ICPP INJECTION WELL
ALTERNATIVES PROJECT
IDAHO NATIONAL ENGINEERING
LABORATORY

FINAL REPORT

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

UNITED STATES
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO
CONTRACT DE-AC07-80ID12115

FLUOR ENGINEERS AND
CONSTRUCTORS, INC.
IRVINE, CALIFORNIA
CONTRACT 475304
OCTOBER 1980

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

FINAL REPORT

ICPP INJECTION WELL
ALTERNATIVES PROJECT
IDAHO NATIONAL ENGINEERING
LABORATORY

UNITED STATES
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO
CONTRACT DE-AC07-80ID12115

FLUOR ENGINEERS
AND CONSTRUCTORS
IRVINE, CALIFORNIA
CONTRACT 475304
OCTOBER 1980

MASTER

NOTICE

This report was prepared by Fluor Engineers and Constructors, Inc. as an account of work sponsored by the U.S. Department of Energy, Idaho Operations Office. Neither the Department of Energy, nor any of its employees, nor Fluor, nor any person acting on their behalf, (a) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights, or (b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

ICPP INJECTION WELL ALTERNATIVES PROJECT

FINAL REPORT

TABLE OF CONTENTS

1.	Introduction	Section 1
2.	Summary	Section 2
3.	Bases for Evaluation	Section 3
4.	Alternative Means for Disposal of Cooling Water and Steam Condensates	Section 4
5.	Alternative Means for Disposal of Chemical Wastes	Section 5
6.	Alternative Means for Disposal of Low Level Radioactive Wastes	Section 6
7.	Alternative Combined Means for Disposal of Aqueous Waste Streams	Section 7
8.	Evaluation of Combined Cases and Recommendations	Section 8
9.	Construction Schedules for Recommended Cases	Section 9
10.	Suggestions for Further Study	Section 10

APPENDICES

Life Cycle Costs

Appendix A

Process Flow Diagrams

Appendix B

For Alternatives CC-1 Thru CC-7

Appendix B

For Alternatives CH-1 Thru CH-7

Appendix B

For Alternatives RW-1 Thru RW-11

Appendix B

For Combined Alternatives CO-1 Thru CO-6

Appendix B

Reproductions From the Conceptual Design Criteria

Appendix C

1.0 INTRODUCTION

For the past 30 years, the Idaho Chemical Processing Plant (ICPP) portion of the Idaho National Engineering Laboratory (INEL) has been obtaining water needed for its operations from the Snake River aquifer, which occupies the entire region underlying the site.

Most of this water has been used for cooling operating equipment, while a small portion has found various process uses. After passing through the ICPP process area, these waters are then returned to the aquifer. A small portion (about 1 percent) of the returned stream contains measurable amounts of radioactivity derived from the miscellaneous process users. (See Table 6.0-1 in Section 6).

This report and the recommendations contained herein are based upon stream flows projected for 1985 as supplied by DOE for the ICPP.

This report examines 26 different alternatives for handling cooling water, chemical, and low level radioactive water disposal. These cases are considered from technical, environmental, safety, and economic points of view.

The evaluations done here are necessarily of a preliminary "screening study" nature. The level of detail is sufficient to eliminate non-viable cases, and to identify those which offer improvements over present practice. The Environmental/Safety Risk Factors were evaluated on a qualitative comparison basis only. Before a recommended improvement is incorporated into the waste disposal system, a conceptual design study should be made which would evaluate all those secondary effects and environmental factors that by the very nature of the screening process, this study has not provided. Certain synergistic combinations have been noted and are discussed in Section 7. Suggestions for further work are included in Section 10.

This report does not make any judgment as to the absolute necessity of implementing any specific alternative to the present practice. It does note, however, whether the operations considered are in regulatory compliance, or are likely to be capable of providing lasting improvement to the waste water system. Detailed calculations were not prepared, rather, qualitative comparisons were made between the various alternatives, and to confirm their relationship with applicable standards. During the conceptual design phase of the alternative selected for improvement of the waste water system, confirming calculations should be made.

Recommendations are included where appropriate.

2.0 SUMMARY

This report covers the investigation of 26 alternative cases. After each of the 26 cases had been investigated, certain combinations were considered as part of an overall upgraded effluent disposal system.

Of the initial 26 cases, the following were considered to be both technically feasible and, based on a qualitative evaluation, potentially acceptable from an environmental/safety point of view: Preliminary screening also indicates that these cases comply with the various applicable regulations.

- CC-2 Disposal of Cooling Water and Steam Condensates to a Shallow Well
- CC-3 Disposal of Cooling Water and Steam Condensates to an Unlined Percolation Pond
- CC-6 Recirculation of Cooling Water and Steam Condensates Utilizing an Evaporative Cooling Tower
- CC-7 Recirculation of Cooling Water and Steam Condensates Utilizing a Heat Exchanger With an Independent Cooling Water Stream
- CH-2 Disposal of Chemical Wastes to an Evaporative Concentrator
- CH-5 Disposal of Chemical Wastes to a Lined Evaporation Pond
- RW-8 Disposal of PEW Condensates by Deep Well Injection
- RW-9 Disposal of PEW Evaporator Effluent Directly to Atmosphere
- RW-11 Separation of the Atmospheric Protection System (APS) from the (PEW) Evaporation System

Based on a comparative economic analysis, synergistic combinations of these cases were developed which were evaluated as total systems for improvement in effluent quality. These combination cases utilized projected flows for 1985 as supplied by DOE. The data developed in preparation of this report is discussed in the subsequent sections.

The current practice of disposing of combined effluent to the ICPP injection well has been in operation for years and based upon discharge data supplied by DOE, they comply with ERDA Manual 0524, Table 1.

Federal EPA and the State of Idaho Injection Well Regulations have recently been promulgated. At the time of issue of this report, the State has not yet established "Primacy." Referencing these regulations, the following observations are made:

1. If the Federal EPA Underground Injection Control programs apply, the strontium concentrations may slightly exceed Federal allowables.
2. If the State of Idaho regulations for injection wells apply, the tritium, strontium, mercury and possibly nitrates may exceed the maximum allowables.
3. The effluent radionuclide content of the present practice appears to be high relative to State and EPA regulations for two related reasons. The present Atmospheric Protection System (APS) includes a condenser which cools the New Waste Calciner Facility (NWCF) off-gas. The condensate from this stream contains nitric acid and tritiated water and is routed to the process evaporator (PEW). In the PEW all the tritiated water and some of the acid pass overhead into the condensate and flow through ion exchangers to the ICPP injection well. The high acidity of the PEW condensate impairs the efficiency of the ion exchangers. It is recommended that the APS condensate be diverted from the PEW and either vaporized to the atmosphere, or routed to other process uses.

Our studies indicated that there are insufficient potential users of APS condensate to allow full recycling of the present volumes of APS condensate. The APS condenser will need to be controlled to prevent production of excess condensate.

After diversion of the APS stream, facilities should be provided for additional neutralization of PEW condensates so that the efficiency of the present ion exchangers can be maximized.

4. The present once-through cooling water system requires large amounts of chemicals for treating and softening of water. Predicted operations in 1985 indicates that there will be an increase in the salt content of the effluent water. Adoption of a recirculating cooling water system will eliminate not only most of the effluent volume flowing to the injection well, but will reduce water treating costs and may reduce pumping costs. It will also eliminate the need for new well and water treating facilities now planned although some upgrade of existing facilities may be required. It is recommended that a recirculating cooling water system to take over the entire cooling load now supplied by raw and softened water be installed.

With the adoption of a recirculating cooling water system, there remain certain blowdown/chemical waste streams which cannot be sent to the aquifer. The recommended approach for handling these streams is to use solar evaporation ponds. As such ponds are expensive, it is important to verify the actual site evaporation rates. In addition, means for periodic salt cake removal and disposal along with their costs should be evaluated.

5. A significant related issue to the sizing of evaporation ponds is the handling of steam condensates. In a recirculating system, excessive water adds to the size of the evaporation ponds. One of the ground rules for this study was that only 30 percent of

the steam condensates would be recovered and the other 70 percent would be routed to the cooling water return. Substantial (\$5-6 million) incentive exists for recovering (or routing elsewhere) 80 percent of the condensate.

6. The design of the waste water system incorporates a radiation monitoring and diversion system to detect and reroute potential radioactive spills. It requires a double failure of both a piece of equipment and the monitoring source to allow a major leak to reach the aquifer. The probability for such an occurrence is low. For positive accident protection, we recommend that consideration be given to installing a series of holding ponds so that major releases resulting from equipment failure will be contained. If adopted, these ponds not only could provide short-term protection, but also could be integrated into a solar evaporation system suitable for a more extensive recirculating cooling tower system.

Additional data substantiating these recommendations and the facilities investigated is given on Tables 2-1 and 2-2.

TABLE 2-1
(Sheet 1)
DISPOSAL OF INDIVIDUAL AQUEOUS WASTE STREAMS AT THE IDAHO CHEMICAL PROCESSING PLANT
SUMMARY OF INDIVIDUAL ALTERNATIVE CASES STUDIED

<u>CASE NO.</u>	<u>MEANS OF DISPOSAL</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
<u>For Cooling Water and Steam Condensates:</u>			
CC-1	Disposal to Existing Well	Viable. Base case - no incremental cost	
CC-2	Disposal to Shallow Well	2,198	2,938
CC-3	Disposal to Percolation Pond	3,094	3,633
CC-4	Disposal to Evaporation Pond	Eliminated due to excessively high cost	
CC-5	Disposal to Big Lost River Channel	Eliminated - environmental uncertainties and low benefit	
CC-6	Recirculation, Utilizing Cooling Tower	11,542	11,107
CC-7	Recirculation, Utilizing Heat Exchanger	11,948	13,522
<u>For Chemical Wastes:</u>			
CH-1	Disposal to Existing Well	Eliminated for environmental reasons	
CH-2	Disposal to Evaporative Concentrator		
	(a) Brine to Evaporation Pond	5,688	7,502
	(b) Brine to Spray Dryer	5,974	9,126
CH-3	Concentration by Reverse Osmosis	Eliminated as technically infeasible	
CH-4	Disposal to Dryer	Eliminated due to high energy cost	
CH-5	Disposal to Solar Evaporation Pond	3,765	4,454
CH-6	Disposal to Percolation Pond or Well	Eliminated for environmental reasons	
CH-7	Disposal to Deep Well	Eliminated due to technical uncertainties (Extensive exploratory work required for reconsideration)	

TABLE 2-1
(Sheet 2)
DISPOSAL OF INDIVIDUAL AQUEOUS WASTE STREAMS AT THE IDAHO CHEMICAL PROCESSING PLANT
SUMMARY OF INDIVIDUAL ALTERNATIVE CASES STUDIED

<u>CASE NO.</u>	<u>MEANS OF DISPOSAL</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
<u>For PEW Evaporator Condensates</u>			
RW-1	Disposal to Existing Well	Eliminated for environmental reasons	
RW-2	Improvement of Cation Exchangers	Eliminated for technical reasons*	
RW-3	Recycle to Process Makeup	Eliminated for technical reasons	
RW-4	Disposal to Shallow Well	Eliminated for environmental reasons	
RW-5	Disposal to Percolation Pond	Eliminated for environmental reasons	
RW-6	Disposal to Solar Evaporation Pond	Eliminated for environmental reasons	
RW-7	Separation by Reverse Osmosis	Eliminated for technical reasons	
RW-8	Disposal to Deep Well	2,644	2,977
RW-9	Disposal Directly to Atmosphere	1,770	2,587
RW-10	Treatment to Remove Tritium	Eliminated for technical and cost reasons	
RW-11	Separation of APS Effluent from PEW System		
	(a) Recycle Portion to Process Makeup	1,089	1,418
	(b) Recycle to Process and $\text{Ca}(\text{NO}_3)_2$ Prod.	2,606	2,209

* Recent innovations and improved process control may allow the ion exchange system to operate on a part-time basis (i.e., when the pH is high enough).

TABLE 2-2
SUMMARY OF COMBINED CASES STUDIED
 SHEET 1

<u>CASE NO.</u>	<u>CHARACTERISTICS</u>	<u>INCREMENT</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
CO-1	Existing case (1985): Cooling water/steam condensates, PEW condensates, and chemical wastes discharge to aquifer thru existing well.	Base Case	-0-	-0-
CO-2	APS effluent separated from PEW system. Cooling water/steam condensate, PEW condensate, and chemical wastes to aquifer through existing well.	Separated APS effluent from PEW system	1,085	1,414
CO-3	APS effluent separated from PEW system. Cooling water/steam condensate, PEW condensate, and chemical wastes to aquifer through holding ponds.	Holding ponds	4,449	5,518
CO-4	APS effluent separated from PEW system. Cooling water/steam condensates to aquifer through holding ponds. Chemical wastes and PEW condensate to solar evaporation ponds.	Solar evaporation ponds	8,051	9,809

TABLE 2-2
SUMMARY OF COMBINED CASES STUDIED
 SHEET 2

<u>CASE NO.</u>	<u>CHARACTERISTICS</u>	<u>INCREMENT</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
CO-5	APS effluent separated from PEW system. Cooling water/steam condensates recirculated through evaporative cooling tower. PEW condensates, chemical wastes, and cooling tower blowdown to solar evaporation ponds.	Cooling water re-circulation system with cooling tower	14,036	14,206
CO-6	APS effluent separated from PEW system. Cooling water recirculated through evaporative cooling tower. Chemical wastes, cooling tower blowdown and PEW condensates to solar evaporation pond. Collection of steam condensates and returns to boiler increased from 30% to about 80%.	Increase collection of steam condensates and return to boiler	8,292	8,293

3.0 BASES FOR EVALUATION

As stated in the Introduction, the purpose of the work covered in this report was to investigate, on a screening study basis, the practicality of 23 different methods of handling effluent waters at the Idaho Chemical Processing Plant (ICPP). The alternative cases were evaluated for technical viability, comparative economic costs, and compliance with existing and pending regulations. Calculations as to viability, costs and regulations were made based on information provided by Idaho office of the DOE. Environmental, health and safety factors were evaluated on a qualitative basis. No detailed cost benefit calculations were made for environmental/safety benefits.

The specific cases studied are described in the scope of work supplied by the Department of Energy in the form of the Conceptual Design Criteria. This document defines not only the scope of the work, but provides required information on stream flow rates and compositions. Extractions from this document are included in Appendix "C" for reference. To the original 23 cases, Fluor added three with DOE concurrence. The three cases are:

- o Closed loop cooling system using heat exchanger (CC-7)
- o Partial evaporation/recycle of PEW condensate (RW-11A)
- o Recycle of PEW condensate with Calcium Nitrate production (RW-11B)

For each case studied, the evaluations were carried out in the following sequence:

- a. Develop a schematic flow diagram of the case, showing operating conditions, material flows and major equipment.

- b. Based on the calculations performed to establish (a), determine whether the proposed case is technically feasible and can be judged to represent reasonable application of the technology. Some case studies were terminated at this point. Technical feasibility was judged primarily on Fluor experience, vendor experience, or the lack of ability to generate reasonable material flows:
- c. For cases judged to be technically feasible, a list of major advantages and disadvantages was prepared, and any significant impacts on environment, health, and safety were noted. Again, at this point, some cases were terminated. Environmental considerations was judged in terms of regulations contained in the following documents:
 - o USERDA Manual Chapter 0524
 - o USEPA Documents:
 - 40 CFR Parts 260 through 265 Hazardous Waste Regulations
 - 40 CFR Part 265 Subpart R
 - 40 CFR Part 122 Subpart B Part 122.30
 - 40 CFR Part 122 Subpart C Underground Injection Control Regulations
 - 40 CFR Part 243 Solid Waste Regulations
 - 40 CFR Parts 122, 123, 124, 125 Consolidated Permit Regulations
 - o Construction and Use of Waste Disposal and Injection Wells - Idaho Department of Water Resources, April 17, 1980

In the detailed discussion sections of this report, we have noted which cases meet or do not meet the requirements of the above documents.

In any event, many of the cases terminated at this stage of the evaluation were so handled because the apparent disadvantages strongly outweighed the apparent advantages. This happened most often in a situation where it was apparent that implementation of the alternative produced no lasting improvement in environmental factors over existing practice. There was no reason to recommend the expenditure of money, sometimes in large amounts, for little or no net gain.

For cases judged to be both technically and environmentally sound, equipment specifications were prepared, pipe material and size determined and preliminary plot layouts developed. This information was used as the bases for the capital cost estimates, operating cost estimates and life cycle cost analyses.

Capital costs were estimated in mid-1980 dollars and do not include escalation to the time that the work would be done. Equipment costs are based on Fluor and vendor estimates. Material costs were obtained from suppliers and current Fluor data. Field labor rates are those in effect at INEL for mid-1980. Construction cost estimates are based on competitively bid fixed price contracts.

Engineering and management costs are included as percentages of construction costs. A suitable contingency is provided to cover changes in scope, the preliminary nature of the design and the degree of completeness of information as well as estimating accuracy.

Operating costs are based on current actual prices of energy and chemicals and current labor costs for similar facilities.

Life cycle cost analyses were prepared using the method outlined in the Federal Register, Volume 45, No. 18, January 23, 1980, page 5627.

Calculations are based on the following parameters:

- o 20 year project life
- o 10 percent interest rate
- o Electricity at \$5.57 per MM Btu, in 1980 dollars
- o Fuel at \$4.36 MM Btu, in 1980 dollars

The analysis and extracts from the Federal Register are included in Appendix "A".

The actual life cycle cost evaluation should be considered as "incremental," compared to a "base case." For each of the three major classes of stream (cooling water, chemical waste, and PEW waste), the base case is essentially the existing practice (projected to 1985) and is priced at zero. In terms of the existing physical facilities at Idaho, a subtle point to note is that the separate waste streams flow together to the injection well, whereas, in effect, the three base cases used for economic evaluation here treat each class of waste as if it flowed separately to the well.

The handling of cost estimates and economic evaluations for the combined (CO) cases in Section 7 is as described above. Where there were interactions between systems, certain components of capital and operating costs were recalculated on new sizing requirements.

Other criteria and information relating to site data, climatological information, soil percolation rates, aquifer characteristics and results of past studies are contained in documents which were supplied to Fluor by DOE and ENICO.

Because of the intermittent nature of the ICPP operations, the qualities and quantities of waste water are subject to substantial variations. If the waste water usage (quantity and quality) given in the "CDC" change, the conclusions reached in the report are also subject to modification. These changes (if any) should be evaluated in depth at the time the conceptual design study is performed.

ALTERNATIVE MEANS FOR DISPOSAL
OF COOLING WATER AND STEAM CONDENSATES

4.0 INTRODUCTION

The current practice at the Idaho Chemical Processing Plant (ICPP) is to collect all cooling water and steam condensates in a system of lateral and trunk drains which ultimately converge on an injection well (CPP-304). At the present time, this system of drains carries not only the cooling water and steam condensates, but also chemical wastes and wastes from the Process Equipment Waste Evaporator (PEW). The latter component contains low level radioactive material (mostly tritium). This system of drains, together with monitoring and diversion stations, pumps, etc., is known as the "service waste system."

There are three trunk drains, two from the "east side" of the CPP complex and one from the "west side." Each of these drains passes through a radiation monitoring station. Two of these drains are diverted automatically to a radioactive waste storage tank (WM-191) in the event that the monitors detect significant radiation levels. Water from this tank is then sampled and tested for radiation levels. If this testing reveals that a "false alarm" has occurred, the water can be returned to the drain system for disposal to the injection well. If radiation levels are not acceptable, the stored water is then processed through the PEW evaporator.

The "west side" trunk drain does not have automatic diversion. If the in-line monitor detects radiation in the waste stream, an alarm is sounded and safety personnel respond by manually diverting the water to WM-191. It is planned that automatic diversions will be installed on this drain by 1985.

This section of the report examines the disposal of cooling water and steam condensates alone, as if they were unmixed with either the chemical wastes or the radioactive wastes from the evaporator and the calciner. Piping which exists as of 1980 plus that presently planned for installation between now and 1985 is considered as "existing" in the various cases. Items identified and described as "new" on drawings and in the text are to be understood as reflecting added requirements (piping and equipment) that must be added for a specific alternative case.

Seven alternative cases were examined. These have been identified with the initials "CC" (for cooling water and steam condensates), followed by a serial number. These cases studied are:

CC-1 Disposal of Cooling Water and Steam Condensates to Existing
Injection Well

CC-2 Disposal of Cooling Water and Steam Condensates to a Shallow Well

CC-3 Disposal of Cooling Water and Steam Condensates to an Unlined
Percolation Pond

CC-4 Disposal of Cooling Water and Steam Condensates to a Lined Evapor-
ation Pond

CC-5 Disposal of Cooling Water and Steam Condensates to Big Lost River
Channel

CC-6 Circulation of Cooling Water and Steam Condensates Utilizing an
Evaporative Cooling Tower

CC-7 Circulation of Cooling Water and Steam Condensates Utilizing Heat
Exchange With an Independent Cooling Water Stream

Alternative Cases CC-1 through CC-5 were in the original "CDC" scope of work. The scope of work also included a case for recycle of cooling water. This was expanded to two cases, CC-6 and CC-7, by Fluor with the approval of DOE.

There are two possible ways for radioactive material to become mixed into the cooling water/condensate stream. First, in the chemical laboratories it is possible for small quantities of radioactive material (e.g., a beaker of diluted matter) to be discarded to the service waste system. This would, however, be a violation of the laboratory standard operating procedure. Further, because the sinks are purposely small (intended mainly to receive cooling water and condensates from laboratory experimental apparatus), they are not convenient for washing and rinsing glassware. This source of contamination has, therefore, been judged to be insignificant as to both intensity and frequency.

Second, if any of certain heaters, coolers, and condensers which are connected to the service waste system should develop a leak, it is possible for radioactive material from the process side of the heat transfer surface to enter the cooling water/condensate system. In normal operation, the pressure on the cooling water side of coolers and condensers is maintained higher than the pressure on the process side, so that if a leak develops, leakage will be out of the cooling water system rather than into it. With steam-heated equipment, the same is true during normal operation. However, during periods when the equipment is shut down, residual steam in the heat exchanger will condense, and the pressure differential can reverse. If there was a leak in the heat exchanger, radioactive material could then leak into the condensate side.

As noted previously, all of the cooling water and condensate waste streams are monitored for radioactivity before being discharged to the injection well. Thus, it is necessary that there be two concurrent

failures (in a heat exchanger and in a monitor) before any significant amounts of radioactive material can be discharged to the aquifer through the injection well. A simultaneous double failure is a low probability event and is generally an acceptable design approach from a safety viewpoint.

Since one of the objectives of this study is to examine the consequences of discontinuing injection well operation, it is necessary to examine alternative means for disposing of the cooling water/condensate stream.

For alternative cases in which the cooling water and steam condensate stream is discharged to the aquifer, either directly or indirectly, three possible means for increasing protection of the aquifer against any accidental release of significant amounts of radioactive material have been considered.

1. Install another monitoring and diversion station on the combined stream downstream from all existing monitors and prior to the final disposal of the water down the well. While superficially this is attractive, in practice it is unlikely to be very effective because the mixed stream would be more diluted than any individual stream which happened to be carrying radioactive material, thus making it more difficult for the monitor to respond to the radiation level present. Further, the more diluted the water sent to the storage tank (WM-191), the longer the PEW evaporator will eventually be occupied to reprocess the water which was diverted.
2. Another means for reducing potential hazard is to install monitoring and diversion stations on each individual feeder pipeline, thus intercepting the radioactive material while it is still relatively more concentrated. This would be both safer (in terms of possible hazard downstream) and would require the processing of less water. The disadvantage is the higher cost of multiple monitoring and diversion stations.

3. A positive means to prevent discharge of hazardous material to the aquifer through the injection well is a series of holding ponds. This concept is one in which there would be several ponds, each capable of holding one day's maximum accumulation of waste water (four million gallons). These ponds would be lined to prevent percolation into the ground. At any one time, one pond would be filling, one would be draining to the injection well, and the remaining ponds would be holding. This would give ample time for manual sampling of the water in the ponds for an accurate determination of hazardous substances present. In the event that hazardous material is found to be present in sufficient quantities to make it inadvisable to return the water to the aquifer, that pond would be kept in a "hold" mode until solar evaporation concentrated the water sufficiently to allow efficient processing in the PEW evaporator. At that time, the water would be pumped back to WM-191. In the meantime, the remaining ponds would continue their normal cycle, with one day less storage until the pond which had been on "hold" could be returned to normal service.

Suggestions 2 and 3 could be used singly or in combination.

Suggestion 3 has been incorporated into combination Cases CO-3 and CO-4 as an optional feature, with a separate line item for the incremental costs.

4.1 ALTERNATIVE CASE CC-1: DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO EXISTING INJECTION WELL

4.1.1 Principal Features

The physical features of this alternative consist of the existing service waste system and injection well (CPP-304).

Figure 4.1-1 is a simplified block flow diagram of the existing drain system at CPP.

If the chemical and radioactive waste systems were separated from the cooling water drains, there would not be any significant amounts of these materials in the service waste system. Low level radioactive wastes would enter only if there were a major equipment failure involving leakage.

Advantages and disadvantages of this alternative are summarized in Figure 4.1-2 which lists arguments "pro" and "con."

Case CC-1 is significant because it is the "baseline" with which the other alternative cases are compared.

4.1.2 Technical Aspects

By 1985 it is expected that the total discharge to the injection well will be a maximum of 2700 gpm. Of this, approximately 200 gpm will be steam condensate, representing about 70 percent of the steam condensed (the remaining 30 percent is collected separately and returned to the boilers).

ALTERNATIVE CC-1 DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO EXISTING INJECTION WELL

FIGURE 4.1-1

ALTERNATIVE CC-1 DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO EXISTING INJECTION WELL

PRO	CON
<p>1. Discharge meets EPA Recommended Standards for Potable Water . Water Quality is Better Than When Chemical Wastes and P.E.W. Condensates are Mixed with Cooling Water (Current Practice).</p> <p>2. No Capital Expenditure Required.</p>	<p>1. Remote Possiblilty of Accidental Release of Radioactive material to the Aquifer.</p>

FIGURE 4.1-2

In considering this alternative, it is assumed that the existing piping (as of 1985 according to present plans) is used and no major changes are contemplated other than those noted below. It is assumed that replacement or addition of piping to comply with the 1985 utility plan will have been completed.

The present (1980) cooling water requirements are approximately 1.2 million gallons per day (average). By 1985 the cooling water requirement will have doubled. At the present time, about half of the water used for cooling is softened, using sodium ion exchange softeners located in Building 606. It is planned that by 1985, all cooling water will be softened.

A process flow diagram (Drawing 475304-CC1-R-001) is included in Appendix "B". This diagram is more detailed than the block flow diagram and the plot plan, and shows all present and proposed piping relevant to this alternative of which Fluor is aware. It also indicates connections to the chemical waste system and low level radioactive water waste system.

An optional variation to this case is to add a series of holding ponds as a positive protection against any possible accidental release of objectionable material to the aquifer, as described in Section 4.0. This would require the construction of a surge tank adjacent to the existing injection well, into which all branches of the service waste system would be directed; a pump station; a pipeline to the southeast corner of the ICPP facility; five holding ponds, each with about 4,000,000 gallons capacity, with distribution piping and valves; and a means for ultimate disposal of the water. The water could either be piped back to the existing injection well, or be discharged down a new shallow well close to the holding ponds. The cost of this option is shown in Case CO-3, Section 7.3.

4.1.3 Cost Estimates

Since this is the base case, costs are taken as "zero" and all other alternatives will be evaluated on the basis of whether costs increase or decrease as a result of the changes entailed.

4.1.4 Environmental Features

1. Liquid Releases

Water discharged to the injection well through this system is normally free of radioactive materials. In terms of water quality other than radioactivity, the collected cooling water and steam condensate streams are equal to or better than (i.e., lower in dissolved solids) the water taken from the production wells. They have accumulated small amounts of iron and other ions, but these are more than offset by the dilution caused by steam condensates which account for about 6 percent of the combined stream. The water is warmer than when it is pumped from the supply wells by 2°F to 4°F. When this water is mixed with the water moving in the aquifer, the temperature difference is dissipated quickly.

2. Airborne Releases and Solid Residues

There are no airborne releases nor solid residues resulting from this method of disposal.

3. Health and Safety Considerations - On-Site Persons

This method of disposal does not entail any health and safety hazards to persons within the CPP and its immediate vicinity.

4. Health and Safety Considerations - Off-Site Persons

As stated in Section 4.0, there is a remote possibility that, as the result of a rare accident, radioactive material could enter the aquifer along with the cooling water and steam condensate discharges. The resulting hazard to off-site persons from such an event is minimal for the following reasons:

- a. The amount of radioactive material entering the aquifer would be small, because as stated in Section 4.0, systems have been designed to minimize the size of individual leaks, and to provide automatic diversion in the event of a leak.
- b. Radioactive material would be dispersed by the cooling water/condensate stream.
- c. The stream would be further diluted by gradual mixing with the water moving in the aquifer.
- d. Evidence obtained from monitoring wells in the vicinity of the injection well reveals that heavy ions such as cesium and strontium are absorbed in the earth and do not migrate far from the injection well. The strontium "plume" downstream from the existing injection well, developed as a result of discharging residual condensates from the PEW evaporator along with the cooling water and steam condensates, extends only 1-1/2 miles from the injection well after 27 years of operation of the CPP.
- e. Water in the aquifer moves at a rate of 3 to 5 feet per day. Since the distance from the injection well to the INEL boundary, in the direction of flow (southwest), is approximately 12 miles, it takes about 35 years for water entering the aquifer at the well to reach the boundary. Tritiated

water moves with the normal water; however, entrained radioactive particles move much more slowly and may see extensive soil capture. During this time, radioactive elements in the water tend to decay, further reducing the intensity of radiation.

- f. By the existing program of periodic sampling of water from monitor wells downstream from the CPP, the movement of radioactive material can be both predicted and observed, and a determination can then be made of the degree of hazard associated with it.

5. Effects on Wildlife

Since all of the water is contained within pipes or other enclosures, there is no interaction with wildlife.

4.2 CASE CC-2: DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO A SHALLOW WELL

4.2.1 Principal Features

This case utilizes the existing service waste system, with one change: the waste stream is returned to the aquifer through a shallow well rather than through the existing well which penetrates into the water-bearing strata below the water table. Unlike the existing injection well, which is located more or less at the middle of the CPP complex, the shallow well is located near the southeast corner of the complex. This location was chosen because there is concern about the possible ill effects of introduction of large amounts of water too close to the deep foundations of the FAST building, currently under construction just south of the injection well. There is also a concern that perched water from the well could recirculate to the production wells.

In order to convey the water to the new location, it is necessary to intercept the streams now going to the injection well. This is done with a collection and surge tank and pump station adjacent to the existing injection well. Pipes now leading to the injection well are relocated so as to discharge into the collection tank. From there, the water is pumped to the shallow well.

Figure 4.2-1 is a simplified block flow diagram of this system.

A plot plan shows the locations of new facilities required for this case (Drawing 475304-P-CC-2).

Advantages and disadvantages of this alternative are summarized in Figure 4.2-3 which lists arguments "pro" and "con."

**ALTERNATIVE CC-2
DISPOSAL OF COOLING WATER AND STEAM CONDENSATES
TO A SHALLOW WELL**

FIGURE 4.2-1

FLUOR	S. MEYER	PLOT PLAN
	M. CUTLER	
	475304-P-CC-2	

**ALTERNATIVE CC-2
DISPOSAL OF COOLING WATER AND STEAM
CONDENSATES TO A SHALLOW WELL**

PRO	CON
<ul style="list-style-type: none">1. Discharge Meets EPA Recommended Standards For Portable Water2. Soil and Rock Layers Between Well and Water Table Provide Some Filter and Adsorption Capacity for Suspended and/or Dissolved Matter	<ul style="list-style-type: none">1. Investment of Capital and Energy Without Major Benefit Over Use of Existing Well2. Remote Possibility of Accidental Release of Some Radioactive Material to a Shallow Well.3. Well May Have to be Pressurized.

FIGURE 4.2-3.

In this alternative, the waste water ultimately returns to the aquifer as with present practice. The significance is that there is a finite time during which the discharge waters are "held up" in the earth and rock layers above the water table before they become mixed with the water in the aquifer. During this period there is opportunity for adsorption and/or ion exchange of any contaminants in the water by the earth, providing a margin of safety and protection to the water in the aquifer.

4.2.2 Technical Aspects

The new features required for this alternative are:

1. A collection and surge tank and pump station adjacent to the existing injection well;
2. A pipeline to convey the water from the collection tank to the shallow well, near the southeast corner of the CPP;
3. A new shallow injection well.

A process flow diagram for this case (Drawing 475304-CC2-R-001) is included in Appendix "B".

The collection and surge tank is designed to hold approximately 20 minutes accumulation of flows at the maximum rate of 2700 gpm or 54,000 gallons. This tank is underground, so that all flows into the tank are by gravity via the existing mains.

There is a 24 inch diameter emergency overflow pipe connecting the surge tank with the existing injection well. This provides for disposal of excess water entering the surge tank in the event of unplanned stoppage of the surge tank pumps. While this represents a direct discharge path to the aquifer, it would require the simul-

taneous failure of a process equipment barrier, the diverter system and the surge pumps to release any contamination.

Two vertical pumps are provided, each with sufficient capacity for the entire flow. These pumps have been priced on the basis of 200 psig discharge pressure. This discharge pressure is assumed to be sufficient to force the water from the well into the surrounding earth. Actual well capacity versus head must be determined empirically on an actual test of the well itself or on one in essentially identical earth. Such information is not available at this time.

The pipeline is carbon steel, 14 inches in diameter, standard schedule pipe. Total length is approximately 3600 feet (the exact length would depend on the location finally chosen for the well). The buried pipe is wrapped and coated and protected by cathodic protection units.

The injection well is 250 feet deep, with the bottom 100 feet of the casing being perforated. This ensures that the water is injected below the first major aquitard (impermeable layer). This in turn ensures that injected water will not mound up around the well and possibly reach the ground surface. The well is 20 inches in diameter at the top and steps down to 16 inches. Casing wall thickness is 0.375 inches, material is ASTM A53 or 120.

An optional variation to this case is to add a series of holding ponds as a positive protection against any possible accidental release of objectionable material to the aquifer, as described above. This would require the construction of five holding ponds, each with about 4,000,000 gallons capacity, with distribution piping and valves. This option is not shown on any of the drawings.

ALTERNATIVE CC-2

Shallow Well	60,000
Surge Tank	400,000
Piping	465,000

Direct Field Costs	925,000
Contractor Overhead and Profit	204,000
Engineering and Management	736,000
Contingency	<u>333,000</u>

Total Capital Cost	\$2,198,000
--------------------	-------------

Life Cycle Cost	\$2,938,000
-----------------	-------------

Figure 4.2-4

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CC-2

TITLE: DISPOSAL OF COOLING WATER AND STEAM CONDENSATE TO A SHALLOW WELL

PART I

•Capital Cost	= \$2,198,000
•O&M Cost	= \$45,500/year
•Energy:	
Electricity	= 4950 MBTU/year
Oil	= 132 MBTU/year
•Economic Life	= 20 years
•Residual Value	= Zero
•Reinvestment Cost	= Zero

PART II

•Present Value Capital Investment	= \$2,198,000
•Present Value O&M	
\$45,500 X 8.51	= \$387,205
•Present Value Energy	
Electricity	= 4950 MBTU X \$5.57/MBTU X 12.61 = \$347,677
Oil	= 132 MBTU X \$4.36/MBTU X 9.4 = \$5410
•Total Present Value	= \$2,938,292

Figure 4.2-5

4.2.3 Cost Estimates

Capital and operating costs for this alternative, over and above the base case, have been estimated. A life-cycle cost analysis has been prepared based on these estimates. Results are presented in Figures 4.2-4 and 4.2-5.

4.2.4 Environmental Features

1. Liquid Releases

Water discharged to the shallow well through this system is normally free of radioactive materials. In terms of water quality other than radioactivity, the collected cooling water and steam condensate streams are equal to or better than (i.e., lower in dissolved solids) the water taken from the production wells. They have accumulated small amounts of iron and other ions, but these are more than offset by the dilution caused by steam condensates which account for about 6 percent of the combined stream. The water is warmer than when it is pumped from the supply wells by 2°F to 4°F. When this water is mixed with the water moving in the aquifer, the temperature difference is dissipated quickly.

The quality of the discharge water is better than required by the governing standards and meets the EPA recommended standards for potable (drinking) water.

In this case, water does not return directly to the aquifer below the water table, but instead percolates down through 150 or more feet of earth before reaching the water table. Since the earth has been demonstrated to have some ion exchange or ion absorption properties (Section 4.1.4), it is expected that any heavy radioactive ions such as strontium and cesium which entered the stream accidentally would be retained in the earth layers above the

water table, at least until the adsorption capacity of that body of earth was fully utilized. The earth layers, therefore, constitute a filter and "safety sponge" between the well and the water table. Since accidental spills are expected to be both small and infrequent, the "sponge" would be effective for many years.

2. Airborne Releases and Solid Residues

There are no airborne releases nor solid residues resulting from this method of disposal.

3. Health and Safety Considerations - On-Site Persons

This method of disposal does not entail any health and safety hazards to persons within the CPP and its immediate vicinity.

4. Health and Safety Considerations - Off-Site Persons

As stated in Section 4.0, there is a remote possibility that, as the result of a rare accident, radioactive material could enter the shallow well along with the cooling water and steam condensate discharges. Before reaching the aquifer, the fluids would first percolate through the intervening earth layers. The resulting hazard to off-site persons from such an event is minimal for the following reasons:

- a. The amount of radioactive material entering the shallow well would be small, for reasons stated in Section 4.0.
- b. Radioactive material would be diluted by the cooling water/condensate stream.

- c. Adsorption and/or ion exchange in the "safety sponge" of earth layers below the shallow injection well would prevent most or all of the heavy ions from reaching the water table.
- d. The stream would be further diluted by gradual mixing with the water moving in the aquifer.
- e. Evidence obtained from monitoring wells in the vicinity of the injection well reveals that heavy ions such as cesium and strontium are absorbed in the earth and do not migrate far from the injection well. (The strontium "plume" downstream from the existing injection well, developed as a result of discharging residual condensates from the PEW evaporator along with the cooling water and steam condensates, extends only 1-1/2 miles from the injection well after 27 years of operation of the CPP).
- f. Water in the aquifer moves at a rate of 3 to 5 feet per day. Since the distance from the injection well to the INEL boundary, in the direction of flow (southwest), is approximately 12 miles, it takes about 35 years for water entering the aquifer at the well to reach the boundary. During this time, radioactive elements in the water will decay, further, reducing the intensity of radiation.
- g. By a program of periodic sampling of water from monitor wells downstream from the CPP, the movement of radioactive material can be both predicted and observed, and a determination can then be made of the degree of hazard associated with it.

5. Effects on Wildlife

Since all of the water is contained within pipes or other enclosures, there is no interaction with wildlife.

6. Environmental Effects During Construction and/or Modification

There will be a sizeable excavation adjacent to the existing injection well, followed by construction of the collection tank and pump structure. It will be necessary to shut down operations for a few hours when the present drain trunk lines are rerouted into this tank. The drilling of the shallow well is localized in an area which should not interfere with other CPP activities.

Since the pipelines which would have to be reconnected presently carry a barely detectable level of radioactivity, only minimal precautions would be required for the workers involved.

4.2.5 Institutional Considerations

Operation and maintenance procedures for the cooling water and steam condensate disposal system are affected only by the addition of the surge tank, pumps, and piping to the system.

4.3 CASE CC-3: DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO AN UNLINED PERCOLATION POND

4.3.1 Principal Features

The physical features of this case consist of the existing service waste drain system, a collection and surge tank and pump station, a pipeline, and a percolation pond. The tank and pump station are located close to the existing injection well (CPP-304). The pond would be located beyond the southeast corner of the CPP, out of the way of all presently proposed or likely future construction for the plant complex.

Figure 4.3-1 is a simplified block flow diagram of this system.

Drawing 475304-P-CC-3 is a plot plan showing the location of new facilities.

Advantages and disadvantages of this alternative are summarized in Figure 4.3-3 which lists arguments "pro" and "con."

As in Cases CC-1 and CC-2, the water ultimately returns to the water body in the aquifer. The significance of this case is that the holdup time for the water in the earth layers above the water table is greater than in Case CC-2 for two reasons:

1. Water is introduced into the earth about 400 feet above the water table instead of 150 to 200 feet as in Case CC-2. It is injected above the upper aquitard layer so that it "perches" and spreads out laterally for a substantial distance (perhaps as much as a mile, although the exact extent is unknown without an extensive drilling survey).
2. Percolation is spread over a large area, instead of being concentrated in the very small area of the shallow well wall surfaces.

**ALTERNATIVE CC-3
DISPOSAL OF COOLING WATER AND STEAM CONDENSATES
TO AN UNLINED PERCOLATION POND**

FIGURE 4.3-1

ICPP INJECTION WELL ALTERNATIVES PROJECT	
FOR DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO	
ALTERNATIVE CC-3 DISPOSAL OF COOLING WATER AND STEAM TO AN UNLINED PERCOLATION POND
FLUOR	PLOT PLAN 475304-P-CC-3

ALTERNATIVE CC-3 **DISPOSAL OF COOLING WATER AND STEAM** **CONDENSATES TO AN UNLINED** **PERCOLATION POND**

PRO	CON
<ol style="list-style-type: none"> 1. Discharge Meets EPA Recommended Standards For Potable Water 2. Bottom of Pond and Soil and Rock Layers Below Pond Provide Some Filter and Adsorption Capacity for Suspended and or Dissolved Matter. 	<ol style="list-style-type: none"> 1. Investment of Capital and Energy Without Major Benefit Over Use Of Existing Well. 2. Remote Possibility of Accidental Release of Radioactive Material to Unlined Pond. 3. Large Land Area Required (Approx. 902,500 sq. ft., or about 670 x 1350 Feet)

FIGURE 4.3-3

The combined effect of these two characteristics is to increase the volume of water being retained between the level of injection and the water table. This in turn means that the time delay before water drains to the water table is increased, and the volume of earth available for adsorption of heavy cations is correspondingly increased. These characteristics mean that protection against accidental discharges of radioactive material into the aquifer is greater than in Case CC-2.

4.3.2 Technical Aspects

The new features required for this alternative are:

1. A collection and surge tank and pump station adjacent to the existing injection well;
2. A pipeline to convey the water from the collection tank to the percolation pond at the southeast corner of the CPP site;
3. A percolation pond.

A process flow diagram for this case (Drawing 475304-CC3-R-001) is included in Appendix "B".

The collection and surge tank is designed to hold 20 minutes accumulation of flows at the maximum rate of 2700 gpm or 54,000 gallons. This tank is underground, so that all flows into it are by gravity via the existing mains.

There is a 24 inch diameter emergency overflow pipe connecting the surge tank with the existing injection well. This provides for disposal of excess water entering the surge tank in the event of unplanned stoppage of the surge tank pumps. While this represents a direct discharge path to the aquifer, it would require the simultaneous failure of a process equipment barrier, the diverter system and the surge pumps to release any contamination.

Two vertical pumps are provided, each with sufficient capacity for the entire flow. Discharge pressure is 70 psig.

The pipeline is carbon steel, 14 inches in diameter, standard schedule pipe. Total length is approximately 3800 feet (the exact length would depend on the location finally chosen for the well). The buried pipe is wrapped and coated and protected by cathodic protection units.

The percolation pond has surface dimensions of 660 by 1320 feet. It is oriented so that the long axis runs northwest/southeast; this orientation places the short axis in line with the prevailing winds (southwest, with northeast being second in frequency), thus minimizing erosion of pond banks by wave action. The pond has an overall depth of 6 feet; this allows for surge capacity and a freeboard to contain wave action. The pond is created by levelling the assigned site and using the material scraped off the surface to build up a peripheral berm or dike. The dike has a water barrier in it, since the water surface in the pond may be above the level of the surrounding land. The bottom of the pond is approximately level, but it is not compacted.

An optional variation to this case is to add a series of holding ponds as a positive protection against any possible accidental release of objectionable material to the aquifer, as described above. This would require the construction of five holding ponds, each with about 4,000,000 gallons capacity, with distribution piping and valves. This option is not shown on any of the drawings.

4.3.3 Cost Estimates

Capital and operating costs, over and above the base case, for this alternative have been estimated. A life cycle cost analysis has been prepared based on these estimates. Results are presented in Figures 4.3-5 and 4.3-6.

ALTERNATIVE CC-3

Percolation Pond	564,000
Surge Tank	364,000
Piping	478,000

Direct Field Costs	1,406,000
Contractor Overhead and Profit	234,000
Engineering and Management	970,000
Contingency	<u>484,000</u>

Total Capital Cost \$ 3,094,000

Life Cycle Cost \$ 3,633,000

Figure 4.3-5

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CC-3

TITLE: DISPOSAL OF COOLING WATER AND STEAM CONDENSATE TO UNLINED POND

PART I

•Capital Cost	= \$3,094,000
•O&M Cost	= \$45,500/year
•Energy:	
Electricity	= 1960 MBTU/year
Oil	= 132 MBTU/year
•Economic Life	= 20 years
•Residual Value	= Zero
•Reinvestment Cost	= \$10,000 in year 7 and 14 (Factors = 0.50 and 0.26)

PART II

•Present Value Capital Investment	= 3,094,000 + 5,000 + 2,600 = \$3,101,600
•Present Value O&M	
\$45,500 X 8.51	= \$387,205
•Present Value Energy	
Electricity	= 1960 MBTU X \$5.57/MBTU X 12.61 = \$137,666
Oil	= 132 MBTU X \$4.36/MBTU X 9.4 = \$5,410
•Total Present Value	= \$3,632,881

Figure 4.3-6

4.3.4 Environmental Features

1. Liquid Releases

As described above, the retention time in the earth above the water table is longer for Case CC-3 than for Case CC-2. Also, the water is spread over a large area at the ground surface. Thus, in the case of a major accidental release of radioactive material to the pond, it would be possible, at least theoretically, to excavate the top layer of contaminated earth and move it to another location for permanent storage pending decay of the radioactivity. This would be expensive and could expose workers to some radioactivity. However, it would give a higher degree of protection to the aquifer.

2. Airborne Releases

Unlike Cases CC-1 and CC-2, the use of a percolation pond results in airborne releases. First, the pond loses substantial amounts of water to the air by solar evaporation. Second, there is a possibility of some pond water being carried into the air by splashing during high winds. This would be of short duration, would not travel far beyond the pond perimeter, and would present no hazard because of the clean nature of the water.

3. Solid Releases

There are no significant solid releases.

4. Health and Safety Considerations

There are no significant health or safety hazards associated with this alternative. The pond is fenced to discourage access to the pond by unauthorized persons.

5. Effects on Wildlife

Properly built fences keep out all of the larger animals found in the area. Small animals, insects, and migratory aquatic birds are attracted to the pond. Under normal conditions, since the water meets EPA standards for potable water, no harmful effects result. This study did not address possible harmful effects to such animal life in the event of a major accidental release, due to a lack of data on frequency and composition of releases and health effects on the various species. Such accidents have never been reported at the ICPP, and, therefore, cannot be regarded as probable events.

A land area of approximately 25 acres is required for the percolation pond, dikes, and peripheral road. This land is withdrawn from the habitat for native animals and birds.

6. Environmental Effects During Construction and/or Modification

Effects during construction of the collection tank, pump station, and pipeline are essentially the same as for Case CC-2. The number of construction workers would be small and should not add significantly to traffic loads. Operation of heavy construction vehicles would be localized in the immediate vicinity of the percolation pond, away from other facilities and main roads.

4.3.5 Institutional Considerations

Operation and maintenance procedures for the cooling water and steam condensate disposal system are affected only by the additional pumps and piping. Occasional surveillance of the pond area, for security and safety reasons, is required. At longer intervals (several years),

there will be major maintenace on the pond; this will include repair of dikes, scarifying the bottom to renew percolation rates, repair of fences and peripheral roadway, etc.

4.4 CASE CC-4: DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO A LINED EVAPORATION POND

4.4.1 Principal Features

The physical features of this case consist of the existing service waste drain system, a collection and surge tank and pump station, and a lined solar evaporation pond. The tank and pump station are located close to the existing injection well (CPP-304). The pond is located beyond the southeast corner of the CPP, out of the way of all presently proposed or likely future construction sites in the plant complex.

Figure 4.4-1 is a simplified block flow diagram of this system.

Figure 4.4-2 is a plot plan showing the location of new facilities.

Advantages and disadvantages of this alternative are summarized in Figure 4.4-3 which lists arguments "pro" and "con."

The significance of this case is that all of the water is evaporated into the air and none is returned to the aquifer.

4.4.2 Technical Aspects

The new features required for this alternative are:

1. A collection and surge tank and pump station adjacent to the existing injection well;
2. A pipeline to convey the water from the collection tank to the percolation pond at the southeast corner of the CPP site;
3. A lined solar evaporation pond.

**ALTERNATIVE CC-4
DISPOSAL OF COOLING WATER AND STEAM CONDENSATES
TO A LINED EVAPORATION POND**

FIGURE 4.4-1

**ALTERNATIVE CC-4
DISPOSAL OF COOLING WATER AND
STEAM CONDENSATES TO A
LINED EVAPORATION POND**

PRO	CON
1. No Water is Discharged to Aquifer, Eliminating All Possibility of Contamination.	1. Extremely Large Land Area Required (Approximately 2.65 Sq. Miles). 2. High Capital Cost (Over \$40,000,000) 3. 2 to 4 Million Gallons per Day are Lost from Snake River Aquifer System.

FIGURE 4.4-3

A process flow diagram for this case (Drawing 475304-CC4-R-001) is included in Appendix "B".

The collection and surge tank is designed to hold 20 minutes accumulation of flows at the maximum rate of 2700 gpm or 54,000 gallons. This tank is underground, so that all flows into the tank are by gravity via the existing mains.

There is a 24 inch diameter emergency overflow pipe connecting the surge tank with the existing injection well. This provides for disposal of excess water in the event of an unplanned stoppage of the surge tank pumps. While this represents a direct discharge path to the aquifer, it would require the simultaneous failure of a process equipment barrier, the diverter system and the surge pumps to release any contamination.

Two vertical pumps are provided, each with sufficient capacity for the entire flow. Discharge pressure is 70 psig.

The pipeline is carbon steel, 14 inches in diameter, standard schedule pipe. Total length is approximately 3800 feet (the exact length would depend on the location finally chosen for the pond). The buried pipe is coated, wrapped and cathodically protected to minimize external corrosion.

The solar evaporation pond has surface dimensions of 6100 by 12,100 feet with a surface area of 2.6 square miles. It is oriented so that the long axis runs northwest/southeast; this orientation places the short axis in line with the prevailing winds (southwest, with northeast being second in frequency), thus minimizing erosion of pond banks by wave action. The pond has an overall depth of 5.1 feet; this allows for annual variations in evaporation rate (including the possibility of a cold wet year with little or no net evaporation), and a freeboard to contain wave action. The pond is created by leveling the assigned

site and using the material scraped off the surface to build up a peripheral berm or dike. The bottom of the pond is approximately level and is compacted. The pond has sides and bottom lined with a thin membrane made of 30 mil polyvinyl chloride (PVC). The liner is covered with a layer of earth to protect it from mechanical damage and photodeterioration. PVC liners are reputed to have been in service in excess of 25 years when so protected. (A more complete discussion of solar ponds appears in Section 5.5.)

4.4.3 Cost Estimates

PVC pond liners can be installed for a cost of approximately 30¢ a square foot. This price presupposes that the owner has graded and compacted the entire pond area and has stockpiled suitable cover material within the perimeter of the pond. The price includes laying the liner, sealing around a reasonable number of penetrations (as for inlet pipes, drains, etc.) and covering the liner with the material provided by the owner. For the present case, with 74,000,000 square feet to be covered, the price of the liner alone would be \$15,000,000. Adding in the cost of grading, building up the berms, fencing, etc., would bring the cost to approximately \$45,000,000. These costs are far in excess of those for other alternatives examined. Because of that and the other disadvantages discussed, study of this case was terminated without preparation of a formal cost estimate or life cycle cost analysis.

4.4.4 Environmental Features

1. Liquid Releases

In this case, there is no release of liquid to the earth, and none of the waste water reaches the aquifer.

2. Airborne Releases

All of the water discharged into the pond eventually evaporates. This includes any water associated with an accidental release of radioactive material to the service waste system. Because such water would be present in extremely low concentrations and because it would be further diluted by mixing with the air into which it would evaporate, any increase in radioactivity over background would be undetectable by any presently known means for any creditable spill.

3. Solid Releases

All solid matter, both suspended particles and material precipitated out of solution as the water evaporates and the solution becomes more concentrated, remains on the bottom of the pond. The volume of this material will cover the bottom of the pond to a depth of less than one inch during the expected 25 year life of the pond. In fact, dirt and sand blown in by the wind can be expected to provide more material deposited in the pond than that brought in with the water.

4. Health and Safety Considerations

There are no significant health or safety hazards associated with this alternative. The pond is fenced to discourage access to the pond by unauthorized persons.

5. Effects on Wildlife

Properly built fences keep out all of the larger animals found in the area. Small animals, insects, and migratory aquatic birds are attracted to the pond. During winter and spring, since the water meets EPA standards for potable water, no harmful effects

result. The pond is normally shallow, and toward the end of summer is normally almost dry with a few scattered pools in low spots. These pools tend to have a high concentration of dissolved solids. This is a situation similar to hundreds of natural ponds and lakes in the desert portions of the United States, and one with which the birds are familiar.

This study did not address possible harmful effects to animal life in the event of a major accidental release due to a lack of data on frequency, composition of releases, and health effects on the various species. Such accidents have never been reported at the ICPP and, therefore, cannot be regarded as probable events.

A land area of approximately 2.6 square miles is required for the evaporation pond. This land is withdrawn from the habitat for native animals and birds.

6. Effect on Snake River System

The entire amount of water evaporated is lost from the Snake River aquifer system. This amounts to 2 to 4 million gallons per day or 2000 to 4000 acre/feet per year. While this is not large in comparison with the total evaporation losses from the Snake River system, it is an avoidable loss. Other alternatives are preferable from this point of view.

7. Environmental Effects During Construction

Effects during construction of the collection tank, pump station and pipeline are essentially the same as for Case CC-2. Large scale grading for the evaporation pond, while it is outside the normal work area of the CPP, generates dust which could be objectionable when the wind blows in the direction of the CPP process areas. The number of construction workers would be small and

should not add significantly to traffic loads. Operation of heavy construction equipment would be localized in the immediate vicinity of the evaporation pond, away from other facilities and main roads.

4.4.5 Institutional Considerations

Operation and maintenance procedures for the cooling water and steam condensate disposal system will be affected only by the addition of pumps and piping. Occasional surveillance of the pond area, for security and safety reasons, is required. At longer intervals (several years), there will be major maintenance on the pond; this will include repair of dikes, repair of fences and peripheral roadway, repairing the liner, etc.

4.5 CASE CC-5: DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO THE BIG LOST RIVER CHANNEL

4.5.1 Principal Features

The physical features of this case consist of the existing service waste drain system, a collection and surge tank and pump station, and a pipeline to the channel of Big Lost River at a point north of the CPP. The tank and pump station are located close to the existing injection well (CPP-304).

Figure 4.5-1 is a simplified block flow diagram of this system.

A plot plan is not included for this case.

Advantages and disadvantages of this alternative are summarized in Figure 4.5-2 which lists arguments "pro" and "con."

As in Cases CC-1, CC-2 and CC-3, the water ultimately returns to the water body in the aquifer. The significance of this case is that it is not necessary to build a percolation pond, and that it is a proven path of disposal. It is comparable with disposal to a percolation pond in these respects:

1. Water is introduced into the earth about 400 feet above the water table, instead of 150 to 250 feet as in Case CC-2 (shallow well). It is delivered above the upper aquitard layer so that it "perches" and spreads out laterally for a substantial distance (perhaps as much as a mile, although the exact extent is unknown without an extensive drilling survey).
2. Injection is spread over a large area instead of being concentrated in the very small area of the shallow injection well wall surfaces.

**ALTERNATIVE CC-5
DISPOSAL OF COOLING WATER AND STEAM CONDENSATES
TO THE BIG LOST RIVER CHANNEL**

FIGURE 4.5-1

ALTERNATIVE CC-5 DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO THE BIG LOST RIVER CHANNEL

PRO	CON
<ol style="list-style-type: none"> 1. Discharge Meets EPA Recommended Standards For Potable Water. 2. Bottom of River Bed, and Soil and Rock Layers Below, Provide Some Filter and Adsorption Capacity for Suspended and/or Dissolved Matter. 3. Only Major Construction Item is 1.3 - Mile Pipeline to River Bed. 	<ol style="list-style-type: none"> 1. Water Eventually Percolates to Water Table in Aquifer, Except for Portion Lost by Evaporation. 2. Possibility of Developing Perched Water Table Near Supply Wells. 3. Remote Possibility of Accidental Release of Radioactive Material to the Big Lost River Channel. 4. Danger of Causing Flooding as a Result of Ice Dams Built Up During Winter.

FIGURE 4.5-2

The combined effect of these two characteristics is to increase the volume of water being retained between the level of injection and the water table, as compared with the shallow well. This in turn means that the time delay before water drains to the water table is increased, and the volume of earth available for adsorption of heavy cations is correspondingly increased. These characteristics mean that protection against accidental discharges of radioactive material into the aquifer is greater than in Case CC-2.

4.5.2 Technical Aspects

The new features required for this alternative are:

1. A collection and surge tank and pump station adjacent to the existing injection well;
2. A pipeline to convey the water from the collection tank to the channel of Big Lost River at a point north from the CPP;
3. A structure in the river channel to discharge the water without eroding the river banks. A process flow diagram for this case (Drawing 475304-CC5-R-001) is included in Appendix "B".
4. A 24 inch diameter emergency overflow pipe connecting the surge tank with the existing injection well. This pipe provides for disposal of excess water entering the surge tank in the event of unplanned stoppage of the surge tank pumps. While this represents a direct discharge path to the aquifer, it would require the simultaneous failure of a process equipment barrier, the diverter system and the surge pumps to release any contamination.

The collection and surge tank is designed to hold 20 minutes accumulation of flows at the maximum rate of 2700 gpm or 54,000 gallons. This tank is underground, so that all flows into the tank are by gravity via the existing mains.

Two vertical pumps are provided, each with sufficient capacity for the entire flow. Discharge pressure is 100 psig.

The pipeline is carbon steel, 14 inches in diameter, standard schedule pipe. Total length is approximately 1.3 miles (the exact length would depend on the route finally chosen to the channel). The buried pipe is coated, wrapped, and cathodically protected to minimize external corrosion.

The distribution structure consists of a concrete lining, bottom and sides, for about 50 feet along the channel. The water from the CPP is introduced into the channel through a hole in the bottom of the concrete lining; that is, the pipe approaches the channel underground and turns upwards under the middle of the channel. This ensures that the water enters the channel below any ice which forms and that its velocity is dissipated within the concrete lined portion of the channel.

4.5.3 Cost Estimates

A cost estimate was not prepared for this case as it was removed from consideration for the reasons stated in Section 4.5.4, items 1 and 7.

4.5.4 Environmental Considerations

1. Liquid Releases

The Big Lost River channel, in this case, becomes an elongated percolation pond with advantages of longer retention time in the earth. There are, however, some additional considerations. First, the Big Lost River channel is much closer to the CPP water supply wells than is the location proposed for the artificial percolation pond. Thus, there is some likelihood of the percolated water being picked up in the supply wells before it had been

thoroughly mixed with and diluted by the main water body in the aquifer.

Second, in wintertime the water at the upstream and downstream extremities of the pool created in the channel will freeze, possibly creating a shallow dam across the channel. We visualize that the water could rise to the level of the dams and freeze some more. This process, repeated several times, could lead to the creation of a substantial dam across the channel by late winter. In the event of a sudden major thaw, this could result in flooding in the vicinity of the CPP and the TRA facilities.

2. Airborne Releases

The Big Lost River channel results in airborne releases by solar evaporation. Any radioactive water present as a result of a creditable accidental discharge is anticipated to be so small, and so diluted, that emissions from the pond would be undetectable compared to background levels.

3. Solid Releases

Any solid particles present in the water would become mixed with river bottom sediments. During periods of water flow in the river channel, these deposits would tend to become spread out over the downstream reaches of the channel and would become essentially indistinguishable from the native materials.

4. Health and Safety Considerations

There do not appear to be any significant health or safety hazards associated with this alternative. However, a decision would have to be made on whether to fence in the portion of the river channel in which the discharged water would remain on the surface.

5. Effects on Wildlife

Wildlife, both indigenous and migratory, would be attracted to the open water in the channel, just as they would if the water occurred naturally. Under normal conditions, since the water meets EPA standards for potable water, no harmful effects result. This study did not address possible harmful effects to such animal life in the event of a major accidental release due to a lack of data on frequency, composition of releases, and health effects on the various species. Such accidents have never been reported at the ICPP and, therefore, cannot be regarded as probable events.

6. Aesthetics

If the discharge point were established sufficiently far downstream from the highway bridge that the water did not "pond" back to the bridge, the water in the channel would not be visible to the casual passerby. Clear water in a river channel should not be objectionable aesthetically.

7. Environmental Effects During Construction and/or Modifications

Effects during construction of the collection pit and pump station are the same as for Case CC-2. The pipeline would have to be constructed through a busy and, in terms of existing underground piping, congested portion of the CPP. North of the CPP boundary, construction of the pipeline and discharge structure would impose minimal disturbance.

This case was eliminated from further consideration due to the potential flooding hazard, because it results in no improvement to aquifer water quality, and because it appears to have high capital cost requirements.

4.5.5 Institutional Considerations

Operation and maintenance procedures for the cooling water and steam condensate disposal system are compatible with those presently in use at the CPP. Occasional surveillance of the percolation area in the river channel is required. Use of the river channel may possibly impose additional constraints for legal reasons.

4.6 CASE CC-6: CIRCULATION OF COOLING WATER UTILIZING AN EVAPORATIVE COOLING TOWER

4.6.1 Principal Features

Alternative Cases CC-1 through CC-5 have in common that the cooling water is disposed of after being used once. Case CC-6 and Case CC-7 following, take a completely different approach; the cooling water is recirculated and reused. In Case CC-6 heat is dissipated to the air in an evaporative cooling tower.

There are additions to the circulating water stream from steam condensates, and there are withdrawals from the system by evaporation, wind drift and blowdown from the cooling tower. A makeup water line is available as needed. For disposing of excess water from the system there is a line leading to a solar evaporation pond.

Figure 4.6-1 is a simplified block flow diagram for alternative Case CC-6. Drawing 475304-P-CC-6 is a plot plan showing new facilities required for this case (Drawing 475304-P-CC-6).

Advantages and disadvantages of this alternative are summarized in Figure 4.6-3 which lists arguments "pro" and "con."

The significance of this case is that the recirculation feature virtually ensures that no objectionable material will enter the aquifer, even under the most remote accidental discharge conditions. It also has the effect of reducing the amount of water pumped from the supply wells, reducing the amount of water which must be softened, reducing the amount of salt required for softening, and reducing the volume of chemical wastes which must be disposed of.

ALTERNATIVE CC-6 RECIRCULATION OF COOLING WATER AND STEAM CONDENSATES UTILIZING AN EVAPORATIVE COOLING TOWER

FIGURE 4.6-1

ICPP INJECTION WELL ALTERNATIVES PROJECT	
FOR DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO	
ALTERNATIVE CC-6 RECIRCULATION OF COOLING WATER AND STEAM CONDENSATES UTILIZING AN EVAPORATIVE COOLING TOWER	
	PLOT PLAN 475304-P-CC-6

**ALTERNATIVE CC-6
RECIRCULATION OF COOLING WATER
AND STEAM CONDENSATES UTILIZING
AN EVAPORATIVE COOLING TOWER**

PRO	CON
1. Minimum Amount of Water Withdrawn From Aquifer.	1. Requires Solar Pond for Final Disposal of Excess Condensate.
2. Third Production Well not Required.	2. Disruption to Normal Traffic within CPP Operating Area During Construction Period.
3. Greatly Reduces Water Treatment Requirements.	3. Considerable Capital Cost.
4. Greatly Reduces Amount of Chemical Wastes to be Disposed of.	4. Wintertime Operation of Cooling Tower can Cause Operating Problems.
5. No Possibility of Accidental Release of Radioactive Material to Aquifer.	5. Drift from Cooling Tower can Cause Local Environmental Problems.
	6. Modest Increase in Cooling Water Temperature.
	7. Chemical Treatment (Chromates) for Cooling Water Loop.

FIGURE 4.6-3

4.6.2 Technical Aspects

The new features required for alternative Case CC-6 are:

1. A collection and surge tank and pump station located adjacent to the existing injection well;
2. An evaporative cooling tower located southeast of the proposed coal-fired boiler;
3. A pipeline to convey cooling water from the collection tank/pump station to the cooling tower;
4. A pump station adjacent to the cooling tower;
5. A pipeline to convey cooled water to Building 606, where it is connected to the discharge line from the ion exchange softeners;
6. A treated water line from the proposed coal-fired boiler plant to the cooling tower, for makeup to the circulation system;
7. A blowdown line, to convey cooling tower blowdown and/or excess system water to a disposal pond;
8. A lined solar evaporation pond, located at the southeast corner of the CPP facility, for disposal of cooling tower blowdown and/or excess water from the circulation loop; and
9. A 24 inch diameter emergency overflow pipe connecting the surge tank with the existing injection well. This pipe provides for disposal of excess water entering the surge tank in the event of unplanned stoppage of the surge tank pumps. While this represents a direct discharge path to the aquifer, it would require the simultaneous failure of a process equipment barrier, the diverter system, and the surge pumps to release any contamination.

10. Additional facilities for water treating and corrosion inhibiting.

The large volume of water in the once-through system prohibits more than minimal treating to prevent corrosion and scale formation. More water treatment is required for a recirculating cooling water system, however.

For the recirculating system, this study has considered the three leading cooling water treatment systems for prevention of corrosion: Chromate, nitrite/borate and organic phosphate. Flexibility in choosing an effective treatment was reduced by one of the ground rules of the study, namely, that 70 percent of the boiler condensates are dumped to the cooling water return line. Since these condensates are far in excess of the amount required for makeup to the cooling water loop, on an average basis, there is a blowdown to the loop of approximately 140 gpm. This means that within a few days after initial startup, the system will essentially be condensate. Condensate is well known for its corrosive properties which exceeds that of either untreated or softened water.

Of the three treatment systems, only organic phosphate is compatible enough with the environment that its ultimate discharge to an aquifer would be within primary and secondary effluent standards. Unfortunately, experience indicates that this treatment is ineffective with condensate.

For the recirculation system with cooling tower, the circulating water is aerobic and the nitrite/borate treatment is ineffective due to rapid oxidation of nitrite to nitrate. This leaves chromate as the only viable alternative. Concentration should be maintained at about 50 ppm. Disposal must not be to the aquifer, either directly or indirectly.

A process flow diagram for this system (Drawing 475304-CC6-R-001) is included in Appendix "B".

The collection and surge tank is designed to hold 20 minutes accumulation of flows at the maximum rate of 2700 gpm or 54,000 gallons. This tank is underground, so that all flows into it are by gravity via the existing mains.

Two vertical pumps are provided, each with sufficient capacity for the entire flow. These pumps have a discharge pressure of 85 psig.

The principal pipelines are carbon steel standard schedule pipe. The buried pipes are coated, wrapped, and cathodically protected to minimize external corrosion. The cooling tower supply line (Item 3 above) is 14 inches in diameter and approximately 7000 feet long.

The cooling towers are of the counter-flow, induced draft type. Two towers are provided, each capable of handling the entire thermal load (i.e., 100 percent installed spare). Thermal load was calculated on the basis of cooling 2700 gpm from 100°F to 72°F with 62°F wetbulb temperature. The cooling water supplied by this system will, therefore, be at 72°F instead of the present 65°F. This increase in temperature was reviewed with DOE and ENICO and found to be acceptable for cooling at the ICPP facilities.

The pump station alongside the cooling towers contains two pumps, each capable of handling the entire flow of 2700 gpm with a differential pressure of 190 psi.

The cooling tower discharge pipeline is 14 inches in diameter. It extends from the cooling tower, parallel to the supply pipeline as far as the collection tank, thence continuing parallel with the existing utility tunnel to Building 606. Calculated delivery pressure into the treated water distribution header is 90 psig.

The makeup line carries treated (i.e., softened) water from the proposed coal-fired boiler plant to the cooling tower basin.

The blowdown line branches off from the cooling tower discharge pipe near the pump discharge and runs to a solar evaporation pond beyond the southeast corner of the CPP. Specific sites have not been chosen for either the cooling tower or the pond, so the length of this pipe (4 inches diameter) is approximated 500 feet.

The solar evaporation pond has surface dimensions of 1700 by 3400 feet, and a surface area of 5,780,000 square feet (133 acres). It is oriented so that the long axis runs northwest/southeast; this orientation places the short axis in line with the prevailing winds (southwest, with northeast being second in frequency), thus minimizing erosion of pond banks by wave action. The pond has an overall depth of 5.1 feet; this allows for annual variations in evaporation rate (including the possibility of a cold wet year with little or no net evaporation), and a freeboard to contain wave action. The pond would be created by levelling the assigned site and using the material scraped off the surface to build up a peripheral berm or dike. The dike has a water barrier in it, since the water surface in the pond may be above the level of the surrounding land. The bottom of the pond is approximately level and is compacted. The pond has sides and bottom lined with 30 mil polyvinyl chloride (PVC). The liner is covered with a layer of earth to protect it against both mechanical damage and photodeterioration. PVC liners are reputed to have been in service in excess of 25 years when so protected. (A more complete discussion of solar ponds appears in Section 5.5.)

Use of a cooling water recirculation system with a cooling tower has important consequences for other parts of the CPP water supply and disposal system.

1. Among all of the alternative cases examined for disposal of cooling water and stream condensates, this alternative results in the minimum amount of water which must be withdrawn from the aquifer and subsequently disposed of. Makeup water to the circulation loop plus the boilers amounts to a maximum of approximately 200 gpm; annual average is approximately 176 gpm.

To this must be added makeup required by the water softeners and any other water system losses. This added makeup ranges from 20 to 100 gpm. Water must also be supplied to the CPP sanitary water system; this was not included in the present study and figures are not at hand. Total maximum withdrawal from the aquifer for this case is in the range of 200 to 300 gpm, plus sanitary system water. This compares with an estimated 1985 maximum rate of 3000 gpm for once-through cooling water systems.

The amount of withdrawal would be reduced still further if a higher percentage of the steam condensates were collected separately and returned to the boiler. This would also reduce the size of the evaporation pond required for ultimate disposal of the wastes. It would also reduce the use of treatment chemicals for the cooling water system and the boiler plant makeup.

2. The reduction in quantity of water required from the aquifer permits deletion of a proposed third supply well from the construction budget and schedule. The capital savings of this well are credited as an offset against the cost of implementing this alternative (Case CC-6).
3. Most of the water softening capacity is required for treatment of cooling water. Both the quantity of cooling water and the percentage of cooling water treated are projected to increase by 1985, to the point where up to 3000 gpm of water will have to be softened. With once-through cooling systems, this softened water is

lost. With this cooling water circulation system, demand for softened water is reduced to a maximum of 300 to 400 gpm as discussed in 1 above. This reduces the amount of salt required for regeneration of the softeners by more than 80 percent. Since salt water from regeneration of softeners is the major source of chemicals which must be disposed of (the others are cation exchangers, demineralizers, boiler blowdown, and cooling tower blowdown), the facilities for disposal of chemical wastes are estimated to be reduced at least 70 percent.

4.6.3 Cost Estimates

Capital and operating costs, over and above the base case, for this alternative have been estimated. A life cycle cost analysis has been prepared based on these estimates. Results are presented in Figures 4.6-4 and 4.6-5.

4.6.4 Environmental Features

1. Liquid Releases

In this case, there is no release of liquid to the earth and none of the waste water reaches the aquifer.

2. Airborne Releases

Water is taken into the air by three different mechanisms. First, between 2 and 3 percent of the circulating water flow evaporates in the cooling tower. Second, there is some wind drift from the cooling tower; this drift is normally negligible. Under average flow conditions (1400 gpm), evaporation from the cooling tower amounts to approximately 45 gpm. Third, water is evaporated from the surface of the lined solar pond. Under

ALTERNATIVE CC-6

Surge Tank	398,000
Piping	1,126,000
Lined Evaporation Pond	4,288,000
Cooling Tower and Water Treating Equipment	496,000

Direct Field Costs	6,308,000
Contractor Overhead and Profit	419,000
Engineering and Management	2,831,000
Contingency	<u>1,984,000</u>

Total Capital Cost \$11,542,000

Life Cycle Cost \$11,107,000

Figure 4.6-4

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CC-6

TITLE: COOLING WATER RECIRCULATION WITH COOLING TOWER

PART I

- Capital Cost = \$11,542,000
- O&M Cost = \$86,000/year (maint)-10,000 (chem) = \$76,000/year
- Energy: =
 - Electricity = \$2750 MBTU/year
 - Oil = 132 MBTU/year
- Economic Life = 20 years
- Residual Value = Zero
- Reinvestment Cost = Zero
- Capital Cost Foregone = [\$1,280,000]

PART II

- Present Value Capital Investment
 - \$11,542,000 - \$1,280,000 = \$10,262,000
- Present Value O&M
 - \$76,000 X 8.51 = \$646,760
- Present Value Energy
 - Electricity = 2750 MBTU X \$5.57/MBTU X 12.61 = \$193,154
 - Oil = 132 MBTU/year X \$4.36/MBTU X 9.4 = \$5410
- Total Present Value = \$11,107,324

Figure 4.6-5

maximum flow conditions, the total of these three flows is approximately 200 gpm, of which 100 are lost from the evaporation pond and 100 from the cooling tower. The actual flows vary considerably with system loading and weather conditions. With the cooling tower and the pond located southeast of the CPP complex, these airborne releases will not impinge on any CPP facilities except possibly during brief periods when the wind is out of the southeast.

All of the water discharged into the pond eventually evaporates, including any radioactive water which could be present as the result of an accidental release of radioactive material to the service waste system. Because of the infrequency and low concentrations associated with any creditable release and dilution, it is anticipated that no increase over background radiation would be detectable.

3. Solid Releases

Any solid particles in the circulating system eventually settle out in the collection tank, the cooling tower basin, or the evaporation pond. In no case are they discharged to the surroundings in an uncontrolled manner.

4. Health and Safety Considerations

There are no significant health or safety hazards associated with this alternative. The pond is fenced to discourage access by unauthorized persons.

5. Effects on Wildlife

Properly built fences keep out all of the larger animals found in the area. Small animals, insects and migratory aquatic birds

could still gain access to the pond. However, the high concentration of salts, including iron and chromium compounds will tend to make the pond unattractive. Such ponds are widely used in modern industrial plants.

This study did not address possible harmful effects to such animal life in the event of a major accidental release, due to a lack of data on frequency, composition of releases, and health effects on the various species. Such accidents have never been reported at the ICPP and, therefore, cannot be regarded as probable events.

A land area of approximately 140 acres is required for the evaporation pond, dikes, and peripheral roads. This land is withdrawn from the habitat for native animals and birds.

6. Aesthetics

The cooling tower is visible from some distance away, but is compatible with other structures in the vicinity. During periods of high relative humidity, a visible plume of condensed water droplets will form downstream from the tower which usually dissipates within a short distance. The solar evaporation pond is not highly visible except from the air and would present a pleasing appearance, except possibly in late summer, due to dry spots.

7. Environmental Effects During Construction

Construction activity extends from Building 606 on the north to the cooling tower and evaporation pond at the southeast extremity of the CPP area. Construction of the cooling tower and evaporation pond, while outside the normal work area of the CPP, may generate dust which could be objectionable if the wind were blowing in the direction of the CPP process areas. The number of construction

workers is small and does not add significantly to traffic loads. Heavy construction traffic is localized in the immediate vicinity of the evaporation pond, away from other facilities and main roads. It is not necessary to cut into any pipeline bearing radioactivity, so there is no hazard due to release of radioactive matter. However, in the CPP operating area, traffic and operations will be disrupted while the pipeline is being installed under existing roads.

8. Other Environmental Effects

Recirculation of the cooling water greatly reduces the amount of salt required for ion exchange water softener regeneration. The amount of salt which must be disposed of is correspondingly reduced; this reduces both the environmental effects and the economics of the chemical waste disposal alternatives which are discussed in Section 5.

4.6.5 Institutional Considerations

Significant additional operating and maintenance procedures are required for this case, as compared with the once-through cases. These new procedures are the direct result of adding new equipment (pumps, cooling tower, evaporation pond) and systems. These facilities are conventional in nature and of a type familiar to INEL personnel, so they pose no unusual demands on skills, nor do they present any unusual safety hazards.

4.7 CASE CC-7: CIRCULATION OF COOLING WATER UTILIZING A HEAT EXCHANGER
WITH AN INDEPENDENT COOLING WATER STREAM

4.7.1 Principal Features

Alternative Cases CC-1 through CC-5 have in common that the cooling water is disposed of after being used once. Case CC-6 and Case CC-7 take a completely different approach; the cooling water is recirculated and reused. In Case CC-7 heat is dissipated through a heat exchanger to an independent stream of cooling water which returns to the aquifer by way of the existing injection well.

There are additions to the circulating water from steam condensates, and there are withdrawals from the system to balance the flows. A makeup water line is available as needed. For disposing of excess water from the system, there is a line leading to a solar evaporation pond.

Figure 4.7-1 is a simplified block flow diagram for alternative Case CC-7. Drawing 475304-P-CC-7 is a plot plan showing new facilities required for this case.

Advantages and disadvantages of this alternative are summarized in Figure 4.7-3 which lists arguments "pro" and "con."

The significance of this alternative is that the recirculation feature virtually ensures that no objectionable material will enter the aquifer, even under the most remote accidental discharge conditions. It also has the effect of reducing the amount of water which must be softened, reducing the amount of salt required for softening, and reducing the volume of chemical wastes which must be disposed of.

ALTERNATIVE CC-7 RECIRCULATION OF COOLING WATER AND STEAM CONDENSATES UTILIZING A HEAT EXCHANGER WITH AN INDEPENDENT COOLING WATER STREAM

FIGURE 4.7-1

ICPP INJECTION WELL
ALTERNATIVES PROJECT

FOR
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

ALTERNATIVE CC-7
RECIRCULATION OF COOLING WATER AND
STEAM CONDENSATES UTILIZING A HEAT
EXCHANGER WITH AN INDEPENDENT
COOLING WATER STREAM

FLUOR

DATE
11/10/00

BY
M. CUTLER

SCALE
1"=100'-0"

PLOT PLAN

475304-P-CC-7 1

ALTERNATIVE CC-7
RECIRCULATION OF COOLING WATER
AND STEAM CONDENSATES UTILIZING A HEAT EXCHANGER
WITH AN INDEPENDENT COOLING WATER STREAM

PRO	CON
<ol style="list-style-type: none">1. Greatly Reduces Water Treatment Requirements.2. Greatly Reduces Amount of Chemical Wastes to be Disposed of.3. Negligible Possibility of Accidental Release of Radioactive Material to Aquifer.	<ol style="list-style-type: none">1. Considerable Increase of Pumping Cost as Compared with Present System.2. Disruption to Normal Traffic within CPP Operating Area During Construction Period.3. Considerable Capital Cost.4. Requires Solar Pond For Final Disposal of Excess Condensate

FIGURE 4.7-3

4.7.2 Technical Aspects

The new features required for alternative Case CC-7 are:

1. A collection and surge tank and pump station located adjacent to the existing injection well;
2. A heat exchanger located close to the pump station and existing injection well (CPP-304);
3. A pipeline to convey recirculated water from the pump station to the heat exchanger, and thence to Building 606, where it is connected to the discharge line from the water softeners;
4. A pipe to carry untreated well water from a connection with existing piping at or near Building 606 to the heat exchanger and thence to the existing injection well (CPP-304). This pipe is parallel with the circulating water pump discharge line (Item 3 above).
5. A makeup water line, to carry treated water from Building 606 to the collection tank when water is needed to charge the recirculation loop or make up for losses from the system;
6. A blowdown pipeline to carry excess and/or blowdown water from the pump station to a solar evaporation pond;
7. A lined solar evaporation pond, at the southeast corner of the CPP facility; and
8. Additional facilities for adding water treating and corrosion inhibitor to the circulation loop.

The large volume of water in the present once-through system prohibits more than minimal treating to prevent corrosion and scale formation. More water treatment is required for a recirculating cooling water system, however.

For the recirculating system, this study has considered the three leading cooling water treatment systems for prevention of corrosion: Chromate, nitrite/borate and organic phosphate. Flexibility in choosing an effective treatment was reduced by one of the ground rules of the study, namely, that 70 percent of the boiler condensates are dumped to the cooling water return line. These condensates are far in excess of the amount required for makeup to the cooling water loop on an average basis, there is a blowdown to the loop of approximately 140 gpm. This means that within a few days after initial startup, the system will essentially be condensate. Condensate is well known for its corrosive properties which exceeds that of either untreated or softened water.

Of the three treatment systems, only organic phosphate is compatible enough with the environment that its ultimate discharge to an aquifer would be within primary and secondary effluent standards. Unfortunately, experience indicates that this treatment is ineffective with condensate.

For the recirculation system with heat exchanger in which the circulating water is anaerobic, either the nitrite/borate treatment or the chromate treatment will provide the necessary protection. Concentration of chromate required is in the range of 200 to 250 ppm, or approximately five times as much as in an aerobic system. Concentration of nitrite/borate required is approximately 500 ppm, or double that of chromate. For this reason, it was decided to base the cost estimates on chromate treatment. Disposal of the chromate-bearing waste must not be to the aquifer, either directly or indirectly.

A process flow diagram for this case (Drawing 475304-CC7-R-001) is included in Appendix "B".

The collection and surge tank is designed to hold 20 minutes accumulation of flows at the maximum rate of 2700 gpm or 54,000 gallons. This tank is underground, so that all flows into the tank are by gravity via the existing mains.

There is a 24 inch diameter emergency overflow pipe connecting the surge tank with the existing injection well. This provides for disposal of excess water entering the surge tank in the event of unplanned stoppage of the surge tank pumps. While this represents a direct discharge path to the aquifer, it would require the simultaneous failure of a process equipment barrier, the diverter system, and the surge pumps to release any contamination.

Two vertical pumps are provided, each with sufficient capacity for the entire flow. These pumps have a discharge pressure of 160 psig.

The principal pipelines are carbon steel, 14 inches in diameter, standard schedule pipe. The circulating water pump discharge line (Item 3 above) is approximately 1000 feet long. The independent cooling water pipe (Item 7 above) is approximately 1200 feet long. These buried pipes are coated, wrapped and cathodically protected to minimize external corrosion.

A plate type exchanger has been selected for the main system heat exchanger service. It is designed to cool 1,350,000 lb/hr of treated cooling water from 100°F to 72°F while warming a 1,512,000 lb/hr stream of "raw" (untreated) well water from 65°F to 90°F. Heat transfer duty is 37,800,000 Btu/hr. As in Case CC-6, the cooling water supply will be 72°F instead of the present 65°F. With DOE/ENICO concurrent, it was assumed to have no impact on water requirements.

The makeup line carries treated (i.e., softened) water. It is a 6 inch diameter carbon steel pipe, 1000 feet long, running parallel to the two 14 inch pipes from Building 606 to the collection tank.

The blowdown line branches off from the circulation pump discharge line downstream from the circulation pumps. It is approximately 4000 feet long and is made of carbon steel pipe, externally coated to inhibit corrosion. It is buried and runs parallel with the existing (as of 1985) utility tunnel as far as the coal-fire boiler plant.

The solar evaporation pond has surface dimensions of 2130 by 4260 feet and a surface area of 9,074,000 square feet (209 acres). It is oriented so that the long axis runs northwest/southeast; this orientation places the short axis in line with the prevailing winds (southwest, with northeast being second in frequency), thus minimizing erosion of pond banks by wave action. The pond has an overall depth of 5.1 feet; this allows for annual variations in evaporation rate (including the possibility of a cold wet year with little or no net evaporation), and a freeboard to contain wave action. The pond is created by levelling the assigned site and using the material scraped off the surface to build up a peripheral berm or dike. The bottom of the pond is approximately level and is compacted. The pond has sides and bottom lined with a thin membrane made of 30 mil polyvinyl chloride (PVC). The liner is covered with a layer of earth to protect it against both mechanical damage and photodeterioration. PVC liners are reputed to have been in service in excess of 25 years when so protected. (A more complete discussion of solar ponds appears in Section 5.5.)

Use of a cooling water recirculation system with a heat exchanger has important consequences for other parts of the CPP water supply and disposal system.

1. Most of the water softening capacity is required for treatment of cooling water. Both the quantity of cooling water and the percent-

age of cooling water treated are projected to increase by 1985, to the point where up to 3000 gpm of water must be softened. With once-through cooling systems, this softened water is lost. With this cooling water circulation system, demand for softened water is reduced to a maximum of 300 to 400 gpm. This reduces the amount of salt required for regeneration of the softeners by 90 percent. Since salt water from regeneration of softeners is the major, though not the only, source of chemicals which must be disposed of (the others are cation exchangers, demineralizers, and boiler blowdown), the facilities for disposal of chemical wastes are reduced at least 70 percent.

4.7.3 Cost Estimates

Capital and operating costs, over and above the base case, for this alternative have been estimated. A life cycle cost analysis has been prepared based on these estimates. Results are presented in Figures 4.7-4 and 4.7-5.

4.7.4 Environmental Features

1. Liquid Releases

The only liquid release to the surroundings from this system is untreated well water. It is heated from 65°F to about 90°F, but is otherwise unchanged. This water is returned to the aquifer by discharge down the existing injection well (CPP-304). Because simultaneous multiple independent failures would be required, we believe that there is not credible path for release of objectionable materials to the aquifer.

2. Airborne Releases

Airborne releases from this system are limited to evaporation from the solar pond. All of the water discharged into the pond

ALTERNATIVE CC-7

Surge Tank	400,000
Piping	558,000
Lined Evaporation Pond	5,912,000
Heat Exchanger and Water Treating Equipment	82,000

Direct Field Costs	6,952,000
Contractor Overhead and Profit	221,000
Engineering and Management	2,659,000
Contingency	<u>2,116,000</u>

Total Capital Cost	\$11,948,000
--------------------	--------------

Life Cycle Cost	\$14,504,000
-----------------	--------------

Figure 4.7-4

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CC-7

TITLE: COOLING WATER RECIRCULATION WITH HEAT EXCHANGER

PART I

- Capital Cost = \$11,948,000
- O&M Cost = \$58,500/yr (maint) + 148,278 (chem) = \$206,778/yr
- Energy:
 - Electricity = 5110 MBTU/year
 - Oil = 132 MBTU/year
- Economic Life = 20 years
- Residual Value = Zero
- Reinvestment Cost = Zero
- Capital Costs Foregone = [\$550,000]

PART II

- Present Value Capital Investment
 - \$11,948,000 - \$550,000 = \$11,398,000
- Present Value O&M
 - \$206,778 X 8.51 = \$1,759,681
- Present Value Energy
 - Electricity = 5110 MBTU X \$5.57/MBTU X 12.61 = \$358,915
 - Oil = 132 MBTU X 4.36/MBTU X 9.4 = \$5,410
- Total Present Value = \$13,522,006

Figure 4.7-5

eventually evaporates, including any radioactive water which would be present as the result of an accidental release of radioactive material to the service waste system. Because such material would be present in extremely low concentrations and because it would be further diluted by mixing with the air into which it would evaporate, the increase in radioactivity over background radiation would be undetectable for any creditable release.

3. Solid Releases

Any solid particles in the circulating system eventually settle out in the collection tank or the evaporation pond. In no case are they discharged to the surroundings in an uncontrolled manner.

4. Health and Safety Considerations

There are no significant health or safety hazards associated with this alternative. The pond is fenced to discourage access to the pond by unauthorized persons.

5. Effects on Wildlife

Properly built fences keep out all of the larger animals found in the area. Small animals, insects, and migratory aquatic birds would still have access to the pond. However, the high concentration of salts, including iron and chromium compounds, will tend to make the pond unattractive. Such ponds are widely used in modern industrial plants.

This study did not address possible harmful effects to animal life in the event of a major accidental release due to a lack of data on frequency, composition of releases, and health effects on the various species. Such accidents have never occurred at the ICPP and, therefore, cannot be regarded as probable events.

A land area of approximately 220 acres is required for the evaporation pond, dikes and peripheral road. This land is withdrawn from the habitat for native animals and birds.

6. Aesthetics

The solar evaporation pond is not highly visible except from the air and would present a pleasing appearance, except possibly in late summer, due to dry spots.

7. Environmental Effects During Construction

Construction activity extends from Building 606 on the north to the evaporation pond at the southeast extremity of the CPP area. Construction of the evaporation pond, while outside the normal work area of the CPP, may generate dust which could be objectionable if the wind were blowing in the direction of the CPP process areas. The number of construction workers is small and does not add significantly to traffic loads. Heavy construction traffic is localized in the immediate vicinity of the evaporation pond, away from other facilities and main roads. It is not necessary to cut into any pipelines bearing radioactivity, so there is no hazard due to release of radioactive matter.

However, in the CPP operating area, traffic and operations will be disrupted while the pipeline is installed under existing roads.

8. Other Environmental Effects

Recirculation of the cooling water greatly reduces the amount of salt required for ion exchange water softener regeneration. The amount of salt which must be disposed of is correspondingly

reduced; this reduces both the environmental effects and the economics of the chemical waste disposal alternatives which are discussed in Section 5.

4.7.5 Institutional Considerations

Significant additional operating and maintenance procedures are required for this case, as compared with the once-through cases. These new procedures are the direct result of adding new equipment (pumps, heat exchanger, evaporation pond) and systems. These facilities are conventional in nature and of a type familiar to INEL personnel, so they pose no unusual demands on skills, nor do they present any unusual safety hazards.

ALTERNATIVE MEANS FOR DISPOSAL OF CHEMICAL WASTES

5.0 INTRODUCTION

Chemical wastes from the ICPP originate primarily in three places.

First, ion exchange water softeners in Building CPP-606 require sodium chloride for regeneration. Current consumption of salt is about 260 tons per year. By 1985, because of both an expected increase in the total amount of water used and an increase in the percentage of total water to be softened, salt consumption is expected to increase to approximately 1500 tons per year. This salt, plus the minerals removed from the water by the ion exchange units, must be disposed of. In addition to wastes from the softeners, there are acid and chemical wastes from the hydrogen/cation exchanger and the demineralizer in the boiler feedwater treatment circuit.

The second class of chemicals appearing in the waste stream originates in the chemical laboratories (Buildings 602, 627 and 637). The quantity is small compared with the water treatment wastes.

The third class of chemical wastes comes from boiler blowdown. This typically amounts to about 10 percent of boiler makeup water and contains 950 ppm of dissolved solids by weight. Chemicals present in the boiler water are those not removed during the feedwater treatment process, plus treatment chemicals added for pH adjustment and to inhibit corrosion.

Current (1980) practice is to allow these wastes to mingle with the cooling water and steam condensate streams in a common service drain system. Together, they are discharged down the existing injection well to the same aquifer from which the water was withdrawn initially.

For purposes of examination of the various alternatives for disposing of the chemical wastes, they are treated in Section 5 of this report as though they were collected and disposed of independently from the other waste streams. Piping present in 1980, plus piping which is planned to be installed by 1985, is used as required in the various cases. Items listed and described as "new" on drawings and in the text are to be understood as reflecting requirements above those existing in 1985 for the specific case being discussed.

Seven alternative cases were examined. These have been identified with the initials "CH" (for chemical wastes), followed by a serial number. The cases studied are:

- CH-1 Disposal of Chemical Wastes to Existing Injection Well
- CH-2 Disposal of Chemical Wastes to an Evaporative Concentrator
- CH-3 Disposal of Chemical Wastes Using Reverse Osmosis as a Concentrator
- CH-4 Disposal of Chemical Wastes by Means of a Dryer
- CH-5 Disposal of Chemical Wastes to a Solar Evaporation Pond
- CH-6 Disposal of Chemical Wastes to a Percolation Pond or a Shallow Well
- CH-7 Disposal of Chemical Wastes by Deep Well Injection

All of these cases were in the original scope of work.

For 1985 conditions the peak flow of chemical waste waters has been estimated at 76,000 gpd. This number is used in sizing pumps, piping, etc. Average flows, on an annual basis, are estimated at 75 percent of the peak. This is used in sizing the solar evaporation pond and for estimating annual costs. Salinity of the chemical waste waters is estimated at 18,000 ppm tds, or 1.8 percent dissolved ions by weight.

A breakdown of the several sources of chemical waste waters is presented in Table 5.0-1. Chemical usage and waste water produced per 1000 gallons of water treated, for each item of water treatment equipment, are presented in Table 5.0-2.

CHEMICAL WASTE PRODUCTION

BASES: PEAK DEMAND IN 1985
 PROCESS STEAM USAGE - 120,000 lb/hr
 DEMINERALIZED WATER - 22 gpm
 PROCESS TREATED WATER - 2,100 gpm

	<u>Softener Reg. Waste</u>	<u>H-Cation Exch. Reg. Waste</u>	<u>Demin. Reg. Waste</u>	<u>Boiler Blowdown</u>	<u>Total Chemical Waste</u>
<u>Items</u>	<u>lbs/day</u>	<u>lbs/day</u>	<u>lbs/day</u>	<u>lbs/day</u>	<u>lbs/day</u>
Ca	1,190	-	-	-	1,190
Mg	358	-	-	-	358
Na & K	1,883	190	56	66	2,195
SO ₄	7	665	226	57	955
Cl	6,070	-	5	26	6,101
PO ₄	-	-	-	6	6
SiO ₂	<u>7</u>	<u>-</u>	<u>6</u>	<u>47</u>	<u>60</u>
Total	9,515	855	293	202	10,865
10 ³ gal/day	41.7*	4.0*	3.4*	26.8	75.9*
TDS ppm	28,000	26,000	10,500	950	17,200

*Backwash water has not been counted. The total wastewater by the backwash of all resin beds is 26,000 gals/day which is routed to the service waste system in alternative cases.

Table 5.0-1

BASES OF CHEMICAL WASTE PRODUCTION

<u>Chemical Usage</u>	<u>Chemicals</u>	<u>Usage</u> <u>lbs/1000 gals Treated</u>
Softeners	Salt	3
H-Cation Exch.	93% H ₂ SO ₄	2.4
Neutralization	100% NaOH	0.25
Demineralizer(*)	93% H ₂ SO ₄	7.6
	100% NaOH	2.7
Boiler	Sodium Sulfite	0.009 lb/1000 lbs. steam
	Phosphate	0.009 lb/1000 lbs. steam

<u>Waste Production Rate</u>	<u>Wastewater</u> <u>gals/1000 gals Treated</u>
Softeners	
Backwash	7.0
Chemical and Rinse	<u>12.5</u>
	19.5
H-Cation Exchanger	
Backwash	7.0
Chemical and Rinse	<u>13.0</u>
	20.0
Demineralizer(*)	
Backwash	18.0
Chemical and Rinse	<u>127.0</u>
	136.0
Boiler Blowdown	10% of makeup

(*)New Two-Bed Demineralizer

Table 5.0-2

In addition to the foregoing, the following assumptions were made in developing the analysis of each case (there are certain exceptions in Case CH-1, as noted therein):

1. All the expanded water treating facilities in 1985 will be located in CPP-606; therefore, the coal-fired boiler will receive completely treated water, and no water treating facilities will be in the coal-fired boiler house.
2. Existing waste water drainage piping in CPP-606 is adequate for collecting the chemical waste.
3. A utility tunnel between CPP-606 and the coal-fired boiler house will be installed for accommodating steam and other utility lines prior to 1985, and the 4-inch chemical waste transfer line will run through this utility tunnel.
4. The coal-fired steam generation system includes a blowdown tank from which the blowdown can be pumped. No blowdown collection tank is provided in this study.
5. No oily contaminant enters into the chemical waste collection system.

5.1 ALTERNATIVE CASE 5.1: DISPOSAL OF CHEMICAL WASTES TO EXISTING INJECTION WELL

5.1.1 Principal Features

This case examines the implications of continuing to discharge chemical wastes down the existing injection well, but without the dilution inherent in mingling them with the cooling water and steam condensates. Disposal of fully diluted wastes, which is the actual "present practice," is treated as a "Combined Case" in Section 7.

Figure 5.1-1 is a simplified block flow diagram for this case. Flow in this system is currently by gravity. It is assumed that the coal-fired boiler plant blowdown will have to be pumped, so a pump is shown in the diagram for that purpose.

Advantages and disadvantages of this alternative are summarized in Figure 5.1-2 which lists arguments "pro" and "con."

This case, while hypothetical, is the simplest possibility and serves as a "baseline" for comparison of other cases.

5.1.2 Technical Aspects

There do not appear to be any technical impediments to disposing of the chemical wastes down the existing injection well.

The flow is acidic because of the sulfuric acid used for regeneration of the hydrogen-cation exchanger. Since this acid would still remain after dilution, it may be thought desirable to neutralize it by addition of an alkaline material. However, for the purposes of this study, no provision was made for such treatment. This case was evaluated on an existing practice basis.

ALTERNATIVE CH-1 DISPOSAL OF CHEMICAL WASTES TO EXISTING INJECTION WELL

FIGURE 5.1-1

**ALTERNATIVE CH-1
DISPOSAL OF CHEMICAL WASTES TO
EXISTING INJECTION WELL**

PROS	CONS
1. Moderate Capital Costs.	1. Degrading Water Quality of of Upper Aquifer.
2. Minimum Operating Costs.	a) 5 Tons of Salt Per Day is Disposed to Aquifer.
	b) Chemical Waste Stream Approximately 20,000 PPM.
	2. No Dilution of Wastes Provided.

FIGURE 5.1-2

5.1.3 Cost Estimates

This case as defined requires no capital expenditure and no operating cost beyond that already incurred by the CPP. The "baseline" cost of this alternative is, therefore, "zero."

5.1.4 Environmental Features

1. Liquid Releases

The environmental feature of this alternative is that it disposes of five tons of salt per day to the aquifer.

2. Airborne and Solid Releases

There are no airborne or solid releases associated with this alternative.

3. Health and Safety Considerations

There is no health or safety hazard to onsite persons. During migration of the salts through the aquifer, the salts gradually mix with the water in the aquifer but move as a recognizable body for an undetermined distance from the point of injection. No attempt has been made, as part of this study, to estimate the extent of this mixing by the time the discharge "plume" would reach the CPP boundaries.

4. Effects on Wildlife

There would be no effects on local wildlife, since the waste never appears at the surface of the ground.

5.1.5 Institutional Considerations

This alternative would not require any institutional changes.

5.2 CASE CH-2: DISPOSAL OF CHEMICAL WASTES TO AN EVAPORATIVE CONCENTRATOR

5.2.1 Principal Features

The chemical wastes are collected from CPP-606, the coal-fired boiler area and other process areas, and are fed to a waste evaporative concentrator evaporator. The evaporator can concentrate the feed at least 16 times; in other words, the concentrate volume from the evaporator is one-sixteenth of the feed volume. The condensate from the evaporator (TDS less than 5 ppm) is recycled to the coal-fired boiler feedwater; this reduces the amount of feedwater treatment required and, therefore, reduces the amount of chemical waste which must be disposed of. The chemical waste feed rate to the evaporator is 68,500 gallons per day at the peak demand of the treated water (see Table 5.0-1). The concentrate is disposed to a lined solar evaporation pond or to a spray dryer.

Figure 5.2-1 is a simplified block flow diagram for this case. Drawing 475304-P-CH-2 is a plot plan showing all new features required for this case.

Advantages and disadvantages of alternative CH-2 are summarized in Figure 5.2-3 which lists arguments "pro" and "con."

The significance of this alternative is that it provides a means for disposing of chemical wastes without any objectionable material reaching the aquifer.

5.2.2 Technical Aspects

1. General

This case breaks down into a number of subcases. First, two different types of evaporative concentrators, with different

ALTERNATIVE CH-2 DISPOSAL OF CHEMICAL WASTES TO AN EVAPORATIVE CONCENTRATOR

FIGURE 5.2-1

ICPP INJECTION WELL ALTERNATIVES PROJECT	
FOR DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO	
ALTERNATIVE CH-2 DISPOSAL OF CHEMICAL WASTES TO AN EVAPORATIVE CONCENTRATOR	
	PLOT PLAN 475304-P-CH-2

**ALTERNATIVE CH-2
DISPOSAL OF CHEMICAL WASTES
TO AN EVAPORATIVE CONCENTRATOR**

PROS	CONS
<ol style="list-style-type: none">1. Technically Feasible.2. Commercially Proven.3. Minimum or No Environmental Impact.4. Small Plot Area Required.5. Simplicity of Operation.6. Credit by Evaporator Condensate Recovery to Boiler Feed Water.7. Reduces Chemical Wastes to Small Volume.8. Reduces Contamination To Aquifer.	<ol style="list-style-type: none">1. High Capital Cost.2. Energy Cost \$50,000/Year.

FIGURE 5.2-3

characteristics, were examined. Second, there were six possible destinations for the evaporator condensate. Third, there were four possible methods for disposal of the brine concentrate. All of these are examined in the subsections following.

The recommended configuration for this case is: (a) a waste concentrator operating on the vapor compression cycle; (b) return of the evaporator condensate to the boiler feed system for boiler makeup; and (c) use of a solar evaporation pond for final disposal of the brine concentrate.

A process flow diagram reflecting these choices appears in Appendix "B". This process flow diagram is on two sheets, Drawings 475304-CH2-4-001 and 002. The 001 drawing shows the existing (as of 1985) piping in the CPP, together with those modifications to the piping which are required for Case CH-2. The 002 drawing shows those facilities which are totally new for Case CH-2.

All of the added facilities for this alternative are current technology. There are no exotic or unproven items.

2. Collection of Chemical Waste Streams

Chemical waste streams from CPP-606 are drained through the existing drainage system to a new collection sump. The CPP-606 chemical waste includes wastewater streams discharged from the various ion exchangers (sodium zeolite softeners, hydrogen-cation exchangers and demineralizer) during regeneration and rinse steps and blowdown of the present oil-fired boilers, if they should be operated to supplement the coal-fired boiler during periods of peak steam demand.

Backwash water streams from the ion exchangers are segregated from the chemical waste by new piping and routed to the service waste system outside CPP-606 for disposal with the cooling water.

The CPP-606 waste requires neutralization because it has excess sulfuric acid.

After neutralization, the CPP-606 chemical waste is pumped to a rubber-lined evaporator feed tank near the coal-fired boiler. The transfer line runs through the utility tunnel all the way to the coal-fired boiler house. The blowdown from the coal-fired boilers is pumped out from the existing blowdown tank and sent to the same evaporator feed tank.

3. Selection of Evaporative Concentrator

The two kinds of evaporative concentrators which are most applicable to high salinity wastewater are mechanical vapor-compression and multiple effect. The former is specifically designed as a waste concentrator, while the latter is intended primarily for use as a crystallizer (i.e., the solid has economic value rather than being a waste) but can be adapted for use as a waste concentrator. One commercially available example of each kind was examined.

The brine concentrator achieves scale-free operation by "seeding" the brine with calcium sulfate crystals. Any scale-forming materials (typically, calcium sulfate and silica) tend to precipitate on the seed particles rather than depositing on the heat transfer surface. The slurry is recycled continuously from the sump at the bottom of the evaporator, back to the top of the bundle. It falls down the tubes forming a thin film on the tube walls. The evaporated vapor is compressed about 2 psi by a vapor compressor in order to get the necessary temperature difference (about 11°F) across the heat transfer surface. By this vapor compression cycle, the brine concentrator achieves a high thermodynamic efficiency; energy input is 98 kwh for each 1000 gallons

processed. The brine concentrator evaporator tubes and feed heat exchanger are constructed of titanium, and its sump, evaporator shell and piping are made of 316L stainless steel. It produces a high quality condensate normally having less than 5 ppm TDS.

The evaporative crystallizer is usually used for producing chemical crystals. The feed can be concentrated up to 25 to 30 percent solid-slurry in the crystallizer. The concentrated slurry is sent to a centrifuge crystal separator. The centrifuge continuously produces wet crystals with 7 percent or less moisture for final drying (in this case, for final disposal) and the concentrated solution (mother liquor) from the centrifuge is returned to the crystallizer for further concentration. The condensate produced from the crystallizer would be of high quality, having less than 10 ppm TDS.

The crystallizer maintains a suspension of crystals by recirculation through its exchanger in order to keep supersaturation in all parts of the crystallizer below the limits required for spontaneous nucleus formation. Although this increases operating time between cleanouts as compared with unseeded brine, frequent heat-exchanger tube cleaning is still expected. Typically, chemical cleaning by acid is required once every 10 days and mechanical cleaning by water pulsation is required once every 6 months for the first effect evaporator. The second and third effect evaporators require cleaning less frequently. Consequently, the crystallizer produces another chemical waste (i.e., the chemicals required for cleaning).

Figure 5.2-4 presents a comparison between the brine concentrator and the evaporative crystallizer. The brine concentrator has higher capital investment but requires lower operating costs and infrequent cleaning. The crystallizer has lower capital cost but

COMPARISON OF PROCESS WASTE EVAPORATOR

	<u>Brine Concentrator</u>	<u>Evaporative Crystallizer</u>
Supplier	Resources Conservation Company (RCC)	Struthers Scientific and International Company
Description	Vertical Tube, Seed- Slurry Scale-Preventing Evaporator with Mechan- ical Vapor Compression	Triple-Effect, Thermo- compression Evaporator with Slurry Circulation
Concentration Ability	16 times	To Crystal
Final Disposal of Concentrate	Evaporation Pond and Land Fill as Dry Solids	Land Fill as Wet Solids
Concentrate for Final Disposal	5000 gals/day	Neg.
Disposal Land Req.	2 by 250,000 sq. ft.	Neg.
Fouling Problem	No	Very Severe
Maintenance	No Special Exchanger Tube Cleaning Required	Frequent Exchanger Tube Cleaning Required Chemical - Once every 10 days Mechanical - Once every 6 months
Miscellaneous		Produce Other Waste Chemical Waste by Chemical Cleaning Cooling Water Waste 875 gpm

Figure 5.2-4 (Sheet 1)

COMPARISON OF PROCESS WASTE EVAPORATOR (Continued)

	<u>Brine Concentrator</u>	<u>Evaporative Crystallizer</u>
<u>Utility Requirement</u> ⁽¹⁾		
Electric Power	260 kw	52 kw
150 psig Steam		7,700 lbs/hr
Cooling Water		875 gpm
<u>Operating Labor, Man-hr/day</u>	3	26
<u>Operating Cost, \$/yr</u>		
Electric Power	35,000	7,200
150 psig Steam	-	455,300
Cooling Water	-	29,500
<u>Capital Cost, \$</u>		
Process Evaporator	2,200,000	400,000
Solar Evaporation Pond	120,000	-

NOTES

(1) Based on 68,000 gals/day of chemical waste feed.

has higher operating costs and requires frequent cleaning. The brine concentrator has been selected for the evaporation of chemical waste because its higher capital cost is compensated by the lower operating cost and the better maintenance performance.

4. Description of Vapor-Compression Waste Concentrator

The collected chemical waste in the feed tank is continuously agitated in order to keep the evaporator feed well mixed.

The chemical waste is trim-conditioned at a pH of 5 to 5.5 by adding either sulfuric acid or caustic soda (depending on the pH of the water arriving at that point at any particular time) before feeding to the deaerator. The feed is then pumped through the feed/condensate heat exchanger. This heat exchanger brings the feed temperature to near its atmospheric boiling point by recovering the sensible heat contained in the hot condensate stream from the evaporator. The heated feed then enters the counterflow, packed column deaerator that strips the carbon dioxide, nitrogen and oxygen. The pH returns to neutral during this operation. The stripping steam and the noncondensable gases are vented to the atmosphere (the stripping steam is supplied as a bleed from the evaporator). After leaving the deaerator, the feed enters the evaporator sump at its boiling temperature. The feed is mixed with the concentrate slurry in the sump and is continuously recirculated to the top of the evaporator. There it is distributed to the inside wall of each tube as a thin film. As the thin film falls down the inside of the tubes, water is evaporated. This vapor passes through a mist eliminator before entering the compressor suction line. The liquid-free vapor then enters the compressor where it is compressed about 2 psi. This pressure increase causes the condensation temperature of the steam to be raised about 11°F above the boiling point of the

recirculating brine. As this steam gives up its heat of condensation, it condenses on the shell side of the tubes and is collected in the product tank. The heat of condensation is transferred through the evaporator tube walls to the falling brine, thus effectively recirculating the latent heat of vaporization. The energy input to the system is supplied by the compressor.

The feed is concentrated about 16 times in the evaporator. The concentrated chemical waste, having about 26 percent dissolved solids and 3.4 percent suspended solids, must be disposed of to a lined solar evaporation pond or by some other means.

The vapor compression brine concentrator is commercially available and has been successfully used in utility service for many years. They are simple to operate.

5. Alternative Means for Disposal of Condensate

Several options for the destination of evaporator condensate are available: injection well disposal, steam generation system makeup, cooling water system makeup, process makeup, fuel element storage basin water makeups, and/or atmospheric disposal of water vapor.

Brine concentrators of the vapor compression type are capable of producing condensate with a purity range below 5 ppm TDS while total hardness ranges below 3 ppm. This high quality makes the condensate desirable for boiler feed makeup. Since the brine concentrator would be located adjacent to the coal-fired boiler, the concentrator condensate could be returned to the boiler feed system with minimum piping. This would reduce the requirements for feedwater treatment chemicals and equipment which partially offsets the cost of the system and was taken as a credit for this alternative.

Disposal to the injection well, atmospheric disposal of water vapor and mingling with the cooling water are also feasible, but are economically less beneficial than use as boiler makeup. Process makeup and/or fuel storage basin makeup do not require sufficient water to warrant the extra investment for distribution.

6. Alternative Means for Disposal of Concentrated Brine

Five means for disposal of the concentrated brine from the brine concentrator were examined:

- a. Solar evaporation pond
- b. Percolation pond
- c. Deep well injection
- d. Fluidized bed dryer
- e. Spray dryer

The first four of these were in the original study plan. The spray dryer was added as an alternative to the fluidized bed dryer when it became evident that the latter is not suited to the service.

In a solar evaporation pond, the free water is evaporated into the air leaving the salts behind in the pond. The concentrate, having 3 to 5 percent suspended solids (calcium sulfate and silica), tends to clog the transfer line; therefore, the line should be flushed with fresh water whenever the process evaporator is shut down.

The solar evaporation pond is lined with a PVC liner, covered with earth and fenced with steel chain link fence to prevent access by large animals and unauthorized persons.

The solar evaporation pond has an evaporation surface of 184,000 square feet (4.2 acres) with a pond depth of 8.3 feet. Land should be reserved for constructing the next pond near the first pond. The first evaporation pond, after being out of service, will be completely dried out within two or three years. Assuming a twenty-year life time for the solar evaporation pond, the amount of dried chemical residue in the out-of-service pond will be approximately 27,000 tons, of which 70 percent is sodium chloride.

Use of a percolation pond is not recommended because the concentrated salts stay in solution and percolate to the aquifer.

Use of a deep well (i.e., into the rhyolite formations underlying the sedimentary and basaltic strata) is not a reliable way of disposing of chemical wastes because of the possibility of precipitated solids to clog the fine openings in the rock, thereby inhibiting percolation. Therefore, this option was dropped from further consideration. (See also Case CH-7, Section 5.7.)

In a fluidized bed dryer, hot air or combustion gases are blown upward through a "grate"; typically, the "grate" may be a bed of porous or granular material such as gravel. The material being dried is introduced above the grate and is kept in suspension by the upward flow of air. Fluidized bed dryers are intended for final drying of material which is already in solid particulate form. They might be made to work with brines, but this is not done on a regular commercial basis, especially with high sodium brines. Accordingly, fluidized bed dryers are not recommended for disposal of brines. (See also Case CH-4, Section 5.4.)

Evaporative equipment intended for recovery of solids from a liquid stream is available in the form of spray or "flash" dryers. In spray dryers, the liquid is sprayed into a hot gas stream. The dryer is

operated in a manner which ensures that the water is evaporated before the droplets reach the floor of the dryer. Any dissolved solids present in the brine will precipitate out and be carried away in the hot air stream. They are separated from the hot air stream in a centrifugal separator. Like the fluidized bed dryer, the spray dryer is intended for recovery of a valuable solid product from a burden of water. It could be used for reducing a liquid waste to a solid residue, as proposed here.

5.2.3 Cost Estimates

Estimates of capital and life cycle costs were made for two subcases. Case CH-2A includes the evaporation plant plus a lined solar pond. Case CH-2B includes the evaporation plant plus a spray dryer. These costs are summarized in Figures 5.2-5, 5.2-6, 5.2-7, 5.2-8.

5.2.4 Environmental Features

1. Releases to the Environment

The only release to the environment is water evaporated from the solar evaporation pond used for final brine disposal. There are no liquid releases. Solid releases are entirely contained within the solar pond. Eventually, when this pond is filled with solid matter, or if the pond were abandoned for some other reason, provision must be made to prevent leaching of the salts into the earth and thence to the aquifer in the event of leaks developing in the pond liner. Since the liner is made of an organic material, it can be expected eventually to deteriorate to the point where leakage will occur, even though this may not happen for several decades. One method is to excavate the accumulated salt and remove it to another location, selected such that leaching into a potable water stream or aquifer cannot occur. Another possibility

ALTERNATIVE CH-2A

(WITH POND)

Waste Concentrator	2,380,000
Lined Evaporation Pond	289,000
Piping	400,000
Miscellaneous Tanks and Equipment	89,000

Direct Field Costs	3,158,000
Contractor Overhead and Profit	158,000
Engineering and Management	1,394,000
Contingency	<u>978,000</u>

Total Capital Cost \$5,688,000

Life Cycle Cost \$7,502,000

Figure 5.2-5

ALTERNATIVE CH-2B

(WITH DRYER)

Waste Concentrator	2,369,000
Piping	373,000
Dryer	459,000
Miscellaneous Tanks and Equipment	88,000
<hr/>	
Direct Field Costs	3,289,000
Contractor Overhead and Profit	149,000
Engineering and Management	1,422,000
Contingency	<u>1,014,000</u>
 Total Capital Cost	 \$5,874,000
 Life Cycle Cost	 \$9,126,000

Figure 5.2-6

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CH-2A

TITLE: DISPOSAL OF CHEMICAL WASTES BY MECHANICAL EVAPORATION PLANT
PLUS LINED SOLAR PONDPART I

•Capital Cost	=	\$ 5,688,000
•O&M Cost	=	\$ 137,000/year
•Energy:		
Electricity	=	8,150 MBTU/year
Oil	=	Zero
•Economic Life	=	20 years
•Residual Value	=	100,000 (Factor 0.15)
•Reinvestment Cost	=	Zero
•Deferred Cost at 20 years	=	\$ 610,000 (Factor = 0.15)

PART II

•Present Value Capital Investment	=	$\$5,688,000 + 0.15 \times 510,000 = \$5,664,500$
•Present Value O&M		
	$\$137,000 \times 8.51$	= $\$1,165,870$
•Present Value Energy		
	Electricity	= $8150 \text{ MBTU} \times \$5.57/\text{MBTU} \times 12.6 = \$571,983$
	Oil	= $(0) \times \$4.36/\text{MBTU} \times 9.4 = 0.0$
•Total Present Value	=	\$7,502,353

Figure 5.2-7

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CH-2B

TITLE: DISPOSAL OF CHEMICAL WASTES BY MECHANICAL EVAPORATION PLANT
PLUS SPRAY DRYERPART I

•Capital Cost	= \$5,874,000
•O&M Cost	= 194,800/year
•Energy:	
Electricity	= 8738 MBTU/year
Oil	= 24,300 MBTU/year
•Economic Life	= 20 years
•Residual Value	= 100,000 (Factor = 0.15)
•Reinvestment Cost	= Zero

PART II

•Present Value Capital Investment	= \$5,874,000 - 15,000 = \$5,859,000
•Present Value O&M	
\$194,800/yr X 8.51	= \$1,657,748
•Present Value Energy	
Electricity	= 8738 MBTU X \$5.57/MBTU X 12.61 = \$613,737
Oil	= 24,300 MBTU X \$4.36/MBTU X 9.4 = \$995,911
•Total Present Value	= \$9,126,396

Figure 5.2-8

is to cover the accumulated salts with another impervious sheet like the liner which would keep rain from dissolving the salts and carrying them down into the aquifer. For purposes of the present study, an allowance of 1 cent per pound is included in the cost estimate to provide for ultimate disposal to an offsite location.

2. Health and Safety Considerations

This alternative poses no significant hazards to personnel, either onsite or offsite. Normal precautions must be exercised around operating equipment. The solar pond is fenced to deter entry of unauthorized persons.

3. Effects on Wildlife

The solar pond offers the only point of impact on wildlife. The area devoted to the pond is removed from habitat. The pond itself, because of the briny nature of the water, should not be attractive to mammals or aquatic birds.

4. Aesthetics

The pond is not highly visible from the ground, but is visible from the air. It appears as a normal body of water most of the time. However, during late summer and fall, it could be discolored by algae or other growths, or by the salts precipitating out of solution.

5. Land Area Requirements

Land area requirements are small. The brine concentrator can be accommodated within the coal-fired boiler perimeter. The solar pond requires approximately 4.2 acres.

6. Environmental Effects During Construction and/or Modification

Most of the construction activity required would be adjacent to the proposed coal-fired boiler, or beyond it to the southeast. The chemical waste pipeline from Building 606 to the coal-fired boiler would be installed in the utility tunnel.

5.2.5 Institutional Considerations

Operation and maintenance of the brine concentrator would require attention on the part of the boiler plant staff. Except during infrequent shutdowns for major maintenance and/or repair, it should be possible for the boiler plant staff to include the brine concentrator in the scope of their activities on a part-time basis, along with other assigned duties. The solar pond should not require more than occasional surveillance. At long intervals (perhaps every ten years), it may be necessary to excavate the accumulated salts and remove them to another dumping place (see 5.1.4(1)).

5.3 CASE CH-3: DISPOSAL OF CHEMICAL WASTES USING REVERSE OSMOSIS AS A CONCENTRATOR

5.3.1 Principal Features

In operating reverse osmosis units, it is necessary to avoid mixing of feed stream components which may lead to precipitation as the stream concentration increases within the units since this results in plugging of the membranes. For this reason, we segregated the chemical wastes into two streams and provided two reverse osmosis units, each with its own filters, pH adjustments, pumps, and controls. The boiler blowdown stream would require facilities for reducing or removing silica. The permeate from the reverse osmosis units is routed to the raw water tank, as it is within potable water standards. The concentrate is disposed of to a solar evaporation pond or by other suitable means.

Figure 5.3-1 is a simplified block flow diagram for this case.

A plot plan was not produced for this case.

Advantages and disadvantages of Case CH-3 are summarized in Figure 5.3-2 which lists arguments "pro" and "con."

This scheme appears excessively complex to operate, in comparison with some other alternatives, and it contains a silica removal step which is not proven technology. Also, the degree of brine concentration achieved is insufficient to make this scheme attractive. For these reasons, it is not a recommended case.

5.3.2 Technical Aspects

A process flow diagram for this alternative appears in Appendix "B" (Drawing Nos. 475304-CH3-4-001 and 002). The 001 drawing shows the

ALTERNATIVE CH-3 DISPOSAL OF CHEMICAL WASTES USING REVERSE OSMOSIS AS A CONCENTRATOR

FIGURE 5.3-1

**ALTERNATIVE CH-3
DISPOSAL OF CHEMICAL WASTES
USING REVERSE OSMOSIS AS A CONCENTRATOR**

PROS	CONS
<ul style="list-style-type: none">1. Low Energy Cost By Itself.2. No Environmental Impact By Itself.3. Reduces Contamination of Aquifer.	<ul style="list-style-type: none">1. Low Technical Feasibility Because of Fouling Components Like Ca SO_4 and Silica.2. Need Two Separate Reverse Osmosis Units for the Ca-Bearing Waste and the SO_4 Bearing Waste.3. Complexity of System and its Operation.4. Poor Ability of Concentration (Approximately Two Times).5. Silica Removal is not Commercially Proven.

FIGURE 5.3-2

existing (as of 1985) piping in the CPP, together with those modifications to the existing piping which are required for this case. The 002 drawing shows those features which are totally new for this case.

The combined chemical waste streams contain two substances in solution which are close to their precipitation threshold concentrations during normal operations. One is calcium sulfate, which can be formed by combination of calcium from regeneration and rinsing of the sodium cycle softeners with sulfate from acid regeneration of the hydrogen-cation exchanger in the boiler feed system. The other is silica, which occurs in the boiler blowdown stream and is in solution as a form of silicate under the high pH condition maintained in the boilers. It tends to precipitate out of solution as silica when the boiler blowdown mixes with the acidic waste from the hydrogen-cation exchanger. Any significant increase in concentration of either of these substances would cause them to precipitate out of solution. If this concentration occurs in a reverse osmosis device, the precipitates will foul the membrane surfaces rapidly. It is not possible to clean such deposits from a reverse osmosis membrane surface either chemically or mechanically. Therefore, the use of reverse osmosis for the treatment of the combined chemical waste streams is not feasible. Waste stream concentrations are compared with concentration limits for reverse osmosis plants in the following table:

	Concentration in ICPP <u>Chemical Waste</u>	Practical Limit in <u>R O System</u>
Calcium Sulfate (CaSO_4)		
Solubility Product, $(\text{MOLS/l})^2$	7.4×10^{-4}	5 to 10×10^{-4}
Silica PPM	95	100

It is possible to avoid the above problem (at least partially) by removing silica from the boiler blowdown, and by keeping the calcium-laden waste from the sodium-cycle water softener regeneration separate from the sulfate-bearing waste streams from the hydrogen-cation exchanger, demineralizer, and boiler blowdown until after each stream has passed through a reverse osmosis concentration step.

This arrangement adds to the complexity of the waste disposal system without correspondingly reducing the uncertainty. It is known that addition of magnesium oxide in a hot lime water treater will effectively remove most of the silica. In principle, a treater using only magnesium oxide, for the sole purpose of removing silica, could be used. However, such equipment is not available commercially and would have to be designed and built especially for this purpose. Since operating experience is not available from other units, there is considerable uncertainty as to whether the unit would operate properly.

There must be two separate reverse osmosis units, each with its own filters, pH adjustment, automatic controls, and high pressure pump. Even with this arrangement, the recovery achieved by the reverse osmosis units is limited by a combination of membrane fouling and high pressure differential across the membranes (because the feed concentration in the calcium-bearing waste stream is around 28,000 ppm TDS) to around 50 percent; this is equivalent to a concentration ratio of 2:1. Thus, the benefit from the scheme is not commensurate with the effort required. The permeate has a salinity of around 500 ppm TDS and is recycled back into the raw water system. The combined brine flow is 38,000 gallons per day or more, with a concentration of 35,000 to 40,000 ppm TDS. This brine is disposed of by one of the alternative means considered elsewhere in this study.

In summary, reverse osmosis can be used in the disposal of the chemical waste streams only if silica is removed from the boiler blowdown

stream, the calcium-bearing streams are kept separated from sulfate-bearing streams until after concentration by two separate reverse osmosis units, and the brine concentrate from the reverse osmosis units is finally disposed of by some other means. In view of the uncertainty of the silica removal step, the limited increase in brine concentration accomplished by the R. O. units, and the complication of the total treatment train, this alternative does not appear attractive in comparison with other alternatives which are available.

For the foregoing reasons, it was concluded that the use of reverse osmosis should be deleted from the list of viable alternatives.

5.3.3 Environmental, Cost, and Institutional Considerations

The use of reverse osmosis equipment as brine concentrators does not create any unusual or dangerous environmental effects. However, since this alternate case has been eliminated on technical grounds, no detailed consideration has been given to either environmental effects, to costs, or to institutional problems.

5.4 CASE CH-4: DISPOSAL OF CHEMICAL WASTES BY MEANS OF A DRYER

5.4.1 Principal Features

Chemical waste streams are collected and pumped to a feed storage tank. From the feed tank, the wastes are pumped to a dryer, where the water is evaporated by contact with a stream of hot air or combustion gases. The water is vented to the atmosphere as a vapor. The solid residue is separated from the gas stream in a centrifugal separator, and can then be transported to a suitable dump site.

Figure 5.4-1 is a simplified block flow diagram of this system.

A plot plan was not produced for this case.

Advantages and disadvantages are summarized in Figure 5.4-2 which lists arguments "pro" and "con."

The principal significance of using a dryer for disposal of chemical wastes is that conversion to vapor and solid residue take place entirely in a controlled process. There is no direct environmental effect of any consequence. The solid residues are collected and disposed of with minimum effort.

5.4.2 Technical Aspects

A process flow diagram for this case appears in Appendix "B", Drawing Numbers 475304-CH4-4-001 and -002.

Fluidized bed and spray dryers are used industrially where it is desired to separate a valuable solid product from a liquid (water) matrix. The water must be evaporated, and there is no opportunity for recycle of the latent heat of vaporization within the dryer, especially

ALTERNATIVE CH-4 DISPOSAL OF CHEMICAL WASTES BY MEANS OF A DRYER

FIGURE 5.4-1

ALTERNATIVE CH-4
DISPOSAL OF CHEMICAL WASTES BY MEANS OF A DRYER

PROS	CONS
1. Technically Feasible.	1. No Industrial Precedent for Such a Low Concentration Feed To Dryer.
2. Produce Solid Waste that is Easy to Dispose Of.	2. High Energy Cost (\$1.5 Million Per Year).
3. No Waste Water Remains For Disposal.	3. High Capital Cost \$1.5 Million For Dryer Alone.
4. Reduces Contamination of Aquifer.	

FIGURE 5.4-2

since the drying typically takes place at relatively low temperatures (i.e., between ambient and 212°F). In order to minimize energy costs, the solution or slurry should be concentrated as high as possible by other means before it enters the dryer. In our case, the solution is less than 2 percent salt by weight (less than 10 percent of saturation) which means that all of the excess water would have to be evaporated, and the solid product is waste.

In a fluidized bed dryer, hot air or combustion gases are blown upward through a "grate"; typically, the "grate" may be a bed of porous or granular material such as gravel. The material being dried is introduced above the grate and is kept in suspension by the upward flow of air. Fluidized bed dryers are intended for final drying of material which is already in solid particulate form. They can be made to work with brines, but this is not done on a commercial basis, especially with high-sodium brines. Accordingly, fluidized bed dryers are not recommended for disposal of brines.

Evaporative equipment intended for recovery of solids from a liquid stream is available in the form of spray or "flash" dryers. In spray dryers, the liquid is sprayed into a hot gas stream. The dryer is operated in a manner which ensures that the water is evaporated before the droplets reach the floor of the dryer. Any dissolved solids present in the brine will precipitate out and be carried away in the hot air stream. They are separated from the hot air stream in a centrifugal separator. Like the fluidized bed dryer, the spray dryer is intended for recovery of a valuable solid product from a burden of water. It could be used for reducing a liquid waste to a solid residue, as proposed here.

5.4.3 Cost Estimates

The table below presents rough estimates of the capital and engery costs for a spray dryer for chemical waste streams. Because of the

magnitude of these costs, plus the fact there is no industrial precedent, Fluor chose to eliminate this alternative from further consideration. Accordingly, no effort was made to refine these cost estimates.

Spray Dryer

Capital Cost	\$ 1,500,000
Utility Requirements:	
Power 94 kwh/1,000 gal	\$ 41,000/yr
Fuel Oil 93 gal/1,000 gal	<u>\$ 1,518,000/yr</u>
	\$ 1,559,000/yr

5.4.4 Environmental Features

Fluidized bed and spray dryers have one distinct environmental advantage: the salts appear as a solid residue (pellets or powder) rather than in a liquid stream which then requires further concentration by some means. The residue can be removed and disposed of in an appropriate land fill with minimum bulk to be handled and minimum problems with "leakage" away from the disposal site.

The principal disadvantage to these dryers from an environmental standpoint is that they require a very large energy input, on a continuous basis, in proportion to the task accomplished.

5.5 CASE CH-5: DISPOSAL OF CHEMICAL WASTES TO A LINED EVAPORATION POND

5.5.1 Principal Features

The principal feature of this case is a solar evaporation pond, located southeast of the coal-fired boiler plant site. All chemical wastes are collected and pumped to this pond. The waste line passes adjacent to the coal-fired boiler plant and picks up the blowdown from the boiler.

Figure 5.5-1 is a simplified block flow diagram for this case. Drawing 475304-P-CH-5 is a plot plan showing the new features required for this case.

The advantages and disadvantages of using a solar pond for disposal of chemical wastes from the CPP are summarized in Figure 5.5-2 which lists arguments "Pro" and "Con".

Use of a solar evaporation pond prevents any objectionable chemical waste material from entering the aquifer, and it requires no expenditure for energy other than pumping.

5.5.2 Technical Aspects

A process flow diagram for this case appears in Appendix "B", Drawing Number 475304-CH5-4-001.

The surface area of the solar pond is based on a net evaporation rate of 15.9 inches per year, adjusted to account for the lower vapor pressure of water from a concentrated brine as compared with pure water. The pond is rectangular, with the width being equal to one-half the length. The pond is oriented with the long axis running northwest/southeast; this places the short axis parallel with the direction of both the most frequent (southwest) and second most frequent (northeast)

ALTERNATIVE CH-5 DISPOSAL OF CHEMICAL WASTES TO A LINED EVAPORATION POND

FIGURE 5.5-1

ICPP INJECTION WELL ALTERNATIVES PROJECT	
FOR DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO	
ALTERNATIVE CH-5 DISPOSAL OF CHEMICAL WASTE TO A LINED EVAPORATION POND
FLUOR	PLOT PLAN 475304-P-CH-5

**ALTERNATIVE CH-5
DISPOSAL OF CHEMICAL WASTES TO
A LINED EVAPORATION POND**

PROS	CONS
<ul style="list-style-type: none">1. Minimum Operating Cost.2. No Discharge To Ground Water.3. Reduces Volume of Chemical Wastes.	<ul style="list-style-type: none">1. Requires Large Plot Area (2.1×10^6 Sq. Ft.)2. Uncertainty of Evaporation Rate Because of Climate Dependence.3. Possible Danger to Some Kinds of Birds.

FIGURE 5.5-2

winds. Pond depth was chosen to allow sufficient volume for a full year with zero net evaporation (a "cold, wet year"), plus space at the bottom for twenty years' accumulation of salts. Pond dimensions based on these criteria are:

Surface area	2,100,000 square feet = 48.2 acres
Length	2050 feet
Width	1025 feet
Depth (including freeboard)	5 feet 6 inches

Two materials are commonly used as pond liners: polyvinyl chloride (PVC); and reinforced chlorinated polyethylene (CPE). This study is based on use of PVC.

PVC (30 mil) is the less expensive of the two materials. It is light-sensitive, and for long life it should be covered with earth or rock to prevent deterioration. Temperature should be kept below 150°F. Cost of installation in the Idaho Falls area would be approximately 30¢ a square foot for the installed liner. In addition, earthwork and excavation is required.

CPE (made by Dow Chemical Co.) is more resistant and more stable than PVC and does not have to be covered to prevent deterioration due to exposure. However, it may be desirable to cover at least some portions of it to prevent mechanical damage.

Either of these liners, properly installed and protected, will last twenty years or more. One installer cited a PVC liner installed in 1953 which is still good.

The pond is designed for 20 year life. The two factors which are likely to limit pond life are (a) the durability of the liner and (b) the rate of accumulation of salts. In both regards, the pond is conservatively designed. Nevertheless, it would be wise to set aside

land area for a second pond. As the first pond approaches the end of its life, the second pond could be built. Then the first pond could be allowed to dry up completely, the salts could be removed to a suitable permanent site, and the old liner removed. This site would then be available for rebuilding when the second pond approached the end of its useful life.

5.5.3 Cost Estimates

Estimates have been made of capital and operating costs for Case CH-5. On the basis of these estimates, a life-cycle cost analysis has been prepared. Results are presented in Figures 5.5-4 and 5.5-5.

5.5.4 Environmental Features

1. Liquid Releases

In this case, there is no release of liquid to the earth, and none of the waste water reaches the aquifer.

2. Airborne Releases

All of the water discharged into the pond eventually evaporates. Solids remain in the pond. Dust is not a factor.

3. Solid Releases

All solid matter, both suspended particles and material precipitated out of solution as the water evaporates and solids become more concentrated, remains on the bottom of the pond.

ALTERNATIVE CH-5COST SUMMARY

Miscellaneous Tanks and Equipment	100,000
Piping	381,000
Lined Solar Evaporation Pond (2.1 million square feet)	1,482,000

Direct Field Costs	1,963,000
Contractor Overhead and Profit	124,000
Engineering and Management	1,063,000
Contingency	<u>615,000</u>

Total Capital Cost \$3,765,000

Life Cycle Cost \$4,454,000

Figure 5.5-4

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CH-5

TITLE: DISPOSAL OF CHEMICAL WASTES TO LINED SOLAR EVAPORATION POND

PART I

•Capital Cost	= \$3,765,000
•O&M Cost	= \$68,500/yr
•Energy:	
Electricity	= 212 MBTU
Oil	= Zero
•Economic Life	= 20 years
•Residual Value	= Zero
•Reinvestment Cost	= Zero
•Deferred Cost at 20 years	= \$610,000 (Factor = 0.15)

PART II

•Present Value Capital Investment	= \$3,765,000 + 0.15 X 610,000 = \$3,856,500
•Present Value O&M	
\$68,500 X 8.51	= \$582,935
•Present Value Energy	
Electricity	= 212 MBTU X \$5.57/MBTU X 12.61 = \$14,890
Oil	= (0) X \$4.36/MBTU X 9.4 + 0.0
•Total Present Value	= \$4,454,325

Figure 5.5-5

4. Health and Safety Considerations

There are no significant health or safety hazards associated with this alternative. The pond is fenced to discourage access to the pond by unauthorized persons.

5. Effects on Wildlife

Properly built fences keep out all of the larger animals found in the area. Small animals, insects, and migratory aquatic birds are attracted to the pond. During winter and spring, the water is moderately saline, but no harmful effects should result. The pond is normally shallow, and toward the end of summer it could be almost dry, with a few pools scattered about in low spots. These pools tend to have a high concentration of dissolved solids. This is a situation similar to hundreds of natural ponds and lakes in the desert portions of the United States and one with which the birds are familiar.

A land area of approximately 55 acres is required for the evaporation pond, dikes, and peripheral road. This land is withdrawn from the habitat for native animals and birds.

6. Environmental Effects During Construction

Construction of the pipeline will cause some disturbance to normal activity at the CPP. Construction of the evaporation pond, while it is outside the normal work area of the CPP, generates dust which could be objectionable if the wind were blowing in the direction of the CPP process areas. The number of construction workers would be small and should not add significantly to traffic loads. Heavy construction traffic would be localized in the immediate vicinity of the evaporation pond, away from other facilities and main roads.

5.5.5 Institutional Considerations

Operation and maintenance procedures for the chemical waste disposal system are essentially the same as at present, with additions for the pumps and additional piping. Occasional surveillance of the pond area, for security and safety reasons, is required. At longer intervals (several years) there will be major maintenance on the pond; this will include repair of dikes, repair of fences and peripheral roadway, repairing the liner, etc.

5.6 CASE CH-6: DISPOSAL OF CHEMICAL WASTES TO A PERCOLATION POND OR A SHALLOW WELL

5.6.1 Principal Features

Chemical wastes are collected separately from cooling water and wastes bearing radioactive material. They are collected in a sump at Building 606 and acidity is neutralized. They are then pumped to a shallow well or a percolation pond, near the southeast corner of the ICPP facility. Blowdown from the coal-fired boiler is added to the stream where the pipeline passes the boiler area.

A simplified block flow diagram is presented in Figure 5.6-1.

A plot plan was not produced for this case.

The advantages and disadvantages of this case are summarized in Figure 5.6-2 which lists arguments "pro" and "con."

While there are some technical difficulties with both of these means of disposal, an overriding consideration is that this alternative allows an undiluted brine with approximately 2 percent total dissolved solids to join the water in the aquifer. Thus, this alternative provides no improvement as compared with alternative Case CH-1 (disposal to the existing injection well). Therefore, this case does not merit further consideration.

5.6.2 Technical Aspects

In order to dispose of the chemical waste streams successfully by either a shallow well or a percolation pond, it would be desirable first to conduct at least a medium-term test to ensure compatibility

ALTERNATIVE CH-6 DISPOSAL OF CHEMICAL WASTES TO PERCOLATION POND

FIGURE 5.6-1

**ALTERNATIVE CH-6
DISPOSAL OF CHEMICAL WASTES
TO PERCOLATION POND**

PROS	CONS
1. Low Capital Cost.	1. Salt Will Percolate to Upper Aquifer Because of High Solubility.
2. Low Operating Cost.	2. Little or No Improvement of Environmental Impact Compared With Existing Practice.

FIGURE 5.6-2

between the waste stream and the earth. That is, it should be ascertained whether there will be chemical reactions between the water and the earth which would inhibit long-term operation of the disposal means. In the absence of such tests, the waste stream should be treated to neutralize any excess acid. There could be long term, slow reduction of percolation rates or plugging of the well caused by precipitates forming within the waste stream itself, but with proper attention to chemistry, this can be avoided. Consequently, it appears that this alternative case is technologically feasible.

5.6.3 Cost Estimates

No estimates have been made for the capital and operating costs for this alternative case since it is eliminated on an environmental basis.

5.6.4 Environmental Features

The prime consideration is that whether the chemical waste stream is injected directly into the water body in the aquifer, as at present, or whether it is disposed of to the upper (normally "dry") layers of the aquifer, the water sooner or later finds its way into the water body in the aquifer and mixes with it. Since this disposal scheme results in no improvement in the quality of the water, as compared with less costly alternatives, it has been judged to have no merit.

5.7 CASE CH-7: DISPOSAL OF CHEMICAL WASTES BY DEEP WELL INJECTION

5.7.1 Principal Features

Chemical wastes are collected and pumped to an injection well located southeast of the proposed coal-fired boiler plant. This well penetrates through the basalt and sedimentary deposits into the underlying rhyolite formation. Because the rhyolite rocks are dense and solid, with only fine fractures running through them, a large injection surface coupled with a high wellhead pressure is required for satisfactory operation. Any particulate matter in the water injected may plug the fractures. Figure 5.7-1 is a simplified block flow diagram of this case.

Advantage and disadvantages of this case are summarized in Figure 5.7-3 which lists the arguments "pro" and "con."

This case is significant because of the potential for disposing of the chemical wastes permanently, in a way which is not likely to result in degradation of a potable water body at any time. The irreversibility of any plugging of the well, plus the high cost of drilling the well, reduce the attractiveness of this case.

5.7.2 Technical Aspects

A process flow diagram for Case CH-7 appears in Appendix "B" (Drawing No. 475304-CH7-4-001).

ALTERNATIVE CH-7 DISPOSAL OF CHEMICAL WASTES BY DEEP WELL INJECTION

FIGURE 5.7-1

**ALTERNATIVE CH-7
DISPOSAL OF CHEMICAL WASTES
BY DEEP WELL INJECTION**

PROS	CONS
1. Low Operating Cost. 2. No Chemicals Discharged to Aquifer.	1. Probability of Plugging of Well. 2. Monitoring of Drinking Water Source Required. 3. Deep Well Injection Will Require Pressurizing. 4. High Capital Cost of Deep Well ≈ \$1 Million.

FIGURE 5.7-3

Chemical waste from CPP-606 is collected in a sump and pumped to a chemical waste surge tank with one day holding capacity. Neutralization by adding NaOH is required for preventing corrosion of the injection facilities. Blowdown from the coal-fired boilers is cooled in a heat exchanger and then pumped to the same surge tank.

The surge tank and deep well injection facilities are located near the coal-fired boiler house for convenience of chemical waste collection and operation of the injection facilities. This location keeps the well-drilling operation, which is a major construction effort, on the periphery of the CPP complex.

The well is 5000 feet deep, of which approximately one-half is in the rhyolite formation. The upper 3500 feet is cased. The lower 1500 feet is either uncased or lined with a perforated case, depending on geologists' assessment of the stability of the formation at the well location.

The principal source of information about the geological structures in the vicinity of the CPP has been obtained from the many production, injection, and monitoring wells which have been drilled. There is only one existing deep well; (approximately 3 miles north of the CPP) which penetrates into the rhyolite formations. No open fractures were found, and the well produces water very slowly. Data obtained on water production have been translated into estimates of the pumping head which would be required if the well were used for injection of water into the formation, rather than for production of water from the formation. The upward trend of wellhead pressures with increasing time of operation is based on estimates of the rate of plugging of the formation due to suspended matter in the water. Obviously, it would be advantageous to make sure that the water is as free of suspended matter as practicable, before it is pumped into the well.

It has been suggested that the existing deep well might be used as an injection well, thus saving the cost of drilling another well. The existing well is unused, and could probably be made available. A pipeline approximately 3 miles long would be required; this would be buried five to six feet deep, for protection both against freezing and against mechanical damage.

As implied above, the performance of a deep well, under the conditions which exist near the CPP, is not predictable with certainty. Even small amounts of finely-divided suspended matter can seriously affect the ease of injection, causing the wellhead pressure to rise. In this case, such suspended matter could result from precipitation of insoluble chemicals within the waste stream, as well as from mechanically entrained particles. This in turn would affect pumping energy cost and, ultimately, pump and motor size. On the other hand, the combined chemical waste waters from the CPP are acidic. It is expected that the acid will tend to open the fractures in the rocks. However, the actual effect would depend on the nature of the material already present in the crevices, and on how the introduced water reacts with the native water in the rhyolite zone. Thus, the risk of being committed to this alternative is high, and it would be time-consuming and expensive to perform tests which would increase the certainty level.

A further uncertainty inherent in the concept of deep well disposal is that there is little information on where the waste water would eventually go after it is injected into the rhyolite formation. (See Section 6.8.)

5.7.3 Environmental, Cost, and Institutional Considerations

The only major construction effort is the drilling of the deep well (unless the existing deep well is used). This is in an area outside the principal areas of activity at the CPP and should not interfere with normal activities. However, since this alternative case has been

eliminated because of technical uncertainties, no detailed consideration has been given to environmental effects, to costs, or to institutional problems.

ALTERNATIVE MEANS FOR DISPOSAL OF
LOW LEVEL RADIOACTIVE WASTES

6.0 INTRODUCTION

Low level radioactive wastes from the Idaho Chemical Processing Plant (CPP) enter the service waste water system in three ways. The principal source is the vapors driven off from low level radioactive waste materials in the Process Equipment Waste Evaporator (PEW). These vapors are primarily water, but can contain significant concentrations of nitric acid, and trace amounts of tritium and radioactive cations such as Cesium-137, Cesium-144, and Strontium-90. A list of the constituents which have been found in the PEW condensate stream is presented in Figure 6.0-1. It must be stressed that these are typical or average values, as the constituents vary both in species and in quantity with each "campaign" of waste disposal. During fuel processing operations, the PEW evaporator produces approximately 11,000 gallons per day. Other operating modes result in less evaporator production. This stream is the source of about 90 percent of the radioactive material entering the service waste system during typical operations at the CPP.

The other two potential sources of radioactive material in the service waste system are improbable and accidental in nature. The first is the possibility of equipment failure resulting in leakage from radioactive streams into heating or cooling streams which discharge to the service waste system. The second is the possibility of "dumping" of a beaker of radioactive material into the wrong sink in the chemical laboratories. These sources are discussed in more detail in Section 4.0, "Introduction to Alternative Means for Disposal of Cooling Water and Steam Condensates."

TYPICAL COMPOSITION OF PEW CONDENSATE

Source: Conceptual Design Criteria (CDC)

<u>Component</u>	<u>Quantity</u>
Gross μ Ci/day	8.8×10^5
>98% from tritium so very little change in gross β	
C-14 μ Ci/day	480
Ce-141 μ Ci/day	0.52
Ce-144 μ Ci/day	5.2
Co-57 μ Ci/day	4.8
Co-60 μ Ci/day	20
Cr-51 μ Ci/day	17
Cs-134 μ Ci/day	196
Cs-137 μ Ci/day	3×10^3
Eu-152 μ Ci/day	9.6
Eu-155 μ Ci/day	11
H-3 μ Ci/day	8.7×10^5
I-129 μ Ci/day	174
I-131 μ Ci/day	654
Mn-54 μ Ci/day	6.1
Na-22 μ Ci/day	2.8
Nb-95 μ Ci/day	480
Pu-238 μ Ci/day	83
Pu-239 μ Ci/day	31
Pu-240 μ Ci/day	1.9
Ru-106 μ Ci/day	2.7×10^3
Sb-125 μ Ci/day	305
Sr-90 μ Ci/day	1.4×10^3
Zn-65 μ Ci/day	1.5
Zr-95 μ Ci/day	253
Ru-103 μ Ci/day	19
Np-237 μ Ci/day	27
U mg/day ⁽¹⁾	$<2.2 \times 10^3$
Hg g/day	17.4
Mn g/day	<4.4
Na g/day	52
Cl g/day	1.3×10^3
F g/day	436
Cr g/day ⁽¹⁾	4.4
Pb g/day	<44
HNO ₃ g/day	2.75×10^5
H ₂ SO ₄ g/day	222

(1) Analyses believed questionable.

Figure 6.0-1

Twelve alternative cases are examined in this section. These have been identified with the initial "RW" followed by a serial number. The cases studied are:

- RW-1 Disposal of PEW Condensates to the Existing Injection Well
- RW-2 Improvement of Performance of PEW Cation Exchangers
- RW-3 Recycle PEW Condensate for Reuse as Process Makeup Water
- RW-4 Disposal of PEW Condensates to a Shallow Well
- RW-5 Disposal of PEW Condensates to an Unlined Percolation Pond
- RW-6 Disposal of PEW Condensates to a Lined Solar Evaporation Pond
- RW-7 Separation of PEW Condensates by Reverse Osmosis
- RW-8 Disposal of PEW Condensates by Deep Well Injection
- RW-9 Disposal of PEW Evaporator Effluent Directly to Atmosphere
- RW-10 Treatment of PEW Condensate to Remove Tritium
- RW-11 Separation of the Atmosphere Protection Systems (APS) from the PEW Evaporator System

Alternative Cases RW-1 through RW-9 were included within the original "Scope of Work" for the study. Cases RW-10 and RW-11 were added by Fluor during the course of the study, with the approval of DOE.

Each of the alternative cases is examined in the sections following. In this section of the report, the low level radioactive waste streams

are treated as though they were alone (i.e., not blended with any other stream). Selected alternatives in which low level radioactive wastes are blended with other streams are examined in Section 7.

6.1 ALTERNATIVE CASE RW-1: DISPOSAL OF PEW CONDENSATES TO EXISTING INJECTION WELL

6.1.1 Principal Features

Alternative Case RW-1 considers the disposal of low level radioactive wastes (generated from the PEW evaporator condensates) down the existing injection well (CPP-304) without being mixed with the cooling water and steam condensate streams. (The actual "present practice" for disposal of ICPP service wastes is treated in Section 7.)

Figure 6.1-1 is a simplified block flow diagram of this case.

Advantages and disadvantages of this alternative case are summarized in Figure 6.1-2 which lists arguments "pro" and "con."

The radioactivity concentration level of this discharge stream by itself would exceed levels specified in ERDAM-0524.

6.1.2 Technical Aspects

A process flow diagram (two sheets) for alternative Case RW-1 appears in Appendix "B". (Drawing 475304-RW1-R-001 and 475304-RW1-4-002).

For the purposes of this study, no provisions were made for neutralization or separate handling of this waste stream.

There do not appear to be any technical impediments to disposing of the low level radioactive wastes down the existing injection well.

ALTERNATIVE RW-1 DISPOSAL OF PEW CONDENSATES TO EXISTING INJECTION WELL

FIGURE 6.1-1

**ALTERNATIVE RW-1
DISPOSAL OF PEW CONDENSATES
TO EXISTING WELL**

PROS	CONS
1. Minimum Shutdown Time . 2. Low Additional Construction Costs.	1. Radionuclide Concentrations Exceed Limits of ERDAM-0524. 2. Adds Chemicals to Aquifer 3. Some Radiation Exposure to Construction Workers .

FIGURE 6.1-2

6.1.3 Cost Estimates

This case as defined requires no capital expenditure and no operating cost beyond that already incurred by the CPP. The cost of this alternative is, therefore, defined as zero so that it can serve as a basis for comparison to other cases.

6.1.4 Environmental Aspects

The concentration of Strontium 90 in the PEW condensate as it exists in the WL-106 and WL-107 holding tanks is approximately 3.31×10^{-5} microcuries per milliliter. The allowable concentration of Strontium 90 in water being discharged in a controlled area is 1.0×10^{-5} mci/ml (reference ERDAM 0524). Since the strontium in the waste stream exceeds the allowable unit, disposal of such a stream by itself is not acceptable.

6.2 ALTERNATIVE CASE RW-2: IMPROVEMENT OF PERFORMANCE OF PEW CONDENSATE CATION EXCHANGERS

6.2.1 Principal Features

The existing system for disposal of low level radioactive wastes includes a cation-hydrogen ion exchanger, the purpose of which is to take up any radioactive cations (e.g., Cesium-137, Strontium-90) which are carried overhead into PEW evaporator condensates and release hydrogen ions into the waste stream in their stead. These ion exchange units have operated marginally and intermittently since the feed stream acidity increased significantly because of changes in the methods of operation. Alternative Case RW-2 has the objective of ascertaining whether their performance can be improved, thereby reliably removing radioactive cations from the PEW condensates before final disposal of the stream.

Figure 6.2-1 is a simplified block flow diagram of this alternative.

Advantages and disadvantages of this alternative are summarized in Figure 6.2-2 which lists arguments "pro" and "con".

The significance of this alternative is that the equipment already exists and would provide a means for capturing and concentrating radioactive cations prior to disposal of the waste stream, if it could be made to operate reliably. No satisfactory means for accomplishing this was found unless existing process operating conditions could be changed. This alternative was, therefore, deleted from the list of viable alternatives. However, the system does operate marginally, and should be reexamined from time to time to determine whether changes elsewhere (e.g. development of new ion exchange resins or changes in operating procedures elsewhere in the CPP) might have the effect of making these ion exchange units operate more satisfactorily.

ALTERNATIVE RW-2 IMPROVEMENT OF PERFORMANCE OF PEW CONDENSATE CATION EXCHANGERS

FIGURE 6.2-1

**ALTERNATIVE RW-2
IMPROVEMENT OF PERFORMANCE OF
PEW CONDENSATE CATION EXCHANGERS**

PROS	CONS
1. Reduces Radionuclides Added to Aquifer.	1. Exceeds Concentration Limits Of ERDAM 0524 For Tritium.
2. No Shutdown .	2. High Acid Content with Low Impurity Content.
3. Low Additional Construction Costs .	3. Some Radiation Exposure to Construction Workers.

FIGURE 6.2-2

6.2.2 Technical Aspects

The purpose of the ion exchange resin beds is to absorb radioactive cations such as cesium and strontium from the PEW condensate stream. Hydrogen ions are released by the resin in place of the ions absorbed. The cations are present in the stream in minute quantities. This system would work well if there were no interferences from other cations. However, the PEW condensates contain high concentrations of nitric acid. This means that the ion exchange resin is being asked to take up heavy cations preferentially while releasing hydrogen ions against the heavy concentration of hydrogen ions already present. It has been determined that the pH (a logarithmic measure of hydrogen ion concentration) of the stream is usually in the range between 0.5 and 2.0. The ion exchange resin will perform its function best when the pH is 2 or above; below that, its ability to carry out the exchange decreases rapidly.

It would be possible to neutralize a portion of the acid by adding a strong base, such as sodium hydroxide. However, because nitric acid is a strongly ionized acid, it is necessary to add enough base to neutralize 99 percent of the acid before the pH rises to 2.0 or above. Additionally, the sodium ions will compete with strontium and cesium for space on the resin. Because of this competition, many of the radioactive ions would not be absorbed but instead would "leak" through the ion exchange bed into the discharge stream so the ion exchange beds would still not be able to function effectively.

Manufacturers of ion exchange resins as well as manufacturers of ion exchange equipment are not aware of any existing resins existing which will take up heavy cations preferentially in the presence of a pH as low as 0.5.

Therefore, the ion exchange resin beds cannot be made to operate satisfactorily unless the acidity of the stream can be reduced at the

source. Separation of the several source streams with the effect of keeping a part of the highly acid stream apart from the other wastes is the subject of another alternative (Case RW-11).

It must be noted that the ion exchange beds are unable to remove tritium from the waste stream and were never intended to do so. Therefore, even if the ion exchange beds were operating satisfactorily in the intended manner, they would provide only a partial solution to the problem of disposing of low level radioactive wastes.

6.2.3 Cost Estimates

No cost estimates were made for alternative RW-2.

6.3 ALTERNATIVE CASE RW-3: RECYCLE PEW CONDENSATE FOR USE AS PROCESS MAKEUP WATER

6.3.1 Principal Features

This case examines the possibility of recycling the PEW condensate for reuse in various ICPP locations. The PEW condensate would be used in place of other supply water. Either it would eventually recycle back to the PEW or it would go directly to the high level radioactive waste storage. Theoretically, recycled water should remain in internal closed loop circulation and would not be discharged directly to the groundwater stream. As a result, the level of radioactivity in the recycling stream would increase and would eventually reach equilibrium based on the distribution of tritium between the calciner stack vapor and liquid streams.

Figure 6.3-1 is a simplified block flow diagram of this case.

Advantages and disadvantages of this case are summarized in Figure 6.3-2 which lists arguments "pro" and "con."

This case was intended to eliminate radioactive discharge to the environment. However, the concept proved to be unworkable because the possible condensate users could not absorb the available stream. This case was, therefore, deleted from the list of viable alternatives.

6.3.2 Technical Aspects

Process Flow Diagram 475304-RW3-4-001 is included in Appendix "B". The prospect of recycle of evaporator condensates to avoid and/or reduce the release of tritium to the environment has only limited possibilities. Many factors influence the assessment of this alternative. These factors are:

**ALTERNATIVE RW-3
RECYCLE OF PEW CONDENSATES
FOR REUSE AS PROCESS MAKE UP**

FIGURE 6.3-1

**ALTERNATIVE RW-3
RECYCLE OF PEW CONDENSATES
FOR REUSE AS PROCESS MAKE UP**

PROS	CONS
1. Reduces Radionuclides to Aquifer.	1. Intermittent ICPP Processes Require Storage of Condensates. 2. Complexity of Contaminated Drain Systems. 3. Inventory of HLLW. 4. Increased Tritium Concentrations at the PEW Evaporator. 5. Only Reduces Waste Stream By 21.7%. 6. Difficult to Operate and Monitor.

FIGURE 6.3-2

1. The intermittent operation of the various ICPP processes.
2. The complexity of the contaminated drain systems.
3. Decontamination operations cannot use contaminated water.

The PEW evaporator produces 11,000 gallons of condensate per day or 4,015,000 gallons per year if operated continuously. The "conceptual design criteria" identifies condensate recycle points which would consume 869,500 gallons per year in 1985 if all ICPP processes were in continuous operation. Under this situation, 21.7 percent of the condensate could be recycled. The balance of the condensate (78.3 percent) would still need to be disposed of in some other way. It is unrealistic to assume that either the PEW evaporator or all plant processes would achieve continuous operation or that all processes would be operated at the same time. Thus, the percentage of the condensate which could actually be recycled is less than 21.7 percent. Proposed ICPP upgrades may reduce process waste flows to the PEW evaporator, and thereby increase the percentage that could be recycled.

A major finding resulting from study of this option is that recycle of the PEW condensate does not appreciably reduce the radioactive release to the environment. Separate processing of the 3200 gallon per day APS condensate stream from the PEW evaporator system would significantly reduce the release of radioactivity while at the same time reducing the acid problem in the PEW evaporator. This possibility is the subject of alternative Case RW-11.

6.3.3 Cost Estimates

No costs were estimated for this case.

6.3.4 Environmental Effects

Because of the indeterminate disposal of three-fourths of the waste, environmental effects were not examined.

6.4 ALTERNATIVE CASE RW-4: DISPOSAL OF PEW CONDENSATES TO A SHALLOW WELL

6.4.1 Principal Features

Alternative Case RW-4 examines the use of a shallow well to dispose of the PEW condensates. In this case, the water from the two condensate collection tanks (WL-106 and WL-107) is pumped to a shallow well located southeast of the present ICPP facilities. The low-level radioactive waste water seeps through the soil from the well into the aquifer. Under this option, no water from the PEW process system is pumped directly to the existing injection well.

Figure 6.4-1 is a simplified block flow diagram for this case.

Advantages and disadvantages of this alternative are summarized in Figure 6.4-2 which lists arguments "pro" and "con."

The significance of this alternative is that the earth and rock layers between the shallow well and the water table provide "sponge" capacity for absorption of radioactive cations. Upon examination, this effect was judged to be inadequate to provide long term protection for the water in the aquifer. This case was eliminated from the list of viable alternatives since the concentration of strontium 90 in the discharged effluent exceeds that allowed by ERDAM-0524, Table II.

6.4.2 Technical Aspects

1. System Description

A process flow diagram for Case RW-4 appears in Appendix "B".
(Drawing 475304-RW4-2-001).

ALTERNATIVE RW-4 DISPOSAL OF PEW CONDENSATES TO A SHALLOW WELL

FIGURE 6.4-1

**ALTERNATIVE RW-4
DISPOSAL OF PEW CONDENSATES
TO A SHALLOW WELL**

PROS	CONS
1. Minimum Shutdown Time.	1. High Acid Content Could Dissolve Soil Layers.
2. Monitored Easily.	2. Uncertainty of Soil Capacity and Filtration Efficiency.
3. Some Filtration of Radionuclides and Chemicals.	3. Uncertainty of Perched Water Tables - Potential for Production Well Contamination.
	4. Continue Addition of Tritium to Aquifer.
	5. Concentrations Exceed ERDAM-0524,

FIGURE 6.4-2

The shallow well system is connected into the PEW evaporation system downstream of the existing radiation monitor. In addition to the well, the system consists of a surge tank, a pump, a radiation monitor with diverter station and connecting pipes. The condensates are monitored within the existing PEW plant and are recycled back to the WL-102 feed tank if they do not meet radiation level standards for disposal.

The stream, after monitoring, is pumped to Surge Tank RW5-V-1 and from there to the shallow well. The surge tank provides a second barrier against accidents as it is also supplied with sampling and monitoring equipment. If the water does not meet radiation disposal requirements, it is recycled back to the PEW.

No designs were developed for this well, since the case was deleted for environmental reasons (see below).

2. Ion Exchange Capabilities of the Earth

The earth has some ion exchange affinity for the cationic radioactive nuclides such as Strontium-90, Cesium-137, Cesium-144, etc. It is uncertain whether the ion exchange capability of the soil is adequate for the complete removal of these radioactive nuclides. Tritium, which is the most abundant radioactive constituent of the PEW stream, is not removed or even reduced by the soil and percolates down to the water table.

3. High Nitric Acid Levels

The PEW condensate contains nitric acid in varying concentrations. The pH of the condensate has varied from 2 down to as low as 0.5. Direct disposal of this acid to the earth may have effects not yet determined such as earth layer destruction and leaching of chemical earth constituents into the groundwater.

6.4.3 Cost Considerations

No cost estimates were made for this case.

6.4.4 Environmental Effects

The concentration of tritium and strontium 90 in the PEW condensate as it exists in the WL-106 and WL-107 holding tanks exceed the values listed in reference ERDAM-0524, Table II. Since the waste stream concentrations exceed the allowable limits, this alternative has been deleted from the list of viable alternatives.

6.5 ALTERNATIVE CASE RW-5: DISPOSAL OF PEW CONDENSATES TO AN UNLINED PERCOLATION POND

6.5.1 Principal Features

Alternative Case RW-5 examines the use of an unlined percolation pond to dispose of the PEW condensates. In this option, the water from the two condensate collection tanks (WL-106 and WL-107) is pumped to a percolation pond located southeast of the present ICPP facilities. Part of the water evaporates and is dispersed into the atmosphere, and the balance seeps through the soil into the aquifer. Under this option, no water from the PEW process system is pumped directly to the existing injection well.

Figure 6.5-1 is a simplified block flow diagram for this case.

Advantages and disadvantages of this alternative are summarized in Figure 6.5-2 which lists arguments "pro" and "con."

The significance of this alternative is that the earth and rock layers between the percolation pond and the water table provide "sponge" capacity for adsorption of radioactive cations. Upon examination, this effect was judged to be inadequate to provide long-term protection for the water in the aquifer. This case was eliminated from the list of viable alternatives since the concentration of strontium 90 in the discharged effluent exceeds that allowed by ERDAM-0524, Table II.

6.5.2 Technical Aspects

1. System Description

A process flow diagram for Case RW-5 appears in Appendix "B".
(Drawing 475304-RW5-2-001).

**ALTERNATIVE RW-5
DISPOSAL OF PEW CONDENSATES
TO AN UNLINED PERCOLATION POND**

FIGURE 6.5-1

**ALTERNATIVE RW-5
DISPOSAL OF PEW CONDENSATES
TO AN UNLINED PERCOLATION POND**

PROS	CONS
1. Minimum Shutdown Time.	1. High Acid Content Could Dissolve Soil and Possibly Embankments.
2. Increased Time Frame Before Chemicals and Radionuclide Reach Aquifer.	2. Soil Capacity Unknown.
3. Some Constituents May Be Filtered Out.	3. Soil Efficiency Unknown.
	4. Addition of Tritium to Aquifer.
	5. Concentrations Exceed ERDAM-0524.

FIGURE 6.5-2

The unlined pond system is connected into the PEW evaporation system downstream of the existing radiation monitor. In addition to the pond, the system consists of a surge tank, a pump, a radiation monitor with diverter station and connecting pipes. The condensates are monitored within the existing PEW plant and are recycled back to the WL-102 feed tank if they do not meet radiation level standards for disposal.

The stream, after monitoring, is pumped to Surge Tank RW5-V-1 and from there to the unlined percolation pond. The surge tank provides a second barrier against accidents as it is also supplied with sampling and monitoring equipment. If the water does not meet radiation disposal requirements, it is recycled back to the PEW.

The percolation pond has surface dimensions 36 by 72 feet, and a depth of 6 feet. This shape provides for surge capacity to take care of variations in flow rate. It also provides a free-board to contain wave action. The pond is aligned with the long axis northwest/southeast. This places the short dimensions parallel with the prevailing winds to minimize wave action.

2. Ion Exchange Capabilities of the Soil

The soil has some ion exchange affinity for the cationic radioactive nuclides such as Strontium-90, Cesium-137, Cesium-144, etc. It is uncertain whether the ion exchange capability of the soil is adequate for the complete removal of these radioactive nuclides. Tritium, which is the most abundant of the radioactive constituents in the PEW stream, is not removed or even reduced in quantity by the soil and ultimately percolates down to the water table. A concentration of radioactive nuclides could occur in the surface earth layers over a period of years.

3. High Nitric Acid Levels

The PEW condensate contains nitric acid in varying concentrations. The pH of the condensate has varied from 2 down to as low as 0.5. Direct disposal of this acid to the soil could have effects not yet determined such as soil layer destruction and leaching of chemical soil constituents into the groundwater.

6.5.3 Cost Estimates

No cost estimates were made for this case.

6.5.4 Environmental Effects

The concentration of tritium and strontium 90 in the PEW condensate as it exists in the WL-106 and WL-107 holding tanks exceed the limits listed in ERDAM-0524, Table II. Since the waste stream concentrations exceed the allowable limits, this alternative has been deleted from the listing of viable alternatives.

6.6 ALTERNATIVE CASE RW-6: DISPOSAL OF PEW CONDENSATES TO A LINED SOLAR EVAPORATION POND

6.6.1 Principal Features

Alternative Case RW-6 is the disposal of PEW condensate to a lined pond where it is evaporated by the sun. Besides the pond, the only significant equipment items are a surge tank, transfer pumps, radiation monitor, diversion station, and an acid neutralization tank.

Figure 6.6-1 is a simplified block flow diagram for this system.

Advantages and disadvantages of this alternative are summarized in Figure 6.6-2 which lists arguments "pro" and "con."

The significance of this case is that all the water in the low-level radioactive waste stream is dispersed into the atmosphere as vapor. There is no liquid release to the earth. However, the residual of radioactive material accumulated in the pond results in unacceptable radiation levels in the vicinity of the pond, after a period of years, and this presents a potential source for spreading radioactive contamination. Therefore, this case was deleted from the list of viable alternatives.

6.6.2 Technical Aspects

1. System Description

A process flow diagram for this case appears in Appendix "B".
(Drawing 475304-RW6-4-001).

The solar pond system connects into the PEW evaporation system downstream of the existing radiation monitor. The waste flows

**ALTERNATIVE RW-6
DISPOSAL OF PEW CONDENSATES
TO A LINED EVAPORATION POND**

FIGURE 6.6-1

**ALTERNATIVE RW-6
DISPOSAL OF PEW CONDENSATES
TO A LINED EVAPORATION POND**

PROS	CONS
1. Does Not Contaminate Aquifer.	1. Radioactivity Levels Around Pond. 2. Potential for Spreading of Radioactive Contaminants. 3. Difficult and Expensive to Protect Wildlife.

FIGURE 6.6-2

to a Waste Surge Tank (RW6-V-1) and to Pump RW6-P-1. An existing radiation monitor is located upstream of RW6-V-1, with a bypass diverter valve downstream of the vessel. During normal operations, the waste stream is pumped to the neutralization (calcium carbonate) tank and solar evaporation pond.

2. Radiation Monitor and Diversion Station

Upon indication of excessive radioactivity, waste flow is diverted back to VES-WL-102. Downstream of the bypass control valve is a flow indicator. Both the flow indicator and radioactivity indicator are connected so that an alarm will sound if either there is a flow to the pond or an indication of excessive radiation. The surge tank has a capacity of one hour for retention of high level radiation material upstream of the bypass valve. This provides time for remedial action to prevent any high level contamination from reaching the pond. This system provides backup to the existing radiation monitor, thereby reducing the chance of high level contamination in the solar pond.

3. Solar Evaporation Pond and Neutralization Tank

The pond is lined with a PVC membrane to prevent leakage to the subsurface. The pond is 450 feet wide by 900 feet long and is located southeast of the existing ICPP facilities. The long axis is oriented northwest/southeast, so that the short dimension is parallel with the prevailing winds. The pond is 6 feet deep and is capable of handling 11,000 gallon per day flow with intermittent 20,000 gallon per day surges. The area is fenced to prevent access to the pond by wildlife and unauthorized persons. A more complete discussion of solar evaporation ponds appears in Section 5.5.

Before entering the pond, the waste stream is neutralized in Neutralization Tank RW6-V-1. The tank is filled upon start-up with calcium carbonate (crushed limestone, or equivalent). The tank holds about 15,000 kg which is equivalent to two months supply at the normal nitric acid concentration in the stream. When the level of solid in the tank becomes low, recharging can be done simply by dumping a truck load of calcium carbonate into the tank. Neutralization occurs according to the following reaction:

The carbon dioxide goes into the air as a gas. The water eventually evaporates leaving a calcium nitrate hydrate in the pond as a residue.

Before passing into the solar pond, the waste stream passes through a second flow indicator and sampling post. This meter allows a check that the flow entering the pond is the same as that entering the waste system. The accuracy of the check allows detection of gross failures, such as plugged or ruptured lines.

A distribution system is provided consisting of a network of perforated polypropylene piping. The pipes are spaced twenty feet apart, running the length of the pond. A line also runs around the edge of the pond, just above the normal liquid level line. This line is used to wash down any sediments which deposit on the pond sides during low liquid level periods.

4. Radiation Effect

The PEW condensate contains very low levels of radioactive contaminants. These contaminants are present in barely distinguishable quantities in the condensate but would accumulate to a point

of significance over the twenty-year design lifetime of the pond. Since wildlife cannot entirely be prevented from using the pond and because the radioactivity would be on an exposed and unprotected surface, the radiological effects have been examined.

The atmospheric concentration of one of the principal radioactive components above the pond after a lifetime of use was considered. Strontium-90 was chosen because it is considered to be a special biological hazard due to its tendency to be retained in the body if ingested.

On the basis of per-unit-quantity of radioactivity, inhalation is considered the most serious route of exposure. Surface contamination, therefore, is usually limited by the inhalation hazard that may arise from resuspension of the contaminant. The quantitative relationship between the concentration of loose surface contamination and consequent atmospheric concentration above the contaminated surface due to stirring up the surface by winds or otherwise, is called the resuspension factor, fr , and is defined by:

$$fr = \frac{\text{ATMOSPHERIC CONCENTRATION, } \mu\text{Ci}/\text{CM}^3}{\text{SURFACE CONCENTRATION, } \mu\text{Ci}/\text{CM}^2} \quad (1)$$

Experimental investigation of the resuspension of loose surface contamination shows that the resuspension factor varies from about 10^{-4} to 10^{-8} depending on the conditions under which the studies were conducted. A value of 10^{-6} is reasonable for the purpose of estimating the hazard from surface contamination. ⁽¹⁾

(1) Introduction to Health Physics, Herman Cember, 1969

The surface concentration of Strontium-90 after 15 years of use with a lined pond of 405,000 square foot area is estimated to be 0.020 $\mu\text{ci}/\text{cm}^2$. This estimate is based on average values given in Figure 6.0-1 and includes consideration for radiation decay. Using the correlation described previously, Strontium-90 exceeds the maximum concentrations in both ERDAM-0524 and the International Commission of Radiological Protection by at least one order of magnitude.

This examination demonstrates that the human hazard from the accumulation of this type of contamination is greater when the material is concentrated and subsequently exposed in an uncontrolled way.

The radiation field over the pond after 15 years of use was estimated based on the accumulation of radionuclides in the concentrations listed in Figure 6.0-1. In this estimate the effect of radioactive decay was considered. The radiation fields at one foot from the surface are 3.3 mr/hr Beta, Gamma for the average case, and 18 mr/hr Beta, Gamma for the maximum case. This estimate has assumed that no upset resulting in the discharge of concentrated radioactive materials to the pond has occurred during the 15 years of operation, and only the primary nuclides were used.

6.6.3 Cost Estimates

No cost estimates were made for alternative Case RW-6.

6.6.4 Environmental Features

1. Radiation Levels

As shown in Section 6.6.2, the radiation levels which are expected to develop in and over the solar pond as it is used during a period of years exceed the permitted values by substantial margins.

In addition to potential adverse effects upon humans, wildlife will be affected. The pond is fenced to prevent intrusion by larger species of fauna such as antelopes. Smaller species can enter the pond area by either tunneling under or passing through the fence. A pond of this size is certain to attract waterfowl which frequent the area. The prospect of providing a mesh type cover over a pond of this size (405,000 square feet) to prevent birds from alighting on the water is unreasonable. Radiation effects on these animals and birds may be comparable with effects on humans.

Since the spread of radioactive contaminants cannot be prevented, and since the potential of inhaling a radioactive dose of Strontium-90 which exceeds the allowable concentration listed in ERDAM-0524 exists, alternative RW-6 was deleted from consideration as a viable alternative.

2. Other Environmental Features

No other environmental aspects of this case were examined.

6.7 ALTERNATIVE CASE RW-7: SEPARATION OF LOW LEVEL RADIOACTIVE WASTES BY REVERSE OSMOSIS

6.7.1 Principal Features

Alternative Case RW-7 considers the feasibility of separating the radioactive ions present in the PEW condensate waste stream from the other constituents of the stream by using the reverse osmosis process. This case examines the reverse osmosis separation step, without attempting to define completely a disposal system utilizing that step.

Figure 6.7-1 is a simplified block flow diagram of this system.

Advantages and disadvantages of this system are summarized in Figure 6.7-2 which lists arguments "pro" and "con."

The significance of alternative Case RW-7 lies in the hope that, by reverse osmosis, the radionuclides could be removed from the low level radioactive waste stream and concentrated sufficiently that they could be reprocessed in existing equipment or disposed of effectively by some other means. Upon examination, however, it became apparent reverse osmosis not only is unable to provide any improvement but actually results in making the disposal problem worse. For this reason, concentration by reverse osmosis was eliminated from the list of viable alternatives.

6.7.2 Technical Aspects

A process flow diagram for alternative Case RW-7 is presented in Appendix "B" (Drawing 475304-RW7-4-001).

The reverse osmosis system is connected into the existing system upstream of the radiation monitor. Process condensates flow to a surge tank (RW7-V-1) where the acid is neutralized with a sodium hydroxide solution. The neutralized stream is pumped through a

ALTERNATIVE RW-7 CONCENTRATION OF PEW CONDENSATES BY REVERSE OSMOSIS

FIGURE 6.7-1

**ALTERNATIVE RW-7
CONCENTRATION OF PEW
CONDENSATES BY REVERSE OSMOSIS**

PROS	CONS
1. Will Remove 90% of All Solids (not Tritium).	1. High Acidity Reduces Membrane Capacity. 2. Neutralization Not Practicable. 3. No Tritium Removal. 4. Low Economic Feasibility. 5. Little Can Be Done With the Waste Streams. 6. Creates More Chemical Wastes Than it Removes.

FIGURE 6.7-2

microfilter and then to the reverse osmosis (R.O.) packaged unit. The R.O. unit consists of two high pressure pumps, two clusters of membrane modules, and controls. Feed is pumped to a pressure of 400 psig and sent through the first cluster. The permeate is repressurized to 400 psig and sent to the second cluster. The concentrate from the second cluster is combined with the concentrate from the first cluster and sent to waste disposal facilities suitable for radioactive material. The permeate stream is monitored for pH, conductivity and radioactivity. If the stream meets specifications, it is sent to waste disposal facilities for "clean" waste. If the stream does not meet specifications, it is sent back to the surge tank or to the PEW evaporator.

Commercially available membranes for reverse osmosis equipment are made of either cellulose acetate or a polyamide. Cellulose acetate is hydrolyzed by either strong acid or strong base, and the pH must be kept within the range between 5 and 7 in order to achieve economic useful life from the membranes. Polyamides are less sensitive to acid, but the pH should still be kept above 3 in order to prevent rapid deterioration of the membranes. The PEW condensates are highly concentrated in nitric acid (pH usually is less than 1.5). Thus, with either membrane, it is necessary to neutralize most of the acid present by adding a strong base.

Sodium hydroxide is preferred, as it is one of the least expensive bases, and the sodium salts which are the result of the neutralization reaction remain in solution and do not precipitate out as the solution is concentrated in the reverse osmosis modules.

Calculations show that during peak evaporator flow rates the PEW evaporator stream is about 3.0 molar nitric acid. To neutralize this acid requires about 6 tons of sodium hydroxide addition per day. If this caustic solution were injected in a 16 percent (4.0 molar) solution, 9100 gallons per day of solution would be required (more concentrated solutions result in freezing the sodium hydroxide solution in

winter). Adding this large amount of fluid effectively causes the R.O. system to double in size. The combined 20,100 gallon per day stream has a total dissolved solids (TDS) content of over 41,000 ppm. With feedwater of this high salinity, the reverse osmosis units can be effectively operated to only about a 2:1 concentration ratio. Thus, the radioactive cations are concentrated to only about twice their entering concentration, and they are now mixed with a large concentration of sodium salts.

A further disadvantage to the reverse osmosis alternative is the fact that the membranes do not distinguish normal water from tritiated water. This means that tritium is not removed from the feed stream. Thus, the permeate stream has a tritium concentration reduced only by dilution with the sodium hydroxide solution added for acid neutralization.

The flow rate of the concentrate stream is about 10,000 gallons per day. It is concentrated in sodium, nitrate and radionuclide ions. The alternatives for disposing of this stream are few. Diversion of this stream back to the Waste Calcining Facility is not feasible due to the high concentration of sodium, which adversely affects the calcining process.

To summarize, reverse osmosis is an expensive process in which an 11,000 gallon per day waste problem is turned into two waste problems: a 10,000 gallon per day tritiated water waste problem and a 10,000 gallon per day concentrated waste problem which is more of a problem than the feed stream, and for which there is no apparent solution. This system creates more problems than it solves and is not a viable alternative.

6.7.3 Cost Estimates

No cost estimates were made for this alternative case.

6.8 ALTERNATIVE CASE RW-8: DISPOSAL OF PEW CONDENSATES BY DEEP WELL INJECTION

6.8.1 Principal Features

The PEW condensate waste is collected and pumped to a deep injection well located south of the Idaho Chemical Processing Plant. This well penetrates through the basalt and sedimentary deposits into the underlying rhyolite formation. Because the rhyolite rocks are dense and solid, with only fine fractures running through them, a large injection surface, possibly coupled with a high wellhead pressure is required for satisfactory operation. Any particulate matter in the water injected tends to plug the fractures.

A simplified block flow diagram is presented in Figure 6.8-1. Drawing 475304-P-RW-8 is a plot plan showing the new features required for this case.

Advantages and disadvantages of this case are summarized in Figure 6.8-3 which lists the arguments "pro" and "con."

This case is significant because of the potential for disposing of the low-level radioactive wastes permanently in a way which may not result in degradation of a potable water body. Uncertainties about possible plugging problems and containment within the rhyolite formation must be further investigated before proceeding with this case. Nevertheless, the case is sufficiently attractive so that cost estimates were completed.

6.8.2 Technical Aspects

A process flow diagram for Case RW-8 appears in Appendix "B" (Drawing 475304-RW8-2-001).

ALTERNATIVE RW-8 DISPOSAL OF PEW CONDENSATES BY DEEP WELL INJECTION

FIGURE 6.8-1

ICPP INJECTION WELL ALTERNATIVES PROJECT	
FOR DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO	
ALTERNATIVE RW-8 DISPOSAL OF PEW CONDENSATES BY WELL INJECTION
FLUOR	PLOT PLAN
1/100'-0"	475304-P-RW-8 1

**ALTERNATIVE RW-8
DISPOSAL OF PEW CONDENSATES
BY DEEP WELL INJECTION**

PROS	CONS
<ul style="list-style-type: none">1. Prevents Radionuclides From Reaching Aquifer.2. Prevents Chemicals From Entering Aquifer.3. Does Not Add Contaminants to Atmosphere.4. Monitoring Wells Exist For Aquifer.	<ul style="list-style-type: none">1. Neutralization Not Practical.2. Deep Well Costly.3. Needs Added Study To Develop Confidence.

FIGURE 6.8-3

Low level radioactive wastes from the PEW evaporator are passed through the existing radiation monitor and pumped to a holding tank with one day holding capacity located near Building 604. From the holding tank the wastes are pumped to the well, which is located on the periphery of the ICPP complex near the southeast corner. This location keeps the well-drilling operation, which is a major construction effort, away from the main activity areas of the CPP complex.

The well is 3500 feet deep, of which approximately one-half is in the rhyolite formation. The upper 2500 feet is cased. The lower 1000 feet is either uncased or lined with a perforated case, depending on geologists' assessment of the stability of the formation at the well location.

The principal source of information about the geological structures in the vicinity of the CPP has been obtained from the many production, injection and monitoring wells which have been drilled. There is only one deep well; that is, one which penetrates to and into the rhyolite formations. Figure 6.8-4 is a diagram of this well, which is approximately 3 miles north of the CPP. No open fractures were found, and the well produces water very slowly. Data obtained on water production have been translated into estimates of the pumping head which would be required if the well were used for injection of water into the formation, rather than for production of water from the formation. The results are presented in Figure 6.8-5. The upward trend of wellhead pressures with increasing time of operation is based on estimates of the rate of plugging of the formation due to suspended matter in the water. The actual slope of the curves would depend on the amount and kind of suspended matter present. Obviously, it would be advantageous to make sure that the water is as free of suspended matter as practicable, before it is pumped into the well. From Figure 6.8-5 it would appear that the 7.6 gpm flow of low-level radioactive waste should not require pressurization of the wellhead. However, because of the

INEL-1

Figure 6.8-4

Predicted Wellhead Pressures Injecting into INEL No. 1 Well Interval 3713-4879 (Open Hole)

Figure 6.8-5

uncertainties surrounding the design of the deep well facilities, provisions for pressurizing the wellhead to 125 psig are included.

If the existing deep well is on the periphery of a buried caldera, as has been presumed, then the boundary between basalts and rhyolite may be farther below the surface at the site of the proposed new well than at the site of the existing well, perhaps by several hundred feet. This assumption would only be determined by actual drilling, as sonic and other tests which can be performed at the surface do not yield an unequivocal picture of the types of formations which are prevalent in the area. This would affect drilling cost, if a specific depth of penetration of the rhyolite formation is desired.

It has been suggested that the existing deep well might be used as an injection well, thus saving the cost of drilling another well. The existing well is unused, and could probably be made available. A pipeline approximately 3 miles long would be required; this would be buried five to six feet deep, for protection both against freezing and against mechanical damage. No further study was made of this option. If deep well injection is ultimately chosen as the preferred method of disposal, this option should be examined in detail.

As implied above, the performance of a deep well, under the conditions which exist near the CPP, is not predictable with certainty. Even small amounts of finely-divided suspended matter can seriously affect the ease of injection. On the other hand, the low-level radioactive waste waters from the CPP are acidic. This could result in opening the fractures in the rocks, thereby improving the permeability of the rhyolite formation in the vicinity of the well. The net effect if these two opposing tendencies could be determined only by actual test which would be difficult and time consuming.

A further uncertainty inherent in the concept of deep well disposal is that there is little information on where the waste water would eventually go after it is injected into the rhyolite formation. Water drawn

from the existing deep well has substantially different characteristics from water in the lower basalt zone lying immediately above. This is interpreted to mean that there is little or no direct communication between the two zones. However, with water injected into the rhyolites under a pressure higher than naturally exists, movement from the rhyolite zone into the lower basalt zone is at least a possibility. Because of the uncertainties inherent in deep well injection, monitoring wells are required. These monitoring wells need to extend only to the bottom of the potable water aquifer. In this case, numerous monitoring wells already exist in the vicinity of the injection well, and no additional wells should be needed.

6.8.3 Cost Estimates

Capital and operating costs for this alternative, over and above the base case (RW-1), have been estimated. A life-cycle cost analysis has been prepared, based on these estimates. Results are presented in Figures 6.8-6 and 6.8-7.

6.8.4 Environmental Features

1. Liquid and Solid Releases

All liquid and solid releases are pumped to the deep injection well and are retained within the rhyolite formations. There are no airborne releases.

2. Health and Safety Considerations

Disposal to a deep well does not create any health problems.

3. Effects on Wildlife

As all releases are contained in pipes, there are no effects on wildlife.

ALTERNATIVE RW-8

Tanks and Equipment	107,000
Piping	218,000
Deep Well	1,000,000
<hr/>	
Direct Field Costs	1,325,000
Contractor Overhead and Profit	75,000
Engineering and Management	831,000
Contingency	413,000
 Total Capital Cost	 \$2,644,000
 Life Cycle Cost	 \$2,977,000

Figure 6.8-6

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: RW-8

TITLE: DISPOSAL OF LLRW TO DEEP WELL

PART I

- Capital Cost = \$2,644,000
- O&M Cost = \$36,500/year
- Energy:
 - Electricity = 244 MBTU/year
 - Oil = 132 MBTU
- Economic Life = 20 years
- Residual Value = Zero
- Reinvestment Cost = Zero

PART II

- Present Value Capital Investment = \$2,644,000
- Present Value O&M
 - \$36,500/year X 8.51 = \$310,615
- Present Value Energy
 - Electricity = 244 MBTU X \$5.57/MBTU X 12.61 = \$17,138
 - Oil = 132 MBTU X \$4.36/MBTU X 9.4 = \$5,410
- Total Present Value = \$2,977,163

Figure 6.8-7

4. Environmental Effects During Construction

The only major construction effort is the drilling of the deep well (unless the existing deep well is used). This is in an area outside the principal areas of activity at the CPP and should not interfere with normal activities.

6.8.5 Institutional Aspects

Case RW-8 does not result in any significant institutional problems or changes.

6.9 ALTERNATIVE CASE RW-9: DISPOSAL OF PEW EVAPORATOR EFFLUENT DIRECTLY TO ATMOSPHERE

6.9.1 Principal Features

In Case RW-9 the "overheads" from the PEW evaporator are maintained in the vapor phase, instead of being condensed, and are discharged to the atmosphere. The overheads are fed to superheaters, passed through a filtration system to remove entrained particles and exhausted through a stack to the atmosphere. The balance of the existing PEW system including condensers, condensate collection tanks, etc., is decommissioned and replaced with the components mentioned above. Alternative RW-9 includes its own independent stack and blowers.

Figure 6.9-1 is a simplified block flow diagram of this case.

Drawing 475304-P-RW-9 is a plot plan showing the additional facilities required by the installation of the new equipment.

Advantages and disadvantages of Case RW-9 are summarized in Figure 6.9-3 which lists arguments "pro" and "con."

The significance of this case is that the process evaporator wastes are effectively dispersed into the atmosphere, and there are no liquid or solid releases from the CPP containing radioactive materials.

6.9.2 Technical Aspects

A process flow diagram for Case RW-9 appears in Appendix "B" (Drawing 475304-RW9-4-001).

The vapor feed stream comes directly from the PEW process equipment waste evaporators (VES-WL-129 and VES-WL-161) located in Building CPP-604. Feed is heated in a primary superheater (RW9-E-1) from

**ALTERNATIVE RW-9
DISPOSAL OF PEW EVAPORATOR EFFLUENT
DIRECTLY TO THE ATMOSPHERE**

FIGURE 6.9-1

ICPP INJECTION WELL ALTERNATIVES PROJECT	
FOR DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO	
ALTERNATIVE RW-9	
DISPOSAL OF PEW EVAPORATOR EFFLUENT DIRECTLY TO ATMOSPHERE
G. HEVERLY M. CUTLER 1/100-00	PLOT PLAN 475304-P-RW-9

**ALTERNATIVE RW-9
DISPOSAL OF PEW EVAPORATOR
EFFLUENT DIRECTLY TO THE ATMOSPHERE**

PROS	CONS
<ul style="list-style-type: none">1. Moderate Capital Cost Required.2. Radiation Concentration at Plant and at Site Boundary Comply with ERDAM-0524	<ul style="list-style-type: none">1. Releases Radionuclides to Atmosphere.2. Releases Nitric Acid to Air.3. Potential Radiation to Plant Operators.

FIGURE 6.9-3

200°F to 325°F and flows to a prefilter (RW9-ME-1) where five micron and larger particles are filtered out. It is then reheated to 325°F in a secondary superheater (RW9-E-2) and passed through a HEPA filter (RW9-ME-2) where over 99.9+ percent of particles, one micron and larger, are removed. The prefilter and HEPA filters, which are enclosed in stainless steel housings, have filtering media entirely composed of fiberglass. A temperature drop of 80°F across the filters has been allowed for in the design. In order to ensure that there is no condensation in the stack, a third heat exchanger is added (RW9-E-3). Feed enters this exchanger at 245°F and is heated to 325°F. All three superheaters use 125 psig steam as the heating fluid.

The filtered vapor then flows through a suction throttle valve upstream from the blower (RW9-B-1). The throttle valve is controlled by pressure at the PEW evaporator. This ensures that the PEW evaporator is maintained at atmospheric pressure, regardless of the suction of the blower. The control scheme compensates, by means of the throttle valve, for a gradual buildup in system pressure drop caused by filter plugging or variable flow rates. Eventually, when the filters are plugged, pressure rises high enough to sound an alarm, indicating the necessity for changing filters.

The blower discharges at a pressure of +6.0 inches of water, which allows enough head to carry the vapor stream up through the stack. The stack (RW9-ME-3) is 20 inches in diameter and 150 feet high. It is constructed of stainless steel and is insulated to prevent heat losses and condensation of the vapor in the stack.

6.9.3 Cost Estimates

Capital and operating costs were estimated for this case, and a life cycle cost analysis was made. Results are summarized in Figures 6.9-4 and 6.9-5.

ALTERNATIVE RW-9

Piping	92,000
Evaporation Plant with Equipment	560,000
150 Foot Stack	116,000

Direct Field Costs	768,000
Contractor Overhead and Profit	129,000
Engineering and Management	608,000
Contingency	265,000

Total Capital Cost	\$1,770,000
--------------------	-------------

Life Cycle Cost	\$2,587,000
-----------------	-------------

Figure 6.9-4

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: RW-9

TITLE: DISPOSAL OF LLRW BY EVAPORATION AND EXHAUSTING BY OWN STACK

PART I

- Capital Cost = \$1,770,000
- O&M Cost = \$ 54,000/year
- Energy:
 - Electricity = 1082 MBTU/year
 - Oil = 6593 MBTU/year
- Economic Life = Superheater 10 years, Rest system 20 years
- Residual Value = 50,000 (Factor = 0.15)
- Reinvestment Cost = \$ 47,000 at 10 year (Factor = 0.39)

PART II

- Present Value Capital Investment = $\$1,770,000 + 0.39 \times 47,000 - 0.15 \times 50,000 = \$1,780,830$
- Present Value O&M
 - $\$54,000/\text{yr} \times 8.51 = \$459,540$
- Present Value Energy
 - Electricity = $1082 \text{ MBTU} \times \$5.57/\text{MBTU} \times 12.61 = \$75,997$
 - Oil = $6593 \text{ MBTU} \times \$4.36/\text{MBTU} \times 9.4 = \$270,208$
- Total Present Value = \$2,586,575

Figure 6.9-5

6.9.4 Environmental Features

1. Airborne Releases

The evaporation (alternative RW-9) system achieves tritium average ground level concentrations that are within ERDAM-0524 control guidelines. Various windspeeds were chosen in unstable, neutral and stable conditions at ambient temperatures of -29°C and $+27^{\circ}\text{C}$. In all cases, the concentrations were below the maximum permissible concentrations. The maximum concentration case was with an ambient temperature of 27°C , a windspeed of 2 meters/per second, and a "C" stability class (corresponding to a temperature inversion condition). This produced an "unstable" condition.

The maximum concentration was 7.9×10^{-13} grams/per cubic meter of air (7.6×10^{-9} microcuries/per ml) 270 meters downwind of the stack. This value is estimated to be accurate within a factor of 3, which is still within the 5×10^{-6} microcuries per milliliter concentration permitted. Maximum I-131 concentration is 129×10^{-12} microcuries per milliliter which is also within concentration limitations. Therefore, from the standpoint of airborne releases, alternative RW-9 is a viable case.

Problems may be encountered with the amount of nitric acid discharged. Preliminary investigations indicate that under normal operating conditions, nitric acid vapors would constitute a small percentage of the total stack flow and would be well mixed before reaching the top of the stack. After leaving stack there would be lots of entrainment and rapid mixing with atmospheric air. Precipitation at the stack exit conditions would occur at minus 25°F , and 100 meters from top of stack at minus 50°F . However, on a rainy day there would be a certain amount of "precipitation scavenging" by the rain down to the ground, (1-2%). For these reasons, the evaporation of the condensate should be curtailed on rainy days.

Also examined was the possibility of using the existing stack and taking advantage of dilution with the 125,000 SCFM air flow. This dilution is advantageous under the proper atmospheric conditions. However, under conditions of high relative humidity, undesirable condensation could also occur in the existing 250 foot stack. It was decided for alternative RW-9 to use an independent stack as described above.

2. Radiation to Operators

During the operation of the condensate evaporation system, the low level radioactive condensate is passed through a series of superheaters and filter units. Over a period of time, radioactive particulate will build-up in the superheaters and the filters will screen out particles carried-over in the vapor stream. In the normal process of plant operation (cleaning superheaters and replacing filter units) the operators will receive some radiation exposure.

3. Liquid and Solid Releases

There are no liquid or solid releases of radioactive material with alternative Case RW-9.

4. Health and Safety Considerations

According to the calculations cited in 1 above, the airborne releases of radioactive materials do not pose a health hazard. Precautions should be taken to protect workers during the replacement of retired equipment in Building 604.

5. Effects on Wildlife

There is no adverse effect on wildlife.

6. Environmental Effects During Construction

Construction activities are confined to the Building CPP-604 and its immediate vicinity. Effects on other areas would be negligible. Exposure of workers to radiation during construction is low in all areas except the evaporator cell in Building CPP-604. In the evaporator cell the radiation background is approximately 50 millirems per hour. It is estimated that the time required to perform the modifications and new 12-inch vapor line installation in this cell will be 127 man-hours. This will result in a radiation exposure of approximately six man-rem.

6.9.5 Institutional Considerations

Replacement of the existing PEW condenser with heaters and filters would change operating procedures but would not impose any unusual or undue burdens upon operating and maintenance personnel.

6.10 ALTERNATIVE CASE RW-10: TREATMENT OF PEW CONDENSATES TO REMOVE TRITIUM

6.10.1 Principal Features

More than 98 percent of the radionuclides present in the PEW evaporator condensates under normal operating conditions is tritium. Virtually all of this is combined with normal hydrogen and oxygen to form tritiated water, HTO. The chemical and physical properties of HTO and H₂O are almost, but not quite, identical. If a means could be found to make use of the differences, it would be possible to pass the PEW condensates through a process step to separate a major portion of the tritium from the rest of the constituents. The tritium-enriched stream could then be disposed of independently from the rest of the PEW waste, thereby rendering the latter more acceptable for disposal.

In alternative Case RW-10, four possible methods for separating tritiated water from normal water are examined:

- Alternative Case RW-10A: Fractional Distillation
- Alternative Case RW-10B: Electrolysis
- Alternative Case RW-10C: Metal Hydride Absorption
- Alternative Case RW-10D: Dual-Temperature Isotope Exchange

Fractional distillation is examined in detail. The other three are examined only briefly.

Figure 6.10-1 is a simplified block flow diagram for the fractional distillation method, Case RW-10A.

Advantages and disadvantages of these alternatives are summarized in Figure 6.10-2 (for Case RW-10A) and 6.10-3 (for Cases RW-10B, RW-10C, and RW-10D) which list arguments "pro" and "con."

**ALTERNATIVE RW-10A
TREATMENT OF PEW CONDENSATE TO
REMOVE TRITIUM BY FRACTIONATION**

FIGURE 6.10-1

**ALTERNATIVE RW-10A
TREATMENT OF PEW CONDENSATE TO
REMOVE TRITIUM BY FRACTIONATION**

FRACTIONATION

PROS	CONS
1. Good Separation.	1. Energy Costs of Approximately \$6 Million/Year.
2. Small Concentrate Stream.	2. Complexity of System.
	3. High Capital Costs for Columns and Building.

FIGURE 6.10-2

**ALTERNATIVE RW-10B, 10C AND 10D
TREATMENT OF PEW CONDENSATE TO REMOVE
TRITIUM BY VARIOUS MEANS**

10B ELECTROLYSIS

PROS	CONS
1. Relatively Simple Process.	1. High Energy Costs.

10C DUAL TEMPERATURE ISOTOPIC EXCHANGE

PROS	CONS
1. Successfully Used For Deuterium Enrichment.	1. Little Data Available for Tritium.

10D METAL HYDRIDE PROCESS

PROS	CONS
1. Good Separation Factors.	1. No Large Scale Units in Operation.

FIGURE 6.10-3

Only distillation has progressed beyond the laboratory stage of development. All are, on the basis of rough estimates, expensive as compared with other disposal options available. Therefore, none of these cases is included in the list of viable alternatives.

6.10.2 Technical and Cost Aspects

1. Case RW-10A: Fractional Distillation

Tritium separation in a fractionating column is technically feasible; however, as the concentration of tritiated water and the relative volatility decrease, the economic feasibility decreases.

The relative volatility (equal to vapor pressure ratio for ideal solutions) between pure water and tritiated water (HTO) is near unity, and decreases with increasing temperature. Thus, in order for any separation to occur, low operating temperatures and pressures must be used. As the pressure decreases, column diameters increase. For this study an average operating temperature of 50°C was chosen. This corresponds to an average operating pressure of 1.8 psia. At these conditions, the relative volatility is 1.065.

The objective in the case studied was to reduce the concentration of tritium by a factor of one hundred. The concentrate flow rate was set at 100 gallons per day; this is an amount which can reasonably be disposed of by long-term storage, by evaporation, or by other suitable means.

Using the Fenske equation, it was determined that 265 trays were needed. This represents a column height of about 400 feet (or 16 columns of 25 feet each). This, from a technical point of view, is not unreasonable.

Using the modified Underwood equation with a relative volatility of 1.065, the minimum reflux ration was calculated as 15.4. Using the Gilliland correlation the reflux ratio was determined to be about 20.0. This means that 20 times the amount of feed to the column must be vaporized and condensed as reflux. This large reflux is needed because of the high product purity required. By having both high vapor and high liquid flow rates in the column (as compared to product rates) extremely high purities can be obtained.

A process flow diagram for this case appears in Appendix "B" (Drawing 475304-RW10-4-001).

As conceived for the purpose of this study, the fractionation system consists of sixteen 25-foot high columns, five feet in diameter; a steam reboiler; and two condensers equipped with vacuum jets.

Vapor feed (from PEW Vessels WL-129 and WL-161) enter into the bottom of column RW-10-V-8. Vapors travel up the column counter-currently with liquid flowing down the column. Vapors flow out the top and into the bottom of column RW-10-V-9. Similarly, the vapors flow through each successive column. Vapors flowing out of column RW-10-V-16 are partially condensed in condenser RW-10-E-2.

Condensation is completed in condenser RW-10-E-3. Liquids from these two condensers are combined. Part is retained as product, while the bulk is sent back to RW-10-V-16 as reflux.

The liquid flows column to column until it reaches column RW-10-V-1. Part of the liquid which flows out the bottom of this

column is kept as bottoms product, while the majority is vaporized in reboiler, RW-10-E-1. The reboiler uses 125 psig steam. To achieve the low operating pressure, a two-stage ejector system is required.

The high reflux rate means that energy must be put into the column reboiler in order to vaporize the distillate and reflux. This same energy is then taken out in the column condenser in order to condense the distillate and reflux. If the heat taken out in the overhead condenser could be recovered and used somewhere else in the plant, the process might be economically feasible. However, due to the low temperature level of this heat, recovery possibilities are few. The reboiler load is 1900 million Btu per day, which, at present steam cost of \$9 per thousand pounds, is about \$6.2 million per year. This figure is very high in comparison with other available options, especially considering the rising cost of energy.

This alternative is unproven and uneconomical and is not included in the list of viable alternatives.

2. Case RW-10B: Electrolysis

By means of an electrolytic cell it is possible to bring about a nonspontaneous oxidation-reduction reaction. Positive ions are attracted to the cathode (reduction), while the negative ions in the solution are attracted to the anode (oxidation). Hydrogen and oxygen will be bubbled off as gas, according to the following equation:

The Encyclopedia of Electro-Chemistry indicates that normal water (H_2O) electrolyzes preferentially to tritiated water (HTO). This

offers the possibility of enriching the tritium content by electrolyzing the normal water away from it. However, the energy costs associated with this alternative are very high; at a power rate of 2 cents/kwhr, the electrical power cost is \$120,000/day or \$2.1 million per year. For this reason, no further work was done on Case RW-10B.

3. Case RW-10C: Metal Hydride Absorption

Vanadium can form hydrides, which preferentially absorb tritium in hydrogen-rich environments (this tritium uptake depends on temperature). According to a report from Brookhaven National Laboratory, 50 ideal stages produced two streams from a feed containing 1 curie/kg of tritium; the first is the tritium-depleted stream of about 97 percent of the feed stream, containing 1 percent of the original tritium, and the other is the tritium-enriched stream of about 3 percent of the feed containing 99 percent of the tritium. This technology, particularly the solid-gas operation, has not developed to the point where large scale process design is feasible. This process has only long-term potential.

4. Case RW-10D: Dual-Temperature Isotope Exchange

Various hydrogen isotopes attached to certain molecules like oxygen (H_2O), sulfur (H_2S), and nitrogen (NH_3), will exchange hydrogen isotopes when mixed together. The equilibrium concentration of isotopes depends on temperature. By controlling temperature, this effect can be utilized for the enrichment of one isotope from the other, as indicated in the following equation:

A plant of this sort has been successfully used for deuterium enrichment. At this time, no data pertaining to tritium appears to be available. It is suggested that laboratory measurement of such data be conducted. This process has only long-term potential.

6.11 ALTERNATIVE CASE RW-11: SEPARATION OF THE ATMOSPHERIC PROTECTION
SYSTEM (APS) FROM THE PEW EVAPORATION SYSTEM

6.11.1 Principal Features

This case recognizes that most of the tritiated water which appears in the PEW evaporator is contained in a condensate stream which is routed to the PEW from the APS. This condensate stream contains tritium because there is tritiated water in the New Waste Calcining Facility (NWCF) feedstock, and most of the off-gas passing through the APS is from the calciner (Tritium Distribution in the Nuclear Industry, B. C. Musgrave, ICP-1041, January, 1974).

Case RW-11 separates this condensate from the PEW system and examines two alternative disposal techniques for the tritiated water. The first technique (Case RW-11A) exhausts the maximum amount of vapor to the existing 250 foot stack, collecting the condensate only when climatic conditions prevent its release to the atmosphere. The condensate would be used for recycle to dissolver and first cycle strip. The second disposal technique (Case RW-11B) exhausts vapors to the 250 foot stack and recycles condensate for dissolver acid, first cycle strip, and calcium nitrate production.

Figure 6.11-1 is a simplified block flow diagram for Case RW-11A.
Figure 6.11-2 is a simplified block flow diagram for Case RW-11B.

Drawings 475304-P-RW-11A and 11B are plot plans showing the location of the principal components. Advantages and disadvantages of this case are summarized in Figures 6.11-5 and 6.11-6 which lists arguments "pro" and "con."

This case prevents the release of tritiated water directly to the waste water system by separating the tritiated water supply stream from the low level waste system.

**ALTERNATIVE BW-11A
SEPARATION OF THE ATMOSPHERIC
PROTECTION SYSTEM (APS) FROM
THE PEW EVAPORATION SYSTEM**

FIGURE 6.11-1

ALTERNATIVE RW-11B SEPARATION OF THE ATMOSPHERIC PROTECTION SYSTEM (APS) FROM THE PEW EVAPORATION SYSTEM WITH CALCIUM NITRATE PRODUCTION

6.11-3

FIGURE 6.11-2

- UNDERGROUND
- 1 1"-CS TO CPP-666
 - 2 1"-S04L SS APS CONDENSATES FROM CPP-604
 - 3 2"-S04L SS VOG TO CPP-604
 - 4 1"-S04L SS ACID TO CPP-604
 - 5 1"-S04L ACID TO DISSOLVERS IN CPP-601
 - 6 1"-CS TRITIATED WATER TO CPP-601
 - 7 1"-CS TRITIATED WATER TO CPP-666
 - 8 1"-S04L SS ACID TO CPP-666
 - 9 1"-CS AIR FROM
 - 10 1"-CS RAW WATER FROM
 - 11 1"-CS CWS FROM
 - 12 1"-CS CWR TO
- ABOVE GROUND ON SLEEPERS & INSULATED
- 13 1"-CS 126 PSIG STEAM FROM
 - 14 1"-CS L.P. STEAM FROM
 - 15 1"-CS CONDENSATE TO

ICPP INJECTION WELL ALTERNATIVES PROJECT	
FOR DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO	
ALTERNATIVE RW-11B SEPARATION OF APS FROM PEW WITH ATMOSPHERIC DISPOSAL AND CALCIUM NITRATE PRODUCTION
FLUOR	HATCH
PLOT PLAN	
475304-P-RW-11B 1	

**ALTERNATIVE RW-11A
SEPARATION OF THE ATMOSPHERIC
PROTECTION SYSTEM (APS) FROM
THE PEW EVAPORATION SYSTEM**

PRO	CON
<ul style="list-style-type: none">1. Majority Of Tritium Is Removed From PEW System.2. Volume Of Tritium Containing Stream Is Greatly Reduced.3. Disposal Of Tritium Effluent Directly To Atmosphere.4. Maximum Utilization Of Ion Exchange Units To Remove Radioactive Particles.	<ul style="list-style-type: none">1. Requires Repiping Of Various Low Level Radioactive Waste Streams To Separate APS Condensate From PEW2. Requires Storage For Waste Streams.

FIGURE 6.11-5

**ALTERNATIVE RW-11B
SEPARATION OF THE ATMOSPHERIC
PROTECTION SYSTEM (APS) FROM THE PEW EVAPORATION
SYSTEM WITH CALCIUM NITRATE PRODUCTION**

PRO	CON
<ol style="list-style-type: none"> 1. Disposal Of Tritium Effluent Directly To Atmosphere. 2. Neutralization Of Highly Acid Stream. 3. Manufacture Of Calcium Nitrate Reduces Requirement For Purchase. 4. Reduces Disposal Of Tritium To The Aquifer Or The Atmosphere. 5. Maximum Utilization Of Ion Exchange Units To Remove Radioactive Particles. 	<ol style="list-style-type: none"> 1. Requires Repiping Of Various Low Level Radioactive Waste Streams To Separate APS Condensate From PEW. 2. Requires Careful Handling Of Waste Streams And Calcium Nitrate Plant Product Streams. 3. Substantial Capital Cost. 4. Requires Hold-Up Tankage. 5. Calcium Nitrate Plant Will Not Remove All Tritium.

FIGURE 6.11-6

6.11.2 Technical Aspects

Tritium constitutes over 98 percent of the total radioactivity found in the Process Equipment Waste (PEW) condensate. The tritium enters the ICPP process system during the dissolution of nuclear fuel. The majority of tritium is released to the atmosphere as gas primarily in the chemical form HT, as part of the dissolver off-gas (DOG). Some tritium becomes tritiated water, primarily in the chemical form HTO. The tritiated water, which is produced in the dissolvers, is removed from the balance of the system in the first cycle raffinate and stored in the high level radioactive waste tanks. This waste becomes the feed to the New Waste Calcining Facility (NWCF) where it is flashed into a vapor which passes to the Atmospheric Protection System (APS). Also entering the APS is the Vessel Off-Gas (VOG) and the Dissolver Off-Gas (DOG), both of which contain tritium. All of these tritium containing vapors pass through the APS condenser (OGF Condenser 104). The major part of the tritium is in the form of HT gas from the DOG and passes through the condenser and up the stack. The vapor stream from the NWCF contains tritiated water, part of which is condensed as it passes through the APS condenser. The uncondensed vapors pass up the stack. The amount of water vapor condensed in the APS condenser depends upon the amount of cooling provided to the condenser. The condensate drains to Vessel WL-102 along with a stack drain and NWCF process off-gas line drain. These two lines supply virtually all of the tritiated water to the (PEW) Process Equipment Waste Evaporator System.

Since tritium constitutes virtually all of the radioactivity in the PEW evaporator condensate, a major reduction in radioactive release to the waste water system will result from the total isolation of the tritiated water from the system. The remaining radioactive constituents comprise only a small fraction of the total radioactivity found in the condensate.

The isolation of the APS condenser stream (approximately 3200 gallons per day) from the PEW has two beneficial effects. First, a reduction of approximately 25 percent in feed flow to the PEW will ensue. Second, the APS condensate stream contains a significant quantity of nitric acid from the NWCF process off-gas. This stream has not been sampled and analyzed during this study but calculations indicate that substantial concentrations of nitric acid are present. With the lower feed rate it will be more practical to adjust the pH of the remaining stream (approximately 8000 gallons per day) so that the PEW condensate will be in an efficient operating range of the ion exchangers. It also appears probable that a higher decontamination factor could then be obtained by increasing the spray on the demister pads and decreasing the takeoff rate. These options need further study to define quantities which were not directly measurable during this study; in particular, the composition of the APS condensate should be measured. Other possible methods for increasing the decontamination factor across the PEW evaporator include double evaporation and increased ion exchange.

The two alternative methods of disposing of the APS tritiated water stream are described in the following sections.

6.11.3 Atmospheric Disposal With Limited Recycle (Alternative RW-11A)

This technique for disposal of the tritium bearing effluents involves exhausting the majority of the vapors in the APS system to the stack. In this case, the cooling water flow to the condenser in the APS is restricted, thereby allowing more vapors to pass through the existing APS superheaters and HEPA filters to the stack. This system also provides two storage tanks (RW-11-V-1A & B) to be used for collection of fluids coming from the stack drain and the NWCF process off-gas line drain. This tankage will be also used to collect water draining the the APS condenser when climatic conditions do not permit the direct discharge to the stack.

The air flow through the stack is approximately 125,000 SCFM. The relative humidity of the air is low enough that under nearly all conditions there is adequate capacity for the addition of the vapors coming from the APS system. However, if a system upset should occur, enough tankage is provided to collect up to 20 days supply of condensate. Such conditions could exist on rainy days, during air inversions, or when the plant HVAC flow is curtailed for some reason.

The collected acidic tritiated water in the tankage system may be used as dissolver acid makeup or first cycle strip makeup. The APS condenser will be used as a control mechanism to condense no more than the amount of water for which there is a user. Emergency dumping will be directly to a high level waste tank. In no case will the tritiated water be permitted outside of the ICPP first cycle system.

6.11.4 Description of Alternative RW-11B System for Condensate Reuse With Calcium Nitrate Plant

Refer to Process Flow Diagram 475304-RW11-4-001 in Appendix "B" and simplified block flow diagram, Figure 6.11-2. The rate of cooling water to the APS condenser is controlled to condense only that amount of tritiated water which can be beneficially used. The remainder is allowed to pass up the existing 250 foot stack.

The lines from the APS condenser, stack drain, and calciner line drain are diverted in the PEW middle gas cell to a receiving vessel where they are pumped directly to the surge tanks RW-11-V1A & B. These tanks provide volume for about three weeks surge. Utilizing charge pump RW-11-P-1, the condensate is pumped as feed to the reactors RW-11-V2A & B and as recycle. Approximately 40 percent of the condensate is fed to the reactors, 34 percent is recycled to the dissolvers, 9 percent is recycled to the first cycle strip. The remain-

ing 17 percent is allowed to pass up the stack. By recycling condensate, the amount of calcium nitrate produced is limited to that amount required for the New Waste Calcining Facility (NWCF). Calcium hydroxide or limestone is fed to the reactors, reacting with nitric acid to yield calcium nitrate:

The calcium hydroxide or limestone is fed to the reactors via a mechanical feed system, such as a "vibra screw feeder." Under normal conditions, only one reactor is in operation at any time. The reactor not in use can be cleaned or charged during this time. Having two reactors also increases the surge capacity of the system, allowing for upset conditions which may occur in the existing operations. The above reaction is exothermic (21 kcal/mole HNO_3). Each reactor is equipped with a cooling water coil to maintain constant temperature in the reactor.

The reactor product is a solution of calcium nitrate and water (some tritiated water is present from the feed). This solution is pumped with RW-11-P-2 to an evaporator, RW-11-V-3. The calcium nitrate concentration can then be controlled and the neutralized water used for other purposes. Water is vaporized in evaporator reboiler, RW-11-E-1. The water is condensed in RW-11-E-2 and stored in surge tank RW-11-V-4. This water is concentrated in tritium and must either be disposed of or recycled. Potential recycle users are dissolver makeup and first cycle strip makeup. Possible disposal methods include revaporization to the stack or disposal to the high level radioactive waste tanks. The concentrated calcium nitrate is pumped by RW-11-P-3 from the evaporator to Vessel MCM-120 (in the NWCF).

ALTERNATIVE RW-11A

Piping	101,000
Tanks, Equipment and Miscellaneous	394,000

Direct Field Costs	495,000
Contractor Overhead and Profit	81,000
Engineering and Management	343,000
Contingency	170,000

Total Capital Cost	\$1,089,000
--------------------	-------------

Life Cycle Cost	\$1,418,000
-----------------	-------------

Figure 6.11-7

ALTERNATIVE RW-11B
(CALCIUM NITRATE)

Calcium Nitrate Plant	855,000
Piping	281,000
Miscellaneous Tanks and Equipment	20,000

Direct Field Costs	1,156,000
Contractor Overhead and Profit	181,000
Engineering and Management	872,000
Contingency	395,000

Total Capital Cost	\$2,604,000
--------------------	-------------

Life Cycle Cost	\$2,117,000
-----------------	-------------

Figure 6.11-8

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: RW-11A

TITLE: SEPARATION OF APS CONDENSATES FROM PEW; EVAPORATION TO STACK AND
RECYCLE REMAINDERPART I

- Capital Cost = \$1,089,000
- O&M Cost = \$36,500/year
- Energy:
 - Electricity = 180 MBTU
 - Oil = 132 MBTU
- Economic Life = 20 years
- Residual Value = Zero
- Reinvestment Cost = Zero

PART II

- Present Value Capital Investment = \$1,089,000
- Present Value O&M
 - $\$36,500 \times 8.51 = \$310,615$
- Present Value Energy
 - Electricity = $180 \text{ MBTU} \times \$5.57/\text{MBTU} \times 12.61 = \$12,643$
 - Oil = $132 \text{ MBTU} \times \$4.36/\text{MBTU} \times 9.4 = \$5,410$
- Total Present Value = \$1,417,668

Figure 6.11-9

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: RW-11B

TITLE: SEPARATION OF APS CONDENSATES FROM PEW; EVAPORATION TO STACK AND
MANUFACTURE OF $\text{Ca}(\text{NO}_3)_2$ IN OWN PLANTPART I

- Capital Cost = \$2,604,000
- O&M Cost = -\$62,500/year
- Energy:
 - Electricity = 399 MBTU
 - Oil = 542 MBTU
- Economic Life = 10 years for screw conveyor (factor = 0.39)
20 years for rest of system
- Residual Value = 50,000 (factor = 0.15)
- Reinvestment Cost = Screw Conveyor 5,000 in year 10 (factor = 0.39)

PART II

- Present Value Capital Investment = \$2,604,000 + 1,950 - 7,500 = \$2,598,450
- Present Value O&M
 $-\$62,500 \times 8.51 = -\$531,875$
- Present Value Energy
 - Electricity = 399 MBTU $\times$ \$5.57/MBTU $\times$ 12.61 = \$28,025
 - Oil = 542 MBTU $\times$ \$4.36/MBTU $\times$ 9.4 = \$22,213
- Total Present Value = \$2,116,813

Figure 6.11-10

6.11.5 Cost Estimates

Capital and operating costs were estimated for these cases, and life cycle cost analyses were made. Results are summarized in Figures 6.11-7, 6.11-8, 6.11-9 and 6.11-10.

6.11.6 Environmental Features

1. Airborne Releases

The evaporation released up the 250 foot stack achieve tritium average ground level concentrations that are within ERDAM-0524 guidelines. Various windspeeds were chosen in unstable, neutral, and stable conditions, at ambient temperatures of -29°C and $+27^{\circ}\text{C}$. In all cases, the concentrations were below the maximum permissible concentrations. The maximum concentration case was with an ambient temperature of 27°C , a windspeed of 2 meters per second, and a "C" stability class (corresponding to a temperature inversion condition). This produced an "unstable" condition. The maximum concentration was 7.9×10^{-13} grams per cubic meter of air (7.6×10^{-9} microcuries per mil) 270 meters downwind of the stack. This value is estimated to be accurate within a factor of 3, which is still within the 5×10^{-6} microcuries per milliliter concentration permitted by ERDAM-0524. Maximum I-131 concentration is 129×10^{-12} microcuries per milliliter which is also within concentration limitations. Therefore, from the standpoint of airborne releases, alternative RW-11 is a viable case.

Problems may be encountered with the amount of nitric acid discharged. Acid rain could pose potential problems under certain adverse climatic conditions. It is under these conditions that the vapors will be condensed at the APS condenser for other uses.

2. Liquid and Solid Releases

There are no liquid or solid releases of radioactive material with alternative Case RW-11.

3. Health and Safety Considerations

According to the calculations cited in 1 above, the airborne releases do not pose a health hazard due to exposure to airborne radioactive materials.

4. Effects on Wildlife

There is no adverse effect on wildlife.

5. Environmental Effects During Construction

Construction activities are confined to the Building CPP-604 and its immediate vicinity. Effects on other areas would be negligible. Exposure of work to radiation during construction is low in all areas except at Building CPP-604.

The installation of either RW-11 case alternative will entail a small amount of radiation exposure. The installation of the collection tank and pumps will be in the middle gas cell. This is the location where the two lines connecting the APS to the PEW will be severed. The radiation field in this area is reported to be approximately 25 millirem per hour following decontamination. The actual work will require adherence to the normal precautions incident while working in contaminated or radioactive areas.

The reconnection of lines and the installation surge tank and pumps is estimated to take approximately 60 man-hours. With a background of 25 millirem per hour this will result in a total dose of 1.5 man-rem.

Radiation exposure during plant operation will be unchanged from existing operations.

6.11.7 Institutional Effects

No significant institutional effects were noted since the types of equipment added are compatible with existing ICPP facilities.

ALTERNATIVE COMBINED MEANS FOR
DISPOSAL OF AQUEOUS WASTE STREAMS

7.0 INTRODUCTION

In Sections 4, 5 and 6 of this report, alternative means for disposal of cooling water/steam condensates, chemical wastes and low-level radioactive wastes have been examined separately. The alternative cases evaluated were selected and/or approved by DOE. In Section 7, these streams are examined together to develop waste disposal approaches that will handle all three kinds of streams concurrently.

The results of the examinations of the separate alternative cases are summarized in Table 7.0-1.

From Table 7.0-1 it is seen that of the seven alternative cases concerned with cooling water and steam condensates, five were judged to be viable. However, these are not all equally useful. Cases CC-2 (shallow well) and CC-3 (percolation pond) are similar; Case CC-3 is more expensive than Case CC-2, with insufficient advantage to justify the extra cost. Therefore, Case CC-3 is not considered further. Case CC-2 offers marginal advantages over Case CC-1 (disposal to existing injection well); it can be regarded as an option to CC-1 in the event that it turns out to be more cost effective to use a shallow injection well near the southeast corner of the ICPP perimeter rather than to use the existing injection well. Cases CC-6 (recirculation with cooling tower) and CC-7 (recirculation with heat exchanger) accomplish the same basic objective. However, Case CC-6 costs less and has greater environmental advantages, compared with CC-7. Therefore, CC-7 is not considered further.

For disposal of chemical wastes, two alternative cases are viable. Case CH-5 (disposal to a solar evaporation pond) is significantly less

TABLE 7.0-1
(Sheet 1)
DISPOSAL OF AQUEOUS WASTE STREAMS AT THE IDAHO CHEMICAL PROCESSING PLANT
SUMMARY OF INDIVIDUAL ALTERNATIVE CASES STUDIED

<u>CASE NO.</u>	<u>MEANS OF DISPOSAL</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
<u>For Cooling Water and Steam Condensates:</u>			
CC-1	Disposal to Existing Well	Viable. Base case - no incremental cost	
CC-2	Disposal to Shallow Well	2,198	2,938
CC-3	Disposal to Percolation Pond	3,094	3,633
CC-4	Disposal to Evaporation Pond	Eliminated due to excessively high cost	
CC-5	Disposal to Big Lost River Channel	Eliminated - environmental uncertainties and low benefit	
CC-6	Recirculation, Utilizing Cooling Tower	11,542	11,107
CC-7	Recirculation, Utilizing Heat Exchanger	11,948	13,522
<u>For Chemical Wastes:</u>			
CH-1	Disposal to Existing Well	Eliminated for environmental reasons	
CH-2	Disposal to Evaporative Concentrator		
	(a) Brine to Evaporation Pond	5,688	7,502
	(b) Brine to Spray Dryer	5,974	9,126
CH-3	Concentration by Reverse Osmosis	Eliminated as technically infeasible	
CH-4	Disposal to Dryer	Eliminated due to high energy cost	
CH-5	Disposal to Solar Evaporation Pond	3,765	4,454
CH-6	Disposal to Percolation Pond or Well	Eliminated for environmental reasons	
CH-7	Disposal to Deep Well	Eliminated due to technical uncertainties	

TABLE 7.0-1
(Sheet 2)
DISPOSAL OF AQUEOUS WASTE STREAMS AT THE IDAHO CHEMICAL PROCESSING PLANT
SUMMARY OF INDIVIDUAL ALTERNATIVE CASES STUDIED

<u>CASE NO.</u>	<u>MEANS OF DISPOSAL</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
<u>For PEW Evaporator Condensates</u>			
RW-1	Disposal to Existing Well	Eliminated for environmental reasons	
RW-2	Improvement of Cation Exchangers	Eliminated for technical reasons	
RW-3	Recycle to Process Makeup	Eliminated for technical reasons	
RW-4	Disposal to Shallow Well	Eliminated for environmental reasons	
RW-5	Disposal to Percolation Pond	Eliminated for environmental reasons	
RW-6	Disposal to Solar Evaporation Pond	Eliminated for environmental reasons	
RW-7	Separation by Reverse Osmosis	Eliminated for technical reasons	
RW-8	Disposal to Deep Well	2,644	2,977
RW-9	Disposal Directly to Atmosphere	1,770	2,587
RW-10	Treatment to Remove Tritium	Eliminated for technical and cost reasons	
RW-11	Separation of APS Effluent from PEW System		
	(a) Recycle Portion to Process Makeup	1,089	1,418
	(b) Recycle to Process and $\text{Ca}(\text{NO}_3)_2$ Prod.	2,606	2,209

costly than either CH-2(A) or CH-2(B) (disposal by evaporative concentration). It is also less costly to operate. Therefore, the CH-2 cases are not considered further.

For disposal of PEW evaporator effluents, three cases appear to be viable: Case RW-8 (disposal to a deep well), Case RW-9 (disposal directly to the atmosphere), and Case RW-11 (separation of APS effluent from the PEW system [two subcases]). RW-8 and RW-9 are both more costly than RW-11. In addition, RW-8 has uncertainties which reduce its attractiveness and could ultimately affect viability. Case RW-11 could not be defined completely on the basis of data available for this study. Nevertheless, it has such attractive features that we believe it should be considered as a part of any improved disposal scheme adopted for the ICPP.

To summarize, the individual alternative cases that are considered in the development of combined cases are the following:

- a. For disposal of cooling water and steam condensates, Case CC-1 (disposal to the existing injection well) with Case CC-2 (disposal to a shallow well) as a convenience alternative. Case CC-6 eliminates the need for disposal.
- b. For disposal of chemical wastes, Case CH-5 (disposal to a solar evaporation pond).
- c. For disposal of PEW evaporator effluents, Case RW-11 (separation of APS effluent from PEW system).

This section addresses combinations of the above disposal alternative cases which we observe to be compatible with each other and which are also compatible with a phased approach to a long-term water program. No attempt has been made to examine all possible combinations of individual alternatives; only those meeting the foregoing criteria.

Other alternatives not approved by DOE are not considered. New information or different data (not within the scope of this study) could lead to different conclusions or other methods of waste disposal. The alternatives selected were evaluated for feasibility, technical advantages and compliance with regulations. Environmental and health/safety factors were evaluated on a qualitative basis, but detailed cost benefit calculations were not prepared.

In examining combinations of alternatives, it was found that in some instances there are interactions among them which affect the combination. For example, disposal of chemical wastes to the existing injection well (Case CH-1) is more nearly acceptable if combined with Case CC-1. This effect is discussed in Section 7.1. Another example is the combination of CH-5 with CC-6; recirculation of cooling water and steam condensates has the effect of reducing the requirements for water softener salt and softener regeneration water by more than 80 percent. This effect is discussed in Section 7.5.

For any alternative cases in which the waste stream is returned to the earth, by any means, the benefits and costs of adding holding ponds to protect against the possibility of an accidental spill are examined. Holding ponds are discussed in Section 4.0; their application in the combined cases is discussed in Section 7.2.

Using the individual alternative cases as "building blocks," it is possible to develop a series of combined cases (designated by the prefix CO), each with certain incremental costs and benefits. These are arranged in ascending order of complexity and environmental benefit.

CO-1 Disposal of all Waste Streams to Existing Injection Well (CC-1 plus CH-1 plus RW-1) (Note: This is the true "Existing Practice" case.)

CO-2 Disposal of Cooling Water and Chemical Wastes to the Aquifer, APS Effluent Separated From PEW System (CC-1 plus CH-1 plus RW-11A)

CO-3 Cooling Water and Chemical Wastes To Aquifer, With Holding Ponds; APS Effluents Separated From PEW System (CC-1 plus CH-1 plus RW-11A plus holding ponds)

CO-4 Cooling Water to Well, Chemical Wastes to Solar Evaporation Pond, APS Effluents Separated From PEW System (CC-2 plus CH-5 plus RW-11(A) plus holding ponds)

CO-5 Recirculation of Cooling Water; Chemical Wastes to Solar Pond; Separation of APS Effluent From PEW System (CC-6 plus CH-5 plus RW-11(A))

CO-6 Recirculation of Cooling Water; Chemical Wastes to Solar Pond; Separation of APS Effluent From PEW System, but With Increased Recovery of Steam Condensates (modified CC-6 plus CH-5 plus RW-11(A)) -

These combined cases are discussed individually in Sections 7.1 thru 7.6. In these discussions, information sufficient for identification of the significant features of each of the component "building block" alternative cases is presented.

7.1 ALTERNATIVE CASE CO-1: DISPOSAL OF ALL WASTE WATER STREAMS TO
EXISTING INJECTION WELL

7.1.1 Principal Features

This case is the existing practice; cooling water, steam condensates, chemical wastes and PEW evaporator condensates are mixed together and discharged to the existing injection well (CPP-304). It may be thought of as a combination of alternative Cases CC-1, CH-1 and RW-1.

A schematic flow diagram of alternative CO-1 is shown in Figure 7.1-1.

Advantages and disadvantages of this case are summarized in Figure 7.1-2 which lists arguments "pro" and "con."

The significance of this case is that it is the point of reference with which the other alternatives are compared. Any expenditure for either capital costs or operating and maintenance costs must be justified by benefits gained over alternative CO-1.

7.1.2 Technical Aspects

Process flow diagrams for alternative CO-1 are included in Appendix B. (Drawings 475304-CO1-R-001, 475304-CO1-4-002 and 475304-CO1-R-003).

The existing service waste system, while it involves an elaborate system of feeder and trunk drains, is basically simple to operate. Flow is mainly by gravity and little pumping is required. Streams are monitored for possible excessive radioactivity and these monitors require occasional maintenance. This scheme has been utilized successfully and with a minimum of operating difficulty for more than 27 years.

ALTERNATIVE CO-1 DISPOSAL OF COOLING WATER, STEAM CONDENSATES CHEMICAL WASTES AND PEW CONDENSATES TO EXISTING INJECTION WELL

FIGURE - 7.1-1

ALTERNATIVE CO-1
DISPOSAL OF ALL WASTE WATER STREAMS
TO EXISTING INJECTION WELL

<u>PRO</u>	<u>CON</u>
1. Existing practice - no changes required. Meets ERDAM-0524 Table 1.	1. Tritium levels exceed State Injection Well Standards.
2. Low pumping (energy) costs	2. Heavy ions are disposed to the aquifer.
	3. Lacks positive protection against accidental spills.
	4. Strontium levels exceed EPA Injection Well Standards.
	5. Approximately 5 tons of salt is disposed to aquifer daily.

Figure 7.1-2

7.1.3 Cost Estimates

Since Case CO-1 utilizes existing facilities plus new facilities which are to be installed by 1985 as parts of improvement projects currently scheduled, there is no incremental cost for either new facilities or operation and maintenance attributable to alternative CO-1. It is the "base case" with which other combined alternatives are compared.

7.1.4 Environmental Features

The U.S. Environmental Protection Agency has recently formally issued regulations pertaining to discharge of wastes into injection wells. The State of Idaho has recently adopted injection well regulations which are more stringent in all essential respects. Selected items from the standards are presented in Figure 7.1-3. Corresponding characteristics of the water in the aquifer, as measured at ICPP, are presented in the same figures for comparison. Maximum permissible concentration levels from ERDAM 0524 are also listed.

Cases CH-1 and RW-1, when examined separately, were eliminated on environmental grounds. However, when these streams are mixed with the cooling water/steam condensate stream, the concentrations of dissolved ions are reduced. The combined stream characteristics are presented in column 6 of Figure 7.1-3.

The State regulations presently do not apply to Federal facilities because the State has not yet received "Primacy." The Idaho regulations require the waste stream to meet "drinking water standards" at the point of injection if the waste stream can reach an aquifer.

It can be seen from Figure 7.1-3 that the wellhead concentration exceeds the State Injection Well Standards for tritium and strontium. The wellhead concentration complies with the EPA Injection Well Standards in the case of tritium but slightly exceeds it in the case of Strontium-90.

TYPICAL COMPARISONS

	STATE INJECTION WELL STANDARDS pCi/L (μ Ci/ml)	CONTROLLED AREA ERDA MANUAL CHAPTER 0524 TABLE I pCi/l (μ Ci/ml)	EPA INJECTION WELL STANDARDS AND ERDAM-0524 TABLE II pCi/l (μ Ci/ml)	RAW WATER CONCENTRATION pCi/l (μ Ci/ml)	PEW CONDENSATE CONCENTRATION* pCi/l (μ Ci/ml)	INJECTION WELL CONCENTRATION pCi/L (μ Ci/ml) (average) (maximum)	
Tritium	2.0×10^4 (2.0×10^{-5})	1.0×10^8 (1.0×10^{-1})	3.0×10^6 (3.0×10^{-3})	4.4×10^3 (4.4×10^{-6})	2.1×10^7 (2.1×10^{-2})	2.3×10^5 (2.3×10^{-4})	1.7×10^6 (1.7×10^{-3})
Strontium-90	8 (8.0×10^{-9})	1.0×10^4 (1.0×10^{-5})	3.0×10^2 (3.0×10^{-7})	2.4 (2.4×10^{-9})	3.31×10^4 (3.31×10^{-5})	3.7×10^2 (3.7×10^{-7})	2.8×10^3 (2.8×10^{-6})
Cerium-144	---	3.0×10^5 (3.0×10^{-4})	1.0×10^4 (1.0×10^{-5})	---	1.2×10^3 (1.2×10^{-6})	1.4×10^1 (1.4×10^{-8})	3.8×10^3 (3.8×10^{-6})
Cesium-137	---	4.0×10^5 (4.0×10^{-4})	2.0×10^4 (2.0×10^{-5})	---	7.2×10^4 (7.2×10^{-5})	7.9×10^2 (7.9×10^{-7})	2.8×10^3 (2.8×10^{-6})
Ruthenium-106	---	4.0×10^5 (4.0×10^{-4})	1.0×10^4 (1.0×10^{-5})	---	6.5×10^4 (6.5×10^{-5})	7.1×10^2 (7.1×10^{-7})	1.3×10^3 (1.3×10^{-6})
Iodine-129	---	5.0×10^4 (5.0×10^{-5})	6.0×10^1 (6.0×10^{-8})	---	4.1×10^3 (4.1×10^{-6})	4.5×10^1 (4.5×10^{-8})	7.6×10^1 (7.6×10^{-8})
	EPA INJECTION WELL STANDARDS	STATE INJECTION WELL STANDARDS		PEW CONDENSATE CONCENTRATION		WELLHEAD CONCENTRATION	

Mercury 0.2 mg/liter .002 mg/liter 0.42 mg/liter 0.005 mg/liter

*Assuming similar flow rates for PEW condensate, total flow will be about twice 1980 conditions; therefore concentrations would be approximately one-half of those shown.

Figure 7.1-3

Other environmental considerations associated with this alternative are as follows.

First, the service waste system depends on radiation monitors and automatic diversion valve stations to prevent any accidental releases of radioactive material from entering the aquifer. While these devices have proven to be highly reliable, it would be more desirable to have a "positive" method (i.e., one which does not depend on unattended automatic devices) to supplement them. A method of providing such positive accident protection is discussed in Section 7.3.

Second, the high salinity of the mixed waste stream is undesirable. This matter is discussed in Section 7.4.

In summary, the injection stream meets the presently applicable ERDAM-0524 Table I standards. However, since the injection stream contains concentrations of certain radionuclides which exceed federal EPA and state standards, a plan should be developed to modify the existing disposal practice as the standards become applicable.*

* DOE has advised that recent modifications to the PEW evaporator system has improved its operation such that the radionuclides in the concentrates now fall within federal EPA allowables.

7.2 ALTERNATIVE CASE CO-2: DISPOSAL OF COOLING WATER, STEAM CONDENSATES, AND CHEMICAL WASTES TO THE AQUIFER; APS EFFLUENTS SEPARATED FROM PEW SYSTEM

7.2.1 Principal Features

In this alternative, cooling water, steam condensates and chemical wastes continue to drain to the existing injection well, as in Case CO-1. The change is that the APS effluents are separated from the PEW system, as described in Case RW-11. The APS effluents are primarily disposed of in the vapor phase to the 250 foot stack with a smaller portion collected for either recycling to dissolvers or extractors. The remaining PEW condensates (about 8000 gallons per day) are drained into the service waste system and disposed of along with the cooling water and other service waste streams.

Schematic flow diagrams for alternative CO-2 are shown in Figures 7.2-1 and 7.2-2.

Advantages and disadvantages of this alternative are summarized in Figure 7.2-3 which lists arguments "pro" and "con."

7.2.2 Technical Aspects

Process flow diagrams for alternative Case CO-2 are included in Appendix "B" (Drawing Numbers 475304-CO2-R-001 and 475304-CO2-4-002).

Technical aspects of the feature of this alternative (separation of APS effluents from the PEW system) are discussed in detail in Section 6.11.

Tritium constitutes over 98 percent of the total radioactivity found in the Process Equipment Waste (PEW) condensate. The tritium enters the ICPP process system during the dissolution of nuclear fuel.

ALTERNATIVE CO-2 DISPOSAL OF COOLING WATER, STEAM CONDENSATES AND CHEMICAL WASTES TO EXISTING INJECTION WELL

FIGURE - 7.2-1

ALTERNATIVE CO-2 SEPARATION OF APS EFFLUENTS FROM PEW SYSTEM

FIGURE - 7.2-2

ALTERNATIVE CO-2
DISPOSAL OF COOLING WATER, STEAM CONDENSATES,
AND CHEMICAL WASTES TO AQUIFER
(APS EFFLUENTS SEPARATED FROM PEW SYSTEM)

<u>PRO</u>	<u>CON</u>
1. Relatively easy and inexpensive to instigate.	1. Discharges 5 tons of salt per day to aquifer.
2. No significant tritium to aquifer.	2. Does not provide positive protection against accidental spills.
3. Removes heavy metals and strontium from waste injection stream to aquifer.	

Figure 7.2-3

The majority of tritium is released to the atmosphere as gas primarily in the chemical form HT. Some tritium becomes tritiated water, primarily in the chemical form HTO. The tritiated water, produced in the dissolvers, is removed from the balance of the system in the first cycle raffinate and stored in the high level waste tanks. This waste becomes the feed to the New Waste Calcining Facility (NWCF) where it is flashed into a vapor which passes to the Atmospheric Protection System (APS). Also entering the APS is the Vessel Off-Gas (VOG) and the Dissolver Off-Gas (DOG), both of which often contain tritium. All of these tritium containing vapors pass through the APS condenser (OGF condenser 104) where some is condensed. The condensate drains to Vessel WL-102 along with a stack drain and NWCF process off-gas line drain. These two lines supply virtually all of the tritiated water to the (PEW) Process Equipment Waste Evaporator System.

Since tritium constitutes virtually all of the radioactivity in the PEW evaporator condensate, a major reduction in radioactive release to the waste water system will result from the total isolation of the tritiated water stream from the rest of the system. The remaining radioactive constituents comprise only a small fraction of the total radioactivity found in the condensate.

The isolation of the APS condenser stream (approximately 3200 gallons per day) from the PEW has two beneficial effects. First, a reduction of approximately 25 percent in feed flow to the PEW will ensue. Second, the APS condensate stream contains a significant quantity of nitric acid from the NWCF process off-gas. This stream has not been sampled and analyzed during this study, but calculations indicate that substantial concentrations of nitric acid are present. With the lower feed rate it will be more practical to adjust the pH of the remaining stream (approximately 8000 gallons per day) so that the PEW condensate will be in an efficient operating range of the ion exchangers.

The net effect is that the APS effluent, which is the source of virtually all of the tritium in the service waste system under existing conditions, is not allowed to enter the PEW system through which it passes to the service waste system. After more effective decontamination by increased ion exchange or other means, the PEW condensates contain only traces of radioactive materials and in concentrations well below levels which are acceptable under both EPA and ERDA standards.

Separation of APS effluents from the PEW system is relatively easy and inexpensive to accomplish. Operation of the revised system does not impose any undue difficulties upon the CPP operation and maintenance staff. We believe this would be a logical and effective first step in any effluent upgrading program.

7.2.3 Cost Estimates

The estimated costs of implementing alternative CO-2, as compared with Case CO-1, are summarized in Figures 7.2-4 and 7.2-5.

7.2.4 Environmental Features

As discussed above, removal of the APS effluents from the service waste system virtually eliminates excess tritium. Certain heavy metallic ions and nitrates also are shown to be present in amounts exceeding only State Injection Well Standards (Table 6.0-1). It is possible that the tests on which the source report was based were not representative. Additional tests should be made over a period of time and under various operating conditions, in order to verify the continued presence of these ions and to determine if these ions can be intercepted at their source. However, even if present, the decontamination effects of increased ion exchange should remove these heavy metal contaminants. With this accomplished, alternative Case CO-2 meets the requirements of the State of Idaho Injection Well Standards.

ALTERNATIVE CO-2

Piping	101,000
Tanks, Equipment and Miscellaneous	394,000

Direct Field Costs	495,000
Contractor Overhead and Profit	81,000
Engineering and Management	343,000
Contingency	170,000

Total Capital Costs	\$1,089,000
---------------------	-------------

Life Cycle Cost	\$1,418,000
-----------------	-------------

Figure 7.2-4

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CO-2

TITLE: •Cooling water and steam condensates, plus chemical wastes to existing injection well.

•APS condensates separated from PEW system.

PART I

- Capital Cost = \$1,089,000
- O & M Cost = \$ 36,500/year
- Energy:
 - Electricity = 180 MBTU
 - Oil = 132 MBTU
- Economic Life = 20 Years
- Residual Value = Zero
- Reinvestment Cost = Zero

PART II

- Present Value Capital Investment = \$1,089,000
- Present Value O & M = $\$36,500 \times 8.51 = \$310,615$
- Present Value Energy
 - Electricity = $180\text{MBTU} \times \$5.57/\text{MBTU} \times 12.61 = \$12,643$
 - Oil = $132\text{MBTU} \times \$4.36/\text{MBTU} \times 9.4 = \$5,410$
- Total Present Value = \$1,417,668

Figure 7.2-5

In this alternative, the waste stream to the injection well also contains chemical wastes. By 1985 these chemical wastes will include approximately five tons of salt (NaCl) per day which will be disposed to the aquifer under alternative Case CO-2. This constitutes approximately 750 ppm of dissolved solids and, over a period of years, could result in degrading the local aquifer waters from its present 300 PPM.

In addition, no "positive" means has been provided to protect against the unlikely occurrence of a "spill."

For this reason, this alternative is only marginally acceptable and is not sufficient to serve as a complete solution.

7.3 ALTERNATIVE CASE CO-3: DISPOSAL OF COOLING WATER, STEAM CONDENSATES, AND CHEMICAL WASTES TO THE AQUIFER THROUGH HOLDING PONDS; APS EFFLUENTS SEPARATED FROM PEW SYSTEM

7.3.1 Principal Features

Alternative Case CO-3 differs from CO-2 in only one respect: cooling water, steam condensates, chemical wastes and PEW condensates (with APS effluents directed elsewhere) pass through a system of holding ponds before being disposed of in the aquifer. The APS effluents are separated from the PEW system as described in detail in Case RW-11. The APS effluents are separately disposed of in the vapor phase to the 250 foot stack with a smaller portion collected for either recycling to the dissolver or to the final stage extractor. The remaining PEW condensates are disposed of to the service waste system.

Advantages and disadvantages of alternative Case CO-3 are summarized in Figure 7.3-3 which lists arguments "pro" and "con". Schematic flow diagrams for alternative CO-3 are shown in Figures 7.3-1 and 7.3-2.

7.3.2 Technical Aspects

Process flow diagrams for alternative Case CO-3 appear in Appendix B (Drawing Numbers 475304-CO3-R-001 and 475304-CO3-2-002).

Technical aspects of separation of APS effluents from the PEW system are discussed in Section 6.11. Since tritium constitutes the major portion of the radioactivity in the PEW evaporator condensate, the isolation of the APS effluent will result in a major reduction in radioactive release to the waste water system. After increased cation exchange, the condensate will contain only traces of radioactive materials.

**ALTERNATIVE CO-3
DISPOSAL OF COOLING WATER, STEAM CONDENSATES
AND CHEMICAL WASTES TO A SHALLOW WELL THROUGH
HOLDING PONDS**

FIGURE – 7.3-1

ALTERNATIVE CO-3 SEPARATION OF APS EFFLUENTS FROM PEW SYSTEM

FIGURE - 7.3-2

ALTERNATIVE CO-3
COOLING WATER, STEAM CONDENSATES AND CHEMICAL WASTES
TO THE AQUIFER THROUGH HOLDING PONDS
(APS EFFLUENTS SEPARATED FROM PEW SYSTEM)

PRO

1. Provides holding period for sampling and testing of waste stream.
2. Provides positive containment of accidental spills.

CON

1. Discharges 5 tons of salt per day to aquifer.

Figure 7.3-3

The holding pond system is designed to retain each day's plant effluent separately for at least one additional day, to allow time for any sampling and testing of the water which may be desired. There are five ponds, each capable of holding one day's accumulation of waste water (a maximum of four million gallons). These ponds are lined to prevent percolation into the ground. At any one time, one pond is filling, one is draining to the injection well and the remaining ponds are holding. This gives ample time for manual sampling of the water in the ponds for an accurate determination of any hazardous substances present. In the event that hazardous material is found to be present in sufficient quantities to make it inadvisable to return the water to the aquifer, that pond is kept in a "hold" mode until solar evaporation concentrates the water sufficiently that it can be efficiently processed through the PEW evaporator. At that time, the water is pumped back to WM-191. In the meantime, the remaining ponds continue their normal cycle with one day less storage until the pond which had been on "hold" is returned to normal service.

The holding ponds are located outside of the present perimeter of the ICPP, near its southeast corner. In order for the waste water stream to get to the ponds, the several component streams must be diverted from the existing injection well, collected in a surge tank and pumped through approximately 7000 feet of 14 inch pipe. The surge tank, pump station and pipeline are the same as those described in Cases CC-2, CC-3 and CC-4.

From the holding ponds, the waste stream may be returned through a separate and parallel pipeline to the existing injection well. It is improbable that this line can be arranged for gravity flow. Therefore, a low-head pump station is required adjacent to the holding ponds.

An alternative to piping the water back to the existing injection well is to drill a new injection well adjacent to the holding ponds. This

now becomes basically the same as Case CC-2 with holding pond option). The choice between these two options is a matter of optimization. On the basis of our preliminary cost estimates, the new injection well appears to be less costly and has been used in the cost summary.

7.3.3 Cost Estimates

The costs of implementing alternative Case CO-3, as compared with Case CO-1, are summarized in Figures 7.3-4 and 7.3-5.

7.3.4 Environmental Features

Alternative CO-3 separates tritium from the waste water system, minimizes heavy metals disposed to the waste stream and provides for a holding period for the waste stream sufficient to allow sampling and testing of the effluent before final discharge to the aquifer.

However, as in Case CO-2, alternative CO-3 waste water stream contains high concentrations of salt which are undesirable.

For this reason, while this alternative provides a degree of accident protection lacking in alternative Case CO-2, it is not recommended as a permanent arrangement.

ALTERNATIVE CO-3

Injection Well	110,000
Surge Tank	401,000
Piping	565,000
Holding Ponds	741,000
Miscellaneous Equipment	394,000

Direct Field Costs	2,210,000
Contractor Overhead and Profit	320,000
Engineering and Management	1,347,000
Contingency	747,000

Total Capital Costs	\$4,624,000
---------------------	-------------

Life Cycle Costs	\$5,693,000
------------------	-------------

Figure 7.3-4

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CO-3

TITLE: •Cooling water, steam condensates and chemical wastes disposed of to injection well through holding ponds.

•APS condensates separated from PEW

PART I

- Capital Cost = \$ 4,624,000
- O & M Cost = \$82,000/Year
- Energy:
 - Electricity = 5130 MBTU
 - Oil = 264 MBTU
- Economic Life = 20 Years
- Residual Value = Zero
- Reinvestment Cost = Zero

PART II

- Present Value Capital Investment = \$4,624,000
- Present Value O & M = \$82,000 X 8.51 = \$697,820
- Present Value Energy
 - Electricity = 5130 MBTU X \$5.57/MBTU X 12.61 = \$360,319
 - Oil = 264 MBTU X \$4.36/MBTU X 9.4 = \$10,820
- Total Present Value = \$5,692,959

Figure 7.3-5

7.4 ALTERNATIVE CASE CO-4: DISPOSAL OF COOLING WATER AND STEAM CONDENSATES TO AQUIFER THROUGH HOLDING PONDS; CHEMICAL WASTES TO LINED EVAPORATION POND; APS EFFLUENT SEPARATED FROM PEW SYSTEM

7.4.1 Principal Features

In alternative Case CO-4, cooling water and steam condensates are discharged to the aquifer through a system of holding ponds. Chemical wastes are collected separately from the cooling water/steam condensate stream and are pumped to a solar evaporation pond. APS effluents are separated from the PEW system and are primarily discharged to atmosphere through the existing 250 foot stack with a smaller portion collected for recycling for process makeup to the dissolver or to the final stage extraction. PEW condensates (minus the APS contribution) are mixed with the cooling water stream for disposal to the service waste water system.

Schematic flow diagrams for alternative CO-4 are shown in Figures 7.4-1, 7.4-2 and 7.4-3.

Advantages and disadvantages of this alternative are summarized in Figure 7.4-4 which lists arguments "pro" and "con." The plot plan for CO-4 is shown on Drawing 475304-P-CO-4.

7.4.2 Technical Aspects

The process flow diagrams for alternative CO-4 included in Appendix B are: Drawing Numbers 475304-CO4-R-001, 475304-CO4-4-002, and 475304-CO4-2-003.

The improvement offered by alternative CO-4, as compared to alternative Cases CO-1, CO-2, and CO-3 is that the chemical wastes are collected separately and are pumped to a lined solar evaporation pond outside the perimeter of the existing ICPP, near the southeast corner.

**ALTERNATIVE CO-4
DISPOSAL OF COOLING WATER AND STEAM CONDENSATES
TO AQUIFER THROUGH HOLDING PONDS**

FIGURE – 7.4-1

ALTERNATIVE CO-4 DISPOSAL OF CHEMICAL WASTES BY LINED EVAPORATION POND

FIGURE - 7.4-2

ALTERNATIVE CO-4 SEPARATION OF APS EFFLUENTS FROM PEW SYSTEM

FIGURE - 7.4-3

ALTERNATIVE CO-4
DISPOSAL OF COOLING WATER AND STEAM CONDENSATES
TO AQUIFER THROUGH HOLDING PONDS:
CHEMICAL WASTES TO LINED EVAPORATION POND
APS EFFLUENT SEPARATED FROM PEW SYSTEM

<u>PRO</u>	<u>CON</u>
1. Waste water discharges meets all Federal and State standards.	1. Cost of treating cooling water (approximately 100%) and then dispose of water to injection well.
2. Provides holding period for sampling and testing of waste stream.	2. The chemical wastes approximately 5 tons per day) must eventually be removed from lined evaporation pond and transported to an approved disposal site.
3. Provides positive containment of accidental spills.	
4. Can logically be incorporated into a larger effluent reduction program.	

Figure 7.4-4

ICPP INJECTION WELL
ALTERNATIVES PROJECT

FOR
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

ALTERNATIVE CO-4
DISPOSAL OF COOLING WATER AND PEW
CONDENSATE TO SHALLOW WELL
VIA LINED HOLDING POND

FLUOR

J. DODSON
M. CUTLER
15100-00

PLOT PLAN
475304-P-CO-4
1

The chemical waste solar evaporation pond has a surface area of 48.2 acres and measures 2050 by 1025 feet. Depth is 5 feet 6 inches. The bottom and sides are lined with a 30 mil PVC liner to prevent percolation of water from the pond into the earth. The entire chemical waste disposal system is described in more detail in Section 5.5.2.

The holding pond system is designed to retain each day's plant effluent separately for at least one additional day, to allow time for any sampling and testing of the water which may be desired. There are five ponds, each capable of holding one day's accumulation of waste water (a maximum of four million gallons). These ponds are lined, to prevent percolation into the ground. At any one time, one pond is filling, one is draining to the injection well, and the remaining ponds are holding. This gives ample time for manual sampling of the water in the ponds for an accurate determination of any hazardous substances present. In the event that hazardous material is found to be present in sufficient quantities to make it inadvisable to return the water to the aquifer, the pond is kept in a "hold" mode until solar evaporation concentrates the water sufficiently that it can be efficiently processed through the PEW evaporator. At that time, the water is pumped back to WM-191. In the meantime, the remaining ponds continue their normal cycle, with one day less storage until the pond which had been on "hold" is returned to normal service.

The holding ponds are located outside of the present perimeter of the ICPP, near the southeast corner. In order for the waste water stream to get to the ponds, the several component streams must be diverted from the existing injection well, collected in a surge tank, and pumped through approximately 7000 feet of 14 inch pipe. The surge tank, pump station, and pipeline are the same as those described in Cases CC-2, CC-3, and CC-4.

From the holding ponds, the waste stream may be returned through a separate and parallel pipeline to the existing injection well. It is improbable that this line can be arranged for gravity flow. Therefore, a low-head pump station would be required adjacent to the hold ponds.

An alternative to piping the water back to the existing injection well is to drill a new injection well adjacent to the holding ponds. This now becomes basically the same as Case CC-2 with holding pond option. The choice between these two options is a matter of optimization. On the basis of our preliminary cost estimates, the new injection well appears to be less costly and has been used in the cost summary for CO-4. Technical aspects of the separation of APS effluents from the PEW system are discussed in detail in Section 6.11 and 7.3.

Tritium constitutes over 98 percent of the total radioactivity found in the Process Equipment Waste (PEW) condensate. The tritium enters the ICPP process system during the dissolution of nuclear fuel.

Since tritium constitutes virtually all of the radioactivity in the PEW evaporator condensate, a major reduction in radioactive release to the waste water system will result from the isolation of the tritiated water from the system. The remaining radioactive constituents comprise only a small fraction of the total radioactivity found in the condensate.

The isolation of the APS condenser stream (approximately 3200 gallons per day) from the PEW has beneficial effects. A reduction of approximately 25 percent in feed flow to the PEW will ensue. With the lower feed rate it will be more practical to adjust the pH of the remaining stream (approximately 8000 gallons per day) so that the PEW condensate will be in an efficient operating range of the ion exchangers.

The net effect of this alternative is that the APS effluent (which is the source of virtually all of the tritium) is not allowed to enter the PEW system, as in alternative CO-3, while the salt and other

chemical wastes are captured and not allowed to enter the aquifer. In addition, the PEW condensates will contain such low levels of contamination that it may be recycled or mixed with the cooling water.

7.4.3 Cost Estimates

The costs of implementing alternative CO-4, as compared with Case CO-1, are summarized in Figures 7.4-5 and 7.4-6.

7.4.4 Environmental Considerations

The salts are collected in the lined solar evaporation pond and during the lifetime of the pond liner presents no environmental hazard. However, the salts will eventually have to be removed to an approved burial site before the liner deteriorates. The lifetime of the liner is estimated to be in excess of 20 years.

With ICPP waste water streams disposed of as described in alternative Case CO-4, all applicable requirements and recommendations of the ERDAM, EPA and Idaho standards for discharge of waste water into an aquifer of potable water quality are met. This alternative is sufficient to serve as a permanent arrangement.

Additional environmental and operational benefits can be obtained by implementation of additional suggestions for modification of the water and waste water systems at the ICPP. These suggestions are discussed in Sections 7.5 and 7.6.

ALTERNATIVE CASE CO-4

Injection Well	110,000
Surge Tank	401,000
Piping	946,000
5 Holding Ponds	741,000
Lined Solar Evaporation Pond	1,482,000
Miscellaneous Tanks and Equipment	494,000

Direct Field Costs	4,174,000
Contractor Overhead and Profit	430,000
Engineering and Management	2,176,000
Contingency	1,358,000

Total Capital Costs	\$8,138,000
---------------------	-------------

Life Cycle Costs	\$9,896,000
------------------	-------------

Figure 7.4-5

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CO-4

- TITLE:
- Cooling water and steam condensates to injection well through holding ponds.
 - Chemical wastes to lined evaporation pond.
 - APS condensates separated from PEW condensates.

PART I

- Capital Cost = \$8,138,000
- O & M Cost = \$150,500/Year
- Energy:
 - Electricity = 5342 MBTU
 - Oil = 264 MBTU
- Economic Life = 20 Years
- Residual Value = Zero
- Reinvestment Cost = Zero
- Deferred cost at 20 Years = \$610,000 (Factor = 0.15)

PART II

- Present Value Capital Investment = $\$8,051,000 + 0.15 \times 610,000 = \$8,229,500$
- Present Value O & M = $\$150,500 \times 8.51 = \$1,280,755$
- Present Value Energy
 - Electricity = $5342 \text{ MBTU} \times \$5.57/\text{MBTU} \times 12.61 = \$375,210$
 - Oil = $264 \text{ MBTU} \times \$4.36/\text{MBTU} \times 9.4 = \$10,820$
- Total Present Value = \$9,896,285

Figure 7.4-6

7.5 ALTERNATIVE CASE CO-5: RECIRCULATION OF COOLING WATER AND STEAM
CONDENSATES; CHEMICAL WASTES TO LINED EVAPORATION POND; SEPARATION
OF APS EFFLUENT FROM PEW SYSTEM

7.5.1 Principal Features

Instead of disposing of cooling water and steam condensates to the aquifer, as in Cases CO-1 through CO-4, these streams are recirculated. The three trunk drains are intercepted before discharging into the injection well and are collected in a surge tank located near the existing well. From this tank, the collected stream is pumped to an evaporative cooling tower located southeast of the coal-fired boiler plant. Blowdown from the system is pumped to a lined solar evaporation pond located near the cooling tower.

Chemical wastes are collected separately and conveyed to the same solar evaporation pond. APS effluents are separated from the PEW system, and are primarily discharged to the atmosphere through the existing 250 foot stack while a smaller portion is collected for process makeup to the dissolver or to the final stage extractor. PEW condensates are conveyed to the lined solar evaporation pond.

Schematic flow diagrams for alternative CO-5 are shown in Figures 7.5-1, 7.5-2 and 7.5-3. The plot plan for alternative CO-5 is shown on Drawing 475304-P-CO-5.

Advantages and disadvantages of this alternative are summarized in Figure 7.5-4 which lists arguments "pro" and "con."

7.5.2 Technical Aspects

There are three major advantages for this alternative.

ALTERNATIVE CO-5 **COOLING WATER AND STEAM CONDENSATES** **CLOSED LOOP COOLING WATER SYSTEM** **UTILIZING AN EVAPORATIVE COOLING TOWER**

FIGURE - 7.5-1

ALTERNATIVE CO-5 DISPOSAL OF CHEMICAL WASTES BY LINED EVAPORATION POND

FIGURE - 7.5-2

ALTERNATIVE CO-5 SEPARATION OF APS EFFLUENTS FROM PEW SYSTEM

FIGURE - 7.5-3

ALTERNATIVE CO-5

- o RECIRCULATION OF COOLING WATER AND STEAM CONDENSATES
 - o DISPOSAL OF CHEMICAL WASTES TO LINED EVAPORATION POND
 - o SEPARATION OF APS EFFLUENT FROM PEW SYSTEM
-

PRO

1. Reduced aquifer water use
2. Reduced chemical use
3. Positive protection against accidental spills
4. Reduced waste salts for disposal
5. No radioactivity to aquifer
6. No salts to aquifer

CON

1. Capital costs
2. Modest increase in temperature of cooling water supply

Figure 7.5-4

1. Makeup water to the circulation loop plus the boilers amounts to an average of approximately 200 gpm. To this must be added makeup required by the chemical water softener treatment system and any other water system losses. This added makeup could range from 20 to 100 gpm. Water must also be supplied to the CPP sanitary water system (this was not included in the present study and figures are not at hand). Total maximum withdrawal from the aquifer for this case is in the range of 200 to 300 gpm, plus sanitary system water. This compares with an estimated 1985 maximum rate of 3000 gpm for once-through cooling water systems.
2. The reduction in quantity of water required from the aquifer using a closed loop system permits deletion of a proposed third supply well from the construction budget and schedule. The capital savings of this well are credited as an offset against the cost of implementing this alternative Case CO-5.
3. Most of the water softening capacity is required for treatment of cooling water. Both the quantity of cooling water and the percentage of cooling water treated are projected to increase by 1985 to the point where up to 3000 gpm of water will have to be softened. With once-through cooling systems, this softened water is lost. With a cooling water circulation system, demand for softened water is reduced to approximately 300 gpm as discussed above. This reduces the amount of salt required for regeneration of the softeners by more than 80 percent. Since salt water from regeneration of softeners is the major, though not the only, source of chemicals which must be disposed of (the other sources are cation exchangers, demineralizers, boiler blowdown, and cooling tower blowdown), the facilities for disposal of chemical wastes are estimated to be reduced by at least 70 percent.

The amount of water added to the recirculation loop is 140 gpm from steam condensates plus approximately 36 gpm from other sources for a total of 176 gpm. Approximately 50 gpm is lost in cooling tower

vaporization and drift. As a result, the net disposal of water to the lined solar evaporation pond from the recirculation loop is 126 gpm. As discussed in Section 7.5.3, this requirement results in a high capital cost and would be reduced significantly by implementing a program to reduce condensate rejection.

Process flow diagrams for alternative Case CO-5 appear in Appendix "B" as Drawing Numbers 475304-CO5-R-001 and 475304-CO5-2-002.

The features required for alternative Case CO-5 are:

1. A collection and surge tank and pump station, located adjacent to the existing injection well;
2. An evaporative cooling tower, located southeast of the coal-fired boiler;
3. A pipeline to convey cooling water from the collection tank/pump station to the cooling tower;
4. A pump station adjacent to the cooling tower;
5. A pipeline to convey the cooled water to Building 606, where it is connected to the discharge line from the ion exchange softeners;
6. A treated water line from the proposed coal-fired boiler plant to the cooling tower, for makeup to the circulation system;
7. A blowdown line, to convey cooling tower blowdown and/or excess system water to the lined solar disposal pond;

8. A pipeline from Building CPP-606 to the lined solar evaporation pond to convey chemical wastes from the water softeners;
9. A pipeline from CPP-604 to convey PEW condensates to solar evaporation pond;
10. A lined solar evaporation pond, located at the southeast corner of the CPP facility, for disposal of cooling tower blowdown, chemical wastes from CPP-606, PEW condensates from CPP-604 and excess water from the circulation loop; and
11. Corrosion inhibitor addition facilities.

Recirculation Water System

The collection and surge tank is designed to hold 20 minutes accumulation of flows at the maximum rate of 2700 gpm or 54,000 gallons. This tank is underground so that all flows into it are by gravity via the existing mains.

Two vertical pumps are provided, each with sufficient capacity for the entire flow. These pumps have a discharge pressure of 85 psig.

The principal pipelines are carbon steel, standard schedule pipe. They are buried and are protected against external corrosion both by wrapping and cathodic protection. The cooling tower supply line is approximately 7000 feet long.

The cooling towers are of the counter-flow, induced draft type. Two towers are provided, each capable of handling the entire thermal load

(i.e., 100 percent installed spare). Thermal load was calculated on the basis of cooling 2700 gpm from 100°F to 72°F, with 62°F wet-bulb temperature. As noted in Case CC-6, this study assumed no significant impacts resulting from increasing the design cooling water temperature from 65° to 72°F.

The pump station alongside the cooling towers contains two pumps, each capable of handling the entire flow of 2700 gpm with a differential pressure of 190 psi.

Additional details of the piping, pipe routing, and the layout of the evaporation pond may be found in Section 4.6.2.

Chemical Wastes

The chemical wastes are also piped to the lined solar evaporation pond located southeast of the coal-fired boiler plant site. The waste line passes adjacent to the coal-fired boiler plant and picks up the blowdown from the boiler.

Figure 7.5-2 is a simplified block flow diagram for this case.

Since the requirement for cooling loop makeup is reduced from approximately 1500 gpm average to 200 gpm, the chemical wastes from the water softeners and demineralizers is also reduced from peak rate of approximately 76,000 gallons per day to approximately 10,000 gallons per day (7 gpm). This, combined with the 19 gpm blowdown from the coal-fired boiler plant, results in 26 gpm of chemical wastes that are added to the lined solar evaporation pond, in addition to the cooling system blowdown.

Separation of APS from PEW

Tritium constitutes over 98 percent of the total radioactivity found in the Process Equipment Waste (PEW) condensate. The tritium enters the ICPP process system during the dissolution of nuclear fuel. This waste becomes the feed to the New Waste Calcining Facility (NWCF) where it is flashed into a vapor which passes to the Atmospheric Protection System (APS). The APS condensate drains to Vessel WL-102 along with drains from the stack and the NWCF process off-gas line. These lines supply virtually all of the tritiated water to the PEW Evaporator System.

Since tritium constitutes virtually all of the radioactivity in the PEW evaporator condensate, a major reduction in radioactive release to the waste water system will result from the isolation of the APS from the PEW. The remaining radioactive constituents comprise only a small fraction of the total radioactivity found in the condensate.

The isolation of the APS condenser stream (approximately 3200 gallons per day) from the PEW has another beneficial effect. The approximately 25 percent reduction in feed flow to the PEW means it will be more practical to adjust the pH of the remaining stream (approximately 8000 gallons per day) so that the PEW condensate will be in an efficient operating range for the ion exchangers.

The rate of cooling water to the APS condenser is controlled to condense only that amount of tritiated water which can be beneficially used as makeup acid to Building CPP-601 dissolver and extractor. The remainder is allowed to pass up the existing 250 foot stack. Added details are given in Case RW-11A, Section 6.11. After the resultant improvement in ion exchange operations, the 8000 gallons per day (5.5 gpm) from the PEW condenser is pumped to the lined pond to be evaporated with the streams from the cooling loop and chemical wastes. The radioactive residual in this water is so low that its use for process makeup should be considered.

The lined solar evaporation pond is sized to handle the combined blowdown from the cooling water recirculation system (126 gpm), chemical wastes (26 gpm), and PEW condensates (5.5 gpm). Based on an evaporation rate of 15.9 inches per year, the evaporation pond is 8.4×10^6 square feet in surface area.

7.5.3 Cost Estimates

The costs of constructing and operating the facilities required for alternative Case CO-5 have been estimated and are summarized in Figures 7.5-5 and 7.5-6.

Close examination reveals that the economics of this alternative have been distorted by a fundamental decision made early in the study. That decision was that only 30 percent of the steam condensates is collected while the remaining 70 percent is allowed to drain to the closed loop cooling water system. It was not feasible within the scope of this study to determine the practicability of installing added condensate collection facilities, but the benefits of such a move would be substantial. As is shown in alternative CO-6, alternative CO-5 is severely penalized because the large amount of steam condensate present substantially increases both the size of the solar evaporation ponds for cooling tower blowdown and the cooling tower treating requirements. These treating requirements are discussed in Cases CC-6 and 7 (Sections 4.6 and 4.7).

7.5.4 Environmental Features

Three significant environmental features of this case are that no waste water is discharged to the aquifer, the water withdrawn from the aquifer is reduced by 80 percent, and the amount of water treatment chemicals required is reduced by more than 80 percent.

COST SUMMARY FOR
ALTERNATIVE CO-5

Surge Tank	398,000
Lined Solar Evaporation Pond	5,434,000
Piping	1,334,000
Cooling Tower and Water Treating Equipment	496,000
Tanks, Equipment, and Miscellaneous	394,000

Direct Field Costs	8,056,000
Contractor Overhead and Profit	515,000
Engineering and Management	3,615,000
Contingency	<u>2,528,000</u>

Total Construction Costs	\$14,714,000
--------------------------	--------------

Life Cycle Costs	\$14,884,000
------------------	--------------

Figure 7.5-5

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CO-5

TITLE: •Cooling water and steam condensates recirculated with cooling tower and lined evaporation pond.

•Chemical wastes to lined evaporation pond.

•APS condensates separated from PEW condensates.

PART I

- Capital Cost	=	\$ 14,714,000
- O & M Cost	=	\$132,500/year
- Energy:		
Electricity	=	3130 MBTU
Oil	=	264 MBTU
- Economic Life	=	20 Years
- Residual Value	=	Zero
- Reinvestment Cost	=	Zero
Capital Cost Foregone	=	[-\$1,280,000]
Deferred Cost at 20 Years	=	\$610,000 (Factor = 0.15)

PART II

- Present Value Capital Investment	=	\$ 14,714,000 - 1,280,000 + 91,500 = \$13,525,500
- Present Value O & M	=	\$132,500 X 8.51 = \$1,127,575
- Present Value Energy		
Electricity	=	3130MBTU X \$5.57/MBTU X 12.61 = \$219,844
Oil	=	264MBTU X \$4.36/MBTU X 9.4 = \$ 10,820
- Total Present Value	=	\$14,883,739

Figure 7.5-6

The solar pond is fenced to inhibit access by wildlife. Aquatic birds, insects, and smaller species of animals cannot effectively be prevented from access to the pond. The pond contains a mixture of cooling water, steam condensate, chemical waste, and PEW condensate. This water is toxic because of the content of salts, and treating chemicals, and is expected to be distasteful to wildlife. The pond water can become saturated with salts, particularly in the late fall. Most creatures stay away from water which is distasteful to them so the danger to wildlife is minimal.

Hazards to construction workers installing the facilities for alternative CO-5 are restricted to those normally encountered in construction work; that is, there are not unusual hazards associated with this case. There is some exposure to radioactivity on the part of the workers making the changes required to separate the APS effluents from the PEW system.

There are no hazards to operating personnel or nonoperating persons on the site other than those normally associated with operations at the ICPP.

7.5.5 Conclusions

As compared with the minimum acceptable facilities described in alternative Case CO-4, alternative Case CO-5 offers long-term environmental and operational advantages, and can be considered as part of a long term effluent improvement program.

7.6 ALTERNATIVE CASE CO-6: RECIRCULATION OF COOLING WATER; CHEMICAL WASTES TO SOLAR EVAPORATION POND; SEPARATION OF APS EFFLUENT FROM PEW SYSTEM; AND COLLECTION AND REUSE OF 80% OF STEAM CONDENSATES

7.6.1 Principal Features

Alternative Case CO-6 is essentially the same as Case CO-5, with one change. Existing practice (1985) is that only about 30 percent of boiler steam condensates are collected and returned to the boiler. The remaining 70 percent are drained into the service waste system where they mingle with cooling water.

As discussed in Sections 7.5.3 and 4.6, this policy results in substantially more costly solar pond and chemical treatment system than is required with condensate recovery.

In Case CO-6 additional steam condensates are collected and returned to the boilers as feed. This reduces the cooling tower blowdown and chemical treating requirements, reduces the size of the solar evaporation pond, and reduces the boiler feedwater treating requirements.

Schematic flow diagrams for alternative CO-6 are shown in Figures 7.6-1, 7.6-2 and 7.6-3.

Advantages and disadvantages of this system are summarized in Figure 7.6-4 which lists arguments "pro" and "con."

7.6.2 Technical Aspects

Process flow diagrams for alternative CO-6 appear in Appendix B as Drawing Numbers 475304-CO6-R-001 and 475304-CO6-2-002.

ALTERNATIVE CO-6 COOLING WATER CLOSED LOOP COLING WATER SYSTEM UTILIZING A EVAPORATIVE COOLING TOWER

FIGURE - 7.6-1

ALTERNATIVE CO-6 DISPOSAL OF CHEMICAL WASTES BY LINED EVAPORATION POND

FIGURE - 7.6-2

ALTERNATIVE CO-6 SEPARATION OF APS EFFLUENTS FROM PEW SYSTEM

FIGURE - 7.6-3

ALTERNATIVE CO-6

- o RECIRCULATION OF COOLING WATER WITH REUSE OF STEAM CONDENSATES
- o DISPOSAL OF CHEMICAL WASTES TO LINED EVAPORATION POND
- o SEPARATION OF APS EFFLUENT FROM PEW SYSTEM

PRO

1. Reduces solar pond size.
2. Reduces cost of water treating chemicals and disposing of salts.
3. Reduces boiler feedwater treating.
4. Reduces makeup pumping from production wells.

CON

1. Capital cost for condensate collection piping.

Figure 7.6-4

ICPP utility projection for 1985 include about 70 percent of steam condensates being discharged to the cooling water system. This assumption has been maintained throughout the study of alternative CO-1 through CO-5.

These steam condensates are returned with cooling water to the tower. The estimated 140 gpm condensate flow far exceeds the makeup requirements so that a substantial cooling tower blowdown, of the order of 100 gpm, is required. This volume of condensate is so large, that in a very few days following initial startup, the circulating cooling water stream will become steam condensate. Condensate is well known for its corrosive properties. In a circulating aerated system of this type, substantial corrosion will occur unless a suitable inhibitor is used. The widest used, most commercially proven corrosion inhibitor is chromate. Therefore, once the condensate is mingled with the cooling water, it is contaminated with chromates and can neither be returned to the boilers nor be discharged to a well. Further, the high blowdown rate means a continuing high treating requirement. A still more costly aspect of handling the condensate in this fashion is shown in Figure 7.6-5. The large excess of condensate which bled to the evaporation ponds means provision for roughly 100 gpm more evaporative capacity must be provided. From cost estimates prepared elsewhere in this report, it may be seen that each 100 gpm of waste disposed of to an evaporation pond will result in the order of \$5-6 million in capital costs. Therefore, if a cooling tower system is to be seriously considered, excess condensate must be collected and returned to the boiler plant or be disposed of separately.

It is beyond the scope of the present study to conceive a condensate collection system and estimate its cost. However, it is possible to indicate the economic incentive for at least considering the possibility. The estimates for alternative CO-6 as listed in Figures 7.6-6 and 7.6-7 are based on 80 percent condensate collection. Under the

FLOW BALANCE - SOLAR POND FEED
APPROXIMATE ANNUAL AVERAGE FLOWS - GPM

<u>Case</u>	<u>CO-5</u>	<u>CO-6</u>
Estimated Steam Condensate Recovery	30%	80% ⁽¹⁾
Condensate Disposal to Cooling Water	140	40
Treated Water Returned to Cooling Water	<u>36</u>	<u>36</u>
New Input to Cooling Water System	176	76
Cooling Tower Circ. Rate, Peak	2700	
Approximate Average ⁽²⁾	1400	
Estimated Losses, Evaporative and Wind	50±10	50±10
Estimated Blowdown Required to Solar Pond for Balance	126	26
Waste Water from PEW	6	6
Softener/Demineralizer Waste	4.5	1.5
Backwash	2.0	0.7
Boiler Blowdown	<u>20</u>	<u>6</u>
	26.5	8
Total Solar Pond Feed	159	40

Notes:

- (1) Arbitrary figure for illustration only.
- (2) Conceptual Design Criteria calls for average equal to 50 percent of peak rate.

Figure 7.6-5

conditions of Case CO-5, the total flow to the solar pond is approximately 159 gpm (annual average). With 80 percent condensate collection, the waste stream would amount to approximately 40 gpm, consisting of cooling tower and boiler blowdown, chemical wastes and PEW condensate. The solar pond would be reduced in area from 8.4×10^6 square feet to 2.1×10^6 square feet. The amount of water requiring treatment for boiler feed would be reduced by 100 gpm (about 50 percent) with corresponding reduction in cost of chemicals.

ALTERNATIVE CO-6

Surge Tank	398,000
Lined Solar Evaporation Pone (2.1×10^6 ft ²)	1,482,000
Piping	1,334,000
Cooling Tower and Water Treating Equipment	496,000
Tanks, Equipment and Miscellaneous	394,000
<hr/>	
Direct Field Costs	4,104,000
Contractor Overhead and Profit	515,000
Engineering and Management	2,338,000
Contingency	<u>1,363,000</u>
 Total Capital Costs	 \$8,320,000
 Life Cycle Cost	 \$8,321,000

Figure 7.6-6

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CO-6

TITLE: •Cooling water and steam condensates recirculated with cooling tower with reduced flow to evaporation pond.

•Chemical Wastes to lined evaporation pond (reduced flow).

•APS condensates separated from PEW condensates.

PART I

- Capital Cost = \$8,320,000
- O & M Cost = \$121,500/Year
- Energy:
 - Electricity = 2980 MBTU
 - Oil = 264 MBTU
- Economic Life = 20 Years
- Residual Value = Zero
- Reinvestment Cost = Zero
- Capital Cost Foregone = [-\$1,280,000]
- Deferred Cost at 20 Years = \$180,000 (Factor = 0.15)

PART II

- Present Value Capital Investment = $\$8,320,000 - 1,280,000 + 27,000 = \$7,067,000$
- Present Value O & M = $\$121,500 \times 8.51 = \$1,033,965$
- Present Value Energy
 - Electricity - $2980 \text{ MBTU} \times \$5.57/\text{MBTU} \times 12.61 = \$209,308$
 - Oil - $264 \text{ MBTU} \times \$4.36/\text{MBTU} \times 9.4 = \$10,820$
- Total Present Value = \$8,321,093

Figure 7.6-7

8.0 EVALUATION OF COMBINED CASES AND RECOMMENDATIONS

In this section the six combined cases discussed in the preceding section are compared and evaluated and Fluor's recommendations are stated. The considerations given to the alternatives are quantitative in the areas of technical adequacy, comparative direct cost estimates and compliance with applicable regulations. On these bases the recommendations presented here are somewhat limited in scope.

8.1 Comparison Tables

Characteristics, incremental physical features and costs for each of the six combined cases are summarized in Table 8-1, sheets 1 and 2. Table 8-2 supplements Table 8-1 with information on operating parameters for the six cases.

8.2 Phased Implementation

The combined cases were chosen to be technically feasible and as economical as possible within the options available. They are arranged in ascending order of considered environmental features and complexity. As can be seen from Table 8-1, costs do not follow the same progression of complexity, since Case CO-6 is only slightly more costly than Case CO-4, while Case CO-5 is much more expensive.

The order of presentation is significant for another reason: each successive case through CO-4 can be a step in a phased approach to dealing with the waste disposal problems. Cases CO-2 and CO-3 each contain improvements over Case CO-1. Case CO-4 embodies the minimum features necessary for a long-term waste water disposal system. CO-5 and CO-6 contain additional recommendations that may provide additional benefits. Later, if a decision is made that a recirculation system will be installed, the features of Case CO-4 may be utilized in that system.

TABLE 8-1
SUMMARY OF CHARACTERISTICS AND COSTS
 SHEET 1

<u>CASE NO.</u>	<u>CHARACTERISTICS</u>	<u>INCREMENT</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
CO-1	Existing case (1985): Cooling water/steam condensates, PEW condensates, and chemical wastes discharge to aquifer thru existing well.	Base Case	-0-	-0-
CO-2	APS effluent separated from PEW system. Cooling water/steam condensate, PEW condensate, and chemical wastes to aquifer through existing well.	Separate APS effluent from PEW system	1,085	1,414
CO-3	APS effluent separated from PEW system. Cooling water/steam condensate, PEW condensate, and chemical wastes to aquifer through holding ponds.	Holding ponds	4,449	5,518
CO-4	APS effluent separated from PEW system. Cooling water/steam condensates to aquifer through holding ponds. Chemical wastes and PEW condensate to solar evaporation ponds.	Solar evaporation ponds	8,051	9,809

TABLE 8-1
SUMMARY OF CHARACTERISTICS AND COSTS
 SHEET 2

<u>CASE NO.</u>	<u>CHARACTERISTICS</u>	<u>INCREMENT</u>	<u>CAPITAL COST (\$000)</u>	<u>LIFE CYCLE COST (\$000)</u>
CO-5	APS effluent separated from PEW system. Cooling water/steam condensates recirculated through evaporative cooling tower. PEW condensates, chemical wastes, and cooling tower blowdown to solar evaporation ponds.	Cooling water recirculation system with cooling tower	14,036	14,206
CO-6	APS effluent separated from PEW system. Cooling water recirculated through evaporative cooling tower. Chemical wastes and PEW condensates to solar evaporation pond. Collection of steam condensates and returns to boiler increased from 30% to about 80%.	Increase collection of steam condensates and return to boiler	8,292	8,293

TABLE 8-2
SUMMARY OF AVERAGE WASTE WATER FLOWS
AND EVAPORATION POND AREAS

Case Number	CO-1	CO-2	CO-3	CO-4	CO-5	CO-6
<u>Disposal to Aquifer, gpm</u>						
Cooling Water	1400	1400	1400	1400	----	----
Steam Condensate	140	140	140	140	----	----
Chemical Waste (incl. Boiler Blowdown)	40	40	40		----	----
Process Waste	8	6	6	6		
TOTAL	1588	1586	1588	1546	----	----
<u>Disposal to Evaporation Ponds, gpm</u>						
Cooling Water	----	----	----	----	36	26
Steam Condensate	----	----	----	----	90	----
Chemical Waste (incl. Boiler Blowdown)	----	----	----	40	26	8
Process Waste	----	----	----	----	6	6
TOTAL	----	----	----	40	158	40
<u>Steam Condensate Return to Boiler, gpm</u>	60	60	60	60	60	160
<u>Cooling Tower Evaporation, gpm</u>	----	----	----	----	50	50
<u>Water Treatment Requirements, gpm</u>						
Softeners	1400	1400	1400	1400	185	75
Cation Exchanges & Demineralizers	155	155	155	155	155	45
<u>Evaporation Pond Surface, 1000 ft²</u>	----	----	----	2100	8400	2100
<u>Evaporation Pond Surface, acres</u>	----	----	----	49	193	49

Case CO-4, as a long-range program for CPP waste treatment, requires construction of a collection and surge tank close to the existing injection well, with an adjoining pump station and pipeline to convey the collected wastes to holding ponds near the southeast corner of the ICPP perimeter. The same collection and surge tank, pump station, and pipeline are required for the recirculating loop Cases CO-5 and CO-6. Thus, these facilities could be built as part of Case CO-4, and later utilized as part of a circulating loop system. Similarly, the holding ponds which are a feature of Case CO-4 can become part of the evaporation pond(s) utilized for final disposal of aqueous wastes in the circulating loop systems; the surface area of the holding ponds would be subtracted from the gross area required for evaporation, in calculating the dimensions of the final evaporation pond.

In Case CO-4 there are two optional methods for returning the water to the aquifer after it leaves the holding ponds: it can be injected through a new injection well, located adjacent to the holding ponds, or it can be pumped through a return pipeline to the existing injection well. If a circulating loop system is adopted as the ultimate objective, returning the water to the existing injection well is the preferred choice. This is because the pump station at the holding pond and the return pipe can become part of the circulating loop when the ultimate system is implemented.

A major part of the cost of installing new piping is in excavating and backfilling the trenches. This is particularly true in the more developed areas of the ICPP. There are plans for major modifications to several facilities of the ICPP. Some of these proposed modifications may entail changes to underground piping systems in the same location as those proposed for the waste water system. This points out the need for an early commitment to an approach for effluent handling to maximize coordination of piping installation with current projects.

A decision between proceeding with Case CO-4 or for implementing a recirculation loop system should be made soon, since current plans for drilling a third supply well and installing a third pump and associated piping are affected along with plans for increasing water softener capacity. These proposed new facilities become unnecessary if a recirculation system is adopted.

8.3 Separation of Steam Condensates from Cooling Water

It is evident from the discussions in Section 7 that there are substantial benefits to be obtained by changing from a once-through cooling system to a recirculating loop with an evaporative cooling tower to dispose of the heat. Comparing Cases CO-5 and CO-6, it is clear that there is an incentive amounting to several millions of dollars, on both a capital cost basis and a life-cycle cost basis, for keeping most of the steam condensates out of the circulating cooling water loop. The principal reason for this is that the evaporation pond becomes smaller as the amount of surplus condensate, in excess of the amount required to balance the evaporative loss in the cooling tower, is reduced.

Case CO-5 shows what happens if recovery of steam condensates is maintained at the approximately 30 percent of total steam flow (on an annual average basis). Case CO-6 shows the cost benefits that result if only sufficient condensate to make up evaporation losses are allowed to enter the cooling water stream. Any reduction in the amount of condensate entering the recirculating loop results in a corresponding reduction in the size of the evaporation pond.

It should be noted that the important criterion is that the condensate be prevented from entering the recirculation loop. What becomes of the surplus condensate is of secondary importance. However, the most obvious and logical thing is to return it to the boilers. This has the effect of reducing the amount of raw makeup water which must be

pumped from the well and treated in the softeners and ion exchangers. This, in turn, further reduces the size of the evaporation pond because of the reduction in the amount of chemical wastes and also reduces the cost of chemicals purchased.

8.4 Environmental Features

8.4.1 Standards for Discharge to Potable Water Aquifers

At the time the present study was initiated, the only effluent waste discharge standard in force was the Energy Research and Development Administration Manual (ERDAM) 0524, the applicable portions of which are concerned specifically with releases of radioactive materials. Since that time, the Environmental Protection Agency (EPA) regulations which hitherto have been proposed, have become enforceable. The State of Idaho has also adopted injection well regulations that make drinking water standards applicable to waste water discharge streams. The primary standards are concerned with substances that are dangerous or hazardous to health.

The combined aqueous waste discharge streams projected for 1985 conditions will not meet the State Injection Well Standards primarily due to trace amounts of tritium and strontium.

The recommended means for correcting this problem is to separate the APS effluent from the PEW system. Several possible methods for either utilizing or disposing of the APS effluents are discussed in Section 6.11. The remaining contributions to the PEW condensates contain low levels of tritium with concentration well below State Injection Well Standards. With the APS effluents removed, it becomes feasible to neutralize the acid in the PEW condensate and make the ion exchangers effective in removing heavy metal ions from the condensate. Thus, this one step, which can be implemented in the existing service waste system, allows the combined effluent to meet regulatory standards for radioactive wastes.

Various possibilities for recycling of the APS condensate are proposed in Section 6.11. These proposed uses are based upon calculations. Actual samples should be taken of this stream to obtain data on the composition of the APS condensate in order to verify the proposed uses.

In addition to the State of Idaho primary standards for drinking water, they have secondary standards which are related mainly to aesthetics - taste, color, odor, etc. Salinity, measured as total dissolved solids (tds), is one of the criteria with 500 ppm total dissolved solids being the maximum concentration. At the ICPP, the combined aqueous wastes, for conditions in 1985, will not meet the State secondary drinking water standards. The principal reason is the excess of sodium chloride, which comes from regeneration of the water softeners. Separation of the chemical wastes from the cooling water system, as proposed in Case CO-4, solves the problem. Implementing the recirculation system, as described in Cases CO-5 and CO-6, lower operating costs by greatly reducing the amount of chemicals consumed.

8.4.2 Protection of Aquifer Against Accidental Releases of Objectionable Material

One of the concerns with the present (1980) waste disposal system has been that it lacks positive protection against accidental releases of excessive amounts of radioactive or other objectionable materials. The present system has double protection in that it would require concurrent failure of the source (e.g., leakage of a heat exchanger) and at the in-line radiation monitor in order for radioactive material to escape to the injection well. While this system is reported to have worked well throughout the 27 years of operation of the ICPP, there still exists a finite possibility that such an incident could occur.

Installation of holding ponds, as described in Case CO-4, would remove this threat. Changing to a recirculation loop, as in Cases CO-5 and CO-6, would also remove the threat since any rupture or leakage would be contained in the loop. From the loop the contaminated water would be transferred to a storage tank for reprocessing.

8.4.3 Discharge of Tritium to the Atmosphere

Under present (1980) operating procedures, about 90 percent of the tritium appearing in the ICPP process system is ultimately discharged up the stack to the atmosphere. Virtually all of this is in the form of gaseous HT molecules. Measurements and calculations of dispersion have shown that the atmospheric concentrations resulting from this practice are well below the maximum levels permitted by ERDAM 0524.

If APS effluents are separated from the PEW system, as proposed in Cases CO-4, CO-5 and CO-6, the amount of tritium discharged to the stack could be increased by as much as 10 percent, the actual amount depending on how much of the APS condensate can be utilized for recycle to the process.

8.4.4 Radiation Hazard to On-site Personnel

At the outset of the present study, there was considerable concern and discussion of possible radiation exposure hazard to personnel. This applied both to workers engaged in making changes to the aqueous waste systems in compliance with recommendations made in this report, and to people in general, whether employees or visitors, within or outside the site boundary.

This study has concluded that radiation exposure is negligible for the alternative cases studied. Workers will receive no radiation exposure while making modification to the cooling water and chemical waste systems. Radiation exposures of a low level nature will be received

by workers modifying the PEW system. These changes will all be made at or near Building CPP-604 where the radiation levels range from 25 to 50 mrem. It has been assumed that changes on the instrumentation and controls for the APS cooling water will be made outside the condenser area, and therefore no radiation exposure would be received during this modification. It is estimated that the total man-rem dose received by workers for the recommended PEW cases will range from 2 man-rem to 6 man-rem.

8.5 Recommendations for Action

Disposal of mixed aqueous waste streams from the ICPP to the Snake River Plain aquifer through an injection well has been practiced for many years without any demonstrable adverse effects on downstream users. Nevertheless, with proposed changes in the operations at the ICPP, together with possible changes in governmental regulations toward protection of potable water resources, disposal as presently practiced may soon become unacceptable and require modification. On the basis of the foregoing considerations, Fluor makes the following recommendations:

1. A specific long-range plan for treatment and disposal of waste water streams at the ICPP should be established. This plan should include the following elements:
 - o Separation of APS effluents from the PEW evaporator system.
 - o Atmospheric discharge or reuse of the APS effluents.
 - o Installation of holding ponds sufficient to retain each day's effluent for at least one day before discharge to the injection well.

- o Separation of chemical wastes from the cooling water disposal system and disposal to an evaporation pond.
- 2. In addition, we recommend that the long-range plan include elements which, if implemented, would make the injection well unnecessary and achieve significant secondary benefits. These additional elements are:
 - o Recirculation of cooling water with heat dissipation in an evaporative cooling tower.
 - o Separate collection and return to the boilers of up to 80 percent of steam condensates.
- 3. The nature of the several elements recommended above is such that a phased approach to implementation of the long-range plan is both feasible and desirable. It is recommended that, after the long-range plan is adopted, those elements of the plant which do not require accumulation of additional design data over a long period of time be implemented promptly so that their beneficial effects can be obtained as soon as possible. Elements of the plan which require more design data, or which must be integrated with other construction activities which are contemplated for the ICPP, should be added as soon as schedule and funding permit.

9.0 CONSTRUCTION SCHEDULE FOR RECOMMENDED CASES

Preliminary Engineer, procurement and construction schedules have been prepared for recommended alternates CO-4 and CO-5.

In general, it appears that the work required by either alternate can be completed in about two years providing that long delivery items are ordered in advance of the contract award and that construction is scheduled for April through November.

The schedules indicate only two items for advance procurement; however, closer study may require other items. Maintaining the April through November period for construction is very important since most work is outdoors and much earthwork is involved.

LEGEND											

COMBINED ALTERNATE CO-4

PRELIMINARY ENGINEERING, PROCUREMENT & CONSTRUCTION SCHEDULE

FLUOR ENGINEERS AND CONSTRUCTORS, INC.
CONTRACT 475309
U.S. DEPARTMENT OF ENERGY
IDAHO FALLS, IDAHO
ICPP INJECTION WELL ALTERNATIVES PROJECT

REMARKS: LONG DELIVERY ITEMS MUST BE ADVANCE PROCURED AND CONSTRUCTION MUST BE SCHEDULED DURING APRIL THRU NOVEMBER TO MEET THIS SCHEDULE.	REV.	DATE	REVISION DESCRIPTION	PREP. BY	APP.
	0	7/22/80	ORIGINAL ISSUE	AMR	

LEGEND											

COMBINED ALTERNATE CO-5

PRELIMINARY ENGINEERING, PROCUREMENT & CONSTRUCTION SCHEDULE

FLUOR ENGINEERS AND CONSTRUCTORS, INC.
CONTRACT 475304
U.S. DEPARTMENT OF ENERGY
IDAHO FALLS, IDAHO
ICPP INJECTION WELL ALTERNATIVES PROJECT

REMARKS: LONG DELIVERY ITEMS MUST BE ADVANCE PROCURED AND CONSTRUCTION MUST BE SCHEDULED DURING APRIL THROUGH NOVEMBER TO MEET THIS SCHEDULE.	REV.	DATE	REVISION DESCRIPTION	PREP. BY	APP.
	0	7/2/82	ORIGINAL ISSUE	AMR	

10.0 SUGGESTIONS FOR FURTHER STUDY

INTRODUCTION

Various sections of this report have indicated that further studies and/or analyses are necessary before actual implementation of modifications to the aqueous waste system. The purpose of Section 10 is to gather together and, where necessary, amplify these suggestions.

10.1 Composition of APS Condensate

The composition of APS condensates was used as the basis for Case RW-11 and, therefore, was a major element of Cases CO-2 through CO-6. This composition was calculated from information on other liquid and gas streams furnished by DOE at the beginning of this study (see Sections 6.11 and 8.5). There have been no measurements of the composition of the APS condensate because there is no sampling tap. Obtaining samples may be difficult since the area is congested and radioactivity levels are high. Nevertheless, actual measurements should be made. Sampling and analysis of APS condensate should be done on a regular basis as the composition changes depending on which processes are being run and what substances are being processed. We believe that separation of the APS condensate from the PEW system should be carried out as rapidly as possible, since extensive design studies do not appear warranted for the separation step.

10.2 Waste Water Flow Rates

A major problem in performing this study was that most of the flows are variable and intermittent. This was recognized at the outset as being inherent in the nature of the operation of the ICPP. There are several processing and water treatment centers, operating essentially independently of each other, and all operating on a batch basis. Any design changes to the aqueous waste system should be preceded by an

in-depth analysis of the flows to be expected from each of the several sources to determine actual peak and average flows and stream qualities. The impact on the costs of individual items of equipment, especially the evaporation pond, could be substantial.

10.3 Atmospheric Evaporation Rates

Sizing and cost estimates for the solar evaporation ponds included in this study were based on an average evaporation rate given in the conceptual design document (CDC). This evaporation rate included an adjustment for salinity in the pond. Since the evaporation pond is the major item of capital cost in the proposed system, we recommend that an in-depth study be made of evaporation rates with salinity of the water in the pond as a parameter. The time-variability of the salinity in the pond should be included in arriving at the appropriate design evaporation rate.

10.4 Heavy Metal Ions

There is some evidence that certain heavy metals, especially mercury, may be discharged occasionally in trace amounts which nevertheless exceed State Injection Well Standards. These data are not conclusive and should be checked carefully. If any such substances are found to be present in objectionable quantities, the sources should be located and isolated.

10.5 Requirements for Chemicals Used in Water Treatment

A consequence of reexamination of waste water flow rates (preceding section) is that requirements for water treatment chemicals may also change. Further, shifting from once-through cooling water and wastage of 70 percent of steam condensate to cooling water recirculation and increased steam condensate recovery will drastically reduce these requirements. The chemical requirements presented in this report were

estimated on the basis of currently estimated water flows and treating plans. These estimates should be confirmed since they affect both the cost of chemicals and the size of the evaporation pond.

10.6 Steam Condensate - Collection and Return to Boiler

As noted in Section 8, an important criterion to the economic attractiveness of a cooling water recirculation system is that the steam condensates be prevented from entering the recirculation loop. What becomes of the surplus condensate is of secondary importance.

10.7 Disposal of APS Effluents to the Atmosphere

After separation of the APS condensate from the PEW system, it becomes desirable to limit the quantity of this stream to that amount which can be recycled to the process users. One possible method of disposal is to "turn down" the APS condenser so as to leave the off-gas in vapor form and allow it to discharge up the stack along with the other gases. Dispersion calculations have shown that, as long as formation of a condensate plume downstream from the stack is avoided, concentrations of materials discharged to the atmosphere remain within acceptable limits. The problem is that the mixture of gases passing through the APS system includes water vapor from sources other than the waste calciner. A major part of this water vapor originates in the air washer equipment in Buildings 601 and 602. The amount of this vapor depends on washer operation which varies with the time of year and with daily weather variations. Thus, it is difficult to predict how much additional water vapor the stack gases can accommodate from the WCF off-gas without causing a condensation plume to develop in the stack effluent. A study is needed to develop instrumentation and a calculation procedure which will enable operators to determine when it is appropriate to discharge the calciner off-gases up the stack and when it is necessary to condense them.

10.8 Separation of Laboratory Chemical Wastes From Cooling Water System

With the present arrangements of sinks and drain piping in the chemical laboratories in Buildings 602, 627 and 637, it is normal for chemical wastes to be discharged to the cooling water system. While chemical wastes from these sources are not large in quantity, relative to chemical wastes originating in the water treatment facilities, they may contain traces of heavy metals which should not be discharged either to the aquifer (as in Case CO-4) or to a circulating cooling water loop (as in Cases CO-5 and CO-6). Means should be found for disposing of laboratory chemical wastes so that they are kept separate from cooling water. This suggestion applies both to existing facilities and to the design of any new laboratory facilities which may be contemplated.

10.9 Cooling Water Temperature

Necessary studies should be conducted to determine whether the 72°F (or similar) temperature of the cooling water in the recirculating cooling systems actually would impact ICPP users. This study assumed there would be no impact on either operability or demand by changing the summer cooling water temperature from its current value of 65° to 72°F.

LIFE CYCLE COST ANALYSIS FACTORS

Life Cycle Cost Analyses were performed on the Alternative Cases for which Cost Estimates were made. The objective of the Life Cycle Cost Analyses is to evaluate all comparable cases on a common basis; to simplify Cost Trade-Off Studies; and to assure that all Alternative evaluations include lifetime energy and maintenance costs as well as capital costs.

The factors included in the LCCA analyses are:

- Initial Capital Investment Cost
- Annual Operating and Maintenance Costs
- Energy Costs
- Replacement Costs
- Residual Values (Salvage Value)
- Time

The Method, and Discount Tables used in preparing the Life Cycle Cost Analyses are contained in the January 23, 1980 Federal Register - Federal Energy Management and Planning Programs, Methodology, and Procedures for Life Cycle Cost Analyses.

The key assumptions included in this Federal Energy Management Document are as follows:

- Instantaneous Construction

NOTE: Estimates are based on 1980 costs which is defined as base year.

- Exclude Inflation
- Annual Discount Rate is 10%
- Energy Prices will rise at rates greater than the rate of Increase in the general price level.

- Operating and Maintenance Costs, and Energy Costs begin accruing at the end of the base year.
- The 1980 cost of Electricity at INEL is \$5.57 per Million BTU.
- The 1980 cost of Fuel oil at INEL is \$4.36 per Million BTU.

Three discount tables from the January 23, 1980 Federal Register are attached. These tables which are used in the Life Cycle Cost Analysis are:

- Table A-1 SPW Factor. Based on a 10 percent Discount Rate, for finding the present Value of Future Non-Fuel, Non-Recurring Costs.
- Table A-2 UPW Factor. Based on a 10 percent Discount Rate, for finding the present Value of Future Non-Fuel, Recurring Costs.
- Table B-10 This table contains the UPW discount table for DOE Region 10 Industrial Sector. The UPW factor in this table has been adjusted to include future Energy price escalation.

The fifteen Alternative Cases evaluated by Life Cycle Cost Analysis are:

1. CC-2 Disposal of cooling water and steam condensates to a shallow well.
2. CC-3 Disposal of cooling water and steam condensates to an unlined percolation pond.
3. CC-6 Circulation of cooling water and steam condensates utilizing an evaporative cooling tower.
4. CC-7 Circulation of cooling water and steam condensates utilizing heat exchange with an independent cooling water stream.
5. CH-2 Disposal of chemical wastes to a process evaporator.
6. CH-5 Disposal of chemical wastes to a solar evaporation pond.
7. RH-8 Disposal of low level radioactive wastes by deep well injection.

8. RW-9 Disposal of low level radioactive wastes by evaporation and discharge to atmosphere.
9. RW-11A Separation of APS stream from PEW, evaporation to stack and recycle remainder.
10. RW-11B Separation of APS stream from PEW; evaporation to stack and manufacture of $CA(NO_3)_2$ in own plant.
11. CO-2 Cooling water and steam condensates, plus chemical wastes to existing injection well.
APS condensates separated from PEW system.
12. CO-3 Cooling water and steam condensates disposed of to injection well through holding ponds. APS condensates separated from PEW.
13. CO-4 Cooling water and steam condensates disposed of to injection well through holding ponds. Chemical wastes to lined evaporation pond. APS condensates separated from PEW.
14. CO-5 Cooling water and steam condensates recirculated with cooling tower and lined evaporation pond. Chemical wastes to lined evaporation pond. APS condensates separated from PEW.
15. CO-6 Cooling water and steam condensates recirculated with cooling tower (reduced flow to evaporation pond. Chemical wastes to lined evaporation pond (reduced flow). APS condensates separated from PEW.

The Life Cycle Cost Analysis sheets for the above cases are attached:

Table A-1.-SPW Factors, Based on a 10 Percent
Discount Rate, for Finding the Present Value of
Future Non-Fuel, Non-Recurring Costs

Years	Factor
1.....	0.91
2.....	0.83
3.....	0.75
4.....	0.68
5.....	0.62
6.....	0.57
7.....	0.50
8.....	0.47
9.....	0.42
10.....	0.39
11.....	0.35
12.....	0.32
13.....	0.29
14.....	0.26
15.....	0.24
16.....	0.22
17.....	0.20
18.....	0.18
19.....	0.16
20.....	0.15
21.....	0.14
22.....	0.12
23.....	0.11
24.....	0.10
25.....	0.09
26.....	0.08
27.....	0.08
28.....	0.07
29.....	0.06
30.....	0.06

TABLE A-1

Table A-2.-UPW Factors, Based on a 10 Percent
Discount Rate, for Finding the Present Value of
Future Non-Fuel, Recurring Costs

Years	Factor
1.....	0.91
2.....	1.74
3.....	2.49
4.....	3.17
5.....	3.79
6.....	4.36
7.....	4.87
8.....	5.34
9.....	5.76
10.....	6.15
11.....	6.50
12.....	6.81
13.....	7.10
14.....	7.37
15.....	7.61
16.....	7.82
17.....	8.02
18.....	8.20
19.....	8.37
20.....	8.51
21.....	8.65
22.....	8.77
23.....	8.88
24.....	8.99
25.....	9.08
26.....	9.16
27.....	9.24
28.....	9.31
29.....	9.37
30.....	9.43

TABLE A-2

UPW DISCOUNT FACTORS ADJUSTED FOR ENERGY PRICE ESCALATION

DOE REGION 10

(WASHINGTON, OREGON, IDAHO, ALASKA)

STUDY PERIOD 1 IS 1980

INDUSTRIAL SECTOR

ELECTRICITY	NATURAL GAS	DISTILLATE	LIQUID GAS	COAL
0.98	1.01	0.91	0.93	0.94
1.94	2.02	1.73	1.79	1.81
2.87	3.04	2.47	2.58	2.63
3.79	4.07	3.14	3.32	3.39
4.68	5.10	3.75	4.01	4.11
5.52	6.06	4.32	4.65	4.78
6.30	6.95	4.86	5.23	5.41
7.03	7.77	5.37	5.78	5.99
7.71	8.54	5.85	6.28	6.54
8.34	9.25	6.30	6.75	7.06
8.93	9.89	6.72	7.20	7.53
9.47	10.48	7.11	7.64	7.96
9.98	11.01	7.47	8.07	8.35
10.45	11.49	7.81	8.49	8.71
10.88	11.93	8.13	8.89	9.04
11.28	12.32	8.42	9.29	9.35
11.65	12.69	8.69	9.67	9.63
11.99	13.01	8.95	10.06	9.88
12.31	13.31	9.18	10.41	10.11
12.61	13.58	9.40	10.76	10.33
12.88	13.83	9.61	11.11	10.52
13.13	14.05	9.80	11.44	10.70
13.37	14.25	9.97	11.77	10.87
13.58	14.44	10.14	12.09	11.02
13.79	14.60	10.29	12.39	11.15
13.97	14.75	10.43	12.69	11.28
14.14	14.89	10.57	12.99	11.40
14.30	15.02	10.69	13.27	11.50
14.45	15.13	10.80	13.55	11.60
14.59	15.23	10.91	13.82	11.69

TABLE B-10

OPERATIONS AND MAINTENANCE COSTS

Life Cycle Cost Analyses were made for eleven selected Alternative Cases. Included in the Life Cycle Costs are Operating and Maintenance Costs. The hourly rate used in calculating O & M costs is \$25.00 per hour which includes overhead. This hourly rate was furnished by DOE/ENICO, Idaho. Following is a tabulation of the time allocated for O & M for each case estimated.

<u>CASE</u>	<u>HOURS PER DAY OPERATING TIME</u>	<u>YEARLY TURN-AROUND MAINTENANCE TIME IN HOURS</u>
CC-2	3	320
CC-3	3	320
CC-6	6	640
CC-7	3	640
CH-2A	9	320
CH-2B	12	320
CH-5	3	80
RW-8	3	160
RW-9	4-1/2	320
RW-11A	3	160
RW-11B	12	320

In addition to the manhours for labor costs an allowance was included in the yearly Operating and Maintenance Costs for Materials. The amount included was a judgemental based upon the complexity of the Alternative Case.

Copies of the Life Cycle Cost Analysis sheets for each of the Alternative Cases estimated are included.

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CC-2

TITLE: DISPOSAL OF COOLING WATER AND STEAM CONDENSATE TO A SHALLOW WELL

PART I

- Capital Cost = \$2,198,000
- O&M Cost = \$45,500/year
- Energy:
 - Electricity = 4950 MBTU/year
 - Oil = 132 MBTU/year
- Economic Life = 20 years
- Residual Value = Zero
- Reinvestment Cost = Zero

PART II

- Present Value Capital Investment = \$2,198,000
- Present Value O&M
 - $\$45,500 \times 8.51 = \$387,205$
- Present Value Energy
 - Electricity = $4950 \text{ MBTU} \times \$5.57/\text{MBTU} \times 12.61 = \$347,677$
 - Oil = $132 \text{ MBTU} \times \$4.36/\text{MBTU} \times 9.4 = \5410
- Total Present Value = \$2,938,292

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CC-3

TITLE: DISPOSAL OF COOLING WATER AND STEAM CONDENSATE TO UNLINED POND

PART I

- Capital Cost = \$3,094,000
- O&M Cost = \$45,500/year
- Energy:
 - Electricity = 1960 MBTU/year
 - Oil = 132 MBTU/year
- Economic Life = 20 years
- Residual Value = Zero
- Reinvestment Cost = \$10,000 in year 7 and 14 (Factors = 0.50 and 0.26)

PART II

- Present Value Capital Investment = $3,094,000 + 5,000 + 2,600 = \$3,101,600$
- Present Value O&M
 - $\$45,500 \times 8.51 = \$387,205$
- Present Value Energy
 - Electricity = $1960 \text{ MBTU} \times \$5.57/\text{MBTU} \times 12.61 = \$137,666$
 - Oil = $132 \text{ MBTU} \times \$4.36/\text{MBTU} \times 9.4 = \$5,410$
- Total Present Value = \$3,632,881

LIFE CYCLE COST ANALYSIS

ALTERNATIVE CASE: CC-6

TITLE: COOLING WATER RECIRCULATION WITH COOLING TOWER

PART I

- Capital Cost = \$11,542,000
- O&M Cost = \$86,000/year (maint)-10,000 (chem) = \$76,000/year
- Energy: =
 - Electricity = \$2750 MBTU/year
 - Oil = 132 MBTU/year
- Economic Life = 20 years
- Residual Value = Zero
- Reinvestment Cost = Zero
- Capital Cost Foregone = [\$1,280,000]

PART II

- Present Value Capital Investment
$$\$11,542,000 - \$1,280,000 = \$10,262,000$$
- Present Value O&M
$$\$76,000 \times 8.51 = \$646,760$$
- Present Value Energy
 - Electricity = 2750 MBTU X \$5.57/MBTU X 12.61 = \$193,154
 - Oil = 132 MBTU/year X \$4.36/MBTU X 9.4 = \$5410
- Total Present Value = \$11,107,324