and one on the south side of the river at a depth of one to two meters. Samples were generally taken monthly, May through October.

Benthic macroinvertebrates

Aquatic macroinvertebrates have been historically used as indicators of the quality of their environment because they are sensitive to many *in situ* stresses. Impacts are determined by changes in number of taxa, number of individuals per taxa, or total biomass measurements. Chehalis River macroinvertebrates have been sampled using both natural and artificial substrates from 1976 to 1980 (Table 6.1-4). Natural substrates were used to determine composition, abundance, and distribution patterns while artifical substrates were used to determine colonization rates.

Six natural substrate samples were generally collected monthly per station (three replicates per substation; Table 6.1-4). The substations correspond to those used for the periphyton program. Samples were generally collected from March through September when the river velocity allowed. A SCUBA diver used a 12.5-cm metal corer to collect each sample to a depth of 13 cm (approximately a volume equal to 1.6 liters). Samples were sieved through a series of screens with six mesh sizes. Substrate composition was determined by weighing the contents of each screen. Macroinvertebrates were defined in this study as organisms retained on a 0.5-mm or larger mesh. Taxonomic identifications were to family or genus except during 1976 when order or family were the lowest level identified.

Artifical substrates consisted of eight 15-cm x 15-cm tempered hardboard plates assembled on a stainless eyebolt with 6 mm spacers. These samplers were then attached to a structure projecting above the river bed to prevent smothering from sediments moving downstream. At collection, each sampler was carefully removed and placed in a fine mesh bag. At the laboratory each sampler was disassembled, scraped, wet-sieved on a 0.5-mm sieve, sorted, and preserved. All organisms were identified to family or genus level and counted.

Stations sampled were the Upstream Discharge Area, the Holding Area, Discharge Area, Intake Area, and Greenbanks Area. These stations are shown on Figure 6.1-1.

Fish

Fish communities in the Chehalis and Satsop Rivers near WNP-3 were intensively studied during 1976 through 1980.(8-12) The objectives of these fish studies were to: 1) collect data to detect impacts caused by plant construction; 2) collect preoperational data for future assessments of potential operational impacts (e.g. cooling tower blowdown); 3) determine the composition, abundance and distribution of species in the study area; 4) determine community characteristics, which include age, condition factors, food habits, growth patterns, incidence of disease and salmonid migratory patterns; and 5) determine angler use of the study area.

River fish were collected by using electroshocking and beach seining techniques from 1976 through 1980 (see Table 6.1-8). Generally, electro- 1
shocking was performed once per month from March through October. In some years, samples were collected in the winter months and/or at greater frequencies.[10,11] From 1976 to 1979 electroshocking was conducted at 1
the Fuller Bridge, Satsop River, Holding Area, Discharge Area and Intake Area sampling stations. The upstream and downstream Discharge and Greenbanks stations were sampled in 1977 and 1978 (see Figure 6.1-1). 1

Typically, beach seining was performed once per month, from May through October at three locations: Holding Area (north shore), Intake Area and Discharge Area. The Fuller Bridge and Greenbanks Areas and Satsop River Area were also sampled in 1976-1977 and 1978, respectively.

In general, fish collected were separated by species and counted; lengths and weights were recorded for up to 50 specimens per species per station per month. In some years all fish greater than 150 mm in fork length were 1
tagged with numbered dart tags.[11] In addition, the age of selected fish specimens was determined from microscopic examination of scales, and the mean condition factors were calculated for salmonids and the four most abundant nonsalmonids.

Supplemental studies to the annual monitoring programs have included: 1) ultrasonic fish tracking to study the behavior of migrating adult salmon in the vicinity of the discharge;[20] 2) determination of food habits for selected species via stomach content analysis;[9,10] 3) a study of juvenile salmonid outmigrant patterns using inclined plane traps, beach seining and dye-marking techniques;[10] 4) documentation of angler use of a 16-km section of the Chehalis River between South Elma bridge and the mouth of Smith Canal.[10-12]

Fish communities in the tributary streams in the site area were studied from 1976 through 1980.[8-12] The objectives of these studies were: 1) document the use of site streams for salmonid spawning and determine the effect of construction activities on these areas; 2) determine the species composition, density, size and age class of fish in the site streams; and 3) estimate the fish populations in site streams.

Stream fish were collected by using an electroshocker. Initially, 15 stations were sampled[8], and in 1979-1980 eight of the original locations were still being sampled.[12] The eight stations included three on Workman and Fuller Creeks and one each on Stein and Ein Creeks (see Figure 6.1-1).

Electroshocking and mark-recapture methods were used from 1977 to 1980 to estimate fish populations and other fishery characteristics (e.g., species composition) at each sampling location. Each sampling station was 200 m in length; to isolate the sample population, block nets were placed at both ends of the sampling station. Two passes were made at each station. Sampling was performed in August 1980 and 1979, from August to October 1978, and from December 1977 through February 1978.

Surveys of salmonid potential have been conducted intermittently on Fuller, Workman, Elizabeth and Hyatt Creeks since 1968.[19] Methods of assessing potential spawning areas were adopted from Burner.[21] At least two surveys were conducted on each stream from November 1977 through January 1978.[9] Six biweekly surveys were made of Fuller Creek and at least one in each of the other streams November 1978 through January 1979, October 1979 through January 1980, and December 1980 through January 1981.[10-12]

Because the cooling tower blowdown may contain concentrations of copper and zinc as corrosion products and concentrated constituents of the makeup water and because these metals are toxic to aquatic biota under certain water quality conditions, the potential impact of the discharge was investigated using standard static 96-hour bioassays with three species of salmonids (rainbow trout, coho salmon, and chinook salmon,).[22] Bioassays were conducted with ambient Chehalis River water (simulated cooling tower blowdown). Atomic absorption spectrophotometry (AAS) and differential pulse anodic stripping voltammetry (DPASV) were used to determine total and labile concentrations, respectively of copper and zinc. In addition, hardness, alkalinity, and pH were determined for all test waters.

A special condition of the NPDES Permit requires that thorough flow-through bioassays be performed to determine sensitivities of resident salmonids to concentrations of copper and zinc in the effluent. These bioassays are scheduled for the 1982-1983 time period.

6.1.2 Groundwater

A series of tests were performed on the alluvial aquifer to determine its characteristics relative to operation of the makeup water well system (see Subsection 3.4.5). The most significant test was performed in November 1980 when the first Ranney Collector was pumped at a constant rate of 18,500 gpm for 48 hours.[23] Water levels were recorded continuously in the collector caisson, three observation wells, and the Chehalis River, and were recorded at four-hour intervals in four observation wells.

Water levels in the collector well and the seven observation wells stabilized rapidly (within the first hour of the test) and followed the cyclic fluctuations of the Chehalis River throughout the remainder of the test period. In a similar manner, water levels recovered rapidly after the end of the test, returning to static conditions within one hour. This rapid stabilization indicates excellent recharge from the Chehalis River and an assured continuous replenishment of the aquifer.

The sensors and electronic circuitry were calibrated quarterly. During the first period, the vendor, Meteorology Research, Inc. (MRI) of Altadena, California, performed the calibrations, while during the second program, Envirosphere Company performed the calibrations. Meteorology Research, Inc. does not recommend and does not perform field calibration of wind speed sensors. In March of 1973, the 10-m wind direction sensor failed and it was necessary to replace the entire speed/direction sensor with a new unit. To insure consistency and accuracy, MRI provided documentation indicating that the two aforementioned wind directions/speed sensors were tested and conformed to the accuracy specifications.

During the second monitoring period, the wind speed sensors were first calibrated on a semiannual basis at the University of Washington wind tunnel in Seattle. Subsequently, the sensors were shipped to the vendor semiannually for calibration and refurbishing.

A second, small meteorological station was established during the first phase approximately 9-km southeast of the plant at about 520 m above MSL. This station operated from May 1973 through October 1973. Instrumentation at this site consisted of a single, self-contained MRI Model 1077 Mechanical Weather Station. The parameters measured were wind speed, wind direction, relative humidity, ambient air temperature, and precipitation.

6.1.3.2 Models

Short-Term Diffusion Model

Formulations for calculating short-term X/Q values have been developed for licensing of nuclear power plants and are discribed in Regulatory Guide 1.145.[25] For the WNP-3 configuration, it is assumed that accidental releases are made at ground level. This assumption provides a conservative estimate of downwind X/Q values. Based on the guidance given in Regulatory Guide 1.145, the X/Q values are calculated using three separate equations. The particular equation which is used depends upon the existing meteorological conditions. The equations are:

$$X/Q = \frac{1}{U_{10}(\pi \sigma_y \sigma_z + A/2)} \qquad \text{Equation 1}$$

$$X/Q = \frac{1}{U_{10}(3\pi \sigma_y \sigma_z)} \qquad \text{Equation 2}$$

$$X/Q = \frac{1}{U_{10}\pi \Sigma_y \sigma_z} \qquad \text{Equation 3}$$

where:

X/Q is relative concentration (sec/m^3)

U_{10} is the hourly average wind speed at the 10-m level (m/sec)

σ_y is the horizontal diffusion parameter (m) determined from downwind distance and stability category

σ_z is the vertical diffusion parameter (m) determined from downwind distance and stability category

Σ_y represents plume meander and building wake effects (m) and is a function of stability category, wind speed and down wind 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 X/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 X/Q value is the larger of the two.

Values of σ_y and σ_z, the horizontal and vertical diffusion parameters are taken from Regulatory Guide 1.145 for the applicable stability category and downwind distance. For extremely stable conditions (Category G), the following relationships are applied: σ_y at Category G = 2/3 σ_y at Category F and σ_z at Category G = 3/5 σ_z at Category F.

The hourly average wind speeds and data were taken from the nearly three years of onsite data. Wind directions were grouped and classified into 16 azimuthal direction sectors of 22.5^o each centered on true north, north-northeast, etc. Calms were defined as hourly average windspeeds below 0.4 m/sec and are assigned a wind speed of 0.3 m/sec. Wind directions during calm conditions were assigned with the same distributional patterns as wind directions in the next three-highest (0.4-1.5 m/sec) speed category classes. The hourly stability category classifications were determined
1 from onsite measurements of vertical temperature difference (see Subsection 2.3.2.3).

Because of the plant vent location, no credit was taken for plume rise in any of the diffusion calculations. It is unlikely that any of the plant's gaseous effluents will mix with vapor plumes from the cooling systems. Even if such mixing did occur, the resultant ground-level X/Q values would be lower than those presented in Subsection 5.2.2. The two-hour concentrations are assumed to be identical to the one-hour values described above. Interpolation of a log-log plot of the two-hour and annual average values (discussed below) was used in the estimation of the 8-hour, 16-hour, 3-day, and 26-day distributions.

Long-Term Diffusion Model

The method used to estimate annual average relative concentrations (X/Q) of routinely released radionuclides assumes that a constant mean wind transports and dilutes the effluent in a single direction from the plant site. The wind speed, direction, and stability category are assumed to prevail over the site vicinity at all distances downwind for the complete hour ascribed to each observation. The modified Gaussian diffusion model is used in this analysis to determine dilution of the effluent.

Since the heights of the effluent stacks are below the height of the reactor building, a ground level release is assumed for these routine releases. This represents a conservative assumption for relative concentrations at all points downwind regardless of the precise nature of the topography. These releases are generally entrained into the building wake, and the size of the building must also be incorporated into an estimate of downwind concentrations. Within one mile of the release point, the assumptions about the release mode are very important. Beyond several miles from the plant, the concentrations are essentially independent of the release mode.

Besides the methods that dilute concentrations of released effluents through diffusion, there are several mechanisms that reduce these concentrations by removing them from the atmosphere. One mechanism is dry deposition, which involves the adsorption of gases or particles on the ground or vegetation that is downwind of the release. A relative plume depletion rate due to dry deposition, based on the scientific literature, is suggested in Regulatory Guide 1.111.[26]

A second removal mechanism is wet deposition, which occurs when the atmospheric effluents are washed out by rain. Wet deposition is particularly applicable to locations with a distinct rainy season, i.e., a high percentage of hours with measurable rainfall. It is also generally applied to sites where an elevated release is assumed. Since ground-level releases are assumed for the WNP-3 site and because the dry deposition curve[26] is sufficiently conservative, wet deposition has not been specifically considered here.

The hourly average data referred to previously also forms the data base for the development of the long-term X/Q estimates. The hourly average values of wind speed, wind direction, and temperature differences are used to generate joint frequency distribution tables for wind speed intervals and wind direction for each of the atmospheric stability classes (see Subsection 2.3.2.3). Calms were treated as a separate wind speed category |1 and distributed among the various wind direction sectors according to the directional distrubution of the lowest wind speed class. Using these frequencies, and the assumption of a ground-level release, average long-term X/Q values were calculated for various downwind distances out to 80 km (50 mi) using the following equation:(26,27)

$$(X/Q)_D = 2.032 \sum_{ij} \frac{N_{ij}}{Nxu_i\Sigma_{zj}(x)}$$

where:

X/Q = relative concentration (sec/m^3)

i = index for wind speed

D = index for wind speed direction sector

j = index for Pasquill stability class

Σ_{zj} = vertical dispersion coefficient (m) of the plume for the given Pasquill stability class

x = downwind distance (m)

u = average wind speed for given wind speed class (m/sec)

1| N_{ij} = number of hours that wind speed interval i, Pasquill stability class j, and wind direction sector D occur simultaneously

N = total hours of valid data.

For a ground-level release, the building wake will increase dilution of the effluent. This can be accounted for by modifying the term Σ_{zj} in the equation above to:

$$\Sigma_{zj}(x) = (\sigma^2_{zj}(x) + D^2_z/2\pi)^{1/2}$$

subject to the restriction that

1| $$\Sigma_{zj}(x) \le \sqrt{3}\,\sigma_{zj}(x)$$

all weather and river conditions, begining about 0930 hours and lasting about 4 hours. Surveys were usually conducted in conjunction with scheduled weekly water quality sample collections.

Small Mammals

Small mammals (mice and shrew) were counted at 169 trap stations in each watershed in 1978 using live trapping and multiple mark-recapture methods. The traps were checked daily for four consecutive days. This technique provided population estimates.

Deer

Black-tailed deer are common to habitats of the site and adjoining lands. The 1978 through 1980 investigations were designed to monitor deer populations in the experimental watersheds to evaluate the effects of plant construction and operation on this important herbivore. |1

Pellet-group counting[37] was used for estimating deer population densities on the experimental watersheds in 1978 through 1980. The technique involves clearing old fecal pellet groups and later counting the number of new pellet groups deposited during a known period on fixed plots distributed throughout the study area.

Pellet-group plots were searched in April/May and in October. Five (in the forested watersheds) or six (in the clearcut watersheds) circular plots, each 25 m^2 in size, were surveyed at each of 10 randomly located sampling stations. To be reasonably certain all pellet groups were found, each plot was searched twice within a 3-day period. The total number of groups found on each plot was used as the observation for each plot. Mean deer densities were estimated for the two periods, assuming a mean defecation rate of 13 pellet groups per deer per day.[38] |1

6.1.5 Radiological Environmental Monitoring

United States Nuclear Regulatory Commission (NRC) regulations require that nuclear power plants be designed, constructed and operated to keep levels of radioactive materials in effluents to unrestricted areas as low as reasonably achievable (ALARA) (10 CFR 50.36a). To assure that such releases are kept as low as practicable, each license authorizing reactor operation includes technical specifications governing the release of radioactive effluents. In-plant monitoring is used to assure that these predetermined release limits are not exceeded. However, as a precaution against unexpected and undefined processes that might allow undue accumulation of radioactivity in any sector of the environment, a radiological environmental monitoring program (REMP) is also included.

The regulations governing the quantities of radioactivity in reactor effluents allow nuclear power plants to contribute, at most, only a few percent increase above normal background radioactivity. Background levels at any one location are not constant but vary with time as they are influenced by external events such as cosmic ray bombardment, weapons test fallout, and seasonal variations. These levels also can vary spatially within relatively short distances reflecting heterogeneity in geological compositions. Because of these spatial and temporal variations, the radiological surveys of the plant environs are divided into preoperational and operational phases. The preoperational phase of the REMP permits a general characterization of the radiation levels and concentrations prevailing before plant operation along with an indication of the degree of natural variation to be expected. The operational phase of the program obtains data which, when considered along with the information obtained in the preoperational phase, assist in the evaluation of the radiological impact of plant operation.

The preoperational monitoring provides the following:

- identification of potentially important dose pathways to be monitored after the plant is in operation;
- measurement of background radiation levels/concentrations and their variation along anticipated important pathways in the area surrounding the plant;
- establishment of a preoperational baseline for statistical comparison of operational environmental data;
- personnel training;
- evaluation of procedures, equipment and techniques.

The early stages of the program will be flexible to accommodate changes in plant planning, land use, and demography and advances in monitoring and radioanalytical laboratory technology. The preoperational REMP is designed to correspond closely with the requirements of the operational monitoring program. Sampling locations were selected on the basis of local ecology, meteorology, and physical, demographic, and cultural characteristics of the region. The frequency of sampling for the preoperational program and the duration of the sampling period will, as a minimum, incorporate the parameters outlined in the NRC Branch Technical Position of November 1979[39] on the radiological portion of Regulatory Guide 4.8.

The specific instrumentation and radioassay techniques and associated minimum detectable levels for the analyses of the sample will depend on the laboratory performing the analyses. However, the laboratory will be required, at the minimum, to meet lower limit of detection (LLD) requirements as defined and outlined by the NRC.[39] The laboratory will also adhere to strict quality control procedures and participate in the Environmental Protection Agency's cross-check program, or its equivalent, to provide assurance of the accuracy of the analyses. When necessary for

TABLE 6.1-3

SUMMARY OF PERIPHYTON STUDIES, 1976-1980

Sample Station	Sample Frequency and Substrate				
	1976	1977	1978	1979	1980
Green Banks	N				
Intake Area		N	NA	NA	A
Holding Area	N	N			
Upstream Discharge Area			NA	N	
Discharge Area	N	N	NA	NA	NA

N = Natural substrates

A = Artificial substrates

TABLE 6.1-4

SUMMARY OF BENTHIC MACROINVERTEBRATE STUDIES, 1976-1980

		March	April	May	June	July	Aug	Sept	Oct	Nov
Holding Area [(a)]	76-C			X	X	X	X	X	X	
	77-C			X	X	X	X	X	X	X
Upstream Discharge Area	78-C			X	X	X	X	X	X	
	78-MP						X			
	79-C		X	X	X	X	X	X		
	79-MP					X		X		
Discharge Area	76-C			X	X	X	X	X	X	
	77-C		X	X	X	X	X	X	X	
	78-C			X	X	X	X	X	X	
	78-MP						X			
	78-B						X			
	79-C	X	X	X	X	X	X	X		X
	79-MP					X		X		X
	80-C			X		X		X		
	80-MP			X		X		X		
Intake Area	77-C		X	X	X	X	X	X	X	
	78-C			X	X	X	X	X	X	
	78-MP						X			
	79-C	X	X	X	X	X	X	X		
	79-MP					X		X		X
	80-MP			X		X		X		
Greenbanks Station	76-C			X	X	X	X	X	X	

(a) Each station generally included a North and South substation.

B = Rock filled baskets/artificial substrates
C = Cores/natural substrate
MP = Multiple plates/artificial substrates
Example: 76-C means in 1976 core samples were collected beginning in March. Each following month marked with an X was similarly sampled.

TABLE 6.1-7 (contd.)

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[a]Deviation may be required if samples are unobtainable due to hazardous conditions, seasonal availability, malfunction of automatic sampling equipment, or other legitimate reasons. All deviations will be documented in the annual report.

[b]Minimum six month preoperational sampling.

[c]Minimum one year preoperational sampling.

[d]Particulate sample filters will be analyzed for gross Beta after at least 24 hours decay. If gross Beta activity is greater than 10 times the mean of the control sample, gamma isotopic analysis should be performed on the individual sample.

[e]Gamma isotopic means identifications and quantification of gamma emitting radionuclides that may be attributable to the effluents of the facility.

[f]Minimum two years preoperational monitoring.

[g]Composite samples will be collected with equipment which is capable of collecting an aliquot at time intervals which are short relative to the compositing period.

[h]Milk samples will be obtained from farms or individual milk animals which are located in sectors with the higher calculated annual average ground-level D/Q's. If Cesium-134 or Cesium-137 is measured in an individual milk sample in excess of 30 pCi/l, then Strontium 90 analysis should be performed.

[i]Fruit and vegetables will be obtained from farms or gardens which use Chehalis River water, if possible, for irrigation and different varieties will be obtained as they are in season. One sample each of root food, leafy vegetables, and fruit should be collected each period.

TABLE 6.1-8

SUMMARY OF RIVER ELECTROFISHING AND BEACH SEINING, 1976-1980

Station	Year	Month J	F	M	A	M	J	J	A	S	O	N	D
Fuller Bridge	1976					ES	ES	ES	ES		ES		
	1976						ES	ES	ES	S	ES	E	
	1978	E		E	ES	E	E	E	E	E	E	E	E
	1979			E	E	E	E	E	E	E	E	E	E
	1980	E	E	E	E	E	E	E	E	E	E	E	E
Satsop River	1976				S	E	ES	ES	ES	ES	S		
	1977						S	S	S	S	ES	E	
	1978	E			ES	S		E	E	E	E	E	
	1979			E	E				E	E	E	E	
	1980	E	E	E	E						E	E	
Holding Area	1976					ES	ES	ES	ES	ES	ES		
	1977				E	ES	ES	ES	ES	S	ES	E	
	1978				E	ES	ES	ES	ES	E	ES	E	
	1979			ES	ES	ES	ES	ES	ES	ES	ES	E	E
	1980	E	E	E	E	E	E	E	E	E	E	E	E
Upstream Discharge Area	1977				E	E	E	E	E		E		
	1978				E	E	E	E	E	E	E	E	E
Discharge	1977				E	E	ES	ES	ES	ES	ES		
	1977					ES	ES	ES	ES	S	ES	E	
	1978	E			E	ES	ES	ES	ES	E	ES	E	E
	1979			ES	ES	ES	ES	ES	ES	ES	ES	ES	E
	1980	E	E	E	ES	ES	ES	ES	ES	ES	ES	E	E
Downstream Discharge Area	1977				E	E	E	E	E		E		
	1978	E			E	E	E	E	E	E	E	E	
Intake Area	1976					ES	ES	ES	ES	ES	ES		
	1977				E	ES	ES	ES	ES	S	ES	E	
	1978	E			ES	ES	ES	ES	ES	E	ES	E	
	1979			ES	ES	ES	ES	ES	ES	ES	ES	E	E
	1980	E	E	E	E	E	E	E	E	E	E	E	E
Greenbanks Area	1976					ES	ES	ED	ES	ES	ES		
	1977						ES	ES	ES	S	ES		
	1978	E			E	E	E	E	E	E	E	E	E

E = Electrofishing
S = Seining

a) of the core inventory, 0.02 percent of the noble gases and 0.02 percent of the halogens are released into the reactor coolant;

b) the reactor coolant inventory prior to the accident is based on 0.5 percent failed fuel;

c) secondary system equilibrium radioactivity prior to the transient is based on a 20 gal/day steam generator leak rate and 10 gpm steam generator blowdown rate; and

d) the main condenser iodine partition factor is 0.001.

The released activity is given in Table 7.1-3 and the offsite exposures and are shown in Table 7.1-8.

7.1.5.3 Steam Generator Tube Rupture

Experience with nuclear steam generators indicates the probability of complete severance of the Inconel vertical U-tubes is remote. No such double-ended tube rupture has ever occurred and is not expected to occur in the WNP-3 steam generators. The more probable modes of failure result in much smaller penetrations of the pressure barrier. They involve the formation of etch pits, small cracks in the U-tubes, or cracks in the welds joining the tubes to the tube sheet. These releases are evaluated under normal plant operations in Section 5.2.

A steam generator tube rupture accident assumed here causes a penetration of the barrier between the reactor coolant system and the main steam system. Radioactivity contained in the reactor coolant then mixes with shell-side water in the affected steam generator and then passes to the turbine and condenser. The noncondensible radioactive materials in the condenser hotwell are discharged to the environment through a charcoal bed absorber by the condenser air ejectors.

It is assumed that the operator has diagnosed the problem and has closed the main steam and feedwater isolation valves for the leaking steam generator. Radioactivity levels in the steam generator blowdown lines from the damaged steam generator are the main indicator. Plant cooldown is initiated by dumping steam from the intact steam generator. After the temperature of the reactor coolant is sufficiently reduced, the operator initiates shutdown cooling and isolates both steam generators. During the plant cooldown period the operator manually regulates safety injection and charging flow rates to maintain a measurable pressurizer water level.

Assumptions for calculating doses include:

a) fifteen percent of the reactor coolant leaks from the primary to secondary system;

b) failed fuel prior to the accident is 0.5 percent;

c) the equilibrium reactor coolant radionuclide concentration prior to the rupture is based on a primary-to-secondary steam generator leak rate of 20 gallons per day and a steam generator blowdown rate of 10 gpm;

d) during the plant cooldown 1,400,000 lb of steam pass through the condenser hotwell from the intact and faulted steam generators;

e) the quantity of noble gases and radioiodines released are proportional to the flow rate of steam through the condenser; and

f) the iodine partition factors for the steam generators and condenser hotwell are 0.01 and 0.001, respectively.

The radioactivity released by this accident is given in Table 7.1-3 and the offsite doses are shown in Table 7.1-8.

7.1.6 Refueling Accidents (Class 6 Accidents)

Class 6 accidents are postulated to occur during refueling operations in the Reactor Building. These accidents are the dropping of a fuel bundle assembly and dropping a heavy object onto the reactor core.

7.1.6.1 Fuel Bundle Drop

The possibility of damage to a fuel assembly as a consequence of equipment failure or mishandling is minimized through equipment design, detailed refueling procedures and personnel training. The reliability of the fuel handling equipment, including the bridge and trolley, the lifting mechanism, the transfer mechanism and all associated instrumentation and controls, is ensured through adoption of preoperational check-out tests. The maximum elevation to which the fuel assemblies can be raised is limited by the design of the handling hoists and manipulators. The refueling equipment platform assembly is constructed to seismic Category I requirements. Considering the precautions of the design and operation
1 procedures, the probability of a refueling accident is considered remote.

The accident that has been postulated is an equipment failure or mishandling event that results in the dropping of a spent fuel assembly into the upper refueling pool during refueling operations. It is further assumed that the assembly falls from a height sufficient to rupture one row of fuel rods, whose gap activity is subsequently released to the refueling pool water. The radioactive gases then bubble through the water which entrains most of the iodine. The remainder escapes to the Reactor Building atmosphere. The airborne radioactivity is then passed through charcoal filters before being released to the environment. Specific assumptions are:

a) the accident occurs one week after reactor shutdown;

the spent fuel storage pool water, with the iodine gases undergoing a scrubbing process as the gas bubbles rise to the surface of the water. The noble gases and remaining iodine gas are then released to the FHB atmosphere where the same ventilation procedures, enacted during a fuel assembly drop accident (Subsection 7.1.7.1) apply. The same assumptions for calculating consequences also are applicable except for the following:

a) the accident occurs 30 days after reactor shutdown; and

b) the gas gap activity in one average fuel assembly (236 fuel rods) is released into the spent fuel pool.

The released radioactivity is given in Table 7.1-3 and the resulting offsite doses and are presented in Table 7.1-8.

7.1.7.3 Fuel Cask Drop Accident

The design of the Fuel Handling Building is such that the only transfer operation that could involve the dropping of a loaded spent fuel cask a significant distance is the transfer of the cask from the spent fuel cask storage area pool to the decontamination area. Assumptions used to calculate releases include:

a) the fuel shipping cask contains seven fuel assemblies;

b) an average of one percent of the noble gas core activity is in each fuel rod gap and is available for release;

c) all of the noble gas gap activity from one fully-loaded fuel shipping cask (120 days cooling) is released;

d) activity is released instantaneously and unfiltered, to the environment.

The estimated released activity is given in Table 7.1-3 and the calculated offsite doses are given in Table 7.1-8.

7.1.8 Accident Initiation Events Considered in Design Basis Evaluation in the Safety Analysis Report (Class 8 Accidents)

This class of accidents is considered in detail in Chapter 15 of the FSAR and are outlined in the following paragraphs.

7.1.8.1 Loss-of-Coolant Accident: Break in a Small Pipe

A loss-of-coolant accident (LOCA) is a malfunction of the Reactor Coolant System that interrupts normal cooling operations and results in the release of reactor coolant, containing radioactive fission products, to the containment. The activity is then released to the atmosphere via leakage from the containment. The probability of such an accident is considered remote.

The plant has been designed, fabricated and constructed under a comprehensive quality assurance program to assure compliance with all applicable specifications and codes. All reactor coolant system components are designed, fabricated and inspected in accordance with ASME Section III, Code Class 1 and Section XI. The major reactor coolant system components are designed for a 40-year operating life. Components are of materials that are compatible with coolant chemistry. Fatigue analyses based on conservative design cyclic transients and primary stress combinations have been evaluated in accordance with the applicable codes. Overpressure protection is assured by ASME Code III safety valves. Technical Specifications, operating procedures and other administrative controls assure plant operating conditions within limits previously determined to be acceptable.

Nonetheless, for the purposes of consequence evaluation a LOCA is postulated with the following assumptions:

a) the average radioactivity inventory in the primary coolant (at 0.5 percent failed fuel) is released into the containment;

b) the Shield Building Ventilation System (SBVS) filter has an efficiency of 99 percent for the iodines;

1 c) the containment leak rate is 0.50 percent/day for the first 24 hours and 0.25 percent/day for the duration of the accident; and

d) five percent of the halogens and all of the noble gases remain airborne and available for leakage from the containment.

The releases to the environment are presented in Table 7.1-4 and offsite exposures are presented in Table 7.1-8.

7.1.8.2 Loss-of-Coolant Accident: Large Pipe Break

The large pipe break accident is considered less probable than the small pipe break LOCA (Subsection 7.1.8.1). This accident is postulated as an unspecified event that results in the break of a large reactor coolant pipe and subsequent release of the reactor coolant inventory. The average radioactivity inventory in the primary coolant (based on 0.5 percent failed fuel) plus two percent of the core inventory of halogens and noble gases are assumed to be released into the containment. Other assumptions are the same as for Subsection 7.1.8.1. A portion of the halogens and all of the noble gases from this release have been assumed to become airborne in the containment and available for leakage.

The released activity is listed in Table 7.1-5 for different durations and the offsite doses are given in Table 7.1-8.

limiting the release of radioactive materials. The probabilities associated with these events are extremely low but the consequences of an individual occurrence are greater than the other accident categories.

7.1.9.1 Assessment Methods

The methodology employed to assess the impacts of a severe accident at WNP-3 is based on the methods employed in the NRC's Reactor Safety Study (RSS).[4] Calculations were performed using the CRAC2 Code[5] which is a revised version of the CRAC (Calculation of Reactor Accident Consequences) Code developed for the RSS. There are five basic sets of input data for the CRAC2 analysis: accident release data, weather data, population data, land use data, and evacuation data. The calculation methodology is summarized in Figure 7.1-1.

The calculation of reactor accident consequences starts with a postulated breach of containment and release of radioactivity. Following the postulated release, the dispersion of the radioactivity, cloud depletion, and ground contamination are calculated from atmospheric dispersion models. Using the resulting air and ground contamination, the dosimetric models determine the doses to individuals. Early and chronic doses to individuals are determined from a number of exposure pathways. Early doses accrue from exposure to the passing cloud (direct radiation and inhalation), and early exposure to the ground contamination. Chronic doses accrue from exposure accumulated at later times including doses from ingestion of contaminated food and/or milk products, inhalation of resuspended ground contamination, and long-term (greater than 7 days) direct exposure to ground contamination.

The health effects are then determined based on the calculated doses and the population distribution around the plant. Several mitigation measures including population evacuation/relocation and, food/land interdiction are considered in the determination of the population doses and health effects. The health effects estimated in CRAC2 are divided into two categories: acute and latent. Acute health effects refer to injuries and fatalities occurring within a year of the accident. The latent effects refer to the somatic effects which later are manifested in the form of cancer during a plateau period assumed to be about 30 years. Lastly, the economic impacts are calculated in terms of property damage and costs. Property damage is specified in terms of interdicted areas of land, crops, and/or milk, while costs include the estimated costs of such interdiction, as well as the direct costs of ground decontamination, and population evacuation or relocation. 1

The results of the CRAC2 consequence model are displayed as a set of cumulative probability distribution functions for specific consequences. These distributions are determined from the calculated magnitude of each consequence for a number of combinations of postulated accident release, weather, and population, as well as the probability of each such combination.

7.1.9.2 Accident Release Categories

The accident sequences which were evaluated are revisions of sequences used for the prototype PWR in the RSS. The four postulated accidents are defined as EVENT V, TMLB, PWR-3, and PWR-7 and represent the spectrum of severe accidents considered possible for a plant such as WNP-3.[6] The radioactive source inventory was based on the core isotopic composition of a 3412 MWth unit[7] multiplied by 1.1 to reflect the larger capacity of WNP-3. The release categories and accident parameters are shown in Table 7.1-9.

All four PWR accidents lead to total or partial core melt. Accident PWR-7 postulates the melt-through of the base mat as the containment failure mode. Release of the radioactive material from containment could result in its introduction into the hydrosphere and, through contact with groundwater, could lead to potential water exposure pathways. Since the rate of travel of these materials through the aquifer to a downstream discharge or withdrawal point is much slower than the air transport of the accompanying atmospheric release, exposures by the liquid pathway are not included in the consequences. This is consistent with the approach used in the RSS. Also a generic study of liquid pathway impacts noted that substantial holdup and mitigation in the vicinity of the containment would be expected in the event of core melt-through at land-based nuclear plants.[8]

7.1.9.3 Atmospheric Dispersion

Data for CRAC2 input consisted of one year of hourly-averaged measurements of the following parameters: wind speed, wind direction (vector-averaged), Pasquill-Gifford stability class, and precipitation. The 8760 hours of data were sorted into 29 distinct weather categories which are randomly sampled by the code. This results in an accurate and economical approxi-
1 | mation of annual average conditions at the plant site.

7.1.9.4 Population

Population doses were based on the projected resident population for the year 2010 out to 200 miles from the plant. The data in Table 2.1-2 was used inside 50 miles with minor redistribution to accomodate the CRAC2 calculation intervals. Population for the eight intervals between 50 and 200 miles was obtained from 1980 city and county census data. Data were assigned to sectors based on areal distribution of the census unit (e.g., city or county) relative to the grid sector. Canadian population were included in the five sectors which encompassed parts of British Columbia. Projections to the year 2010 for the 50 to 200 mile area were based on the composite growth factor of 1.43 applied to the 1980 numbers.

7.1.9.5 Land Use and Economic Data

Land use and economic data are based on regional averages. Economic information includes decontamination costs (for farms and residential, business, and public areas), relocation costs, property value, and food costs (dairy and non-dairy). Farm information specific to the WNP-3 region included planting/harvest months, fraction of state land devoted to farming, fraction of farm revenue from dairy production, annual average farm sale, and average farm land value. Also the state and land/water fraction for each area element were specified.

7.1.9.6 Evacuation Measures

Evacuation of inhabitants within a downwind fan-shaped area was considered in the accident consequence assessment. It is assumed that all people living in the plume exposure pathway, within 10 miles of the plant, would evacuate upon notification of an actual or imminent release of significant quantities of radioactivity. Of the parameters which are used as CRAC2 input, response time is the most critical. Response time is the sum of four separate phases:

1. the time from the initiating event to when the reactor operator notifies authorities;
2. time required by authorities to interpret information and decide to evacuate;
3. time required to notify public; and
4. time required by public, once notified, to respond.

Considerable planning and effort have gone into minimizing response time at WNP-3. A computerized emergency dose assessment system with graphics has been developed to provide responsible authorities accurate and easily interpreted data. This system should allow authorities to begin public notification within one-half hour of the reactor operator's recognition of an actual or imminent release. A warning system is being developed to provide effective notification of the public. The warning system will be composed primarily of multiple sirens, although other methods of warning may also be utilized in specific areas. 1

Because of the many factors affecting response time, and the large dependency of acute effects upon early warning, it is appropriate to separate the calculation into five response times which are shown in Table 7.1-10. Evacuation scenario I is equivalent to that used in the RSS.[4] Within five miles of the plant, the site-specific evacuation (scenario II) is more effective than assumed in the RSS; in the 5 to 10 mile zone the response times are similar to those used in the RSS. The additional 9-hour category in the 5 to 10 mile zone is reflective of EPA studies[9] which report 10 hours as the time necessary to completely evacuate a rural area. The efficiency of evacuation in the 5 to 10 mile range is expected to be better than indicated by the response times in Table 7.1-10.

Evacuation parameters common to both scenarios are the same as those used in
1 the RSS and are listed in Table 7.1-10. The effective evacuation speed of 10
mph has been verified for the WNP-3 site using the CLEAR Code.[10]

7.1.9.7 Accident Consequences and Risk Measures

The health and economic impacts calculated for the various postulated accidental releases from WNP-3 are presented in the form of probability distributions. Calculated health effects include early fatalities and latent cancer deaths resulting from potential radiological exposures. Whole body and
1 thyroid exposure are also calculated. Economic effects include the direct costs of emergency action undertaken during the accident and the estimated costs of mitigation actions that might be taken following the accident. All four release categories contribute to the results, with the consequences from each being weighted by the associated probability of occurrence.

1 The probability distributions for acute fatalities for the two evacuation scenarios are shown in Figure 7.1-2. The distributions are determined primarily by release category EVENT V. Table 7.1-9 shows that EVENT V has the largest core inventory release fractions of the four accidents and therefore produces the greatest radioactive release. The amount of radioactivity released is particularly critical to the prediction of acute fatalities because the CRAC2 code uses a threshold exposure for acute deaths. Only EVENT V produces exposures near the threshold and, therefore, only it results in significant contribution to early fatalities.

1 The latent cancer fatalities in the 200-mile population are plotted in Figure 7.1-3. The curves have similar contributions from all accident sequences except PWR-7 which contributes significantly less than the others. The population within 50 miles experiences the majority of the latent cancer fatalities.

In contrast to acute fatalities which have a threshold, latent effects have no threshold. Latent effects are integral effects over a large area and are accumulated over long periods of time after the accident. Continued exposure to contaminated land would contribute to the long-term doses. These long-term doses would therefore depend on the interdiction strategy. For population groups that would be located relatively close to the reactor, the interdiction strategy allows permanent relocation. Therefore, no long-term exposure to highly-contaminated land would occur and the inhaled radionuclides would determine their dose commitment, and in such cases, only persons who were
1 directly exposed to the plume would contribute to the latent cancer fatalities. The probabilities of whole body doses and thyroid doses to individuals within 250 miles are given in Figure 7.1-4.

The total economic costs include the costs of evacuation or relocation of the population, as well as decontamination of land and interdiction of agricultural products and or land. The probability distribution (Figure 7.1-5) of the economic costs is composed of contributions from all accident sequences except PWR-7. The radiological consequences of PWR-7 are so small that the economic consequences are significantly smaller than in the other accidents. The interdiction cost is the greatest contributor to the cost curve. The economic and interdiction consequences are also partially sensitive to the amount of radioactivity released. The choice of an interdiction criterion can control the economic costs. This is because the cost of interdicting land is very high if no decontamination is done. CRAC2 assumes a decontamination factor of greater than 20 before permanent interdiction of land is calculated. The interdiction levels used in these calculations are basically those which were used in the Reactor Safety Study.[4]

The total person-rem for the population within 200 miles is plotted in Figure 1
7.1-6 for the site-specific evacuation scenario. All accident sequences
contribute to the person-rem curves with PWR-7 contributing only to the low
consequences with higher probabilities. 1

7.1.9.8 Uncertainties

The discussions in the preceding subsection provide insight into the risk
associated with hypothetical severe accidents at WNP-3. The methodology has
been based on the Reactor Safety Study.[4] The study has been reviewed
subsequently, and several findings and recommendations concerning the RSS were
issued. The most significant finding was that the methodology is sound al-
though the error bands were too small. The source of uncertainties in the 1
accident probabilities have been outlined in the RSS, and uncertainties in the
consequence analysis are discussed in this section.

In the RSS, uncertainties were considered in two broad groups: the dispersion-dosimetric model, and the dose-response criteria. The first group includes uncertainties in the release fractions, probabilities, and physical characteristics of the accidents and the atmospheric dispersion. The second group includes individual dose-response and cost parameters. These factors affect only their corresponding consequences. The various uncertainties are discussed as they apply to the plant.

In general, the calculation of early fatalities is most sensitive to the first
group of uncertainties, especially the release magnitude. The release frac-
tions and other accident parameters were based on an accident analysis of
another older PWR design. The mitigating effects of improvements in engi-
neered safety features and implementation of site-specific aspects of the TMI 1
action plan were not considered; the actual risks associated with WNP-3 should
be less than the calculated values discussed in Subsection 7.1.9.7.

The other consequences, latent cancer fatalities and property damage, appear to be less sensitive to the first group of uncertainties. These constitute integral effects over a large area and are more a function of the total population and cost parameters than of accident characteristics.

References for Section 7.1

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2. "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969", Federal Register, 45(116):40101, June 13, 1980.

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4. Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Appendix 6: Calculation of Reactor Accident Consequences, WASH-1400, U.S. Nuclear Regulatory Commission, Washington, D.C., October 1975.

5. Calculations of Reactor Accident Consequences, Version 2-CRAC2, SAND 81-1994 (Draft Report), NUREG/CR-2326, Sandia National Laboratories, Albuquerque, New Mexico, July 1981.

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1 10. CLEAR (Calculates Logical Evacuation and Response): A Generic Transportation Network Model for the Calculation of Evacuation Time Estimates, NUREG/CR-2504, U.S. Nuclear Regulatory Commission, Washington, D.C., March 1982.

TABLE 7.1-3

ACTIVITY (CURIES) RELEASED TO THE ENVIRONMENT BY ACCIDENT CLASSES 3-7

	Accident Class[(a)]										
Isotope	3.1	3.2	3.3	3.4	5.2	5.3	6.1	6.2	7.1	7.2	7.3
Kr-85m	3.5(2)[(b)]		1.4(3)		1.87(0)	2.87(2)	2.22(-12)	2.51(-4)	4.43(-10)		
Kr-85	3.3(1)		1.3(4)		5.89(-2)	6.31(0)	1.21(-2)	3.88(1)	2.42(0)	3.86(1)	3.82(2)
Kr-87	5.8(1)		2.3(2)		3.35(0)	1.54(2)					
Kr-88	3.5(2)		1.4(3)		4.82(0)	4.42(2)		5.73(-8)			
Xe-131m	3.0(3)		1.2(4)		6.00(-2)	3.89(1)	7.10(-3)	2.68(1)	1.42(0)	5.89(0)	2.99(-1)
Xe-133	1.4(5)		5.4(5)		1.56(1)	4.07(3)	1.23(0)	5.68(3)	2.45(2)	1.90(2)	1.38(-2)
Xe-135	1.7(3)		6.8(3)		2.75(0)	6.94(2)	1.62(-6)	8.96(-1)	3.24(-4)		
Xe-138	1.1(1)		4.2(1)		1.16(1)	1.06(2)					
I-131	3.0(0)	2.44(-4)	1.2(1)	9.8(-4)	7.28(-5)	5.77(-3)	1.70(-5)	6.78(-2)	3.32(-3)	7.34(-3)	
I-132	7.5(-3)	3.98(-6)	3.0(-2)	1.6(-5)	7.43(-5)	1.16(-3)					
I-133	3.5(-1)	1.31(-4)	1.4(0)	5.2(-4)	1.47(-4)	6.27(-3)	1.97(-7)	6.44(-3)	3.94(-5)	4.10(-12)	
I-134	2.5(-3)	7.10(-7)	1.0(-2)	2.8(-6)	1.58(-4)	9.48(-4)					
I-135	7.8(-2)	2.22(-5)	3.1(-1)	8.9(-5)	1.36(-4)	4.24(-3)	1.53(-12)	5.70(-6)	3.06(-10)		

(a)Accident Class as in Table 7.1-1. Also corresponds to text subsection as 7.1.x.x.

(b)Numbers in parentheses denote power of 10.

TABLE 7.1-4

ACTIVITY (CURIES) RELEASED TO THE ENVIRONMENT
BY A SMALL PIPE BREAK ACCIDENT

	Duration of Release			
Isotope	0-8 hr	8-24 hr	1-4 day	4-30 day
Kr-85m	*(a)	*	*	*
Kr-85	*	*	*	*
Kr-87	*	*	*	*
Kr-88	*	*	*	*
Xe-131m	*	*	*	*
1 Xe-133	5.27	9.87	17.55	34.75
Xe-135	*	*	*	*
Xe-138	*	*	*	*
I-131	*	*	*	*
I-132	*	*	*	*
I-133	*	*	*	*
I-134	*	*	*	*
I-135	*	*	*	*

(a) * Indicates release is less than 1.0 Ci for noble gas and 10^{-4} for iodine.

TABLE 7.1-5

ACTIVITY (CURIES) RELEASED TO THE ENVIRONMENT BY A LARGE PIPE BREAK ACCIDENT

Isotope	Duration of Release 0-8 hr	8-24 hr	1-4 day	4-30 day
Kr-85m	5.80(2)[a]	2.00(2)	8.55(0)	*[b]
Kr-85	3.20(1)	6.40(1)	1.43(2)	1.22(3)
Kr-87	4.17(2)	5.95(0)	*	*
Kr-88	1.11(3)	1.71(2)	*	*
Xe-131m	2.72(1)	5.27(1)	1.07(2)	4.35(2)
Xe-133	7.72(3)	1.44(4)	2.57(4)	5.10(4)
Xe-135	1.06(3)	8.90(2)	1.87(2)	*
Xe-138	2.72(2)	*	*	*
I-131	1.92(-2)	3.67(-2)	7.10(-2)	2.12(-1)
I-132	2.75(-2)	4.95(-2)	7.65(-2)	8.47(-2)
I-133	3.45(-2)	4.67(-2)	3.02(-2)	3.07(-3)
I-134	6.70(-3)	*	*	*
I-135	2.50(-2)	1.57(-2)	1.87(-3)	*

(a) Numbers in parentheses denote power of 10.

(b) * Indicates release is less than 1.0 Ci for noble gas and 10^{-4} for iodine.

TABLE 7.1-6

ACTIVITY (CURIES) RELEASED TO THE ENVIRONMENT
BY A CONTROL EJECTION ACCIDENT

Isotope	Duration of Release			
	0-8 hr	8-24 hr	1-4 day	4-30 day
Kr-85m	5.77(1)[a]	2.08(0)	*[b]	*
Kr-85	3.2(0)	6.5(0)	1.4(1)	1.2(2)
Kr-87	4.20(0)	*	*	*
Kr-88	1.11(2)	1.71(1)	*	*
Xe-131m	3.22(0)	6.30(0)	1.27(1)	5.15(1)
Xe-133	8.25(2)	1.54(3)	2.75(3)	5.45(3)
Xe-135	1.13(2)	9.47(1)	1.99(1)	*
Xe-138	2.72(1)	*	*	*
I-131	1.95(-3)	3.75(-3)	7.20(-3)	2.16(-2)
I-132	1.95(-3)	3.52(-3)	5.42(-3)	6.02(-3)
I-133	3.50(-3)	4.72(-3)	3.07(-3)	3.10(-4)
I-134	6.80(-4)	*	*	*
I-135	2.52(-3)	1.58(-3)	*	*

(a)Numbers in parentheses denote power of 10.

(b) * Indicates release is less than 1.0 Ci for noble gas and 10^{-4} for iodine.

TABLE 7.1-7

ACTIVITY (CURIES) RELEASED TO THE ENVIRONMENT
BY A STEAMLINE BREAK ACCIDENT

Isotope	Small Steamline Break	Large Steamline Break
Kr-85m	8.37(-3)[a]	8.37(-3)
Kr-85	2.01(-4)	2.01(-4)
Kr-87	4.45(-3)	4.45(-3)
Kr-88	1.28(-2)	1.28(-2)
Xe-131m	1.13(-3)	1.14(-3)
Xe-133	1.20(-1)	1.20(-1)
Xe-135	2.02(-2)	2.02(-2)
Xe-138	3.05(-3)	3.07(-3)
I-131	1.99(-4)	9.95(-4)
I-132	4.33(-5)	2.12(-4)
I-133	2.22(-4)	1.11(-3)
I-134	2.99(-5)	1.50(-4)
I-135	1.41(-4)	7.05(-4)

[a] Numbers in parentheses denote power of 10.

TABLE 7.1-8

SUMMARY OF OFFSITE DOSES FROM PLANT ACCIDENTS (CLASSES 3-8)

Class[a]	Accident	Whole Body Dose (rems) at Exclusion Area Boundary	Thyroid Dose (rems) at Exclusion Area Boundary	Whole Body Population[f] Dose (man-rems)	Thyroid Population[f] Dose (man-rems)
3.1	Waste Gas Decay Tank Malfunction	1.46×10^{-1}	1.84×10^{-1}	2.14×10^{1}	2.70×10^{1}
3.2	Liquid Waste Storage Tank Malfunction	5.67×10^{-9}	1.68×10^{-5}	3.31×10^{-7}	2.46×10^{-3}
3.3	Waste Gas Decay Tank Rupture	5.68×10^{-1}	7.39×10^{-1}	8.32×10^{1}	1.08×10^{2}
3.4	Liquid Waste Holdup Tank Rupture	2.26×10^{-8}	6.70×10^{-5}	3.32×10^{-6}	9.82×10^{-3}
5.2	Off-Design Transient that Induces Fuel Failure and Steam Generator Leak	9.15×10^{-4}	7.70×10^{-6}	1.34×10^{-1}	1.13×10^{-3}
5.3	Steam Generator Tube Rupture	4.11×10^{-2}	4.69×10^{-4}	6.02×10^{0}	6.88×10^{-2}
6.1	Fuel Bundle Drop Onto Core	9.92×10^{-7}	1.02×10^{-6}	1.45×10^{-4}	1.49×10^{-4}
6.2	Heavy Object Drop Onto Core	4.58×10^{-3}	4.14×10^{-3}	6.72×10^{-1}	6.07×10^{-1}
7.1	Fuel Assembly Drop in Fuel Storage Pool	1.98×10^{-4}	1.98×10^{-4}	2.90×10^{-2}	2.91×10^{-2}
7.2	Heavy Object Drop Onto Fuel Rack	1.55×10^{-4}	4.37×10^{-4}	2.29×10^{-2}	6.41×10^{-2}
7.3	Fuel Cask Drop	2.70×10^{-5}	----(b)	3.96×10^{-3}	-----
8.1	Small Loss-Of-Coolant Accident[c]	9.90×10^{-6}	7.65×10^{-8}	4.12×10^{-3}	3.65×10^{-4}
8.2	Large Loss-Of-Coolant Accident[d]	5.12×10^{-2}	5.05×10^{-4}	6.05×10^{0}	1.89×10^{0}
8.4	Rod Ejection Accident[e]	5.17×10^{-3}	5.07×10^{-5}	6.45×10^{-1}	1.91×10^{-1}
8.5	Small Steamline Break	1.21×10^{-6}	1.63×10^{-5}	1.77×10^{-4}	2.38×10^{-3}
8.6	Large Steamline Break	1.28×10^{-6}	8.13×10^{-5}	1.87×10^{-4}	1.19×10^{-2}

(a) From Table 7.1-1. Also corresponds to text subsection as 7.1.x.x.
(b) Denotes no thyroid dose from this accident.
(c) 2-hr accident. Doses of LPZ for 30-day accident are: whole body - 1.[illegible]x10^{-6} rem and thyroid - 1.0x10^{-10} rem.
(d) 2-hr accident. Doses of LPZ for 30-day accident are: whole body - 2.9x10^{-4} rem and thyroid - 4.5x10^{-5} rem.
(e) 2-hr accident. Doses of LPZ for 30-day accident are: whole body - 6.6x10^{-4} rem and thyroid - 2.3x10^{-5} rem.
(f) Doses to population within 50 miles.

TABLE 7.1-9

REBASELINED RSS PWR ACCIDENT RELEASE CATEGORIES

Accident Sequence	Probability Per Reactor Year	Time[a] (hr)	Duration[b] (hr)	Warning[c] (hr)	Energy (10^6 Btu/hr)	Fraction of Core Inventory Released: Xe-Kr	I[d]	Cs-Rb	Te-Sb	Ba-Sr	Ru[e]	La[f]
Event V	2×10^{-6}	1.0	1.0	0.5	0.5	1.0	0.64	0.82	0.41	0.1	0.04	0.006
TMLB	3×10^{-6}	2.5	0.5	1.0	170	1.0	0.31	0.39	0.15	0.04	0.02	0.002
PWR-3	3×10^{-6}	5.0	1.5	2.0	6	0.8	0.2	0.2	0.3	0.02	0.03	0.003
PWR-7 Melt	4×10^{-5}	10.0	10.0	1.0	N/A	6×10^{-3}	2×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}

(a) Time interval between start of hypothetical accident (shutdown) and release of radioactive material to the atmosphere.

(b) Total time during which the major portion of the radioactive material is released to the atmosphere.

(c) Time interval between recognition of impending release (decision to initiate public protective measures) and the release of radioactive material to the atmosphere.

(d) Organic iodine is combined with elemental iodines in the calculations. Any error is negligible since the release fraction is relatively small for all large release categories.

(e) Includes Ru, Rh, Co, Mo, Tc.

(f) Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

TABLE 7.1-10

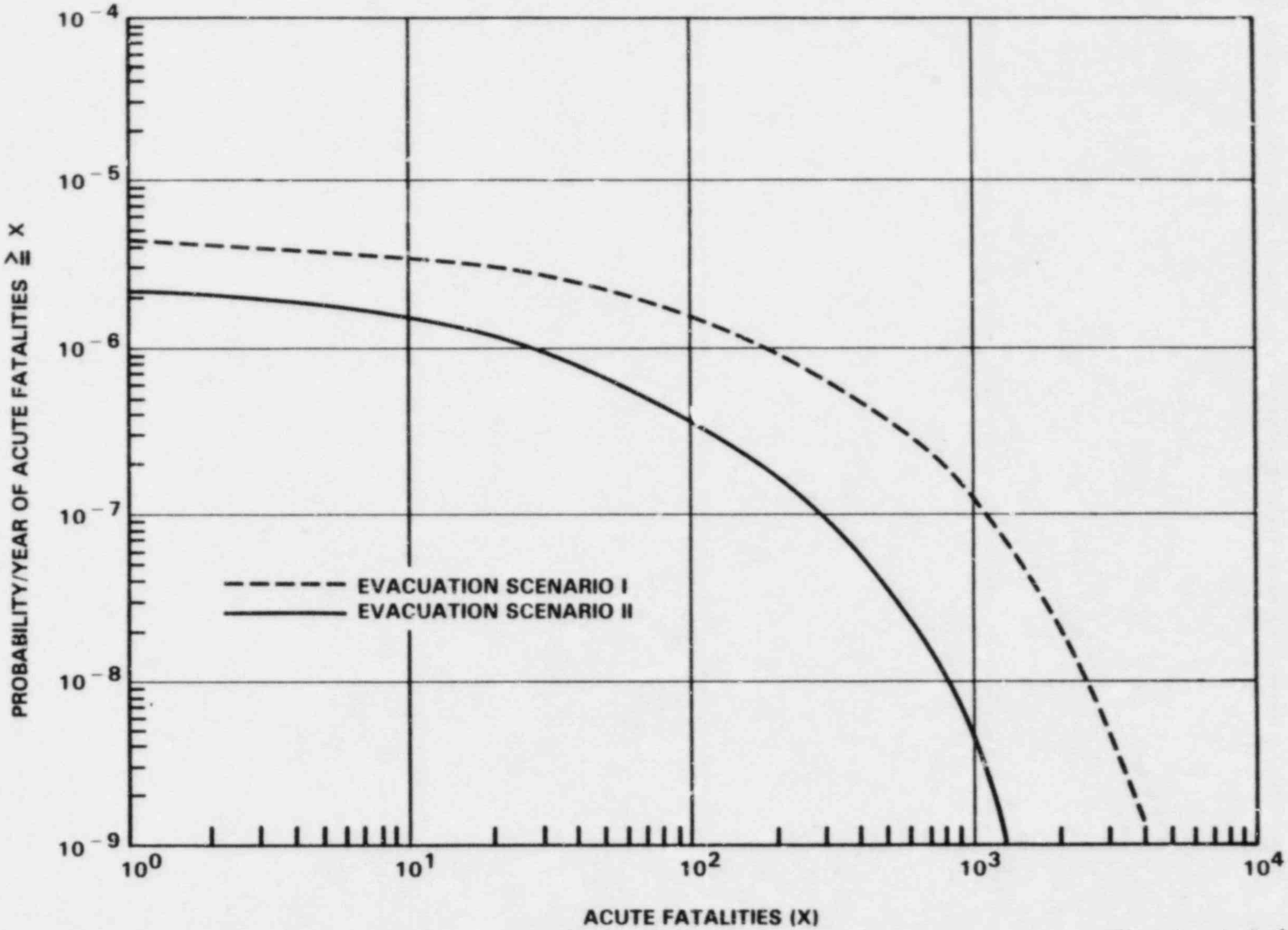
EVACUATION PARAMETERS

Response Times

	Distance (mi)	Time (hr)	Probability (%)
Evacuation Scenario I	0-10	1	30
	0-10	3	40
	0-10	5	30
Evacuation Scenario II	0-5	1	100
	5-10	1	25
	5-10	3	25
	5-10	5	25
	5-10	9	25

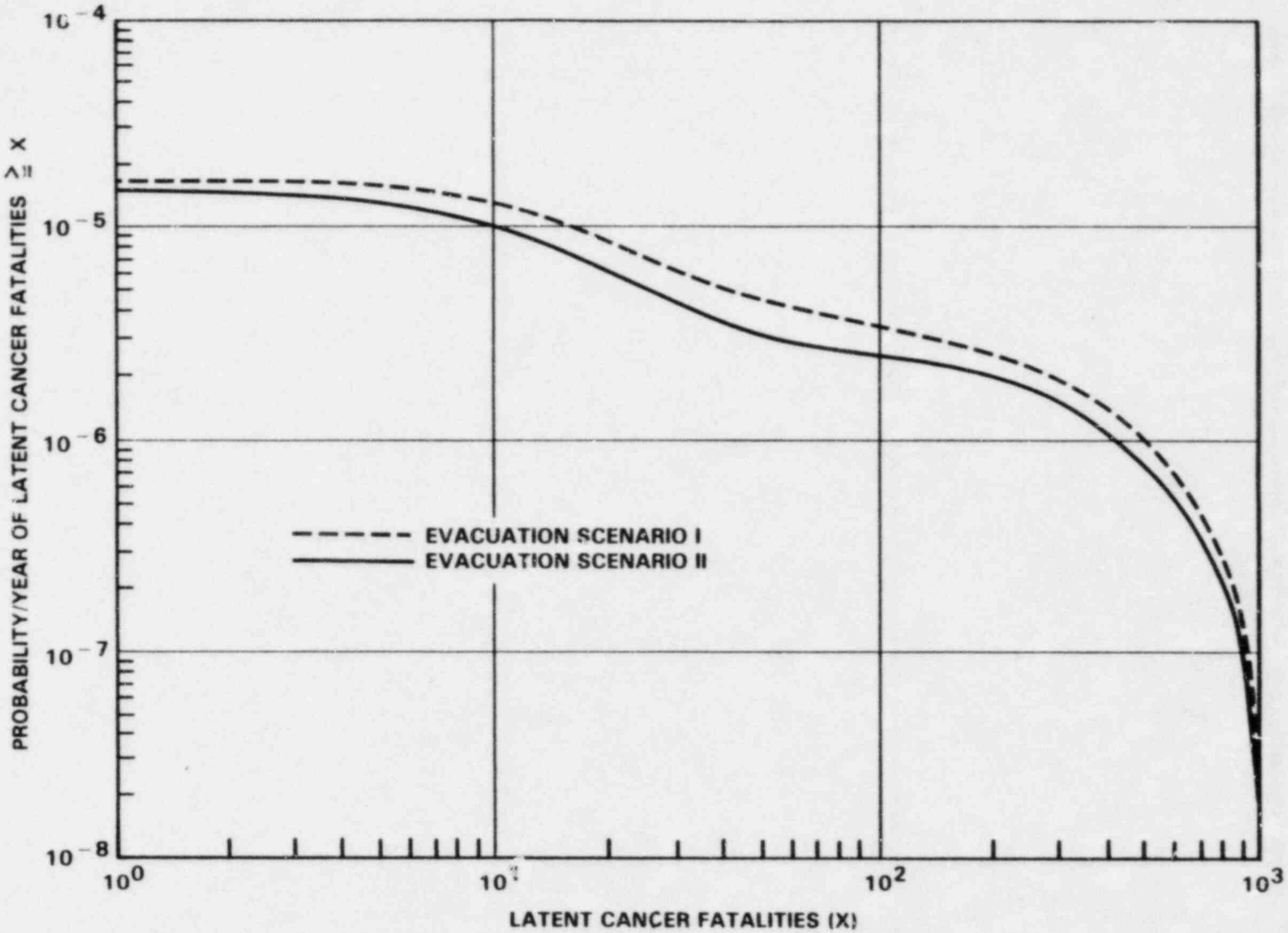
Parameters Common to Evacuation Scenarios

Evacuation Speed (m/sec)	4.470E+00
Maximum Distance of Evacuation (m)	1.609E+04
Distance Moved by Evacuees (m)	2.414E+04
Sheltering Radius (m)	1.609E+04
Evacuation Scheme (1 or 2)	2.000E+00
Exposure Duration (days)	0.
Cloud Shielding - Stationary People	7.5005-01
Cloud Shielding - Moving Evacuees	1.000E-00
Cloud Shielding - Sheltering	5.000E-01
Cloud Shielding - No Emergency Action	7.500E-01
Ground Shielding - Stationary People	3.300E-01
Ground Shielding - Moving Evacuees	5.000E-01
Ground Shielding - Sheltering	8.000E-02
Ground Shielding - No Emergency Action	3.300E-01
Breathing Rate Stationary Evacuees ($m/^3sec$)	2.660E-04
Breathing Rate Moving Evacuees	2.660E-04
Breathing Rate Sheltering Region One	1.330E-04
Breathing Rate Sheltering Region Two	2.660E-04
Radius of Circular Area Evac Near Reactor (m)	8.045E+03
Width of Evacuated Arc (degrees)	9.000E+01
Evacuation Direct Cost ($/evacuee/day)	9.500E+01
Max Duration of Release for Key Shaped Evac (hr)	3.000E+00



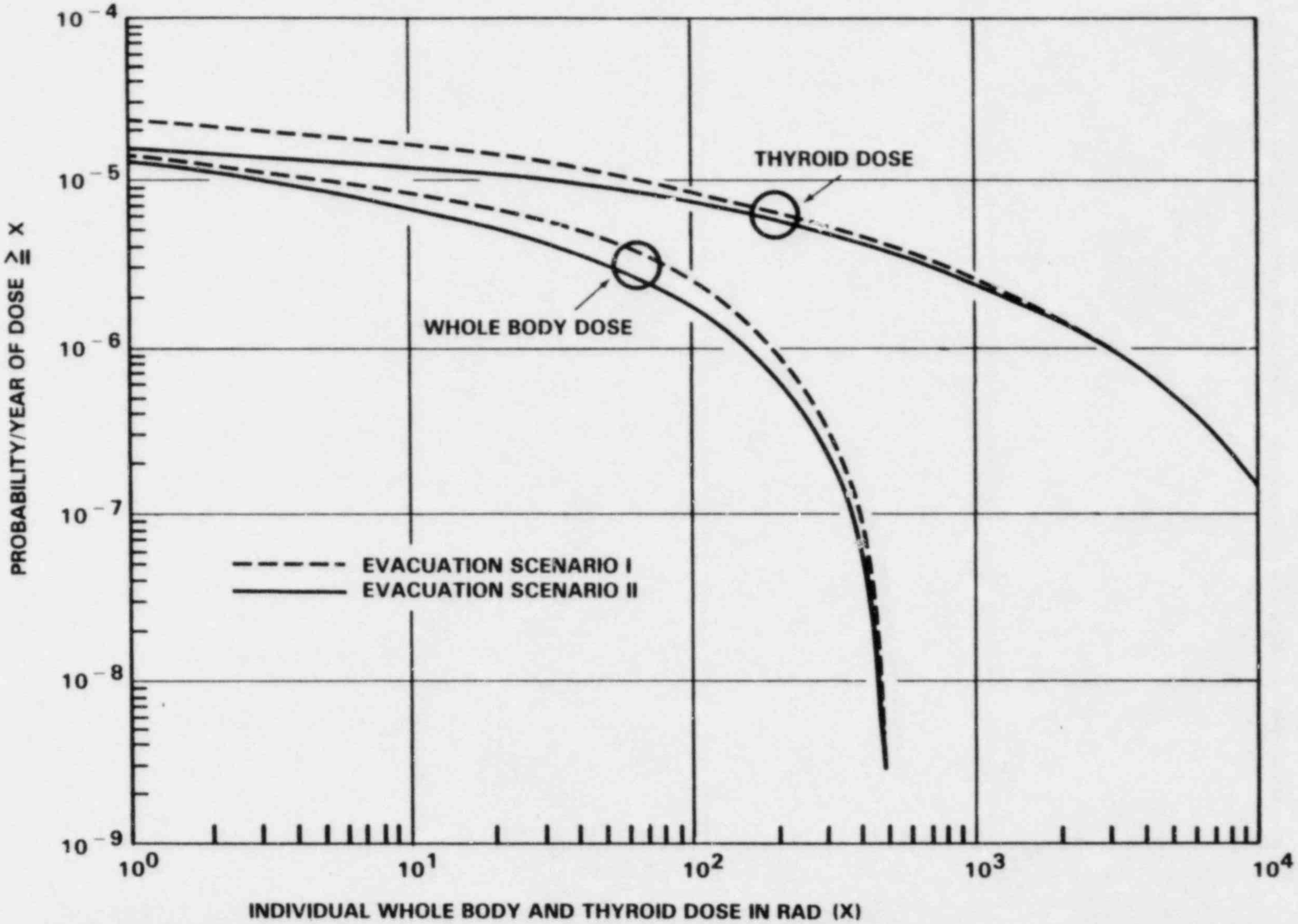
Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	PROBABILITY VS. ACUTE FATALITIES	FIGURE 7.1-2



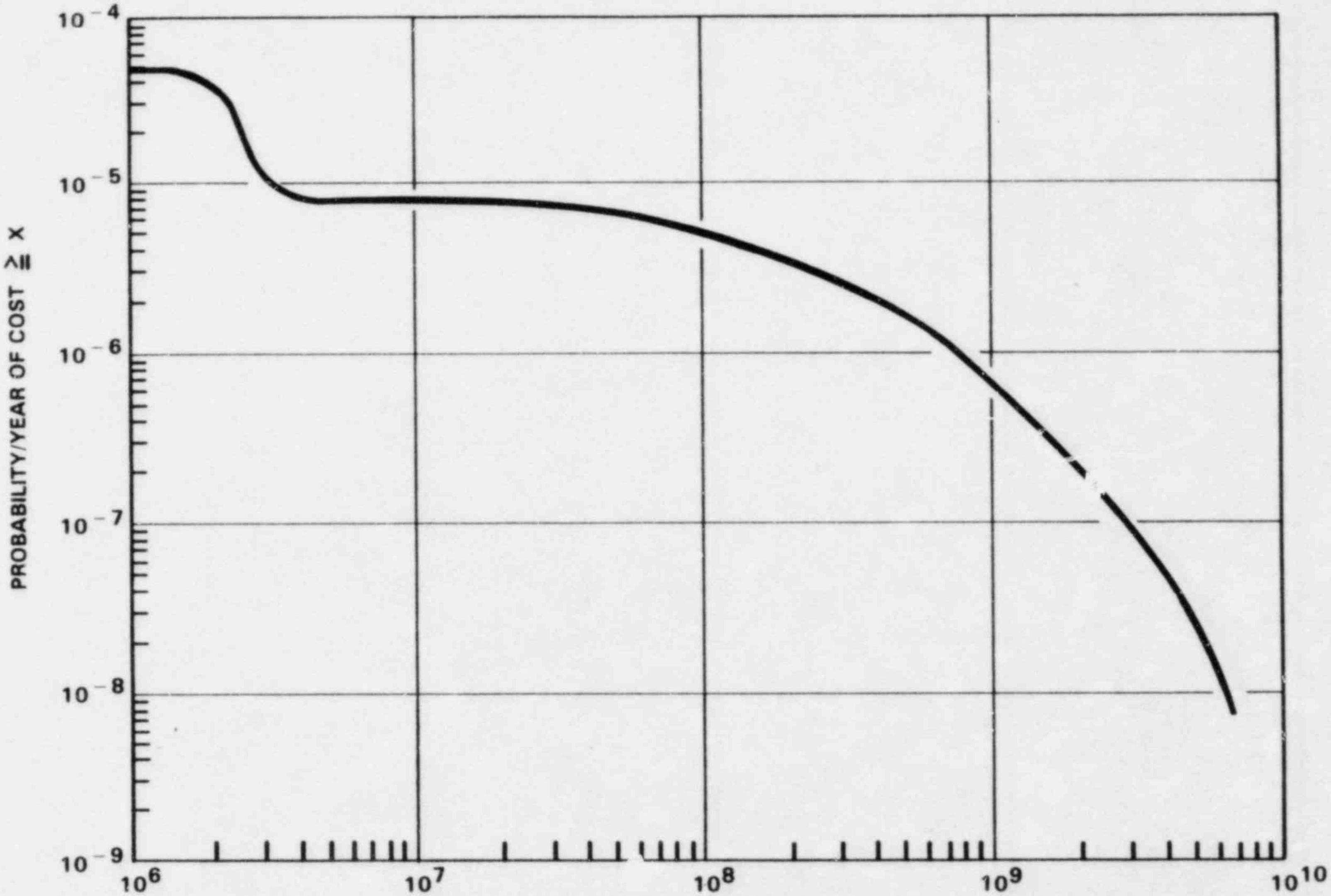
Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	PROBABILITY VS. LATENT CANCER FATALITIES	FIGURE 7.1-3



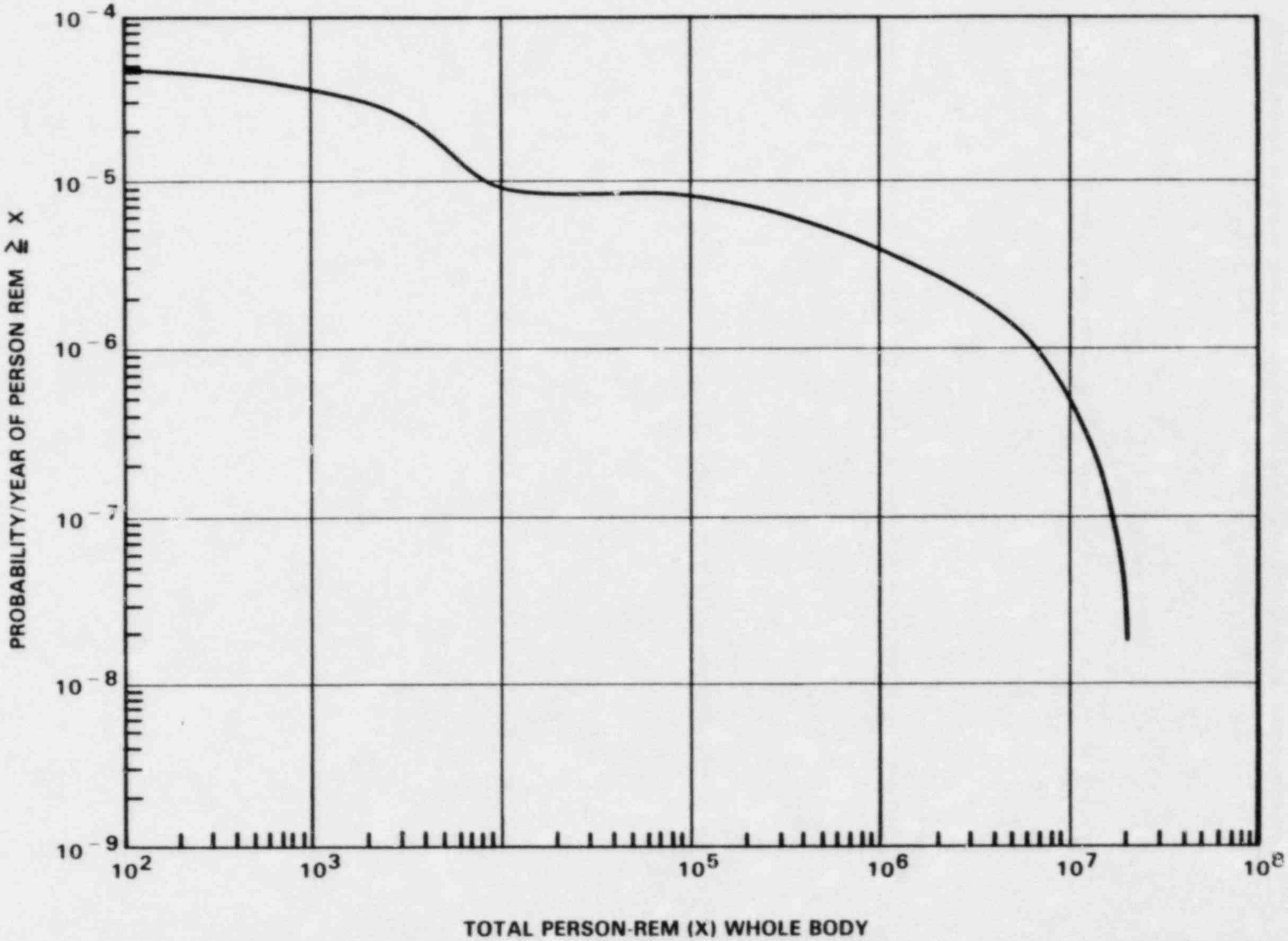
Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	PROBABILITY VS. WHOLE BODY AND THYROID DOSE	FIGURE 7.1-4



Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	PROBABILITY VS. TOTAL COST	FIGURE 7.1-5



Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT	PROBABILITY VS. POPULATION WHOLE BODY DOSE	FIGURE 7.1-6

FIGURE DELETED

Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT		FIGURE 7.1-7

FIGURE DELETED

Amendment 1 (Dec 82)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT No. 3 OPERATING LICENSE ENVIRONMENTAL REPORT		FIGURE 7.1-8

8.2 COSTS OF OPERATION

8.2.1 Internal Costs

The internal costs associated with WNP-3 can be separated into two categories: (1) the capital costs for constructing the facility and (2) the annual costs of operation. Tables 8.2-1 and 8.2-2 show those costs, respectively. Table 8.2-2 also includes levelized annual costs for the cost items and the present worth of the electricity. All annual costs, except for the interest and depreciation, are subject to approximately the same degree of inflation.

8.2.1.1 Capital Costs of Construction

The capital costs associated with WNP-3 construction have several components as listed below.

Item	($ in thousands)
Direct Construction Costs	$1,566,875
Escalation and Contingencies	693,917
Sales Tax	99,579
Engineering and Construction Mgmt	292,763
Owners Direct Cost (a)	366,813
Interest During Construction, Net	1,093,330
Other Net Costs	14,609
Total Plant Cost	$4,127,886

The Supply System cost of constructing the transmission facilities (Satsop Substation to WNP-3), exclusive of the main step-up transformer, is estimated to be $1,440,000.

8.2.1.2 Operating and Maintenance Costs

The initial core fuel scheduled for loading in June 1986 is estimated to cost $75.2 million exclusive of applicable capitalized interest. The Supply System presently estimates that fuel valued at $2,300,000 will be consumed during test and startup activities prior to commercial operation. The annual fuel costs after startup vary with the energy output from the plants.

(a) All Supply System costs that can be attributed directly to the project.

The estimated costs for operating WNP-3 Projects are listed in Table 8.2-2. Such costs were determined in a manner consistent with generally accepted accounting principles and conventional public utility practices.

8.2.1.3 Plant Decommissioning Costs

The plant decommissioning will occur at the end of the project life - currently estimated to be 40 years. The Supply System presently estimates $160 million in 1988 dollars will be sufficient to provide for dismantlement 50 years after final shutdown. Funding will be provided by a uniform annual charge to the power purchasers; collections will be deposited in a segregated fund and reinvested until needed.

8.2.2 External Costs

No adverse socioeconomic impact is expected from operation of WNP-3. Because adequate housing and public services were available for the construction force, the permanent operations staff will not create incremental demands.

The Supply System has conducted a program to monitor and mitigate socioeconomic impacts associated with construction of WNP-3. This program has been successful in alleviating potential impacts and it will continue through the balance of construction. The in-migrating operational staff, coming after the two-unit construction peak (1981), is not expected to create incremental demands for services or have a major impact on the local economy. The addition of operations personnel (scheduled for 60 in 1982 and 320 in 1986) will not occur at a time or location where communities are experiencing severe socioeconomic impacts.

1 The costs to local governments for services required by the permanent operational staff and their families are expected to be compensated for by local taxes paid by individual workers who become permanent residents. In addition, the project will provide abundant tax revenues to the area taxing districts from the privilege (generation) tax ($1 million/yr) and from the sales tax on fuel reloads (approximately $2-3 million/yr of which 8-10% goes to local areas) during plant operation.

Long-term external costs associated with land use in the site area will be minimal. Restricted area previously open to hunters will not be available during operation. Fishing on the Chehalis River will not be limited by plant operation. Land occupied by the plant and support facilities was primarily used for timber production. The timber produced was neither unique nor significant in the total regional product. Continued displacement of this use on about 150 acres during operation represents a negligible reduction of the regional product. Timber management will continue on the majority of the approximately 2,200 acres owned or leased by the Supply System for the project.

TABLE 8.2-1

ESTIMATED COSTS PRIOR TO OPERATION OF WNP-3[a]

FERC Account		10^3 \$
320	Land & Land Rights	12,478
321	Structures & Improvements	1,386,615
322	Reactor Plant Equipment	1,275,818
323	Turbogenerator Unit	606,726
324	Accessory Electric Equipment	362,810
325	Miscellaneous Power Plant Equipment	164,756
	Total Nuclear Production Plant	3,809,203
353	Station Equipment	54,766
399	Other Tangible Property	263,917
	Total	\$4,127,886

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[a]Total capital costs including private owners' share.

TABLE 8.2-2

ESTIMATED ANNUAL COST OF OPERATION OF WNP-3[a]

	FY 1988 Cost (10^3\$)
Fixed Annual Costs:	
Interest	228,269
Depreciation	72,351
Operation and Maintenance	53,439
Other Net Costs	6,316
Total Fixed Annual Costs . .	360,375
Variable Annual Costs:	
Fuel Cost[c]	93,118
Other Net Costs	(18,393)
Total Variable Annual Costs	74,725
Total Annual Costs	\$435,100
Generation (kWh x 10^6)[c]	4,783
Generation Cost: (mills/kWh)	91
1 Generation Cost Present Worth (mills/kWh)[b]	39

[a] Based on estimated Supply System costs of operation; payments under Net-Billing Agreements and Project Exchange Agreements will differ from amounts shown.

[b] Based on assumed escalation rate of 9% per annum for 30 years.

[c] @ 63% capacity factor.

APPENDIX B

RADIOLOGICAL DOSE CALCULATION PARAMETERS

Parameters for Calculating Doses from Liquid Effluents Using LADTAP Code (Reference 5.2-3)

Parameter	Value	Source/Comment
Liquid Discharge (blowdown)	6 cfs	Figure 3.4-1
1 Population, 50-Mile Radius in Year 2000	755,800	Table 2.1-2
Source Terms		Tables 3.5-6 and 5.2-1
Shorewidth Factor	0.2	Reg. Guide 1.109 (Reference 5.2-6), Table A-2
Dilution Factors:		
Aquatic food, Chehalis River	1,100	Average river flow = 6600 cfs, Page 2.4-1
1 River shoreline & water recreation	1,100	
Drinking and irrigation water	1,100	
Aquatic food, Grays Harbor	11,000	Assumed 10x of river dilution
Aquatic food, Ocean	110,000	Assumed 100x of river dilution
Transit Time (hr)		
Maximum individual, drinking (hypothetical)	1	2 mi downstream at average velocity = 2.6 fps
Maximum and average individual, water activities	2.8	5 mi at average velocity
Water Consumption (l/yr)		
Average individuals	Adult - 370	Reg. Guide 1.109, Table E-4.
1	Teen - 260	No downstream withdrawls for
	Child - 260	internal consumption.
	Infant - 260	Assumed consumption by one person
Maximum individuals	Adult - 730	Reg. Guide 1.109, Table E-5.
	Teen - 510	Assumed household 2 mi
	Child - 510	downstream
1	Infant - 370	
Fish Consumption (kg/yr)		
Average individual	Adult - 6.9	Reg. Guide 1.109, Table E-4
	Teen - 5.2	
	Child - 2.2	
	Infant - 0	
Maximum individual	Adult - 21.0	Reg. Guide 1.109, Table E-5
	Teen - 16.0	
	Child - 6.9	
	Infant - 0	

Parameter	Value	Source/Comment
Invertebrate (seafood) Consumption (kg/yr)		
Average individual	Adult - 1.0 Teen - 0.8 Child - 0.3 Infant - 0	Reg. Guide 1.109, Table E-4
Maximum individual	Adult - 5.0 Teen - 3.8 Child - 1.7 Infant - 0	Reg. Guide 1.109, Table E-5
Algae Consumption	0	
Shoreline Usage		
Average individual (hr/yr)	Adult - 8.3 Teen - 47.0 Child - 9.5 Infant - 0	Reg. Guide 1.109, Table E-4
Maximum individual (hr/yr)	Adult - 12.0 Teen - 67.0 Child - 14.0 Infant - 0	Reg. Guide 1.109, Table E-5
Population (man-hr/yr)	27,000	Montesano population x average adult (8.3 hr/yr)
Swimming Usage		
Average individual (hr/yr)	4	PSAR, Page 11.6-10a
Maximum individual (hr/yr)	40	Assumed 10 times average.
Population (man-hr/yr)	12,800	Montesano population x 4 hr/yr.
Boating Usage		
Average individual (hr/yr)	4	PSAR, Page 11.6-10a
Maximum individual (hr/yr)	Adult - 200 Teen - 40 Child - 40	Assumed adult spent 200 hrs fishing, others 10 times average.
Population (man-hr/yr)	12,800	Montesano population x 4 hr/yr.
Fish Harvest (kg/yr)		
Sport	23,200	Chehalis catch (2,900 per Subsection 2.1.3) x 8 kg/ fish average.
Commercial	50,000	Table 2.1-10, Chehalis and Lower Chehalis
	75,000	Table 2.1-10, Grays Harbor
	910,000	Table 2.1-10, Ocean

Parameter	Value	Source/Comment
Invertebrate Harvest (kg/yr)	18,000	Assumed Grays Harbor catch per Table 2.1-10 Washington Dept. of Fisheries (telecon April 5, 1982) suggested that crab were caught in ocean, not harbor.
Sport	0	
Commercial	0	
Food Yield (kg/m^2)		
Vegetation	0.5	Table 2.1-9, Grays Harbor County
Leafy vegetables	2.0	Reg. Guide 1.109, Table E-15
Milk and meat (cow feed)	4.0	Table 2.1-9, Grays Harbor County
1 Food Production Downstream		
Vegetation (kg/yr)	2.5×10^6	Table 2.1-9, Grays Harbor County
Leafy vegetables (kg/yr)	2.2×10^3	Estimated per calc. log
Milk (l/yr)	9.5×10^6	Grays Harbor Cnty, adjusted per calc. log
Meat (kg/yr)	3.5×10^6	Table 2.1-9, Grays Harbor County
Irrigation Rate (l/m^2/month)	110	ER-CP, Page A5 2.4
Growing Period (days)		
Vegetation	70	Typical crop irrigation periods for western Washington.
Leafy Vegetables	7C	
Milk and Meat	180	

Parameters for Calculating Doses from Gaseous Effluents Using GASPAR Code (Reference 5.2-7)

Parameter	Value	Source/Comment
Population within 50-miles in year 2000	755,800	Table 2.1-2
Source Terms		Tables 3.5-9 and 5.2-2
X/Q by Sector		Table 5.2-3
D/Q by Sector		Table 5.2-4
Fraction Of The Year:		
Leafy vegetables grown	0.4	PSAR, Subsection 2.1.4.2
Cows or goats on pasture	1.0	Supply System telecon with Grays Harbor Co. Extension Agent, April 5, 1982
Fraction of Cow or Goat Intake From Pasture	1.0	Reference 5.2-7, Page 2-3
Fraction of Crop From Garden	0.76	Reg. Guide 1.109, Table E-15
Total Food Production, 50 Miles		Table 2.1-9
Vegetation (kg/yr)	2.5 E+07	
Leafy Vegetables (kg/yr)	7.4 E+05	
Milk (l/yr)	1.5 E+08	
Meat (kg/yr)	8.8 E+06	
Annual Average Humidity (%)	64	PSAR, Subsection 2.3.2
Annual Average Temperature (^{o}F)	50.7	PSAR, Subsection 2.3.2
Number of Special Locations	6	
Location (name)	Vegetable Garden	Information from computer run of Reference 5.2-2
Distance/Direction	1.5 mi NNE	
X/Q no decay, undepleted (Sec/m^3)	3.1 E-06	
X/Q 2.26 days decay, undepleted (Sec/m^3)	3.0 E-06	
X/Q 8.0 days decay, depleted (Sec/m^3)	2.6 E-06	
D/Q (1/m^2)	6.3 E-09	

1

1

Parameter	Value	Source/Comment
Location (name)	Meat Cattle	Information from computer run of Reference 5.2-2
Distance/Direction	1.6 mi NNE	
X/Q no decay, undepleted (Sec/m^3)	2.8 E-06	
X/Q 2.26 days decay, undepleted (Sec/m^3)	2.8 E-06	
X/Q 8.0 days decay, depleted (Sec/m^3)	2.4 E-06	
D/Q (1/m^2)	5.6 E-09	