EE-DEC-0020
REV A

FORT ST. VRAIN
SITE SPECIFIC
DECOMMISSIONING COST ESTIMATE
BASIS FOR
PRELIMINARY DECOMMISSIONING PLAN

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1.0 PURPOSE

The purpose of this engineering evaluation (EE) is to document the decommissioning cost estimate that was submitted in the Preliminary Decommissioning Plan (Ref. Letter P-89228). Only costs associated with decommissioning are the subject of this engineering evaluation.

2.0 SUMMARY

The various phases of decommissioning were reviewed and the estimated costs during each period were determined. The costs were outlined in Tables 1 thru 4 for each of the four periods of decommissioning. The four decommissioning periods, time frames, and associated costs are as follows:

1) Defueling and component removal period, 1988-1993, $19,554,000.

2) Fuel storage period, 1993-2019, $16,148,000.

3) PCRV decay period, 2021-2043, $9,794,000.

4) PCRV decontamination/dismantlement period, 2044-2046, $34,571,000.

These costs were then summarized on Table 5 to show what the yearly costs were expected to be. The details of the cost estimate were included in Attachment A to this engineering evaluation.

3.0 SCOPE

This cost estimate was based on the following defueling and decommissioning scenario for FSV:

Defueling and Component Removal Period:

- FSV is permanently shutdown and defueling is started at the end of March, 1990.

- Defueling is completed by October, 1992.

- A six month component removal period follows defueling. Contaminated systems are cleaned-up, the control rod drive and orificing assemblies and the helium circulators are removed and disposed of and the plant is readied for SAFSTOR during this period.

Fuel Storage Period:

- The plant is kept in a SAFSTOR mode until the year 2044. During this period, it is assumed spent fuel is stored on-site in an Independent Spent Fuel Storage Installation (ISFSI) until the year 2020, at which time it is transferred to the Federal Repository.

PCRV Decay Period:

- The PCRV residual radioactivity continues to decay.

Decontamination/Dismantlement Period:

- The remaining contaminated portions of the plant including the PCRV are decontaminated and dismantled during a 31 month period starting in the year 2044.

- The 10CFR Part 50 license is terminated in the year 2046.

Only costs associated with decommissioning as defined by the Draft Regulatory Guide DG-1003 were included in this cost estimate. Other costs associated with defueling and storage of spent fuel were not included.

MAJOR COST ESTIMATE ASSUMPTIONS

- Salvage value for any equipment or materials was not assumed or taken credit for.

- The cost estimate was based on bringing the plant to a state in which all materials are free-releasable based on the radiation levels of the materials. The cost of bringing the plant site down to the original corn field was not included (ie. the cost of tearing down the major structures was not included).

- It was assumed that existing facilities would be used whenever possible, such as the hot service facility. Existing buildings would be used for construction office space and storage space.

- It was assumed that the site was not used by any other function such as converting the usable turbine side of the plant into a fossil fired facility.

- It was assumed that the fuel is stored in an ISFSI using dry storage casks and the salvage value or resale value of the dry storage casks offset the cost of decontaminating or disposing of the casks after they were used in the year 2020.

- It was assumed that decommissioning costs were associated with the removal or decontamination of all radioactive material down to unrestricted release limits. Costs for the removal of fuel from the PCRV and the storage of fuel on-site and the appropriate fuel storage supporting costs were not considered decommissioning related.

- Many of the costs were estimated in 1987 dollars. Therefore, all costs were escalated to 1989 dollars. Escalation factors of 1.041 for 1988 and 1.05 for 1989 were used based on PSC Financial estimates for the Consumer's Price Index for All Urban Consumers as forecasted by Data Resources Inc.

- Technology for remote dismantling of portions of the PCRV to unrestricted releasable limits exists today and was assumed to take place in the year 2044. Costs for this dismantlement phase were based on a feasibility study performed by a Contractor. A summary of this study is included in Attachment B. A cost sensitivity study was performed and all the high range costs associated with the base radwaste volume were assumed from that study except in the area of waste disposal costs. For these costs, the base case disposal costs were assumed for the base radwaste volume.

- A contingency was assumed to be 25% for all costs except those for PCRV dismantlement, where contingencies ranged from 20% to 140%.

- PSC personnel were assumed to remove some of the PCRV internal components and operate and maintain systems as required. All other decommissioning labor was assumed to be performed by contract workers.

- Contract labor pricing was assumed to be $50 per hour except for the estimates from the dismantlement study which detailed the labor pricing. (Ref. Attachment B.)

- The cost for shipping of low level waste was assumed to be $2,400/shipment. The burial cost was assumed to be $150/cu. ft.

- A 15% fee was assumed for the contractor performed component removal and PCRV decontamination/dismantlement work.

- Unrestricted-release limits were assumed as follows:

  - Reg. Guide 1.86 was used for surface contamination

  - A value of 10 mRem/yr or 5 micro R per hour was assumed for materials remaining on the site after release.

4.0 APPROACH

In terms of the cost estimate, there were basically four periods associated with decommissioning of FSV. The first period, called the defueling and component removal period began in 1990 and was the period in which the fuel and some PCRV components were assumed to be removed. These components included the control rods and drives and the helium circulators. In addition, the contaminated systems outside of the PCRV were assumed to be cleaned up during this period. Following the defueling and component removal period came a period called fuel storage. During this period, fuel segment 9 was assumed to be stored on-site in an ISFSI since no location was available for permanent storage until the Federal Repository was built and available. Fuel was predicted to remain on-site until the year 2020. Once the fuel was moved from the site, the PCRV was allowed to sit and decay for an additional 25 year period to allow the internal radiation levels to decay to minimize exposures and reduce the amount of contaminated material to be removed. This 25 year period was identified as the PCRV decay period. Finally, the PCRV was assumed to be dismantled and decontaminated during the fourth and final period. This period was called the decontamination and dismantle period and was estimated to last for 31 months.

The costs were estimated and broken down into categories which included burial costs, O&M costs, capital costs and labor costs. The costs were also broken into two categories; those related to decommissioning as defined by the NRC and those other costs not associated with decommissioning which would still be incurred by PSC. The costs not associated with decommissioning were not the subject of this engineering evaluation. Some of the costs were clearly associated with decommissioning. Some of the indirect overhead costs were not clearly separable into decommissioning and non-decommissioning costs so these costs were usually shared. All of the costs were then tabulated in the summary tables which were included in this engineering evaluation.

5.0 EVALUATION

All of the details of the cost estimate were included in Attachment A of this engineering evaluation. Details of the PCRV dismantlement feasibility and cost study were included in Attachment B.

6.0 CONCLUSION

A summary of the cost estimate was included on Tables 1 thru 5. The tables contain the following information:

Table 1-Detailed cost of the Defueling Period
Table 2-Detailed cost of the Fuel Storage Period
Table 3-Detailed cost of the Decay Period
Table 4-Detailed cost of the Decon/Dismantle Period
Table 5-Yearly costs associated with Decommissioning

DECOMMISSIONING COST SUMMARY Rev. Date 20-Jan-89

DEFUELING AND COMPONENT REMOVAL PERIOD (In $1000's, $1989)

PRELIMINARY DECOMMISSIONING PLAN BASIS

DIRECT COSTS	BURIAL	O&M	CAPITAL	LABOR	TOTAL COST
CRDOA Removal	$584	$342	$0	$3,396	$4,322
Helium Circulators	$38	$2	$0	$58	$98
Helium Purif & Decon Sys	$105	$11	$0	$99	$215
Liquid & Gas Waste Sys	$79	$7	$0	$111	$196
Misc Contaminated Sys	$23	$2	$0	$28	$53
Fire Protection Sys	$0	$0	$164	$682	$846
INDIRECT COSTS					
Security Force	$0	$3	$6	$1,073	$1,082
Decon Matl's & Equip	$0	$69	$0	$0	$69
Plant O&M	$0	$216	$0	$1,960	$2,176
Pre-Decommissioning	$0	$865	$0	$959	$1,824
Consultants	$0	$14	$0	$155	$169
PSC Labor	$0	$200	$0	$1,714	$1,914
Insurance	$0	$2,679	$0	$0	$2,679
TOTAL DIRECTS & INDIRECTS	$828	$4,410	$170	$10,235	$15,643
CONTINGENCIES	$207	$1,103	$42	$2,559	$3,911
TOTAL 1989 DOLLARS	$1,035	$5,513	$212	$12,794	$19,554

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FUEL STORAGE PERIOD (In $1000's, $1989)
PRELIMINARY DECOMMISSIONING PLAN BASIS

DIRECT COSTS	BURIAL	O&M	CAPITAL	LABOR	TOTAL COST
Balance of Plant	$0	$696	$0	$1,452	$2,147
INDIRECT COSTS					
Plant O&M	$0	$544	$0	$0	$544
Consultants	$0	$2,117	$0	$0	$2,117
PSC Labor	$0	$60	$0	$7,022	$7,082
Insurance	$0	$1,512	$0	$0	$1,512
TOTAL CONSTR & INDIRECTS	$0	$4,929	$0	$8,474	$13,403
CONTINGENCIES	$0	$1,232	$0	$2,118	$3,351
TOTAL 1989 DOLLARS	$0	$6,162	$0	$10,592	$16,754

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PCRV DECAY PERIOD (In $1000's, $1989)
PRELIMINARY DECOMMISSIONING PLAN BASIS

DIRECT COSTS	BURIAL	O&M	CAPITAL	LABOR	TOTAL COST
Balance of Plant	$0	$478	$0	$1,156	$1,634
INDIRECT COSTS					
Security Force	$0	$0	$0	$0	$0
Plant O&M	$0	$126	$0	$0	$126
Consultants	$0	$1,257	$0	$0	$1,257
PSC Labor	$0	$16	$0	$2,288	$2,304
Overheads	$0	$0	$0	$0	$0
Insurance	$0	$2,514	$0	$0	$2,514
TOTAL CONSTR & INDIRECTS	$0	$4,391	$0	$3,444	$7,835
CONTINGENCIES	$0	$1,098	$0	$861	$1,959
TOTAL 1989 DOLLARS	$0	$5,488	$0	$4,305	$9,794

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DECONTAMINATION/DISMANTLE PERIOD (In $1000's, $1989)
PRELIMINARY DECOMMISSIONING PLAN BASIS

DIRECT COSTS	BURIAL	O&M	CAPITAL	LABOR	TOTAL COST
Core Components	$2,717	$638	$0	$2,234	$5,589
PCRV Components	$2,667	$7,452	$0	$9,436	$19,555
INDIRECT COSTS					
Security Force	$0	$140	$0	$1,059	$1,199
Plant O&M	$0	$68	$0	$0	$68
Prepare Activity Spec	$0	$455	$0	$0	$455
Contractor Fee (15%)	$0	$3,772	$0	$0	$3,772
Consultants	$0	$403	$0	$0	$403
PSC Labor	$0	$39	$0	$3,139	$3,178
Overheads	$0	$0	$0	$0	$0
Insurance	$0	$353	$0	$0	$353
TOTAL CONSTR & INDIRECTS	$5,384	$13,319	$0	$15,867	$34,571
CONTINGENCIES	$0	$0	$0	$0	$0
TOTAL 1989 DOLLARS	$5,384	$13,319	$0	$15,867	$34,571

DECOMMISSIONING COST SUMMARY Rev. Date 20-Jan-89

YEARLY DECOMMISSIONING COSTS (In $1000's, $1989)

PRELIMINARY DECOMMISSIONING PLAN BASIS

YEAR**	BURIAL	O&M	CAPITAL	LABOR	CONTINGENCY	TOTAL
DEFUELING & COMPONENT REMOVAL PERIOD						
1988	$0	$277	$0	$71	$87	$436
1989	$0	$636	$0	$887	$381	$1,904
1990-BEGIN D/F (MAR)	$0	$930	$170	$0	$275	$1,375
1991	$0	$1,496	$0	$0	$374	$1,870
1992-BEGIN C/R (NOV)	$0	$873	$0	$3,092	$991	$4,956
1993-END C/R (APR)	$828	$198	$0	$6,185	$1,803	$9,014
SUB TOTAL	$828	$4,410	$170	$10,235	$3,911	$19,554
FUEL STORAGE PERIOD						
1993 (MAY) THRU 2019	$0	$178	$0	$306	$121	$606
SUB TOTAL	$0	$4,751	$0	$8,167	$3,230	$16,148
FUEL SHIPPING PERIOD						
2020	$0	$178	$0	$306	$121	$606
SUB TOTAL	$0	$178	$0	$306	$121	$606
PCRV DECAY PERIOD						
2021 THRU 2043	$0	$191	$0	$150	$85	$426
SUB TOTAL	$0	$4,391	$0	$3,444	$1,959	$9,794
PCRV DECONTAMINATION/DISMANTLE PERIOD						
2044	$2,084	$5,156	$0	$6,142	$0	$13,382
2045	$2,084	$5,156	$0	$6,142	$0	$13,382
2046 (JUL)	$1,216	$3,008	$0	$3,583	$0	$7,806
SUB TOTAL	$5,384	$13,319	$0	$15,867	$0	$34,571
			TOTAL ACCUMULATED DECOM COST			$80,672

ATTACHMENT A

DETAILS OF THE COST ESTIMATE

ALL PERIODS

Several costs were used from a previous cost estimate which were originally in 1987 dollars. Therefore, the costs from the previous cost estimate were escalated from 1987 to 1989 dollars. Based on information from PSC Long Term Finance, the following escalation factors were used:

1988--- 1.041
1989--- 1.050

This gives a total escalation of 1.041 x 1.050 = 1.093

This is denoted as "i" in this attachment in all costs which were escalated to $1989.

All continuing costs which are constant over a period of time for the various periods are broken down into per month or per year averages. These average costs are multiplied by the period duration in order to determine the total cost. This period duration is denoted as "t" in all costs where this is applicable.

DEFUELING PERIOD COSTS

Period duration: Defueling period (D/F) = 34 months
Component removal period (C/R) = 6 months

CRDOA REMOVAL:

These costs are considered to be decommissioning costs. These costs are spread over the component removal period evenly except where specifically identified. The costs are summarized on Table A1. The labor and O&M costs included in this category are in support of CRDOA removal. Therefore, costs include support organizations such as plant operations, engineering, QA, health physics, licensing, planning and scheduling, maintenance and training along with fuel deck personnel performing the CRDOA removal.

BURIAL: During the last 6 months, the control rod drive assemblies will be removed from the PCRV, shipped and buried.

CRD assemblies	= 78.5 cu. ft. x 44 =	3454 cu. ft.
CRD absorbers	= 20.0 cu. ft. x 22 =	440 cu. ft.
	TOTAL BURIAL =	3894 cu. ft.

O&M costs: O&M costs include the costs associated with the Labor O&M of \$300,000/yr x i (or approx. \$27,000/mo), the cost of component shipping (see below) and, the cost of storage liners for the RCDs in the FSW of \$45,000 x i.

For component shipping cost: The CRD absorbers are assumed to be separated from the assemblies and shipped via the shielded FSV-1 casks (2/cask). The assemblies are then shipped via conventional means.

CRD absorber strings = \$104,000 total (based on past experience using FSV-1 cask)
CRD assemblies = 11 shipments

Labor costs: A total labor cost of \$6,200,000/yr x i (or approx. \$566,000/mo) is incurred due to the component removal work.

HELIUM CIRCULATORS:

These costs are considered to be decommissioning costs. These costs are spread over the component removal period evenly except where specifically identified. It is planned that the lower sections of the helium circulators be removed from the PCRV as soon as possible. This can be done once the fuel is removed from the PCRV. The four circulators in the penetrations will have to be removed and all five circulators (including the spare) will have to be buried as low level waste. The following costs are estimated and are summarized on Table A-1.

Burial:
Volumes: The main assembly is assumed to be put into a sleeve whole and buried. The assembly is approx. 64" long by 40" dia.

Volume = (64" x 3.14 x 20" x 20")/1728 cu in/cu ft
= 47 cu. ft/ circ
= 250 cu. ft for all five circulators approximately

O&M costs:
Included in the O&M costs are the costs for shipping of the circulators. For the helium circulators, it is assumed that 5 circulators can be shipped in 1 shipment using a flat bed truck.

Labor cost:
The total labor cost includes the cost to remove the 4 circulators from the PCRV and the cost to disassemble the circulators for shipping. The fifth circulator must be shipped and disposed of but it is located out-of-core as a spare. It is assumed that no decontamination work is performed.

Total Estimated Labor cost = $58,000

HELIUM PURIFICATION AND DECONTAMINATION SYSTEMS: SYSTEMS 23 & 61

These costs are considered to be decommissioning costs. These costs are spread over the component removal period evenly except where specifically identified.

The costs associated with the decontamination of the helium purification system and the decontamination system are included here. For some contaminated components, removal and burial would be less expensive and easier than decontamination and these cost are also included here. All of the costs are summarized on Table A-1.

O&M costs include expenses for decon work = \$2000/week
Labor costs for decon work = \$26,000/week

Purification/Decon system, time estimate for decontamination efforts = 3 weeks
Labor cost for decon = 3 week x \$26,000/wk = \$78,000
O&M cost for decon = (3 week x \$2000/wk) x i = \$7,000 approx.

In addition to decontamination efforts, it is predicted that some of the purification train components, including the regeneration compressor and decon pumps, will have to be removed and buried. It is estimated that 518 m-h are required to remove the entire system 23. Assuming that only 30% of system 23 will have to be removed, the cost for removal is approx:

Cost = 518 m-h x .3 x \$50/hr = \$7770 or approx \$8000
For system 61, an estimated 96 m-h are required to remove the decon pumps
Cost = 96 m-h x \$50/hr = \$4800 or approx \$5000

Therefore, a total labor cost for decontamination and removal efforts = (\$78,000 + \$8000 + \$5000) x i = \$99,000 (Labor)

Burial costs:
It is estimated that a total of 700 cu. ft will have to be buried. The waste volume for system 61 is negligible.

The waste will have to be shipped and it is assumed 2 shipments will be required.

LIQUID AND GAS WASTE SYSTEMS: SYSTEMS 62 & 63

These costs are considered to be decommissioning costs. These costs are spread over the component removal period evenly except where specifically identified. The costs associated with the decontamination of the liquid and gas waste systems are included here. For some contaminated components, removal and burial would be less expensive and easier than decontamination and these costs are also included here. All of the costs are summarized on Table A-1.

O&M costs include expenses for decon work = \$2000/week
Labor costs for decon work = \$26,000/week

Liquid and gas waste system time estimate for decontamination efforts = 2 weeks
Labor cost for decon = 2 week x \$26,000/wk = \$52,000
O&M cost for decon = (2 week x \$2000/wk) x i = \$4,000 approx.

In addition to decontamination efforts, it is predicted that some of the liquid waste and gas waste system components, including the pumps and some valves, will have to be removed and buried. It is estimated that 192 m-h are required to remove system 62 pumps, 2050 m-h for system 62 piping and valves, 144 m-h for system 63 pumps and 4492 m-h for system 63 piping and valves. Since only selected valves require removal, assume only 10% of the estimated man hours for all the system piping and valves is required. Therefore, the cost for removal is approx:

Cost = (192 + 2050 x .1 + 144 + 4490 x .1)m-h x \$50/hr = \$49,500
or approx. \$50,000 for the removal of system 62 & 63 components
(labor cost)

Therefore, a total labor cost for decontamination and removal efforts = (\$52,000 + \$50,000) x i = \$111,000 (approx. labor)

Burial costs:
It is estimated that a total of 75 + 450 cu. ft will have to be buried for system 62 & 63 respectively.

The waste will have to be shipped and it is assumed 1 shipment will be required.

MISC CONTAMINATED SYSTEMS:

These costs are considered to be decommissioning costs. These costs are spread over the component removal period evenly except where specifically identified. The costs associated with the decontamination of the fuel storage wells, fuel handling machine, auxiliary transfer cask and equipment storage wells are included here. For some contaminated components, removal and burial would be less expensive and easier than decontamination and these costs are also included here. All of the costs are summarized on Table A-1.

O&M costs include expenses for decon work = \$2000/week
Labor costs for decon work = \$26,000/week

Misc. contaminated systems, time estimate for decontamination efforts = 1 week
Labor cost for decon = 1 week x \$26,000/wk = \$26,000
O&M cost for decon = (1 week x \$2000/wk) x i = \$2000 approx.

In addition to decontamination efforts, it is predicted that some parts of the fuel handling machine and ATC (grapple heads etc) will have to be removed and buried. Removal costs for these components will be small and are ignored for this cost estimate. Therefore, a total labor cost for decontamination and removal efforts = $26,000 x i = $28,400 = $28,000 approx.

Burial costs:
It is estimated that a total of 50 cu. ft will have to be buried for the fuel handling machine and 100 cu. ft for the ATC.

The waste quantity is small and is assumed to be shipped with other shipments.

FIRE PROTECTION SYSTEM:

These costs are considered to be decommissioning costs. These costs are spread over the component removal period evenly except where specifically identified. The costs included here are the costs associated with modification of fire protection system so adequate fire protection can be provided throughout the SAFSTOR period. The exact fire protection measures which will be required are not defined at this time so the following assumptions and costs will be used for the cost estimate:

Capital = $150,000 x i = $164,000, this is an assumed cost for any modifications (yet undefined) which may be required to bring the system to its proper configuration.

Labor = (3 men x 8 hr/day x $50/hr x 5days/week x 52 week/yr x 2 yr) x i = $682,000, this is an approximate cost for removing all flammable materials including congested cable areas during the period of component removal.

SECURITY FORCE:

This cost is shared as a decommissioning cost and a non-decommissioning cost. The cost is spread out evenly over the entire defueling and component removal period except where specifically identified.

The decommissioning portion of these costs are as follows:

O&M Cost = $3,000
Capital Cost = $6,000
Labor Cost = $1,073,000

DECON MATERIALS & EQUIPMENT:

These costs are considered to be decommissioning costs. These costs are spread over the component removal period evenly except where specifically identified. The costs included in the category are those costs for the rental of decontamination materials and equipment to be used in the decontamination effort of the systems identified above. The cost is considered an O&M cost since it is the rental of such equipment. It has been estimated that equipment is required at a rate of $10,500/week for a period of 6 weeks total. The total cost is therefore $63,000 x i = $69,000.

PLANT O&M:

This cost is shared as a decommissioning cost and a non-decommissioning cost. The decommissioning portion is spread out evenly over the entire component removal period except where specifically identified. The amount of the cost charged to decommissioning is proportional to the amount of direct cost which was charged to decommissioning for each category. The Plant O&M costs include all of the costs associated with maintaining the plant systems functional during the defueling period. Actual cost center data was taken for the first 5 months of 1987 and averaged over the year. Then an estimated future adjusted average was used to determine an estimated future cost during the component removal period. In reality, the costs would gradually decline from 100% of the yearly average costs at the time of reactor shutdown to the minimal staffing at the end of the component removal period. However for this cost estimate, an average for all support staffs has been assumed and will be applied over the entire period to determine the total Plant O&M cost.

The PSC cost centers which were considered to be Plant O&M were the following:

-4500, Division Manager
-4510, Station Manager
-4511, Supt. Operations
-4512, Supt. Maintenance
-4519, Nuclear Betterment Engineering
-4538, Reactor Maintenance

The adjusted average factors are discussed below.

- Cost center 4538, reactor maintenance, all costs are considered 0 since the direct costs associated with CRDOA removal have already accounted for these costs.

- Cost center 4510, station manager, a few special costs are included for this cost center and are discussed below:

  Fuel oil - This cost is expected to remain high at a level of 30% of current costs. This is expected to drop from 100% since the auxiliary boilers will not be used to supply the amount of steam used during operation to various components but will be required to supply steam for building heat during the winter months.

  Water - This cost is expected to remain high also at a level of 40%. Water will not be required at near the quantity for make-up to the condensate, service water and circulator water systems as during normal operation. However, water will still be required for domestic use and for decontamination and flushing of systems as they are prepared for SAFSTOR.

  Electric power - This cost is assumed to drop to a level of 50% since many of the components are not used or are used with a lower power demand than during power operation.

- Manpower, This cost was assumed to be 30% on average for the period except for nuclear betterment which was assumed to be lower due to the decrease in calibration and surveillances required.

- Employee expenses, These costs are assumed to drop to 10% since some overtime meals etc. are expected for these cost centers.

- Contract, The only cost center expected to use contract labor is maintenance and this is assumed to drop to 10%.

- Material, The costs for materials for most cost centers is expected to drop to 10% or 5% due to the decreased activity and procurement of new items and tools.

- Transportation, Transportation costs are assumed to drop to 0 except for the division manager cost center who may still attend a few meetings and maintenance who may require shipping of some materials.

- Equipment, Equipment costs are assumed to drop to 10% due to decreased activity.

- Space, Space costs are assumed to drop to 0 for all cost centers except nuclear betterment due to reduced staffs. Nuclear betterment is assumed to drop to 25% since they will still require trailers for space part of the time.

- Service, All service is assumed to drop to 0 except for some in maintenance. This is due to reduced staffing requirements and elimination of special studies or services which were required during power operation.

The manpower costs were summed to determine the total labor costs for these cost centers and the remaining costs were charged as O&M costs. The costs were then split between decommissioning and non-decommissioning and the final costs associated with decommissioning are as follows:

O&M cost = \$5,400/mo
Labor cost = \$49,000/mo

O&M cost = \$5,400/mo x (34 mo + 6 mo) = \$216,000
Labor cost = \$49,000/mo x (34 mo + 6 mo) = \$1,960,000

The costs are calculated over the entire period since some decommissioning work will take place during the entire period. The costs are charged only to the component removal period however.

PRE-DECOMMISSIONING:

These costs are considered to be combined non-decommissioning and decommissioning costs. The decommissioning portion of the costs is 60% and the non-decommissioning portion is 40% (see below). The Pre-decommissioning costs are those costs, both PSC labor and outside consultants, which are required for the planning of decommissioning and defueling operations. The cost breakdown for the year 1988 and those expected for 1989 are shown below. Once defueling has started, all planning dollars are included in the general Plant O&M and PSC Labor Categories.

The following costs are based on the decommissioning job order for the year 1988:

Consultants (Jan-Nov)	= \$347,000	
PSC Labor (Jan-Nov)	= \$131,000	
Expected Consultants (Dec)	= \$231,000	
Expected PSC Labor (Dec)	= \$ 17,000	
Total 1988 cost	= \$726,000	(actual \$1988)
Total 1988 consultant	= \$578,000	(O&M cost)
Total 1988 PSC labor	= \$148,000	(Labor cost)

Of the total consultant cost, approximately \$363,000, or approximately 60%, of the total consultant cost is associated with decommissioning. The remainder is associated with defueling. Therefore, assume 60% of the total consultant cost and PSC cost is associated with decommissioning and the remaining 40% is not associated with decommissioning for both the years 1988 and 1989. The above costs are actual costs, so they must be divided by the contingency so the final costs in the yearly breakdowns reflect actual costs since the total is multiplied by the contingency.

For the year 1989, the following is planned for the budget for the decommissioning cost center:

Decommissioning consultants	= \$ 600,000
Misc. consultants (defueling)	= 380,000
PSC labor	= \$1,480,000

Approximately 60% of the consulting costs is associated with decommissioning, so the above assumption about 60% for decommissioning is valid. The expected 1989 costs are multiplied by the contingency in the end like all other costs.

Total O&M cost = \$578,000/1.25 + \$980,000 = \$1,442,000

Total Labor cost = \$148,000/1.25 + \$1,480,000 = \$1,598,000

For the above costs, 60% is allocated to decommissioning.

CONSULTANTS:

This cost is shared as a decommissioning cost and a non-decommissioning cost. The cost is spread out evenly over the entire component removal period except where specifically identified.

All of the consultant costs for studies during this period should be covered by the pre-decommissioning costs. Once defueling has started, there appears to be no costs associated with consultants except the associated environmental monitoring program (which is assumed to be continued by Colorado State University, CSU), the auditing programs (which is assumed to be continued by an outside party) and some contract labor support as identified below. These QA and environmental costs are categorized as O&M costs with the maintenance cost categorized as labor.

The decommissioning portion of these costs are as follows:

Environmental monitoring	= $ 8,000
QA auditing	= $ 6,000
Total O&M	= $ 14,000

Contract Maintenance labor = $155,000

PSC LABOR:

This cost is shared as a decommissioning cost and a non-decommissioning cost. The cost is spread out evenly over the entire component removal period except where specifically identified. The amount of the cost charged to decommissioning is proportional to the amount of direct cost which was charged to decommissioning for each category.

The PSC Labor costs included all of the costs associated with support organizations that are required during the component removal period. Actual cost center data was taken for the first 5 months of 1987 and averaged over the year. Then an estimated future adjusted average was assumed to determine an estimated future cost during the component removal period. In reality, the costs would gradually decline from 100% of the yearly average costs at the time of reactor shutdown to the minimal staffing at the end of the component removal period. However, for this cost estimate, an average for all support staffs has been assumed and will be applied over the entire period to determine the total PSC labor cost.

The PSC cost centers which were considered to be PSC labor were the following:

- 4514, Planning and scheduling
- 4530, Tech admin service manager
- 4531, Security
- 4532, Nuclear documents supr
- 4534, Technical services
- 4536, Supr tech service engineering
- 4537, Plant engineering
- 4539, Emergency Preparedness
- 4540, Support services manager
- 4541, Health physics
- 4542, Radiochemistry
- 4543, FSV water chemistry
- 4545, Supr training
- 4546, Operator training
- 4547, Technical training
- 4548, Training support
- 4700, Nuclear Engineering
- 4800, Manager, nuclear licensing and fuels

The adjusted average factors are discussed below.

- Cost center 4531, Security, All costs are considered 0 since the direct costs associated with security are listed separately.

- Manpower, This cost was assumed to be 20% on average for the period for a majority of the cost centers. Emergency preparedness, technical training and training support are assumed to be required only at a level of 10%. On the other hand, due to the large amount of radioactive materials being handled, it was assumed that health physics would be required at a level of 80% and radiochemistry at 40%. In addition, due to the modifications that are required and the shutting down of systems, it was assumed 30% of engineering would be required.

- Employee expenses, These costs are assumed to drop to 0% for most cost centers and 10% for the cost centers which may experience some overtime meals etc.

- Contract labor, This cost is assumed to drop to 0% for all cost centers.

- Material, The costs for materials for most cost centers is expected to drop to 0% or 5% due to the decreased activity and procurement of new items and tools. It is assumed to drop to a level of only 30% for nuclear documents due to the continuation of paper work, and 20% for support services. Due to the radioactive materials handling, 80% is assumed for health physics and 20% for radiochemistry. Due to the draining of all liquid systems, a level of 30% was assumed for water chemistry.

- Transportation, Transportation costs are assumed to drop to 0 except for engineering and licensing who may still attend a few meetings with the NRC and consultants and health physics who may require shipping of some materials.

- Equipment, Equipment costs are assumed to drop to between 0% and 30% due to decreased activity.

- Space, Space costs are assumed to drop to 0 for all cost centers except tech services, training, engineering and licensing due to decreased staffing levels. Those cost centers requiring space are assumed to drop to 20% or 30% since they will still require trailers or office space part of the time.

- Service, All service is assumed to drop to 0 except for the following. This is due to reduced staffing requirements and elimination of special studies or services which were required during power operation. Services at a level of 20% is assumed for nuclear documents due to the paper work continuing, 20% is assumed for tech services for computer support, 50% is assumed for health physics and 80% for radiochemistry for support due to the volume of radioactive waste, 20% for training outside support, 1% for engineering due to the reduction of projects and 5% for licensing for continued outside licensing support.

The manpower costs were summed to determine the total labor costs for these cost centers and the remaining costs were charged as O&M costs. The costs were then split between decommissioning and non-decommissioning and the decommissioning portion of the final costs are as following:

O&M cost = $5000/mo
Labor cost = $42,800/mo

O&M cost = $5000/mo x (34 mo + 6 mo) = $200,000
Labor cost = $42,800/mo x (34 mo + 6 mo) = $1,714,000

INSURANCE:

The cost of insurance is arbitrarily assumed to be 50% decommissioning cost and 50% non-decommissioning incurred cost as long as fuel remains on site and is considered an O&M cost.

The decommissioning portion of insurance is assumed to be the following:

Cost = $77,500/mo during defueling

Cost = $ 7,300/mo during component removal

The cost is calculated and spread out over the entire defueling and component removal periods. Therefore, the total cost is:

Insurance cost = $77,500/mo x 34 mo
+ $7,300/mo x 6 mo

= $2,679,000

CONTINGENCIES is an additional cost added to the entire cost estimate to cover all unknown costs. An industry average of 25% is used for this cost estimate.

SAFSTOR

FUEL STORAGE PERIOD COSTS

AND

PCRV DECAY PERIOD COSTS

Note: All of the following costs are spread out over the entire period and are defined in terms of an annual cost multiplied by the period duration.

The fuel storage period is defined as the period when the contaminated PCRV is intact and awaiting delayed dismantling and the fuel is being stored on-site in the ISFSI. In this period, FSV would have 10CFR Part 50 and Part 72 licenses. Duration = 27 yr. + 8 mo.

The PCRV decay period is defined as the period after which the fuel is shipped off-site and only the contaminated PCRV remains intact awaiting delayed dismantlement. In this period, FSV would have a 10CFR Part 50 license only. Duration = 23 yrs.

BALANCE OF PLANT:

These costs are considered decommissioning costs. For the periods with fuel on-site, the costs associated with maintaining all of the systems operational (other than those at the fuel storage facility) are listed below:

SUMMARY OF SYSTEMS,
MODIFICATIONS AND COSTS

	O&M COSTS PARTS	O&M COSTS LABOR	CAPITAL COSTS
System 16-ATC*	0	5200	0
System 41-Circ water make-up	0	7600	0
System 44-Domestic water	0	1000	0
System 45-Fire protection	100	6100	0
System 72-Building sump	17700	9300	0
-Building cranes	1000	5200	0
System 75-Fire pump house HVAC	0	500	0
-Building sump	0	100	0
-Building cranes	500	2600	0
TOTAL COST	$19300	$37600	$0

* The ATC will probably not be required but the cost is included to be conservative.

O&M cost = $19,300/yr or approx $19,000/yr
Labor cost = $37,600/yr or approx $38,000/yr

In addition, it is assumed for this evaluation that the Tech support center would be used for office space for the site assigned personnel. Therefore, the following additional costs are required:

O&M cost = $3500/yr or approx $4000/yr
Labor cost = $1500/yr or approx $2000/yr

In addition, the cost of performing the surveillance and calibrations on the fire detection system and fire water pumps was not included above. Assume it will take 2 men 5 days to do the work twice a year.

Cost = 2 men x 5 days/surv x 2 surv/yr x 8 hr/day x \$50/hr = \$8000/yr (labor)

Total O&M cost with fuel on-site = \$19,000/yr + \$ 4,000/yr = \$23,000/yr
Total labor cost with fuel on-site = \$38,000/yr + \$ 2,000/yr + \$ 8,000/yr = \$48,000/yr

For the period when the fuel is off-site, it is assumed for this evaluation that the Tech support center would not be used for office space for the site assigned personnel since the number of personnel will be much less than during the previous periods. All other costs remain the same.

Total O&M cost with fuel off-site = \$19,000/yr
Total labor cost with fuel off-site = \$38,000/yr + \$8000/yr = \$46,000/yr

FUEL STORAGE PERIOD

O&M cost = \$23,000/yr x i x t

Labor cost = \$48,000/yr x i x t

These costs are considered decommissioning costs since most of the activity is associated with maintaining the shutdown buildings and contaminated PCRV on-site.

PCRV DECAY PERIOD
O&M cost = \$19,000/yr x i x t
Labor cost = \$46,000/yr x i x t
These costs are considered decommissioning costs since all of the activity is associated with maintaining the shutdown buildings and contaminated PCRV on-site.

PLANT O&M:

This cost is considered a decommissioning cost. The only item which this cost covers is the house power required. All other costs of maintaining and operating plant systems is already covered in Balance of Plant or in PSC Labor.

Approximate electrical loads are as follows for the periods when fuel is on site:

- Security lighting = 10 kw
- Tech support center heating load = 144 kw, cooling load = 40 ton = 480,000 btu/hr = 140 kw
- misc loads = 5 kw
- Total loads = 160 kw approx

Use 1/2 of this value as a yearly night and day average.
Cost = 80 kw x 24 hr/day x 365 day/yr x $.025/kwhr = $17,520 or approx $18,000/yr

For the PCRV decay period when all fuel is removed from the site, approximate electrical loads are assumed to be 20 kw for this cost estimate. This load should be small since trailers or a small building would probably be used for the onsite personnel and no security lighting should be required.

Cost = 20 kw x 24 hr/day x 365 day/yr x $.025/kwhr = $4380/yr or approx $5000/yr

FUEL STORAGE PERIOD
O&M cost = $18,000/yr x i x t

PCRV DECAY PERIOD
O&M cost = $5,000/yr x i x t

CONSULTANTS:

This cost is considered as a decommissioning cost. For the periods with fuel on-site, the only costs associated with consultants are the costs to perform the environmental monitoring program and audits.

Estimated auditing cost = $30,000/yr
Estimated Environmental monitoring cost = $40,000/yr
Total cost with fuel on-site = $30,000 + $40,000/yr = $70,000/yr

After the fuel is off-site, the same frequency and cost to perform the environmental monitoring is assumed for the PCRV decay period as the fuel storage period. As far as auditing goes, it is assumed that only one audit is required every two years at $20,000/audit.

Auditing cost = $20,000/audit x 1 audit/2 years = $10,000/yr
Environmental monitoring cost = $40,000/yr
Total cost with fuel off-site = $10,000/yr + $40,000/yr
= $50,000/yr

FUEL STORAGE PERIOD
O&M cost = \$70,000/yr x i x t

PCRV DECAY PERIOD
O&M cost = \$50,000/yr x i x t

PSC LABOR:

This cost is shared as a decommissioning cost and a non-decommissioning cost. The amount of the cost charged to decommissioning is proportional to the amount of direct cost which was charged to decommissioning for each category.

The following staffing requirements are assumed for FSV during the period when the contaminated PCRV (Part 50 license) and the ISFSI (Part 72 license) are both on-site:

Position	# of people	\$/yr	Total
Plant Manager	1	\$50,000	\$50,000
Decom. Supp/Plan Supr	1	35,000	35,000
Engineer	1	35,000	35,000
Licensing Engineer	1	35,000	35,000
HP Tech.	1/2	35,000	17,500
Secretary/Admin. Supp.	1	30,000	30,000
I&C Tech.	1/2	20,000	10,000
QA Engineer	1/2	35,000	17,500
Total	6 1/2		\$230,000

78% of the above costs were assumed to be charged to decommissioning. These costs do not include overhead charges for benefits, insurance, etc., so these wage amounts shall be increased by 30%.

Total period costs = \$230,000/yr x 1.3 x .776 for labor.

A factor of .74% will be assumed to be required for misc. O&M costs

Total period cost = \$230,000/yr x 1.3 x 0.0074 = \$2,000/yr
approx. for O&M

In the case where the PCRV is still on-site but the fuel has been removed off-site, the following staffing requirements are assumed for FSV during the PCRV decay period:

Position	# of people	$/yr	Total
Engineer	1/2	35,000	17,500
Professional (NED, Licensing, QA etc.)	1	35,000	35,000
HP Tech.	1/2	35,000	17,500
Total	2		$70,000

Total period costs = $70,000/yr x 1.3 for labor. A factor of .74% will be assumed as before to be required for misc. O&M costs.

Total period cost = $70,000/yr x 1.3 x 0.0074 = $500 x 1.3 approx. for O&M

FUEL STORAGE PERIOD
O&M cost = $2,000/yr x i x t
Labor cost = $230,000/yr x 1.3 x .776 x i x t

PCRV DECAY PERIOD
O&M cost = $500/yr x 1.3 x i x t
Labor cost = $70,000/yr x 1.3 x i x t

INSURANCE:

The cost of insurance is arbitrarily assumed to be 50% decommissioning cost and 50% PSC incurred cost as long as fuel remains on site. When fuel is off-site but the contaminated PCRV remains on-site, the insurance cost is 100% decommissioning. It is assumed to be categorized as an O&M cost.

An estimated cost of approximately $100,000/yr will be used in this cost estimate for the cost of insuring FSV once fuel is removed from the core.

FUEL STORAGE PERIOD
O&M cost = (1000,000/yr x i x t)/2

PCRV DECAY PERIOD
O&M cost = $100,000/yr x i x t

CONTINGENCIES

As stated before, a 25% contingency factor is applied to all costs.

COMPONENT REMOVAL & DECONTAMINATION/DISMANTLE PERIOD COSTS

Note: Most of the following costs are spread out over the entire period and are defined in terms of a monthly cost multiplied by the period duration.

The PCRV decontamination/dismantle period is defined as the period when the contaminated PCRV is decontaminated and dismantled to a free release limit for all materials. In addition, component removal tasks (dummy blocks, reflector blocks, and steam generators) are also performed during this period. The duration of the period is 31 months.

CORE COMPONENTS, STEAM GENERATORS:

This cost is considered a decommissioning cost. The costs associated with core components involve a contractor performing the work of removing the dummy fuel blocks, reflector blocks and steam generators in conjunction with the dismantling of the PCRV as described below. The contractor would remove the top of the PCRV and remove the above components using the same equipment used to dismantle the remaining portions of the PCRV as described below. In addition, the contractor would also perform the work of removal and disposal of the steam generators. The costs used in this EE are based on a study which is summarized in Attachment B to this EE. The costs are based on a contractor performing the work and are assumed to be linear over the project duration. The high radwaste volume costs are used due to the low probability that the dummy blocks, helium circulators and steam generators can be decontaminated for free release (which is the basis for the base radwaste volume). The high case costs for the high radwaste volume are used for everything except burial to account for unforeseen contingencies. For the burial cost, the base case costs for the high radwaste volume are used since $150/cu. ft. seems reasonable for a predicted burial cost. The contingency is included in the cost since the high range costs are assumed.

Burial costs:

To obtain the burial cost for delayed dismantlement subtract the burial cost for the circulators ($38,000) and the CRDs ($584,000) from the total cost (Table B-7).

Burial cost = $3,339,000 - 38,000 - 584,000 = $2,717,000

Labor costs:

These costs include the cost of manual and non-manual labor. Subtract the costs for events 11.4, 11.5, 11.18, 11.19 of the study since this work was already completed. (Ref. Tables B5 & B7)

Labor cost = $687,000 + $1,708,000 - $52,800 - $17,700 - $34,100 - $56,600 = $2,234,000

O&M Costs:

These costs include the cost of equipment and services. Subtract the costs for events 11.4, 11.5, 11.18, and 11.19 of the study since this work was already completed. (Ref. Tables B5 & B7)

O&M Cost = \$706,000 - \$7,500 - \$800 - \$59,400 = \$638,000

Note: \$706,000 is approximately \$509,000 + \$184,000

PCRV COMPONENTS:

This cost is considered a decommissioning cost. The following section determines the cost associated with the decontamination and/or dismantlement of all the remaining PCRV components whose radiation level still exceeds that for materials which could be free released. The plan would involve removal (labor cost), shipping (O&M cost) and burial (burial cost) of the contaminated components. The activation analysis and the plateout study predicts that the following components would have to be removed and buried:

- large side reflector blocks
- boronated spacer blocks
- core barrel
- insulation and cover plates
- core support posts and blocks
- core support floor
- liner
- a portion of the PCRV concrete

The costs used in this EE are based on a study that was performed which is summarized in Attachment B of this EE. The costs are based on a contractor performing the work and are assumed to be linear over the project duration. The base radwaste volume costs are used since they appear to be most reasonable. The high case costs for the base radwaste volume are used for everything except burial to account for unforeseen contingencies. For the burial cost, the base case costs for the base radwaste volume are used since \$150/cu. ft. seems reasonable for a predicted burial cost. The contingency is included in the cost since the high range costs are assumed.

Burial costs:

The study included in Attachment B evaluated dismantlement of the PCRV after 5 years following reactor shutdown. For a 50 year SAFSTOR period, it was assumed that all internal PCRV components (except the concrete) assumed to be disposed of in the study will still require disposal. For the concrete, the activation analysis showed that very little to no concrete will require removal after 50 years of decay. Therefore, very little concrete was assumed to be buried. This later proved to be an inaccurate assumption. Based on the current activation analysis, approximately 18" of concrete on the side walls will require disposal. This results in an approximate volume of 5700 cubic feet of concrete. The resulting cost would be $855,000 which is small compared to the total cost and is covered by the contingencies. For the estimate, the following was assumed. A ratio of the concrete volume and total waste volume assumed in the report was used to determine burial costs. The concrete volume to the total volume is: % concrete = 8628/26,672 cu ft = 1/3 approx. Therefore, assume only 2/3 of original burial cost at 50 years. (Ref. Table B-7)

Burial cost = $4,001,000 x 2/3 = $2,667,000

O&M Costs:

These costs include the cost of transportation, equipment and services: (Ref. Table B-7)

O&M Cost = $7,236,000 + $216,000 = $7,452,000

Labor costs:

These costs include the cost of manual and non-manual labor: (Ref. Table B-7)

Labor cost = $2,696,000 + $6,740,000 = $9,436,000

SECURITY FORCE:

This cost is considered a decommissioning cost. Since portions of the facility will be dismantled during this period and large quantities of contaminated materials will be handled during this period, security personnel will be assumed to be required. It will be assumed for this cost estimate that security at a level shown below is required for this dismantling/decontamination period. A 25% contingency is added.

O&M = (2 x \$20,000/yr x i)/12 x 1.25 x t
= \$3,300/mo x i x t x 1.25

Labor cost = (2 x \$150,000/yr x i)/12 x 1.25 x t
= \$25,000 x i x t x 1.25

PLANT O&M:

This cost is considered a decommissioning cost. The only item which this cost covers is the house power required during the PCRV dismantlement period. All other costs of maintaining and operating plant systems is already covered in PSC Labor.

Approximate electrical loads are as assumed to be 100 kw for this cost estimate.

Cost = 100 kw x 24 hr/day x 365 day/yr x \$.025/kwhr = \$21,900/yr or approximately \$22,000/yr

Total period cost = (\$22,000/yr x i)/12 x t = \$2,000/mo x i x t approximately. (considered an O&M cost)

PREPARE ACTIVITY SPEC:

This cost is considered a decommissioning cost since it is planning work for dismantling the PCRV. This cost is associated with the writing of the specification and contract which will detail the work that must be performed during the dismantling/decontamination of the PCRV. This spec will then be converted into detailed work packages which will specify the actual work steps to be taken during dismantling and decontaminating the PCRV. This activity also involves planning and other miscellaneous activities for dismantling. Assume outside labor is used to perform this work and that it takes 4 people 1 year to perform the work. This work will probably be done prior to this period but the costs will be included in this period. For the writing of the Activity Spec.:

Cost = 4 people x 52 weeks x 40 hr/wk x \$50/hr x i = \$416,000 x i

CONTRACTOR FEE:

Since it was assumed the decontamination/dismantlement work would be performed by a contractor, a fee will be required by the contractor. This was not included as part of the costs estimated in Attachment B. For this evaluation a fee of 15% times the total contractor cost will be assumed. The total cost is as follows and is categorized as O&M cost.

Cost = 0.15 x ($5,589,000 + $19,555,000) = $3,772,000

CONSULTANTS:

This cost is considered a decommissioning cost. Part of the costs associated with consultants are the costs to perform the environmental monitoring program and audits. Other consultants may be utilized for advice during the work effort but these costs should be offset by reduced reliance on PSC labor if consultants are used. Therefore, consulting costs for this cost estimate are:

Auditing cost = $30,000/yr
Environmental monitoring cost = $40,000/yr

In addition, the environmental impact documentation must be updated for the dismantling project and this cost was not part of the costs estimated in Attachment B. A cost of $200,000 will be assumed for this estimate.

Total O&M cost = $200,000 + ($30,000 + $40,000)/12 x i x t
approx. = $200,000 + $6,000 x i x t

PSC LABOR:

This cost is considered a decommissioning cost. Based on PSC organizational staffing levels outlined in the report in Attachment B plus additional PSC project management personnel expected, the following staffing requirements are assumed for FSV during the PCRV dismantlement project:

Position	# of people	$/yr	Total $/yr
Station manager	1	55,000	55,000
QA manager	1	45,000	45,000
Nuclear support mgr	1	45,000	45,000
Decommissioning mgr	1	45,000	45,000
Security supervisor	1	45,000	45,000
Health Physics sup	1	45,000	45,000
Training supervisor	1	45,000	45,000
Industrial safety sup	1	45,000	45,000
Secretary/admin support	2	20,000	40,000
Engineer	3	40,000	120,000
Trainers	2	35,000	70,000
Misc. (NRC interface, burial site interface, contract writers, payroll etc.)	5	30,000	150,000
Total	20 people		$750,000

PSC labor will be assumed to be used to control the project. The above costs must be increased by 30% to account for costs for benefits, lost time etc. A 25% contingency is included since the overall cost does not include a contingency.

Labor cost = ($750,000/yr x 1.3 x 1.25)/12 x t
= $81,000/mo x t x 1.25

As before, a .74% factor is applied for O&M costs:

O&M cost = $81,000 x 0.0074 = $600/mo so assume $1,000/mo O&M
O&M cost = $1,000/mo x t x 1.25

INSURANCE:

This cost is considered a decommissioning cost. The same insurance cost for the PCRV decay period is assumed for the PCRV dismantle/decontamination period. This estimate will be multiplied by 1.25 since the contingency factor is not applied to the overall cost.

Cost = ($100,000/yr x i)/12 x t x 1.25

CONTINGENCIES:

Contingencies are already included in the costs. Therefore, no additional contingency is added.

Table A-1

DECOMMISSIONING COST BREAKDOWN
COMPONENT REMOVAL RELATED COSTS
(In $1000's, $1989)

Rev. Date 20-Jan-89

DIRECT/INDIRECT COST	BASIS	BURIAL cu. ft	NUMBER SHIPMENTS	DECON Man-wk	BURIAL COST	O&M COST	CAPITAL COST	LABOR COST
CRDOA Removal								
o Burial	44 CRDOAs	3894			$584			
o Labor	($566,000/mo)							$3,396
o Labor O&M	($27,000/mo)					$162		
o RCD Liners						$49		
o CRD Liners						$0		
o Shipping	CRDOAs		11			$26		
o Shipping	Absorbers		22			$104		
TOTALS		3894	33	0	$584	$342	$0	$3,396
Helium Circulators								
o Burial	4 Circs	250			$38			
o Shipping			1			$2		
o Removal								$58
o Decon								
TOTALS		250	1	0	$38	$2	$0	$58
Helium Purification & Decontamination Systems								
o Burial		700			$105			
o Shipping			2			$5		
o Removal	250 m-h							$14
o Decon				3		$7		$85
TOTALS		700	2	3	$105	$11	$0	$99

Table A-1 (cont.)

DECOMMISSIONING COST BREAKDOWN
COMPONENT REMOVAL RELATED COSTS
(In $1000's, $1989)

Rev. Date 20-Jan-89

DIRECT/INDIRECT COST	BASIS	BURIAL cu. ft	NUMBER SHIPMENTS	DECON Man-wk	BURIAL COST	O&M COST	CAPITAL COST	LABOR COST
Liquid & Gas Waste Systems								
o Burial		525			$79			
o Shipping			1			$2		
o Removal	990 m-h							$54
o Decon				2		$4		$57
TOTALS		525	1	2	$79	$7	$0	$111
Misc. Contaminated Systems								
o Burial		150			$23			
o Shipping			0			$0		
o Removal								
o Decon				1		$2		$28
TOTALS		150	0	1	$23	$2	$0	$28

Attachment B

PCRV Decontamination/Dismantlement Conceptual Plan and Cost Estimate

1.0 INTRODUCTION

The purpose of this study is to develop a conceptual plan and a cost estimate to decontaminate and dismantle the prestressed concrete reactor vessel (PCRV) and its internal components at the Fort St. Vrain (FSV) Nuclear Generating Station. The scope of this study is summarized as follows:

- o Estimate the potential radiation exposure incurred in completing the project
- o Determine the residual radioactivity limit for releasing materials for unrestricted use
- o Provide a time estimate and schedule for the decontamination/dismantlement
- o Identify methods and estimate costs for radwaste shipping and burial
- o Perform a sensitivity analysis to define boundaries for the cost estimate uncertainties

In accordance with the work scope, this study is limited by the following resources and conditions:

- o The FSV plateout study results will be used to estimate radioactive contamination levels on PCRV components.
- o The PSC activation analyses will be used to determine the volume of PCRV concrete to be removed.
- o The noncontaminated (i.e., below releasable limits) portions of the PCRV and shall be left in place.
- o Only the decontamination/dismantlement of the PCRV and internal components will be addressed; the balance of the power plant will already be dispositioned prior to SAFSTOR.

2.0 PROJECTIONS FOR IMPLEMENTATION OF PLAN

The primary objectives of this study is to provide cost and resources projections for the early decontamination and dismantlement of the FSV PCRV. The costs and resources required to implement the plan include the following:

- o Event schedules and manpower loadings to decontaminate and dismantle the radioactive portions of the PCRV

- o Cost estimates for implementing the decontamination and dismantlement plan 5 years and 15 years after shutdown. These costs are also used to predict costs after 55 years of SAFSTOR

- o Estimates of radiation exposure incurred in performing the decontamination/dismantlement plan

- o A sensitivity analysis that indicates the cost estimate range of uncertainty

In accordance with scope, the cost projections rely upon the following assumptions:

- o A third party will manage the dismantlement effort an an independent project.

- o Denver labor rates will be used in cost estimates for manual labor. Normal Contractor rates will be used for non-manual labor.

- o A one-shift per day, 50-hour work week will be standard for site operations during decommissioning.

- o Costs are reported in 1988 dollars.

- o The salvage value for structures and components is excluded from the cost estimate.

- o No interest on funds has been included during the decommissioning period.

- o A 40-hour work week will be standard for all home office work.

- o The cost for site surveillance, plant maintenance, and systems operation during decommissioning is not included in the estimates.

- o The cost of nuclear liability insurance is not included in the cost estimate.

- o No costs for use of site facilities, staff, or services were included.

- o No contractor profit is included in the cost estimate.

2.1 Schedule of Decontamination/Dismantlement Activities

The schedule of decontamination and dismantlement activities is depicted in Figure B-1. This schedule treats several preplanning events as prerequisites because they should be completed prior to initiation of the plan. These events are shown in month zero. This schedule lasts for 31 months and covers all four phases: planning, preparation, implementation, and verification.

2.2 Manpower Requirements

Manpower is a significant cost factor associated with implementation of the PCRV decontamination/dismantlement plan. Two labor categories are used to describe these costs: manual and nonmanual. The manual labor category includes workers who do the hands-on physical work: craftsmen, equipment operators, construction trades, and servicemen. Nonmanual labor refers to project management personnel, engineers, health physics technicians, and professionals who plan, control, and administratively support the work.

Figures B-2 thru B-7 present the labor distribution over 31 months for manual, nonmanual, and manual plus nonmanual categories, respectively.

2.3 Equipment and Services Lists

The equipment and services required for this project are listed in Tables B1 and B2.

The listed equipment items are divided into three categories: small tools, construction equipment, and specialty equipment.

The services list identifies subcontracted activities required for this project. Because the decontamination and dismantlement prime contractor is assumed to be experienced in all manual and nonmanual tasks, and extensive use is to be made of existing facilities, this list compromises only three subcontracted activities.

2.4 Radwaste Volumes and Types

The origins, volumes, and weights of radioactively contaminated wastes generated during decontamination and dismantlement operations are listed in Table B3. Waste volumes were estimated for individual events of the plan; the numbers in Table B3 are a sum of the waste volumes calculated for the individual events.

2.5 Radiation Exposure Estimate

Manual and nonmanual labor hours were used to estimate radiation exposure associated with the PCRV decontamination/dismantlement events. In events where the majority of activity is performed with remote technology, exposures are small because procedures will require work practices and engineered devices that minimize personnel exposure. For other tasks, exposure time is adjusted downward to represent only the portion of the event where direct radiation exposures are possible. Radiation exposure for health physics personnel who perform the surveys and monitoring activities are included in the estimates. Table B4 provides the exposure estimate for the PCRV decontamination/dismantlement events.

2.6 Cost Estimate and Sensitivity Analysis

- Cost Estimate

  Table B5 provides base case (i.e., 5 years after shutdown) cost estimates for labor and equipment to perform the FSV PCRV decontamination/dismantlement events.

- Sensitivity Analysis Events 1-10

  A cost sensitivity analysis was performed to show how project costs vary with the critical parameters: radwaste volume, labor, equipment and services, radwaste transportation , and radwaste disposal. This variance is used instead of a contingency.

  Table B6 displays the variance estimated for each parameter addressed in the analysis. The total dollar ranges calculated for the listed parameters are summarized in Table B7.

The following paragraphs discuss the critical parameters used in the sensitivity analysis and describe factors that affect increases and decreases in magnitude of these parameters.

Waste Volume

The projection of radioactive waste quantities to be dispositioned is based on a number of factors applied to the analysis of neutron activation of PCRV materials. One such factor concerning neutron streaming through penetrations in the top head and core support floor could add appreciably to the activation of concrete and steel in the head and the lower PCRV cavity.

The net effect of this consideration could be that the radwaste volume increases by 5,000 cubic feet. Likewise, it is estimated that this radwaste volume could reduce by 4,300 cubic feet if average neutron fluxes are used to calculate the PCRV concrete activation depth.

Manual Labor

Labor rates for current agreement union building trades were used for the development of manual labor costs for this study. Depending on the availability and demand for skilled union craft experienced in the nuclear industry at the time of the project, labor agreements at the prevailing building trades rates may be difficult to negotiate. In addition, a premium on wages and/or fringe benefits may be required to incorporate contract provisions addressing craft experience, prohibition of strikes, grievance procedures, etc., due to the relatively hazardous nature of the work and the requirement for minimizing the project duration. Unplanned events and additional tasks may increase the work effort. The net affect of these factors is estimated to be no more than a 20% increase in manual labor cost.

If an open shop prime contractor is selected for the project, labor rates lower than those in prevailing union agreements would be in effect. Non-union craft could also be required to perform multiple tasks that overlap traditional craft disciplines. It is estimtaed that the overall net effects of this approach would be no change to the project schedule and as much as a 25% decrease in manual labor cost.

Nonmanual Labor

Every contractor of meduim and large scale projects has its own system of project management and control, and some systems are more labor intensive than others. A project management system that differs significantly from the one envisioned for this study, or the occurence of unforeseeable management/engineering requirements could increase nonmanual labor costs by as much as 35%.

Equipment and Services

Equipment, materials, and services were estimated at quantities and durations deemed sufficient to perform the work scope in an efficient and uninterrupted manner. Factors that could increase the costs over those estimated by as much as 25%, or decrease the costs by as much as 10%, include the following:

- Abnormal changeout of failed parts in purchased equipment and existing plant equipment
- Above-normal changeout of rented equipment due to frequent breakdowns
- Enhanced or reduced requirements for redundancy of materials and equipment installed for safety-related systems
- Abnormal usage of consumables, e.g. anti-C clothing
- Slower or faster than predicted performance by major subcontractors
- The unpredictable effects of supply vs. demand for equipment, materials, and services at the time of project performance

- A change in the regulatory climate for the nuclear industry which changes project requirements

Waste Transportation

Waste transportation costs vary with the distance between the source of the waste and the disposal site; fees imposed by Federal, State, and County regulatory agencies and by the disposal site operator; and supply and demand factors affecting the hazardous waste transportation business at the time the porject is performed. The unit cost used in the base case study estimate could vary in the range of -17% to + 140% as a result of these variables. The high variance includes the possibility of having to ship the waste to the Hanford Reservation, Washington.

Waste Disposal

Waste disposal unit costs are a function of several variables, including the following:

- The number of licensed disposal sites within economically viable transportaion distance (supply and demand factors)

- Existing agreements between the source operator and the disposal site operators

- Volume of waste to be disposed (negotiation of discount unit cost)

- Fees imposed by regulatory agencies

- Fees, surcharges, and taxes imposed at the disposal site

The unit cost used in the base case study estimate could vary in the range of -17% to +100% as a result of these variables.

- Sensitivity Analysis - Event 11

The parameters used in the Event 11 sensitivity analysis are the same used for the PCRV components except for radwaste volume, which is described below.

The projection of radioactive waste quantities to be dispositioned is based on a number of factors applied to the analysis.

One such factor is the ability to decontaminate major components including the 12 steam generators, the 4 circulators, and all of the dummy fuel blocks. If this approach is not used, or if decontamination is not successful in reducing the residual radioactivity to releasable limits, then the base volume of radwaste will increase by 70%. In contrast, the base case volume cannot be reduced appreciably because the graphite reflector blocks are activated and cannot be decontaminated to releasable levels. Therefore, low radwaste volume is equal to the base case volume.

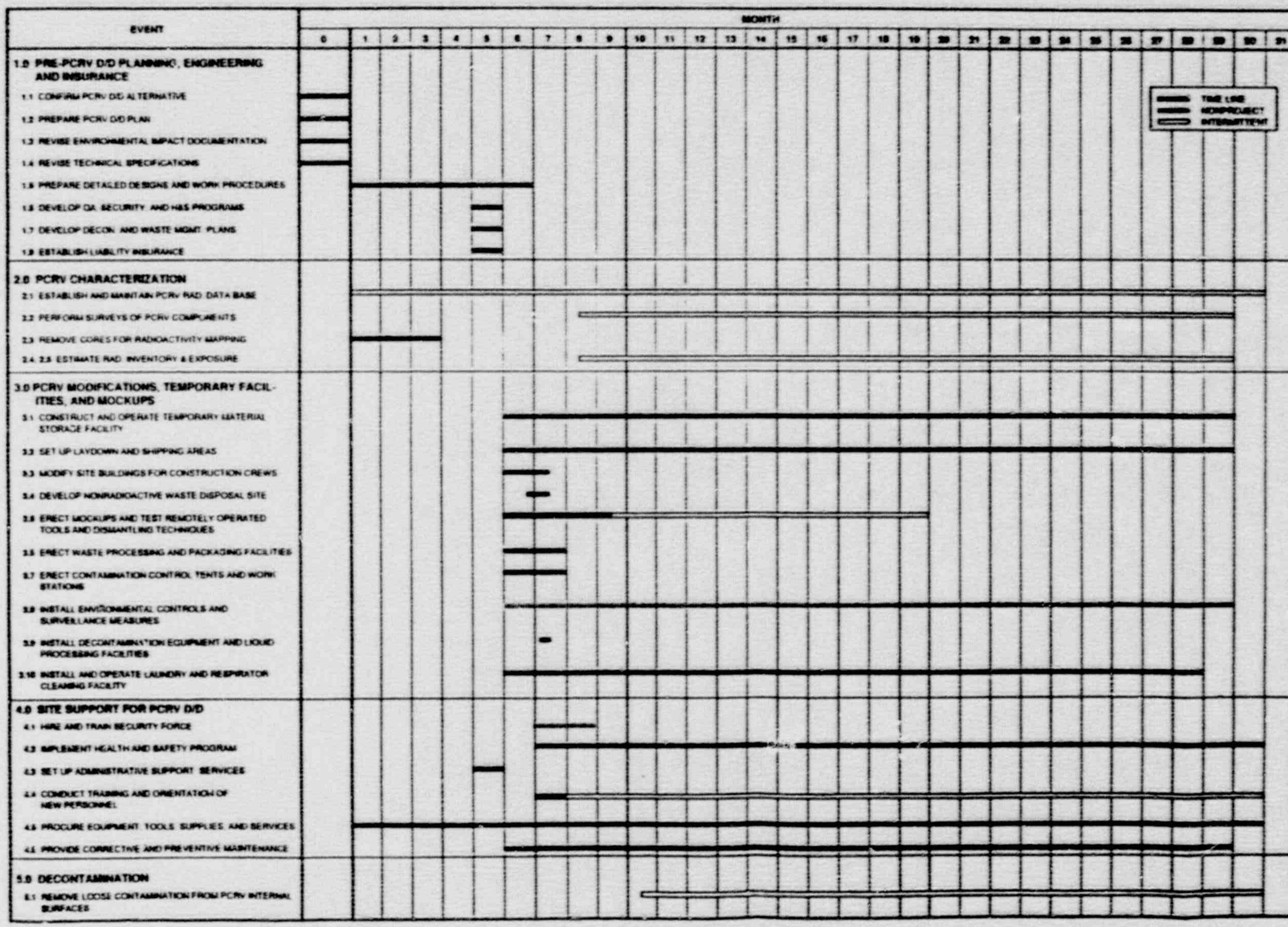


FIGURE 81
MODIFIED FSV PCRV
DECONTAMINATION/
DISMANTLEMENT SCHEDULE

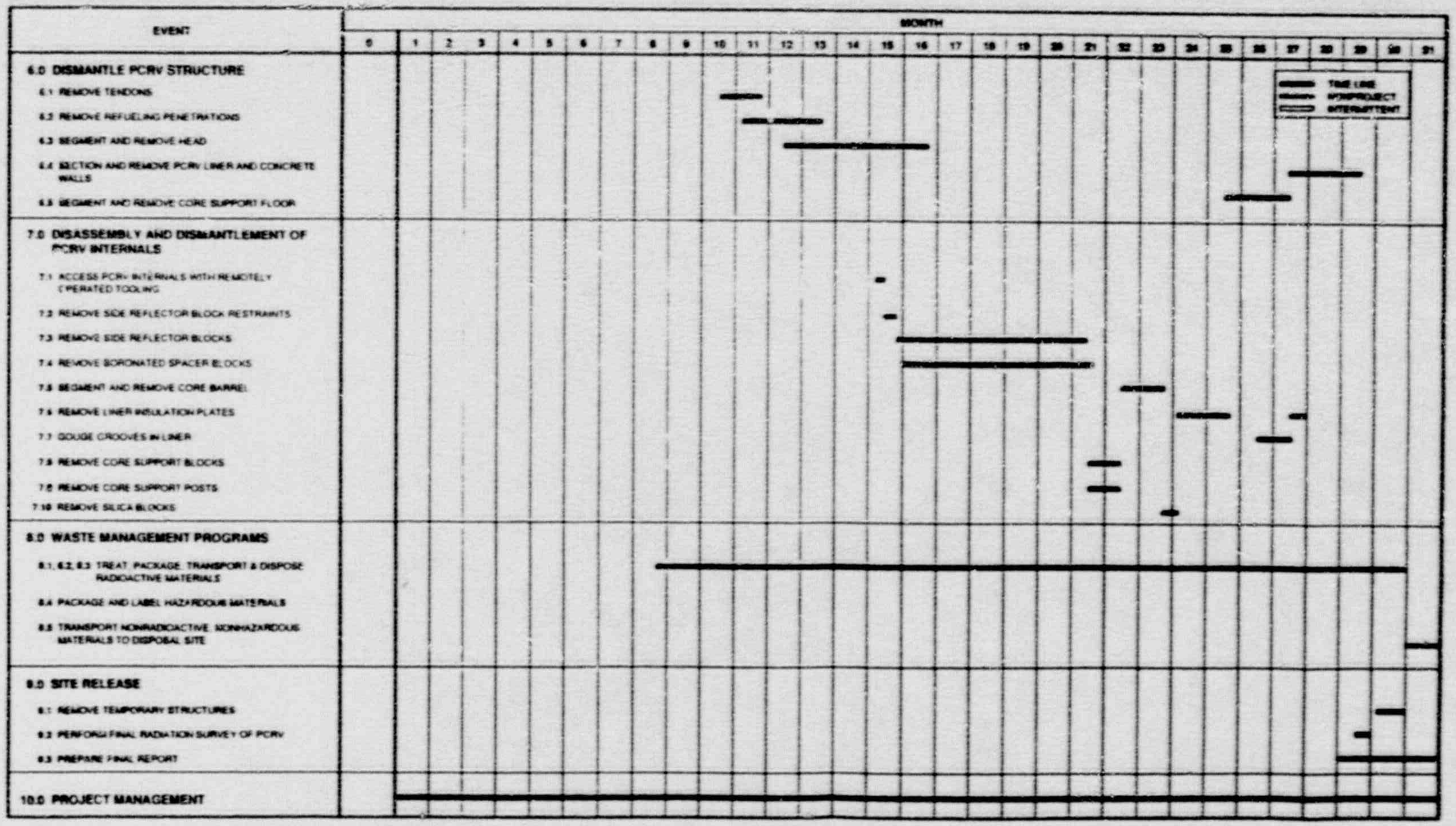


FIGURE B1 (cont.)
MODIFIED FSV PCRV
DECONTAMINATION/
DISMANTLEMENT SCHEDULE

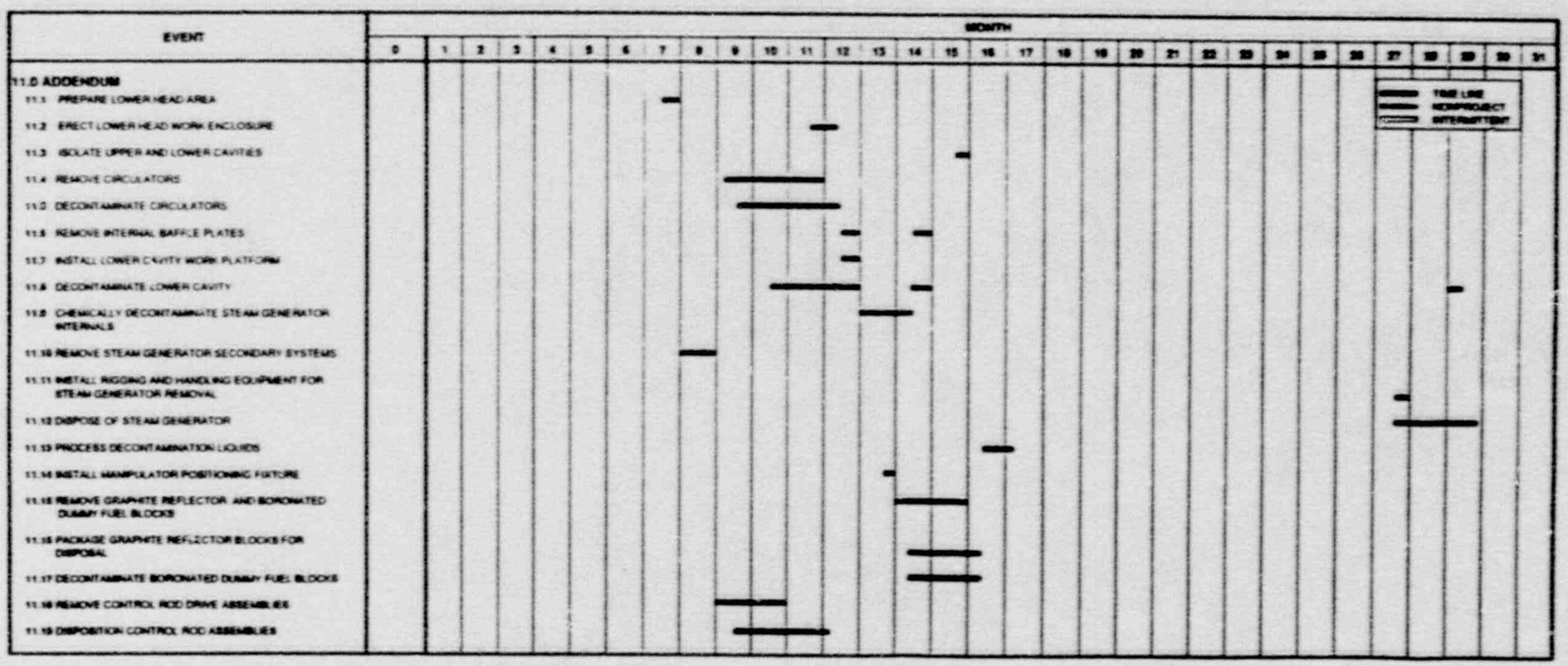


FIGURE 81 (cont.)
MODIFIED FSV PCRV
DECONTAMINATION/
DISMANTLEMENT SCHEDULE

LABOR HOURS FOR EVENTS 1 THRU 10

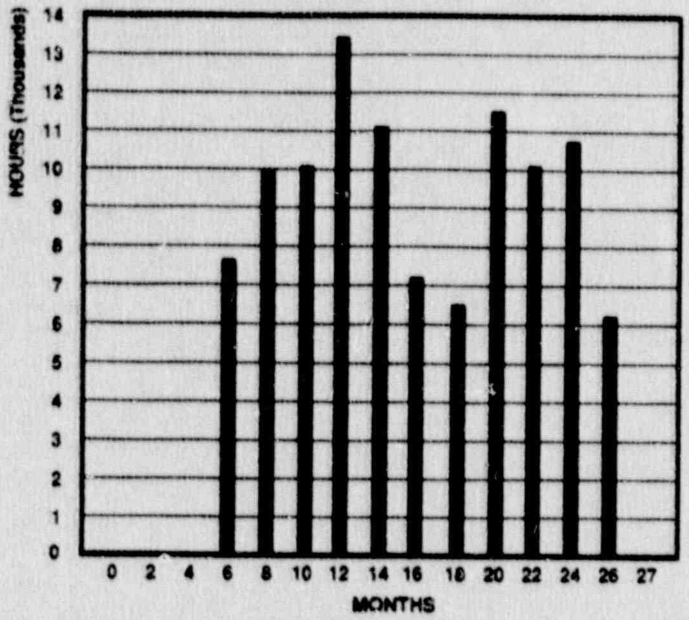


FIGURE B2
SUMMARY OF MANUAL HOURS
(TIME PHASED)

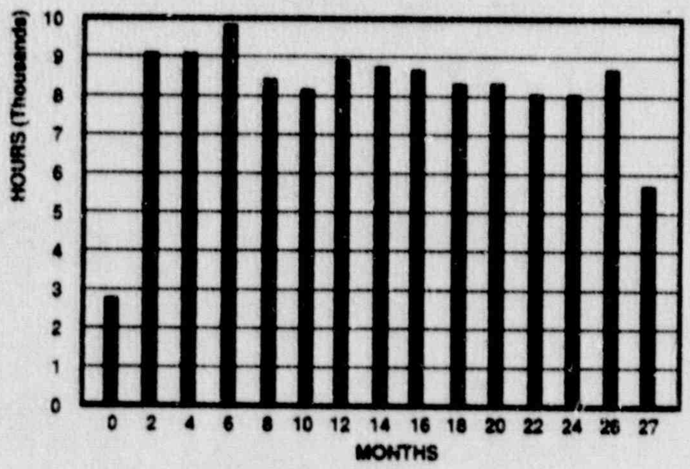


FIGURE B3
SUMMARY OF NONMANUAL HOURS
(TIME PHASED)

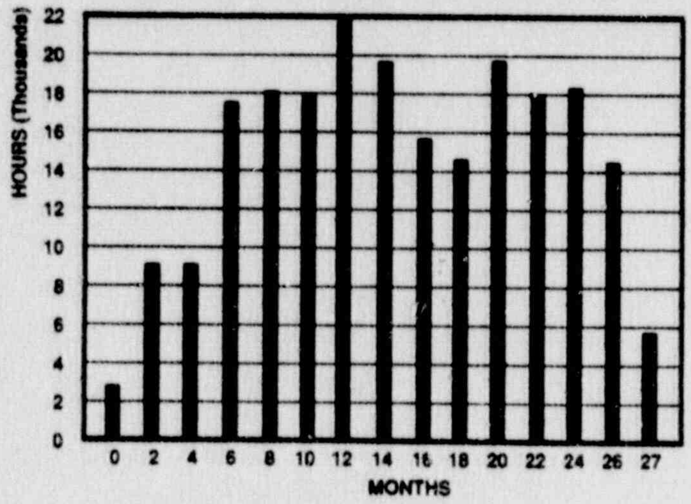


FIGURE B4
SUMMARY OF MANUAL PLUS NONMANUAL LABOR HOURS
(TIME PHASED)

LABOR HOURS FOR EVENT 11

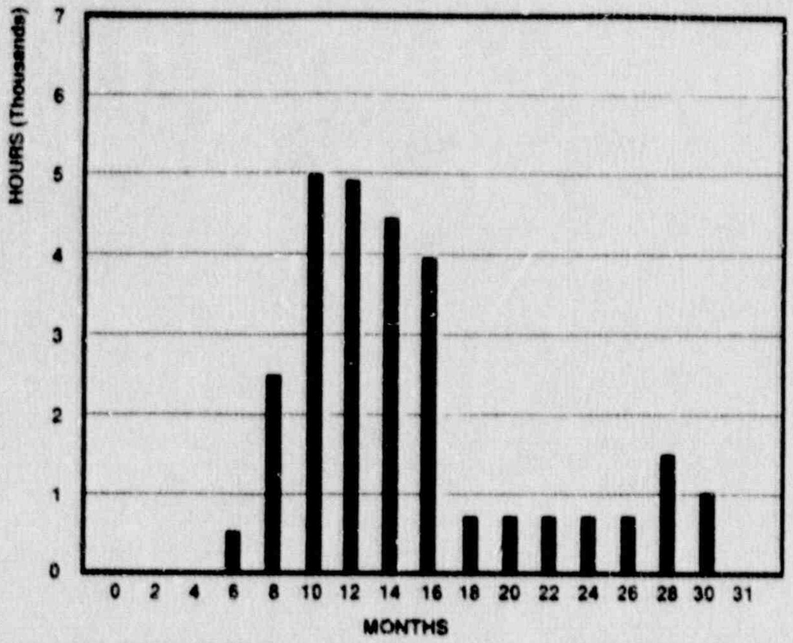


FIGURE B5
SUMMARY OF MANUAL HOURS
(TIME PHASED)

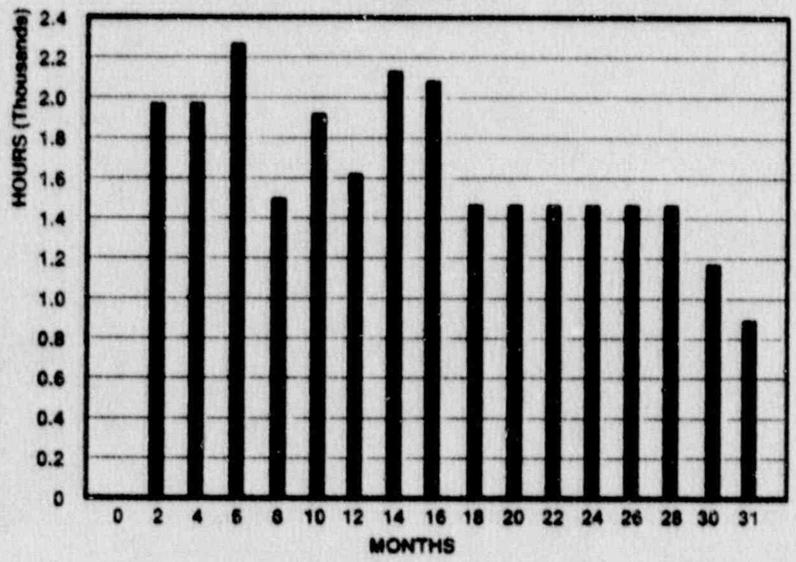


FIGURE B6
SUMMARY OF NONMANUAL HOURS
(TIME PHASED)

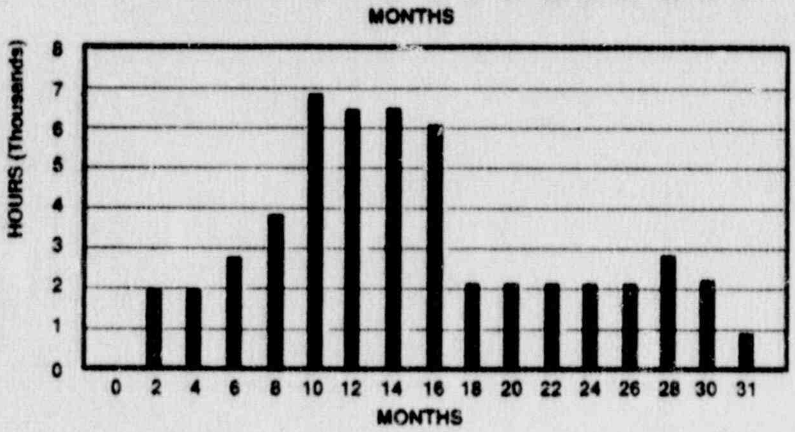


FIGURE B7
SUMMARY OF MANUAL PLUS NONMANUAL HOURS
(TIME PHASED)

TABLE B1
EQUIPMENT AND SERVICES REQUIREMENTS (EVENTS 1-10)

DESCRIPTION	QUANTITY
SMALL TOOLS	
HAND TOOLS	A/R
HAND TRUCKS	2
JACKHAMMER	1
VACUUM CLEANERS, HEPA FILTERED	4
COME ALONGS	2
IMPACT WRENCHES	3
ABRASIVE SAWS	3
CONSTRUCTION EQUIPMENT	
CAT D-6 BULLDOZER	1
20-TON CRANE, RUBBER TIRED	1
10-TON CRANE, RUBBER TIRED	1
FORKLIFTS	2
2-1/2 TON STAKE-BED TRUCK	1
LAUNDRY TRAILER	1
INDUSTRIAL HEATER	1
RIGGING AND APPURTENANCES	A/R
SCAFFOLDING	A/R
SPECIALTY EQUIPMENT	
MANIPULATOR POSITIONING FIXTURES	4
HOIST HOOKING FIXTURES	2
SPACER BLOCK HOIST LATCHING FIXTURES	2
MANIPULATORS	5
HOT CELL HOISTS	2
SMOOTH DRUM COMPACTOR	EXISTING
AIR COMPRESSOR/HOSES/AIR JET NOZZLE	1
1 HP SUBMERSIBLE WASTEWATER PUMP/HOSES	1
DECON WATER PUMPS, 2-4 GPM/HOSES	2
DECON WATER HOLDING TANKS	2
WATER JET PUMP/HOSES/NOZZLE	1
WELDING MACHINE AND APPURTENANCES	1
BORONATED PIN REMOVAL FIXTURES	2

A/R = AS REQUIRED S/C = SUBCONTRACTOR FURNISHED

TABLE B1 (cont.)
EQUIPMENT AND SERVICES REQUIREMENTS (EVENTS 1-10)

DESCRIPTION	QUANTITY
SPECIALTY EQUIPMENT (CONT.)	
MANIPULATOR CONTROL CONSOLES	3
CCTV CAMERAS/APPURTENANCES	14
PCRV SPRAY NOZZLES/HOSES/FITTINGS	2
PLASMA ARC POWER SUPPLIES	2
PLASMA ARC TORCH FIXTURES/CLAMPS	4
PLASMA ARC CORE BARREL RING GUIDE	1
PLASMA ARC CORE BARREL VERTICAL TORCH GUIDE	1
R-BUILDING OVERHEAD CRANE	EXISTING
PCRV HOISTS/BASKET LIFTS	2
PORTABLE LIGHTING	A/R
PCRV POWER CABLING	A/R
PCRV DUST SUPPRESSION MISTERS	2
MISCELLANEOUS TOOLS TO FIT MANIPULATOR ARM	A/R
GRAPHITE BLOCK LATCHING FIXTURES	2
GRAPHITE POST LATCHING FIXTURES	2
MFP FOOTING FIXTURES	2
CORE SUPPORT OUTER BLOCK ATTACHING FIXTURES	2
SILICA BLOCK HOIST ATTACHMENTS	2
METAL INSERT HOIST ATTACHMENTS	2
DIAMOND WIRE CUTTER	S/C
DIAMOND WALL SAW	S/C
DIAMOND CORER	S/C
AIRBORNE CONTAMINATION REMOVAL HVAC	A/R
WATERBORNE CONTAMINATION REMOVAL DEMINERALIZER	A/R
PCRV TOOLS' HYDRAULIC SYSTEMS	A/R
HEALTH AND SAFETY/ENVIRONMENTAL EQUIPMENT	A/R
PUG MILL	1
GRAPHITE GRINDING AND BORING TOOL	A/R
SERVICES	
LAUNDRY TRAILER	S/C
CONCRETE CUTTING AND CORING	S/C
LABORATORY ANALYSIS	S/C

A/R = AS REQUIRED S/C = SUBCONTRACTOR FURNISHED

TABLE B2
EQUIPMENT AND SERVICES FOR EVENT 11

DESCRIPTION	QUANTITY
SPECIALTY EQUIPMENT	
ELECTRIC HOIST	1
TRANSFER SKIP	1
FOAMING EQUIPMENT	1
PUMP SKID	1
WASTE FILTER SKID	1
CHEMICAL MAKEUP SKID	1
BRACING AND JACKING EQUIPMENT	1
MANIPULATOR MAST FOOTING	2
BLOCK HOIST HOOKING FIXTURE	2
DEFUELING MACHINE AND FIXTURES	EXISTING
CONTROL ROD DRIVE ASSEMBLY RACK	2
HYDRAULIC SHEAR TOOLS	1
MANIPULATOR POSITIONING STAND	1
MECHANICAL SAW	1
EQUIPMENT RACK	1
END CAPS	4
DRILL RIG	1
ION EXCHANGER	1
HOLDING RACK	1
STEP LADDER	A/R
RIGGING EQUIPMENT	A/R
AUXILIARY TRANSFER CASK	EXISTING

A/R = AS REQUIRED

TABLE B3
RADWASTE COMPILATION
(EVENTS 1-10)

ITEM NO.	DESCRIPTION	SHIPPED* VOL.-cf	SHIPPED** WEIGHT-lb
1	PCRV TOP HEAD PENETRATIONS	1,716	140,400
2	REFLECTOR SPACER	1,914	154,000
3	SIDE REFLECTOR BLOCKS	6,720	720,000
4	BORONATED DOWELS	200	25,000
5	CORE BARREL	2,506	540,000
6	GRAPHITE FLOOR	3,500	375,000
7	PCRV CONCRETE	8,626	1,321,600
8	INSULATED PLATES	1,048	188,000
9	DAW	440	25,000
	TOTAL/ALL EVENTS	**26,670**	**3,489,000**

* BASED ON EXTERNAL PACKAGE DIMENSIONS

** INCLUDES DUNNAGE BRACING SHIELDING AND PACKAGE WEIGHT

TABLE B3 (cont.)
RADWASTE COMPILATION FOR EVENT 11

ITEM NO.	DESCRIPTION	SHIPPED VOL. - cf	SHIPPED WT. - lb
1	STEAM GENERATOR CHEMICAL RESIDUE	162	11,000
2	UHP DECON RESIDUE	132	8,700
3	CONTROL ROD DRIVES	3,300	500,000
4	GRAPHITE REFLECTOR BLOCKS	9,500	212,000
5	Helium Circulators (Note 1)	250	100,000
6	Steam Generators (Note 1)	6,566	600,000
7	Dummy Fuel Elements (Note 1)	2,350	450,000
	TOTAL	22,260	1,881,700

Note 1 - These components were not part of the base volume case, but make up the additional 70% volume in the high volume case.

TABLE B4
RADIATION EXPOSURE ESTIMATES FOR
FSV PCRV DECONTAMINATION/DISMANTLEMENT

EVENT	DESCRIPTION	MANUAL HOURS	NON-MANUAL HOURS	@ 5 YEARS EXPOSURE MAN REM	@ 15 YEARS EXPOSURE MAN REM
1.0	PRE-PCRV D/D PLANNING, ENGR'NG., & INSURANCE	0	17,248	0	0
2.0	PCRV CHARACTERIZATION	0	427	<1	<1
3.0	PCRV MOD., TEMP. FACILITIES & MOCKUPS	27,302	1,520	0	0
4.0	SITE SUPPORT FOR PCRV D/D	8,720	34,260	0	0
5.0	DECONTAMINATION	1,050	0	<1	<1
6.0	DISMANTLEMENT OF PCRV STRUCTURE	25,819	0	423	108
7.0	DISASSEMBLY/DISMANTLEMENT PCRV INTERNALS	26,497	2,295	550	138
8.0	WASTE MANAGEMENT PROGRAMS	13,560	0	95	24
9.0	SITE RELEASE	1,950	2,060	0	0
10.0	PROJECT MANAGEMENT	0	57,384	0	0
	TOTAL/ALL EVENTS	104,897	115,193	1,068	270

TABLE B4 (cont.)
RADIATION EXPOSURE ESTIMATES FOR EVENT 11

EVENT	DESCRIPTION	MANUAL HOURS	NONMANUAL HOURS	5-YR. EXPOSURE MAN REM	15-YR. EXPOSURE MAN REM
11	EVENT 11	~ 27,000	~ 25,500	110	78

TABLE B5
COST ITEMS FOR THE FSV PCRV DECONTAMINATION/DISMANTLEMENT
(SUMMARY OF COST BY EVENT)

(Dollars in Thousands)

EVENT	DESCRIPTION	LABOR MANUAL	LABOR NON-MANUAL	EQUIP. MAT'L & OTHER	TOTAL COST
1.1	CONFIRM PCRV D/D ALTERNATIVE	0.0	61.9	9.6	71.5
1.2	PREPARE PCRV D/D PLAN	0.0	54.0	0.0	54.0
1.3	REVISE ENVIRONMENTAL IMPACT ASSESSMENT (EIA)	0.0	0.0	0.0	0.0
1.4	REVISE TECHNICAL SPECIFICATIONS	0.0	33.5	0.0	33.5
1.5	PREPARE DETAILED WORK PROCEDURES & MACHINE DESIGN	0.0	749.0	0.0	749.0
1.6	DEVELOP PROJECT QA PROGRAM	0.0	0.0	0.0	0.0
1.7	DEVELOP DECONTAMINATION AND WASTE MANAGEMENT PLANS	0.0	7.7	0.0	7.7
1.8	ESTABLISH GENERAL LIABILITY INSURANCE	0.0	0.0	53.0	53.0
EVENT 1 SUBTOTAL		**0.0**	**906.2**	**62.6**	**968.8**
2.1	ESTABLISH AND MAINTAIN PCRV RADIOLOGICAL DATA BASE	0.0	16.8	0.0	16.8
2.2	PERFORM SURVEYS OF PCRV COMPONENTS	0.0	0.0	45.0	45.0
2.3	REMOVE CORES FOR RADIOACTIVE MAPPING	0.0	0.0	9.5	9.5
2.4	ESTIMATE RADIOACTIVITY INVENTORY	0.0	1.9	0.0	1.9
2.5	ESTIMATE RADIATION EXPOSURE	0.0	1.9	0.0	1.9
EVENT 2 SUBTOTAL		**0.0**	**20.6**	**54.5**	**75.1**
3.1	CONSTRUCT AND OPERATE TEMPORARY MATERIAL STORAGE FACILITY	214.3	105.5	148.6	468.4
3.2	SET UP LAYDOWN AND SHIPPING AREAS	15.7	0.0	68.6	84.3
3.3	PERFORM SITE BUILDINGS MODIFICATIONS	44.1	0.0	95.0	139.1
3.4	DEVELOP NON-RADIOACTIVE WASTE DISPOSAL SITE	8.8	0.0	18.3	27.1
3.5	ERECT MOCKUPS AND TEST REMOTELY OPERATED TOOLS	273.6	62.5	1,343.0	1,679.1
3.6	ERECT WASTE PROCESSING AND PACKAGING FACILITIES	16.3	0.0	137.0	153.3
3.7	ERECT CONTAMINATION CONTROL TENTS AND WORK STATION	45.3	0.0	74.6	120.0
3.8	INSTALL ENVIRONMENTAL CONTROL AND SURVEILLANCE MEASURES	0.0	0.0	0.0	0.0
3.9	INSTALL DECONTAMINATION EQUIPMENT AND LIQUID PROCESSING FACILITIES	3.3	0.0	140.7	144.0
3.10	INSTALL AND OPERATE LAUNDRY AND RESPIRATOR CLEANING	2.8	0.0	26.8	29.6
EVENT 3 SUBTOTAL		**624.4**	**168.0**	**2,052.6**	**2,845.0**

TABLE B5 (cont.)
COST ITEMS FOR THE FSV PCRV DECONTAMINATION/DISMANTLEMENT
(SUMMARY OF COST BY EVENT)

EVENT	DESCRIPTION	LABOR		EQUIP. MAT'L. & OTHER	TOTAL COST
		MANUAL	NON-MANUAL		
4.1	HIRE AND TRAIN SECURITY FORCES	0.0	0.0	0.0	0.0
4.2	IMPLEMENT HEALTH AND SAFETY PROGRAM	5.2	1,259.7	515.4	1,780.3
4.3	SET UP ADMINISTRATIVE SUPPORT SERVICES	0.0	0.0	0.0	0.0
4.4	CONDUCT TRAINING & ORIENTATION OF NEW PERSONNEL	34.3	0.0	0.0	34.3
4.5	PROCURE EQUIPMENT, TOOLS, SUPPLIES & SERVICES	0.0	0.0	0.0	0.0
4.6	PERFORM CORRECTIVE AND PREVENTATIVE MAINTENANCE	193.0	0.0	10.0	203.0
EVENT 4 SUBTOTAL		**232.5**	**1,259.7**	**525.4**	**2,017.6**
5.1	REMOVE LOOSE CONTAMINATION FROM PCRV INTERNAL SURFACES	22.5	0.0	11.0	33.4
EVENT 5 SUBTOTAL		**22.5**	**0.0**	**11.0**	**33.4**
6.1	REMOVE TENDONS	128.1	0.0	66.5	194.6
6.2	REMOVE REFUELING PENETRATIONS	40.4	0.0	12.2	52.6
6.3	SEGMENT AND REMOVE HEAD	176.4	0.0	1,198.7	1,375.1
6.4	SECTION AND REMOVE LINER AND CONCRETE WALLS (ACTIVATED PORTION ONLY)	122.4	0.0	706.7	829.1
6.5	SEGMENT AND REMOVE CORE SUPPORT FLOOR	64.7	0.0	191.2	256.0
EVENT 6 SUBTOTAL		**532.1**	**0.0**	**2,175.3**	**2,707.4**
7.1	ACCESS PCRV INTERNALS WITH REMOTELY OPERATED TOOLING	11.1	1.3	0.5	12.9
7.2	REMOVE SIDE REFLECTOR BLOCK RESTRAINTS	5.7	3.5	16.4	25.6
7.3	REMOVE SIDE REFLECTOR BLOCKS	40.1	23.7	10.0	73.8
7.4	REMOVE BORONATED SPACER BLOCKS	160.4	47.4	117.9	325.7
7.5	SEGMENT AND REMOVE CORE BARREL	26.9	14.4	42.0	83.2
7.6	REMOVE LINER INSULATION PLATES	233.1	0.0	42.4	275.6
7.7	GOUGE GROOVES IN LINER	27.4	0.0	0.2	27.6
7.8	REMOVE CORE SUPPORT BLOCKS	27.8	4.1	70.0	101.9
7.9	REMOVE CORE SUPPORT POSTS	0.0	0.0	0.0	0.0
7.10	REMOVE SILICA BLOCKS	14.2	0.0	9.0	23.2
EVENT 7 SUBTOTAL		**546.5**	**94.4**	**308.4**	**949.5**

(Dollars in Thousands)

TABLE B5 (cont.)
COST ITEMS FOR THE FSV PCRV DECONTAMINATION/DISMANTLEMENT
(SUMMARY OF COST BY EVENT)

EVENT	DESCRIPTION	LABOR MANUAL	LABOR NON-MANUAL	EQUIP. MAT'L & OTHER	TOTAL COST
8.1	VOLUME REDUCTION AND PROCESSING OF RADWASTE MATERIAL	40.8	0.0	10.1	50.9
8.2	PACKAGE AND LABEL RADIOACTIVE WASTE GENERATED BY DECONTAMINATION/DISMANTLEMENT	81.6	0.0	488.1	569.7
8.3	TRANSPORT RADIOACTIVE WASTE TO BURIAL SITE	124.5	0.0	4,105.5	4,230.0
EVENT 8 SUBTOTAL		**246.9**	**0.0**	**4,603.7**	**4,850.7**
9.1	REMOVE TEMPORARY STRUCTURES	41.6	0.0	20.0	61.6
9.2	PERFORM RADIATION SURVEY OF PCRV	0.0	0.0	42.0	42.0
9.3	PREPARE FINAL REPORT	0.0	84.7	4.0	88.7
EVENT 9 SUBTOTAL		**41.6**	**84.7**	**66.0**	**192.3**
10.0	PROJECT MANAGEMENT	0.0	2,458.9	20.0	2,478.9
EVENT 10 SUBTOTAL		**0.0**	**2,458.9**	**20.0**	**2,478.9**

(Dollars in Thousands)

TABLE B5 (cont.)
COST ITEMS FOR THE FSV PCRV DECONTAMINATION/DISMANTLEMENT
(SUMMARY OF EVENT 11 COSTS)

EVENT	DESCRIPTION	LABOR MANUAL	LABOR NON-MANUAL	EQUIP. MAT'L & OTHER	TOTAL COST
11.1	PREPARE LOWER HEAD AREA	30.4	0.0	17.5	47.9
11.2	ERECT LOWER HEAD WORK ENCLOSURE	31.1	0.0	9.5	40.7
11.3	ISOLATE UPPER AND LOWER CAVITIES	4.2	0.0	17.7	21.9
11.4	REMOVE CIRCULATORS	52.8	0.0	7.5	60.3
11.5	DECONTAMINATE CIRCULATORS	17.7	0.0	0.8	18.5
11.6	REMOVE INTERNAL BAFFLE PLATES	9.9	0.0	0.0	9.9
11.7	INSTALL LOWER CAVITY WORK PLATFORM	11.5	0.0	13.2	24.7
11.8	DECONTAMINATE LOWER CAVITY	11.0	0.0	0.0	11.0
11.9	CHEMICALLY DECONTAMINATE LOWER STEAM GENERATOR INTERNALS	10.7	0.0	32.3	43.0
11.10	REMOVE STEAM GENERATOR SECONDARY SYSTEMS	5.8	0.0	1.0	6.8
11.11	INSTALL RIGGING AND HANDLING EQUIPMENT FOR STEAM GENERATOR REMOVAL	6.1	0.0	0.5	6.6
11.12	STEAM GENERATOR DISPOSITION	14.5	0.0	0.0	14.5
11.13	PROCESS DECONTAMINATION LIQUIDS	0.0	0.0	3.0	3.0
11.14	INSTALL MANIPULATOR POSITIONING FIXTURE	5.6	1.6	10.0	17.2
11.15	REMOVE GRAPHITE AND BORONATED DUMMY FUEL BLOCKS	83.5	49.3	10.0	142.9
11.16	PACKAGE GRAPHITE BLOCKS FOR DISPOSAL	0.0	0.0	128.1	128.1
11.17	DECONTAMINATE BORONATED DUMMY FUEL BLOCKS	26.7	0.0	0.0	26.7
11.18	REMOVE CONTROL ROD DRIVE ASSEMBLIES	23.8	10.3	0.0	34.1
11.19	DISPOSITION OF THE CONTROL ROD ASSEMBLIES	44.3	12.3	59.4	116.1
11.20	PREPARE DETAILED DESIGN AND WORK PROCEDURES	0.0	172.3	0.0	172.3
11.21	SITE SUPPORT	79.6	291.0	46.8	417.5
11.22	WASTE MANAGEMENT PROGRAMS	103.3	0.0	2,059.1	2,162.5
11.23	PROJECT MANAGEMENT	0.0	728.1	0.0	728.1
	EVENT 11 SUBTOTAL	572.6	1,265.1	2,416.5	4,254.1

(Dollars in Thousands)

TABLE B6
COST VARIANCE FOR CRITICAL PARAMETERS (EVENTS 1-10)

DESCRIPTION	HIGH	BASE	LOW
RADWASTE VOLUME	+18%	TABLE B3	-16%
MANUAL LABOR	+20%	TABLE B5	-25%
NONMANUAL LABOR	+35%	TABLE B5	0%
EQUIPMENT AND SERVICES	+25%	TABLE B5	-10%
RADWASTE TRANSPORTATON	+140%	TABLE B5	-20%
RADWASTE DISPOSAL	+100%	TABLE B5	-17%

TABLE B6 (cont.)
COST VARIANCE FOR CRITICAL PARAMETERS (EVENT 11)

DESCRIPTION	HIGH	BASE	LOW
RADWASTE VOLUME	+ 70%	TABLE B3	0%
MANUAL LABOR	+ 20%	TABLE B5	-20%
NONMANUAL LABOR	+ 35%	TABLE B5	0%
EQUIPMENT AND SERVICES	+ 25%	TABLE B5	-10%
RADWASTE TRANSPORTATION	+140%	TABLE B5	-20%
RADWASTE DISPOSAL	+100%	TABLE B5	-17%

TABLE B7
EARLY DISMANTLEMENT OF THE FSV PCRV
(EVENTS 1-10) SENSITIVITY ANALYSIS

BASE RADWASTE VOLUME 26,670 CF	HIGH	BASE	LOW
MANUAL LABOR	2,696	2,247	1,685
NONMANUAL LABOR	6,740	4,993	4,993
EQUIPMENT AND SERVICES	7,236	5,789	5,210
TRANSPORTATION	216	90	72
DISPOSAL	8,001	4,001	3,320
TOTAL	24,889	17,119	15,280

HIGH RADWASTE VOLUME 31,473 CF	HIGH	BASE	LOW
MANUAL LABOR	2,696	2,247	1,685
NONMANUAL LABOR	6,740	4,993	4,993
EQUIPMENT AND SERVICES	7,236	5,789	5,210
TRANSPORTATION	255	106	85
DISPOSAL	9,441	4,721	3,918
TOTAL	26,368	17,855	15,891

LOW RADWASTE VOLUME 22,400 CF	HIGH	BASE	LOW
MANUAL LABOR	2,696	2,247	1,685
NONMANUAL LABOR	6,740	4,993	4,993
EQUIPMENT AND SERVICES	7,236	5,789	5,210
TRANSPORTATION	181	76	60
DISPOSAL	6,721	3,360	2,789
TOTAL	23,574	16,464	14,737

(Dollars in Thousands)

TABLE B-7 (cont.)
EARLY DISMANTLEMENT OF THE FSV PCRV
SENSITIVITY ANALYSIS

(EVENT 11)

BASE VOLUME CASE 13,094 CF	HIGH	BASE	LOW
MANUAL LABOR	687	573	429
NONMANUAL LABOR	1,708	1,265	1,265
EQUIPMENT & SERVICES	509	407	367
TRANSPORTATION	108	45	36
DISPOSAL	3,928	1,964	1,630
TOTAL	**6,940**	**4,254**	**3,727**
HIGH VOLUME CASE 22,260 CF	**HIGH**	**BASE**	**LOW**
MANUAL LABOR	687	573	429
NONMANUAL LABOR	1,708	1,265	1,265
EQUIPMENT & SERVICES	509	407	367
TRANSPORTATION	184	77	61
DISPOSAL	6,678	3,339	2,771
TOTAL	**9,766**	**5,661**	**4,894**
LOW VOLUME CASE 13,094 CF	**HIGH**	**BASE**	**LOW**
MANUAL LABOR	687	573	429
NONMANUAL LABOR	1,708	1,265	1,265
EQUIPMENT & SERVICES	509	407	367
TRANSPORTATION	108	45	36
DISPOSAL	3,928	1,964	1,630
TOTAL	**6,940**	**4,254**	**3,727**

(Dollars in Thousands)

ATTACHMENT 4

FORT ST. VRAIN SURVEY AND ANALYSES RESULTS

Attachment 4 contains the following information:

Pages	Information Provided
2 - 3	Radiochemistry water sample results for the Condensate System (System 31).
4 - 6	Turbine Building Sump Radiochemistry water sample results.
7 - 8	Radiochemistry water sample results for the Cooling Tower (C/T) Basin. (Cooling tower basin samples are identified in the "Remarks" column as "C/T BASIN")
9 - 17	Results of recent radiological surveys of the Turbine Building (W-*).
18 - 21	Results of recent radiological surveys of plant areas inside the protected area (M-*).

PUBLIC SERVICE CO OF COLORADO
FORT ST. VRAIN

RADIOCHEMICAL SYSTEM SUMMARY   REPORT PERIOD OF : 1 189 TO 111389   DATE : 13-NOV-89

SYSTEM 31.

RC-NO	DATE	TIME	SAMPLED BY	REMARKS	ALPHA-ACT	BETA-ACT	TRIT-ACT	35S-ACT	89SR-ACT	90SR-ACT	SPEC.#
26.001	1 289	1155	ALDERMAN	SR 5.3.7-WK1	<1.21E-08	<3.08E-08	1.94E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 15
26.002	1 989	1112	FRAHM	SR 5.3.7-WK2	<1.25E-08	<5.22E-08	3.73E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 94
26.003	11689	955	ALDERMAN	SR 5.3.7-WK3	<8.59E-09	<4.74E-08	2.48E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 181
26.004	12389	1130	MADISON	SR 5.3.7-WK4	<8.34E-09	<4.62E-08	3.11E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 287
26.005	13089	1020	CHAMBERS	SR 5.3.7-WK5	<1.35E-08	<4.40E-08	2.20E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 371
26.006	2 689	1016	FRAHM	SR 5.3.7-WK6	<1.08E-08	<4.74E-08	7.22E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 419
26.007	21089	1146	FRAHM		<1.18E-08	<4.44E-08	7.04E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 455
26.008	21389	1315	ALDERMAN	SR 5.3.7-WK7	<1.45E-08	<4.20E-08	1.15E-06	<0.90E-01	<0.00E-01	<0.00E-01	SD 476
26.009	22189	900	MADISON	SR 5.3.7-WK8	<1.38E-08	<4.35E-08	1.31E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 519
26.010	22789	1042	CHAMBERS	SR 5.3.7-WK9	<1.03E-08	<4.84E-08	7.44E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 570
26.011	3 689	847	FRAHM	SR 5.3.7-WK10	<1.19E-08	<4.32E-08	1.41E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 612
26.012	31389	820	ALDERMAN	SR 5.3.7-WK11	<1.44E-08	<4.27E-08	1.34E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 658
26.013	32089	1000	MADISON	SR 5.3.7-WK12	<1.35E-08	<4.43E-08	**<3.59E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 705
26.014	32889	1255	CHAMBERS	SR 5.3.7-WK13	<1.04E-08	<4.37E-08	2.96E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 773
26.015	4 389	819	FRAHM	SR 5.3.7-WK14	<8.48E-09	<4.41E-08	1.75E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD 825
26.016	4 789	854	FRAHM		<3.95E-09	<4.99E-08	8.59E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 869
26.017	41089	1015	ALDERMAN	SR 5.3.7-WK15	<1.26E-08	<4.75E-08	3.37E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 891
26.018	41789	1035	MADISON	SR 5.3.7-WK16	1.28E-08	5.41E-08	* 5.39E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD 957
26.019	42489	1335	CHAMBERS	SR 5.3.7-WK17	<1.35E-08	<4.25E-08	3.65E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1016
26.020	5 189	1138	FRAHM	SR 5.3.7-WK18	<1.19E-08	<4.56E-08	1.69E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1079
26.021	5 489	827	FRAHM		<1.34E-08	<4.13E-08	1.84E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1100
26.022	5 889	845	ALDERMAN	SR 5.3.7-WK19	<1.35E-08	<4.49E-08	5.76E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD1128
26.023	51589	934	MADISON	SR 5.3.7-WK20	<8.48E-09	<4.85E-08	5.89E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1197
26.024	52289	1140	MADISON	SR 5.3.7-WK21	<1.19E-08	<4.69E-08	1.34E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1267
26.025	52989	645	FRAHM	SR 5.3.7-WK22	<1.20E-08	<4.69E-08	1.21E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1322
26.026	6 589	830	ALDERMAN	SR 5.3.7-WK23	<1.50E-08	<4.78E-08	1.27E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1398
26.027	61289	1015	MADISON	SR 5.3.7-WK24	<6.69E-09	<4.89E-08	1.20E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1488
26.028	61989	1025	CHAMBERS	SR 5.3.7-WK25	**<8.33E-09	**<4.87E-08	2.17E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1551
26.029	62689	1200	FRAHM	SR 5.3.7-WK26	<1.38E-08	<4.75E-08	1.91E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1609
26.030	7 389	904	FRAHM	SR 5.3.7-WK27	<5.97E-09	<5.03E-08	1.10E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1657
26.031	71089	1030	MADISON	SR 5.3.7-WK28	<1.04E-08	<4.91E-08	1.36E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1721
26.032	71789	1002	CHAMBERS	SR 5.3.7-WK29	<1.21E-08	<4.84E-08	8.57E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1771
26.033	72489	1007	FRAHM	SR 5.3.7-WK30	<1.20E-08	<4.44E-08	1.08E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1833
26.034	73189	755	ALDERMAN	SR 5.3.7-WK31	<1.20E-08	<4.51E-08	1.70E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1898
26.035	8 789	820	ALDERMAN	SR 5.3.7-WK32	<1.32E-08	<4.56E-08	1.46E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1958
26.036	81489	1005	CHAMBERS	SR 5.3.7-WK33	<1.58E-08	5.90E-08	1.52E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD2021
26.037	82189	1100	MADISON	SR 5.3.7-WK34	1.54E-08	<4.07E-08	1.28E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD2083
26.038	82889	1300	ALDERMAN	SR 5.3.7-WK35	2.03E-09	<4.88E-08	* 8.29E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2181
26.039	9 589	950	MADISON	SR 5.3.7-WK36	<1.35E-08	<4.32E-08	3.64E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2260
26.040	91189	819	CHAMBERS		<1.34E-08	<4.90E-08	1.33E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD2313
26.041	91589	1333	CHAMBERS		<1.64E-08	<4.51E-08	1.78E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD2335
26.042	91889	855	ALDERMAN		<1.32E-08	6.27E-08	* 8.82E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2376
26.043	92389	1100	MADISON		1.36E-08	<4.26E-08	1.29E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD2459
26.044	10 589	1435	POET		<1.46E-08	<4.90E-08	1.22E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD2533
26.045	10 989	1250	CHAMBERS		<1.34E-08	<4.30E-08	1.32E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD2553
26.046	101689	855	ALDERMAN		<1.71E-08	<4.91E-08	* 2.69E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2607
26.047	102389	945	MADISON		<1.35E-08	<4.36E-08	2.66E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2648
26.048	103089	1057	POET		<1.23E-08	<4.42E-08	2.18E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2713
26.049	11 689	1250	CHAMBERS		<1.39E-08	<4.74E-08	1.08E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2882
26.050	111389	900	ALDERMAN		<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	SD

MINIMUM	3.95E-09	4.07E-08	3.59E-07	0.00E-01	0.00E-01	0.00E-01
AVERAGE	[illegible]E-08	4.69E-08	6.56E-[illegible]	0.00E-01	0.00E-01	0.00E-01
NUMBER OF SAMPLES	49	49	49	0	0	0

TOTAL NUMBER OF SAMPLES : 50

NOTE-2 :
* = AVERAGE OF TWO OR MORE ALIQUOTS.
R = RESULTS OF SECOND ANALYSIS.
< = LESS THAN MDA.
ALL ACTIVITIES EXPRESSED IN MICROCURIES/MILLILITER UNLESS NOTED

RADIOCHEMICAL SYSTEM SUMMARY REPORT PERIOD OF : 1 189 TO 111389 DATE : 13-NOV-89

TURBINE BUILDING SUMP EFFLUENT

RC-NO	DATE	TIME	SAMPLED BY	REMARKS	ALPHA-ACT.	BETA-ACT.	TRIT-ACT.	35S-ACT.	89SR-ACT.	90SR-ACT.	SPEC #
4.001	1 289	1130	ALDERMAN		<1.21E-08	<3.00E-08	1.36E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 24
4.002	1 489	845	CHAMBERS		7.97E-09	<3.09E-08	1.17E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 45
4.003	1 689	810	MADISON		<1.07E-08	7.59E-08	1.35E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 60
4.004	1 989	823	FRAHM		<1.27E-08	<3.24E-08	1.79E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 106
4.005	11189	803	FRAHM		<1.72E-08	<3.36E-08	1.95E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 131
4.006	11389	757	FRAHM		<1.71E-08	<3.35E-08	1.64E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 150
4.007	11689	950	ALDERMAN		<8.65E-09	<4.75E-08	1.51E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 185
4.008	11889	800	ALDERMAN		<8.56E-09	<4.55E-08	1.52E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 226
4.009	12089	1010	ALDERMAN		<1.49E-08	<4.45E-08	1.14E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 261
4.010	12389	1120	MADISON		1.96E-08	<4.64E-08	1.02E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 290
4.011	12589	845	MADISON		<1.22E-08	6.47E-08	1.42E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 322
4.012	12789	810	MADISON		<1.49E-08	<4.46E-08	* 6.21E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 338
4.013	13089	822	CHAMBERS		<1.35E-08	<4.40E-08	1.28E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 367
4.014	2 189	745	CHAMBERS		<1.23E-08	<4.79E-08	3.71E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 393
4.015	2 389	845	CHAMBERS		<1.37E-08	<4.57E-08	1.60E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 403
4.016	2 689	803	FRAHM		<1.08E-08	<4.74E-08	2.14E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 431
4.017	2 889	757	FRAHM		7.98E-09	<4.40E-08	1.15E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 443
4.018	21089	854	FRAHM		<1.19E-08	<4.45E-08	6.38E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 457
4.019	21389	1005	ALDERMAN		<1.56E-08	<4.44E-08	8.49E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 469
4.020	21689	814	CHAMBERS		<1.33E-08	<4.62E-08	8.08E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 488
4.021	21789	823	FRAHM		*<1.03E-08	*<4.87E-08	3.68E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 498
4.022	22189	820	MADISON		<4.97E-08	<4.72E-08	3.99E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 525
4.023	22289	755	MADISON		<1.44E-08	<4.99E-08	<3.61E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 538
4.024	22489	700	MADISON		<3.94E-09	<4.48E-08	8.14E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 549
4.025	22789	853	CHAMBERS		<1.03E-08	<4.87E-08	4.70E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 565
4.026	3 189	810	CHAMBERS		<1.46E-08	<4.71E-08	7.15E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 583
4.027	3 389	735	MADISON		*<1.19E-08	*<4.52E-08	4.79E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 590
4.028	3 689	726	FRAHM		<1.17E-08	<4.52E-08	6.61E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 623
4.029	3 889	1310	MADISON		<1.02E-08	<4.38E-08	4.73E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 631
4.030	31089	807	FRAHM		<1.33E-08	<4.44E-08	<3.63E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 638
4.031	31389	815	ALDERMAN		<1.44E-08	<4.27E-08	* 1.17E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 657
4.032	31589	1315	ALDERMAN		<1.44E-08	<4.65E-08	2.12E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 678
4.033	31789	1140	ALDERMAN		<1.22E-0[illegible]	<4.63E-08	1.01E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 708
4.034	32089	1002	MADISON		<1.57E-08	<4.43E-08	*<3.59E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 710
4.035	32289	1105	ALDERMAN		<1.02E-08	<4.44E-08	7.70E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 730
4.036	32389	835	ALDERMAN		<1.02E-08	<4.44E-08	9.49E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 732
4.037	32889	938	CHAMBERS		<1.04E-08	<4.37E-08	1.45E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 775
4.038	32989	805	MADISON		<5.90E-09	<4.44E-08	5.66E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD 780
4.039	33189	748	CHAMBERS		1.27E-08	<4.58E-08	2.43E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 799
4.040	4 389	808	FRAHM		1.29E-08	<4.41E-08	3.82E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 826
4.041	4 589	815	FRAHM		<1.20E-08	<4.46E-08	5.77E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 854
4.042	4 789	1250	FRAHM		2.56E-08	<4.99E-08	3.28E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 870
4.043	41089	1013	ALDERMAN		1.20E-08	4.76E-08	1.25E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD 898
4.044	41289	1455	ALDERMAN		<1.34E-08	<4.28E-08	2.12E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD 917
4.045	41489	955	ALDERMAN		<1.34E-08	<4.28E-08	1.88E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD 930
4.046	41789	1037	MADISON		<8.45E-09	<4.37E-08	1.96E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD 966
4.047	41989	835	ALDERMAN		<1.41E-08	<4.72E-08	2.16E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD 977
4.048	42189	815	MADISON		2.14E-08	<4.39E-08	2.46E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD 990
4.049	42489	1010	CHAMBERS		<1.35E-08	4.48E-08	2.34E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1015
4.050	42689	818	CHAMBERS		<1.63E-08	5.88E-08	3.31E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1037
4.051	42889	820	CHAMBERS		<1.59E-08	<4.34E-08	2.68E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1048
4.052	5 189	903	FRAHM		<1.19E-08	<4.56E-08	7.75E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD1075
4.053	5 389	723	FRAHM		<1.59E-08	<4.94E-08	1.16E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1091
4.054	5 589	743	CHAMBERS		<1.05E-08	<4.47E-08	7.82E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD1107
4.055	5 889	840	ALDERMAN		<1.35E-08	<4.49E-08	1.93E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD1129

4.057	31289	815	ALDERMAN	<1.80E-08	<4.49E-08	4.45E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD1172
4.058	31589	940	MADISON	1.03E-08	<4.85E-08	2.92E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1202
4.059	31789	750	MADISON	<1.94E-08	<4.74E-08	2.64E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1222
4.060	31989	830	MADISON	1.27E-08	<5.07E-08	4.79E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1240
4.061	32289	1145	MADISON	<1.19E-08	<4.70E-08	6.29E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1263
4.062	32489	825	CHAMBERS	<1.34E-08	<4.68E-08	6.33E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1286
4.063	32689	745	CHAMBERS	1.30E-08	<4.67E-08	7.30E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1306
4.064	32989	451	FRAMM	1.34E-08	<4.72E-08	8.87E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1321
4.065	33189	1000	CHAMBERS	<1.21E-08	<4.65E-08	8.69E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1349
4.066	6 289	748	FRAMM	1.31E-08	<4.72E-08	7.34E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1370
4.067	6 589	900	ALDERMAN	<1.50E-08	<4.79E-08	6.80E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1394
4.068	6 789	1040	ALDERMAN	<1.21E-08	<4.80E-08	6.14E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1442
4.069	6 989	1300	ALDERMAN	<1.36E-08	<5.09E-08	6.36E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1468
4.070	61289	1110	MADISON	1.32E-08	<4.89E-08	3.89E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1490
4.071	61489	845	MADISON	<2.07E-08	5.54E-08	9.46E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1512
4.072	61689	815	MADISON	<1.21E-08	<4.80E-08	9.69E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1522
4.073	61989	820	CHAMBERS	<1.23E-08	<4.41E-08	8.91E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1539
4.074	62189	735	CHAMBERS	<1.07E-08	<5.24E-08	8.42E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1565
4.075	62389	830	CHAMBERS	<8.82E-09	<5.04E-08	1.07E-04	<0.00E-01	<0.00E-01	<0.00E-01	SD1583
4.076	62689	728	FRAMM	<1.38E-08	<4.76E-08	6.22E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1606
4.077	62889	807	FRAMM	<1.63E-08	<5.36E-08	6.18E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1629
4.078	63089	820	FRAMM	<1.35E-08	<4.78E-08	7.49E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1641
4.079	7 389	828	FRAMM	1.41E-08	<5.09E-08	9.10E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1666
4.080	7 589	845	ALDERMAN	<1.46E-08	<4.82E-08	5.36E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1692
4.081	7 789	820	ALDERMAN	<1.05E-08	<5.00E-08	6.90E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1698
4.082	71089	1000	MADISON	<1.05E-08	<4.92E-08	7.79E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1722
4.083	71289	930	MADISON	<1.48E-08	<4.66E-08	6.72E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1739
4.084	71489	800	MADISON	<6.02E-09	<4.59E-08	5.13E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1748
4.085	71789	1430	CHAMBERS	<1.22E-08	<4.87E-08	2.55E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1770
4.086	71989	825	CHAMBERS	7.83E-09	<4.49E-08	3.67E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1790
4.087	72189	806	CHAMBERS	<1.05E-08	<4.31E-08	5.24E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1806
4.088	72489	851	FRAMM	<1.21E-08	5.24E-08	9.19E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1836
4.089	72689	740	FRAMM	1.56E-08	<4.58E-08	7.33E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1859
4.090	72889	1015	FRAMM	<8.39E-09	4.50E-08	7.74E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1875
4.091	73189	745	ALDERMAN	<1.20E-08	<4.52E-08	4.81E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1897
4.092	8 289	1330	ALDERMAN	<1.93E-08	<4.34E-08	9.30E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1925
4.093	8 489	805	ALDERMAN	<1.32E-08	<5.05E-08	5.73E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1934
4.094	8 789	1320	ALDERMAN	<1.34E-08	<4.57E-08	4.52E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1962
4.095	8 989	1045	MADISON	<1.20E-08	<4.45E-08	4.58E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1982
4.096	81189	815	MADISON	<1.58E-08	<4.75E-08	6.95E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD1991
4.097	81489	900	CHAMBERS	<1.59E-08	7.88E-08	6.40E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2011
4.098	81689	813	CHAMBERS	<1.47E-08	4.74E-08	8.93E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2036
4.099	81889	139	FRAMM	1.57E-08	<4.40E-08	5.67E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2047
4.100	82189	945	MADISON	1.29E-08	4.16E-08	7.97E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2086
4.101	82389	844	CHAMBERS	<1.58E-08	<4.37E-08	1.90E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2103
4.102	82589	938	CHAMBERS	<1.70E-08	5.61E-08	4.77E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2162
4.103	82889	947	CHAMBERS	<1.80E-08	<4.90E-08	3.58E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2191
4.104	83089	800	ALDERMAN	<1.04E-08	<4.65E-08	4.02E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2206
4.105	9 189	930	ALDERMAN	<1.47E-08	<4.20E-08	1.09E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2227
4.106	9 489	1055	MADISON	1.36E-08	<4.34E-08	1.41E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2261
4.107	9 689	1125	MADISON	1.82E-08	5.67E-08	1.16E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2276
4.108	9 889	1300	MADISON	<1.36E-08	5.67E-08	1.49E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2298
4.109	91189	816	CHAMBERS	<1.36E-08	<4.91E-08	1.67E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2325
4.110	91389	805	POET	<1.71E-08	5.12E-08	3.54E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2341
4.111	91589	746	CHAMBERS	<1.04E-08	<4.51E-08	3.86E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2351
4.112	91889	1310	ALDERMAN	<1.35E-08	8.62E-08	1.21E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2373
4.113	92089	810	ALDERMAN	<1.70E-08	<4.80E-08	4.27E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2410
4.114	92289	805	ALDERMAN	<1.21E-08	<4.70E-08	3.05E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2425
4.115	92589	1100	MADISON	<1.05E-08	<4.26E-08	5.99E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2444
4.116	92789	1300	MADISON	<1.50E-08	<4.61E-08	4.91E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2470
4.117	92989	800	MADISON	<1.33E-08	<4.66E-08	4.93E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2482
4.118	10 289	945	POET	<1.04E-08	<4.55E-08	3.37E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2497
4.119	10 489	835	POET	<1.71E-08	<4.58E-08	5.60E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2517
4.120	10 689	835	POET	<1.47E-08	<4.90E-08	4.16E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2540
4.121	10 989	1005	CHAMBERS	<1.35E-08	<4.31E-08	5.05E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2556
4.122	101189	732	CHAMBERS	<1.59E-08	<4.35E-08	6.06E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2579
4.123	101389	816	CHAMBERS	<1.20E-08	<4.35E-08	5.23E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2586

4.125	101889	835	ALDERMAN	<1.61E-08	<4.13E-08	1.70E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2623
4.126	102089	745	ALDERMAN	<9.52E-09	<4.73E-08	2.53E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2635
4.127	102389	1030	MADISON	1.53E-08	<4.36E-08	1.60E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2632
4.128	102589	730	MADISON	<1.46E-08	5.27E-08	1.31E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2676
4.129	102789	1250	ALDERMAN	<1.35E-08	<4.47E-08	1.12E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2690
4.130	103089	1052	POET	1.50E-08	<4.42E-08	1.54E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2714
4.131	11 189	1045	ALDERMAN	<1.71E-08	<4.67E-08	1.09E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2738
4.132	11 389	1310	POET	<1.59E-08	<4.74E-08	1.15E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD2866
4.133	11 689	1050	CHAMBERS	<1.59E-08	<4.74E-08	6.93E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD2881
4.134	11 889	802	CHAMBERS	<1.21E-08	<4.51E-08	8.37E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD2923
4.135	111089	945	MADISON	<1.34E-08	<4.34E-08	4.70E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD
4.136	111389	805	ALDERMAN	<1.20E-08	<4.35E-08	4.21E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD
MAXIMUM				4.97E-08	8.62E-08	1.07E-04	0.00E-01	0.00E-01	0.00E-01	
MINIMUM				5.90E-09	4.13E-08	3.59E-07	0.00E-01	0.00E-01	0.00E-01	
AVERAGE				1.34E-08	4.78E-08	3.07E-05	0.00E-01	0.00E-01	0.00E-01	
NUMBER OF SAMPLES				136	136	136	0	0	0	

TOTAL NUMBER OF SAMPLES : 136

NOTE-2 :
* = AVERAGE OF TWO OR MORE ALIQUOTS.
R = RESULTS OF SECOND ANALYSIS.
< = LESS THAN MDA.
ALL ACTIVITIES EXPRESSED IN MICROCURIES/MILLILITER' UNLESS NOTED

PUBLIC SERVICE CO OF COLORADO
FORT ST.VRAIN

RADIOCHEMICAL SYSTEM SUMMARY

REPORT PERIOD OF : 1 109 TO 111309

DATE : 13-NOV-89

COOLING TOWER (C/T BASIN) SAMPLES

ENVIRONMENTIAL CROSS-CHECK SAMPLES.

SC-NO	DATE	TIME	SAMPLED BY	REMARKS	ALPHA-ACT.	BETA-ACT.	TRIT-ACT.	33G-ACT.	89SR-ACT.	90SR-ACT.	SPEC #
37.001	1 409	1000	CHAMBERS	[redacted]	<8.38E-09	<6.72E-09	<3.57E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.002	1 409	1200	CDH	E-41	<4.57E-09	7.76E-09	<3.49E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.003	11409	1310	CSU	A-23	<5.73E-09	1.16E-08	2.92E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.004	11409	1200	CSU	A-21	<4.65E-09	6.55E-09	<3.49E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.005	2 809	1117	CHAMBERS	[redacted]	1.34E-08	2.26E-08	<3.50E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.006	2 809	1330	CDH	E-41	<3.82E-09	<5.33E-09	<3.61E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.007	21109	1115	CSU	A-23	4.33E-09	5.68E-09	2.64E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.008	21109	1140	CSU	A-21	4.76E-09	<5.34E-09	<3.61E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.009	3 809	1200	MADISON	[redacted]	2.42E-08	<4.42E-08	<3.64E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.010	3 809	1400	CDH	E-41	7.06E-09	1.64E-08	<3.57E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.011	31109	1200	CSU	A-23	5.60E-09	1.37E-08	3.15E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.012	31109	1230	CSU	A-21	<3.88E-09	9.79E-09	6.41E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.013	4 509	1018	FRAHM	C/T BASIN	* 3.46E-08	* 5.24E-08	<3.63E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.014	4 509	1300	CDH	E-41	1.07E-08	9.07E-09	1.02E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.015	4 809	1150	CSU	A-21	8.33E-09	1.76E-08	<3.48E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.016	4 809	1230	CSU	A-23	1.56E-08	2.28E-08	1.98E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.017	5 309	1112	FRAHM	C/T BASIN	1.34E-08	1.49E-08	<3.49E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.018	5 309	1300	CDH	E-41	3.75E-09	8.49E-09	*<3.40E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.019	51309	1330	CSU	A-21	9.28E-09	<5.40E-09	<3.46E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.020	51309	1410	CSU	A-23	7.63E-09	7.71E-09	2.33E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.021	61009	1230	CSU	A-23	<3.02E-09	1.31E-08	1.37E-05	<0.00E-01	<0.90E-01	<0.00E-01	SD
37.022	61009	1300	CSU	A-21	3.06E-09	<5.00E-09	*<3.44E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.023	61409	1345	CDH	E-41	2.69E-08	1.32E-08	*<3.44E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.024	62109	1050	CHAMBERS	C/T BASIN	1.10E-08	1.61E-08	<3.44E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.025	7 809	1030	CSU	A-23	1.27E-08	9.43E-09	1.45E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.026	7 609	1050	CSU	A-21	1.71E-08	6.94E-09	<3.39E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.027	73109	600	ALDERMAN	C/T BASIN	3.96E-08	6.13E-08	<3.44E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.028	81209	1200	CSU	A-23	6.26E-09	1.09E-08	1.92E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.029	81209	1230	CSU	A-21	6.79E-09	6.06E-09	<3.33E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.030	81609	1130	CHAMBERS	C/T BASIN	* 1.97E-08	* 2.58E-08	4.85E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.031	82309	1100	CDH	E-41	1.05E-08	1.10E-08	<5.55E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.032	9 609	1245	MADISON	C/T BASIN	4.87E-09	1.31E-08	6.16E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.033	9 609	1430	CDH	E-41	9.00E-09	1.22E-08	5.55E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.034	9 909	1140	CSU	A-23	<2.15E-09	1.46E-08	1.77E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.035	9 909	1205	CSU	A-21	7.78E-09	2.15E-08	<3.39E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.036	101409	905	CSU	A-21	8.61E-09	1.51E-08	<3.38E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.037	101409	940	CSU	A-23	1.71E-08	9.92E-09	4.50E-05	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.038	10 309	1300	CDH	E-41	8.06E-09	9.57E-09	* 7.01E-06	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.039	101809	815	FSV	[redacted]	7.24E-09	5.61E-09	<3.38E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.040	11 809	1000	CHAMBERS	[redacted]	5.01E-09	6.78E-09	<3.44E-07	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.041	11 809	1235	CDH	E-41	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.042	111109	930	CSU	A-23	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	SD
37.043	111109	850	CSU	A-21	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	<0.00E-01	SD

	ALPHA-ACT.	BETA-ACT.	TRIT-ACT.	33G-ACT.	89SR-ACT.	90SR-ACT.
MAXIMUM	3.96E-08	6.13E-08	4.50E-05	0.00E-01	0.00E-01	0.00E-01
MINIMUM	2.15E-09	5.00E-09	1.02E-07	0.00E-01	0.00E-01	0.00E-01
AVERAGE	1.05E-08	1.44E-08	6.46E-06	0.00E-01	0.00E-01	0.00E-01
NUMBER OF SAMPLES	40	40	40	0	0	0

TOTAL NUMBER OF SAMPLES : 43

NOTE-2 :
$ = AVERAGE OF TWO OR MORE ALIQUOTS.
N = RESULTS OF SECOND ANALYSIS.
(= LESS THAN MDA.
ALL ACTIVITIES EXPRESSED IN MICROCURIES/MILLILITER' UNLESS NOTED

W-1

Technician Stroud

Inst./Ser. No. Tesla 3945 Cal Due Date 12/31/89

β MDA Bb 21 DPM/100cm²

RO-2 /Ser. No. 3960 Cal Due Date 3/31/90

RM 14/15/Ser No. 3957 Cal Due Date 12/31/89

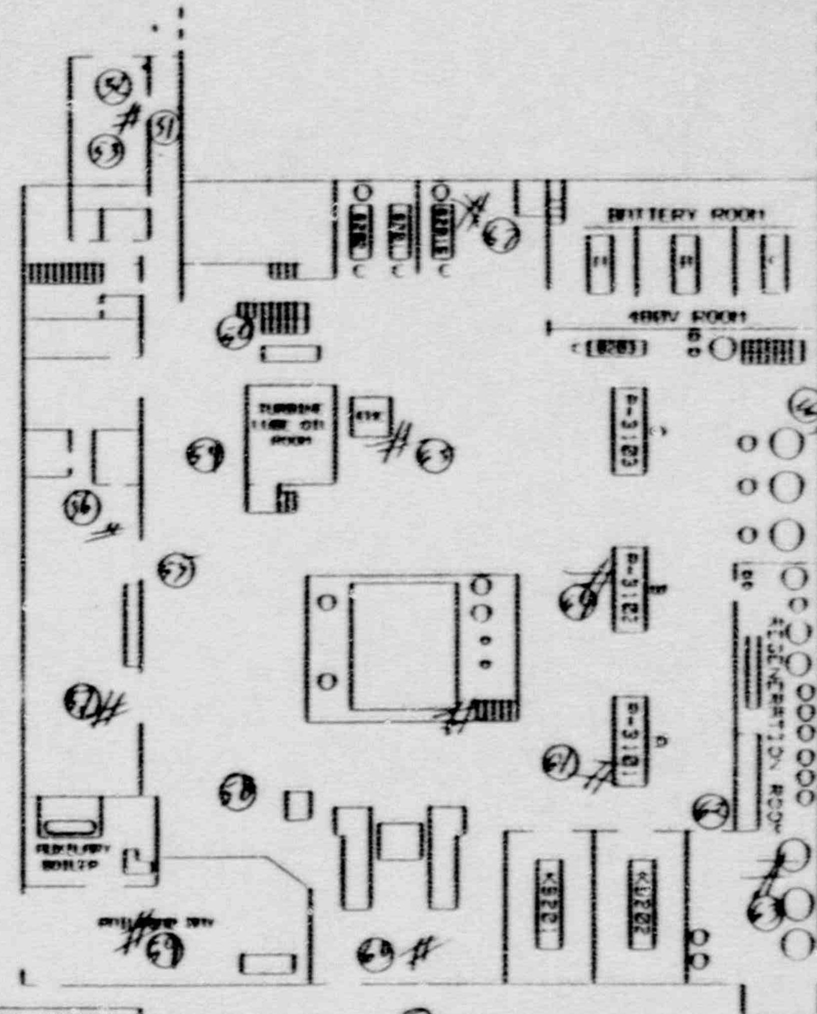
Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²

Comments:

- All radiation readings in mR/hr
- All general access areas < 2.0 mR/hr and MDA unless noted
- All wipes < MDA unless noted FRISKER BKGD 60 CPM

\# INDICATES DIRECT FRISK



WIPE LEGEND
□ WALL
△ EQUIPMENT
○ FLOOR

POWER LEVEL 0 %

GRADE FLOOR
ELEVATION 4791' 0"

REVIEWED BY: [signature] DATE: 6/13/89

Date 11-11-89 Time 1630

Technician Sicord

Inst./Ser. No. Tasil2/ 3945 Cal Due Date 12/31/89

β MDA Gkz 21 DPM/100cm²

RO-2 /Ser. No. 3960 Cal Due Date 3/31/90

RM-14/15/Ser No. 3957 Cal Due Date 12/31/89

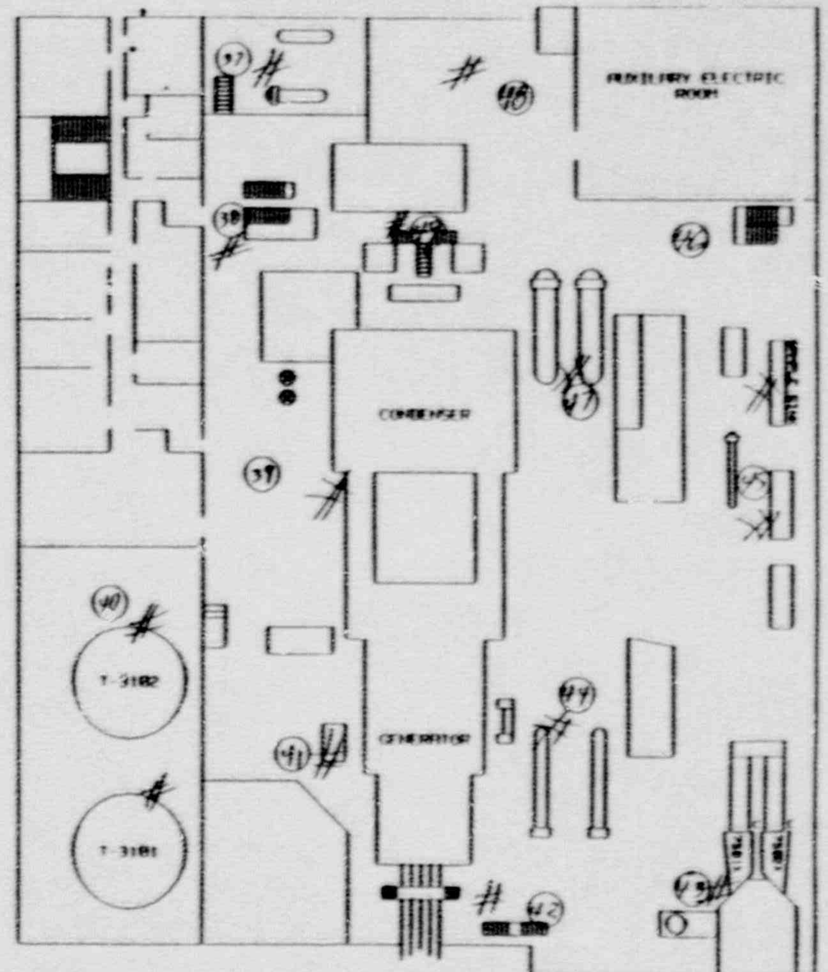
Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²

Comments:
- All radiation readings in mR/hr
- All general access areas < 2.0 mR/hr and MDA unless noted
- All wipes < MDA unless noted FRISKER BKGD 60 CPM

# INDICATES DIRECT FRISK

W-2



WIPE LEGEND
□ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL 0 %

MEZZANINE FLOOR
ELEVATION 4811'-0"

REVIEWED BY: [signature] DATE: 11/17/89

W-3

Date 11-11-89 Time 1630

Technician Stroud

Inst./Ser. No. 3296 12 3945 Cal Due Date 12 31 89

β MDA 8621 DPM/100cm²

RO 2 /Ser. No. 3960 Cal Due Date 3/31/90

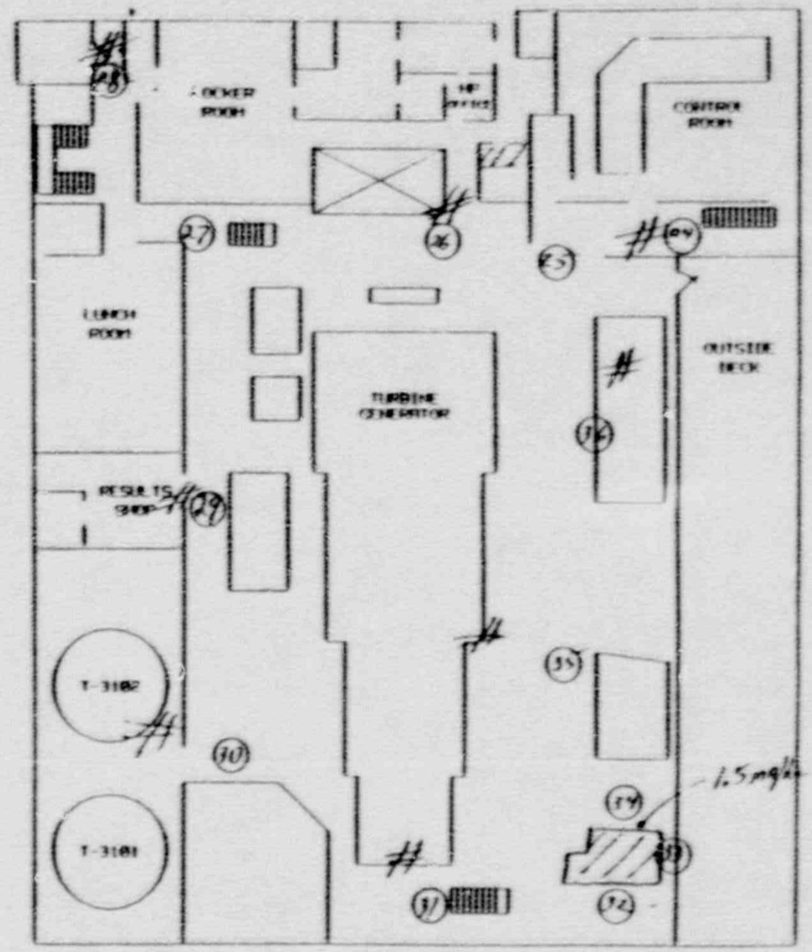
PM 14/15/Ser No. 3757 Cal Due Date 12 31 89

Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²

Comments:
- All radiation readings in mR/hr
- All general access areas < 2.0 mR/hr and MDA unless noted
- All wipes < MDA unless noted FRISKER BKGD 60 CPM

# INDICATES DIRECT FRISK



WIPE LEGEND	
□	WALL
Δ	EQUIPMENT
O	FLOOR

POWER LEVEL 0 %

OPERATING FLOOR ELEVATION 4829'-0"

REVIEWED BY: [signature] DATE: 11/12/89

W-4

Date 11-11-89 Time 1630

Technician Stroud

Inst./Ser. No. 19x21/ 3945 Cal Due Date 12/31/89

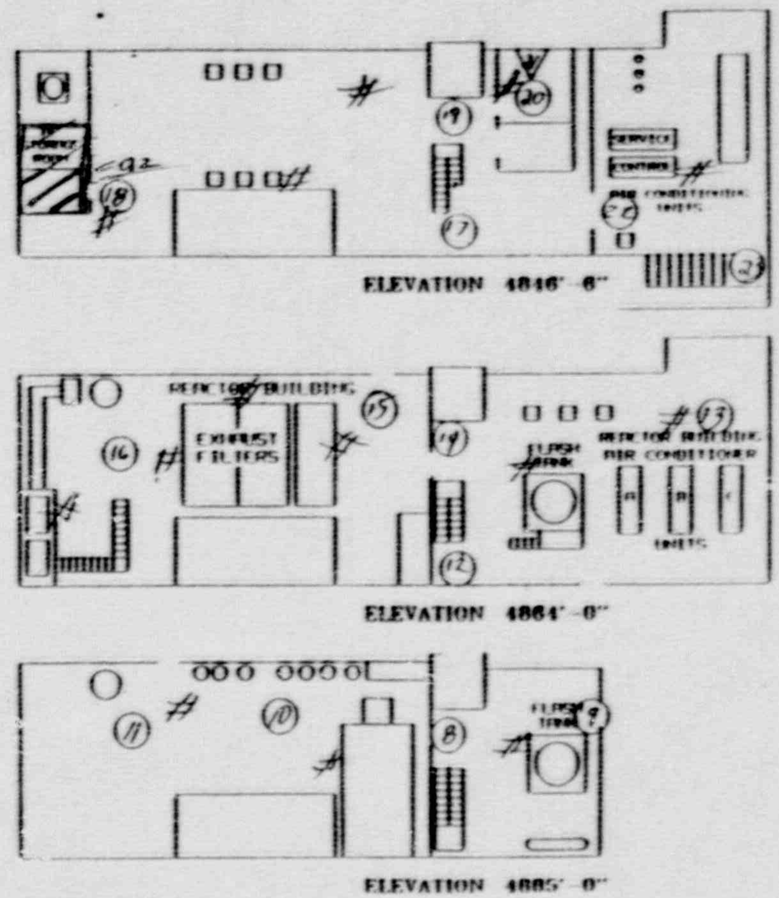
β MDA 86 21 DPM/100cm²

RO-2 /Ser. No. 3960 Cal Due Date 3/31/90

RM-14/15/Ser No. 3957 Cal Due Date 12/31/89

Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²



Comments:

* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted FRISKER BKGD 60 CPM

# INDICATES DIRECT FRISK

WIPE LEGEND
□ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL 0 %

REVIEWED BY: [signature] DATE: 11/12/89

W-5

Date 11-11-87 Time 10:20

Technician Ed Strock

Inst./Ser. No. ~~ASC12~~ 3945 Cal Due Date 12/31/87

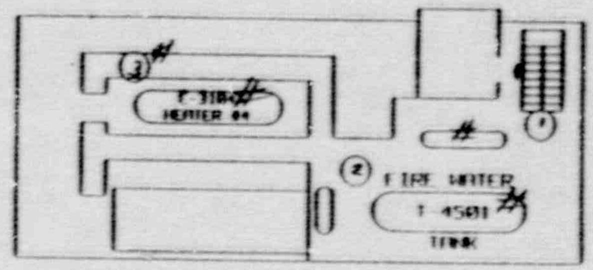
β MDA 8?? 21 DPM/100cm²

RO-2 /Ser. No. 3960 Cal Due Date 3/31/90

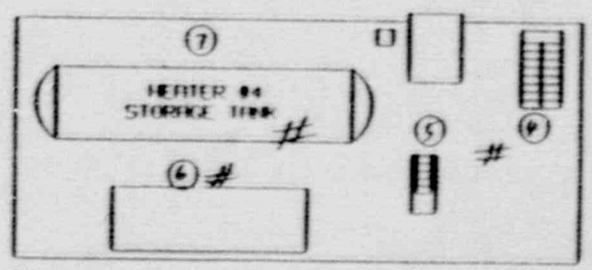
RM-14/15/Ser No. 3957 Cal Due Date 12/31/87

Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²



ELEVATION 4921'-6"



ELEVATION 4904'-0"
TURBINE BUILDING

Comments:

* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted

FRISKER BKGD 60 CPM

# INDICATES DIRECT FRISK

WIPE LEGEND
☐ WALL
△ EQUIPMENT
○ FLOOR

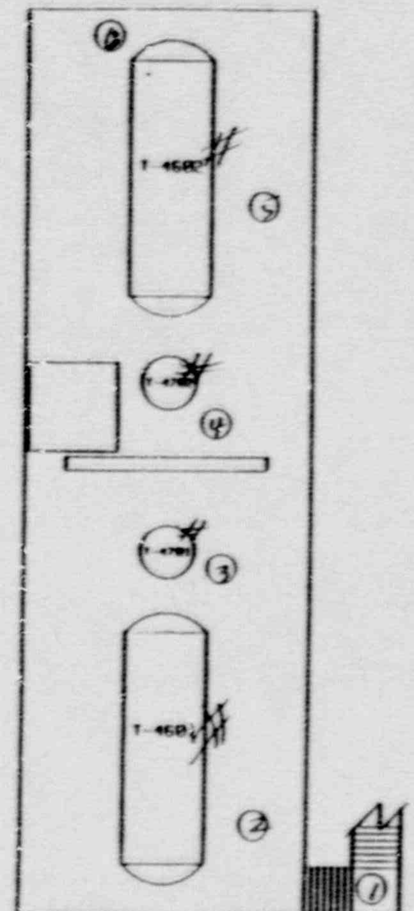
POWER LEVEL 0 %

REVIEWED BY: [signature] DATE: 11/13/87

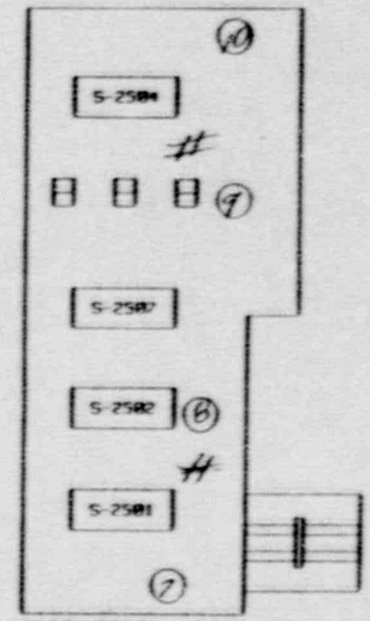
W-G

Date 11-11 89 Time 1630
Technician [illegible signature]
Inst./Ser. No. 14x-RL 3945 Cal Due Date 12/31/89
β MDA 8621 DPM/100cm²
RO-2 /Ser. No. 3960 Cal Due Date 3/31/90
RM-14/15/Ser No. 3957 Cal Due Date 12/31/89
Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²



ELEVATION 4916'-8"



ELEVATION 4906'-8"

Comments:
* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted FRISKER BKGD 80 CPM

\# INDICATES DIRECT FRISK

WIPE LEGEND
□ WALL
△ EQUIPMENT
○ FLOOR

POWER LEVEL 0 %

REVIEWED BY: [signature] DATE: 11/14/89

W-7

Date 11-11-89 Time 1630

Technician Ed Stroud

Inst./Ser. No. [illegible] 3945 Cal Due Date 12/31/89

β MDA 21 DPM/100cm²

RO-2 /Ser. No. 3960 Cal Due Date 3/31/90

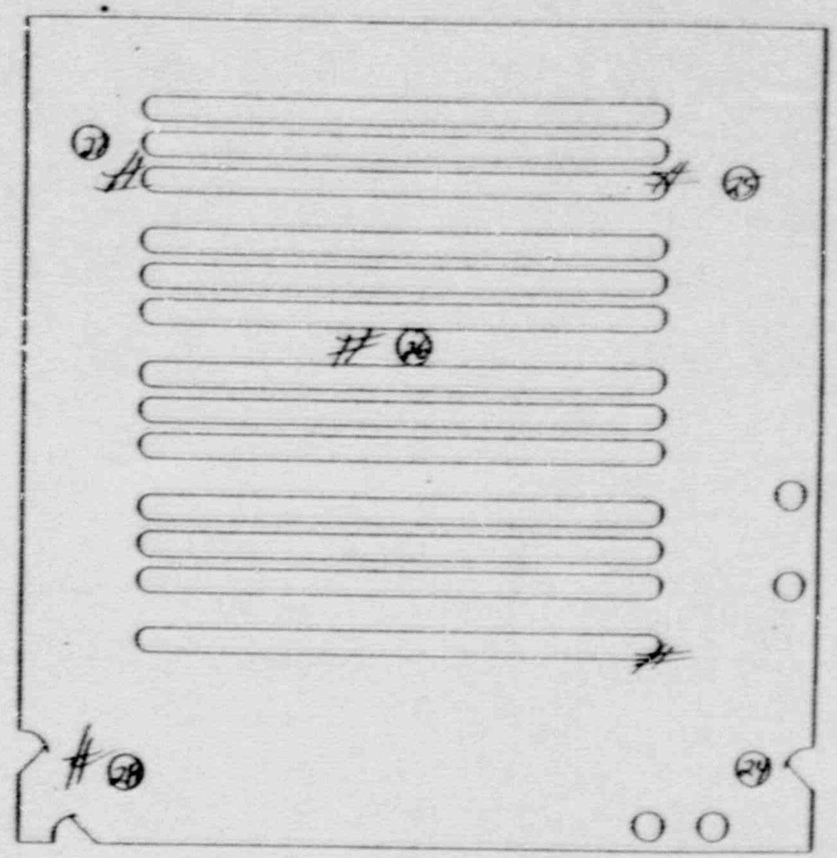
RM-14/15/Ser No. 3957 Cal Due Date 12/31/89

Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm^2	WIPE No.	WIPE BETA DPM/100 cm^2	WIPE No.	WIPE BETA DPM/100 cm^2

Comments:
* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted FRISKER BKGD 60 CPM

# INDICATES DIRECT FRISK



Rx BUILDING HELIUM STORAGE
ELEVATION 4791'-0"

WIPE LEGEND
□ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL 0 %

REVIEWED BY: [signature] DATE: 11/12/89

W-8

Date 11-11-89 Time 16 30

Technician Straud

Inst./Ser. No. [illegible] 3945 Cal Due Date 12/31/89

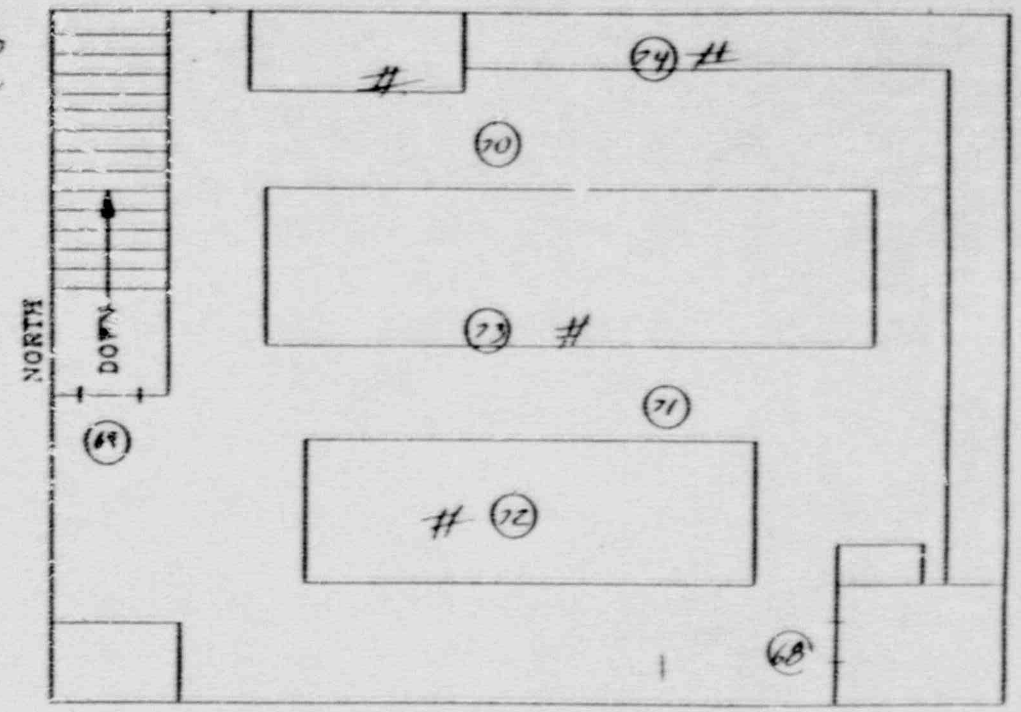
β MDA [illegible] 21 DPM/100cm²

RO-2 /Ser. No. 3960 Cal Due Date 3/31/90

RM-14/15/Ser No. 3957 Cal Due Date 12/31/89

Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²



WATER CHEMICAL LABORATORY

Comments:
* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted FRISKER BKGD 60 CPM

# INDICATES DIRECT FRISK

WIPE LEGEND
□ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL - 0 %

REVIEWED BY: [illegible] DATE: 11/12/89

W-12

Date 11-11-89 Time 1630

Technician Ed Strod

Inst./Ser. No. 1asc12/3945 Cal Due Date 12/31/89

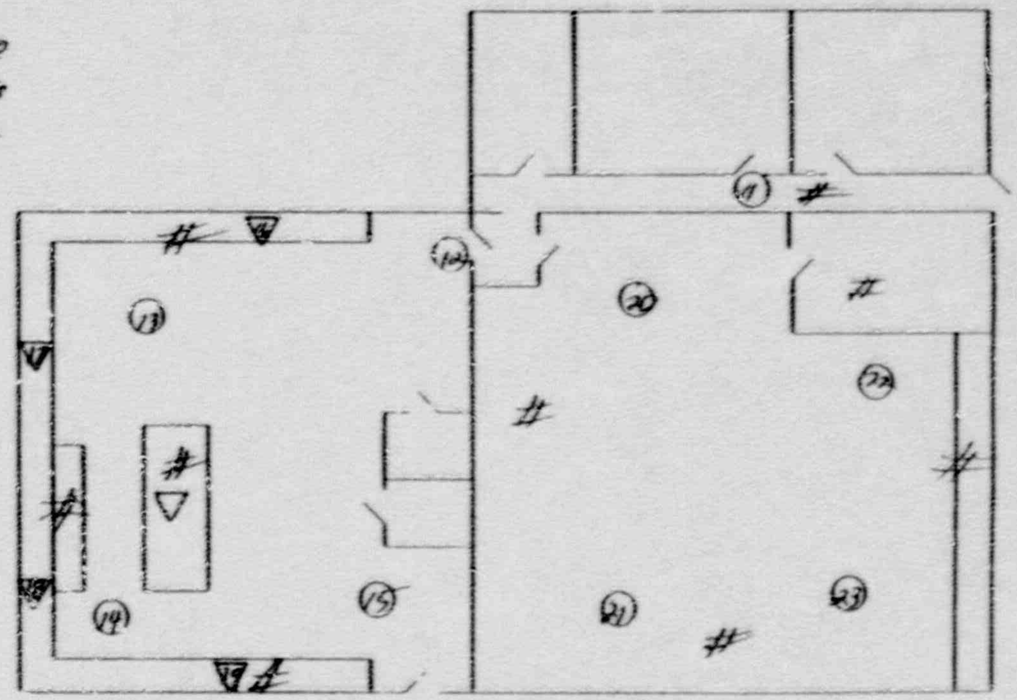
β MDA 96.21 DPM/100cm²

RO-2 /Ser. No. 3960 Cal Due Date 3/31/90

RM-14/15/Ser No. 3957 Cal Due Date 12/31/89

Inst./Ser. No. ___/___ Cal Due Date __/__/__

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²



RADIOCHEMISTRY LABORATORY

Comments:
* All radiation readings in mR/hr
* All general access areas : 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted FRISKER BKGD 60 CPM

# INDICATES DIRECT FRISK

WIPE LEGEND
□ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL 100 %

REVIEWED BY: [signature] DATE: 11/12/89

M-1

Date 10-30-89 Time 1245

Technician Maena K. Porter

Inst./Ser. No. RSCR/3945 Cal Due Date 12/31/89

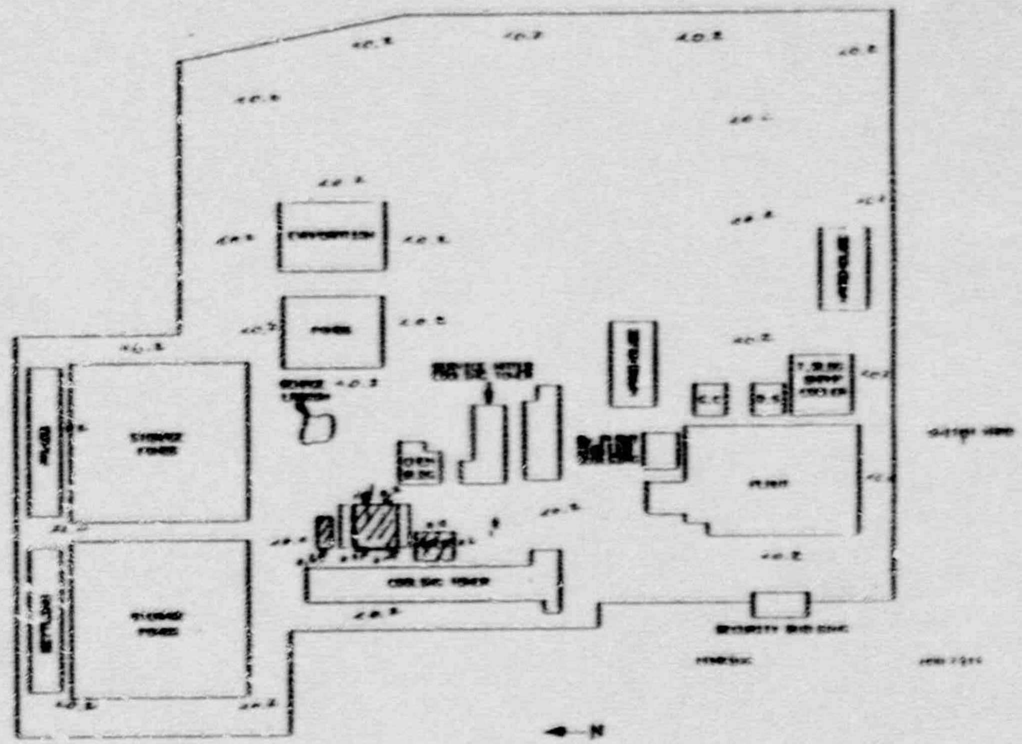
β MDA 21 DPM/100cm²

RO-2 /Ser. No. 5315 Cal Due Date 3/31/90

RM-14/15/Ser No. ______ Cal Due Date __/__/__

Inst./Ser. No. ___/___ Cal Due Date __/__/__

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²



Comments:
- All radiation readings in mR/hr
- All general access areas < 2.0 mR/hr and MDA unless noted
- All wipes < MDA unless noted FRISKER BKGD ______ CPM

\# INDICATES DIRECT FRISK

No items found leaking on corroded north of computer bldg

WIPE LEGEND
□ WALL
△ EQUIPMENT
○ FLOOR

POWER LEVEL Ø

REVIEWED BY: [signature] DATE: 11/3/89

Date 10-30-89 Time 1245

Technician Maura K. Porter

Inst./Ser. No. MC12/3945 Cal Due Date 12/31/89

β MDA 21 DPM/100cm²

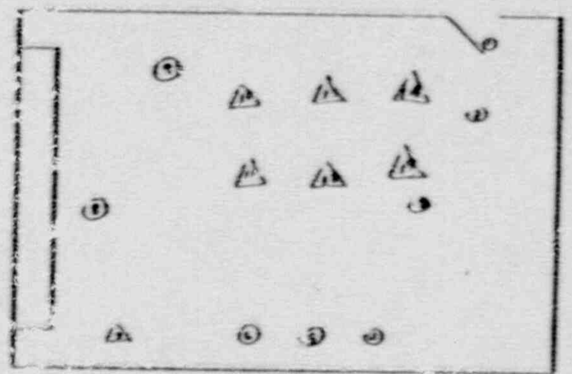
RO-2 /Ser. No. 3315 Cal Due Date 3/31/90

RM-14/15/Ser No. ____ Cal Due Date _/_/_

Inst./Ser. No. ___/___ Cal Due Date _/_/_

M-3

WIPE NO.	WIPE BETA DPM/100 cm²	WIPE NO.	WIPE BETA DPM/100 cm²	WIPE NO.	WIPE BETA DPM/100 cm²



RESULTS LUNCH ROOM
ELEVATION 4791'-0"

Comments:
* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted

FRISKER BKGD ______ CPM

# INDICATES DIRECT FRISK

WIPE LEGEND
☐ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL Ø %

REVIEWED BY: [signature] DATE: 11/3/89

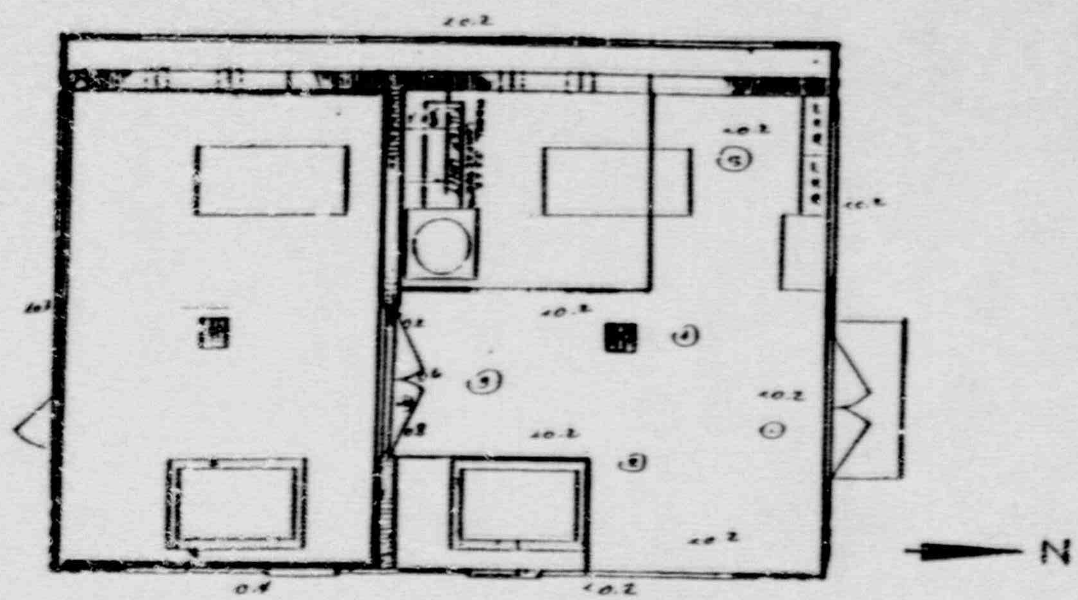
Page 19

M-4

Date 10-30-89 Time 1245.
Technician Marna K. Porter
Inst./Ser. No. MC12/ 3945 Cal Due Date 12/31/89
β MDA 21 DPM/100cm²
RO-2 /Ser. No. 3315 Cal Due Date 3/31/90
RM-14/15/Ser No. Cal Due Date / /
Inst./Ser. No. / Cal Due Date / /

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²

Compactor Building



Comments:
* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted FRISKER BKGD ______ CPM

\# INDICATES DIRECT FRISK

No drums or bags found leaking or corroded in compactor bldg. rad/c area

WIPE LEGEND
□ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL ∅ %

REVIEWED BY: DATE: 11/3/89

Date 10-30-89 Time

Technician Marna K. Porter

Inst./Ser. No. PRC12/3945 Cal Due Date 12/31/89

β MDA 21 DPM/100cm²

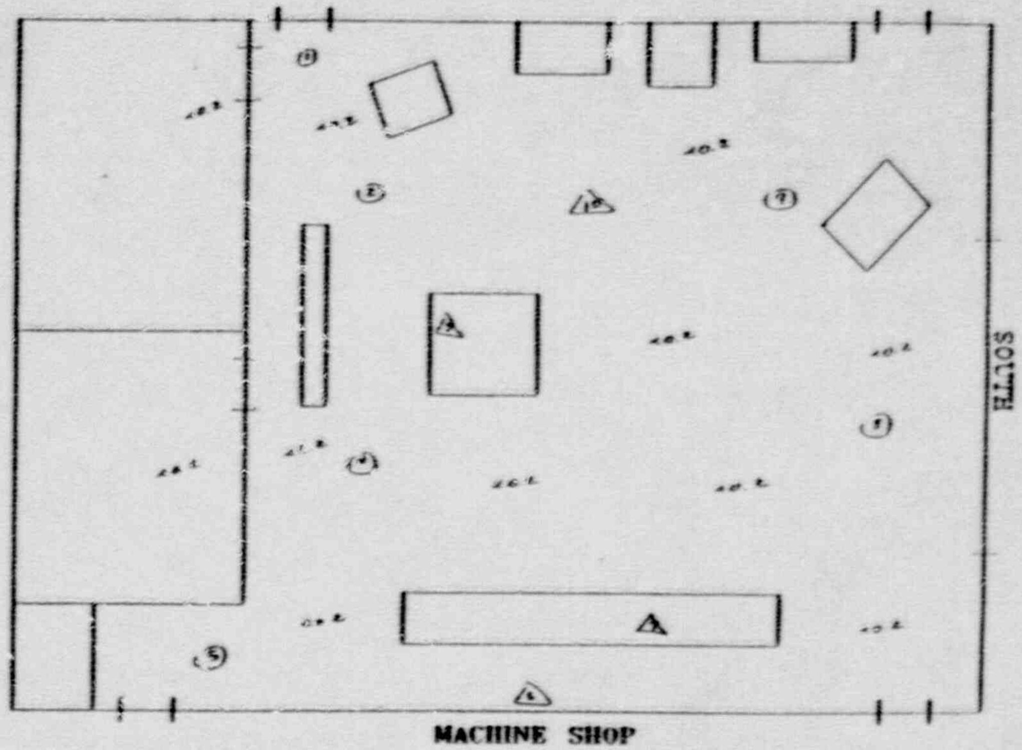
RO-2 /Ser. No. 3315 Cal Due Date 3/31/90

RM-14/15/Ser No. Cal Due Date / /

Inst./Ser. No. / Cal Due Date / /

M-5

WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²	WIPE No.	WIPE BETA DPM/100 cm²



Comments:
* All radiation readings in mR/hr
* All general access areas < 2.0 mR/hr and MDA unless noted
* All wipes < MDA unless noted

FRISKER BKGD ______ CPM

# INDICATES DIRECT FRISK

WIPE LEGEND
□ WALL
Δ EQUIPMENT
O FLOOR

POWER LEVEL 0 %

REVIEWED BY: [signature] DATE: 11/3/89

ATTACHMENT 5

ANNUAL RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

(P-89151), dated April 20, 1989.

Public Service

Public Service Company of Colorado
P.O. Box 840
Denver, CO 80201-0840

R.O. WILLIAMS, JR.
SENIOR VICE PRESIDENT
NUCLEAR OPERATIONS

April 20, 1989
Fort St. Vrain
Unit No. 1
P-89151

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

Docket No. 50-267

SUBJECT: Annual Radiological Environmental Monitoring Report

Gentlemen:

Enclosed please find a copy of the Fort St. Vrain Nuclear Generating Station Radiological Environmental Monitoring Program Annual Summary Report for 1988. The report is submitted in accordance with section 7.5.1d of the Fort St. Vrain Technical Specifications.

A copy of the Summary Report is also being sent to the Director, Office of Nuclear Reactor Regulation, per the requirements of section 7.5.1d of the Technical Specifications. Please contact Mr. Mike Holmes at (303) 480-6960 if you have any questions regarding the Report.

Sincerely,

R. O. Williams, Jr.
Senior Vice President
Nuclear Operations

ROW:DDM/bw

Enclosure

8904275098 2pp

cc: Regional Administrator, Region IV
Attention: Mr. T. F. Westerman, Chief
Projects Section B

Mr. R. E. Farrell
Senior Resident Inspector
Fort St. Vrain

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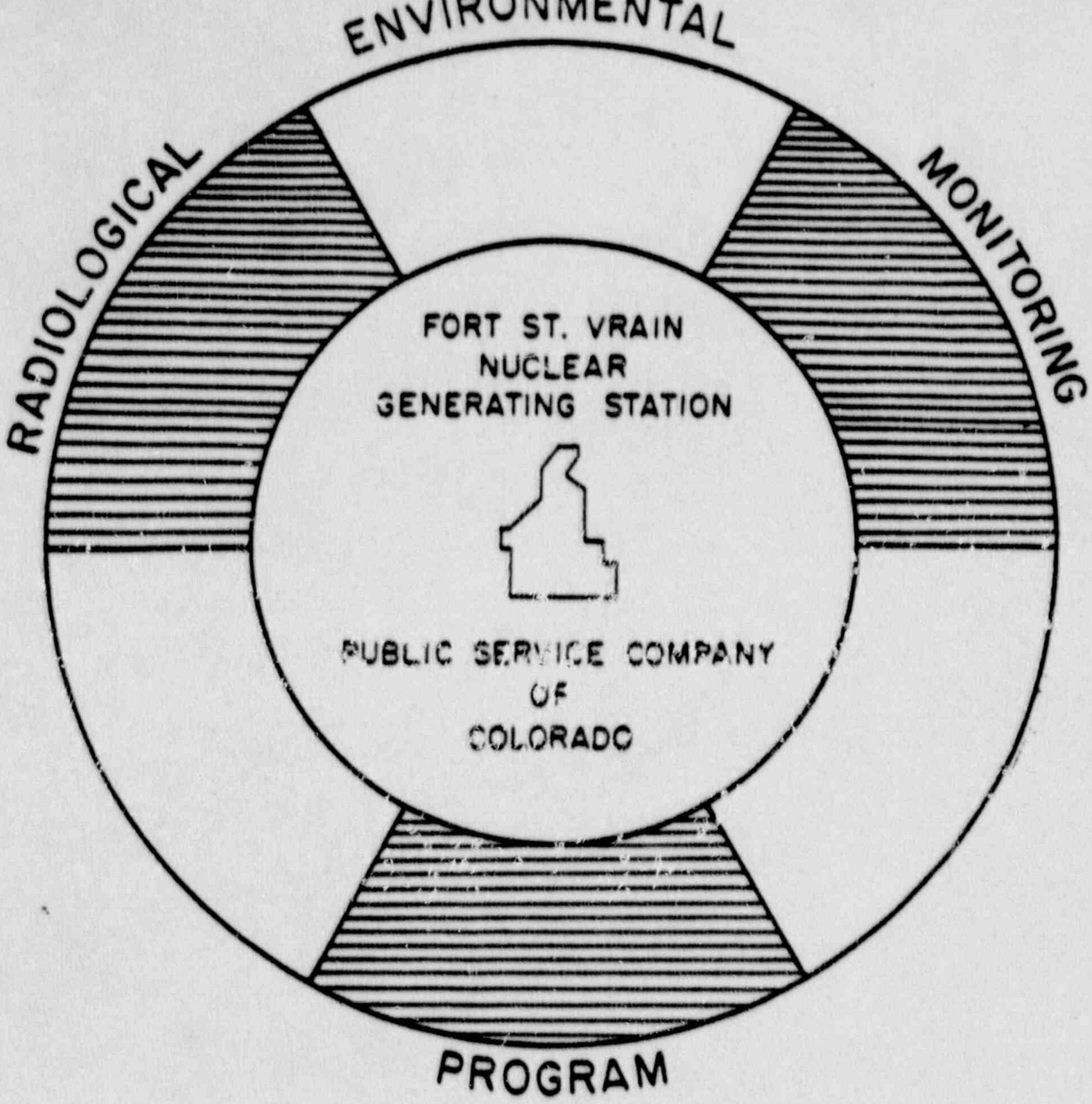
Licensing Review By (letter only)

Date: 4-20-89

ENCLOSURE IS AN APPROVED DOCUMENT



SUMMARY REPORT

1988

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COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO 80523

130pp

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

For the Fort St. Vrain Nuclear Generating Station
Operated by the Public Service Co. of Colorado

Summary Report
for the Period
January 1, 1988 - December 31, 1988

Prepared by: ______________________ ________
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Reviewed by: ______________________ 4/19/89
Superintendent of Chemistry and Radiation Protection — Date

Reviewed by: ______________________ 4-19-89
Radiochemistry Supervisor — Date

Approved by: ______________________ 4/20/89
Nuclear Support Services Manager — Date

Acknowledgements

Many persons have contributed to this project during 1988, and it is important to acknowledge their effort. We also wish to thank the citizens from whose farms, homes, and ranches we collect the environmental samples. Without their cooperation the project would not be possible.

The persons working directly on the project have been:

Joseph Bianconi	Graduate Research Assistant
Deborah Blunt	Graduate Research Assistant
John Fleming	Student Employee
Roger Gerdes	Undergraduate Student
Patti Kelley	Student Employee
Grant T. Reid	Programmer
Charles Sampier	Chief Electronic Technician
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I. Introduction to Radiological Environmental Monitoring Data for the Period January 1, 1988 - December 31, 1988

During 1988 the Fort St. Vrain Nuclear Generating Station produced thermal energy as follows:

Month	Dates with Thermal Energy Generation	Gross Thermal Energy Production (MWH)
Jan.	1-31	402,863
Feb.	1-10	100,788
	12-29	139,596
Mar.	1-31	455,973
Apr.	1-7	61,530
	21-30	99,147
May	1-6	88,111
	18-31	73,962
June	1-30	458,144
July	1-5	74,262
Aug.-Dec.	0	0
Total for 1988		1,954,378

A complete and detailed listing of radioactivity released by all effluent routes may be found in the Public Service Company of Colorado Semi-annual Effluent Release Reports for 1988 to the U.S. Nuclear Regulatory Commission. When possible in this report, any correlation of radioactivity in environmental samples with the effluent release data is discussed. These discussions are presented in the appropriate sample type section and in the summary section, II.H.

Table III.A.2 lists the LLD values achievable by the counting systems used during 1988 on project samples. These values are given for typical sample sizes, counting times and decay times. The LLD is, therefore, an a priori parameter to indicate the capability of the detection system used. The LLD values in Table III.A.2 were calculated as suggested in NUREG-0472.

Throughout the report, however, when a sample result is listed as less than a specified value, that value is the calculated MDC (minimum detectable concentration). This approach is analogous to that of Currie (NUREG/CR-4007): the MDC is the same as S_C, the critical signal, and the LLD is equal to S_D, the detectable signal. The MDC value applies to the actual sample size, counting time and decay time applicable to that individual sample. It is calculated as:

$$MDC = 2.33\ \sigma_B/E\ Y\ V\ E^{-\lambda t}$$

Where: σ_B = Standard deviation of background count rate

E = Counting efficiency, c s^{-1} pCi^{-1}

Y = Chemical yield

V = Sample mass or volume

λ = 0.693/Half-life

t = Decay time between sample collection and analysis

This calculation method assumes that E and Y are constants and makes no allowance for systematic error.

It should be noted that we have not used the notation < MDC for values less than MDC. Rather, we report the result as less than the actual MDC value. Because the MDC is dependent upon variables such as the background count time and sample size, the value will be different for each sample type and even within sample type.

Essentially all radioactivity values measured on this project are near background levels and, more importantly, near the MDC values for each radionuclide and sample type. It has been well-documented that environmental radioactivity values exhibit great inherent variability. This is partly due to sampling and analytical variability, but most importantly due to true environmental or biological variability. As a result, the overall variability of the surveillance data is quite large, and it is necessary to use mean values from a rather large sample population size to make any conclusions about the absolute radioactivity concentrations in any environmental pathway.

Environmental radiation surveillance data also commonly exhibit non-normal frequency distributions. Usually the data can be satisfactorily treated using log-normal statistics. However, when the number of observations is small, i.e., less than 10, log-normal treatment is tentative. The geometric means and geometric standard deviations are calculated for each sample set. If any data point measured resulted in a negative value, the corresponding MDC is used in the calculation of the log-normal statistics. (Negative values are possible due to the statistical nature of radioactivity counting.) In Section II.H. Conclusions and Summary, the geometric means and geometric standard deviations for the reporting period of 1988 are listed in Table II.H.2.

The arithmetic mean for each sample set is also listed in Table II.H.2. All measured values, both positive and negative, are used in the calculations of the arithmetic mean. This is the suggested practice by Gilbert (Health Physics 40:377, 1984) and the NRC (NUREG/CR-4007).

Many sets of data were compared in this report. The statistical test used was either a "t"-test or a paired "t"-test. If data sets are noted to be significantly different or not significantly different, the confidence for the statement is at the 95% level (α = 0.05).

In this report we have footnoted appropriate tables with the maximum permissible concentration applicable to each radionuclide. We have chosen to list the maximum permissible concentrations as found in Appendix B Table II of 10CFR20. This is the concentration in water or air of each radionuclide which if ingested or inhaled continuously would singularly produce the maximum permissible radiation dose rate to a specified individual member of the general public. That value is 500 mrem/year, but must include the dose from all possible sources, and, therefore, cannot be solely due to reactor effluent. As stated in 10CFR20 these are the maximum concentrations above natural background that a licensee may release to an unrestricted area. It is assumed that no direct ingestion or inhalation of effluents can occur at the restricted area boundary and that dilution and dispersion decreases the concentration before it reaches nearby residents. This is certainly the case for the Fort St. Vrain environs.

There is no specified maximum permissible dose rate or dose commitment for residents near the Fort St. Vrain reactor from the reactor effluents. Such limits for water cooled reactors are found in 10CFR50 Appendix I. These are judged as "As Low as Reasonably Achievable" dose rates from such reactor types and, although not directly applicable to the Fort St. Vrain gas cooled reactor, can be used for comparison purposes.

A limit that does apply is the independent maximum permissible dose commitment rate set by the E.P.A. (40CFR190) for any specified member of the general public from any part of the nuclear fuel cycle. This value is 25 mrem/year, the dose rate to the whole body from all contributing radionuclides excluding background and medical radiation dose rate.

Dose commitments are calculated for hypothetical individuals for any mean concentrations noted in unrestricted areas that are significantly above control mean values.

The following is the footnote system used in this report.

a. Sample lost prior to analysis.

b. Sample missing at site.

c. Instrument malfunction.

d. Sample lost during analysis.

e. Insufficient weight or volume for analysis.

f. Sample unavailable.

g. Analysis in progress.

h. Sample not collected (actual reason given).

i. Analytical error (actual reason given).

N.A. Not applicable.

II. Surveillance Data for January Through December 1988 and Interpretation of Results

A. External Gamma-ray Exposure Rates

The average measured gamma-ray exposure rates expressed in mR/day are given in Table II.A.1. The values were determined by CaF_2:Dy (TLD-200) dosimeters at each of 41 locations (see Table III.B.1). Two TLD chips per package are installed at each site and the mean value is reported for that site. The mean calculated total exposure is then divided by the number of days that elapsed between pre-exposure and post-exposure annealing to obtain the average daily exposure rate. The TLD devices are changed quarterly at each location. Fading during field exposure is minimized by the post-annealing readout procedure.

The TLD data indicate that the arithmetic mean measured exposure rate in the facility area for all of 1988 was 0.36 mR/day. The mean exposure rate was 0.36 mR/day for the adjacent area and 0.34 mR/day for the reference area. These mean values were not significantly different from each other.

The exposure rate measured at all sites is due to a combination of exposure from cosmic rays, from natural gamma-ray emitters in the earth's crust and from ground surface deposition of fission products due to previous world-wide fallout. The variation in measured values is due to true variation of the above sources plus the variation due to the measurement method. The purpose of the two TLD rings around the reactor is not to measure gamma-rays generated from the reactor facility itself, but to document the presence or absence of gamma-ray emitters deposited upon the ground from the reactor effluents. Since the inception of power production by the reactor, there has been no detectable increase in the external exposure rate due to reactor releases. Fallout, both from the Chinese nuclear weapon tests and from the Chernobyl accident, was detected in the past.

The TLD system was calibrated by exposing chips to a scattered gamma-ray flux produced in a cavity surrounded by uranium mill tailings. This produces a gamma-ray spectrum nearly identical to that from natural background measured in the reactor environs. The quality control program includes calibration before readout of each quarterly batch of TLD devices.

For comparison purposes, the EPA in EPA 520/5-88-057 Report #53 lists 0.38 $\pm$ 0.11 mR/day for the background external exposure rate in Denver.

Table II.A.1 Gammma Exposure Rates. (mR/day) 1988

Facility Area	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
F-1	0.35	0.43	0.42	0.44
F-2	0.33	0.40	0.36	0.46
F-3	0.37	0.36	0.37	0.42
F-4	0.32	0.35	0.43	0.37
F-5	0.36	0.39	0.37	0.38
F-6	0.30	0.32	0.35	0.36
F-7	0.30	0.37	0.35	0.38
F-8	0.34	0.33	0.40	0.41
F-9	0.43	0.30	0.37	0.41
F-10	0.34	0.37	0.38	0.39
F-11	0.34	0.34	0.41	0.46
F-12	0.30	0.31	0.40	0.44
F-13	0.31	0.25	0.33	0.37
F-14	0.33	0.20	0.34	0.39
F-15	0.32	0.35	0.34	0.35
F-16	0.33	0.35	0.36	0.43
F-17	0.37	0.36	0.39	0.35
F-18	0.33	0.39	0.44	0.41
$\bar{X}$ (1.96σ)	0.34(0.062)	0.34(0.11)	0.38(0.06)	0.40(0.069)
Adjacent Area				
A-1	0.30	0.42	0.40	0.36
A-2	0.34	0.38	0.39	0.43
A-3	0.31	0.41	0.37	0.42
A-4	0.32	0.36	0.38	0.36
A-5	0.36	0.36	0.38	0.34
A-6	0.35	0.31	0.37	0.35
A-7	0.31	0.36	0.38	0.44
A-8	0.32	0.45	0.41	0.41
A-9	0.37	0.38	0.39	0.42
A-10	0.33	0.42	0.41	0.47
A-11	0.33	0.35	0.37	0.39
A-12	0.33	0.32	0.32	0.41
A-13	0.31	0.31	0.34	0.35
A-14	0.34	0.30	0.34	0.38
A-15	0.35	0.28	0.36	0.36
A-16	0.34	0.23	0.36	0.40
A-17	0.34	0.28	0.38	0.42
A-20	0.36	0.38	0.42	0.46
$\bar{X}$ (1.96σ)	0.33(0.039)	0.35(0.11)	0.38(0.05)	0.39(0.077)
Reference Area				
R-2	0.30	0.29	0.34	b
R-3	0.31	0.36	0.35	0.40
R-4	0.29	0.33	0.31	0.36
R-5	0.27	0.37	0.33	0.37
R-7	0.28	0.40	0.33	0.42
$\bar{X}$ (1.96σ)	0.29(0.031)	0.35(0.082)	0.30(0.03)	0.39(0.052)

b TLD packet removed from pole by vandals.

II.B. Ambient Air Concentrations

1. Gross Beta Activity

The air concentrations of long lived particulate gross beta activity measured at the facility and reference sampling sites are listed in Tables II.B.1a-1d for each quarter of 1988. A-19, while technically in the adjacent zone, is only a few meters from the facility boundary and logically should be considered a facility site. It has been termed a facility site since the inception of the monitoring program. The reference sites R-3, R-4, and R-11 are all new locations as of January 1, 1984 and sufficiently distant to be considered reference (control) locations. (See Table III.B.1).

The reported concentrations are listed in units of femtocuries per cubic meter of ambient air, although the measured activity is due to a combination of radionuclides almost all of which are naturally occurring. It should be noted that the current technical specifications no longer require measurement of gross alpha activity. All filters, however, are saved indefinitely for later alpha activity analysis if needed.

The mean gross beta concentration in air for all facility stations for all of 1988 was 26 fCi/m^3. The mean concentration for all references stations was 24 fCi/m^3. This slight difference was statistically significant at 95% confidence level but not significant at 97.5% level. In any case the slight difference was not due to reactor effluents because specific fission product concentrations, e.g. ^{137}Cs, were not statistically higher in the facility area. Any real difference was due to naturally occurring radionuclides. There was also no evidence of fission product or activation product debris in surface air from the reentry of COSMOS 1900. The U.S.S.R. satellite was predicted to reenter the earth's atmosphere between mid September and early October 1988.

The gross beta data for 1988 have been added to the plot of air concentrations observed since 1973 (Figure II.B.1). In this figure the half-yearly mean values for the facility sites are plotted with the values from the reference sites. The contribution from Chernobyl is clearly evident in 1986. It can be observed that overall mean values are not significantly different and that world-wide fallout, principally due to Chinese atmospheric nuclear weapon tests, is the predominant contributor to the measured values over the period shown.

There has never been a significant difference observed between facility and reference sites. Thus, it can be again concluded that reactor air effluents of particulate fission products or activation products are not a source of dose commitment for the Fort St. Vrain environs population.

Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m^3)
a) First Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
Jan 2	49(3.1)*	32(2.3)	40(3.0)	22(2.2)	44(4.0)	30(2.2)	c-1
Jan 9	40(2.3)	44(2.4)	45(2.4)	44(2.3)	54(4.8)	35(1.9)	34(2.0)
Jan 16	29(1.7)	25(1.5)	27(2.0)	31(2.0)	13(2.9)	18(1.4)	29(1.5)
Jan 23	19(1.8)	15(1.5)	19(1.6)	18(1.4)	18(1.9)	25(2.0)	21(1.6)
Jan 30	21(1.6)	21(1.4)	21(1.8)	17(1.5)	24(2.3)	16(1.2)	19(1.2)
Feb 6	67 (2.8)	37(2.1)	83(4.2)	45(1.6)	68(2.3)	41(1.8)	45(2.0)
Feb 13	44(2.1)	30(1.7)	44(2.1)	31(2.5)	27(1.5)	27(1.4)	36(1.7)
Feb 20	12(1.2)	9.9(1.0)	11(0.97)	11(0.97	12(1.1)	11(1.0)	9.6(0.91)
Feb 27	20(1.6)	19(7.1)	17(1.2)	15(1.6)	19(1.3)	17(1.2)	15(1.2)
Mar 5	25(1.5)	19(1.2)	25(1.4)	26(1.3)	23(1.4)	22(1.4)	25(1.6)
Mar 12	15(1.3)	8.2(0.84)	11(1.5)	12(1.1)	12(1.1)	12(1.0)	10(1.1)
Mar 19	24(1.5)	22(1.4)	25(1.4)	23(1.3)	22(1.4)	21(1.5)	15(1.4)
Mar 26	20(1.7)	17(1.2)	17(2.0)	18(1.4)	17(1.3)	17(1.3)	c-1
$\bar{x}$	30	23	30	24	27	22	24
1.96 σ	16	10	20	11	17	8.7	11

Facility Sites		Reference Sites	
MAX: 83	$\bar{X}$(1.96 σ) 27 (15)	MAX: 68	$\bar{X}$(1.96 σ) 24 (13)
MIN: 8.2	n 52	MIN: 9.6	n 37

* 1.96 σ (Due to counting statistics.)

Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m³)

b) Second Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
4/2/88	15 (1.5)*	12 (1.2)	14 (1.2)	15 (1.2)	17 (1.3)	17 (1.4)	14 (1.3)
4/9/88	26 (2.0)	34 (2.2)	23 (1.4)	22 (2.0)	23 (1.5)	25 (1.5)	20 (1.3)
4/16/88	27 (0.62)	31 (2.1)	26 (1.4)	27 (1.4)	23 (1.4)	25 (1.6)	24 (1.5)
4/22/88	27 (0.62)**	23 (0.59)	24 (0.75)	23 (1.4)	21 (0.79)	21 (0.65)	30 (8.5)
4/30/88	19 (0.77)	16 (0.61)	17 (0.55)	17 (0.52)	18 (0.58)	17 (0.55)	17 (0.67)
5/7/88	22 (1.6)	13 (0.56)	17 (0.67)	18 (1.2)	23 (1.1)	17 (0.56)	19 (0.78)
5/14/88	17 (0.57)	17 (0.76)	19 (0.65)	19 (0.67)	c-1	13 (2.0)	18 (0.84)
5/21/88	16 (0.49)	38 (2.5)	32 (1.5)	17 (1.2)	12 (0.61)	11 (0.58)	15 (0.72)
5/28/88	20 (1.2)	21 (1.3)	c-1	25 (1.5)	18 (1.9)	24 (1.3)	24 (1.6)
6/4/88	22 (1.1)	20 (1.2)	25 (3.8)	21 (2.2)	22 (1.4)	20 (1.1)	21 (1.5)
6/11/88	22 (1.2)	18 (1.3)	24 (1.3)	24 (1.5)	56 (2.0)	25 (1.5)	24 (1.6)
6/18/88	36 (3.1)	19 (1.0)	23 (1.5)	20 (2.1)	20 (1.4)	20 (1.2)	23 (1.5)
6/25/88	21 (2.4)	24 (1.5)	26 (1.4)	25 (1.6)	24 (1.5)	26 (1.5)	28 (0.90)
$\bar{X}$ 1.96σ	22 11	22 15	22 9.8	21 7.0	23 22	20 9.6	21 9.4
MAX: 38 MIN: 12		$\bar{X}$ (1.96σ) 22(11) n 50			MAX: 56 MIN: 11	$\bar{X}$(1.96σ) 21(14) n 38	

* 1.96σ (Due to counting statistics.)

** April 22 value represents a two week period.

c-1 Volume inadequate for accurate analysis - pump malfunction.

Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m³)

c) Third Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
7/2/88	19.0 (1.2)*	18.0 (1.0)	b	b	20.0 (1.4)	19.0 (1.1)	18.0 (1.4)
7/9/88	e	20.0 (1.5)	17.0 (1.3)	24.0 (1.7)	19.0 (1.4)	19.0 (1.2)	21.0 (1.7)
7/16/88	24.0 (1.4)	21.0 (1.2)	46.0 (3.9)	23.0 (2.6)	30.0 (2.6)	23.0 (1.3)	24.0 (1.7)
7/23/88	23.0 (1.3)	25.0 (1.5)	25.0 (1.4)	28.0 (1.7)	22.0 (1.3)	27.0 (1.5)	27.0 (1.9)
7/30/88	30.0 (1.4)	26.0 (1.3)	33.0 (2.0)	31.0 (2.9)	25.0 (1.4)	29.0 (1.3)	32.0 (1.8)
8/6/88	41.0 (3.4)	24.0 (1.7)	22.0 (1.3)	23.0 (1.6)	20.0 (1.2)	25.0 (1.4)	26.0 (1.9)
8/13/88	23.0 (1.1)	20.0 (1.2)	23.0 (1.5)	12.0 (2.0)	22.0 (1.1)	23.0 (1.2)	25.0 (1.7)
8/20/88	21.0 (1.2)	24.0 (1.5)	27.0 (1.4)	e	23.0 (1.4)	25.0 (1.5)	54.0 (4.0)
8/27/88	34.0 (1.5)	30.0 (1.4)	53.0 (3.4)	30.0 (2.3)	31.0 (1.5)	30.0 (1.4)	34.0 (2.0)
9/3/88	32.0 (1.5)	34.0 (1.8)	18.0 (1.3)	37.0 (1.5)	32.0 (1.5)	26.0 (1.5)	e
9/10/88	30.0 (1.6)	27.0 (1.4)	32.0 (2.1)	31.0 (2.4)	12.0 (1.1)	27.0 (1.5)	41.0 (2.7)
9/17/88	16.0 (1.1)	16.0 (1.2)	16.0 (1.3)	13.0 (0.88)	16.0 (1.1)	12.0 (1.1)	34.0 (2.0)
9/24/88	39.0 (1.6)	30.0 (1.4)	32.0 (1.8)	42.0 (1.8)	18.0 (1.4)	14.0 (1.2)	b
X 1.96σ	28 (16)	24 (10)	29 (22)	27 (18)	22 (12)	23 (11)	31 (20)
MAX: 53 X(1.96σ) 27 (17) MIN: 12 n 48					MAX: 54 X(1.96σ) 25 (16) MIN: 12 n 37		

* 1.96σ (Due to counting statistics).
e Insufficient volume for accurate analysis.
b Filter missing at site.

Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m^3)

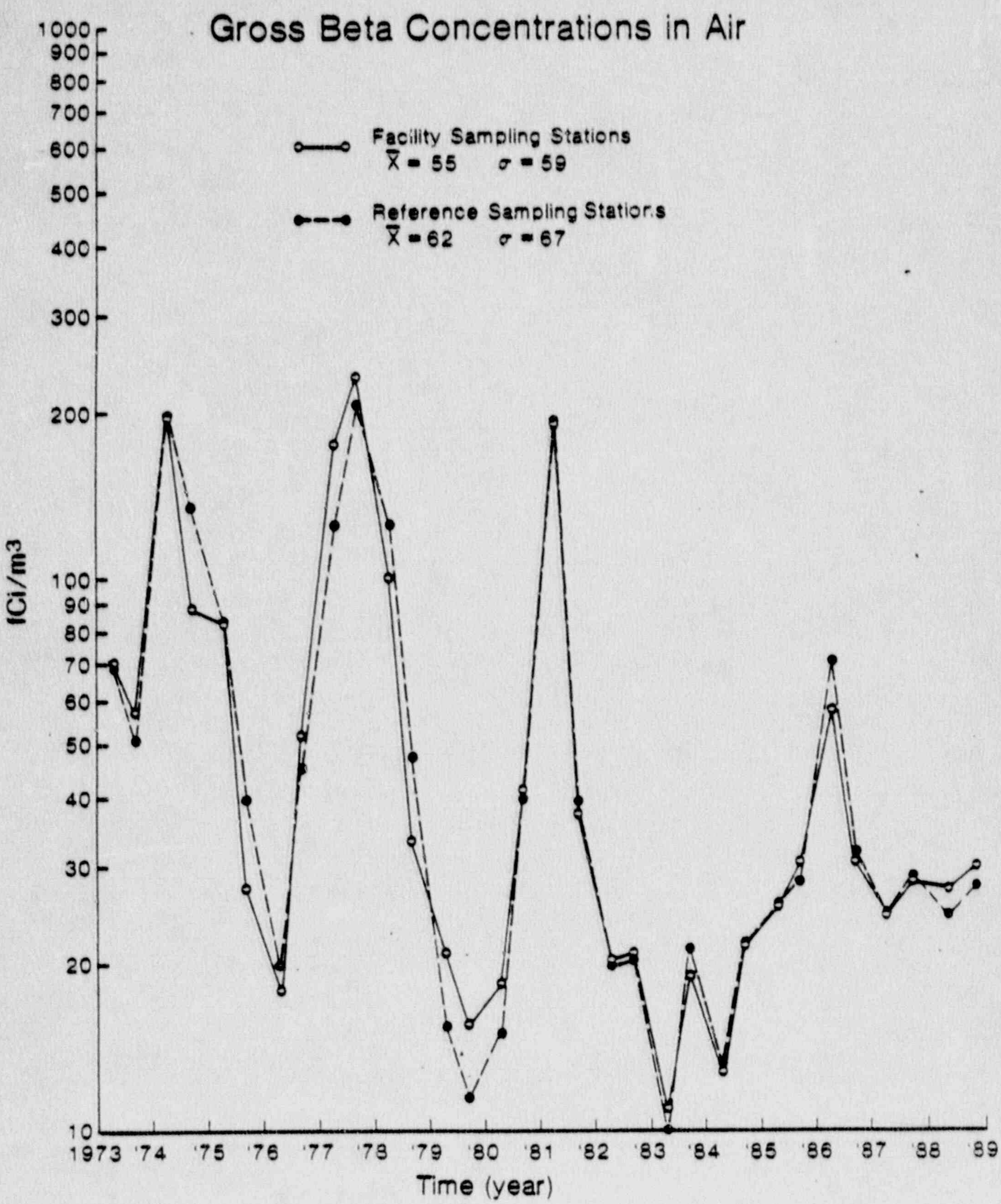
d) Fourth Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/1/88	35 (1.9)*	24 (1.8)	27 (1.5)	26 (2.2)	24 (1.3)	26 (1.5)	26 (1.9)
10/8/88	30 (1.4)	40 (4.1)	27 (2.2)	30 (1.2)	25 (1.3)	35 (1.7)	42 (2.7)
10/15/88	34 (1.6)	44 (19)	38 (1.8)	36 (2.6)	34 (1.6)	37 (1.9)	38 (2.5)
10/22/88	23 (1.4)	e	23 (1.5)	40 (2.1)	20 (1.3)	20 (1.5)	27 (2.3)
10/29/88	23 (1.5)	25 (2.4)	26 (1.6)	21 (1.3)	22 (1.3)	24 (1.6)	42 (1.4)
11/5/88	33 (1.8)	28 (1.4)	35 (2.0)	32 (1.4)	27 (1.4)	31 (1.5)	24 (1.8)
11/12/88	18 (1.8)	18 (1.4)	19 (1.4)	20 (2.1)	15 (1.1)	18 (1.4)	8.8 (2.1)
11/19/88	26 (1.6)	22 (1.1)	16 (1.7)	19 (1.3)	11 (1.2)	33 (2.1)	21 (1.6)
11/26/88	26 (1.4)	25 (1.6)	27 (1.6)	21 (2.7)	22 (1.4)	31 (1.9)	28 (1.6)
12/3/88	35 (1.7)	22 (1.3)	27 (1.9)	24 (1.5)	16 (1.3)	15 (1.1)	17 (1.4)
12/10/88	59 (8.1)	30 (1.8)	38 (2.0)	35 (2.6)	26 (1.5)	28 (1.6)	26 (1.6)
12/16/88	26 (1.5)	31 (2.3)	26 (1.8)	27 (1.5)	18 (1.3)	24 (1.2)	38 (2.7)
12/24/88	26 (1.2)	24 (1.5)	25 (1.6)	24 (2.1)	19 (1.4)	22 (1.3)	26 (1.6)
12/31/88	44 (1.8)	43 (1.7)	45 (2.4)	59 (2.5)	37 (1.7)	36 (1.7)	40 (1.9)
$\bar{X}$	31	29	28	30	23	27	29
1.96 σ	20	16	15	21	14	14	20
MAX: 59 MIN: 16	$\bar{X}$(1.96σ) 30 (18) n 55				MAX: 42 MIN: 8.8	$\bar{X}$(1.96σ) 26 (16) n 42	

* 1.96σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

Figure II.B.1


Gross Beta Concentrations in Air
Facility Sampling Stations
$\overline{X}$ = 55 σ = 59
Reference Sampling Stations
$\overline{X}$ = 62 σ = 67
fCi/m3
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
1973 '74 '75 '76 '77 '78 '79 '80 '81 '82 '83 '84 '85 '86 '87 '88 '89
Time (year)

2. Tritium Activity

Atmospheric water vapor samples are collected continuously by passive absorption on silica gel at all seven air sampling stations (four in the facility area and three in the reference area). The specific activity of tritium in water extracted from these weekly samples for 1988 is listed in Tables II.B.2a-2d. The corresponding tritium concentration in air (pCi/m^3) is calculated from the specific activity data using weekly mean temperatures and dew points measured at the FSV meteorological tower. The measuring point is at a height of 2 m from the surface. The tritium air concentrations are shown in Table II.B.3a-3d.

The principle release mode of tritium from the reactor is batch liquid releases from holding tanks (system 62). The tank water is first analyzed and then released with sufficient additional dilution, if necessary, to not exceed 10CFR20 concentration limits. The summary of tritium release by all modes is shown in Table II.B.4. The summary indicates that the total tritium released in 1988 was 2.8 times greater than in 1987 for all routes. (See 1987 annual report to the USNRC). This effluent release was detected principally at two of the air sampling sites.

Sampling locations F-16 and A-19 are located near the Goosequill Ditch, which is the common route for liquid effluent tritium release. Tables II.B.2a-2d indicate a strong correlation of elevated atmospheric tritium concentrations corresponding to the batch release of tritium in water along the ditch. Due to evaporation while in transit, elevated tritium concentrations in air have been observed for these two locations often in past years. The concentrations observed, however, have always been below the limit of regulatory concern. The occasional elevated values at the reference sites are assumed to be statistically false positive values.

The mean value for sites F-16 and A-19 were significantly greater than for all other sites during the year. When all four facility sites are averaged, however, the total mean value was 470 pCi/L. The mean for the three reference sites was less than the MDC value of 250 pCi/L. The mean for the facility stations was significantly greater than the mean for the adjacent stations. Radiation dose commitment estimates are not warranted on the basis of elevated air concentration values alone. Inhalation is not a significant pathway for dose to humans. The milk and food product pathway is the only significant source of radiation dose to humans from environmental tritium. See results for these pathways in sections II.D and II.E.

Since the same relative humidity is assumed for all sites, Table II.B.3 shows the same site dependence on reactor effluent as Table II.B.2. Only the units used to measure tritium in surface air are different.

Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

a) First Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
1/2/88	e	630 (430)*	e	2100 (430)	830 (430)	1100 (430)	e
1/9/88	960 (430)	890 (430)	600 (350)	1100 (430)	700 (430)	770 (430)	< 290
1/16/88	460 (350)	430 (420)	1200 (430)	2800 (440)	650 (430)	< 410	<410
1/23/88	< 290	e	460 (350)	e	450 (350)	< 290	380 (350)
1/30/88	550 (310)	370 (310)	490 (310)	610 (310)	360 (310)	< 260	< 260
2/6/88	< 260	< 260	< 260	450 (310)	< 260	440 (310)	e
2/13/88	< 230	380 (270)	640 (270)	620 (270)	490 (270)	960 (280)	520 (270)
2/20/88	560 (310)	490 (310)	820 (310)	760 (310)	< 260	360 (310)	750 (310)
2/27/88	< 380	760 (460)	< 380	930 (470)	< 380	< 380	< 380
3/5/88	600 (310)	1000 (310)	810 (310)	950 (310)	570 (310)	870 (310)	790 (320)
3/12/88	400 (320)	320 (320)	760 (330)	800 (330)	800 (330)	600 (320)	1100 (330)
3/19/88	280 (310)	< 260	< 260	570 (310)	460 (310)	< 260	450 (310)
3/26/88	< 260	< 260	310 (310)	280 (310)	330 (310)	460 (310)	570 (310)

* 1.96 σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

b) Second Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
4/2/88	< 250	380 (310)*	450 (310)	420 (310)	560 (310)	420 (310)	< 260
4/9/88	< 250	< 250	290 (300)	570 (310)	310 (300)	330 (300)	540 (320)
4/16/88	< 250	< 250	< 250	< 250	e	< 250	< 250
4/22/88	< 220	< 220	< 220	< 220	350 (270)	< 250	< 250
4/30/88	< 250	< 250	340 (370)	< 250	e	< 250	< 250
5/7/88	< 250	< 250	490 (370)	640 (370)	390 (370)	< 250	< 250
5/14/88	< 250	< 250	500 (370)	890 (380)	< 250	< 250	< 250
5/21/88	< 250	< 250	560 (370)	1400 (380)	< 250	< 250	< 250
5/28/88	< 250	< 250	560 (370)	1100 (380)	< 250	< 250	< 250
6/4/88	< 250	< 250	610 (370)	1100 (380)	< 250	< 250	< 250
6/11/88	< 250	< 250	1600 (390)	1300 (380)	< 250	< 250	< 250
6/18/88	< 250	< 250	1600 (390)	1900 (390)	< 250	330 (370)	< 250
6/25/88	< 250	e	< 250	570 (270)	< 250	< 250	< 250

* 1.96 σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

c) Third Quarter, 1988

Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
7/2/88	< 260	< 260	< 260	< 260	< 260	< 260	< 260
7/9/88	< 250	< 250	520 (380)*	560 (380)	< 250	< 250	< 250
7/16/88	< 250	e	280 (370)	870 (380)	< 250	< 250	<250
7/23/88	< 250	<250	760 (380)	1300 (390)	< 250	< 250	< 250
7/30/88	< 260	< 260	890 (390)	700 (380)	< 260	< 260	< 260
8/6/88	< 250	< 250	440 (370)	570 (380)	< 250	< 250	< 250
8/13/88	< 250	< 250	490 (380)	490 (380)	< 250	< 250	< 250
8/20/88	< 250	< 250	1500 (390)	1300 (390)	< 250	< 250	< 250
8/27/88	< 250	< 250	870 (380)	920 (380)	< 250	< 250	< 250
9/3/88	< 260	< 260	510 (380)	660 (380)	430 (380)	< 260	< 260
9/10/88	< 260	< 260	970 (380)	1200 (390)	< 260	< 260	< 260
9/17/88	< 260	< 260	< 260	< 260	< 260	< 260	< 260
9/24/88	< 260	< 260	700 (380)	510 (380)	< 260	< 260	< 260

* 1.96 σ (Due to counting statistics.)
e Insufficient volume for accurate analysis.

Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

d) Fourth Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/1/89	< 260	< 260	980 (390)*	970 (390)	< 260	< 260	< 260
10/8/89	e	e	830 (390)	580 (390)	< 260	< 260	e
10/15/89	< 260	e	1200 (400)	< 260	< 260	< 260	< 260
10/22/88	620 (380)	1100 (380)	< 250	1100 (380)	< 250	< 250	< 250
10/29/88	620 (380)	520 (380)	1700 (400)	2900 (410)	350 (370)	< 250	610 (380)
11/5/88	870 (380)	690 (380)	1100 (390)	1500 (390)	570 (380)	e	820 (380)
11/12/88	800 (370)	700 (370)	660 (370)	1200 (380)	660 (370)	830 (370)	590 (370)
11/19/88	790 (370)	790 (370)	990 (370)	1100 (370)	670 (370)	560 (370)	810 (370)
11/26/88	720 (340)	540 (340)	850 (340)	710 (340)	890 (340)	540 (340)	480 (340)
12/3/88	800 (330)	580 (330)	1000 (330)	1500 (340)	790 (330)	740 (330)	570 (330)
12/10/88	570 (310)	450 (310)	300 (310)	700 (320)	250 (310)	250 (310)	430 (310)
12/17/89	460 (310)	350 (310)	610 (320)	540 (310)	500 (310)	< 210	230 (310)
12/24/89	350 (210)	460 (310)	< 210	600 (320)	260 (310)	450 (310)	750 (320)
12/31/89	< 210	< 210	< 210	480 (310)	< 210	220 (310)	< 210

* 1.96 σ (Due to counting statistics.)

e - Insufficient volume for accurate analysis.

Table II.B.3 Tritium Concentrations in Air (pCi/m^3)

a) First Quarter, 1988

Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
1/2/88	e	0.95 (0.65)*	e	3.2 (0.67)	1.3 (0.65)	1.7 (0.65)	e
1/9/88	1.5 (0.67)	1.4 (0.67)	0.93 (0.54)	1.7 (0.67)	1.1 (0.67)	1.2 (0.67)	< 0.50
1/16/88	1.4 (1.0)	1.3 (1.2)	3.5 (1.3)	8.3 (1.3)	1.9 (1.3)	< 1.3	< 1.3
1/23/88	< 0.66	e	1.1 (0.84)	e	1.1 (0.84)	< 0.77	0.91 (0.84)
1/30/88	1.7 (0.98)	1.2 (0.98)	1.5 (0.98)	1.9 (0.98)	1.1 (0.98)	< 0.90	< 0.90
2/5/88	< 0.70	< 0.70	< 0.70	1.2 (0.79)	< 0.73	1.1 (0.79)	e
2/13/88	< 0.76	1.1 (0.81)	1.9 (0.81)	1.9 (0.81)	1.5 (0.81)	2.9 (0.84)	1.6 (0.81)
2/20/88	2.1 (1.1)	1.8 (1.1)	3.0 (1.1)	2.8 (1.1)	< 1.0	1.3 (1.1)	2.7 (1.1)
2/27/88	< 1.7	3.1 (1.9)	< 1.7	3.8 (1.9)	< 1.7	< 1.7	< 1.7
3/5/88	2.7 (1.4)	4.5 (1.4)	3.7 (1.4)	4.3 (1.4)	2.6 (1.4)	4.0 (1.4)	3.6 (1.5)
3/12/88	1.3 (1.1)	1.1 (1.1)	2.6 (1.1)	2.7 (1.1)	2.7 (1.1)	2.0 (1.1)	3.7 (1.1)
3/19/88	0.75 (0.83)	< 0.77	< 0.77	1.5 (0.83)	1.2 (0.83)	< 0.77	1.2 (0.83)
3/26/88	< 0.92	< 0.92	1.0 (1.0)	0.90 (1.0)	1.1 (1.0)	1.5 (1.0)	1.8 (1.0)

* 1.96 σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

Table II.B.3 Tritium Concentrations in Air (pCi/m^3)

b) Second Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
4/2/88	< 0.95	1.3 (1.1)*	1.5 (1.1)	1.4 (1.1)	1.9 (1.1)	1.4 (1.1)	< 0.98
4/11/88	< 1.2	< 1.2	1.3 (1.3)	2.5 (1.3)	1.3 (1.3)	1.4 (1.3)	2.3 (1.4)
4/16/88	< 1.3	< 1.3	< 1.3	< 1.3	e	< 1.3	< 1.3
4/22/88	< 1.3	< 1.3	< 1.3	< 1.3	1.9 (1.5)	< 1.5	< 1.5
4/30/88	< 1.3	< 1.3	1.7 (1.8)	< 1.3	e	< 1.3	< 1.3
5/7/88	< 1.3	< 1.3	2.3 (1.7)	3.0 (1.7)	1.8 (1.7)	< 1.3	< 1.3
5/14/88	< 1.4	< 1.4	2.5 (1.9)	4.5 (1.9)	< 1.4	< 1.4	< 1.4
5/21/88	< 1.8	< 1.8	3.6 (2.4)	9.1 (2.5)	< 1.8	< 1.8	< 1.8
5/28/88	< 2.0	< 2.0	4.2 (2.8)	8.2 (2.8)	< 2.0	< 2.0	< 2.0
6/4/88	< 2.0	< 2.0	4.3 (2.6)	7.8 (2.6)	< 2.0	< 2.0	< 2.0
6/11/88	< 2.4	< 2.4	14 (3.4)	3.3 (3.3)	< 2.2	< 2.2	< 2.2
6/18/88	< 2.5	< 2.5	15 (3.6)	18 (3.6)	< 2.5	3.0 (3.4)	< 2.5
6/25/88	< 2.4	e	< 2.4	5.0 (2.4)	< 2.4	< 2.4	< 2.4

* 1.96 σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

Table II.B.3 Tritium Concentrations in Air (pCi/m^3)

c) Third Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
7/2/88	< 3.0	< 3.0	< 3.0	< 3.0	<3.0	< 3.0	< 3.0
7/9/88	< 2.7	< 2.7	5.1 (3.7)	5.5 (3.7)	< 2.7	< 2.7	< 2.7
7/16/88	< 2.7	e	2.7 (3.6)	8.5 (3.7)	< 2.7	< 2.7	< 2.7
7/23/88	< 2.2	< 2.2	6.1 (3.1)	11 (3.2)	< 2.2	< 2.2	< 2.2
7/10/88	< 2.7	< 2.7	8.5 (3.7)	6.7 (3.6)	< 2.7	< 2.7	< 2.7
8/6/88	< 2.8	< 2.8	4.4 (3.7)	5.7 (3.8)	< 2.8	< 2.8	< 2.8
8/13/88	< 2.4	< 2.4	4.3 (3.3)	4.3 (3.3)	< 2.4	< 2.4	< 2.4
8/20/88	< 2.5	< 2.5	14 (3.6)	12 (3.6)	< 2.5	< 2.5	< 2.5
8/27/88	< 2.4	< 2.4	7.7 (3.3)	8.1 (3.3)	< 2.4	< 2.4	< 2.4
9/3/88	< 2.0	< 2.0	3.6 (2.7)	4.6 (2.7)	3.0 (2.7)	< 2.0	< 2.0
9/10/88	< 1.6	< 1.6	5.5 (2.2)	6.8 (2.2)	< 1.6	< 1.6	< 1.6
9/17/88	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
9/24/88	< 1.6	< 1.6	4.0 (2.2)	2.9 (2.2)	< 1.6	< 1.6	< 1.6

* 1.96 σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

Table II.B.3 Tritium Concentrations in Air (pCi/m^3)

d) Fourth Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/1/88	< 1.5	< 1.5	5.1 (2.0)*	5.1 (2.0)	< 1.5	< 1.5	< 1.5
10/8/88	e	e	4.7 (2.2)	3.3 (2.2)	< 1.6	< 1.6	e
10/15/88	< 1.4	e	5.9 (2.0)	< 1.4	< 1.4	< 1.4	< 1.4
10/22/88	3.2 (2.0)	5.7 (2.0)	< 1.4	5.7 (2.0)	< 1.4	< 1.4	< 1.4
10/29/88	2.4 (1.5)	2.0 (1.5)	6.6 (1.5)	11 (1.6)	1.4 (1.4)	< 1.1	2.4 (1.5)
11/5/88	3.4 (1.5)	2.7 (1.5)	4.3 (1.5)	5.9 (1.5)	2.2 (1.5)	e	3.2 (1.5)
11/12/88	3.1 (1.4)	2.7 (1.4)	2.5 (1.4)	4.6 (1.4)	2.5 (1.4)	3.2 (1.4)	2.3 (1.4)
11/19/88	2.7 (1.3)	2.7 (1.3)	3.4 (1.3)	3.7 (1.3)	2.3 (1.3)	1.9 (1.3)	2.8 (1.3)
11/26/88	2.4 (1.1)	1.8 (1.1)	2.8 (1.1)	2.3 (1.1)	2.9 (1.1)	1.8 (1.1)	1.6 (1.1)
12/3/88	2.1 (0.85)	1.5 (0.85)	2.6 (0.85)	3.9 (0.88)	2.0 (0.85)	1.9 (0.85)	1.5 (0.85)
12/10/88	1.1 (0.62)	0.90 (0.62)	0.60 (0.62)	1.4 (0.64)	0.50 (0.62)	0.50 (0.62)	0.86 (0.62)
12/17/88	1.1 (0.74)	0.83 (0.74)	1.5 (0.76)	1.3 (0.74)	1.2 (0.74)	< 0.66	0.55 (0.74)
12/24/88	1.0 (0.60)	1.3 (0.88)	< 0.66	1.7 (0.91)	0.74 (0.88)	1.3 (0.88)	2.1 (0.88)
12/31/88	< 0.48	< 0.48	< 0.48	1.0 (0.65)	< 0.48	0.46 (0.65)	< 0.48

* 1.96 σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

Table II.B.4 Tritium Released (Ci) in Reactor Effluents, 1988

TRITIUM RELEASED (CI) IN REACTOR EFFLUENTS, 1988													
MODE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Continuous (Turbine Building Sump)	1.69	2.06	3.00	1.47	2.28	2.65	1.21	.101	.0303	.0217	.00803	.0347	14.56
Batch Release (Reactor Building Sump)	.0347	.0565	.0709	.124	.233	.276	.316	.202	.365	.249	.0178	.0233	1.97
Batch Release (System 62)	26.9	7.42	2.20	1.61	19.3	28.0	14.4	11.8	11.2	11.0	4.34	6.53	144.7
Gaseous Stack	.554	.693	.0831	.588	1.02	.320	.560	.0493	.0304	.0376	.0422	.0406	4.02
TOTAL	29.18	10.23	5.35	3.79	22.83	31.25	16.49	12.15	11.63	11.31	4.41	6.63	165.25

3. Concentrations of Gamma-ray Emitting Radionuclides in Ambient Air

Tables II.B.5a-5d list the concentrations of I-131 in air as measured by activated charcoal sampling and Ge(Li) gamma-ray spectrum analysis. Each sample from the seven air sampling stations is counted within 96 hours after collection. A 100 minute count and a sample volume of 800 m^3 is required to achieve an MDC of 33 fCi/m^3. Radon daughters and Thoron daughters are trapped on the particulate filter ahead of the charcoal trap. Radon-222 daughter in-growth on the charcoal does not provide interference to the region of interest for I-131 using the Ge(Li) high resolution spectrometry. Any positive I-131 activity is corrected for radioactive decay back to the midpoint of the collection period. Decay correction to the midpoint of the sampling period is appropriate as any I-131 in air would not arrive at the sampling stations at a constant rate, but rather in pulses of short duration compared to the collection period. This is the case whether the I-131 source term would be weapons testing fallout or reactor stack effluent.

There were only occasional positive values very near the MDC value and all are assumed to be false positives. I-131 concentrations due to reactor effluent have never been detected in any sample type in the Fort St. Vrain environs.

Table II.B.6 lists measured ambient air concentrations of Cs-134 and Cs-137. These values are from gamma-ray spectrum analyses on weekly air filters composited quarterly from each of the seven air sampling stations. The occasional positive Cs-137 concentrations measured are likely due to resuspension of surface soil. The Cs-137 activity is due to Chernobyl (or previous) fallout which is bound by clay minerals on the surface of undisturbed soil. For the entire year, the mean of the facility stations was not different from the mean of the reference stations.

Although only Cs-134 and Cs-137 are reported, each gamma-ray spectrum is scanned for evidence of peaks from other fission products and activation products. Normally only gamma-ray activity due to the naturally occurring background radionuclides are observed. During the second quarter of 1986, however, many other radionuclides were observed due to the Chernobyl accident. Of these only Cs-137 can still be detected.

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

a) First Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-17	A-19	R-3	R-4	R-11
1/2/88	33(39)*	< 28	< 30	< 23	< 35	< 20	< 28
1/9/88	< 17	< 19	< 10	< 34	< 34	< 32	< 24
1/16/88	< 15	< 17	20(23)	< 18	< 23	< 15	< 12
1/23/88	< 21	27(27)	< 32	< 23	< 22	< 25	< 12
1/30/88	< 35	< 27	< 13	< 21	< 20	< 19	< 16
2/6/88	< 19	< 15	< 34	< 18	C-1	< 35	< 11
2/13/88	< 23	< 17	22(22)	< 27	< 19	< 16	< 19
2/20/88	< 14	< 20	< 15	< 26	< 16	< 22	< 16
2/27/88	< 22	C-1	< 29	< 20	< 25	< 15	< 30
3/5/88	< 26	< 23	< 25	< 14	< 28	< 23	< 15
3/12/88	< 18	< 18	< 18	< 19	< 29	< 14	< 16
3/19/88	< 23	< 16	< 30	< 19	< 18	< 28	< 21
3/26/88	32(36)	< 26	< 35	< 21	< 21	< 16	C-1

* 1.96 σ (Due to counting statistics.)

C-1 Pump malfunction, sample volume too low for accurate analysis.

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

b) Second Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
4/02/88	< 24	< 23	< 12	< 15	< 16	< 28	< 25
4/09/88	< 28	< 42	< 15	< 34	< 12	< 21	< 14
4/16/88	< 22	< 26	< 18	< 21	< 19	< 33	< 25
4/22/88	< 22**	< 4.4	< 27	< 33	< 12	< 16	c-1
4/30/88	< 30	< 18	< 14	< 10	< 21	< 18	< 20
5/07/88	< 31	< 18	< 17	< 28	< 34	< 16	< 29
5/14/88	< 28	< 14	< 13	< 16	c-1	< 25	< 13
5/21/88	< 21	< 37***	< 28	< 22	< 35	< 16	< 23
5/28/88	28 (28)*	< 17	c-1	< 15	27 (30)	< 19	< 19
6/04/88	< 15	< 22	< 35	< 32	< 21	< 17	< 12
6/11/88	< 11	< 11	< 23	< 19	< 23	< 17	< 26
6/18/88	< 23	< 16	< 13	< 22	< 16	< 14	< 24
6/25/88	< 35	< 16	< 26	< 14	< 27	< 13	< 24

* 1.96 σ (Due to counting statistics.)

** April 22 value represents a two week period.
*** LLD not met because pump malfunction resulted in low volume.
c-1 Volume inadequate for accurate analysis - pump malfunction.

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

c) Third Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
7/02/88	< 35.0	< 16.0	< 19.0	< 33.0	< 22.0	< 18.0	< 16.0
7/09/88	e	< 31.0	< 15.0	< 29.0	< 20.0	< 19.0	< 25.0
7/16/88	< 27.0	< 26.0	< 24.0	< 23.0	< 28.0	< 15.0	< 28.0
7/23/88	< 16.0	< 14.0	< 21.0	< 30.0	< 19.0	< 16.0	< 18.0
7/30/88	< 11.0	< 12.0	< 34.0	< 25.0	< 16.0	< 9.2	< 14.0
8/06/88	< 26.0	< 25.0	< 9.9	< 19.0	< 20.0	< 26.0	< 30.0
8/13/88	< 14.0	< 19.0	< 24.0	< 19.0	< 17.0	28.0 (27.0)*	< 22.0
8/20/88	< 16.0	< 29.0	< 32.0	f-1	< 32.0	< 14.0	< 17.0
8/27/88	< 11.0	< 13.0	< 28.0	< 33.0	< 18.0	< 18.0	< 13.0
9/03/88	< 11.0	< 32.0	< 19.0	< 19.0	< 20.0	< 15.0	< 13.0
9/10/88	< 13.0	< 16.0	< 22.0	< 26.0	< 15.0	< 24.0	< 34.0
9/17/88	< 29.0	< 15.0	< 24.0	< 30.0	< 14.0	< 25.0	< 16.0
9/24/88	< 19.0	< 9.3	< 21.0	< 16.0	< 10.0	< 12.0	< 23.0

* 1.96 σ (Due to counting statistics.)

e Insufficient volume for accurate analysis.

f-1 Sample unavailable in field due to wind damage to pump head.

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

d) Fourth Quarter, 1988

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/01/88	< 10.0	< 23.0	< 27.0	< 28.0	< 16.0	< 36.0	< 19.0
10/08/88	< 17.0	< 27.0	< 22.0	< 11.0	< 9.7	< 15.0	< 12.0
10/12/88	< 26.0	e	< 16.0	< 29.0	< 22.0	< 22.0	< 21.0
10/19/88	< 14.0	e	< 26.0	< 23.0	< 26.0	< 13.0	< 33.0
10/29/88	< 21.0	< 34.0	< 35.0	< 27.0	< 10.0	< 17.0	< 28.0
10/26/89	< 10.0	< 24.0	< 33.0	< 5.9	< 30.0	< 29.0	< 7.6
11/9/88	< 28.0	< 23.0	< 23.0	< 27.0	< 9.0	< 17.0	< 16.0
11/16/88	< 16.0	< 20.0	< 25.0	< 20.0	< 12.0	< 23.0	< 27.0
11/23/88	< 15.0	< 13.0	< 14.0	< 29.0	< 32.0	< 11.0	< 15.0
11/30/88	< 20.0	< 23.0	< 26.0	< 23.0	< 14.0	< 26.0	< 25.0
12/7/88	< 4.6	< 27.0	< 11.0	< 27.0	< 7.9	< 4.5	< 15.0
12/14/88	12 (14)*	< 11.0	< 7.3	16 (17)	< 31.0	< 16.0	< 14.0
12/21/88	< 13.0	< 16.0	< 22.0	< 19.0	< 14.0	< 17.0	< 18.0
12/28/88	< 22.0	< 23.0	< 12.0	< 20.0	< 8.5	< 18	< 19.0

* 1.96 σ (Due to counting statistics.)
e Insufficient volume due to pump malfunction.

Table II.B.6 Radiocesium Concentrations in Ambient Air. (fCi/m^3)

1988 Collection Date	Radio-nuclide	Facility Sites				Reference Sites		
		F-7	F-9	F-16	A-19	R-3	R-4	R-11
1st Quarter	Cs-134	< 1.6	< 2.1	< 1.9	< 1.6	< 9.9	< 10	< 8.8
	Cs-137	< 1.8	< 2.1	< 1.9	< 1.7	< 10	16(13)*	< 9.2
2nd Quarter	Cs-134	< 3.3	< 2.6	< 3.5	< 2.9	< 3.3	< 2.8	< 2.9
	Cs-137	< 3.2	< 2.9	< 3.7	4.0 (3.5)	< 3.4	< 3.3	< 3.3
3rd Quarter	Cs-134	< 1.4	< 1.6	< 1.6	< 2.0	< 0.51	< 0.58	< 0.97
	Cs-137	< 1.4	1.9 (2.0)	< 1.5	< 2.1	0.55 (0.64)	< 0.59	< 1.1
4th Quarter	Cs-134	< 1.2	2.1 (2.1)	< 0.64	< 0.89	< 0.76	< 0.41	< 0.75
	Cs-137	< 1.2	4.4 (2.1)	0.73 (0.80)	< 0.90	< 0.81	< 0.41	< 0.81

* 1.96 σ (Due to counting statistics.)

II.C. Radionuclide Concentration in Water

1. Drinking Water

Drinking water is sampled weekly and composited biweekly at two locations. Location R-6 is the well used for drinking water by the town of Gilcrest, Colorado, and R-3 is a water tap located on the CSU dairy farm. The Gilcrest well is the nearest public water supply that could be affected by the reactor effluents. R-3 samples are from the Fort Collins drinking water supply and serve as a reference location since its source is run-off surface water from the Rocky Mountains to the West. However, water treatment systems for the two water supplies are very different.

Table II.C.1 shows gross beta concentrations measured in 1988 from each water supply. The mean for the Gilcrest site was again significantly higher than the Reference site in Fort Collins. This is only due to the different water treatment practices. The city of Gilcrest does not filter its water and natural radionuclide concentrations are responsible for the higher measured concentrations. As can be observed in Table II.H.2, the mean for the entire year for the Gilcrest site was not greater than in previous years.

Table II.C.2 lists measured tritium concentrations in these same two drinking water sources. The yearly arithmetic mean value for the Gilcrest location was greater than MDC. The mean yearly concentration measured in the Gilcrest supply was statistically greater than in the Fort Collins supply. The difference, while very small, can be used to estimate a radiation dose commitment to the Gilcrest population for the period. Assume the following:

1. The critical individual is an adult.
2. The average annual intake of tap water is 388 ml/day (ICRP-23).
3. The mean concentration for Gilcrest residents during the year is the measured difference between the two potable water sources, i.e. 370-120 = 250 pCi/L.

Therefore by ICRP-26,30 dose commitment methodology the weighted committed dose equivalent rate, $\dot{H}$, is calculated as:

$$\dot{H} = \left(\frac{250\ \text{pCi}}{\text{L}}\right)\left(\frac{0.39\ \text{L}}{\text{day}}\right)\left(\frac{365\ \text{d}}{\text{y}}\right)\left(\frac{0.037\ \text{Bq}}{\text{pCi}}\right)\left(\frac{1.7\times10^{-11}\text{Sv}}{\text{Bq}}\right)\left(\frac{10^{2}\text{rem}}{\text{Sv}}\right)$$

$$= \frac{2.2\times10^{-6}\text{rem}}{\text{y}} \equiv \frac{2.2\times10^{-3}\text{mrem}}{\text{y}}$$

(For a 5-14 year old child the weighted committed dose equivalent rate would only be 1.10×10^{-3} mrem/y).

This committed dose rate would still be trivial in absolute terms and certainly is when compared to background dose rates of approximately 300 mrem/year as calculated by the same methodology. Since ^{3}H was not detected in milk or other foods, intake of water from these sources is not included.

The EPA limit for community drinking water systems is 20,000 pCi/L for tritium. Figure II.C.1 shows tritium concentration in Gilcrest drinking (potable) water source.

The two drinking water supplies are also analyzed for fission product and activation product concentrations. A sample of 18 liters is passed through Dowex 1-x8 anion exchange resin and the resin then counted by Ge(Li) spectrometry for I-131. A three liter aliquot of the original sample is counted directly for the other gamma-ray emitters.

Inspection of Table II-C.3 reveals occasional positive values of radionuclide concentration, but with the exception of Cs-137, these are interpreted to be random variations. The Cs-137 is the residue from the 1986 Chernobyl accident fallout as well as from past world-wide fallout from nuclear weapon testing.

Table II.C.1
Gross Beta Concentrations in Biweekly Composites of Drinking Water. (pCi/L)

Collection Date 1988	Gilcrest City R-6	Fort Collins City R-3 (Reference)
1/2 & 1/9	7.7 (2.5) *	1.1 (0.58)
1/16 & 1/23	5.5 (2.5)	0.78 (0.56)
1/30 & 2/6	7.2 (2.5)	0.46 (0.54)
2/13 & 2/20	9.4 (2.6)	1.8 (0.61)
2/27 & 3/5	6.7 (2.5)	0.84 (0.56)
3/12 & 3/19	4.3 (2.4)	0.59 (0.56)
3/26 & 4/2	8.1 (1.9)	1.3 (0.59)
4/9 & 4/16	7.5 (1.8)	1.1 (0.45)
4/22 & 4/30	7.3 (1.8)	2.0 (0.43)
5/7 & 5/14	6.8 (1.9)	1.1 (0.44)
5/21 & 5/28	8.7 (2.6)	0.92 (0.57)
6/4 & 6/11	5.6 (2.4)	0.90 (0.57)
6/18 & 6/25	5.4 (2.4)	0.99 (0.57)
7/2 & 7/9	5.5 (2.4)	1.0 (0.57)
7/16 & 7/23	9.1 (2.6)	0.99 (0.57)
7/30 & 8/8	5.9 (2.5)	0.65 (0.55)
8/13 & 8/20	8.0 (2.6)	0.97 (0.57)
8/27 & 9/3	3.0 (2.3)	1.1 (0.57)
9/10 & 9/17	6.5 (2.5)	1.2 (0.58)
9/24 & 10/1	7.1 (2.5)	1.1 (0.58)
10/8 & 10/15	7.4 (2.5)	0.99 (0.57)
10/22 & 10/29	9.0 (2.6)	0.92 (0.57)
11/5 & 11/12	5.7 (2.5)	0.91 (0.57)
11/19 & 11/26	7.8 (2.5)	1.1 (0.57)
12/3 & 12/10	7.1 (2.5)	1.1 (0.58)
12/17 & 12/24	5.5 (2.4)	1.3 (0.59)

* 1.96 σ (Due to counting statistics.)

Table II.C.2
Tritium Concentrations in Biweekly Composites of Drinking Water. (pCi/L)

Collection Date 1988	Gilcrest City R-6	Fort Collins City R-3 (Reference)
1/2 & 1/9	350 (360)*	< 300
1/16 & 1/23	< 290	< 290
1/30 & 2/6	450 (310)	< 290
2/13 & 2/20	370 (270)	340 (270)
2/27 & 3/5	230 (270)	380 (270)
3/12 & 3/19	610 (310)	310 (310)
3/26 & 4/2	560 (280)	< 230
4/9 & 4/16	490 (310)	< 230
4/22 & 4/30	890 (310)	240 (280)
5/7 & 5/14	350 (310)	< 260
5/21 & 5/28	530 (310)	< 260
6/4 & 6/11	< 250	< 250
6/18 & 6/25	< 250	< 250
7/2 & 7/9	< 250	< 250
7/16 & 7/23	< 250	< 250
7/30 & 8/6	< 250	< 250
8/13 & 8/20	< 250	< 250
8/27 & 9/3	340 (370)	< 250
9/10 & 9/17	280 (370)	< 250
9/24 & 10/1	< 260	< 260
10/8 & 10/15	< 250	280 (370)
10/22 & 10/29	870 (380)	590 (380)
11/5 & 11/12	830 (340)	470 (340)
11/19 & 11/26	800 (340)	720 (340)
12/3 & 12/10	960 (340)	660 (340)
12/17 & 12/24	640 (320)	600 (320)

* 1.96 σ (Due to counting statistics.)

TABLE II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 1/9/88		for two weeks ending 1/23/88		for two weeks ending 2/6/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.21	< 0.42	< 0.22	< 0.43	< 0.48	< 0.24
Cs-134	< 1.7	< 2.0	< 1.9	< 2.0	< 3.6	< 3.0
Cs-137	< 2.0	4.4(3.6)	3.2(3.4)	< 3.4	< 4.2	< 4.7
Zr-95	< 3.7	< 4.6	< 4.3	< 4.8	< 8.3	< 6.5
Nb-95	< 1.9	< 1.8	< 1.9	< 1.8	< 3.3	< 2.8
Co-58	< 1.6	< 1.9	< 1.8	< 1.8	< 3.2	< 3.0
Mn-54	< 1.7	< 2.0	< 1.9	2.5(2.3)	< 3.6	< 3.0
Zn-65	< 14	< 5.0	< 5.2	< 4.7	< 8.6	< 7.2
Fe-59	6.5(5.1)*	< 5.1	< 4.3	< 4.9	< 8.8	< 7.4
Co-60	< 1.6	< 2.1	< 1.9	< 2.1	< 3.9	< 3.0
Ba-140	< 2.8	< 4.4	< 2.8	< 3.1	< 5.7	< 6.5
La-140	< 3.2	< 5.1	< 3.2	< 3.6	< 6.6	< 7.5

* 1.96 σ (Due to counting statistics.)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 2/20/88		for two weeks ending 3/5/88		for two weeks ending 3/19/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.41	0.47(0.55)*	< 0.46	< 0.47	< 0.19	< 0.42
Cs-134	< 2.4	< 2.3	< 1.9	< 2.1	< 2.2	< 2.0
Cs-137	< 3.0	< 3.3	< 2.9	< 3.2	< 2.3	3.3(2.8)
Zr-95	< 6.1	< 5.3	< 4.3	< 4.6	< 4.8	< 4.6
Nb-95	< 2.3	< 2.1	< 1.7	< 1.9	< 2.0	< 1.8
Co-58	< 2.4	< 2.1	< 1.8	< 2.0	< 2.2	< 1.9
Mn-54	< 2.5	< 2.2	< 1.9	< 2.1	< 2.1	< 1.9
Zn-65	< 6.0	< 5.5	< 4.6	< 5.0	< 5.3	< 4.6
Fe-59	< 6.4	< 4.9	< 4.8	< 5.1	< 4.9	< 4.5
Co-60	< 2.5	< 2.3	2.0(2.3)	< 2.1	< 2.2	< 2.1
Ba-140	< 6.2	< 3.2	< 2.8	< 3.1	< 4.5	< 4.4
La-140	< 7.1	< 3.7	< 3.2	< 3.6	< 5.8	< 5.0

* 1.96 σ (Due to counting statistics.)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 4/02/88		for two weeks ending 4/16/88		for two weeks ending 4/30/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.18	< 0.21	< 0.15	< 0.6	< 0.47	< 0.36
Cs-134	< 2.2	< 2.4	< 2.2	< 2.5	< 1.8	< 2.5
Cs-137	< 2.6	< 2.9	< 5.3	< 2.9	< 3.3	< 3.0
Zr-95	< 4.9	< 5.5	< 4.9	< 6.0	< 4.0	< 5.8
Nb-95	< 1.9	< 2.1	< 2.0	< 2.2	< 1.7	< 2.2
Co-58	< 1.9	< 2.2	< 2.1	< 2.3	< 1.7	< 2.3
Mn-54	< 2.2	< 2.4	< 2.2	< 2.4	< 1.8	< 2.5
Zn-65	< 5.1	< 5.7	< 5.4	< 5.6	< 4.3	< 5.8
Fe-59	< 5.0	< 5.8	< 4.8	< 5.5	< 4.0	< 5.9
Co-60	< 2.3	< 2.5	< 2.2	< 2.6	< 1.8	< 2.7
Ba-140	< 3.4	< 3.8	< 4.6	< 5.7	< 2.6	< 5.9
La-140	< 3.9	< 4.4	< 5.3	< 6.6	< 3.0	< 6.8

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 5/14/88		for two weeks ending 5/28/88		for two weeks ending 6/11/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.43	0.44(0.52)*	< 0.52	< 0.34	< 0.49	< 0.42
Cs-134	< 2.5	< 1.8	< 2.1	< 1.6	< 1.6	< 2.1
Cs-137	< 3.0	2.6(3.1)	< 2.5	4.7(2.3)	3.4 (2.2)	< 2.5
Zr-95	< 5.7	< 3.9	< 4.7	< 3.6	< 3.6	< 4.8
Nb-95	< 2.2	< 1.6	3.8 (2.5)	< 1.7	2.6 (1.9)	< 1.9
Co-58	< 2.2	< 1.6	< 2.0	2.3(1.9)	< 1.6	< 1.9
Mn-54	< 2.5	< 1.8	< 2.1	< 1.7	< 1.7	< 2.1
Zn-65	< 5.9	< 4.2	7.4 (6.6)	< 3.9	< 3.8	< 4.9
Fe-59	< 7.6	< 4.0	< 5.4	4.6(5.4)	< 4.3	< 4.7
Co-60	< 2.7	< 1.8	< 2.0	< 1.5	< 1.5	< 2.3
Ba-140	< 12.0	< 2.6	< 3.8	< 4.2	< 3.7	< 5.6
La-140	< 13.0	< 3.0	< 4.4	< 4.8	< 4.3	< 6.4

* 1.96 σ (Due to counting statistics.)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 6/25/88		for two weeks ending 7/9/88		for two weeks ending 7/23/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.15	0.46(0.49)	< 0.26	< 0.26	< 0.26	< 0.22
Cs-134	< 0.97	< 1.0	< 2.0	< 1.1	< 3.0	1.6 (2.2)
Cs-137	2.6 (1.4)*	< 1.2	< 2.4	< 1.4	< 3.6	< 2.4
Zr-95	2.6 (2.9)	< 2.1	< 5.0	< 2.5	< 6.9	< 4.3
Nb-95	< 1.0	< 0.90	< 1.8	< 1.1	< 2.8	< 1.9
Co-58	< 0.88	< 0.91	< 2.0	< 1.1	< 2.7	< 1.7
Mn-54	< 0.95	< 1.0	< 2.0	1.4 (1.4)	3.7 (3.6)	< 1.8
Zn-65	5.6 (3.2)	< 2.4	< 4.7	< 2.8	< 8.4	< 5.7
Fe-59	< 2.4	< 2.5	5.7 (6.3)	< 3.0	< 6.9	< 5.1
Co-60	< 0.92	< 0.91	< 2.1	< 1.2	< 3.2	< 1.9
Ba-140	< 3.1	< 1.6	< 5.3	< 3.2	< 4.8	< 4.4
La-140	< 3.5	< 1.9	< 6.1	< 3.7	< 5.5	< 5.0

* 1.96 σ (Due to counting statistics.)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 8/6/88		for two weeks ending 8/20/88		for two weeks ending 9/3/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.33	< 0.27	< 0.24	< 0.18	< 0.15	< 0.29
Cs-134	< 1.5	< 2.4	< 2.5	< 2.2	< 1.3	< 1.8
Cs-137	< 1.8	4.9 (3.5)	< 3.0	< 2.6	2.2 (1.9)	3.5 (3.1)
Zr-95	< 3.5	< 5.8	< 5.9	< 4.9	< 2.9	< 3.9
Nb-95	3.1 (1.8)*	< 2.6	< 2.3	< 2.1	< 1.3	< 1.5
Co-58	< 1.5	< 2.4	< 2.4	< 2.1	< 1.2	< 1.7
Mn-54	< 1.5	< 2.6	< 2.5	< 2.5	< 1.3	< 1.8
Zn-65	< 5.0	< 7.1	< 6.7	< 5.2	< 4.2	< 4.5
Fe-59	< 4.3	6.7 (7.4)	< 6.2	7.5 (6.9)	< 3.2	< 3.9
Co-60	1.4 (1.7)	< 2.2	< 2.7	< 2.0	< 1.3	< 1.7
Ba-140	3.9 (4.5)	< 4.1	< 4.0	< 4.9	< 2.3	< 2.6
La-140	4.5 (5.2)	< 4.7	< 4.6	< 5.7	< 2.7	< 2.9

* 1.96 σ (Due to counting statistics.)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 9/17/88		for two weeks ending 10/1/88		for two weeks ending 10/12/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.24	< 0.19	< 0.26	< 0.26	< 0.48	< 0.16
Cs-134	< 2.5	< 1.5	< 2.2	< 1.9	< 1.8	< 2.2
Cs-137	< 3.0	< 1.8	< 2.6	< 2.9	5.5 (3.2)	< 3.3
Zr-95	< 5.8	< 3.4	< 5.0	< 4.6	< 4.0	< 5.0
Nb-95	< 2.5	< 1.6	< 1.9	< 1.8	< 1.7	< 2.0
Co-58	< 2.3	< 1.5	< 2.0	< 1.9	< 1.8	< 2.2
Mn-54	< 2.4	< 1.5	2.4 (2.6)	< 1.9	< 1.8	< 2.1
Zn-65	< 7.4	< 5.1	< 6.0	< 5.1	< 4.7	< 5.6
Fe-59	< 5.6	5.2 (5.0)*	< 5.0	< 4.4	< 4.6	< 5.6
Co-60	< 2.2	< 1.5	< 2.3	< 2.0	< 1.8	< 2.2
Ba-140	< 6.3	< 3.6	5.5 (6.1)	< 4.2	< 4.2	< 3.2
La-140	< 7.2	< 4.2	6.4 (7.0)	< 4.8	< 4.8	< 3.7

* 1.96 σ (Due to counting statistics.)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 10/29/88		for two weeks ending 11/12/88		for two weeks ending 11/26/88	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	0.49(0.49)*	< 0.44	< 0.32	< 0.4	< 0.23	< 0.21
Cs-134	< 2.2	< 1.4	< 2.3	< 2.1	< 2.2	< 1.5
Cs-137	< 2.6	< 1.6	6.6 (4.1)	< 3.1	5.6 (3.8)	< 1.7
Zr-95	< 4.6	< 3.0	< 5.0	< 4.6	< 5.1	< 3.0
Nb-95	< 2.2	< 1.4	< 2.1	< 2.0	< 2.0	< 1.4
Co-58	< 2.0	< 1.2	< 2.2	< 2.1	< 2.2	< 1.3
Mn-54	< 2.2	1.8 (1.7)	< 2.3	< 2.1	< 2.2	< 1.4
Zn-65	< 5.8	3.7 (4.2)	< 5.8	< 5.3	< 5.5	< 3.7
Fe-59	< 5.5	< 3.2	< 5.1	< 4.8	< 5.0	< 3.7
Co-60	< 1.8	< 1.3	2.4 (2.7)	< 2.1	3.3 (2.6)	< 1.4
Ba-140	< 3.5	< 2.3	6.0 (5.9)	< 4.8	< 4.6	< 2.5
La-140	< 4.1	< 2.6	7.0 (6.8)	< 5.5	< 5.3	< 2.9

* 1.96 σ (Due to counting statistics.)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 12/10/88		for two weeks ending 12/24/88			
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3		
I-131	< 0.44	< 0.17	< 0.12	< 0.44		
Cs-134	< 1.1	< 1.2	< 1.8	< 0.65		
Cs-137	2.2 (1.5)*	1.7 (1.6)	< 2.7	0.99 (0.95)		
Zr-95	< 2.6	< 2.9	< 4.3	2.1 (1.9)		
Nb-95	< 1.1	< 1.2	< 1.7	1.2 (0.84)		
Co-58	< 1.1	< 1.2	< 1.7	< 0.59		
Mn-54	< 1.1	< 1.2	< 1.8	1.0 (0.81)		
Zn-65	5.5 (3.5)	< 2.8	< 4.4	6.9 (2.1)		
Fe-59	< 2.8	< 3.0	< 4.0	< 1.9		
Co-60	1.8 (1.2)	< 1.1	< 1.7	< 0.62		
Ba-140	< 3.1	< 2.0	< 4.4	< 1.1		
La-140	< 3.6	< 2.2	< 5.0	< 1.3		

* 1.96 σ (Due to counting statistics.)

2. Surface Water

Surface water is collected monthly from four sites. Since the reactor water effluent can be directed to either river course, there are upstream and downstream sampling locations on both the St. Vrain Creek and on the South Platte River.

Table II.C.4 shows tritium concentrations measured during 1988 at the four surface water sites. Most of the values were less than MDC. The arithmetic mean value for the downstream locations in 1988 was not significantly different from the two upstream locations (Table II.H.2). In fact the mean values were identical. The EPA lists 300 $\pm$ 200 pCi/L for tritium measured in a Platte River sample collected on 1/4/88 for comparison purposes.

Table II.C.5 shows measurements of fission product and activation product concentrations in surface water samples collected monthly. There were occasional positive values, but the mean of the downstream sites was not significantly different from the mean of the upstream sites during 1988 for any of the gamma-ray emitting radionuclides measured. This has been the case since the inception of reactor operations at the Fort St. Vrain site. The occasional positive values are either fallout Cs-137, which can be expected, or values close to the uncertainty limits and assumed to be false positives.

In addition to the monthly sampling of the South Platte River and St. Vrain Creek, a continuous water sample is collected at station A-25. An aliquot of the farm pond outlet is sampled every 80 minutes and the composite collected weekly. The weekly composites are then combined and analyzed monthly. The results of these samples are also shown in Tables II.C.4 and II.C.5. For every month there was evidence of measurable tritium release (see Table II.C.4). Mean values for the other radionuclides were less than MDC except for Cs-137. The correlation of the tritium concentrations with the effluent release report is high.

Table II.C.4
Tritium Concentrations in Surface Water. (pCi/L)

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.)

Figure II.C.1

Tritium Concentrations in Water 1974-1988

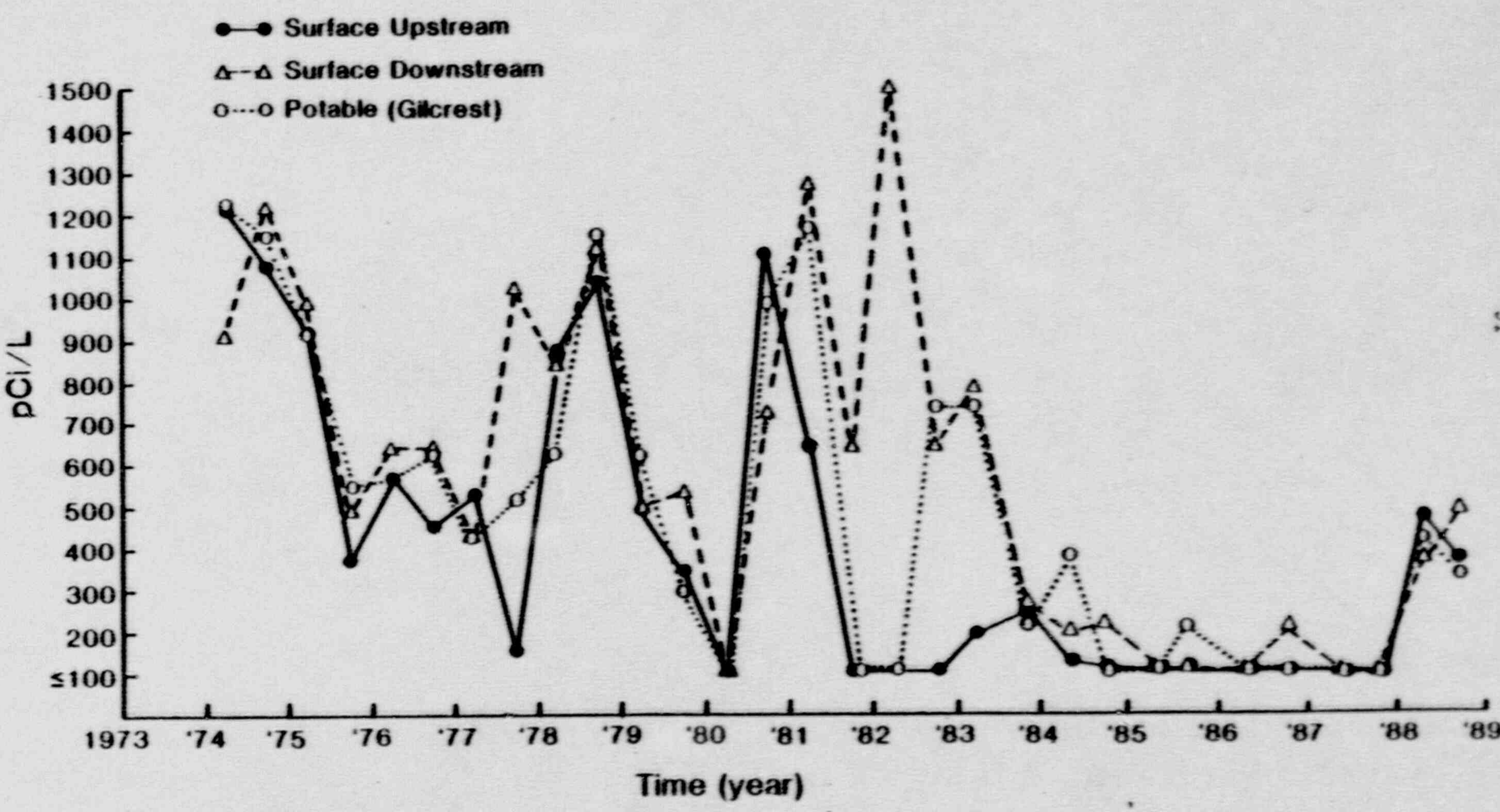


Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 1/09/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.2	< 2.6	< 2.2	< 1.4	< 1.4
Cs-137	< 2.7	< 5.0	< 2.7	< 1.7	2.2 (2.1)
Zr-95	< 5.3	< 5.2	< 4.4	< 3.1	< 3.3
Nb-95	< 2.0	< 2.1	3.8(2.6) *	< 1.4	< 1.3
Co-58	< 2.1	< 3.4	< 2.1	< 1.3	< 1.6
Mn-54	< 2.2	< 2.2	< 2.2	< 1.5	< 1.5
Zn-65	< 5.6	< 8.3	< 5.8	< 3.7	< 3.4
Fe-59	< 5.2	< 5.3	7.1(6.8)	< 3.8	< 4.6
Co-60	< 2.4	< 2.5	< 2.2	< 1.9	< 1.5
Ba-140	< 4.4	< 3.7	4.3(5.2)	< 2.9	< 2.3
La-140	< 5.0	< 4.3	4.9(6.0)	< 3.3	< 2.6

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 2/13/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.5	< 3.3	< 2.9	< 3.8	< 1.7
Cs-137	< 3.6	7.5(6.1)*	< 3.4	< 4.7	2.5 (2.5)
Zr-95	< 5.5	< 7.2	< 6.7	< 9.3	< 4.1
Nb-95	< 2.3	< 3.0	< 2.6	< 3.4	< 1.5
Co-58	< 2.4	< 3.3	< 2.7	< 3.5	< 1.6
Mn-54	< 2.5	< 3.3	< 2.9	< 3.9	< 1.7
Zn-65	< 6.2	< 8.0	< 7.0	< 9.2	< 4.1
Fe-59	< 5.8	< 8.4	< 6.8	< 9.1	< 4.1
Co-60	< 2.5	< 3.4	< 3.1	< 4.3	< 1.9
Ba-140	< 4.4	< 5.6	< 4.8	< 6.4	< 5.9
La-140	< 5.1	< 6.4	< 5.5	< 7.4	< 6.8

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 3/12/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 3.8	< 3.8	< 2.4	< 2.5	< 1.7
Cs-137	< 4.5	< 5.5	< 2.8	< 3.0	2.8 (2.4)*
Zr-95	< 8.9	< 8.4	< 5.7	< 5.7	< 3.9
Nb-95	< 3.6	< 3.4	< 2.2	< 2.2	< 1.5
Co-58	< 3.5	< 3.6	< 2.1	< 2.2	< 1.6
Mn-54	< 3.8	< 3.8	< 2.4	< 2.5	< 1.6
Zn-65	< 9.2	< 9.1	< 5.6	< 5.9	< 4.0
Fe-59	< 9.4	< 8.2	< 5.5	< 5.9	< 3.9
Co-60	< 4.0	< 3.9	< 2.7	< 2.8	< 1.8
Ba-140	< 6.3	< 5.7	< 3.9	< 4.1	< 5.8
La-140	< 7.2	< 6.6	< 4.4	< 4.7	< 6.6

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 4/09/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 1.8	< 2.5	< 2.1	< 2.2	4.1 (3.0)
Cs-137	< 2.7	4.1(4.4)*	< 2.5	< 3.2	<3.0
Zr-95	< 4.2	< 5.5	< 4.9	< 5.0	< 5.7
Nb-95	< 1.7	< 2.4	< 1.9	< 2.0	<2.2
Co-58	< 1.7	< 2.5	< 1.9	< 2.0	<2.2
Mn-54	< 1.8	< 2.5	< 2.0	< 2.1	<2.5
Zn-65	< 4.4	< 6.0	< 4.7	< 5.1	<6.1
Fe-59	< 4.2	< 6.0	< 4.7	< 5.0	<5.7
Co-60	< 1.8	< 2.4	< 2.2	< 2.2	<2.6
Ba-140	< 2.7	< 4.8	< 3.8	< 3.2	< 3.9
La-140	< 3.1	< 5.5	< 4.4	< 3.7	< 4.5

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 5/21/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.1	< 2.5	< 2.5	< 2.8	2.2 (2.7)
Cs-137	< 2.7	< 3.7	< 3.7	< 3.4	< 3.4
Zr-95	5.5 (6.1)*	< 5.4	< 5.7	< 6.5	< 5.7
Nb-95	< 2.0	< 2.2	< 2.2	< 2.5	< 2.0
Co-58	< 2.0	< 2.4	< 2.4	< 2.5	2.9 (2.9)
Mn-54	2.6 (2.6)	< 2.4	< 2.5	< 2.7	< 2.3
Zn-65	< 5.2	< 5.8	< 5.9	< 6.4	< 5.4
Fe-59	< 5.1	< 5.5	< 5.7	< 6.9	< 6.2
Co-60	< 2.3	< 2.5	< 2.5	< 2.9	< 2.3
Ba-140	< 3.5	< 3.6	< 3.7	< 4.4	< 3.3
La-140	< 4.0	< 4.1	< 4.2	< 5.1	< 3.8

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 6/11/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 3.2	4.4 (4.0)*	< 1.5	< 2.5	< 2.0
Cs-137	< 4.8	< 4.1	3.3 (2.2)	3.6 (3.7)	3.9 (3.5)
Zr-95	< 6.8	< 8.0	< 3.2	< 5.8	< 4.5
Nb-95	< 2.7	< 3.1	< 1.5	< 2.3	< 1.7
Co-58	< 3.1	< 3.1	< 1.4	< 2.4	< 1.8
Mn-54	< 3.0	< 3.4	< 1.5	< 2.5	< 1.9
Zn-65	< 7.3	< 8.0	< 3.9	< 6.0	< 4.5
Fe-59	< 7.5	< 8.1	< 4.0	< 5.7	< 6.1
Co-60	< 3.2	< 3.7	< 1.4	< 2.7	< 1.9
Ba-140	< 4.7	< 5.6	< 2.9	< 4.1	< 2.8
La-140	< 5.4	< 6.5	< 3.3	< 4.7	< 3.3

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 7/09/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.0	< 3.0	< 1.4	< 1.5	< 2.0
Cs-137	< 2.4	6.7 (5.2)	< 1.9	2.0 (2.1)	< 2.3
Zr-95	< 5.0	< 7.0	< 3.5	< 3.4	< 4.5
Nb-95	< 1.9	< 2.8	< 1.5	< 1.4	< 1.8
Co-58	< 1.9	< 2.9	< 1.3	< 1.4	< 1.8
Mn-54	< 2.0	< 2.9	< 1.5	< 1.5	< 2.0
Zn-65	5.8 (5.7)*	< 6.9	< 4.0	< 3.8	< 4.3
Fe-59	< 5.0	< 6.9	< 4.0	< 3.6	< 5.0
Co-60	< 2.2	< 2.9	< 1.4	< 1.4	< 1.8
Ba-140	< 3.3	< 5.4	< 2.6	< 2.3	< 7.5
La-140	< 3.8	< 6.2	< 3.0	< 2.7	< 8.7

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 8/13/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.8	< 2.3 **	< 3.5	< 3.2	< 1.3
Cs-137	4.2 (5.0)*	3.9 (3.5)	< 4.1	< 3.8	2.0 (2.0)
Zr-95	< 6.4	< 5.3	< 8.0	7.4 (8.8)	< 2.9
Nb-95	< 2.6	< 2.4	< 2.9	< 3.0	< 1.3
Co-58	< 2.6	< 2.1	< 3.2	< 2.9	< 1.4
Mn-54	< 2.7	< 2.4	< 3.4	< 3.2	< 1.4
Zn-65	< 7.4	< 6.3	< 8.7	< 7.9	< 3.5
Fe-59	< 6.2	< 6.2	9.1 (9.4)	< 7.3	< 4.1
Co-60	< 2.8	< 2.1	< 3.6	< 3.2	< 1.3
Ba-140	< 4.2	< 4.3	< 5.5	< 5.2	< 2.1
La-140	< 4.8	< 5.0	< 6.4	< 6.0	< 2.5

* 1.96 σ (Due to counting statistics.)

** COLLECTED AUGUST 20

Table II.C.5 Radionuclide Concentrations in Surface Water. (pCi/L)

Collection Date: 9/10/88

	Downstream Sites		Upstream Sites		Effluent
Radio-nuclide	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 3.4	< 2.0	< 3.0	< 2.2	< 2.1
Cs-137	< 4.1	3.4 (2.9)*	< 4.5	< 2.5	4.5 (3.9)
Zr-95	< 8.2	< 4.2	< 6.7	< 4.4	< 4.7
Nb-95	< 3.3	< 2.1	< 2.9	< 1.9	< 2.0
Co-58	< 3.1	< 1.9	< 2.8	< 2.0	< 2.0
Mn-54	< 3.3	< 1.9	< 3.1	< 2.0	< 2.1
Zn-65	< 8.7	< 5.7	< 8.2	< 6.0	< 5.9
Fe-59	< 7.8	7.0 (6.1)	< 7.2	< 5.6	< 4.9
Co-60	< 3.6	< 2.0	< 3.1	< 1.9	< 2.1
Ba-140	< 5.5	< 3.5	< 4.7	< 3.3	< 3.2
La-140	< 6.3	< 4.1	< 5.4	< 3.8	< 3.6

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 10/08/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.2	2.6 (2.5)	< 4.0	< 4.1	< 1.6
Cs-137	4.1 (4.0)*	4.6 (3.6)	< 5.9	< 4.9	2.5 (2.3)
Zr-95	< 5.0	< 4.8	< 9.1	< 9.5	< 3.6
Nb-95	< 2.1	< 1.9	< 3.9	< 3.6	< 1.8
Co-58	< 2.1	< 2.0	< 3.8	< 3.7	< 1.5
Mn-54	< 2.2	< 2.0	< 3.8	< 4.0	< 1.6
Zn-65	< 5.5	< 5.1	< 10.0	< 9.7	< 4.9
Fe-59	< 5.2	< 4.8	< 9.0	< 9.2	< 4.0
Co-60	< 2.2	< 2.1	< 4.2	< 4.4	< 1.5
Ba-140	< 3.2	< 3.7	< 6.2	< 6.5	< 6.5
La-140	< 3.7	< 4.3	< 7.1	< 7.5	< 7.5

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 11/19/88

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.0	< 2.0	< 1.4	< 2.5	< 2.0
Cs-137	3.3 (3.5)*	< 2.5	< 1.7	< 2.9	< 2.5
Zr-95	< 4.6	< 4.8	< 3.1	< 5.5	< 4.7
Nb-95	< 1.8	< 1.8	< 1.3	< 2.5	< 1.8
Co-58	2.4 (2.3)	< 1.9	< 1.3	< 2.3	< 1.9
Mn-54	< 1.9	< 2.0	< 1.4	< 2.6	2.1 (2.5)
Zn-65	< 4.8	< 4.8	< 3.6	< 6.6	< 4.7
Fe-59	< 4.6	< 4.8	3.7 (4.4)	< 6.0	< 4.8
Co-60	< 2.0	< 2.2	< 1.4	< 2.5	3.1 (2.6)
Ba-140	< 2.9	< 3.9	< 2.4	< 5.1	< 3.3
La-140	< 3.3	< 4.5	< 2.7	< 5.8	< 3.7

* 1.96 σ (Due to counting statistics.)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 12/17/88

Radio- -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.2	< 0.89	< 0.70	< 1.3	< 0.86
Cs-137	< 3.0	1.6 (1.3)	0.92 (0.99)	3.6 (1.9)	2.0 (1.2)
Zr-95	< 5.5	< 2.0	< 1.5	3.7 (3.9)	< 2.4
Nb-95	< 2.4	1.3 (1.1)	< 0.66	< 1.4	1.6 (1.2)
Co-58	< 2.1	< 0.82	< 0.64	< 1.3	< 1.0
Mn-54	4.3 (2.9)*	1.3 (1.1)	< 0.69	< 1.3	< 0.89
Zn-65	12.0 (7.9)	6.2 (3.0)	4.2 (2.0)	6.8 (4.5)	5.1 (2.8)
Fe-59	< 5.9	< 2.6	< 1.8	< 3.3	3.3 (3.7)
Co-60	< 2.2	< 0.9	< 0.67	< 1.4	< 0.83
Ba-140	< 5.1	< 2.6	< 1.4	< 2.3	< 1.4
La-140	< 5.8	< 3.0	< 1.6	< 2.6	< 1.6

* 1.96 σ (Due to counting statistics.)

3. Ground Water

Ground water is sampled quarterly at two locations. These are at F-16, a well on the farm immediately north and the closest to the reactor down the hydrological gradient, and at R-5, the Ehrlich feedlot. Table II.C.7 lists the measured concentrations of fission products and activation products in ground water. The Cs-137 results are not surprising due to residue of Chernobyl fallout, and the other results above MDC are assumed to be statistically false positive values.

For comparison purposes, Table II.C.8 lists the Maximum Permissible Concentration values in drinking water for each of the radionuclides listed in Tables II.C.4-7.

Table II.C.6 Radionuclide Concentrations in Ground Water. (pCi/L)

Radionuclide	1st Quarter 3/12/88		2nd Quarter 6/11/88		3rd Quarter 9/24/88		4th Quarter 1/28&2/4/89	
	F-16	R-5	F-16	R-5	F-16	R-5	F-16	R-5
Cs-134	< 3.6	< 2.5	< 2.4	< 1.4	< 2.1	< 2.3	< 2.1	< 2.3
Cs-137	< 5.6	5.9(4.5)*	4.4 (4.2)	1.8(2.2)	11.0 (3.1)	3.9 (3.9)	11 (3.1)	3.9 (3.9)
Zr-95	< 8.3	< 5.6	< 5.3	< 3.2	< 5.1	< 5.0	< 5.1	< 5.0
Nb-95	< 3.8	< 2.3	< 2.3	< 1.3	< 2.3	< 2.1	< 2.3	< 2.1
Co-58	< 3.5	< 2.4	< 2.2	< 1.3	< 1.9	< 2.1	< 1.9	< 2.1
Mn-54	< 3.7	< 2.4	< 2.3	2.1(1.8)	3.1 (2.6)	< 2.2	3.1 (2.6)	< 2.2
Zn-65	< 11	< 6.4	< 6.2	< 3.4	12.0 (7.9)	< 5.3	12 (7.9)	< 5.3
Fe-59	< 8.7	< 5.7	5.6 (6.5)	< 3.6	5.2 (6.1)	5.4 (6.4)	5.2 (6.1)	5.4 (6.4)
Co-60	< 3.7	< 2.6	< 2.3	< 1.3	< 2.3	5.4 (2.6)	< 2.3	5.4 (2.6)
Ba-140	< 5.5	< 4.4	< 3.9	< 2.5	6.5 (4.8)	< 3.4	6.5 (4.8)	< 3.4
La-140	< 6.3	< 5.1	< 4.5	< 2.8	7.5 (5.6)	< 3.9	7.5 (5.6)	< 3.9

* 1.96 σ (Due to counting statistics.)

Table II.C.7 Tritium Concentrations in Ground Water 1988.

	Facility F-16	Reference R-5
3/12/88	< 280	340 (340)
6/11/88	< 220	< 220
9/24/88	< 260	< 260
1/28/89	1000 (330)*	540 (330)

* 1.96σ (Due to counting statistics.)

Table II.C.8 Maximum Permissible Concentrations in Drinking Water. (10CFR20, Appendix B, Table II)

H-3	3×10^6 pCi/L
I-131	3×10^2 pCi/L
Cs-134	9×10^3 pCi/L
Cs-137	2×10^4 pCi/L
Zr-95	6×10^4 pCi/L
Nb-95	1×10^5 pCi/L
Co-58	1×10^5 pCi/L
Mn-54	1×10^5 pCi/L
Zn-65	1×10^5 pCi/L
Fe-59	6×10^4 pCi/L
Co-60	5×10^4 pCi/L
Ba-140	3×10^4 pCi/L
La-140	2×10^4 pCi/L

II.D. Milk

The dairy food chain is the critical pathway for possible radiation dose commitment around any nuclear facility. The critical individual would be an infant consuming milk produced from cows grazing local pastures. Milk is the critical pathway for possible dose commitment to humans from environmental contamination of H-3, I-131, Cs-137 and Sr-90. For this reason milk is sampled extensively to document the presence or absence of radioactivity due to reactor operations. A three liter milk sample is counted for determination of Cs-137, Cs-134 and Ba-La-140. To measure I-131 at the required LLD of 1.0 pCi/L, an 18 liter sample is concentrated by anion exchange and the resin counted by gamma-ray spectroscopy. The method of treating the milk is modified from that of McCurdy and Mellor, Health Physics 38: 203-213, 1980.

There are no dairies (or personal milk cows) in the facility area, 1.6 km radius. The six dairies in the adjacent area, 1.6-8 km radius, were selected as they are located in the highest X/Q areas (refer to updated FSAR). The description of these locations can be found in Table III.B.1 and Figure III.B.2. The single reference location dairy, R-8, is 22.5 km West of the reactor in the least predominant wind direction. Herd management practices are virtually identical at all dairy locations. The cows in the milking herd are never on pasture but under dry-lot management typical of Eastern Colorado (see Appendix).

Table II.D.1 lists the concentrations of all radionuclides that are investigated in milk samples. During 1988, elevated concentrations of I-131 were again observed only at site A-22. The source of this I-131 is from nuclear medicine thyroid therapy practice in the Denver hospitals. The releases enter the S. Platte River just North of Denver.

A-22 dairy uses irrigation ditch water for its herd during the summer rather than well water. The ditch (Independence) receives S. Platte water upstream of FSV. This observation was first made in 1985 and discussed at length in the 1985 REMP summary report. Unfortunately, A-22 dairy could not provide milk samples during the last quarter of 1988 due to efforts to meet production quotas. The dairy has rejoined the program beginning in January.

During October, when milk was not available from A-22, four extra water samples were collected from the Independence Ditch at the dairy location. The I-131 concentrations on those four dates are given below.

Date	I-131 pCi/L	± 1.96
10/1/88	1.4	± 0.35
10/8/88	8.0	± 0.85
10/15/88	4.0	± 0.69
10/22/88	2.0	± 0.44

If ditch water were the only source of drinking water for the A-22 herd during this period, it can be assumed that milk concentrations would have been approximately the same as the water concentration. The ditch flow was stopped in November and December.

Figure II.D.1 shows the frequency and magnitude of the I-131 concentrations observed at the A-22 dairy in recent years. The large peak observed in May and June of 1986 is of course due to Chernobyl fallout, but all other peaks are due to hospital release in Denver.

K-natural, as measured by K-40, is extremely constant in milk. The mean literature value for cow milk is 1.5 g/L. K concentrations are homeostatically controlled and independent of K intake. K-nat is measured in all milk samples as a quality control measure for the other radionuclides determined in the same sample by gamma-ray spectrometry, but K-nat concentrations are no longer reported in Table II.D.1.

Elevated tritium concentrations in milk due to reactor effluents have never been observed in 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). As noted in previous reports, the reported tritium concentration in milk is the tritium in water extracted from the milk. Contamination of milk samples by any radionuclide due to reactor effluents has never been observed during the operational periods of Fort St. Vrain.

For comparison purposes, the EPA lists a measured Cs-137 concentration in milk from Denver as 9 $\pm$ 6 pCi/L on 1/4/88.

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	1/30/88	1/30/88	1/30/88	1/30/88	1/09/88	1/09/88	1/30/88
I-131	< 0.46	< 0.4	< 0.34	< 0.4	< 0.54	< 0.47	< 0.39
Cs-134	< 2.2	< 3.8	< 2.5	< 2.6	< 2.3	< 1.6	< 4.1
Cs-137	< 2.6	< 4.6	< 3.1	< 4.0	3.8 (4.1)	1.9(2.2)	9.2(7.2)
Ba-140	4.2(4.7)*	< 6.2	< 4.2	< 4.7	4.3(4.5)	3.1(3.3)	< 5.9
La-140	4.9(5.4)	< 7.2	< 4.9	< 5.4	5.0(5.1)	3.6(3.8)	< 6.8
Collection Date	2/20/88	2/27/88	2/27/88	2/27/88	2/13/88	2/13/88	2/06/88
I-131	< 0.27	< 0.38	< 0.47	< 0.37	< 0.44	< 0.28	< 0.31
Cs-134	< 2.4	< 2.9	< 2.5	< 3.5	< 2.5	< 1.6	< 3.4
Cs-137	< 3.5	4.7(5.3)	< 3.1	< 5.0	< 3.1	< 2.0	< 4.1
Ba-140	< 3.5	< 5.2	< 4.8	< 6.1	< 4.5	3.8(3.5)	< 6.4
La-140	< 4.1	< 6.0	< 5.6	< 7.0	< 5.1	4.4(4.1)	< 7.4
Collection Date	3/26/88	3/26/88	3/19/88	3/19/88	3/12/88	3/12/88	3/05/88
I-131	< 0.29	< 0.25	< 0.33	< 0.41	< 0.21	< 0.23	< 0.38
Cs-134	< 2.8	< 1.8	< 2.6	4.0(2.8)	< 5.2	< 2.5	< 2.5
Cs-137	< 3.4	3.8(3.3)	< 3.2	5.9 (4.1)	< 6.0	8.0(3.7)	7.8(4.1)
Ba-140	< 5.3	< 3.2	< 4.2	< 3.4	< 8.5**	< 3.9	< 5.0
La-140	< 6.1	< 3.7	< 4.8	< 3.9	< 9.8	< 4.5	< 5.7

* 1.96 σ (Due to counting statistics.)
** Insufficient volume to achieve LLD due to technician error.

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/l).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	4/30/88	4/30/88	4/22/88	4/22/88	4/09/88	4/09/88	4/02/88
I-131	C.65(0.67)*	< 0.34	< 0.27	< 0.31	< 0.28	< 0.3	< 0.34
Cs-134	< 4.1	< 4.0	< 2.6	< 1.7	< 2.8	6.5(4.8)	< 3.9
Cs-137	5.9 (7.0)	< 5.9	< 3.2	< 1.9	< 3.4	17(5.9)	< 4.6
Ba-140	< 5.7	6.8(7.1)	< 5.0	< 3.1	< 4.5	< 6.2	< 6.1
La-140	< 6.5	7.8(8.2)	< 5.7	< 3.6	< 5.2	< 7.2	< 7.0
Collection Date	5/07/88	5/07/88	5/07/88	5/07/88	5/14/88	5/14/88	5/14/88
I-131	< 0.28	< 0.3	< 0.4	< 0.32	< 0.49	< 0.35	< 0.32
Cs-134	< 3.1	< 3.5	< 3.4	< 3.7	< 2.8	3.0 (3.1)	< 2.8
Cs-137	< 4.6	< 4.1	< 5.1	4.4(5.2)	< 3.4	13.0 (4.7)	6.9 (4.2)
Ba-140	< 8.1 (6.9)	< 5.4	< 5.8	< 5.9	< 5.1	< 3.8	< 4.5
La-140	< 9.3 (8.0)	< 6.2	< 6.6	< 6.7	< 5.9	< 4.4	< 5.1
Collection Date	5/21/88	5/21/88	5/21/88	5/21/88	5/28/88	5/28/88	5/28/88
I-131	< 0.36	< 0.45	< 0.35	< 0.29	< 0.49	< 0.29	< 0.24
Cs-134	< 1.5	< 2.1	< 2.2	< 2.3	< 4.1	< 2.6	1.8 (2.0)
Cs-137	4.8(3.6)	3.4 (3.7)	< 2.7	< 2.8	9.9 (7.5)	11.0 (3.8)	2.5 (2.5)
Ba-140	< 2.9	< 3.0	< 3.6	< 5.8	< 6.2	< 4.0	< 2.7
La-140	< 3.4	< 3.4	< 4.1	< 6.7	< 7.1	< 4.6	< 3.1

* 1.96 σ (Due to counting statistics.)

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	6/11/88	6/04/88	6/04/88	6/04/88	6/11/88	6/11/88	6/11/88
I-131	< 0.27	< 0.25	1.7 (.76)	< 0.22	< 0.26	< 0.32	< 0.19
Cs-134	< 3.2	< 2.3	< 2.4	< 3.3	< 3.4	< 1.4	4.0 (2.9)
Cs-137	5.7 (5.7)*	< 3.3	< 3.4	< 5.0	< 4.2	2.3 (2.0)	5.8 (3.5)
Ba-140	< 4.7	< 3.3	< 4.1	< 6.0	< 5.5	< 2.2	< 3.8
La-140	< 5.4	< 3.8	< 4.7	< 6.9	< 6.4	< 2.6	< 4.4
Collection Date	6/20/88	6/18/88	6/18/88	6/25/88	6/25/88	6/25/88	6/25/88
I-131	< 0.18	< 0.21	< 0.21	< 0.46	< 0.31	< 0.31	< 0.2
Cs-134	< 1.9	< 1.9	< 2.0	< 3.5	< 1.9	2.5 (2.8)	< 2.6
Cs-137	7.1(3.3)	3.7 (3.3)	< 2.5	11.0 (6.4)	< 2.1	7.3 (4.2)	< 3.1
Ba-140	< 2.8	< 2.8	4.0(4.8)	< 5.2	< 3.3	< 4.2	< 5.2
La-140	< 3.2	< 3.2	4.6(5.5)	< 5.9	< 3.8	< 4.8	< 5.9
Collection Date	7/02/88	7/02/88	7/02/88	7/16/88	7/09/88	7/09/88	7/09/88
I-131	< 0.23	< 0.43	< 0.43	< 0.28	< 0.14	< 0.14	< 0.23
Cs-134	< 1.5	< 2.2	2.5 (2.8)	< 1.4	< 1.7	< 2.2	< 2.6
Cs-137	< 2.1	< 2.7	< 2.8	< 1.7	< 1.9	< 2.7	< 3.2
Ba-140	< 3.6	< 4.5	< 3.9	< 2.3	< 2.8	< 4.1	< 4.2
La-140	< 4.1	< 5.2	< 4.5	< 2.6	< 3.2	< 4.7	< 4.8

* 1.96 σ (Due to counting statistics.)

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	7/23/88	7/16/88	7/23/88	7/23/88	7/30/88	7/30/88	7/23/88
I-131	< 0.42	< 0.24	0.64 (0.36)*	< 0.3	< 0.35	< 0.33	< 0.32
Cs-134	< 2.6	< 2.9	< 2.4	< 2.8	< 2.2	< 2.8	< 3.5
Cs-137	< 3.0	< 3.5	4.2 (3.5)	< 3.5	< 2.9	< 3.4	< 5.1
Ba-140	< 3.8	< 4.9	< 3.8	< 5.1	< 4.3	< 5.4	< 5.7
La-140	< 4.4	< 5.6	< 4.4	< 5.8	< 5.0	< 6.3	< 6.6
Collection Date	8/06/88	8/06/88	8/06/88	8/06/88	8/13/88	8/13/88	8/13/88
I-131	< 0.26	< 0.3	0.81 (0.34)	< 0.27	< 0.23	< 0.17	< 0.23
Cs-134	< 2.1	< 3.8	< 3.3	< 1.8	< 2.3	< 3.0	< 3.2
Cs-137	< 2.9	6.6 (5.4)	7.8 (4.9)	< 2.1	< 2.7	< 4.4	< 3.9
Ba-140	4.4 (5.3)	< 6.1	< 5.4	< 2.8	< 3.6	< 4.3	< 5.4
La-140	6.0 (6.1)	< 7.1	< 6.3	< 3.2	< 4.2	< 4.9	< 6.2
Collection Date	8/20/88	8/20/88	8/27/88	8/20/88	8/27/88	8/27/88	8/27/88
I-131	< 0.18	< 0.3	< 0.25	< 0.18	< 0.22	< 0.25	< 0.17
Cs-134	< 2.2	< 3.2	< 3.1	< 2.9	< 2.2	< 3.3	< 3.5
Cs-137	< 2.6	4.4 (4.7)	< 3.5	< 4.4	3.1 (3.1)	< 3.9	< 5.3
Ba-140	< 3.4	< 5.2	6.4 (6.2)	< 4.4	< 4.1	< 5.2	< 5.2
La-140	< 3.9	< 6.0	7.4 (7.1)	< 5.0	< 4.7	< 6.0	< 5.9

* 1.96 σ (Due to counting statistics.)

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	9/03/88	9/03/88	9/10/88	9/03/88	9/10/88	9/10/88	9/10/88
I-131	< 0.21	< 0.37	0.78 (0.36)	< 0.24	< 0.28	< 0.13	< 0.34
Cs-134	< 2.3	< 1.9	< 3.2	< 2.7	< 3.0	< 2.0	< 1.6
Cs-137	< 2.9	2.5 (2.5)*	8.3 (4.6)	3.5 (3.9)	< 4.2	< 2.5	2.8 (2.2)
Ba-140	< 4.2	< 3.0	< 5.2	< 4.9	< 4.7	< 3.2	< 2.4
La-140	< 4.9	< 3.5	< 5.9	< 5.6	< 5.4	< 3.6	< 2.8
Collection Date	9/17/88	9/24/88	f	9/17/88	9/24/88	9/24/88	9/17/88
I-131	< 0.19	< 0.25		< 0.34	0.41 (0.46)	< 0.33	< 0.31
Cs-134	< 3.6	< 2.3		< 2.4	< 3.0	< 2.5	< 2.8
Cs-137	< 4.4	< 2.7		5.1 (4.3)	< 4.4	4.1 (4.3)	4.1 (3.9)
Ba-140	< 5.8	< 3.7		< 3.5	< 4.5	< 3.5	9.7 (5.6)
La-140	< 6.6	< 4.3		< 4.0	< 5.1	< 4.1	11.0 (6.4)
Collection Date	10/08/88	10/29/88	f	10/22/88	10/15/45	10/08/88	10/29/88
I-131	< 0.23	< 0.4		< 0.32	< 0.45	< 0.37	< 0.21
Cs-134	< 2.6	2.3 (2.8)		< 2.1	< 2.1	< 1.7	< 2.8
Cs-137	< 2.8	< 2.8		5.5 (3.7)	< 2.5	4.7 (2.4)	< 3.4
Ba-140	< 3.7	< 4.4		< 3.8	< 3.4	< 2.8	< 4.8
La-140	< 4.3	< 5.0		< 4.3	< 3.9	< 3.2	< 5.5

* 1.96 σ (Due to counting statistics.)
f Dairyman could not spare volume while qualifying for annual quota.

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	11/12/88	11/05/88	f	10/29/88	11/19/88	11/19/88	11/05/88
I-131	< 0.18	< 0.27		< 0.4	< 0.28	< 0.38	< 0.33
Cs-134	< 2.6	< 1.5		< 1.7	1.9 (2.2)	< 2.1	< 2.1
Cs-137	3.7 (3.7)*	2.1 (2.1)		< 1.9	< 2.8	< 2.5	< 2.5
Ba-140	< 4.1	3.1 (3.6)		< 3.3	< 3.4	< 3.3	< 3.8
La-140	< 4.7	3.6 (4.2)		< 3.7	< 3.9	< 3.8	< 4.3
Collection Date	12/10/88	12/03/88	f	12/03/88	12/24/88	12/17/88	f
I-131	< 0.31	< 0.24		0.41 (0.37)	< 0.43	< 0.33	
Cs-134	< 3.4	< 2.4		< 2.6	< 1.5	< 1.6	
Cs-137	< 5.2	< 3.5		< 3.2	3.3 (2.2)	1.9 (2.2)	
Ba-140	< 6.6	< 3.4		< 4.6	< 3.0	< 2.5	
La-140	< 7.6	< 3.9		< 5.3	< 3.5	< 2.9	

* 1.96 σ (Due to counting statistics.)

f A-22 dairyman could not spare volume while qualifying for annual quota. R-8 dairyman declared bankruptcy and could not be replaced before end of year.

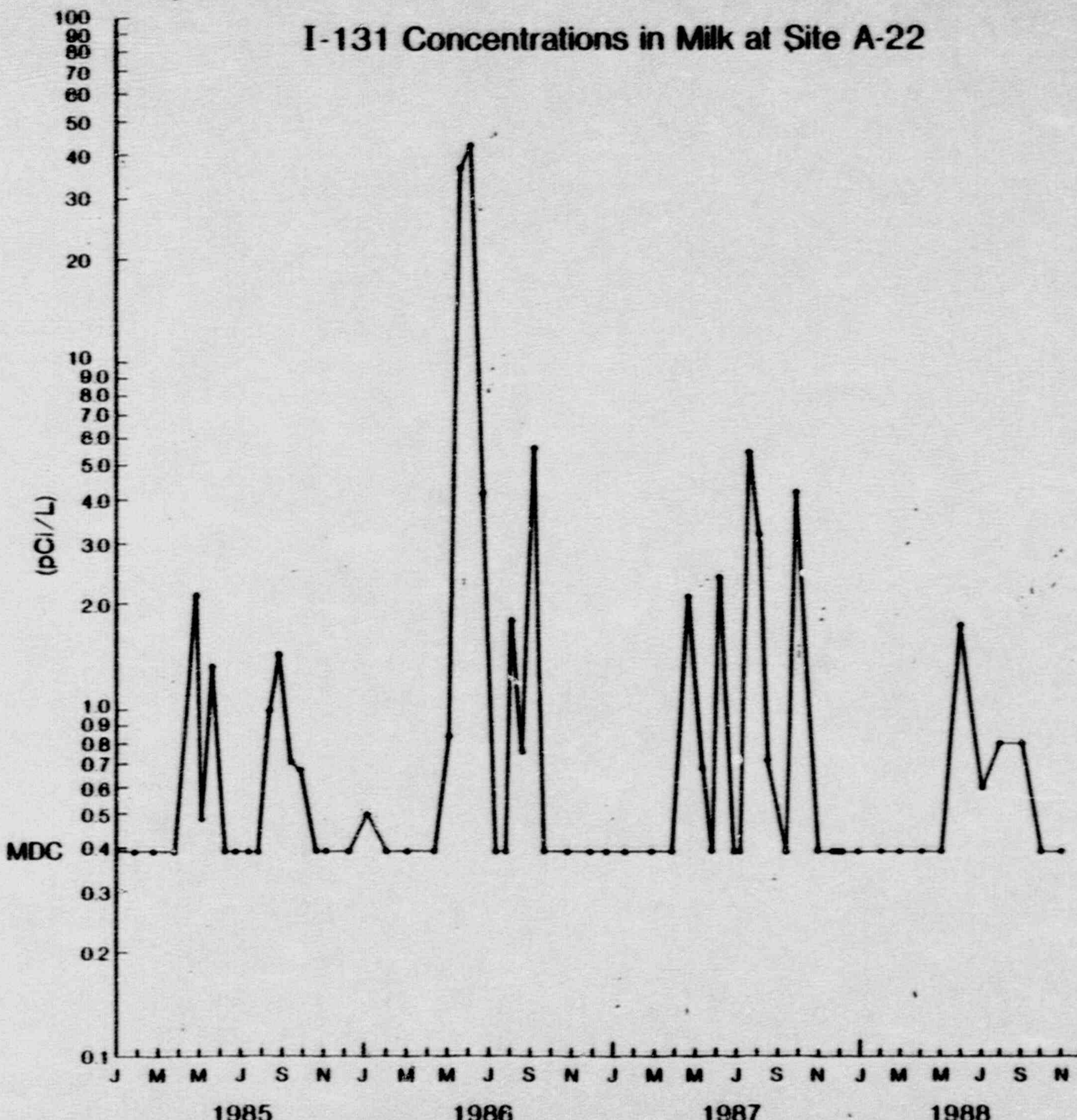

I-131 Concentrations in Milk at Site A-22
(pCi/L)
100
90
80
70
60
50
40
30
20
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
MDC 0.4
0.3
0.2
0.1
J M M J S N J M M J S N J M M J S N J M M J S N
1985
1986
1987
1988

Figure II.D.1

Table II.D.2 Tritium Concentrations in Milk. (pCi/L) a) First half, 1988.

Adjacent Sites						Reference
A-6	A-18	A-22	A-23	A-24	A-26	R-8
1/30/88 < 230	1/30/88 < 230	1/30/88 < 230	1/30/88 < 230	1/9/88 410 (420)*	1/9/88 < 290	1/30/88 < 230
2/20/88 < 230	2/27/88 < 230	2/27/88 < 230	2/27/88 < 230	2/13/88 290 (280)	2/13/88 < 220	2/8/88 < 230
3/26/88 < 230	3/26/88 < 230	3/19/88 390 (310)	3/19/88 < 230	3/12/88 < 280	3/12/88 < 280	3/5/88 < 220
4/30/88 < 250	4/30/88 450 (310)	4/22/88 270 (310)	4/22/88 520 (310)	4/9/88 380 (310)	4/9/88 560 (310)	4/2/88 480 (310)
5/7/88 360 (370)	5/7/88 < 250	5/7/88 < 250	5/7/88 < 250	5/14/88 < 250	5/14/88 < 250	5/14/88 < 250
5/21/88 < 250	5/21/88 < 250	5/21/88 < 250	5/21/88 < 250	5/28/88 < 250	5/28/88 < 250	5/28/88 < 250
6/11/88 < 250	6/4/88 < 250	6/4/88 < 250	6/4/88 < 250	6/11/88 440 (370)	6/11/88 < 250	6/11/88 < 250
6/18/88 < 250	6/18/88 < 250	6/18/88 < 220	6/25/88 < 220	6/25/88 < 250	6/25/88 < 250	6/25/88 < 250

* 1.96 σ (Due to counting statistics.)

Table II.D.2 Tritium Concentrations in Milk. (pCi/l) b) Second half, 1988.

Adjacent Sites						Reference
A-6	A-18	A-22	A-23	A-24	A-26	R-8
7/2/88 < 250	7/2/88 < 250	7/2/88 < 250	7/16/88 < 250	7/9/88 < 250	7/9/88 < 250	7/9/88 < 250
7/23/88 < 250	7/16/88 < 250	7/23/88 < 250	7/23/88 < 250	7/30/88 < 250	7/30/88 < 250	7/23/88 < 250
8/6/88 < 260	8/6/88 < 260	8/6/88 < 260	8/6/88 < 260	8/13/88 < 260	8/13/88 < 260	8/13/88 < 260
8/20/88 < 260	8/20/88 < 260	8/27/88 < 260	8/20/88 < 260	8/27/88 < 260	8/27/88 < 260	8/27/88 < 260
9/3/88 < 250	9/3/88 < 250	9/10/88 < 250	9/3/88 < 250	9/10/88 < 250	9/10/88 280 (380)*	9/10/88 < 250
9/17/88 < 260	9/24/88 < 250	f	9/17/88 < 250	9/24/88 < 250	9/24/88 < 250	9/17/88 290 (380)*
10/8/88 d	10/29/88 370 (380)	f	10/22/88 500 (380)	10/15/88 d	10/8/88 d	10/29/88 390 (350)
11/12/88 560 (350)	11/5/88 500 (350)	f	11/5/88 650 (380)	11/19/88 490 (350)	11/19/88 640 (350)	11/5/88 300 (350)
12/10/88 870 (340)	12/3/88 600 (340)	f	12/3/88 740 (340)	12/24/88 690 (340)	12/17/88 870 (340)	f

* 1.96 σ (Due to counting statistics.)

d Sample lost during analysis.

f Dairyman at A22 was meeting annual quota; Dairy at R8 went out of business.

II.E. Food Products

Food sampling locations were selected 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. The locations of these food product collection sites are described in Table III.B.1. One sample of each principal class of food products was collected from these locations. Locations and available produce often change due to owner needs, harvest time, harvest size, etc.

Each sample is homogenized without drying immediately after collection. The sample is then counted by gamma-ray spectroscopy. Table II.E.1 lists the date of collection and the results for the 1988 harvest. Three of the food samples showed detectable Cs-137 from past Chernobyl fallout deposition and two showed marginal but detectable concentrations of Cs-134, also from Chernobyl. The I-131 concentration result in the zucchini sample from A-30 was rech[illegible]nd confirmed. The result was certainly not due to reactor effluent but probably the result of the use of irrigation water from the S. Platte River. In section II.D, concentrations of I-131 from Denver hospital use were documented in irrigation ditches off the Platte River. The gamma-ray spectra were scanned for other radionuclides, but only the naturally occurring were observed, presumably due to surface soil deposits.

Table II.E.1 Radionuclide Concentrations in Food Products (pCi/kg)

Collection Date 9/13/88

Location	Food Type	I-131	Cs-134	Cs-137
A-8	CORN	< 5.9	< 6.5	< 7.8
A-9	MELONS	< 2.9	< 3.0	< 4.4
A-27	TOMATOES	< 8.3	< 7.0	< 8.3
A-28	BEANS	< 18.0	< 10.0	< 12.0
A-29	ONIONS	< 2.8	< 2.7	5.1 (3.9)
A-30	ZUCCHINI	9.1 (11.0)*	8.3 (6.0)	16.0 (8.8)
A-31	BROCCOLI	< 8.0	14.0 (10.0)	10.0 (12.0)
R-12	POTATOS	< 2.8	< 3.1	< 3.5
R-13	BEETS	< 6.5	< 4.3	< 4.9
R-14	BEET TOPS	< 7.6	< 8.3	< 9.4

*1.96 σ (Due to counting statistics.)

II.F. Aquatic Pathways

Table II.F.1 shows radionuclide concentrations measured in fish samples collected at F-19, A-25 and R-10 on two dates in 1988. The fish were collected by shocking and netting and the composite sample was homogenized without cleaning and analyzed on a wet weight basis. The only two positive values were due to Cs-137, assumed to be due to fallout.

Table II.F.2 shows the measured concentrations of both Cs-137 and Cs-134 in surface sediment collected at R-10, the downstream location. There was measurable activity of CS-137 clearly due to the Chernobyl fallout. The Cs-134 results are doutbful. The cesium ions are bound nearly irreversibly by the clay mineral matrix in the sediment.

Monitoring for Corbicula fluminea, a species of freshwater clam, was conducted at all fish sampling sites. These monitoring dates coincided with the fish collection dates. Corbicula have been introduced to North America from Asia. The freshwater clams are now found in large river systems in the U.S. from coast to coast. The Colorado Division of Wildlife has stated that Corbicula have been found in Northern Colorado at Boyd Lake, some 30 miles from the Fort St. Vrain Nuclear Generating Station. However, to this date, our samplings have indicated no evidence of Corbicula in any of the sampling sites of the reactor surface water courses.

Table II.F.1
Radionuclide Concentrations in Fish. (pCi/kg)

Collection Date	First Half			Second Half		
Radionuclide	Upstream F-19	Effluent A-25	Downstream R-10	Upstream F-19	Effluent A-25	Downstream R-10
Cs-134	< 7.5	< 3.8	< 15.0	< 15.0	< 9.3	< 17.0
Cs-137	< 8.7	14 (5.4)*	< 18.0	< 18.0	< 11.0	22.0 (23.0)
Co-58	< 6.9	< 3.5	< 17.0	< 17.0	< 8.5	< 15.0
Mn-54	< 7.1	< 3.7	< 15.0	< 15.0	< 9.1	< 17.0
Zn-65	< 19.0	< 9.4	< 41.0	< 41.0	< 26.0	< 43.0
Fe-59	< 14.0	< 6.3	< 24.0	< 24.0	< 15.0	< 35.0
Co-60	< 8.1	< 4.2	< 16.0	< 16.0	< 9.8	< 18.0

* 1.96 σ (Due to counting statistics.)

Table II.F.2 Radionuclide Concentrations in Sediment from R10. (pCi/kg)

Radionuclide	Collection Date 6/11/88
Cs-134	21 (21)*
Cs-137	150 (21)
Radionuclide	**Collection Date 11/5/88**
Cs-134	16 (9.8)
Cs-137	130 (9.2)

* 1.96 σ (Due to counting statistics.)

II.G. Sample Crosscheck Program

To assure the accuracy and precision of the environmental data obtained from the radiation surveillance program provided for the Fort St. Vrain reactor, Colorado State University participates in a number of interlaboratory and intralaboratory quality assurance programs. The U.S. Environmental Protection Agency (EPA) sponsored laboratory intercomparison studies program is the principal crosscheck. This involves the analysis of a variety of environmental media containing various levels of radionuclides. The media, type of analysis and frequency of analysis for the EPA program are summarized below.

Medium	Analysis (radionuclide)	Frequency
Water	H-3	Triannually
Water	Gross beta, gross alpha	Bimonthly
Water	Co-60, Zn-65, Cs-134, Cs-137	Triannually
Water	I-131	Semiannually
Air particulate filters	Cs-137, gross beta, gross alpha	Semiannually
Milk	I-131, Cs-137	Triannually

For each radionuclide analysis of a particular medium, three independent measurements are performed and all results are reported to the EPA. It should be noted that during the year, our laboratory became certified by the EPA for drinking water analysis.

Table II.G.1 gives the EPA crosscheck data for 1988. The EPA uses the term, Estimated Laboratory Precision (ELP), calculated as one standard deviation for one determination. The normalized deviation of our mean from the known is calculated as:

$$\frac{\text{CSU mean value - EPA known value}}{\sigma\sqrt{n}}$$

Where: σ = standard deviation of the mean of all participating laboratory results

n = number of analyses by our laboratory, normally $n=3$

The control limit is determined by the mean range of all results and three standard deviations of the range. If any result exceeds two standard deviations from the mean (warning level), the result is unacceptable. Whenever our mean value falls outside this limit, the calculations are rechecked and the sample reanalyzed if possible. During 1988 all results except 12 were within the warning level. The results exceeding the warning level have the notation (n) in Table II.G.1. If possible, the corrected values are shown in the table. The recheck process and conclusion are given below for these samples.

1. No explanation for variation known. All possibilities investigated. All program samples during this period were reanalyzed and recounted.
2. Count yield in error, new calibration in April produced correct value.
3. All results in error were low. It is concluded that Co, Ru, Zn, and Cr do not transfer well from the EPA vessel to our laboratory vessel due to chemical form of the tracer radionuclides. The Cs-137 and Cs-134 results were correct. All Cs compounds are extremely soluble and therefore transferred well. Therefore, it is concluded that these EPA results do not have any direct bearing on program results for any of the radionuclides tested. The efficiency curve for each

detector and each geometry is only a function of gamma-ray absorption in the detector. No other conclusion than the above is possible. Carrier will be added to future samples.

4. Technician allowed excessive decay before ion exchange treatment and subsequent counting. The decay reduced the I-131 concentration below detectable levels. (Technician has since been replaced.)
5. Count yield for K-40 was too high. Calibration was changed on the basis of new calibration result.
6. Wrong count yield was used for one of the two Ge(Li) detector systems. The corrected value was within the EPA warning level.

Table II.G.2 lists independent results for H-3 in water samples split between this laboratory and the Colorado Department of Health, Radiation Control Division and the laboratory at the Fort St. Vrain Generating Station. The comparison between laboratories in general was acceptable.

Table II.G.3 lists the results of gross beta analyses of the split water samples. The procedural differences between the laboratories were previously investigated and minimized. It is concluded that the differences can be attributed only to statistical uncertainty.

Table II.G.4 shows results of an intralaboratory crosscheck program. Replicate samples are independently analyzed. The replicate results are not statistically different and imply that the precision of the methods is acceptable.

Recently approximately 30% of all laboratory calculations that partly involve technician input were recalculated by a different technician. No input or calculation errors were detected. This result gives further credence to the laboratory results which are not solely computer calculated and listed.

Table II.G.1 EPA Cross-Check Data Summary. 1988

Date	Radio-nuclide	CSU Value	EPA Value	1 E.L.P.*	Normalized Deviation from known**
			WATER TRITIUM		
Feb 12	H-3[1]	5400	3327	362	+10.09
Jun 10	H-3[1]	4300	5565	557	-3.99
Oct 14	H-3	2300	2316	350	+0.01
			WATER, ALPHA/BETA		
Jan 22	alpha	3.7	4	5	-0.12
	beta	7.0	8	5	-0.35
Mar 18	alpha	12	6	5	+2.08
	beta	6	13	5	-2.42
May 20	alpha	10	11	5	-0.35
	beta	11	11	5	+0.00
Jul 22	alpha	11	15	5	-1.50
	beta	4.3	4	5	+0.12
Sep 23	alpha	4.7	8	5	-1.15
	beta	7.3	10	5	-0.92
Nov 25	alpha	4	9	5	-1.73
	beta	8.7	9	5	-0.12
			WATER I-131		
Apr 8	I-131[2]	7.4	7.5	0.75	-0.38
Aug 5	I-131	66	76	8	-2.09
Dec 9	I-131	110	115	12	-1.30
			EPA Performance Test		
Oct 18	beta	49	54	5	-1.85
	Cs-134	14	15	5	-0.23
	Cs-137	18	15	5	+1.15

* E.L.P. Expected laboratory precision.

** Normalized deviation = (CSU mean - EPA known)/(σ / n), if this value falls between the upper and lower warning levels, the accuracy is acceptable.

Table II.G.1 EPA Cross-Check Data Summary. 19 88

Date	Radio-nuclide	CSU Value	EPA Value	1 E.L.P.*	Normalized Deviation from known**
			WATER, GAMMA		
Feb 5	Co-60	65	69	5	-1.27
	Zn-65	78	94	9.40	-2.95
	Ru-106	95	105	10.50	-1.70
	Cs-134	59	64	5	-1.73
	Cs-137	99	94	5	1.56
Jun 3	Co-60	12	15	5	-0.92
	Zn-65	91	101	10	-1.73
	Ru-106[3]	135	195	20	-5.20
	Cs-134	17	20	5	-1.15
	Cs-137	28	25	5	1.15
Oct 7	Co-60[3]	14	25	5	-3.93
	Zn-65[3]	123	151	15	-3.19
	Ru-106[3]	116	152	15	-4.16
	Cs-134	22	25	5	-1.15
	Cs-137	18	15	5	0.92
	Cr-51[3]	200	251	25	-3.53
			MILK		
Feb 26	I-131[4]	<3	4	0.40	----
Jun 24	I-131	79	94	9	-2.95
	Cs-137	54	51	5	0.61
	K-40[5]	1540	1600	80	-1.22
Oct 28	I-131[6]	106	91	9	2.89
	Cs-137	55	50	5	1.85
	K-40	1500	1600	80	-2.09
			AIR FILTER		
Mar 25	alpha	18	20	5	-0.69
	beta	51	50	5	0.35
	Cs-137	16	16	5	0.0
Aug 26	alpha	8.0	10	5	-0.69
	beta	29	30	5	-0.35
	Cs-137	13	10	5	1.15

* E.L.P. Expected laboratory precision.

** Normalized deviation = (CSU mean - EPA known)/(σ/n); if this value falls between the upper and lower warning levels, the accuracy is acceptable.

Table II.G.2

Tritium Crosscheck Analyses on Split Water Samples Determined by Colorado State University, Colorado Department of Health, and Public Service Company.

Collection Date	Sample Location	Tritium Concentrations pCi/L CSU	CDH	PSC
January	A-25*	110,000 (990)	8110 (253)	9240 (541)
	A-21	<290	-401 (-167)	<343
	E-41	610 (310)	43 (172)	437 (418)
February	A-25	24000 (560)	21028 (346)	22800 (687)
	A-21	600 (350)	-5 (-165)	<344
	E-41	1400 (320)	1179 (179)	924 (427)
March	A-25	31000 (580)		27400 (727)
	A-21	780 (290)		<344
	E-41	550 (310)		<344
April	A-25	4800 (360)		4110 (465)
	A-21	260 (300)		<336
	E-41	<250		<339
May	A-25	45000 (660)		40300 (829)
	A-21	470 (310)		<334
	E-41	280000 (1500)		246000 (1840)
June	A-25	33000 (480)		41600 (848)
	A-21	330 (260)		622 (424)
	E-41	35000 (750)		38200 (821)
July	A-25	38000 (770)		42300 (871)
	A-21	<260		<367
	E-41	<260		<367
August	A-25	4400 (430)		3810 (492)
	A-21	<250		<365
	E-41	<250		<365
September	A-25	9000 (500)		9360 (541)
	A-21			1580 (434)
	E-41	<250		3400 (461)
October	A-25	37000 (770)		37500 (831)
	A-21	<250		<356
	E-41	460 (380)		<356
November	A-25	23000 (620)		35500 (802)
	A-21	550 (310)		<346
	E-41	640 (340)		...
December	A-25	28000 (660)		36800 (820)
	A-21	960 (320)		<356
	E-41	740 (340)		<348

* A composite of 1/9 and 1/12 grab sample.

Gross Beta Crosscheck Analyses on Split Water Samples Determined by Colorado State University, Colorado Department of Health, and Public Service Company of Colorado.

Collection Date	Sample Location	Gross Beta Concentrations pCi/L CSU	CDH	PSC
January	A-25	15 (6.1)	20 (5)	8.49 (6.56)
	A-21	11 (5.8)	9 (4)	10.30 (6.54)
	E-41	16 (6.1)	17 (3)	10.50 (6.90)
February	A-25	13 (5.9)	17 (5)	6.72 (5.80)
	A-21	9.9 (5.9)	13 (4)	10.50 (6.04)
	E-41	11 (5.8)	11 (7)	10.60 (5.99)
March	A-25	9.4 (5.9)		16.40 (6.77)
	A-21	5.2 (5.6)		10.20 (5.83)
	E-41	32 (7.3)		62.40 (53.50)
April	A-25	19 (6.4)		15.60 (6.50)
	A-21	13 (6.0)		8.00 (5.60)
	E-41	21 (6.5)		15.70 (7.20)
May	A-25	17 (6.3)		<5.13
	A-21	7.1 (5.7)		8.30 (6.40)
	E-41	12 (5.9)		9.89 (6.52)
June	A-25	10 (5.8)		6.94 (6.54)
	A-21	15 (6.1)		6.62 (6.42)
	E-41	16 (6.2)		11.80 (7.07)
July	A-25	11 (5.8)		12.10 (6.14)
	A-21	12 (5.9)		12.00 (6.36)
	E-41	6.7 (5.6)		9.47 (6.32)
August	A-25	11 (5.8)		5.63 (6.63)
	A-21	11 (5.9)		6.80 (7.05)
	E-41	8.4 (5.6)		8.52 (6.85)
September	A-25	12 (5.8)		10.10 (6.90)
	A-21	6.0 (5.6)		14.60 (7.44)
	E-41	9.1 (5.7)		<5.25
October	A-25	11 (5.8)		7.12 (6.50)
	A-21	7.0 (5.6)		<5.15
	E-41	11 (5.8)		8.62 (6.67)
November	A-25	35 (12)		11.00 (7.00)
	A-21	11 (5.8)		6.00 (7.00)
	E-41	9.6 (5.7)		...
December	A-25	15 (6.0)		11.70 (6.75)
	A-21	13 (6.0)		13.10 (6.79)
	E-41	15 (6.0)		13.30 (6.87)

Table II.G.4 Intralaboratory Crosscheck Results, (pCi/L).
(Replicate Analysis of Same Sample)

Drinking Water

Radio-Nuclide	1st Quarter A	1st Quarter B	2nd Quarter A	2nd Quarter B	3rd Quarter A	3rd Quarter B	4th Quarter A	4th Quarter B
Cs-134	< 2.0	< 2.2	< 1.6	< 1.2	< 3.0	< 2.7	< 1.8	< 1.9
Cs-137	< 2.5	5.3 (3.9)	4.7 (2.3)	3.8 (1.7)	< 3.6	13 (4.8)	< 2.7	2.9 (2.8)
Zr-95	< 4.7	< 4.9	< 3.6	< 2.6	< 6.9	< 6.1	< 4.3	< 4.5
Nb-95	< 1.8	< 2.0	< 1.7	< 1.2	< 2.8	< 2.7	< 1.7	< 1.8
Co-58	< 2.0	< 2.0	2.3 (1.9)	< 1.0	< 2.7	< 2.5	< 1.7	< 1.8
Mn-54	< 2.0	< 2.2	< 1.7	< 1.2	3.7 (3.6)	3.3 (3.2)	< 1.6	< 2.0
Zn-65	< 4.8	< 5.4	18 (5.4)	11 (3.8)	< 8.4	< 8.2	< 4.4	< 4.7
Fe-59	< 4.7	< 4.8	4.6 (5.4)	< 3.4	< 6.9	13 (8.0)	< 4.0	9.1 (6.1)
Co-60	< 2.2	< 2.2	< 1.5	< 1.1	< 3.2	< 2.7	< 1.7	< 2.1
Ba-140	< 3.2	< 4.6	< 4.2	< 3.3	< 4.8	< 4.0	< 4.4	< 3.1
La-140	< 3.7	< 5.3	< 4.3	< 3.7	< 5.5	< 4.6	< 5.0	< 3.6
Gross Beta	7.7 (2.5)*	6.2 (2.4)	7.5 (2.5)	4.2 (2.4)	9.1 (2.6)	7.3 (2.5)	5.5 (2.4)	4.0 (2.4)
H-3	670 (280)	820 (320)	< 250	230 (260)	< 250	< 250	640 (320)	800 (320)

Milk

Radio-Nuclide	1st Quarter A	1st Quarter B	2nd Quarter A	2nd Quarter B	3rd Quarter A	3rd Quarter B	4th Quarter A	4th Quarter B
Cs-134	< 4.4	< 4.1	< 2.6	< 2.4	< 1.4	< 2.1	< 1.6	< 1.5
Cs-137	< 5.1	5.9 (4.5)	11 (3.8)	15 (4.5)	< 1.7	< 2.5	1.9 (2.2)	< 1.7
Ba-140	< 7.1	< 5.7	< 4.0	< 3.5	< 2.3	< 3.3	< 2.5	< 2.2
La-140	< 8.1	< 6.5	< 4.6	< 4.0	< 2.6	< 3.8	< 2.9	< 2.5
H-3	< 230	< 230	< 220	< 230	990 (350)	870 (340)	640 (320)	800 (320)

* 1.96 σ (Due to counting statistics.)

II.H. Summary and Conclusions

Table II.H.1 summarizes the radiation and environmental radioactivity measurements conducted during 1988 in the environs of the Fort St. Vrain Nuclear Generating Station, owned and operated by Public Service Company of Colorado. The values for each sample type may be compared to pre-operational and operational periods for this reactor, as well as to the values from other U.S. environmental monitoring programs (e.g., EPA 520). It must be emphasized, however, that the mean values in Table II.H.1 are only the means of the values greater than MDC, the statistically minimum detectable concentration. The range also is given only for detectable measurements. The mean and range values, therefore, are not the true means or ranges if any of the values in the sample population were less than MDC. The format of Table II.H.1 is a requirement of the NRC.

Inspection of Table II.H.1 reveals that there were no individual measurements except I-131 due to release from Denver and/or Boulder hospitals that exceeded the Reporting Level (RL) (see Table III.A.3). The Chernobyl fallout was still observable in several sample types.

For the category of gross beta concentrations in drinking water, the mean for the Gilcrest well was again significantly greater than for the reference supply located in Fort Collins. This difference cannot be due to reactor effluent activity for the following reasons:

a. None of the individual fission product or activation product radionuclides measured were significantly higher in the Gilcrest drinking water.

b. Tritium concentrations measured at Gilcrest were only slightly statistically greater than those in Fort Collins. Assuming that Gilcrest residents consumed only this tap water as their drinking water source, the calculated weighted dose commitment rate to the critical individual (adult) was less than 1.2×10^{-3} mrem/year. This is a negligible dose rate. Tritium is the only significant radionuclide measured in the air or water effluent from FSV. Since it is far more mobile than any of the specific radionuclides, if in the unlikely event that effluent activity were reaching the Gilcrest aquifer, elevated tritium concentrations would be the first and most sensitive indicator.

c. The city of Gilcrest does not filter and treat its water to the same degree as Fort Collins. This has been verified and evidenced by the fact that the gamma-ray spectra of the suspended solids from Gilcrest water samples show only elevated concentrations of the natural radionuclides. It has been concluded in previous reports that the elevated gross beta concentrations in Gilcrest water are due to elevated concentrations of the naturally occurring U-238, and Th-232 decay products. The suspended solids are higher in Gilcrest water samples due to less filtration of the water.

For the category of tritium in surface water, as has been the case since reactor operation, elevated concentrations were noted at station A-25, the outlet of the (Goosequill) farm pond. A-25 is directly in the principal effluent route and elevated concentrations should be expected, to correlate with release schedules. Elevated concentrations of tritium have never been observed, however, in any human food source in direct or indirect contact with the farm pond water. Downstream surface water concentrations of tritium have occasionally been elevated, but there is significant dilution before any human use of this water. During 1988 elevated tritium concentrations were observed downstream on several occasions but the mean values for the first and second half of 1988 were not significantly greater than in upstream surface water. An historical summary of tritium concentration in upstream, downstream and potable surface water for six month periods from 1974 to 1988 is depicted in Figure II.C.1. The potable water concentrations plotted are those for the Gilcrest city water well.

I-131 was observed again in milk samples from Dairy A-22. Because the reactor did not release any significant fission products during 1988, the source of the I-131 concentrations in milk could not be reactor effluent. It was documented in the 1985 annual report that the source of the I-131 concentrations during that year was not due to the reactor but due to nuclear medicine use and release upstream of the reactor. This was an important observation as I-131 is certainly a critical radionuclide in human dose commitment possibilities, a fact of which the general public is aware. This discovery prompted increased monitoring for I-131. Upstream nuclear medicine releases of I-131 is, therefore, the only likely source of the I-131 observed again in milk samples during 1988. Irrigation water samples confirmed this conclusion.

Cs-137 was also observed in many environmental samples due to the Chernobyl fallout.

Table II.H.2 presents an additional summary of mean values for selected sample types. The sample types and radionuclides were chosen on the basis of their importance in documenting possible radiation dose to humans. Air and surface water would be the predominant environmental transport routes and drinking water and milk would be the predominant sources of radiation dose if significant radioactivity release from FSV occurred. Table II.H.2 also allows comparison to the three most recent years of operation.

The arithmetic means in Table II.H.2 were calculated for all sample results. It should be noted that the tabular data presented in the body of this report contain only positive calculated values. Any calculated values less than zero or less than the minimum detectable concentration (MDC) are listed as less than the actual MDC for that sample analysis. However, the actual result in all cases was used in the calculation for the arithmetic mean values for the period. Therefore, all values, negative as well as positive, were included. This procedure is now generally accepted and gives a proper estimate of the true mean value. Because of this procedure, however, the values listed in Table II.H.2 cannot be calculated directly from the tabular values in the report. It must be emphasized that while it is true that no sample can contain less than zero radioactivity, due to the random nature of radioactive decay, it is statistically possible to obtain sample count rates less than background and hence a negative result. It is equally true that many sample types do in fact have zero concentrations of certain radionuclides. Therefore, to obtain the correct mean value from the distribution of analytical results, all positive results must be averaged with all negative results. If the negative results were omitted, the resulting arithmetic mean would be falsely biased high.

From log-normal analysis of each data set for each 12 month period, the geometric mean and geometric standard deviations are also presented in Table II.H.2. The log-normal probability treatment is to plot all data for each sample type over the year on log-probit coordinates. The samples are ranked by increasing activity concentration and the cumulative percentage of rankings are plotted on the probit abcissa versus the activity concentration of the log ordinate. The geometric mean value, $\bar{X}_g$, is determined directly from the 50th percentile point. The geometric standard deviation is simply the slope of the line which can be calculated from the ratio between 84.1 percentile point and the 50th percentile. In a normal distribution, the arithmetic standard deviation is an additive parameter to the arithmetic mean, i.e. $(\bar{X} \pm \sigma)$; whereas, in the log-normal distribution the geometric standard deviation, σ_g, is a multiplicative parameter to the geometric mean $(\bar{X}_g \div \sigma_g)$. The area between $\bar{X}_g$ multiplied by σ_g and $\bar{X}_g$ divided by σ_g should contain 68% of the frequency values. With the log-normal analysis, no bias results from using either actual values or less than MDC values in estimating the geometric mean. The geometric mean is identical to the median.

From the values presented in Tables II.H.1 and II.H.2 and the tabular data of the report, the following observations and conclusions may be drawn:

1. Tritium was again the only radionuclide that was detected in significant concentrations in any of the effluent pathways that could be attributed to reactor operation. Since the tritium is released as tritiated water, the dilution by the surrounding hydrosphere is great. Although in 1988 a few elevated levels of tritiated water could be detected in downstream surface water samples, the mean values of downstream surface water was not statistically greater than upstream concentrations. The

tritium concentrations measured in milk produced by the nearest dairy herd were also all less than MDC.

2. Figure II.C.1 is a plot of tritium measured in surface water samples over the period 1974-1988. During the period the predominant source term is that of fallout deposition. There is some delay period in the peaks due to the mean residence time of tritium in the hydrosphere and input from other areas. Beginning in 1981, an increase can be observed in the downstream locations relative to upstream. This small increase is statistically significant, however, the radiation dose commitment that can be calculated as a result of possible ingestion of this as drinking water was found to be negligible as compared to natural background radiation dose rates. This was discussed in the 1986 annual report.
3. As in every previous report, it was again apparent that for most sample types the variability observed around the mean values was great. This variability is due to counting statistics and methodological variation, but principally due to true environmental variation (often termed sampling error). It must be recognized and accounted for in analysis of any set of environmental data before meaningful conclusions can be drawn.
4. The Chernobyl accident fallout has totally obscured what fission product debris has remained in the FSV environs from the October 1980 Chinese atmospheric nuclear weapon test. The biosphere will contain the Chernobyl fallout, particularly Cs-137, for an equally long period. Nuclear weapon test fallout has since the inception of the project been noted to be

the predominant source term above natural background. It is the variation in fallout deposition, in addition to the variation in naturally occurring radionuclides, that mandates the large number of environmental samples to detect any possible radioactivity due to reactor effluents. A simple comparison of pre-operational and operational values is of little value for most sample types because the fallout deposition was considerably greater during the pre-operational period.

5. The prompt and sensitive detection of the Chinese weapon test and Chernobyl fallout in the past assures that the environmental monitoring program is of adequate scope and sensitivity to detect any accidental releases from the FSV reactor operation. It can be concluded from the data collected by the environmental monitoring program that the radiation dose commitments calculated for the closest inhabitants or other parts of the nearby ecosystems due to current reactor effluents are negligible. Natural background radiation and the dose commitment from atmospheric fallout are the only known significant sources of radiation dose to the residents of the area.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
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Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name Distance & Direction	Locations with Highest Annual Mean: Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Direct Radiation (mR/day)	TLD (163)	0.37 (72/72) (0.20-0.46)	0.36 (72/72) (0.23-0.47)	F-1-Gate to Goosequill 1.3 km 20°	0.41 (4/4) (0.35-0.44)	0.33 (19/19) (0.27-0.42)	0
Air, Particulates (fCi/m^3)	Grossβ (360)	27 (206/206) (8.2-67)		F-7-Farm CR21 & CR34 1.5 km 145°	28 (52/52) (12-67)	24 (154/154) (8.8-68)	0
	Gamma Spectrometry						
	Cs-134 (28)	2.1 (1/16)		F-9-Farm CR19½ & CR34 1.5 km 185°	2.1 (1/4)	<10	0
	Cs-137 (28)	2.8 (4/16) (0.73-4.4)		A-19 Hunting Cabin Goosequill 1.7 km 5°	4.0 (1/4)	8.3 (2/12) (0.55-16)	0
Air, Charcoal (pCi/m^3)	I-131 (361)	23.8 (8/206) (12-33)		F-9-Farm CR19½ & CR34 1.5 km 185°	27 (1/50)	27.5 (2/155) (27-28)	0
Air, Atmospheric Water Vapor (pCi/m^3)	H-3 (356)	790 (124/203) (280-2900)		A-19-Hunting Cabin, Goosequill 1.7 km 5°	970 (46/52) (280-2900)	560 (59/153) (220-1100)	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name, Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Drinking Water (pCi/L)	Grossβ (52)	6.8 (26/26) (4.3-9.4)		R-6 Gilcrest City Water 9.3 km 60°	6.8 (26/26) (4.3-9.4)	1.1 (26/26) (0.46-1.8)	0
	H-3 (52)	561.8 (17/26) (230-960)		R-6, Gilcrest City, Water 9.3 km 60°	561.8 (17/26) (230-960)	459 (10/26) (240-660)	0
	Gamma Spectrometry						
	I-131 (52)	0.49 (1/26)		R-6, Gilcrest City Water 9.3 km 60°	0.49 (1/26)	0.46 (3/26) (0.44-0.47)	0
	Cs-134 (52)	<3.6		R-3 Ft.Collins City Water 45 km 330°	1.8 (1/26)	1.8 (1/26)	0
	Cs-137 (52)	3.9 (8/26) (2.2-6.6)		R-6, Gilcrest City Water 9.3 km 60°	3.9 (8/26) (2.2-6.6)	3.3 (8/26) (0.99-4.9)	0
	Zr-95 (52)	2.6 (1/26)		R-6, Gilcrest City Water 9.3 km 60°	2.6 (1/26)	2.1 (1/26)	0
	Nb-95 (52)	3.2 (3/26) (2.6-3.8)		R-6, Gilcrest City Water 9.3 km 60°	3.2 (3/26) (2.6-3.8)	1.2 (1/26)	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name, Distance & Direction	Locations with Highest Annual Mean: Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Drinking Water (pCi/L)	Co-58 (52)	<3.2		R-3 Ft. Collins City Water 45 km 330°	2.3 (1/26)	2.3 (1/26)	0
	Mn-54 (52)	3.1 (2/26) (2.4-3.7)		R-6 Gilcrest City Water 9.3 km 60°	3.1 (2/26) (2.4-3.7)	1.7 (4/26) (1.0-2.5)	0
	Zn-65 (52)	6.2 (3/26) (5.5-7.4)		R-6 Gilcrest City Water 9.3 km 60°	62 (3/26) (5.5-7.4)	5.3 (2/26) (3.7-6.9)	0
	Fe-59 (52)	6.1 (2/26) (5.7-6.1)		R-3 Ft. Collins City Water 45 km 330°	6.3 (4/26) (4.6-7.5)	6.3 (4/26) (4.6-7.5)	0
	Co-60 (52)	2.2 (5/26) (1.4-3.3)		R-6 Gilcrest City Water 9.3 km 60°	2.2 (5/26) (1.4-3.3)	<3.9	0
	Ba-140 (52)	5.2 (3/26) (3.9-6.0)		R-6 Gilcrest City Water 9.3 km 60°	5.2 (3/26) (3.9-6.0)	<6.5	0
	La-140 (52)	6.0 (3/26) (4.5-7.0)		R-6 Gilcrest City Water 9.3 km 60°	6.0 (3/26) (4.5-7.0)	<7.5	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name, Distance & Direction	Locations with Highest Annual Mean: Mean (f)b Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Surface Water (pCi/L)	H-3 (60)	13166 (29/36) (340-54000)		A-25 Goosequill 2.2 km 20°	31000 (12/12) (12000-54000)	649 (13/24) (260-1900)	0
	Gamma Spectrometry						
	Cs-134 (60)	3.3 (4/36) (2.2-4.4)		R-10 S. Platte at CO 60 10 km 290°	3.5 (2/12) (2.6-4.4)	<4.1	0
	Cs-137 (60)	3.7 (18/36) (1.6-7.5)		R-10 S. Platte at CO 60 10 km 290°	4.5 (7/12) (1.6-7.5)	2.7 (5/24) (0.92-3.6)	0
	Zr-95 (60)	5.5 (1/36)		F-19 S. Platte 1.2 km 90°	5.6 (2/12) (3.7-7.4)	5.6 (2/24) (3.7-7.4)	0
	Nb-95 (60)	1.5 (2/36) (1.3-1.6)		A-21 St. Vrain Bridge 2.4 km 220°	3.8 (1/12)	3.8 (1/24)	0
	Co-58 (60)	2.7 (2/36) (2.4-2.9)		A-25 Goosequill 2.2 km 20°	2.9 (1/12)	<3.8	0
	Mn-54 (60)	2.6 (4/36) (1.3-4.3)		F-20 St. Vrain 1.5 km 345°	3.4 (2/12) (2.6-4.3)	<4.0	0
	Zn-65 (60)	7.3 (4/36) (5.1-12.0)		F-20 St. Vrain 1.5 km 345°	8.9 (2/12) (5.8-12.0)	5.5 (2/24) (4.2-6.8)	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

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Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name, Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Surface Water (pCi/L)	Gamma Spectrometry						
	Fe-59 (60)	5.2 (2/36) (3.3-7.0)		R-10 S. Platte at CO 60 10 km 290°	7.0 (1/12)	6.6 (3/24) (3.7-9.1)	0
	Co-60 (60)	3.1 (1/36)		A-25 Goosequill 2.2 km 20°	3.1 (1/12)	<9.0	0
	Ba-140 (60)	<7.5		--	--	<6.5	0
	La-140 (60)	<8.7		--	--	<7.5	0
Ground Water (pCi/L)	H-3	<220		--	--	340 (1/4)	0
	Gamma Spectrometry						
	Cs-134 (8)	<3.6		---	---	<2.5	0
	Cs-137 (8)	8.8 (3/4) (4.4-11.0)		F-16 3 Bar Ranch 1.2 km 0°	8.8 (3/4) (4.4-11.0)	3.9 (4/4) (1.8-5.9)	0
	Zr-95 (8)	<8.3		---	---	<5.6	0
	Nb-95 (8)	<3.8		---	---	<2.3	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

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Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name, Distance & Direction	Locations with Highest Annual Mean: Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Ground Water (pCi/L)	Gamma Spectrometry						
	Co-58 (8)	<3.5		---	---	<2.4	0
	Mn-54 (8)	3.1 (2/4) (3.1-3.1)		F-16 3 Bar Ranch 1.2 km 0°	3.1 (2/4) (3.1-3.1)	2.1 (1/4)	0
	Zn-65 (8)	12.0 (2/4) (12.0-12.0)		F-16 3 Bar Ranch 1.2 km 0°	12.0 (2/4) (12.0-12.0)	<6.4	0
	Fe-59 (8)	5.3 (3/4) (5.2-5.6)		F-16 3 Bar Ranch 1.2 km 0°	5.3 (3/4) (5.2-5.6)	5.4 (2/4) (5.4-5.4)	0
	Co-60 (8)	<3.7		---	---	5.4 (2/4) (5.4-5.4)	0
	Ba-140 (8)	6.5 (2/4) (6.5-6.5)		F-16 3 Bar Ranch 1.2 km 0°	6.5 (2/4) (6.5-6.5)	<4.4	0
	La-140 (8)	7.5 (2/4) (7.5-7.5)		F-16 3 Bar Ranch 1.2 km 0°	7.5 (2/4) (7.5-7.5)	<6.3	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name, Distance & Direction	Locations with Highest Annual Mean: Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Sediment (pCi/kg.dry)	Gamma Spectrometry						
	Cs-134 (2)	18 (2/2) (16-21)		R-10 S. Platte at CO 60 10 km 290°	18 (2/2) (16-21)	---	0
	Cs-137 (2)	140 (2/2) (130-150)		R-10 S. Platte at CO 60 10 km 290°	140 (2/2) (130-150)	---	0
Milk (pCi/L)	H-3 (111)	500 (19/95) (270-870)		A-23 Leroy Odenbaugh Dairy 4.1 km 83°	600 (4/17) (500-740)	360 (4/16) (290-480)	0
	Gamma Spectrometry						
	I-131 (114)	0.77 (7/98) (0.41-1.7)		A-22 Percy Odenbaugh Dairy 5 km 90°	0.98 (4/13) (0.64-1.7)	<0.39	0
	Cs-134 (114)	3.4 (6/98) (1.9-6.5)		A-26 L & F Dairy 8 km 240°	4.0 (3/17) (2.5-6.5)	2.9 (2/16) (1.8-4.0)	0
	Cs-137 (114)	5.5 (34/98) (1.9-17)		A-26 L & F Dairy 8 km 240°	7.1 (10/17) (1.9-17)	5.6 (7/16) (2.5-9.2)	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name Distance & Direction	Locations with Highest Annual Mean: Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Milk (pCi/L)	Gamma Spectrometry						
	Ba-140 (114)	4.8 (10/98) (3.1-8.1)		A-6 Hendrickson Dairy 6 km 112°	5.6 (3/17) (4.2-8.1)	9.7 (1/16)	0
	La-140 (114)	5.6 (10/98) (3.6-9.3)		A-6 Hendrickson Dairy 6 km 112°	6.4 (3/17) (4.9-9.3)	11.0 (1/16)	0
Food Products (pCi/kg, wet)	Gamma Spectrometry						
	I-131 (10)	9.1 (1/10)		A-30 19440 CR 25½ 6.3 km 52°	9.1 (1/1)	---	0
	Cs-134 (10)	11 (2/10) (8.3-14)		A-31 19801 CR 25½ 6.5 km 52°	14 (1/1)	---	0
	Cs-137 (10)	10 (3/10) (5.1-16)		A-30 19440 CR 25½ 6.3 km 52°	10 (1/1)	---	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

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Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analysis Performed	Facility Locations Mean (f)[b] range	Adjacent Locations Mean (f)[b] range	Locations with Highest Annual Mean: Name, Distance & Direction	Locations with Highest Annual Mean: Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Fish (pCi/kg, wet)	Gamma Spectrometry						
	Cs-134 (6)	<17		---	---	<15	0
	Cs-137 (6)	18 (2/4) (14-22)		R-10 S. Platte at CO 60 10 km 290°	22 (1/2)	<18	0
	Co-58 (6)	<17		---	---	<17	0
	Mn-54 (6)	<17		---	---	<15	0
	Zn-65 (6)	<43		---	---	<41	0
	Fe-59 (6)	<35		---	---	<24	0
	Co-60 (6)	<18		---	---	<16	0

[b]Mean and range based upon detectable measurements only. Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.2 Summary Table of Geometric Means, Geometric Standard Deviations and Arithmetic Means for Selected Sample Types.

	1985 $\bar{X}_g$	1985 σ_g	1985 $\bar{X}$	1986 $\bar{X}_g$	1986 σ_g	1986 $\bar{X}$	1987 $\bar{X}_g$	1987 σ_g	1987 $\bar{X}$	1988 $\bar{X}_g$	1988 σ_g	1988 $\bar{X}$
Atmospheric Water Vapor (pCi/L)												
H-3												
Facility	200	1.0	<250	220	2.1	<240	190	2.2	<230	400	2.6	470
Reference	190	1.1	<250	120	2.4	<240	190	1.9	<230	250	2.7	172
Air (fCi/m^3)												
Gross Beta												
Facility	27	1.0	28	29	2.0	44	24	1.5	26	25	1.4	27
Reference	25	1.0	27	31	2.0	51	24	1.4	25	23	1.4	24
I-131												
Facility	11	1.1	<43	18	2.5	14	12	2.9	1.1	10	5.5	1.9
Reference	13	1.1	<36	16	5.5	19	12	2.9	1.2	10	5.8	<4.5
Cs-137												
Facility	1.7	1.3	<4.4	2.5	3.3	4.1	1.3	2.6	0.33	1.6	1.9	0.73
Reference	2.1	2.1	<4.4	2.0	4.7	4.5	1.1	2.6	0.44	1.4	5.8	1.0

Table II.H.2 **Summary Table of Geometric Means, Geometric Standard Deviations and Arithmetic Means for Selected Sample Types.**

	1985			1986			1987			1988		
	$\bar{X}_g$	σ_g	$\bar{X}$	$\bar{X}_g$	σ_g	$\bar{X}$	$\bar{X}_g$	σ_g	$\bar{X}$	$\bar{X}_g$	σ_g	$\bar{X}$
Drinking Water (pCi/L)												
H-3												
Gilcrest	190	1.1	160	130	2.9	<240	150	[illegible]	75	310	3.1	370
Ft. Collins	180	1.0	<250	210	1.4	<240	210	2.7	<230	260	2.0	120
Gross Beta												
Gilcrest	4.8	1.0	5.2	3.8	1.4	4.0	4.7	1.5	5.1	6.7	1.3	6.8
Ft. Collins	1.0	1.1	1.2	1.3	1.9	1.6	0.7	1.5	.79	1.0	1.4	1.1
I-131												
Gilcrest	0.2	1.3	0.004	0.2	2.4	0.14	0.2	2.1	.052	0.17	2.0	0.099
Ft. Collins	0.2	1.0	0.077	0.2	1.7	<0.49	0.2	3.5	.071	0.18	2.5	0.083
Cs-137												
Gilcrest	1.8	1.1	1.5	2.6	2.1	1.4	1.8	2.1	2.1	1.7	2.9	1.7
Ft. Collins	1.4	1.1	1.7	2.0	3.3	1.3	1.9	3.1	1.1	1.7	2.1	1.4

Table II.H.2 Summary Table of Geometric Means, Geometric Standard Deviations and Arithmetic Means for Selected Sample Types.

	1985			1986			1987			1988		
	$\bar{X}_g$	σ_g	$\bar{X}$	$\bar{X}_g$	σ_g	$\bar{X}$	$\bar{X}_g$	σ_g	$\bar{X}$	$\bar{X}_g$	σ_g	$\bar{X}$
Surface Water (pCi/L)												
H-3												
Effluent	1300	1.3	2700	7800	4.3	15000	4200	3.5	7700	30000	1.6	31000
Downstream	340	1.8	220	180	3.3	72	170	2.3	21	370	2.3	430
Upstream	140	2.0	<250	230	1.4	<240	160	2.3	<230	300	2.7	430
Cs-137												
Effluent	2.2	1.2	1.4	2.8	1.6	2.8	1.5	4.5	1.7	2.5	1.4	1.9
Downstream	2.2	1.1	2.1	1.8	2.5	1.7	2.2	2.7	0.01	2.4	2.9	2.5
Upstream	1.9	1.3	1.3	1.9	3.1	1.5	2.3	3.0	0.32	1.7	2.6	1.4
Milk (pCi/L)												
H-3												
Adjacent	170	1.1	<250	190	1.8	<240	200	1.6	<230	230	2.1	70
Reference	190	1.1	<250	140	3.6	<240	160	2.5	<230	180	2.8	<220
I-131												
Adjacent	0.22	1.0	0.02	0.46	12	3.9	0.22	3.1	0.15	0.20	2.8	0.046
Reference	0.21	1.1	0.47	0.68	5.9	3.8	0.14	5.2	0.02	0.17	2.1	<0.17
Cs-137												
Adjacent	2.1	1.0	1.7	5.8	3.4	11	3.1	2.3	3.2	2.0	3.4	2.7
Reference	1.9	1.2	1.6	7.6	4.2	13	2.7	3.2	3.6	2.4	3.5	3.3

III. Radiological Environmental Monitoring Program

A. Sample Collection and Analysis Schedule

Table III.A.1 outlines the sampling design, the collection frequency and the type of analysis for all environmental samples. It should be repeated that this schedule was only adopted January 1, 1984, and while different in certain aspects from the previous schedule, has as its intent the same objective. That objective is to document the radiation and radioactivity levels in the critical pathways of dose to humans. Such data is necessary to prove that reactor radioactivity effluents produce environmental concentrations that are within appropriate environmental protection limits and at the same time are as low as reasonably achievable.

During 1988, there were no changes in the sampling program. As noted in II.D. A-22 dairy temporarily suspended the supply of milk samples. The control dairy, R-8, went out of business in December and a new location was found starting in January of 1989.

Table III.B.1 gives the description of each sampling location by number, sector and distance from the reactor. These descriptions were expanded somewhat in this report. Each of these sampling locations (except certain reference locations) can be identified on scale maps (Figures III.B.1 and III.B.2). Topographical maps showing greater detail, as well as photographs of principal sampling sites are on file in the CSU laboratory.

During June of 1988 the land-use census was conducted to determine the locations of the nearest residence, the nearest milk animal, and the nearest garden producing broad leaf vegetation in each of the 16 meteorological sectors around the reactor. These locations by address are shown in Table III.C.1. Figure III.C.1 shows these locations in each sector. At the time of the 1988 census it was verified that the closest permanent residence in Sector 16 (17250 CR 19 1/2) was the critical receptor with regards to mean annual dose commitment. However, that residènce was abandoned early in the fall. The closest resident now is at the Russell farm F-16.

A few residents in the sampling sectors up to a distance of 8 km from the plant have cows or goats that could be used for personal milk consumption. However, from direct discussion with these persons, this is not a common practice and most milk produced is transported to commercial processors. The milk produced locally is diluted by a large milk shed, processed and distributed over a large area for consumption.

Table III.A.2 lists the LLD concentration values for each sample type and radionuclide measured in this report. These LLD values are the actual values pertinent to the sample sizes, counting yields, and counting times used in the project. Typical decay periods were used in the calculations. It should be noted that the LLD values are in all cases equal to or less than those required by the technical specifications.

Table III.A.3 lists the USNRC reporting level for each sample type and radionuclide.

Table III.A.1 Operational Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling Collection Frequency	Type and Frequency of Analysis
AIRBORNE			
Tritium Oxide Radioiodine and Particulates	Samples from seven locations: Four samples from off-site locations (in different sectors) of the highest calculated annual average ground level D/Q and airborne X/Q. One sample from the vicinity of a community having the highest calculated annual average ground level D/Q. Two samples from control location 15 to 30 kilometers (10 to 20 miles) distant and in the least prevalent wind direction.	Continuous sampler operation with sample collection weekly or as required by dust loading, whichever is more frequent.	Radioiodine Canister: Analyze weekly for I-131 liquid scintillation counting for tritium on water vapor extracted from silica gel on each sample collected. Particulate Sampler: Gross beta radioactivity following filter change, composite (by location) for gamma isotopic quarterly.[a]
DIRECT RADIATION	Forty stations with two or more dosimeters or one instrument for measuring and recording dose rate continuously to be placed as follows: 1) an inner ring of stations in the general area of the site boundary and an outer ring in the 4 to 5 mile range from the site with a station in each sector of each ring (16 sectors x 2 rings = 32 stations). The balance of the stations, eight, shall be placed in special interest areas such as population centers, nearby residences, schools, and in two or three areas to serve as control stations.	Quarterly exposure.	Gamma dose quarterly.
WATERBORNE			
Surface	One sample upstream, each stream, one sample downstream.	Samples collected monthly.	Gamma isotopic analysis and tritium monthly.
Surface (Farm Pond)	One sample in immediate area of discharge.	Composite sample over one week period. The weekly composites will be combined for the monthly sample.	Gamma isotopic analysis and composite for tritium monthly.

[a] If gross beta activity in air or water is greater than ten times the yearly mean of control sample for any medium, gamma isotopic analysis should be performed on the individual samples.

Table III.A.1 Operational Radiological Environment Monitoring Program

TABLE 8.2-1

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling Collection Frequency	Type and Frequency of Analysis
Ground	Samples from two sources most likely to be affected.	Quarterly	Gamma isotopic and tritium.
Drinking	One sample from the nearest water supply which could be affected by facility's discharge.	Composite sample over two week period.	Composite for tritium, gross beta, and gamma isotopic analyses every two weeks.
	One sample from a control location.		
Sediment from Shoreline	One sample from downstream area with existing or potential recreational value.	Semi-annually	Gamma isotopic analyses semi-annually.
INGESTION			
Milk	Samples from milking animals in all locations, up to a total of three locations, within 5 kilometers.	Semi-monthly when animals are on pasture, monthly at other times.	Gamma isotopic and I-131 analysis semi-monthly when animals are on pasture; monthly at other times.
	One sample from milking animals in each of three areas between 5 to 8 kilometers distant having the highest dose potential. b		
	One sample from milking animals at a control location (15 to 30 kilometers) distant and in the least prevalent wind direction).	Semi-monthly when animals are on pasture, monthly at other times.	Gamma isotopic and I-131 analysis semi-monthly when animals are on pasture; monthly at other times.
Aquatic Biota	Sample fish in vicinity of discharge point, upstream and downstream.	Sample semi-annually.	Gamma isotopic analyses.
Food Products	One sample of each principal class of food products from any area which is irrigated by water in which liquid plant wastes have been discharges.	At time of harvest.	Gamma isotopic analyses.

[b] The dose shall be calculated for the maximum organ and age group using the methodology contained in Regulatory Guide 1.109 and the actual parameters particular to the site.

Table III.A.2 Detection Capabilities for Environmental Sample Analysis

Lower Limit of Detection (LLD)*

Analysis	Water (pCi/L)	Airborne Particulate or Gas (fCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Food Products (pCi/kg, wet)	Sediment (pCi/kg,dry)
Gross Beta	3.86	3.25				
H-3	494					
I-131	0.89	66.4		0.89	56.8	
Cs-134	5.58	8.06	19.5	4.98	44.4	90.6
Cs-137	6.68	7.86	18.5	6.14	44.6	100
Zr-95	10.12					
Nb-95	4.12					
Co-58	4.60		12.8			
Mn-54	4.68		12.7			
Zn-65	10.94		23.6			
Fe-59	8.40		31.4			
Co-60	4.40		14.5			
Ba-140	6.66			8.00		
La-140	7.66			9.16		

* As suggested in NUREG-0472. All values are at or below values listed in Table 8.2-2 of technical specifications.

Table III.A.3 Reporting Levels for Nonroutine Operating Reports

REPORTING LEVELS FOR NONROUTINE OPERATING REPORTS

REPORTING LEVEL (RL)

Analysis	Water (pCi/ℓ)	Airborne Particulate or Gas (pCi/m³)	Fish (pCi/kg,wet)	Milk (pCi/ℓ)	Broad Leaf Vegetation (pCi,kg, wet)
H-3	2×10^{4} (a)				
Mn-54	1×10^{3}		3×10^{4}		
Fe-59	4×10^{2}		1×10^{4}		
Co-58	1×10^{3}		3×10^{4}		
Co-60	3×10^{2}		1×10^{4}		
Zn-65	3×10^{2}		2×10^{4}		
Nb-95,Zr-95	4×10^{2}				
I-131	2	0.9		3	1×10^{2}
Cs-134	30	10	1×10^{3}	60	1×10^{3}
Cs-137	50	20	2×10^{3}	70	2×10^{3}
Ba-140,La-140	2×10^{2}			3×10^{2}	

[a] For drinking water samples. This is 40CFR Part 141 value.

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	F-1	Pole by gate to Goosequill road on dirt extension of CR 21.	1	1.3
	F-2	21st pole N of ditch on dirt extension of CR 21 just before road drops down to river bottom.	2	1.1
	F-3	17th pole N of ditch on dirt extension of CR 21 or first pole N of E-W road.	3	0.7
	F-4	15th pole N of ditch on dirt extension of CR 21, S of pump road, midway between F-3 and F-5.	4	0.7
	F-5	11th pole N of ditch on dirt extension of CR 21, near drive to pump house.	5	0.6
	F-6	8th pole N of ditch on dirt extension of CR 21, by E-W concrete ditch, S of bridge.	6	0.8
	F-7	Old dairy barn, 1st pole N after crossing ditch on dirt extension of CR 21.	7	1.2
	F-8	1st pole W of pump house on N side of road 0.4 km E of CR 19½.	8	1.3
	F-9	Pole E of first shed at intersection of CR 19½ and CR 34.	9	1.5
	F-10	Pole on NW corner of intersection of dirt extension of CR 19 and 34.	10	1.5

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	F-11	7th pole N of intersection of dirt extension of CR 19 with CR 34.	11	1.2
	F-12	0.5 km S of FSV Visitor Center take dirt road W across field, go into farmyard of Aristocrat Brangus. (If chain across road enter from CR 36). TLD is located on pole at SE corner of corral across from Aristocrat Brangus office.	12	1.0
	F-13	Take first dirt road S of Visitor Center. Go W across railroad tracks, follow dirt road to metal staircase going down off dike. TLD is taped to railing.	13	0.5
	F-14	2nd pole 0.1 km S intersection CR 36½ & Rd 19.	14	1.5
	F-15	2nd pole 0.7 km S of intersection of CR 38 on CR 19.	15	1.5
	F-16	Pole at NE corner of potato cellar at 3 Bar Ranch (Russell's).	1	1.2
	F-17	Visitor Center, on N end of cross beam over entrance.	13	0.2
	F-18	Pole closest to house on SW corner, 17250 CR 19½. The address of 17250 is taped to the Mountain Bell underground cable warning post.	16	0.8

Table III.B.1 Radiological Environmental Monitoring Program (continued) Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	A-1	Pole on NW corner of intersection of CR 44 and CR 21.	1	6.7
	A-2	Pole on NE corner intersection of CR 42 and CR 25½.	2	6.8
	A-3	Pole on NE corner of intersection of CR 42 and CO 60.	3	7.5
	A-4	1st pole NE of intersection of CR 29 and CR 38, take CR 29 E out of Gilcrest to CR 38.	4	7.4
	A-5	SE corner of CR 34 and CR 29. Taped to road sign on SW corner of intersection.	5	7.2
	A-6	Pole on S side of CR 32 near drive to dairy 13278 CR 32.	6	7.1
	A-7	Niles Miller dairy. 0.4 km E of US 85 on CR 30. TLD is located on pole at NE corner of house.	7	7.3
	A-8	On CO 66 (CR30) farm on S side of road (address 9476) Pole in front of house.	8	4.7
	A-9	Corner of CO 66 (CR 30) and CR 19, Miller produce stand. Second pole S on CR 19, on E side of road.	9	4.6
	A-10	Pole on SE corner at intersection CR 26½ & CR 15.	10	7.8
	A-11	At intersection of CO 66 and CR 13, 2nd pole N of corner.	11	7.2

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	A-12	On CR 34, pole E of house N of Lake Thomas 2 km from I-25.	12	7.2
	A-13	Pole opposite lake, N of silage pits E side of CR 13 2.9 km N of CR 34.	13	5.8
	A-14	Intersection of CR 13 and CR 40, NW corner.	14	6.9
	A-15	Intersection of CR 42 and CR 15, NW corner.	15	6.7
	A-16	Intersection of CR 44 and CR 19, SW corner.	16	6.8
	A-17	Platteville school (S edge of town on Main St.) pole on NW corner just outside school intramural field.	6	5.9
	A-20	1st pole N of white picket fence and driveway into turkey farm on S end of building that is parallel with CR 19.	9	2.5

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	R-1	Milliken School, on CR 21½. TLD is located on pole which is located at SE corner of Lola park, across the street from school.		9.3
	R-2	Johnstown School (Letford Elementary), turn left at school crossing on Idaho St. onto Joy Ave. and proceed to school. TLD is located on pole at SE corner of main entrance to school on W side of town.		10.8
	R-3	CSU dairy farm on W Drake, N of Vet Hospital, Ft. Collins, CO. Pole is E of hay barn next to railroad tracks.		45.1
	R-4	Air sampler corner US 287 and CO 66, Longmont Dairy Store. TLD is located on pole directly behind air sampler.		20.5
	R-7	Behind Gilcrest School quonset auditorium, pole on SW end of school property, just before garage.		9.3

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Airborne	F-7	Farm at intersection of CR 21 and CR 34. Air sampler is located on west side of shop. Silica gel inside building on N end of workbench.	7	1.5
	F-9	First shed along drive at end of Rd 19½ intersection with Rd 21. Silica gel is located in shed.	9	1.5
	F-16	Potato cellar at 3 Bar Ranch (Russell's). Silica gel in mailbox on tree to S of pump.	16	1.2
	A-19	Hunting cabin between Goosequill ditch and Platte River. Air sampler is on W side of cabin, silica gel is in box on tree north of air sampler.	1	1.7
	R-3	Colorado State University Dairy, W. Drake Rd., Ft. Collins, CO. W side of shed directly N of main dairy building. Silica gel inside mailbox.		45.1
	R-4	Intersection of US 66 and US 287, E side of dairy store, north edge of Longmont. Silica gel in mailbox attached to utility pole.		20.5
	R-11	Air sampler is located in alley behind Johnstown, CO PSC office, 13712 Main St., next to garage. Silica gel is located next to air sampler in mailbox.		10.5

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Waterborne Surface	F-19	S. Platte at dam located on dirt road E of pump house #3 directly E of reactor.	4	1.2
	F-20	St. Vrain creek on Rd. 19½ 0.3 km from discharge into St. Vrain creek. Directly N of reactor.	16	1.5
	A-21	St. Vrain creek at bridge on Rd. 34, E of Rd. 19.	11	2.4
	A-25	Goosequill Pond outlet. Continuous sampler located in green box adjacent to the green shed on the N end of the pond.	1	2.2
	R-10	S. Platte river at bridge on CO 60 where highway has just turned and headed South.		10.1
Ground	F-16	Well behind residence at 3 Bar Ranch (Russell's).	1	1.2
	R-5	Ehrlich feed lot, North side of CO 66 approximately 0.8 km East of WCR 25. Drive north along dirt road approximately 0.27 km to field water spigot on West side of road.		9.0
Drinking	R-3	CSU dairy W Drake Rd., Ft. Collins, CO, N of Vet Hospital. Water sample is taken from hydrant inside the entrance to the milking parlor.		45.1
	R-6	Gilcrest U.S. Post Office located on Birch St. and Rd. 40 off of Hwy 85. Water taken from utility sink inside Post Office.		9.3

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Waterborne				
Sediment from Shoreline	R-10	Sediment from S. Platte River at bridge on CO 60.		10.1
Ingestion				
Milk	A-6	Hendrickson Dairy, 13278 Rd. 32 (Grand Ave.) 1.6 km E of US 85.	6	7.1
	A-18	Boos Dairy, 11258 W Rd. 40, W of US 85 behind modular home.	2	4.7
	A-22	Percy Odenbaugh Dairy, S on dirt rd from "Percy Odenbaugh Dairy" sign on Rd 36 E of Rd 23.	5	3.2
	A-23	Leroy Odenbaugh Dairy, 11733 Rd 36, W of Rd 25.	4	4.1
	A-24	Marostica Dairy, 20718 Rd 17, 4 miles S of CO 60.	16	6.9
	A-26	L & F Dairy (Fiechtner), E of Rd 13 on Rd 32.	11	7.8
	R-8	Arlo Johnston Farm, located off Exit 255 W of I-25 directly N of Johnson's Corner restaurant.		22.5
Fish				
	F-19	S. Platte at dam located on dirt Rd E of pump house #3 directly E of reactor.	4	1.1
	A-25	Goosequill pond outlet.	1	2.2
	R-10	S. Platte river at bridge on CO 60.		10.1

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Food Products	A-23	Leroy Odenbaugh Dairy, 11733 CR 36, W of CR 25	4	4.1
	A-28	Conrad Walter Farm, 11470 CR 38,	2	3.6
	A-29	Gutfelder Farm, 12027 CR 42.	4	7.0
	A-30	Cr 46 & US 85.	4	7.0
	R-6	Gilcrest Grocery.		9.3
	R-10	NW corner of S. Platte & CO 60.		10.1
	R-13	Richardson Truck Farm, 21210 CO 60.		9.5

Figure III.B.1

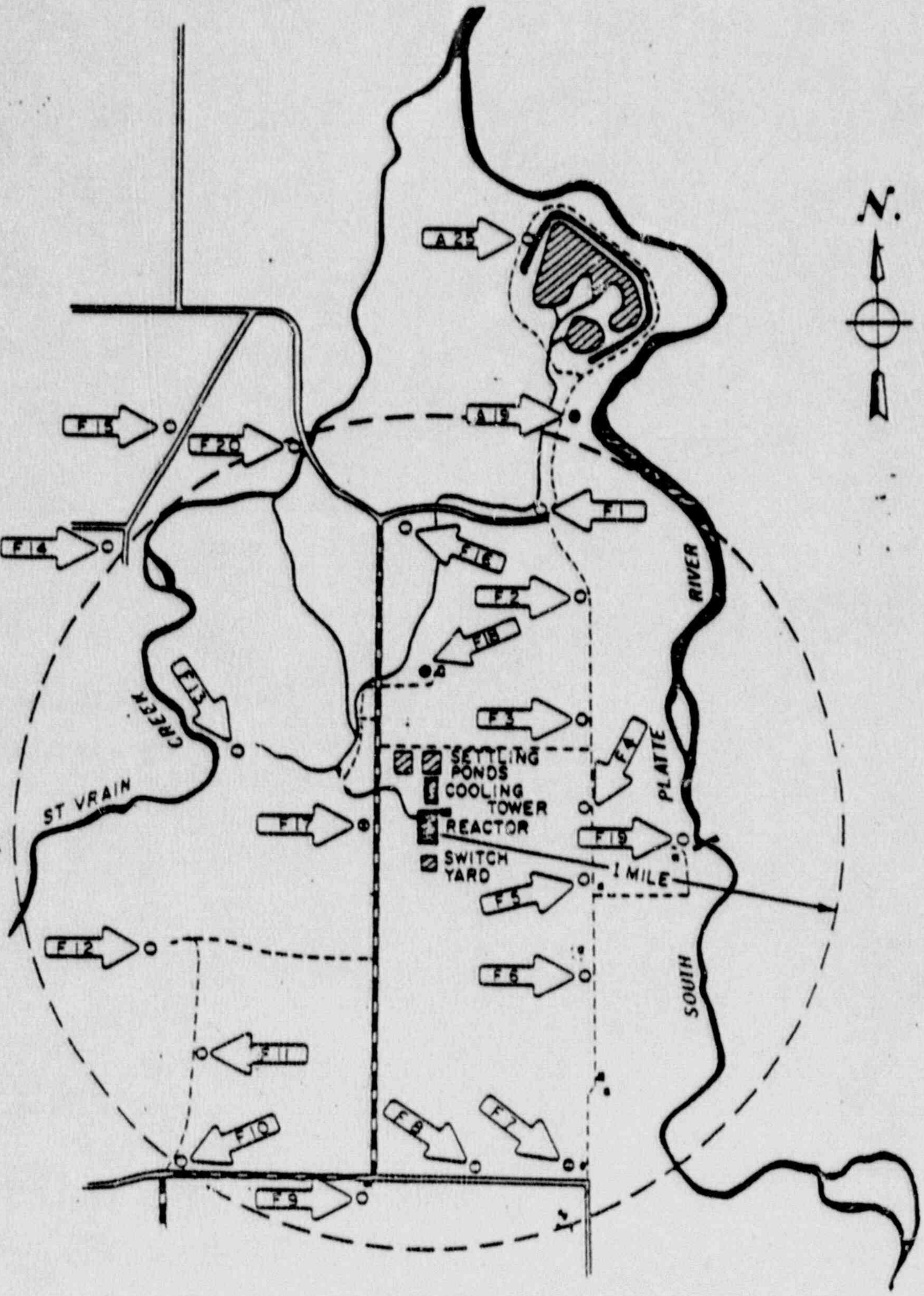


Figure III.B.2

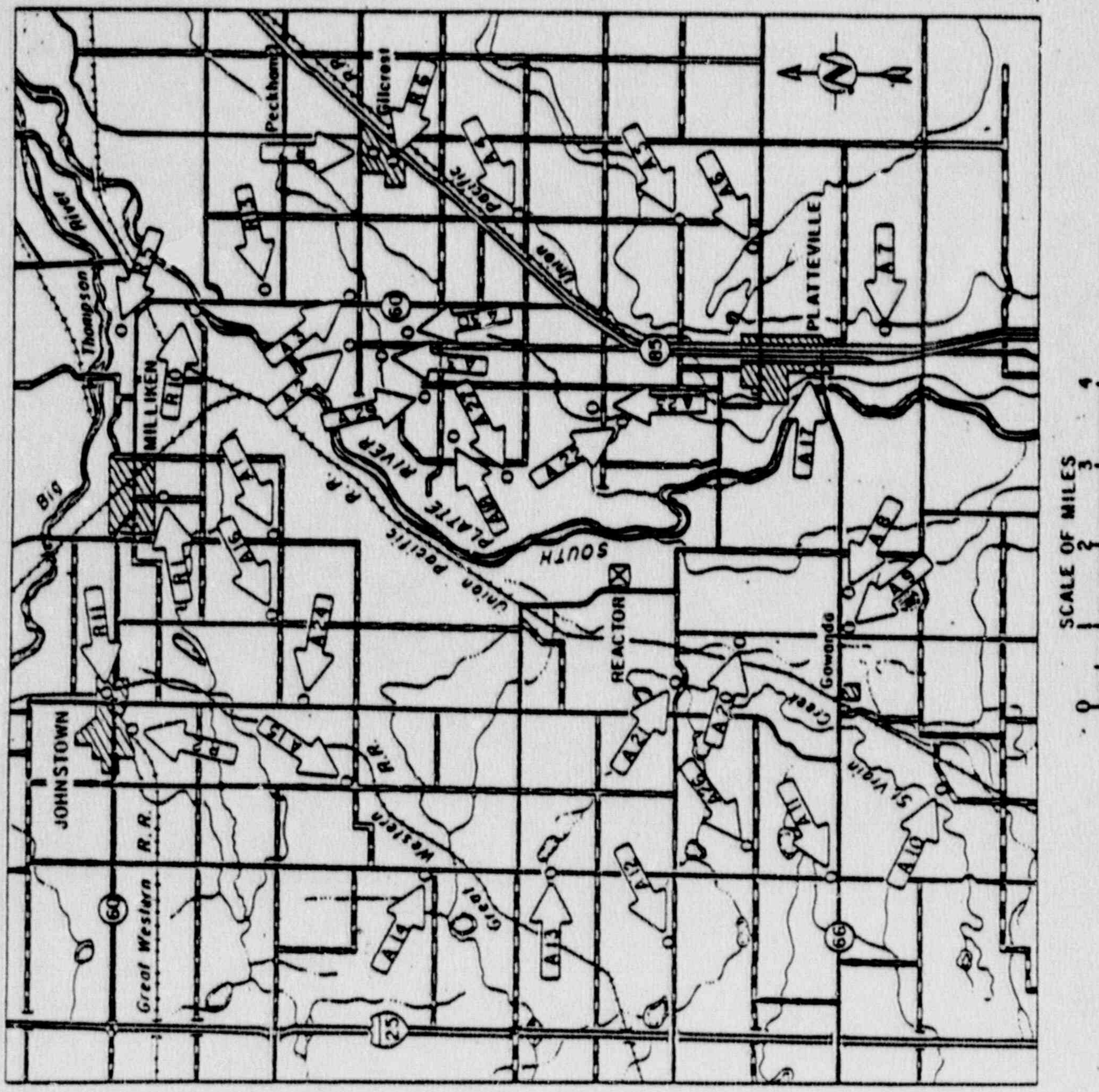
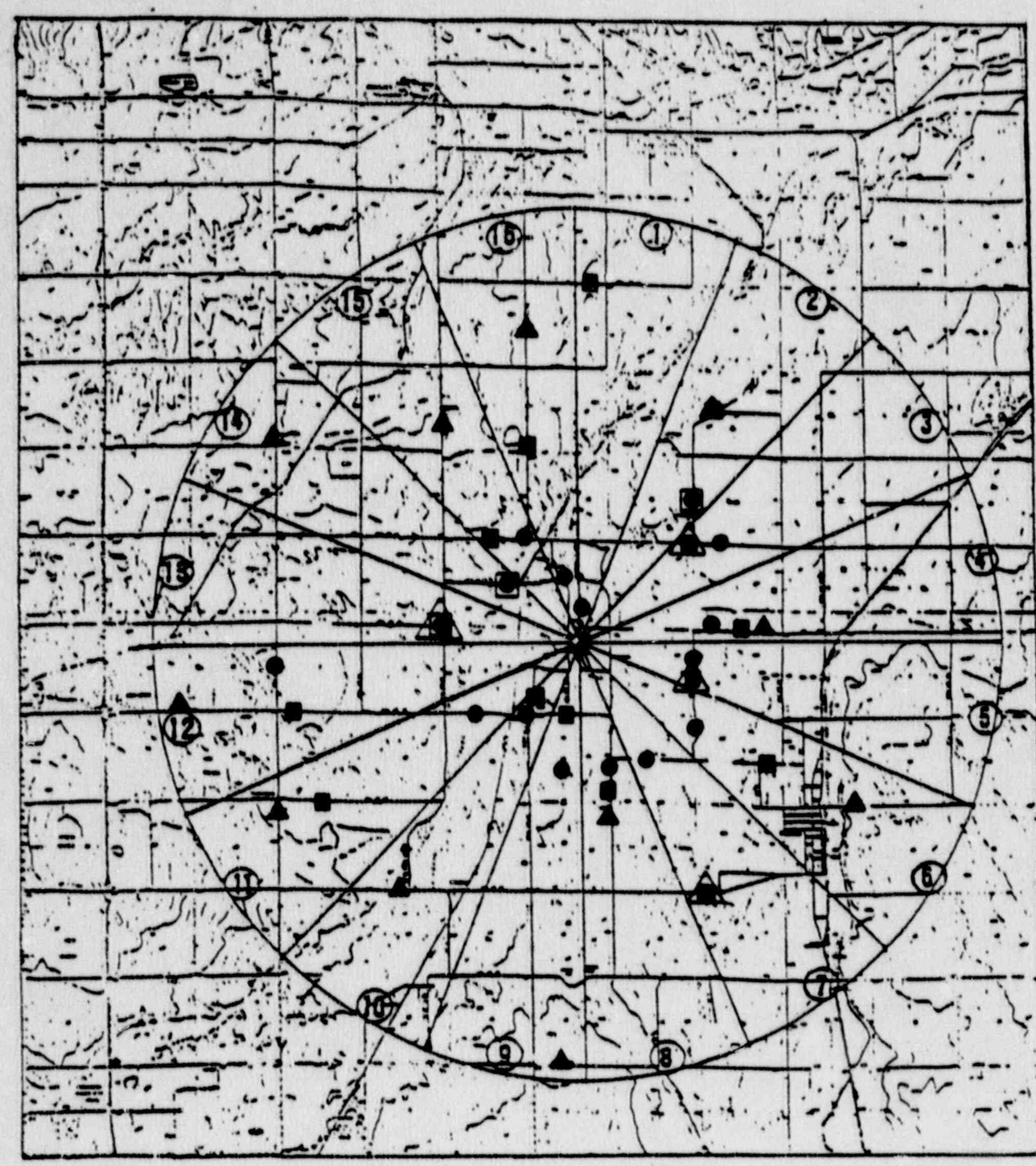


Table III.C.1 1988 Land Use Census*

Sector	Nearest Residence	Nearest Garden	Nearest Milk Animal
1	17578 CR 19½	9626 CR 44**	***
2	18311 CR 23	18311 CR 23**	11283 CR 40½**
3	11750 CR 38**	11165 CR 38	11165 CR 38
4	11247 CR 36	11419 CR 36**	11733 CR 36**
5	16543 CR 23	16134 CR 23	16134 CR 23
6	11056 CR 32**	11056 CR 32	13278 CR 32
7	9999 CR 34	11176 CR 30½**	11176 CR 30½**
8	15883 CR 21	15225 CR 21	14261 CR 21
9	9434 CR 34	9379 CR 34**	9033 CR 26
10	9061 CR 34	15424 CR 19**	7388 CO 66
11	8745 CR 34	6769 CR 32**	15152 CR 13**
12	16465 CR 17	6519 CR 34**	4663 CR 34**
13	17038 CR 17	17038 CR 17	17038 CR 17**
14	8900 CR 36½	8900 CR 36½	18442 CR 13**
15	18100 CR 19**	8560 CR 38**	19461 CR 17**
16	9239 CR 38**	19108 CR 19**	18986 CR 19**

* Census date: June 8, 1988
** New location
***No milk animal located

Figure III.C.1 Land Use Census, 1988.



● Nearest residence

■ Nearest garden

▲ Nearest milk animal

Appendix I

During 1988 Dr. Gerald M. Ward, Professor of Animal Sciences was hired as a liason between the local farmers and ranchers and this program. Dr. Ward is a dairy scientist but has had over 25 years of experience in many aspects of fallout studies and of dairy food chain transport of fission products, principally, Cs-137. Dr. Ward was instrumental in many discussions with the local farmers and provided the following report.

Survey of Dairy Farms Providing Milk for Environmental Monitoring of the St. Vrain Nuclear Power Plant

March 24-25, 1988

Gerald M. Ward

All of the farmers were contacted except Arlo Johnston (near Johnson's Corner) although his dairy operation was observed. All operations are rather conventional for Northern Colorado. Cows are kept permanently in open lots on a dirt surface. The winter manure pack is removed at this time of year. Some of the lots have an open-faced shed for shelter, some have a fence on the north side and some no protection at all. During cold weather and muddy spells straw is often placed in the corrals for bedding. The one exception is a covered feeding area at the Henrickson Dairy which is also the largest (about 300 cows). However, most of the time is spent in an open shed.

Herd sizes except for Henrickson range from 50 to 90 cows per dairy.

The survey day was very windy and dusty. It is obvious that top soil can flow into corrals. The surface area of corrals in northern Colorado is about 350 to 500 ft^2 per cow which means that the potential contamination area is small.

The only drinking water supply for cows in all cases except one is from a rural water supply which comes from Carter Lake. On one farm (Percy Odenbaugh) cows have access to water from an irrigation ditch during the time that water is running in the ditch. His cows, unlike on other farms, also have access to water from a well on his farm as well as from the rural water supply.

None of the milking cows on any of the farms have access to pasture or green-chopped feed. Hay on all the farms is stacked outside and is not covered. Silage is stored in trench silos and generally covered with plastic.

Two dairies, Henrickson and Marostica purchase all their hay, the latter from his next-door neighbor. The other farmers produced a part or all their own hay. Purchased hay is generally from Weld Co. Those who feed corn silage produce their own.

No apparent differences between dairy farms were noted that could be used to explain differences in the transfer of airborne radionuclides to milk.

A few goats were seen in a yard near the Odenbaugh farm. It was not determined if they were milk goats.

ATTACHMENT 6

FORT ST. VRAIN ACTIVATION ANALYSIS

(EE-DEC-0010, Rev. A, dated 8/31/89).