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March 20, 1992
Fort St. Vrain
Unit No. 1
P-92123

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

ATTN: Dr. Seymour H. Weiss, Director
Non-Power Reactor, Decommissioning and
Environmental Project Directorate

Docket No. 50-267

SUBJECT: ENVIRONMENTAL REPORT SUPPLEMENT FOR DECOMMISSIONING -- RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

REFERENCES:
1. NRC Letter, Erickson to Crawford, dated November 19, 1991 (G-91246)
2. PSC Letter, Crawford to Weiss, dated July 10, 1991 (P-91219)

Dear Dr. Weiss:

This letter provides additional information regarding the Fort St. Vrain (FSV) Environmental Report Supplement for Decommissioning, as requested in Reference 1. The information provided with this letter demonstrates that the environmental impacts of planned FSV decommissioning activities are not significant. In addition, the attachment describes an enhanced monitoring program that will be implemented for decommissioning to ensure that these impacts are not significant.

The decommissioning alternative proposed by Public Service Company of Colorado (PSC) is early dismantlement and decontamination (DECON) of Fort St. Vrain, a High Temperature Gas-cooled Reactor. PSC evaluated the environmental impacts of this proposed alternative and did not identify any site specific characteristics that would be significantly different from those studied generically by the NRC in NUREG-0586. The impacts of the proposed action are not significantly different from those

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associated with either the operation or decommissioning of other commercial reactors, and they do not significantly affect the human environment. Therefore, PSC considers that the attached information, combined with the original submittal of the FSV Environmental Report Supplement for Decommissioning (Reference 2), supports a Finding of No Significant Impact for this proposed action.

The information provided in the attachment, combined with the information that has been provided in responses to NRC questions regarding the Proposed Decommissioning Plan, will be incorporated into a revision to the Environmental Report Supplement. This revision will be submitted to the NRC by April 30, 1992.

If you have any questions regarding this information, please contact Mr. M. H. Holmes at (303) 620-1701.

Sincerely,

Donald W. Warembourg

Donald W. Warembourg
Manager, Nuclear Operations

DWW/SWC/lmg

Attachment

cc: Regional Administrator, Region IV

Mr. J. B. Baird
Senior Resident Inspector
Fort St. Vrain

Mr. Robert M. Quillin, Director
Radiation Control Division
Colorado Department of Health

SUPPLEMENT TO APPLICANT'S ENVIRONMENTAL REPORT

POST OPERATING LICENSE STAGE, FOR FORT ST. VRAIN DECOMMISSIONING

PSC RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

Dated November 19, 1991

Introduction

In a letter dated July 10, 1991, Public Service Company of Colorado (PSC) submitted a Supplement to the Fort St. Vrain (FSV) Environmental Report, to demonstrate that the environmental impacts of decommissioning the facility would not be significant. The NRC's November 19, 1991 Request for Additional Information (RAI, G-91246) provided several specific questions about this Supplement and also identified a general request for more detailed supporting information.

In this response to the RAI, PSC provides information comparable to that provided by the NRC in various NUREGs to assess the technology, safety and costs of decommissioning other nuclear facilities. PSC considers that this submittal supports the issuance of a Finding Of No Significant Impact (FONSI) for FSV decommissioning activities.

NUREGs have been prepared to evaluate the environmental impacts of decommissioning reference PWRs (NUREG/CR-0130), BWRs (NUREG/CR-0672), multiple reactor sites (NUREG/CR-1755), and research and test reactors (NUREG/CR-1756). As summarized in the Final Generic Environmental Impact Statement (GEIS) on Decommissioning of Nuclear Facilities (NUREG-0586), the NRC determined that the environmental impacts of decommissioning these facilities are bounded by the impacts already accepted for operation of these facilities.

The previous NUREGs did not consider the unique features of a High Temperature Gas Cooled Reactor. Therefore, the NRC stated that the decommissioning of FSV will require the preparation of a detailed site-specific Environmental Assessment to determine whether the potential impacts are significantly different from those of an LWR and whether such impacts are significant.

PSC considers that the information provided in this RAI response, combined with the information provided in the Supplement to Applicant's Environmental Report, Post Operating License Stage - Decommissioning, July 1991, supports a determination that the site specific environmental impacts of decommissioning Fort St. Vrain are small when compared to the impacts envisioned for operating the plant, or an LWR, over its entire lifetime. Using the same methodology used in the GEIS, a FONSI should be able to be prepared without the necessity of preparing a site-specific Environmental Impact Statement for FSV decommissioning.

PSC has reviewed the Supplement to Applicant's Environmental Report, Post Operating License Stage for FSV Decommissioning, to determine the additional information and detail necessary for the preparation of a FONSI. This attachment provides the following:

1. A response to NRC Comment No.1, identifying an error in the ER Supplement. The planned liquid effluent release rates are consistent with the discussion of blowdown flows in the historical Final Environmental Statement.

2. A discussion of PSC's plans to release tritium via liquid effluent discharges, as addressed in NRC Comment No. 2. This discussion provides a description of the plans and controls for releasing tritiated water into the Goosequill Ditch and the environs. The dilution effects of discharging into the surrounding river system are evaluated, and tritium concentrations are compared to EPA safe drinking water standards.

   This discussion includes an analysis of the potential pathways for radiation doses from the liquid effluent. Potential downstream uses for FSV effluent are evaluated and compared with previous operational releases and with the resultant effects on the environment determined by the FSV Radiological Environmental Monitoring Program.

3. A detailed assessment of the decommissioning alternatives for Fort St. Vrain, as required by 10 CFR 51.45(b)(3), and as addressed in NRC Comment No. 3. This assessment compares the environmental impacts of the SAFSTOR, DECON, and ENTOMB alternatives for Fort St. Vrain. In addition, this assessment compares these impacts with those determined acceptable for LWRs.

4. A narrative analysis of each of the 10 CFR 51.45 considerations.

Liquid Effluent Discharge Flow Rates

NRC Comment No. 1:

> From page 4-9 of the ER Supplement, you state that the 1500-2000 gpm discharge flow rates "are greater than those discussed in the historical FSV Final Environmental Statement." During the October 22, 1991 meeting with the staff, PSC indicated that it possessed discharge permits for approximately twice the values discussed in the ER supplement. The appropriate values need to be reconciled and the supporting information presented.

PSC Response:

The historical FSV Final Environmental Statement (FES) states that the maximum blowdown flows would be 2650 gpm. This is sufficient to cover the 2000 gpm liquid effluent release planned for decommissioning, and is near the maximum flow that the Goosequill Ditch can carry.

The statement on page 4-9 of the ER Supplement was in error. In fact the FES states that the average flow in the blowdown line is expected to be 2065 gpm, with a maximum of 2650 gpm (Section III.D.6).

The Environmental Report Supplement will be corrected at its next revision.

ER Additional Discussion for Tritium Releases

NRC Comment No. 2:

> From page 4-4 of the ER Supplement, you state that "the use of surface water from the site is limited almost entirely to irrigation." The NRC cannot make an assessment of the relationship to water usage for irrigation purposes and that for public water supply (see Table 4.1-1), based on the information provided. While the tritiated water flow rates may not be viewed as radiologically significant (there is a stated commitment to meet 10 CFR Part 20), it is nevertheless important to assess the potential pathways (for example, location and species of fish and the crops irrigated).

PSC Response:

1. Response Summary

This response describes PSC's plans to release approximately 500 Curies of tritiated water into the river system downstream of Fort St. Vrain, over about a 200 day time period. While this release is sizable, it is not large when compared to normal releases from operating Pressurized Water Reactor plants. During its operational phase, FSV released over 2100 Curies of tritium, with a peak annual release of 370 Curies. During this time, PSC conducted extensive environmental monitoring. Monitoring of downstream drinking water, surface water, fish, crops, milk, and atmospheric sampling has consistently shown that these releases have (1) not resulted in downstream tritium concentrations that exceeded the EPA Safe Drinking Water Standards (in 40 CFR 141), and (2) not resulted in elevated concentrations of tritium in any human food source in direct or indirect contact with liquid effluent.

2. Historical Tritium Discharges

Tritiated water at Fort St. Vrain largely comes from the removal of moisture from primary coolant (helium). Updated FSAR Section 2.7.2 stated that an average of 300 Curies of tritium would be released annually as liquid and gaseous effluent. Actual tritium releases in liquid effluent are shown in Table T-1, based on the Semiannual Radioactive Effluent Release Reports. Over 2100 Curies of tritium have been released as liquid effluents since 1978. The greatest annual tritium release was 370 Curies in 1983. If normal plant operations had continued for the entire 35 year period of the facility operating license (1973 to 2008), and if an average of 200 Curies of tritium were released as liquid effluent each year, a total of 7000 Curies of tritium would have been released into the downstream river system.

The projected release of 500 Curies of tritium during the Fort St. Vrain decommissioning period is bounded by typical annual releases from a number of Light Water Reactors. A review of the Semiannual Radioactive Effluent Release Reports from other nuclear facilities (Reference 1) shows that Pressurized Water Reactors have annually released similar quantities of tritium to the environment. As illustrated in Table T-2, annual tritium releases of over 500 Curies are commonly made by over a dozen single unit PWRs, including two facilities that typically release several thousand Curies of tritium each year.

3. Tritiated Water Release Plans

During the Fort St. Vrain decommissioning project, the Prestressed Concrete Reactor Vessel (PCRV) cavity will be flooded with water to provide shielding and contamination control. As described in PSC's response to NRC questions on the Proposed Decommissioning Plan (Reference 2), flooding the PCRV will result in the release of radionuclides into the water. This water, designated as PCRV Shield Water, will be processed through demineralizers before it is released into the environs. These demineralizers have been designed to reduce the concentration of all radionuclides except for tritium. It is expected that cobalt-60, cesium-137, and iron-55 will still be detectable prior to dilution. The concentration of these three radionuclides will be reduced by the demineralizers to an average concentration approximately 1.0 % of the current MPC values identified in 10 CFR 20, Appendix B, Table II, Column 2. Liquid effluent is diluted by a minimum factor of 110 before discharge to the Goosequill Ditch. With this dilution, the concentration of Co-60, Cs-137, and Fe-55 in the water leaving the plant into unrestricted areas will be considerably less than the 10 CFR 20 MPC values.

As described in the response to RAI Question No. 38 (Reference 2), the amount of tritium that was produced during reactor operation and the extent to which it will be leached out or washed off of internal core components cannot be reasonably determined with certainty at this time. The maximum amount of tritium that could have been produced has been identified by activation analysis. Based on British test data, PSC estimates that approximately 500 Curies of tritium will enter the PCRV Shield Water and will be processed and released as liquid effluent.

This evaluation focuses on a release of 500 Curies of tritium.

Tritium released via the liquid effluent pathway could actually be released in greater total quantities, as long as the concentrations and resultant dose consequences are maintained within regulatory requirements, and as long as the total quantity is consistent with previously accepted Environmental Statements.

The NRC has previously evaluated and accepted the environmental consequences of annual releases of 8000 Curies of tritium in liquid effluent at the Haddam Neck Nuclear Generating Station (Reference 3). If the actual amount of tritium released into the PCRV Shield Water System is greater than 500 Curies, PSC has established an upper limit for liquid effluent releases of 8000 Curies of tritium, to be released over a period of time greater than one year. Up to 8000 Curies of tritium in liquid effluent will be released within the following limits:

1. EPA Safe Drinking Water Standards in 40 CFR 141 (20,000 Pci/ml average concentration), at the downstream sampling location located at the Colorado Route 60 bridge over the South Platte River, approximately 5 miles downstream of the effluent discharge location,

2. 10 CFR 50 Appendix I limitations on doses to individual members of the public (1.5 mrem whole body per quarter, 3 mrem whole body per year), and

3. 10 CFR 20 MPC limits on concentrations in effluents released to unrestricted areas (e.g., 0.003 μCi/ml for tritium in existing 10 CFR 20).

Administrative controls will be implemented to ensure that the above limits are met. The above standards also ensure compliance with the EPA public dose limits in 40 CFR 190 of 25 mrem per year. This amount of tritiated water (8000 Curies) can be released over about a 23 month time frame without impacting currently planned decommissioning schedules.

If tritium quantities exceed 8000 Curies, the PCRV Shield Water will be processed and disposed of in a manner that does not involve release to surface water. The actual processing will most likely involve use of an absorbent material that would allow disposal as solid waste, using the methodologies described in Reference 2. Disposal of tritiated water processed in this manner would require less than one acre at a licensed burial site, and would involve a minimal impact on the environment.

3.1 Liquid Effluent Processing

Releases of PCRV Shield Water will be processed through the PCRV Shield Water System (described in the response to RAI Question No. 11, Reference 2), where filters and demineralizers will substantially reduce the concentration of radionuclides such as cobalt-60, cesium-137, and iron-55. Since tritium cannot be removed by the Shield Water System, it will be removed by diluting it and releasing it to the environs in a controlled manner. As Shield Water is released, it will be replaced with clean water.

Initially, water to be released will be transferred to a liquid waste holdup tank in the existing FSV radioactive liquid waste system (System 62), for sampling and analysis. After the water in the PCRV has been processed to the extent that the concentrations of Co-60, Cs-137, and Fe-55 in the entire PCRV water volume are less than approximately 1.0 % of the 10 CFR 20 MPCs, and after tritium has been reduced to less than the 10 CFR 20 MPC, then this water will be sent directly to the discharge line, where it will be diluted with blowdown flow and released. The liquid waste holdup tank will not be used. At that time, the entire PCRV will be considered a process tank and releases will be made directly to the dilution point, as long as no activities are in progress inside the PCRV that could stir up additional contaminants.

The liquid waste system consists of two 3000 gallon receivers, a 3000 gallon monitoring (or holdup) tank, and associated filters and demineralizers. The holdup tank will be sampled and analyzed for tritium and other principal radionuclides. Based on sample results and the limits in the FSV Offsite Dose Calculation Manual (ODCM), an allowable release rate will be determined to ensure that the established limits will not be exceeded.

PSC projects that initial tritium concentrations will allow liquid waste in the holdup tank to be discharged at a rate of 1.4 to 10 gpm. Liquid effluent will be diluted by the cooling tower blowdown flow prior to release to the Goosequill Ditch. A minimum cooling tower blowdown flow of 1100 gpm is defined in the ODCM, and PSC is planning to release tritiated liquid effluent at a total flow rate of approximately 2000 gpm. This is within the 2650 gpm maximum blowdown flow identified in the FSV Final Environmental Statement (FES, Reference 4).

3.2 Dilution Water Source

Dilution water will be taken from the surrounding rivers (South Platte River or St. Vrain Creek) and released via the cooling tower blowdown line, where it is mixed with radioactive liquid effluent. Availability of 2000 gpm for dilution water flow is assured throughout decommissioning, as this is less than the 4100 gpm circulating water makeup flow that was available during normal plant operations.

The Final Environmental Statement, Figure III-14 (Reference 4), shows that 4100 gpm was diverted from the rivers during operations, to allow for cooling tower blowdown of 1800 gpm and cooling tower evaporation of 2300 gpm. The 4100 gpm makeup flow was only 35 % of the available surface water rights owned by PSC, so the availability of 2000 gpm for dilution flow during decommissioning is assured.

3.3 Liquid Effluent Release Path

The same liquid effluent release path will be used during decommissioning as was used during normal plant operations. As shown in Figure T-1 (which is similar to Figure 4.1-5 of the Environmental Report Supplement, Reference 5), diluted liquid effluent will normally be released from the FSV protected area to the Goosequill Ditch. From the concrete lined Goosequill Ditch, liquid effluent then flows into the Jay Thomas Ditch, where additional dilution may occur, and then on to a 25 acre farm pond that contains about 32 million gallons of water. Water flows approximately 8700 feet from the plant to the farm pond.

For ALARA purposes, PSC will supply water from the South Platte River to the Jay Thomas ditch during liquid effluent releases when tritium concentrations are near 10 CFR 20 MPC limits. This flow will mix with liquid effluent in the Goosequill Ditch and provide additional dilution. There may be some periods when the Jay Thomas ditch is being used by the local farmers to irrigate their fields, and flow may not be available for dilution of the Goosequill. However, this is considered to be of limited duration. It is noted that PSC has water rights to Jay Thomas ditch water that ensure a supply of water to the plant for cooling tower blowdown; however, these water rights do not preclude diversion of water for irrigation purposes from locations between the plant supply point and the connection to the Goosequill ditch.

After further mixing and evaporation in the farm pond, liquid effluent is released from the pond overflow structure into the South Platte River where it is further diluted. Approximately 100 yards downstream, this stream is diluted again by the addition of flow from the St. Vrain Creek, which has annual flows approximately 60% of the South Platte River annual flows.

As described in the Final Environmental Statement, liquid effluent may be diverted to the St. Vrain Creek in lieu of being released to the Goosequill Ditch, but this release path is only used during abnormal circumstances. This release path diverts plant effluent through a natural drainage slough to the St. Vrain Creek. This is not a normal flow path and, as during plant operations, it will be used on a limited basis for brief periods of time.

3.4 Surface Water Dilution

Dilution of liquid effluent in downstream surface waters depends to a large extent on river flow rates. PSC has reviewed historical river flow rates and has evaluated the dilution that can be expected during the FSV tritium releases during decommissioning. Historical river concentrations from the FSV REMP confirm that sufficient dilution exists to maintain river tritium concentrations below the EPA Safe Drinking Water Standards.

3.4.a Calculated River Dilution

Downstream surface water tritium concentration will vary due to many considerations, and is particularly affected by river flow rates. South Platte River flow rates have stabilized since the Chatfield Reservoir was installed over 40 miles upstream in the early 1970s. FSV FSAR Section 2.5 lists average monthly flow rates for the nine year period from 1971 through 1979. Seasonal flow variations during this time period are as follows:

Average ('75-'79 data)	353 cfs (158,000 gpm)
Peak flow (May)	1077 cfs (483,000 gpm)
Minimum flow (December)	249 cfs (112,000 gpm)

These flow rates were taken at the upstream gauging station in Henderson, and are somewhat reduced by irrigation ditches that take water before it gets to Fort St. Vrain. However, much of this irrigation water is returned to the rivers as groundwater, and in addition, the St. Vrain Creek joins the South Platte River approximately 100 yards downstream of the farm pond outlet and adds an annual average flow of 203 cfs. In Reference 6, CSU graduate student C. Dacey estimates the nominal river flow at the convergence of the two rivers to be 632 cfs (283,000 gpm).

With a 2000 gpm discharge flow into and out of the farm pond, this results in a nominal dilution factor of 140. If the discharge concentration is 0.003 μCi/ml (the existing 10 CFR 20 MPC), the resulting river concentration would be slightly over the EPA Safe Drinking Water Standard of 20,000 pCi/l. However, this calculation shows that the 20,000 Pci/l limit can be met by slightly reducing the release rate, slightly reducing the discharge concentration, or by additional dilution of the discharge flow (with water from the Jay Thomas Ditch, for example).

3.4.b REMP Measured Downstream Data

The FSV REMP samples surface water upstream and downstream of the plant to determine the impact of plant operations. The attached Figure T-2 shows the results of this sampling from 1974 through 1988 (Reference 7). A clear increase in downstream tritium concentrations can be seen over upstream concentrations during 1978, 1981, 1982, and 1983, when FSV had annual tritium releases of several hundred Curies.

The data in Figure T-2 shows a peak downstream concentration of 1500 pCi/l. Even acknowledging that the correlation between the monthly surface water samples and the times of releases may not be ideal, there is considerable margin between the peak measured value of 1500 pCi/l and the EPA limit of 20,000 pCi/l. It is concluded that downstream water concentrations have been maintained within the EPA Safe Drinking Water Standards.

3.4.c Comparison with Farm Pond Outlet Water

The REMP has also compared the farm pond outlet water with downstream river water. From 1984 through the present, a continuous sampler has been installed on the outlet of the farm pond. A sample of the farm pond outlet water is taken approximately every 80 minutes, and the composite is collected weekly. The weekly composites are then combined and analyzed monthly.

The attached Table T-3 compares the analyses of monthly samples of effluent from the farm pond, and from upstream and downstream surface water samples. This data for 1988 (when 161 Curies of tritium were released) clearly shows that effluent with tritium levels that exceed the EPA standard is substantially diluted in the South Platte River (e.g., in June, when there was no detectable upstream tritium concentration, the farm pond outlet was 45,000 pCi/l and the downstream river concentration was 590 pCi/l).

3.5 Other Tritium Release Alternatives

Two other options were evaluated for releasing tritium, including (1) construction of a large shallow water impoundment for solar evaporation of tritium and (2) installation of a series of mechanical evaporators for forced evaporation of tritium. Both of these alternatives were determined to be less desirable than releasing tritiated water via the normal liquid effluent release path.

Solar evaporation from a shallow water impoundment (i.e., pond) was determined to be less desirable at this time for the following reasons:

1. The evaporation rate cannot be controlled.
2. Rainfall or snow could add to the amount of tritiated liquid to be evaporated.
3. Access fencing and an impoundment liner would be required.
4. It would be difficult to prevent migrating birds and small animals from entering the area.
5. Additional occupational radiation exposure to a decommissioning worker, standing 100 m from the pond for 8 hr per day for 200 days (e.g., a security guard) is conservatively calculated to be 342 mrem. This is based on a 10 gpm release of 500 Curies of tritium in liquid effluent, and it includes Co-60, Cs-137, and Fe-55.
6. The impoundment presents an additional accident source term, specifically in the event of rupture of the impoundment lining.
7. Additional costs are associated with lining the impoundment.
8. Disposal of sludge and ultimate decontamination of the impoundment area must be performed, whereas no additional remediation to the Goosequill ditch areas is expected.
9. The inhalation dose to an adult member of the public standing 100 m from the pond is conservatively calculated to be 0.43 mrem during a 2 hr exposure.

Mechanical evaporators were also determined less desirable at this time for the following reasons:

1. A large throughput mechanical evaporator is expensive and requires constant attention.
2. A number of evaporators are required for the necessary throughput and operational flexibility in the event of an evaporator breakdown.
3. The additional occupational radiation exposure to a decommissioning worker standing 100 m from the

evaporator for 8 hr per day for 200 days is conservatively calculated to be 342 mrem. This is based on a 10 gpm release of 500 Curies of tritium in liquid effluent and it includes Co-60, Cs-137, and Fe-55.

4. Eventual decontamination and disposal of evaporators is required.
5. The inhalation dose to an adult member of the public standing 100 m from the evaporator is conservatively calculated to be 0.43 mrem during a 2 hr exposure.

4. Radiological Consequences

The radiological consequences of releasing tritium into the environs downstream of Fort St. Vrain have been thoroughly evaluated and documented via the FSV Environmental Radiation Surveillance Program (ERSP, 1983 and before) and the Radiological Environmental Monitoring Program (REMP, 1984 and after). The relationships (or independence) between releases of tritium from the plant and concentrations of tritium in the environment have been observed through these programs. These field observations are of significant value in assessing the impact of the planned 500 Curie tritium release during decommissioning.

As during plant operations, liquid effluents during decommissioning are controlled to ensure compliance with the public dose limits of 10 CFR 20 and 10 CFR 50 Appendix I. The most limiting requirements are in Appendix I, which PSC has committed to in the proposed Decommissioning Technical Specifications. Appendix I limits dose or dose commitment to a member of the public from radioactive materials in liquid effluents released to unrestricted areas to the following:

a. During any calendar quarter to less than or equal to 1.5 millirem to the whole body and to less than or equal to 5 millirems to any organ, and

b. During any calendar year to less than or equal to 3 millirems to the total body and to less than or equal to 10 millirems to any organ.

PSC requested assistance from Dr. James Johnson, the Colorado State University (CSU) Professor who directed the previous ERSPs and REMPs, in evaluating the radiological consequences of the planned liquid effluent releases. The following discussion is derived from his analyses.

As noted previously, the PCRV Shield Water System will include demineralizers that have been designed to ensure that radionuclides such as Co-60, Cs-137, and Fe-55 are reduced to an average concentration less than approximately 1.0 % of the current 10 CFR 20 MPCs prior to dilution and release. These radionuclides are further reduced by an ion exchange phenomenon with the sediment in the bottom of the ditch. From the junction of the Goosequill ditch and the Jay Thomas ditch, the ditch bottom is sediment and radionuclide absorption will occur on the clay mineral sediments.

The parameter describing this reduction is called the distribution coefficient, and has been studied extensively in agronomy and radioecological literature. A conservative value of the distribution coefficient is 1000 for Co-60 and Fe-55, and 200 for Cs-137 (Reference 8). Therefore the concentration of these radionuclides will reach an equilibrium value 200 to 1000 times less than the concentration entering the system before any aquatic or biological uptake occurs. Taking a conservative case where humans were to directly ingest waterfowl or some other food source with water contents equivalent to consuming 2 liters per day of this water, a resultant Committed Effective Dose Equivalent (CEDE), using ICRP-30 dose commitment parameters, would be 4.4 E-4 mrem for Co-60, which is negligible. The CEDE is a weighted sum of all organ and tissue doses and should be compared with whole body dose limits. CEDEs for Cs-137 and Fe-55 would be comparable and further pathway analysis for these radionuclides is not warranted.

4.1 Pathways

As tritium in liquid effluent progresses into the environment, it is potentially available to various sources of public consumption in three basic concentrations:

1. At approximately the 10 CFR 20 MPC limit of 0.003 μCi/ml in the Goosequill Ditch and the farm pond,
2. At the EPA Safe Drinking Water Standard limit of 20,000 pCi/l in the downstream surface water, and
3. At a more diluted level in the groundwater that reaches the Gilcrest town well, which is used for public drinking water.

Cattle and waterfowl have access to water in the Goosequill Ditch. For various reasons that are discussed later, ingestion of these food sources is not considered reasonable, however, doses have been calculated.

The most reasonably conservative pathways are considered to be the following:

1. Consumption of drinking water from the Gilcrest town well,
2. Consumption of milk from a family cow pastured on fields irrigated from downstream surface water from the South Platte River,
3. Consumption of vegetables from a local garden watered from downstream water from the South Platte River,
4. Consumption of beef pastured on fields irrigated from downstream surface water from the South Platte River,
5. Consumption of waterfowl from downstream surface water in the South Platte River basin, and
6. Consumption of fish from downstream surface water in the South Platte River basin.

Based on Dr. Johnson's evaluation in his specific review of the planned decommissioning releases and in his previous REMP or ESRP reports, the above pathways are evaluated as follows:

4.2 Consumption of Gilcrest Well Water

The closest downstream public water supply is the Gilcrest town water well. This well is shallow, as evidenced by high nitrate concentrations, from fertilizers used by area farmers. During previous tritium releases, PSC has sampled Gilcrest well water and has not been able to establish a definitive correlation with tritium concentrations in FSV effluent. A CSU graduate student published a master's thesis that stated that a possible groundwater flowpath from the farm pond to the Gilcrest well does exist (Reference 6), and in the course of PSC's environmental sampling efforts, the Gilcrest well water has on occasion had detectable tritium concentrations (which have been well below EPA standards for safe drinking water). Based on REMP observations that tritium has been detected in the Gilcrest water well, this pathway is considered the most significant route of tritium to local inhabitants.

Dr. Johnson reviewed the FSV tritium release data and the corresponding tritium concentrations measured at the Gilcrest town well since 1984. The nominal effective dilution volume was determined for the hydrological environment between the plant release point and the Gilcrest town well. This effective dilution volume was then applied to the release of approximately 500 Curies of tritium. Dr. Johnson calculated the resultant drinking water concentration to be 1000 pCi/l and then calculated the associated doses (Reference 9). The committed effective dose equivalent (CEDE) to an adult member of the general public consuming only Gilcrest well water during the 200 day estimated release period is conservatively calculated to be 0.026 mrem. As discussed previously, the CEDE should be compared to whole body dose limits.

There is another well located closer to the farm pond than the Gilcrest well, but it is not used for drinking water. This well is on the Russell farm and is located south of the farm pond. Domestic water on the Russell farm is supplied by a pipeline from the Central Weld County Water District.

4.3 Milk Consumption

As described in previous REMP reports and as recently confirmed in the 1990 Land Use Census (Reference 10), there are no dairies or personal milk cows within a 1 mile (1.6 km) radius of the plant. Six dairies within 5 miles (8 km) of the plant have been extensively sampled in the REMP programs. The REMP report for 1988 stated that elevated tritium concentrations due to reactor effluents have never been observed during the operational period of the reactor. This implies the tritium from reactor effluents is not contributing any radiation dose to humans via the milk pathway. Tritium concentrations in milk should respond rapidly to changes in tritium concentrations of the forage water intake or drinking water intake to the cow. This is due to the short biological half life for water in the cow (about three days for the lactating cow).

In 1988, Dr. Gerald Ward, CSU Professor of Animal Sciences, surveyed the dairies in the REMP program (Reference 7). This survey determined that herd management practices are similar at all dairy locations. The cows in the milking herd are never on pasture that could be irrigated by downstream water but instead are under dry-lot management typical of Eastern Colorado.

The 1990 Land Use Census confirmed that there are no milk animals in areas with direct access to the Goosequill ditch or the farm pond. A few residents up to a distance of 5 miles (8 km) from the plant have cows or goats that could be used for personal milk consumption. However, from direct discussions held between CSU surveyors and local residents, personal consumption is not a common practice and all cow milk produced is transported to commercial processors. The milk produced locally is diluted, processed, and distributed over a large area for consumption. CSU concluded in the 1990 REMP that elevated radionuclides (I-131 from upstream medical uses was the radionuclide of concern at that time) from the closest dairy farm would never be detected in the composite milk supply.

Notwithstanding the above, a conservative calculation was performed of doses resulting from drinking milk from a family cow that had grazed on pasture land irrigated from South Platte River water containing tritium at 20,000 pCi/l. The resultant CEDE dose from drinking only this milk for the entire 200 day portion of an assumed 400 liter annual consumption is 0.048 mrem.

4.4 Vegetable Consumption

The 1990 Land Use Census in the REMP (Reference 10) confirmed that there are no gardens in the area with access to the Goosequill ditch or the farm pond. Thus, the downstream water that could be used to irrigate crops and vegetables for human consumption will be diluted by the downstream rivers.

The intake of tritiated water from crops and vegetables irrigated by downstream water is a possible dose pathway. The FSV REMP has sampled food products and analyzed for principle gamma emitters. No radionuclides have been found that were attributed to FSV effluent releases.

The REMP has typically monitored six to twelve locations from areas possibly irrigated by surface water downstream of the FSV discharge point or by well water from the aquifer most likely to be contaminated by seepage from the farm pond. One sample of each principal class of food product was collected at each location, and typically included items such as corn, melons, tomatoes, beans, onions, zucchini, broccoli, potatoes, beets, beet tops, squash, turnips, cucumbers, and cabbage.

Based on the fact that no gamma emitting radionuclides attributed to FSV activities have been detected in crops and vegetables during previous monitoring, this pathway is not considered a likely source of tritium to local inhabitants. Nevertheless, if an individual were to consume a 200 day portion of an assumed annual consumption of 340 kg of vegetables from a local garden watered with South Platte River water at 20,000 pCi/l, the resultant CEDE would be 0.14 mrem.

4.5 Consumption of Beef and Waterfowl

Beef cattle are not a likely exposure pathway. Typical cattle sent to slaughter are removed to a dry feed lot for approximately 90 days before slaughter, based on an evaluation performed by Dr. Gerald Ward, Professor of Animal Sciences at CSU. Assuming the biological half-life of water in the beef cow is approximately eight days, this produces at least ten biological half-lives before slaughter. Notwithstanding these common practices, it is conceivable that beef cattle grazing in pastures irrigated from the South Platte River were slaughtered for private consumption, bypassing the feed lot process.

The area around the downstream surface waters has a plentiful supply of ducks and geese. Hunting is permitted in season, and it is possible that waterfowl that have been drinking surface water could be consumed.

If an individual consumed a 200 day portion of an assumed annual combined beef and waterfowl consumption of 110 kg, that had been drinking or pasturing on land irrigated from the South Platte River at 20,000 pCi/l, the resultant CEDE dose would be 0.046 mrem.

4.6 Consumption of Fish

There are few if any sport fish in the river near the farm pond outlet. Carp are present in these waters, but they are generally not consumed. Nevertheless, if an individual were to consume a 200 day portion of an assumed annual consumption of 21 kg, 90% of which is water at 20,000 pCi/l, the resultant CEDE would be 0.013 mrem.

4.7 Total Dose Due to Above Pathways

The total CEDE to an individual consuming each of the above food sources over the 200 day period of the tritium release is 0.27 mrem, which is within 10 CFR 50, Appendix I limits. This is conservative in that it assumes a constant concentration in the water source for the entire 200 day period, and tritium concentrations are expected to gradually reduce with time as the tritium in the PCRV Shield Water is released.

If the actual amount of tritium in the PCRV Shield Water is 8000 Curies, as discussed previously, the release duration will be extended beyond 200 days. In this case, the assumed tritium concentrations could be sustained for greater than one year. The annual CEDE dose from the reasonably conservative pathways described above is calculated to be 0.50 mrem, which is within 10 CFR 50, Appendix I limits.

4.8 Beef Consumption - Goosequill Water Supply

Beef cattle have access to liquid effluent at several locations along the Goosequill Ditch and at the farm pond. This is not considered a realistic dose pathway, however, due to local agricultural practices. Dr. Gerald Ward, Professor of Animal Sciences at CSU, was consulted about beef cattle practices. Based on his discussions with Ben Houston, the local rancher whose cattle are pastured in the area near the plant, he determined that the local cattle are registered purebred Aberdeen Angus cattle and nearly all are sold for breeding purposes. Cattle that are sent to slaughter are removed to a dry feed lot for approximately 90 days before slaughter. Assuming the biological half-life of water in the beef cow is approximately eight days, this produces at least ten biological half-lives before slaughter. Dr. Ward also confirmed that no beef cattle are slaughtered for personal use or local consumption directly out of the pastures, without having gone through the dry feed lot process.

Notwithstanding the above, PSC determined the resultant doses from consuming beef from one of the local cows that consumed Goosequill water. Since some of the water provided to the cattle for drinking water comes from the Carter Lake domestic water supply, it was assumed that 50% of the drinking water was FSV liquid effluent, at its release limit of 0.003 μCi/ml of tritium. It was also assumed that the animal is slaughtered after tritium concentration has reached a maximum steady state level in its tissues, and 60% of the tissue weight is water. An individual who consumed 40 kg of this animal would receive a CEDE dose of 2.3 mrem, using a CEDE dose commitment factor for tritium of 6.4 E-8 mrem/μCi. This CEDE is calculated by ICRP-30 methodology, using a dose commitment factor from EPA-520/1-88-020. Consumption of 40 kg of beef would likely occur over a period of time greater than 3 months, since the assumed consumption of beef and waterfowl combined is 110 kg for an entire year. Therefore, it is reasonable to assume that this CEDE should be compared to the annual dose limit. While substantial, this dose due to the hypothetical consumption of this animal would be within the 10 CFR 50 Appendix I limits.

4.9 Waterfowl Consumption - Goosequill Water Supply

The area around the farm pond has a plentiful supply of ducks and geese, the majority of which are considered migratory and transient. There is a sizable resident waterfowl population and hunting has been a practice in the past. To eliminate this pathway during the tritium release period during decommissioning, PSC will post the farm pond area and hunting will not be permitted.

Notwithstanding the no hunting policy, the dose due to consuming waterfowl from the farm pond is calculated. It is reasonable to assume that an individual could consume 5 waterfowl (ducks and/or geese) per year. The CEDE dose from consuming 5 waterfowl, weighing an average of 4 kg each, where 60% of the weight is assumed to be water (half of which came from the farm pond at the release concentration of 0.003

μCi/ml of tritium and half of which is from time spent in the adjacent rivers and is diluted to less than 20,000 pCi/l), would be 1.2 mrem. This dose is within the 10 CFR 50 Appendix I limits.

4.10 Fish Consumption - Goosequill Water Supply

There are no sport fish in the flow path to the farm pond or in the farm pond itself. Carp are present in these waters, but they are generally not consumed. During the tritium release period for decommissioning, PSC will post the farm pond and fishing will not be permitted.

Notwithstanding the no fishing policy, the dose due to consumption of fish from the farm pond is calculated. An individual who consumed 11.5 kg of fish (200 days portion of the 21 kg annual fish consumption identified in Regulatory Guide 1.109), 90% of which is water at 0.003 μCi/ml, would receive a CEDE dose of 2.0 mrem. This dose would likely be received over more than three months and would be within 10 CFR 50 Appendix I limits.

Due to the fact that the consumption of fish, waterfowl, and beef cattle that have been in contact with Goosequill water is highly hypothetical, PSC considers that the above CEDE doses need not be considered in combination with each other. Thus it is shown that even these unlikely pathways result in doses to the public that are within regulatory limits.

4.11 Inhalation

The REMP program collects atmospheric water vapor samples continuously by passive absorption on silica gel at two locations near the Goosequill ditch. Although elevated tritium levels have been observed, the 1988 REMP report indicates that the tritium levels have always been below the limit of regulatory concern and that inhalation is not a significant pathway for dose to humans.

The area around the Goosequill ditch is unrestricted but it is not an area where members of the public or decommissioning workers would spend time. Occasionally brush or other trash must be removed from the ditch but this is not a time consuming task. There are no buildings or work stations located adjacent to the ditch, and occupational activity is very limited. This is not considered to be a significant pathway for tritium during decommissioning, either through inhalation or skin absorption.

4.12 Other Aquatic Pathways

Since tritium is a constituent of the water being released, diluted, and carried downstream, it will not be deposited along the shoreline or in sediment. Due to the distribution coefficient ion exchange discussed previously, other radionuclides are not expected to be released to the surface water. No other aquatic pathways are considered reasonable.

5. Non-Radiological Effluent Release Considerations

As described in the referenced response to RAI Question No. 11, sodium hydroxide will be added to the PCRV shield water for pH control and hydrogen peroxide will be added for a biocide. Approximately 600 lb. of 50 % wt sodium hydroxide and 550 gallons of 30 % wt hydrogen peroxide will be used in total during decommissioning. These chemicals will be released or disposed of in accordance with applicable NPDES permit requirements.

6. Enhanced Monitoring Program

At several times during plant operations, enhanced monitoring programs were implemented to better understand the impact of plant activities on the environment. In a similar manner, PSC will implement an enhanced monitoring program during the release of tritiated PCRV Shield Water.

This program will include weekly sampling of the farm pond outlet (from the continuous sampler), of upstream and downstream river locations, of the nearest farm wells, and of the Gilcrest well.

Adequate river flow is necessary for effluent dilution, however flow cannot be monitored at FSV because there is no river flow gauging station near the plant. To ensure adequate dilution, during the first three months of releases of PCRV Shield Water (when tritium concentrations are expected to be at their highest levels), PSC will enhance the environmental monitoring program by performing daily downstream sampling and analysis for tritium concentration. After the first three months, weekly sampling will be performed.

This enhanced monitoring program will allow PSC to take appropriate actions (e.g., adjust discharge flow, adjust dilution flows from the plant or the Jay Thomas Ditch) to ensure that tritium concentrations downstream of the convergence of the South Platte River and the St. Vrain Creek do not exceed the EPA Safe Drinking Water Standard (i.e., 20,000 pCi/l average).

The results of this enhanced monitoring program will be reported in the annual REMP reports that will be prepared throughout the decommissioning period.

PSC will also implement an enhanced surveillance of the Goosequill ditch to clean out debris in a timely manner. This will minimize opportunities for ditch water to back up and possibly overflow into pasture areas.

7. State of Colorado Considerations

The liquid effluent release limits described above are consistent with current limitations in effect for surface waters in the State of Colorado. This information is based on conversation with Mr. Ken Weaver of the Colorado Department of Health, Radiation Protection Division, on March 19, 1992.

8. Conclusion

The potential release to the environment of approximately 500 Ci of tritium, as PSC currently projects, will have no greater impact on the environment than the releases made during previous operations of FSV and during current operations at LWR nuclear facilities. Based on a release of 500 Curies of tritium, the projected doses to an individual consuming downstream river water, drinking milk from a family cow, and eating vegetables from a family garden irrigated with this water are within regulatory limits.

PSC's environmental monitoring programs, conducted by the Colorado State University (CSU), have provided a substantial data base against which the planned releases can be compared. In addition, these programs provide independent confirmation of the effectiveness of PSC's controls on the release of radioactive materials to the environment.

9. References

1. NUREG/CR-2907, BNL-NUREG-51581, Radioactive Materials Released from Nuclear Power Plants, Brookhaven National Laboratory, 1988

2. PSC Letter, Crawford to Weiss, dated January 9, 1992 (P-92014)

3. Final Environmental Statement, Haddam Neck Plant, October 1973, Docket No. 50-213

4. Final Environmental Statement Related to Operation of the Fort St. Vrain Nuclear Generating Station, August 1972, U. S. AEC Directorate of Licensing

5. Supplement to Applicant's Environmental Report, Post Operating License Stage - Decommissioning, July 1991, submitted via PSC Letter, Crawford to Weiss, dated July 10, 1991 (P-91219)

6. Potential Groundwater Contamination by Tritium from Fort St. Vrain Nuclear Cenerating Station, Colorado State University Master's Thesis, C. A. Dacey, 1985

7. Radiological Environmental Monitoring Program Summary Report for 1988, Colorado State University, submitted via PSC Letter, Williams to NRC, dated April 20, 1989 (P-89151)

8. Transport in Surface Waters, Onishi et al, 1981

9. CSU Letter, Dr. J. Johnson to S. Chesnutt, dated January 31, 1992 (G-92069)

10. Radiological Environmental Monitoring Program Summary Report for 1990, Colorado State University, submitted via PSC Letter, Crawford to NRC, dated April 12, 1991 (P-91133)

ANNUAL FSV RELEASES OF TRITIUM IN LIQUID EFFLUENT

Year	Tritium Released (Ci)
1978	275 Ci
1979	128 Ci
1980	220 Ci
1981	241 Ci
1982	271 Ci
1983	370 Ci
1984	137 Ci
1985	17 Ci
1986	127 Ci
1987	56 Ci
1988	161 Ci
1989	112 Ci
Total to 1989	2115 Ci

Table T-1

ANNUAL RELEASES OF TRITIUM IN LIQUID EFFLUENT

FROM PRESSURIZED WATER REACTORS

Data taken from NUREG/CR-2907, Volume 9, Annual Report for 1988, July 1991, Table 6
(Tritium values in Curies)

Facility	1984	1985	1986	1987	1988
Callaway 1	29	588	435	448	893
DCCook 1&2	1370	1140	695	1970	1100
Haddam Neck	3660	5760	2580	3170	1180
Indian Point 3	587	340	567	340	573
Farley 1	423	603	714	637	516
Farley 2	356	502	622	505	753
Millstone 3			541	590	547
Salem 1	330	923	410	379	635
San Onofre 1	34	2380	453	2270	1530
Summer 1	225	311	375	736	755
Waterford 3		25	431	525	503
Zion 2	511	521	446	440	558

Notes:

1. This listing only includes facilities with annual releases in excess of PSC's projected 500 Curie release
2. DC Cook is a multiple reactor site, but is included because the individual unit releases would be greater than 500 Ci.

Table T-2

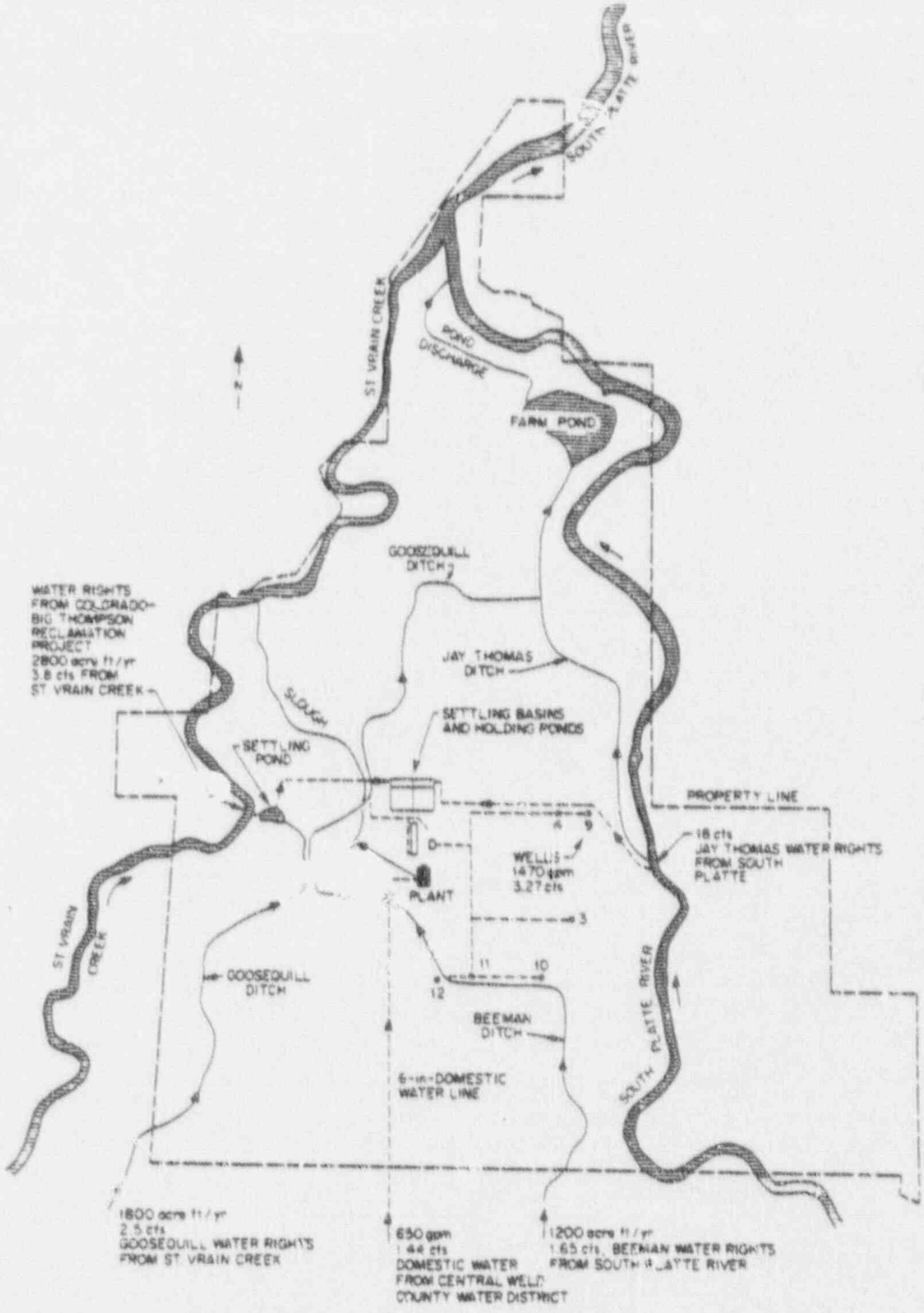
Tritium Concentrations in Surface Water. (pCi/L) for 1988

Collection Date	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
January	530(420)*	340(310)	< 290	< 290	53000(370)
February	< 290	580(350)	600(350)	1900(450)	27000(510)
March	< 290	400(270)	780(290)	410(270)	23000(520)
April	340(310)	340(310)	260(300)	430(310)	5400(370)
May	650(310)	540(310)	470(310)	410(310)	31000(470)
June	< 220	590(260)	< 220	< 220	45000(830)
July	< 250	820(380)	< 250	< 250	25000(660)
August	< 250	560(370)	< 250	340(370)	12000(520)
September	< 250	< 250	< 260	< 260	12000(520)
October	500(380)	640(380)	< 250	< 250	38000(770)
November	660(320)	640(320)	550(310)	770(320)	24000(620)
December	670(320)	1000(320)	960(320)	550(310)	28000(670)

* 1.96 σ (Due to counting statistics.)

1. Tritium released in liquid effluents in 1988 was 161 Curies
2. Numbers in parentheses represent the statistical accuracy of the measured concentration.
3. "Less than" values indicate the minimum detectable value

TABLE T-3



IRRIGATION DITCHES AROUND FORT ST. VRAIN NUCLEAR GENERATING STATION

FIGURE T-1

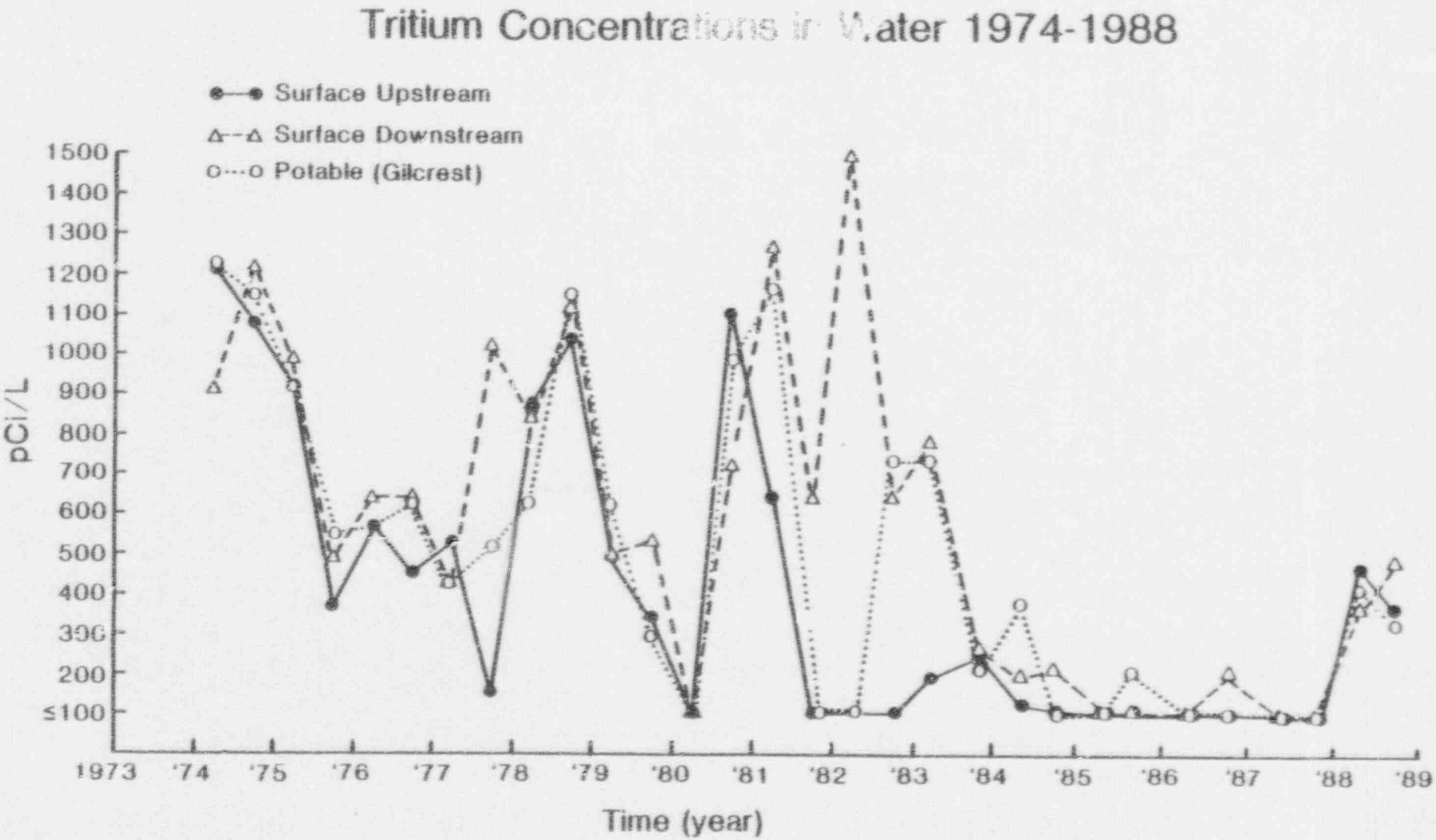

Tritium Concentrations in Water 1974-1988
Surface Upstream
Surface Downstream
Potable (Gilcrest)
pCi/L
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
≤100
1973
'74
'75
'76
'77
'78
'79
'80
'81
'82
'83
'84
'85
'86
'87
'88
'89
Time (year)

FIGURE T-2

Comparison of Decommissioning Alternatives

NRC Comment No.3:

> Finally, the intent of 10 CFR 51.45(b)(3) and Appendix A to Part 51 Subpart A, consideration of environmental effects of alternatives to the proposed action, is an essential element of environmental reviews by the NRC. PSC provided an economic comparison of alternatives in Chapters 6 and 7 of the ER. An economic evaluation is an important element of the alternatives assessment; however, an environmental assessment of the alternatives, irrespective of the proposed action, is still required and must be provided to the NRC for inclusion in our Environmental Assessment.

PSC Response:

1. Introduction

This discussion considers the three decommissioning alternatives, DECON, SAFSTOR, and ENTOMB, in a manner similar to that used in the NRC's Final Generic Environmental Impact Statement (GEIS) on the decommissioning of nuclear facilities (NUREG-0586, Reference 1). The GEIS does not address decommissioning a High Temperature Gas-cooled Reactor (HTGR) like Fort St. Vrain, but it does consider Light Water Reactors (LWRs), including Pressurized Water Reactors (PWRs), Boiling Water Reactors (BWRs), and multiple reactor stations. Also, although less applicable to FSV decommissioning, the GEIS considers decommissioning activities at nuclear research and test reactors, nuclear fuel reprocessing plants, small mixed oxide fuel fabrication plants, UF6 conversion plants, uranium fuel fabrication plants, and non-fuel-cycle nuclear facilities.

This discussion demonstrates that the environmental impacts of decommissioning the Fort St. Vrain facility are bounded by the previously accepted impacts of either (1) operating Fort St. Vrain, (2) decommissioning an LWR, or (3) operating an LWR. This is the same approach taken in the GEIS to show the acceptability of the environmental impacts of decommissioning these facilities.

2. Description of Alternatives

The three decommissioning alternatives are discussed as follows:

2.a DECON

DECON is defined as the immediate removal and disposal of all radioactivity in excess of levels which would permit release of the facility for unrestricted use. A detailed description of FSV dismantlement plans is provided in the Proposed Decommissioning Plan (PDP), Section 2.3. As described in the PDP, the FSV site will not be completely torn down and restored to a corn field. Non-radioactive equipment and structures will generally be retained and converted, as necessary, for potential future use as a natural gas-fired generating station. Much of the piping and equipment in the reactor building will not be removed even though it is not needed for the converted plant, because it is expected to be readily decontaminated and released for unrestricted use. The extent of dismantlement and equipment removal is consistent with the description of DECON practices in the GEIS. The end result is the release of the site and any remaining structures for unrestricted use as early as 39 months after the end of reactor defueling.

DECON is advantageous because it allows termination of the NRC license shortly after cessation of defueling operations and eliminates a radioactive site. The GEIS concludes that DECON is advantageous if the site is required for other purposes or if the site is extremely valuable; both of these reasons apply to the FSV site because of its potential for conversion to a gas-fired generating station and because the FSV switchyard is valuable for power distribution within the PSC system. The GEIS also states that DECON is advantageous in that the reactor operating staff is available to assist with decommissioning and that continued surveillance and maintenance is not required. The disadvantage of DECON, as stated in the GEIS, is the higher occupational radiation dose compared to the other alternatives.

An intangible benefit of DECON, which was a consideration in the decision to undertake this alternative at Fort St. Vrain, is that DECON is more equitable to future generations. The current generation decided to build Fort St. Vrain, and the current generation received the power generated by the plant. DECON does not encumber future generations with the risks, costs, and responsibility for dismantling Fort St. Vrain.

2.b SAFSTOR

SAFSTOR involves safely storing the nuclear facility for up to approximately 60 years, so that residual radioactivity can decay to levels that will reduce occupational radiation exposure during subsequent final decontamination. As noted in the GEIS, most of the occupational dose reduction occurs in the first 30 years after shutdown, due to the decay of cobalt-60 which is a large contributor to worker exposure.

PSC evaluated a SAFSTOR period until 2043, after which the plant would be dismantled, decontaminated, and released for unrestricted use by 2046. In the 54 years after shutdown, Co-60 (with a half-life of 5.26 years) would largely decay away, but europium (Eu-154) would still be present in the PCRV concrete to the degree that concrete removal would be required. Also, remote handling equipment would be required for some of the internal core components. Tritium, with a half-life of 12.3 years will be reduced over four half-lives, but would still be a consideration.

SAFSTOR Preparation Activities

The unique nature of the HTGR design, with all primary coolant system equipment located inside the Prestressed Concrete Reactor Vessel (PCRV), allows the plant to be prepared for an extended decay period with relatively little effort. Unlike LWR facilities, the FSV reactor building was accessible during normal operations, so extensive chemical decontamination of plant systems is not required to allow access during the decay period.

The initial FSV SAFSTOR preparation activities would involve removal of certain accessible components (e.g., control rod drive assemblies and helium circulators) as soon as practicable after shutdown. This would reduce burial costs which are expected to increase over time. For components with special handling equipment like the helium circulators, early removal would also allow use of knowledgeable operating personnel. All PCRV penetrations will be capped and seal welded shut unless the penetrating component remains in place (e.g., steam generators).

Decay Period Activities

Activities during the decay period include routine industrial surveillance, building maintenance, and security. A minimal level of dedicated staff, familiar with nuclear requirements, will be maintained. An environmental monitoring program will be maintained, periodic NRC inspections are expected, and an appropriate level of ANI insurance will be maintained.

Delayed Dismantlement Activities

Since remote handling equipment would still be required at the end of the decay period, the SAFSTOR dismantlement methodologies would be the same as are planned for DECON. The PCRV sectioning operation would still involve cutting concrete through the inner tendon tubes, so concrete waste volumes (which are a major part of the decommissioning waste volumes) will be largely the same as for DECON. It is possible that further concrete cutting and volume reduction techniques will be attractive in 2043, so that only a portion of the PCRV concrete inside the inner tendon tubes would be shipped for disposal; however, the feasibility of these techniques is speculative at this time and no credit was taken for a significant reduction in waste volumes after the decay period. The assumed SAFSTOR waste volumes at FSV represent a substantial difference from the reference PWR and BWR studies, which assumed a major reduction (to 10%) in waste volume for SAFSTOR, due to the decay of many contamination and activation products to background levels. This also results in higher estimated costs for FSV SAFSTOR than are estimated for the LWRs.

As discussed in the GEIS, SAFSTOR is advantageous in that it results in reduced occupational radiation exposure. However, the disadvantages are that a Possession Only License must be maintained and met under 10 CFR Part 50 at all times. Also, continuing inspections are required and the experienced staff will not be available at the end of the safe storage period to assist in decontamination.

A further disadvantage of SAFSTOR is the uncertainty in costs and regulations over the 50 year decay period. Regulatory changes that could affect release criteria or disposal requirements are difficult to predict and may change due to public perceptions and economic realities. Historically, the impact of regulatory changes has been to increase costs to licensees and this potential must be acknowledged for the future. Also, waste disposal costs will likely increase faster than the rate of inflation. Historically these costs have been increasing at 11.9% per year, which could have a significant impact on decommissioning costs. An additional liability is the Price-Anderson Act. This liability currently exists as long as PSC retains a 10 CFR Part 50 license, and could be very costly to the Company.

2.c ENTOMB

As described in GEIS Section 4.3.3, ENTOMB means the complete isolation of radioactivity from the environment by means of massive concrete and metal barriers until the radioactivity has decayed to levels which permit unrestricted release of the facility. The barriers must prevent the escape of radioactivity and prevent deliberate or inadvertent intrusion. The length of time during which the integrity of the entombing structure must be maintained depends on the inventory of radioactive nuclides present.

As discussed in the GEIS, the ENTOMB option is advantageous because of reduced occupational and public exposure to radiation compared to DECON, because little surveillance is required, and because little land is required. It is disadvantageous because the integrity of the entombing structure must be assured in some cases for hundreds or thousands of years, because a possession-only license under 10 CFR Part 50 would be required, and because entombing contributes to the number of sites permanently dedicated to radioactive materials containment. Also, the environmental impacts of ENTOMB could be quite high should large amounts of radioactivity escape from a breached structure during the entombment period.

As indicated in Section 6.3.2 of the Environmental Report Supplement for Decommissioning (Reference 2), the ENTOMB alternative may be useful when dealing with smaller reactor facilities, but the NRC has indicated that this alternative is not a viable choice for power reactors such as Fort St. Vrain. ENTOMB is not a realistic decommissioning alternative and it is not further evaluated.

3. Costs

The costs of DECON and SAFSTOR at Fort St. Vrain are identified in Table A-1. For comparison, costs for comparable decommissioning activities at PWR and BWR facilities are provided, based on information provided in the GEIS (Reference

1), NUREG/CR-0130, Addendum 4 (Reference 3) for a reference PWR facility, and in NUREG/CR-0672, Addendum 3 (Reference 4) for a reference BWR facility.

The commitment of financial resources is not the most important environmental impact of decommissioning, although it is an important consideration. The costs identified in Table A-1 illustrate that DECON is a reasonable alternative for Fort St. Vrain. For ease of comparison, the costs in Table A-1 are listed in two ways: (1) as they were published in reference documents and (2) converted to constant 1991 dollars. In order to provide a common basis for comparison, PSC adjusted certain costs as follows:

a. Table A-1 identifies costs for future activities in terms of constant dollars, without taking into account any discounting factors. This affects SAFSTOR costs and is the methodology used in the NRC's decommissioning studies for LWRs (References 1, 3 and 4). However, it is a common practice to reduce future costs by accounting for the cost of capital, so that the present value of work in the future is less than the cost of work performed in the present.

   Using cost of capital methods, the costs of SAFSTOR dismantlement activities performed in 50 years would escalate at the rate of inflation (say for example, 5 percent). However, the SAFSTOR funds set aside to cover these activities are invested at a normally higher rate (for example, 9 percent), so that the funds to be set aside to cover dismantlement activities in 50 years are less than the funds that would be needed to pay for the work today. Using this method of discounting future costs, the \$172.7 million FSV SAFSTOR cost identified in Table A-1 would be only about \$58.7 million in discounted dollars; this is comparable to the \$80.9 million estimated SAFSTOR cost previously identified in the FSV Preliminary Decommissioning Plan (which was a discounted figure).

b. Table A-1 identifies PWR and BWR decommissioning costs that have been escalated from the 1986 costs identified in References 1, 3, and 4. PSC escalated the 1986 costs using actual inflation rates of 1.90% (1986), 3.66% (1987), 4.08% (1988), 4.83% (1989), 5.40% (1990), and 4.23% (1991). This method escalates all cost components (e.g., labor, energy, and waste disposal costs) at the same rate. Although this method is not strictly accurate, it is supportive of a general cost comparison.

c. Table A-1 identifies cost differentials that would result from use of an outside contractor, since that is the method chosen by PSC for the FSV dismantlement. The decommissioning studies in References 3 and 4 estimate that the cost differential for use of an outside contractor for DECON is $14.8 million for a reference PWR (an additional 17%) and $22.9 million for a reference BWR (an additional 21%). To estimate the costs for SAFSTOR dismantlement with an outside contractor, PSC increased the PWR and BWR SAFSTOR dismantlement costs identified in References 3 and 4 by the same percentages.

d. Table A-1 identifies SAFSTOR costs for LWR facilities for a 50 year decay period. This decay period is basically the same as the 52 year decay period planned for Fort St. Vrain. The 50 year decay period costs were obtained from the PWR and BWR studies in References 3 and 4, since the GEIS (Reference 1) only identifies costs for 10, 30, and 100 year decay periods.

e. Table A-1 identifies an FSV DECON cost of $138.3 million. This cost was based on the $157.5 million cost estimate provided in the PDP, converted from future value dollars to 1991 dollars for ease of comparison. This cost includes 18 months for planning and engineering and 39 months to complete dismantlement and decontamination/ disposal activities. As described in the PDP, this cost is based on the fixed price contract between PSC and the Westinghouse project team.

The cost information discussed above and summarized in Table A-1 illustrates that DECON is a reasonable decommissioning alternative for Fort St. Vrain. The estimated cost for DECON activities at Fort St. Vrain is comparable to similar activities at a reference PWR or BWR facility. As identified in the GEIS, these costs are substantial but, in comparison to the costs of building and operating a nuclear power plant, the decommissioning costs are substantially less than the $2-plus billion and 12 years it takes to license and construct a new power plant.

The FSV SAFSTOR cost estimate differs from the LWR SAFSTOR estimates in several areas. The FSV SAFSTOR Preparation costs are substantially lower than the comparable LWR costs because, unlike the LWRs, substantial system decontamination efforts are not required to prepare the FSV reactor building for access. This is further discussed in Section 2.b above. FSV Decay Period costs are greater than those estimated for the LWRs, as the FSV estimate includes costs to retain a minimal level of qualified nuclear personnel and a minimum dedicated industrial security force. Also, FSV's annual ANI insurance premium estimate alone is greater than the annual costs estimated for the LWRs. FSV dismantlement costs are greater than the LWR costs largely because FSV waste disposal volumes will not be reduced as substantially as LWR wastes, as discussed in Section 2.b above.

It is noted here that the costs of waste disposal in the future could greatly impact the costs of the SAFSTOR option at all plants, although actual future disposal costs are difficult to predict. Waste disposal costs have historically been increasing at about 11.9% per year. Because of various uncertainties in future regulations, volume reduction techniques, and disposal site availability, this escalation rate was not taken into consideration in the Table A-1 costs. However, an 11.9% escalation rate has a cost impact that is considerably greater than the normal rate of inflation, and would substantially impact the FSV waste disposal costs that were based on $140 per cubic foot.

4. Personnel Exposure

This discussion addresses occupational exposures, exposures due to waste transportation (worker and public), and public exposures due to accidents.

4.a Occupational Exposure

The collective worker doses due to DECON and SAFSTOR activities at FSV are identified in Table A-3, along with doses for comparable activities at the reference PWR and BWR provided in the GEIS.

The primary disadvantage of the DECON alternative is the higher occupational doses when compared to other alternatives. This disadvantage at FSV is perhaps more noticeable than at LWRs because of the exceptionally low occupational doses experienced during FSV reactor operations. Due to the unique HTGR design, annual occupational doses were normally less than 3 person-rem, with the maximum annual dose being 35 person-rem during an extended outage when all 37 control rod drive mechanisms were rebuilt. Thus, the 499 person-rem that PSC estimates as a collective dose for the entire 39 month dismantlement period (433 person-rem for dismantlement plus 33 person-rem for transportation) is greater than previous or projected operational doses. Although the FSV DECON occupational dose is not bounded by normal HTGR plant operations, it is bounded by normal LWR plant operations and also by estimated LWR decommissioning doses.

The dose of 499 person-rem over 39 months for this one-time project is bounded by normal operating doses at LWRs. According to the NRC's report entitled "LWR Occupational Dose Data for 1990," the average collective annual dose at a BWR in 1990 was 433 person rem and the average collective annual dose at a PWR in 1990 was 291 person-rems. Therefore, the 499 person-rem collective dose for the 39 months of FSV DECON is less than that experienced during normal operations at an LWR.

The 499 person-rem occupational dose for DECON is also substantially less than the estimated doses for decommissioning an LWR, as provided in the GEIS. As shown in Table A-3, the estimated occupational doses for the reference PWR are 1215 person-rem for DECON and 333 person-rem for SAFSTOR. For the reference BWR, the estimated occupational doses are 1874 person-rem for DECON and 361 person-rem for SAFSTOR.

The transportation dose estimates due to the shipment of FSV waste will be described in the following section, and are based on methodology used in the GEIS.

The SAFSTOR occupational dose estimate of 22 person-rem is based on the assumption that the major remaining dose contributors will be tritium remaining in the core graphite and europium remaining in the PCRV concrete. The Co-60 dose contribution will essentially disappear. With a 8.56 year half-life for Eu-154 and a 12.3 year half-life for tritium, in 54 years the doses can be expected to decrease to less than 5% of the doses determined for DECON. The 433 person-rem DECON dose is used as a base since it is assumed that the same methodology will be used for SAFSTOR disassembly.

For decommissioning workers, external exposure to radioactive materials is the dominant exposure pathway, since inhalation and ingestion are minimized or eliminated as pathways by protective techniques, clothing and breathing apparatus.

4.b <u>Transportation Doses</u>

The FSV occupational exposure data described above includes doses from the transportation of radioactive wastes. These are estimated to be 66 person-rem to truck and train transportation workers from DECON waste shipments and 59 person-rem for SAFSTOR shipments. These estimates for radiation doses from truck and rail transport of radioactive material are based on the method given in Reference 5, which was used in the review of PWR decommissioning costs and technology (Reference 3). Consistent with Reference 3, the following assumptions are made:

1) Shipments will be made in accordance with Department of Transportation regulations (49 CFR 173.393) that set the following limits:

   - 1000 Mr/hr at 3 ft (1 m) from the external surface of the package (provided the package is transported in a closed vehicle)

   - 200 mR/hr at the external surface of the vehicle

   - 10 mR/hr at any point 6 ft (2 m) from the vehicle

   - 2 mR/hr at any normally occupied position in the vehicle.

2) Two truck drivers during a 1200 mile trip from FSV to Richland, Washington would probably spend no more than 29 hours inside the cab (12 hours assumed in Reference 3 for a 500 mile trip ratioed to a 1200 mile trip) and 2 hours outside the cab (twice the time assumed in Reference 3 for a 500 mile trip) at an average distance of about 6 feet (2 m) from the truck.

3) Normal truck servicing enroute would require that two garage men spend no more than 10 minutes about 6 ft (2 m) from a shipment.

4) Onlookers from the general public might be exposed to radiation when a truck stops for fuel or for the drivers to eat. The onlooker dose is calculated on the basis than 10 people spend an average of 3 minutes each at a distance of about 6 feet (2 m) from a shipment (0.00025 person-rem per shipment).

5) The cumulative dose to the general public from truck shipments is based on a population dose of 1.2 E-5 person-rem per km (Reference 5).

6) Train brakemen during the 1200 mile trip would probably spend 10 minutes in the vicinity of a shipping cask car during each stop. Assume an exposure rate of 25 mrem/hr at an average distance of about 3 feet (1 m) from the cask car (Reference 3). Assume two brakemen at each stop and a stop every 100 miles.

7) The onlooker dose for train shipments is based on an onlooker population of 10 people who each spend 3 minutes at an average distance of about 6 feet (2 m) from a shipment (0.00025 person-rem per shipment).

8) The cumulative dose to the general public from rail shipments is based on a population dose of 1.2 E-5 person-rem/km (Reference 5). This is the same population dose assumed for truck shipments.

The occupational and public transportation doses are presented in Table A-4. These doses are based on 385 truck shipments (as described in Reference 2) and 12 rail shipments (one for each steam generator) made to the radioactive waste disposal facility in Richland, Washington. LWR decommissioning estimates in the GEIS include at least five times the waste projected for FSV DECON. This results in greater doses to transportation workers and the general public. It is noted that the transportation route from FSV passes through rural areas (the only urban area along the route is Ogden, Utah), so the estimated public doses are considered very conservative.

The FSV DECON occupational doses for transportation are less than those for LWR DECON (66 person-rem for FSV versus 102 person-rem for a PWR and 110 person-rem for a BWR. However, the FSV SAFSTOR transportation doses are greater (59 person-rem for FSV versus 12 person-rem for a PWR and 24 person-rem for a BWR). This is because the FSV waste volume assumptions for SAFSTOR are based on the concrete cutting methodology and not on the remaining activity level.

PSC considers that all other risks associated with transportation of FSV wastes, whether from DECON or SAFSTOR, are bounded by the analyses in the GEIS. The number of shipments is less than that considered for the reference PWR and BWR facilities. Also, the types of shipments and packaging, and the limits on shipment inventories are both bounded by the same DOT regulations. PSC plans to make about 385 truck shipments over a distance of 1200 miles. This distance is greater than the 500 miles evaluated in the GEIS, but the number of shipments is much less than the 1363 shipments evaluated for the reference PWR and 1495 for the reference BWR. Therefore the accident risks to workers and the public for FSV waste shipments will be no greater than that evaluated in the GEIS.

4.c Public Doses - Normal

Three important radiation exposure pathways need to be considered in the evaluation of the radiation safety of normal reactor decommissioning activities: inhalation, ingestion, and external exposure to radioactive materials. The GEIS concludes that inhalation would be the dominant pathway for public radiation exposure at an LWR. As described in the tritium discussion, at FSV the dominant pathway for public exposure is ingestion of foods containing tritium, transported from tritiated water released into the environment. Although this is the dominant pathway, it is not significant since releases will be controlled to maintain river concentrations within EPA safe drinking water limits and to ensure that public doses do not exceed the limits of 40 CFR 190.

The amount of tritium estimated to be released as liquid effluent is 500 Curies for DECON. This is greater than the liquid effluent tritium releases made during plant operations. As identified in the previous discussion on tritium releases, FSV typically released around 200 Curies of tritium in liquid effluent during plant operation, with a peak annual release of 370 Curies in 1983. This release is bounded, however, by annual releases typically made at many PWRs. As identified in Reference 6, at least a dozen PWRs in the United States typically release over 500 Curies per year and two facilities typically release several thousand Curies of tritium in liquid effluent each year.

For SAFSTOR, much of the radioactivity would have decayed and shielding water may not be needed. If PCRV shielding water were used, the amount of tritium released in liquid effluent would be substantially reduced. Based on a 54 year decay of 100,000 Curies of tritium in the core graphite, and assuming a 0.5% release rate, 28 Curies of tritium would be released as liquid effluent during SAFSTOR.

The Committed Effective Dose Equivalent (CEDE) to the maximally exposed member of the public has been calculated to be 0.27 mrem from all reasonable pathways during DECON, due to a release of 500 Curies of tritium in liquid effluent. An additional calculation was performed for the hypothetical case where one of the beef cattle that graze near the plant and could drink liquid effluent is consumed; the CEDE from consumption of this beef is calculated to be 2.3 mrem. These doses are described in the discussion on tritium releases provided elsewhere in this submittal.

The inhalation radiation dose to the public from airborne radionuclide releases during DECON is estimated to be negligible, as it was in the GEIS. As described in the PDP and in the Decommissioning Technical Specifications, PSC will maintain the reactor building in a subatmospheric condition with filtered ventilation during activities that could hypothetically create airborne releases. This will minimize the release of airborne contaminants to the public.

4.d <u>Public Doses - Accidents</u>

Potential doses to the maximally exposed member of the public from postulated accidents are identified in PDP Section 3.4. For DECON, the first year doses are a maximum of:

121 mrem whole body and
215 mrem lung,

due to a fire of packaged waste outside the reactor building and within the Emergency Planning Zone where the airborne releases cannot be filtered.

For SAFSTOR at FSV, the maximum public doses have been determined to be:

4.75 mrem whole body and
4.77 mrem lung,

also due to a fire outside the reactor building.

These doses are greater than the LWR decommissioning accident doses presented in the GEIS, where the highest accident doses were:

3.6 E-2 mrem for the reference PWR and
9 E-2 mrem for the reference BWR.

The FSV postulated accident doses are considerably greater than the LWR accident doses, largely due to conservatisms included in the FSV calculations. For example, PSC assumed an atmospheric dispersion factor of 3.5 E-2, where the LWR calculations used a factor of 6.5 E-4; use of the LWR dispersion factor would reduce the FSV calculated doses by a factor of 50.

The postulated FSV DECON accident doses are substantially less than the potential doses to the public from postulated operational accidents. The highest bounding dose identified in the FSV FSAR is a 2.5 rem whole body dose. This dose is identified in FSAR Section 14.11 for the maximum hypothetical accident, a rapid depressurization of the PCRV.

5. Waste Volume

Waste volumes for decommissioning are estimated as follows (in cubic feet):

FSV DECON	128,000
FSV SAFSTOR (52 yrs)	115,000
PWR DECON	648,000
PWR SAFSTOR (50 yrs)	65,000
BWR DECON	670,000
BWR SAFSTOR (50 yrs)	63,000

LWR waste values were obtained from the GEIS, converted from cubic meters.

As discussed in Section 2.b above, the FSV SAFSTOR waste volume estimate is not substantially reduced from the DECON waste volume, which is significantly different from the LWR assumptions. This is largely due to the fact that the continued presence of Eu-154 in the PCRV concrete will require its removal during SAFSTOR dismantlement activities. PSC would plan to use the same concrete removal methodology for SAFSTOR as will be used for DECON. This involves removing the PCRV concrete inside the inner row of tendon tubes and will not significantly reduce the required disposal volumes.

The FSV DECON waste estimate is greater than the waste generated during plant operation. The Final Environmental Statement estimated that approximately 400 cubic feet of solid waste per year would be released. However, the FSV DECON waste volume is considerably less than the waste volumes projected for LWR DECON activities.

6. Environmental Consequences

Radiation doses and costs associated with possible FSV decommissioning alternatives are discussed above. In the cases of both DECON and SAFSTOR, the FSV environmental effects of greatest concern (i.e., radiation dose and radioactivity released to the environment) are substantially less than the same effects resulting from normal LWR operation and maintenance. They are also substantially less than the effects of LWR decommissioning.

A major environmental consequence of decommissioning, other than radiation dose and dollar cost, is the commitment of land area to the disposal of radioactive waste. The waste volumes identified for FSV DECON or SAFSTOR can be accommodated in less than 2 acres of shallow-land burial. Two acres is a small area in comparison with the 2798 acres at the FSV site, and also in comparison with the approximately 50 acres occupied by the fenced area of the plant and other plant buildings, storage ponds, parking lots, and switchyard equipment.

Other environmental consequences of decommissioning are minor compared to the environmental consequences of building and operating a nuclear facility, particularly an LWR. Water use and evaporation are reduced. The Final Environmental Statement discusses an operating cooling tower evaporation rate of as much as 2300 gpm, and this is the largest flow rate that is contemplated for dilution of tritiated water released during decommissioning. This water will not be lost since it will be returned to the downstream surface waters.

The number of workers on site at any time will be no greater than when FSV was in operation. The transportation network is generally in place, but would likely require some future maintenance if SAFSTOR were chosen. Transportation of steam generators by rail will require upgrading the rail spur into the site for any dismantlement option, but this is considered a minor activity.

Disturbance of the ground cover will not take place to any appreciable extent, except for some small degree of soil remediation that may be required to remove any contamination that might be found. The Initial Radiological Site Characterization Program results are still inconclusive about whether any soil remediation will be required. This activity would likely be required for both DECON and SAFSTOR.

The socioeconomic impacts on the surrounding communities are not significantly different for either DECON or SAFSTOR. In either case, PSC plans to convert the facility to a natural gas-fired generating station, so the local tax base will not be greatly affected. There will be significant activity shortly after the completion of reactor defueling for either alternative. For DECON, radioactive components and systems will be dismantled and the plant will be converted for generation. For SAFSTOR, the PCRV and certain radioactive components will be prepared for long term safe storage and the plant will be converted for generation. This would then be followed by a dismantlement period from 2043 until 2046.

7. Summary Comparison of Decommissioning Alternatives

The decommissioning alternative proposed for Fort St. Vrain is DECON. The discussion in Section 6 above shows that the environmental consequences of both DECON and SAFSTOR are acceptable and, with the exception of radiation exposures, basically the same, largely due to the similarity in dismantlement methodologies for the two alternatives.

Table A-5 provides a summary comparison of the DECON and SAFSTOR alternatives for Fort St. Vrain and for reference PWR and BWR facilities. The cost of FSV DECON is less than the cost of FSV SAFSTOR on a constant dollar basis. However, when the cost of capital is taken into consideration, the present value FSV SAFSTOR cost is less than the cost of FSV DECON. The FSV DECON cost is comparable to the DECON costs identified for LWRs. Also, although FSV DECON results in greater worker and public exposures than FSV SAFSTOR, the worker doses are less than those for DECON activities or even for normal operations at LWRs. The potential public doses resulting from postulated DECON accidents at Fort St. Vrain are greater than those postulated for LWRs, but they are less than those identified for accidents while Fort St. Vrain was operating. The amount of tritium released in liquid effluent is considerably greater for FSV DECON than it is for FSV SAFSTOR.

The chief advantage of DECON over SAFSTOR is that it removes the uncertainties associated with future disposal costs and regulatory requirements. Also, DECON does not encumber future generations with the responsibility for this action.

In general, the environmental impacts are minimal in comparison with accepted impacts of operating and decommissioning LWR power plants. No site specific characteristics were identified that would result in environmental impacts that would be significantly different from those studied generically. The impacts of DECON at Fort St. Vrain are not significantly different from the impacts of DECON at reference LWR facilities (as identified in the GEIS) and these impacts do not significantly affect the human environment.

8. References

1. Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, NUREG-0586, August 1988

2. Applicant's Environmental Report, Post Operating License Stage, Supplement for Decommissioning, July 1991, submitted via PSC Letter, Crawford to Weiss, dated July 10, 1991 (P-91219)

3. Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station, NUREG/CR-0130, 1978, through Addendum 4, 1988

4. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station, NUREG/CR-0672, 1980, through Addendum 3, 1988

5. Environmental Safety of Transportation of Radioactive Materials to and From Nuclear Power Plants, Directorate of Regulatory Standards, WASH-1238, 1972

6. Radioactive Materials Released from Nuclear Power Plants, Brookhaven National Laboratory, NUREG/CR-2907, BNL-NUREG-51481, 1988

DECOMMISSIONING COSTS

(Costs are in millions)

Activity	Previously Published Cost: Utility Staffing	Previously Published Cost: Use of External Contractor	PSC Determined Levelized Cost(1) - 1991 Dollars - Use of External Contractor
FSV			
DECON	--	157.5 (2)	138.3
SAFSTOR			
- Preparation	--	--	2.6 (3)
- Decay Period	--	--	37.6 (4)
- Dismantlement	--	--	132.5
SAFSTOR TOTAL	--	--	172.7 (3)
SAFSTOR Present Value			58.7 (5)
PWR (6)			
DECON	88.7	103.5	131.0
SAFSTOR			
- Preparation	21.8	27.5	34.8
- Decay Period (7)	6.4	6.4	8.1
- Dismantlement	40.5	47.4 (8)	60.0
- Other Costs (9)	4.8	4.8	6.1
SAFSTOR TOTAL	73.5	86.1 (8)	109.0
BWR (10)			
DECON	108.9	131.8	166.9
SAFSTOR			
- Preparation	41.0	50.9	64.4
- Decay Period (11)	6.0	6.0	7.6
- Dismantlement	48.3	58.4 (12)	73.9
- Other Costs (13)	4.6	4.6	5.8
SAFSTOR TOTAL	99.9	119.9 (12)	151.8

Explanatory Notes are on the following page.

Table A-1

Notes for Table A-1:

1. The Levelized Costs have been adjusted from published data for ease of comparison. All levelized costs are provided in 1991 dollars and reflect use of an external contractor.
2. The \$157.5 million cost for FSV DECON is in future dollars, based on when they are spent. Reference PDP Section 5.2.3.
3. The FSV SAFSTOR costs do not include the sunk costs and costs to terminate the Westinghouse contract that would be actual PSC SAFSTOR costs if the SAFSTOR alternative were selected today. These additional costs would bring the total FSV SAFSTOR cost to \$196.6 million, in 1991 dollars.
4. FSV Decay Period costs based on \$723,000 per year for 52 years, as illustrated on the following Table A-2. Includes NRC Licensing charges.
5. FSV SAFSTOR Present Value determined by escalating 1991 cost at projected inflation rates of about 5%, and discounting that figure back at 9%.
6. Published PWR costs obtained from NUREG/CR-0130, Addendum 4 and NUREG-0586, except for contractor costs for dismantlement. SAFSTOR costs are for a 50 year SAFSTOR period. Published Costs are in 1986 dollars.
7. Decay Period costs based on \$128,000 per year identified in NUREG/CR-0130, Addendum 4, for 50 years.
8. Dismantlement contractor cost determined by increasing the 40.5 Million cost for utility staffing by 17%, which is the cost differential between utility staff and contractor costs for PWR DECON dismantlement activities.
9. Other Costs include pre-decommissioning engineering costs and NRC Licensing Activity charges (approximately \$0.01 million per year, per NUREG-0586, Table 4.3-1).
10. Published BWR costs obtained from NUREG/CR-0672, Addendum 3 and NUREG-0586, except for contractor costs for dismantlement. SAFSTOR costs are for a 50 year SAFSTOR period. Published costs are in 1986 dollars.
11. Decay Period costs based on \$120,000 per year identified in NUREG/CR-0672, Addendum 3, for 50 years.
12. Dismantlement contractor cost determined by increasing the 48.3 Million cost for utility staffing by 21%, which is the cost differential between utility staff and contractor costs for BWR DECON dismantlement activities.
13. Other Costs include pre-decommissioning engineering costs and NRC Licensing Activity charges (approximately \$0.01 million per year, per NUREG-0586, Table 5.3-1).

ANNUAL FSV SAFSTOR DECAY PERIOD COSTS

Staffing w/overheads (1 professional, 1 craft, minor management involvement)	130,000
Security (2 guards/shift, 4 shifts)	240,000
Insurance (Based on ANI conversations)	200,000
Environmental Monitoring (50% of current program)	68,000
Utilities (domestic water, housepower)	25,000
Maintenance (Building maintenance)	40,000
NRC Charges (Annual inspections)	20,000
TOTAL Annual Costs	723,000

Table A-2

OCCUPATIONAL DOSES

Activity	Dose (person-rem) DECON	SAFSTOR
FSV		
Dismantlement/Decon	433	22
Transportation	66	59
Total	499	81
PWR		
Dismantlement/Decon	1115	321
Transportation	100	12
Total	1215	333
BWR		
Dismantlement/Decon	1764	337
Transportation	110	24
Total	1874	361

Notes:

1. LWR data from NUREG-0586, Final Generic Environmental Impact Statement.
2. LWR SAFSTOR data is for 30 year storage period, the closest data given in the GEIS to the planned 54 year period at FSV.

Table A-3

TRANSPORTATION DOSES

	FSV		PWR		BWR	
	DECON	SAFSTOR	DECON	SAFSTOR	DECON	SAFSTOR
Occupational (person-rem)						
Truck Drivers	62	55	95	10	100	21
Garage men	3	3	4	0.4	5	1
Trainmen	1	1	3	2	5	2
Total	66	59	102	12	110	24
Public (person-rem)						
Onlookers	0.1	0.1	7	1	7	2
General Public	9	8	15	2	3	1
Total	9	8	22	3	10	3
Number of Shipments						
Truck	385	358	1363	139	1495	318
Train	12	12	28	-	43	-
Distance (miles)						
Truck	1200	1200	500	500	500	500
Train	1200	1200	1500	1500	1500	1500

Notes:
1. PWR data from NUREG/CR-0130, Decommissioning the Reference PWR, Section 11
2. BWR data from NUREG/CR-0672, Decommissioning the Reference BWR, Appendix N
3. "-" means information is not identified in the references

Table A-4

DECOMMISSIONING SUMMARY TABLE

	FSV		PWR		BWR	
	DECON	SAFSTOR	DECON	SAFSTOR[5]	DECON	SAFSTOR[5]
Cost (in $ millions) (1,2)	138.3	172.7[3]	131.0	109.0	166.9	151.8
Worker Exposure (collective, person-rem)						
Dismantlement/Decon	433	22	1115	321	1764	337
Transportation	66	59	100	12	110	24
Total	499	81	1215	333	1864	361
Public Exposure						
Transportation (collective, person-rem)	9	8	22	3	10	3
Accident[4] (individual, mrem)	121	5	3.6E-2	2.1E-4	9.0E-2	9.0E-2
Waste Volume (cubic feet)	128,000	115,000	648,000	65,000	670,000	63,000

(1) Constant 1991 Dollars
(2) Includes use of an outside contractor
(3) Does not include $23.9 million in sunk costs and costs required to terminate current DECON contracts; present value is $58.7 million in discounted dollars.
(4) Worst case possible accident exposures to maximally exposed individual. Doses are first year whole body exposure data, except BWR doses are lung doses.
(5) 50 year SAFSTOR data for costs and waste volumes, 30 year SAFSTOR exposure data.

NRC General Comment:

PSC's review should assure that the ER Supplement considers and analyzes each of the issues identified in 10 CFR 51.45 to provide the NRC staff with a comprehensive analysis of the environmental effects for your proposed decommissioning plans.

PSC Response:

10 CFR 51.45(b) states that "The environmental report shall contain a description of the proposed action, a statement of its purposes, a description of the environment affected, and discuss the following considerations:

(1) The impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance;

(2) Any adverse environmental affects which cannot be avoided should the proposal be implemented;

(3) Alternatives to the proposed action. The discussion of alternatives shall be sufficiently complete to aid the Commission in developing and exploring, pursuant to section 102(2)(E) of NEPA, "appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." To the extent practicable, the environmental impacts of the proposal and the alternatives should be presented in comparative form;

(4) The relationship between local short-term uses of the human environment and the maintenance and enhancement of long-term productivity; and

(5) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

The discussion of many of these considerations has been provided either in the original submittal of the Applicant's Environmental Report, Post Operating License Stage, Supplement for Decommissioning (called the ER Supplement, for the remainder of this discussion) in July 1991, or in the material provided previously in this submittal. Due to the often lengthy nature of these discussions, information provided previously will generally be incorporated by reference and will not be repeated in its entirety.

1. DESCRIPTION OF PROPOSED ACTION

The proposed action is to decommission the Fort St. Vrain Nuclear Generating Station by use of the early dismantlement and decontamination alternative (DECON). The descrir ion of PSC's planned DECON activities is provided in Section 3 of the ER Supplement, and is further described in the Proposed Decommissioning Plan and in PSC's written responses to NRC questions.

DECON is the immediate removal and disposal of all radioactivity in excess of levels which would permit release of the facility for unrestricted use. As described in the PDP, the FSV site will not be completely torn down and restored to a corn field. The non-radioactive equipment and structures will generally be retained and converted, as necessary, for potential future use as a natural gas-fired generating station. Much of the piping and equipment in the reactor building will not be removed even though it is not needed for the converted plant, because it is expected to be readily decontaminated and released for unrestricted use. The end result is the release of the site and any remaining structures for unrestricted use as early as 39 months after the end of reactor defueling.

2. PURPOSE OF PROPOSED ACTION

The purpose of DECON, as identified in Section 1.1 of the ER Supplement, is to reduce residual radioactivity to a level that permits release of the Fort St. Vrain facility for unrestricted use, and that also permits termination of the license.

3. DESCRIPTION OF ENVIRONMENT AFFECTED

A description of the affected environment is provided in Section 4.1 of the ER Supplement. Overall, the areas directly affected by decommissioning Fort St. Vrain include the following:

1) The same areas on the Fort St. Vrain site that were disturbed during plant construction and operation. This site is located in Weld County, Colorado, between the South Platte River and the St.Vrain Creek, approximately 3-1/2 miles northwest of Platteville and 35 miles north of Denver.

2) Radioactive low level waste disposal site(s) that will likely be the same sites used during plant operation, and in any case will be licensed for this purpose.

3) The same transportation routes that were used during plant construction or during plant operation.

4) The same replacement power sources that were utilized during plant operation.

4. DISCUSSION OF ENVIRONMENTAL CONSIDERATIONS

4.1. IMPACTS OF PROPOSED ACTION

The impacts of DECON activities at Fort St. Vrain are addressed in Sections 4 and 5 of the ER Supplement and in the information provided in previous sections of this submittal. In general, the impacts of decommissioning the facility will be positive. The facility will be released for unrestricted use and relatively small amounts of burial space (approximately 2 acres) will be committed for waste disposal. This space is small compared to the approximately 50 acres occupied by plant buildings, ponds, and other facilities.

The costs in dollars and occupational radiation exposure are generally small in comparison to decommissioning costs and operational exposures at light water reactor facilities. Also, the impacts on the environment due to planned releases of tritium are minimized by ensuring that downstream surface water tritium concentrations do not exceed the EPA Safe Drinking Water Standard of 20,000 pCi/l (40 CFR 141).

4.2. ADVERSE ENVIRONMENTAL EFFECTS

Detailed descriptions of the impact of the Fort St. Vrain decommissioning are found in the following Environmental Report Supplement sections:

4.4 Ambient Air Quality

4.5 Effects of Chemical and Biocide Discharges

4.6 Effects of Sanitary Waste Discharges

4.7 Endangered Species

4.8 Other Effects (noise, runoff, socioeconomic)

5.0 Environmental Impacts of Accidents

Additionally there are a number of decommissioning related environmental impact drivers. The term "impact drivers" as used here refers to the precursors to possible environmental impacts. For example, the incremental work force needed to accomplish decommissioning activities is not an environmental impact, per se, but the resultant effects on housing, transportation, schools, etc., are environmental impacts (Reference 1). The environmental impact drivers for decommissioning are:

- Labor hours and work force size
- Labor costs
- Occupational radiation exposure
- Capital costs (hardware, materials and equipment used during decommissioning)
- Radioactive waste volumes

Labor Hours and Work Force Size

The staffing plan for professionals and crafts labor includes a total of 487 man-years of support by professionals and up to 120 craftsmen per quarter involved in the decommissioning operations. These figures are a net decrease from operations during nuclear power generation.

Labor Costs

It is estimated that over $138 million will be spent on the decommissioning project and as much as 20 percent of that amount is expected to accrue to the local economy.

Occupational Radiation Exposure

A summary of occupational radiation exposure (ORE) estimates for Fort St. Vrain decommissioning is provided in Table 4.3-1 of the ER Supplement. The total exposure is 433 person-rem for dismantlement, as detailed in ER Supplement Table 4.3-2. An additional 66 person-rem is estimated for transportation, for a total of 499 person-rem. These numbers, while not large, are greater than the actual ORE history for a similar period of time during FSV power operation. However, these ORE rates are comparable to ORE rates occurring in the nuclear power industry.

Capital Costs

Most of the hardware, materials, and equipment used during decommissioning will be purchased out of state by the project team. Thus, no positive impact is expected on the local tax base from purchase of major system components. There will, however, be a positive impact on the local tax base from the mobilization of professionals and craft labor to the FSV decommissioning site.

Radioactive Waste Volumes

The expected volume of solid radioactive waste produced is nearly 128,000 cubic feet. This consists of 113,972 cubic feet from the PCRV and 13,991 cubic feet from the Balance of Plant (BOP). These values are detailed in ER Supplement Tables 3.4-3 and 3.4-4.

The radioactive waste volumes associated with a reference BWR and PWR are 670,000 cubic feet and 648,000 cubic feet respectively (Reference 2). This represents a burial ground area of less than two acres for a reference LWR.

The expected burial ground area for the radioactive wastes from Fort St. Vrain decommissioning is considerably less than two acres. This is a small area when compared to the release for unrestricted use of the approximately 50 fenced acres occupied by the plant buildings and structures.

4.3. ENVIRONMENTAL IMPACTS FROM ALTERNATIVES TO PROPOSED ACTION

The environmental impacts from both the DECON and SAFSTOR alternatives are discussed in PSC's response to NRC question No. 3, provided previously in this submittal.

The SAFSTOR alternative considered for Fort St. Vrain involves a brief SAFSTOR preparation period, a decay period until 2043, and a dismantlement period from 2043 to 2046. The FSV plant can be prepared for the 52 year decay period by removing a few components from the prestressed concrete reactor vessel (PCRV) such as the helium circulators and the control rod drives, and then seal welding shut all of the penetrations to the PCRV. The decay period involves general industrial security provisions, typical industrial facility inspections, and general building maintenance. The final dismantlement methodology will be the same for SAFSTOR as is planned for DECON.

The decay period allows most of the radioactive materials to decay away, but remote handling techniques will still be required. Because of the reduced levels of radiation, SAFSTOR results in lower doses to workers (22 person-rem versus 433 person-rem for dismantlement workers), and lower levels of tritium released in liquid effluent (28 Curies versus 500 Curies). The waste volume is not significantly reduced, however, because the dismantlement methodology will remove the same amount of PCRV concrete as for DECON. The cost of SAFSTOR in constant 1991 dollars is $172.7 million, which is greater than the $138.3 million cost of DECON in constant 1991 dollars. However, by accounting for the cost of capital, the present value cost of SAFSTOR in discounted 1991 dollars is $58.7 million.

4.4. LOCAL SHORT TERM USES VERSUS LONG-TERM PRODUCTIVITY

Short-Term Uses

Section VIII of the Final Environmental Statement (FES) Related to the Operation of the Fort St. Vrain Nuclear Generating Station concluded that the short term effects from construction included erosion from freshly graded ground, unavoidable heavy traffic, and noise. While it is expected that decommissioning will also result in some of the same short term effects, these effects, as well as additional ones, were evaluated in Section 4 of the ER Supplement. Specifically, the following effects were evaluated:

1. Ambient air quality
2. Noise
3. Effects of chemical and biocide discharge
4. Effects of sanitary waste discharge
5. Endangered species
6. Runoff
7. Socioeconomic

However, as discussed in Section 4.0 of the ER Supplement, these short term effects are expected to be less pronounced than the effects from construction and possible continued plant operation. Therefore, it is concluded that the short term use of the decommissioning area by decommissioning workers will not adversely affect the productivity of the local area.

Long-Term Productivity

The Fort St. Vrain site consists of 2798 acres owned by PSC. Approximately 600 acres within the site area is designated as the industrial complex, containing the reactor and power producing facility, of which only about 50 acres are fenced. The reactor building occupies only a few acres within the industrial complex. Farming has been continued on the remaining site areas, including a portion of the industrial area.

PSC does not intend to make the reactor area available for any use other than power production. The facility includes a switchyard and transmission lines that are an integral part of PSC's electric power distribution system, and will not change with FSV decommissioning. Also, the FSV site includes an Independent Spent Fuel Storage Facility (ISFSI) which is currently in use and is licensed through November 30, 2011. The decommissioned site will be retained indefinitely as an industrial complex. Therefore, there is no conflict between short term uses and the long term productivity of the FSV site.

4.5. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The generic implications of decommissioning power reactors were evaluated by the NRC in NUREG-0586 (Reference 2). The NRC concluded that:

"Decommissioning of nuclear facilities is not an imminent health and safety problem. Decommissioning of a nuclear facility generally has a positive environmental impact. At the end of facility life, termination of a nuclear license is the goal. Termination requires decontamination of the facility so that the level of any residual radioactivity remaining in the facility or the site is low enough to allow unrestricted use of the facility and site. Commitment of resources, compared to operational aspects, is generally small. The major environmental impact of decommissioning is the commitment of small amounts of land for waste burial in exchange for reuse of the facility and site for other purposes."

This is also true for Fort St. Vrain since decommissioning of the facility does not involve the commitment of any significant amount of resources. The facility, after decommissioning, will continue to occupy the same space that was previously evaluated in the NRC's Final Environmental Statement (FES) for operation of the plant, with the addition of approximately two acres for waste disposal at a licensed waste burial site. No resources not previously considered in the FES are required for decommissioning.

4.6. PROPOSED ACTION AND ALTERNATIVES

The alternatives considered for decommissioning are DECON and SAFSTOR. These alternatives and the associated environmental impacts are discussed in PSC's response to NRC RAI question No. 3, provided previously in this submittal. The conclusion of the discussion is that DECON is a reasonable decommissioning alternative for Fort St. Vrain, and the associated environmental impacts are less than those evaluated for decommissioning and operation of typical Light Water Reactor facilities.

The cost of DECON at FSV is less than the cost of SAFSTOR on a constant dollar basis, but when the cost of capital is taken into consideration, the present value SAFSTOR cost is less expensive than DECON. The FSV DECON cost is comparable to the DECON costs identified for LWRs.

Although DECON results in greater worker and public exposures than SAFSTOR, the worker doses are less than those for DECON or even for normal operations at LWRs. The potential public doses resulting from postulated DECON accidents at FSV are greater than those postulated for LWRs, but they are less than those identified for hypothetical accidents while FSV was operating. DECON results in greater amounts of tritium released in liquid effluent than SAFSTOR, but the planned release of 500 Curies of tritium during DECON is comparable to typical releases at numerous operating PWR facilities.

The chief advantage of DECON over SAFSTOR is that it removes the uncertainties associated with future disposal costs and regulatory requirements. Also, DECON does not encumber future generations with the responsibility for this action.

In general, the environmental consequences of DECON at Fort St. Vrain are not significant when compared with accepted consequences of operating and decommissioning LWR power plants. No site specific characteristics were identified that would result in environmental impacts that would be significantly different from those studied generically. The impacts of DECON at Fort St. Vrain are not significantly different from the impacts of DECON at LWRs, and they do not significantly affect the human environment.

5. REFERENCES

1. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, NRC, August 1991

2. Generic Environmental Impact Statement for Decommissioning Nuclear Facilities, NUREG-0586, NRC, 1988