## 4.5 Radiation Exposure to Construction Workers

During the construction of STP 3 & 4, workers will be exposed to several potential sources of radiation. This section identifies the potential sources of radiation and estimates the doses that workers would receive during the construction of STP 3 & 4 due to the operation of STP 1 & 2. In addition, with STP 3 scheduled to be operational one year earlier than STP 4, STP 3 will be a source of radiation for STP 4 construction workers during that year. Thus, the dose contribution from STP 3 sources of radiation is also evaluated.

Three types of sources are considered: direct radiation, gaseous effluents, and liquid effluents. Subsection 4.5.2 identifies the specific sources of each type, Subsection 4.5.3 quantifies the dose rates in the construction area from each source, and Subsection 4.5.4 estimates the maximum annual doses to each worker as well as the entire workforce.

### 4.5.1 Site Layout

The physical location of STP 3 & 4 relative to STP 1 & 2 is presented in Figure 4.5-1. As the figure indicates, STP 3 & 4 will be located northwest of the protected area of STP 1 & 2. Hence, construction activity would take place outside the protected area for STP 1 & 2, but inside the Exclusion Area Boundary (EAB) for STP 1 & 2.

### 4.5.2 Radiation Sources

During the construction of STP 3 & 4, the construction workers will be exposed to radiation sources from the operation of STP 1 & 2, as described in the following subsections. Also identified are the STP 3 sources that the construction workers on STP 4 will be exposed to during the year of construction when STP 3 is operational.

#### 4.5.2.1 Direct Radiation Sources

The primary sources of direct radiation at STP 1 & 2 are the waste monitor tanks located south of STP 1 & 2. There are three waste monitor tanks per unit located outside, containing low-level liquid radwaste collected from laundry and hot shower drains and processed liquids from the waste holdup tanks and the floor drain tank. Because of the shielding provided by the Fuel Handling Building and the Mechanical Auxiliary Building, no other direct radiation is anticipated, nor has any been detected, northwest of the STP 1 & 2 protected area in the direction of STP 3 & 4.

There are three other potential sources of direct radiation south and west of the proposed location for STP 3 & 4: the Onsite Staging Facility (OSF), which includes Warehouse “D” and outside storage areas, the Old Steam Generator Storage Facility (OSGSF), and the proposed Long-Term Storage Facility (LTSF) for storing replaced reactor vessel heads. The LTSF will be located next to the OSGSF. Following the closure of the Barnwell facility in South Carolina, the OSF is expected to be used to store high-integrity containers (HICs) until a waste disposal facility becomes available for generators of radwaste from Texas. Figure 4.5-3 shows the existing location of the OSF near the OSGSF. Since the OSF interferes with the proposed construction, plans

are being made to move the facility to a location further away from the construction area before the start of primary construction activities on STP 3 & 4. Furthermore, there is a plan to upgrade the shielding of the OSF outside storage areas after the move to reduce the dose rate in the construction area from this source to background level.

One of the activities that takes place in the OSF is the transfer of radioactive materials from one shielded container to another; this takes place in the radioactive waste truck bay on the south side of STP 1 & 2. There are approximately 10 such transfers per year with the HIC unshielded for up to 10 minutes during each transfer, thereby contributing incremental, infrequent doses in the area. However, because the distance is more than 2000 feet between the radioactive waste truck bay and the STP 3 & 4 construction site and there are intervening buildings that provide shielding, it is anticipated that radiation from this source would not be detectable in the construction area.

The primary source of direct radiation exposure to the workers on STP 4 will be the gamma radiation from Nitrogen-16 in the STP 3 steam lines and steam-bearing components such as turbines, moisture separators, and reheaters (FSAR Section 12.2.1.3).

### 4.5.2.2 Gaseous Effluent Sources

Gaseous effluents at STP 1 & 2 originate at each unit's vent on the roofs of their respective Mechanical Auxiliary Buildings. Sources of gaseous effluent at STP 1 & 2 include containment purging, the ventilation systems of the auxiliary building and the turbine building, and the gaseous waste processing system. Table 4.5-1 shows the maximum annual releases of gaseous effluents, based on the STP 1 & 2 Radioactive Effluent Release Reports for 2002 to 2006 (References 4.5-1 to 4.5-5).

For STP 3, the primary release point is the Reactor Building plant stack. This stack serves as the release point for the Reactor Building, Turbine Building, and Radwaste Building. Other exhaust points for clean releases are the roof top vents for the Control and Service Buildings and the Service Building health physics room roof vent (FSAR Section 11.3). The postulated releases of gaseous effluents from STP 3 are 2.7E6 MBq/yr of tritium and 1.9E8 MBq/yr of fission gases, iodines, and particulates (FSAR Table 12.2-20).

### 4.5.2.3 Liquid Effluent Sources

STP 1 & 2 liquid effluent batch releases include liquid radwaste treated by the liquid waste processing system and secondary chemical regeneration waste. STP 1 & 2 liquid effluent continuous releases include liquid effluents resulting from primary to secondary leakage or other plant operations. Table 4.5-2 shows the maximum annual releases of liquid effluents, based on the STP 1 & 2 Radioactive Effluent Release Reports for 2002 to 2006 (References 4.5-1 to 4.5-5).

For STP 3, effluents may be released from the high conductivity waste sample tanks, the low conductivity waste sample tanks, and the hot shower drain sample tank (FSAR

Section 11.2.3.1). The releases are estimated to be 3.0E5 MBq/yr of tritium and 7.7E3 MBq/yr of iodines and particulates (FSAR Table 12.2-22).

### 4.5.3 Construction Site Dose Rates

Dose rates at the construction site are estimated based on dose rate measurements and calculations. Although the construction workers will occupy a large area over the course of the construction period, dose rates are estimated based on average distances from radiation sources.

#### 4.5.3.1 Direct Radiation Dose Rates

The direct radiation dose rates from STP 1 & 2 sources are based on thermoluminescent dosimeter (TLD) measurements taken at various onsite locations from 2002 through 2006. This 5-year period provides sufficient data to be representative of plant conditions. Monitoring Stations 9 to 16 are located along the north and west sides of the STP 1 & 2 protected area fence in the direction of STP 3 & 4, as shown in Figures 4.5-1 and 4.5-2. The quarterly doses at these TLD locations, which provide a good indication of direct radiation from the STP 1 & 2 power block, are shown in Tables 4.5-3 to 4.5-7. Although the dose rates at the construction site during the periodic transfers of radioactive waste between shielded containers is expected to be negligible, as indicated in Subsection 4.5.2.1, any contribution from this activity is reflected in the TLD readings. These tables show that the maximum dose rate measured at Monitoring Stations 9 to 16 over the 5 years is 18.9 mR per quarter.

In 1986, before the operation of STP 1 & 2, the measured background dose rate at the site boundary was 15.4 mR/quarter (References 4.5-1 to 4.5-5, Table 8-1). Some of the direct radiation measurements around the protected area fence are lower than at the site boundary because the protected area was excavated and backfilled with sand and gravel that contained less naturally occurring radioactive material than exists in the native clay found near the site boundary. The dose rate of 15.4 mR/quarter continues to be used as the reference background dose rate for adjusting measurements at STP 1 & 2 (Reference 4.5-5). Subtracting the background dose rate of 15.4 mR/quarter from the maximum protected area fence reading of 18.9 mR/quarter yields a net maximum dose rate of 3.5 mR/quarter, as shown in Table 4.5-8.

The Radiological Environmental Monitoring Program (REMP) was expanded in 2006 to systematically collect data at the OSGSF. As indicated in Figure 4.5-3, Monitoring Stations 25 to 28 are situated along the perimeter of the OSGSF. The 2006 TLD readings at these locations are shown in Table 4.5-7. The peak OSGSF measurement is 16.7 mR/quarter. Subtracting the background dose rate of 15.4 mR/quarter yields a net maximum dose rate of 1.3 mR/quarter, as shown in Table 4.5-8.

The construction location for STP 3 & 4 is farther away from STP 1 & 2 and the OSGSF than are the respective TLD stations where dose rates are measured from each source. The STP 1 & 2 Offsite Dose Calculation Manual (ODCM) indicates that the dose rate at a TLD from a given source may be extrapolated to another location as follows (Reference 4.5-6, Section 4.7):

$D_{loc} = D_{TLD} * (R_{TLD}/R_{loc})^2$ (Equation 4.5-1)

Where:

$D_{loc}$ = Dose rate at a location (mrem/yr)

$D_{TLD}$ = Dose rate at TLD (mrem/yr)

$R_{TLD}$ = Distance from source to TLD

$R_{loc}$ = Distance from source to location

This relationship is based on a sufficiently large distance between source and receptor such that the source may be treated as a point. When the distance between source and receptor is smaller, the dose rate at the receptor may be estimated as follows:

$D_{loc} = D_{TLD} * (R_{TLD}/R_{loc})$ (Equation 4.5-2)

In determining direct radiation dose rates, it is assumed that the worker is located in the center of the construction area of the unit (either STP 3 or 4) nearest to the source. Given that workers will move about the construction area over the course of a year, it is reasonable to select the center of the area as a representative location for occupancy.

In Table 4.5-9, direct radiation dose rates are determined as follows:

- STP 1 & 2 – The dose rate from this source at the construction location is calculated using Equation 4.5-2. The annual dose rate at the TLD is obtained by multiplying the quarterly dose rate from Table 4.5-8 by a factor of 8 (to account for four quarters and double for conservatism), yielding a dose rate of 28 mrem/yr at the STP 1 & 2 protected area fence. As indicated in Subsection 4.5.2.1, there are a number of sources that could be contributing to this dose rate. Based on Figures 4.5-1 and 4.5-2, the distance from each source to the fence is approximately 600 feet and the distance from each source to the center of the STP 3 construction area is approximately 2300 feet. Putting $D_{TLD}$ = 28 mrem/yr, $R_{TLD}$ = 600 ft, and $R_{loc}$ = 2300 feet into Equation 4.5-2 yields a dose rate of 7.3 mrem/yr at the construction location, as shown in Table 4.5-9.

- OSGSF – As with the STP 1 & 2 source, the annual dose rate at the OSGSF TLD is obtained by multiplying the quarterly dose rate from Table 4.5-8 by a factor of 8, yielding a dose rate of 10 mrem/yr. Based on Figure 4.5-3, the distance from the OSGSF to the TLD is about 10 feet. Based on Figure 4.5-1, the distance from the OSGSF to the center of the STP 4 construction area is about 700 feet. Putting $D_{TLD}$ = 10 mrem/yr, $R_{TLD}$ = 10 ft, and $R_{loc}$ = 700 ft into Equation 4.5-2 yields a dose rate of 0.15 mrem/yr. However, a calculation using MORSE, a multigroup gamma ray transport Monte Carlo computer code, estimated a skyshine dose rate of about 1 mrem/yr at a distance of 700 feet from the OSGSF, with the OSGSF having all

eight steam generators from STP 1 & 2 stored within it. Table 4.5-9 shows this higher dose rate from the OSGSF at the construction location.

- LTSF – Since the LTSF is proposed to be located next to the OSGSF, the distance from this source to the center of the STP 4 construction area is assumed to be 700 feet, the same as the OSGSF. The calculated dose rate at a distance of 700 feet from the LTSF, with both reactor vessel heads from STP 1 & 2 stored within it, is 0.07 mrem/yr. This is conservatively rounded up to 1 mrem/yr, as shown in Table 4.5-9.

- OSF – As indicated in Subsection 4.5.2.1, the OSF will be relocated and have additional shielding provided such that the dose rate from this source will be negligible at the STP 3 & 4 construction location. However, the dose rate from the OSF is conservatively assumed to be 1 mrem/yr at the construction location, as shown in Table 4.5-9.

- STP 3 – STP 3 must be considered as a source of direct radiation at the STP 4 construction site in the timeframe between STP 3 becoming operational and STP 4 becoming operational. The plant shielding design acceptance criteria for the ABWR specify a maximum dose rate due to direct and scattered radiation of 2.5 mrem/yr at the EAB. As indicated in Section 2.7, the distances from STP 3 to the EAB and to the STP 4 reactor are 0.58 and 0.17 mile, respectively. Using Equation 4.5-1, the maximum dose rate to the STP 4 construction workers may be estimated as follows:

$$D_{STP4} = (2.5) * (0.58/0.17)^2 = 29 \text{ mrem/yr}$$

In calculating the dose rates in Table 4.5-9, no credit is taken for any shielding provided by structures under construction.

### 4.5.3.2 Gaseous Effluent Dose Rates

Based on the STP 1 & 2 REMPs for 2002 to 2006, Table 4.5-10 shows the annual dose rates to the maximally exposed member of the public at the site boundary or the nearest residence due to the release of gaseous effluents (References 4.5-1 to 4.5-5). The table also shows the composite maximum annual dose rate for each organ over these 5 years. These dose rates were calculated using the methodology found in the STP 1 & 2 ODCM (Reference 4.5-6). These offsite dose rates are used to estimate construction doses in Subsection 4.5.4.2.

Using the atmospheric dispersion factors in Section 2.7, the calculated dose rates at STP 4 due to gaseous effluents from STP 3 are 6.6, 12, and 16 mrem/yr to the total body, thyroid, and skin, respectively.

### 4.5.3.3 Liquid Effluent Dose Rates

Based on the STP 1 & 2 REMPs for 2002 to 2006, Table 4.5-11 shows the annual dose rates to the maximally exposed member of the public at the site boundary or the

nearest residence due to the release of liquid effluents (References 4.5-1 to 4.5-5). The table also shows the composite maximum annual dose rate for each organ over these 5 years. These dose rates were calculated using the methodology found in the STP 1 & 2 ODCM (Reference 4.5-6).

The calculated annual liquid effluent dose rates to the maximally exposed individual offsite from STP 3 are shown in Table 5.4-5.

The offsite dose rates from STP 1, 2, and 3 are calculated at the Little Robbins Slough area due to sport fish ingestion and shoreline exposure. These dose rates are used to estimate construction location doses in Subsection 4.5.4.3.

## 4.5.4 Construction Worker Doses

Construction worker doses are conservatively estimated assuming the maximum dose rate for each pathway (direct radiation, gaseous, and liquid effluents), an exposure time of 2080 hours per year, based on 40 hours per week for 52 weeks a year, and a peak loading of 5950 construction workers per year (Table 3.10-2). The maximum annual dose from each pathway and the total annual dose are estimated in the following subsections.

### 4.5.4.1 Direct Radiation Doses

Table 4.5-9 shows the dose rates from STP 1 & 2, the OSGSF, the LTSF, the OSF, and STP 3 at the construction location. Although the maximum dose rate from STP 1 & 2 is in the STP 3 construction area and the maximum dose rates from the OSGSF and the LTSF are in the STP 4 construction area, the two sets of dose rates are conservatively added. No credit is taken for shielding provided by any intervening structures between the three sources and the construction location.

Table 4.5-9 shows the resulting annual doses to construction workers, obtained by multiplying the dose rates by the exposure duration of 2080 hours per year.

### 4.5.4.2 Gaseous Effluent Doses

Table 4.5-10 shows the total body and organ dose rates to the maximally exposed member of the public, based on the annual effluent reports for STP 1 & 2 (References 4.5-1 to 4.5-5). These reports also estimate the maximum annual total body dose to a hypothetical member of the public who is on the STP site. Although onsite organ doses are not presented in the annual effluent reports, the ratio of the total body dose onsite to that offsite may be used to estimate the organ doses onsite. This is done for the years 2002 through 2006 in Table 4.5-12, yielding the maximum annual onsite doses to construction workers from STP 1 & 2 over the 5-year period. The estimated doses are doubled to address measurement uncertainty.

The gaseous effluent doses from STP 3 to the construction workers at STP 4 are shown in Table 4.5-13, which also summarizes the doses from STP 1 & 2 and the total from all three units. This table also shows the total effective dose equivalent (TEDE). The TEDE value is calculated in accordance with ICRP 30 (Reference 4.5-7) by

multiplying the thyroid dose by a weighting factor of 0.03 and adding the product to the total body dose.

### 4.5.4.3 Liquid Effluent Doses

Table 4.5-11 shows the annual liquid effluent dose rates to the maximally exposed member of the public due to sport fish ingestion and shoreline exposure. Although construction workers would not be exposed to those pathways at the construction site, it is conservatively assumed that the construction workers receive the same doses as the maximally exposed member of the public. Furthermore, the doses are doubled to address measurement uncertainty.

The liquid effluent doses from STP 3 to the maximally exposed member of the public due to sport fish ingestion and shoreline exposure are shown in Table 5.4-5. Although, in all probability, STP 4 construction workers would not be exposed to those pathways at the construction site, it is conservatively assumed that the construction workers receive the same doses as the maximally exposed member of the public.

Table 4.5-14 shows the doses from STP 1 & 2 and from STP 3 as well as the total from all three units. This table also shows the TEDE dose, calculated in accordance with ICRP 30 (Reference 4.5-7) by multiplying the GI-tract dose by a weighting factor of 0.3 and adding the product to the total body dose.

### 4.5.4.4 Total Doses

The maximum annual doses to construction workers from all three pathways (direct radiation, gaseous effluents, and liquid effluents) during any year of the construction of STP 3 & 4 occur during the year that STP 3 is operational and STP 4 is under construction. These doses are summarized in Table 4.5-15. The maximum construction worker doses are compared to the occupational dose limits in 10 CFR 20.1201 in Table 4.5-16. The doses are also compared to the limits in 10 CFR 20.1301 and 40 CFR 190.10 for members of the public in Tables 4.5-17 and 4.5-19, respectively. The calculated doses meet the public dose criteria of 10 CFR 20.1301 and 40 CFR 190.10.

Table 4.5-18 shows that the doses would not meet the design objectives of 10 CFR 50, Appendix I, for gaseous and liquid effluents if the construction area is considered to be an unrestricted area, and the construction workers are considered to be members of the public. These calculated doses assume a full power equilibrium core with power history for the entire year. It is not expected that STP 3 will be at 100% power during the full year that STP 4 is still under construction. During this period, STP 3 will be undergoing startup testing. Full power operation is likely to occur only for about 25% of this first year, resulting in decreased annual doses from those presented in Table 4.5-18.

As indicated in Table 3.10-2, the peak workforce strength during any month of construction is 5950 people. Although this peak is scheduled to last for less than a year, it is conservatively assumed that the peak is maintained over the course of an entire year for the purpose of calculating the maximum annual workforce dose. Based

on the TEDE dose rate of 18 mrem/yr from Table 4.5-15, the maximum annual collective dose to the construction work force is estimated to be:

(5950 people)(0.018 rem) = 107 person-rem

The doses are based on dose rate measurements and calculations. It is possible that these estimated dose rates would change in the future as site conditions change. However, the STP site would be continually monitored during the construction period and appropriate actions would be taken as necessary to ensure that doses to the construction workers are as low as is reasonably achievable (ALARA). In addition, the Operational Radiation Protection Program described in FSAR Section 12.5S will be in place while STP 3 is operating with STP 4 still under construction. Thus, there will be ample oversight to ensure that doses to construction workers remain ALARA during the construction period.

Given that doses to the STP 3 & 4 construction workers meet the public dose criteria of 10 CFR 20 and 40 CFR 190, it is concluded that the radiological impact on construction workers is SMALL and no mitigation is required.

### 4.5.5 References

4.5-1 "2002 Radioactive Effluent Release Report," South Texas Project Electric Generating Station, February 2003.

4.5-2 "2003 Radioactive Effluent Release Report," South Texas Project Electric Generating Station, April 2004.

4.5-3 "2004 Radioactive Effluent Release Report," South Texas Project Electric Generating Station, April 2005.

4.5-4 "2005 Radioactive Effluent Release Report," South Texas Project Electric Generating Station, April 2006.

4.5-5 "2006 Radioactive Effluent Release Report," South Texas Project Electric Generating Station, April 2007.

4.5-6 "Offsite Dose Calculation Manual (ODCM)," South Texas Project, Rev 14.

4.5-7 "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Part 1, International Commission on Radiological Protection, Pergamon Press, 1979.

**Table 4.5-1 Maximum Annual Gaseous Effluents from STP 1 & 2**

| Effluent Type | Activity Released (MBq) | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | 2006 | Maximum |
| Fission gases | 1.5E+07 | 8.5E+06 | 9.9E+06 | 5.1E+06 | 5.0E+06 | 1.5E+07 |
| Iodine | 3.8E-01 | 1.4E+01 | 5.9E+00 | 4.0E+01 | 1.5E+00 | 4.0E+01 |
| Particulates | 1.6E+02 | 1.3E+01 | 2.0E+01 | 1.2E+02 | 3.1E+01 | 1.6E+02 |
| Tritium | 2.5E+06 | 2.8E+06 | 1.0E+07 | 7.8E+06 | 3.2E+06 | 1.0E+07 |
| Total | 1.8E+07 | 1.1E+07 | 2.0E+07 | 1.3E+07 | 8.2E+06 | 2.5E+07 |

References 4.5-1 to 4.5-5.

**Table 4.5-2 Maximum Annual Liquid Effluents from STP 1 & 2**

| Effluent Type | Activity Released (MBq) | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | 2006 | Maximum |
| Tritium | 9.6E+07 | 2.7E+07 | 1.0E+08 | 7.1E+07 | 8.3E+07 | 1.0E+08 |
| Dissolved noble gases | 3.2E+04 | 2.6E+05 | 5.1E+02 | 4.7E+04 | 2.8E+02 | 2.6E+05 |
| Other | 6.2E+03 | 4.4E+03 | 1.9E+03 | 2.8E+03 | 1.6E+03 | 6.2E+03 |
| Total | 9.6E+07 | 2.7E+07 | 1.0E+08 | 7.2E+07 | 8.3E+07 | 1.0E+08 |

References 4.5-1 to 4.5-5.

**Table 4.5-3 2002 TLD Measurements at STP 1 & 2 Monitoring Stations**

| Station Number | Average Dose by Quarter (mR) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 9 | 12.9 | 11.8 | 18.9 | 12.2 |
| 10 | 12.4 | 11.1 | 14.1 | 13.2 |
| 11 | 11.5 | 11.0 | 12.0 | 11.4 |
| 12 | 12.5 | 11.3 | 13.3 | 11.9 |
| 13 | 12.3 | 11.1 | 13.1 | 11.7 |
| 14 | 12.2 | 11.4 | 13.3 | 11.3 |
| 15 | 13.0 | 12.1 | 13.9 | 11.9 |
| 16 | 12.7 | 11.1 | 13.0 | 12.1 |

Reference 4.5-1.

Note: These are for the locations shown in Figure 4.5-2. The maximum reading is 18.9 mR at Station Number 9.

**Table 4.5-4 2003 TLD Measurements at STP 1 & 2 Monitoring Stations**

| Station Number | Average Dose by Quarter (mR) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 9 | 12.9 | 13.1 | 12.7 | 13.0 |
| 10 | 12.5 | 13.0 | 12.5 | 12.6 |
| 11 | 11.7 | 11.4 | 12.0 | 11.8 |
| 12 | 12.7 | 12.5 | 12.6 | 11.8 |
| 13 | 12.6 | 12.5 | 12.1 | 12.2 |
| 14 | 12.6 | 12.6 | 12.4 | 12.3 |
| 15 | 13.2 | 12.8 | 13.2 | 12.9 |
| 16 | 12.5 | 12.5 | 13.0 | 12.7 |

Reference 4.5-2.

Note: These are for the locations shown in Figure 4.5-2. The maximum reading is 13.2 mR at Station Number 15.

**Table 4.5-5 2004 TLD Measurements at STP 1 & 2 Monitoring Stations**

| Station Number | Average Dose by Quarter (mR) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 9 | 13.1 | 13.1 | 13.4 | 12.9 |
| 10 | 12.5 | 12.6 | 13.5 | 12.1 |
| 11 | 11.5 | 11.5 | 12.3 | 11.2 |
| 12 | 12.1 | 12.3 | 12.9 | 12.5 |
| 13 | 12.0 | 12.3 | 13.1 | 12.8 |
| 14 | 12.3 | 12.1 | 13.2 | 12.3 |
| 15 | 13.5 | 12.9 | 13.5 | 13.3 |
| 16 | 13.2 | 12.4 | 13.4 | 12.8 |

Reference 4.5-3.

Note: These are for the locations shown in Figure 4.5-2. The maximum reading is 13.5 mR at Station Numbers 10 and 15.

**Table 4.5-6 2005 TLD Measurements at STP 1 & 2 Monitoring Stations**

| Station Number | Average Dose by Quarter (mR) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 9 | 14.7 | 13.7 | 11.5 | 11.6 |
| 10 | 14.6 | 12.9 | 11.2 | 11.4 |
| 11 | 13.8 | 12.6 | 10.5 | 10.7 |
| 12 | 13.9 | 13.7 | 11.2 | 11.3 |
| 13 | 14.5 | 13.6 | 11.8 | 12.1 |
| 14 | 14.2 | 13.6 | 11.1 | 11.6 |
| 15 | 15.0 | 14.6 | 11.7 | 12.3 |
| 16 | 14.7 | 13.1 | 10.9 | 12.1 |

Reference 4.5-4.

Note: These are for the locations shown in Figure 4.5-2. The maximum reading is 15.0 mR at Station Number 15.

**Table 4.5-7 2006 TLD Measurements at STP 1 & 2 Monitoring Stations**

| Location | Station Number | Average Dose by Quarter (mR) | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| STP 1 & 2 Protected Area Fence | 9 | 12.8 | 12.2 | 12.4 | 13.4 |
| | 10 | 11.9 | 11.5 | 12.1 | 12.2 |
| | 11 | 11.4 | 11.5 | 11.7 | 13.3 |
| | 12 | 12.3 | 13.1 | 12.2 | 13.0 |
| | 13 | 12.9 | 12.7 | 12.3 | 13.1 |
| | 14 | 12.3 | 11.6 | 12.1 | 12.4 |
| | 15 | 12.8 | 12.5 | 13.6 | 14.0 |
| | 16 | 12.6 | 12.1 | 12.7 | 13.0 |
| OSGSF | 25 | 13.8 | 12.6 | 12.5 | 12.6 |
| | 26 | 16.7 | 15.1 | 15.9 | 15.3 |
| | 27 | 15.6 | 13.6 | 14.1 | 14.7 |
| | 28 | 14.1 | 12.1 | 12.1 | 13.8 |

Reference 4.5-5.

Note: These are for the locations shown in Figures 4.5-2 and 4.5-3. The maximum readings are 14.0 mR at STP 1 & 2 protected area fence and 16.7 mR at the OSGSF.

**Table 4.5-8 Maximum Quarterly Measured Dose Rates at STP 1 & 2 and OSGSF**

| Location | Dose Rate (mrem/quarter) | | |
|---|---|---|---|
| | Maximum Measured | Background | Net |
| STP 1 & 2 Protected Area Fence | 18.9 | 15.4 | 3.5 |
| OSGSF | 16.7 | 15.4 | 1.3 |

Note: The maximum measured dose rates are from Tables 4.5-3 to 4.5-7. The net dose rate is obtained by subtracting the background dose rate.

**Table 4.5-9 Direct Doses to Construction Workers**

| Source | Distance from Source (ft) | | Dose Rate (mrem/yr) | | Annual Dose to Worker (mrem) |
|---|---|---|---|---|---|
| | To TLD Location | To Construction Location | TLD Location | Construction Location | |
| STP 1 & 2 | 600 | 2300 | 28 | 7.3 | 1.7 |
| OSGSF | 10 | 700 | 10 | 1.0 | 0.24 |
| LTSF | – | 700 | – | 1.0 | 0.24 |
| OSF | – | – | – | 1.0 | 0.24 |
| STP 3 | – | 900 | – | 29 | 6.9 |
| Total for STP 1 & 2 | – | – | – | 10 | 2.4 |
| Total for STP 1, 2 & 3 | – | – | – | 39 | 9.3 |

Note: All doses are at the center of STP 4 construction area. The distance of 900 ft from STP 3 to STP4 corresponds to 0.17 mile (ER Section 2.7). The other distances are estimated from Figures 4.5-1, 4.5-2, and 4.5-3.

The dose rates at the TLD locations are based on Table 4.5-8, with a factor of two applied for conservatism.

STP 1 & 2 dose rate at the construction location is obtained using Equation 4.5-2. For the OSGSF, the construction location dose rate is estimated from a Monte Carlo calculation as this dose rate is higher than that based on the TLD measurement. The dose rate from the proposed LTSF is also based on a calculation. The dose from the OSF is an estimate.

STP 3 dose rate at the construction location is obtained using Equation 4.5-1. If the calculated dose rate at the construction location is less than 1 mrem/yr, it is rounded up to 1 mrem/yr. The annual doses are obtained by multiplying the construction location dose rates by the ratio of 2,080 hr/yr to 8,760 hr/yr.

**Table 4.5-10 Gaseous Effluent Annual Dose Rates from STP 1 & 2 to the Maximally Exposed Member of the Public**

| Organ | Source | Dose Rate (mrem/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2002 | 2003 | 2004 | 2005 | 2006 | Maximum |
| Total Body | Noble Gases | 4.4E-03 | 1.9E-03 | 3.4E-03 | 1.8E-03 | 3.1E-03 | 4.4E-03 |
| | Iodine, Particulates, Tritium | 1.5E-03 | 1.5E-03 | 5.5E-03 | 5.3E-03 | 2.2E-03 | 5.5E-03 |
| | Total | 5.9E-03 | 3.4E-03 | 8.9E-03 | 7.1E-03 | 5.3E-03 | 8.9E-03 |
| Skin | Noble Gases | 9.0E-03 | 5.0E-03 | 7.2E-03 | 3.0E-03 | 6.5E-03 | 9.0E-03 |
| Thyroid | Iodine, Particulates, Tritium | – | 1.2E-02 | 3.2E-02 | 2.2E-02 | 1.3E-02 | 3.2E-02 |

References 4.5-1 to 4.5-5.

Note: The doses due to noble gases are for a hypothetical receptor at the site boundary. The doses due to iodine, particulates, and iodines are for the nearest individual. Although the two contributions are at different locations, they are conservatively summed. The 2002 report did not include a thyroid dose.

**Table 4.5-11 Liquid Effluent Annual Dose Rates from STP 1 & 2 to the Maximally Exposed Member of the Public**

| | Dose Rate (mrem/yr) | | | | | |
|---|---|---|---|---|---|---|
| Organ | 2002 | 2003 | 2004 | 2005 | 2006 | Maximum |
| Total Body | 1.5E-02 | 4.3E-03 | 1.6E-02 | 1.1E-02 | 1.3E-02 | 1.6E-02 |
| GI-Tract | 1.5E-02 | 4.5E-03 | 1.6E-02 | 1.1E-02 | 1.3E-02 | 1.6E-02 |

References 4.5-1 to 4.5-5.

**Table 4.5-12 Annual Gaseous Effluent Doses to Construction Workers from STP 1 & 2**

| Year | Total Body Dose (mrem) | | Dose Ratio (Onsite/Offsite) | Onsite Dose (mrem) | |
|---|---|---|---|---|---|
| | Offsite | Onsite | | Skin | Thyroid |
| 2002 | 0.0059 | 0.17 | 29 | 0.26 | – |
| 2003 | 0.0034 | 0.12 | 36 | 0.18 | 0.43 |
| 2004 | 0.0089 | 0.84 | 95 | 0.68 | 3.0 |
| 2005 | 0.0071 | 0.20 | 28 | 0.086 | 0.63 |
| 2006 | 0.0053 | 0.14 | 27 | 0.17 | 0.33 |
| Maximum | | 1.7 | | 1.4 | 6.0 |

Note: The total body offsite doses are from Table 4.5-10.

The onsite skin and thyroid doses are obtained by multiplying the offsite skin and thyroid doses from Table 4.5-10 by the total body dose ratio.

In the last row, a factor of two is applied for conservatism.

**Table 4.5-13 Annual Gaseous Effluent Doses to Construction Workers**

| Source | Annual Dose (mrem) | | | |
|---|---|---|---|---|
| | Total Body | Thyroid | Skin | TEDE |
| STP 1 & 2 | 1.7 | 6.0 | 1.4 | 1.9 |
| STP 3 | 6.6 | 12 | 16 | 7.0 |
| Total | 8.3 | 18 | 17 | 8.9 |

Note: The doses from STP 1 & 2 are from Table 4.5-12. The doses from STP 3 are calculated based on the atmospheric dispersion from STP 3 to STP 4, as shown in ER Section 2.7.

In accordance with ICRP 30 (Reference 4.5-7), the TEDE value is obtained by applying a weighting factor of 0.03 to the thyroid dose and adding the product to the total body dose.

**Table 4.5-14 Annual Liquid Effluent Doses to Construction Workers**

| Source | Annual Dose (mrem) | | |
|---|---|---|---|
| | Total Body | GI-Tract | TEDE |
| STP 1 & 2 | 0.032 | 0.032 | 0.042 |
| STP 3 | 0.00026 | 0.00043 | 0.00039 |
| Total | 0.032 | 0.032 | 0.042 |

Note: The doses from STP 1 & 2 from Table 4.5-11 are multiplied by an uncertainty factor of two.

The STP 3 doses are from Table 5.4-5, assuming the workers receive the same doses as the maximally exposed individual offsite.

In accordance with ICRP 30, the TEDE value is obtained by applying a weighting factor of 0.3 to the GI-tract dose and adding the product to the total body dose.

**Table 4.5-15 Construction Worker Annual Dose Summary**

| Pathway | Annual Dose (mrem) | | |
|---|---|---|---|
| | Total Body | Critical Organ | TEDE |
| Direct Radiation | 9.3 | – | 9.3 |
| Gaseous Effluents | 8.3 | 18 | 8.9 |
| Liquid Effluents | 0.032 | 0.032 | 0.042 |
| Total | 18 | 18 | 18 |

Note: The individual pathway doses are from Tables 4.5-9, 4.5-13, and 4.5-14. Although the critical organs are different for the gaseous and liquid effluent pathways, they are conservatively added. Direct radiation to critical organ is not measured.

**Table 4.5-16 Comparison of Annual Doses with 10 CFR 20.1201 Criteria for Occupational Doses**

| Organ | Annual Dose (rem) | |
|---|---|---|
| | Worker | Limit |
| TEDE | 0.018 | 5 |
| Organ other than lens of the eye | 0.018 | 50 |
| Lens of the eye | 0.018 | 15 |
| Skin | 0.017 | 50 |

Note: The doses for TEDE and organ other than lens of the eye are from Table 4.5-15.

The skin dose is from Table 4.5-13.

The dose to the lens of the eye is assumed to be the critical organ dose from Table 4.5-15.

**Table 4.5-17 Comparison of Annual Doses with 10 CFR 20.1301 Criteria for Members of the Public**

| Criteria | Worker | Limit |
|---|---|---|
| Annual Dose (mrem TEDE) | 18 | 100 |
| Unrestricted area dose rate (mrem/hr) | 0.0088 | 2 |

Note: The annual worker dose is from Table 4.5-15. The unrestricted dose rate is obtained by dividing the annual dose by the exposure time of 2,080 hr/yr.

**Table 4.5-18 Comparison of Annual Doses with 10 CFR 50, Appendix I Criteria for Effluents for Individuals in an Unrestricted Area**

| Pathway | Annual Dose (mrem) | |
|---|---|---|
| | Worker | Design Objective |
| Whole body dose from liquid effluents | 0.00026 | 3 |
| Organ dose from liquid effluents | 0.00043 | 10 |
| Whole body dose from gaseous effluents | 6.6 | 5 |
| Skin dose from gaseous effluents | 16 | 15 |
| Organ dose from radioactive iodine and radioactive material in particulate form from gaseous effluents | 12 | 15 |

Note: The liquid and gaseous effluent doses are from Tables 4.5-14 and 4.5-13, respectively, for STP 3.

**Table 4.5-19 Comparison of Annual Doses with 40 CFR 190.10 Criteria for Members of the Public**

| Organ | Annual Dose (mrem) | |
|---|---|---|
| | Worker | Limit |
| Whole body | 18 | 25 |
| Thyroid | 18 | 75 |
| Other organ | 18 | 25 |

Note: The annual worker doses are from Table 4.5-15.

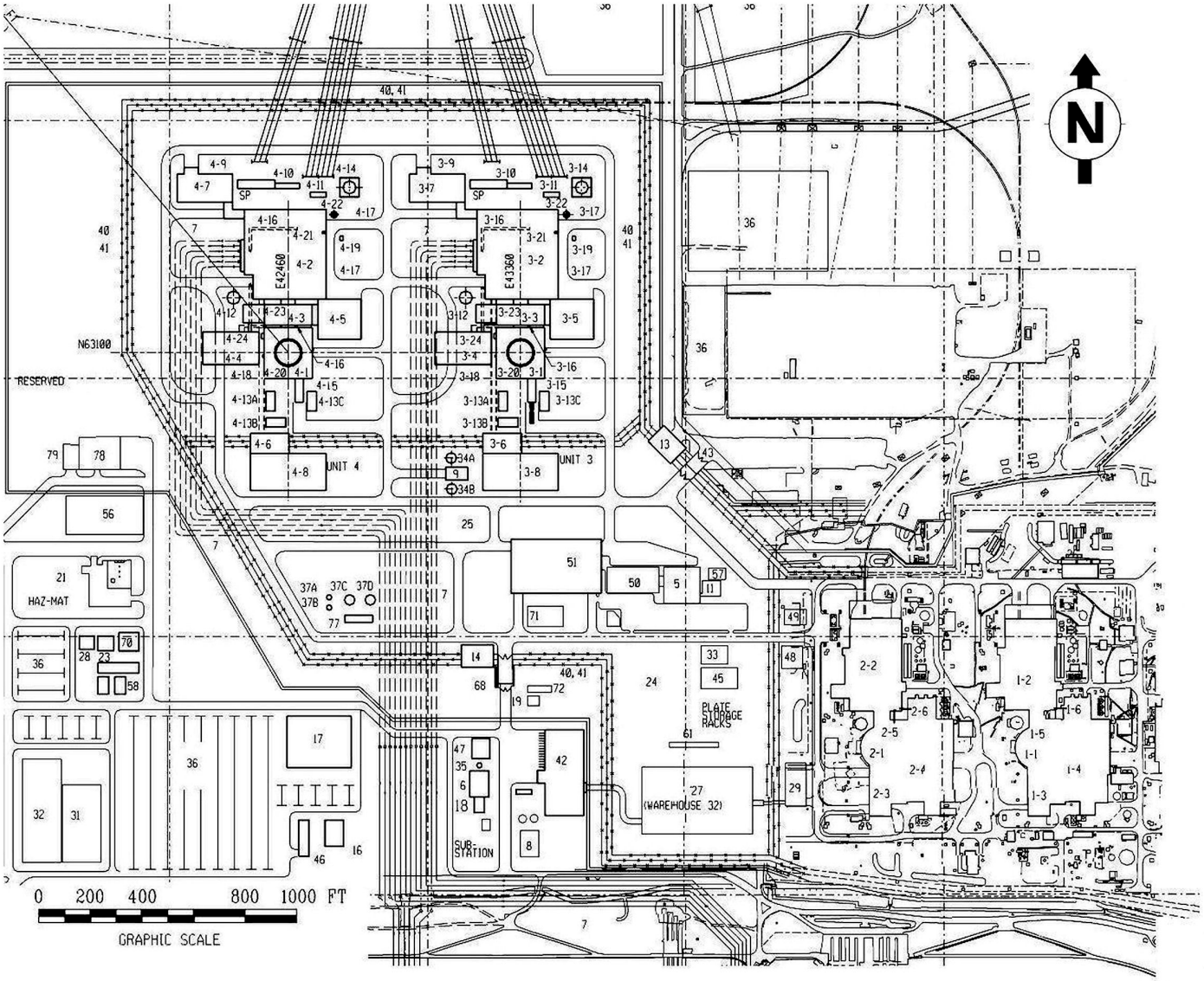


**Figure 4.5-1 Site Layout**

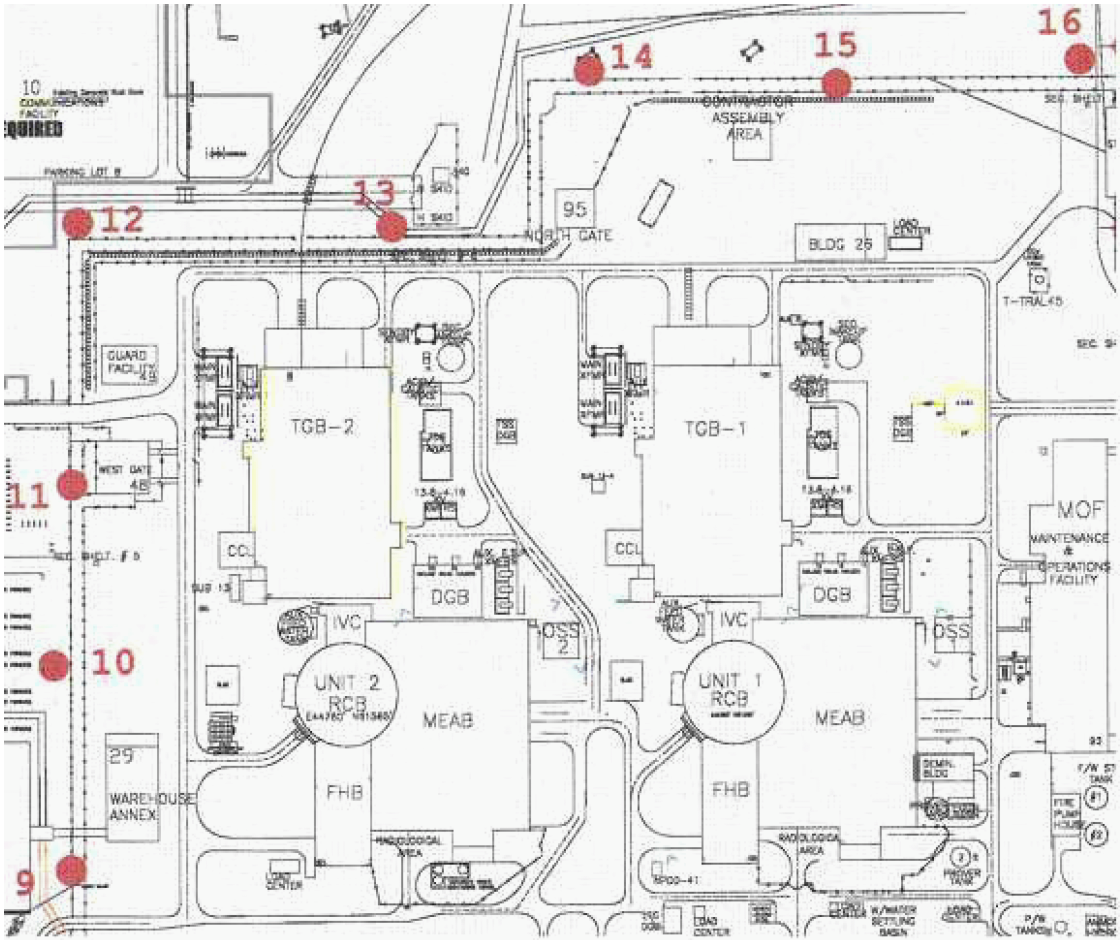


**Figure 4.5-2 Locations of TLD Monitoring Stations at STP 1 & 2**

Reference 4.5-5, Figure 8-1.

Note: Monitoring Stations 9 to 16 are located along the west and north parts of the STP 1 & 2 protected area fence in the direction of STP 3 & 4.

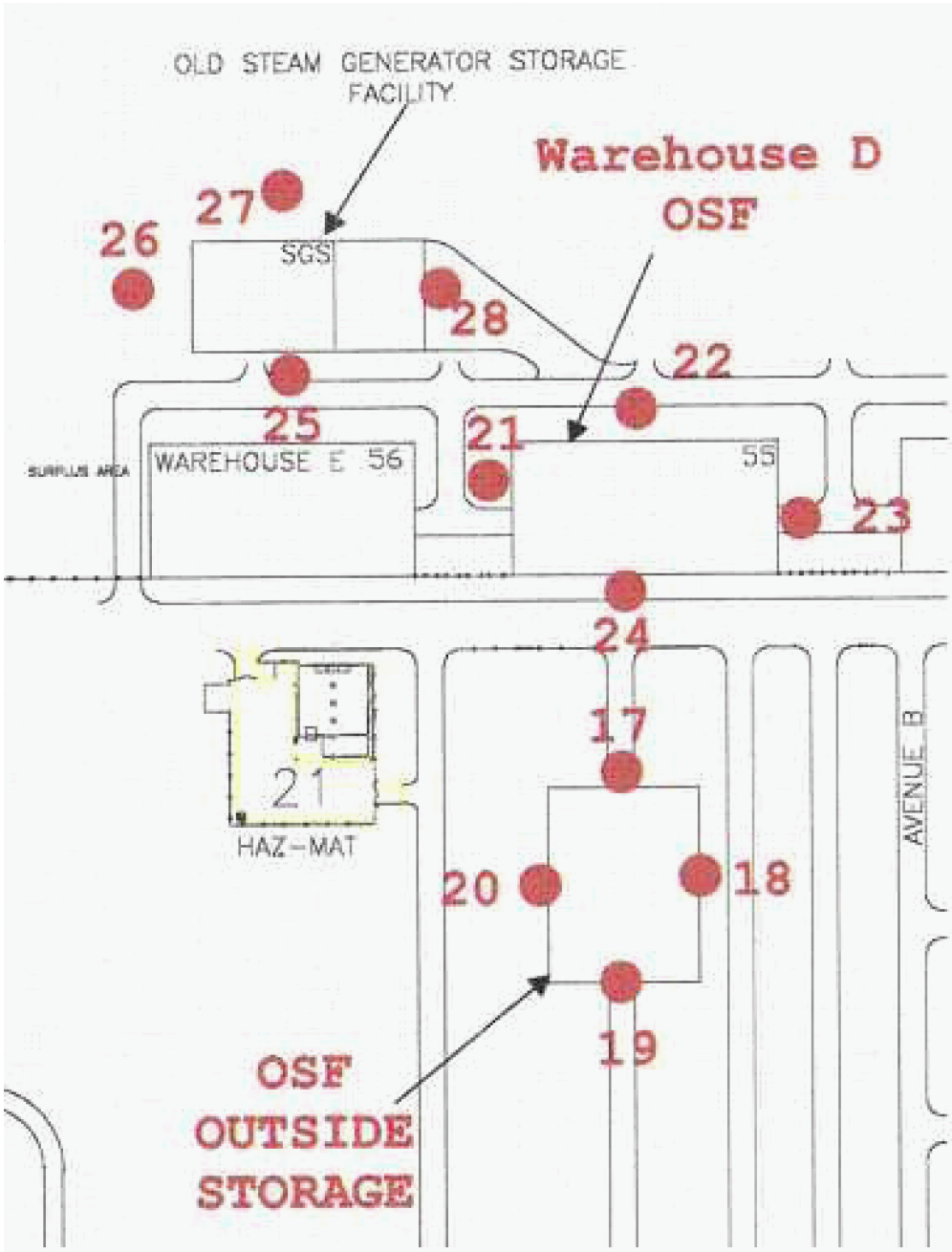


**Figure 4.5-3 Locations of TLD Monitoring Stations at OSGSF**

Reference 4.5-5.

Note: The OSGSF is west of STP 4, as indicated in Figure 4.5-1.

The OSF will be relocated prior to start of construction on STP 3 & 4.