APPLICATION FOR APPROVAL TO DISPOSE OF VERY LOW-LEVEL RADIOACTIVE WASTE

1.0 Purpose

In accordance with 10 CFR 20.302(a), the Washington Public Power Supply System requests NRC approval for the proposed disposal of eight contaminated Moisture Separator Reheater (MSR) tube bundles with associated assemblies and four small spools of piping with estimated waste volumes of 7400 and 370 cubic feet, respectively. This application addresses the specific information requested in 10 CFR 20.302(a).

2.0 Waste Description

2.1 Contaminated Moisture Separator Reheater Assemblies

During the refueling/maintenance outage in the Spring of 1987, the Supply System replaced eight MSR tube bundles including tube sheets, hemispherical heads and associated components. These bundles were replaced because of possible design inadequacies resulting in erosion and poor performance. The MSR tube assemblies, being on the steam side of a Boiling Water Reactor, have low levels of radioactive contamination.

Moisture separator reheaters are important components of the main steam and turbine systems at WNP-2. They mechanically remove excess moisture from the high pressure turbine exhaust steam and then reheat the dried steam prior to passing the steam on to the low pressure turbines. This drying and reheating process minimizes erosion of the low pressure turbines caused by excessive moisture and increases the overall efficiency of the low pressure turbines.

WNP-2 employs two MSRs, one on each side of the turbine on the 501-foot elevation of the Turbine Building. Each MSR consists of an outer shell, moisture separator chevrons and four tube bundles (one high pressure and one low pressure at each end). Each MSR tube bundle is comprised of a large number of 3/4 inch carbon steel U-tubes, roller expanded at each end into a single tube. The physical dimensions of the tube bundle, including hemispherical head, are approximately 4.5 feet in diameter and 43 feet in length. The drawing of a typical MSR tube bundle is shown in Figure 1.

Radiological survey data of the MSR tube bundles are shown in Table 1. External exposure rates ranged from background for half of the bundles to 20 mR/hr near the hemispherical head of two of the bundles. External smear surveys taken on the tubes, showed contamination levels ranging from <1,000 dpm/100 cm2 to 3,000 dpm/100 cm2. Internal exposure rates, measured near the center of the MSR hemispherical heads, ranged from <0.1 mR/hr to 12 mR/hr. The average internal exposure rate was 3.7 mR/hr. Internal smear survey results ranged from <1,000 dpm/100 cm2 to 300,000 dpm/100 cm2 on one tube sheet. The average internal smearable contamination level was estimated to be 78,000 dpm/100 cm2.

The estimated radioactivity of the MSR tube assemblies is shown below as a function of radionuclide and concentration. Total radioactivity estimates were based on exposure rate measurements taken near the center of the hemispherical heads, germanium analysis of MSR tube pieces, and the amount of contaminated surface area. Moisture separator reheater data and radioactivity content calculations are shown in Table 2. A gamma ray spectrometry analysis of an internal smear is shown in Table 3.

ESTIMATED RADIONUCLIDE CONTENT
OF MSR TUBE ASSEMBLIES

Radionuclide	Half-life(yrs)	Avg Distribution(%)	Avg Concentration(pCi/gm)
Mn-54	0.857	1.5	3
Co-60	5.27	50	100
Zn-65	0.67	48.5	97

2.2 Contaminated Pipe Spools

During the refueling outage in the Spring of 1987, the Supply System removed four spools of carbon steel piping from the 471-foot elevation of the Turbine Building. These spools of pipe, located in the steam side of the plant, were removed so that preseparators could be installed between the high pressure turbine and the MSRs. The overall dimensions of a pipe spool are about 6 ft in length and just over 3 ft in diameter.

Radiological survey data of the pipe spools are shown in Table 4. The pipes were not externally contaminated and had background external exposure rates. Internal exposure rates, measured near the center of the pipes, ranged from 0.25 mR/hr to 0.6 mR/hr. The average internal exposure rate was 0.41 mR/hr. Internal smearable contamination levels were <1,000 dpm/100 cm2 on two of the pipes and up to 3,000 dpm/100 cm2 on the other two pipes.

Radioactivity levels of the pipe spools are shown below as a function of radionuclide and concentration. Total radioactivity estimates were based on exposure rate measurements taken in the center of the pipe spools. A gamma ray spectrometry analysis of an internal smear is shown in Table 5. Pipe spool data and radioactivity content calculations are shown in Table 6.

ESTIMATED RADIONUCLIDE CONTENT
OF PIPE SPOOLS

Radionuclide	Half-Life(yrs)	Avg Distribution(%)	Avg Concentration(pCi/gm)
Mn-54	0.857	3.5	10
Co-60	5.27	35	102
Zn-65	0.67	61	177
Sb-125	2.76	0.5	1.5

3.0 Proposed Disposal Method

3.1 Disposal Site Location and Description

The proposed disposal site is within the WNP-2 controlled area on property leased by the Supply System from the US Department of Energy. Disposal would occur at the refuse landfill located just southwest of the cooling towers and inside the plant perimeter fence (see Figure 2). This landfill has been used for disposal of construction debris since 1976, although usage has become infrequent since completion of construction in 1984. Figure 3 shows the location relative to access routes, site area facilities, and the Columbia River.

The surface soils in the area of the landfill consist of reworked sands and gravels. Soils and foundation investigations prior to plant construction show that the site is underlain with approximately 45 ft (down to approximately 395 ft MSL) of glaciofluvial sediments (WNP-2 FSAR Section 2.5.1.2.7). These sediments consist of loose-to-medium dense, fine-to-coarse sand with scattered gravel. Natural water content of the glaciofluvial sands is 2-4%. Below approximate elevation 395 ft MSL, soils consist of very dense, sandy gravels with interbedded sandy and silty layers. This zone, which is almost 200 ft thick, is known as the middle Ringold formation. The groundwater table is located in this zone at approximately 380 ft MSL which is about 60 ft below ground surface. Groundwater flow in the unconfined aquifer is toward the discharge boundary at the Columbia River approximately 3 1/2 miles east of the proposed disposal site.

The climate at the disposal site is characterized as mid-latitude semiarid. The area is subject to low humidities, large diurnal and annual ranges of temperatures, and modest precipitation averaging 6 to 7 inches annually and occurring mostly as rain in the winter and spring months. Natural recharge of the aquifer from precipitation is negligible since the evaporation potential averages 45 inches per year. The predominant winds are from the northwest quadrant and average 7 1/2 miles per hour. When winds are from the ENE or NE, as they are approximately 5% of the time, humidity at the proposed disposal location can exceed natural humidity due to the overhead cooling tower vapor plume.

3.2 Waste Preparation and Burial

The waste components described in Section 2.0 are stored onsite. In preparation for burial the open outlets of the MSR tube bundles will be sealed with steel plates. The tube bundles and the pipe spools will be wrapped with laminated vinyl fabric. The miscellaneous MSR components will be placed in metal storage bins (spec. US DOT Type A) and metal drums.

The disposal site will be prepared within the existing landfill excavation. The contaminated components will be placed and backfill will be compacted in a manner which minimizes voids and prevents subsidence. Approximately three feet of soil will be placed over the contaminated components. A land survey will be performed to record the burial site coordinates and posts and/or signs will be erected to mark the area.

The handling of the waste during preparation and disposal will be in accordance with Plant health physics procedures. There may be external exposures to workers during this process, but the individual exposures should be no greater than would be associated with disposal at a site licensed under 10 CFR Part 61.

4.0 Evaluation of Radiological and Environmental Impact

The radiological impact of the proposed waste disposal was evaluated by considering potential modes of exposure including; 1) external exposure from standing on the ground above the disposal site, 2) internal exposure from the inhalation of resuspended radionuclides, 3) internal exposure from the ingestion of food grown on the disposal site, and 4) internal exposure from drinking potentially contaminated groundwater.

The most plausible post-burial radiation exposure is the external exposure accrued by persons working above the disposal site. Calculations and assumptions used in the evaluation of this exposure are shown in Table 7. The annual dose to an individual from external exposure is conservatively estimated to be 0.9 mrem. The integrated lifetime dose to an individual is estimated to be less than 7 mrem. Among the conservatisms is the assumption that the individual stands on the site 2000 hours per year. In fact, this area is unoccupied except during infrequent landfilling operations.

Internal exposure from the inhalation of resuspended radionuclides and ingestion of crops grown on the disposal site is considered unlikely due to the proposed vinyl wrapping and the soil cover. Also, crop production is not a land use anticipated for the site, at least during the term of the Supply System's control of the property.

An internal exposure due to consumption of groundwater contaminated by waste materials is not considered plausible for several reasons. First, with the low precipitation, there is no mechanism to remove the contamination from the components and transport it 40-50 feet down to the water table. Secondly, there are no wells drawing from the unconfined aquifer downgradient of the disposal site. There are two wells in use at the Supply System's WNP-1 site about 7000 ft east of the proposed disposal location. However, these wells are 372 ft and 465 ft deep and, based on stratigraphy and water quality data, appear to draw from a semi-confined aquifer in the Ringold conglomerates and the upper fractured basalt flow. Based on these factors, the groundwater pathway is not considered realistic. Nevertheless, even if it were assumed that all the radioactivity reached the groundwater beneath the disposal site, the concentration of Co-60, the radionuclide with the longest half-life, would be reduced by a factor of 6000-7000 at the WNP-1 wells due to radioactive decay and sorption (WNP-2 FSAR Section 2.4.13.3). There would be additional reduction due to dispersion in the aquifer.

The nonradiological environmental impacts of the disposal will be negligible. The proposal does not involve the disturbance of new ground nor does it represent a new land use. The area has been previously excavated for borrow material and backfilled with native soils and construction debris. The material which has been landfilled in the area is dry, nonhazardous solid waste which will not create moist, acidic conditions conducive to movement of the radionuclides. The waste components are scrap metal and are not a concern with respect to hazardous waste regulation (see 40 CFR 261.6(a)(3)(iv)).

5.0 Summary

Contaminated tube bundles and pipe spools presently in storage at WNP-2 require disposal. If, these components were packaged and disposed of as radioactive waste, the disposal would cost approximately $305,000 and use approximately 7800 ft3 of licensed burial space at the US Ecology, Inc. site on the Hanford Reservation. The Supply System proposes to dispose of these components by burial on the WNP-2 site at a cost savings of approximately $270,000. Neither the material to be disposed of nor the disposal operation will present an undue radiological risk to public health and safety. In addition, the disposal will not adversely affect the environs. Therefore, the Supply System is requesting approval of onsite disposal in accordance with 10 CFR 20.302(a).

Table 1. MSR Tube Bundle Radiological Survey Data

MSR Tube Bundle No.	External Exposure Rate (mR/hr)	External Smearable Contamination (dpm/100 cm^2)	Internal* Exposure Rate (mR/hr)	Internal Smearable Contamination (dpm/100 cm^2)
1	0.2 - Background	1,000	0.1	<1,000
2	1.0 - Near Head	1,000	3.0	100,000
3	8.0 - Near Head	<1,000	6.0	120,000
4	0.2 - Background	<1,000	0.2	2,000
5	0.2-0.3 - Background	<1,000	0.2	<1,000
6	0.2 Background	3,000	<0.1	<1,000
7	20 - Near Head	<1,000	12.0	300,000
8	20 - Near Head	1,000	8.0	100,000

* Taken in center of hemispherical head

Table 2. MSR Tube Bundle Data and Radioactivity Content Calculations

A. MSR Tube Bundle Data

1. Tube bundle heat transfer area

   1st stage = 2nd stage = 22,600 ft^2 (2.1E+7 cm^2)

2. Tube bundle Weight

   1st stage = 27,200 lb (1.23E+7 gm)
   2nd stage = 33,200 lb (1.51E+7 gm)

3. Tube bundle volume

   390 ft^3 (1.1E+7 cm^3)

4. Misc. assembly area

   1000 ft^2 (9.3E+5 cm^2)

5. Misc. assembly weight

   5000 lb (2.3E+6 gm)

6. Misc assembly volume

   325 ft^3 (9.2E+6 cm^3)

B. Radioactivity Calculations

1. Radionuclides

Isotope	Half-life (yrs)	Avg. Distribution *(%)
Mn-54	0.857	1.5
Co-60	5.27	50
Zn-65	0.67	48.5

* Estimated by taking average of internal smears and germanium analysis of tube piece.

2. Radionuclide Content

   a. Hemispherical heads

   The radionuclide activity in the hemispherical heads was estimated from exposure rate measurements as follows.

$$\mathring{X}(R/hr) = \frac{dps}{4\pi r^2} \times \frac{MeV}{d} \times \mu en/\rho\,(cm^2/gm) \times \frac{1.6E\text{-}6\,erg}{MeV} \times \frac{10^2\ rad}{erg/gm} \times \frac{3600\ sec}{hr} \times \frac{R}{0.869\ Rad}$$

Where: $\mathring{x}$ = avg. exposure rate measured in hemispherical head = 3.7 mR/hr

dps = estimated activity per head

MeV/d = 3.074 for Co-60 and Zn-65 per Rad Health Handbook

μ_{en}/ρ = 0.028 cm^2/gm for 1-MeV photons per Rad Health Handbook

r = 33 cm avg. radius of hemispherical head (head is divided in two by divider plate)

Solving for dps:

$$dps = \frac{\mathring{x}\ (R/hr)}{4.2E-10\ R\cdot sec/hr\cdot d} = \frac{3.7E-3R/hr}{4.2E-10\ R\cdot sec/hr\cdot d} = 8.8E+6\ dps$$

$$8.8E+6\ dps \times \frac{uCi}{3.7E+4\ dps} = 2.4E+2\ uCi$$

$$\frac{2.4E+3\ uCi}{half\ hemisphere} \times \frac{2\ half\ hemisphere}{tube\ bundle} \times 8\ tube\ bundle = 3.8E+3\ uCi = 3.8\ mCi$$

b. MSR tubes and miscellaneous components

The germanium results of a 30.4 cm^2 piece of MSR tube are as follows:

Isotope	Estimated Activity (uCi)
Mn-54	3.7E-5
Co-60	1.4E-3
Zn-65	1.8E-3
Total	3.2E-3

The total activity in all the tubes is calculated as follows:

$$\frac{2.1E+7\ cm^2/tube\ bundle}{30.4\ cm^2} \times 8\ bundles \times 3.2E-3\ uCi = 1.8E+4\ uCi = 18\ mCi$$

The total activity in the miscellaneous components is calculated as follows:

$$\frac{3.2E-3\ uCi}{30.4\ cm^2} \times 9.3E+5\ cm^2 = 98\ uCi$$

3. Radioactivity per unit mass

$$\frac{21.9E+3\ \text{uCi*}}{2.3E+6\ \text{gm} + \left(4\ \text{tube bundle} \times \frac{1.23E+7\ \text{gm}}{\text{tube bundle}}\right) + \left(4\ \text{tube bundle} \times \frac{1.51E+7\ \text{gm}}{\text{tube bundle}}\right)} =$$

2.0E-4 uCi/gm

Note: There are four (4) 1st stage and four (4) 2nd stage tube bundles.

4. Radioactivity per unit area

$$\frac{21.9E+3\ \text{uCi}}{9.3E+5\ \text{cm}^2 + \left(\frac{2.1E+7\ \text{cm}^2}{\text{tube bundle}}\right) \times (8\ \text{tube bundle})} = 1.3E-4\ \text{uCi/cm}^2$$

5. Radioactivity per unit volume

$$\frac{21.9E+3\ \text{uCi}}{9.2E+6\ \text{cm}^3 + \left(\frac{1.1E+7\ \text{cm}^3}{\text{tube bundle}} \times 8\ \text{tube bundle}\right)} = 2.3E-4\ \text{uCi/cm}^3$$

* Includes activity from hemispherical heads, MSR Tubes and miscellaneous components.

Table 3. Gamma Ray Spectrometry Nuclide Summary of MSR Tube Bundle #8

SAMPLE NUMBER: 88-8538
SAMPLE VOLUME= 1.000001
SAMPLE DATE = 12-DEC-88
SAMPLE TIME = 13:00:00

LIVE TIME : 1800
REAL TIME : 1850
DEAD TIME %: 2.7

GEOMETRY :47mm Planchet Shelf 1 -- ORT1
ACQUISITION STARTED: 12-DEC-88 19:46:00

NUCLIDE	TIME OF COUNT ACTIVITY Uci/cc	TIME CORRECTED ACTIVITY Uci/cc	PERCENT UNCERTAINTY COUNTING 2 S
Mn-54	4.953E-03	4.956E-03	7.3
Co-60	1.747E-01	1.747E-01	.5
Zn-65	1.482E-01	1.483E-01	.8
AP-511	2.589E-03	2.589E-03	7.3

TOTAL ACTIVITY= 3.31E-01 Uci/cc

Table 4. Pipe Spool Radiological Survey Data

Pipe Spool No.	Internal Exposure Rate (mR/hr)	Internal Smearable Contamination (dpm/100 cm^2)
1	0.4	<1000
2	0.25	<1000
3	0.4	3000
4	0.6	3000

Table 5. Gamma Ray Spectrometry Nuclide
Summary of Pipe Spool #1

SAMPLE NUMBER: 88-8478
SAMPLE VOLUME= 1.000001
SAMPLE DATE = 09-DEC-88
SAMPLE TIME = 15:00:00

LIVE TIME : 1800
REAL TIME : 1809
DEAD TIME %: 0.5

GEOMETRY :47mm Filter Shelf 1 -- ORT3
ACQUISITION STARTED: 09-DEC-88 15:40:00

NUCLIDE	TIME OF COUNT ACTIVITY Uci/cc	TIME CORRECTED ACTIVITY Uci/cc	PERCENT UNCERTAINTY COUNTING 2 S
Mn-54	3.127E-03	3.127E-03	6.6
Co-60	2.369E-02	2.369E-02	1.2
Zn-65	3.291E-02	3.291E-02	1.4
Sb-125	8.201E-04	8.201E-04	15.5
K-40	7.601E-04	7.601E-04	31.3
AP-511	4.682E-04	4.682E-04	14.2

TOTAL ACTIVITY= 6.18E-02 Uci/cc

Table 6. Pipe Spool Data and Radioactivity Content Calculations

A. Pipe Spool Data

1. Length (l): 6 ft (183 cm)

2. Diameter (d): 3.1 ft (94.5 cm)

3. Thickness: 1 in carbon steel

4. Surface Area (π x d x l):

   π x 94.5 cm x 183 cm = 5.4E+4 cm^2

5. Mass: 2300 lb (1.04E+6 gm)

6. Volume: (π x $d^2/4$ x l):

   π x $(94.5 \text{ cm})^2/4$ x 183 cm = 1.28E+6 cm^3

B. Radioactivity Calculations

1. Radionuclides

Isotope	Half-life (yrs)	Avg. Distribution (%)
Mn-54	0.857	3.5
Co-60	5.27	35
Zn-65	0.67	61
Sb-125	2.76	0.5

2. Radionuclide Content

The radionuclide activity (C_i) was estimated from exposure rate measurements taken in the center of the pipe as follows*:

$$D_p = \frac{\Gamma C_i}{r} (2 \tan^{-1} l/h)$$

where: D_p = avg. exposure rate in center of pipe = 0.41 mR/hr

Γ = weighted avg. specific gamma ray constant for nuclide mix = 6.4 R · cm^2 per hr · mCi

C_i = estimated activity per unit pathlength in mCi/cm

r = pipe radius = 47.2 cm

l = length of pipe from end to center = 91.4 cm

h = distance from pipe to center of pipe = 47.2 cm

Solving for C_l:

$$C_l = \frac{D_p \cdot r}{\Gamma (2\tan^{-1} l/h)} = \frac{(4.1E-4\ R/hr)(47.2\ cm)}{6.4\ \frac{R \cdot cm^2}{m \cdot mCi} \times 2\tan^{-1} \frac{91.4}{47.2}} = 1.6E-3\ mCi/cm$$

Total Activity:

1.6E-3 mCi/cm x 183 cm/pipe x 4 pipes = <u>1.2 mCi</u>

3. Radioactivity per unit area

$$\frac{1.2E+3\ uCi}{\frac{5.4E+4\ cm^2}{pipe} \times 4\ pipes} = 5.6E-3\ uCi/cm^2$$

4. Radioactivity per unit mass

$$\frac{1.2E+3\ uCi}{\frac{1.04E+6\ gm}{pipe} \times 4\ pipes} = 2.9E-4\ uCi/gm$$

5. Radioactivity per unit volume

$$\frac{1.2E+3\ uCi}{\frac{1.28E+6\ cm^3}{pipe} \times 4\ pipes} = 2.3E-4\ uci/cm^3$$

*Taken from page 295 of "Introduction to Health Physics", Herman Cember, 2nd Edition.

Table 7. Estimated Annual External Exposure to an Individual From Standing Above the MSR Tube Assemblies and Pipe Spools

	Radionuclide	Average Concentration (pCi/cc)	Average Surface Deposition[a] (pCi/m^2)	External Dose Factors[b] ($mrem/hr/pCi/m^2$)	Covered Dose Rate[c] (mrem/hr)	Annual Dose[d] (mrem)
A.	MSR TUBE ASSEMBLIES					
	Mn-54	3.4E+0	3.4E+5	5.8E-9	2.0E-6	3.9E-3
	Co-60	1.2E+2	1.2E+7	1.7E-8	2.0E-4	4.1E-1
	Zn-65	1.1E+2	1.1E+7	4E-9	4.4E-5	8.8E-2
B.	PIPE SPOOLS					
	Mn-54	8.0E+0	8.0E+5	5.8E-9	4.6E-6	9.3E-3
	Co-60	8.1E+1	8.1E+6	1.7E-8	1.4E-4	2.8E-1
	Zn-65	1.4E+2	1.4E+7	4E-9	5.6E-5	1.1E-1
	Sb-125	1.0E+0	1.0E+0	--	--	--
TOTAL					4.5E-4	8.9E-1

a The average surface deposition was estimated by assuming that all of the radioactivity in the contaminated components was deposited on the top 10 cm surface and that the average concentrations of radionuclides in the wastes were the same as the measured concentrations.

b External dose factors were taken from Table E-6 of Reg. Guide 1.109, Rev. 1. Table E-6 did not have an external dose factor for Sb-125, however its contribution to the annual dose is insignificant.

c The covered dose rate was calculated using a dose attenuation factor of 1000 for a plane monodirectional source including build-up factor from Jaeger, R.G., Ed., Engineering Compendium on Radiation Shielding, Vol. 2, Figure 9.1-54. Springer Verlag, Berlin, 1968. Relevant data used was soil cover of 91.4 cm, mean soil density of 1.65 gm/cc and a photon energy of 1 MeV.

d Annual dose was based on an occupancy of 2000 hours per year.

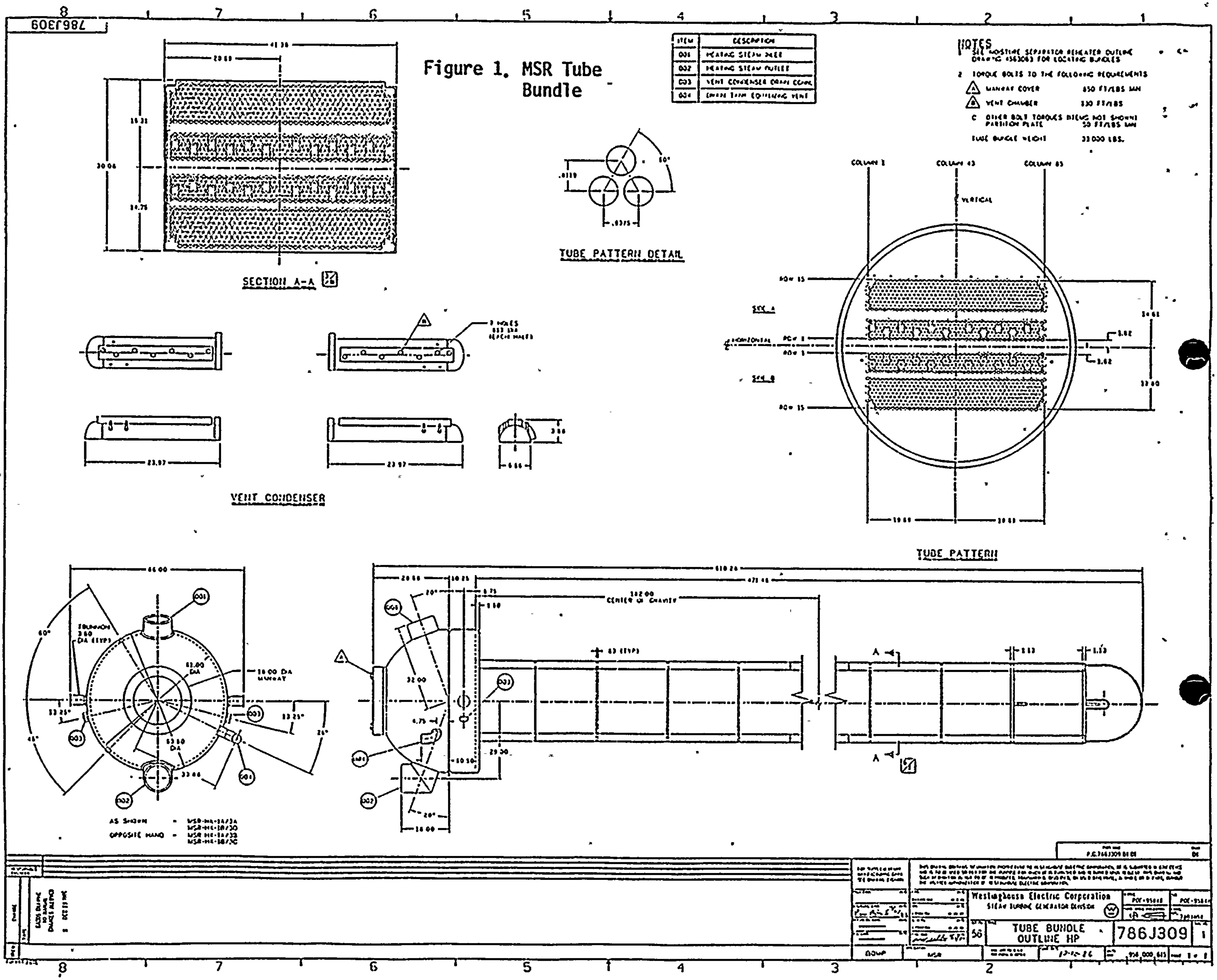

Figure 1. MSR Tube Bundle

Figure 2. WNP-2 Site Photo

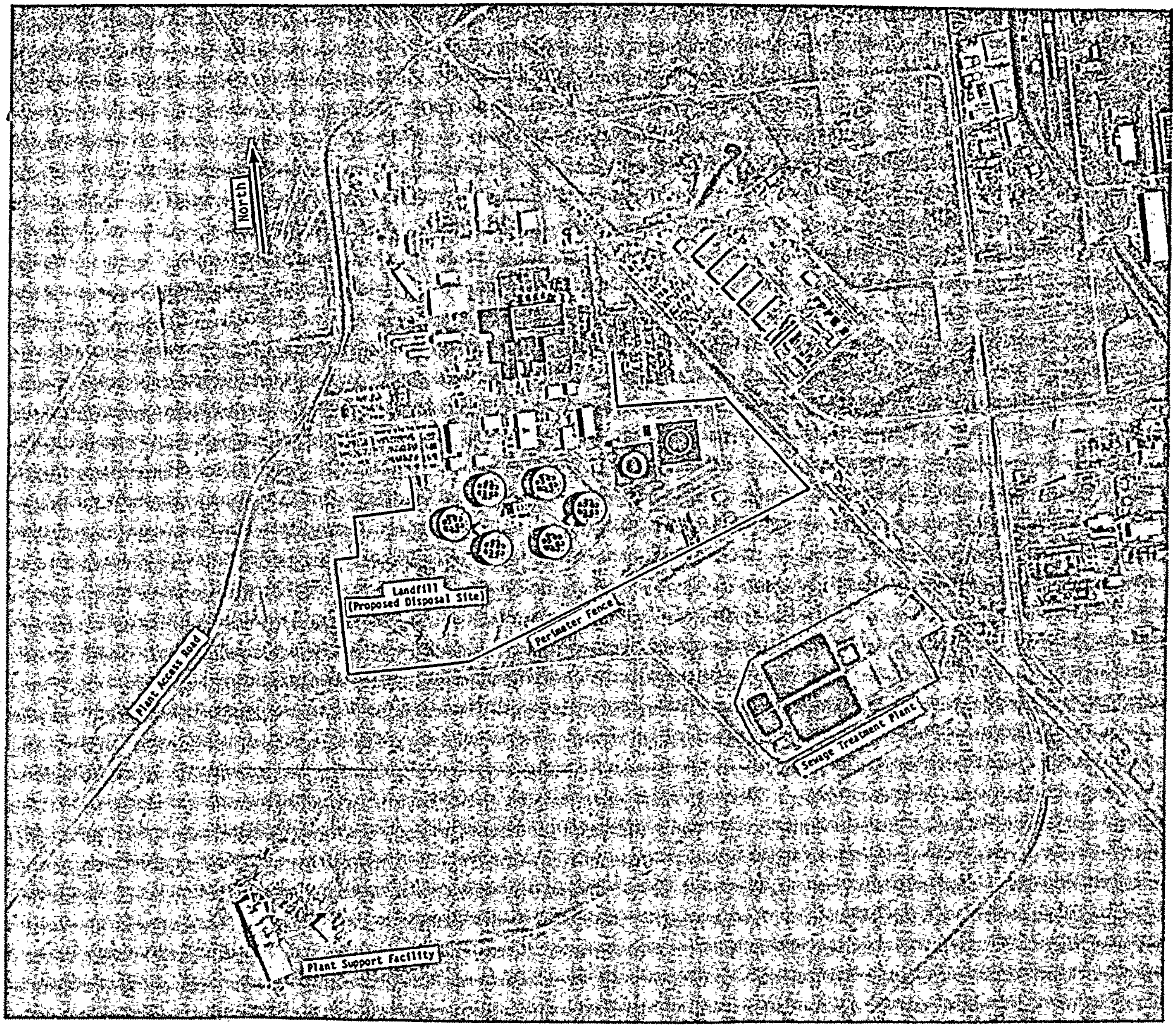

FIGURE 3. WNP SITE MAP