<u>ENVIRONMENTAL IMPACT APPRAISAL</u>

<u>BY THE OFFICE OF NUCLEAR REACTOR REGULATION</u>

<u>LICENSE NOS. DPR-31 AND DPR-41</u>

<u>FLORIDA POWER AND LIGHT COMPANY</u>

<u>TURKEY POINT PLANT UNITS 3 AND 4</u>

<u>DOCKET NOS. 50-250 AND 50-251</u>

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1.0 PROPOSED ACTION

By letter dated September 20, 1977 Florida Power and Light Company (FPL) submitted a report[1] entitled "Steam Generator Repair Report Turkey Point Units 3 and 4." This report has been supplemented on December 20, 1977, March 7, April 25, June 20, August 4, and December 15, 1978 and January 26, 1979. The report describes a proposed program to repair the six steam generators in Units 3 and 4 by replacing the lower assembly, including the tube bundles, of each generator.

FPL plans to repair all six steam generators in Turkey Point 3 and 4. The Unit 4 steam generators have the most tubes plugged and therefore will be repaired first. The repair of Turkey Point 3 steam generators is expected to be started about one year later. Since power demands in the FPL system peak in the summer, and the repair is expected to take from six to nine months per unit, the repair should be started in the fall in order to be completed before the next summer peak demand. When FPL submitted the repair plan on September 20, 1977 the corporate plan was to be prepared to start the repair for Unit 4 in October 1978. The repair of Unit 4 steam generator is now not expected to start before fall of 1979.

2.0 BACKGROUND

In order to provide the NRC staff with an independent basis for evaluating the radiological impacts associated with the repair of degraded steam generators at large pressurized water reactors (PWRs), we contracted with Battelle Pacific Northwest Laboratories (PNL) to perform a generic radiological assessment of the steam generator repair and disposal operations. This assessment has been published in an NRC report[2] NUREG/CR-0199," Radiological Assessment of Steam Generator Removal and Replacement."

Information useful to the environmental review is also contained in the NRC staff's Safety Evaluation (SE)[3] on the repair project, particularly the sections evaluating (1) the measures to reduce corrosion, (2) the As Low As is Reasonably Achievable (ALARA) considerations, and (3) the radiological consequences of postulated accidents.

The steam generator repair program proposed by FPL is similar to the one proposed by the Virginia Electric Power Company (VEPCO)[4,5,6]. The two plants are similar. Each of the plants contain two Westinghouse three loop PWR's and commenced commercial operation in 1972 and 1973. Both plants began operation using a sodium phosphate secondary water chemistry treatment and both plants changed to all volatile chemistry treatment (AVT); Turkey Point in late 1974, Surry in early 1975. The repair program of the Surry units was approved in January 1979.

2.1 History of Steam Generator Operation

Turkey Point Units 3 and 4 began commercial operation on December 14, 1972, and September 9, 1973, respectively. Like almost all units with U-tube design steam generators, they began operation using a sodium phosphate secondary water chemistry treatment. Largely to correct a wastage and caustic stress corrosion cracking encountered with the phosphate treatment, most PWRs with a U-tube design steam generator using a phosphate treatment for the secondary coolant have now converted to an all volatile chemistry (AVT). Both Turkey Point 3 and 4 were converted around August, 1974.

In 1975, radial deformation, or the so-called "denting," of steam generator tubes occurred in several PWR facilities including Turkey Point 3 and 4, after 4 to 14 months operation, following the conversion from a sodium phosphate treatment to an AVT chemistry for the steam generator secondary coolant. On September 15, 1976, during normal operation, one U-tube in the innermost row parallel to the rectangular flow slots in steam generator A at Surry Unit No. 2 rapidly developed a substantial primary to secondary leak (about 80 gpm).

Subsequent to the 80 gpm leak at Surry Unit 2, the NRC has imposed augmented inservice inspection requirements on Surry Units 1 and 2, Turkey Point Units 3 and 4, San Onofre Unit 1 and Indian Point Unit 2. In addition, operating restrictions and limited periods of operation, typically six months, between inspections are also imposed at Surry Units 1 and 2 and Turkey Point Units 3 and 4. The augmented inspection requirements include an assessment of the magnitude and progression of tube denting, and support plate deformation and/or cracking.

2.2 Reasons for Steam Generator Repair

The six steam generators at Turkey Point Units 3 and 4 have all undergone a significant amount of degradation since they began operation. The wastage and denting phenomena, discussed earlier, have led to tube wall thinning, support plate flow slot hourglassing and plate ligament cracking, tube denting, stress corrosion cracking, and several instances of reactor coolant leakage through cracked tubes. As of May 1979, tube plugging for various reasons has resulted in removing about 17.5% of the steam generator tubes in Unit 3 and about 20.5% of the tubes in Unit 4 from continuing service.

Due to the continuing denting related problems, the certainty of additional tube plugging that may result in power derating, and the economic considerations for operating with substantially reduced heat transfer capacities on the two units, Florida Power & Light Company (FPL) submitted a proposal[1] for the replacement of the degraded portions of the steam generators.

3.0 REMOVAL AND REINSTALLATION OPERATIONS

A drawing showing the principal parts of a typical steam generator is presented in Figure 3.1. Figure 3.2 shows the regions where the main cuts are proposed to remove the degraded steam generator. It shows also the radiation levels in these regions. A brief description of the FPL proposed repair procedure follows.

FPL is planning to repair all six steam generators at the Turkey Point plant, Units 3 and 4. The units will be repaired in series; one unit will be conducting normal power operations while the other unit is undergoing steam generator repairs. The repair will consist of replacing the lower assembly of each steam generator including the shell and the tube bundle and refurbishing and partially replacing the steam separation equipment in the upper assembly. The old lower assembly will be removed from the containment building through the existing equipment hatch and transported to a special storage facility that will be constructed on the Turkey Point site. The new lower assemblies will arrive at the site by barge. They will be transferred to a wheeled transporter and hauled on the existing road to the containment building equipment hatch.

Prior to the repair work, the unit will be shut down and all systems will be placed in condition for long term layup. The reactor vessel head will be removed for refueling. All of the normal procedures for fuel cooling and fuel removal will be followed. The fuel will be removed from the reactor and placed in the spent fuel storage facility and then the reactor vessel head will be replaced. The equipment hatch will be opened and access control will be established. The biological shield wall and a section of the operating floor concrete and structural steel will be removed to provide access to the steam generator. Guide rails will be installed for transporting the lower assembly through the equipment hatch.

After this preparatory work, the cutting of system piping will begin. This will include cutting and removal of sections of steam lines, feedwater lines, reactor coolant inlet and outlet lines, and miscellaneous smaller lines for the service air and water and the instrumentation system. The steam generator will then be cut at the transition cone and the upper shell will be removed. The steam generator supports will be disassembled and the steam generator lower assembly will be lowered and placed in a horizontal position on a transport mechanism. This mechanism will carry the assembly through the equipment hatch. A mobile crane will lift the lower assembly onto a transporter that will carry it to the steam generator storage facility on the site.

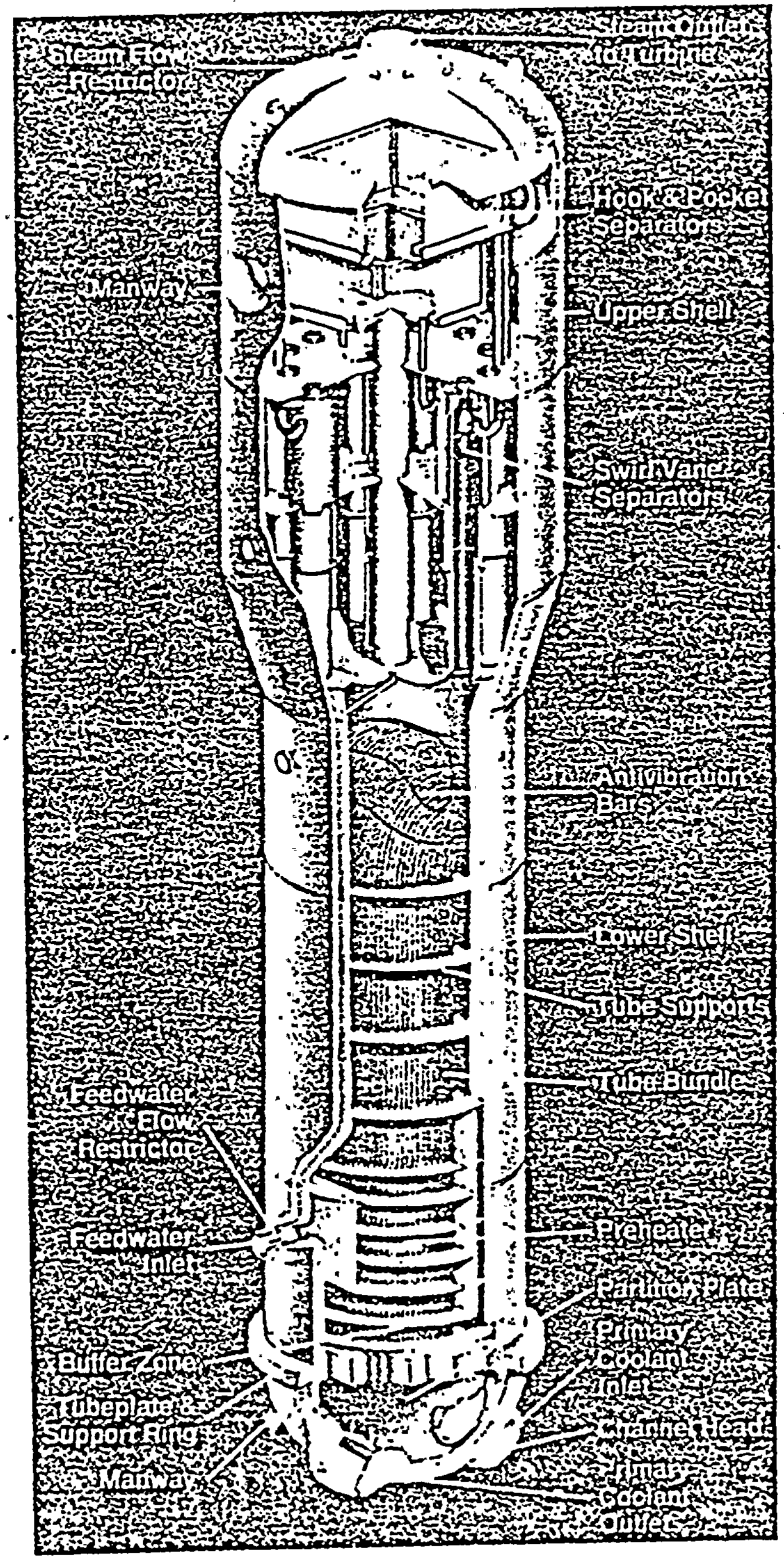
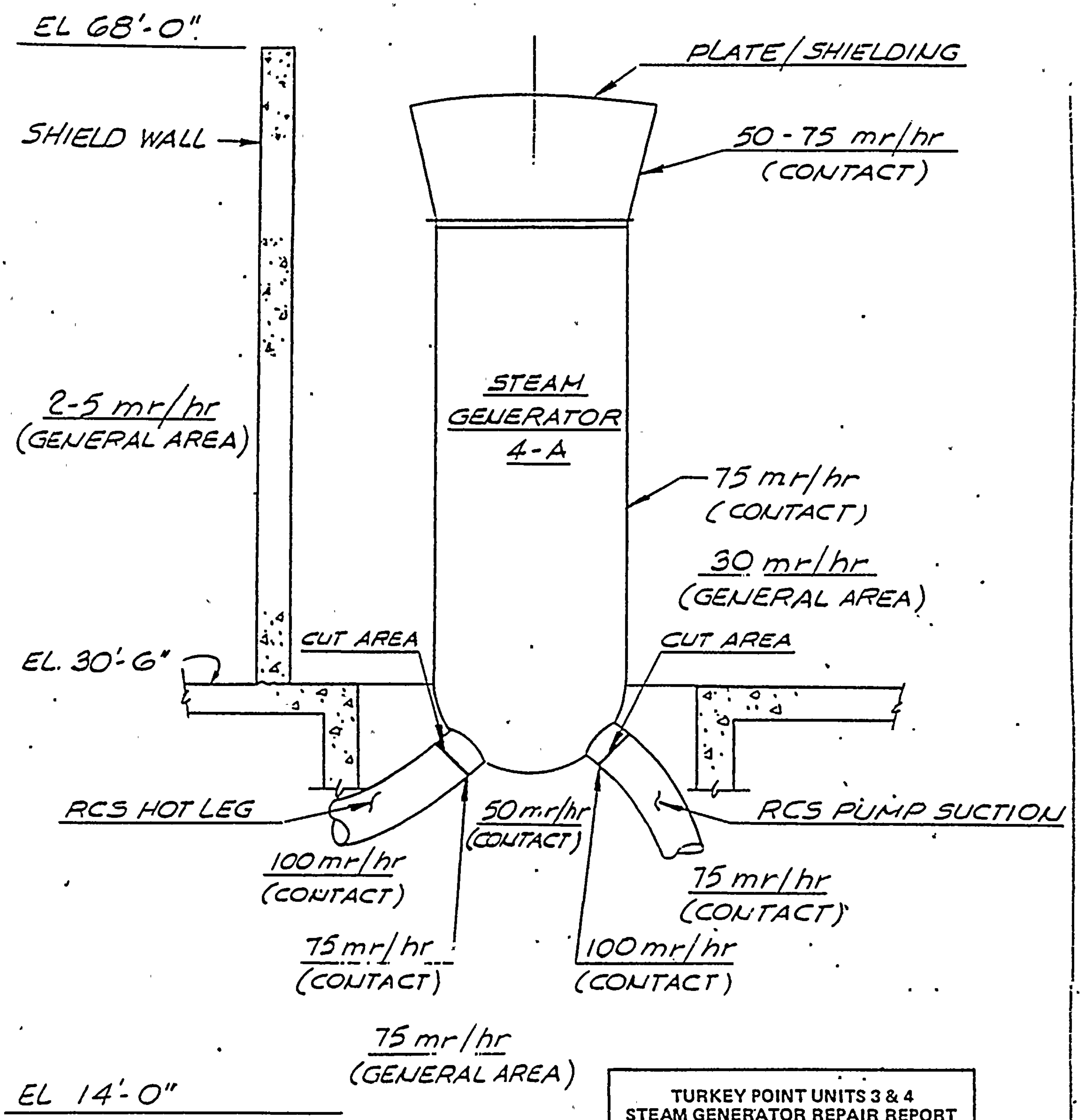


Figure 3.1 . A TYPICAL WESTINGHOUSE STEAM GENERATOR



TURKEY POINT UNITS 3 & 4
STEAM GENERATOR REPAIR REPORT

DOSE RATES AROUND STEAM
GENERATOR 4A

Figure 3.2

After removal and storage of all three steam generator lower assemblies, their replacements will be transported from the barge dock or temporary storage location to the equipment hatch. The same machinery used to remove the lower assemblies will be used to install the new assemblies in their cubicles. The steam generator support system will be reinstalled and the upper assembly with its refurbished internals will be mounted on the lower assembly. After welding the two assemblies together, the piping will be reconstructed. Following these major repair activities there will be cleaning, hydrostatic testing, baseline inservice inspections, and pre-operational testing of instruments, components and systems. Then the reactor will be refueled and startup tests will be. performed. The performance of the repaired steam generators will be tested for moisture carryover and verification of thermal and hydraulic characteristics.

4.0 ENVIRONMENTAL IMPACTS OF STEAM GENERATOR REPAIR PROJECT

4.1 Radiological Assessment

4.1.1 Occupational Exposure

The generic radiological assessment of steam generator repair, prepared for the NRC by PNL and reported in NUREG/CR-0199,[2] provides an upper bound estimate of the occupational doses and off-site radiological releases associated with the repair of steam generators at a large PWR. The conservatisms in the PNL methods of assessment, described below, provide the opportunity to reduce occupational doses for the repair operations in specific cases considerably below the generic estimates in NUREG/CR-0199.

The PNL estimates were derived by dividing the repair program into sub-activities ("maintenance activities") and ascertaining the estimated exposure rates for each sub-activity. The man-hours required for each sub-activity multiplied by the corresponding exposure rates in rem per hour gave the exposure in man-rem for each sub-activity. The total exposure for the repair program is the sum of all the sub-activity exposures.

Repair program sub-activities were developed by PNL as a composite of the work descriptions for repair of the steam generators at Surry and Turkey Point as determined by VEPCO and FPL. Man-hour estimates for each activity were developed by PNL based on prior experience with similar activities, using standard estimating techniques. Exposure rates were based on information from several sources includi g data from measurements made at several operating PWRs including the Turkey Point Units. PNL usually selected exposure rate values on the high end of the range of values measured at the several plants.

The generic estimate of the total occupational whole body dose for the repair of the three steam generators associated with each reactor unit was presented in NUREG/CR-0199[2] as a range of values, 3380 to 5840 man-rem per unit. Both ends of this range were conservatively estimated and represent upper bound values. The upper value, 5840 man-rem per unit was estimated assuming no credit for dose saving techniques. The lower value, 3380 man-rem per unit was estimated taking credit for three dose reduction methods: (1) shielding by raising the steam generator water level, (2) using a limited amount of remote tooling, and (3) increasing the source-to-receiver distance.

The FPL occupational exposure estimates include a detailed estimate of doses, based on major job functions, of 1300 man-rem per unit. This detailed estimate does not include dose reductions from use of temporary shielding and local decontamination or dose costs from their implementation. It does include the dose reduction due to the three reduction methods listed above and measures such as pre-job planning and pre-job training. FPL has estimated a range of doses for the steam generator repair program of from 650-1450 man-rem per unit. This range of doses reflects the uncertainties in estimating job man-hours and radiation intensities, and in predicting the effectiveness of temporary shielding and the exposures during its installation. Therefore, although FPL has not included the effect of temporary shielding and local decontamination in its detailed estimates, FPL has considered the effect in its predicted range of doses.

In view of the above discussion, the lower end of the generic range, 3380 man-rem per unit is taken as the appropriate estimate for comparison with the detailed estimate of 1300 man-rem per unit. A summary comparing FPL detailed estimates with our generic estimates from NUREG/CR-0199[2] for the four main phases of the project is given in Table 4.1. Figure 3.2 shows the radiation levels in the regions where the main cuts are proposed to remove the degraded steam generator.

Table 4.1

Comparison of Occupational Collective Whole Body Dose Estimates

Phase	NRC Generic Estimate Dose, man-rem/unit	FPL Estimate Dose, man-rem/unit
Preparation	450	257
Removal	1100	436
Installation	1800	569
Storage	30	39
Total	3380	1301

The differences between the detailed estimates are accounted for by the same factors discussed above for the total estimates. FPL calculations of doses used commonly accepted practices for calculating doses and took into account the dose reduction measures proposed to maintain doses As Low As Reasonably Achievable (ALARA), including pre-job training and use of remote tools where practicable. Temporary shielding and local decontamination will be used when such measures are determined to be consistent with ALARA requirements. In Section 3 of its report[1], FPL has documented its consideration of the guidance with regard to ALARA issues in Regulatory Guide 8.8, Revision 2.[7] We have reviewed the FPL treatment of ALARA issues in detail in Section 2.6 of our SE.[3] We concluded that the FPL efforts to maintain occupational doses ALARA during the repair effort are acceptable.

In summary, the above discussion shows that the differences between the lower generic estimate (3380 man-rem per unit) and the FPL detailed estimate (1300 man-rem per unit) can be reconciled in consideration of (1) the use of lower dose rates measured at Turkey Point in the FPL estimate and (2) the use of more dose reducing measures by FPL than in the generic estimate. We therefore conclude that the FPL detailed estimate of 1300 man-rem per unit is a more realistic estimate than 3380 man-rem per unit for the repair of the steam generators in one Turkey Point unit. Consequently, in the remainder of this appraisal, we have used 1300 man-rem per unit as the occupational dose for the steam generator repair work at Turkey Point.

To put into perspective the occupational doses to be incurred in repairing steam generators, it is helpful to compare these doses with (1) those expected from the normal operation of nuclear plants, (2) the projected long-term man-rem reduction resulting from steam generator repair and (3) the doses from major maintenance operations at other plants.

Although the AEC was starting to compile occupational exposure estimates for nuclear power plant operation at the time that the Turkey Point FES[9] was prepared in 1972, such exposures were not specifically considered in the Turkey Point FES.

In recent environmental statements, we have estimated an annual occupational dose of about 500 man-rem per reactor unit, averaged over the life of the plant (30-40 years). This value is based on the average of annual doses received at operating plants. In 1977, the average occupational dose per unit for light water reactors in the United States was 570 man-rem.[8] The doses ranged from 87 to 3140 man-rem per reactor unit, with major maintenance during the year accounting for the larger values. Occasional large doses associated with major maintenance, such as the 1300 man-rem dose per unit for the proposed steam generator repair, will occur. NRC regulations require that measures be taken to keep these doses ALARA.

In 1976 and 1977, workers at Turkey Point received whole body doses of 600 man-rem[1] and 450 man-rem[1] (combined totals for both units), respectively, during the inspection and plugging of degraded steam generator tubes. The total occupational doses for the two units combined were 1184 man-rem in 1976 and 1036 man-rem in 1977. These doses are comparable to the 570 man-rem per unit per year average for U.S. light water reactors in 1977.[8] At the end of Section 3.1 in our SE[3], we concluded that the proposed repair would eliminate the potential for the kinds of the tube degradation observed to date. Based on our experience with plants without severe denting problems and our conclusion regarding corrosion reduction, doses due to the inspection and plugging of degraded tubes would be markedly reduced. We conclude that occupational exposure after the repair will be reduced by hundreds of man-rem per year for the two units combined. This would result in total occupational exposures at Turkey Point lower than the national average value for light water reactors (570 man-rem per unit in 1977). We further conclude that the dose reduction of hundreds of man-rem per year would, over a period of years tend to offset the immediate one-time dose of about 1300 man-rem for repairing the three steam generators in each unit.

FPL has estimated that the occupational dose for the inspection and repair of degraded steam generator tubes will be reduced to 100 man-rem per year for the two Turkey Point units combined after the repair has been completed. Based on our experience regarding such inspections, we find this to be a realistic estimate.

The reduction of occupational exposure resulting from the repair effort may be estimated by subtracting the estimated annual dose after repair from the observed annual dose before repair. The doses of 600 man-rem in 1976 and 450 man-rem in 1977 are considered representative of exposures related to steam generator operation at the Turkey Point Units before repair. Subtracting the after-repair dose of 100 man-rem from the before-repair range of 450 to 600 man-rem leads to a reduction of 350 to 500 man-rem per year. At these rates of reduction the 2600 man-rem cost of the repair would be offset in about 5 to 7 years.

Operating experience at the Turkey Point plant over the last three years demonstrates that the steam generators can continue to operate with the degraded tubes plugged, but frequent inspection and plugging as performed during the last three years would be required to assure that the integrity of the steam generators would be maintained. At the current rate of tube plugging, somewhat over 3% per year, it is our judgment that, with continued inspections and plugging, the Turkey Point units could be safely operated and, even if reduced power were required, the economic balance would favor continued operation of the units, as opposed to decommissioning the reactors.

In summary, we have drawn the following conclusions regarding occupational radiation exposure. The FPL estimate of 1300 man-rem per unit for the repair of the steam generators is reasonable. This dose falls within the range of annual occupational doses which have been observed in recent years.[8] In our SE[3] we conclude that FPL is taking the necessary steps to insure that occupational doses will be maintained ALARA. Finally, the renovation of the steam generators will lead to an occupational dose reduction of hundreds of man-rem per year. This dose reduction over a period of several years will recoup the immediate large one-time dose resulting from the repair operation. The individual risks associated with the exposures involved in the repair program will be controlled and limited so as not to exceed the limits set forth in 10 CFR Part 20 for occupational exposure. These limits assure that the hazard to any exposed individual is small.

For a 2600 man-rem increase in occupational exposure, the increased risk of premature fatal cancer induction is predicted to be less than one event (0.2 events from data for the population as a whole as given in the BEIR report).[14] The increased risk from this exposure with respect to genetic effects to the ensuing five generations is also predicted to be less than one event (0.5 events from data for the population as a whole as given in the BEIR report). For the selected population of workers exposed in the repair program, consisting principally of males in the age ranges from 20 to 40, these risks would tend to be somewhat less. Therefore, we conclude that the impact of occupational radiation dose from the repair effort will not be environmentally significant.

4.1.2 Public Radiation Exposure

Our independent analysis of the gaseous and liquid releases of radioactivity from the plant site during the steam generator repair project is based in large part on the generic report, NUREG/CR-0199.[2] The estimates of releases in this report are upper bound values, based on conservatively high estimates for each type of release.

Similar estimates of the gaseous and liquid effluents during the repair were made by FPL.[1] These estimates were based on the specific equipment design and procedures to be used at the Turkey Point Plant. Table 4.2 presents the NUREG/CR-0199 estimates[2] and FPL estimates[1] of the radioactive effluents which will be released as a result of the repair effort. Table 4.2 also presents the FPL reported average radioactive effluent releases for 1976[14] and 1977[16] and the annual average radioactive effluent release estimates presented in the Turkey Point FES.[9]

Table 4.2 shows that the releases for the repair effort estimated by FPL and PNL are much lower (except for the airborne particulates) than the Turkey Point 1976 and 1977 releases and the FES[9] annual average estimates. For airborne particulates, the FPL estimates of releases are in the same range as or lower than the 1976 and 1977 releases as shown in Table 4.2. The Turkey Point FES does not present numerical estimates of airborne particulate and tritium releases. However, airborne particulates and tritium are small dose contributors compared to radioiodine and noble gases for the highest dose pathways of exposure to individuals in the general public. Therefore, the conclusions regarding dose consequences presented in the FES are still valid.

Table 4.2

Radioactive Effluents for Turkey Point Plant

	Steam Generator Repair		Operating Experience		FES
Type of Radioactive Effluent	FPL Release Estimates (Ci/Unit)	NUREG/ CR-0199 Release Estimates (Ci/Unit)	1976 Average Releases (Ci/Unit)	1977 Average Releases (Ci/Unit)	Annual Average Realease Estimates (Ci/Unit/Yr)
GASEOUS					
Noble Gases	-	-	7800	12,000	3650
Halogens (Iodines)	0.0021[a]	included in particulates	0.3	0.7	0.8*
Particulates	0.0085[a]	0.0001	0.038	0.026	-
Tritium	-	-	3	2.0	-
LIQUID					
Mixed fission & activation products	0.55	0.14	4.3	4.5	28
Tritium	185	190	390	460	1000

* includes particulates

a These are the releases for Unit 3; the releases for Unit 4 will be slightly smaller since Unit 4 is less contaminated.

The FPL estimates of gaseous releases from the repair effort are the same as the NRC estimates (SE Section 2.6.3), but larger than the PNL generic estimate because FPL will be using a different filtration scheme than assumed by PNL. For the gaseous releases from pipe cutting, FPL used commonly accepted calculational methods (for example, in calculating the kerf for each cut and in assuming that all radioactive material adhering to the inner cut surface would become airborne). Therefore, we conclude that the FPL estimates of gaseous releases, were carried out in an acceptable manner and represent reasonable estimates.

In Table 4.2, the estimates for liquid releases of tritium vary widely because FPL plans to store the reactor coolant water for reuse, whereas the generic (NUREG/CR-0199)[2] estimate assumes that the coolant is discharged after processing for nuclides other than tritium. However, FPL has estimated the magnitude of the release should it become necessary to discharge the coolant. Any such release would be treated by the chemical and volume control systems prior to release and would amount to a maximum of 0.8 Ci of mixed fission and activation products released from the reactor coolant system. The FPL estimate for the release of mixed fission and activation products is larger than the generic estimate because the latter did not include the releases of the secondary coolant nor the local decontamination solutions. Both estimates included the activities in laundry waste water. FPL based its estimates of releases from the laundry waste water and secondary coolant on past measurements of these sources at Turkey Point. FPL used commonly accepted methods to calculate the releases from local decontamination solutions. Based on these several considerations, we conclude that FPL has made reasonable estimates of the radioactive liquid effluents during the repair effort, and that these estimates correspond well to our own best estimates.

Any liquid effluent containing radioactivity would be discharged into the condenser cooling water and subsequently be discharged into the closed cycle cooling canal. Pursuant to a Final Judgment in the U. S. District Court for the Southern District of Florida (Civil Action No 70-328-CA; reproduced in Appendix C of the FES[9]) Florida Power and Light Company shall not discharge into Biscayne Bay or Card Sound any water used for cooling its condensers at its generating facilities at Turkey Point.

Our estimates of dose to individuals and to the population as a whole in the area surrounding the Turkey Point site are based on the radioactive effluents which FPL estimated for the repair effort (summarized in Table 4.2) and on the calculational methods presented in Regulatory Guides 1.109, 1.111 and 1.113.[10,11,12] We conclude that offsite individuals will receive doses from the repair effort of the same order as, or less than, the annual dose consequences presented in the

FES.[9] The doses to the population within 50 miles will be less than 5 man-rem to the thyroid or total body from liquid effluents, and less than 2 man-rem to the thyroid or total body from airborne effluents. Every year the same population (about 2 million) will receive a total body dose of about 200,000 man-rem from the natural background radiation in the vicinity of Turkey Point (0.1 rems per year).[13] Thus, the population total body dose from the repair effort is less than 0.01% of the annual dose due to natural background. On these bases, we conclude that the doses to individuals in unrestricted areas and to the population within 50 miles due to gaseous and liquid effluents from the repair project will not be environmentally significant.

FPL has estimated that the repair of one unit will result in a total solid waste volume (exclusive of the steam generators lower sections) of 27,400 cubic feet (about 780 cubic meters) containing 130 Ci to be shipped to a licensed burial facility. Based on the information presented in NUREG/CR-0199,[2] we estimate that 81,000 cubic feet (3,850 cubic meters) of solid waste will be generated per unit. Our estimate of the volume is higher than the FPL estimate; however, we find the FPL estimate of 130 Ci reasonable. This does not include the radoactivity on the inside surfaces of the old steam generators. In 1976 and 1977, Turkey Point generated an annual average of 44,400 cubic feet (about 1255 cubic meters) of solid waste per unit containing 450 Ci per unit of radioactivity.[2 14] Since the solid wastes represent a radiological impact which is smaller than the impact from solid wastes from normal operation and an increase in volume of solid waste which is less than 3% over the life of the plant, we conclude that the radiological impact is not environmentally significant.

The steam generator lower sections may be considered as solid waste; however, facilities are not available for barge unloading of such large pieces of radioactive waste. Truck hauling would require cutting the sections into smaller pieces and would entail the additional dose accumulated during the cutting and packaging process. For these reasons the steam generator lower sections will be stored on site for a period of time. This period may be for as long as the life of the plant at which time the disposal of of the sections would become part of the decommissioning process of the plant. The period may last just until facilities for barge shipment become available.

On the basis of long term onsite storage of the degraded steam generators until the reactors are decommissioned, there will be essentially no radioactive effluents from the generators for 30 years. Final disposal at that time will result in small offsite gaseous and liquid radioactive releases, because a large fraction of the radioactive nuclides in the steam generators will have decayed in 30 years.

The steam generators will be stored in an onsite storage facility which will be a concrete structure approximately 110 ft. by 60 ft. with a height of 17 ft. The outside walls will be about 2 ft. thick. The stored steam generators will present a source of direct and scattered radiation. We estimate that each steam generator will contain about 1000 Ci of radioactivity which is about 65% Cobalt-60, the principal contributor to direct dose. This is based on the estimate of the contamination of steam generator primary side surfaces given in NUREG/CR-0199.[2] We estimate a dose rate of less than 0.0001 milli-rem per hour at the nearest site boundary due to this activity. An individual spending an entire year at this location would receive less than 1 milli-rem of radiation exposure. This dose would be approximately halved every 5 years because of the decay of the principal contributing activity, Co-60. FPL made a similar calculation and reached the same conclusion. Since this dose represents roughly one percent of the annual dose from natural background,[14] we conclude that the dose impact to the public from the stored generators will be minimal and not environmentally significant.

The repair effort will return the plant to the design condition on which our evaluation in the FES[9] was based. Therefore, we conclude that the estimates of routine releases of radioactivity and the potential doses to the public from those effluents after the repair will remain as presented in the FES.

Since our estimates of radioactive effluents from FPL during normal operation after the repair effort are about the same or lower than those effluents presented in the FES,[9] we conclude that the impact on biota other than man will be no greater than that impact presented in the FES.

In summary, the offsite doses resulting from the steam generator repair will be less than those from recent plant operation since the expected releases of radioactive material as a result of the repair effort will be less than the releases from normal operation. These doses are comparable to doses presented in the FES,[9] and small compared to the annual doses from natural background radiation. Therefore, the radiological impact of the repair project to the public will not significantly affect the human environment.

4.2 Economic Costs of Steam Generator Repair

Steam generators generally are built with more tubes than necessary to allow for any tubes that may have to be plugged. We have evaluated the Turkey Point plant and find that each unit can operate safely with up to 25% of the steam generator tubes plugged. If the percentage of plugged tubes gets high enough so that there is not enough heat transfer surface, the unit will have to be operated at some level of power less than 100%. If the unit is required to operate at some lower level of power, the operation is referred to as derated. In addition to the percentage of plugged tubes, the nuclear peaking factor, F_Q (a number which is related to the uniformity of the neutron flux over all positions in the reactor core), imposes limitations on the unit, and depending upon the fuel burnup, is also expected to require the plant to derate. Based on the above discussion and the latest amendment to the Technical Specifications[22] it is likely that unit 4 will be derated for cycle 7, which is expected to begin in the Fall of 1980. Unit 3 has about 3% less plugged tubes than unit 4 and therefore may be expected to be derated about one year after unit 4.

FPL has estimated that, over the life of the plant, the proposed steam generator repair project will result in a net dollar savings of at least $200,000,000 compared with the cost of continued operation of the existing steam generators, with an optimistic assumed scenario of tube plugging and derating. The cost of purchasing and installing the steam generator lower assemblies and associated activities is estimated at about $102,000,000 for the two units.

The cost of onsite storage and final disposal of the six degraded lower assemblies is expected to be about $2,000,000. The estimate for replacement power during the outage for repair is about $124,000,000. The total project cost is therefore about $228,000,000.

The cost of replacement power during the outage is based on the FPL estimate of $300,000 per day per unit and an outage duration of 207 days per unit. The FPL estimate of $300,000/day-unit based on differential fuel costs is reasonable in view of the fact that replacement power would be provided by oil and gas-fired units which FPL would press into service. (690,000 kW X 24 hrs/day X a fuel differential cost of about $0.018/kW hr. = $298,000/day/unit). We consider this replacement power cost estimate reasonable.

The FPL estimated net saving of $200,000,000 is based largely on the cost of replacement capacity. We assessed the reasonableness of this estimate by comparing it to the cost of replacement power if both units had to be derated. The replacement power cost would be about $480,000,000 for only 10 years of derated operation at an assumed derating rate of 3% per year beginning when 25% of the tubes were plugged. If the derated period lasted longer the cost would be larger. (The current rate of tube degradation is such that the rate of tube plugging is about 3% per year.)

The calculation was made as follows. For the first year of derating the cost would be,

$$\left(\frac{0.03}{1-0.25}\right) \times \$219,000,000 = \$8,760,000$$

The 0.03 corresponds to 3% derating per year, the 1-0.25 term corresponds to the number of remaining sound tubes after 25% are plugged. The $219,000,000 is the yearly cost of replacement power due to fuel differential cost for two units at $300,000 per day per unit. By the end of the second year of derating, the cumulative cost would be three times as high ($26,300,000) since the first 3% derated batch of tubes would have been out for two years and the second 3% derated batch of tubes would have been out for one year, for an effective total of three years of 3% derating. By the end of the third year of derated operation the cumulative cost would be six times the first year cost (3+2+1). After ten years the cumulative cost would be,

$$\frac{0.03}{1-0.25} \times 219,000,000,000 \times 55 = \$482,000,000.$$

$$(55 = 10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1)$$

Therefore, the estimate that $200,000,000 would be saved over the life of the plant, even after spending $102,000,000 for the steam generator repair, is conservative. The present value of the replacement power assuming a net discount rate of 3% (corresponding to a discount rate of 10% minus an inflation rate of 7%) would be about $390,000,000.

The FPL estimate of $2,000,000 for final disposal of the degraded steam generators assumes onsite storage for 30 years followed by sectioning and shipment to a licensed burial facility for low-level waste. This estimate is not out of line when compared to recent estimates[15] for the decommissioning of complete reactors by dismantlement after a cooling period (about $30,000,000).

This consideration of costs does not take into account the continuing costs of tube inspection and plugging services, nor the costs of possible future modifications to control corrosion, if the repair is not done. It also does not consider the cost of the reduced generating capacity and the current lack of reliability and availability. In 1978, the approximate outage times for steam generator tube inspection and plugging were 10.5 days for Unit 3 and 27 days for Unit 4. Experience at the Turkey Point Plant indicates that such an inspection takes about ten days when combined with a refueling outage and about 21 days when not combined with a refueling outage. Inspections have been carried out about two times per year.

4.3 Non-Radiological Environmental Costs

The non-radiological impacts of the repair project on the environment are small compared to those of building and operating the reactors. These small costs include the commitment of about one acre of land on the site for the storage of the degraded steam generators for the life of the station. There will be some noise generated by onsite equipment and a small effect on local traffic by approximately 100 construction workers per shift, but these effects will be insignificant. The material costs of the proposed action will be a small fraction of those of building the original units[1] (Table 6.2-1).

4.4 Environmental Impact of Postulated Accidents

As is discussed in our SE,[3] the design and plant operating parameters which are relevant to accident analyses will not change as a result of the steam generator repair effort. Therefore, the assessment of the environmental impact of postulated accidents presented in the FES[9] for Turkey Point Plant Units 3 and 4 will be unchanged and remain valid. However, there are types of accidents due to the operations involved in the repair effort which we have considered.

One type of postulated accident related to the repair effort would involve the dropping and rupture of a removed steam generator outside the reactor containment while it was being transported to the storage vault. This accident would involve the rupture of the steel covers which will have been welded over each of the steam generator cuts to prevent the spread of the neutron-activated corrosion products adhering to the inner surfaces. The method used to assess the radiological consequences of a rupture which could release contamination on the primary side surfaces to the atmosphere is described in our SE.[3] We assumed that 0.1 percent of the primary side activity became airborne and used an atmospheric dispersion factor of 5.5×10^{-6} seconds per cubic meter. On this basis, we concluded that this accident would result in a dose of 0.02 rem to the lungs of an individual at the site boundary. The dose consequences of such a drop accident inside containment would be lower since the containment ventilation system would reduce the radioactivity released to the environment.

We have also analyzed the impact of a postulated breach of the steam generator seal while it is in the storage building. We note that the radioactive material involved is plated onto the internals of the steam generator; it does not wash off during operation which involves rapidly flowing water at over 500°F. Also, the radioactive material would be dried in place and would tend to come loose in flakes or pieces, if it did come loose at all. If the welded plates that seal the openings of the steam generator should be breached by some accident, much of the radioactive material would be trapped in the tubes and crevices, plated on the internal surfaces, and would be in flakes or pieces that would not easily escape from the break. Even dust or liquids would not find a ready path to escape in large quantities because of the complexity of the internals and lack of simple flow paths. Assuming that some material did escape, any material in gaseous or dust form would have an effect such as described in the previous paragraph. The remainder of any escaping material would be in flakes or pieces that would tend to stay in the surface layers of the dirt and could be removed if necessary. However, for the purpose of this assessment we have assumed that 0.1% of the activity as given in Table 3.4-1 of the SE[3] would escape the steam generator due to some accident and that surface and/or ground water would be involved in spreading the radioactive material.

First, we assumed that the release would be to surface water caused by flooding (by rain storm, hurricane, or combinations of such storms). According to 10 CFR Part 20, Appendix B, Table II, the maximum allowable concentration of Co-60 in water is 5×10^{-5} uCi/ml. For a 0.1% release, the volume of water required for dilution would be about 20 acre-feet per steam generator. This amount of water would be easily exceeded many times by any flooding event that would breach the generators. In addition, the contaminated water would eventually be carried to Biscayne Bay where dilution would be several orders of magnitude greater than that required.

Next, we assumed that the release would be to ground water and we arbitrarily assumed that breaching occurred and that the radioactive material would enter the ground at the floor of the storage building. The radioactive material would migrate downward through the unsaturated (vadose) zone to the Biscayne aquifer. During this migration the radioactive material would be dispersed in the soil and radionuclide particles may be retarded due to ion exchange with the soil. On entering the groundwater, radioactive material would migrate in the direction of the hydraulic gradient (seaward). The radioactive material would be diluted in the groundwater and further dispersed and retarded. The radioactive material would migrate seaward toward Loch Rosetta which is roughly 650 feet from the steam generator storage building. There are no ground water users[9] between the storage area and Biscayne Bay, which is east of Loch Rosetta. Water from the cooling canal is returned to Lock Rosetta where it is picked up by the plant intake and recirculated. The postulated radioactive material in the ground water would be intercepted by Loch Rosetta and mixed with cooling canal return water. Therefore, the radioactive material would become part of the liquid effluents of the plant and subject to plant restrictions on liquid radioactive releases. In addition, the facilities radiological monitoring program, which is performed routinely, is intended to detect unanticipated buildup of radioactivity in environment.

If the plant was not in operation at the time of the breaching event, there would be little or no water circulating through Lock Rosetta. However, with four units at the site it is not likely that this would be the case for longer than an hour or so.

Loch Rosetta is saline and therefore not usable for drinking water. Also, since it is on plant property, it is not accessible to the general public. Nevertheless, in this case, a mixing in the Loch would reduce the concentration. Radioactive material transported by groundwater would enter the Loch over a long period of time primarily due to dispersion and retardation. Therefore, even with the above conservative assumptions, the release of radioactive material postulated is not expected to exceed 10 CFR Part 50.

Accordingly, we conclude that the proposed temporary storage of the steam generators will not cause an adverse environmental impact on the public due to public due to unacceptable surface or ground water contamination.

FPL has analyzed the potential for steam generator crane rigging accidents which may affect the refueling water storage tank and primary water storage tank. They conclude that rigging operations will be conducted in areas sufficiently removed from these tanks to preclude damage to these structures. They have also evaluated the potential for a steam generator being dislodged from the rigging and striking the radwaste or fuel handling building. They concluded that both buildings are capable of withstanding all postulated impacts with no breach of integrity. We have evaluated the FPL report[1] and concur with this conclusion.

In summary, we conclude that the consequences of postulated accidents from the repair operation would not be environmentally significant.

5.0 Impacts of Alternatives

The basic choices of future action regarding the tube degradation problem are (1) repair of the degraded steam generators, (2) continuation of the present mode of operation, (with increasing costs in plant efficiency and occupational exposure), and (3) shutdown of the Turkey Point Units 3 and 4 and replacement by generating plants of different design. The option of operating the FPL system without Turkey Point 3 and 4 is not feasible in light of our review of the power demand in the FPL service area.[9,20,21]. FPL opted for repairing the degraded steam generators, with changes in design, materials and operating procedures calculated to eliminate the tube denting problem. The units can be run in a derated mode and no doubt would be operated in a derated mode in preference to shutting the units down with no replacement power.

In the absence of methods to arrest or greatly reduce denting, the continuation of operation for an extended period in the present mode is impractical. With tube degradation and plugging continuing at the present rate, the units would likely be derated within a few years as discussed earlier in Section 4.2. FPL has estimated the cost of replacement power, based on fuel differential costs, to be about $300,000 per day for the shutdown of a unit. Consequently, as discussed in Section 4.2, the cost of derating the Turkey Point units would be about $480,000 in ten years. Also, the man-rem cost of occupational exposure during the inspection and plugging of degraded tubes would continue. The cumulative dose due to inspection and plugging would exceed the 2600 man-rem cost of the repair in five to seven years.

Laboratory test programs on the denting phenomenon are currently underway to define the corrosion process more precisely and to develop preventive measures such as corrosion inhibitors. While the combination of steam generator secondary side cleaning and corrosion inhibitors is being studied by some utilities to combat denting in its early stages, the denting phenomenon at Turkey Point is too advanced for such measures to be practical. Therefore, FPL cannot count on a greatly reduced future rate of tube degradation to justify continuing the present mode of operation.

The option of shutting down the Turkey Point Units and replacing them with Units of different design is easily shown to be much more costly than that of repairing the steam generators. FPL estimates[1] (Section 7.7) that the capital cost of new nuclear units with improved steam generators would be about $2.0 billion dollars and would require about 12 1/2 years to build. New fossil units would cost about $1.5 billion in capital and require about 8 years to build. The capital cost for gas turbine units would be about $310 million and would require about two years to build. VEPCO made similar comparisons for the steam generator repair program at the Surry Station and found that the cost comparison overwhelmingly favored the repair option.

Based on our review of the above figures we find that the time and cost estimates are reasonable. We conclude that the plant replacement option is not economically feasible. In addition, there would be significant environmental impacts from such a large scale construction operation. The most practical overall option is therefore to repair the degraded steam generators.

In the remainder of this section, we shall consider the radiological and economic costs of several alternative ways of repairing and disposing of the degraded steam generators. An important item in estimating economic costs is the cost of replacment power during unit outage. The FPL cost estimate of $62,000,000 for the replacement power needed during the 207 day outage of each unit corresponds to a replacement power cost of about $300,000 per unit per day of outage. The replacement power cost of $300,000 per day is based on the availability of fossil fired fuel capacity which normally would be used only during periods of peak demand. The repair program was planned to be carried out during the seasonal periods of relatively low demand. However, if shutdown is required during peak demand periods, or if long-term derating is necessary, new replacement capacity would have to be installed resulting in replacement power costs about 50% higher.

5.1 Decontamination

FPL has estimated[1] (Section 8.2) that chemical decontamination of the steam generators before cutting would result in a net saving of 150 to 400 man-rem (two unit total) in occupational exposure. However, it would cost about 2 weeks in additional outage of each unit. Replacement power for this additional outage would cost about $8,000,000. In addition, a quantity of liquid radioactive waste would be produced (VEPCO estimated[4] about 200,000 gallons.)

Based on our knowledge of the limited experience of the nuclear industry in large scale, high volume chemical decontamination of reactor coolant systems, we can make the following statements: decontamination would add significant expense and time delays to the repair effort, including the cost of replacement power during those time delays; there is a degree of uncertainty about the compatibility of the decontamination fluid with materials in the coolant system; the research and testing which would be required to provide adequate assurance of material compatibility to obtain our approval to decontaminate would have an adverse impact on the cost and schedule of this repair effort; while the lower dose rates resulting from decontamination would reduce occupational dose during the repair operations, occupational radiation doses received during the decontamination effort itself would at least partially offset the dose reduction; decontamination would not remove the radioactivity inside tubes which are plugged; large volumes of contaminated fluids would be produced and require processing and that processing would incur further costs and occupational doses. In summary, we conclude that the costs of decontamination, including costs due to time delays and additional occupational doses, would outweigh the subsequent dose reduction. Therefore, although we believe that local decontamination may be advantageous, the use of large scale decontamination in this repair effort is not a viable option.

5.2 Retubing of Existing Steam Generators

The retubing operation would involve (1) removing the upper or dome portion of the steam generator, (2) removing the lower assembly internals and tubes, (3) replacing the latter with state-of-the-art internals and tubes, (4) refurbishing the upper internals, and (5) welding the dome back in place. FPL has estimated[1] (Section 7.3 and 7.4) that the cost of this operation in both dollars and occupational exposure would be higher than the proposed replacement of the complete lower assembly. Further, it should be noted that shop fabrication of new lower assemblies could provide more positive assurance that the quality of the repaired generators was acceptable.

On the other hand, we are aware of recent developments by Westinghouse in the technology of in-place refurbishment which show some promise of reducing unit outage and personnel exposure below the values for the FPL proposed repair method. A detailed proposal of the Westinghouse in-place refurbishment is being reviewed.[18] If our assessment is favorable, in-place retubing may be an alternative for steam generator repairs in the future. Estimates of the time required to wait for the NRC approval of retubing for the Turkey Point Plant indicate that it would likely take a minimum of two years for this approval to be granted. This includes time for the NRC staff to approve the Westinghouse Plan, time for FPL to adapt the Westinghouse plan to Turkey Point and to prepare a report for the NRC to review and approve, and time for the NRC review. It does not include time for any additional technical problems to be solved. The economic cost of derating was discussed in Section 4.2.

In the time frame contemplated for the proposed licensing action, this is not considered to be an available alternative to the proposed action. Contributing to this judgement are the following facts; 1) the NRC approval of the retubing technique is not assured, 2) ability to reuse the tube sheet is not assured, 3) continued operation with the present steam generators would continue the higher industrial exposure rate, and 4) Unit 4 and Unit 3 both would likely be derated before the retubing process is implemented.

5.3 Replacement of the Entire Steam Generator

FPL considered this alternative in two ways. Based on FPL analysis, which we have reviewed and found reasonable, a construction opening in the containment wall about 20 feet wide and 40 feet high would be required, since the upper assembly of the steam generator could not pass through the existing equipment hatch. An alternative plan also considered was removal of the steam generator through a 20 foot diameter hole in the containment dome. The personnel exposure for these alternatives would be about the same as for the proposed repair, because essentially the same high-dose operations will be required in each case. Elimination of the cut across the diameter of each steam generator results in only a small saving of radiation exposure. The capital costs are estimated to be about 15% higher. The principal cost difference is due to an estimate additional outage of about 100 days per unit for the alternative. This corresponds to an additional requirement of about $60,000,000 worth of replacement power during the repair of both units, calculated at the rate of about $300,000 per day of outage per unit.

In summary, this alternative would have essentially the same environmental impact as the FPL proposal (primarily occupational dose) and greater economic cost. Also, there would be significant structural repairs involved to assure that the containment is returned to the original state after completion of this repair program. For these reasons, we conclude that the FPL proposed repair method is preferable.

5.4 Alternate Disposal Methods

In the Appendix to NUREG/CR-0199[2] the radiological costs of several alternative methods for the disposal of the degraded steam generators are evaluated. The results of this analysis are summarized in Table 5.1.

From the table it is seen that the options involving intact shipment would have the lower radiological costs; but intact shipment is possible only by barge and (at present) there is no licensed burial ground with facilities for off-loading an entire lower assembly from a barge. On the basis of environmental impact (largely occupational dose) we conclude that immediate intact shipment would be the best alternative. The second best alternative is long term storage with intact shipment. We note that the proposed disposal method would leave open the option of intact shipment should the appropriate facilities become available during the storage period.

We conclude that the next best alternative, on the basis of environmental impact would be long-term storage of the generators onsite until the reactors are decommissioned, followed by sectioning and shipment at that time. This is the plan proposed by FPL.

Table 5.1

Steam Generator Disposal Alternatives[2]

Option	Approximate Man-Rem per Steam Generator	Approximate Airborne Release, Ci per Generator
Immediate intact shipment	2.4[c]	Negligible[b]
Long-term[a] storage (including surveillance) with intact shipment	10	Negligible[b]
Long-term[a] storage with cut-up and shipment	16	0.005
Short-term storage with cut-up		
- at 5 yr.	230	0.026
- at 15 yr.	60	0.015
Immediate cut-up and shipment by rail/truck - no decontamination	580	0.042
Immediate cut-up and shipment by rail/truck - with chemical decontamination	270	0.010

[a] 30 to 40 years

[b] Since the steam generator will be sealed before it is removed from containment, no release of radioactive material is expected during the repair operation.

[c] Estimates for short-term storage followed by intact shipment would be only slightly larger than this, perhaps 5 man-rem.

Immediate cut-up and shipment to a burial facility would involve a substantial cost in occupational exposure, even after chemical decontamination. Comparing Tables 5.1 and 4.2, it is seen that the airborne releases from the segmenting operation would be larger than those from the rest of the repair effort.

The five disposal alternatives considered by FPL[1] (Section 5.4) and their estimated economic and radiological costs are given in Table 5.2 for the disposal of six steam generators.

According to the FPL estimates, the proposed disposal method of on-site storage with final disposition at the time of plant decommissioning is expected to result in the least cost in dollars and in radiation exposure.

On the basis of our evaluation above we conclude that the proposed disposal method costs less in radiation exposure than alternatives available at present. The proposed onsite storage leaves open the option of intact barge shipment in the event that a burial ground with adequate off-loading facilities becomes available. We also conclude that the other available alternatives offer no environmental advantage over the option selected by FPL.

Table 5.2

Cost of Alternate Disposal Methods (FPL)[1]

	Method	Cost, dollars	Exposure[a], Man-rem
a.	Cut up and disposal near term with no decontamination	$4,560,000	1500-3000
b.	Cut up and disposal near term With solidification agent	$4,220,000	800-1600
c.	Cut up and disposal near term with decontamination	$4,750,000	250-1100
d.	Long term on-site storage with deferred cut up and disposal	$2,490,000	20-40
e.	Long term on-site storage with disposition during decommissioning	$2,020,000	1-3

[a]Note that these doses are for six lower assemblies. The estimates in Table 5.1 are for one lower assembly.

6.0 Basis and Conclusion for not Preparing an Environmental Impact Statement

We have reviewed the proposed steam generator repair action and have reached the following conclusions.

(1) The proposed replacement of the lower assemblies of the steam generator is the best available option, from both the radiological and economic standpoints, for eliminating the tube degradation problem.

(2) The one-time occupational dose of 1300 man-rem per unit for the repair effort falls within the range of annual occupational doses which have been experienced in U.S. light water reactors in recent years. Occupational exposures of this order, or larger, would be accumulated in the order of 5 to 7 years by continued operation of the Turkey Point plant should the repair program not be carried out. The proposed repair program would restore the generators to the condition evaluated in the FES and would result in an occupational dose reduction of hundreds of man-rem per year because there would be a marked reduction in the amount of tube inspection and tube plugging required to keep the generators in acceptable operating condition. Therefore, the proposed action will result in a net reduction in occupational dose over the life of the plant.

We have reviewed the dose reduction measures to be used by FPL and conclude that the dose would be ALARA. We conclude that the adverse health effects from such an exposure are not significant.

(3) The new steam generator design incorporates features which will eliminate the potential for the various forms of tube degradation observed to date.

(4) Offsite doses resulting from the steam generator repair will be less than those from recent plant operations, comparable to doses presented in the FES, and small compared to the annual doses from natural background radiation. Therefore, the offsite doses will not be significant.

(5) The alternatives to the proposed action offer no environmental advantage. Continued operation of the Turkey Point units in the present mode, with frequent shutdowns to inspect and plug degraded tubes and to eventually build replacement capacity, would result in greater environmental and economic costs than the proposed actions. FPL has estimated that, by implementing the new program, there would be a net saving of about $200,000,000, compared to continued operation in the present condition, even

though the immediate cost of the repair would be about $228,000,000. The option of replacing the Turkey Point plant nuclear units with fossil-fired units entails a significant environmental cost and is prohibitively expensive. Available alternative methods of steam generator repair have higher environmental costs and higher economic cost than the proposed repair method.

On the basis of the foregoing analysis, we conclude that the proposed steam generator repair action will not significantly affect the quality of the human environment.

We have reviewed this proposed facility modification relative to the requirements set forth in 10 CFR Part 51 and the Council of Environmental Quality's Guidelines, 40 CFR 1500.6. We have determined that the proposed license amendment will not significantly affect the quality of the human environment. Therefore, the staff has found that an environmental impact statement need not be prepared, and that pursuant to 10 CFR 51.5(c), the issuance of a negative declaration to this effect is appropriate.

Date: June 29, 1979

7.0 REFERENCES

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3. Safety Evaluation by the Office of Nuclear Reactor Regulation, License Nos. DPR-31 and DPR-41, Florida Power and Light Co., Turkey Point Plant Units 3 and 4, Docket Nos. 50-250 and 50-251, U.S. Nuclear Regulatory Commission, May 14, 1979.

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19. Letter from A. Schwencer NRC, to R. E. Uhrig, FPL transmitting Amendments 38 and 31 to Facility Operating License Nos. DPR-31 and DPR-41, dated October 26, 1978.

20. "Final Environmental Statement related to the Constructions of St Lucie Plant Unit 2", Section 8.1, U.S. Atomic Energy Commission, May, 1974.

21. Letter from R. E. Uhrig, FPL to V. Stello, NRC dated July 20, 1977 transmitting "Report on Systems Disturbance, May 16, 1977", Florida Power and Lights Co., June 29, 1977.

22. Letter from A. Schwencer NRC, to R. E. Uhrig, FPL dated June 15, 1979 transmitting Amendment Nos. 49 and 41 to the Turkey Point licenses.